Habitat Elements and Life Stage Matrix for Wildlife Species of Interest in Mount Spokane State Park

Western Toad
(*Bufo boreas*)

Pacific Biodiversity Institute

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Kim Romain-Bondi
kim@pacificbio.org

Hans Smith
hans@pacificbio.org

Susan Snetsinger
susansnet@yahoo.com

Katy White
katy.white@gmail.com

Peter Morrison
pm@pacificbio.org

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Pacific Biodiversity Institute
P.O. Box 298
Winthrop, Washington 98862
509-996-2490

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Introduction

Pacific Biodiversity Institute (PBI) was contracted by the Washington State Parks and Recreation Commission (WSPRC) under Service Agreement AE 709-191 to create a wildlife habitat element and life stage matrix. The matrix created was based on extensive literature review and expert consultation for 21 target species of interest in a 5,000 acre section of Mount Spokane State Park (MSSP). Figure 1 illustrates the 5,000 acre section of park relevant to this report.

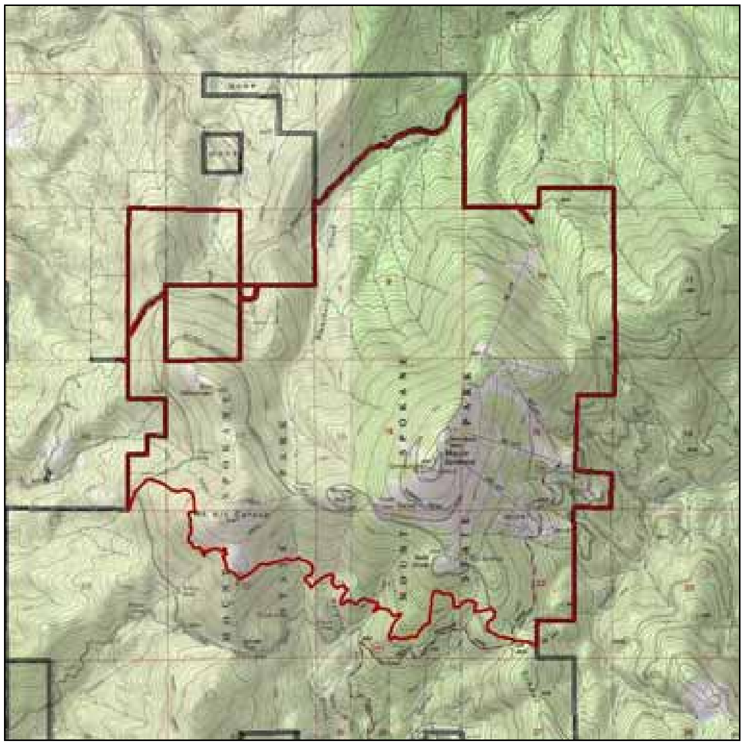

Figure 1. Project area (red polygons) for the Habitat Elements and Life Stage Matrix.

A wildlife habitat element and life stage matrix is a reference table and supporting documentation that condenses a large amount of data and information regarding factors effecting habitat suitability for multiple species of wildlife within a specified landscape. The purpose of the matrix is to provide planners, managers, and researchers with a comprehensive list of scientifically credible habitat elements that can be used to conduct habitat suitability studies and assessments for a large suite of species in the landscape of interest. The matrix thereby increases the efficiency of designing inventory protocols for habitat suitability studies and allows for inventories with limited budgets to be more cost effective in collecting multiple habitat element statistics within a single inventory. Identification of key habitat elements is derived through extensive scientific literature review and interviews with wildlife experts.

Methods

Literature Review

We conducted a review of peer-reviewed and government literature detailing habitat suitability characteristics for 21 wildlife species identified as species of conservation interest in MSSP. These species of interest were developed by Washington Department of Fish and Wildlife (H. Ferguson, unpublished, 2007). These species of interest are listed in Table 1. More details regarding the conservation or protection status of this species is presented in Appendix A.

Table 1. Focal wildlife species of Mt. Spokane State Park.

Species	Scientific Name	WDFW Species of Concern	Federal Status
Carnivores			
Gray wolf	*Canis lupus*	Endangered	Endangered
Canadian lynx	*Lynx canadensis*	Threatened	Threatened
Wolverine	*Gulo gulo*	Candidate	Species of Concern
American marten	*Martes americana*	None	None
Ungulates			
Rocky Mountain elk	*Cervus elaphus*	None	None
White-tailed deer	*Odocoileus virginianus ochrourus*	None	None
Moose	*Alces alces*	None	None
Birds			
Northern goshawk	*Picoides arcticus*	Candidate	Species of Concern
Boreal owl	*Aegolius funereus richardoni*	Monitor	None
Pileated woodpecker	*Dryocopus pileatus*	Candidate	None
Black-backed woodpecker	*Picoides arcticus*	Candidate	None
Dusky grouse	*Dendragapus obscurus pallidus*	None	None
Brown creeper	*Certhia americana*	None	None
Winter wren	*Troglodytes troglodytes*	None	None
Olive-sided flycatcher	*Contopus cooperi*	None	None
Small mammals			
Pika	*Ochotona princeps*	None	None
Pygmy shrew	*Sorex hoyi*	Monitor	None
Silver-haired bat	*Lasionycteris noctivagans*	None	None
Hoary bat	*Lasiurus cinereus*	None	None
Other species			
Western toad	*Bufo boreas*	Candidate	Species of Concern
Compton tortoiseshell butterfly	*Nymphalis vaualbum*	Monitor	None

Habitat suitability and habitat use can change dramatically between different life-stages for each species. We organized Habitat Elements for each focal species by various life-stages that were i) likely to occur in the MSSP region, and ii) critical to the species and potentially a limiting factor in their life cycle. If a life stage was not addressed for a wildlife species, either it did not meet these requisites, or there was insufficient data in the literature to address specific habitat elements for the species. Table 2 lists the life-stage groups addressed for each focal species. The life-stage groups were chosen based on information provided to us by the Washington Department of Fish and Wildlife (H. Ferguson, unpublished, 2007).

Table 2. Life-Stages by which habitat elements are organized in the matrix.

Species	Life-Stage
Carnivores	
Gray wolf	dispersal
	summer foraging
	winter foraging
Canada lynx	breeding,denning
	dispersal
	summer foraging
	winter foraging
Wolverine	summer foraging
	winter foraging
American marten	non-winter cover, foraging
	winter cover/, foraging
Ungulates	
Rocky Mountain elk	cover
	summer/fall foraging
	winter foraging
White-tailed deer	early/late winter foraging
	mid-winter cover
Moose	breeding/calving
	cover
	summer foraging
	winter foraging
Other species	
Western toad	breeding/metamorphosis
	migration,foraging
Compton tortoiseshell butterfly	breeding/metamorphosis,foraging

Species	Life-Stage
Birds	
Northern goshawk	foraging
	breeding/ nesting
Boreal owl	breeding/nesting
	foraging,roosting
Pileated woodpecker	breeding/nesting
	foraging
	roosting
Black-backed woodpeckers	breeding/nesting
	foraging
Dusky grouse	breeding/nesting
	summer foraging
	winter foraging,roosting
Brown creeper	breeding/nesting
	foraging
Winter wren	breeding/nesting,summer foraging
Olive-sided flycatcher	breeding/nesting
	foraging
Small mammals	
North American pika	breeding/nesting,foraging
	dispersal
Pygmy shrew	breeding/parturition, foraging
Silver-haired bats	Breeding/parturition,roosting
	foraging
Hoary bats	day roosting
	foraging

We reviewed available literature for each species and corresponding life-stage. During our reviews we made notes recording the habitat element variables defined and presented in each document that affected general habitat suitability. Each variable was then scrutinized to ascertain whether it was measurable or quantifiable during field surveys or via spatial analysis. Variables were also scrutinized as to whether they were elements relevant to the landscape in or around MSSP. Variables deemed measurable, critical to habitat suitability, and/or relevant in the landscape around MSSP were then selected for inclusion into the matrix. Often, there was contradicting information about a species habitat requirement and the variables important to a specific life-stage. Some of the contradictions may have resulted from habitat use differences between locations where various research was conducted, variability in habitats or life processes across the species range, methods used by researchers to test hypotheses, or lack of information altogether. Any elements selected from a specific piece of literature that were deemed measurable and/or relevant to the MSSP landscape were evaluated against other pieces of literature, if they existed.

When conducting our literature review, we relied more heavily on existing peer-reviewed Habitat Suitability Index (HSI) models when available. The published HSI models provide discreet documentation for each measurable habitat element, and identified parameters by which each element contributes to habitat suitability. Throughout our research, we emphasized species habitat accounts based on local conditions in and around MSSP whenever possible. We gave preference to local information such as wildlife data from the U.S. Forest Service Idaho Panhandle National Forest, modeled habitat elements in the Pacific Northwest, or habitat descriptions in the literature relevant to eastern Washington and Oregon. However, when local or regional data was not available, we used whatever species information we could find to identify key habitat elements.

Individual Species Summaries

Following the literature review, we summarized the relevant literature for each of the 21 focal species. For consistency, these individual species summaries were organized into a pre-determined format (Figure 2). Each species summary is included in this report. The format of the summaries adheres to the following order: First we recorded information about the species range and general habitat requirements. Second, we identified the distribution of the species in MSSP, and made a list of any existing habitat models uncovered from the literature search. Then, for each life-stage we identified key measurable habitat elements from the literature affecting habitat suitability. Briefly we described these elements and their parameters according to the literature. We also described how they may relate to MSSP and the species distribution in the study area. After each description of key habitat elements, a table is provided summarizing the key habitat element variables affecting habitat suitability and their associated parameters. Lastly, we discussed risk factors associated with each species and potential impacts to the species related to changes in habitat condition. This information was gleaned from the literature, but is not meant to be a full review of impacts to each species. At the end of each species summary are the literature cited and/or references used in completing each summary.

Species Common Name *(Species scientific name)*

General discussion of habitat use, life-stages, and habitat suitability

Distribution In MSSP

Existing Habitat Models

Habitat Elements for Each Life-Stage

Focused discussion of identified habitat elements and their affects on habitat suitability for a given life-stage.

Table summarizing habitat elements for each life-stage

Variables	Parameters

Risk Factors

References

Figure 2. Example template used to organize the species summaries based on the literature review.

In the habitat elements table (above), it is important to note that all variables and associated parameters do not need to be met for there to be adequate habitat for the species at MSSP. In some cases, variables are intended to be combined in an "either/or" context, rather than an "and" context. Parameters and their associations with other parameters are described in more detail in the Habitat Elements discussion section for each life-stage.

Expert Consultation

After we performed the species summaries, we consulted with regional and local wildlife experts who reviewed the documents to help point out missing materials and and/or provide information that was not available in the literature we reviewed. Reviewers were chosen based on their level of expertise with each wildlife species (see Appendix B for list of wildlife experts and the species they reviewed). Expert comments ranged from notes about general habitat requirements to detailed critiques of identified parameters for MSSP. We incorporated their notes and comments into our final summaries and the resulting matrix table.

Creation of the Matrix Table

From the habitat element tables presented in each species summary, we created a master matrix table of all habitat elements and their associated life–stage relationship for each focal species (See the Master Matrix Tables on pages 19 - 25). We used an excel spreadsheet pivot table to organize the datasets. In the resulting matrix table, habitat elements are individually listed for each row, while the species and their life-stages are individually listed for each column. A value of 1 is given to the proper cell in the table where habitat suitability for a specific species life-stage is directly affected by a listed habitat element. Summaries of the amount of habitat elements documented in the matrix for each species' life-stage, each habitat element theme, and the amount of species life-stages requiring a particular habitat element are all presented within the tables. A sample template of the Master Matrix Table is provided in Figure 3.

		Species1		Species2	**Species Group Grand Total**
		Life-Stage1	Life-Stage2	Life-Stage1	
Themes	**Elements**				
Theme1	Element 1	1		1	**2**
	Element 2	1	1		**2**
Theme1 Total		**2**	**1**	**1**	**4**
Grand Total Per Life Stage		**2**	**1**	**1**	**4**

Figure 3. Example template of the Master Matrix Table.

General Notes about Selected Habitat Elements

Lack of standardization in names, metrics, and scales for the variety of habitat elements described across a wide range of literature posed a considerable problem in organizing the information for this project. Throughout many of the documents we reviewed, definitions of terms were not provided and terminology had to be interpreted based on our own experience with each wildlife species. In the interest of providing a more cohesive and integrated matrix table, we attempted to reclassify the names of variables provided from the literature into logical groups so that similar variables could be cross-walked between species and between life-stages. Table 3 presents the final list of habitat element names we used in classifying related terms and habitat element concepts described in the literature.

For the sake of organization and clarity, we grouped key habitat elements into habitat element "themes" in the Master Matrix table. These theme groups provide some context as to the nature of the relationship between the arrays of elements to each other. The habitat elements described under each theme group may or may not have quantifiable or measurable parameters. Parameters for these habitat elements are explained in each species summary.

As mentioned above, it is important to note that all variables and associated parameter values in the habitat matrices for each species do not need to be met for there to be adequate habitat for the species at MSSP. In some cases, these variables are intended to be combined in an "either/or" context, rather than an "and" context where all parameters need to be met. For example, the presence of coarse woody debris is identified as a habitat element for dusky grouse (*Dendragapus obscurus pallidus*) breeding/nesting. Dusky grouse may nest in open habitats or in forested habitats. Coarse, woody debris can provide cover at a forested nesting site, but is not a critical element for nests in more open habitats, where coarse woody debris is not present but adequate cover is provided by shrubs. In this case, either a specified level of coarse woody debris cover or a specified level of shrub cover may be necessary, but both are not simultaneously necessary.

Table 3. List of key habitat elements derived from the literature review and incorporated into the Master Matrix Table.

Themes	Habitat Elements
Anthropogenic Related	Abandoned/closed roads and trails
	Human infrastructure
	Road density
Aquatic Habitats	Aquatic Vegetation
	Stream corridors
	Water bodies
	Water body depth
	Water body size
	Water body temperature
Distance Related Elements	Distance between breeding/nesting and foraging habitat
	Distance between cover vegetation
	Distance between trees
	Distance for active roads
	Distance from breeding habitat
	Distance from breeding ponds
	Distance from cover habitat
	Distance from developed infrastructure
	Distance from foraging habitat
	Distance from forest edge
	Distance from herbaceous or shrub cover to forest cover
	Distance from talus
	Distance from water bodies and stream corridors
Disturbance Related	Burned areas
	Clear-cuts
	Fire / bug-kill severity
	Time after disturbance event
Land Cover	Cover type (General Habitat Types)
	Snowfields
Topography	Aspect
	Elevation
	Landforms
	Slope
Unique Habitat Elements	Rock crevices
Vegetation Community Characteristics	Area of non-forested cover type
	Coarse woody debris
	Coarse woody debris cover
	Coarse woody debris diameter

Themes	Habitat Elements
Vegetation Community Characteristics Continued	Coarse woody debris length
	Dominant tree or shrub species composition
	Dominant tree species composition
	Forest canopy cover
	Forest canopy height
	Forest composition
	Forest edges
	Forest patch size
	Forest successional stage
	Herbaceous canopy cover
	Herbaceous cover
	Herbaceous height
	Horizontal canopy structure
	Large trees
	Leaf litter and duff
	Shrub canopy cover
	Shrub heights
	Snag decay class
	Snag density
	Snag diameter
	Snag height
	Snag recruitment trees
	Snag/tree cavities
	Snags
	Snow depth
	Tree canopy
	Tree density
	Tree diameter
	Tree height
	Tree or shrub density
	Tree or shrub stem diameter
	Tree or snag density
	Tree or snag diameter
	Tree or snag height
	Tree size
	Tree/snag character

Association with Terms in the Habitat Unit Map

In review of the literature, land cover classification or cover types are defined and described in various ways. In order to standardize cover types associated with each species and life stage, we interpreted habitats used by each species from the literature, and reclassified their habitat types into the General Habitat Types developed for the MSSP Habitat Unit Map for the study area (Smith and Morrison 2009). Therefore our habitat elements for each species and the cover type classification on MSSP can be cross-referenced in this map. Table 4 provides a description of the general habitat types mapped in MSSP.

Table 4. Descriptions of habitat types in Mount Spokane State Park that were used as cover types variables in the Habitat Element Matrix.

General Habitat Type	Description
Blowdown - Shrubland	shrubland where a large stand mortality event killed the existing forest and much of the legacy tree stems have fallen to the ground
Conifer Woodland / Meadow	area with a widely open conifer forest canopy and herbaceous meadow-like conditions in between the canopy gaps
Conifer Woodland / Shrubland	area with a widely open conifer forest canopy and dense shrub cover in between the canopy gaps
Developed	area is significantly altered or impacted by human development and/or disturbances
Riparian Conifer Forest	area within 30 meters of a mapped stream segment that has a closed conifer forest canopy
Riparian Conifer Woodland / Shrubland	area within 30 meters of a mapped stream segment that has a widely open conifer forest canopy and dense shrub cover in between the canopy gaps
Riparian Developed	area within 30 meters of a mapped stream segment that is significantly altered or impacted by human development and/or disturbances
Riparian Shrubland	area within 30 meters of a mapped stream segment covered mostly by shrubs
Rock Outcrop	area contains large exposures of bedrock with minimal vegetation cover over the exposures
Scree/Boulder/Talus Fields	area consists mostly of loose rocks and/or boulders - vegetation coverage is minimal
Shrubland / Meadow	area possesses a mosaic of shrubland and meadow like conditions
Shrubland	area covered mostly by shrubs
Upland Conifer Forest	An upland (non-riparian) area mostly covered by a closed conifer forest canopy
Upland Meadows	area is covered mostly by herbs and/or grasses
Wetland Conifer Woodland / Shrubland	area mapped as wetland by NWI and has a widely open conifer forest canopy and dense shrub cover in between the canopy gaps

Forest Successional Stage Classifications

When describing forest characteristics, we used forest successional stage classes as provided by the WSPRC Protocols for vegetation community inventories. However, we adapted the stand age parameter of mature forests from 90-200 years of age to 80 to 200 years old. This re-classified age class was consistent for most target species utilizing mature to old growth forests in the literature. Forest successional stage classes used in the matrix are defined in Table 5.

Table 5. Forest successional stage classifications.

Forest Successional Stage	Age in years
Very Young	0 – 40
Young	40 – 80
Mature	80 – 200
Old-growth	200 +

We also reclassified forest successional stages in our matrix from the available literature for each wildlife species to be more consistent in our descriptors. For example, if a document described an important habitat element as an old-growth forest older than 100 years in age, we reclassified this as a mature and old-growth forest.

Wildlife x Habitat Element Matrix

The following tables (Tables 6 - 9) present a crosswalk matrix which details the habitat elements we identified for the life-stages of the 21 wildlife species in MSSP. All habitat elements and life-stages are based on literature review and expert consultation. Tables are ordered by Carnivores, Ungulates, Birds, Small Mammals, and Other Species. The numeric values in each table refer to the number of times a particular habitat element is relevant for a particular species life stage (see the Creation of the Matrix Table section on page 13 for more information).

Carnivores

Table 6. Wildlife Life-Stage x Habitat Element Matrix– Carnivores:

		American Marten		**Canada Lynx**				**Gray Wolf**			**Wolverine**		**Carnivores Grand Total**
		Non-Winter Cover/Foraging	Winter Cover/Foraging	Breeding/Denning	Dispersal	Summer Foraging	Winter Foraging	Dispersal	Summer Foraging	Winter Foraging	Summer Foraging	Winter Foraging	
Themes	**Elements**												
Anthropogenic Related	Abandoned/closed roads and trails							1	1				**2**
	Human infrastructure							1	1	1			**3**
	Road density								1	1	1	1	**4**
Anthropogenic Related Total								**2**	**3**	**2**	**1**	**1**	**9**
Aquatic Habitats	Stream corridors											1	**1**
Aquatic Habitats Total												**1**	**1**
Distance Related Elements	Distance between cover vegetation				1								**1**
	Distance between trees		1										**1**
Distance Related Elements Total			**1**		**1**								**2**
Land Cover	Cover type			1		1	1	1	1	1	1	1	**8**
	Snowfields											1	**1**
Land Cover Total				**1**		**1**	**1**	**1**	**1**	**1**	**1**	**2**	**9**
Topography	Aspect			1									**1**
	Elevation									1	1	1	**3**
	Landforms				1			1					**2**
	Slope						1						**1**
Topography Total				**1**	**1**		**1**	**1**		**1**	**1**	**1**	**7**
Vegetation Community Characteristics	Coarse woody debris cover	1	1	1									**3**
	Coarse woody debris diameter	1	1										**2**
	Dominant tree species composition		1										**1**
	Forest canopy cover	1	1										**2**
	Forest successional stage			1									**1**
	Shrub canopy cover	1				1							**2**
	Shrub heights					1							**1**
	Snag density	1	1										**2**
	Snag diameter	1	1										**2**

Themes	Elements	American Marten Non-Winter Cover/Foraging	American Marten Winter Cover/Foraging	Canada Lynx Breeding/Denning	Canada Lynx Dispersal	Canada Lynx Summer Foraging	Canada Lynx Winter Foraging	Gray Wolf Dispersal	Gray Wolf Summer Foraging	Gray Wolf Winter Foraging	Wolverine Summer Foraging	Wolverine Winter Foraging	Carnivores Grand Total
	Tree density	1	1	1									**3**
	Tree diameter	1	1										**2**
	Tree or shrub density						1						**1**
	Tree or shrub stem diameter						1						**1**
	Tree size			1									**1**
Vegetation Community Characteristics Total		**8**	**8**	**4**		**2**	**2**						**24**
Grand Total Per Life Stage		**8**	**9**	**6**	**2**	**3**	**4**	**4**	**4**	**4**	**3**	**5**	**52**

Ungulates

Table 7. Wildlife Life-Stage x Habitat Element Matrix– Ungulates:

Themes	Elements	Rocky Mountain Elk Winter Foraging	Rocky Mountain Elk Cover	Rocky Mountain Elk Summer/Fall Foraging	White-tailed Deer Early/ Late Winter Foraging	White-tailed Deer Mid-Winter Cover	Moose Summer Foraging	Moose Winter Foraging	Moose Cover	Moose Breeding/Calving	Ungulates Grand Total
Aquatic Habitats	Stream corridors						1				**1**
	Water bodies						1			1	**2**
Aquatic Habitats Total							**2**			**1**	**3**
Distance Related Elements	Distance from water bodies and stream corridors			1							**1**
	Distance from foraging habitat		1			1					**2**
	Distance for active roads	1	1	1							**3**
	Distance from cover habitat			1	1			1			**3**
Distance Related Elements Total		**1**	**2**	**3**	**1**	**1**		**1**			**9**
Land Cover	Cover type		1		1	1	1	1	1	1	**7**
Land Cover Total			**1**		**1**	**1**	**1**	**1**	**1**	**1**	**7**
Topography	Aspect	1		1	1	1				1	**5**
	Elevation	1		1	1	1					**4**
	Landforms	1		1	1					1	**4**
	Slope	1		1	1	1	1	1		1	**7**
Topography Total		**4**		**4**	**4**	**3**	**1**	**1**		**3**	**20**
Vegetation Community Characteristics	Dominant tree species composition								1		**1**
	Forest canopy cover	1	1	1	1	1			1		**6**
	Forest successional stage		1		1	1		1	1	1	**6**
	Shrub canopy cover				1		1	1		1	**4**

Themes	Elements	Rocky Mountain Elk: Winter Foraging	Rocky Mountain Elk: Cover	Rocky Mountain Elk: Summer/Fall Foraging	White-tailed Deer: Early/ Late Winter Foraging	White-tailed Deer: Mid-Winter Cover	Moose: Summer Foraging	Moose: Winter Foraging	Moose: Cover	Moose: Breeding/Calving	Ungulates Grand Total
	Forest patch size		1								**1**
	Snow depth							1			**1**
	Forest canopy height								1		**1**
Vegetation Community Characteristics Total		**1**	**3**	**1**	**3**	**2**	**1**	**3**	**4**	**2**	**20**
Disturbance Related	Burned areas						1				**1**
	Clear-cuts						1				**1**
Disturbance Related Total							**2**				**2**
Grand Total Per Life Stage		**6**	**6**	**8**	**9**	**7**	**7**	**6**	**5**	**7**	**61**

Birds

Table 8. Wildlife Life-Stage x Habitat Element Matrix– Birds:

		Northern Goshawk		Boreal Owl		Pileated Woodpecker			Black-backed Woodpecker		Dusky Grouse			Brown Creeper		Winter Wren	Olive-sided Flycatcher		Birds Grand Total
Themes	**Elements**	Nesting	Foraging	Breeding/ Nesting	Foraging/ Roosting	Foraging	Breeding/ Nesting	Roosting	Foraging	Breeding/ Nesting	Summer Foraging	Breeding/ Nesting	Winter Foraging/ Roosting	Foraging	Breeding/ Nesting	Breeding/ Nesting/ Summer Foraging	Foraging	Breeding/ Nesting	
Aquatic Habitats	Stream corridors															1			**1**
	Water bodies															1	1		**2**
Aquatic Habitats Total																**2**	**1**		**3**
Distance Related Elements	Distance from developed infrastructure	1																	**1**
	Distance from forest edge	1																	**1**
	Distance from herbaceous or shrub cover to forest cover											1							**1**
	Distance from breeding habitat												1						**1**
	Distance from water bodies and stream corridors															1			**1**
Distance Related Elements Total		**2**										**1**	**1**			**1**			**5**
Land Cover	Cover type			1	1	1	1	1	1	1		1	1	1	1	1	1		**13**
Land Cover Total				**1**	**1**	**1**	**1**	**1**	**1**	**1**		**1**	**1**	**1**	**1**	**1**	**1**		**13**
Topography	Elevation			1	1														**2**

Themes	Elements	Northern Goshawk		Boreal Owl		Pileated Woodpecker			Black-backed Woodpecker		Dusky Grouse			Brown Creeper		Winter Wren	Olive-sided Flycatcher		Birds Grand Total
		Nesting	Foraging	Breeding/ Nesting	Foraging/ Roosting	Foraging	Breeding/ Nesting	Roosting	Foraging	Breeding/ Nesting	Summer Foraging	Breeding/ Nesting	Winter Foraging/ Roosting	Foraging	Breeding/ Nesting	Breeding/ Nesting/ Summer Foraging	Foraging	Breeding/ Nesting	
Themes	**Elements**																		
	Slope	1	1																**2**
Topography Total		**1**	**1**	**1**	**1**														**4**
Vegetation Community Characteristics	Coarse woody debris cover					1													**1**
	Coarse woody debris diameter					1													**1**
	Dominant tree species composition			1	1														**2**
	Aspen stands										1								**1**
	Forest canopy cover	1	1		1							1			1			1	**6**
	Forest successional stage	1	1	1	1	1	1	1					1	1	1	1	1	1	**13**
	Shrub canopy cover	1	1									1				1			**4**
	Shrub heights	1	1									1							**3**
	Snag density						1	1	1	1								1	**5**
	Snag diameter					1	1	1	1	1				1	1			1	**8**
	Tree density	1																1	**2**
	Tree diameter	1												1	1				**3**
	Tree size																	1	**1**
	Tree height	1	1																**2**
	Snags	1															1		**2**
	Area of non-forested cover type		1																**1**
	Large trees		1																**1**
	Tree or snag diameter			1															**1**
	Tree or snag density			1															**1**
	Snag decay class						1	1		1									**3**
	Snag recruitment trees						1	1											**2**
	Snag height					1				1									**2**
	Coarse woody debris length					1													**1**

Themes	Elements	Northern Goshawk: Nesting	Northern Goshawk: Foraging	Boreal Owl: Breeding/ Nesting	Boreal Owl: Foraging/ Roosting	Pileated Woodpecker: Foraging	Pileated Woodpecker: Breeding/ Nesting	Pileated Woodpecker: Roosting	Black-backed Woodpecker: Foraging	Black-backed Woodpecker: Breeding/ Nesting	Dusky Grouse: Summer Foraging	Dusky Grouse: Breeding/ Nesting	Dusky Grouse: Winter Foraging/ Roosting	Brown Creeper: Foraging	Brown Creeper: Breeding/ Nesting	Winter Wren: Breeding/ Nesting/ Summer Foraging	Olive-sided Flycatcher: Foraging	Olive-sided Flycatcher: Breeding/ Nesting	Birds Grand Total
	Coarse woody debris											1				1			**2**
	Herbaceous canopy cover											1							**1**
	Herbaceous height											1							**1**
	Forest edges											1					1	1	**3**
	Herbaceous cover										1								**1**
	Forest composition												1						**1**
	Tree canopy												1						**1**
	Tree/snag character														1				**1**
	Forest patch size															1			**1**
Vegetation Community Characteristics Total		**8**	**7**	**4**	**3**	**6**	**5**	**5**	**2**	**4**	**2**	**7**	**3**	**3**	**5**	**4**	**3**	**7**	**78**
Disturbance Related	Time after disturbance event								1	1									**2**
	Fire / bug-kill severity														1				**1**
	Burned areas																1		**1**
Disturbance Related Total									**1**	**1**					**1**		**1**		**4**
Grand Total Per Life Stage		**11**	**8**	**6**	**5**	**7**	**6**	**6**	**4**	**6**	**2**	**9**	**5**	**4**	**7**	**8**	**6**	**7**	**107**

Small Mammals & Other Wildlife Species

Table 9. Wildlife Life-Stage x Habitat Element Matrix–Small Mammals and Other Wildlife Species:

Themes	Elements	American Pika: Dispersal	American Pika: Breeding/ Nesting and Foraging	American Pygmy Shrew: Foraging and Breeding/ Parturition	Silver-haired Bat: Foraging	Silver-haired Bat: Breeding and Roosting	Hoary Bat: Foraging	Hoary Bat: Day-Roosting	**Small Mammals Grand Total**	Western Toad: Breeding/ Metamorphosis	Western Toad: Migration/ Foraging	Compton's Tortoiseshell Butterfly: Breeding/ Metamorphosis/ Foraging	**Other Species Grand Total**
Anthropogenic Related	Human infrastructure					1			**1**				**0**
Anthropogenic Related Total						**1**			**1**				**0**

		American Pika		American Pygmy Shrew	Silver-haired Bat		Hoary Bat		**Small Mammals Grand Total**	Western Toad		Compton's Tortoiseshell Butterfly	**Other Species Grand Total**
		Dispersal	Breeding/ Nesting and Foraging	Foraging and Breeding/ Parturition	Foraging	Breeding and Roosting	Foraging	Day-Roosting		Breeding/ Metamorphosis	Migration/ Foraging	Breeding/ Metamorphosis/ Foraging	
Themes	**Elements**												
Aquatic Habitats	Stream corridors				1		1		**2**		1	1	**2**
	Water bodies				1		1		**2**	1			**1**
	Water body depth								**0**	1			**1**
	Water body size								**0**	1			**1**
	Water body temperature								**0**	1			**1**
	Aquatic Vegetation								**0**	1			**1**
Aquatic Habitats Total					**2**		**2**		**4**	**5**	**1**	**1**	**7**
Distance Related Elements	Distance from talus		1						**1**				**0**
	Distance between breeding/nesting and foraging habitat	1							**1**				**0**
	Distance from breeding ponds								**0**		1		**1**
Distance Related Elements Total		**1**	**1**						**2**		**1**		**1**
Land Cover	Cover type		1	1	1	1	1	1	**6**			1	**1**
Land Cover Total			**1**	**1**	**1**	**1**	**1**	**1**	**6**			**1**	**1**
Topography	Aspect								**0**		1		**1**
	Elevation		1						**1**				**0**
Topography Total			**1**						**1**		**1**		**1**
Vegetation Community Characteristics	Forest canopy cover								**0**		1		**1**
	Forest successional stage				1	1	1	1	**4**				**0**
	Large trees							1	**1**				**0**
	Tree or snag diameter					1			**1**				**0**
	Coarse woody debris			1					**1**	1	1		**2**
	Forest edges						1		**1**				**0**
	Leaf litter and duff			1					**1**				**0**
	Snag/tree cavities					1			**1**				**0**
	Tree or snag height					1			**1**				**0**

		American Pika		American Pygmy Shrew	Silver-haired Bat		Hoary Bat		**Small Mammals Grand Total**	Western Toad		Compton's Tortoiseshell Butterfly	**Other Species Grand Total**
		Dispersal	Breeding/ Nesting and Foraging	Foraging and Breeding/ Parturition	Foraging	Breeding and Roosting	Foraging	Day-Roosting		Breeding/ Metamorphosis	Migration/ Foraging	Breeding/ Metamorphosis/ Foraging	
Themes	**Elements**												
	Horizontal canopy structure				1		1		**2**			1	**1**
	Dominant tree or shrub species composition								**0**			1	**1**
Vegetation Community Characteristics Total				**2**	**2**	**4**	**3**	**2**	**13**	**1**	**2**	**2**	**5**
Unique Habitat Elements	Rock crevices					1			**1**				**0**
Unique Habitat Elements Total						**1**			**1**				**0**
Grand Total Per Life Stage		**1**	**3**	**3**	**5**	**7**	**6**	**3**	**28**	**6**	**5**	**4**	**15**

Species Summaries - Carnivores

Gray Wolf *(Canis lupus)*

The gray wolf is the largest of the wild dogs. Historically, the species ranged across much of North America, although it has been recently extirpated from numerous areas. Reintroduction efforts combined with protection through designation as being Federally Endangered have allowed wolf populations to expand recently in the conterminous United States, although stable populations are still restricted to the Rocky Mountain region and northern Great Lakes states (Fuller 1995, Mech et al. 1995, Mladenoff et al. 1995, Pletscher et al. 1997, USFWS et al. 2002). In Washington State, wolf populations were reduced to near extinction prior to the early 1900s, however numbers have increased in recent years due to natural recolonizations in Washington (S. Fitkin, WDFW Wildlife Biologist, pers. comm.) and successful reintroductions in Idaho (Wisdom et al. 2000).

Wolf home ranges are generally large (Fritts and Mech 1981, Hayes 1992, Peterson et al. 1984, Atkinson and Janz 1994, Bangs and Fritts 1993); wolf packs in the Rocky Mountains occupy, on average, a home range between 500 and 2000 km^2 (Carroll et al. 1999). During winter months, a wolf pack home range will contract dramatically to areas where prey densities congregate.

Wolves exhibit social dominance, and live in packs based around a family unit that occupy a set territory, although lone animals with no pack affiliation exist and may disperse long distances from their natal pack. As wolves spend a good proportion of the year raising pups, the habitat needed for reproduction is strongly related to their foraging habitat, which needs to be adjacent to or close to reproducing habitat.

Gray wolves are currently not using MSSP for breeding, denning, or pack establishment. They may be using the Park for dispersal, and in the future as part of a pack's territory (H. Ferguson, WDFW Wildlife Biologist, pers. comm.). Because there are currently no known denning areas on MSSP, we did not discuss breeding/denning habitat as a life requisite for the Mount Spokane area.

Distribution In MSSP

Unverified sightings of lone wolves have occurred in and around Mt. Spokane State Park, but there is not considered to be a resident pack in the park or the surrounding area. The park most likely provides good dispersal and foraging habitat for lone wolves.

Existing Habitat Models

Carroll C., P.C. Paquet, and R.F. Noss. 1999. Modeling carnivore habitat in the Rocky Mountain region: A literature review and suggested strategy. World Wildlife Fund, Canada.

Houts, M.E. 2001. Modeling gray wolf habitat in the Northern Rocky Mountains. M.A. Thesis, University of Kansas, USA.

Larsen T., and W.J. Ripple. 2006. Modeling gray wolf (*Canis lupus*) habitat in the Pacific Northwest, USA. Journal of Conservation Planning 2:17-33.

Oakleaf, J.F., D.L. Murray, J.R. Oakleaf, E.E. Bangs, C.M. Mack, D.W. Smith, J.A. Fontaine, M.D. Jimenez, T.J. Meier, and C.C. Niemeyer. Habitat selection by recolonizing wolves in the Northern Rocky Mountains of the United States. The Journal of Wildlife Management 70:554-563.

Whittington, J., C.C. St. Clair, and G. Mercer. 2005. Spatial responses of wolves to roads and trails in mountain valleys. Ecological Applications 15:543-553.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Singleton, Peter H.; Gaines, William L.; Lehmkuhl, John F. 2002. Landscape permeability for large carnivores in Washington: a geographic information system weighted-distance and least-cost corridor assessment. Res. Pap. PNW-RP-549. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 89 p.

Summer Foraging Habitat Elements

Prey availability may be the single most important factor for considering wolf habitat (Larsen and Ripple 2006). Wolves primarily prey on ungulates; therefore they depend on habitat types that provide adequate conditions for deer and elk populations. When ungulate populations are low or seasonally unavailable, wolves eat alternative prey such as beaver, snowshoe hare, rodents and carrion. In MSSP, areas identified as having high seasonal habitat suitability for elk and deer are habitats of highest suitability for wolf foraging.

Larsen and Ripple (2006) developed an HSI model to estimate the suitability of foraging habitat for wolves (both packs and lone individuals). Their findings indicate that prey availability, and thus wolf foraging suitability, can be estimated using forest cover conditions. A review in Larsen and Ripple (2006) showed that wolf territories were typically found in areas of forest cover, instead of areas of shrubs or grass. In the Rocky Mountains, wolves prefer foraging in areas with significant coniferous forests cover across the landscape (Houts 2001). In MSSP, all non-developed cover types that provide habitat to wolf prey species in the summer would provide good habitat for wolf foraging.

Roads and development do not necessarily deter wolf use, but human activity (that can be associated with roads) can deter wolf use (Larsen and Ripple 2006). In some cases abandoned and closed roads can increase wolf access to foraging sites. In MSSP, closed roads and trails may be used by foraging wolves for access to prey populations, but areas of significant human use, such as in developed cover types or along active roads and popular trails, likely would exclude wolves from foraging in an area.

Wolves are known to avoid areas with high road densities. Higher densities of roads increase the chance of wolves being seen and killed. Carroll et al. (1999) found that as road densities increased, wolves used the area to a lesser extent. When road densities exceeded 0.58 km/km^2 (0.36 miles/sq. mile), no wolves were present. Similarly, Oakleaf et al. (2006) found that wolf packs occupied areas with 2-wheel drive road densities of 0.44 km/km^2 (0.27 miles/sq. mile), while wolves did not use areas where 2-wheel drive road densities exceeded 0.62 km/km^2 (0.39 miles/sq. mile). Singleton et al (2002) studied landscape permeability for large carnivores in Washington State and developed models for wolves that describe as optimal less than <1.6 km of road per 0.9-km radius circle. It is speculated that areas may be utilized by wolves even when road densities exceed these limits, although the habitat may be a population sink due to increased human mortality (Mech 1989). Assuming active road densities do not exceed 0.36 miles/sq. mile within MSSP, roads should not greatly impede wolf foraging habitat.

Table 10. Habitat elements for gray wolf summer foraging.

Variables	Parameters
Cover type	Any used by wolf prey
Abandoned/closed roads and trails	Present
Human infrastructure	Avoided (Developed cover types)
Road density	< 0.36 miles / sq. mile

Winter Foraging Habitat Elements

Similar to summer foraging habitat, prey availability may be the single most important factor for considering winter wolf foraging habitat (Larsen and Ripple 2006). Wolves primarily prey on ungulates; therefore they depend on habitat types that provide adequate winter conditions for deer and elk populations. When ungulate populations are low or seasonally unavailable, wolves eat alternative prey such as beaver, snowshoe hare, rodents and carrion. In a winter study of two wolf packs in Jasper (Alberta, Canada), Whittington et al (2005) found both packs selected for low elevations, shallow slopes, and southwest aspects. In MSSP, areas identified as having high seasonal habitat suitability for elk and deer are habitats of highest suitability for wolf foraging. In the winter, these areas would include stands with open forest canopies where prey congregate in herds providing wolves with easy visibility for predation attempts (J. Rohrer, USFS Wildlife Biologist, pers. comm.). In MSSP, all cover types providing cover and forage habitat for wolf prey in the winter provide optimal foraging habitat for wolves in winter. The uppermost winter elevation used by wolf prey in the area (elk, moose and deer) is estimated at less than 3500 feet.

Larsen and Ripple's (2006) HSI model estimated that an important indicator of habitat suitability was percentage of public land. They state that increased percent public land means less human presence and fewer roads. Similarly, Oakleaf et al. (2006) developed a model using federal ownership, human density, and forest land cover. As MSSP is entirely public land, this at first seems relatively unimportant, however, management of public land can alter the suitability of habitat. For example, while wolves would normally use open areas to forage during the winter, areas such as the open ski hill, which has high levels of human activity during the winter months, would not be suitable wolf foraging habitat. This indicates that even within public lands, management can alter habitat suitability. Developed habitat types associated with the ski resort in MSSP are likely avoided habitat by wolves during winter months.

Wolves have been shown to avoid high density roaded areas (Carroll et al.1999, Oakleaf et al.2006). Whittington et al. (2005) documented two wolf packs during winter seasons using forests, rivers and meadows for travel 79% of the time; they also traveled within 25 meters (82 feet) of high- and low-use roads and trails, and railway lines 21% of the time. Wolves in this study avoided areas when there was a high probability of encountering people, and were more likely to cross low-use roads and trails than high-use roads and trails (Whittington et al. 2004). Assuming open road densities do not exceed 0.36 miles/sq. mile within MSSP, roads should not impede wolf foraging habitat.

Table 11. Habitat elements for gray wolf winter foraging.

Variables	Parameters
Elevation	< 3500 feet
Cover type	Any used by wolf prey
Human infrastructure	Avoided (Developed cover types)
Road density	< 0.36 miles / sq. mile

Dispersal Habitat Elements

Dispersing individuals are common in wolf packs, especially in expanding populations (Carroll et al. 1999). Age at dispersal depends on prey and wolf densities, with lower prey and higher wolf densities prompting earlier dispersal, often in yearlings (Boyd and Pletscher 1999). Similarly, when prey densities are high, wolves will often remain with their natal pack longer, often times until adulthood (Boyd and Pletscher 1999). Dispersal distances are on average 148 km (92 miles), although a dispersal of 840 km (520 miles) has been recorded (Boyd et al. 1995).

Studies in the Rockies have identified topographic funnels, cover types used by prey, distance from human development centers, and low human presence as elements important to wolf dispersal (reviewed in Carroll et al. 1999). These habitat elements are similar to seasonal foraging elements, and are applicable to MSSP. Topographic funnels in MSSP include saddles, ridgelines and valley bottoms, which would be used by dispersing wolves. Seasonal foraging habitat for elk, deer and moose in MSSP would provide habitat for wolf dispersal.

Wolves will disperse through poorer quality habitats, although more dispersals occur when higher quality habitat exists, thus reducing mortality risks and increasing population connectivity (Oakleaf et al. 2006). Carroll et al. (1999) found wolves in areas of low human disturbance did not use suboptimal habitats but rather used preferred habitats. Dispersal direction is known to be affected by availability of lands without conflicting human use (Boyd and Pletscher 1999). MSSP has high year-round visitor use due to the close proximity to Spokane and outdoor recreational interests of its citizens. The level of disturbance and relatively small area of MSSP may qualify the area as suboptimal habitat for wolves. In MSSP, it is likely that human infrastructure and areas of heavy human disturbance in the Park would be avoided by dispersing wolves during the winter and summer seasons. Closed roads and trails might be used during dispersal movements.

Table 12. Habitat elements for gray wolf dispersal.

Variables	Parameters
Landforms	Saddles, ridgelines, valley bottoms
Cover type	Any used by wolf prey
Abandoned/closed roads and trails	Present
Human infrastructure	Avoided (Developed cover types)

Risk Factors

Historically the main risk factor for wolves has been human persecution, primarily hunting, trapping, and predator control programs (Carroll et al. 1999). The protected status of the gray wolf had limited the impacts of human persecution, although illegal hunting still occurs and reduces wolf populations to a larger degree than is commonly acknowledged. With the recent delisting of wolves in the U.S. Rocky Mountains from the Endangered Species Act (USFWS 2009), there will likely be significant increases in human-caused mortality. Increased active road densities negatively impacts wolves, and although wolves will make use of linear features such as trails and low-use roads, high-use roads are avoided (Whittington et al. 2005). High-use roads pose a high road-kill danger to wolves. Many wolves, including long-distance dispersing wolves, are killed each year on roadways. Managing roadways in parks and other protected areas to minimize traffic and creating wildlife overpasses on highways could serve to minimize wolf road-mortality.

Habitat fragmentation and degradation mainly in the form of human-use intensity negatively impacts wolves, by reducing population and pack connectivity, increasing the size of pack territories, reducing prey densities, and/or reducing the potential for wolf packs to occupy areas of land. Managing habitat to maintain connectivity corridors, and maintaining large sections of intact habitat will protect wolf populations into the future.

References

Atkinson, K.T., and D.W. Janz. 1994. Effect of wolf control on Black-tailed Deer in the Nimpkish valley on Vancouver Island. British Columbia Ministry of Environment, Lands and Parks. Wildlife Bulletin No. B-73. 32 pp.

Bangs, E E., S.H. Fritts, J.A. Fontaine, D.W. Smith, K.M. Murphy, C.M. Mack, and C.C. Niemeyer. 1998. Status of gray wolf restoration in Montana, Idaho, and Wyoming. Wildlife Society Bulletin 26:785-798.

Boyd, D.K., and M.D. Jimenez. 1994. Successful rearing of young by wild wolves without mates. Journal of Mammalogy 75:14-17.

Boyd, D.K., P.C. Paquet, S. Donelon, R.R. Ream, D.H. Pletscher, and C.C. White. 1995. Transboundary movements of a recolonizing wolf population in the Rocky Mountains. Pp. 135-140 *In*: Carbyn, L.N., S.H. Fritts, and D.R. Seip, eds. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, University of Alberta, Edmonton, Alberta.

Boyd, D.K., and D.H. Pletscher. 1999. Characteristics of dispersal in a colonizing wolf population in the central Rocky Mountains. The Journal of Wildlife Management 63:1094-1108.

Carroll C., P.C. Paquet, and R.F. Noss. 1999. Modeling carnivore habitat in the Rocky Mountain region: A literature review and suggested strategy. World Wildlife Fund, Canada.

Fritts, S.H., and L.D. Mech. 1981. Dynamics, movements, and feeding ecology of a newly protected wolf population in northwestern Minnesota. Wildlife Monograph 80:1-79.

Fuller, T.K. 1995. Comparative population dynamics of North American wolves and African wild dogs. Pp. 325-328. *In*: Carbyn, L.N., S.H. Fritts, and D.R. Seip, eds. Ecology and Conservation of Wolves in a Changing World. Canadian Circumpolar Institute, University of Alberta, Edmonton, Alberta.

Hayes, R.D. 1992. An experimental design to test wolf regulation of ungulates in the Aishihik area, southwest Yukon. Yukon Department of Renewable Resources, Whitehorse, Yukon. TR-92-6. 54 pp.

Houts, M.E. 2001. Modeling gray wolf habitat in the Northern Rocky Mountains. M.A. Thesis, University of Kansas, Lawrence, Kansas.

Kuyt, E. 1972. Food habits and ecology of wolves on Barren-ground Caribou range in the Northwest Territories. Canadian Wildlife Service. Report Series No. 21. 35 pp.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Larsen T., and W.J. Ripple. 2006. Modeling gray wolf (*Canis lupus*) habitat in the Pacific Northwest, USA. Journal of Conservation Planning 2:17-33.

Mech, L.D. 1970. The wolf. The Natural History Press, Garden City, New Yorl. 384 pp.

Mech, L.D. 1974. *Canis lupus*. *In*: Mammalian species, volume 37. American Society of Mammalogists. 6 pp.

Mech, L.D. 1989. Wolf population survival in an area of high road density. American Midland Naturalist 121:387-389.

Mech, L.D., S.H. Fritts, and D. Wagner. 1995. Minnesota wolf dispersal to Wisconsin and Michigan. American Midland Naturalist 133:368-370.

Mladenoff, D.J., T.A. Sickley, R.G. Haight, and A.P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in northern Great Lakes region. Conservation Biology 9:279-294.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Oakleaf, J.F., D.L. Murray, J.R. Oakleaf, E.E. Bangs, C.M. Mack, D.W. Smith, J.A. Fontaine, M.D. Jimenez, T.J. Meier, and C.C. Niemeyer. Habitat selection by recolonizing wolves in the Northern Rocky Mountains of the United States. The Journal of Wildlife Management 70:554-563.

Peterson, R.O., J.D. Woolington, and T.N. Bailey. 1984. Wolves of the Kenai Peninsula, Alaska. Wildlife Monographs 88:1-52.

Pletscher, D.H., R.R. Ream, D.K. Boyd, M.W. Fairchild, and K.E. Kunkel. 1997. Population dynamics of a recolonizing wolf population. Journal of Wildlife Management 61:459–465.

Potvin, M.J., T.D. Drummer, J.A. Vucetich, D.E. Beyer, R.O. Peterson, and J.H. Hammill. 2005. Monitoring and habitat analysis for wolves in upper Michigan. Journal of Wildlife Management 68:1660-1669.

Singleton, Peter H.; Gaines, William L.; Lehmkuhl, John F. 2002. Landscape permeability for large carnivores in Washington: a geographic information system weighted-distance and least-cost corridor assessment. Res. Pap. PNW-RP-549. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 89 p.

U.S. Fish and Wildlife Service (USFWS), Nez Perce Tribe, National Park Service, and USDA Wildlife Services. 2002. Rocky Mountain Wolf Recovery 2001 Annual Report. Meier, T., ed. US Fish and Wildlife Service, Ecological Services, Helena, Montana.

U.S. Fish and Wildlife Service (USFWS). 2009. Federal Register…

Walton, L.R., H.D. Cluff, P.C. Paquet, and M.A. Ramsay. 2001. Movement patterns of barren-ground wolves in the central Canadian arctic. Journal of Mammalogy 82:867-876.

Weaver, J.L. 1994. Ecology of wolf predation amidst high ungulate diversity in Jasper National Park, Alberta. Ph.D. Thesis, University of Montana, Missoula, Montana.

Whittington, J., C.C. St. Clair, and G. Mercer. 2004. Path tortuosity and the permeability of roads and trails to wolf movement. Ecology and Society 9:4.

Whittington, J., C.C. St. Clair, and G. Mercer. 2005. Spatial responses of wolves to roads and trails in mountain valleys. Ecological Applications 15:543-553.

Wisdom, M.J., R.S. Holthausen, B.C. Wales, C.D. Hargis, V.A. Saab, D.C. Lee, W.J. Hann, T.D. Rich, M.M. Rowland, W.J. Murphy, and M.R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale rends and management implications. *In*: Quigley, T.M., ed. Interior Columbia Basin ecosystem management project: scientific assessment. USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-485. 529 pp.

Canada Lynx *(Lynx canadensis)*

The Canada lynx is a medium sized carnivore species inhabiting the boreal forests of Alaska, Canada, and south into the northern portions of the United States. They are animals suited for high elevation, winter snow conditions. Their feet size, weight ratio, and general foraging patterns adapt this animal for mountainous terrain and to hunt their primary winter prey, the snowshoe hare. Their range has contracted and populations have declined over the past several decades on the southern periphery (Ruggiero et al. 2000), which led to the recent listing of the Canada lynx as Threatened under the Endangered Species Act (USFWS 2000).

Lynx habitat is closely tied snowshoe hare ecology. More recent research on lynx and hare populations in the southern portion of the lynx range indicates that both species regularly use fragmented landscapes (Murray et al. 2008). Female lynx are believed to establish temporary dens throughout their home range once kittens are old enough to travel, but not yet capable of hunting (Bailey 1981). The family group uses relatively open understory through mature forests as travel habitat between foraging and denning sites (Koehler and Brittell 1990).

While lynx occurrence is strongly correlated with the presence and abundance of snowshoe hares, in the southern portion of their range they may take advantage of other prey sources such as red squirrels, carrion, mice, and voles (Koehler and Aubry 1994, Parker et al. 1983, Apps 1999, Murray et al. 2008). For southern lynx populations, hare populations are low compared to northern boreal forests (Murray et al. 2008), and red squirrels are a very important alternate prey species (Aubry et al. 2000). In the Selkirk Mountains specifically, lynx population density is most likely more stable and lower than in its northern range, and lynx hunting and foraging strategies tend to mimic strategies used by northern lynx populations during times of low hare density (Koehler and Aubry, 1994).

Lynx in the Selkirk Mountains need to travel longer distances and through more undesirable habitats, and therefore have larger and more diverse home ranges that are dictated by prey availability (Aubrey et al. 2000). In northern Idaho, primary lynx habitat is mostly associated with subalpine fir/Engelmann spruce habitats, except in the extreme northern portion of Idaho and northeastern Washington (Priest Lake Ranger District) where moist cedar-hemlock forests are considered their primary habitat. Lynx are also strongly associated with lodgepole pine stands (Johnson and Cassidy 1997). In general, these habitats have long, cold winters with persistent snow accumulations. Secondary lynx habitats includes moist Douglas-fir, grand fir, and western larch forests (IPNF 2006).

Distribution In MSSP

There have been multiple sightings and tracks in MSSP, although there has been no evidence of denning. Existing forest conditions in the park provide adequate habitat for denning, foraging, and dispersal.

Existing Habitat Models

Banner, A., and S. Schaller. 2001. Canada Lynx Habitat Model. US Fish and Wildlife Service, Gulf of Maine Program, Gulf of Maine Watershed Habitat Analysis, Falmouth, Maine. (Available online: http://www.fws.gov/r5gomp/gom/habitatstudy/metadata/Canada_lynx_model.htm).

Idaho Panhandle National Forest (INPF). 2006. Appendix 9: Species Habitat Estimates for the Idaho Panhandle National Forests. USDA Forest Service, Idaho Panhandle National Forest. 10 pp.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Roloff, G.J.; Wilhere, G.F.; Quinn, T. and Kohlmann, S. 2001. An overview of models and their role in wildlife management. In: Johnson, D.H. and O'Neil, T.A. Wildlife-Habitat relationships in Oregon and Washington. Corvallis, OR : Oregon State University Press 512-536.

Singleton, Peter H.; Gaines, William L.; Lehmkuhl, John F. 2002. Landscape permeability for large carnivores in Washington: a geographic information system weighted-distance and least-cost corridor assessment. Res. Pap. PNW-RP-549. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 89 p.

Breeding/Denning Habitat Elements

Lynx denning habitat is recognized as requiring mature forests with ample coarse woody debris (CWD) cover. For maternal dens in the southern range of lynx (including the Selkirk Mountains), these types of areas provide the best security and thermal cover for kittens (Aubry et al. 1999, Stinson 2000). Late-seral stage forests tend to provide the blowdowns, root tangles, windthrow, snags, and deadfall required to create adequate horizontal cover for denning, (Aubrey 1999, Koehler 1990, Moen et al. 2008, Organ et al. 2008, Squires et al. 2008) and the presence of such horizontal cover is likely the most critical component for protecting kittens and successful denning (Murray et al. 2008).

Late-seral forest stands also typically support multiple tree species, multiple canopy layers, dense patches of saplings, and mature trees with high cone productivity (Beauvais et al. 2001). These characteristics translate into higher abundances of snowshoe hares and red squirrels, as well as abundant den structures (Beauvais 1997, Beauvais et al. 2001, Hodges 2000, Buskirk et al. 2000a). In MSSP, mature to old-growth upland conifer forests provide the best habitat for lynx denning. These include forest stands with at least 8 trees per acre greater than 24 inches in diameter at breast height (Morrison et al. (2007). Coarse woody debris cover over the forest floor of greater than 25 percent is an important habitat element.

Lynx in their southern range are known to select for northern aspects for denning habitat (Koehler 1990, Stinson 2000). This element should be consistent within MSSP.

Table 13. Habitat elements for lynx breeding/denning.

Variables	Parameters
Aspect	Northerly
Cover type	Upland Conifer Forest
Forest successional stage	Mature to old-growth
Tree size	> 24 inches DBH
Tree density	> 8 trees per acre
Coarse woody debris cover	> 25%

Summer Foraging Habitat Elements

Lynx foraging habitat is directly linked to lynx prey habitat. Moderate to abundant understory cover provides the best habitat for lynx prey in non-winter seasons (Koehler et al. 2008, Maletzke et al. 2008, Vashon et al. 2008, Koehler and Aubry 1994). In MSSP, forests with shrub canopy cover greater than 20 percent, with average shrub heights between 1.5 to 20 feet high, provide ideal summer foraging habitat for lynx (Morrison et al. 2007). Areas in MSSP mapped as Upland Conifer Forest, Conifer Woodland / Shrubland, Conifer Woodland / Meadow, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, and Wetland Conifer Woodland / Shrubland may provide suitable lynx foraging habitat.

Table 14. Habitat elements for lynx summer foraging.

Variables	Parameters
Cover type	Upland Conifer Forest, Conifer Woodland / Shrubland, Conifer Woodland / Meadow, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Wetland Conifer Woodland / Shrubland
Shrub canopy cover	> 20%
Shrub heights	1.5 - 20 ft

Winter Foraging Habitat Elements

The availability of lynx winter foraging habitat is more restrictive than non-winter habitat because the suitability of habitat for lynx prey is more restrictive in winter. Lynx tend to focus more of their diet on snowshoe hair during the winter (Koehler and Aubry 1994); hence, snowshoe hare abundance and availability drives winter foraging habitat suitability for lynx.

During the winter, snowshoe hares supplement their diets by browsing on small twigs, buds, bark, and conifer needles (Stinson 2000). Conifer cover appears to be an important factor for winter habitat suitability because conifers provide greater concealment from predators, lighter snowpacks, and warmer understory temperatures (Koehler and Aubry 1994). Areas with high densities (>3000 stems per acre) of small diameter trees and shrub stems (< 2.5 inches in diameter) have been shown to contain the highest abundance of snowshoe hares in winter. However, the small diameter stems must be above the height of the typical winter snow pack to provide habitat suitability to snowshoe hares

(Koehler and Aubry 1994). Lynx tend to avoid activities on slopes greater than 40% in winter months (Stinson 2001). In MSSP, all forest or woodland cover types can provide suitable lynx winter foraging habitat. Areas with over 3000 stems per acre of tree and shrub stems less than 2.5 inches in diameter provide suitable habitat. Areas with less than 40% slope are required for adequate winter foraging.

Table 15. Habitat elements for lynx winter foraging.

Variables	Parameters
Slope	< 40%
Cover type	Any forest or woodland types
Tree or shrub stem diameter	< 2.5 inches DBH
Tree or shrub density	> 3000 stems per acre

Dispersal Habitat Elements

Lynx require areas with overhead and horizontal cover, and usually avoid moving through open areas larger than 100 meters (300 feet) in width (Stinson 2000). Lynx often use ridgelines, saddles and forested riparian areas when dispersing and traveling among foraging patches and dens (Stinson 2000). Pole and mature coniferous stands that may not provide optimal hunting or denning cover are important for providing cover for movements from one hunting area to another (Stinson 2000).

In MSSP, areas with less than 300 feet in distance between adequate trees or shrubs for cover provide the best habitat for lynx dispersal. Ridgelines, saddles, and valley bottoms provide the best landforms for lynx dispersal.

Table 16. Habitat elements for lynx dispersal.

Variables	Parameters
Landforms	Saddles, ridgelines, valley bottoms
Distance between cover vegetation	< 300 feet

Risk Factors

High intensity recreational use occurring at ski areas may provide a level of disturbance that effectively precludes lynx use (at least temporarily) of otherwise suitable habitat (Ruediger et al. 2000). Recreational use also has the potential to complicate the relationship between lynx, generalist carnivores, and snow depth (Beauvais et al. 2001). Packed roads and trails are used as travel corridors by generalist carnivores (e.g. coyote, mountain lions, bobcats), allowing them to range into formerly snowbound areas (Aubry et al. 2000, Buskirk et. al 2000b). These carnivore species will compete with lynx for prey and can adversely effect lynx. However, Murray et al. (2008) points out that while snowmobile trails can improve access to remote areas for other carnivore species, it is unlikely that habitat use patterns of these competitor species would sufficiently be modified to displace or outcompete lynx, especially if competitor species are restricted to hard-packed trails (based on Bunnell et al. 2004 and Kolbe et al. 2007 studies). The amount of disruption brought by competing predators accessing areas historically hunted solely by lynx in winter depends on the extent of recreational use and the associated amount of packed snow. In areas of intensive winter recreation, like the upper mountain at Mt. Spokane, the extent of packed snow may be quite high, meaning that lynx competitors are able to successfully outcompete lynx in winter hunting and possibly catch and kill lynx when encounters occur. The movement of potential lynx competitors in MSSP to historically deep snow habitats due to anthropomorphic activities is a question that needs further study.

Timber cutting may reduce the amount and/or quality of foraging habitat available for lynx, by affecting the spatial arrangement of foraging and denning habitats, which in turn influences kitten survival (Ruediger et al. 2000). Some harvesting regimes have removed coarse woody debris from the forest, adversely impacting habitat for lynx prey species. Clearcuts and or other created openings in the forest canopy may reset succession of a given forest stand and thus provide early-seral conifer stands, which can be good habitat for snowshoe hares. However, brushy early regeneration in clearcuts is not common in the drier forest stands of eastern Washington, where regrowth does not produce the structure or vegetation conducive to high snowshoe hare production (Beauvais et al. 2001, Buskirk et al. 2000a, Hodges 2000), and almost never provides good habitat for red squirrels (Aubry et al. 2000). For snowshoe hares, large-scale forest fragmentation from timber activities can be deleterious because as hares become increasingly restricted to small patches with adequate cover, higher predation rates from a variety of carnivores tend to increase local extinction risks (Wolff 1981, Keith et al. 1993, Wirsing et al. 2002). Livestock grazing within lynx habitat may adversely impact important microsites such as high elevation riparian meadows and willow communities, thus also reducing snowshoe hare habitat (Ruediger et al. 2000).

Additional research is needed to quantify how landscape changes at lower latitudes are affecting lynx, and especially how global climate change will influence distributions and abundances of prey (Murray et al. 2008). In the far northern latitudes, climatic and habitat conditions are favorable for lynx and snowshoe hares (Buskirk et al. 2000a). However, around MSSP, where soil moisture in summer is lower, higher elevation forests experience higher evaporation rates, and mountain ranges cause patterns of soil moisture and snow deposition to be much more localized. Areas of boreal forest are therefore more patchily distributed in this southern most part of the species' range (Buskirk et al. 2000b). This may also mean that lynx favor more mesic north-facing aspects than they do farther north, as was found on the Okanogan Plateau of Washington (Buskirk et al. 2000a).

The impact of forest fire surpression is not well understood, however fire exclusion has altered the natural mosaic of forest successional states, possibly resulting in less snowshoe hare habitat over time (Ruediger et al. 2000). Stand replacing fires occurring after long-term fire suppression are hypothesized to have short-term detrimental effects on lynx prey species and their habitats, with a potential for long-term negative effects depending on vegetation responses post fire (Buskirk et al. 2000a). Road construction to suppress wildfires may increase presence and thus competition from other competing carnivore species in lynx habitat. In addition, fire-related activities that eliminate cover for prey species, such as creation of fuel breaks, may have detrimental effects (Ruediger et al. 2000).

Finally, risk factors that may impede lynx movements within their home range include both paved highways with high traffic volume, particularly if it continues during nighttime (Ruediger et al. 2000).

References

Apps, C.D. 1999. Space-use, diet, demographics, and topographic associations of lynx in the southern Canadian Rocky Mountains: a study. Pp. 351-371. *In*: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey and J.R. Squires, eds. Ecology and Conservation of Lynx in the United States. University Press of Colorado and the USDA Rocky Mountain Research Station.

Banner, A., and S. Schaller. 2001. Canada Lynx Habitat Model. US Fish and Wildlife Service, Gulf of Maine Program, Gulf of Maine Watershed Habitat Analysis, Falmouth, Maine.

Aubry K.B., G.M. Koehler, and J.R. Squires. 1999. Ecology of Canada lynx in southern boreal forests. Pp. 373-396. *In*: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey and J.R. Squires, eds. Ecology and Conservation of Lynx in the United States. University Press of Colorado and the USDA Rocky Mountain Research Station.

Aubry, K.B., G.M. Koehler, and J.R. Squires. 2000. Ecology of Canada lynx in southern boreal forests. *In*: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.S. Squires, eds. The scientific basis for lynx conservation in the contiguous United States. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah. General Technical Report RMRSGTR-30.

Bailey, T.N. 1981. Factors of bobcat social organization. Pp. 984-1000. *In*: Chapman, J.A., and D. Pursley, eds. Worldwide Furbearer Conference proceedings. Frostburg, Maryland.

Beauvais, G.P. 1997. Mammals in fragmented forest in the Rocky Mountains: community structure, habitat selection, and individual fitness. Ph.D. Thesis, University of Wyoming, Laramie, Wyoming.

Beauvais, G.P., D. Keinath, J. Ratner. 2001. Habitat mapping and field surveys for lynx *(Lynx canadensi*s) on lands administered by the USDI - bureau of land management in Wyoming. Wyoming Natural Diversity Database - University of Wyoming, Laramie, Wyoming. 15 pp.

Bunnell, K.D., J.T. Flinders, M.L. Wolfe, and J.A. Bissonette. 2004. Quantifyiing the potential impacts of coyotes and snowmobiles on lynx conservation in Utah and the Intermountain West. Western Forest Carnivore Committee Meeting. Whitefish, Montana.

Buskirk, S.W., L.F. Ruggiero, and C.J. Krebs. 2000b. Habitat fragmentation and interspecific competition: implications for lynx conservation. Pp. 83-100. In: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires, eds. Ecology and conservation of lynx in the United States. USDA Forest Service. General Technical Report RMRS-GTR-30WWW.

Buskirk, S.W., L.F. Ruggiero, K.B. Aubry, D.E. Pearson, J.R. Squires, and K.S. McKelvey. 2000a. Comparative ecology of lynx in North America. Pp. 397-417. In: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires, eds. Ecology and conservation of lynx in the United States. USDA Forest Service. General Technical Report RMRS-GTR-30WWW.

Hodges, K.E. 2000. Ecology of snowshoe hares in southern boreal and montane forests. Pp 163-206. *In*: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires, eds. Ecology and conservation of lynx in the United States. University of Colorado Press, Boulder, Colorado.

Idaho Panhandle National Forest (INPF). 2006. Appendix 9: Species Habitat Estimates for the Idaho Panhandle National Forests. USDA Forest Service, Idaho Panhandle National Forest. 10 pp.

Keith, L.B., S.E.M. Bloomer, and T. Willebrand. 1993. Dynamics of a snowshoe hare population in a fragmented habitat. Canadian Journal of Zoology 71:1385-1392.

Koehler, G.M. and K.B. Aubry. 1994. Lynx. Pp. 74-98. *In*: Ruggiero, L.F., K.B., Aubry, S.W. Buskirk, L.J. Lyon, and W.J. Zielinski, eds. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine. USDA Forest Service. General Technical Report RM-254.

Koehler, G.M., and J.D. Brittell. 1990. Managing spruce-fir habitat for lynx and snowshoe hares. Journal of Forestry 88:10-14.

Koehler, G.M. 1990. Population and habitat characteristics of lynx and snowshoe hares in north central Washington. Canadian Journal of Zoology. 68:845-851.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Johnson, D. H., and T.A. O'Neil eds. 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State Univ. Press. 736 p. + CD

Kolbe, J.A., J.R. Squires, D.H. Pletscher, and L.F. Ruggiero. 2007. The effect of snowmobile trails on coyote movements within lynx home ranges. Journal of Wildlife Management 71:1409-1418.

Maletzke, B.T., G.M. Koehler, R.B. Wielgus, K.B. Aubry, and M.A. Evans. 2008. Habitat conditions associated with lynx hunting behavior during winter in northern Washington. Journal of Wildlife Management 72:1473-1478.

McKelvey, K.S., Y.K. Ortega, G.M. Koehler, K.B. Aubry, and J.D. Britell. 2000. Canada lynx habitat and topographic use patterns in north central Washington: a reanalysis. Pp. 307-336. *In*: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires, eds. Ecology and conservation of lynx in the United States. USDA Forest Service. General Technical Report RMRS-GTR-30WWW.

Moen, R., C.L. Burdett, and G.J. Niemi. 2008. Movement and habitat use of Canada lynx during denning in Minnesota. Journal of Wildlife Management 72:1507-1513.

Morrison, P.H., H.M. Smith IV, G.F. Wooten, and S.D. Snetsinger. 2007. Forest Health Assessment and Plan for the 2006-2007 project area of Mount Spokane State Park. Pacific Biodiversity Institute, Winthrop, Washington. 370 pp. and 406 pp. Appendix.

Mowat, G., K.G. Poole, M. O'Donoghue. 2000. Ecology of lynx in northern Canada and Alaska. *In*: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.S. Squires, eds. The scientific basis for lynx conservation in the contiguous United States. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah. General Technical Report RMRSGTR-30.

Murray, D.L., T.D. Steury, and J.D. Roth. 2008. Assessment of Canada lynx research and conservation needs in the southern range: another kick at the cat. The Journal of Wildlife Management 72:1463-1472.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: February 25, 2009).

Organ, J.F., J.H. Vashon, J.E. McDonald, A.D. Vashon, S.M. Crowley, W.J. Jakubas, G.J. Matula, and A.L. Meehan. 2008. Within-stand selection of Canada lynx natal dens in northwest Maine, USA. Journal of Wildlife Management 72:1514-1517.

Parker, G.R., J.W. Maxwell, and L.D. Morton. 1983. The ecology of the lynx (*Lynx canadensis*) on Cape Breton Island. Canadian Journal of Zoology 61:770-786.

Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, L.J. Lyon, and W.J. Zielinski, eds. 1994. The Scientific basis for conserving forest carnivores in the western United States:

American marten, fisher, lynx, and wolverine. USDA Forest Service, General Technical Report RM-254.

Ruediger, B., J. Claar, S. Gniadek, B. Holt, L. Lewis, S. Mighton, B. Naney, G. Patton, T. Rinaldi, J. Trick, A. Vandehey, K.F. Wahl, N. Warren, D. Wenger, and A.Williamson. 2000. Canada lynx conservation assessment and strategy. USDA Forest Service, USDI Fish and Wildlife Service, USDI Bureau of Land Management, and USDI National Park Service, Missoula, Montana. Forest Service Publication #R1-00-53. 142 pp.

Singleton, Peter H.; Gaines, William L.; Lehmkuhl, John F. 2002. Landscape permeability for large carnivores in Washington: a geographic information system weighted-distance and least-cost corridor assessment. Res. Pap. PNW-RP-549. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 89 p.

Squires, J.R. and T. Laurion. 2000. Lynx home range and movement in Montana and Wyoming - preliminary results. Chapter 11. *In*: Ruggiero, L.F., K. B. Aubry, S. W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.S. Squires, eds. Ecology and conservation of lynx in the United States. University Press of Colorado, Boulder, Colorado. 480 pp.

Squires, J.R., N.J. Decesare, J.A. Kolbe, and L.F. Ruggiero. 2008. Hierarchical den selection of Canada lynx in western Montana. Journal of Wildlife Management 72:1497-1506.

Stinson, D.W. 2000. Draft Washington State recovery plan for the lynx. Washington Department of Fish and Wildlife, Olympia, Washington. 86 pp. and 5 maps.

U.S. Fish and Wildlife Service (USFWS). 2000. Determination of threatened status for the contiguous U.S. distinct population segment of the Canada lynx and related rule. Federal Register 65:16052-16086.

Vashon, J.H., A.L. Meehan, J.F. Organ, W.J. Jakuvas, C.R. McLaughlin, A.D. Vashon, and S.M. Crowley. 2008. Diurnal habitat relationships of Canada lynx in an intensively managed private forest landscape in northern Maine. Journal of Wildlife Management 72:1488-1496.

Wirsing, A.J., T.D. Steury, and D.L. Murray. 2002. A demographic analysis of a southern hare population in a fragmented habitat: evaluating the refugium model. Canadian Journal of Zoology 80:169-177.

Wisdom, M.J., R.S. Holthausen, B.C. Wales, C.D. Hargis, V.A. Saab, D.C. Lee, W.J. Hann, T.D. Rich, M.M. Rowland, W.J. Murphy, and M.R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale rends and management implications. *In*: Quigley, T.M., ed. Interior Columbia Basin ecosystem management project: scientific assessment. USDA

Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-485. 529 pp.

Wolff, J.O. 1981. Refugia, dispersal, predation, and geographic variation in snowshoe hare cycles. Pp. 441-449. *In*: Myers, K, and C.D. MacInnes, eds. Proceedings of the International Lagomorph Conference, 12-16 August 1979, Guelph, Ontario.

Wolverine *(Gulo gulo)*

In North America, wolverines are distributed across the northern boreal forests and tundra habitats, their range extending from Alaska, the Yukon and Northwest Territories, south to the Northern Rocky Mountains of Montana and Idaho, and Cascade Mountain range of Washington and Oregon (Singleton et al 2002). Population trends in North America show a range contraction since the 1840's (Wisdom et al. 2000), with the onset of extensive European exploration, fur trade, and settlement (Hash 1987). State records in the northwest have shown very low numbers until after the 1950's. More recently, wolverine sightings have increased throughout Washington, Idaho, and Montana, and it is believed there has been a return of these elusive animals to areas where they had not been recorded in many years. Smaller clusters of wolverine sightings have been documented near the Kettle and Selkirk Ranges in northeastern Washington (Edelmann and Copeland 1999).

Wolverines have large home ranges, varying from 100 to 900 km^2 (39 to 347 sq. miles) depending on food abundance (Banci 1994). They can travel extremely long distances, with large daily movements not necessarily associated with dispersal to new home ranges (John Rohrer, USFS Wildlife Biologist, pers. comm., Banci 1994).

Wolverines are considered a generalist species; their diet includes carrion, small mammals, birds and berries (Weaver et al. 1996, Copeland 1996). While generalists in their diet, their source habitat is more specialized and restricted to high elevation alpine tundra, subalpine, and montane forests (Banci 1994, Copeland et al. 2007). Wolverines utilize most structural stages of these habitats for winter and summer foraging. For denning/reproduction, wolverines focus on very specific habitat features in subalpine basins such as talus and large downed trees (Banci 1994, Copeland 1996).

Specific landscape features and special habitat elements are required for wolverine denning habitat. These features include subalpine cirque basins with isolated talus surrounded by trees, down logs and hollow trees for natal den sites (Copeland 1996, Pulliainen 1968). Since alpine cirques do not exist on Mount Spokane, denning habitat is not is not included in the life-stage matrix for wolverine habitat in MSSP.

Distribution In MSSP

Multiple sightings of wolverines have occurred in and around Mount Spokane State Park, and habitat connectivity corridors and foraging habitat exist in the area. Johnson and Cassidy (1997) show core habitat for wolverine at Mt. Spokane and a sighting just north of the mountain.

Existing Habitat Models

Copeland, J.P. 1996. Biology of the wolverine in central Idaho. M.S. Thesis, University of Idaho, Moscow, Idaho.

Rowland, M.M., M.J. Wisdom, D.H. Johnson, B.C. Wales, J.P. Copeland, and F.B. Edelmann. 2003. Evaluation of landscape models for wolverines in the interior northwest, United States of America. Journal of Mammalogy 84:92-105.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Singleton, Peter H.; Gaines, William L.; Lehmkuhl, John F. 2002. Landscape permeability for large carnivores in Washington: a geographic information system weighted-distance and least-cost corridor assessment. Res. Pap. PNW-RP-549. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 89 p.

Summer Foraging Habitat Elements

Wolverines show a preference for higher elevations during summer months, potentially as a response to seasonal food availability (Copeland 2007). Northern aspects may be preferred for summer foraging according to one study (Copeland 2007). More recent work by Copeland (2007) found wolverines to select for steep slopes during the summer, which might reflect a preference for higher elevation habitats (positively correlated with steeper slopes). Singleton et al (2002) use an elevation parameter for habitat prediction of > 1500 meters (4921 feet). Consultation with expert reviewer J. Rohrer (USFS, Wildlife Biologist, pers. comm.) indicates that summer foraging for wolverines in the North Cascades occurs at elevations greater than 5000 feet. Areas in MSSP greater than 5000 feet in elevation may provide suitable habitat for summer wolverine foraging.

Copeland (1996) indicates that wolverines in Idaho often crossed natural openings such as burned areas, meadows, or open mountain tops. However, other research has indicated that wolverines avoid recent clear-cuts and burns (Hornocker and Hash 1981), and grass-shrub communities on southern exposures (Copeland 2007). This avoidance of open areas, even on mountain tops, may be related to a lack of snow, hot temperatures, or a general lack of prey availability (Copeland 2007). Avalanche slopes and snowfields are habitat elements important for wolverine summer foraging (J. Rohrer, USFS, Wildlife Biologist, pers. comm.). Rock habitat has also been modeled in several studies (Copeland 2007, Copeland 1996, May et al 2006), however rock use is most likely associated with high-elevation alpine tundra habitats (May et al 2006, Copeland 2007). It is not clear from the literature if wolverines have a preference for any particular mapped cover type in MSSP besides an avoidance of human disturbed areas.

Human disturbances, described as road and population densities (human activity and presence), were found to correspond negatively with observations of wolverines across the Columbia Basin (Rowland et al. 2003). When evaluating a landscape model for wolverines in the interior Northwest, habitat and road-density classes of moderate (0.44 to 1.06 km/ km^2 (0.27-0.66 miles/sq. mile)) to low density roads (<0.44 km/ km^2 (<0.27 miles/sq. mile)) were effective at predicting historic observations of wolverines (Rowland et al. 2003). Mt. Spokane was incorporated into their project area. Similarly, the predicting occurrence of wolverines declined when road densities exceeded approximately 1.7 km/km^2 (1.1 miles/sq. mile) in the Rocky Mountain region (Carroll et al. 2001). In MSSP, road densities of less than 0.27 miles/sq. mile may assist in predicting wolverine summer foraging habitat.

Table 17. Habitat elements for wolverine summer foraging.

Variables	Parameters
Elevation	> 5000 feet
Cover Type	Any type except human disturbed areas
Road density	< 0.27 miles / sq. mile

Winter Foraging Habitat Elements

Wolverines shift their movements downslope during the winter months, extending into mid-elevation Douglas fir and lodgepole pine habitats, while grass-shrub communities at lower elevations are still avoided (Copeland 2007). A preference may exist for areas that provide good habitat for wintering ungulates, and thus a good source of carrion for wolverines (Copeland 2007). Hornocker and Hash (1981) found 70% of their winter wolverine locations in medium to scattered timber. It is not clear from the literature if wolverines have a preference for any particular mapped cover type in MSSP besides an avoidance of human disturbed areas. Elevations greater than 3500 feet should provide habitat for winter foraging in MSSP.

Wolverines are thought to be sensitive to winter recreation activities, including heli-skiing, snowmobiling, backcountry skiing, logging, and hunting (Banci 1994, Krebs and Lewis 2000), especially during reproduction and near natal denning sites (Copeland 1996). However, in wolverine winter foraging, travel, and dispersal, it is unclear whether human disturbance plays a strong role in wolverine site selection. In MSSP, the same road density parameters used to described summer foraging habitat (< 0.27 miles/sq. mile) are probably applicable.

Wolverines are known to cross vast landscapes even in the winter months. Not only do wolverines utilize slightly lower elevation forests in winter, but they often travel along stream corridors, primarily looking for ungulate prey or perhaps for an easier travel corridor (Banci 1994). Snowfields are important landforms for foraging wolverines (J. Rohrer, WDFW Wildlife Biologist, pers. comm.). Stream corridors and snowfields contribute to winter foraging habitat suitability for wolverine in MSSP.

Table 18. Habitat elements for wolverine winter foraging.

Variables	Parameters
Elevation	> 3500 feet
Snowfields	Present
Cover Type	Any type except human disturbed areas
Stream corridors	Present
Road density	< 0.27 miles / sq. mile

Risk Factors

Habitat loss and fragmentation as a result of habitat destruction, climate change and other types of disturbance have potential serious effects on species with special habitat needs such as the wolverine. One threat is a broad scale decline in wolverine habitat when management practices influence subalpine communities, particularly when they reduce the presence and opportunity for carrion availability (Copeland et al. 2007). The USDA Forest Service (Wisdom et al. 2000) identified loss of montane and subalpine old-growth forests and associated forest structure as a key issue to address for long-term protection of wolverine habitat. Wisdom et al. (2000) lists clear-cutting as negatively affecting wolverine populations. They suggest increasing the representation of late-seral forests in all cover types, and identifying mid-successional forests where attainment of late-successional conditions can be accelerated for wolverine habitat (Wisdom et al. 2000).

In addition to protection of wolverine habitats, dispersal and travel corridors are necessary to connect large refugia that maintain wolverine populations, or even maintain an individual's home range. These dispersal corridors likely do not require the same habitat attributes necessary to support self-sustaining populations of wolverines (Banci 1994). Therefore, atypical or low quality habitats may be important, especially if they connect otherwise isolated wolverine populations and allow for genetic exchange or colonization (Ruggiero et al. 1994). Wisdom et al. (2000) recommends identifying and managing select areas to create desired conditions such as large, contiguous blocks of forest cover with abundant snags, large logs, low road densities, and connectively to subalpine cirque habitats required for denning security and summer foraging habitat.

People, roads, and development are a much more controversial subject for protecting wolverines and their habitats (Ruggiero et al 1994). Generally speaking, wolverines are a highly mobile animal whose dispersal movements are likely to be more influenced by human disturbance than by forest habitat characteristics (Singleton and Lehmkuhl 1999). Negative impacts are found when human disturbance actions result in higher road and people densities, greater vehicle capabilities/technologies, decreased cover associated with shrubs, increased agriculture and urban-developed areas, and increased interest in high elevation winter recreation (Wisdom et al. 2000, Singleton and Lehmkuhl 1999, Singleton et al. 2002, Rowland et al. 2003). Human impacts associated with roads and people may also displace localized and seasonally abundant sources of food such as carrion, salmon-spawning streams, and possibly berry patches (Ruggiero et al. 1994).

Copeland (2007) questions the sensitivity of wolverines to human presence. He found no relationship between wolverine presence and maintained trail systems, which may have been a result of low frequency of human presence on the trails. It was not uncommon to find one of his study animals near an active campground during the summer. Furthermore, studies in the North Cascades in recent years have photographed and trapped wolverines in areas used heavily by snowmobiles (J. Rohrer, USFS Wildlife Biologist, pers. comm.). It is therefore unclear whether the relationship between wolverines and humans is in fact a cause-effect relationship or simply due to the species' tendency to reside in areas that are generally inhospitable to human development (Copeland 2007).

Although not mentioned in the literature, global warming may pose a threat to wolverines across their range. Literature suggests that one reason wolverines move to higher elevation summer habitats is to find cooler temperatures (Hornocker and Hash 1981). Special landscape features such as glacial cirques and alpine meadows found in these cool climates are likely to change with the effects of global warming. These warmer temperatures may pose a threat to high elevation wolverine prey such as the pika, marmot, and Columbia ground squirrel. The effects of global warming may also decrease available habitat, since warmer temperatures change the forest composition and push elevation boundaries of cooler montane and subalpine forests upwards.

References

Banci, V. 1994. Wolverine. Pp. 99-127. *In*: Ruggiero, L.F., K.A. Augry, S.W. Burskirk, L.J. Lyon, and W.J. Zielinski, eds. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-254:1-184.

Carroll, C., R.F. Noss, and P.C. Paquet. 2001. Carnivores as focal species for conservation planning in the Rocky Mountain region. Ecological Applications 11:961-980.

Copeland, J.P., J.M. Peek, C.R.. Groves, W.E. Melquist, K.S. McKelvey, G.W. McDaniel, C.D. Long, and C.E. Harris. 2007. Seasonal habitat associations of the wolverine in central Idaho. Journal of Wildlife Management 71:2201-2212.

Copeland, J.P. 1996. Biology of the wolverine in central Idaho. M.S. Thesis, University of Idaho, Moscow, Idaho.

Edelmann, F., and J. Copeland. 1999. Wolverine distribution in the northwestern United States and a survey in the Seven Devils Mountains of Idaho. Northwest Science 73:295-300.

Hash, H.S. 1987. Wolverine. Pp. 574-585. *In*: M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources, Toronto, Ontario.

Hornocker, M.G., and H.S. Hash. 1981. Ecology of he wolverine in northwestern Montana. Canadian Journal of Zoology 59:1286-1301.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Krebs, J.A., and D. Lewis. 2000. Wolverine ecology and habitat use in the North Columbia Mountains: progress report. Pp. 695-703. *In*: L.M. Darling, ed. Proceedings of a conference on the biology and management of species and habitats at risk. British Columbia Ministry of Lands, Environment and Parks, Victoria, British Columbia, and University College of the Caribou, Kamloops, British Columbia.

May, R., A. Landa, J. van Dijk, J.D.C. Linnell, and R. Anderson. 2006. Impact of infrastructure on habitat selection of wolverines *Gulo gulo*. Wildlife Biology 12:285-295.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Pulliainen, E. 1968. Breeding biology of the wolverine (*Gulo gulo* L.) in Finland. Annales Zoologica Fennici. 5:338-344.

Rowland, M.M., M.J. Wisdom, D.H. Johnson, B.C. Wales, J.P. Copeland, and F.B. Edelmann. 2003. Evaluation of landscape models for wolverines in the interior northwest, United States of America. Journal of Mammalogy 84:92-105.

Ruggiero, L.F., S.W. Buskirk, K.B. Aubry, L.J. Lyon, and W.J. Zielinski. 1994. Information needs and a research strategy for conserving forest carnivores. Pp. 138-152. *In*: Ruggiero, L.F., K.A. Augry, S.W. Burskirk, L.J. Lyon, and W.J. Zielinski, eds. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolvering in the western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-254. 184 pp.

Singleton, P. H. and Lehmkuhl, J. F. 1999. Assessing wildlife habitat connectivity in the interstate 90 Snoqualmie Pass corridor, Washington. Pp. 75-84. *In*: Evink, G., P. Garrett, and D. Ziegler, eds. Proceedings of the third International conference on wildlife ecology and transportation, September 13-16, 1999, Missoula, Montana. Florida Department of Transportation. Tallahassee, Florida. Report No. FL-ER-73-99.

Singleton, P.H., W.L. Gaines, and J.F. Lehmkuhl. 2002. Landscape permeability for large carnivores in Washington: a geographic information system weighted-distance and least-cost corridor assessment. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. PNW-RP-549. 89 pp.

Weaver, J.L., P.C. Paquet, and L.F. Ruggiero. 1996. Resilience and conservation of large carnivores in the Rocky Mountains. Conservation Biology 10:964-976.

Wisdom, M.J., R.S. Holthausen, B.C. Wales, C.D. Hargis, V.A. Saab, D.C. Lee, W.J. Hann, T.D. Rich, M.M. Rowland, W.J. Murphy, and M.R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale rends and management implications. *In*: Quigley, T.M., ed. Interior Columbia Basin ecosystem management project: scientific assessment. USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-485. 529 pp.

American Marten *(Martes americana)*

The American marten is a medium sized carnivore which ranges from Alaska south to California, throughout Canada and into the northeastern United States. Martens are associated with boreal coniferous forests, but also inhabit mixed coniferous and deciduous habitats (Thompson and Harestad 1994). In the Pacific Northwest, martens are associated strongly with mature to old-growth conifer forests with dense canopies and high stem densities (Koehler et al 1975, Meslow et al. 1981, Buskirk et al. 1989, Koehler et al. 1990, Buskirk and Powell 1994). They are found to avoid forest shrub and pole stages (Thompson and Harestad 1994). Due to their strong associations with older forests and coarse woody debris, Northwest Forest Management Guidelines have focused on American marten as a management indicator species for forest harvest practices (Thompson and Harestad 1994, USFS 1993).

Marten are active year-round and do not hibernate in the winter. Food availability is probably the most important factor affecting marten distribution (Mech and Rogers 1977). Marten consume a wide variety of resources throughout the year. From the spring to fall months their diet includes small mammals, invertebrates, birds, carrion, and berries (Weckwerth and Hawley 1962). During the winter months, small mammals are consumed almost exclusively (Cowan and Mackay 1950, Koehler and Hornocker 1977). They track their prey mainly above ground, then ambush and excavate burrows (Spencer and Zielinski 1983). During winter months, marten exploit subnivean prey species.

Distribution In MSSP

Marten are listed as a regular occupant of Mount Spokane State Park, as existing forest structures provide denning, foraging and security habitats.

Existing Habitat Models

Pacific Biodiversity Institute created a Habitat Suitability Index (HSI) Model in 2007 for Mount Spokane State Park, based on peer-reviewed primary literature (Morrison et al. 2007). We also used habitat elements from the following HSI models:

Allen, A. W. 1982. Habitat suitability index models: marten. US Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.11. 9 pp.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Kirk, T.A. 2006. Building and testing a habitat suitability model for the American marten *(Martes americana*) in northeastern California. Humboldt State University, Arcata, California. 21 pp.

Timossi, I.C., E.L. Woodard, and R.H. Barrett. 1995. Habitat suitability models for use with Arc/Info: marten. California Department of Fish and Game, CWHR Program, Sacramento, California. CWHR Technical Report No. 7. 24 pp.

Takats, L., R. Stewart, M. Todd, R. Bonar, J. Beck, B. Beck, and R. Quinlan. 1999. American marten winter habitat: habitat suitability index model, version 5. Foothills Model Forest, Hinton, Alberta.

Non-Winter Cover and Foraging Habitat Elements

Martens are foraging generalists whose diets in the non-winter months consist of small mammals, carrion, birds, eggs, insects, fruit, nuts, and berries (Buskirk and Ruggiero, 1994). The presence of understory characteristics such as shrub cover, coarse woody debris (CWD), and snags are critical to provide adequate foraging and resting opportunities for martens, and increased habitat conditions for potential prey and browse species. Shrubs increase habitat value for marten by directly providing food sources such as berries and fruits, and also contribute to microhabitat complexity, which may help increase the availability of marten prey. Shrubs also provide cover for active martens. Greater than ten percent shrub cover was designated as ideal habitat for martens in MSSP, which does not include large shrubs over 20 ft tall, nor extremely small shrubs (Morrison et al. 2007).

Snags within the forest provide structure as well as refuge sites and cover. Large snags and live deformed trees have exclusively been documented in California as resting sites for martens (Spencer 1987). Similarly, coarse woody debris (CWD) provide similar foraging and resting opportunities. Allen (1982) modeled areas with 25-50 percent CWD covering the surface of the ground as ideal marten habitat. He designated adequate downfall as being at least 7.6 cm (3 inches) in diameter. In MSSP, areas with 20 to 50 percent coarse woody debris cover at least 3 inches in diameter provide ideal habitat for marten resting and hunting (lower and higher percentages either provide too little or too much forest understory structure). Areas with a snag density of at least eight snags per acre of at least 12 inches DBH also provide ideal habitat (Morrison et al. 2007).

Marten rely on boreal conifer forests or mixed deciduous and conifer forests for hunting, resting and reproduction (Allen 1982). They also use riparian areas, meadows, wetlands, and forest edges, assuming they provide adequate cover (Buskirk and Powell 1994). Large clearings are typically avoided by marten (Martin 1987, Hawley and Newby 1957, Allen 1982), however others believe that openings may be used during the summer months for foraging, if adequate food and cover are present (Koehler and Hornocker 1977). In Colorado, martens were observed at distances between 0.8 and 3.2 km (0.5-2 miles) from forest cover during summer months, but this was almost always on a large boulder field hunting pikas (Streeter and Braun 1968). In MSSP, good marten habitat can exist within any of the mapped non-developed cover types in the Habitat Unit Map, as long as suitable cover is present.

Optimal marten cover habitat for summer months was 40 to 60 percent forest canopy cover within mixed-conifer forests (Koehler and Hornocker 1977; Spencer et al. 1983;

Martin 1987). These sites supported the greatest number of rodent populations, however too much or too little forest canopy cover leads to decreased suitability. According to Takats et al. 1999, forest canopy cover <30% and >70% reduces habitat suitability. Also, while pole sized and young forest stands provide some cover, mature or old-growth stands seem to provide optimum cover (Allen 1982). In MSSP, forest canopy cover between 30 to 70 percent provides optimal marten non-winter foraging and cover habitat. Older forests with larger trees (>8 trees/acre greater than 24 inches DBH) also provide more optimal conditions (Morrison et al. 2007).

Table 19. Habitat elements for marten non-winter cover and foraging.

Variables	Parameters
Forest canopy cover	> 30% and < 70%
Tree diameter	> 24 inches DBH
Tree density	> 8 trees per acre
Snag diameter	> 12 inches DBH
Snag density	> 8 snags per acre
Coarse woody debris cover	20% - 50%
Coarse woody debris diameter	> 3 inches
Shrub canopy cover	> 10%

Winter Cover and Foraging Elements

While marten are foraging generalists during the non-winter seasons, food availability and diversity decreases substantially in the winter months, forcing marten to become mostly dependent on hunting small mammals (Bull 2000, Cowan and Mackay 1950, Koehler and Hornocker 1977).

The presence of coarse woody debris becomes substantially more important to marten foraging success in the winter, because it offers opportunities to access subnivean spaces where prey species may occur (Buskirk and Ruggiero, 1994). These "entry" sites are also important as marten resting sites, which are located beneath the snow's surface within natural cavities around stumps, logs, and snags (Steenton and Major 1982, Spencer 1987, Burskirk et al. 1989). Snags offer increased opportunity for hunting success as they provide critical wintertime habitat for prey species (Buskirk and Ruggiero 1994). Areas in MSSP with 20 to 50 percent coarse woody debris cover at least 3 inches in diameter offer ideal resting and hunting habitat for martens (Allen 1982). Also, areas with a snag density of at least eight snags per acre of at least 12 inches DBH provide ideal habitat (Morrison et al. 2007).

Marten are more reliant in winter on mature to old-growth forest stands with greater than 50 percent forest canopy cover. These stands provide better thermal cover and habitat conditions for prey species. Revised models have doubled the importance of forest canopy cover relative to other attributes previously modeled for in marten winter habitat (Timossi et al. 1995). In MSSP, stands with greater than 50% forest canopy cover are very important for marten winter habitat. Also, older forests with larger trees (>8 trees/acre greater than 24 inches DBH) provide more optimal conditions (Morrison et al. 2007).

Martens are associated with boreal coniferous forests as well as mixed coniferous and deciduous habitats (Thompson and Harestad 1994). While forest openings and clearings may be used during summer months, they are more likely to be avoided during the winter months (Koehler and Hornocker 1977). Martens have been recorded traveling across meadows 50 meters (165 ft) wide and greater with a scattering of trees in the central Sierra Nevadas and in Maine, but their routes were often direct and they did not stop or hunt in them (Hargis and McCullough 1984, Soutiere 1979). In MSSP, areas with trees less than 165 feet apart may provide suitable marten habitat.

Martens show preference for spruce-fir forests (Yeager and Remington 1956, Marshall 1951, Clark and Campbell 1976, Bowman and Robitaille 1997). Areas in MSSP with at least 50% forest canopy composition as either spruce or fir provide ideal marten winter habitat (Allen 1982, Takats et al. 1999).

Table 20. Habitat elements for marten winter cover and foraging.

Variables	Parameters
Dominant tree species composition	> 50% spruce or fir
Forest canopy cover	> 50%
Tree diameter	> 24 inches DBH
Tree density	> 8 trees per acre
Snag diameter	> 12 inches DBH
Snag density	> 8 snags per acre
Coarse woody debris cover	20% - 50%
Coarse woody debris diameter	> 3 inches
Distance between trees	< 165 feet

Risk Factors

Timber harvesting has been thought to be the greatest risk factor contributing to the regional decline of marten populations (Yeager 1950). Commercial logging operations typically remove the forest structure necessary for foraging, resting, and denning sites. Prey composition and numbers change when forest canopy cover is reduced and logs and snags are removed by logging practices. Marten in Wyoming did not utilize harvested timber stands for at least one year after cutting (Clark and Campbell 1976). In Maine, marten rarely used clearcut areas less than 15 years old (Soutiere 1979). Steventon and Major (1982) recorded strong evidence of avoidance of clearcuts, however islands of uncut softwoods adjacent to clearcuts were heavily utilized for cover and foraging in summer and winter.

Reductions in size of mature to old-growth forest stands from management activities are conservation issues to address for maintaining habitat for this forest-dependent species. Studies of landscape-level patterns found that at a threshold of 25% openings, martens disappeared from the landscape, raising concerns over the viability of populations in areas subject to extensive timber harvest (Hargis and Bissonette 1997 in Timossi et al. 1995). This suggests that to stop their population decline, it may be necessary to leave large tracts of forested land intact and exempt from commercial timber harvest, while managing for late-successional characteristics. National forest health practices within the United States Forest Service have changed over the last decade to incorporate the many levels of habitat attributes necessary for mature-forest dwelling species. Forest characteristics such as extensive large diameter trees and snags (Bull et al. 1997), and a more open forest floor with decaying wood are important factors when maintaining forest health conditions.

The impact of forest fire suppression efforts is not well understood, however it is thought that fire exclusion has generated dense understory conditions which make it difficult for marten to efficiently find food. Stand-replacing fires occurring after long-term fire suppression is also hypothesized to have detrimental effects on prey species, thus affecting marten foraging habitat.

References

Allen, A. W. 1982. Habitat suitability index models: marten. US Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.11. 9 pp.

Bissonette, J.A., R.J. Fredrickson, and B.J. Tucker. 1989. American marten: a case for landscape-level management. North American Wildlife and Natural Resource Conference Transcripts 54:89-99.

Bowman, J.C., and J.F. Robitaille. 1997. Winter habitat use of American martens, *Martes americana*, within second-growth forest in Ontario, Canada. Wildlife Biology 3:97-105.

Bull, E.L. 2000. Seasonal and sexual differences in American marten diet in northeastern Oregon. Northwest Science 74:186-191.

Bull, E.L., C.G. Parks, and T.R. Torgersen. 1997. Trees and logs important to wildlife in the Interior Columbia River Basin. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GRT-391. 55 pp.

Buskirk, S.W. 1984. Seasonal use of resting sites by marten in south-central Alaska. Journal of Wildlife Management 48:950-953.

Buskirk, S.W., and S.O. MacDonald. 1984. Seasonal food habits of marten in south-central Alaska. Canadian Journal of Zoology 62:944-950.

Buskirk, S.W., and L.L. McDonald. 1989. Analysis of variability in home-range size of the American marten. Journal of Wildlife Management 53:997-1004.

Buskirk, S.W., and L.F. Ruggiero. 1994. American marten. Pp. 7-37. *In*: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, L.S. Lyon, and W.J. Zielinski, eds. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States.

Buskirk, S.W., and R.A. Powell. 1994. Habitat ecology of fishers and American martens. Pp. 283-296. *In*: S.W. Buskirk, A.S. Harestad, M.G. Raphael, and R.A. Powell, eds. Martens, sables, and fishers: ecology and conservation. Cornell University Press, Ithaca, New York. 484 pp.

Buskirk, S.W., S.C. Forrest, M.G. Raphael, and H.J. Harlow. 1989. Winter resting site ecology of marten in the central Rocky Mountains. Journal of Wildlife Management 53:191-196.

Carroll, C., P.C. Paquet, and R.F. Noss. 1999. Modeling carnivore habitat in the Rocky Mountain Region: A literature review and suggested strategy. World Wildlife Fund, Canada.

Clark, T.W., and T.M. Campbell. 1976. Population organization and regulatory mechanisms of martens in Grand Teton National Park, Wyoming. Pp. 293-295. *In*: Proceedings of the first conference on scientific research in the National Parks, Department of the Interior, National Park Service, Transcripts of Proceedings Series 5, Volume I.

Corn, J.G., and M.G. Raphael. 1992. Habitat characteristics at marten subnivean access sites. Journal of Wildlife Management 56:442-448.

Cowan, I.M., and R.H. Mackay. 1950. Food habits of the marten *(Martes americana*) in the Rocky Mountain region of Canada. Canadian Field Nataturalist. 64:100-104.

Hargis, C.D., and D.R. McCullough. 1984. Winter diet and habitat selection of marten in Yosemite National Park. Journal of Wildlife Management 48:140-146.

Hargis, C.D., and J.A. Bissonette. 1997. Effects of forest fragmentation on populations of American marten in the intermountain west. Pp. 437-451. *In*: Proulx, G., H.N. Bryant, and P.M. Woodard, eds. *Martes*: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton.

Hawley, V.D., and F.E. Newby. 1957. Marten home ranges and population fluctuations. Journal of Mammalogy 38:174-184.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Kirk, T.A. 2006. Building and testing a habitat suitability model for the American marten *(Martes americana*) in northeastern California. Humboldt State University, Arcata, California. 21 pp.

Koehler, G.M., and M.G. Hornocker. 1977. Fire effects on marten habitat in the Selway-Bitterroot Wilderness. Journal of Wildlife Management 41:500-505.

Koehler, G.M., J.A. Blakesley, and T.W. Koehler. 1990. Marten use of successional forest stages during winter in north-central Washington. Northwestern Naturalist 71:1-4.

Koehler, G.M., W.R. Moore, and A.R. Taylor. 1975. Preserving the pine marten: management guidelines for western forests. Western Wildlands 2:31-36.

Marshall, W.H. 1951. Pine marten as a forest product. Journal of Forestry 49:899-905.

Martin, S.K. 1987. The ecology of the pine marten (*Martes americana*) at Sagehen Creek, California. Ph.D. Thesis, University of California, Berkeley, California. 223 pp.

Martin, S.K. 1994. Feeding ecolgy of American martens and fishers. Pp 297-315. *In*: Buskirk, S.W., A.S. Harestad, M.G. Raphael, and R.A. Powell, eds. Martens, sables, and fishers: ecology and conservation. Cornell University Press, Ithaca, New York. 484 pp.

Mech, L.D., and L.L. Rogers. 1977. Status, distribution, and movements of martens in northeastern Minnesota. USDA Forest Service, North-Central Forest Experimental Station, Resource Paper NC-143. 7 pp.

Meslow, E.C., C. Maser, and J. Verner. 1981. Old-growth forests and wildlife habitat. North American Wildlife and Natural Resource Conference Transcripts 46:329-335.

Morrison, P.H., H.M. Smith, G.F. Wooten, and S.D. Snetsinger. 2007. Forest Health Assessment and Plan for the 2006-2007 project area of Mount Spokane State Park. Pacific Biodiversity Institute, Winthrop, Washington. 370 pp. and 406 pp. Appendix.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Phillips, D.M., D.J. Harrison, and D.C. Payer. 1998. Seasonal changes in home-range area and fidelity of martens. Journal of Mammalogy 79:180-190.

Snyder, J.E. 1984. Marten use of clear-cuts and residual forest stands in western Newfoundland. M.Sc. Thesis, University of Maine at Orono, Orono, Maine. 31 pp.

Soutiere, E.C. 1979. Effects of timber harvesting on marten in Maine. Journal of Wildlife Management 43:850-860.

Spencer, W.D. 1981. Pine marten habitat preferences at Sagehen Creek, California. M.Sc. Thesis, University of California, Berkeley, California. 121 pp.

Spencer, W.D. 1987. Seasonal rest-site preferences of pine martens in the northern Sierra Nevada. Journal of Wildlife Management 51:616-621.

Spencer, W.D., R. H. Barrett, and W.J. Zielinski. 1983. Marten habitat preferences in the northern Sierra Nevada. Journal of Wildlife Management 47:1181-1186.

Steventon, J.D., and J.T. Major. 1982. Marten use of habitat in commercially clear-cut forest. Journal of Wildlife Management 46:175-182.

Streeter, R.G., and C.E. Braun. 1968. Occurrence of marten, *Martes american*a, (Carnivora: Mustelidae) in Colorado alpine areas. Southwest. Naturalist 13:449-451.

Strickland, M.A., and C.W. Douglas. 1987. Marten. Pp. 530-546. *In*: Novak, M, J.A. Baker, M.E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Trappers Association, North Bay, Ontario. 1150 pp.

Takats, L., R. Stewart, M. Todd, R. Bonar, J. Beck, B. Beck, and R. Quinlan. 1999. American marten winter habitat: habitat suitability index model, version 5. Foothills Model Forest, Hinton, Alberta.

Timossi, I.C., E.L. Woodard, and R.H. Barrett. 1995. Habitat suitability models for use with ArcInfo: Marten. California Department of Fish and Game, CWHR Program, Sacramento, California. CWHR Technical Report No. 7. 24 pp.

Thompson, I.D., and P.W. Colgan. 1987. Numerical responses of martens to a food shortage in northcentral Ontario. Journal of Wildlife Management 51:824-835.

Thompson, I, and A. Harestad. 1994. Effects of logging on American martens, and models forhabitat management. Pp. 355-367. In: Buskirk, S.W., A.S. Harestad, M.G. Raphael, and R.A. Powell, eds. Martens, sables, and fishers: biology and conservation. Cornell University Press, Ithaca, New York.

U.S. Forest Service (USFS). 1993. Draft supplemental environmental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. *In*: Appendix A: Forest Ecosystem Management Assessment Team. Forest ecosystem management: an ecological, economic, and social assessment (FEMAT Report).

Weckwerth, R.P., and V.D. Hawley. 1962. Marten food habits and population fluctuations in Montana. Journal of Wildlife Management 26:55-74.

Wynne, K.M., and J.A. Sherburne. 1984. Summer home range use by adult marten in northwestern Maine. Canadian Journal of Zoology 62:941-943.

Yeager, L.E. 1950. Implications of some harvest and habitat factors on pine marten management. Transcript of the North American Wildlife Conference 15:319-334.

Yeager, L.E., and J.D. Remington. 1956. Sight observations of Colorado martens. Journal of Mammalogy 37:521-524.

Species Summaries - Ungulates

Rocky Mountain Elk *(Cervus Elaphus)*

Rocky Mountain elk are found in 21 states and 6 provinces of North America. The tremendous variety of ecosystem types in which they historically occurred, from prairie to dense coastal rainforest, is a testament to their adaptability. Today elk in the west are often found in coniferous forests associated with mountains, foothills, or canyon rangelands (Skovlin et al. 2002). The most productive habitats for elk are landscapes with a mosaic of forested and open habitat patches, which provide for both cover and foraging needs. The wet, temperate forests of the Columbia Mountains and the Pacific coast, with their large continuous tracts of Douglas fir, hemlock and cedar, were historically relatively unproductive for elk (Skovlin et al. 2002).

Elk are generalists, feeding on a variety of grasses, forbs, shrubs and trees. Some populations migrate between summer and winter ranges, but many do not have true migrations and just move seasonally up and down slopes. Others may stay on winter range year round (Irwin 2002). Elk typically expand their home range from spring to midsummer, moving upslope with the receding snow and new growth of grasses. During summer they seek thermal relief in forested cover of northeasterly aspects (Skovlin et al. 2002). Elk typically stay on summer ranges as long as possible, until snow depth or extreme temperatures trigger movement downslope to winter ranges (Irwin 2002). Like summer range, adjacent forest and open habitats are important for winter habitat. Snow depth is one of the most important factors affecting winter habitat use (Poole and Mowat 2005). Forest cover provides security and snow interception and some forage. Open areas provide more productive forage, and higher solar radiation for thermal regulation. Winter range is widely considered a limiting aspect for elk. Increasing pressures on low elevation public and private lands from human activities and grazing of domestic livestock have greatly limited use of traditional elk winter ranges.

Numerous studies have been conducted on elk habitat. Most current literature emphasizes forage quality and quantity and security cover as critical components for habitat models. Particular emphasis is placed on the importance of high quality summer/fall forage for breeding and over-winter survival of elk. Winter thermal cover is no longer considered a primary limiting factor and has even been shown to have negative consequences on elk energetics (Cook et al. 1998). However, elk use forested stands for security in winter and other seasons, although Edge et al. (1990) suggest that it may not be important except where elk are hunted and/or harassed.

Elk range during winter months is limited in MSSP due to high snow depths and general lack of available forage. Winter habitat elements are discussed in this report, however according to local experts they may leave the park for more suitable habitats in mid-winter (H. Ferguson, WDFW wildlife biologist, pers. comm.).

Distribution In MSSP

Year-round regular concentrations. Breeding, calving and year-round foraging habitats,

Existing Habitat Models

Buckmaster, G., M. Todd, K. Smith, R. Bonar, B. Beck, J. Beck, and R. Quinlan. 1999. Elk winter foraging: Habitat Suitability Index model version 5. Foothills Research Institute, Alberta, Canada.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Mowat, G. 1999. Literature review for deer and elk winter range modeling. Timberland Consultants Ltd., Nelson, British Columbia.

Roloff, G.J. 1998. Habitat potential model for Rocky Mountain elk. Pp. 158-175. *In*: deVos, J.C., ed. Proceedings of the 1997 deer/elk workshop. Arizona Game and Fish Department, Phoenix, Arizona.

Thomas, J.W., D.A. Leckenby, M. Henjum, R.J. Pedersen, and L.D. Bryant. 1988. Habitat-effectiveness index for elk on Blue Mountain winter ranges. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-218. 28 pp.

Cover Habitat Elements

Elk use cover throughout the year and studies refer to a variety of cover types including security cover, hiding cover, escape cover, thermal cover (summer and winter), and snow-interception cover.

Security cover, hiding cover, and escape cover all refer to cover that elk use for escape/hiding/protection from hunters, predators, or harassment. Thomas et al (1979) defines security cover as vegetation capable of hiding 90% of a standing adult elk at 61 m (200 ft) or less. Lyon and Christensen (1992) describe security as "The protection inherent in any situation that allows elk to remain in a defined area despite an increase in stress or disturbance associated with the hunting season or other human activities." Roloff et al. (2001) found that appropriate modeling of security cover was one of the most significant factors in performance of an elk habitat suitability model.
Thermal cover was integrated into older models, but more recent literature suggests advantages of thermal cover for elk are negligible. In an explicit study of the theory of thermal cover as a limiting factor for elk, Cook et al. (1998) found that thermal cover of winter range actually reduced elk condition, survival, and reproduction. In contrast, they found that solar radiation during the winter from open areas enhanced elk energetics. Despite the difference, they observed elk behavioral preference for coniferous forest to open areas and suggested there may be psychological benefit to cover.

Whether cover is used for psychological reasons (Cook et al 1998), snow-interception (Mowat 1999), or protection from predators or harrassment, it is often modeled with a small and common set of parameters (Skovlin et al 2002). For example, to reduce confusion, Thomas et al (1988) dropped the modifiers of "hiding" and "thermal" and modeled a single class of "cover" used by elk in fall and winter. Similarly, the cover variables listed below should identify habitats that provide cover for a suite of purposes.

Elk typically use coniferous forests for all types of cover (Thomas 1979, Cook et al. 1998, Canfield et al. 1999). Conifer forests provide better snow-interception than deciduous forests in winter. One study in Idaho noted that although elk use coniferous forests for cover, they often avoided cool-moist grand fir and subalpine fir habitat types for cover in the fall and winter (Irwin & Peek 1983). In MSSP, all cover types mapped as woodlands or forest could have high suitability for elk cover habitat. It is not inherently clear from the literature how dominant tree species cover may affect habitat suitability, but cool-moist forest habitats do exist in the Mt. Spokane area, primarily on northerly aspects.

The most common variable used to describe cover habitat is forest canopy cover. It is also the variable with the greatest degree of consistency in its parameter values. Moderate to dense coniferous forests with high forest canopy cover typically provide good security and snow-interception cover. Suggested ranges for ideal overstory canopy cover are 70 to 100 percent. In Idaho and western Montana, Irwin and Peek (1983) and Edge et al. (1987) identified cover habitat as greater than 75% forest canopy cover. Thomas (1979) in the Blue Mountains of Oregon called forest with canopy cover between 40% and 70% "marginal" cover, and canopy cover greater than 70% "satisfactory" cover. According to local wildlife experts, 70% canopy cover may be too high for elk cover need in MSSP (H. Ferguson pers. comm.). We therefore suggest use of 50% or greater canopy cover for identifying cover habitat at MSSP.

Structurally, cover habitat has been described as forests with trees at least 10 cm (3.9 inches) DBH at densities greater than 150 trees/hectare (61 trees/acre, Roloff et al. 2001). In the Blue Mountains of Oregon, Thomas (1979) described an overstory of conifers greater than 12 meters (39 ft) tall as providing "satisfactory" cover. These structural characteristics are found in young to mature forests. Pole-timber and old-growth are also identified as important cover types at various times of the year (Irwin and Peek 1983). As specific structural parameters can vary widely among regions and forest types, we chose forest successional types as the over-arching variable, and specify very young, young, mature, and old-growth forests all as forest successional stages that may provide elk cover habitat.

Security cover is used year-round, but is particularly important in the fall for hunted populations (Rowland et al. 2000). Road closures and low road densities are an important element in providing such security (Thomas et al. 1979, Lyon and Christensen 1992). For hunted populations, a suggested minimum patch size of security habitat is 250 acres and guidelines developed for Montana specify that elk security areas be located at least more than 0.5 miles from open roads (Hillis et al. 1991). Where elk are not hunted or harassed, Edge et al. (1990) suggest security cover may not be as important as other habitat variables. In MSSP, ideal security cover patch sizes are greater than 250 acres, and greater than 0.5 miles from an open road system. According to local wildlife experts, "urban" elk in the Mt. Spokane area may utilize cover patches with less size and distance from roads than this (H. Ferguson pers. comm.).

Distance to forage areas is an important aspect determining use of cover. Some habitats used for cover have forage available in the understory, but others do not. Elk typically use cover within 200 meters (656 ft) of forage (Leckenby 1984).

Table 21. Habitat elements for Rocky Mountain elk cover.

Variables	Parameters
Cover type	Any forest or woodland types
Forest successional stage	Very young to old-growth
Forest canopy cover	> 50%
Forest patch size	> 250 acres
Distance from foraging habitat	< 656 feet
Distance for active roads	> 0.5 miles

Summer/Fall Foraging Habitat Elements

Availability of quality forage during key seasons is critical for elk reproduction and survival. Despite strong evidence that nutrition is a primary constraint on elk populations, many habitat models inadequately address forage quality and quantity, if these factors are included at all (Davis 2005). Elk diets vary seasonally, annually, and by area (Edge et al. 1988). Developing detailed, site-specific models of forage quality and quantity is complex and costly, so most habitat studies use a generic set of variables that provide a coarse framework for identifying habitat with good forage potential. However, Thomas et al (1988), Cook (2002), and Roloff (1998) provide useful frameworks and data for potential development of detailed forage models.

Highest quality forage in summer and fall is often found in cover types and/or forest stands with relatively open canopies. Thomas (1979) identified all forest types with less than 40% canopy cover as elk forage habitat. In MSSP, all forest, woodland, shrubland and meadow cover types with less than 40% tree canopy cover are important foraging habitat elements.

Water can be a limiting resource in summer. For Roosevelt elk in Oregon, Cole et al. (2004) found that elk used areas greater than 300-meters (984-ft) from streams less than expected. Mackie (1970) in Thomas (1979) wrote that optimal summer range is within 0.5 miles of water. A distance of less than 0.5 miles from water is an important habitat element for summer/fall elk foraging in MSSP.

Elk use of forage decreases as distance to cover increases. Some habitat models have accounted for forage-cover relationships by using hypothesized ideal ratios of the two (e.g. 60/40 forage to cover ratio for west-side forests (Davis 2005)). A model for the Blue Mountains in Oregon showed that elk use of cover is disproportionately greater within 274 meters (900 ft) of forage areas (Thomas et al. 1988, using results from Leckenby 1984 study). In MSSP, the forage area to cover distance of 900 ft or less is a key habitat element, based on the Thomas et al. (1998) study.

Elk use moderate slopes on summer range. Most elk used slopes between 15% and 30% in western Montana (Zahn 1974), while Marcum (1975) found slopes between 27% and 58% received more use for feeding and bedding. Other studies have found less consistent patterns, with slope class varying among seasons and years (Mackie 1970, Harper 1971). In MSSP, slopes ranging from 0% to 60% are suitable for summer/fall foraging habitat.

Elk often use upper slopes, regardless of season (Skovlin et al. 2002). In summer, use of upper slopes may be related to cooling wind patterns, visibility or cover type. Valley bottoms are also used likely because of their association with riparian habitat as a source of late-summer food and water (Skovlin et al. 2002). In MSSP, valley bottoms and upper slopes are preferred landform features for elk summer habitat. According to local experts, summer elevation parameters for elk foraging are less than 5,000 ft (H. Ferguson pers. comm.).

Aspect is often referenced in elk habitat studies and there is considerable variability within and across seasons. A general trend appears to be higher use of north and east facing aspects during summer months. These provide the coolest habitats in summer and the highest quality and most succulent forage in the fall (Skovlin et al. 2002). These aspects are probably important for elk foraging suitability in MSSP.

Roads are widely recognized as a primary factor affecting elk use of foraging habitats. They provide access for poaching, and have been shown to increase energetic costs, as well as decrease elk survival (Cole et al. 1997). Some research suggests traffic intensity, periodicity, and time of use for each road should be incorporated into models, assuming this information is available (Roloff 1998). When this data is not available, others have used road type (e.g. primary, secondary, primitive roads), or road density (Lyon 1983) in modeling road effects. Rowland et al. (2000) found a strong linear increase in elk use of habitat away from roads during spring and summer and suggests that use of road buffers (as opposed to road density), is the most reliable way of incorporating this element into habitat models.

Unsworth et al. (1998) found that elk in roaded areas tended to use habitats with greater canopy cover relative to unroaded areas. Some elk habitat models scale effects of roads by adjacent security cover or tree canopy-cover classes (Lyon 1979, Roloff 1998). In one study of more open environments, the road influenced elk use up to several hundred meters (Thomas 1979), while in denser forests of western Oregon, elk use decreased by 50% within 60 meters (197 ft) of secondary roads, but did not decrease at greater distances (Witmer and DeCalesta 1985). In northern Idaho forests, Irwin and Peek (1983) found elk preferred foraging greater than 400 meters (1312 ft) from open roads, while a study in Oregon found elk used areas less than or equal to 150 m (492 ft) from roads less than expected, regardless of whether the road was open or closed (Cole et al 2004). However, according to local wildlife experts, the "urban" elk of the Mt. Spokane area may not be as affected by road in selecting for foraging habitat (H. Ferguson pers. comm.). Distances of 200 feet from active roads should provide suitable foraging habitat in MSSP for elk.

Table 22. Habitat elements for Rocky Mountain elk summer/fall foraging.

Variables	Parameters
Slope	0 - 60%
Aspect	Northerly, Easterly
Elevation	< 5000 feet
Landforms	Upper slopes, valley bottoms
Forest canopy cover	< 40%
Distance from cover habitat	< 900 feet
Distance from water bodies and stream corridors	< 0.5 miles
Distance for active roads	> 200 feet

Winter Foraging Habitat Elements

Winter habitats are notably reduced from those of summer, in some areas shrinking to only 4-6% of annual ranges (Poole and Mowat 2005). Elk prefer grass when it is available, but in winter consume greater amounts of forbs and shrubs. Elk winter range is typically low elevation, low to moderate slope, and southerly aspects.

Slopes of elk winter range were 20-60% in an Idaho study (Hershey and Leege 1982, Unsworth et al. 1998), and less than 90% in West Kootenay, British Columbia (Mowat 1999). South and west aspects are used in the winter due to warmer conditions and less snow pack (Irwin and Peek 1983, Mowat 1999, Unsworth et al. 1998, Thomas et al 1988). In MSSP, ideal elk winter foraging habitat is primarily flat or moderate slopes (0%-60%) on south and west facing aspects.

In fall and winter, elk migrate down slope, triggered by snow accumulation and/or temperature extremes at higher elevations (Irwin 2002). Elevation was found as the most important and significant variable when modeling snow depth and winter elk habitat use (Poole and Mowat 2005). For the west Kootenay, B.C., Mowat (1999) describes elk winter habitat as less than 1500 m (4921 ft) in elevation. According to local wildlife experts, elk likely move to lower elevations (<3500 feet) during winter months, down to Douglas-fir/ponderosa pine woodland habitat in search of food resources. In MSSP, elevations less than 3,500 feet provide suitable habitat for winter elk foraging.

Elk make regular use of certain topographic features. They often forage on upper slopes, where there is higher solar radiation and quicker snowmelt (Canfield et al. 2002). They also regularly use large valley bottoms (Tefler 1978), as well as ridgelines (H. Ferguson pers. comm.). In MSSP, such topographic features are important components of winter foraging habitat.

Grassland communities dominated by Idaho fescue (*Festuca idahoensis*) or bluebunch wheatgrass (*Agropyron spicatum*) are common and preferred foraging areas and comprise much of the elk winter ranges in the Northwest (Thomas et al. 1988). Elk also forage in open forests in the winter, typically with less than 40% canopy cover (Thomas et al. 1988). In MSSP, open forests and woodlands with less than 40% canopy cover, as well as shrublands and grasslands are important elk winter forage elements.

Roads have a strong influence on elk utilization of foraging habitat, as is described in detail in the summer/fall forage section above. In MSSP, preferred elk forage habitat is likely greater than 200 feet from open roads during the winter season, as identified in summer/fall foraging.

Table 23. Habitat elements for Rocky Mountain elk winter foraging.

Variables	Parameters
Slope	0 - 60%
Aspect	Southerly, Westerly
Elevation	< 3500 feet
Landforms	Valley bottoms, upper slopes, ridgelines
Forest canopy cover	< 40%
Distance for active roads	> 200 feet

Risk Factors

Adequate nutrition is one of the most significant factors affecting elk survival and reproduction (Skovlin et al. 2002). Access to high quality forage in summer and fall directly impacts over-winter survival, calf growth rates, pregnancy rates and other factors influencing population dynamics (Davis 2005). Domestic grazing by livestock on summer and winter ranges can reduce forage available for elk (Thomas et al. 1988,). Human disturbance is a primary factor affecting elk habitat use and can notably increase energetic costs of elk, leading to decreases in elk survival (Canfield et al. 1999). Elk have been shown to avoid roads, which in some cases may reduce their ability to access higher quality foraging sites.

References

Alldredge M.W., J.M. Peek, and W.A. Wall. 2002. Nutritional quality of forages used by elk in northern Idaho. Journal of Range Management 55: 253-259.

Buckmaster, G., M. Todd, K. Smith, R. Bonar, B. Beck, J. Beck, and R. Quinlan. 1999. Elk winter foraging: Habitat Suitability Index model version 5. Foothills Research Institute, Alberta, Canada.

Canfield, J.E., L.J. Lyon, J.M. Hillis, and M.J. Thompson. 1999. Ungulates. Pp. 6.1-6.25. *In*: Joslin, G., and H. Youmans, eds. Effects of recreation on Rocky Mountain wildlife: a review for Montana. Montana Chapter of The Wildlife Society, Committee on Effects of Recreation on Wildlife. 307 pp.

Cole, E.K., M.D. Pope, and R.G. Anthony. 1997. Effects of road management on movement and survival of Roosevelt elk. Journal of Wildlife Management 61:1115-1126.

Cole, E.K., M.D. Pope, and R.G. Anthony. 2004. Influence of road management on diurnal habitat use of Roosevelt elk. Northwest Science 78: 313-321.

Cook, J.G. 2002. Nutrition and food. Pp. 259-350. In: Toweill, D.E., and J.W. Thomas, eds. North American elk: ecology and management. Smithsonian Institution Press, Washington, D.C.

Cook, J.G., L.J. Quinlan, L.L. Irwin, L.D. Bryant, R.A. Riggs, and J.W. Thomas. 1996. Nutrition-growth relations of elk calves during late summer and fall. Journal of Wildlife Management 60: 528-541.

Cook, J.G., L.L. Irwin, L.D. Bryant, R.A. Riggs, and J.W. Thomas. 1998. Relations of forest cover and condition of elk: a test of the thermal cover hypothesis in summer and winter. Wildlife Monographs 141:1-61.

Cook, R.C., J.G. Cook, and L.D. Mech. 2004. Nutritional condition of northern Yellowstone elk. Journal of Mammalogy 85:714-722.

Davis, R.W. 2005. A FIS-based habitat model predicting elk nutritional condition in the Pacific Northwest. Ph.D. Thesis, University of Illinois, Urbana, Illinois. 117 pp.

Edge, W.D., C.L. Marcum, and S.L. Olson. 1987. Summer habitat selection by elk in western Montana: a multivariate approach. Journal of Wildlife Management 51:844-851.

Edge, W.D., C.L. Marcum, and S.L. Olson-Edge. 1988. Summer forage and feeding site selection by elk. Journal of Wildlife Management 52:573-577.

Edge, D.W., S.L. Olson-Edge, and L.L. Irwin. 1990. Planning for wildlife in national forests: elk and mule deer habitats as an example. Wildlife Society Bulletin 18:97-98.

Gratson, M.W. and C.L. Whitman. 2000. Road closures and density and success of elk hunters in Idaho. Wildlife Society Bulletin 28:302-310.

Harper, J.A. 1971. Ecology of Roosevelt elk. Oregon State Game Commission, Portland, Oregon. 29 pp.

Hillis, J.M., M.J. Thompson, J.E. Canfield, L.J. Lyon, C.L. Marcum, P.M. Dolan, and D.W. McCleerey. 1991. Defining elk security: the Hillis paradigm. Pp. 38-43. *In*: A.G. Christensen, L.J. Lyon, and T.N. Lonner, eds. Proceedings of elk vulnerability symposium. Montana State University, Bozeman, Montana.

Hershey, T.J., and T.A. Leege. 1982. Elk movements and habitat use on a managed forest in north-central Idaho. Idaho Department of Fish and Game. Wildlife Bulletin10. 24 pp.

Hobbs, N.T. and D.M. Swift. 1985. Estimates of habitat carrying capacity incorporating explicit nutritional constraints. Journal of Wildlife Management 49:814-822.

Irwin, L.L. 2002. Migration. Pp. 493-514. *In*: Toweill, D.E., and J.W. Thomas, eds. North American elk: ecology and management. Smithsonian Institution Press, Washington, D.C.

Irwin, L.L. and J.M. Peek. 1983. Elk habitat use relative to forest succession in Idaho. Journal of Wildlife Management 47:664-672.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Leckenby, D.A. 1984. Elk use and availability of cover and forage habitat components in the Blue Mountains, Northeast Oregon, 1976-1982. Oregon Department of Fish and Wildlife, Research and Development, Portland, Oregon. 40 pp.

Leege, T.A., and W.O. Hickey. 1977. Elk-snow-habitat relationships in the Pete King drainage, Idaho. Idaho Department of Fish and Game, Idaho Wildlife Bulletin.

Lyon, L.J. 1979. Habitat effectiveness for elk as influenced by roads and cover. Journal of Forestry 77:658-660.

Lyon, L.J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry 81:592-595.

Lyon, L.J., and A.G. Christensen. 1992. A partial glossary of elk management terms. USDA Forest Service, Intermountain Research Station, Ogden, Utah. 6 pp.

Mackie, R.J. 1970. Range ecology and relations of mule deer, elk, and cattle in the Missouri River Breaks, Montana. Wildlife Monographs 20:1-79.

Marcum, C.L. 1975. Summer-fall habitat selection and use by a western Montana elk herd. Ph.D. Thesis, University of Montana, Missoula, Montana. 188 pp.

Mirik, M., J.E. Norland, R.L. Crabtree, and M.E. Biondini. 2005. Hyperspectral one-meter-resolution remote sensing in Yellowstone National Park, Wyoming: I. Forage nutritional values. Rangeland Ecology & Management 58:452-458.

Mowat, G. 1999. Literature review for deer and elk winter range modeling. Timberland Consultants Ltd., Nelson, British Columbia.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Nelson, J.R., and T.A. Leege.1982. Nutrition requirements and food habits. Pp. 323-367. *In*: Thomas, J.W., and D.E. Toweill, eds. Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania.

Poole, K.G., and G. Mowat. 2005. Winter habitat relationships of deer and elk in the temperate interior mountains of British Columbia. Wildlife Society Bulletin 33:1288-1302.

Roloff, G.J. 1998. Habitat potential model for Rocky Mountain elk. Pp. 158-175. *In*: deVos, J.C., ed. Proceedings of the 1997 deer/elk workshop. Arizona Game and Fish Department, Phoenix, Arizona.

Roloff, G.J., J.J. Millspaugh, R.A. Gitzen, and G.C. Brundige. 2001. Validation tests of a spatially explicit habitat effectiveness model for Rocky Mountain elk. Journal of Wildlife Management 65:899-914.

Rowland, M.M., M.J. Wisdom, B.K. Johnson, and J.G. Kie. 2000. Elk distribution and modeling in relation to open roads. Journal of Wildlife Management 64:672-684.

Rowland, M.M., M.J. Wisdom, B.K. Johnson, and M.A. Penninger. 2005. Effects of Roads on Elk: Implications for Management in Forested Ecosystems. Pp. 42-52. *In*: Wisdom, M.J., ed. The Starkey Project: a synthesis of long-term studies of elk and mule deer. Reprinted from the 2004 Transactions of the North American Wildlife and Natural Resources Conference, Alliance Communications Group, Lawrence, Kansas.

Skovlin, J.M. 1982. Habitat requirements and evaluations. *In*: Thomas, J.W., and Toweill, D.E., eds. Elk of North America: ecology and management. Wildlife Management Institute, Washington, D.C.

Skovlin, J.M., P. Zager, and B.K. Johnson. 2002. Elk habitat selection and evaluation. Pp. 531-555. *In*: Toweill, D.E., and J.W. Thomas, eds. North American elk: ecology and management. Smithsonian Institution Press, Washington, D.C.

Sweeney, J.M., and J.R. Sweeney. 1984. Snow depths influencing winter movements of elk. Journal of Mammalogy 65:524-526.

Thomas, J.W., ed. 1979. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA Forest Service. Agriculture Handbook No. 553. 512 pp.

Thomas, J.W., D.A. Leckenby, M. Henjum, R.J. Pedersen, and L.D. Bryant. 1988. Habitat-effectiveness index for elk on Blue Mountain winter ranges. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-218. 28 pp.

Unsworth, J.W., L. Kuck, M.D. Scott, and E.O. Garton. 1993. Elk mortality in the Clearwater drainage of northcentral Idaho. Journal of Wildlife Management 57:495-502.

Unsworth, J.W., L. Kuck, E.O. Garton, and B.R. Butterfield. 1998. Elk habitat selection on the Clearwater National Forest, Idaho. Journal of Wildlife Management 62:1255-1263.

Wisdom, M.J., L.R. Bright, C.G. Carey, W.W. Hines, R.J. Pedersen, D.A. Smithey, J.W. Thomas, and G.W. Witmer. 1986. A model to evaluate elk habitat in western Oregon. USDA Forest Service, Pacific Northwest Region, Portland, Oregon. Publication No. R6-F&WL-216-1986. 36 pp.

Witmer, G.W., and D.S. DeCalesta. 1985. Habitat use by female Roosevelt elk in the Oregon coast range. Journal of Wildlife Management 47:933-939.

Zahn, H.M. 1974. Seasonal movements of the Burdette Creek elk herd. Montana Fish and Game Department, Helena, Montana. Job Completion Report W-120-R-4. 70 pp.

White-tailed Deer *(Odocoileus virginianus ochrourus)*

White-tailed deer are a widespread species, found throughout the United States and Canada. The subspecies found in the area of Mt. Spokane is the Northwest white-tailed deer, *Odocoileus virginianus ochrourus*. Deer are generalists and use a wide variety of forested and open habitats, feeding on grasses, forbs and shrubby browse (NatureServe 2008). White-tailed deer habitat overlaps with that of mule deer, but more often they are found in "riparian zones, brushy draws, and agricultural lands … where they can successfully compete for forage and space" (Christensen et al. 1995). Their range has expanded as timber harvest has created more early seral forest foraging habitat than was historically available. Although white-tailed deer do not typically migrate long distances, in mountainous regions they move up and down slope seasonally in response to forage and snow conditions (Christensen et al. 1995).

Winter habitat is generally considered the limiting factor for deer. During winter, deer seek to conserve energy and forage on what is available given energy constraints. In early and late winter, forage quality and quantity are considered the most important elements determining habitat use. In mid-winter however, snow-depth becomes the critical factor, in some cases restricting deer to only 4-6% of annual ranges (Poole and Mowat 2005). Large river valley bottoms and low elevation south and southwest facing slopes are important winter habitats (Canfield et al. 1999).

During spring, deer are in their poorest condition of the year, having suffered notable weight losses during the winter. The early greening of forage at lower elevations and southern slopes (winter range) is important to deer in recovering from winter stresses (Canfield et al 1999). Calves are born in May and June. Summer forage quality is important for calves in building energy reserves for winter, for bulls growing antlers and preparing for rut, and for increased energy needs of lactating females. As summer progresses, deer may migrate upward in elevation to access high-quality forage, feeding on vegetation in early phenological stages and utilizing seeps, springs, and other wet sites (Canfield et al. 1999). For hunted populations, availability of security habitat is important during the fall.

Because deer preferences for spring and summer foraging habitat are extremely general and not a limiting factor in Mt Spokane State Park, in the interest of efficiency we limited our literature review of habitat suitability to identifying habitat elements relevant to deer use during the winter months.

Distribution In MSSP

White-tailed deer are found year-round in regular concentrations in Mt. Spokane State Park. Suitable habitats for breeding, fawning, and year-round foraging are known to be present within the park. Johnson and Cassidy (1997) have MSSP mapped as core habitat and indicate sighting records for Spokane County.

Existing Habitat Models

Gould, D., K. Smith, B. Beck, J. Beck, R. Bonar, M. Todd, and R. Quinlan. 1999. White-tailed deer winter habitat: habitat suitability index model, version 5. Foothills Experimental Forest, Alberta. (Available online: http://foothillsresearchinstitute.ca/Content_Files/Files/HS/HS_report13.pdf).

Mowat, G. 1999. Literature review for deer and elk winter range modeling. Prepared for: J.H. Huscroft Ltd, Creston, British Columbia. (Available online: http://www.for.gov.bc.ca/hfd/library/frbc1999/FRBC1999MR169.pdf).

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Early/Late Winter Foraging Habitat Elements

During early and late winter, white-tailed deer have high forage demands and choose habitats based on quantity and quality of forage. Unlike mid-winter, snow depth at these times is less likely to be a deterrent to habitat use of preferred forage areas. In the north Priest River drainage of Washington and Idaho, Pauley et al. (1993) found snow depths less than 30 cm (12 inches, typical of early and late winter) were not limiting, and habitat use at this time was based primarily on forage-related factors.

In winter, white-tailed deer browse on numerous species of shrubs, deciduous saplings, and coniferous trees. Preferred forage sites are typically forested, with higher densities of conifers than deciduous trees, and with high shrub and sapling cover. Studies have identified a variety of foraging cover types. In northeast Washington and northwest Oregon, Pauley et al. (1993) found white-tailed deer used primarily dry forest habitat types. These included pole-sized forests with dense deciduous and evergreen shrub cover, as well as mature forest stands. An HSI model for winter foraging habitat in the Foothills Model Forest in Alberta included shrub cover as variable for deer winter foraging habitat Gould et al (1999). In MSSP, all Conifer Forests and Woodlands, and Riparian Shrublands provide potential suitability for white-tailed deer early and late winter foraging. Forested areas with higher shrub cover have higher suitability for foraging habitat.

Forest structural elements associated with white-tailed deer foraging habitat include structural stage, canopy height, canopy cover, and tree density. Pauley et al. (1993) notes that white-tailed deer use both pole-sized and mature forests. Using canonical analysis, they describe forested foraging habitats as “moderately stocked with relatively tall (24 m (79 ft) canopy height), closed (74% mean canopy cover) canopies.” Utilized stands were “moderately stocked forests” with an average density of 650-700 mature trees per hectare (263-283/acre). Mowat (1999)’s winter foraging model for the west Kootenays, British Columbia includes canopy cover between 40 and 70%. In MSSP, canopy cover between 40 and 80 percent provides ideal foraging habitat conditions. Forests in the pole and mature structural stages are important foraging habitat elements. Not enough information exists within the literature to parameterize suitable foraging conditions based on canopy height.

The most important winter foraging habitat conditions are associated with topography and elevation. Topographic features associated with winter foraging habitat are low elevations, gentle slopes, south and west-facing aspects, and valley bottoms. In Oregon and Washington, Pauley et al. (1993) identified valley bottoms and adjacent gentle, south and west-facing slopes (5-10% grade) as important foraging habitats. Elevations used in their study ranged from 759 to 778 meters (2490-2552 ft). In Alberta, Canada, however, suitable habitat was modeled up to 1500 meters (4921 ft) in elevation (Gould et al. 1999). Based primarily on Pauley et al. (1993)'s study, areas in MSSP with elevations lower than 2600 ft, slopes less than 10%, south and west facing aspects, and that are or are near valley bottoms are the most important topographic variables for white-tailed deer early and late winter foraging.

Although the use of separate models for winter forage and winter cover are recommended, the spatial adjacency of these habitats is a critical component for deer (Mowat 1999, Gould et al. 1999). The closer foraging habitat is to cover, the greater the value of that habitat. White-tailed deer typically used cover and foraging habitats within 140 to 220 meters (459-722 ft) of each other in the Foothills Forest Habitat Suitability Model in Alberta (Gould et al. 1999). In the Champion Forest of Alberta, white-tailed deer typically use such habitats within 180 meters (591 ft) of each other (MacCallum and Ebel 1985). Based on these studies, areas in MSSP with an adjacency element of 591 ft or less between foraging and cover habitats improves suitability.

Table 24. Habitat elements for white-tailed deer early/late winter foraging.

Variables	Parameters
Slope	< 10%
Aspect	Southerly, Westerly
Elevation	< 2600 feet
Landforms	Valley bottoms, gentle slopes
Cover type	Conifer Woodland / Shrubland, Conifer Woodland / Meadow, Wetland Conifer Woodland / Shrubland, Riparian Conifer Forest, Riparian Shrubland, Riparian Woodland / Shrubland, Upland Conifer Forest
Forest successional stage	Very young to mature
Forest canopy cover	40 - 80%
Shrub canopy cover	Moderate to dense
Distance from cover habitat	< 591 feet

Mid-Winter Cover Habitat Elements

During mid-winter, white-tailed deer shift habitat use, from a focus on foraging to one of conserving energy and avoiding areas of heavy snow cover. Earlier studies describe winter cover in regards to thermal regulation. However, there is increasing evidence that winter cover is primarily beneficial to deer in terms of intercepting snow, thereby reducing energy expenditure of movement (Poole and Mowatt 2005). Preferred winter cover habitat of white-tailed deer is coniferous, closed-canopied forests. These stands may have relatively little understory, and so adjacency of foraging habitat is important.

Forests used for winter cover are older, taller, dominated by conifers, and have more canopy cover than forests used primarily for foraging (Pauley et al. 1993, Gould et al. 1999, Mowatt 1999). In the northern Priest River drainage in Washington and Idaho, white-tailed deer preferred old, closed-canopied forests for cover. These stands averaged 238 years of age, 31 meters (102 ft) tall, with 87% canopy cover (Pauley et al. 1993). Winter cover HSI models have identified key variables as old-growth forest (Mowatt 1999), tree canopy cover greater than 70 percent (Gould et al. 1999, Mowatt 1999), and tree canopy height between 4 and 10 meters (13-33 ft) tall (Gould et al. 1999). Based on these studies, in MSSP mature to old-growth Upland Coniferous and/or Riparian Coniferous Forests with canopy cover greater than 70 percent are key variables for winter cover.

Snow depth is the most important variable in determining winter cover habitat. Although forest canopy cover (as identified above) is the variable most influencing snow depth, where such data is poor or lacking, Poole and Mowatt (2005) provide a model using topographic variables as surrogates for snow depth. Their model is based on elevation, slope and solar radiation. Mowatt (1999) also uses topographic variables to identify winter cover habitat. For the west Kootenay region, he models cover habitat as less than 1400 meters (4593 ft) in elevation, slopes of 16-90 percent, and warm aspects of 136 to 285 degrees. In MSSP, snow depth at 1400 meters, even with forest cover, is still quite high, therefore we lowered this parameter value to 914 meters (3000 ft). In MSSP, areas with slope less than 90 percent, and south to westerly aspects contribute increased habitat suitability for mid-winter cover habitat.

As described under the previous section (early/late winter foraging habitat), the closer foraging and cover habitats are to each other, the greater the value of those habitats (Mowat 1999, Gould et al. 1999). White-tailed deer typically use cover and foraging habitats within 180 meters (591 ft) of each other (MacCallum and Ebel 1985). In MSSP, a distance less than 591 ft from foraging habitat as an important cover habitat element.

Table 25. Habitat elements for white-tailed deer mid-winter cover.

Variables	Parameters
Slope	< 90%
Aspect	Southerly, Westerly
Elevation	< 3000 feet
Cover type	Riparian Conifer Forest, Upland Conifer Forest
Forest successional stage	Mature to old-growth
Forest canopy cover	> 70%
Distance from foraging habitat	< 591 feet

Risk Factors

White-tailed deer are common and widespread. They are regulated through hunting, and there is little concern over population viability. However, there are a number of factors that may negatively affect deer populations. Winter is a particularly vulnerable time for white-tailed deer as they are geographically constrained, with limited foraging opportunity. Human disturbances on wintering grounds, including use of roads and recreation trails, and harassment by domestic dogs, can lead to greater levels of physical stress and energy expended (Canfield et al. 1999). Other factors affecting white-tailed deer include potential competition for forage by domestic livestock, declines in early successional vegetation for forage associated with reduced timber harvest and wildfire exclusion, and poaching (Christenson et al. 1995).

References

Canfield, J.E., L.J. Lyon, J.M. Hillis, and M.J. Thompson. 1999. Ungulates. Pp. 6.1-6.25. *In*: Joslin, G., and H. Youmans, eds. Effects of recreation on Rocky Mountain wildlife: a review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307 pp.

Christensen, A.G., L.J. Lyon, R. Pedersen, P. Harrington, W.L. Bodie, R. Johnson, and B. O'Gara. 1995. Ungulate Assessment in the Columbia River Basin. Rocky Mountain Research Station.

Gould, D., K. Smith, B. Beck, J. Beck, R. Bonar, M. Todd, and R. Quinlan. 1999. White-tailed deer winter habitat: Habitat suitability index model, version 5. Foothills Experimental Forest, Alberta. (Available online: http://foothillsresearchinstitute.ca/Content_Files/Files/HS/HS_report13.pdf).

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

MacCallum, B., and G.R.A. Ebel. 1985. Ecological considerations for the wildlife of the Champion forest management area, Alberta. Alberta, Forestry, Lands, and Wildlife Report, Edmonton, Alberta.

Moen, A.N. 1976. Energy conservation by white-tailed deer in the winter. Ecology 57:192-198.

Mowat, G. 1999. Literature review for deer and elk winter range modeling. Prepared for: J.H. Huscroft Ltd, Creston, British Columbia. (Available online: http://www.for.gov.bc.ca/hfd/library/frbc1999/FRBC1999MR169.pdf).

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: February 25, 2009).

Pauley, G.R., J.M. Peek, and P. Zager. 1993. Predicting white-tailed deer habitat use in northern Idaho. Journal of Wildlife Management 57:904-913.

Poole K.G., and G. Mowat. 2005. Winter habitat relationships of deer and elk in the temperate interior mountains of British Columbia. Wildlife Society Bulletin 33:1288-1302.

Moose *(Alces alces)*

Moose are the largest ungulate species in the world (Chen 2001). They range throughout the northern latitude boreal forests, and are found in northeastern and northcentral Washington. They are thought to have arrived in North America from Asia about 11,000-14,000 years ago, shortly before flooding of the Bering land bridge (Hundertmark et al. 2003).

Comparative studies of different moose populations found that habitat preferences of moose are not fixed and change as the relative abundance of available habitat changes (Osko et al. 2004).
Moose forage in summer months as browsers in open habitat dominated by shrubs, and on plants associated with wetlands and waterbodies. Moose summer diet is mostly comprised of early-successional deciduous tree and shrub leaves (Renecker and Schwartz 1998). During the winter months, when trees are leafless, moose consume the stems of the same deciduous species they utilize during summer months, however less vegetation is accessible because snow covers the ground vegetation (Dussault 2002). Overall, moose densities in an area are largely determined by the availability of winter deciduous browse (Crête 1989). Their movements incorporate the use of more protected mature conifer forests in the summer and winter months, to help them take advantage of lower snow accumulations, higher-quality winter forage, protection from predators, insulation from extreme weather conditions, and a diversity of vegetation successional stages (Maier et al 2005).

Moose breeding season extends from mid-September to late November. Moose calving grounds are site specific locations, where maternal females move to secluded areas for birthing just days before calving (Addison et al. 1990, Bowyer et al. 1999, Poole et al. 2007). Movements are then restricted for a new calf and mother for up to 2 weeks postpartum (Addison et al. 1990). Presumably, female moose select for calving ground habitat characteristics that reduce the risk of predation to the new calf (Bailey and Bangs 1980, Addison et al. 1990, Langley and Pletscher 1994). Selection of calving grounds may ultimately be related to trade-offs between minimizing risk of predation and meeting increased nutritional needs for lactating females (Poole et al. 2007). Calf survival is an important factor affecting moose population dynamics; calving grounds are considered a limiting factor in areas where top predators such as the wolves and bears have a regulatory impact on moose populations (Mech et al. 1987).

There have been many modeled habitat selection criteria for moose. Habitat Suitability Index models are difficult to utilize for this species because their habits and habitats across its range. Additionally, moose regularly use alternate habitats for feeding and resting sites which have completely different vegetation characteristics (Rothley 2001). HSI models therefore may underestimate the importance of preferred habitats and the use of site specific empirical data should be promoted to help refine model applications to take local conditions into account (Dettki et al. 2003; Fankhauser and Enggist 2004).

Distribution In MSSP

Moose are year-round occupants of MSSP, with forest and wetland habitats providing breeding, calving and year-round foraging.

Existing Habitat Models

Chen, H. 2001. GIS-Based habitat models of indicator mammals (cougar, moose, elk, and thirteen-lined ground squirrel) in the Municipal District of Foothills, Southwest Alberta. Environmental Committee - Wildlife Habitat Research Project, The Municipal District of Foothills, No 31. University of Calgary, Calgary, Alberta.

Dussault, C., R. Courtois, and J. Ouellet. 2006. A habitat suitability index model to assess moose habitat selection at multiple spatial scales. Canadian Journal of Forest Research 36:1097-1107.

Hepinstall J.A., L.P. Queen, and P.A. Jordan. 1996. Application of a modified Habitat Suitability Index model for moose. Photogrammetric Engineering and Remote Sensing 62:1281-1286.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Puttock, G.D., P. Shakotko, and J.G. Rasaputra. 1996. An empirical habitat model for moose, *Alces alces*, in Algonquin Park, Ontario. Forest Ecology and Management 81:169-178.

Osko T.J., M.N. Hiltz, R.J. Hudson, and S.M. Wasel. 2004. Moose habitat preferences in response to changing availability. Journal of Wildlife Management 68:576-584.

Breeding/Calving Habitat Elements

Moose calving habitat preferences are highly variable both among and within studies. Selection is both for and against hiding cover, forage availability, distance to water, and slope steepness (Leptic and Gilbert 1986, Addison et al. 1990, Altman 1963, Bowyer et al. 1999). One strategy for moose is to calf in an area where forage quantity and quality are relatively low, but visibility is increased therefore reducing the risk of predation. A second strategy is to calf in an area with higher forage values especially of willows, decreased distance to water, and decreased slope, say closer to the riparian habitat along a river (Poole et al. 2007, Bowyer et al. 1999). Therefore, visibility and forage availability are the critical factors in which moose make tradeoffs (Bowyer et al. 1999).

Topography, slope, aspect and elevation are identified throughout the literature as important elements for neonatal calving grounds. Female moose seek locally elevated features such as hilltop and upper slope topography (Wilton and Gamer 1991), with relatively flat ground (Scarpitti et al. 2007, Jacqmain et al. 2008, Chen 2001, Maier et al. 2005) and southerly exposure (Bowyer et al. 1999, Scarpitti et al. 2007). These aspects are thought to increase visibility, helping in the detection of predators. In MSSP, topographical features such as hilltops, ridgelines, and valley bottoms, with southerly exposures and slopes of 0-10 percent offer the highest suitability for moose calving sites. Although elevation is found to be a broad scale predictor of calving areas (Poole et al. 2007, Wilton and Garner 1991), in MSSP inclusion of this element as a suitability predictor is difficult because studies are site specific and elevation parameters vary widely.

Based on availability, female moose tend to utilize areas immediately adjacent to waterbodies, islands, wetlands, or riparian sites that provide protective cover and soft ground (Leptich and Gilbert 1986, Jacqmain et al. 2008). Moose take advantage of these areas during high spring water runoff because they increase protection for newborn calves by decreasing access for predators (Leptich and Gilbert 1986, Poole et al. 2007, Addison et al. 1993). Areas in close proximity to water tend to have increased shrub densities, including willows (Poole et al. 2007, Bowyer et al. 1999). Scarpitti et al. (2007) documented mean shrub densities at calving sites ranging between 40-60 percent, while Chen (2001) stated that 30 percent shrub/sapling cover should contribute to moose foraging habitat for all life stages. In MSSP, waterbodies as well as wetland and riparian habitat cover types may contribute to suitable moose calving habitat. Mapped wetland and riparian cover types for moose calving habitat include Riparian Conifer Forest, Wetland Conifer Woodland / Shrubland, Riparian Conifer Woodland / Shrubland, and Riparian Shrubland. Areas with greater than 30 percent shrub/sapling cover should contribute to calving habitat suitability.

Coniferous forests and mixed deciduous/coniferous stands provide microhabitat conditions that help conceal neonatal moose from predators (Scarpitti et al. 2007). Forest types selected as calving sites ranged from cedar-hemlock, Douglas-fir, montane spruce, spruce-fir, subalpine fir and mixed forest types (Poole et al. 2007, Bowyer et al. 1999, Scarpitti et al. 2007). Preferred habitat for calving sites is documented in some literature as mature forests greater than 80 years in age with forest canopy cover of greater than 70 percent (Scarpitti et al. 2007, Chen 2001, Pierce and Peek 1984). Expert consultation on moose calving habitat at MSSP indicated that moose utilize areas with far less than 70% canopy cover, and forests less than 80 years in age (H. Ferguson pers. comm.). In addition to woodland, shrublands and riparian forests, moose may use young to old-growth Upland Conifer Forests in MSSP as suitable habitat for moose calving. There is not enough information from the literature to define forest canopy cover for moose calving habitat in MSSP.

There is variability from the literature on how distance to human developments and active roads affect the suitability of moose calving sites. One study hypothesized that parturient moose were selecting for high levels of human activity, possibly to deter predators (Bowyer et al. 1999). Another studies observed no relationship between birth sites and their distances to human habitation (Langley and Pletscher 1994). Other studies identified distances to roads as greater than 487 meters (1598 ft, Scarpitti et al. 2007) and mean distances to human developments as greater than 500 meters (1640 ft, Bowyer et al. 1999) as important suitability elements for moose calving. In MSSP moose birthing site selection varies considerably, and distance to or from developments and human disturbances are not key habitat elements according to local experts (H. Ferguson pers. comm.).

Table 26. Habitat elements for moose breeding/calving.

Variables	Parameters
Slope	0 - 10%
Aspect	Southerly
Landforms	Hilltops, ridgelines, valley bottoms
Cover type	Blowdown - Shrubland, Conifer Woodland / Shrubland, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Riparian Shrubland, Shrubland, Shrubland / Meadow, Upland Conifer Forest, Wetland Conifer Woodland / Shrubland
Water bodies	Present
Forest successional stage	Young to mature
Shrub canopy cover	> 30%

Summer Foraging Habitat Elements

Moose habitat selection has been studied extensively from Maine to Alaska to Idaho. The range of studies and reports show great variation in summer habitat selection associated with a mosaic of habitats. During summer months, riparian vegetation associated with wet meadows and open water are preferred, likely because moose can both forage on high-sodium aquatic plants as a source of browse and use the environment as thermal cover to cool down during hot days (Peek 1998, Jacqmain et al. 2008, Crossley and Gilbert 1983). Riparian areas also serve as movement corridors to foraging locations (Jacqmain et al. 2008). Preferences for foraging habitats have been shown for shrublands, closed and open conifer wetlands (Osko et al. 2004), as well as lowland and upland deciduous, mixed and coniferous forests (Osko et al. 2004, Pierce and Peek 1984, Leptich and Gilbert 1989). In MSSP, vegetation associated with water bodies are classified as riparian and wetland cover types. All existing cover types in MSSP provide potential moose summer foraging habitat, except for developed sites where natural vegetation has been removed.

Moose use open canopy sites during the early spring to summer months (Pierce and Peek 1984). Moose population densities are greatest where early successional deciduous tree and shrub forage species are the most abundant, such as very young forest stands 15-30 years in age, as well as forest edge habitats (Dussault 2006). These areas are often where new stem growth has occurred in regenerating shrubs and trees due to fires, windthrow, clear-cutting, insect outbreaks and other disturbances (Maier et al. 2005, Hundertmark et al.1990, Loranger et al. 1991, Crête et al. 1995). Chen's (2001) HSI model defined preferred foraging habitat as 5-30 year old forests dominated by greater than 30 percent shrub cover. In MSSP, shrub cover within the range of 5-95 percent is a habitat element contributing to increased suitability (H. Ferguson pers. comm.). Other forest and shrub cover characteristics in MSSP that would contribute to moose foraging habitat would include presence of burned areas, clear cuts, or other areas which experience natural or anthropogenic disturbances, excluding highly developed sites.

Moose are known to avoid variable terrain and utilize areas of flat to moderate slopes (less than 30 degrees) during summer foraging seasons (Chen 2001, Maier et al. 2005). In MSSP, moose have been observed foraging on hillsides with up to 50 percent slope (H. Ferguson pers. comm.). All areas less than 50 percent slope have higher habitat suitability for moose foraging in MSSP.

Table 27. Habitat elements for moose summer foraging.

Variables	Parameters
Slope	< 50%
Cover type	All cover types
Stream corridors	Present
Water bodies	Present
Shrub canopy cover	5 - 95%
Burned areas	Present
Clear-cuts	Present

Winter Foraging Habitat Elements

Moose winter home ranges are largely restricted to areas within or adjacent to summer home ranges (Dunn 1976, Crossley and Gilbert 1983, Leptich and Gilbert 1989), largely because the highest quality and density of forage can be found in the same landscape (Dussault et al. 2006). Optimal winter foraging habitat for moose is early successional communities (Chen 2001). Moose feed primarily on twigs of shrubby browse during winter months. A few stable species that are most common in moose seasonal diets include aspen, birch, and willow (Chen 2001). In MSSP, winter foraging habitat where shrub densities are highest are likely in open woodlands and shrublands which include mapped cover types such as Blowdown – Shrubland, Conifer Woodland / Shrubland, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Riparian Shrubland, Shrubland, Wetland Conifer Woodland / Shrubland.

In southeastern British Columbia and south-central Montana, moose winter foraging habitat was associated with high shrub cover (23 %), low forest canopy cover (15 %), and low tree density (Poole and Stuart-Smith 2005, VanDyke 1995). Poole and Stuart-Smith (2005) found that shrub cover (especially willow cover) appeared to be the main factor in determining winter moose foraging areas. In further studies, Poole and Stuart-Smith (2006) found lower crown closure was the strongest determinant of stand-scale winter habitat selection for female moose. Based on expert opinion for MSSP, very young to young forest stands (from 0-80 years in age) as well as shrublands have higher habitat suitability for wintering moose populations. Areas with 5 to 95 percent shrub cover would likely be suitable winter foraging habitat for moose in MSSP (H. Ferguson, WDFW Wildlife Biologist, pers. comm.).

Elevation is one of the strongest determinants of late-winter foraging habitat, which is likely a surrogate for snow-depth (Poole and Stuart-Smith 2006). Snow depths between 50 to 70 cm (20-28 inches) are thought to impede moose movements (Renecker and Schwartz 1998), and depths greater than 90 cm (35 inches) are considered an impediment to moose survival (Thompson and Vukelich 1981, Hundertmark et al. 1990). Snow depths in Poole and Stuart-Smith's (2005) study did not reach these depths, and was not an influence on moose foraging activity. In MSSP, snow depths greater than 35 inches may decrease foraging habitat for wintering moose populations.

Moose utilize steeper terrain during winter months, possibly because upper slope environments may provide for better predator detection capabilities (Jacqmain et al. 2008). In MSSP, slopes less than 50% should be adequate for moose winter foraging.

Food may be the key factor in assessing habitat suitability for moose; however for an area to be highly suitable for moose, food resources must be interspersed with sufficient cover (Dussault et al. 2006). Optimum winter foraging habitat is a function of interspersion, or the distance from thermal cover to foraging habitat. Allen et al. (1987 in Chen 2001) in the Lake Superior region found moose moved distances up to 100 meters (328 ft) from cover. Dussault et al. (2006) found that interspersion between cover and food (Suitability Index- SI_{edge}) more accurately depicted moose habitat suitability within larger landscapes near the boreal forests north of the city of Québec. SI_{edge} values increased when highly contrasting forest stands providing cover were juxtaposed with food habitat types. In MSSP, interspersion ratios of cover and foraging habitat are likely high, due to the extensive forested landscape in the area. However, assessment of the most suitable areas for winter foraging in relation to cover habitat in MSSP will require further analyses.

Table 28. Habitat elements for moose winter foraging.

Variables	Parameters
Slope	< 50%
Cover type	Blowdown - Shrubland, Conifer Woodland / Shrubland, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Riparian Shrubland, Shrubland, Upland Conifer Forest, Wetland Conifer Woodland / Shrubland
Snow depth	< 35 inches
Forest successional stage	Very young to Young
Shrub canopy cover	5 - 95%
Distance from cover habitat	Interspersion ratios

Cover Habitat Elements

While open non-forested areas provide high food availability for moose, a trade-off is that these areas also increase exposure to predation and extreme weather conditions (Dussault et al. 2004). A mature to old-growth forest stand provides good thermal cover and is the best shelter from solar radiation and deep snow. These forest stands also reduce the energetic costs of locomotion in snow, and increase concealment potential from predators (Coady 1974, Courtois and Crête 1988, Timmermann and McNicol 1988, Renecker and Schwartz 1998, Courtois et al. 2002, Dussault et al. 2004, Dussault et al. 2005a). Moose in north-central Idaho concentrated in localized old-growth and mature forests during winter and spring months, and to a large extent during summer months where forest canopy cover was greater than 70 percent (Pierce and Peek 1984). These forests also provide visual obstructions which may reduce the risk of predation for moose (Mysterud and Ostbye 1999; Altendorf et al. 2001; White and Berger 2001). In MSSP, cover types preferred by moose for cover habitat include Riparian Conifer Forest and Upland Conifer Forest. Forests with greater than 70% forest canopy cover, and that are in the successional categories of either mature or old-growth provide the highest suitability for moose cover habitat.

Cover habitat in an HSI model developed by Chen (2001) defines cover in mature and old-growth forests as greater than 60 percent coniferous species, and with canopy heights of greater than 10 meters (33 ft). In MSSP, potentially important habitat elements for moose cover may include tree species composition of greater than 60 percent coniferous trees in a stand, and forest canopy heights of greater than 33 ft.

Table 29. Habitat elements for moose cover.

Variables	Parameters
Cover type	Riparian Conifer Forest, Upland Conifer Forest
Dominant tree species composition	> 60% conifer trees
Forest successional stage	Mature to old-growth
Forest canopy cover	> 70%
Forest canopy height	> 33 feet

Risk Factors

Moose are relatively adaptable to their environment, and as such roads and human activities have little influence on habitat effectiveness. Moose are known to benefit from timber harvesting activities, which can create open habitat for increased summer foraging opportunities. Although vegetative characteristics are probably the ultimate factor governing habitat selection by moose, there is growing evidence that selection also depends on geographical factors such as topography, roads, and human settlement (Dettki et al. 2003; Nikula et al. 2004). These factors may affect moose at a finer scale.

While forestry activities may beneficially create more open moose habitat, they also create new roads that facilitate access for hunters and large openings where moose are more vulnerable. This can lead to higher harvest rates and population declines (Potvin et al. 2005). Commercial forestry harvest regimes and access roads also open access to predators and continually alter habitat composition and structure. These aspects can be detrimental to female cow movements prior to parturition, and to calf survival. Many authors have suggested that optimal neonatal habitat should provide forage resources to support the high energy demands of lactation (Altmann 1963, Leptich and Gilbert 1986, Bowyer et al. 1999), as well as security that reduces predation risk (Leptich and Gilbert 1986; Addison et al. 1990, 1993; Bowyer et al. 1999).

References

Addison, E.M., W.L. Wilton, R.E. McLaughlin, and M.E. Buss. 1990. Calving sites of moose in central Ontario. Alces 26:142-153.

Addison, E.M., R.F. McLaughlin, D.J.H. Fraser, and M.E. Buss. 1993. Observations of pre- and post-partum behaviour of moose in central Ontario. Alces 29:27-33.

Altendorf, K.B., J.W. Laundré, C.A. Lopez Gonzalez, and J.S. Brown. 2001. Assessing effects of predation risk on foraging behavior of mule deer. Journal of Mammalogy 82:430-439.

Altmann, M. 1963. Naturalistic studies of maternal care in moose and elk. Pp. 233-253. *In*: Rheingold, H.L., ed. Maternal behavior in mammals. John Wiley & Sons, New York, New York.

Bailey, T.N., and E.E. Bangs. 1980. Moose calving areas and use on the Kenai National Wildlife Refuge, Alaska. Proceedings of the North American Moose Conference and Workshop 16:289-313.

Bowyer, R. T., V. van Ballenberghe, J.G. Kie, and J. A. K. Maier. 1999. Birth-Site Selection by Alaskan Moose: Maternal Strategies for Coping with a Risky Environment. Journal of Mammology, 80:1070-1083.

Bowyer, R.T., V. Van Ballenberghe, and J.G. Kie. 2003. Moose (*Alces alces*). Pp. 931-964. *In*: Feldhamer, G.A., B. Thompson, and J. Chapman. The Johns Hopkins University Press, Baltimore, Maryland.

Chen, H. 2001. GIS-Based habitat models of indicator mammals (cougar, moose, elk, and thirteen-lined ground squirrel) in the Municipal District of Foothills, Southwest Alberta. Environmental Committee - Wildlife Habitat Research Project, The Municipal District of Foothills, No 31. University of Calgary, Calgary, Alberta.

Coady, J.W. 1974. Influence of snow on behaviour of moose. Naturaliste Canadiene (Quebec) 101:417-436.

Courtois, R., and M. Crête. 1988. Déplacements quotidiens et domains vitaux des orignales du sud-ouest du Québec. Alces 38:167-176.

Courtois, R., C. Dussault, and F. Potvin. 2002. Habitat selection by moose (*Alces alces*) in clear-cut landscapes. Alces 38:177-192.

Crête, M. 1989. Approximation of *K* carrying capacity for moose in eastern Quebec. Canadian Journal of Zoology 67: 373-380.

Crête, M., B. Drolet, J. Huot, M.J. Fortin, and G.J. Doucet. 1995. Chronoséquence après feu de la diversité de mammifères et d'oiseaux au nord de la forêt boréale québécoise. Canadian Journal of Forest Research 25:1509-1518.

Crossley, A., and J.R. Gilbert. 1983. Home range and habitat use of female moose in northern Maine – a preliminary look. Proceedings of the Northeast Wildlife Conference 39:67-75.

Dettki, H., R.. Löfstrand, and L. Edenius. 2003. Modeling habitat suitability for moose in coastal northern Sweden: empirical vs. process-oriented approaches. Ambio 32:549-556.

Dussault, C. 2002. Influence des contraintes environnementales sur la sélection de l'habitat de l'orignal (*Alces alces*). Ph.D. Thesis, Université Laval, Québec.

Dussault, C., Ouellet, J.-P., Courtois, R., Huot, J., Breton, L., and Larochelle, J. 2004. Behavioural responses of moose to thermal conditions in the boreal forest. Ecoscience, 11: 321–328.

Dussault, C., Ouellet, J.-P., Courtois, R., Huot, J., Breton, L., and Jolicoeur, H. 2005a. Linking moose habitat selection to limiting factors. Ecography 28: 619-628.

Dussault, C., R. Courtois, J.-P. Ouellet, and I. Girard. 2005b. Space use of moose in relation to food availability. Canadian Journal of Zoology 83: 1431-1437.

Dussault, C., R. Courtois, and J. Ouellet. 2006. A habitat suitability index model to assess moose habitat selection at multiple spatial scales. Canadian Journal of Forest Research 36:1097-1107.

Dunn, F. 1976. Behavioral study of moose. Maine Department of Inland Fisheries and Wildlife Project. W-66-R-6. Job 2-1. 39 pp.

Fankhauser, R., and P. Enggist 2004. Simulation of alpine chamois *Rupicapra r. rupicapra* habitat use. Ecological Modelling 175:291-302.

Goddard, J. 1970. Movements of moose in a heavily hunted area of Pntario. Journal of Wildlife Management 24:439-445.

Hepinstall J.A., L. P. Queen, and P. A. Jordan. 1996. Application of a modified Habitat Suitability Index model for moose. Photogrammetric Engineering and Remote Sensing . 62:1281-1286.

Hundertmark, K.J., W.L. Eberhardt, and R.E. Ball. 1990. Winter habitat use by moose in southeastern Alaska: implications for forest management. Alces 26:108-114.

Hundertmark, K. J., R. T. Bowyer, G. F. Shields, and C. C. Schwartz. 2003. Mitochondrial phylogeography of moose (*Alces alces*) in North America. Journal of Mammalogy 84:718-728.

Jacqmain, H., C. Dussault, R. Courtois, and L. Belanger. 2008. Moose-habitat relationships: integrating local Cree native knowledge and scientific findings in northern Quebec. Canadian Journal of Forestry Resources 38:3120-3132.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Langley, M.A., and D.H. Pletscher. 1994. Calving areas of moose in northwestern Montana and southeastern British Columbia. Alces 30:127-135.

Leptich, D.J., and J.R. Gilbert. 1986. Characteristics of moose calving sites in northern Maine: a preliminary investigation. Alces 22:69-81.

Leptich, D.J., and J.R. Gilbert. 1989. Summer home range and habitat use by moose in northern Maine. The Journal of Wildlife Management 53:880-885.

Loranger, A.J., T.N. Bailey, and W.W. Larned. 1991. Effects of forest succession after fire in moose wintering habitats on the Kenai Peninsula, Alaska. Alces 27:100-109.

Maier, J.A.K., J.M. Ver Hoef, A.D. McGuire, R.T. Bowyer, L. Saperstein, and H.A. Maier. 2005. Distribution and density of moose in relation to landscape characteristics: effects of scale. Canadian Journal of Forestry Resources 35:2233-2243.

Mech, L.D., R.E. McRoberts, R.O. Peterson, and R.E. Page. 1987. Relationship of deer and moose populations to previous winters' snow. Journal of Animal Ecology 56:615-627.

Mysterud, A., and E. Østbye. 1999. Cover as a habitat element for temperate ungulates: effects on habitat selection and demography. Wildlife Society Bulletin 27:385-394.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Nikula, A., S. Heikkinen, and E. Helle. 2004. Habitat selection of adult moose *Alces alces* at two spatial scales in central Finland. Wildlife Biology 10:121-135.

Osko T.J., M.N. Hiltz, R.J. Hudson, and S.M. Wasel. 2004. Moose habitat preferences in response to changing availability. Journal of Wildlife Management 68:576-584.

Peek, J.M., D.L. Urich, and R.J. Mackie. 1976. Moose habitat selection and relationships to forest management in northeastern Minnesota. Wildlife Monographs 48.

Peek, J.M. 1998. Habitat relationships. Pp. 351-376. *In*: Schwartz, C.C., and L.A. Renecker, eds. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C.

Pierce, D.J., and Peek, J.M. 1984. Moose habitat use and selection patterns in north-central Idaho. The Journal of Wildlife Management, 48: 1335–1343.

Pierce, D.J. 1983. Food habits, movements, habitat use and population parameters of moose in north central Idaho and relationships to forest management. M.Sc. Thesis, University of Idaho, Moscow, Idaho. 205 pp.

Puttock, G.D., P. Shakotko, and J.G. Rasaputra. 1996. An empirical habitat model for moose, *Alces alces*, in Algonquin Park, Ontario. Forest Ecology and Management 81:169-178.

Poole, K.G. and K. Stuart-Smith. 2005. Fine-scale winter habitat selection by moose in interior montane forests. Alces, Annual 2005, pg 1-8. Accessed online: http://findarticles.com/p/articles/mi_hb006/is_41/ai_n29241110/?tag=content;col1 .

Poole, K.G. and K. Stuart-Smith. 2006. Winter habitat selection by female moose in western interior montane forests. Can. J. Zool. 84: 1823–1832.

Poole, K.G., R. Serrouya, and K. Stuart-Smith. 2007. Moose calving strategies in interior montane ecosystems. Journal of Mammalogy 88:139-150.

Potvin F., L. Breton, and R. Courtois. 2005. Response of beaver, moose, and snowshoe hare to clear-cutting in a Quebec boreal forest: a reassessment 10 years after cut. Canadian Journal of Forestry Research, 35:151-160.

Renecker, L.A., and C.C. Schwartz. 1998. Food habits and feeding behavior. Pp. 403-440. *In*: Schwartz, C.C., and L.A. Renecker, eds. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C.

Rothley, K.D. 2001. Manipulative, multi-standard test of a white-tailed deer habitat suitability model. Journal of Wildlife Management 65:953-963.

Scarpitti, D. L., P. J. Pekins, and A. R. Musante. 2007. Characteristics of neonatal moose habitat in northern New Hampshire. Alces, 11 pgs.

Thomas, J.W. 1979. Wildlife habitats in managed forest: the Blue Mountains of Oregon and Washington. USDA Forest Service, Portland, Oregon. Agriculture Handbook 553.

Thompson, I.D., and M.F. Vukelich. 1981. Use of logged habitats in winter by moose cows with calves in northeastern Ontario. Canadian Journal of Zoology 59:2103-2114.

Timmermann, H.R., and J.G. McNicol. 1988. Moose habitat needs. Forestry Chronicles 64: 238-245.

Van Ballenberghe, V., and J.M. Peek. 1971. Radio-telemetry studies of moose in northeastern Minnesota. Journal of Wildlife Management 35:63-71.

White, K.S., and J. Berger. 2001. Antipredator strategies of Alaskan moose: are maternal trade-offs influenced by offspring activity? Canadian Journal of Zoology 79:2055-2062.

Wilton, M., and D. Garner. 1991. Preliminary findings regarding elevation as a major factor in moose calving site selection in south central Ontario, Canada. Alces 27:111-117.

Species Summaries - Birds

Northern Goshawk *(Accipiter gentilis)*

The northern goshawk is the largest of the *accipiter* raptors in North America. The species is holarctic in distribution, inhabiting boreal forests throughout the northern portion of their range (Alaska and Canada), and inhabiting montane forests in the southern portion of their range (western United States and Mexico). In Washington and Oregon, goshawks nest in all forested mountain ranges (Marshall 1992). Due to their large size, they forage on a variety of prey species associated with mature to old-growth forests such as ruffed grouse, woodpeckers, squirrels, snowshoe hares, and other lagomorphs. They forage by flying rapidly through the open understory of dense forests and through small forest openings. They nest in large intact blocks of mature to late-successional conifer forests where prey densities are high.

Goshawks typically take up year round residence in an area, and are thought to undergo short migrations between higher and lower elevations based on prey densities (Squires and Reynolds 1997). On occasion, large numbers migrate southward, apparently in response to declines in prey populations (Bent 1937, Doyle and Smith 1994, Mueller et al. 1977, Squires and Reynolds 1997). Goshawks are a Federal Species of Concern and are a candidate for being listed as threatened in Washington State.

Distribution In MSSP

There are several known primary and alternate nest sites within Mount Spokane State Park. They are considered year-round residents in MSSP. Smith et al (1997) map goshawk breeding activity and core habitat for goshawk in the Mt. Spokane area.

Existing Habitat Models

Idaho Panhandle National Forest (INPF). 2006. Appendix 9: Species Habitat Estimates for the Idaho Panhandle National Forests. USDA Forest Service, Idaho Panhandle National Forest. 10 pp.

Mahon, T., E. McClaren, and F. Doyle. 2006. Parameterization of the northern goshawk (*Accipiter gentilis laingi*) habitat model for coastal British Columbia: nesting and foraging habitat suitability model and territory analysis model.

Machmer, M.M., G.F. Utzig, T.M. Gaines, C. Savignac, and J. Dulisse. 2000. Development of a northern goshawk habitat suitability index for forest types of the Kootenay region. In: L.M. Darling, ed. 2000. Proceedings of a conference on the biology and management of species and habitats at risk, Kamloops, B.C. 15-19 Feb, 1999. Volume One. B.C. Ministry of Environment, lands and Parks, Victoria, B.C. and University College of the Caribou, Kamloops B.C. 490 pp.

Mahon, T., and D. Wahl. 2004. Verification of wildlife habitat suitability ratings for the northern goshawk (Accipiter gentilis) in the Otter Creek watershed, Merritt TSA. Prepared for: Tolko Industries Ltd.18 pp.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Breeding/Nesting Habitat Elements

Goshawks generally nest in dense, mature to old-growth coniferous forests with high forest canopy cover and sparse ground cover (Bull and Hohmann 1994, Daw and DeStefano 2001, Hargis et al. 1994, Reynolds et al 1982, Siders and Kennedy 1994, Squires and Ruggiero 1996, Younk and Bechard 1994). Mahon et al. (2003) describes forest canopy cover as "probably the most important structural variable relating to nest area suitability". They identify canopy cover above 70 percent as optimal for nesting goshawks in an HSI model developed for northwest British Columbia. Mature to old-growth conifer forests with 45 to 70 percent canopy cover provide optimal nesting habitat conditions for northern goshawks in MSSP.

Clear flight ways in the low and mid-canopy are required for good nesting habitat (Mahon et al., 2006). Presence of large trees with high crown bottoms surrounding the nest tree provide these open fly ways, and large open branches provide important perch sites for hunting adults and post-fledging birds (Desimone and Hayes 2003, Mahon et al. 2003). The availability and proximity of snags for use as plucking posts also contribute to nesting habitat (Marshall, 1992). Mahon et al.'s (2006) HSI model requires a forest stand height of greater than 19.5 meters (64 ft) for optimal nesting habitat, which is probably true in MSSP as well. To estimate goshawk nesting habitat with adequate large tree densities in MSSP, Morrison et al. (2007) selected as optimal forest stands with a minimum of 8 trees per acre with 24 inches diameter at breast height. Morrison et al. (2007) also selected as optimal stands where shrub cover was less than 15 percent and shrub height stayed below 14 ft. Snag presence is an important element of goshawk nesting habitat in MSSP.

Slopes with steepness greater than 40 percent seem to be avoided for nesting (Mahon et al. 2006). In MSSP, slopes less than 40 percent may provide optimal nesting habitat for goshawks.

Goshawks are known to be sensitive to human activity, and are generally associated with more remote habitats. Ideally, they nest in interior forests, away from edge habitat. Nesting success is thought to improve as distance from developed areas and habitat edges increase. Mahon et al. (2003) found nesting goshawks greater than 50 meters (164 ft) away from both human development and forest edges. In MSSP, distances greater than 165 feet from developed areas and large patches of non-forested land (such as clearcuts, shrublands, meadows, and human infrastructure) may increase the likelihood of nesting goshawks.

Table 30. Habitat elements for northern goshawk breeding/nesting.

Variables	Parameters
Slope	< 40%
Forest successional stage	Mature to old-growth
Forest canopy cover	> 70%
Tree diameter	> 24 inches DBH
Tree height	> 65 feet
Tree density	> 8 trees per acre
Snags	Present
Shrub canopy cover	< 15%
Shrub heights	< 14ft
Distance from developed infrastructure	> 165 feet
Distance from forest edge	> 165 feet

Foraging Habitat Elements

Prey availability is the primary factor influencing goshawk use of habitat; their main prey items include ruffed grouse, woodpeckers, squirrels, snowshoe hares, and other small mammals and birds. Goshawks prefer closed canopy forests with large trees present, and are associated with mature to old-growth conifer forests (Reynolds et al. 1992, Mahon et al. 2006). They also utilize forest edges and small forest openings less than 4 acres in size for hunting, assuming prey densities are high (Reynolds et al. 1992). In MSSP, mature to old-growth forests provide optimal foraging habitat for goshawks. Also, all areas mapped as a non-forested cover types that are less than 4 acres in size could provide suitable foraging habitat.

Goshawk preferences for open mid- and lower-canopy flyways can be explained by the bird's large body size and shape, which allows for maneuverability and short rapid flights through dense forest stands (Mahon et al. 2006). The goshawk is a height-zone generalist, taking prey from the ground and shrub canopies, and fewest prey taken from the tree canopy (Reynolds 1979; Reynolds and Meslow 1984). Therefore, an open understory allows for visibility of prey when hunting in an otherwise dense forest environment (Reynolds et al. 1992). In MSSP, shrub canopy cover less than 15% and shrub heights less than 14 feet tall should allow for open flyways in the forest canopy while providing prey cover in the shrubby lower canopy (Morrison et al. 2007).

Similarly, moderate to high forest canopy cover in mature to old-growth forests tends to correlate to open understories for hunting goshawks (Mahon et al. 2003). The presence of large trees with big branches suitable for landing on and supporting the weight of mature individuals improves habitat suitability (Mahon et al. 2006). Mahon et al.'s (2006) HSI model describes as optimal forest heights greater than 19.5 meters (64 ft) for foraging goshawks in northwestern British Columbia. In forests below this height prey availability is assumed to be greatly reduced due to high young tree stem densities. Mahon et al (2003) also state that moderate to high forest canopy cover tends to correlate to open understories which goshawks use as foraging flyways. Their model estimated forest canopy cover greater than 70 percent as preferred goshawk foraging habitat. In

MSSP, forest canopy heights of greater than 65 feet and forest canopy cover over 70 percent would provide optimal goshawk foraging habitat.

Lower gradient slopes are typically richer sites producing larger trees and are associated with higher prey densities (Mahon et al. 2003). Mahon et al.'s (2003) HSI model identified slopes less than 70% as adequate foraging habitat for goshawks. In MSSP, less than 70 percent slope should have higher prey densities and increased foraging habitat for goshawks.

Table 31. Habitat elements for northern goshawk foraging.

Variables	Parameters
Slope	< 70%
Forest successional stage	Mature to old-growth
Forest canopy cover	> 70%
Tree height	> 65 feet
Large trees	Present
Shrub canopy cover	< 15%
Shrub heights	< 14ft
Area of non-forested cover type	< 4 acres

Risk Factors

There is concern that goshawk populations may be declining in western North America. Their conservation status is considered imperiled to vulnerable in many of the lower 48 states (NatureServe 2008). It has been suggested that these declines are associated with forest structural and compositional changes over the last 100 years due to commercial forestry practices, wildfire suppression, and livestock grazing (Graham et al. 1999).

The impact of wildfire suppression is not well understood, however it is thought that fire exclusion has generated dense understory conditions which make it difficult for goshawks to efficiently find food. Stand replacing fires occurring after long-term fire exclusion are also hypothesized to have detrimental effects on prey species, thus affecting goshawk nesting and foraging habitat.

To avoid impacting nesting habitat of northern goshawks, land managers should monitor and manage known nesting habitat to be sure it is surrounded by suitable foraging habitat (Reynolds et al. 1992). Commercial salvage logging operations often remove the forest structure necessary for nesting and foraging, by reducing stand density and canopy cover, and removing large nest and perch trees. Additionally, prey composition and numbers change when forest canopy cover is reduced and the logs and snags are removed by logging practices. Logging operations have had direct impacts on nest failure due to abandonment during incubation and nestling periods (Boal and Mannan 1994, Squires and Reynolds 1997).

Following canopy reduction by logging, goshawks are often replaced by other raptors including the red-tailed hawk (*Buteo Jamaicensis*), great horned owl (*Bubo Virginianus*), and long-eared owl (*Asio Otus*; Crocker-Bedford 1990, Erdman et al. 1998). The great horned owl is especially significant, as it is a predator to both adult and nestling goshawks (Boal and Mannan 1994, Erdman et al. 1998, Rohner and Doyle 1992), and may further decrease goshawk presence after logging.

Reductions in the size of mature to old-growth forest stands as a result of forest cutting is a key conservation issue to address for maintaining habitat for this forest dependent species. Foraging areas for goshawks are large, and they hunt opportunistically and defend their territories avidly; foraging areas can total approximately 5400 acres (Reynolds et al 1992). Strategies to abate goshawk decline include leaving large tracts of forest intact, exempt from commercial timber harvest and managed for late-successional characteristics (Reynolds et al. 1992).

References

Bent, A.C. 1937. Life histories of North American birds of prey. Part 1. United States National Museum. Bulletin 137. 409 pp.

Boal, C.W., and R.W. Mannan. 1994. Northern goshawk diets in ponderosa pine forests on the Kaibab Plateau. Studies in Avian Biology 16:7-102.

Bull. E.L., and J.E. Hohmann. 1994. Breeding biology of northern goshawks in northeastern Oregon. Studies in Avian Biology 16:103-105.

Crocker-Bedford, D.C. 1990. Goshawk reproduction and forest management. Wildlife Society Bulletin 18:262-269.

Daw, S.K., and S. DeStefano. 2001. Forest characteristics of northern goshawk nest stands and post-fledgling areas in Oregon. Journal of Wildlife Management 65:59-65.

Desimone, S.M., and D.W. Hayes. 2003. Northern goshawk (*Accipter gentilis*). *In*: Larsen, E.M., J.M. Aserrad, and N. Nordstrom, eds. Management recommendations for Washington's priority species, volume IV: birds.

Doyle, F.I., and J.M.N. Smith. 1994. Population responses of northern goshawks to the 10-year cycle in numbers of snowshoe hares. Studies in Avian Biology 16:122-129.

Erdman, T.C., D.F. Brinker, J.P. Jacobs, J. Wilde, and T.O. Meyer. 1998. Productivity, population trend, and status of northern goshawks, *Accipiter gentilis atricapillus*, in northeastern Wisconsin. Canadian Field Naturalist 112:17-27.

Graham, R.T., R.L. Rodriguez, K.M. Paulin, R.L. Player, A.P. Heap, and R. Williams. 1999. The northern goshawk in Utah: habitat assessment and management recommendations. USDA Forest Service, Rocky Mountain Research Station. General Technical Report RMRS-GTR-22. 48 pp.

Hargis, C.D., C. McCarthy, and R.D. Perloff. 1994. Home ranges and habitats of northern goshawks in eastern California. Studies in Avian Biology 16:66-74.

Hayward, G.D., and R.E. Escano. 1989. Goshawk nest-site characteristics in western Montana and northern Idaho. Condor 91:476-479.

Idaho Panhandle National Forest (INPF). 2006. Appendix 9: Species Habitat Estimates for the Idaho Panhandle National Forests. USDA Forest Service, Idaho Panhandle National Forest. 10 pp.

Machmer, M.M., G.F. Utzig, T.M. Gaines, C. Savignac, and J. Dulisse. 2000. Development of a northern goshawk habitat suitability index for forest types of the Kootenay region. *In*: Darling, L.M., ed. 2000. Proceedings of a conference on the biology and management of species and habitats at risk, Kamloops, B.C. 15-19 Feb, 1999. Volume One. British Columbia Ministry of Environment, Lands and Parks, Victoria, B.C., and University College of the Caribou, Kamloops British Columbia. 490 pp.

Mahon, T., D. Morgan, and F. Doyle. 2003. Northern Goshawk *(Accipiter gentilis*) Habitat in the North Coast Forest District: Foraging Area and Nest Area Habitat Suitability Models. 23 pp.

Mahon, T., E. McClaren, and F. Doyle. 2006. Parameterization of the northern goshawk (*Accipiter gentilis laingi*) habitat model for coastal British Columbia: nesting and foraging habitat suitability model and territory analysis model. Unpublished report. 44 pp.

Mahon, T., and D. Wahl. 2004. Verification of wildlife habitat suitability ratings for the northern goshawk (Accipiter gentilis) in the Otter Creek watershed, Merritt TSA. Prepared for Tolko Industries Ltd. 18 pp.

Marshall, D.B. 1992. Status of the northern goshawk in Oregon and Washington. Audubon Society of Portland, Portland, Oregon. 34 pp.

McClaren, E. 1998. "Queen Charlotte" goshawk (*Accipiter gentilis laingi*) population inventory summary for Vancouver Island, British Columbia (1997/1998). Prepared for the BC Wildlife Branch, Ministry of Environment, Lands and Parks, and the BC Conservation Foundation. 54 pp.

McGrath, M.T., S. DeStefano, R.A. Riggs, L.L. Irwin, and G.J. Roloff. 2003. Spatially explicit influences on northern goshawk nesting habitat in the interior Pacific Northwest. Wildlife monographs. Oregon Cooperative Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon.

Morrison, P.H., H.M. Smith IV, G.F. Wooten, and S.D. Snetsinger. 2007. Forest Health Assessment and Plan for the 2006-2007 project area of Mount Spokane State Park. Pacific Biodiversity Institute, Winthrop, Washington. 370 p. + one 406 pp. Appendix.

Mueller, H.S., D. Berger, and G. Allez. 1977. The periodic invasions of goshawks. Auk 85:652-653.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Reynolds, R.T., E.C. Meslow, and H.M. Wight. 1982. Nesting habits of coexisting *Accipiter* in Oregon. Journal of Wildlife Management 46:124-131.

Reynolds, R.T., R.T. Graham, M.H. Reiser, R.L. Bassett, P.L. Kennedy, D.A. Boyce, G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. General Technical Report RM-217. 90 pp.

Rohner, C., and F.I. Doyle. 1992. Food-stressed great horned owl kills adult goshawk: exceptional observation of community process? Journal of Raptor Research 26:261-263.

Siders, M.S., and P.L. Kennedy. 1994. Nesting habitat of Accipiter hawks: is body size a consistent predictor of nest habitat characteristics? Studies in Avian Biology 16:92-96.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Speiser, R., and T. Bosakowski. 1987. Nest site selection by northern goshawks in northern New Jersey and southeastern New York. Condor 89:387-394.

Squires, J.R., and L.F. Ruggiero. 1996. Nest-site preference of northern goshawks in southcentral Wyoming. Journal of Wildlife Management 60:170-177.

Squires, J.R., and R.T. Reynolds. 1997. Northern goshawk (*Accipiter gentilis*). No. 298. In A. Poole, and F. Gill, eds. The Birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania. 32 pp.

Younk, J.V., and M.J. Bechard. 1994. Breeding ecology of the northern goshawk in high-elevation aspen forests of northern Nevada. Studies in Avian Biology 16:119-121.

*Boreal Owl (***Aegolius funereus richardsoni***)*

Boreal owls inhabit high elevation (above 4,000 ft) mature and old-growth coniferous forests, where they tend to be year-round residents with a consistent home-range. They occur worldwide in boreal forests. In North America they historically occurred only in Canada, however in the last 40 years, eruptions south into the northeastern United States have occurred, and now breeding populations have been reported in many western states (Heinrich et al. 1999).

Boreal owl habitat requirements for breeding, roosting, and foraging are very similar, and all are primarily associated with prey availability. Summer and winter habitat ranges overlap, however boreal owls use seasonal shifts in their hunting strategies. For example, boreal owls snow plunging for winter prey, and hunting open areas like clear cuts and agricultural fields during early spring before vegetation grows up and diminishes visibility (Hayward and Hayward 1993, Heinrich et al. 1999). Summer and winter prey includes small mammals such as voles and mice (Hayward et al. 1993).

Prey availability is the most important component of boreal owl foraging and roosting habitat. Roost sites are in conifer trees, and are tightly associated with their foraging area. Boreal owls roost in a new site each day, and use sites dispersed throughout their home range to increase hunting opportunities. Habitat elements for boreal owl roosting and foraging in MSSP are represented as a single habitat element x life stage matrix to emphasize the interconnected relationship between these life requisites.

Distribution In MSSP

Boreal owls are uncommon year-round residents in the mountains of northeast Washington (BirdWeb 2008). They are listed as wildlife potentially found in Mount Spokane State Park, for both breeding and foraging.

Existing Habitat Models

Heinrich, R., J. Watson, B. Beck, J. Beck, M. Todd, R. Bonar and R. Quinlan. 1999. Boreal owl nesting and roosting habit: Habitat Suitability Index model, version 5. Foothills Model Forest, Hinton, Alberta, Canada.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Breeding/Nesting Habitat Elements

Boreal owls nest primarily in tree and snag cavities built by primary excavators, such as the pileated woodpecker and northern flicker. Nest trees of sufficient size and number must be present within an area to ensure there are multiple suitable nesting sites to meet the boreal owl’s nesting requirements.

Breeding/nesting habitat requires mature to old growth trees with structural diversity for adequate nesting cavities. In Idaho, Montana and Washington, calling sites (recognized as potential breeding sites) were characterized by mature conifer forests (Hayward et al. 1993) within sub-alpine fir, western hemlock, and Englemann spruce forests (Palmer 1986). Lodgepole pine forests are also recognized as important forest types for boreal owls (Sallabanks et al. 2001; Hayward and Verner 1994). Nest sites in Idaho occurred in stands that averaged 57 trees per hectare (23 per acre) of trees over 38 cm (15 inches) in diameter at breast height (dbh) (Hayward et al. 1993). Stands used for nesting contained an average of 9 snags per ha over 38-cm dbh (Hayward and Verner 1994). Forest structure within nest stands of Alberta, Canada was documented to be at least 30 large deciduous trees and conifer snags per hectare (12 per acre) greater than 35 cm (14 inches) in diameter at breast height (Heinrich et al. 1999). Nests were generally located in snags or large trees where the diameter at the cavity averaged 41-cm and the tree dbh averaged 64-cm (Hayward and Verner 1994). In MSSP mature to old-growth areas mapped as Upland Coniferous and Riparian Coniferous Forests provide suitable habitat for boreal owl breeding/nesting (H. Ferguson, WDFW Wildlife Biologist, pers. comm.). Dominant tree species for nesting boreal owls may include sub-alpine fir, western hemlock, lodgepole pine and Englemann spruce. Forest stands with at least 23 trees and snags per acre that are greater than 14 inches in diameter at breast height should provide adequate breeding/nesting habitat in MSSP.

Nesting elevations for boreal owls are documented above 1500 meters (5184 ft), and rarely below 4000 ft (Palmer 1986, Hayward et al. 1987, Holt and Hillis 1987, O'Connell 1987). In MSSP, areas at greater than 4000 ft in elevation should provide suitable nesting habitat.

Table 32. Habitat elements for boreal owl breeding/nesting.

Variables	Parameters
Elevation	> 4000 feet
Cover type	Riparian Conifer Forest, Upland Conifer Forest
Dominant tree species composition	Sub-alpine fir, western hemlock, lodgepole pine or Englemann spruce
Forest successional stage	Mature to old-growth
Tree or snag diameter	> 14 inches DBH
Tree or snag density	> 23 stems per acre

Foraging and Roosting Habitat Elements

Hunting for boreal owls is opportunistic throughout the year. In winter, mature forests lack a snow crust which facilitates plunge diving for prey. In early spring, boreal owls will hunt open areas like clear-cuts and agricultural fields before vegetation grows up and diminishes visibility (Hayward and Hayward 1993, Heinrich et al. 1999). They also hunt along natural forest openings and meadows. In summer, mature forests have less herbaceous cover than open sites, providing greater access to prey. According to local wildlife experts, boreal owls will use young to old-growth forests in MSSP for foraging/roosting (H. Ferguson, WDFW Wildlife Biologist, pers. comm.). Removal of forest patches larger than several hectares will have a negative effect on foraging habitat

(Hayward and Verner 1994). This is true even when created openings might lead to an increase in prey populations because boreal owls hunt from perches and do not foray far into openings. Mapped cover types in MSSP such as Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Upland Conifer Forest, Upland Conifer Woodland / Meadow, and Upland Meadow provide roosting and foraging habitat (H,. Ferguson, WDFW Wildlife Biologist, pers. comm.).

There may be a shift in concentration of activity to lower elevations in winter to take advantage of lower snow accumulations, but winter and summer elevation ranges completely overlap. In MSSP, elevations above 3,500 ft may provide suitable habitat for foraging and roosting (H. Ferguson, WDFW Wildlife Biologist, pers. comm.).

In the northern Rocky Mountains, mature spruce-fir forest was recorded as important for foraging (Hayward et al. 1993), and stands with greater than 50% conifer composition were best for roosting (Heinrich et al. 1999). In MSSP, spruce-fir and other coniferous forest types are important habitat elements for boreal owl foraging and roosting. Stands with greater than 50 percent conifer species as canopy dominants also are important habitat elements for boreal owl foraging and roosting.

Roosting habitat quality for the boreal owl is related positively to overstory forest canopy cover, which provides cooler microclimates (Hayward et al. 1993). Hienrich et al.'s (1999) HSI model indicates that forest stands with forest canopy cover values less than 20 percent do not provide adequate habitat, while stands with greater than 50% forest canopy cover of trees > 8 cm (3.1 inches) in diameter at breast height provide highly suitable habitat. In MSSP, stands with > 50 percent forest canopy cover should provide optimal roosting habitat suitability.

Boreal owls typically use low perch branches for foraging (Hayward et al. 1993), and roost at an average height of 14 meters (46 ft, Palmer 1986). Heinrich et al.'s (1999) HSI model uses suitable foraging and roosting canopy height as greater than 46 feet. Additionally, the HSI model uses a composition of least 100 trees per hectare (40 per acre) at greater than 25.7 cm (10 inches) in diameter at breast height (Heinrich et al. 1999). According to local wildlife experts, these tree size, canopy height, and tree density parameters may be too large for MSSP (H. Ferguson, WDFW Wildlife Biologist, pers. comm.). Further research and field analysis would be required to determine optimal parameters for local management purposes.

Table 33. Habitat elements for boreal owl foraging and roosting.

Variables	Parameters
Elevation	> 3500 feet
Cover type	Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Upland Conifer Forest, Upland Conifer Woodland / Meadow, Upland Meadow
Dominant tree species composition	> 50% conifer trees, Spruce-fir
Forest successional stage	Young to old-growth
Forest canopy cover	> 50%

Risk Factors

The recent history of forest fire suppression in the western United States has created fuel conditions in some forest types that result in larger, more intense fires. As boreal owls require mature and older coniferous forests, intense forest fires may remove large trees and temporarily damage suitable foraging areas. Research has shown that the removal of old, structurally diverse forests which can happen with intense forest fires, can decrease breeding success and survival, especially of males (Hakkarainen et al. 2008).

Timber harvest can reduce availability of mature and older forest structural components used for foraging, breeding and roosting, and often reduces primary prey populations (Ramirez and Hornocker 1981). Indirect effects of forest harvesting practices can also eliminate nesting cavities (Hayward and Hayward 1993). In managed forests, uneven-age timber management practices may allow for maintenance of good foraging habitat, but clear-cut logging does not (Hayward and Hayward 1993). Boreal owl habitat conservation should focus on maintaining snags similar to snag management guidelines for pileated woodpeckers (Rodrick and Milner 1991).

Genetic analysis has shown that population genetic connectivity remains even when habitat connectivity is lacking, thus the conservation priority for this species is maintaining sufficient nesting and foraging habitat (Koopman et al. 2007). Related to loss of foraging habitat, boreal owls can be nomadic following fluctuations in prey densities (Hayward and Hayward 1993). This can make accurate population estimates difficult, complicating conservation efforts.

References

BirdWeb. 2008. BirdWeb: learn about the birds of Washington state. Seattle Audubon Society, Seattle, Washington. Available online: http://www.birdweb.org/birdweb/index.aspx, Accessed: June 28, 2008).

Hakkarainen, H., E. Korpimaki, T. Laaksonen, A. Nikula, and P. Suorsa. 2008. Survival of male tengmalm's owls increases with cover in old forest in their territory. Oecologia 155:479-486.

Hayward, G. D.; Verner, J. 1994. Flammulated, boreal, and great gray owls in the United States: A technical conservation assessment. Gen. Tech. Rep. RM-253. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 214 p. 3 Maps.

Hayward, G.D., P.H. Hayward, and E.O. Garton. 1993. Ecology of boreal owls in northern Rocky Mountains, USA. Wildlife Monographs 124:1-59.

Hayward, G. D. and P. H. Hayward. 1993. Boreal owl (Aegolius funereus), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York. (Available online: http://bna.birds.cornell.edu/bna/species/063).

Hayward, G.H., P.H. Hayward, E.O. Garton, and R. Escano. 1987. Revised breeding distribution of the boreal owl in the northern Rocky Mountains. Condor 89:431-432

Heinrich, R., J. Watson, B. Beck, J. Beck, M. Todd, R. Bonar and R. Quinlan. 1999. Boreal owl nesting and roosting habit: habitat suitability index model, version 5. Foothills Model Forest, Hinton, Alberta.

Holt, D.W., and M. Hillis 1987. Current status and habitat associations of forest owls in western Montana. Pp 281-286. *In*: Nero, R.W., R.J. Clark, R.J. Knapton, and R.H. Hanre, eds. Biology and conservation of northern forest owls: symposium proceedings. USDA Forest Service. General Technical Report RM-142.

Johnson, D. H., and T.A. O'Neil eds. 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State Univ. Press. 736 p. + CD

Koopman, M.E., G.D. Hayward, and D.B. McDonald. 2007. High connectivity and minimal genetic structure among North American boreal owl (*Aegolius funereus*) populations, regardless of habitat matrix. Auk 124:690-704.

Korpimaki, E. 1988. Effects of territory quality on occupancy, breeding performance and breeding dispersal in Tengmalms owl. Journal of Animal Ecology 57:97-108.

Lofgren, O., B. Hornfeldt, and B.G. Carlsson. 1986. Site-tenacity and nomadism in tengmalms owl (*Aegolius funereus* (L)) in relation to cyclic food-production. Oecologia 69:321-326.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

O'Connell, M.W. 1987. Occurrence of the boreal owl in northeastern Washington. Pp 185-188. *In*: Saurola, P., R.W. Nero, R.J. Clark, R.J. Knapton, and R.H. Hamre, eds. Biology and conservation of northern forest owls. USDA Forest Service. General Technical Report RM-142.

Palmer, D.A. 1986. Habitat selection, movements and activity of Boreal and Saw-whet owls. M.Sc. Thesis, Colorado State University, Fort Collins, Colorado.

Ramirez, P. and M. Hornocker. 1981. Small mammal populations in different-aged clear-cuts in northwestern Montana. Journal of Mammalogy 62: 400-403.

Rodrick, E., and R. Milner. 1991. Management recommendations for Washington's priority habitats and species. Unpublished report, Washington Department of Wildlife, Olympia, Washington.

Sallabanks, R., B. Marcot, R. A. Riggs, C. A. Mehl, and E. B. Arnett. Chapter 8: Wildlife of eastside (interior) forests and woodlands. In: Johnson, D.H. and T.A. O'Neil, eds. Wildlife-Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press; 2001:213-238.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Pileated Woodpecker *(Dryocopus pileatus)*

The pileated woodpecker is the largest of the North American woodpeckers. They are considered a keystone species of the Pacific Northwest (Aubry and Raley 2002), preferring tall, closed-canopy, coniferous forests. Their activities substantially alter the physical structure of the forest environment, influencing both habitat available for other species, and various ecosystem processes (Mills et al. 1993, Simberloff 1998). Many studies have described pileated woodpecker nesting activities and their habitat requirements, due to the intensive management of forested environments in the Pacific Northwest. The Northwest Forest Plan recommends retaining and creating old growth forest ecosystems with large and old trees to provide adequate habitat for nesting pileated woodpeckers (Bull and Meslow 1977).

Pileated woodpeckers are local migrants that may utilize differing parts of their home range on a seasonal basis, based on resource availability. They are the only species in the northwest region that forages primarily by creating cavities to excavate invertebrate prey from snags and live trees. Because of this unique behavior, pileated woodpeckers cavities are important to a broad array of secondary cavity-using species, of which over 20 species have been recorded nesting or roosting in pileated woodpecker openings (Aubry and Raley 2002).

Forest management practices developed in the 1990's in the Pacific Northwest attempted to protected pileated nesting and foraging habitat by requiring minimum densities of large, hard snags in mature and old growth forest conditions (USFS and USBLM 1994). Pileated woodpecker roost trees have been identified to differ from nesting trees by the presence of late stages of decay, which form hollow chambers in the bole of the tree (Bull et al 1992). These roost trees play a critical role in the pileated woodpecker's life cycle, and are an important component of the forest ecosystem. Again, many other species such as flying squirrels, bats, bushy-tailed woodrats, martens, northern flickers, and Vaux's swifts are known to use the pileated woodpecker's excavated roosting cavities (Bull et al. 1997).

Distribution In MSSP

Pileated woodpeckers are listed as wildlife potentially found in Mount Spokane State Park, for both breeding and foraging. Confirmed breeding evidence at Mt Spokane is marked on a map of their core habitat in Washington State (Smith et al 1997). Our field crews in 2007 and 2008 observed pileated woodpeckers and their cavities during their surveys at Mt. Spokane.

Existing Habitat Models

Idaho Panhandle National Forest (INPF). 2006. Appendix 9: Species Habitat Estimates for the Idaho Panhandle National Forests. USDA Forest Service, Idaho Panhandle National Forest. 10 pp.

Schroeder, R.L. 1982. Habitat suitability index models: pileated woodpecker. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.39. 15 pp.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Breeding/Nesting Habitat Elements

Characteristic nest trees are giant trees, and most often the largest trees available within mature to old-growth conifer forests (Bull et al 1986). In MSSP, mapped Upland Conifer Forests, Riparian Conifer Forests, Riparian Woodland / Shrublands, Conifer Woodland / Shrublands, and Conifer Woodland / Meadow cover classes that are classified as being in mature to old-growth successional stages should provide optimal nesting habitat for pileated woodpeckers.

For optimum nesting requirements, it is recommended that there are at least 10 snags per acre of trees 65 centimeters (26 inch) diameter at breast height (dbh) available for pileated woodpeckers (Bull and Meslow 1977, Aubry and Raley 2002, Thomas et al 1979). Higher densities of large trees most often occur in mature to old-growth forests, providing nesting and roosting habitat for pileated woodpeckers (Mellan et al 1992). In MSSP, densities of greater than 10 large trees per acre of trees greater than 26 inch DBH may be too high a parameter required for nesting pileated woodpeckers (H. Ferguson, WDFW Wildlife Biologist, pers. comm.). Densities of 5 or more large trees per acre of trees greater than 26 inch dbh may provide optimal nesting habitat in MSSP.

Large diameter nest trees and snags require an early stage of decay to be able to provide structural support for pileated woodpecker nests, and softened heartwood to facilitate primary excavation (Aubry and Raley 2002, Harris 1983, Harestad and Keisker 1989, McClelland and McClelland 1999, and Bull 1987). Potential nest trees often are inferred from the presence of broken tops on live trees (Wagener and Davidson 1954, Bull et al 1986) and quantified when greater than 3 meters (9.8 ft) of deadtop are present above live branches (Aubry and Raley 2002). Parks et al. (1997) describes decay Class 2 as snags: dead for some time, having lost some branches and some bark, and including some evidence of decay. In MSSP, large diameter trees have higher nesting potential when greater than 9.8 feet of deadtop are present above live branches, or when heartrot is present. Similarly, large snags classified in MSSP as decay Class 2 are more likely to provide nesting habitat for pileated woodpeckers.

Table 34. Habitat elements for pileated woodpecker breeding/nesting.

Variables	Parameters
Cover type	Upland Conifer Forest, Riparian Conifer Forest, Riparian Woodland / Shrubland, Conifer Woodland / Shrubland, Conifer Woodland / Meadow
Forest successional stage	Mature to old-growth
Snag recruitment trees	> 9.8 ft dead/broken top above live branches or heart rot present
Snag diameter	> 26 inches DBH
Snag density	> 5 snags per acre
Snag decay class	2

Foraging Habitat Elements

Pileated woodpeckers are the only woodpecker known to excavate extensively in dead and downed wood such as stumps, logs, and snags (Bull and Meslow 1977, Bull et al. 1986, Bull and Holthausen 1993). Their foraging excavations focus mainly on larger diameter dead wood harboring carpenter ants and woodboring beetles (Bull et al. 1986). Logs, stumps, and snags of any species are suitable as long as they are above a minimum threshold size and thus suitable for insect infestations (Bull and Meslow 1977). Snags and coarse woody debris used by pileated woodpeckers for foraging excavations are characterized by diameters greater than 25 cm (9.8 inches; Bull and Holthausen 1993, Bull et al 1986). In Northeastern Oregon, live trees and down logs were used as feeding sites when greater than 15 meters (49 ft) in length/ height (Bull et al 1986). The coarse woody debris measured in these forests was dense, with over 10 percent of the forest ground covered with suitable logs (Bull and Meslow 1977). In MSSP, pileated woodpecker foraging habitat is enhanced when coarse woody debris or snag diameters are greater than 9.8 inches, and length/heights are greater than 50 feet. Pileated woodpecker foraging habitat increases when coarse woody debris cover of the forest floor is greater than 10% of the forest floor.

Pileated woodpeckers forage in larger areas than their nesting and roosting home range, concentrating on immature forests greater than 40 year of age (Mellan et al 1992). In MSSP, young to old-growth Upland Conifer Forests, Riparian Conifer Forest, Wetland Woodland / Shrubland, Riparian Woodland / Shrublands, Conifer Woodland / Shrubland, and Conifer Woodland / Meadow cover classes may provide the necessary foraging habitat for pileated woodpeckers.

Table 35. Habitat elements for pileated woodpecker foraging.

Variables	Parameters
Cover type	Upland Conifer Forest, Riparian Conifer Forest, Wetland Woodland / Shrubland, Riparian Woodland / Shrublands, Conifer Woodland / Shrubland, and Conifer Woodland / Meadow
Forest successional stage	Young to old-growth
Snag diameter	> 9.8 inches
Snag height	> 50 feet
Coarse woody debris cover	> 10%
Coarse woody debris diameter	> 9.8 inches
Coarse woody debris length	> 50 feet

Roosting Habitat Elements

Pileated woodpecker roosting trees differ from nesting trees in their degree of decay class. The hollow interior and ability for primary cavity nesters to excavate the soft heartwood of later stages of decay allow for multiple entrances and large openings for communal night roosting (Aubry and Raley 2002). Forest stand suitability for roosting is expected within a climax forest community, greater than 70 years of age where large decadent trees are prevalent (Mellan et al 1992). In MSSP, pileated woodpeckers will use mature to old-growth Upland Conifer Forests, Riparian Conifer Forest, Wetland Woodland / Shrubland, Riparian Woodland / Shrublands, Conifer Woodland / Shrubland, and Conifer Woodland / Meadow for roosting habitat. Areas will increase in value for roosting habitat when large diameter snags are in later stages of decay, especially in classes 2 and 3. Similar to nesting habitat, there is higher roosting snag recruitment potential from live trees when greater than 9.8 feet of deadtop are present above live branches. The presence of hollow chambers in live or dead trees, and/or the presence of heart rot allowing for easier roost excavations increase habitat suitability.

On the Olympic Peninsula of Washington, roosting habitat is classified as optimum when there are at least 10 adequate roosting snags per acre (Aubry and Raley 2002). Bull and Meslow (1977) describe a minimum of 4 adequate snags per acre. These communal roost trees are further classified as extra large in size, with diameter at breast height over 125 cm (49 inches) and optimally greater than 27.5 meters (90 ft) tall (Aubry and Raley 2002). In MSSP, communal roosting for pileated woodpeckers may be limited by the absence of these large snag sizes and densities, however availability of smaller snags would still provide individual night roosting opportunities (H. Ferguson, WDFW Wildlife Biologist, pers. comm.). In MSSP, forested areas with greater than 4 large snags per acre will increase the habitat potential for pileated woodpecker roosting. Large snags classified in MSSP as greater than 26 inches DBH (similar to nesting tree size) should provide at least individual roosting habitat for pileated woodpeckers (H. Ferguson, WDFW Wildlife Biologist, pers. comm.).

Table 36. Habitat elements for pileated woodpecker roosting.

Variables	Parameters
Cover type	Upland Conifer Forests, Riparian Conifer Forest, Wetland Woodland / Shrubland, Riparian Woodland / Shrublands, Conifer Woodland / Shrubland, and Conifer Woodland / Meadow
Forest successional stage	Mature to old-growth
Snag recruitment trees	> 9.8 ft dead/broken top above live branches or heart rot present
Snag diameter	> 26 inches DBH
Snag density	> 4 snags/acre
Snag decay class	2, 3

Risk Factors

Reductions in the size of mature to old-growth forest stands from forestry harvest management activities is a key conservation issue to address for pileated woodpeckers. Foraging areas for pileated woodpeckers are large; a minimum-sized unit of 320 acres (420 ha) is needed for a single nesting pair's territory (Bull and Meslow 1977), and at least 2471 acre (1000 ha) blocks are recommended to manage an area for the needs of multiple nesting pairs (Bull and Holthausen 1993). Strategies to promote and maintain pileated woodpecker habitat include leaving large tracts of mature to old-growth forested land, preserving optimal forest habitats, connecting forest reserves, and managing timber stands for late-successional forest characteristics.

To maintain pileated woodpecker habitat and populations, forest practices have changed over the last decade to incorporate the many levels of habitat attributes necessary for woodpecker life processes. Forest characteristics such as extensive, mature trees and snags, a more open forest floor with decaying wood, and a relatively humid environment that promotes fungal decay and invertebrate populations, are all important factors when maintaining forest health conditions ideal for pileated woodpeckers. National forest health practices within the U. S. Forest Service have tried to incorporate these objectives into their harvesting guidelines (USFS and USBLM 1994).

References

Aubry, K.B., and C.M. Raley. 2002. The pileated woodpecker as a keystone habitat modifier in the Pacific Northwest. USDA Forest Service, General Technical Report PSW-GTR-181.

Bate, L.J. 1995. Monitoring woodpecker abundance and habitat in the central Oregon Cascades. M.Sc. Thesis. University of Idaho, Moscow, Idaho.

Bull, E.L. 1987. Ecology of the pileated woodpecker in northeastern Oregon. Journal of Wildlife Management 51: 472-481.

Bull, E.L., and R.S. Holthausen. 1993. Habitat use and management of pileated woodpeckers in northeastern Oregon. Journal of Wildlife Management 57:335-345.

Bull, E.L., and E.C. Meslow. 1977. Habitat requirements of the pileated woodpecker in northeastern Oregon. Journal of Forestry 75:335-337.

Bull, E.L., S.R. Peterson, and J.W. Thomas. 1986. Resource partitioning among woodpeckers in northeastern Oregon. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. Resource Note PNW-444. 19 pp.

Bull, E.L., R.S. Holthausen, and M.G. Henjum. 1992. Roost trees used by pileated woodpeckers in northeastern Oregon. Journal of Wildlife Management. 56:786-793.

Harestad, A.S., and D.G. Keisker. 1989. Nest tree use by primary cavity-nesting birds in south central British Columbia. Canadian Journal of Zoology 67:1067-1073.

Harris, R.D. 1983. Decay characteristics of pileated woodpecker nest trees. Pp. 120-128. *In*: Davis, J.W., G.A. Goodwin, and R.A. Ockenfels, eds. Snag habitat management: proceedings of the symposium; 1983 June 7-9; Flagstaff, Arizona. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, General Technical Report RM-99.

Idaho Panhandle National Forest (INPF). 2006. Appendix 9: Species Habitat Estimates for the Idaho Panhandle National Forests. USDA Forest Service, Idaho Panhandle National Forest. 10 pp.

McClelland, B.R., and P.T. McClelland 1999. Pileated woodpecker nest and roost trees in Montana: links with old-growth and forest "health". Wildlife Society Bulletin 27:846-857.

Mellan, T.K., E.C. Meslow, and R.W. Mannan. 1992. Summer time home range and habitat use of pileated woodpeckers in western Oregon. Journal of Wildlife Management 56:96-103.

Mills, L.S., M.E. Soule, and D.F. Doak. 1993. The keystone-species concept in ecology and conservation. BioScience 43:219-224.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Parks, C.G., E.L, Bull, and T.R. Torgersen. 1997. Field guide for the identification of snags and logs in the Interior Columbia River Basin. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-390. 40 pp.

Simberloff, D. 1998. Flagships, umbrellas, and keystones: is single-species management passe in the landscape era? Biological Conservation 83:247-257.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Thomas, J.W., R.G. Anderson C. Maser, and E.L. Bull. 1979. Snags. Pp. 60-77. *In*: Thomas, J.W., ed. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA Forest Service, Washington, D.C. Agricultural Handbook 553.

USFS and USBLM (USDA Forest Service and Department of Interior Bureau of Land Management). 1994. Final supplemental environmental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Washington, D.C. 532 pp. and Appendices.

Wagener, W., and R. Davidson. 1954. Heartrot in living trees. Botanical Review 20:61-134.

Black-backed Woodpecker *(Picoides arcticus)*

The black-backed woodpecker is a medium sized woodpecker residing in coniferous forests across northern North America. Black-backed woodpeckers are habitat specialists, associated with recent fires and burns or other large-scale natural disturbances that create standing snags (Tobalske 1997, Dixon and Saab 2000, Haggard and Gaines 2001, and Saab et al. 2002). Their association is specifically with early, post-disturbance habitats with high snag densities where their primary macroinvertebrate food sources are most abundant (Dudley and Saab 2007, Dixon and Saab 2000, Murphy and Lehnhausen 1998, Saab et al 2004). They are capable of migrating large distances to locate such areas.

While high densities of black-backed woodpeckers can be found in post-fire habitats, they also nest in live and dead trees of various species and forest types (Dixon and Saab 2002). They are even known to nest in telephone poles. Black-backed woodpeckers often excavate nest cavities in sapwood, which decays more quickly than heartwood. Consequently, this species prefers dead conifers for their thicker sapwood layer, and smaller-diameter trees for the higher percentage of sapwood (Bull et al. 1986).

Oregon-Washington Partners in Flight associate black-backed woodpecker with lodgepole pine forests (Altman 2000). They describe lodgepole pine forests as a key source of habitat critical to black-back woodpeckers on the east-slopes of the Cascades. The US Forest Service regards black-backed woodpeckers as a species of management concern in 12 of the 13 Forest Service administrative units within the Northern Region.

Distribution In MSSP

Black-backed woodpeckers are listed as wildlife potentially found breeding and foraging in Mount Spokane State Park.

Existing Habitat Models

Russell, E.R., V.A. Saab, and J.G. Dudley. 2007. Habitat-Suitability Models for Cavity-Nesting Postfire Landscape. Journal of Wildlife Management 71:2600-2655.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Breeding/Nesting Habitat Suitability Elements

Black-backed woodpeckers are known to select for areas with recent fires or other large-scale natural disturbances that create fresh standing snags (Tobalske 1997, Dixon and Saab 2000, Haggard and Gaines 2001, and Saab et al. 2002). Areas with a high density of small diameter snags, notably after a high-severity forest burn or bug-kill event, provide the highest suitability for breeding and nesting habitat (Dixon and Saab 2000, Saab and Dudley 1998, Saab et al. 2002, Bull et al. 1986, Goggans et al. 1988). Saab et

al's (2002) post-fire study in southwestern Idaho found the mean number of snags greater than 23 centimeters (9 inch) dbh was106.3 ±15.7 snags per hectare (43 snags/acre) surrounding black-backed woodpecker nesting trees. Given post-fire or bug-kill events, snag densities quantified as greater than 30 snags/acre would benefit black-backed woodpecker nesting habitat in MSSP (H. Ferguson, WDFW Wildlife Biologist, pers comm.).
The greatest influence on occupancy of nest cavities in burned forests is thought to be "time since fire" (Saab et al. 2004, 2007). In various studies, nest sites peaked between 3 and 5 years post fire (Saab et al. 2007, Hutto and Gallo 2006), and the species is recorded to rapidly colonize after a stand-replacing fire within one to two years. After 5 years, they become rare due to presumable lack of preferred prey (Saab et al 2004). In MSSP, any natural disturbance that causes a die off of live trees and leaves behind a density of standing snags should provide optimal habitat for black-backed woodpeckers. One to five years post-fire / post-disturbance tree mortality provides the most optimal nesting habitat.

Low densities of black-backed woodpeckers are known to nest in conifer forests, focusing on a variety of live and dead trees such as Douglas-fir, ponderosa pine, lodgepole pine, western larch, subalpine fir, and aspen (Hoffman 1997, Caton 1996, Bull et al. 1986). In is suspected that they remain in low density in forested habitats until a wildfire or disturbance related event incurs high tree mortality. They are capable of migrating large distances to locate such areas. In MSSP mapped cover types Upland Conifer Forest, Riparian Conifer Forest, Riparian Woodland / Shrubland, Wetland Woodland / Shrubland, Conifer Woodland/ Shrubland, and Conifer Woodland / Grassland should provide nesting potential for low densities of black-backed woodpeckers (H. Ferguson, WDFW Wildlife Biologist, pers. comm.).

Black-backed woodpeckers select the smallest diameter and the highest densities of hard snags compared to other cavity nesting birds (Saab et al. 2002, Russell et al. 2007). Black-backed woodpeckers are able to excavate the hardest snags available, and typically nest in light to medium decayed trees often with intact tops (Saab and Dudley 1998, H. Ferguson, WDFW Wildlife Biologist, pers. comm.). Goggans et al. (1988) verified heartrot in all nest trees, and some external indicator of decay such as dead limbs, split tops, or scarring within very close proximity to the nest cavity. In MSSP, snags within decay classes 1 or 2 provide the best nesting conditions for black-backed woodpeckers.

Nesting studies have found relatively consistent diameter and heights of nest trees throughout the western U.S. (Saab et al 2002, Bull et al. 1986, Hoffman 1997, and Caton 1996). Nest tree diameters have measured approximately 40 centimeters (16 inches) diameter at breast height (Saab 2002, Russell et al. 2007, Bull et al. 1986, Caton 1996), except for one study who found nest tree diameter averaged 27 cm dbh (10 inches; Hoffman 1997). Similarly, mean nest trees heights have measured between 19 meters (62 feet) and 32.7 meters (88 feet; Hoffman 1997, Bull et al. 1986, Caton 1996). In MSSP, presence of snags greater than 10 inches in diameter and greater than 62 feet tall should accommodate suitable snag requirements for black-backed woodpeckers.

Table 37. Habitat elements for black-backed woodpecker breeding/nesting.

Variables	Parameters
Cover type	Upland Conifer Forest, Riparian Conifer Forest, Riparian Woodland / Shrubland, Wetland Woodland / Shrubland, Conifer Woodland / Shrubland, and Conifer Woodland / Grassland
Snag diameter	> 10 inches DBH
Snag height	> 62 feet
Snag density	> 30 snags per acre
Snag decay class	1 or 2
Time after disturbance event	1 to 5 years

Foraging Habitat Suitability Elements

Black-backed woodpecker foraging habitat requires early succession post-fire habitats, primarily due to high prey densities of bark and wood-boring beetles (Murphy and Lehnhausen 1998, Powell 2000, Dudley and Saab 2007, Russell et al. 2007). Similar to nesting habitats, black-backed woodpeckers become rarer after a post-fire period of 5 years, presumably due to a reduction of preferred prey availability (Saab et al 2004, IPNF 2006). In MSSP, areas with high tree mortality created by wildfire or insect outbreak within a 1 to 5 year timeframe will increase available foraging habitat for black-backed woodpeckers. Black-backed woodpeckers could be found in low densities foraging in MSSP in Upland Conifer Forest, Riparian Conifer Forest, Riparian Woodland / Shrubland, Wetland Woodland / Shrubland, Conifer Woodland/ Shrubland, and Conifer Woodland / Grassland.

According to the literature, there is considerable variation in the size and density of standing trees used by invertebrate prey and black-backed woodpeckers. Invertebrates concentrate on large snags and within high densities of snags on the landscape, especially post-fire or other tree mortality event. On the Idaho Panhandle National Forest, retention of at least 64 snags/hectare (26 snags per acre) of at least a 2.5 cm (1 inch) diameter at breast height are recommended for management of post-fire black-backed woodpecker foraging habitats. In MSSP, post fire/ bug-kill areas with at least 26 snags per acre of greater than 1 inch diameter would provide suitable foraging habitat.

Table 38. Habitat elements for black-backed woodpecker foraging.

Variables	Parameters
Cover type	Upland Conifer Forest, Riparian Conifer Forest, Riparian Woodland / Shrubland, Wetland Woodland / Shrubland, Conifer Woodland / Shrubland, and Conifer Woodland / Grassland
Snag diameter	> 1 inches DBH
Snag density	> 26 snags per acre
Time after disturbance event	1 to 5 years

Risk Factors

To maintain potential black-backed woodpecker habitat and populations, forest management practices must identify natural disturbances as a necessary life process for this species. These woodpeckers are dependent on moderate to severe tree mortality events to increase snag availability for nesting and foraging opportunities. Wildfire and insect outbreak both may lead to increased habitat for black-backed woodpeckers.

Forest fires are a primary agent of natural disturbance in the Western U.S. Fire suppression over the last 100 years has had a substantial impact on bird species associated directly with fire related habitats (Heij 2000). Saab and Dudley (1998) found that high intensity stand replacing fires had a positive effect on nesting success for black-backed woodpeckers, while fire suppression had a negative effect and prescribed fire with stand management had no effect on nesting success for black-backed woodpeckers. Prescribed fire treatments do not adequately produce suitable habitat for black-backed woodpeckers, who concentrate on large, high-severity wildfires (Kotliar et al. 2002). However, black-backed woodpeckers have occasionally been found nesting in stands following a prescribed fire (Saab and Block 2006).

Black-backed woodpeckers are potentially vulnerable to local extinction if post-fire salvage logging reduces or eliminates high-quality habitats (Murphy and Lehnhausen 1998). To avoid negative impacts, land managers should monitor and manage for potential nesting habitat, surrounded by suitable foraging habitat (Russell et al. 2007). When a wildfire or bug-kill does occur, commercial salvage logging operations that reduce and remove snags negatively impact nest and foraging habitat for black-backed woodpeckers. Forest management activities post-fire should be directed away from these types of salvage logging operations (Russell et al 2007), or if salvaging, maintain at least 40% of suitable snags unsalvaged (Altman 2000). Leaving a clumped versus a uniform distribution of snags was also found as a critical benefit to nesting black-backed woodpecker habitat (Saab et al. 2002, Saab and Dudley 1998).

References

Altman, B. 2000. Conservation strategy for landbirds of the east-slope of the Cascade mountains in Oregon and Washington. American Bird Conservancy. Boring, Oregon. 81 pp.

Bonn, J., B. Dixon, E. Kennedy, and D. Pengeroth. 2007. Black-backed woodpecker: northern region overview: key findings and project considerations. Draft report by the black-backed woodpecker working group.

Bull, E.L., S.R. Peterson, and J.W. Thomas. 1986. Resource partitioning among woodpeckers in northeastern Oregon. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. Resource Note PNW-444. 19 pp.

Bull, E.L., C.G. Parks, and T.R. Torgerson. 1997. Trees and logs important to wildlife in the Interior Columbia River basin. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-391. 55 pp.

Dixon, R. D., and V. A. Saab. 2000. Black-backed Woodpecker (Picoides arcticus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/509

Dudley, J.G. 2005. Home range size and foraging habitat of black-backed woodpeckers. M.Sc. Thesis, Boise State University, Idaho.

Dudley, J.G., and V.A. Saab. 2007. Home range size of black-backed woodpeckers in burned forests of southwestern Idaho. Western North American Naturalist 67: 593-600.

Forristal, C., V. Saab, and A. Markus. 2005. Examining the influence of post-wildfire timber harvest on sensitive woodpecker reproduction. 2005 Progress Report. 9 pp. (Available online: http://www.rmrs.nau.edu/lab/4251/birdburns).

Goggans et al. 1988. Habitat use by three-toed and black-backed woodpeckers, Deschutes National Forest, Oregon. Oregon Department of Fish and Wildlife – Nongame Wildlife Program Report 87-3-02. 43 pp.

Haggard, M., and W.L.Gaines. 2001. Effects of stand-replacement fire and salvage logging on a cavity-nesting bird community in eastern Cascades, Washington. Northwest Science 75:387-396.

Hejl, S.J. 2000. A strategy for maintaining healthy populations of western coniferous forest birds. *In*: Bonney, R., D.N. Pashley, R.J. Cooper, L., Niles, eds. Strategies for bird conservation: The partners in flight planning process; Proceedings of the 3rd partners in flight workshop; 1995 October 1-5; Cape May, New Jersey. Proceedings RMRS-P-16. Ogden, Utah: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Hoyt, J.S. 2000. Habitat associations of black-backed *Picoides arcticus* and three-toed *P. tridactylus* woodpeckers in the northeastern boreal forest of Alberta. Ph.D. Thesis, University of Alberta, Edmonton, Alberta.

Hoyt, J.S., and S.J. Hannon. 2002. Habitat associations of black-backed and three-toed woodpeckers in the boreal forest of Alberta. Canadian Journal of Forest Research 32:1881-1888.

Hutto, R.L. 1995. Composition of bird communities following stand-replacement fires in northern Rocky Mountain (USA) conifer forests. Conservation Biology 9:1041-1058.

Hutto, R.L., and S.M. Gallo. 2006. The effects of postfire salvage logging on cavity-nesting birds. Condor 108:817-831.

Idaho Panhandle National Forest (INPF). 2006. Appendix 9: Species Habitat Estimates for the Idaho Panhandle National Forests. USDA Forest Service, Idaho Panhandle National Forest. 10 pp.

Johnson, D.H., and T.A. O'Neil. 2001. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvalis, Oregon. 736 pp.

Kotliar, N.B., S. Heil, R.L. Hutto, V.A. Saab, C.P. Meicher, and M.E. McFadzen. 2002. Effects of fire and post-fire salvage logging on avian communities in conifer-dominated forests of the western United States. Studies in Avian Biology 25:49-64.

Martin, K., and J.M. Eddie. 1999. Nest webs: A community-wide approach to the management and conservation of cavity nesting birds. Forest Ecology and Management 115:243-257.

Murphy, E.C., and W.A. Lehnhausen. 1998. Density and foraging ecology of woodpeckers following a stand-replacement fire. Journal of Wildlife Management 62:1359-1372.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Parks, C.G., E.L, Bull, and T.R. Torgersen. 1997. Field guide for the identification of snags and logs in the Interior Columbia River Basin. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-390. 40 pp.

Powell, H.D.W. 2000. The influence of prey density on post-fire habitat use of the black-backed woodpecker. M.Sc. Thesis, University of Montana, Missoula, Montana.

Raphael, M.G., and M. White. 1984. Use of snags by cavity-nesting birds in the Sierra Nevada. Wildlife Monographs 86:1-66.

Russell, E.R., V.A. Saab, and J.G. Dudley. 2007. Habitat-Suitability Models for Cavity-Nesting Postfire Landscape. Journal of Wildlife Management 71:2600-2655.

Saab, V., R. Brannon, J. Dudley, L. Donohoo, D. Vanderzanden, V. Johnson, and H. Lachowski. 2002. Selection of fire-created snags at two spatial scales by cavity-nesting birds. *In*: Shea, P.J., W.F. Laudenslayer, Jr., B. Valentine, C.P. Weatherspoon, and T.E. Lisle, eds. Proceedings of the symposium on the ecology and management of dead wood in western forests, Reno, Nevada. USDA Forest Service, Pacific Southwest Research Station, PSW-GTR-181.

Saab, V., J. Dudley, and W. Thompson. 2004. Factors influencing occupancy of nest cavities in recently burned forests. Condor 106:20-36.

Saab, V.A., H.D.W. Powell, N.B. Kotliar, and K.R. Newlon. 2005. Variation in fire regimes of the Rocky Mountains: implications for avian communities and fire management. Studies in Avian Biology 30:76-96.

Saab, V., R. Russell, and J.G. Dudley. 2007. Nest densities of cavity-nesting birds in relation to postfire salvage logging and time since wildfire. Condor 109:97-108.

Saab, V.A., and W. Block 2006. Final report to the Joint Fire Science Program. Project #01-1-3-25. Prescribed fire strategies to restore wildlife habitat in ponderosa pine forests of the Intermountain West.

Saab, V.A., and J. Dudley. 1998. Responses of cavity-nesting birds to stand-replacement fire and salvage logging in ponderosa pine/Douglas-fir forests of southwestern Idaho. USDA Forest Service, Rocky Mountain Research Station, Research Paper RMRS-RP-11.

Short, L.L. 1974. Habits and interactions of North American three-toed woodpeckers (*Picoides arcticus* and *Picoides tridactylus*). American Museum Novitates 2547:1-42.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Taylor, J., and E. Schachtell. 2002. Black-backed woodpecker habitat analysis of six Idaho Panhandle National Forest at two scales. Unpublished mimeo on file, Idaho Panhandle National Forests, Coeur d'Alene, Idano.

Tobalske, B.W. 1997. Lewis's woodpecker (*Melanerpes lewis*). Account 284. *In*: Poole, A., and F. Gill, eds. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and the American Ornithologists' Union, Washington, D.C.

Weinhagen, A.C. 1998. Nest-site selection by the black-backed woodpecker in northeast Vermont. M.Sc. Thesis, University of Vermont, Burlington, Vermon

Dusky Grouse *(Dendragapus obscurus pallidus)*

Formerly known as the blue grouse, the species *Dendragapus obscurus* was split into two groups, the sooty (or coastal) grouse subspecies, and dusky (interior) grouse subspecies based on distinctions in their geographic ranges (AOU 1983). The dusky grouse inhabits inter-mountain coniferous forests mixed with deciduous trees and shrubs, as well as sagebrush-grassland areas in western North America.

Dusky grouse prefer open brushy habitats during spring and summer. These areas provide good visibility, and security cover from predators and extreme weather. Spring and summer diet consists of a variety of green leaves, fruits, seeds, flowers, animal matter, and conifer needles (Marshall 1946, Stewart 1944, Beer 1943, King and Bendell 1982). During winter, dusky grouse prefer dense high elevation coniferous forests in which they roost nocturnally (Zwickell & Bendell 2005, Cade and Hoffman 1993, Pelren 1996) and feed almost entirely on conifer needles (Beer 1943, Marshall 1946, Harju 1974, Boag 1958, and Zwickel and Bendell 1986, Zwickel and Bendell 2005). This altitudinal migration is localized, and typically a short distance directly adjacent to their breeding grounds. Autumn migration can also be a dispersal mechanism however, (Bendell and Elliott 1967) and some studies have recorded dispersals over 30 miles (Bauer 1962, Zwickell & Bendell 2005, Mussehl 1960).

Distribution In MSSP

Dusky grouse are fairly common year-round residents in the Selkirk Mountains (BirdWeb 2008). They are listed as potential breeding populations in Mount Spokane State Park. Although no chicks have been documented on MSSP by WDFW wildlife biologists, harvest records in the area and adults seen on MSSP during the breeding season lead experts to believe the population is at least stable and reproducing (H. Ferguson and M. Schroeder, WDFW Wildlife Biologists, pers. comm.).

Existing Habitat Models

Schroeder, R.L. 1984. Habitat suitability index models: Blue grouse. United States Fish and Wildlife Service. FWS/OBS-82/10.81.19 pp. (Available online: http://www.nwrc.usgs.gov/ wdb/pub/hsi/hsi-081.pdf).

Martinka, R.R. 1972. Structural characteristics of blue grouse territories in southwestern Montana. Journal of Wildlife Management 36:498-510.

Steinhoff, H.W. 1958. A rating scale for blue grouse range in Colorado. Proceedings of the Society for American Foresters, Wildlife Section. Pp. 133-138.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Breeding/Nesting Habitat Elements

Dusky grouse typically migrate from higher elevation forested winter habitat down to lower elevation open habitats in the spring for breeding. The structural diversity of tree, shrub, and herbaceous vegetation within this more open habitat is a major factor influencing dusky grouse breeding and nesting habitat suitability, both for food and for cover (Schroeder 1984, Zwickel and Bendell 1972). In MSSP cover types which incorporate dusky grouse breeding/nesting habitat may include: Upland Conifer Forests, Conifer Woodland / Shrubland, Conifer Woodland / Meadow, Riparian Conifer Forests, Riparian Shrubland, Riparian Conifer Woodland / Shrubland, Shrublands, Shrubland / Meadow, Upland Meadow, and Wetland Conifer Woodland / Shrubland.

Herbaceous vegetation provides food (insect and vegetative), cover, and water, and is especially important to females and their broods. Optimal herbaceous vegetative cover and height allows for unrestricted movements and provides adequate concealment cover for a brood (Schroeder 1984). Schroeder's (1984) assessment of optimal herbaceous densities and heights were 40 to 75 percent herbaceous canopy cover (Mussehl 1963, Harju 1974, Stauffer 1983), at a canopy height of 8-20 inches (20.3 to 50.8 cm) (Mussehl 1963, Weber 1975, Stauffer 1983). In MSSP, herbaceous vegetation at a canopy height of 8 to 20 inches, and herbaceous density of 40 to 75 percent cover should provide optimal cover and foraging for nesting dusky grouse and brood rearing.

Nest site characteristics are extremely variable, but nests are almost always located on the ground. Shrub cover provides necessary protection and food for breeding and nesting dusky grouse. In 612 nests studied by Zwickel and Bendell (2004), only 2% of nest sites did not have some sort of cover. In young forested environments, nests are found under small conifers, logs or stumps; under shrubs, or rock overhangs (Zwickel and Bendell 2005). In older seres or mature forest, nests are often at the base of a large tree, with no immediate cover except the trunk. Subalpine nests are often under kruppelholz subalpine fir (M. Degner, pers. comm. in Zwickel and Bendell 2005). Cover habitat in shrub-steppe almost always consists of shrub overhangs. In MSSP, shrubs, small or large conifers, and coarse woody debris may all provide cover for dusky grouse nest sites.

Moderate shrub densities of 10-30 percent cover provide optimal habitat for nests and brood rearing. More shrub cover than this amount can restrict grouse movements and obstruct visibility, while lower shrub densities do not provide enough cover for nesting and escape (Martinka 1972, Schroeder 1984). Schroeder's (1984) HSI model describes shrub height over 18 inches as optimum habitat for dusky grouse, because lower shrub heights will not provide adequate concealing cover, and tall shrubs may provide useful habitat similar to small trees. In MSSP, shrub cover greater than 18 inches, and shrub density of 10-30 percent crown cover should provide optimal breeding and nesting for dusky grouse.

Territorial males primarily use small thickets of conifers, which provide protection from weather and predators, and good visibility during courtship activities (Martinka 1972, Donaldson and Bergerud 1974). Females with broods increase their use of cover in deciduous thickets as herbaceous vegetation dries out during the summer (Mussehl 1960). Forest canopy cover of 20 to 50 percent provides optimal cover during the breeding and nesting season. (Bendell and Elliott 1966, Donaldson and Bergerud 1974, Boag 1966). Habitat suitability decreases as forest canopy cover approaches 75 percent (Redfield et al. 1970). In MSSP, forest canopy cover of 0 to 50 percent should provide beneficial habitat during the breeding and nesting season.

The relationship between trees, shrubs, and herbaceous vegetation, or the interspersion of these habitat elements, is important for dusky grouse breeding and nesting. Preferred territories for breeding males and brood-rearing females contain edge habitat with trees interspersed in more open habitat (Schroeder 1984, Mussehl 1963, Martinka 1972, Donaldson and Bergerud 1974). Schroeder's (1984) interspersion component identifies a distance of less than 0.4 kilometers (0.25 miles) from herbaceous or shrub cover types to forest cover types or open habitats with scattered trees. In MSSP, forest edges may provide beneficial habitat for breeding and nesting dusky grouse. An interspersion distance of 0.25 miles from herbaceous or shrub cover types to adequate forest cover types depicts the best breeding and nesting habitats.

Table 39. Habitat elements for dusky grouse breeding/nesting.

Variables	Parameters
Cover type	Upland Conifer Forest, Conifer Woodland / Shrubland, Conifer Woodland / Meadow, Riparian Conifer Forest, Riparian Shrubland, Riparian Conifer Woodland / Shrubland, Shrublands, Shrubland / Meadow, Upland Meadow, and Wetland Conifer Woodland / Shrubland
Forest canopy cover	0 - 50%
Coarse woody debris	Present
Shrub canopy cover	10 - 30%
Shrub heights	> 18 inches
Herbaceous canopy cover	40 - 75%
Herbaceous height	8 - 20 inches
Forest edges	Present
Distance from herbaceous or shrub cover to forest cover [1]	< 0.25 miles

[1] interspersion component used only in shrub or herbaceous cover types that do not contain trees (Schroeder 1984)

Summer Foraging Habitat Elements

Dusky grouse diets include a broad spectrum of plant species that vary locally and change seasonally, and may be eaten only when phenologically appropriate (Zwickel and Bendell 2005). Juveniles begin feeding on their own from the time nest is abandoned, at about one day old. The female likely determines travel routes but does not feed juveniles or direct them to specific items of food (Zwickel and Bendell 2005). Summer foraging habitats can have similar characteristics to brood habitat, however summer foraging habitat is less restrictive.

Dusky grouse eat mainly vegetable matter throughout year (leaves and flowers, shrub berries, and conifer needles), but there may be more heavy use of invertebrates by small juveniles in early summer, and by older grouse in mid summer to early autumn (Zwickel and Bendell 2005). Aspen stands (*Populus tremuloides*) provide imporant food and cover habitat for dusky grouse (M. Schroeder, WDFW wildlife biologist, pers. comm.). In spring, hens with young broods often select non-forested areas and forest clearings, often mesic sites with lush herbaceous vegetation, perhaps because of increased insect abundance (Mussehl 1963). In mid to late summer, grouse may move to more mesic sites, or areas with greater forest canopy cover as herbaceous vegetation in open areas desiccates (Marshall 1946, Zwickel 1973 in Zwickel and Bendell 2005). Herbaceous cover present in MSSP provides foraging habitat for dusky grouse. Aspen stands increase habitat suitability if present.

Table 40. Habitat elements for dusky grouse summer foraging.

Variables	Parameters
Aspen stands	Present
Herbaceous cover	Present

Winter Foraging and Roosting Habitat Elements

Dusky grouse winter foraging and roosting habitat is designated as interior montane forests (Zwickell and Bendell 2005), or any stand dominated by conifers and adjacent to subalpine parklands (Pelren and Crawford 2001). Not many studies have been conducted in lower elevation forests for wintering dusky grouse, however Pelren and Crawford (2001) report that open, patchy ponderosa pine forests do provide winter range habitat. In MSSP, all mapped conifer forest and woodland cover class types could provide adequate winter habitat for dusky grouse.

Subalpine firs and certain growth forms of Douglas-fir may be used selectively for night roosts to minimize energy costs imposed by weather (Pekins et al. 1991). Typical tree roosts are in large conifers with dense foliage (Zwickell & Bendell 2005). These trees provide perches, insulation, and forage (Pekins et al. 1991, Cade 1982). In MSSP, mature to old-growth seral stage forests are an important habitat element, reflecting the presence of larger perch trees required for winter roosting. Forests with large subalpine firs or Douglas-firs with dense tree canopies provide the best suitability for winter roosting.

Altitudinal migration to upper elevation winter range is typically a short distance and directly adjacent to breeding areas (Zwickell & Bendell 2005, Cade and Hoffman 1993, Pelren 1996). Winter habitat must be in close proximity to breeding habitat, and at MSSP, distances less than 15 km (9.3 miles) should provide dispersal distance from breeding habitat to wintering foraging habitat. Longer dispersals have been documented, but this figure represents an optimal distance for dusky grouse seasonal migration.

Table 41. Habitat elements for dusky grouse winter foraging and roosting.

Variables	Parameters
Cover type	All forest and woodland cover types
Forest successional stage	Mature to old-growth
Forest composition	Large subalpine firs or Douglas-firs present
Tree canopy	dense
Distance from breeding habitat	< 9.3 miles

Risk Factors

Risk factors for dusky grouse include grazing and logging. Domestic livestock grazing can be intensive in prime nesting and rearing habitats of the dusky grouse. The type of grazing, the timing (spring, summer and fall), and the intensity can all have significant impacts on the vegetative structure and species composition during brood rearing season (Mussehl 1963, Bracken pers. comm., Schroeder pers. comm.).

Forest harvest regimes can be both detrimental and beneficial to dusky grouse, depending on the type of harvest and prior forest condition. Selective logging may be beneficial when it opens the canopy and allows for regeneration of shrubs and thickets (Martinka 1972). However, habitat may be compromised during road building and log removal operations if existing thickets are destroyed; large areas of slash left after logging are not used by grouse. Logging at higher elevations may adversely impact winter ranges (Cade and Hoffman 1990, Zwickel and Bendell 1985), but effects are not fully understood. Winter habitat should be managed to perpetuate the existence of large trees which are important as roost sites (Pekins et al. 1991).

Direct human impacts threatening the species are urbanization and increasing recreational development in montane areas. Further study is needed to determine the extent of these threats (Zwickel & Bendell 2005). We did not find specific information on risk factors for dusky grouse related to downhill skiing and other high-intensity winter recreation activities, but there is considerable evidence of risk to similar grouse species (black grouse (*Tetrao tetrix*) and red grouse (*Lagopus leucurus scoticus*)) from ski resort developments in Europe (Johnson and O'Neil 2001). Rates of band recovery suggest that hunters have a light impact on populations in most areas (Zwickel & Bendell 2005).

References

American Ornithologists' Union (AOU). 1983. Checklist of North American birds, 6th edition. Allen Press, Inc., Lawrence, Kansas. 877 pp.

Beer, J. 1943. Food habits of the blue grouse. Journal of Wildlife Management 7:32-44.

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

Bendell, J.F., and P.W. Elliott. 1967. Behaviour and the regulation of numbers in blue grouse. Canadian Wildlife Service Report, Series 4. 76 pp.

BirdWeb. 2008. BirdWeb: learn about the birds of Washington State [web application]. Seattle Audubon Society, Seattle, Washington. (Available online: http://www.birdweb.org/birdweb/index.aspx, Accessed: June 28, 2008).

Boag, D.A. 1958. The biology of the blue grouse of the Sheep River area. M.Sc. Thesis, University of Alberta, Edmonton, Alberta.

Boag, D.A. 1966. Population attributes of the blue grouse in southwestern Alberta. Canadian Journal of Zoology 44:799-814.

Cade, B.S. 1982. Characteristics and habitat preferences of wintering populations of blue grouse. Colorado Division of Wildlife, Job Progress Report, Federal Aid Project W-37-R-35:215-241.

Cade, B.S., and R.W. Hoffman. 1993. Differential migration of blue grouse in Colorado. Auk 110:70-77.

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

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

Hoffman, R.W. 1981. Population dynamics and habitat relationships of blue grouse. Colorado Division of Wildlife, Job Final Report, Federal Aid Project W-37-R-34:103-171. Personal communication (letters dated 8 March and 10 May, 1983). Colorado Division of Wildlife, Wildlife Resource Center, Fort Collins, Colorado.

Johnson, D. H., and T.A. O'Neil eds. 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State Univ. Press. 736 p. + CD

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

King, R.D., and J.F. Bendell. 1982. Foods selected by blue grouse (*Dendragapus obscurus fuliqinosus*). Canadian Journal of Zoology 60:3268-3281.

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

Martinka, R.R. 1972. Structural characteristics of blue grouse territories in southwestern Montana. Journal of Wildlife Management 36:498-510.

Mussehl, T.W. 1960. Blue grouse production, movements, and populations in the Bridger Mountains, Montana. Journal of Wildlife Management 24:60-68.

Mussehl, T.W. 1963. Blue grouse brood cover selection and land-use implications. Journal of Wildlife Management 27:547-555.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Pekins, P.J., F.G. Lindzey, and J.A. Gessaman. 1991. Physical characteristics of blue grouse winter use trees and roost sites. Great Basin Naturalist 51:244-248.

Pelren, E.C. 1996. Blue grouse winter ecology in northeastern Oregon. Ph.D. Thesis, Oregon State University, Corvallis, Oregon.

Pelren, E.C., and J.A. Crawford. 1999. Blue Grouse nesting parameters and habitat associations in northeastern Oregon. Great Basin Naturalist 59:368-373.

Pelren, E.C., and J.A. Crawford. 2001. Blue grouse winter movements, habitat, and survival in northeastern Oregon. Northwest Science 75:372-377.

Redfield, J.A., F.C. Zwickel, and J.F. Bendell. 1970. Effects of fire on numbers of blue grouse. Proceedings of the Tall Timbers Fire Ecology Conference 10:63-83.

Remington, T.E., and R.W. Hoffman. 1996. Food habits and preferences of Blue Grouse during winter. Journal of Wildlife Management 60:808-817.

Schroeder, R.L. 1984. Habitat suitability index models: blue grouse. USDA Fish and Wildlife Service. FWS/OBS-82/10.81. 19 pp. (Available online: http://www.nwrc.usgs.gov/ wdb/pub/hsi/hsi-081.pdf).

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

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

Stauffer, D.M., and S.R. Peterson. 1985. Ruffed and blue grouse habitat use in southeastern Idaho. Journal of Wildlife Management 49:459-466.

Steinhoff, H.W. 1958. A rating scale for blue grouse range in Colorado. Proceedings of the Society for American Foresters, Wildlife Section. Pp. 133-138.

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

U.S. Fish and Wildlife Service. 1981. Standards for the development of habitat suitability index models. 103 ESM. Unpublished report. USDA Fish and Wildlife Service, Division of Ecological Services.

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

Weber, D.A. 1975. Blue grouse ecology, habitat requirements, and response to habitat manipulation in north-central Utah. Utah Cooperative Wildlife Resource Unit, Special Report 33. 66 pp.

Zwickel, F.C, and J.F. Bendell. 1972. Blue grouse, habitat, and populations. Proceedings of the International Ornithologists Congress 15:150-169.

Zwickel, F.C., and J.F. Bendell. 1986. Variations in the winter diet of blue grouse. Journal of the World Pheasant Association 11:44-52.

Zwickel, F.C., and J.F. Bendell. 2004. Blue grouse: their biology and natural history. National Research Council Research Press, Ottawa, Ontario.

Zwickel, F.C., and J.F. Bendell. 2005. Blue grouse (*Dendragapus obscurus*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York. (Available online: http://bna.birds.cornell.edu/bna/species/015).

Brown Creeper *(Certhia americana)*

Brown creepers are year-round residents in late-successional coniferous and mixed coniferous-deciduous forests throughout much of North America. They prefer closed-canopy forests, with an abundance of large dead/dying trees for nesting, and large live trees for foraging. They are significantly more common in old forests with multi-layered structure (Adams and Morrison 1993, Johnson and O'Neil 2001). Brown creepers forage by creeping along tree trunks, gleaning small insects, spiders, and other invertebrates from the bark with their bill. Nesting occurs primarily in dead or dying trees, in the crevices where bark has separated from the tree trunk, and at various heights in the forest canopy. Nests are generally made of twigs, bark strips, moss, and leaves. Winter and summer ranges are similar; however non-coastal populations of brown creepers migrate from their higher-elevation summer grounds to lower elevations in the winter. Outside of the breeding season, brown creepers often flock with kinglets, nuthatches, and chickadees.

Brown creeper populations have declined in much of North America, however the population appears to be doing well in Washington, with a slight increase since 1966, according to the state's Breeding Bird Survey (BirdWeb 2002). Brown creepers are fairly common year-round in the North Cascade Mountains of Washington. The Mt. Spokane area contains core zone habitat for brown creepers, and confirmed, probable and possible breeding records according to the Washington State GAP analysis (Smith et al. 1997).

Distribution In MSSP

Brown creepers are potentially found in MSSP, for both breeding and foraging.

Existing Habitat Models

Banks, T., D. Farr, R. Bonar, B. Beck, and J. Beck.1999. Brown creeper reproductive habitat model, habitat suitability index model, version 3. Prepared for: Weldwood Forest Management Area, Foothills Model Forest, Alberta.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Timossi, I.C., and R.H. Barrett. 1995. Habitat suitability models for use with ArcInfo: brown creeper. California Department of Fish and Game, CWHR Program, Sacramento, California.

Wells, R., A. Norris , N. Mahoney, K. Stuart-Smith, and K. De Groot. 2008. Forest Science Program Project Y082069 Web Module: Incidental Take and Protecting Habitat for Migratory Birds: An East Kootenay Pilot Project.

Breeding/Nesting Habitat Suitability Elements

Brown creeper nests are built in bark crevices of large snags and dead portions of large live trees. Studies in the western Cascades, northern Idaho, and western Montana found brown creepers significantly associated with abundance of large trees and snags (Hansen et al.1995a, Hejl and Paige 1994, Hejl et al. 2002). The sizes of large live and dead trees vary between region and tree species. In old-growth cedar-hemlock forests in northern Idaho, nest-tree size ranged between 19–115 cm (7.5 – 45 inch) diameter at breast height (dbh) (Hejl et al. 2002). In unmanaged Douglas-fir/western hemlock forests in southern Washington Cascades, mean nest-tree dbh measured 58.8 cm (23 inches; Lundquist and Mariani 1991).

In MSSP, live trees and snags greater than 7.5 inches DBH with defects such as loose bark or hollow chambers would provide important habitat for nesting brown creepers. An abundance of large live trees and snags would increase the potential for brown creeper nesting success. However, wildlife expert H. Ferguson confirms that brown creepers use smaller diameter snags and live trees in the MSSP region than is documented in the literature (WDFW Wildlife Biologist, pers. comm.).

In the Western U. S., brown creepers are found in a variety of forest types, but are most abundant in mature to old-growth forests with high forest canopy cover (Verner and Boss 1980, Hejl and Verner 1988, and Mannan and Siegel 1988 in Hejl et al. 2002). Studies find brown creeper preference for mesic conifer forests in the Pacific Northwest (Hejl et al. 2002), mature spruce-fir and lodgepole pine forests in the central Rockies (Raphael 1987 in Hejl et al. 2002, Versaw 1998 in Hejl et al 2002), mature cedar- hemlock forests in northern Idaho (Hejl and Paige 1994), spruce-fir forests in British Columbia (Wetmore et al. 1985), and mature mixed-conifer forests in the north-western Rocky Mountains (Hutto and Young 1999). In the boreal forests of Canada, brown creepers are commonly found in mature coniferous forests and mixed stands of conifers with quaking aspen, balsam poplar, or birch (Campbell et al. 1997 in Hejl et al 2002). In MSSP, mature to old-growth forests mapped as Riparian Conifer Forest or Upland Conifer Forest may provide habitat for nesting brown creepers.

Densities of large trees and large snags are important forest elements for brown creepers (Mariani and Manuwal 1990, Blewett and Marzluff 2005, Hejl et al. 2002). In a semi-developed area of Seattle, Washington, higher brown creeper densities during the nesting season were associated with higher percentages of forest cover, larger forest patch sizes, the presence of tall snags and higher densities of snags (Blewett and Marzluff 2005). The presence of snags influences the breeding and foraging habitat in MSSP, however the literature does not provide adequate information to identify specific snag structure parameters for the region. Likewise, optimal forest canopy cover parameters are not clear from the literature for the Mt. Spokane region, but higher canopy cover percentages are assumed to be more optimal.

Brown creepers are also known to be opportunistic nesters, using recently burned areas of moderate to high severity; which may be related to increased availability of snags for nesting (Kotliar et al. in press in Hejl et al. 2002). In MSSP, insect infestations may be used as a surrogate for burned areas, where moderate to high severity tree mortality provides an increased availability of snags for nesting brown creepers.

Table 42. Habitat elements for brown creeper breeding/nesting.

Variables	Parameters
Cover type	Riparian Conifer Forest, Upland Conifer Forest
Forest successional stage	Mature to old-growth
Forest canopy cover	Higher percentages
Tree diameter	> 7.5 inches DBH
Snag diameter	> 7.5 inches DBH
Tree/snag character	Bark present and loosened, hollow chambers
Fire / bug-kill severity	Moderate to high

Foraging Habitat Suitability Elements

Brown creepers are bark gleaners, foraging for a variety of insects and larvae, spiders, eggs, and ants on the trunks and major limbs of live trees. To a lesser extent, they also forage for prey on dead portions of live trees and snags (Lundquist and Manuwal 1990). Creepers select large-diameter live trees, which tend to have more deeply furrowed bark (Weikel and Hayes 1999) and higher arthropod densities than young trees, thus allowing for more energy-efficient foraging (Mariani and Manuwal 1990). In Douglas-fir forests of the Washington Cascades, brown creeper abundance was associated with very large (≥100 cm; 39 inches DBH) Douglas-fir trees (Mariani and Manuwal 1990). Lundquist and Manuwal (1990) also reported brown creepers foraging more than expected on live trees 50 cm (20 inches) DBH or greater. In MSSP, large live and dead trees greater than 20 inch DBH provide increased foraging habitat for brown creepers.

Brown creepers forage in mature and old-growth forests, and reach peak abundance in structurally complex, closed-canopy stands, greater than 100 years old (Hansen et al. 1995b). In the Washington Cascades, populations were found to be most abundant in mature forests greater than 80 years old (Manuwal 1991). While brown creepers are most abundant in old growth forests, they also utilize mature forests during winter months, and show less fidelity to old growth areas during this season (Anthony et al. 1996). Also during winter months, brown creepers are found in a wider variety of wooded habitats (Tyler 1948, Williams and Batzli 1979; in Hejl et al. 2002) and forested suburban and urban areas, and orchards (DeGraaf and Rudis 1986, Dorn and Dorn 1990, Harrap and Quinn 1995; in Hejl et al. 2002). In MSSP, mature to old-growth forest stands mapped as Upland Conifer Forest, Riparian Conifer Forest, Conifer Woodland/ Shrubland, Riparian Conifer Woodland / Shrubland, Wetland Conifer Woodland / Shrubland and Conifer Woodland / Grasslands should provide suitable brown creeper foraging habitat.

Table 43. Habitat elements for brown creeper foraging.

Variables	Parameters
Cover type	Upland Conifer Forest, Riparian Conifer Forest, Conifer Woodland / Shrubland, Riparian Conifer Woodland / Shrubland, Wetland Conifer Woodland / Shrubland and Conifer Woodland / Grassland
Forest successional stage	Mature to old-growth
Tree diameter	> 20 inches DBH
Snag diameter	> 20 inches DBH

Risk Factors

Concern for this species is based on its strong association with older forests, particularly unlogged forests. The critical components for this species seem to be large-diameter live trees for foraging and large-diameter dead or dying trees for nesting. Immature, second –growth stands (even 100-yr old stands), and logged stands provide less suitable habitat as they may lack enough of the important structural components (Hejl et al. 2002). Brown creepers appear to be interior forest specialists in many areas (Blewett and Marzluff 2005, Hejl et al. 2002), thus forest fragmentation may pose a risk to this species.

Brown creepers were abundant in western conifer forests that had experienced moderate to severe burns, perhaps due to increased snag availability in proximity to live trees for nesting and foraging (Heijl et al. 2002). Cahall and Hayes (2009) describe post-fire salvage logging as reducing habitat suitability for brown creepers, and they suggest that fire suppression practices may have had a negative impact on brown creeper in recent decades.

Blewett and Marzluff (2005) studies on brown creepers in suburban environments show that increased development may negatively affect brown creepers, however land management may mitigate for brown creeper habitat with retention of large forest patch sizes and large diameter trees and snags.

References

Adams, E. M., and M.L. Morrison. 1993. Effects of forest stand structure and composition on red-breasted nuthatches and brown creepers. Journal of Wildlife Management 57:616-629.

Anthony, R.G., G.A. Green, E.D. Forsman, and S.K. Nelson. 1996. Avian abundance in riparian zones of three forest types in the Cascade Mountains, Oregon. Wilson Bulletin 108:280-291.

Banks, T., Farr, D., Bonar, R., Beck, B., and Beck, J. 1999. Brown creeper reproductive habitat model, habitat suitability index model, version 3. Prepared for: Weldwood Forest Management Area, Foothills Model Forest, Alberta.

Beedy, E.C. 1981. Bird communities and forest structure in the Sierra Nevada of California. Condor 83: 97-105.

BirdWeb. 2008. BirdWeb: learn about the birds of Washington State [web application]. Seattle Audubon Society, Seattle, Washington. (Available online: http://www.birdweb.org/birdweb/index.aspx, Accessed: February 25, 2009).

Blewett C.M., and J.M. Marzluff. 2005. Effects of urban sprawl on snags and the abundance and productivity of cavity-nesting birds. The Condor 107:678-693.

Cahall, R.E., and J.P. Hayes. 2009. Influences of post-fire salvage logging on forest birds in the eastern Cascades, Oregon, USA. Forest Ecology and Management 257:1119-1128.

Campbell, R. W., N. K. Dawe, I. McTaggart-Cowan, J. M. Cooper and G. W. Kaiser. 1997. The birds of British Columbia. Vol. 3: passerines—flycatchers through vireos. R. Br. Columbia Mus., Victoria.

Franzreb, K.E. 1985. Foraging ecology of brown creepers in a mixed-coniferous forest. Journal of Field Ornithology 56:9-16.

Hansen, A.J., W.C. McComb, R. Vega, M.G. Raphael, and M. Hunter. 1995a. Bird habitat relationships in natural and managed forests in the west Cascades of Oregon. Ecological Applications 5:555-569.

Hansen, A.J., S.L. Garman, J.F. Weigand, D.L. Urban, W.C. McComb, and M.G. Raphael. 1995b. Alternative silvicultural regimes in the Pacific Northwest: simulations of ecological and economic effects. Ecological Applications 5:535-554.

Hejl, S.J., K.R. Newlon, M.E. Mcfadzen, J.S. Young, and C.K. Ghalambor. 2002. Brown Creeper (*Certhia americana*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York. (Available online: http://bna.birds.cornell.edu/bna/species/669).

Hejl, S.J., and L.C. Paige. 1994. A preliminary assessment of birds in continuous and fragmented forests of western redcedar/western hemlock in northern Idaho. Pp. 189-197 *In*: Baumgartner, D., J. Lotan, and J. Tonn, eds. Interior cedar-hemlock-white pine forests: ecology and management. Washington State University, Pullman, Washington.

Hutto, R.L., and J.S. Young. 1999. Habitat relationships of landbirds in the northern region. USDA Forest Service. General Technical Report RMRS-32.

Johnson, D. H., and T.A. O'Neil eds. 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State Univ. Press. 736 p. + CD

Kotliar, N.B., S.J. Hejl, R.L. Hutto, V. Saab, C.P. Melcher, and M.E. McFadzen. 2002. Effects of wildfire and post-fire salvage logging on avian communities in conifer-dominated forests of the western United States. Studies in Avian Biology 25:49-64.

Lundquist, R.W., and D.A. Manuwal. 1990. Seasonal differences in foraging habitat of cavity-nesting birds in the southern Washington Cascades. Studies in Avian Biology 13:218-225.

Lundquist, R. W. and J. M. Mariani. 1991. Nesting habitat and abundance of snag-dependent birds in the southern Washington Cascade Range. Pp. 220–239 *in* Wildlife and vegetation of unmanaged Douglas-fir forests (L. F. Ruggiero, K. B. Aubry, A. B. Carey, and M. H. Huff, tech. coords.). U.S. For. Serv. Gen. Tech. Rep. PNW-285.

Mannan, R.W., and E.C. Meslow. 1984. Bird populations and vegetation characerisitcs in managed and old-growth forests, northeastern Oregon. Journal of Wildlife Management 48:1219-1238.

Manuwal, D.A. 1991. Spring bird communities in the Douglas-fir forests of the southern Washington Cascades. Pp. 161-174. *In*: Ruggiero, L.E., K.B. Aubry, A.B. Carey, and M.H. Huff, eds. Wildlife and vegetation of unmanaged Douglas-fir forests. USDA Forest Service. General Technical Report PNW-GTR-285.

Mariani, J.M., and D.A. Manuwal.1990. Factors influencing Brown Creeper (*Certhia americana*) abundance patterns in the southern Washington Cascade range. Studies in Avian Biology 13:53-57.

Mayrhofer, M. 2006. Spatial point processes and brown creepers (*Certhia americana*): estimating habitat use of a silvicultural experiment. M.Sc. Thesis, University of Washington, Seattle, Washington. 68 pp.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Poulin, J., M. Villard, M. Edman, P.J. Goulet, and A. Eriksson. 2008. Thresholds in nesting habitat requirements of an old forest specialist, the brown creeper (*Certhia americana*), as conservation targets. Biological Conservation 141:1129-1137.

Raphael, M. G. 1987. Nongame wildlife research in subalpine forests of the central Rocky Mountains. Pp. 113–122 *in* Management of subalpine forests: building on 50 years of research. U.S. For. Serv. Gen. Tech. Rep. RM-149.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon

Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Timossi, I.C., and R.H. Barrett. 1995. Habitat suitability models for use with ArcInfo: brown creeper. California Deptartment of Fish and Game, CWHR Program, Sacramento, California.

Versaw, A. 1998. Brown Creeper. Pp. 362–363 *in* Colorado breeding bird atlas (H. E. Kingery, ed.). Colorado Bird Atlas Partnership and Colorado Div. Wildl., Denver.

Weikel, J.M., and J.P. Hayes. 1999. The foraging ecology of cavity-nesting birds in young forests of the Northern Coast Range of Oregon. Condor 101:58–66.

Wells, R., A. Norris, N. Mahoney, K. Stuart-Smith, and K. De Groot. 2008. Incidental take and protecting habitat for migratory birds: an east Kootenay pilot project. Forest Science Program Project Y082069 Web Module.

Wetmore, S.P., R.A. Keller and G.E.J. Smith. 1985. Effects of logging on bird populations in British Columbia as determined by a modified point-count method. Canadian Field Naturalist 99: 224–233.

Winter Wren *(Troglodytes troglodytes)*

Winter wrens prefer habitats of dense tangles and thickets in coniferous and mixed forests. Due to the availability of these habitats, the winter wren is a permanent resident throughout Washington State. In eastern Washington, winter wrens are usually found above the Ponderosa pine zone and confined to north-facing slopes with dense trees. During the winter, in colder parts of the state, winter wrens leave late in the fall for wintering grounds throughout the western United States or south, in any type of woodland or lower valley with more mild temperatures (Bent 1948, reviewed in Hejl et al. 2002).

Winter wrens primarily prefer mature to old growth, closed-canopy conifer forests with structurally complex forest floors (Hejl et al. 2002). They can also live in other forest types as long as there is dense understory. Dead wood plays a critical role in wren foraging and nesting habitat. Insects and spiders are the predominant prey (BirdWeb 2008), and the wrens methodically search low substrates, probe bark on fallen dead wood and less commonly in the litter, and glean prey from foliage, trunks, the ground, along banks of streams and from the surface of the water (Hejl et al. 2002). They also use snags, downed logs, and large trees for nesting and roosting (Hejl et al. 2002).

In spring, males sing their extended complex songs from mid- and high-level perches, and also from low down, in the understory, on fallen logs and underbrush (BirdWeb 2008). Territories are often established along streams or other water sources (Hejl et al. 2002). Males are highly territorial (Hejl et al. 2002). Nests are built in natural cavities, usually within six feet of the ground. The cavities can be in upturned roots of downed trees or rotten stumps, old woodpecker holes, rock crevices, under porches, or any other low cavity (BirdWeb 2008).

Winter wren foraging habitat is closely associated with their nesting habitat, therefore we describe these life stages together in one habitat element matrix.

Distribution In MSSP

Although Winter Wrens are still common in Washington state, Breeding Bird Survey data show a significant decline of 5.6% per year from 1982 to 1991 (BirdWeb 2008). Winter Wrens are listed as wildlife potentially occurring in Mount Spokane State Park, for both breeding and foraging. Confirmed breeding evidence at Mt Spokane is marked on a map of their core habitat in Washington State (Smith et al 1997).

Existing Habitat Models

Gould, D., D. Farr, B. Beck, J. Beck, and R. Bomar. 1999. Winter wren reproductive habitat: habitat suitability index model, version 5. Report for Weldwood Forest Management Area, Alberta. 6 pp.

Myers, W. L. and J. A. Bishop. 1993. Pennsylvania conservation gap avian habitat model for the winter wren (*Troglodytes troglodytes*); 90 meter resolution. Land and Water Building, University Park, PA. (Accessed online at:

http://mercury.ornl.gov/metadata/nbii/html/pasda/www.pasda.psu.edu_documents_metadata_clearinghouse_gap-paabpbg09050.html)

Krohn, W.B. 2003. Winter wren potential habitat predicted from range limits, habitat relationships, and habitats. Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME. Available online: http://mercury.ornl.gov/metadata/nbii/html/ngap/www.nbii.gov_metadata_mdata_gap_me_bpbg0905.html

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Breeding/Nesting and Summer Foraging Habitat Elements

Complex understories associated with mature to old-growth forests are integral to winter wren habitat. They provide perches for breeding songs, cavities for nests, structure to decrease predation risks, and coarse woody debris for foraging resources. In the central Oregon coast range, winter wrens were found in all elevations of unmanaged mature coniferous and mixed deciduous/coniferous forests (McGarigal and McComb 1992). In eastern Washington, winter wrens are usually found above the ponderosa pine zone, in complex, mature coniferous and mixed deciduous/coniferous forests. In MSSP, mature to old-growth forests in mapped Riparian Conifer Forest and Upland Conifer Forest cover types may provide breeding/nesting and foraging habitat for winter wrens.

Current recommendations (untested) from Oregon-Washington Partners in Flight for west-side forests (Altman 1999) include: (1) provide unmanaged or lightly managed (to create old-growth characteristics) mature (80–200 yr) and old-growth (>200 yr) forest in blocks >30 ha and (2) in managed forests with a rotation age >60 yr, provide (a) an average of 10 downed logs/ha with a diameter >61 cm and 15.2 m long, (b) shrub cover (woody or ferns) >60% within 3 m of ground, (c) tree trunks with a mean diameter of 40 cm for foraging, and (d) riparian buffer zones within harvest units >40 m wide (>90 m preferable; Hagar 1999). In MSSP, these specific parameters may be too restrictive since they were developed for west-side forests. However, coarse woody debris and shrub cover are key habitat elements associated with winter wren nesting and foraging habitat.

On a landscape scale, winter wrens are sensitive to habitat fragmentation and have been found to be associated with larger patch sizes. In northwestern California, winter wren abundance decreases sharply in patches less than 20 hectares (50 acres) (Rosenberg and Raphael 1986 in Altman 1999). In the Oregon Coast Range and southern Washington Cascades they are associated with lower levels of fragmentation (Altman 1999). On a finer habitat scale, natural disturbances that create small openings in the forest and lead to greater shrub development may increase suitable habitat for winter wrens (Godfrey 1986, Holmes and Robinson 1988, Peterjohn and Rice 1991). Large forest patches (>20 hectares) in MSSP would provide breeding and foraging habitat for winter wrens.

Breeding territories, nests, and foraging areas frequently are associated with water such as streams, bogs, swamps, and lakes (Hejl et al. 2002, Verner and Boss 1980, Godfrey 1986, Peck and James 1987, Peterjohn and Rice 1991, Brauning 1992, McGarigal and McComb 1992). In coastal British Columbia, 55% of winter wren nests were found within 5 meters (16 feet) of riparian systems, and areas greater than 8 m (26 feet) from riparian systems were avoided (Waterhouse 1998 in Hejl et al. 2002). Recommendations (untested) from Oregon-Washington Partners in Flight for *western* forests (Altman 1999) include riparian buffer zones within harvest units >40 m wide (130 feet; Hagar 1999). In MSSP, all water bodies and stream corridors provide increased winter wren nesting and foraging habitat. A distance up to 25 feet from waterbodies and stream corridors should account for increased nesting and foraging habitat suitability.

Table 44. Habitat elements for winter wren breeding/nesting and summer foraging.

Variables	Parameters
Cover type	Riparian Conifer Forest, Upland Conifer Forest
Stream corridors	Present
Water bodies	Present
Forest successional stage	Mature to old-growth
Coarse woody debris	Present
Shrub canopy cover	Dense
Forest patch size	> 20 hectares
Distance from water bodies and stream corridors	< 25 feet

Risk Factors

Loss and fragmentation of mature and old-growth coniferous habitat in western North America may pose a threat to winter wren populations (Hejl et al. 2002). Fragmented habitats on the breeding grounds can negatively affect "habitat interior" species such as the winter wren, a species that nests away from habitat edges. As large habitat patches are fragmented into smaller patches, the proportion of edge to interior habitat increases (Saab and Rich 1997), which decreases habitat conditions required by foraging and nesting winter wrens. Partners in Flight groups are concerned about winter wrens in Washington, Oregon, Montana, and the southern Blue Ridge and Allegheny Mountains, owing to the negative effects of logging and fragmentation, and the associations of this species with complex forest floors and rare community types (Hejl et al. 2002).

National forest health practices within the U.S. Forest Service have tried to incorporate forest characteristics into harvesting guidelines, to protect necessary life processes of forest dwelling birds such as extensive mature trees and snags, a more open forest floor with decaying wood, and a relatively humid environment that promotes fungal decay and invertebrate populations. These are all important objectives for maintaining forest health conditions.

References

Altman, B. 1999. Conservation strategy for landbirds in coniferous forests of western Oregon and Washington, version 1.0. American Bird Conservancy and Oregon-Washington Partners in Flight.

Altman, B. 2000. Conservation strategy for landbirds in the northern Rocky Mountains of eastern Oregon and Washington, version 1.0. American Bird Conservancy and Oregon-Washington Partners in Flight.

Bent, A.C. 1948. Life histories of North American nuthatches, wrens, thrashers, and their allies. United States National Museum, Washington, D.C. Bulletin 195.

BirdWeb. 2008. BirdWeb: learn about the birds of Washington State [web application]. Seattle Audubon Society, Seattle, Washington. (Available online: http://www.birdweb.org/birdweb/index.aspx, Accessed: June 28, 2008).

Brauning, D.W. 1992. Atlas of breeding birds in Pennsylvania. University of Pittsburgh Press, Pittsburgh, Pennsylvania.

Gilbert, F.F. and R. Allwine. 1991. Spring bird communities in the Oregon Cascade Range. USDA Forest Service, Portland, Oregon. Report 285.

Godfrey, W.E. 1986. The birds of Canada, revised edition. National Museum of Natural Sciences, Ottawa, Ontario. 596 pp. and plates.

Gould, D., D. Farr, B. Beck, J. Beck, and R. Bomar. 1999. Winter wren reproductive habitat: habitat suitability index model, version 5. Report for Weldwood Forest Management Area, Alberta. 6 pp.

Hagar, J.C. 1999. Influence of riparian buffer width on bird assemblages in western Oregon. Journal of Wildlife Management 63:484–496.

Hejl, S.J., J.A. Holmes, and D.E. Kroodsma. 2002. Winter Wren (*Troglodytes troglodytes*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York. (Available online: http://bna.birds.cornell.edu/bna/species/623, Accessed: June 28, 2008).

Holmes, R.T., and S.K. Robinson. 1988. Spatial patterns, foraging tactics, and diets of ground-foraging birds in a northern hardwoods forest. Wilson Bulletin 100:377-394.

Manuwal, D.A., and M.H. Huff. 1987. Spring and winter bird populations in a Douglas-fir forest. Journal of Wildlife Management 51:586–595.

McGarigal, K., and W.C. McComb. 1992. Streamside versus upslope breeding bird communities in the central Oregon Coast Range. Journal of Wildlife Management 56:1021.

McGarigal, K., and W.C. McComb. 1995. Relationships between landscape structure and breeding birds in the Oregon Coast Range. Ecological Monographs 65:235-260.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Peck, G.K., and R.D. James 1987. Breeding birds of Ontario: nidiology and distribution; volume 2: passerines. Life Sciences Miscellaneous Publications. Royal Ontario Museum, Toronto, Ontario.

Myers, W. L. and J. A. Bishop. 1993. Pennsylvania conservation gap avian habitat model for the winter wren (*Troglodytes troglodytes*); 90 meter resolution. Land and Water Building, University Park, PA. (Accessed online at: http://mercury.ornl.gov/metadata/nbii/html/pasda/www.pasda.psu.edu_documents_metadata_clearinghouse_gap-paabpbg09050.html)

Peterjohn, B.G., and D.L. Rice. 1991. The Ohio breeding bird atlas. Department of Natural Resources, Columbus, Ohio.

Rosenberg, K. V. and M. G. Raphael. 1986. Effects of forest fragmentation on vertebrates in Douglas-fir forests. Pp. 263–272 *in* Wildlife 2000: modeling habitat relationships of terrestrial vertebrates (J. Verner, M. L. Morrison, and C. J. Ralph, eds.). Univ. of Wisconsin Press, Madison.

Semenchuk, G.P. 1992. Atlas of breeding birds of Alberta. Federation of Alberta Naturalists, Edmonton, Alberta.

Saab, V.A., and T.D. Rich. 1997. Large-scale conservation assessment for neotropical migratory land birds in the interior Columbia river basin. USDA. Technical Report PNW-GTR-399. 56 pp.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Verner, J., and A.S. Boss 1980. California wildlife and their habitats: western Sierra Nevada. USDA Forest Service. General Technical Report PSW-37.

Krohn, W.B. 2003. Winter wren potential habitat predicted from range limits, habitat relationships, and habitats. Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME. (Available online: http://mercury.ornl.gov/metadata/nbii/html/ngap/www.nbii.gov_metadata_mdata_gap_me_bpbg0905.html)

Olive-sided flycatcher *(Contopus cooperi)*

Olive-sided flycatchers are highly associated with pure coniferous forest stands throughout North America, although they are occasionally found in mixed deciduous/coniferous forests (NatureServe 2008). The olive-sided flycatcher's wintering grounds range from Panama south to the Andes. They migrate north to their spring breeding grounds, which range from the United States (mainly in the western US) north to Canada and Alaska. Their breeding grounds are typically forests and woodlands, especially burned areas with standing dead trees. They arrive in the higher elevations of Washington between the end of April and June for the breeding season, and usually move downslope after nesting to mature, evergreen montane forests (Altman 1997). Their primary needs include perching posts (snags and live trees) adjacent to open air for foraging, and coniferous forest edges for breeding (Altman and Sallabanks 2000).

Olive-sided flycatchers prey almost exclusively on flying insects, favoring bees, but they also commonly take flies, moths, grasshoppers, dragonflies, and beetles (Forbush 1927, Bent 1942). Because olive-sided flycatchers locate their prey visually, they require habitats that offer exposed perches with unobstructed air space for foraging (Altman and Sallabanks 2000, Beal 1912, Forbush 1927, Bent 1942, Terres 1980, Eckhardt 1979). They typically forage within clearings at heights near or above the canopy of adjacent forests, although this varies by gender and weather conditions. Males typically forage from the tops of prominent perch trees and snags; females from subdominant and understory perches in trees, snags, and especially large root wads of fallen trees.

Distribution In MSSP

Olive-sided flycatchers are documented as fairly common in the nearby Selkirk mountains (BirdWeb 2008). They are listed as wildlife potentially found in Mount Spokane State Park, for both breeding and foraging.

Existing Habitat Models

Gulf of Maine habitat model for olive-sided flycatcher. (Accessed online at: http://www.fws.gov/r5gomp/gom/habitatstudy/metadata/olive-sided_flycatcher_model.htm).

Maine Gap Analysis: Olive-sided Flycatcher potential habitat predicted from range limits, habitat relationships, and habitats. (Accessed online at: http://mercury.ornl.gov/metadata/nbii/html/ngap/www.nbii.gov_metadata_mdata_gap_me_bpae3201.html).

Pennsylvania conservation gap avian habitat model for the olive-sided flycatcher (*Contopus borealis*); 90 m resolution. (Accessed online at: http://mercury.ornl.gov/metadata/nbii/html/pasda/www.pasda.psu.edu_documents_metadata_clearinghouse_gap-paabpae32010.html).

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K.

M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Breeding/Nesting Habitat Elements

Olive-sided flycatcher breed in North American conifer forests, mixed conifer/deciduous forests, and conifer woodlands, at mid- to high-elevations (920–2130-m; 3018-6988-ft, Altman and Sallabanks 2000). Olive-sided flycatchers concentrate their breeding and nesting activities at the edges of forested stands where trees are generally greater than 40 years old (Meslow and Wight 1975). Nesting habitat in MSSP occurs on the edges of conifer forest stands.

Occurrence of nests are influenced by the presence of tall trees and canopy structure, which serve as singing and foraging perches. Relatively open forest canopies of less than 40 percent canopy cover are important for foraging flyways (Altman and Sallabanks 2000). Specific forest types where nests are found include dry Douglas-fir (*Pseudotsuga menzeisii*) and grand fir (*Abies grandis*) forests in west-central Idaho (Altman and Sallabanks 2000) and spruce and fir forests in Oregon (Robertson and Hutto 2007). Nests have also been observed in trembling aspen (*Populus tremuloides*) and willow (*Salix* spp.) patches in southern British Columbia (Campbell et al. 1997). In MSSP, areas with open forest canopies with less than 40 percent cover should provide optimal olive-sided flycatcher breeding/nesting habitat.

Olive-sided flycatcher nesting success improves with increasing densities of snags and trees greater than 10 cm (3.9 inches) DBH, based on findings in the Oregon Cascades (Altman 2000, modeled by Vesley et al. 2007). The live tree and snag density indices developed for nesting HSI models use approximately 72 to 120 live trees per hectare (29-50 live trees per acre), and 18 to 37 snags per hectare (44-91 per acre), both measuring trees/snags greater than 10 cm (3.9 inches) DBH (Vesley et al. 2007, based on Altman 2000 study). In MSSP, ideal nesting habitat for olive-sided flycatchers may be represented by these tree and snag densities.

Table 45. Habitat elements for olive-sided flycatcher breeding/nesting.

Variables	Parameters
Forest successional stage	Young to old-growth
Forest canopy cover	< 40%
Tree size	> 4 inches DBH
Tree density	> 72 trees per acre
Snag diameter	> 4 inches DBH
Snag density	> 44 snags per acre
Forest edges	Edge of forest stands

Foraging Habitat Elements

Primary foraging habitat for olive-sided flycatchers outside of the breeding season is mature, evergreen montane forest (Altman 1997), typically in edge habitat or in an open forest canopy, and less commonly in interior forests (Rosenberg and Raphael 1986).

Open forest canopies likely increase foraging efficiency by providing unobstructed views and flight paths for pursuing insects (Altman and Sallabanks 2000, Evans and Finch 1994). This includes a variety of forest, woodland, and open sites with tall, scattered trees, especially where tall, dead snags are present. Forest edges and woodlands in MSSP represent optimal olive-sided flycatcher foraging habitat. The edge of any mapped forest cover class and any woodland cover class within the park could provide optimal habitat for olive-sided flycatcher foraging. Areas with tall snags present add to foraging suitability for olive-sided flycatchers in MSSP.

To predict optimum foraging habitat, Vesley et al. (2007) used a landscape suitability sub-index. Their foraging suitability sub-index is based on the relative density of high-contrast edges in a potential home range, and is calculated by the difference in average height of dominant trees between two patches. Higher densities of high contrast edges provide quality foraging habitat.

Burned areas are important cover types for foraging flycatchers, due to increased snags and prey densities associated with post-fire communities (Hutto 1995), although some studies have found reduced food availability and foraging rates for flycatchers in recent burn areas (Meehan and George 2003). Water bodies including wetlands are important because olive-sided flycatchers show an association with water, which may be due to higher insect abundances (Altman and Sallabanks 2000). Watersheds with clear-cuts are shown to have greater abundances of olive-sided flycatchers than watersheds without (Evans and Finch 1994). In MSSP, landscape features associated with olive-sided flycatchers may include forest edges, forest clearings, burned areas, and water bodies.

Table 46. Habitat elements for olive-sided flycatcher foraging.

Variables	Parameters
Cover type	Any forest or woodland types
Water bodies	Present
Forest successional stage	Mature
Snags	Present
Forest edges	Edge of forest stands
Burned areas	Present

Risk Factors

Although olive-sided flycatcher populations are still secure in many areas, significant declines have occurred in recent decades (a loss of 68% from 1966-2000, Natureserve 2008). Breeding Bird Stations (BBS) documented the olive-sided flycatcher as one of 10 forest species that likely have declined in the past 25 years (Hejl 1994). The cause of the decline is unknown, but scientists speculate that it may be due to habitat loss on the wintering grounds, or a decrease in suitability of habitat on the breeding grounds.

Forest health practices within the U. S. Forest Service have tried to incorporate forest characteristics into their harvesting guidelines to protect necessary life processes of forest dwelling birds. Forest characteristics incorporated include extensive mature trees and snags, a more open forest floor with decaying wood, and a relative humid environment that promotes fungal decay and invertebrate populations. These forest health attributes are important for olive-sided flycatchers.

There is controversy over the claim that "forestry practices mimic the appearance of disturbed landscapes, and therefore can substitute for natural disturbances". Research shows that logged areas are less productive than historically burned sites, which may have an impact on olive-sided flycatchers. Artificially disturbed forests may give a songbird (such as an olive-sided flycatchers) an ecological clue for settling in an area, however the site acts as an "ecological trap", negatively affecting the species due to lack of prey or increased nest predation (Robertson and Hutto 2007). In selectively harvested forest, the nesting success and population density of olive-sided flycatchers decreased in selectively harvested forests over control sites in naturally burned forests (Robertson and Hutto 2007).

Forest fires are a primary agent of natural disturbance in the west (Hejl 2000), and birds have evolved with this agent of change over the millennia. Fire suppression over the last 100 years has had a substantial impact on habitat, and it is possible that bird species associated with fire-maintained forest structures have been negatively affected by fire suppression (Hejl 2000). Salvage logging in burned areas can decrease the quantity and quality of suitable perch and nest sites for olive-sided flycatchers. If these management practices occur, it is suggested that some snags and live trees be left uncut, so as to retain some forest structure necessary for wildlife species such as the olive-sided flycatcher.

References

Altman, B. 1997. Olive-sided Flycatcher in western North America: Status review. Prepared for USDA Fish and Wildlife Service, Oregon State Office, Portland, Oregon. 59 pp.

Altman, B., and R. Sallabanks. 2000. Olive-sided Flycatcher (*Contopus cooperi*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology Ithaca, New York. (Available online: http://bna.birds.cornell.edu/bna/species/502).

Altman, B. 2000. Conservation strategy for landbirds of the east-slope of the Cascade mountains in Oregon and Washington. American Bird Conservancy, Boring, Oregon. 81 pp.

Beal, F.E.L. 1912. Food of our more important flycatchers. USDA. Biological Survey Bulletin 44. 67 pp.

Bent, A.C. 1942. Life histories of North American flycatchers, larks, swallows, and their allies. United States National Museum, Washington, D.C., Bulletin 79.

BirdWeb. 2008. BirdWeb: learn about the birds of Washington State [web application]. Seattle Audubon Society, Seattle, Washington. (Available online: http://www.birdweb.org/birdweb/index.aspx, Accessed: June 28, 2008).

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, M.C.E. McNall, and G.E.J. Smith. 1997. The birds of British Columbia; volume 3: flycatchers through vireos. 693 pp.

Eckhardt, R.C. 1979. The adaptive syndromes of two guilds of insectivorous birds in the Colorado U.S.A. Rocky Mountains. Ecological Monographs 49:129-150.

Evans, D.M., and D.M. Finch. 1994. Relationships between forest songbird populations and managed forests in Idaho. Pp. 308–314. *In*: Covington, W.W., and L.F. DeBano, eds. Sustainable ecological systems: implementing an ecological approach to land management. USDA Forest Service. General Technical Report RM-247.

Forbush, E.H. 1927. Birds of Massachusetts and other New England States; part 2: land birds from bob-whites to grackles. Massachusetts Department of Agriculture, Boston, Massachusetts. 461 pp.

Hagar, J., S. Howlin, and L. Ganio. 2004. Short-term response of songbirds to experimental thinning of young Douglas-fir forests in the Oregon Cascades. Forest Ecology and Management 199:333-347.

Hejl, S.J. 1994. Human-induced changes in bird populations in coniferous forests in western North America during the past 100 years. Studies in Avian Biology 15:232-246.

Hejl, S.J. 2000. A strategy for maintaining healthy populations of western coniferous forest birds. *In*: Bonney, R., D.N. Pashley, R.J. Cooper, and L. Niles, eds. Strategies for bird conservation: the partners in flight planning process; proceedings of the 3rd partners in flight workshop; 1995 October 1-5; Cape May, New Jersey. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah. RMRS-P-16.

Hutto, R.L. 1995.Composition of bird communities following stand-replacement fires in northern Rocky Mountain forests. Conservation Biology 9:1041-1058.

Meehan, T.D., and T.L. George. 2003. Short-term effects of moderate- to high-severity wildfire on a disturbance-dependent flycatcher in northwest California. Auk 120:1102-1113.

Meslow, E.C., and H.M. Wight. 1975. Avifauna and succession in Douglas-fir forests of the Pacific Northwest. Pp. 266-271. *In*: Smith, D.R., ed. Proceedings of the symposium on management of forest and range habitats for non-game birds. USDA Forest Service. General Technical Report WO-1.

Miller, S.G., R.L. Knight, and C.K. Miller. 1998. Influence of recreational trails on breeding bird communities. Ecological Applications 8:162-169.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Robertson, B.A., and R.L. Hutto. 2007. Is selectively harvested forest an ecological trap for olive-sided flycatchers? Condor 109:109-121.

Rosenberg, K., and M.G. Raphael. 1986. Effects of forest fragmentation on vertebrates in Douglas-fir forests. Pp. 263–272. *In*: Verner, J., M.L. Morrison, and C.J. Ralph, eds. Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, Wisconsin.

Scott, V.E., G.L. Crouch, and J.A. Whelan 1982. Response of birds and small mammals to clearcutting in a subalpine forest in central Colorado. USDA Forest Service. Resource Note RM-422.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State. Volume 4 in Washington State Gap Analysis Final Report (K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich, Eds). Seattle Audubon Society Publications in Zoology No. 1, Seattle. xi + 538 pp. 3 color plates, 6 tables, 10 figures, 244 maps.

Terres, J.K. 1980. The Audubon Society encyclopedia of North American birds. Alfred A. Knopf, New York, New York.

Tobalske, B.W., R.C. Shearer, and R.L. Hutto 1991. Bird populations in logged and unlogged western larch/Douglas-fir forest in northwestern Montana. USDA Forest Service. Resource Paper INT-442.

Vesley, D., M.T. McGrath, and B.C. McComb. 2007. Appendix: habitat capability index for olive-sided flycatcher (*Contopus cooperi*). *In*: Spies, T.A., B.C. McComb, R.S.H. Kennedy, M.T. McGrath, K. Olsen, and R.J. Pabst. Potential effects of forest policies on terrestrial biodiversity in a multi-ownership province. Ecological Applications. 17:48–65.

Species Summaries – Small Mammals

American Pika *(Ochotona princeps)*

The American pika is a common resident of rock and talus slopes of mountainous regions throughout the western United States. Pikas are active diurnally throughout the year. They eat mostly grasses and forbs, and create and store food in "hay piles" for winter consumption and nesting material. Their diet during early spring gestation is composed of hay piles from the preceding summer. Pika young are born upon snow recession in the spring, when spring forage of alpine vegetation can meet the high metabolic demand of lactation (Miller 1972, Smith 1978, Smith and Ivans 1983).

In Washington State, pikas are restricted to alpine and subalpine habitats, where they primarily use the talus-meadow interface. The openings and holes in the rocks are used as shelter from predators, refuge from warm temperatures during the summer and cold temperatures during the winter, and ideal nesting sites. Since pikas have a very small home range throughout the year, and because their diets are similar during winter and summer months, a single habitat element matrix defines breeding/nesting and year-round foraging.

Distribution In MSSP

Pikas are year-round residents of alpine talus habitats in Mt. Spokane State Park. The population has not been surveyed in recent years, and it is unknown if the colony still occupies talus slopes on Mt. Spokane (H. Ferguson, WDFW Wildlife Biologist, pers. comm.).

Existing Habitat Models

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Breeding/Nesting and Foraging Habitat Elements

American pikas are found in subalpine talus habitats, and are active throughout the year. They feed on grasses and forbs, and travel a short distance from talus slopes to graze during summer and fall months. They preferentially feed amongst inter-talus vegetation, and typically venture up to one meter (3.3 ft) from talus cover when harvesting food and haying resources (Roach et al. 2001, Huntley et al. 1986). In MSSP, cover types mapped as Scree/Boulder/Talus and Upland Meadows above 5000 feet (subalpine to alpine habitats) are pika habitat. A buffer distance of 5 feet from talus habitat accounts for the limited distance pikas travel from security to forage.

Table 47. Habitat elements for pika breeding/nesting and foraging.

Variables	Parameters
Elevation	> 5000 feet
Cover type	Scree / Boulder / Talus, Upland Meadows
Distance from talus	< 5 feet

Dispersal Habitat Elements

Distance is a limiting factor for pika dispersal. As the population increases or habitat diminishes over time, pika densities and juvenile dispersal are dependent on connectivity to adjacent areas (Bunnell and Johnson 1974, Franken and Hik, 2004). Juvenile immigration movements have been recorded as intra-patch dispersal movements (Smith 1989). Observational studies indicate that juvenile pikas tend to remain close to their natal home ranges, and rarely disperse more than 50 meters (164 ft) from their weaning habitat (Smith 1989). In MSSP, distances less than 165 feet between adequate breeding, nesting, and foraging areas are required to be optimal for dispersal.

Table 48. Habitat elements for intra-patch pika dispersal.

Variables	Parameters
Distance between breeding/nesting and foraging habitat	< 165 feet

Risk Factors

Metapopulations, or spatially isolated species populations depend on inter-patch dispersal movements to maintain adequate genetic exchange. These movements allow for gene flow between populations and colonization of new areas. Metapopulation models for pikas predict that dependence on habitat patch size and connectivity contribute to pika populations being more prone to extinction resulting from demographic and stochastic (randomly occuring) events (Hanski 1994, Hanski et al 1996). In a California study comparing discrete islands of habitat for pikas, Smith (1980) found turnover (extinction or recolonization) of island habitats occurred more often on small or medium-sized islands. Within these island size categories, turnover increased with isolation. At Mt. Spokane State Park, limited habitat size and isolation from other nearby pika populations and habitats may increase potential for extinction of the population.

Increasing temperatures associated with global warming pose a threat to pikas, because pikas are sensitive and negatively affected by warm temperatures. During warmer weather, pika's curtail their activity and take refuge under the talus rocks, not allowing them to forage the potential maximum amount of time during a day (Smith 1989). Warm temperatures also impose stress on their vagility, decreasing their ability to successfully colonize vacant habitat during dispersal movements. A 2005 study reported that 7 out of 25 sampled populations of American pika throughout the western U.S. have disappeared due to climate change (Beever et al. 2003, Grayson 2005). They confirmed the now-extinct and extant populations of pikas were moving up in elevation and their ranges contracting, most likely due to increased temperatures at lower elevations (Beever et al. 2003, Grayson 2005). This may be a significant threat to pikas at Mt. Spokane State

Park, who depend on the very limited alpine talus habitat near the top of the mountain and cool weather conditions.

References

Altman, B. 2000. Conservation strategy for landbirds of the east-slope of the Cascade mountains in Oregon and Washington. American Bird Conservancy, Boring, Oregon. 81 pp.

Bunnell, S.D., and D.R. Johnson. 1974. Physical factors affecting pika density and dispersal. Journal of Mammalogy 55:866-869.

Dearing, M.D. 1996. Disparate determinants of winter and summer diet selection in a generalist herbivore, *Ochotona princeps*. Oecologia 108:467-478.

Dearing, M.D. 1997. The function of haypiles of pikas (*Ochotona princeps*). Journal of Mammalogy 78:1156.

Franken, R.J., and D.S. Hik. 2004. Influence of habitat quality, patch size and connectivity on colonization and extinction dynamics of collared pikas *Ochotona collaris*. Journal of Animal Ecology 73:889-896.

Grayson, D.K. 2005. A brief history of Great Basin pikas. Journal of Biogeography 32:2103-2011.

Hafner, D.J., and R.M. Sullivan. 1995. Historical and ecological biogeography of nearctic pikas (Lagomorpha, Ochotonidae). Journal of Mammalogy 76:302-321.

Hanski, I. 1994. A practical model of metapopulation dynamics. Journal of Animal Ecology 63:151-162.

Hanski, I., A. Moilanen, T. Pakkala, M. Kuussaari. 1996. The quantitative incidence function model and persistence of an endangered butterfly metapopulation. Conservation Biology 10:578-590.

Huntley, N.J., A.T. Smith, and B.L. Ivins. 1986. Foraging behavior of the pika (*Ochotona princeps*), with comparisons of grazing versus haying. Journal of Mammalogy 67:139-148.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Miller, J.S. 1972. Timing of breeding of pikas in southwestern Alberta. Canadian Journal of Zoology 50:665.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Peacock, M. M. 1997. Metapopulations and Wildlife Conservation. - book reviews. Ecology. (Available online. http://findarticles.com/p/articles/mi_m2120/is_n6_v78/ai_20413034/, Accessed June 30, 2009).

Roach, W.J., N. Huntly, and R. Inouye. 2001. Talus fragmentation mitigates the effects of pikas, *Ochotona princeps*, on high alpine meadows. Oikos 92:315-324.

Smith, A.T. 1974. Distribution and dispersal of pikas – consequences of insular population structure. Ecology 55:1112-1119.

Smith, A.T. 1978. Comparative demography of pikas (*Ochotona*) – effect of spatial and temporal age-specific mortality. Ecology 59:133-139.

Smith, A. T. 1980. Temporal Changes in Insular Populations of the Pika (Ochotona Princeps). Ecology 61:8-13.

Smith, A.T. 1989. Population Structure of Pikas: Dispersal versus Philopatry. *In*: Chepko-Dade, B.D., and Z.T. Halpin, eds. Mammalian Dispersal Patterns: The Effects of Social Structure on Population Genetics. University of Chicago Press, Chicago, Illinois. 360 pp.

Smith, A.T., and B.L. Ivans. 1983. Reproductive tactics of pikas – why have 2 litters. Canadian Journal of Zoology 61:1551-1559.

American Pygmy Shrew *(Sorex hoyi)*

American pygmy shrews are distributed throughout the boreal regions of North America, ranging from Alaska to the east coast of Canada, and south into the northern United States with disjunct populations in the Southern Rockies (e.g., northern Colorado) and Appalachians (NatureServe 2008). Pygmy shrews are considered rare throughout their range and are not expected to occur in high densities (Van Zyll de Jong 1983). Trends on population status of pygmy shrews in the Columbia Basin are unknown (Wisdom et al. 2000).

Pygmy shrews are the smallest mammal in North America, with adults weighing only 3 grams. Shrews are insectivores (Ryan 1986, Whitaker and French 1984), specializing on small spiders and other soft-bodied invertebrates (Badyaev 2009). They have incredibly high metabolic rates of 1200 heartbeats per minute, and they must eat three times their body weight daily to survive. Due to this high metabolic rate, they prefer moist environments to meet their high moisture requirements, where there also tends to be a diverse and abundant food supply. Adequate soil moisture and leaf litter (and the invertebrate prey base it supports) are often suggested as important determinants of shrew diversity and abundance (Getz, 1961; Kirkland, 1991). Pygmy shrews are active throughout the year, but seem to be less active above ground during the warmest summer months (Feldhamer et al. 1993), supporting the idea that cooler soil and forest conditions are necessary (Badyaev 2009).

There is very little specific information available on pygmy shrews, especially in the Pacific Northwest. Pygmy shrews are generally considered non-migratory and diets and habitats should be similar throughout the winter and summer months. Little is known about breeding, parturition, or dispersal of the species, except that highest birth rates are thought to take place during the spring. Juvenile dispersal is minimal, less than 50 yards (150 ft) from the birth nest (Badyaev 2009). Therefore, we combine year-round foraging and breeding/parturition habitat elements in the habitat elements matrix for pygmy shrews.

Distribution In MSSP

Pygmy shrews are listed as wildlife potentially occurring within MSSP. They are estimated to occur in the northeastern portion of the Columbia River Basin, primarily within the Northern Glaciated Mountains where MSSP is located (Wisdom et al. 2000). There are mapped records for pygmy shrew in Ferry County in similar habitat about 36 miles east of MSSP (Johnson and Cassidy 1997).

Existing Habitat Models

Marcot, B. G. In press. Natural resource assessment and risk management. *In*: Naim, P., P.H. Wuillemin, P. Leray, O. Pourret, and A. Becker, eds. Réseaux bayésiens (Bayesian networks; in French). Eyrolles, Paris, France. (Accessed online at: http://www.plexusowls.com/PDFs/bbns%20in%20nr%20mgt.pdf).

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Breeding/Parturition and Foraging Habitat Elements

Pygmy shrews occupy a wide variety of habitat types throughout the United States, from upland hardwood forests in the southeast (Feldhamer et al. 2002), to open dry coniferous forests in Montana (Montana field guide). They have been captured in southern Wyoming and northern Colorado, associated with bogs and moist spruce-fir forest meadows (Brown 1966, 1967), in mesic grand fir-subalpine fir-Engelmann spruce forest in the Idaho Panhandle, and ponderosa pine-lodgepole pine-Douglas-fir forest in northeastern Washington (Stinson and Reichel 1985, Foresman 1986). Pygmy shrews potentially occupy all structural stages of upland conifer forests, including all shrub-herb-tree regeneration habitat types in the northern half of the Columbia Basin (Wisdom et al. 2000). Wisdom et al. (2000) recommend managing for late-seral stage forests as a source habitat to improve the potential for pygmy shrew habitat. In MSSP, mapped cover types for pygmy shrew foraging and breeding/parturition include Upland Conifer Forest, Conifer Woodland/ Meadow, Conifer Woodland/ Shrubland, Riparian Conifer Forest, Riparian Conifer Woodland/ Shrubland, Shubland/Meadow, Upland Meadows, and Wetland Conifer Woodland/ Shrubland.

High densities of coarse woody debris (CWD) are commonly associated with small mammals, because it provides excellent cover (Bull et al 1997) and ideal climatic conditions for abundant invertebrate prey. Ohmann and Waddell (2002) describe regional patterns of variation in dead wood across mid to late successional habitats currently present throughout eastern Washington and Oregon. Their late-successional stage forest model specifically measured 5.1% coarse woody debris cover for Montane mixed conifer forests, where logs are greater than 12.5 cm (4.9 inches) large end diameter and greater than 2 meters (6.6 ft) long, and decay class ranges between 1 and 4. In MSSP, this regional assessment of coarse woody debris indirectly relates to potential pygmy shrew habitat, however more research is needed to assess if these estimates would accurately depict suitable habitat for the species. Coarse woody debris is a habitat element likely necessary for pygmy shrew breeding/parturition and foraging.

Leaf litter and duff layers are considered important micro-habitat sites for shrew species because they provide cool and moist conditions for their hyperactive metabolisms, and they concentrate abundant invertebrate resources. This is particularly important because shrews' metabolisms are not tolerant of heat, and they cannot survive exposure to temperatures higher than 77 degrees F (Badyaev 2009). The literature does not quantify or characterize litter or duff associated with shrews, however this would be an important habitat variable for pygmy shrews at MSSP.

Table 49. Habitat elements for American pygmy shrew breeding/parturition and foraging.

Variables	Parameters
Cover type	Upland Conifer Forest, Conifer Woodland / Meadow, Conifer Woodland / Shrubland, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Shubland / Meadow, Upland Meadows, and Wetland Conifer Woodland / Shrubland
Coarse woody debris	Present
Leaf litter and duff	Present

Risk Factors

Very few studies have been conducted on American pygmy shrews, and therefore there are few documented species responses to disturbance (Warren 1996). Habitat loss as a result of high-intensity or rapid disturbance and potentially climate change could negatively affect the species. For example, rapid changes such as logging a moist coniferous forest and creating a dry open shrub community can alter the abundance of soft-bodied invertebrates to a dominance of hard-bodied beetles, which are a less ideal prey for shrews (Badyaev 2009). The stress of malnutrition on pregnant shrews results in numerous developmental abnormalities in offspring, such as greatly asymmetrical jaws and disrupted dental and skeletal development (Badyaev 2009).

The direct effects of prescribed fire on pygmy shrews has been studied. In South Dakota, pygmy shrews' response to spring burning appeared neutral to positive, when their preferred wetland habitat retained sufficient cover and food resources (Behrend and Tester 1988, in Warren 1996). As well, fuel reduction treatments with minimal change to canopy cover or leaf litter depth had little impact on shrews (Greenberg and Miller 2007). However, fall burns in dry basins and high-intensity burning that kills trees and dramatically reduces shade and leaf litter depth, can reduce the abundance of some shrew species and all shrews combined, at least in the short term (Greenberg and Miller 2007).

Shrews are unusually vulnerable to the most recent of threats of accelerated global warming. Shrews depend on micro-site landscape features such as moist soil conditions and dense forest understories, with high densities of quickly decaying coarse woody debris and snags. Stresses imposed by global warming include warmer temperatures, leading to decreased soil moisture and forest humidity, and more severe wildfires. Shrews' metabolisms are not tolerant of heat, and they cannot survive exposure to temperatures higher than 77 degrees F (Badyaev 2009). These stresses, along with other human landscape altering activities, pose particular threat to their limited dispersal, which may only be 50 to 100 yards during their short 14 month life span. "Add to the mix synchronous population cycles, preferences for unfragmented habitats and intolerance of heat, and whole populations can disappear in just a few years under rapid and accelerating global warming" (Badyaev 2009). On the other hand, masked shrews studied in Alaska were found to have increased body size during the second half of the twentieth century, hypothesized to account for higher food availability in winter months as a result of improved (warmer) weather conditions due to global warming (Tom-Yov

2005). Thus in the short term, warmer climate conditions may benefit pygmy shrew foraging during the coldest and otherwise most limiting months of the year.

References

Badyaev, A. 2009. The Maiming of the Shrew. National Wildlife Magazine, National Wildllife Federation, volume 47, no. 2.

Brown, L.N. 1966. First record of the pygmy shrew in Wyoming and description of a new subspecies (Mammalia: Insectivora). Proceedings of the Biological Society of Washington 79:49-52.

Brown, L.N. 1967. Ecological distribution of six species of shrews and comparison of sampling methods in the central Rocky Mountains. Journal of Mammalogy 48:617-623.

Bull, E.L., C.G. Parks, and T.R. Torgersen. 1997. Trees and logs important to wildlife in the Interior Columbia River Basin. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-391. 55 pp.

DeGraaf, R.M., D.P. Snyder, and B.J. Hill. 1991. Small mammal habitat associations in poletimber and sawtimber stands of four forest cover types. Forest Ecology and Management 46:227-242.

Feldhamer, G.A., J.C. Whittaker, and S.R. Bloemer. 2002. Often unseen fauna: small mammals and mesocarnivores on Land Betweeen The Lakes.

Feldhamer, G.A., R.S. Klann, A.S. Gerard, and A.C. Driskell. 1993. Habitat partitioning, body size, and timing of parturition in pygmy shrews and associated soricids. Journal of Mammalogy 74:403-11.

Fimble, R. 2008. Forest vegetation composition and wildlife habitat assessment: Mount Spokane State Park: Request for proposal (RFP). 10 pp.

Ford, W.M., J. Laerm, and K.G. Barker. 1997. Soricid response to forest stand age in southern Appalachian cove hardwood communities. Forest Ecology and Management 91:175-181.

Foresman, K.R. 1986. *Sorex hoyi* in Idaho: a new state record. Murrelet 67:1-82.

Getz, L.L. 1961. Factors influencing the local distribution of shrews. American Midland Naturalist 65:67-88.

Greenberg, C.H., and S. Miller. 2007. Short-term response of shrews to prescribed fire and mechanical fuel reduction in a Southern Appalachian upland hardwood forest. Forest Ecology and Management 243:231-236.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Kirkland, G.L.1991. Competition and coexistence in shrews (Insectivora: Soricidae). Pp. 15-22. *In*: Findley, J.S., and T.L. Yates, eds. The biology of the Soricidae. University of New Mexico Press, Albuquerque, New Mexico.

Montana Field Guide - Pygmy Shrew - *Sorex hoyi*. (Available online: http://fieldguide.mt.gov/detail_AMABA01250.aspx).

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Ohmann, J.L., and K.L. Waddell. 2002. Regional patterns of dead wood in forested habitats of Oregon and Washington. USDA Forest Service. General Technical Report PSW-GTR-181. 27 pp.

Ryan, J.M. 1986. Dietary overlap in sympatric populations of pygmy shrews, Sorex hoyi, and masked shrews, *Sorex cinereus*, in Michigan (USA). Canadian Field Naturalist 100:225-8.

Stinson, D.W., and J.D. Reichel. 1985. Rediscovery of the pygmy shrew in Washington. Murrelet 66:59-60.

van Zyll de Jong, C.G. 1983. Handbook of Canadian Mammals. National Museum of Natural Sciences, Ottawa, Ontario.

Warren, N. 1996. ICBEMP (Interior Columbia Basin Ecosystem Management Project) pygmy shrew review. 5 pp.

WDFW. 2008. Living with Wildlife Informational Website. Washington Department of Fish and Wildlife. (Available online: http://wdfw.wa.gov/wlm/living/moles.htm).

Whitaker J.O., Jr., French T.W. 1984. Foods of six species of sympatric shrews from New Brunswick. Canadian Journal of Zoology 62:622-6.

Wisdom, M.J., R.S. Holthausen, B.C. Wales, C.D. Hargis, V.A. Saab, D.C. Lee, W.J. Hann, T.D. Rich, M.M. Rowland, W.J. Murphy, and M.R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale rends and management implications. *In*: Quigley, T.M., ed. Interior Columbia Basin Ecosystem Management Project: scientific assessment. USDA

Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-485. 529 pp.

Yom-Tov, Y., and J. Yom-Tov. 2005. Global warming, Bergmann's rule and body size in the masked shrew *Sorex cinereus* Kerr in Alaska. Journal of Animal Ecology. 74:803-808.

Silver-haired bat *(Lasionycteris noctivagans)*

The silver-haired bat is one of the larger bats inhabiting Pacific Northwest forests, and is easily distinguished from the smaller *Myotis*, or mouse-eared bats. Silver-haired bats range from southern Alaska and central Canada, throughout the US and south into northern Mexico. They are secondary-cavity roosters, using cracks and fissures in tree bark and woodpecker cavities as their habitat for roosting and young rearing. Variables such as sex, age, and breeding condition play a role in roost selection. Christy and West (1993) identify key requirements of suitable roost sites including proximity to drinking and foraging habitat, protection from predators, and favorable temperature and moisture regimes.

Silver-haired bats are local summer residents of the Interior Columbia Basin, ranging throughout Oregon, Washington and Idaho (Wisdom et al. 2000). They are thought to migrate out of the Columbia Basin during winter months, most likely due to environmental conditions and the lack of availability of food resources. Migration distances and routes have not been determined, but they are thought to leave Washington by September and return in July the following year (Shump and Shump 1982). Female silver-haired bats return to the Pacific Northwest in the early spring, and favorable climatic conditions east of the Washington Cascade range may increase suitable foraging days and allow breeding females to breed more regularly (Thomas and West 1991).

Distribution In MSSP

They are known to forage and roost in and around Mount Spokane State Park. Johnson and Cassidy (1997) have MSSP mapped as core habitat and indicate sighting records for Spokane County.

Existing Habitat Models

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Breeding/Parturition and Roosting Habitat Elements

Silver-haired bats are generally considered solitary roosters in our range (Christy and West 1993), which include individual non-reproducing females, males and migrants (Betts 1998). Telemetry studies have recently recognized cavities high in the canopy of large diameter trees providing habitat for roosting maternity colonies (Betts 1996, Crampton and Barclay 1996, Mattson et al. 1996, Vonhof 1996, and Vonhof and Barclay 1996).

Of these few studies conducted on individual roosts and maternity roosting colonies, roosting cavities were characterized as relatively isolated from nearby trees, the nest tree heights protruding above the canopy, with large basal diameters, and having moderate stages of decay (Betts 1998, Crampton and Barclay 1998). These attributes are thought to possibly provide a suitable auditory and visual landscape, protection from predators, and maintenance of a proper microclimate (Betts 1998). Betts (1998) document mean measurements of six maternity colony roost trees in northeastern Oregon as 59.8 cm ± 14.2 (18 - 29 inches) diameter at breast height, and 26.7 ± 7.8 m (62 -113 ft) tall. Most roost trees protruded above the forest canopy. In MSSP, these parameters are probably higher than what is needed for breeding and roosting silver-haired bats (H. Ferguson, WDFW Wildlife Biologist, pers. comm.). Therefore nest tree size and height are generally mentioned as habitat elements, but the optimal parameters in MSSP are not known.

Silver-haired bats are generally considered forest-dwelling bats, and in some areas prefer old stands. Existing studies on silver-haired bats found activity levels in old-growth forests to be significantly higher than in young or mature forests (Crampton and Barclay 1998, Parker et al. 1996, Perkins and Cross 1988, Thomas 1988). This may be due to the greater abundance of large, old trees that meet better roosting requirements (Christy and West 1993, Perkins and Cross 1988). Because roosting requirements are not well known or understood, it is difficult to identify old-growth forests as a habitat element for breeding and roosting, especially in MSSP where the species is not well studied. In MSSP, young to old-growth forests may be used by breeding and roosting silver-haired bats.

Silver-haired bats have been documented using a variety of upland conifer forests, deciduous woodlands, and riparian aspen woodlands for roosting (Wisdom et al. 2000, Betts 1996, Crampton and Barclay 1998). Within these habitats, silver-haired bat roosts were in the upper half of dense slopes of ponderosa pine, grand fir, and Douglas-fir forests (Betts 1998), but they also used old stands of mixed aspen woodlands (Wisdom et al 2000, Crampton and Barcley 1998). Betts (1998) found the average forest canopy cover for roost trees was 41.5 ± 11.9 percent. In MSSP, mapped cover types that may provide adequate habitat for breeding and roosting silver-haired bats include: Upland Conifer Forest, Conifer Woodland / Meadow, Conifer Woodland / Shrubland, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, and Wetland Conifer Woodland / Shrubland. Tree species composition and forest canopy cover are not identified as habitat elements for breeding and roosting silver-haired bats in MSSP, because site specific studies have not been conducted on this species.

Little is known about silver-haired bat roosting and breeding habitat. Even though a few studies have been conducted to help identify the basic biology of the species, sample sizes are insufficient (K. Woodruff, USFS Wildlife Biologist, pers. comm.). Silver-haired bats are known to roost and rear young in bark cavities, live and dead trees, rock crevices, caves or mines, and spaces under siding or tarpaper on buildings (Christy and West 1993). In MSSP, anthropogenic habitat elements such as human infrastructure (buildings) may contribute to silver-haired bat roosting habitat, but that is not known. Since no caves or mines are known to exist in MSSP, we excluded these variables. Cavities in live or dead trees or rock crevices are probably the most important habitat elements for bat roost sites in MSSP. Scree / Boulder / Talus Field cover type may provide the rock crevices needed for roosting bats in MSSP.

Table 50. Habitat elements for silver-haired bat breeding/parturition and roosting.

Variables	Parameters
Cover type	Conifer Woodland / Meadow, Conifer Woodland / Shrubland, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Upland Conifer Forest, Wetland Conifer Woodland / Shrubland, Scree / Boulder / Talus Field
Rock crevices	Present
Forest successional stage	Young to old-growth
Tree or snag diameter	Large
Tree or snag height	Protruding above forest canopy
Snag/tree cavities	Present
Human infrastructure	Siding spaces on buildings

Foraging Habitat Elements

Silver-haired bats are opportunistic feeders, eating a variety of moths, flies, beetles, and other insects (Whitaker et al. 1977). They are one of the slowest flying bats, using echolocation to pursue their prey over short distances. Silver-haired bats are highly maneuverable, and utilize small clearings for foraging forays to opportunistically feed on swarms of insects, sometimes very close to the ground (Barclay 1985).

Many studies have documented that old-growth forest stands provide better foraging opportunities adjacent to roosting habitat, and that bat activities decline dramatically under clear-cut and secondary growth conditions (Crampton and Barclay 1998, Parker et al. 1996, Perkins and Cross 1988, Thomas 1988). Silver-haired bats have been documented foraging in riparian habitat, and in deciduous forests and woodlands (Parker et al. 1996, Crampton and Barclay 1998, Kalcounis et al. 1999). Even though silver-haired bat foraging activity is thought to decrease in clearcuts and secondary forests, there is insufficient data to assume they do not use these areas. In MSSP, all cover types may potentially be used for silver-haired bat foraging. Mature to old-growth forests with canopy gaps may be important foraging habitat elements for silver-haired bats in MSSP.

Water bodies with larger surface areas are typically needed for larger species of bats to collect drinking water while in flight, however Betts (1996) found both silver-haired bats and hoary bats using small to large intermittent streams for foraging and travel. Lactating females have high water consumption requirements, making water access important during foraging (Cross 1986). In MSSP, all small to large water bodies and stream corridors may contribute important foraging habitat for silver-haired bats.

Table 51. Habitat elements for silver-haired bat foraging.

Variables	Parameters
Cover type	Blowdown - Shrubland, Conifer Woodland / Meadow, Conifer Woodland / Shrubland, Developed, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Riparian Developed, Riparian Shrubland, Rock Outcrop, Scree / Boulder / Talus Fields, Shrubland / Meadow, Shrubland, Upland Conifer Forest, Upland Meadows, Wetland Conifer Woodland / Shrubland
Stream corridors	Present
Water bodies	Present
Forest successional stage	Mature to old-growth
Horizontal canopy structure	Forest gaps present

Risk Factors

Several risk factors have been identified in the literature to have an adverse and negative impact on forest bat species' habitats and/or their prey base. These include impacts from human management activities include forestry and heavy grazing practices, direct human disturbance, roads and associated firewood harvesting, and pesticide use.

Forest conversion and streamside disturbances have degraded and fragmented riparian vegetation, negatively impacting the shrub-herbaceous wetland/riparian foraging areas for the hoary and silver-haired bats (Wisdom et al. 2000). Harvest regimes that decrease tall and large snag and trees reduce potential breeding and roosting sites; many studies have documented that old-growth provides summer roosting and foraging habitat, and bat activities decline dramatically under secondary growth and clearcut conditions (Crampton and Barclay 1998, Parker et al. 1996, Perkins and Cross 1988, Thomas 1988).

Grazing is another management activity with potential adverse impacts on habitat and insect prey of bat species (Clark 1988, Nagorsen and Brigham 1993). To sustain bat populations in grazed forests, old stands must be retained and roost sites preserved by managing the forest at the stand or landscape level (Crampton and Barclay 1998).

Human disturbance activities can cause abandonment of bat roosts and increase mortality when bats come out of torpor. Known colonies of bats should be monitored and human activities withheld from known areas to ensure roosting and nursery colony protection (Wisdom et al. 2000). Roads may facilitate harvest of snags for collection as firewood, affecting roosting habitat for bat species. Forest roads should be closed if not in use, or have fuel wood regulations actively enforced to minimize removal of large and remnant trees, and maintain sufficient numbers and distributions (Wisdom et al. 2000).

Pesticide use has been linked to declines of insect species, and may negatively affect hoary and silver-haired bats by reducing food supplies and subjecting them to contaminated prey (Clark 1981). Also, direct contact with relatively short-lived organophosphates can kill bats during application (Clark 1988).

References

Barclay, R.M.R. 1985. Long-range versus short-range foraging strategies of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats and the consequences for prey selection. Canadian Journal of Zoology 63:2507-2515.

Barclay, R.M.R. 1986. The echolocation calls of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats as adaptations for long- versus short-range foraging strategies and the consequences for prey selection. Canadian Journal of Zoology 64:2700-2705.

Betts, B.J. 1996. Roosting behaviour of silver-haired bats (*Lasionycteris noctivagans*) and big brown bats (*Eptesicus fuscus*) in northeast Oregon. Bats and Forests Symposium 23:55.

Betts, B.J. 1998. Roosts used by maternity colonies of silver-haired bats in northeastern Oregon. Journal of Mammalogy 79:643-650.

Christy, R.E., and S.D. West. 1993. Biology of bats in Douglas-fir forests. *In*: Huff, M.H., R.M. Holthausen, and K.B. Aubry, eds. Biology and management of old-growth forests. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-308. 28 pp.

Clark, D.R. 1988. Environmental contaminants and the management of bat populations in the United States. Pp 409-413. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-166.

Clark, D.R. 1981. Bats and environmental contaminants: a review. Department of the Interior, Fish and Wildlife Service, Washington, DC. Special Report on Wildlife 235. 27 pp.

Crampton, L.H., and R.M.R. Barclay. 1998. Selection of roosting and foraging habitat by bats in different-aged aspen mixed-wood stands. Conservation Biology 12:1347-58.

Cross 1986. Bats. Pp. 297-517. *In*: Cooperidge, A. Y., R.J. Boyd, H.R. Stuart, eds. Inventory and monitoring of wildlife habitat. Department of the Interior, Bureau of Land Management Service Center, Denver, Colorado.

Kalcounis, M.C., K.A. Hobson, and R.M. Brigham, and K.R. Hecker. 1999. Bat activity in the boreal forest: importance of stand type and vertical strata. Journal of Mammalogy 80:673-682.

Kunz, T.H. 1982. Roosting ecology of bats. *In*: Kunz, T.H., ed. Ecology of bats. Plenum Press, New York, New York. 55 pp.

Nagorsen, D.W., and M.R. Brigham. 1993. Royal British Columbia museum handbook: Bats of British Columbia, Volume 1, The mammals of British Columbia. UBC Press, Vancouver. 164 pp.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Idaho Panhandle National Forest (INPF). 2006. Appendix 9: Species Habitat Estimates for the Idaho Panhandle National Forests. USDA Forest Service, Idaho Panhandle National Forest. 10 pp.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Parks, C.G., E.L, Bull, and T.R. Torgersen. 1997. Field guide for the identification of snags and logs in the Interior Columbia River Basin. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-390. 40 pp.

Parker, D.I., J.A. Cook, and S.W. Lewis. 1996. Effects of timber harvest on bat activity in southeastern Alaska's temperate rainforests. *In*: Barclay, M.R., and R.M. Brigham, eds. Bats and forests symposium, held October 19-21, 1995. Victoria, British Columbia.

Perkins, J. M., and S. P. Cross. 1988. Differential use of some coniferous forest habitat by hoary and silver-haired bats in Oregon. Murrelet 69:21-24.

Rolseth, S.L., C.E. Koehler, and R.M.R. Barclay. 1994. Differences in the diets of juvenile and adult hoary bats, *Lasiurus cinereus*. Journal of Mammology 75:394-398.

Shump, K.A., and A.U. Shump. 1982. Mammalian species, *Lasiurus cinereus*. The American society of Mammologists 185:1-5.

Thomas, J.W., and S.D. West. 1991. Forest age associations of bats in the Washington Cascades and Oregon Coast Ranges. Pp. 295-303. *In*: Ruggiero, L.F., D.B. Aubrey, A.B. Carey, and M.H. Huff, eds. Wildlife and vegetation of unmanaged Douglas-fir forests. USDA Forest Service. General Technical Report PNW-GTR-285. 533 pp.

Thomas, D.W. 1988. The distribution of bats in different ages of Douglas-fir forests. Journal of Wildlife Management 52:619-26.

Van Zyll de Jong, C.G. 1985. Handbook of Canadian Mammals. Volume 2. Bats. National Museums of Canada, Ottawa, Ontario. 212 pp.

Wisdom, M.J., R.S. Holthausen, B.C. Wales, C.D. Hargis, V.A. Saab, D.C. Lee, W.J. Hann, T.D. Rich, M.M. Rowland, W.J. Murphy, and M.R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale rends and management implications. *In*: Quigley, T.M., ed. Interior Columbia Basin ecosystem management project: scientific assessment. USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-485:1-529.

Whitacker, J.O., C. Maser, and L.E. Keller. 1977. Food habitats of bats of western Oregon. Northwest Science 51:46-55.

Hoary Bat *(Lasiurus cinereus)*

The hoary bat is considered one of the larger bats inhabiting the forests of the Pacific Northwest, and is easily distinguished from the smaller *Myotis*, or mouse-eared bats. Hoary bats are the most widespread of all American bats, ranging from Canada to Guatemala, throughout South America, and even in Hawaii (Shump and Shump 1982). They are unique in that they are foliage roosters, meaning they roost on branches of trees, using the foliage and height of their roost to disguise and protect themselves from predators.

Hoary bats are local summer residents of the Interior Columbia Basin, ranging throughout Oregon, Washington and Idaho (Wisdom et al. 2000). They are considered rare and/or uncommon in Washington State. They are thought to migrate out of the Columbia Basin during winter months, most likely due to sensitivity to cold environmental conditions and a lack of available food resources (Wisdom et al. 2000). Migration distances and routes have not been determined, but they are thought to leave Washington State by September and return in July the following year (Shump and Shump 1982). Hoary bats are not known to return to Washington State until after the birthing and rearing seasons in June and July (Thomas and West 1991). Therefore hoary bats are probably limited to using habitat for foraging and as dayroost sites in Mount Spokane State Park.

Distribution In MSSP

Hoary bats are known to forage and roost in and around Mount Spokane State Park. Museum records also exist in the area (Johnson and Cassidy 1997).

Existing Habitat Models

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Day-Roosting Habitat Elements

Roost site requirements for hoary bats are hypothesized to exist in old-growth conifer forests (Perkins and Cross 1988). Existing studies on hoary bats have found activity levels in old-growth forests to be significantly higher than in young or mature forests (Crampton and Barclay 1998, Parker et al. 1996, Perkins and Cross 1988, Thomas 1988). This is probably due to the greater abundance of large, old trees that meet the species specific roosting requirements (Christy and West 1993, Perkins and Cross 1988). Older conifer forests also provide the proper combination of shelter, open space, and accessibility required by these large bats for flight space and roosting (Perkins and Cross 1988). However, since little mist netting has been done to assess presence of hoary bats throughout all habitats in MSSP, there is not clear evidence of specific cover types to identify hoary bat roosting habitat in the park (K. Woodruff, USFS Wildlife Biologist, pers. comm.). In MSSP, young to old-growth forests may provide adequate roosting habitat for the species, however mature to old-growth forests with large trees most likely provide the best roosting conditions.

Hoary bats have been documented using a variety of conifer and riparian habitats for roosting (Wisdom et al. 2000, Betts 1996, Crampton and Barclay 1998). Since they are foliage roosters and roost in all levels of the canopy (Shump and Shump 1982, Christy and West 1993), older coniferous forests are likely to provide crowns that begin higher off the ground and have needles more concentrated toward the edge of the canopy (Perkins and Cross 1988). Furthermore, hoary bats are the only species of bat not found to roost in human-made structures. In MSSP, hoary bat roosting habitat may occur in Upland Conifer Forests, Riparian Conifer Forests, and all Conifer and Riparian Woodlands (H. Ferguson, WDFW Wildlife Biologist, pers. comm.). Field studies are limited both temporally and spatially throughout the northwest, and thus important habitats for roosting may be left out in this description (K. Woodruff, USFS Wildlife Biologist, pers. comm.).

Some data has been collected on conifer forest canopy cover by Betts (1998). He found the average forest canopy cover around roost trees was 41.5 ± 11.9 %, however sample sizes were small. Another hypothesis is that hoary bats utilize edge habitat for roost sites, which puts them nearer to forest openings for foraging forays (Shump and Shump 1982, Perkins and Cross 1988). Further research on hoary bat roosting habitat is needed to clarify the details associated with vegetation community characteristics at MSSP,

Table 52. Habitat elements for hoary bat day-roosting.

Variables	Parameters
Cover type	Upland Conifer Forest, Riparian Conifer Forest, Conifer Woodland / Meadow, Conifer Woodland / Shrubland, Riparian Conifer Woodland / Shrubland, Wetland Conifer Woodland / Shrubland
Forest successional stage	Mature to old-growth
Large trees	Present

Foraging Habitat Elements

Hoary bats are large rapid fliers and are relatively unmaneuverable (Barclay 1985). They eat larger moths, beetles, mosquitoes, dragonflies, and other prey which can be caught aerially or gleaned from the ground or foliage (Barclay 1985, 1986, Rolseth et al. 1994, Shump and Shump 1982, Whitaker et al.1977). These bats rely on their vision as well as lower-frequency echolocation calls when hunting (Van Zyll de Jong 1985). Their foraging flights are typically high over the water or ground surface. These attributes make hoary bats more efficient foragers in open habitats (Christy and West 1993, Rolseth et al. 1994, Barclay 1985). They are commonly found foraging along forest edges, roads, or open areas within the forest (Van Zyll de Jong 1985, Barclay 1985, Shump and Shump 1982, Perkins and Cross 1988). In MSSP, meadows, forest edges, forest openings, and roads may provide open areas for foraging hoary bats.

Many studies have documented that old-growth forest stands provide foraging opportunities adjacent to roosting habitat, and that bat activities decline dramatically under clearcut and secondary growth conditions (Crampton and Barclay 1998, Parker et al. 1996, Perkins and Cross 1988, Thomas 1988). Within old-growth forests, hoary bats can be found foraging in riparian habitat, and deciduous forests and woodlands (Parker et al. 1996, Crampton and Barclay 1998, Kalcounis et al. 1999). All mapped cover types in MSSP may provide suitable foraging habitat for hoary bats. However, for forested cover types, only mature to old-growth forests provide suitable habitat.

Water bodies with larger surface areas are typically needed for larger species of bats to collect drinking water while in flight, however Betts (1996) found hoary bats using small to large intermittent streams for foraging and travel. Lactating females have higher water consumption requirements (Cross 1986). In MSSP, water bodies and stream corridors likely provide an important habitat features for foraging hoary bats.

Table 53. Habitat elements for hoary bat foraging.

Variables	Parameters
Cover type	All cover types
Stream corridors	Present
Water bodies	Present
Forest successional stage	Mature to old-growth
Forest edges	Present
Horizontal canopy structure	Forest gaps present

Risk Factors

Several risk factors have been identified in the literature to have an adverse and negative impact on forest bat species' habitats and/or their prey base. Impacts can be negative from human management activities include forestry and heavy grazing practices, direct human disturbance, roads and associated firewood harvesting, and pesticide use.

Forest conversion and streamside disturbances have degraded and fragmented riparian vegetation, negatively impacting the shrub-herbaceous wetland/riparian foraging areas for the hoary and silver-haired bats (Wisdom et al. 2000). Harvest regimes that decrease tall and large snag trees reduce potential breeding and roosting sites. Many studies have documented that old-growth provides summer roosting and foraging habitat, and bat activities decline dramatically under secondary growth and clearcut conditions (Crampton and Barclay 1998, Parker et al. 1996, Perkins and Cross 1988, Thomas 1988).

Grazing is another management activity with potential adverse impacts on habitat and insect prey of bat species (Clark 1988, Nagorsen and Brigham 1993). To sustain bat populations in grazed forests, old stands must be retained and roost sites preserved by managing the forest at the stand or landscape level (Crampton and Barclay 1998).

Human disturbance activities can cause abandonment of bat roosts and increase mortality when bats come out of torpor. Known colonies of bats should be monitored and human activities withheld from known areas to ensure roosting and nursery colony protection (Wisdom et al. 2000). Roads may facilitate harvest of snags for collection as firewood, adversely affecting roosting habitat for bat species. Forest roads should be closed if not in use, or have fuel wood regulations actively enforced to minimize removal of large and remnant trees, and maintain sufficient numbers and distributions (Wisdom et al. 2000).

Pesticide use has been linked to declines of insect species, and may negatively affect hoary and silver-haired bats by reducing food supplies and subjecting them to contaminated prey (Clark 1981). Also, direct contact with relatively short-lived organophosphate pesticides can kill bats during application (Clark 1988).

References

Barclay, R.M.R. 1985. Long-range versus short-range foraging strategies of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats and the consequences for prey selection. Canadian Journal of Zoology 63:2507-2515.

Barclay, R.M.R. 1986. The echolocation calls of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats as adaptations for long- versus short-range foraging strategies and the consequences for prey selection. Canadian Journal of Zoology 64:2700-2705.

Betts, B.J. 1996. Roosting behaviour of silver-haired bats (*Lasionycteris noctivagans*) and big brown bats (*Eptesicus fuscus*) in northeast Oregon. Bats and Forests Symposium 23:55.

Betts, B.J. 1998. Roosts used by maternity colonies of silver-haired bats in northeastern Oregon. Journal of Mammalogy 79:643-650.

Christy, R.E., and S.D. West. 1993. Biology of bats in Douglas-fir forests. *In*: Huff, M.H., R.M. Holthausen, and K.B. Aubry, eds. Biology and management of old-growth forests. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-308. 28 pp.

Clark, D.R. 1988. Environmental contaminants and the management of bat populations in the United States. Pp 409-413. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-166.

Clark, D.R. 1981. Bats and environmental contaminants: a review. Department of the Interior, Fish and Wildlife Service, Washington, DC. Special Report on Wildlife 235. 27 pp.

Crampton, L.H., and R.M.R. Barclay. 1998. Selection of roosting and foraging habitat by bats in different-aged aspen mixed-wood stands. Conservation Biology 12:1347-58.

Cross 1986. Bats. Pp. 297-517. In: Cooperidge, A. Y., R.J. Boyd, H.R. Stuart, eds. Inventory and monitoring of wildlife habitat. Department of the Interior, Bureau of Land Management Service Center, Denver, Colorado.

Johnson, R.E. and K.M. Cassidy. 1997. Mammals of Washington State: Location data and modeled distributions. Volume 3 of the Washington State Gap Analysis Final Report. Washington Cooperative Fish and Wildlife Research Unit, Univ. of Washington, Seattle, WA

Kalcounis, M.C., K.A. Hobson, and R.M. Brigham, and K.R. Hecker. 1999. Bat activity in the boreal forest: importance of stand type and vertical strata. Journal of Mammalogy 80:673-682.

Kunz, T.H. 1982. Roosting ecology of bats. *In*: Kunz, T.H., ed. Ecology of bats. Plenum Press, New York, New York. 55 pp.

Nagorsen, D.W., and M.R. Brigham. 1993. Royal British Columbia museum handbook: Bats of British Columbia, Volume 1, The mammals of British Columbia. UBC Press, Vancouver. 164 pp.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Idaho Panhandle National Forest (INPF). 2006. Appendix 9: Species Habitat Estimates for the Idaho Panhandle National Forests. USDA Forest Service, Idaho Panhandle National Forest. 10 pp.

Parks, C.G., E.L, Bull, and T.R. Torgersen. 1997. Field guide for the identification of snags and logs in the Interior Columbia River Basin. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. General Technical Report PNW-GTR-390. 40 pp.

Parker, D.I., J.A. Cook, and S.W. Lewis. 1996. Effects of timber harvest on bat activity in southeastern Alaska's temperate rainforests. *In*: Barclay, M.R., and R.M. Brigham, eds. Bats and forests symposium, held October 19-21, 1995. Victoria, British Columbia.

Perkins, J. M., and S. P. Cross. 1988. Differential use of some coniferous forest habitat by hoary and silver-haired bats in Oregon. Murrelet 69:21-24.

Rolseth, S.L., C.E. Koehler, and R.M.R. Barclay. 1994. Differences in the diets of juvenile and adult hoary bats, *Lasiurus cinereus*. Journal of Mammology 75:394-398.

Shump, K.A., and A.U. Shump. 1982. Mammalian species, *Lasiurus cinereus*. The American society of Mammologists 185:1-5.

Thomas, J.W., and S.D. West. 1991. Forest age associations of bats in the Washington Cascades and Oregon Coast Ranges. Pp. 295-303. *In*: Ruggiero, L.F., D.B.

Aubrey, A.B. Carey, and M.H. Huff, eds. Wildlife and vegetation of unmanaged Douglas-fir forests. USDA Forest Service. General Technical Report PNW-GTR-285. 533 pp.

Thomas, D.W. 1988. The distribution of bats in different ages of Douglas-fir forests. Journal of Wildlife Management 52:619-26.

Van Zyll de Jong, C.G. 1985. Handbook of Canadian Mammals. Volume 2. Bats. National Museums of Canada, Ottawa, Ontario. 212 pp.

Wisdom, M.J., R.S. Holthausen, B.C. Wales, C.D. Hargis, V.A. Saab, D.C. Lee, W.J. Hann, T.D. Rich, M.M. Rowland, W.J. Murphy, and M.R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale rends and management implications. *In*: Quigley, T.M., ed. Interior Columbia Basin ecosystem management project: scientific assessment. USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-485:1-529.

Whitacker, J.O., C. Maser, and L.E. Keller. 1977. Food habitats of bats of western Oregon. Northwest Science 51:46-55.

Species Summaries – Other Species

Western Toad *(Bufo boreas)*

The Western toad is the most widely distributed amphibian in western North America (Cambell 1970). Its range extends from the western United States northward into Canada and Alaska. However populations have been declining and are imperiled in the south-eastern extent of their range. The species is found in a wide variety of habitats, ranging from desert springs to mountainous wetlands, and they range into a variety of upland habitats around ponds, lakes, reservoirs, and slow-moving streams. Within these habitats, western toads use microhabitats such as small, moist patches of soil at the base of trees, burrows under logs and within stumps, rodent burrows, dense ground cover, and tree root tangles (Davis 2000). Western toads are considered semi-aquatic, and migrate locally and seasonally between aquatic breeding and terrestrial non-breeding habitats. They are also fossorial, digging their own burrows for winter hibernation in loose soils, shelters, or under logs and rocks.

Breeding grounds consist of waterbodies such as shallow ponds and lake margins, where eggs and larvae can develop. Eggs are single-file long jelly strings, resembling strings of black beads, which are wound around and entwined in pre-emergent vegetation. These strings can cover an extensive area and be up to 30 feet in length, in masses of up to 16,500 eggs per clutch (Stebbins 1951). Western toad tadpoles congregate in masses of up to millions of individuals, which act as important converters of biomass and a tremendous prey source for other animals (Wind and Dupuis 2002; Davis 2000). Young larvae filter suspended plant material in wetlands and waterbodies for food, or feed on bottom detritus.

Females lay their eggs in early spring after they reach sexual maturity at five or six years of age (Carey et al 2005). After breeding activity, female western toads make long-distance movements which are largely terrestrial, presumably to foraging sites that satisfy the energetic demands of egg production (Carey et al. 2005). Males on the other hand, have smaller home ranges that often are closer to water sources and breeding sites (Muths 2003, Bartelt et al. 2004). Adult toads are opportunistic feeders on invertebrates and occasionally small mammals (Nussbaum et al. 1983, Davis 2000). Their diet consists largely of bees, beetles, ants, and arachnids.

Western toads hibernate for three to six months (Wind and Dupuis 2002), burrowing deep enough into the soil to prevent freezing and provide moisture to prevent desiccation (Wind and Dupois 2002). Their body temperature is closely correlated with substrate temperatures, and they therefore utilize high water tables, a constantly flowing stream, and/or deep winter snow to maintain air temperatures above freezing within the hibernaculum (Campbell 1970).

Due to a lack of specific habitat elements cited in the literature, we did not create a habitat element matrix for winter hibernation for western toads.

Distribution In MSSP

The western toad is a regular occupant of Mount Spokane State Park.

Existing Habitat Models

Pearson, K. J. 2004. Habitat suitability index model for the western toad (*bufo boreas*). Pp. 148-159. *In*: Blouin, F., B.N. Taylor, and R.W. Quinlan (eds). 2004. The southern headwaters at risk project: A multi-species conservation strategy for the headwaters of the Oldman River. Volume 2: Species Selection and Habitat Suitability Models. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 90, Edmonton, AB.

Dvornich, K. M., K. R. McAllister, and K. B. Aubry. 1997. Amphibians and Reptiles of Washington State: Location Data and Predicted Distributions. Pp. 146. *In* K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich (Eds.), Washington State Gap Analysis - Final Report, Vol. 2. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, Washington.

Breeding/Metamorphosis Habitat Elements

Western toads breed in aquatic habitats including a variety of water bodies such as warm, shallow ponds or lake margins. Perennial lakes and oxbows are highly suitable for breeding western toads (Pearson 2004), and ephemeral water bodies may be used if the water lasts long enough into the season for full metamorphosis. Typically, water bodies (excluding rivers) which are greater than 200 hectares (494 acres) in size are considered to be of no habitat value to western toads because they lack suitable egg-laying habitat, substrates, and/or are prone to fish impacts such as disease or increased predation (Kats et al. 1988), and disturbances such as motor boats and high winds (Pearson 2004). In MSSP, all water bodies (excluding rivers) less than 494 acres in size may provide suitable breeding habitats for western toads.

Water bodies suitable for western toad breeding are shallow, with a preference for relatively warm water temperatures (Hossack and Corn 2007). Temperature is greatly affected by solar exposure and the amount of forest cover over the waterbody. Higher pond temperatures increase breeding activity, and larval metamorphosis rates (Pyare et al. 2005). Open habitats such as those resulting from severe stand-replacing fires provide beneficial habitat due to greater sun exposure and increased water temperatures, and may indirectly facilitate increased breeding activity (Guscio et al. 2007). Wetlands with temperatures above 36° C (96.8° F) at the 5-cm (2 inches) depth are considered lethal to tadpoles (Karlstrom 1962; Beiswenger 1978). Hossack and Corn (2007) found occupied and colonized wetlands well below this temperature. Eggs are usually deposited in shallow water less than 50 cm (20 inches) deep (Wind and Dupois 2002), but usually deeper than 15 cm (6 inches, Sullivan 1994). In MSSP, water bodies with areas of water depth less than 20 inches but at least 6 inches deep, and water temperatures at the 2 inch depth of less than 97° F should provide suitable habitat for western toad oviposition and tadpole rearing.

Vegetation and coarse woody debris are critical components of western toad breeding ponds. Strings of eggs are laid in the shallow waters entwined around submerged vegetation, and tadpoles require adequate vegetation or woody debris for cover and foraging (COSEWIC 2003, Sullivan 1994). Pyare et al. (2005) found 35% floating, 59% emergent, and 40% submerged vegetation in occupied western toad ponds in southwest Alaska. Waterbodies with pre-emergent, floating and emergent vegetation and/or woody debris in MSSP should provide suitable western toad breeding habitat. There is not enough information from the literature to designate the amount and/or types of aquatic vegetation or woody debris required for suitable breeding toad habitat.

Table 54. Habitat elements for western toad breeding/metamorphosis.

Variables	Parameters
Water bodies	Present
Water body depth	6 - 20 inches
Water body size	< 494 acres
Water body temperature	< 97° F at 2 inches deep
Aquatic Vegetation	Pre-emergent and emergent vegetation present
Coarse woody debris	Present

Migration and Foraging Habitat Elements

The non-breeding life cycle for western toads encompasses seasonal migratory movements away from and back to the breeding pond for summer foraging and winter hibernation. Observations and research of western toad movements indicate a wide variety of dispersal distances from the breeding pond. Maximum western toad adult dispersal distances are recorded up to 2-6 km (1.2-3.7 miles), however most movements are within 1000 meters (3280 ft) from the breeding pond (Bartelt et al. 2004; Muths 2003; Bull 2006).

While adult western toads are known to travel these lengthy distances within suitable habitat, juvenile toadlets are only known to disperse up to 300 m (984 ft) from their natal pond in search of upland terrestrial or wetland habitats (Davis 2000). Management recommendations have focused on protecting a buffer surrounding breeding ponds, with buffers varying from 150 to 721 meters (492-2365 ft) based on habitat and individual population movements (Bartelt et al. 2004, Muths 2003, Pearson 2004). Muths (2003) reports that 92% of distances moved from breeding sites were within a 700 m (2297 ft) distance. In MSSP, the conservative approach without field derived data would be to consider areas within 3280 ft of a potential breeding pond to be suitable habitat for adult and juvenile movements. Southern, eastern, and western aspects are also important habitat elements based on male and female movement preferences (Bartelt et al. 2004, Bull 2006).

Both juvenile dispersers and adult toads utilize streams as travel corridors, and seeps and riparian habitat in montane forests serve as critical summer growth sites (Schmetterling and Young 2008). In MSSP, all riparian cover types and stream corridors should provide suitable habitat for western toad migration and summer foraging sites.

Coarse woody debris is considered favorable to western toads, as it provides good foraging opportunities for ants and small mammals, as well as adequate microsite habitat with cover, humidity, and moisture (Bartelt et al. 2004). In MSSP, areas with downed woody debris should provide suitable habitat for western toads, however the literature reviewed did not document an amount or type of woody debris necessary for toad movements and foraging habitat.

While thermal cover and moisture conditions are needed for western toad movements, too much canopy cover (although it provides moisture) may provide too little solar radiation for toads to achieve preferred body temperatures (Bartelt 2000). Adult toads prefer open habitats over closed canopy coniferous forest (Bull 2006). Bartelt et al. (2004) found that female toads were in open forests (< 50 % canopy cover) more frequently than closed forests. In MSSP, western toads have been seen in denser forest canopies up to 75% canopy cover (H. Ferguson, WDFW Biologist, pers. comm.). Upland conifer forests with forest canopy cover less than 75 percent should provide suitable habitat for toad foraging and dispersal.

Besides the open forest canopy, western toads are found to extensively use terrestrial habitats dominated by shrub cover (Bartelt et al. 2004, Pearson 2004), wet meadows, and uplands (Muths 2003). Some studies have also shown a preference for open habitats associated with recently disturbed landscapes such as wildfire events (Guscio et al. 2007, Hossack and Corn 2007). Other cover types which may allow toad movements in MSSP include shrubland, upland meadow, and wetland/ shrubland cover types. Forest edges and very young forests associated with recent disturbance events may also provide shrubby habitat for terrestrial toad movements and foraging. Toads have also been seen underneath human buildings and associated with other human debris, therefore human infrastructure may provide additional habitat in MSSP (H. Ferguson pers. comm.).

Table 55. Habitat elements for western toad migration and foraging.

Variables	Parameters
Aspect	Westerly, Easterly, Southerly
Stream corridors	Present
Forest canopy cover	< 75%
Coarse woody debris	Present
Distance from breeding ponds	< 3280 feet

Risk Factors

Western toad populations have been declining throughout their range, however precipitous declines and in some cases extirpation, are documented in portions of the Rocky Mountains and on Vancouver Island (Carey 1993, Davis 2000). The specific causes of such declines have not been positively identified, but research suggests disease, fungal pathogens, habitat modification, susceptibility to UV radiation, predation, and / or presence of introduced salmonids (Wind and Dupuis 2002; Davis 2000; Carey 1993).

Disease and fungal pathogens have been documented as contributing to the decline of western toad and other amphibian populations. A combination of environmental factors or synergistic effects is hypothesized to stress toads, causing immune system depression, fungal outbreaks, and indirectly causing immunosuppression (Carey 1993) and chytridiomycosis (Leoffler 2000, Muths et al. 2003). Fungi are also thought to be introduced during fish stocking (Kiesecker and Blaustein 1997). Infections caused by fungal outbreaks are decreasing the species ability to fight disease and other infectious agents (Carey 1993). Eggs and adult toads are highly susceptible to fungal pathogens, which are leading to crashes of western toad metapopulations and hence extirpation of populations in many western states (Muths et al. 2003).

Although there is a significant ongoing debate about the causes of global amphibian declines, there is now a virtual consensus among scientists that the status of amphibians is loosely tied to ecological integrity of systems (Pyare et al. 2005). Habitat destruction and degradation may be partly responsible for amphibian declines (Chen et al. 1993, Carey et al. 1999). Because western toads utilize terrestrial habitat adjacent to breeding ponds for much of their life cycle, activities such as logging and human development that cause large changes in thermal and moisture conditions of the forest, and alter or remove habitat adjacent to breeding sites, have been identified as potentially detrimental to western toad populations. These activities also limit the environment available for dispersing individuals (Rothermel and Semlitsch 2002).

Ecological integrity of amphibian ecosystems is also tied to global warming impacts. Changes in environmental conditions, temperatures, and increased intensity of fire regimes have the potential to change the physical and biological interactions of wetlands on western toads. Specific interactions include timing of breeding, growth and development rates, timing of emergence from hibernation, and fertility rates (Hossack and Corn 2007). Global warming also poses another possibility for decline related to the sensitivity of eggs to increased levels of ultraviolet radiation (Blaustein et al. 1994).

Predation has been observed and hypothesized to increase from introductions of fish species, water impoundment projects, and land-uses that increase predator activity in an area. In the Cascade Range of Oregon, persistent predation of adult western toads by ravens during the breeding season appears to have contributed significantly to some population declines (Olson 1992). Predation by ravens has also been observed in Colorado and Idaho (Olson 1989, Brothers 1994).

Insufficient buffers may be a critical component of habitat loss for western toads, as ski area expansion is cited as an example of detrimental development occurring in habitats occupied by the boreal toad, which is a subspecies of the western toad (Muths 2003). Muths (2003) describes the detrimental effects of infrastructural support such as lift operations, lodging, residences, food services and parking facilities on boreal toad habitat, and claims that the minimal setback requirements from wetlands is insufficient for protecting the species. Similarly, Goates et al. (2007) found standard implementation of 30.5 meter buffers did not protect all critical habitats for boreal toads, especially because many small streams and seeps used by toads were outside of buffer zones. Wetland buffers set by regulatory entities did not protect meadow, upland, and stream habitats intensively used by boreal toads outside of their breeding pond habitat. Furthermore, unsuitable habitat such as developments, urbanized areas dominated by buildings and pavement, and major road systems, can play a role in creating non-permeable barriers to toad movements.

References

Bartelt, P.E., C.R. Peterson, and R.W. Klaver. 2004. Sexual differences in the post-breeding movements and habitats selected by western toads (*Bufo boreas*) in southeastern Idaho. Herpetologica 60:455-467.

Bartelt, P.E. 2000. A biophysical analysis of habitat selection in western toads (*Bufo boreas*) in southeastern Idaho. Ph.D. Thesis, Idaho State University, Pocatello, Idaho.

Beiswenger, R.E. 1978. Responses of *Bufo* tadpoles (Amphibia, Anura, Bufonidae) to laboratory gradients of temperature. Journal of Herpetology 12:499-504.

Blaustein, A.R., D.G. Hokit, R.K. O'Hara, and R.A. Holt. 1994. Pathogenic fungus contributes to amphibian losses in the Pacific Northwest. Biological Conservation 67:251-254.

Brothers, D.R. 1994. *Bufo boreas* (western toad) predation. Herpetological Review 25:117.

Bull, E. 2006. Sexual differences in the ecology and habitat selection of western toads (*Bufo boreas*) in northeastern Oregon. Herpetological Conservation and Biology. 1:27-38.

Campbell, J.B. 1970. Hibernacula of a population of *Bufo boreas boreas* in the Colorado Front Range. Herpetologica. 26:278-282.

Carey, C. 1993. Hypothesis concerning the causes of the disappearance of boreal toads from the mountains of Colorado. Conservation Biology 7:355-362.

Carey, C.C., N. Cohen, and L. Rollins-Smith. 1999. Amphibian declines: an immunological perspective. Developmental and Comparative Immunology 23:459-472.

Carey, C., P.S. Corn, M.S. Jones, L.J. Livo, E. Muths, and C.W. Loeffler. 2005. Factors limiting the recovery of boreal toads (*Bufo b. boreas*). Pp. 222-236. *In*: Lannoo, M., ed. Amphibian declines: the conservation status of United States species. Unversity of California Press, Berkeley, California.

Chen, J., J.F. Franklin, and T.A. Spies. 1993. Contrasting microclimates among clearcut, edge, and interior of old-growth Douglas-fir forest. Agricultural and Forest Meteorology 63:219-237.

Corn, P.S. 1993. *Bufo boreas* (boreal toad) predation. Herpetological Review 24:57.

Davis, T.M. 2000. Ecology of the western toad (*Bufo boreas*) in forested areas on Vancouver Island, final report. British Columbia Ministry of Forests, Forest Renewal, Victoria, British Columbia. 28 pp.

Dvornich, K. M., K. R. McAllister, and K. B. Aubry. 1997. Amphibians and Reptiles of Washington State: Location Data and Predicted Distributions. Pp. 146. *In* K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich (Eds.), Washington State Gap Analysis - Final Report, Vol. 2. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, Washington.

Guscio, C.G., B.R. Hossack, L.A. Eby, and P.S. Corn. 2007. Post-breeding habitat use by adult boreal toads (*Bufo boreas*) after wildfire in Glacier National Park, USA. Herpetological Conservation and Biology 3:55-62.

Goates, M.C., K.A. Hatcha, and D.L. Eggett. 2007. The need to ground truth 30.5 m buffers: A case study of the boreal toad (*Bufo boreas*). Biological Conservation 138:474-483.

Hossack, B.R., and P.S. Corn. 2007. Responses of pond-breeding amphibians to wildfire: short-term patterns in occupancy and colonization. Ecological Applications 17:1403-1410.

Hossack, B.R., and P.S. Corn. 2008. Wildfire effects on water temperature and selection of breeding sites by the boreal toad (*Bufo boreas*) in seasonal wetlands. Herpetological Conservation and Biology 3:46-54.

Karlstrom, E.L. 1962. The toad genus *Bufo* in the Sierra Nevada of California: ecological and systematic relationships. University of California Publications in Zoology 62:1-92.

Kats, L.B., J.W. Petranka, and A. Sih. 1988. Antipredator defenses and the persistence of amphibian larvae with fishes. Ecology 69:1865-1870.

Kiesecker, J.M., and A.R. Blaustein 1997. Influences of egg laying behavior on pathogenic infection of amphibian eggs. Conservation Biology 11:214-220.

Leoffler, C. 2000. Report on the status and conservation of the boreal toad, *bufo boreas boreas*, in the southern Rocky Mountains. Colorado Division of Wildlife, Denver, Colorado.

Maxell, B.A. 2000. Management of Montana's amphibians: a review of factors that may present a risk to population viability and accounts on the identification, distribution, taxonomy, habitat use, natural history, and the status and conservation of individual species. University of Montana, Wildlife Biology Program, Missoula, Montana. Report to USFS Region 1, Order Number 43-0343-0-0224. 161 pp.

Muths, E. 2003. Home range and movements of boreal toads in undisturbed habitat. Copeia 2003:160-165.

Muths, E., P.S. Corn, A.P. Pessier, and D.E. Green. 2003. Evidence for disease related amphibian decline in Colorado. Biological Conservation. 110:357-365.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Nussbaum, R.A., E.D. Brodie, and R.M. Storm. 1983. Amphibians and reptiles of the Pacific Northwest. University Press of Idaho, Moscow, Idaho. 332 pp.

Olson, D.H. 1992. Ecological susceptibility of high elevation Oregon anuran amphibians to population fluctuations. Abstract, 6th Annual Meeting of the Society for Conservation Biology. pp. 102.

Olson, D.H. 1989. Predation on breeding western toads (*Bufo boreas*). Copeia 1989:391-397.

Pearson, K. J. 2004. Habitat suitability index model for the western toad (*Bufo boreas*). Pp. 148-159. *In*: Blouin, F., B.N.Taylor, and R.W.Quinlan, eds. The southern headwaters at risk project: A multi-species conservation strategy for the headwaters of the Oldman River. Volume 2: Species Selection and Habitat Suitability Models. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, Alberta. Alberta Species at Risk Report No. 90.

Pyare, S., R.E.Christensen III, R.Carstensen, and M.J. Adams. 2005. Preliminary assessment of breeding site occurrence, microhabitat, and sampling of western toads in Glacier Bay. Pp. 16-19. *In*: Piatt, J.F., and S.M. Gende, eds. Proceedings of the Fourth Glacier Bay Science Symposium, October 26–28, 2004. USGS. Information and Technology Report USGS/BRD/ITR-2007-5047, Washington, D.C.

Rothermel, B.B., and R.D. Semlitsch. 2002. An experimental investigation of landscape resistance of forest vs. old-field habitats to emigrating juvenile amphibians. Conservation Biology 16:1324-1332.

Schmetterling, D.A., and M.K. Young. 2008. Summer movement of boreal toads (*Bufo boreas boreas*) in two western Montana basins. Journal of Herpetology 42:111-123.

Stebbins, R.C. 1951. Amphibians of western North America. University of California Press, Berkeley, California. 539 pp.

Sullivan, J. 1994. *Bufo boreas*. *In*: Fire Effects Information System. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.

U.S. Department of the Interior, Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered or threatened species; proposed rule. 50 CFR Part 17. Federal Register. 59: 58982-59028.

Wind, E, and L.A. Dupuis. 2002. COSEWIC status report on the western toad *Bufo boreas* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario, Canada.

Compton's Tortoiseshell Butterfly *(Nymphalis vau-album)*

The Compton's tortoiseshell butterfly is widely distributed, ranging from southeastern Europe, across Asia and over most of North America, from Alaska to Labrador and south to West Virginia and Utah (Gillam 1956). They are a large and long-lived butterfly, prone to huge bursts in numbers and mass migrations that can take them hundreds of kilometers (or more) from their birthplace (Acorn and Sheldon 2006). They also are known in some years to spend their entire lives in the same small patch of forest (Acorn and Sheldon 2006). Like most butterflies, Compton's tortoiseshell butterfly requires exposure to sun and thus active adults select open habitats such as meadows, forest glades, forest clearings, and riparian areas (A. Potter, WDFW Wildlife Biologist, pers. comm.). They are sometimes found in aggregations around wet spots on the ground (Gillam 1956).

This butterfly lives in areas of deciduous or coniferous forests. Eggs are laid on the leaves of birch, willow and popular trees during late spring. Caterpillars eat the leaves of host plants and emerge from encasing as adult butterflies in the fall. Compton's Tortoiseshell butterflies hibernate under the bark of trees during the winter (Scott 1986). They can also hang among dead leaves, if available, during winter months (Arnett 1985).

Struttman (1997) describes the Compton's Tortoiseshell butterfly as fairly common throughout its habitat, although rare along the edges of its range. Compton's tortoiseshell butterflies are thought to occur in Mt. Spokane State Park. MSSP is known as a Washington State butterfly hotspot because it has a diversity of site conditions including beneficial elevation gradients and plant diversity (A. Potter, WDFW Wildlife Biologist, pers. comm.).

Distribution In MSSP

There is one documented PHS sighting of a Compton's tortoiseshell butterfly on MSSP.

Existing Habitat Models

None

Breeding/Metamorphosis and Foraging Habitat Elements

Like most butterflies that require exposure to sun, active adult Compton's tortoiseshell butterflies select open habitats such as meadows, forest glades, forest clearings, and riparian areas (Pyle et al 2002). Adults feed on sugars from tree sap, scat, rotting fruit, and flower nectar. In the larval stage, Compton Tortoiseshell caterpillars consume leaves of willow (*Salix* spp), quaking aspen (*Populus tremuloides*) or birch (*Betula* spp). Water and paper birch (*Betula occidentalis, B. papyrifera*) are two larval food plants confirmed in southeast British Columbia (Pyle et al. 2002). In MSSP, mapped cover types where Compton's Tortoiseshell butterflies may breed or forage include: Conifer Woodland / Meadow, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Riparian Shrubland, Riparian Developed, Upland Meadow, Shrubland, Shrubland / Meadow, and Wetland Conifer Woodland / Shrubland. Dominant tree or shrub species that would host larval caterpillars include birch, willow and aspen. Stream corridors and forest openings may also provide foraging habitat for Compton's Tortoiseshell butterflies.

Table 56. Habitat elements for Compton's tortoiseshell butterfly breeding/metamorphosis and foraging.

Variables	Parameters
Cover type	Conifer Woodland / Meadow, Riparian Conifer Forest, Riparian Conifer Woodland / Shrubland, Riparian Shrubland, Riparian Developed, Upland Meadow, Shrubland, Shrubland / Meadow, Wetland Conifer Woodland / Shrubland
Stream corridors	Present
Dominant tree or shrub species composition	Willow, birch, aspen
Horizontal canopy structure	Forest gaps present

Risk Factors

There are no documented risks in the reviewed literature associated with Compton's Tortoiseshell butterflies.

References

Acorn, J. and I. Sheldon. 2006. Butterflies of B.C. Lone Pine Publishing. Edmonton, AB. Canada.

Arnett. R. 1985. American Insects. New York: Van Nostrand Reinhold Company *in* Diversity Web, University of Michigan Museum of Zoology. Accessed online: http://animaldiversity.ummz.umich.edu/site/accounts/information/Nymphalis_vau-album.html

Gillam, N. W. 1956. Nymphalis vau-album (Schiffermuller & Denis), A Holarctic Species (Lepidoptera : Nymphalidae). Psyche 63:27-29.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. (Available online: http://www.natureserve.org/explorer, Accessed: June 28, 2008).

Pyle, R. M., I. Ulsh, and D. Nunnallee. 2002. The Butterflies of Cascadia: A Field Guide to All the Species of Washington, Oregon, and Surrounding Territories. Seattle Audubon Society

Scott, J. A. 1986. Butterflies of North America. Stanford, California: Standford University Press *in* Diversity Web, University of Michigan Museum of Zoology. Accessed online: http://animaldiversity.ummz.umich.edu/site/accounts/information/Nymphalis_vau-album.html

References

Cooper, D. B., K.E. Neiman, and D.W. Roberts. 1991. Forest Habitat Types of Northern Idaho: A Second Approximation. USDA USFS. GTR INT-236. 143 pp.

Crawford, R. 1993 Washington State Parks Natural Forest Inventory – Mt. Spokane.

Morrison, P.H., H.M. Smith IV, G.F. Wooten and S.D. Snetsinger. 2007. Forest Health Assessment and Plan for the 2006-2007 project area of Mount Spokane State Park. Pacific Biodiversity Institute, Winthrop, Washington. 370 p. + one 406 pp. Appendix (PDF)

Smith, H.M. IV and P.H. Morrison. 2009. Description of the Habitat Unit Map for Mount Spokane State Park. Pacific Biodiversity Institute, Winthrop, Washington. 9 pp.

Williams, C.K., B.F. Kelley, B.G. Smith, and T.R. Lillybridge. 1995. Forested plant association of the Colville National Forest. USDA USFS Gen Tech Report PNW-GTR-360. Portland, OR. 140 pp.

Appendix A. Wildlife Species Conservation Status

COMMON NAME	SCIENTIFIC NAME	CLASS	IUCN RED LIST	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS	WDFW PHS	COSEWIC
American Marten	*Martes americana*	Mammalia	LC	G5	S4	–	–	regular occurrence	–
American Pika	*Ochotona princeps*	Mammalia	LC	G5	S5	–	–	–	–
American Pygmy Shrew	*Sorex hoyi*	Mammalia	LC	G5	S2S3	–	SM	–	–
Black-backed Woodpecker	*Picoides arcticus*	Aves	LC	G5	S3	–	SC	breeding areas, regular occurrences	–
Boreal Owl	*Aegolius funereus*	Aves	LC	G5	S3	–	SM	–	–
Brown Creeper	*Certhia americana*	Aves	LC	G5	S4S5B, S5N	–	–	–	–
Canada Lynx	*Lynx canadensis*	Mammalia	LC	G5	S1	FT	ST	any occurrence	NAR
Compton Tortoiseshell Butterfly	*Nymphalus vaualbum watsoni*	Insectivora						suspected occupant	
Dusky (Blue) Grouse	*Dendragapus obscurus*	Aves	LC	G5	S4	–	–	breeding areas, regular concentratio n	–
Gray Wolf	*Canis lupus*	Mammalia	LC	G4	S1	FE	SE	any occurrence	NAR
Hoary Bat	*Lasiurus cinereus*	Mammalia	LC	G5	S3	–	–	–	–
Moose	*Alces alces*	Mammalia	LC	G5	S2S3	–	–	regular concentratio ns	–
Northern Goshawk	*Accipiter gentilis*	Aves	LC	G5	S2S3B, S3N	FCo	SC	breeding areas, including alternate nest sites and post-	–

COMMON NAME	SCIENTIFIC NAME	CLASS	IUCN RED LIST	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS	WDFW PHS	COSEWIC
								fledging foraging areas	
Olive-sided Flycatcher	*Contopus cooperi*	Aves	NT	G4	S3B	–	–	–	T
Pileated Woodpecker	*Dryocopus pileatus*	Aves	LC	G5	S4	–	SC	breeding areas	–
Rocky Mountain Elk	*Cervus elaphus*	Mammalia	LC	G5T5	SNR	–	–	calving areas, migration corridors, regular concentrations in winter	–
Silver-haired Bat	*Lasionycteris noctivagans*	Mammalia	LC	G5	S3	–	–	–	–
Western Toad	*Bufos boreas*	Amphibia	NT	G4	S3	FCo	SC	any occurrence	SC
White-tailed Deer	*Odocoilesu virginianus*	Mammalia	LC	G5	S5	–	–	migration corridors, regular concentrations in winter	–
Winter Wren	*Troglodytes troglodytes*	Aves	LC	G5	S5	–	–	–	–
Wolverine	*Gulo gulo*	Mammalia	V	G4T3Q	S1	FCo	SC	any occurrence	SC

GLOSSARY OF CONSERVATION STATUS TERMS AND STATUSES:

IUCN (International Union for Conservation of Nature) red list:
(http://www.iucnredlist.org/)

EX – Extinct
EW – Extinct in the Wild
CR – Critically Endangered – taxa that are facing a higher risk of global extinction
EN – Endangered – taxa that are facing a higher risk of global extinction
VU – Vulnerable – taxa that are facing a higher risk of global extinction
NT – Near Threatened – taxa that are either close to meeting the threatened thresholds or that would be threatened were it not for an ongoing taxon-specific conservation programme
LC – Least Concern – taxa that have been evaluated to have a low risk of extinction
DD – Data Deficient – taxa cannot be evaluated because of insufficient information
NE – Not Evaluated – taxa that have not yet been assessed

Global Rank:
(http://www.dnr.state.md.us/wildlife/rte/rank_status.pdf)
(http://www1.dnr.wa.gov/nhp/refdesk/lists/animal_ranks.html)

G1 – Critically imperiled globally (5 or fewer occurrences)
G2 – Imperiled globally (6-20 occurrences)
G3 – Either very rare and local throughout its range or found locally in a restricted range (21-100 occurrences)
G4 – Apparently secure globally
G5 – Demonstratably secure globally
GH – Of historical occurrence throughout its range
GU – Possibly in peril range-wide but status uncertain
GX – Believed to be extinct throughout former range
GNR – Not ranked to date
Tn – Rarity of an infraspecific taxon, numbers similar to those for Gn ranks above
Q – Questionable taxonomy
? – Indicates that the rank is somewhat uncertain
two codes represent an intermediate rank

Washington State Rank:
(http://www1.dnr.wa.gov/nhp/refdesk/lists/animal_ranks.html)

S1 – Critically imperiled (5 or fewer occurrences)
S2 – Imperiled (6-20 occurrences), very vulnerable to extirpation
S3 – Rare or uncommon (21-100 occurrences)
S4 – Apparently secure, with many occurrences
S5 – Demonstratably secure in state
SA – Accidental in state

SE – An exotic established in state
SH – Historical occurrences only but still expected to occur
SN – Regularly occurring, usually migratory, nonbreeding animals
SR – Reported, but without persuasive documentation
SRF – Reported in error but this error persisted in the literature
SU – Status uncertain, need more information
SX – Apparently extirpated from the state
SP – Likely to occur or to have occurred but without documentation
SZ – Not of conservation concern (not SE or SA)
SNA – Not applicable (element is not a suitable target for conservation)
SNR – not yet ranked
? – Indicates that the rank is somewhat uncertain
B and N qualifiers are used to indicate breeding and nonbreeding status, respectively, of migrant species whose nonbreeding status (rank) may be quite different from their breeding status in the state
two codes represents an intermediate rank

Federal Status:
(http://ecos.fws.gov/tess_public/)
(http://wdfw.wa.gov/wlm/diversty/soc/soc.htm)
(http://wdfw.wa.gov/wlm/diversty/soc/state_monitor.htm)
FE: Federal Endangered
FT: Federal Threatened
FC: Federal Candidate
FCo: Federal Species of Concern

WDFW (Washington Department of Fish and Wildlife) Species of Concern:
(http://wdfw.wa.gov/wlm/diversty/soc/soc.htm)
(http://wdfw.wa.gov/wlm/diversty/soc/state_monitor.htm)
SE: State Endangered
ST: State Threatened
SC: State Candidate
SS: State Sensitive
SM – State Monitor – for status and distribution, to prevent from becoming endangered, threatened, or sensitive

WDFW Priority Habitats and Species (PHS):
(http://wdfw.wa.gov/hab/phslist.htm)

Committee on the Status of Endangered Wildlife in Canada (COSEWIC):
(http://www.cosewic.gc.ca/eng/sct5/index_e.cfm)
X – Extinct – a species that no longer exists
XT – Extirpated – a wildlife species that no longer exists in the wild in Canada, but exists elsewhere
E – Endangered – a wildlife species facing imminent extirpation or extinction

T – Threatened – a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction
SC – Special Concern – a wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats
DD – Data Deficient – a category that applies when the available information is insufficient (a) to resolve a wildlife species' eligibility for assessment or (b) to permit an assessment of the wildlife species' risk of extinction
NAR – Not At Risk – a wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances

Appendix B. Wildlife Experts

1) John Rohrer
District Wildlife Biologist, USDA Forest Service- Methow Ranger District, Winthrop, WA. (509) 996-4001, jrohrer@fs.fed.us

- Gray wolf
- Wolverine
- Canada lynx

2) Howard Ferguson
District Wildlife Biologist, Region I- Washington Dept of Fish and Wildlife, Spokane, WA. (509) 892-1001 ext. 328, Howard.Ferguson@dfw.wa.gov

- Moose
- Rocky Mountain elk
- White-tailed deer
- Olive-sided flycatcher
- Boreal owl
- Brown creeper
- Western toad
- Hoary bat
- Silver-haired bat
- Pileated woodpecker
- Black-backed woodpecker
- Dusky grouse

3) Kent Woodruff
Wildlife Biologist, USDA Forest Service- Methow Ranger District, Winthrop, WA. (509) 996-4043, kwoodruff@fs.fed.us

- Hoary bat
- Silver-haired bat

4) Ann Potter
Wildlife Biologist, Washington Dept of Fish and Wildlife, Olympia, WA. (360) 902-2496, Ann.Potter@dfw.wa.gov

- Compton Tortoiseshell butterfly

5) Dale Swedberg
Wildlife Area Manager, Washington Dept of Fish and Wildlife, Sinlehekin Wildlife Area, WA. (509) 223-3358, Dale.Swedberg@dfw.wa.gov

- Compton Tortoiseshell butterfly

6) Ken Bevis
Habitat Biologist, Washington Dept of Fish and Wildlife, Winthrop, WA. (509) 996-2253, Ken.Bevis@dfw.wa.gov

- Pileated woodpecker

- Black-backed woodpecker

7) Michael Schroeder
Grouse Biologist, Washington Dept of Fish and Wildlife, Bridgeport, WA. (509) 686-2692, Michael.Schroeder@dfw.wa.gov

- Dusky grouse