BONNEVILLE POWER ADMINISTRATION

Habitat Evaluation Procedures (HEP) Report;

Precious Lands Wildlife Management Area

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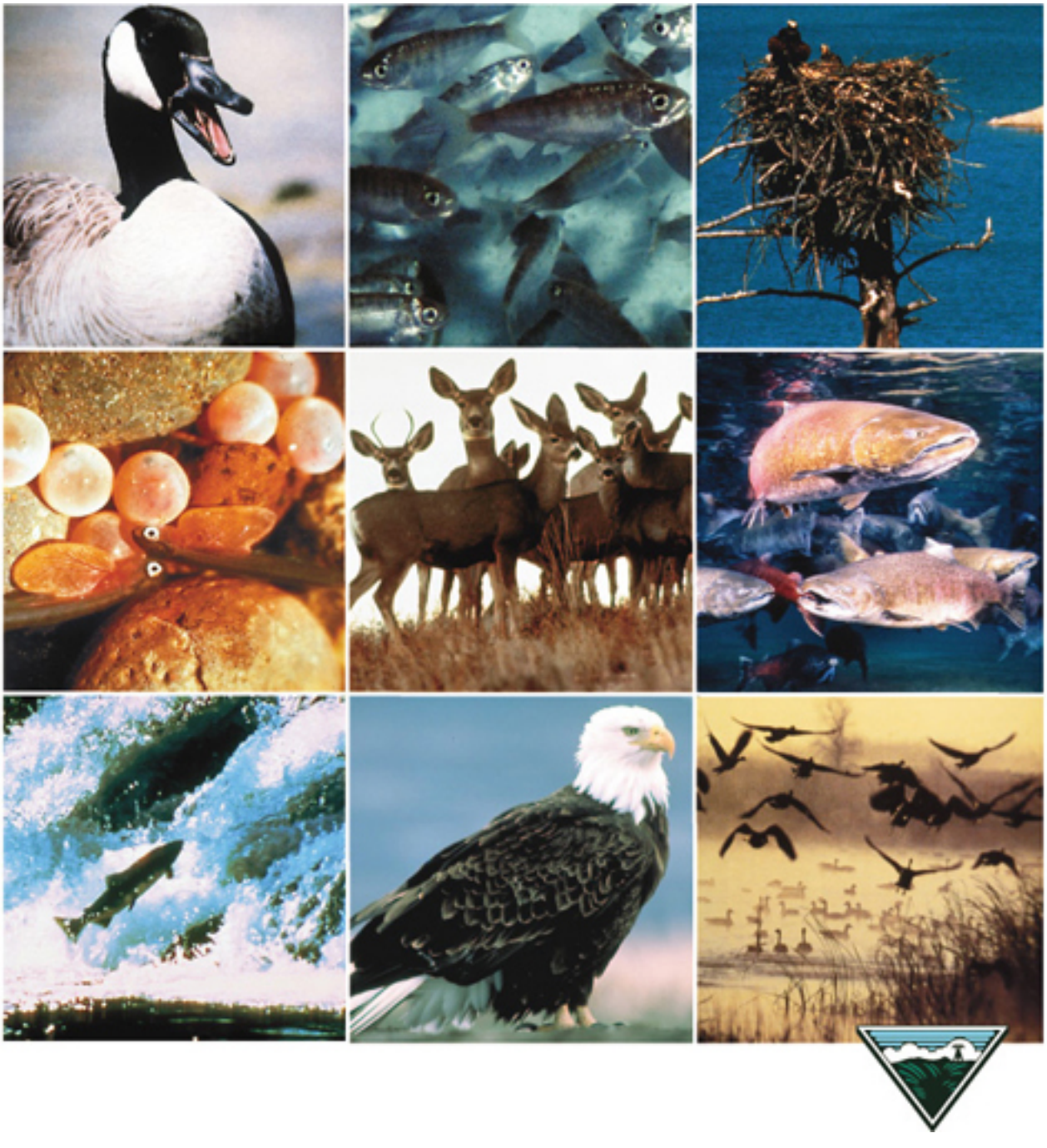

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Precious Lands Wildlife Management Area
Habitat Evaluation Procedure Report

December 30, 2003

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1.0 Introduction

The Nez Perce Tribe (NPT) currently manages a 15,325 acre parcel of land known as the Precious Lands Wildlife Management Area that was purchased as mitigation for losses incurred by construction of the four lower Snake River dams. The Management Area is located in northern Wallowa County, Oregon and southern Asotin County, Washington (Figure 1). It is divided into three management parcels - the Buford parcel is located on Buford Creek and straddles the WA-OR state line, and the Tamarack and Basin parcels are contiguous to each other and located between the Joseph Creek and Cottonwood Creek drainages in Wallowa County, OR. The project was developed under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501), with funding from the Bonneville Power Administration (BPA). The acreage protected under this contract will be credited to BPA as habitat permanently dedicated to wildlife and wildlife mitigation.

A modeling strategy known as Habitat Evaluation Procedure (HEP) was developed by the U.S. Fish and Wildlife Service and adopted by BPA as a habitat equivalency accounting system. Nine wildlife species models were used to evaluate distinct cover type features and provide a measure of habitat quality. Models measure a wide range of life requisite variables for each species and monitor overall trends in vegetation community health and diversity. One product of HEP is an evaluation of habitat quality expressed in Habitat Units (HUs). This HU accounting system is used to determine the amount of credit BPA receives for mitigation lands.

After construction of the four lower Snake River dams, a HEP loss assessment was conducted to determine how many Habitat Units were inundated behind the dams. Twelve target species were used in that evaluation: Canada goose, mallard, river otter, downy woodpecker, song sparrow, yellow warbler, marsh wren, western meadowlark, chukar, ring-necked pheasant, California quail, and mule deer. The U.S. Army Corp of Engineers and the Washington Department of fish and Wildlife subsequently purchased numerous properties to mitigate for the identified Snake River losses. These projects, however, were not sufficient to mitigate for all the HU's lost. The Northwest Power Planning Council amended the remaining 26,774 HU's into their 1994-1995 Fish and Wildlife Program as being unmitigated (NPPC 2000), which allowed the Nez Perce Tribe to contract with BPA to provide HU's through the Precious Lands Project.

The Precious Lands project contains a different composition of cover types than those assessed during the lower Snake loss assessment. For example, no mallard or Canada goose habitat exists on Precious Lands but the area does contain conifer forest, which was not present on the area inundated by dam construction. These cover type differences have resulted in a slightly different suite of species for the current HEP assessment. Target species for Precious Lands are downy woodpecker, yellow warbler, song sparrow, California Quail, mule deer, sharp-tailed grouse (brood rearing), western meadowlark, beaver, and black-capped chickadee. This list is a reflection of the available cover types and the management objectives of the Nez Perce Tribe. For example, chukar was not used in the present assessment because it is an introduced Eurasian game bird that does

not provide an accurate representation of the ecological health of the native grasslands it was supposed to represent. Initial model runs using the chukar confirmed this suspicion so the brood-rearing section of the sharp-tailed grouse model was used instead. Additionally, the beaver model was used in place of the river otter model because the otter model used in the loss assessment was not a published model, was overly simplistic, and did not provide an accurate assessment of riparian condition. The beaver model, however, provides a detailed evaluation of overstory class structure that the NPT felt was a good compliment to the yellow warbler and song sparrow models that evaluated understory shrub layers. Overall, such substitutions should result in a more accurate evaluation of the ecological conditions on Precious Lands, and provide better information for decision making.

A baseline HEP analysis was initiated on the Precious Lands in 2000, and data collection continued throughout the 2001 and 2002 field seasons. In the future, HEP analysis will be used to evaluate habitat changes resulting from management activities. Repeat surveys will be useful in assessing long-term trends in plant community health, weed encroachment, wildlife limiting factors, habitat degradation, and establishing desired future condition guidelines for the management program.

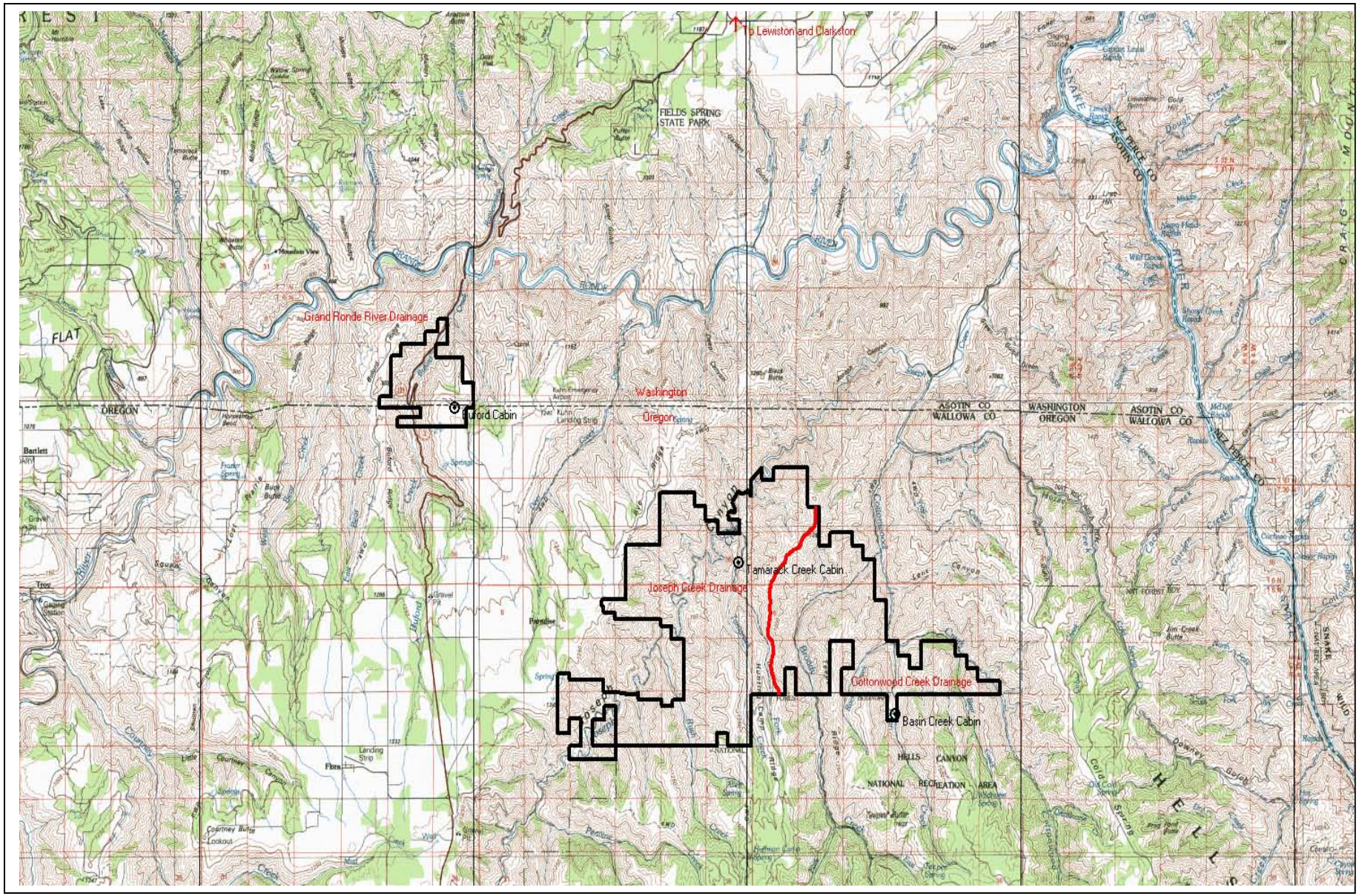
1.1 Vegetation Description

Climate, topography and elevation all significantly influence the type and extent of plant communities throughout the study area. Northerly aspects are dominated by mixed conifer forests and shrub fields, with the occasional interspersion of Idaho fescue/ prairie junegrass communities[1]. Bunchgrass communities dominate south and west aspects due to low soil moisture and high annual mean temperatures. Easterly aspects support all vegetation types, predominantly with trees at higher elevations and grasses at lower elevations. Areas previously burned or logged contain open woodlands comprised of few conifers, tall shrubs, and sparse conifer regeneration in the understory.

Riparian corridor vegetation consists primarily of black cottonwood or white alder with diverse understory shrubs and occasional Douglas-fir, larch or ponderosa pine. In a few sites quaking aspen is a significant component of the riparian overstory. Moist draws, springs, and intermittent streams typically support dense thickets of black hawthorn.

[1] See Table 20 in Appendix D for a complete list of scientific plant names mentioned in the text.

Figure 1. Precious Lands Wildlife Management Area Location Map



1.2 Cover Types – Descriptions and Acreage

Four general cover types are represented on the Precious Lands Wildlife Management Area – Grassland, Shrub, Conifer, and Riparian. Cover type classifications are further stratified into 10 distinct sub-types for HEP analysis, which allows transects to be grouped by similar limiting factors. Grasslands will be assessed as Agriculture, Good, or Degraded grass communities, shrub cover will be split into Short and Tall shrub categories, and conifer cover types will be referenced as Conifer, Open conifer, Burnt conifer shrub, and Burnt conifer grass. Figures 2 and 3 show basic cover type distribution on the Precious Lands. Riparian cover is all lumped as a single cover type.

Due to the size and terrain of the study area, initial classification of cover types was conducted on a gross scale. Cover polygons are mapped in 5-acre blocks, and further classified by aspect. Because of this scale, many small shrub patches and narrow stringers of vegetation do not show up as separate and significant habitat features. It is recognized that in broad expanses of grassland habitats these other vegetative features become more significant to wildlife as security, foraging, and reproductive cover. Additional surveys and improved cover-typing methods will continue to refine this scale, and more accurately depict the integration of various vegetation characteristics. Future monitoring will use cover type classifications further stratified into 13 distinct sub-types to better meet management objectives and to acknowledge ecological changes and variability in some communities. Grasslands will be split into Excellent, Good, Fair, and Poor categories, and riparian areas will be assessed as Riparian Shrub, Riparian Hardwood, and Riparian Conifer.

Health and diversity of a cover type are evaluated by applying models that measure habitat variables associated with a target wildlife species chosen specifically to assess each community. By measuring how well each site meets the particular species' life requisites, habitat diversity can be monitored over time by tracking changes in each habitat variable. Nine wildlife species similar to those used in the lower Snake River loss assessment were chosen to evaluate the Precious Lands.

<u>Grassland</u>
Target wildlife species: mule deer, Western meadowlark, and sharp-tailed grouse. Grassland sites comprise 74% of the total acreage on the Precious Lands and have been separated into Agriculture, Good grassland, and Degraded grassland for the purpose of HEP analysis. In 2001 approximately 124 acres were in agricultural production. 'Good' and 'Degraded' classifications are based on percent cheatgrass and average herbaceous height. High percentages of cheatgrass indicate recent disturbances such as grazing or erosion, and height is used to differentiate between the shorter cheatgrass and the taller native bunchgrass communities. Degraded grasslands cover 2,929 acres, have an average herbaceous height of 24cm, and contain an average 36% cheatgrass. Good grassland sites cover 8,423 acres, average 37cm herbaceous height, and average 20% cheatgrass.

Shrub

Target wildlife species: mule deer, song sparrow, and California quail. Shrub communities are separated by Tall shrub and Short shrub designations. Tall shrub sites cover 598 acres and are dominated by ninebark or smooth sumac. The average height of Tall shrub vegetation is 1.0m. Short shrub sites are dominated by a mix of snowberry and rose species, and cover 545 acres. Average height of Short shrub vegetation is 0.4m.

Riparian

Target wildlife species: mule deer, song sparrow, downy woodpecker, yellow warbler, and beaver. Riparian sites are all evaluated as a single cover type in the HEP model runs, even though the range of dominant vegetation varies widely and includes hawthorn shrub, riparian hardwood, riparian conifer, riparian mixed, and riparian shrub. Due to limited time and funding, it was not feasible to establish multiple transects in each riparian cover type to allow analysis as separate communities. In addition, past flood and fire events drastically changed streambed and vegetation structure of some drainages, making them highly variable and difficult to delineate. This cover type only represents 609 acres out of the entire study area, but due to the wide range of diverse canopy structure types, nine transects were established to assess the most variation possible.

Conifer

Target wildlife species: mule deer and black-capped chickadee. Percent evergreen canopy cover and recent fire events distinguish conifer community types. Closed conifer sites are characterized by >30% evergreen canopy cover, Open conifer sites have <30% evergreen canopy cover, and two recently burned sites that are designated as Burned Conifer Grass and Burned Conifer Shrub, have zero evergreen cover and are currently dominated by either grass or shrub species, respectively. The burnt sites are expected to mature back into Open conifer or Conifer communities and are being monitored for regeneration success. Conifer sites total 630 acres, Open conifer covers 1,189 acres, and the two burned sites together total 312 acres.

Figure 2. Cover Type Distribution on the Buford Parcel of the Precious Lands Wildlife Management Area

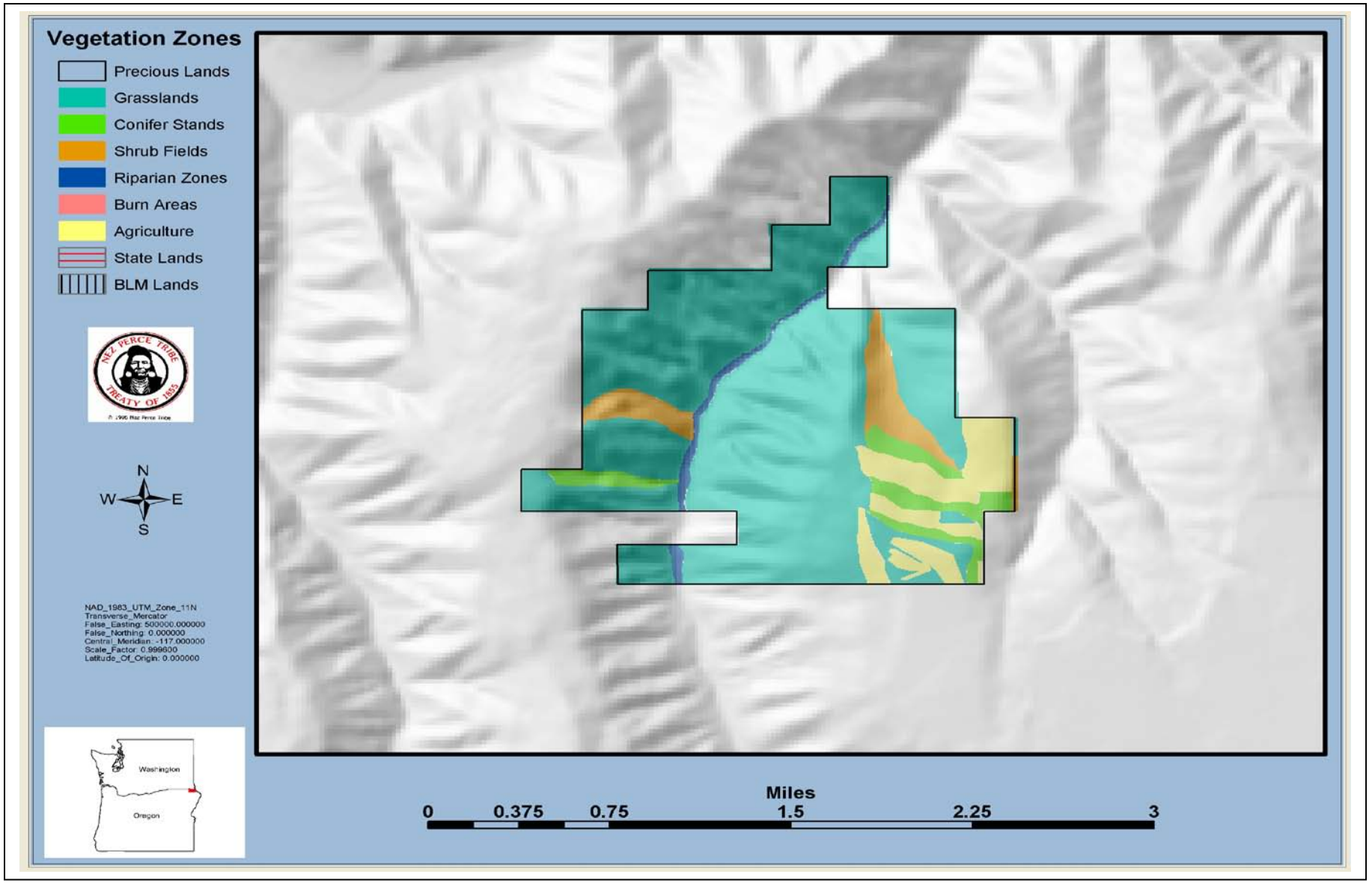
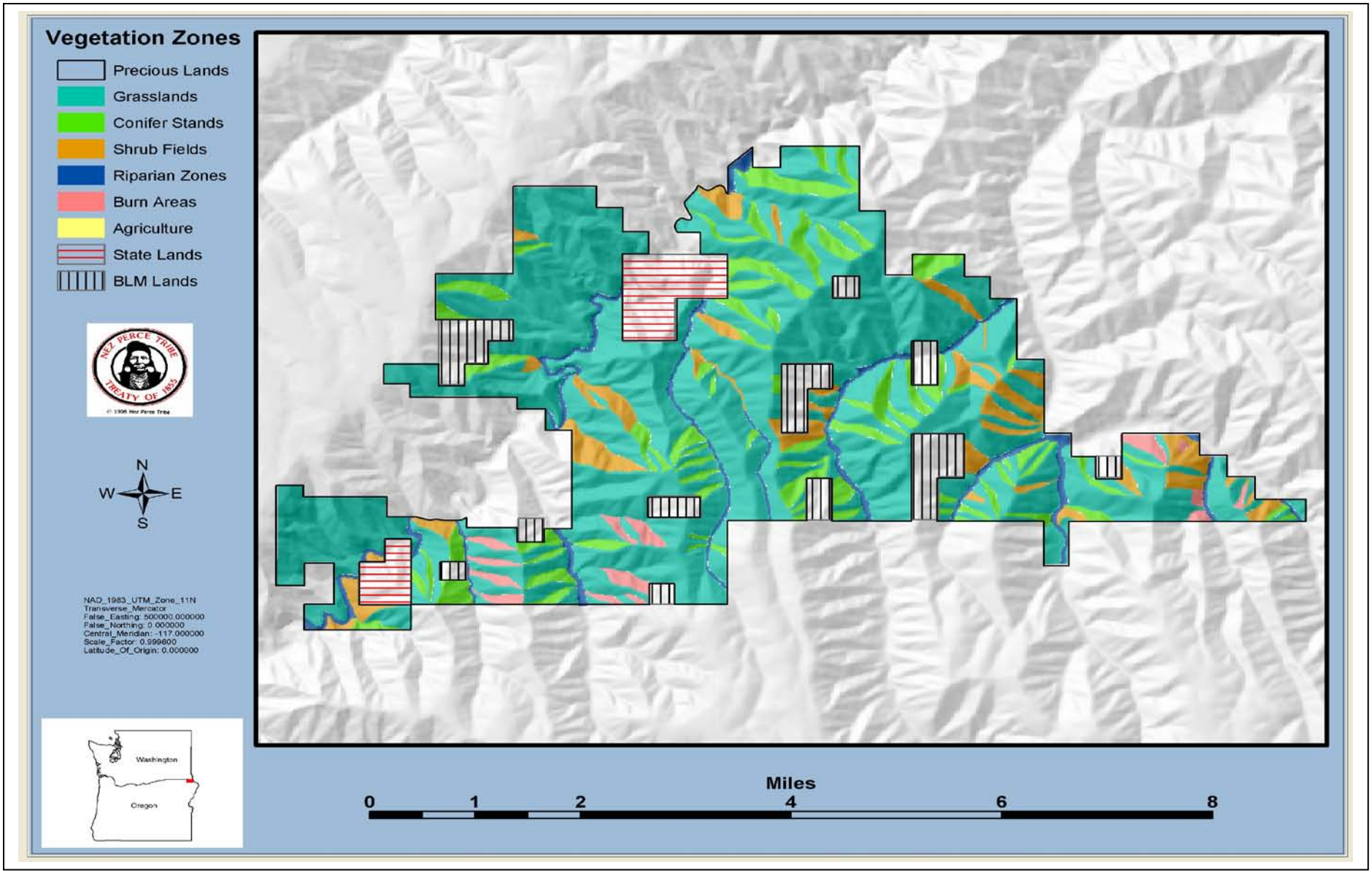


Figure 3. Cover Type Distribution on the Tamarack-Basin Parcels of the Precious Lands Wildlife Management Area



2.0 Methods

HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Data are applied to graphs that determine an HSI value for each habitat variable and how well it meets the life requisites of the target wildlife species. Each HSI variable graph can be found listed by species in Appendix B. HSI values range from 0.0 – 1.0 and are multiplied by potential acreage to determine amount and quality of habitat available to target wildlife species.

Of the original 35 HEP transects that were established, 24 will be chosen as permanent monitoring sites. The permanent transects will be evaluated at five-year intervals to track long-term vegetation trends. The 24 permanent sites were chosen by location and cover type – the goal was to have the greatest distribution of transects throughout the entire study area, with plots that represent the typical characteristics of each cover type variety. Long-term monitoring will be conducted using HEP data collection procedures, but not limited to particular wildlife variables. For example, *percent cover of target weedy species, percent microbiotic crust cover,* and *percent bare ground* data will be collected as important habitat health indicators, but they are not specifically tied to a particular wildlife model or variable. A discussion of all HEP variables and their management applications can be found in section 2.5. A summary chart of the HEP data collection results can be found in Appendix A.

2.1 Target Species

Target wildlife species models chosen for the Precious Lands HEP analysis are: beaver (Allen 1983), black-capped chickadee (Schroeder 1982a), California quail (USACE 1989), sharp-tailed grouse (Ashley 2002), downy woodpecker (Schroeder 1982b), mule deer (Ashley 2001), song sparrow (USFWS 1979), Western meadowlark (Schroeder and Sousa 1982), and yellow warbler (Schroeder 1982c). Originally, river otter was selected as a target species for riverine habitats but was replaced by beaver due to the lack of a suitable otter model that could be used on the Precious Lands watersheds. The beaver model provides a more detailed evaluation of riparian community condition compared to the relatively simple otter model used on the Lower Snake Assessment. The chukar model (USFWS 198?) was originally used to assess the Lower Snake dam losses, but as a management tool the model fails to distinguish between quality grassland habitats and degraded grassland habitats. Chukar was replaced with sharp-tailed grouse in an attempt to find a better model that delineates grassland quality while still staying within a similar species guild.

A description of the rational for selecting each species, and the HSI variables measured can be found in Table 1. A more thorough documentation of model runs for each species and resulting data can be found in Appendix C.

Table 1. Target wildlife species: their HSI variables and use

HSI Variables	Beaver	Black-Cap Chickadee	CA Quail	Sharp–tail Grouse	Downy Woodpeckr	Mule Deer	Song Sparrow	Western Mdowlark	Yellow Warbler
# herbaceous species									
% herbaceous cover			V1					V1	
% cover palatable herb. spp.						V5			
% grass cover				V3				V2	
% cover of forbs				V4					
% herb cover of native spp.				V5					
% herb cover of exotic spp.				V6					
% area with brood cover				V7					
Avg herbaceous height			V4					V3	
% shrub canopy cover <6m							V1	V5	V1
Average shrub height	V4		V6			V3			V2
Average height shrubs <6m							V2		
% hydrophytic shrub cover									V3
% shrub cover	V3		V5						
% cover pref. shrubs <1.5m						V1			
# preferred shrub species						V2			
% cover of shrubs <1.5m						V4			
% tree canopy cover	V1	V1							
Tree canopy volume		V3							
% trees in 1-6" dbh class	V2								
% evergreen canopy >1.5m						V10			
Avg height overstory trees		V2							
Basal area					V1				
# snags >6" dbh/ac					V2				
# snags 4-10" dbh/ac		V4							
Spp. Comp. of woody veg.	V5								
Dist. to forest/tree savanna									
Distance to shrub cover									
Distance to potable water							V3		
Distance to perch								V4	
Dist. to exposed rocky area									
Distance to roost			V2						
Distance to escape cover			V3						
Topographic class/ diversity						V9			
Crops within 1.6km						V6			
Aspect						V7			
Road density						V8			
% lake surface with water lily	V6								
% stream gradient	V7								
Avg annual water fluctuation	V8								

Species Use Rationale

	Beaver	Black-cap Chickadee	CA Quail	Sharp-tail Grouse	Downy Woodpeckr	Mule Deer	Song Sparrow	Western Mdowlark	Yellow Warbler
Snag Dependent		X			X				
Important Game Species			X			X			
Declining Population Trend				X					X
Riparian forest habitats	X				X				
Riparian shrub habitats	X						X		X
Upland Shrub habitats			X			X		X	
Grassland habitats				X		X		X	
Conifer forest habitats		X							

2.2 Baseline HEP survey routes

In 2000, 23 baseline HEP transects (10 grassland, 3 shrub, 6 riparian, and 4 conifer) were randomly established and sampled within the Precious Lands Wildlife Management Area. A further six transects (3 shrub and 3 conifer) were completed in 2001 to better sample cover types that were either highly variable or poorly represented in the 2000 sampling effort. A final six transects (3 grassland and 3 riparian) were completed during 2002 in attempt to sample across a wider range of grassland aspects, and in previously unsampled creek drainages. Spreadsheets summarizing data collected on each transect are located in Appendix A. Total baseline HEP sampling efforts yielded 35 plots by the end of 2002 (Figures 4 and 5).

2.3 Implementation

For the purpose of long-term monitoring, 24 of the 35 plots have been selected to represent each of 13 unique habitat communities. Each of these permanently established HEP plots will be surveyed once every five years, and sampling will be conducted using the standard USFW protocols (USFWS 1980a, 1980b). Two plots will be sampled in every vegetative category to monitor succession and community health trends. Recently burned sites represent a relatively small classification type and have only a single plot to characterize each of them.

Vegetation class categories: Excellent, Good, Fair, and Poor Grasslands; Short Shrub; Tall Shrub; Riparian Shrub; Riparian Hardwood; Riparian Conifer; Open Conifer; Conifer; Burnt Conifer Shrub (one plot only); Burnt Conifer Grass (one plot only).

2.4 Plot establishment protocols

Random starting points are established using a random number grid. Sites were originally stratified by cover type, with a large portion of the plots located in Grassland habitats, and subsequent sampling efforts were used to better document less sampled habitats.

Transects are divided into 100 ft. segments, and transect length is determined using a "running mean" to estimate variance (95% probability of being within 10% of the true mean for *percent tree canopy cover*, *percent herbaceous cover* and/or *percent shrub canopy cover*).

$$\text{Sample size equation: } n = \frac{t^2 \times s^2}{E^2}$$

Where: t = value at 95 percent confidence interval with suitable degrees of freedom
s = standard deviation
E = desired level of precision, or bounds

Figure 4. Distribution of HEP Plots on the Buford Parcel of the Precious Lands Wildlife Management Area

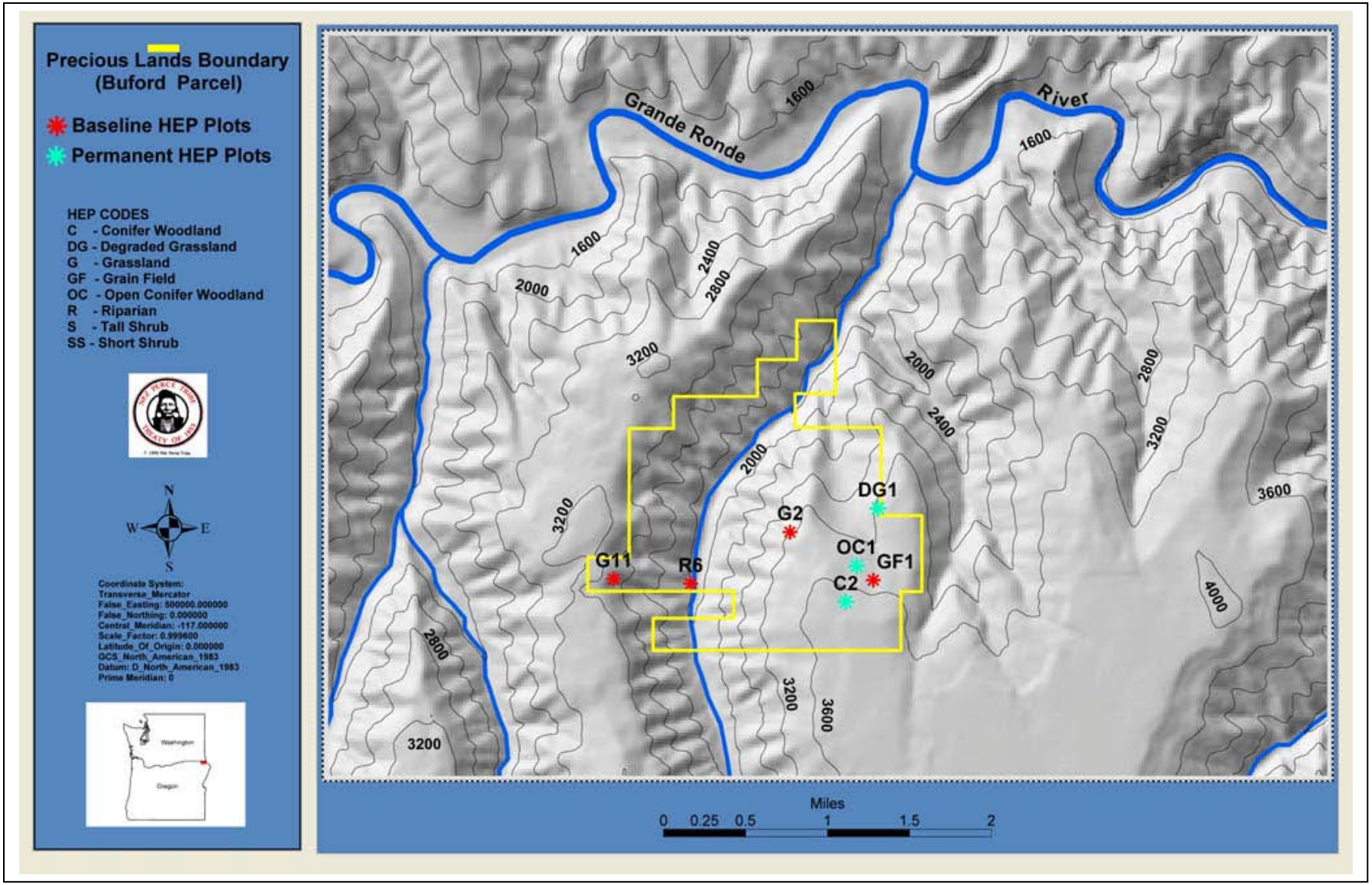
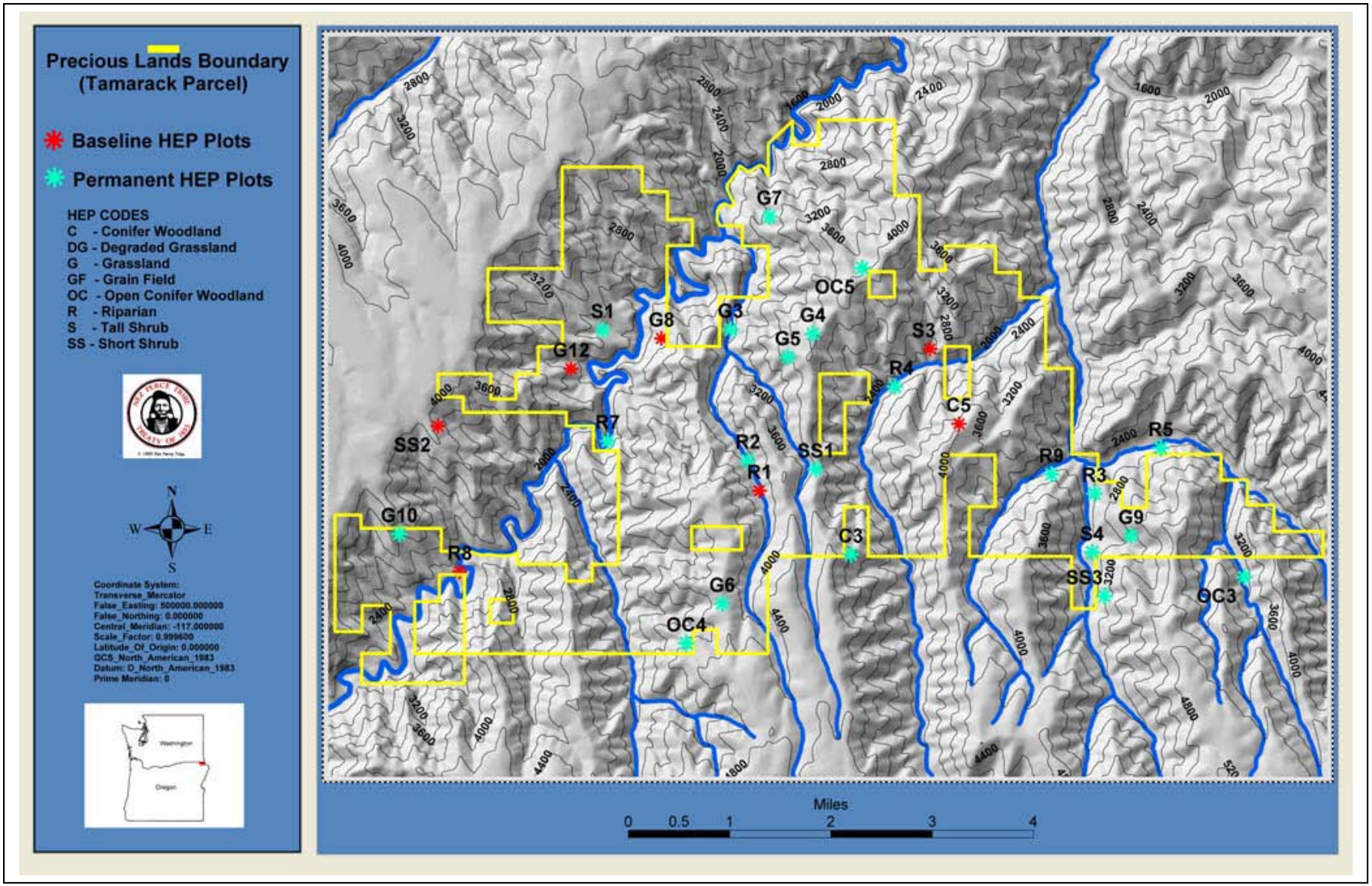


Figure 5. Distribution of HEP Plots on the Tamarack-Basin Parcels of the Precious Lands Wildlife Management Area



Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer along the inside edge of the cover type. It is not possible to follow this procedure in some riparian corridors that are very narrow and closely delineated by the water channel. In these cases, the transect is run through the center of the riparian vegetation, as far from each edge as possible.

To establish a transect, a 5 ft tall metal post or 2.5 ft length of rebar is pounded into the ground at the random starting point. The post is painted orange and marked with pink plus pink/black stripe flagging to distinguish HEP plots from other study plots. An aluminum tag indicating date, location, and transect number is wired onto the post. A plastic orange safety cap is pressed onto the top of the rebar markers. Aspect, slope, and other site information are recorded at this time. All plant species encountered along the transect are listed on the cover sheet as native/naturalized, or weed species. Weed species of special concern are yellow starthistle, rush skeletonweed, various knapweeds, and various thistles. When encountered, these species are marked on a map for future management efforts.

A random number table is used to select an azimuth between 0 and 360 degrees. The tape is run along the chosen azimuth and will continue for each 100-foot segment until the cover type changes or obstacles are encountered, i.e. inaccessible terrain. Transects are run at least 100 ft inside the edge of the cover type when possible to avoid edge-effect variation. Any time an azimuth is changed, the new distance and azimuth are noted, and flagging is placed at the point of change. Pink plus pink/black stripe flagging is placed at the end of each 100 ft. segment and marked with plot number and transect length up to that point. A photograph is taken of the transect from the starting point, sighting down the length of the tape. An information plaque is placed unobtrusively in the frame of the photo indicating plot name, date, time of day, photograph number, azimuth, and data collector's initials (see report cover photograph). Photo number is noted on the data sheet. Where possible, transects will have GPS location data recorded, and later entered into a GIS database.

Cover type and HSI models determine the variables sampled along any given transect. Listed below are sampling methods used to measure variables within Grassland, Shrub, Riparian, and Conifer cover types. Other variables that may be necessary to run the HSI models can be derived from the field data, topographic maps, or aerial photographs.

2.5 Data collection protocol

Explanations of variable parameters in sections 2.5.1 through 2.5.4 are defined and described the first time they are listed – all succeeding sections will list the variable title without explanation to limit redundancy. All data collection follows a similar procedure, and herbaceous, shrub, and tree data are collected on every plot. Data specific to a particular target species is included in the 'other' section of data collection.

Herbaceous measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrat is a rectangular $0.5m^2$ microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

Shrub canopy cover is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible "hits" per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible "hits" per 100 ft segment). Shrub measurements are collected on the tallest part of a shrub that crosses directly above each sampling interval mark.

Tree measurements are taken every ten feet along the transect and within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

Other variables measure life requisites of target species or important management characteristics of a community and cover a wide range of data collection techniques.

Variables used in an HSI model are indicated in bold. The term (derived) after the variable title indicates data that were compiled by GIS, aerial photograph, map, or data manipulation in the office after initial data collection efforts were completed in the field.

2.5.1 Grassland data collection variables

HERBACEOUS DATA (microplot) – grassland

Total herbaceous cover – ocular estimate of percent of the microplot shaded by any grass or forb species. Plant material that hangs over into the plot but is rooted outside the frame is still included in cover totals.

Percent palatable cover – ocular estimation of the area covered by all the select palatable grasses and forbs listed on the data sheet, and any species known by the data collector to be palatable to mule deer, i.e. clover. (Note: Palatable cover is not a percent of the total herbaceous cover, it is a stand-alone measurement of area covered. *Percent palatable cover* will never exceed *total herbaceous cover*.)

Average herbaceous height – direct measurement made with a pocket rod to the nearest tenth of a foot. Two heights are taken in the microplot and averaged.

Number of herbaceous species – a count of the unique herbaceous species represented in the microplot, whether they are rooted in or not. (Note: lone fragments are not counted due to their unknown origin, but rooted stalks hanging over into the plot are counted). No distinction is made between native and exotic species.

Percent grass – an ocular estimate of total area covered by grass species within the microplot, without regard to palatability or native/exotic status.

Percent cover palatable forbs – an ocular estimate of percent cover for each of three forb species known to be palatable to mule deer: Balsamroot, Buckwheat, and Lupine. Covers of all three are added together to get a total palatable forb estimate.

Percent cover palatable grasses – an ocular estimate for percent cover of select grass species within the microplot known to be palatable to mule deer. Select grasses: Bluebunch Wheat, Idaho Fescue, Sandberg's Bluegrass, and Prairie Junegrass. "T" is used to indicate trace amounts (<1%) of a particular species in the plot. Relative cover of these grass species will be used as an indicator of grassland health in addition to mule deer habitat quality.

Percent cover target weedy species – an ocular estimate of total area covered by particular undesirable plant species. During 2000-2002 data collection, only cheatgrass was recorded, but for future management purposes the following weedy species will be monitored: Kentucky bluegrass, medusahead, red threeawn, and yellow starthistle. Other species may be added in the future as necessary.

Cover pole – an ocular estimate of hiding cover available to mule deer. Data are gathered every 20 ft along the transect using a cover pole marked in tenths of feet. Readings are a percentage of a 1.5m (5 ft) cover pole totally obscured from sight at a distance of 10 ft. Four readings are taken at each interval, each ten feet out from the sampling point – 2 parallel and 2 perpendicular to the line of the transect.

Percent bare ground – an ocular estimate of area within the microplot consisting of exposed rock or soil substrate and not covered by litter, duff, microbiotic crust, or herbaceous vegetation. This is not a model variable but is considered significant for management as an indicator of erosion and potential weedy invasions.

Percent crust – an ocular estimate of area within the microplot covered by microbiotic crust. Crusts form due to cyanobacteria and lichen growth on healthy, undisturbed soil and are usually darker than non-crusted soil. This variable is not used in any model but is considered significant in measuring grassland recovery after livestock impacts.

SHRUB DATA (transect) – grassland

Average distance to shrub cover – a direct measure of distance to the nearest shrub community that could be used as hiding cover for birds. If distance is >50 m the data is collected as an ocular estimate.

Percent cover shrubs – line intercept 'hit' or 'miss'. Measurements are taken every 2 or 5 feet depending on shrub density.

Number of preferred shrub species ≥ 10% of the total shrub cover (derived) – number of shrub species that are preferred by mule deer that comprise at least 10 percent of the total shrub cover.

Average shrub height – direct measure with a pocket rod of all 'hit' shrubs along the transect. Height taken on the tallest shrub that intersects the transect at the sampling interval. Both species and age class are noted. A standard 4-letter code is used to name species. The code is comprised of the first two letters of the genus name and the first two letters of the species name. Pacific Ninebark (*Physocarpus malvaceus*) is noted as PHMA. Age class of shrubs is noted for future management efforts. Age indicates relative health and vigor of a community and can point out areas of limited forage and/or cover potential that may need restoration. The age classification is applied to the plant as a whole, not just the piece of vegetation intersecting the tape. Age classes are as follows:

Y – young, non-reproductive seedlings
M – mature, produced fruit or flowers that year
D – decadent, 25-50% dead
VD – very decadent, >50% dead
DD – dead

Percent cover preferred shrubs < 1.5m tall (derived) – cover of shrubs preferred by mule deer < 1.5 m (50 tenths of a foot) in height. Separated from total shrub intercept data in the office.

Percent cover shrubs < 1.5m tall – cover of all shrubs < 1.5 m (50 tenths of a foot) in height. Separated from total shrub intercept data in the office.

Percent canopy cover of shrubs < 6m tall – cover of only the shrubs < 6 m (197 tenths of a foot) in height. Separated from total shrub intercept data in the office.

TREE DATA (transect) – grassland

Percent evergreen canopy >1.5m – line intercept 'hit' or 'miss'. Ten direct measurements along each 100 foot section of the transect (one every 10 feet) taken with a moosehorn densitometer. Species code and diameter breast height (dbh) of 'hit' trees are noted. Species code follows the same 4-letter code as noted in the grassland 'herbaceous' section, and dbh is measured with a loggers tape.

Distance to forest/ tree savanna (derived) – GIS measurement to the nearest Conifer or Open Conifer cover type.

OTHER DATA – grassland

Average distance to exposed rock - (direct measure in the field during 2002, derived in 2000-01 from GIS). Average distance to rocky outcrops, cliffs or boulder fields.

Average distance to perch – direct measure to any object that stands above the surrounding vegetation and can be used as a perch by meadowlarks. If distance is >50 m the data is collected as an ocular estimate.

Crops within 1.6 km – 'yes' or 'no'

Aspect – direct measurement of slope orientation in degrees using a compass.

Road density (derived) – ratio of kilometers of paved road surface to square kilometers of habitat. Measured from maps.

Topographic Diversity (derived) – interspersion of topographic features as defined in the mule deer model.

2.5.2 Shrub data collection variables

See section 2.5.1 for all previously mentioned variable descriptions

HERBACEOUS DATA (microplot) – shrub

Total herbaceous cover
Percent palatable cover
Average herbaceous height
Number of herbaceous species
Percent grass
Percent cover palatable forbs
Percent cover palatable grasses
Percent cover target weedy species
Percent bare ground
Percent crust

SHRUB (transect) – shrub

Percent cover shrubs
Average shrub height
Average height of shrubs < 6m tall (derived)
Percent cover preferred shrubs < 1.5m tall (derived)
Percent cover shrubs < 1.5m tall
Percent canopy cover of shrubs < 6m tall
Cover pole

TREE DATA (transect) – shrub

Percent evergreen canopy >1.5m
Distance to forest/ tree savanna (derived)

OTHER DATA – shrub

Average distance to perch (derived) – Estimated from GIS maps and data collectors' recollection.

Average distance to escape cover (derived) – Measure of distance to nearest cover type offering game birds concealment and protection from predators - dense vegetation, <1.5 m, and possibly armed, i.e. blackberries or hawthorn. Estimated from GIS maps.

Average distance to roost cover (derived) - nearest cover type offering roosts for game birds - shrubs or trees >1.5m in height. Estimated from GIS maps.

Distance to potable water (derived) – distance to year-round drinking water. Measured from maps.

Crops within 1.6 km
Aspect
Road density (derived)
Topographic Diversity (derived as per Mule Deer model)

2.5.3 Riparian data collection variables

See sections 2.5.1 and 2.5.2 for previously mentioned variable descriptions

HERBACEOUS DATA (microplot) – riparian

Total herbaceous cover
Percent palatable cover
Average herbaceous height
Number of herbaceous species
Percent grass
Percent cover palatable forbs
Percent cover palatable grasses
Percent cover target weedy species
Percent bare ground
Percent crust

SHRUB (transect) – riparian

Percent cover shrubs
Average shrub height
Average height of shrubs < 6m tall (derived)
Percent cover preferred shrubs < 1.5m tall (derived)
Percent cover shrubs < 1.5m tall
Percent canopy cover of shrubs < 6m tall
Cover pole
Number of preferred shrub species ≥ 10% of the total cover (derived)

Percent shrubs consisting of hydrophytic species (derived) – percent of shrubs known to exist only in wet (mesic) environments. Hydrophytic species were separated from shrub intercept data in the office. See section 4.2 for a listing of hydrophytic species.

TREE DATA (transect and circle plot) – riparian

Distance to forest/ tree savanna (derived)

Percent tree canopy cover - line intercept 'hit' or 'miss'. Ten direct measurements along each 100 foot section of the transect (one every 10 feet) taken with a moosehorn densitometer. All species, regardless of conifer or deciduous class, are recorded. Species code and diameter breast height (dbh) of 'hit' trees are noted. Species code follows the same 4-letter code as noted in the grassland 'herbaceous' section, and dbh is measured with a loggers tape.

Percent evergreen canopy (derived) – tree cover contributed by evergreen species only. Separated from total tree canopy cover data in the office.

Percent evergreen canopy >1.5m (derived) – tree cover contributed only by evergreen species > 1.5 m tall. Separated from tree canopy cover data in the office.

Percent deciduous trees 1-6" dbh (derived) – direct count of the deciduous trees in the 1-6 inch dbh class and greater than 15 feet tall that are found in the $^{1}/_{10}$ acre circular plot. This variable is considered derived because it does not fall completely within a single age class. Data was therefore used from the Sapling class as a conservative estimate. Age class of trees within the $^{1}/_{10}$ acre plot are tallied by hardwood/conifer category and size class. Size classes are defined as follows:

Sapling = trees < 4" dbh
Pole = trees 4" $\leq$ 8" dbh
Mature = trees > 8" dbh

Average tree height – direct measure of the closest tree (>15 ft tall) at the 50 ft and 100 ft marks along the transect. Staying at the same contour elevation as the tree base, a logger's tape is used to measure out from the tree a distance approximately the same length as the tree is tall. A clinometer is used to measure the angle (in % slope) to the top of the tree. Height is calculated by: (distance from tree) x (% slope), then adding the observer's height.

Species composition of woody vegetation (derived) – a classification of riparian vegetation based on the dominant tree species. Classes are as follows:

A - Aspen, Willow, Cottonwood, Alder dominant (>50%)
B - Other deciduous species dominant
C - Coniferous species dominant

Number of snags >6 in dbh per acre – direct count in the $^{1}/_{10}$ acre circle plot at the end of each 100 ft segment of the transect. Dbh (measured with a loggers tape) and snag condition are noted for each snag >4" dbh and >6 ft tall. Snag condition scale follows Parks et al. (1997):

1 = newly dead, still has branches and bark, top still intact
2 = recently dead, some branches and bark missing, broken topped
3 = old dead, branches and bark gone, heartwood decay, bayonet top

Square foot basal area per acre – direct measure with a 10-factor prism in the $^{1}/_{10}$ acre circle plot at the end of each 100 ft segment. The prism is held directly over the

center of the circle (the 100 ft mark of the transect tape). A count is made by pivoting around the prism and tallying basal "hits" for the area surrounding the $^{1}/_{10}$ acre plot.

Down woody debris – a continuous tally recorded along each 100 ft segment of the transect. A single tally mark is made for each down log/debris that crosses the plane of the transect and marks are summed every 100 feet. Debris must be >4" dbh at the point where it intersects the tape.

WATER DATA – riparian

Stream Gradient (% slope) - direct measurement of stream slope using a clinometer at the initial establishment of a transect.

Average annual water fluctuation (derived) – a characterization of stream flows based on the data collectors' knowledge and past experience with the stream system. Classes are as follows:

A - Small fluctuation
B - Moderate fluctuation
C - Extreme fluctuation or lack of water during some part of the year

Percent lacustrine surface dominated by water lily (derived) – the study area lacks any lakes or ponds – the only bodies of water are streams. Therefore, there are no lacustrine features to measure or water lily species present.

Distance to potable water (derived)

OTHER DATA – riparian

Average distance to escape cover (derived)
Average distance to roost cover (derived)
Crops within 1.6 km
Aspect
Road density (derived)
Topographic Diversity (derived as per Mule Deer model)

2.5.4 Conifer data collection variables

See sections 2.5.1 through 2.5.3 for previously mentioned variable descriptions

HERBACEOUS DATA (microplot) – conifer

Total herbaceous cover
Percent palatable cover
Average herbaceous height
Number of herbaceous species
Percent grass
Percent cover palatable forbs
Percent cover palatable grasses
Percent cover target weedy species

Percent bare ground
Percent crust

SHRUB (transect) – conifer
Percent cover shrubs
Average shrub height
Percent cover preferred shrubs < 1.5m tall *(derived)*
Percent cover shrubs < 1.5m tall
Number of preferred shrub species ≥ 10% of the total cover *(derived)*
Cover pole

TREE DATA (transect and circle plot) – conifer
Distance to forest/ tree savanna (derived)
Percent tree canopy cover
Percent evergreen canopy >1.5m (derived)
Average tree height
Square foot basal area per acre
Down woody debris

Number of snags 4-10 in dbh per acre – direct count in the $^{1}/_{10}$ acre circle plot at the end of each 100 ft segment of the transect. Dbh (measured with a loggers tape) and snag condition are noted for each snag >4" dbh and >6 ft tall. Snag condition scale follows Parks et al. (1997):

1 = newly dead, still has branches and bark, top still intact
2 = recently dead, some branches and bark missing, broken topped
3 = old dead, branches and bark gone, heartwood decay, bayonet top

OTHER DATA – conifer
Distance to potable water (derived)
Crops within 1.6 km
Aspect
Road density (derived)
Topographic Diversity (derived as per Mule Deer model)

3.0 Results

The large study area, rugged terrain, highly variable cover types, and limited access have created logistical challenges for data collection resulting in a substantial time commitment and smaller sample size than would be optimal. Random sampling was distributed throughout the study area, but the number of samples is probably not sufficient to run a successful power of analysis test. Because this is a monitoring program, not a research project, it was felt that sampling was sufficient for a baseline characterization of the landscape while still maintaining a program within realistic budget constraints.

The initial mapping of the study area was created with GIS software and resulted in a 15,359 acre figure. In actuality, the total acreage for the Precious Lands is 15,325. This is a < 1% margin of error due to slight variations in cover type polygon borders and road right-of-way boundaries. This small amount of variation was considered acceptable for the size of the area involved, and the resulting GIS acre figure of 15,359 is used in all HEP calculations. The GIS-produced cover type acreage can be found in Table 2.

Table 2. Cover type codes and GIS acreage

Cover Type	Habitat Code	Cover Type Acres
Riparian	R	609
Open Conifer	OC	1,189
Conifer	C	630
Burnt Conifer Shrub	BCS	213
Burnt Conifer Grass	BCG	99
Agriculture	A	124
Degraded Grass	DG	2,929
Good Grass	GG	8,423
Tall Shrub	TS	598
Short Shrub	SS	545
TOTAL ACRES		15,359

Habitat Suitability Index (HSI) values have been calculated for all target wildlife species. These values represent a relative measure of habitat quality based on the variables measured and the wildlife model used. All HSI values fall between 0.0 – 1.0, with 1.0 considered optimal habitat. Using HSI values, habitats can be rated as:

Poor……(0.00 - 0.20)	Good…….. (0.51 - 0.70)
Marginal ……(0.21 - 0.30)	Excellent…… (0.71 - 0.99)
Fair…… (0.31 - 0.50)	Optimal…….. (1.0)

To derive the Habitat Unit (HU) figure for a species, the HSI rating is multiplied by the acres of habitat used by that species. Some models evaluate the suitability of each cover type separately, and each respective HSI value is only multiplied by acres of habitat in that cover type. Other models evaluate the entire landscape for overall habitat quality, and the overall HSI figure is applied to the summed acres of all cover types used.

Some cover types were evaluated by up to six species, which stacks the habitat acres for that cover type six times and results in more habitat acres assessed than actual project acres. A ratio of stacked HU's to actual habitat acres was derived, to determine HU's/acre. Appendix C details variable data and model results for each target species as well as HU values. HSI ratings by species and habitat type are summarized in Table 3. Resulting HU values are found in Table 4.

Table 3. Species HSI Ratings by Cover Type

Target Species HSI Ratings by Cover Type

Black-capped Chickadee	Cover Type	SI Food	SI Repro.	Habitat HSI
	OC	0.64	0.50	**0.25**
	C	0.99	1.00	**0.99**
	BCS	0.00	1.00	**0.00**
	BCG	0.00	0.00	**0.00**

Mule Deer	Cover Type	SI Food	SI Cover	Overall HSI
	R	0.31		**0.15**
	A	0.08		
	DG	0.18		
	GG	0.17		
	TS	0.40		
	SS	0.64		
	OC		0.62	
	C		0.93	

Downy Woodpecker	Cover Type	SI Food	SI Repro.	Habitat HSI
	R	0.48	0.59	**0.52**

California Quail	Cover Type	SI Food	Food EOA	SI Escape	Escape EOA	SI Roost	Roost EOA	Overall HSI
	R	0.67	0.21	1.00	0.31	0.97	0.30	**0.73**
	TS	0.14	0.04	0.81	0.24	0.11	0.03	
	SS	0.15	0.04	0.47	0.13	0.06	0.02	

Beaver	Cover Type	Habitat HSI
	R	**0.06**

Song Sparrow	Cover Type	Habitat HSI
	R	**0.73**
	TS	**0.57**

Western Meadowlark	Cover Type	Habitat HSI
	A	**0.50**
	DG	**0.68**
	GG	**0.67**

Sharp-tailed Grouse	Cover Type	Habitat HSI
	A	**0.22**
	DG	**0.39**
	GG	**0.61**

Yellow Warbler	Cover Type	Habitat HSI
	R	**0.68**

Table 4. Habitat Acreage and Resulting HU totals

ACTUAL TOTAL ACRES

Cover Type Codes	Actual Acres
(R) - Riparian	609
(OC) - Open Conifer	1,189
(C) - Conifer	630
(BCS) - Burnt Conifer Shrub	213
(BCG) - Burnt Conifer Grass	99
(A) - Agriculture	124
(DG) - Degraded Grass	2,929
(GG) - Good Grass	8,423
(TS) - Tall Shrub	598
(SS) - Short Shrub	545
	15,359

Because multiple species are used to assess each cover type, total acres of habitat become stacked and exceed actual acres

STACKED TOTALS - Acres of Habitat and HU's

Species	Cover Types Assessed as Habitat	Acres Habitat	Habitat Units (HU's)
Beaver	R	609	37
Black-Capped Chickadee	OC, C, BCS, BCG	2,131	921
California Quail	TS, SS, R	1,752	1,279
Sharp-tailed Grouse	A, GG, DG	11,476	6,307
Downy Woodpecker	R	609	317
Mule Deer	R, OC, C, A, DG, GG, TS, SS	15,047	2,257
Song Sparrow	R, TS	1,207	786
Western Meadowlark	A, GG, DG	11,476	7,697
Yellow Warbler	R	609	414
		44,916	20,015
		stacked habitat acres	stacked HU's

20,015 hu / 15,359 ac = stacked HU's/ acre
= 1.3 HU/ac

1.3 HU/ac x 15,359 ac = 19,967 total HU

RELATIVE HU's

Species HU's	Relative HU's (species HU's / total HU's)	Relative Percent	Relative Species HU's
Beaver	37 / 20,015	0.00%	0
Black-Capped Chickadee	921 / 20,015	5.00%	998
California Quail	1,279 / 20,015	6.00%	1,198
Sharp-tailed Grouse	6,307 / 20,015	32.00%	6,390
Downy Woodpecker	317 / 20,015	2.00%	399
Mule Deer	2,257 / 20,015	11.00%	2,196
Song Sparrow	786 / 20,015	4.00%	799
Western Meadowlark	7,697 / 20,015	38.00%	7,588
Yellow Warbler	414 / 20,015	2.00%	399
		100.00%	19,967

3.1 Limiting Factors of Target Species

After running each HSI model, limiting factors were found that seemed to most influence the habitat quality or life requisites of each target wildlife species. These limiting factors will be used to identify needs and prioritize future management strategies.

Mule Deer

The Mule Deer (Winter) Habitat Suitability Model by Ashley and Berger (1999) was applied to 2000-01 HEP data because it was considered the most current model available, but after running the data it seemed to be a poor fit for the cover types present on the Precious Lands and the year-round use by deer. It is designed primarily for shrub-steppe habitats in winter, and poorly characterizes the grassland dominated cover types throughout the year. Several different mule deer models were examined and the Pine Creek Mule Deer HEP Model (Ashley 2001) was chosen as a more ecologically sound assessment tool for this particular study area. The Pine Creek model is a modified version of the Winter Mule Deer model and uses many of the same variables, however it weights them differently to acknowledge that this is year-round range that continuously offers forage and cover, not just seasonal winter range. Additionally, the Pine Creek model does not reduce the HSI value to zero if a particular variable is absent, but stops at a low-end value of 0.05. This model assumes that suitable habitat requirements may still be met, even with the lack of a preferred variable. The model used to assess the lower Snake River losses was also evaluated, but it was overly simple and did not measure conifer cover types for either food or cover requisites.

The Precious Lands study area is largely comprised of grasslands that lack browse shrubs, or an evergreen component for thermal cover. In addition, those evergreen cover types that might offer mule deer cover in the winter months are usually located on the cooler NW to NE aspects that rate poorly in winter mule deer preference. Shrub data was not collected in the grassland cover types during 2000-01 and these variables were estimated at zero. Although this was an approximation, the zero estimate was supported by data collection efforts in 2002, in which only a single shrub was encountered on three new grassland transects. Results of the Pine Creek model indicate that forage values are more limiting to mule deer than cover components due to the large percentage of open grasslands that do not contain suitable shrubs or conifers. Forage cover types and their SI ratings are as follows: Agriculture 0.08, Degraded grass 0.18, Good grass 0.17, Riparian 0.31, Tall shrub 0.40, and Short shrub 0.64. Thermal cover SI ratings are as follows: Open conifer 0.62, and Conifer 0.93. The overall HSI value for mule deer, based on the interspersion of forage and cover requisites throughout the Precious Lands is 0.15.

Black-capped Chickadee

Percent tree canopy cover is the greatest limiting factor of SI Food in all cover types except conifer. The conifer cover type rated the highest habitat HSI at 0.99, while open conifer rated 0.25, and both burned cover types rated 0.00 due to lack of trees or snags. This species will be useful in monitoring the re-establishment of conifers in burn areas, and the HSI rating is expected to increase as tree canopy cover increases.

Sharp-tailed Grouse

Originally, chukar was chosen as a target species to assess grassland habitats, but the model fails to distinguish between undisturbed bunchgrass and degraded cheatgrass communities. Chukars are an exotic species that prefer steep, rocky terrain, and both the seeds and leaves of cheatgrass are considered an important food source. From an ecological management perspective the chukar model does not measure habitat variables essential to establishing or maintaining a quality native bunchgrass community.

The sharp-tailed grouse model created by Ashley (2002) is sensitive to exotic grass components and was considered a better measure of native grassland health. The model is still in an unpublished draft form, but has been used on other BPA crediting projects (personal communication, P. Ashley 2003). The model is broken down into three life requisite assessments, (nesting, brood rearing, and winter cover), and an HSI value is figured separately for each. The steepness of the terrain would zero-out the nesting HSI values, and winter habitat HSI values are primarily based on shrub cover, which is not a management concern in these grassland habitats. Therefore, the brood rearing requisite was used alone to generate the grassland HSI value, and seemed the best measure of native grassland communities. The brood rearing requisite monitors a variety of grassland features that significantly effect habitat quality, and will be a useful management tool in the future.

Good grasslands rated a 0.61 HSI, the main limiting factor being a lack of herbaceous forbs. Degraded grasslands rated a 0.39 HSI due to a lack of native grasses and forbs, and an overabundance of exotic herbaceous species. Agricultural fields were most limited by a lack of forbs and rated a 0.22.

Downy Woodpecker

Lack of snags is a significant limiting factor in both upper and lower Tamarack Creek sites, and *Basal area* is a significant limiting factor in three of the nine riparian transects. The two Tamarack transects are dry riparian sites with a very low number of trees or snags for feeding or reproduction life requisites, while Cottonwood Creek experienced recent flood events which substantially reduced both standing live trees and snags. Habitat HSI is 0.52. The USFWS model (Schroeder 1982) was used.

Beaver

Originally, river otter was selected as a target species for riverine habitats but was replaced by beaver due to the lack of a suitable otter model that could be used on the Precious Lands watersheds. The beaver model provides a more detailed evaluation of riparian community condition compared to the relatively simple otter model used on the Lower Snake Assessment.

Very little habitat in the study area is suitable for beaver due to seasonal water fluctuations that reduce the SI Water value to zero in 8 of 9 transects. Lack of small diameter hardwood trees for feeding is also a significant limiting factor in 3 of the riparian areas sampled. HSI value for the entire riparian cover type is 0.06, and only Broady Creek had any amount of suitable beaver habitat.

Western Meadowlark
Agricultural fields are limited by large areas of uniform grass coverage without perches, and 4 of the 12 grassland transects are limited by low percent grass cover. Habitat HSI ratings for each cover type are as follows: Good grass 0.67, Disturbed grass 0.68, and Agriculture 0.50. This model has similar limitations as the discarded chukar model, in that it lacks a variable to distinguish between good and degraded grassland sites. The Western meadowlark model was used to assess lower Snake River losses, and since another more suitable grassland model could not be found for this region, it has been kept to maintain consistency among the assessment species.

Yellow Warbler
Drainages that have experienced the greatest change due to flood events (Cottonwood Creek and Buford Creek) are most significantly limited by a lack of shrub cover, while the remaining four riparian sites are limited by *Percent hydrophytic shrubs*. The HSI for riparian habitat is 0.68.

Song Sparrow
Distance to potable water is a limiting factor for 3 shrub transects and 2 riparian transects (upper and lower Tamarack Creek) where water was either absent or underground at the time of sampling. Both highly disturbed riparian transects (Cottonwood Creek and Buford Creek) were most limited by *Percent shrub cover*. Habitat HSI ratings are: Riparian 0.73, and Tall shrub 0.57.

California Quail
In all three life requisite categories (food, escape, and roost), the Tall shrub and Short shrub cover types rated poorly for both roost and food requirements. Of the three habitat types utilized, riparian areas rated the best, with the most limiting factor being food. Overall HSI for California quail habitat is 0.73.

4.0 Discussion

HEP results are being used to shape management activities on the Precious Lands. Management activities will address limiting factors wherever possible to improve habitat conditions for target species. In some cases, optimal conditions for one species can result in undesirable conditions for another. Management actions will try to capture the highest quality habitat conditions that benefit the greatest number of species. In addition to the nine target species from the HEP process, other wildlife species will also be considered.

Depending on current conditions, some areas may be managed for specific habitat values or to increase value for a particular wildlife species. For example, conifer stands on the Buford parcel may be treated with prescribed burns to create snags and open stands of mature pine and fir that are preferred by the black-capped chickadee. In the more remote areas of the Basin parcel, conifer stands may be managed as closed canopy sites with abundant undergrowth as quality thermal cover for mule deer.

Because the Precious Lands Wildlife Management Area is overwhelmingly dominated by grassland habitat, the importance of riparian, shrub, and forest communities is elevated. Such areas of increased vertical height and habitat diversity support greater numbers and diversity of breeding birds (NPT, unpublished data), and provide critical thermal and hiding cover for other species such as deer, elk, and small mammals.

Forest canopy development in riparian areas and conifer stands has been identified as a management objective. Past fire and flooding events have negatively impacted the overstory trees in some areas, and structural conditions within riparian and forest communities may require active management to reach desired conditions. For example, trees may be girdled in some forested stands to increase nesting habitat for black-capped chickadee and pileated woodpeckers. In ponderosa pine stands, small diameter trees may be removed to promote a more open, fire-resistant condition. Prescribed burning may also be used in pine stands to remove fuels and regenerate understory browse for deer and elk. Tree planting may be required on some older burned sites (most notably in the Bear and Rush Creek areas) to re-establish forested conditions. In all cases, treatments will be site-specific depending on the current conditions, ease of access, project costs, and probability of success.

There were approximately 124 acres of rolling benches under cultivation for wheat and hay production. Some of these areas have been planted with native bunchgrasses, forbs, shrub seedlings, and/or ponderosa pine seedlings (where soils are deep enough) over the last few years. These benches will continue to be restored to native species over time.

4.1 Desired Future Conditions

Simple trend estimations throughout the entire project landscape are difficult to assess due to high variability resulting from floods, fires, grazing, and extreme topographical influences. Conditions can differ greatly throughout transects, even when located within similar cover types. Life requisites of target wildlife species, combined with the plant association characteristics derived from Johnson and Simon (1987) will be used to monitor plant community health and establish levels of successful management.

Increasing trends for tree, shrub and herbaceous cover are expected in areas where livestock grazing has been discontinued. Cover of shrubs and herbaceous species palatable to livestock are expected to increase 5-10% within the first 5-year sampling period after cattle removal. A similar trend in tree canopy closure may not be evident for 10-15 years, as saplings are not considered a component of the overstory until greater than 15 feet tall.

HEP data will be used to monitor trends in vegetation, and management activities will be designed to reach a certain desired future condition (DFC). Cover types within the project area are highly variable and few exhibit uniform characteristics that may be used as a standard. Therefore, DFC objectives were developed based on criteria that optimize

habitat needs for the greatest number of target species. Each of the four general cover types (Grassland, Shrub, Conifer, and Riparian) has associated species chosen from the HEP process that assess community health and production trends. Additional species have been taken into consideration when a cover type fills a particular life requisite, even if the species was not used for the original crediting analysis. A range of condition was chosen from the habitat requirements of all associated wildlife species, and an attempt was made to span the highest range of quality habitat for the greatest number of species.

The specific requisites of an "optimal" habitat may differ greatly from what the plant association can actually produce. In consideration of this, each DFC was verified with a regional plant association reference (Johnson and Simon 1987) to confirm that ranges established by wildlife needs are consistent with characteristics of high quality plant communities. Target ranges are left fairly broad to allow for site-specific adaptations, fluctuating budgets, and catastrophic changes such as fires and floods, while still providing a guideline to meet diverse wildlife needs. Cover types with a habitat feature that fails to maintain a value within 15% of the DFC range, or habitat values that increase or decrease more than 15% outside the DFC range in a five-year sample period, will be considered a management priority.

Grassland community DFC:

≥40% Bluebunch wheat cover
< 20% cheatgrass
30-35 cm average herbaceous height

Bluebunch wheat is the dominant herbaceous species throughout the majority of the grassland cover type, with an occasional interspersion of Idaho fescue or Sandberg's bluegrass. The invasion of noxious weeds and non-native species degrade the quality of native bunchgrass communities, especially when those communities are converted to near-monocultures of one or just a few species (Schmid et al. 2001). Grasslands will be managed toward the mid- to late-seral condition, with established bunchgrass hummocks free of cheatgrass or other weedy species in the interspaces. Cheatgrass is typically shorter than bunchgrass; therefore, the average herbaceous height may be an indicator of weedy abundance or decreased value as wildlife cover. Species used to develop grassland DFC's are: Western meadowlark, sharp-tailed grouse, and mule deer.

Healthy grasslands

Currently, healthy grasslands (designated as either Excellent or Good) comprise over 70% of the total grassland cover type on the Precious Lands. Average height over all healthy grasslands is 38cm, and 'Excellent' grasslands contain less than 10% cheatgrass, while 'Good' grasslands contain less than 30% cheatgrass. In the future, healthy grassland communities should not show an increase of more than 10% cheatgrass or other exotics, and these areas will be actively managed by methods such as spraying, spading or hand pulling to contain the spread of undesirable species. The permanent HEP plots assigned to monitor the healthy grassland communities are: 'Excellent' plots: G-4 and G-5, and 'Good' plots: G-3 and G-10.

Degraded grasslands

Degraded grasslands average 36% cheatgrass cover and a height of 27cm. They are divided into 'Fair' and 'Poor' categories and will be monitored using HEP. Restoration techniques will be tested on small, weedy plots to find the most cost effective methods of restoring native bunchgrass and reducing exotic species on these sites. However, due to the rugged terrain and inaccessibility of many areas, full restoration and cheatgrass eradication is not cost effective at this time. The permanent HEP plots assigned to monitor this cover type are: 'Fair' plots: G-7 and G-9, and 'Poor' plots: DG-1 and G-6.

Shrub community DFC:

A mosaic of seral stages with the majority in the mature class
Shrub canopy cover – 40-80%
Herbaceous cover – 30-50%

Shrub fields support a wide variety of wildlife species, and function as travel corridors between the low elevation riparian areas and upland forest or grassland communities. Species used to develop shrub community desired conditions are: mule deer, California quail, yellow warbler, sharp-tailed grouse (winter cover), and song sparrow. The moderate range of shrub cover and high range of herbaceous canopy cover offers a high quality mix of concealment, roost, thermal protection, and browse opportunities. The goal for both Tall and Short shrub communities is a mosaic of different seral stages across the entire project area, with:

60% of the shrub communities having 40-65% canopy cover,
20% having >65% canopy cover, and
20% having <40% canopy cover.

Short shrub and Tall shrub

Both Short shrub and Tall shrub communities are highly valuable as thermal and hiding cover for many species of wildlife, and management by removal or burning is not anticipated at this time. Some shrub communities have been subject to disturbance by livestock, fire, flood, etc. as were mentioned above, but little change is anticipated in tree, shrub, or herbaceous cover of the climax stage shrub fields. Shrub communities tend to increase with the exclusion of grazing (Johnson and Simon 1987), and an increase in shrub cover is expected over time where grazing has been recently removed. Grazing may be used in the future to create or maintain low-density shrub cover in some areas. Restoration practices may be implemented if shrub cover shows a downward trend exceeding 15% loss of cover. Restoration may not be considered a priority unless areas in decline exceed the desired 20% low-density seral stage as mentioned above. The permanent HEP plots assigned to monitor Tall shrub communities are S-1 and S-4, and Short shrub communities are SS-1 and SS-3.

Conifer community DFC:

The forested communities offer cover in all seasons and fill many life requisites for wildlife. Because use varies so greatly among species, the DFC's were split into three categories to accommodate differing sites and wildlife needs. Percent canopy cover and recent fire events divide evergreen community classifications. Mule deer, blue grouse, pileated woodpecker, and black-capped chickadee were used to develop desired conditions for conifer communities, in combination with verification from Johnson and

Simon (1987). Forest bats were also taken into consideration and the large snag requisite was added.

Open Conifer

Tree canopy cover – 10-30%
Shrub canopy cover – 40-80%
Herbaceous cover – 30-50%
Snags – ≥ 2 snags/acre of 4-10" dbh, and ≥ 0.5 snags/acre of ≥20" dbh

Open Conifer sites have <30% evergreen canopy cover, and are classified in the Ponderosa pine/ common snowberry plant association. It is recommended that this community be managed in uneven seral stages (Johnson and Simon 1987). This cover type will be managed using activities such as thinning and prescribed burns to open decadent stands and reduce the risk of fire, disease, and insect damage. Where necessary, trees may be girdled to obtain the desired size and quantity of snags. The permanent HEP plots assigned to monitor Open conifer communities are OC-1 and OC-5.

Conifer

Tree canopy cover – 60-85%
Shrub canopy cover – 20-40%
Herbaceous cover – 30-50%
Snags – ≥ 2 snags/ac of 4-10" dbh, and ≥ 0.5 snags/acre of ≥20" dbh

Conifer sites are characterized by >30% evergreen canopy cover, and are classified in the Douglas fir/ ninebark plant association. These sites tend to have a denser shrub component than Open Conifer sites, and thinning or grazing may be applied to reduce the shrub density in some areas. Where necessary, trees may be girdled to obtain the desired size and quantity of snags. The permanent HEP plots assigned to monitor the Conifer communities are C-2 and C-3.

Burned Conifer

Tree canopy cover – 10-30%
Shrub canopy cover – 40-80%
Herbaceous cover – 30-50%
Snags – ≥ 2 snags/acre of 4-10" dbh, and ≥ 0.5 snags/acre of ≥20" dbh

Two sites that were burned in the 1998 Teepee Butte fire (Bear creek OC-3, and Tamarack ridge OC-4) (Figure 5) are designated as Burned Conifer Shrub and Burned Conifer Grass. The two burned sites have "0" evergreen cover and are currently dominated by grass or shrub species. They have the potential to develop back into Open Conifer communities and are being monitored for regeneration success. The extensive burn removed a large percentage of the mature conifers that would have functioned as seed sources for the re-establishment of historic conifer cover, and initial baseline HEP surveys have shown very little conifer regeneration in the Bear Creek drainage. Restoration planting to re-establish trees, possibly combined with understory burning to thin dense shrub thickets, may be implemented to increase tree canopy cover as budgets permit. Conifer cover will be compared to historic aerial photographs to measure restoration success.

Riparian community DFC:
In 1996 Buford and Cottonwood Creeks experienced flooding events that greatly altered riparian vegetation structure and stream bank morphology. These areas are expected to show an increase of 15-20% tree and shrub cover over a 20-year period, and should exhibit an increasing trend at each of the 5-year monitoring intervals. The 1996 flood also impacted Joseph Creek but it is a naturally 'flashy' system, experiencing extreme flow changes annually, and is therefore not expected to exhibit the same level of continuous increase in tree and shrub cover over time. Vegetation on Joseph Creek should increase by 5-10%, but is expected to be set back repeatedly from high spring runoff. Restoration efforts may be implemented if it is determined (through stream surveys) that revegetation and channel modification could effectively reduce the magnitude of annual spring flooding events. Riparian communities that were not affected by flooding are expected to maintain current levels of tree, shrub and herbaceous cover.

For long-term monitoring and planning, the general riparian cover type will be divided into three separate sub-types: Riparian shrub, Riparian hardwood, and Riparian conifer. Due to the high variability of the riparian systems, site-specific considerations will be taken into account depending on the target wildlife needs and the goal of each project.

Riparian shrub

Shrub height – > 6 ft average
Shrub cover – 40-80%
Herbaceous cover – 25-75%

Riparian Shrub communities are located in either dry drainages filled with hawthorn scrub, or wet riparian draws dominated by hydrophytic shrub species (see section 4.2 for a list of hydrophytic shrubs). Hawthorn dominant communities tend to develop after livestock grazing has eliminated the more palatable shrub species, and while these dense thickets are good roost and cover sites they are often too dense for many wildlife species' 'optimal' preference. Some of these dense hawthorn patches will need to be opened up by mechanical means or prescribed fire to meet the Riparian Shrub DFC. Mule deer, song sparrow, yellow warbler, and California quail were used to develop DFC's for this cover type. The permanent HEP plots assigned to monitor Riparian shrub communities will be located along Tamarack creek (R-2) and Broady creek (R-4).

Riparian hardwood

Snags – > 4 snags/acre of 4-10" dbh, and $\geq$ 0.5 snags/acre of $\geq$20" dbh
Shrub height – > 6 ft average
Tree cover – 50-75%
Basal area – 40-80 ft^2/acre

A mix of any of the following species dominates the overstory in riparian hardwood communities: black cottonwood, white alder, water birch, quaking aspen, or willow. This cover type supports moderate to high shrub cover, but HEP results suggest it is below the DFC for shrub height at this time. Shrub height is expected to increase within the next five years as vegetation recovers from grazing impacts. In addition, snags of the proper size are less abundant than the desired DFC level (current avg. 3.25 snags/ac). Future management strategies will include the creation of more snags in this cover type. Downy woodpecker, beaver, black-capped chickadee, and yellow warbler were used to develop

DFC's for this community. Forest bats were also taken into consideration and the large snag requisite was added. The permanent HEP plots assigned to monitor the Riparian hardwood communities are Cottonwood creek (R-5) and North Joseph creek (R-7).

Riparian conifer

Snags – > 2 snags/acre of 4-10" dbh, and ≥ 0.5 snags/acre of ≥20" dbh
Shrub height – > 3 ft average
Shrub cover – 30-70%
Tree cover – 60-75%

Riparian conifer communities are found along narrow canyons of shaded, cool drainages. Streams may flow intermittently or year-round. Currently, shrub cover is only slightly higher than the DFC range. Mule deer and black-capped chickadee were used to develop DFC's. Forest bats were also taken into consideration and the large snag requisite was added. The permanent HEP plots assigned to monitor the Riparian conifer communities will be located along Basin creek (R-3) and Rock creek (R-9).

4.2 Data Collection Procedures – Omissions, Changes, and Derivations

The Precious Lands HEP process was originally designed around the guidelines of the Lower Snake River Compensation assessment. While the methodology was followed as closely as possible, some changes were made.

Model substitutions or alterations

- Blue grouse was removed as a target species. Blue grouse was only an optional species, and it was decided that the two other species (mule deer and black-capped chickadee) were sufficient to assess conifer habitats. Blue grouse was originally selected as a measure of conifer habitats, but the model (Schroeder 1984) in fact assesses every habitat type on the study area and excessively stacked total acres of habitat.

- Sharp-tailed grouse was substituted for chukar as a grassland target species. Chukar was originally chosen to assess grassland habitats in the Lower Snake Comp, but the model fails to distinguish between undisturbed bunchgrass and degraded cheatgrass communities. Chukars are an exotic species and the seeds and leaves of cheatgrass are considered an important food source. From an ecological management perspective the chukar model does not measure habitat variables essential to establishing or maintaining a quality native bunchgrass community. The sharp-tailed grouse model is sensitive to exotic grass components and was considered a better measure of native grassland health. The model is broken down into three life requisite assessments, (nesting, brood rearing, and winter cover), and an HSI value is figured separately for each. The brood rearing requisite was used alone to generate the grassland HSI value, and seemed the best measure of native grassland health.

- The Winter mule deer model (Ashley and Berger 1999) was applied to 2000-01 HEP data because it was considered the most current model available, but after running the data it seemed to be a poor fit for the cover types present on the Precious Lands and failed to account for habitats used year-round. It is designed primarily for shrub-steppe habitats in winter, and poorly characterizes the grassland-dominated cover types used throughout the year. The Pine Creek Mule Deer HEP Model (Ashley 2001) was chosen as a more ecologically sound assessment tool for this particular study area. The Pine Creek model is a modified version of the Winter mule deer model and uses many of the same variables, however it weights them differently to acknowledge that this is year-round range that continuously offers forage and cover, not just seasonal winter range. Additionally, the Pine Creek model does not reduce the HSI value to zero if a particular variable is absent, but stops at a low-end value of 0.05. This model assumes that suitable habitat requirements may still be met, even with the lack of a preferred variable. The model used to assess the Lower Snake Comp losses was also evaluated, but it was overly simple and did not measure conifer cover types for either food or cover requisites.

- Black-capped Chickadee was used only on conifer cover types. Though the model could be applied to riparian habitats, it was decided that riparian habitats were well represented by other target species where conifer cover types were not.

Data Omissions

2000 was the first year of HEP data collection and plot establishment. Some HSI variables were manipulated to fit the study site, and there were some omissions and exceptions to established protocol:

- Cover pole data (hiding cover) were not collected in 2000. Cover data were collected on all appropriate HEP plots thereafter.

- No evergreen tree data were collected on grassland or shrub sites, and all variables pertaining to trees in these cover types are considered “0”. These data were measured in 2002, and the coverage was still “0”.

- No shrub data was collected on the grassland plots in 2000-2001 and all variables pertaining to shrubs in grasslands are considered “0”. These data were measured in the field in 2002 and only a single shrub was encountered on three grassland transects, therefore the assumption of “0” shrub cover is considered accurate.

- During 2000-01 shrub intercept data was collected on only the tallest shrub that intersected the transect tape at the sampling interval. Unfortunately, some models are only designed to use the tallest shrub at or below a particular height. Variables such as *Percent cover of shrubs <1.5m, Percent cover of shrubs <6m,* and *Average height of shrubs <6m* were not correctly sampled until 2002. HSI model data were run in the fall of 2001 based on conservative estimates for these variables. Height estimates were derived by removing all intercept “hits” that fell

outside the range of the variable. For example, *Average height of shrubs <1.5m* was estimated by disregarding all shrub "hits" 1.5m or greater. It is recognized that just because the maximum shrub height exceeded the proper range, it is possible that there were lower, 'sub-maximum' understory shrubs that might have fulfilled the requirements. To avoid making inconsistent or erroneous assumptions in the office, a conservative method was applied that used only the partial data set and knowingly underestimated total shrub canopy cover. For 2002 data collection, separate measurement classes were created and shrub height <1.5m and <6m were each sampled in the field instead of estimated in the office.

Derived Data

- *Average annual water fluctuation* is estimated from personal knowledge of the stream systems in the area. Most drainages are "flashy" and experience high spring runoff events and some occasionally go dry in the summer months.

- During 2000 and 2001, variables such as *Distance to potable water, Average distance to shrub cover, Distance to forest/tree savanna, Distance to exposed rocks, Road density, Proximity of crops,* and *Topographic diversity* were determined in the office from maps or aerial photographs. *Average distance to shrub cover* and *Distance to exposed rocks* were measured in the field in 2002.

- *Distance to escape cover* and *Distance to exposed rock* were not collected on any transects during 2000 or 2001. Figures used in HSI models are estimates derived from maps. These data were collected in 2002 on all appropriate sites.

- *Distance to roost* and *Distance to perch* data were only collected on grassland plots during 2000 (no grassland plots were sampled in 2001, and no cover types were sampled for this data in 2000 or 2001). These data were collected in 2002.

- Variables such as *Percent hydrophytic species, Percent lacustrine surface dominated by water lily, Number of preferred species >10% cover*, and *Percent cover preferred shrubs* are derived in the office by analysis of field data.

- Preferred shrub species are very site specific and were not well defined on the Precious Lands until fall 2001. Shrub species considered palatable to mule deer:

Alder spp.	Oregon grape	Redstem ceanothus	Serviceberry
Apple	Oceanspray	Red osier dogwood	Snowberry
Chokecherry	Plum	Rocky Mtn. maple	Wax currant
Ninebark	Prickly currant	Rosa spp.	Willow spp.

- Shrub species considered hydrophytic are:

Alder	Elderberry	Rocky Mtn. maple	Wax currant
Black hawthorn	Prickly currant	Spirea	
Cascara	Raspberry	Syringa (Mock orange)	
Chokecherry	Red osier dogwood	Thimbleberry	

- Age classes of trees within the circle plot are tallied separately in a deciduous/ conifer category and by size. The beaver model measures trees within a 1-6" dbh class and does not fit any of the age categories sampled. This variable was analyzed using the 'Sapling' age class, thereby conservatively underestimating the actual value of this habitat component due to the exclusion of the 5" and 6" dbh trees. Size classes are defined as follows:
  Sapling: <4" dbh and <15 ft tall
  Pole: 4 - 8" dbh
  Mature: >8" dbh

Literature Cited

Allen, A. W. 1983. Habitat Suitability Index Model: Beaver. US Department of the Interior, Fish and Wildlife Service, FWS/OBS-82/10.30. Revised. 20 pp.

Anderson, S. and K. Gutzwiller. 1996. Habitat Evaluation Methods. Pages 592-606 *in*: T. A. Bookhout, ed. Research and Management Techniques for Wildlife and Habitats. Fifth ed., rev. The Wildlife Society, Bethesda, MD. xiii + 740pp.

Ashley, P. 2001. Pine Creek Mule Deer HEP Model. Developed for Warm Springs Tribe, Warm Springs, OR. Unnumbered.

Ashley, P. 2002. Draft Sharp-tailed Grouse Habitat Suitability Model. Revised February 2002. Unpublished.

Ashley, P. and M. Berger. 1999. Habitat Suitability Model – Mule Deer (Winter). Developed for Bonneville Power Administration, Division of Fish and Wildlife, Portland, OR. iv + 34pp.

USFWS. 1980a. Habitat as a Basis for Environmental Assessment, Ecological Services Manual (ESM) 101. Division of Ecological Services, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. Unnumbered.

USFWS. 1980b. Habitat Evaluation Procedures (HEP), Ecological Services Manual (ESM) 102. Division of Ecological Services, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. Unnumbered.

Hays, R. L., C. Summers and W. Seitz. 1981. Estimating Wildlife Habitat Variables. Western Energy and Land Use Team, Office of Biological Services, U.S. Fish and Wildlife Service, Department of Interior, Washington, D.C. 20240. viii + 111pp.

Hickman, J. C., ed. 1993. The Jepson Manual Higher Plants of California. University of California Press, Berkeley, CA. 1400 pp.

Hitchcock, C. L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, WA. 730 pp.

Johnson, C. and S. Simon. 1987. Plant Associations of the Wallowa-Snake Province. Wallowa-Whitman National Forest. USDA Forest Service, Pacific Northwest Region, R6-ECOL-TP-255A-86. 400 p. + appdx

Northwest Power Planning Council. 2000. Columbia River Basin Fish and Wildlife Program. Council Document 2000-19. 61 pp. + appdx

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, PNW-GTR-390. 40 p.

Schmid, B., J. Joshi and F. Schläpfer. 2001. Empirical Evidence for Biodiversity-Ecosystem Functional Relationships. Pages 120-150 *in*: A. Kinzig, S. Pacala, and D. Tilman, eds. The Functional Consequences of Biodiversity. Princeton University Press, Princeton, New Jersey. xxvi + 366 pp.

Schroeder, R. L. 1982a. Habitat Suitability Index Model: Black-capped Chickadee. US Department of the Interior, Fish and Wildlife Service, FWS/OBS-82/10.37. 12 pp.

Schroeder, R. L. 1982b. Habitat Suitability Index Model: Downy Woodpecker. US Department of the Interior, Fish and Wildlife Service, FWS/OBS-82/10.38. 10 pp.

Schroeder, R. L. 1982c. Habitat Suitability Index Model: Yellow Warbler. US Department of the Interior, Fish and Wildlife Service, FWS/OBS-82/10.27. 7 pp.

Schroeder, R. L. 1984. Habitat Suitability Index Model: Blue Grouse. US Department of the Interior, Fish and Wildlife Service, FWS/OBS-82/10.81. 19 pp.

Schroeder, R., and P. Sousa. 1982. Habitat Suitability Index Model: Eastern Meadowlark. US Department of the Interior, Fish and Wildlife Service, FWS/OBS-82/10.29. 9 pp. Modified for Western Meadowlark.

U.S. Army Corps of Engineers. 1989. California Quail HSI Model. Developed for Lower Snake River Application. Unpublished.

U.S. Fish and Wildlife Service. 198?. Chukar HSI Model. US Department of the Interior, Ecoregion 3131. Model modified 10-18-89 for use on the Lower Snake River by U.S. Army Corps of Engineers.

U.S. Fish and Wildlife Service. 1979. Song Sparrow HSI Model. US Department of the Interior, Ecoregion 2410. Model modified 10-18-89 for use on the Lower Snake River.

Appendix A

HEP Results by Cover Type

Tables 5-10 use many variables and terms that are explained in the following text. All information is from 2000-2002 data collection and analysis. Full discussion of variables and protocols is covered in the preceding report body text.

ALL COVER TYPES

- Road Density
  Buford property is appx 2.3 sq. mi.=3.7 sq. km (only Buford accessible in winter)
  Road (paved) is appx 3 mi = 4.6 km.
  4.6 sq km rd / 3.7 sq. km habitat = 1.24 km rd/ km habitat
- Mule deer Topographic diversity:
  A - Level terrain, <5% slope D - Rolling - rims, ridges and drainages
  B - Level, w/ drainages E - Mountainous terrain, slopes >25%
  C - Rolling terrain, 5-25% slope
- Numbers in **red** represent data that was not collected to a 95% confidence interval due to extreme variability of the cover type on that plot
- All numbers in **blue** were estimated in the office. All estimates are made to the best of our knowledge and are conservative approximations.
- The word **Permanent** above a transect column on the data tables indicates one of 24 plots that will be rotationally monitored for long-term habitat trend data.

GRASSLAND

- Average distance to shrub cover on all grassland sites is .66 km - using GIS maps.

SHRUB

- Percent grass was estimated for plots SS-1 and S-1 where data were not collected in the field. Estimates were derived by finding the average ratio of
  % grass to % herbaceous cover from the other two samples in each cover type (SS and S) and applying that same ratio to the estimated plot.

CONIFER - none

RIPARIAN

- Species composition of woody vegetation:
  A - Aspen, Willow, Cottonwood, Alder dominant (>50%)
  B - Other deciduous species dominant
  C - Coniferous species dominant
- Annual water fluctuation:
  A - Small fluctuation
  B - Moderate fluctuation
  C - Extreme fluctuation or lack of water during some part of the year

Table 5. HEP Results for Good Grassland Plots

GOOD GRASSLANDS

Associated species - Western Meadowlark, Sharp-tailed Grouse, Mule Deer

	DESCRIPTIONS & VARIABLES			**Permanent** good	**Permanent** excellent	**Permanent** excellent		**Permanent** good	
	Plot	**GF-1** Buford	**G-2** Buford	**G-3** Tamarack	**G-4** Tamarack	**G-5** Tamarack	**G-8** Tamarack	**G -10** Paradise	**average**
	Area description	Wheat field	Crest to Buford Crk	Saddle W of cabin	E Central Rdg	W Central Rdg	E Jsph Crk, .75mi SW cabin	NE of Prdise Grass Bird stn 5	
	Year established	6/29/00	7/6/00	7/10/00	7/11/00	7/11/00	7/25/00	7/2/02	
HERB	# Herb spp	2.6	6.4	6.6	6	7.3	5.8	6.2	5.8
	% Herb cover	97.8	53.9	78.5	61.2	55.1	67.3	53.3	66.7
	% Grass cover	100	42.8	70.7	57.4	44.4	58.3	43.3	59.6
	Avg herb height (cm)	57.7	31.4	34.2	34.9	33.8	35.1	36.6	37.7
	% Cover palatable herb	99.4	44.7	71.5	57.8	45.8	64.9	43.2	61.0
	% Cheatgrass	<1	27.2	30	10	9	13	29.1	19.7
	# Prefer shrub spp ≥ 10% cover	0	0	0	0	0	0	0.0	
SHRUB	% Cover prefer shrubs <1.5m	0	0	0	0	0	0	0.0	
	% Cover shrubs <1.5m	0	0	0	0	0	0	0.0	
	% Canopy cover of shrubs <6m	0	0	0	0	0	0	0.0	
	Avg shrub height (m)	0	0	0	0	0	0	0.0	
	Distance to shrub cover (km)	0.1	0.4	0.4	1.0	0.9	0.7	0.0	
TREE	% Evergreen canopy >1.5m	0	0	0	0	0	0	0.0	
MISC	Dist to forest/ tree savanna (km)	0.1	1.0	0.5	1.0	1.0	1.0	0.1	
	Distance to exposed rocks (km)	1.0	0.1	0.1	0.1	0.5	0.1	0.0	
	Distance to perch (m)	50	6.3	6.6	41.1	12.5	13.8	8.0	
	Crops within 1.6 km (Y/N)	Y	Y	N	N	N	N	N	
	Aspect (degrees)	5	249	122	104	220	233	136	
	Road density: km rd/km^2 habitat	1.24	1.24	0	0	0	0	0	
	Topo diversity (Mule deer model)	D	D	D	D	D	D	D	

Table 6. HEP Results for Degraded Grassland Plots

DEGRADED GRASSLANDS

Associated species - Western Meadowlark, Sharp-tailed Grouse, Mule Deer

	DESCRIPTIONS & VARIABLES	**Permanent** poor	**Permanent** poor	**Permanent** fair	**Permanent** fair			
	Plot	**DG-1** Buford	**G-6** Tamarack	**G-7** Tamarack	**G-9** Basin	**G-11** Buford Ridge	**G-12** Joseph	**average**
	Area description	Disturbed grass	Tamarack ridge	E of Jsph Crk, 1mi N of cabin	3/4 mi NE of cabin	N of Buford Rdg ponds	2mi N bottom of Jkmn rd	
	Year established	6/28/00	7/12/00	7/18/00	8/7/00	7/17/02	7/30/02	
HERB	# Herb spp	7.4	6.4	5.8	7.2	6.1	4.3	6.2
	% Herb cover	81.7	46.8	74.7	81.3	55.2	77.4	69.5
	% Grass cover	73.9	37.6	62.6	70.9	30.5	68.5	57.3
	Avg herb height (cm)	16.5	29.7	30.4	29.1	30.5	28.3	27.4
	% Cover palatable herb	73.9	39.3	72.2	71.2	30.9	68.6	59.4
	% Cheatgrass	69	<1	33	39	8.3	31.9	36.2
	# Prefer shrub spp ≥10% cover	0	0	0	0	0.0	0.0	
SHRUB	% Cover prefer shrubs <1.5m	0	0	0	0	0.0	0.0	
	% Cover of shrubs <1.5m	0	0	0	0	0.0	0.3	
	% Cover of shrubs < 6m	0	0	0	0	0.0	0.3	
	Avg shrub height (m)	0	0	0	0	0.0	0.0	
	Distance to shrub cover (km)	1.0	0.5	1.2	0.4	0.1	0.0	
TREE	% Evergreen canopy >1.5m	0	0	0	0	0.0	0	
MISC	Dist to forest/ tree savana (km)	0.5	1.0	1.0	1.0	1.1	0.9	
	Dist to exposed rocks (km)	0.1	1	0.1	0.7	0.0	0.13	
	Distance to perch (m)	79.2	22	27.2	31.7	14.8	28.7	
	Crops within 1.6 km (Y/N)	Y	N	N	N	N	N	
	Aspect (degrees)	265	220	234	254	124	92	
	Road density: km rd/ km^2 habitat	1.24	0	0	0	1.24	0	
	Topo diversity (Mule deer model)	D	D	D	D	D	D	

Table 7. HEP Results for Shrub Plots

SHRUB

Associated species - Mule Deer, California Quail, Song Sparrow

	DESCRIPTIONS & VARIABLES	Permanent short shrub		Permanent short shrub	Permanent tall shrub		Permanent tall shrub
	Plot	**SS-1** snowberry	**SS-2** snowberry	**SS-3** snowberry	**S-1** ninebark	**S-3** sumac	**S-4** ninebark
	Area description	1mi N Tmrk gate	SE Paradise tree farm	E of Basin cabin	Rye Shrub	2mi up Broady	.5 mi N Basin cabin
	Year established	6/26/00	8/14/01	8/20/01	6/14/00	8/16/00	8/2/01
HERB	# Herb spp	4.5	5.2	3.5	5.6	4.3	2.5
	% Grass cover	58.2	58.3	44.4	68.0	77.0	40.7
	% Herb cover	76.6	79.0	57.3	72.7	80.5	45.7
	% Cover palatable herb	72.0	45.9	29.8	87.6	77.1	37.9
	Avg herb height (cm)	25.7	30.3	31.0	20.1	22.9	20.0
SHRUB	% Cover shrubs	78.1	50.0	82.5	63.9	36.7	88.3
	% Cover shrubs <1.5m	77.5	50.0	80.8	50.0	34.2	51.7
	% Cover preferred shrubs <1.5m	76.9	50.0	80.0	43.1	7.5	51.7
	% Canopy cover of shrubs <6m	78.1	50.0	82.5	63.9	36.7	88.3
	# Prefer shrub spp $\geq$ 10% cover	2	2	3	3	1	1
	Avg height shrubs <6m (m)	0.4	0.3	0.6	1.0	0.7	1.4
	Avg shrub height (m)	0.4	0.3	0.6	1.0	0.7	1.4
TREE	% Evergreen canopy >1.5m	0.0	0.0	0.0	0.0	0.0	0.0
MISC	Crops within 1.6 km (Y/N)	N	N	N	N	N	N
	Aspect (degrees)	230	97	266	42	95	311
	Dist. to forest/ tree savanna (km)	0.2	0.2	0.2	0.2	0.2	0.2
	Dist. to escape cover (m)	100	500	250	500	100	200
	Dist. to perch (m)	50	100	50	25	25	25
	Dist. to roost cover (m)	100	500	250	400	100	200
	Dist. to potable water (km)	1.6	0.7	0.2	0.7	0.1	0.3
	Road density: km rd/ km^2 habitat	0	0	0	0	0	0
	Topo diversity (Mule deer model)	D	D	D	D	D	D

Table 8. HEP Results for Conifer Plots

CONIFER

Associated species - Mule Deer, Black-Capped Chickadee

	DESCRIPTIONS & VARIABLES	Permanent	Permanent	
	Plot	**C-2** (conifer)	**C-3** (conifer)	**C-5** (conifer)
	Area description	2nd Buford pilot	Tamarack - Upbrdy bird plot	Broady Creek - S ridge
	Year established	6/15/00	7/19/00	8/21/01
HERB	# Herb spp	4.3	4.6	2.2
	% Herb cover	61.5	53.2	42.7
	Avg herb height (cm)	18.1	13.0	13.7
	% Cover palatable herb spp	70.8	7.3	23.3
SHRUB	% Cover shrubs	65.8	70.8	82.5
	% Cover shrubs <1.5m	61.3	51.7	68.3
	% Cover preferred shrubs <1.5m	60.4	50.8	68.3
	# Preferred shrub spp $\geq$ 10% total cover	4	3	2
	Avg shrub height (m)	0.7	0.4	1.0
TREE	% Evergreen canopy >1.5m	54.6	72.5	48.3
	% Tree canopy closure	54.6	72.5	48.3
	Avg height of overstory trees (m)	21.0	17.6	19.2
	# Snags 4-10" DBH/ acre	3.1	35.0	6.0
MISC.	Aspect (degrees)	10	28	320
	Crops within 1.6 km (Y/N)	Y	N	N
	Distance to potable water (m)	300	900	1100
	Dist. to forest/ tree savanna (km)	0	0	0
	Road density (km rd/ km^2 habitat)	1.24	0	0
	Topo diversity (per M deer model)	C	E	E

Table 9. HEP Results for Open Conifer Plots

OPEN CONIFER

Associated species - Mule Deer, Black-Capped Chickadee

	DESCRIPTIONS & VARIABLES	Permanent	Permanent	Permanent	Permanent
	Plot	**OC-1** (Open conifer)	**OC-3** (Burn conifer shrub)	**OC-4** (Burn conifer grass)	**OC-5** (Open conifer)
	Area description	1st Buford pilot	Bear Creek - burn	Tamarack Ridge - burn	Tamarack - N Central Rdg
	Year established	6/8/00	7/26/01	8/15/01	7/26/00
HERB	# Herb spp	4.8	4.4	2.9	4.9
	% Herb cover	52.5	76.5	81.2	68.9
	Avg herb height (cm)	21.9	27.0	61.0	24.7
	% Cover palatable herb spp	54.2	18.2	1.0	5.5
SHRUB	% Cover shrubs	67.2	47.5	16.3	60.6
	% Cover shrubs <1.5m	56.9	37.5	16.3	50.0
	% Cover preferred shrubs <1.5m	56.8	19.2	16.3	50
	# Prefer shrub spp ≥ 10% cover	4	3	3	5
	Avg shrub height (m)	1.0	1.1	0.3	0.9
TREE	% Evergreen canopy >1.5m	11.7	0.0	0.0	31.1
	% Tree canopy closure	11.7	0.0	0.0	31.1
	Avg height of overstory trees (m)	15.6	20.8	23.2	17.4
	# Snags 4-10" DBH/ acre	6.7	11.7	0.0	0.0
MISC.	Aspect (degrees)	40	327	352	30
	Crops within 1.6 km (Y/N)	Y	N	N	N
	Distance to potable water (m)	500	300	3500	2000
	Dist. to forest/ tree savanna (km)	0	0.2	0.2	0
	Road density (km rd/ km^2 habitat)	1.24	0	0	0
	Topo diversity (Mule deer model)	C	D	E	E

Table 10. HEP Results for Riparian Plots

RIPARIAN

Associated species - Mule Deer, Song Sparrow, Downy Woodpecker, Yellow Warbler, and Beaver

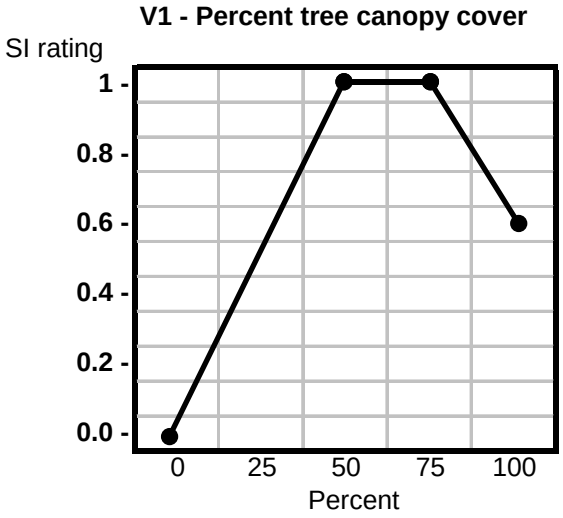
	DESCRIPTIONS & VARIABLES		**Permanent** shrub	**Permanent** conifer	**Permanent** shrub	**Permanent** hardwood		**Permanent** hardwood		**Permanent** conifer
	Plot	**R-1**	**R-2**	**R-3**	**R-4**	**R-5**	**R-6**	**R-7**	**R-8**	**R-9**
	Area description	Up Tmrck Crk	Low Tmrck Crk	Basin Crk	Broady Crk	Cttnwd Crk	Buford Crk	N Jseph Crk	S Jseph Crk	Rock Crk
	Year established	8/1/00	8/2/00	8/8/00	8/15/00	8/17/00	8/22/00	7/22/02	8/19/02	8/22/02
HERB	# Herb spp	4.5	4.12	1.9	3.7	3.5	2.6	2.5	2.7	1.8
	% Herb cover	74.4	63.9	44.5	61.9	30.6	21	12.6	38	21.8
	Avg herb height (cm)	18.4	24.4	24.1	35.3	19.7	24.4	10.7	26.2	20.1
	% Cover palatable herb spp	1.97	30.9	0	0	11.6	7.9	0.37	0	0
SHRUB	% Cover shrubs	65.8	74.1	78.8	62.5	22.4	25.6	55.6	72.5	72
	% Cover shrubs <1.5m	39.2	37.3	44.4	37.5	11.7	15.3	45.3	55	60
	% Canopy cover of shrubs <6m	65.8	72.3	78.8	62.5	22.1	25.6	55.6	72.5	72
	% Cover preferred shrubs <1.5m	34.2	26.8	29.4	13.8	8.6	6.3	22.8	20	28.1
	Avg height shrubs <6m (m)	1.4	1.9	1.6	1.8	1.5	1.3	1.8	2.1	1.8
	Avg shrub height (m)	1.4	1.9	1.6	1.8	1.6	1.3	1.8	2.1	1.8
	# Prefer shrub spp ≥ 10% cover	4	1	2	1	3	1	1	0	2
	% Shrubs of hydrophytic spp	35	59	44	84	41	67	78	76	67
	Species comp. of woody veg	C	no trees	C	A	A	A	A	A	A
TREE	% Tree canopy cover	12.5	0	66.3	28.6	1.4	42	95.5	70	75
	% Evergreen canopy cover	10.8	0	32.5	2.9	0.59	0	0	0	50
	% Evergreen canopy >1.5m	10.8	0	32.5	2.9	0.59	0	0	0	50
	% Deciduous trees 1-6" DBH	19.1	0	12.1	28.1	79.1	81.8	43	43	9
	Sq ft basal area/ acre	15.8	0	43.8	27.1	8.2	39.4	55	40	41
	Avg tree height (m)	12.3	0	13	14.2	17.1	13.9	13.2	13.6	24.3
	# Snags >6" DBH/ acre	0	0	3.8	17.1	3.5	16.9	3	9	6.3
WATER	Distance to potable water (km)	2.0	1.0	0.0	0.0	0.0	0.0	0	0	0.4
	% Water surface having water lily	0	0	0	0	0	0	0	0	0
	Ann water fluctuation (Beaver)	C	C	C	B	C	C	C	C	C
	Stream gradient (% slope)	25	8	13	2	3	4	3	3	16
MISC	Crops within 1.6 km (Y/N)	N	N	N	N	N	Y	N	N	N
	Dist. to forest / tree savanna (km)	0	1	0	0	0.1	0.1	1.4	0.76	0
	Dist. to roost cover (m)	10	10	10	10	40	10	0.5	2	0.75
	Dist. to escape cover (m)	10	10	10	10	25	20	5.6	5	2.4
	Road density (km rd/ km^2 habitat)	0	0	0	0	0	1.24	0	0	0
	Aspect (degrees)	320	332	359	296	244	5	30	95	50
	Topo diversity (Mule deer)	E	D	E	D	D	D	D	D	E

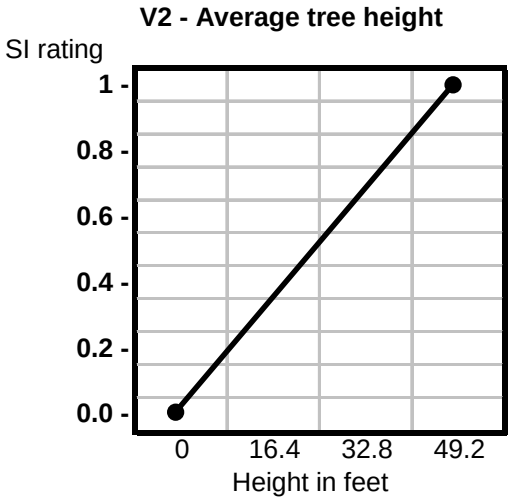
Appendix B

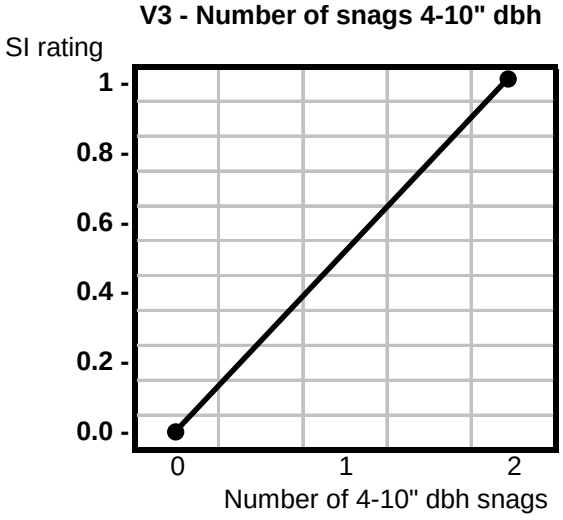
Habitat Suitability Index Variable Models and Graphs by Species

BLACK-CAPPED CHICKADEE

HABITAT SUITABILITY INDEX (HSI) GRAPHS







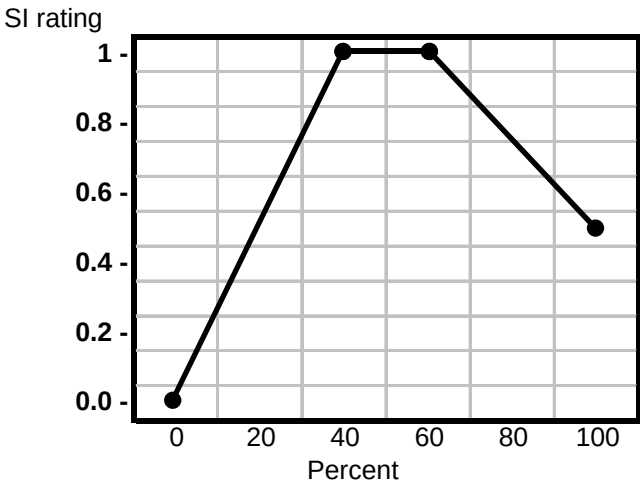
Black-capped Chickadee model: HSI equations and analysis techniques

- SI Food = $(V1 \times V2)^{1/2}$
- SI Repro = V3
- HSI = lesser of Food or Reproduction SI values

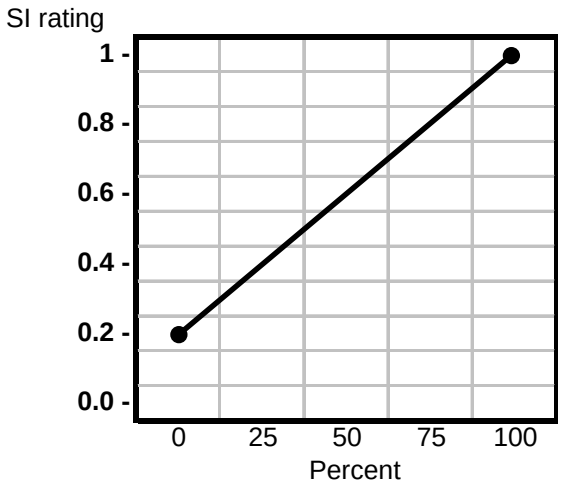
BEAVER

HABITAT SUITABILITY INDEX (HSI) GRAPHS

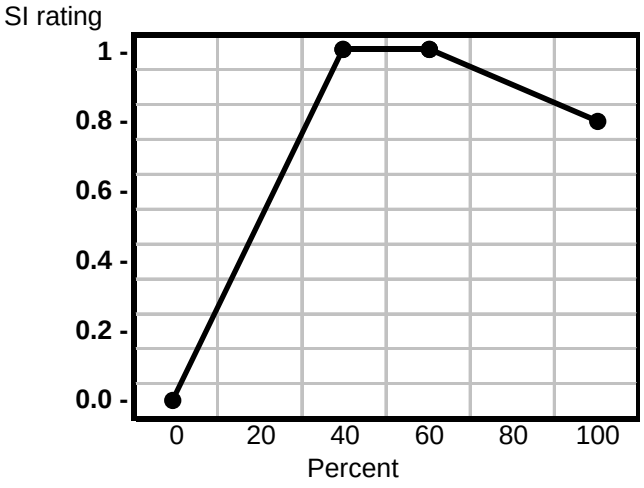
V1 - Percent tree canopy closure



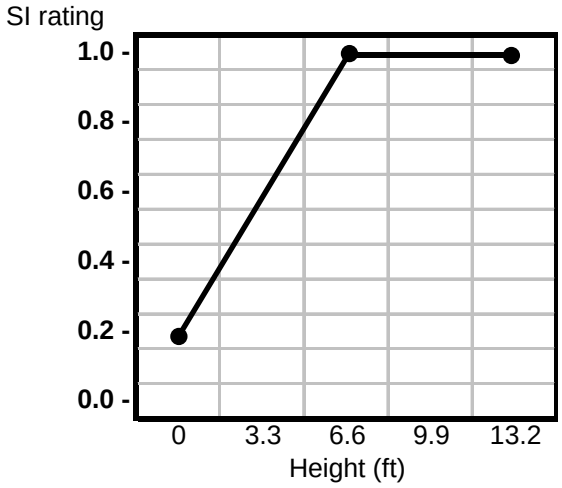
V2 - Percent trees 1-6" dbh



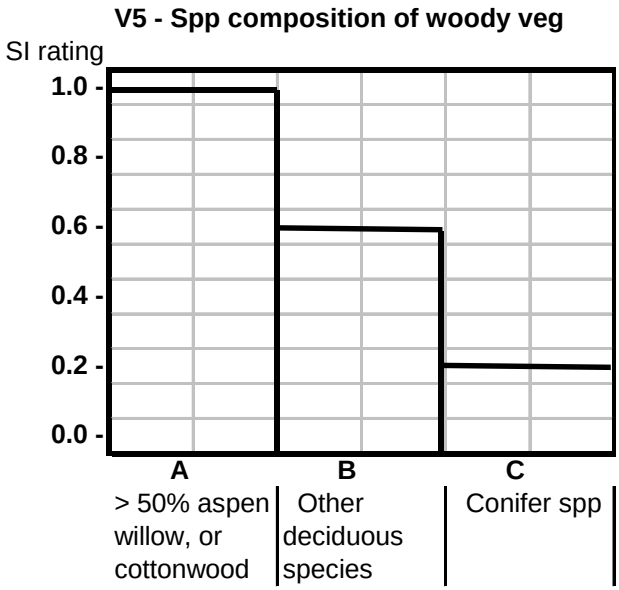
V3 - Percent shrub canopy closure

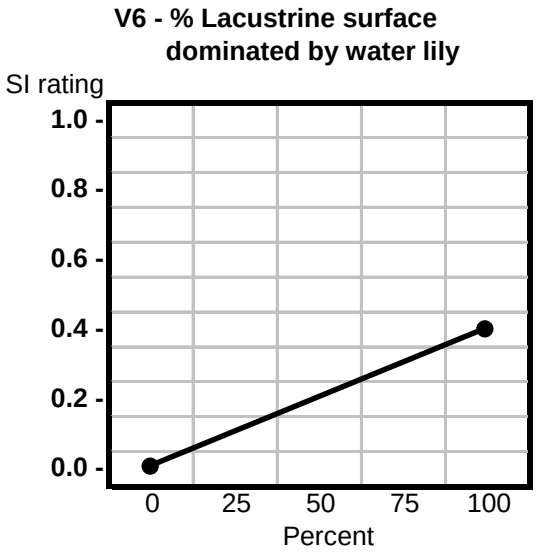


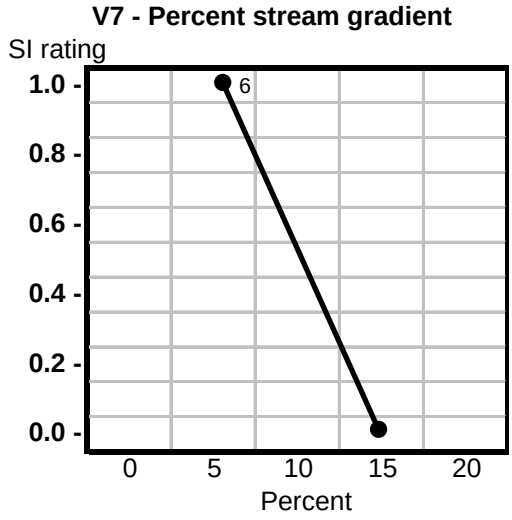
V4 - Average shrub height

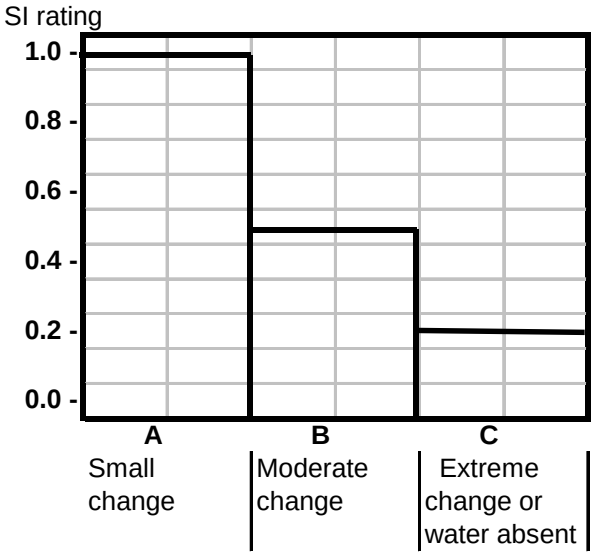


BEAVER – Continued

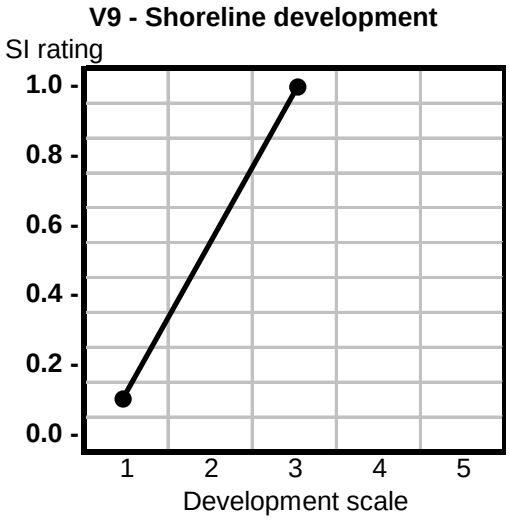








BEAVER – Continued



Beaver model: HSI equations and analysis techniques

For riverine systems:

- SI Food = b + c/ 1.5

  $b = [(V1xV2)^{1/2}xV5]^{1/2} + [(V3xV4)^{1/2}xV5]^{1/2}$

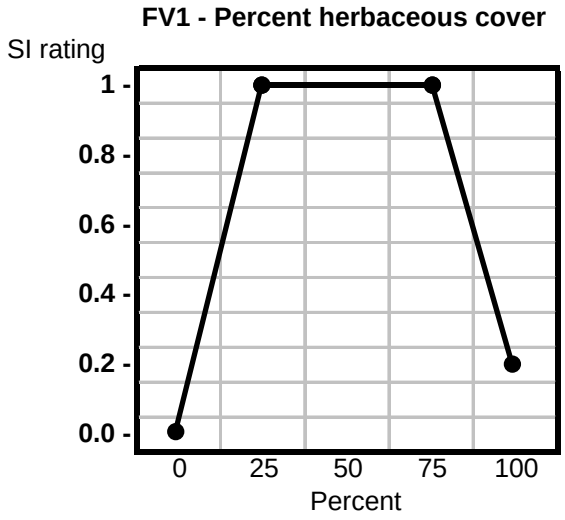
  $c = .5\ [(V1xV2)^{1/2}xV5]^{1/2} + [(V3xV4)^{1/2}xV5]^{1/2}$

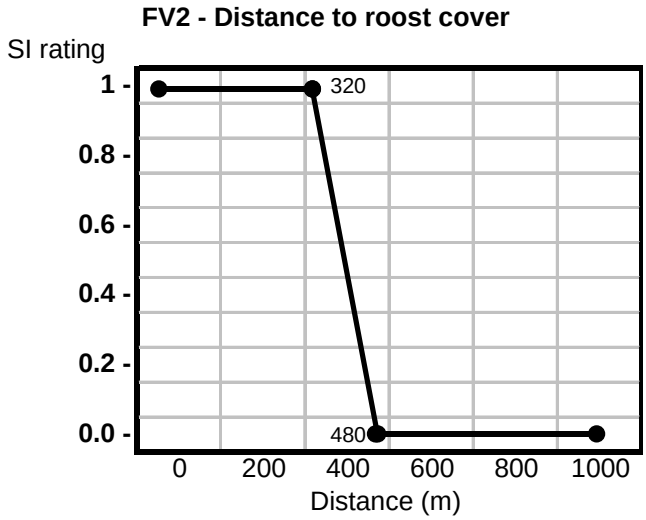
- SI water is the lowest value of V7 or V8.
- Variable V6 and V9 apply only to lacustrine systems. Precious Lands riparian systems are predominantly riverine, so these variables were removed

CALIFORNIA QUAIL

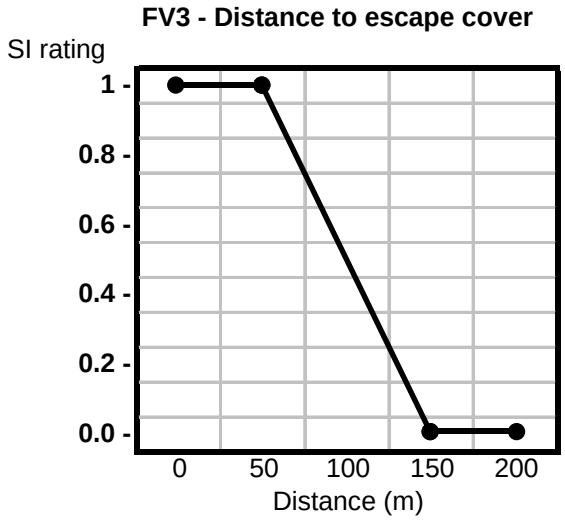
HABITAT SUITABILITY INDEX (HSI) GRAPHS

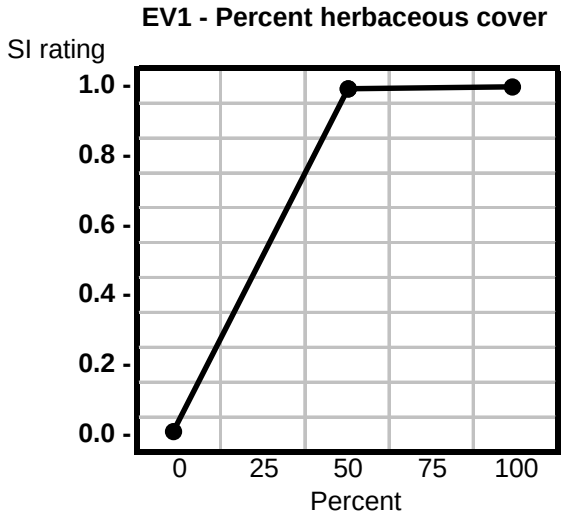
FOOD REQUISITES: (FV)





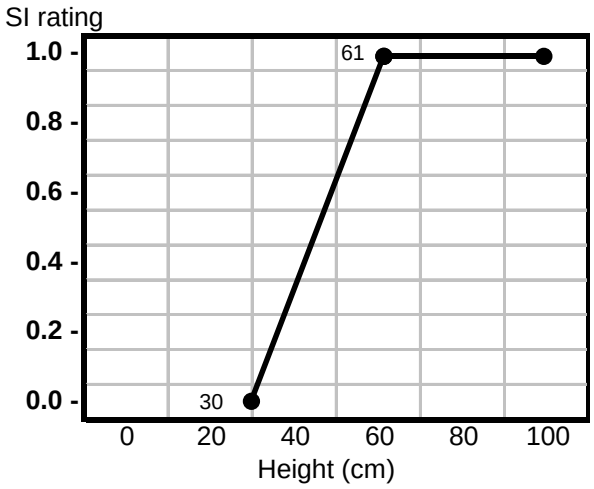
ESCAPE REQUISITES: (EV)



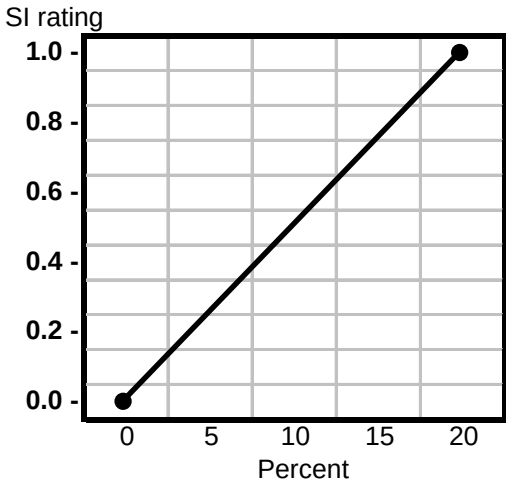


CALIFORNIA QUAIL - Continued

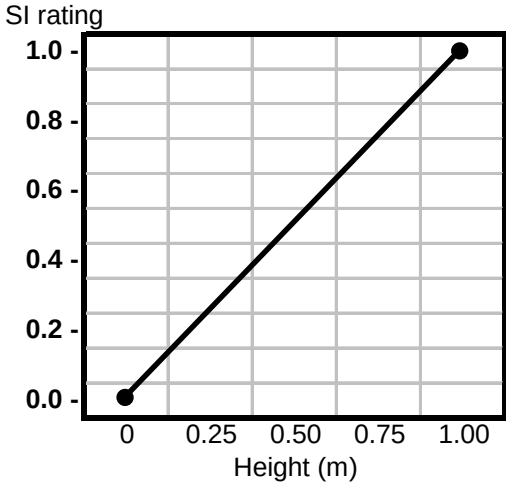
EV2 - Herbaceous height



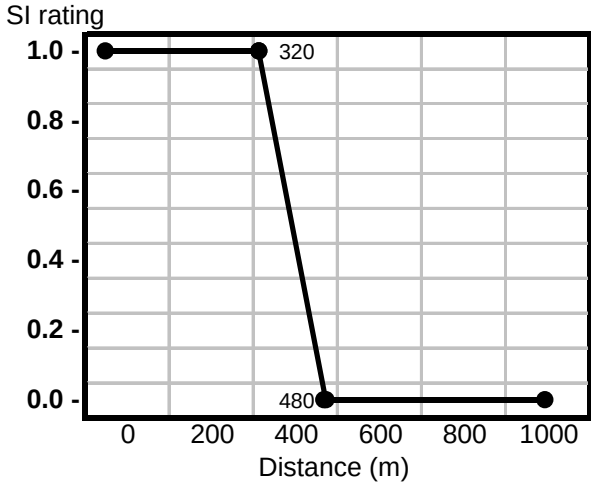
EV3 - Percent shrub cover



EV4 - Shrub height

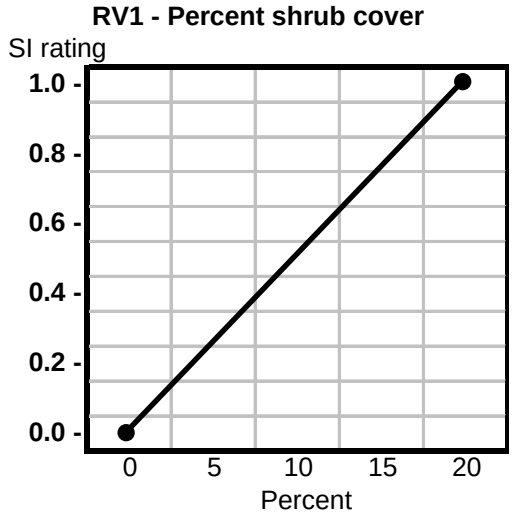


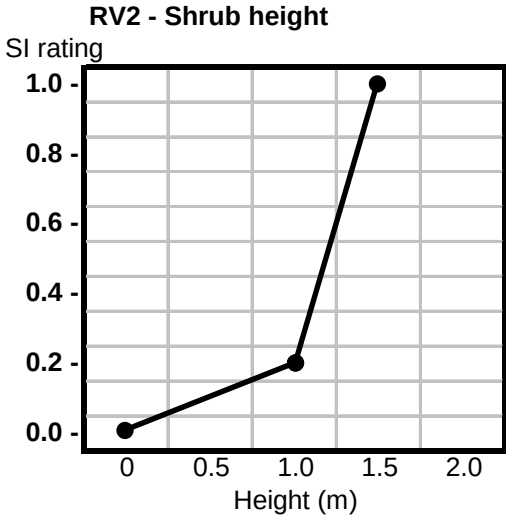
EV5 - Distance to roost cover

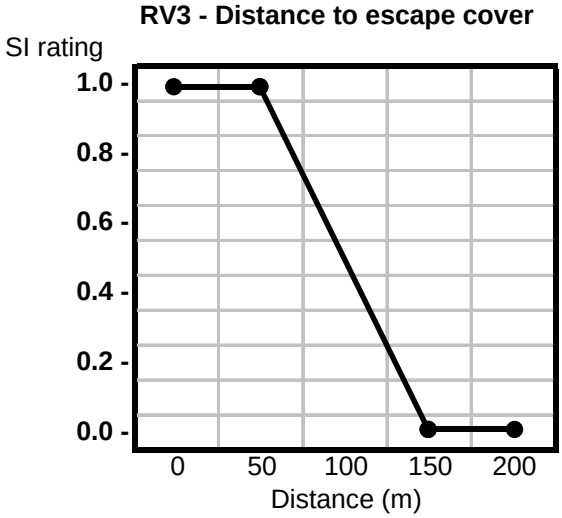


CALIFORNIA QUAIL – Continued

ROOST REQUISITES: (RV)

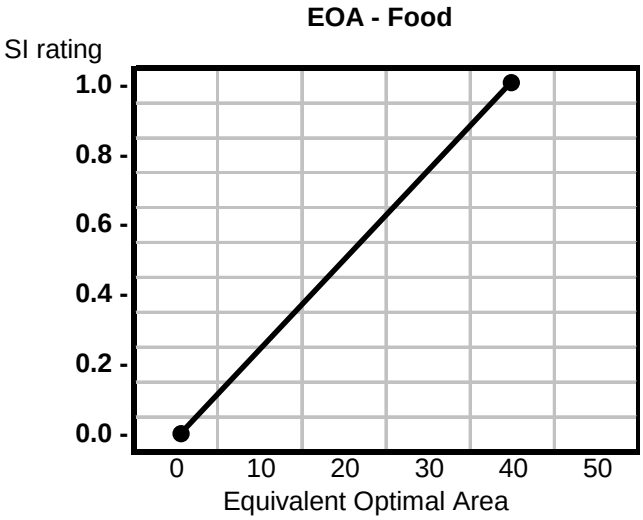


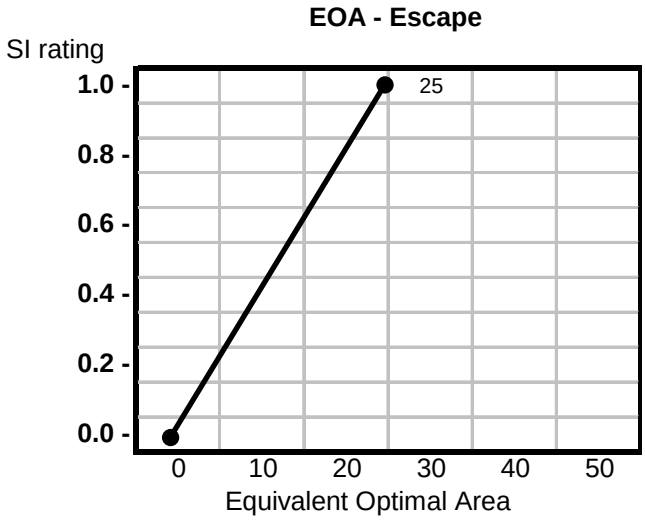


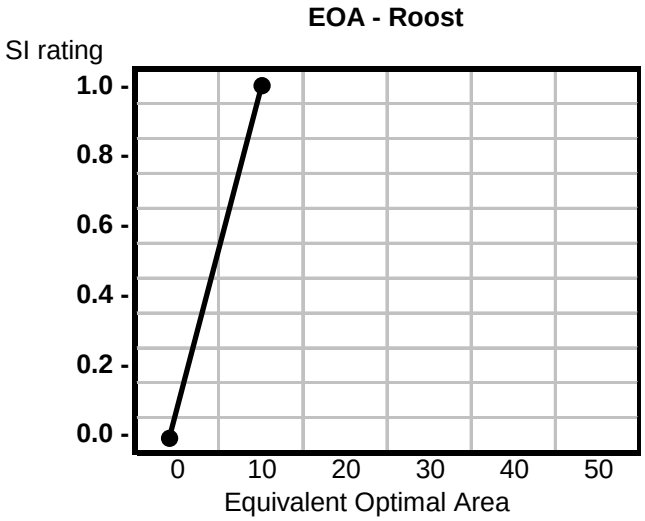


CALIFORNIA QUAIL - Continued

EQUIVALENT OPTIMAL AREA CHARTS: (EOA)







California Quail model: HSI equations and analysis techniques

Relative area = Cover type acres divided by the total acres of habitat.
Only cover types used by quail were included as habitat types
Numbers in red (other than acre totals) represent data not collected to 95% CI

Riparian =	609 acres	35%
S. shrub =	545 acres	31%
T. shrub =	598 acres	34%
total acres =	1752	

Food

SI food = (FV1 x .75) x lesser of FV2 or FV3
Food Equivalent Optimal Area (EOA) = (Food SI) x (relative area).
These FEOA values are summed and applied to the Food EOA graph to derive an HSI value
Sum of F-EOAs = 0.29

Escape

SI escape = EV5 x larger of either (EV1 x EV2)1/2 , or (EV3 x EV4)1/2
Escape EOA = (Escape SI) x (relative area).
These EEOA values are summed and applied to the Escape EOA graph to derive an HSI value
Sum of E-EOAs = 0.68

Roost

SI roost = $(RV1 \times RV2)^{1/2}$ x RV3
Roost EOA = (Roost SI) x (relative area).
These REOA values are summed and applied to the Roost EOA graph to derive an HSI value
Sum of R-EOAs = 0.35

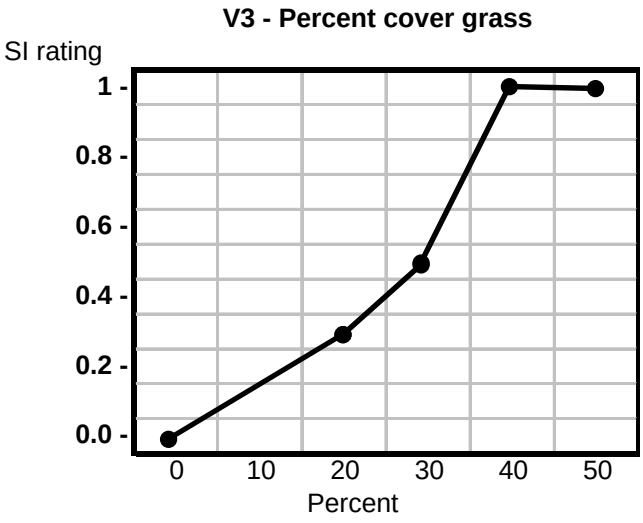
Overall HSI:

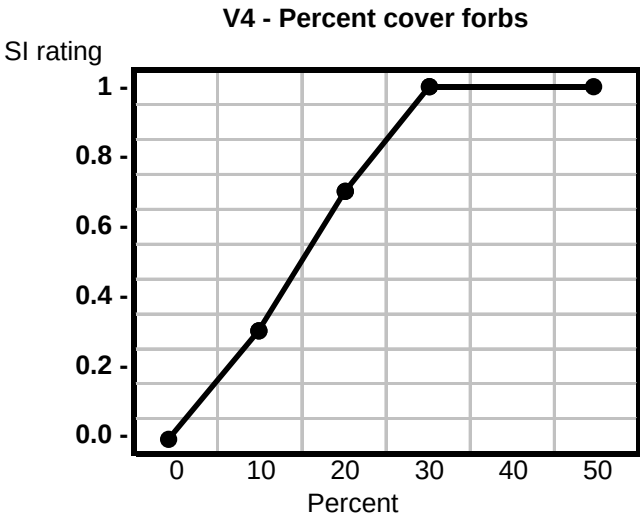
The lesser of the three HSI values is the overall HSI for the study area.
29% Food EOA = HSI of 0.73
68% Escape EOA = HSI of 1.0
35% Roost EOA = HSI of 1.0
Overall HSI = 0.73

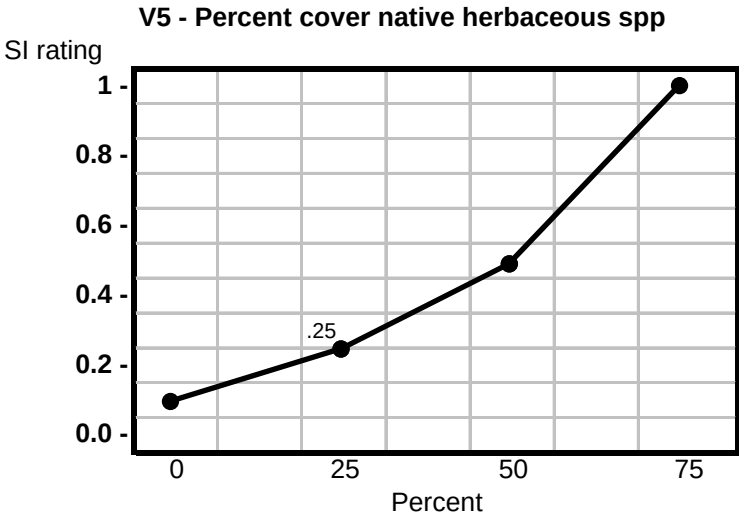
0.73 x 1752ac = **1279 HU**

Sharp-tailed Grouse

HABITAT SUITABILITY INDEX (HSI) GRAPHS
Brood rearing only

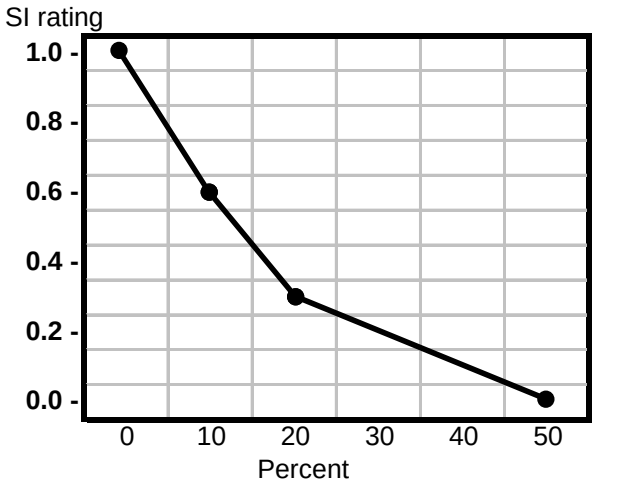




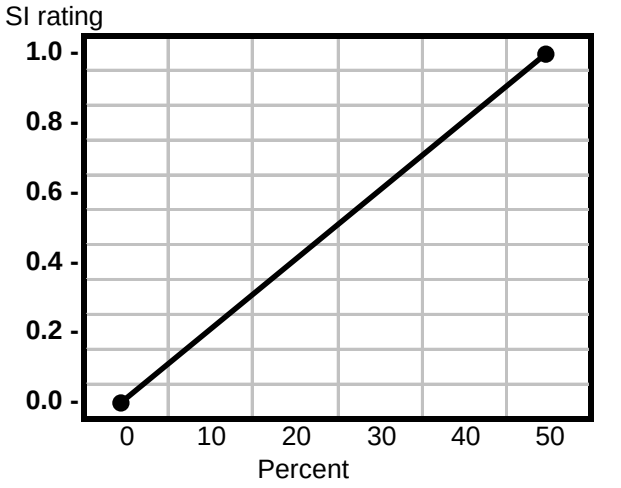


SHARP-TAILED GROUSE - Continued

V6 - Percent cover exotic herbaceous spp



V7 - Percent area providing brood cover



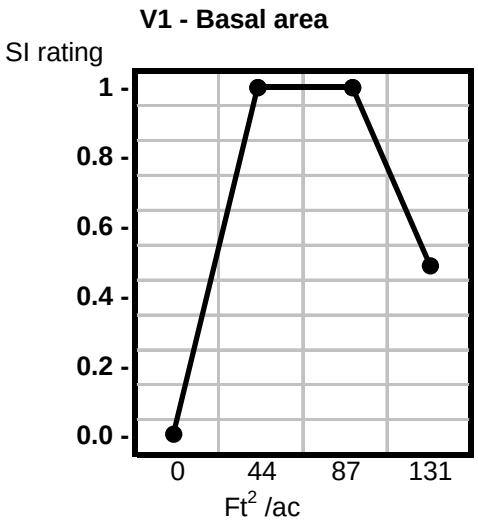
Sharp-tailed Grouse model (brood rearing only): HSI equations and analysis techniques

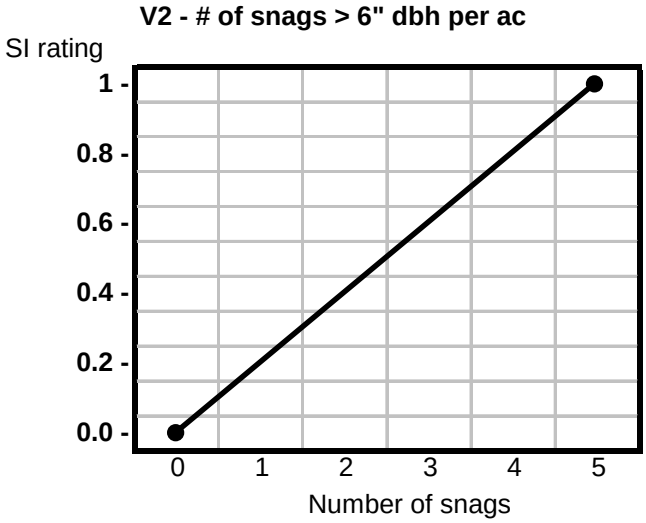
Brood rearing HSI equation

$[\{(V3 + V4)/2\} (V5 \times V6)^{1/2} \times V7]^{1/3}$

DOWNY WOODPECKER

MODEL HABITAT SUITABILITY INDEX (HSI) GRAPHS



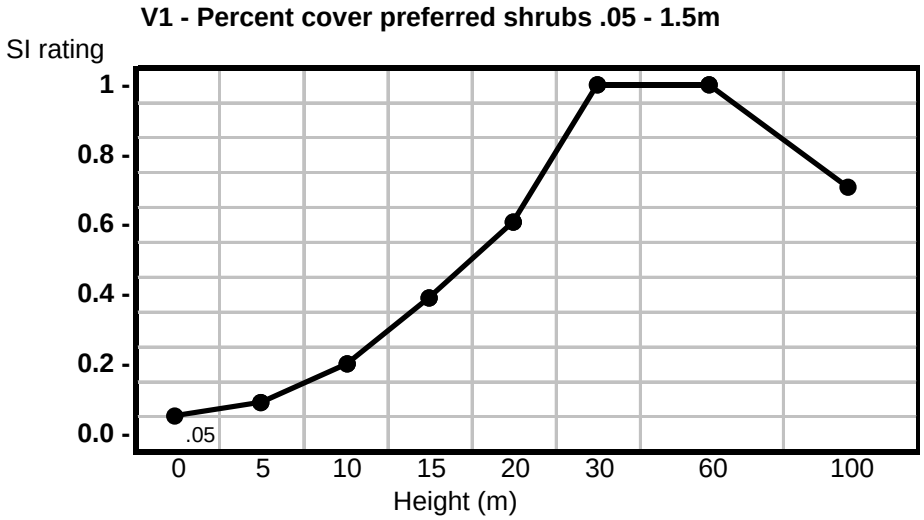


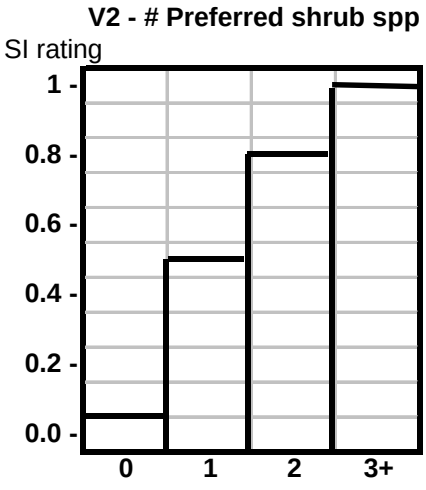
Downy Woodpecker model: HSI equations and analysis techniques

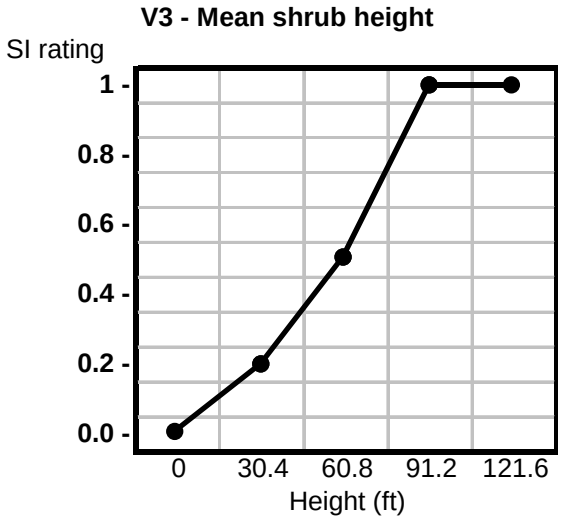
- HSI = lower of V1 or V2

MULE DEER

HABITAT SUITABILITY INDEX (HSI) GRAPHS
Winter model/Pine Creek Model

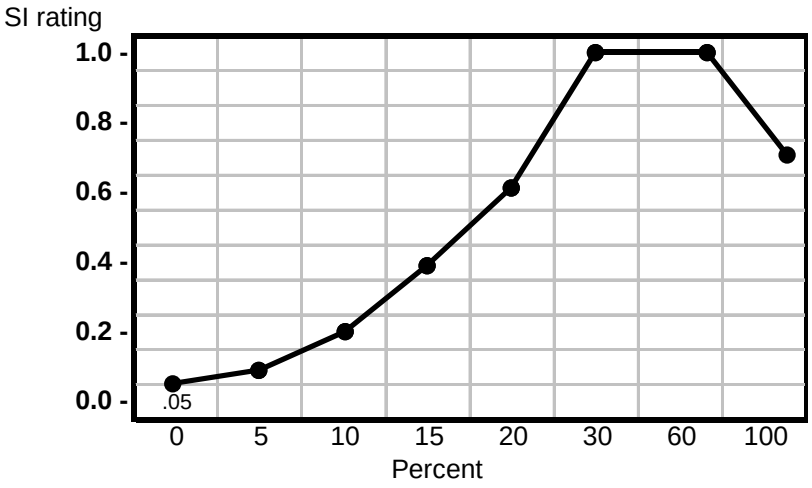




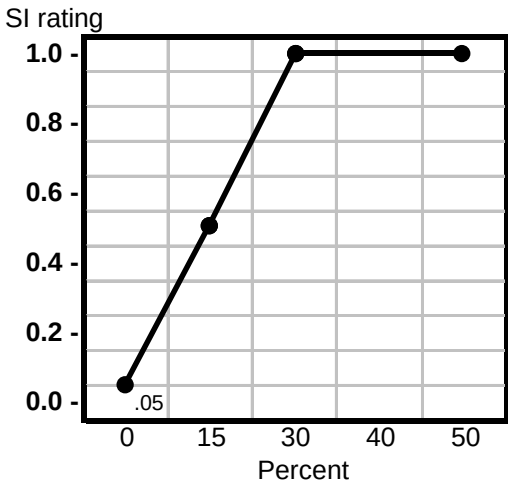


MULE DEER - Continued

V4 - Percent cover all shrubs .05 - 1.5m tall



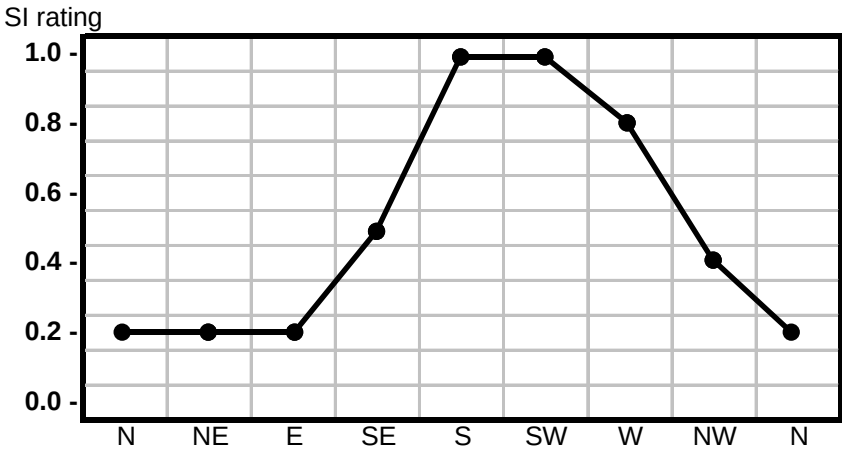
V5 - Percent cover palatable herbaceous spp



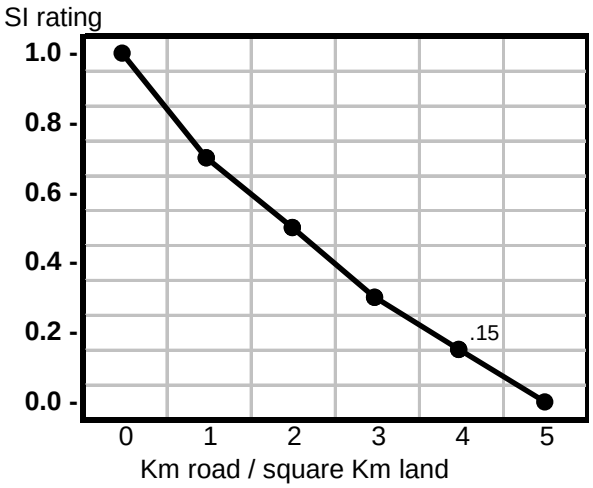
V6 - Presence of suitable crops within 1 mile of study area

Yes = 1.0
No = 0.0

V7 - Aspect

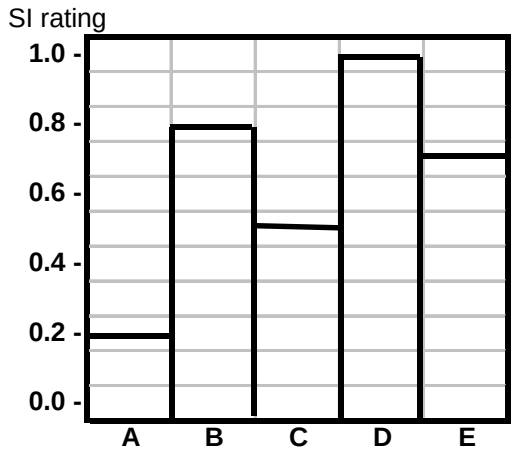


V8 - Road density



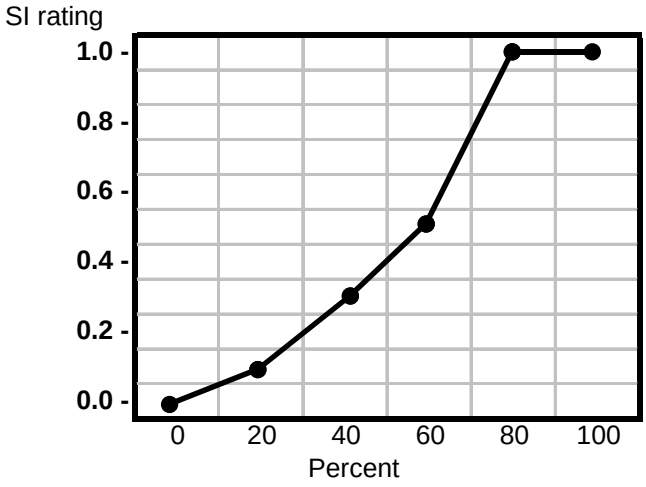
MULE DEER – Continued

V9 - Topographic diversity



A - Level terrain, less than 5% slope
B - Level terrain broken by drainages
C - Rolling terrain 5-25% slope
D - Rolling terrain with rims, ridges, or drainages
E - Mountainous terrain with slopes >25%

V10 - Percent evergreen canopy (>1.5m)

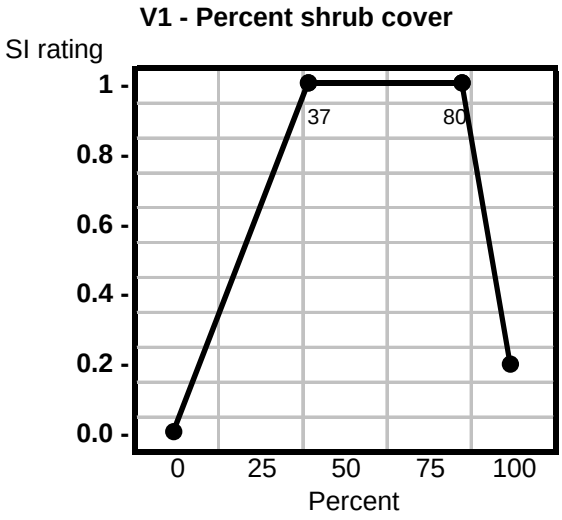


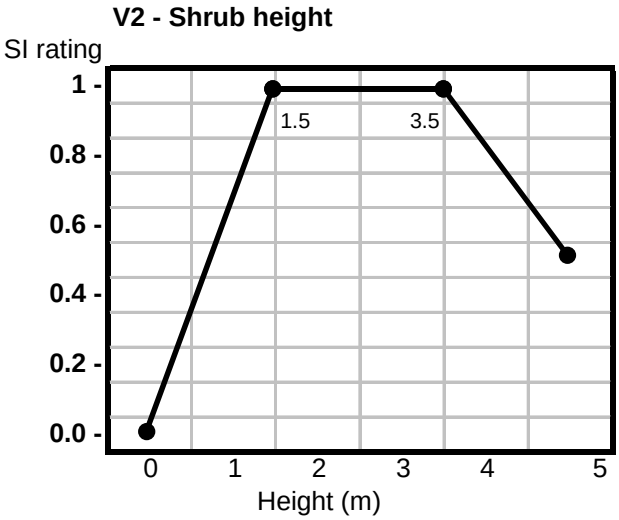
Mule Deer model: HSI equations and analysis techniques

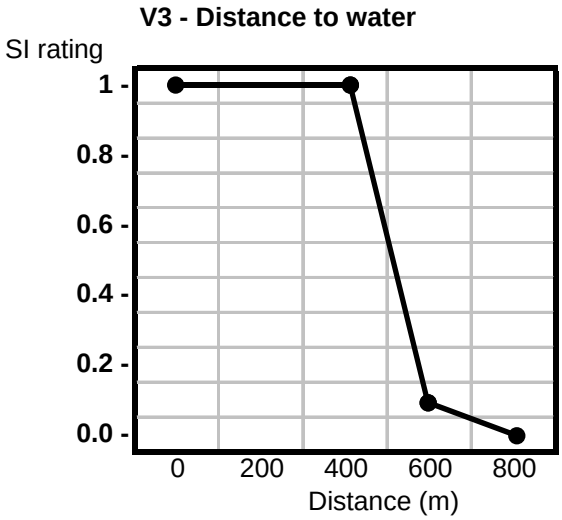
- Conifer & Open conifer provide thermal cover, all other cover types were assessed as forage habitat
- Optimal habitat: 60% forage and 40% cover , so Food and Cover SI's are divided by 0.6 and 0.4
  - Food SI = $\{[(V1 \times V2 \times V3 \times V4 \times V5^{1/5}) + V6] \times V7\}^{.625} \times V8$
    (Food SI) / 0.6 = **Food Index**
  - Cover SI = (V9 x 0.8) + V10
    (Cover SI) / 0.4 = **Cover Index**
- HSI = lower of either Food Index or Cover Index

SONG SPARROW

HABITAT SUITABILITY INDEX (HSI) GRAPHS







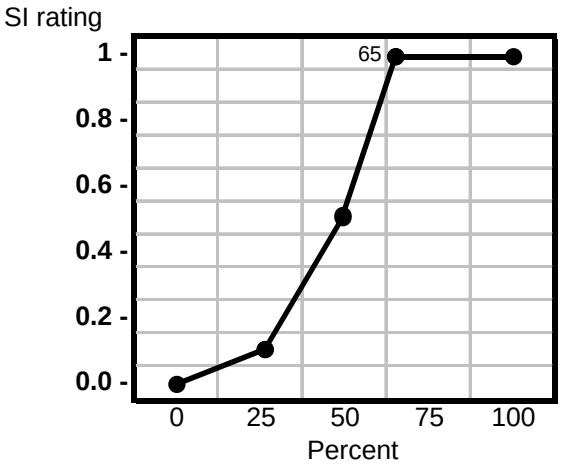
Song Sparrow model: HSI equations and analysis techniques

HSI = the lesser value between V3, or $(V1 \times V2)^{1/2}$

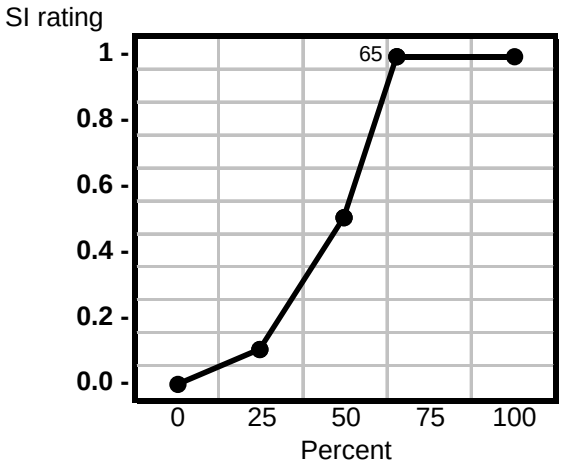
WESTERN MEADOWLARK

HABITAT SUITABILITY INDEX (HSI) GRAPHS

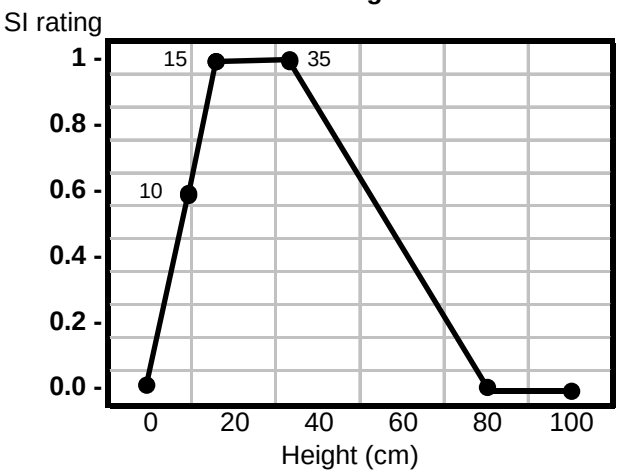
V1 - Percent herbaceous cover



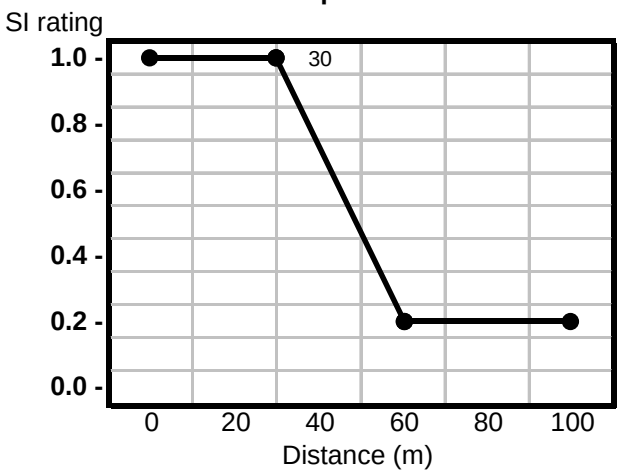
V2 - Percent cover grass



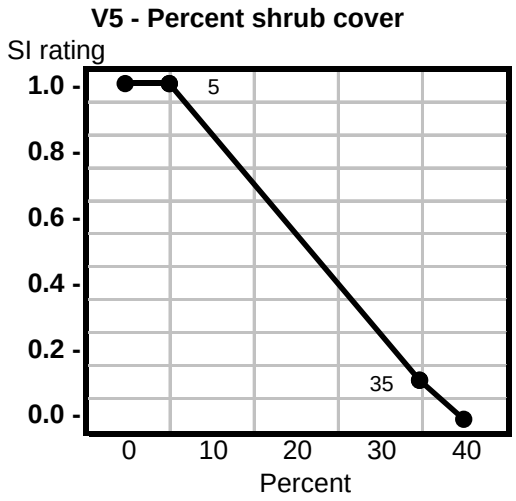
V3 - Herbaceous height



V4 - Distance to perch



WESTERN MEADOWLARK - Continued

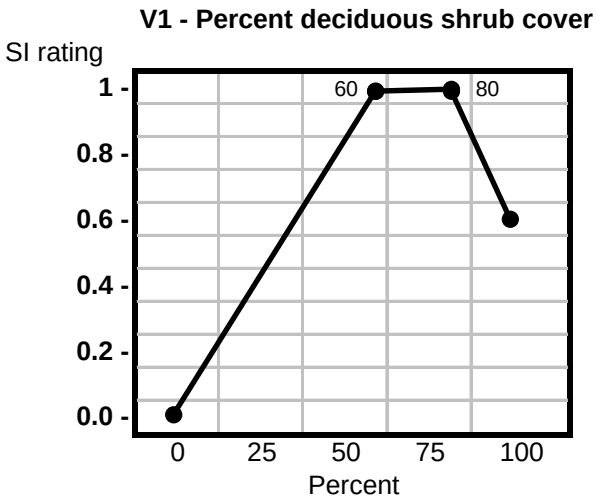


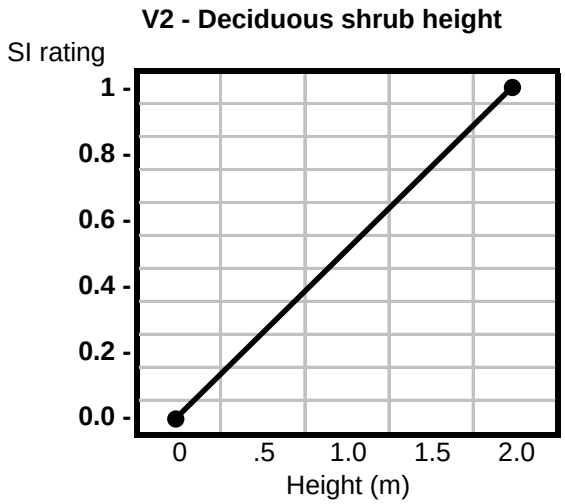
Western Meadowlark model: HSI equations and analysis techniques

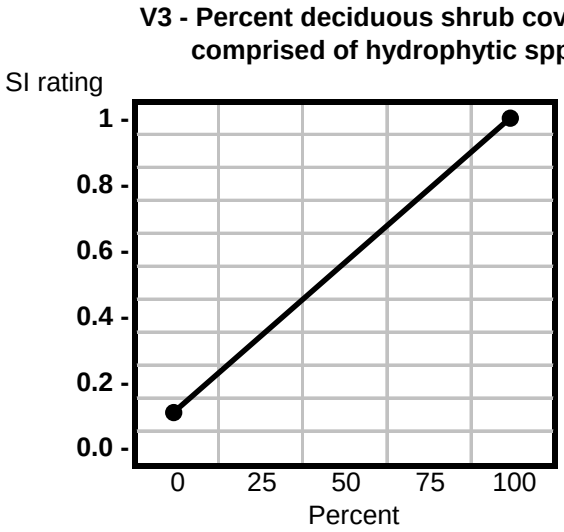
- HSI = $(V1 \times V2 \times V3 \times V4)^{1/2} \times V5$

YELLOW WARBLER

HABITAT SUITABILITY INDEX (HSI) GRAPHS







Yellow Warbler model: HSI equations and analysis techniques

- HSI = Reproduction SI = $(V1 \times V2 \times V3)^{1/2}$

Appendix C

Model Runs and Resulting Data per Target Wildlife Species

Tables 11 – 19 are a compilation of HEP data, collected during 2000-2002. An explanation of equations and analysis techniques are listed for each species. All numbers in red within the tables represent data not collected to a 95% confidence interval due to highly variable habitats.

Table 11. Results and Data from Beaver HSI Model Run

Riparian - 609 acres

Transect	Variable	Variable Value	SI Value	SI Food	SI Water	Transect HSI	**Total HU's**
R - 1	V1 - % tree canopy cover	12.5	0.25	0.65	0.00	0.00	**37**
Up Tamrk	V2 - % trees 1-6 dbh	19.1	0.35				
	V3 - % shrub cover	65.8	0.98				
	V4 - Avg shrub height (m)	1.4	0.70				
	V5 - Spp of woody veg.	C	0.20				
	V7 - % stream gradient	25.0	0.00				
	V8 - Avg water fluctuation	C	0.00				
R - 2	V1 - % tree canopy cover	0.0	0.00	0.00	0.00	0.00	
Low Tmrk	V2 - % trees 1-6 dbh	0.0	0.20				
	V3 - % shrub cover	74.1	0.93				
	V4 - Avg shrub height (m)	1.9	0.95				
	V5 - Spp of woody veg.	N/A	0.00				
	V7 - % stream gradient	8.0	0.80				
	V8 - Avg water fluctuation	C	0.00				
R - 3	V1 - % tree canopy cover	66.3	0.95	0.75	0.00	0.00	
Basin	V2 - % trees 1-6 dbh	12.1	0.30				
	V3 - % shrub cover	78.8	0.91				
	V4 - Avg shrub height (m)	1.6	0.80				
	V5 - Spp of woody veg.	C	0.20				
	V7 - % stream gradient	13.0	0.20				
	V8 - Avg water fluctuation	C	0.00				
R - 4	V1 - % tree canopy cover	28.6	0.68	1.00	0.50	0.50	
Broady	V2 - % trees 1-6 dbh	28.1	0.42				
	V3 - % shrub cover	62.5	0.99				
	V4 - Avg shrub height (m)	1.8	0.90				
	V5 - Spp of woody veg.	A	1.00				
	V7 - % stream gradient	2.0	1.00				
	V8 - Avg water fluctuation	B	0.50				
R - 5	V1 - % tree canopy cover	1.4	0.03	1.00	0.00	0.00	
Cttnwd	V2 - % trees 1-6 dbh	79.1	0.85				
	V3 - % shrub cover	22.4	0.55				
	V4 - Avg shrub height (m)	1.6	0.80				
	V5 - Spp of woody veg.	A	1.00				
	V7 - % stream gradient	3.0	1.00				
	V8 - Avg water fluctuation	C	0.00				

Table 11. Beaver Continued

R - 6	V1 - % tree canopy cover	42.0	1.00	1.00	0.00	0.00
Buford	V2 - % trees 1-6 dbh	81.8	0.87			
	V3 - % shrub cover	25.6	0.61			
	V4 - Avg shrub height (m)	1.3	0.65			
	V5 - Spp of woody veg.	A	1.00			
	V7 - % stream gradient	4.0	1.00			
	V8 - Avg water fluctuation	C	0.00			
R - 7	V1 - % tree canopy cover	95.5	0.52	1.00	0.00	0.00
N Joseph	V2 - % trees 1-6 dbh	43.0	0.56			
	V3 - % shrub cover	55.6	1.00			
	V4 - Avg shrub height (m)	1.8	0.90			
	V5 - Spp of woody veg.	A	1.00			
	V7 - % stream gradient	3.0	1.00			
	V8 - Avg water fluctuation	C	0.00			
R - 8	V1 - % tree canopy cover	70.0	0.87	1.00	0.00	0.00
S Joseph	V2 - % trees 1-6 dbh	43.0	0.56			
	V3 - % shrub cover	72.5	0.94			
	V4 - Avg shrub height (m)	2.1	1.00			
	V5 - Spp of woody veg.	A	1.00			
	V7 - % stream gradient	3.0	1.00			
	V8 - Avg water fluctuation	C	0.00			
R - 9	V1 - % tree canopy cover	75.0	0.83	1.00	0.00	0.00
Rock	V2 - % trees 1-6 dbh	9.0	0.28			
	V3 - % shrub cover	72.0	0.94			
	V4 - Avg shrub height (m)	1.8	0.90			
	V5 - Spp of woody veg.	A	1.00			
	V7 - % stream gradient	16.0	0.00			
	V8 - Avg water fluctuation	C	0.00			
				0.82	0.06	Avg = .06

Beaver model: HSI equations and analysis techniques

For riverine systems:

- SI Food = b + c/ 1.5

  $b = [(V1xV2)^{1/2}xV5]^{1/2} + [(V3xV4)^{1/2}xV5]^{1/2}$

  $c = .5\ [(V1xV2)^{1/2}xV5]^{1/2} + [(V3xV4)^{1/2}xV5]^{1/2}$

- SI water is the lowest value of V7 or V8.
- Variable V6 and V9 apply only to lacustrine systems. Precious Lands riparian systems are predominantly riverine, so these variables were removed

Table 12. Results and Data from Black-capped Chickadee HSI Model Run

Open Conifer - acres 1189

Transect	Variable	Variable Value	SI Value	SI Food	SI Repro.	Transect HSI	HU's	Total HU's
OC-1	V1 - % tree CC	11.7	0.25	0.50	1.00	0.50	297	**921**
1st Buford pilot	V2 - Avg tree ht (m)	15.6	1.00					
	V3 - #snags 4-10" dbh /ac	6.7	1.00					
OC-5	V1 - % tree CC	31.1	0.60	0.77	0.00	0.00		
Tamarack	V2 - Avg tree ht (m)	17.4	1.00					
N Hnt Camp Rdg	V3 - #snags 4-10" dbh /ac	0.0	0.00					
						0.25		

Burnt Conifer Shrub - acres 213

Transect	Variable	Variable Value	SI Value	SI Food	SI Repro.	Transect HSI	HU's
OC - 3	V1 - % tree CC	0.0	0.00	0.00	1.00	0.00	0
Bear Creek burn	V2 - Avg tree ht (m)	20.8	1.00				
	V3 - #snags 4-10" dbh /ac	11.7	1.00				
						0.00	

Burnt Conifer Grass - acres 99

Transect	Variable	Variable Value	SI Value	SI Food	SI Repro.	Transect HSI	HU's
OC - 4	V1 - % tree CC	0.0	0.00	0.00	0.00	0.00	0
Tmrk ridge burn	V2 - Avg tree ht (m)	23.2	1.00				
	V3 - #snags 4-10" dbh /ac	0.0	0.00				
						0.00	

Conifer - acres 630

Transect	Variable	Variable Value	SI Value	SI Food	SI Repro.	Transect HSI	HU's
C - 2	V1 - % tree CC	54.6	1.00	1.00	1.00	1.00	624
2nd Buford pilot	V2 - Avg tree ht (m)	21.0	1.00				
	V3 - #snags 4-10" dbh /ac	3.1	1.00				
C - 3	V1 - % tree CC	72.5	1.00	1.00	1.00	1.00	
UpBrody bird plot	V2 - Avg tree ht (m)	17.6	1.00				
	V3 - #snags 4-10" dbh /ac	35.0	1.00				
C - 5	V1 - % tree CC	48.3	0.95	0.97	1.00	0.97	
Brody Cr, S ridge	V2 - Avg tree ht	19.2	1.00				
	V3 - #snags 4-10" dbh /ac	6.0	1.00				
						0.99	

Black-capped Chickadee model: HSI equations and analysis techniques

- SI Food = $(V1 \times V2)^{1/2}$
- SI Repro = V3
- HSI = lesser of Food or Reproduction SI values

Table 13. Results and Data from California Quail HSI Model Run

Riparian - acres 609, relative area 35%

Transect	Variable	Variable Value	SI Value	SI Food	F-EOA	SI Escape	E-EOA	SI Roost	R-EOA	HSI	Total HU's
R - 1	FV1 - % herbaceous cover	74.4	1.00	0.75						0.73	**1279**
Up Tamrk	FV2 - Dist. to roost (m)	10.0	1.00								
	FV3 - Dist. to escape cover (m)	10.0	1.00								
	EV1 - % herbaceous cover	74.4	1.00			1.00					
	EV2 - Avg herb. height (cm)	18.4	0.00								
	EV3 - % shrub canopy cover	65.8	1.00								
	EV4 - Avg shrub height (m)	1.4	1.00								
	EV5 - Dist. to roost (m)	10.0	1.00								
	RV1 - % shrub canopy cover	65.8	1.00					0.88			
	RV2 - Avg shrub height (m)	1.4	0.77								
	RV3 - Dist. to escape cover (m)	10.0	1.00								
R - 2	FV1 - % herbaceous cover	63.9	1.00	0.75							
Low Tmrk	FV2 - Dist. to roost (m)	10.0	1.00								
	FV3 - Dist. to escape cover (m)	10.0	1.00								
	EV1 - % herbaceous cover	63.9	1.00			1.00					
	EV2 - Avg herb. height (cm)	24.4	0.00								
	EV3 - % shrub canopy cover	74.1	1.00								
	EV4 - Avg shrub height (m)	1.9	1.00								
	EV5 - Dist. to roost (m)	10.0	1.00								
	RV1 - % shrub canopy cover	74.1	1.00					1.00			
	RV2 - Avg shrub height (m)	1.9	1.00								
	RV3 - Dist. to escape cover (m)	10.0	1.00								
R - 3	FV1 - % herbaceous cover	44.5	1.00	0.75							
Basin	FV2 - Dist. to roost (m)	10.0	1.00								
	FV3 - Dist. to escape cover (m)	10.0	1.00								
	EV1 - % herbaceous cover	44.5	0.88			1.00					
	EV2 - Avg herb. height (cm)	24.1	0.00								
	EV3 - % shrub canopy cover	78.8	1.00								
	EV4 - Avg shrub height (m)	1.6	1.00								
	EV5 - Dist. to roost (m)	10.0	1.00								
	RV1 - % shrub canopy cover	78.8	1.00					1.00			
	RV2 - Avg shrub height (m)	1.6	1.00								
	RV3 - Dist. to escape cover (m)	10.0	1.00								
R - 4	FV1 - % herbaceous cover	61.9	1.00	0.75							
Broady	FV2 - Dist. to roost (m)	10.0	1.00								
	FV3 - Dist. to escape cover (m)	10.0	1.00								
	EV1 - % herbaceous cover	61.9	1.00			1.00					
	EV2 - Avg herb. height (cm)	35.3	0.17								
	EV3 - % shrub canopy cover	62.5	1.00								
	EV4 - Avg shrub height (m)	1.8	1.00								
	EV5 - Dist. to roost (m)	10.0	1.00								
	RV1 - % shrub canopy cover	62.5	1.00					1.00			
	RV2 - Avg shrub height (m)	1.8	1.00								
	RV3 - Dist. to escape cover (m)	10.0	1.00								
R - 5	FV1 - % herbaceous cover	30.6	1.00	0.75							
Cttnwd	FV2 - Dist. to roost (m)	40.0	1.00								
	FV3 - Dist. to escape cover (m)	25.0	1.00								
	EV1 - % herbaceous cover	30.6	0.58			1.00					
	EV2 - Avg herb. height (cm)	19.7	0.00								
	EV3 - % shrub canopy cover	22.4	1.00								
	EV4 - Avg shrub height (m)	1.6	1.00								
	EV5 - Dist. to roost (m)	40.0	1.00								
	RV1 - % shrub canopy cover	22.4	1.00					1.00			
	RV2 - Avg shrub height (m)	1.6	1.00								
	RV3 - Dist. to escape cover (m)	25.0	1.00								

Table 13. California Quail Continued

Riparian cont.

Transect	Variable	Variable Value	SI Value	SI Food	F-EOA	SI Escape	E-EOA	SI Roost	R-EOA
R - 6	FV1 - % herbaceous cover	21.0	0.82	0.62					
Buford	FV2 - Dist. to roost (m)	10.0	1.00						
	FV3 - Dist. to escape cover (m)	20.0	1.00						
	EV1 - % herbaceous cover	21.0	0.41			1.00			
	EV2 - Avg herb. height (cm)	24.4	0.00						
	EV3 - % shrub canopy cover	25.6	1.00						
	EV4 - Avg shrub height (m)	1.3	1.00						
	EV5 - Dist. to roost (m)	10.0	1.00						
	RV1 - % shrub canopy cover	25.6	1.00					0.81	
	RV2 - Avg shrub height (m)	1.3	0.66						
	RV3 - Dist. to escape cover (m)	20.0	1.00						
R -7	FV1 - % herbaceous cover	12.6	0.50	0.38					
N Joseph Crk	FV2 - Dist. to roost (m)	0.5	1.00						
	FV3 - Dist. to escape cover (m)	5.6	1.00						
	EV1 - % herbaceous cover	12.6	0.25			1.00			
	EV2 - Avg herb. height (cm)	10.7	0.00						
	EV3 - % shrub canopy cover	55.6	1.00						
	EV4 - Avg shrub height (m)	1.8	1.00						
	EV5 - Dist. to roost (m)	0.5	1.00						
	RV1 - % shrub canopy cover	55.6	1.00					1.00	
	RV2 - Avg shrub height (m)	1.8	1.00						
	RV3 - Dist. to escape cover (m)	5.6	1.00						
R - 8	FV1 - % herbaceous cover	38.0	0.75	0.56					
S Joseph Crk	FV2 - Dist. to roost (m)	2.0	1.00						
	FV3 - Dist. to escape cover (m)	5.0	1.00						
	EV1 - % herbaceous cover	38.0	0.75			1.00			
	EV2 - Avg herb. height (cm)	26.2	0.00						
	EV3 - % shrub canopy cover	72.5	1.00						
	EV4 - Avg shrub height (m)	2.1	1.00						
	EV5 - Dist. to roost (m)	2.0	1.00						
	RV1 - % shrub canopy cover	72.5	1.00					1.00	
	RV2 - Avg shrub height (m)	2.1	1.00						
	RV3 - Dist. to escape cover (m)	5.0	1.00						
R - 9	FV1 - % herbaceous cover	21.8	0.90	0.68					
Rock	FV2 - Dist. to roost (m)	0.8	1.00						
	FV3 - Dist. to escape cover (m)	2.4	1.00						
	EV1 - % herbaceous cover	21.8	0.38			1.00			
	EV2 - Avg herb. height (cm)	20.1	0.00						
	EV3 - % shrub canopy cover	72.0	1.00						
	EV4 - Avg shrub height (m)	1.8	1.00						
	EV5 - Dist. to roost (m)	0.8	1.00						
	RV1 - % shrub canopy cover	72.0	1.00					1.00	
	RV2 - Avg shrub height (m)	1.8	1.00						
	RV3 - Dist. to escape cover (m)	2.4	1.00						
				0.67	0.21	1.00	0.31	0.97	0.30

Table 13. California Quail Continued

Short Shrub - acres 545, relative area 31%

Transect	Variable	Variable Value	SI Value	SI Food	F-EOA	SI Escape	E-EOA	SI Roost	R-EOA
SS - 1	FV1 - % herbaceous cover	76.6	0.99	0.45					
Tamrk gate	FV2 - Dist. to roost (m)	100.0	1.00						
	FV3 - Dist. to escape cover (m)	100.0	0.60						
	EV1 - % herbaceous cover	76.6	1.00			0.63			
	EV2 - Avg herb. height (cm)	25.7	0.00						
	EV3 - % shrub canopy cover	78.1	1.00						
	EV4 - Avg shrub height (m)	0.4	0.40						
	EV5 - Dist. to roost (m)	100.0	1.00						
	RV1 - % shrub canopy cover	78.1	1.00					0.17	
	RV2 - Avg shrub height (m)	0.4	0.08						
	RV3 - Dist. to escape cover (m)	100.0	0.60						
SS - 2	FV1 - % herbaceous cover	79.0	0.91	0.00					
SE of tree	FV2 - Dist. to roost (m)	500.0	0.00						
farm	FV3 - Dist. to escape cover (m)	500.0	0.00						
	EV1 - % herbaceous cover	79.0	1.00			0.00			
	EV2 - Avg herb. height (cm)	30.3	0.03						
	EV3 - % shrub canopy cover	50.0	1.00						
	EV4 - Avg shrub height (m)	0.3	0.30						
	EV5 - Dist. to roost (m)	500.0	0.00						
	RV1 - % shrub canopy cover	50.0	1.00					0.00	
	RV2 - Avg shrub height (m)	0.3	0.06						
	RV3 - Dist. to escape cover (m)	500.0	0.00						
SS - 3	FV1 - % herbaceous cover	57.3	1.00	0.00					
E of Basin	FV2 - Dist. to roost (m)	250.0	1.00						
cabin	FV3 - Dist. to escape cover (m)	250.0	0.00						
	EV1 - % herbaceous cover	57.3	1.00			0.77			
	EV2 - Avg herb. height (cm)	31.0	0.30						
	EV3 - % shrub canopy cover	82.5	1.00						
	EV4 - Avg shrub height (m)	0.6	0.60						
	EV5 - Dist. to roost (m)	250.0	1.00						
	RV1 - % shrub canopy cover	82.5	1.00					0.00	
	RV2 - Avg shrub height (m)	0.6	0.12						
	RV3 - Dist. to escape cover (m)	250.0	0.00						
				0.15	0.04	0.47	0.13	0.06	0.02

Table 13. California Quail Continued

Tall Shrub - acres 598, relative area 34%

Transect	Variable	Variable Value	SI Value	SI Food	F-EOA	SI Escape	E-EOA	SI Roost	R-EOA
S -1	FV1 - % herbaceous cover	72.7	1.00	0.00					
Rye shrub	FV2 - Dist. to roost (m)	400.0	0.60						
	FV3 - Dist. to escape cover (m)	500.0	0.00						
	EV1 - % herbaceous cover	72.7	1.00			0.60			
	EV2 - Avg herb. height (cm)	20.1	0.00						
	EV3 - % shrub canopy cover	63.9	1.00						
	EV4 - Avg shrub height (m)	1.0	1.00						
	EV5 - Dist. to roost (m)	400.0	0.60						
	RV1 - % shrub canopy cover	63.9	1.00					0.00	
	RV2 - Avg shrub height (m)	1.0	0.20						
	RV3 - Dist. to escape cover (m)	500.0	0.00						
S - 3	FV1 - % herbaceous cover	80.5	0.90	0.41					
Broady	FV2 - Dist. to roost (m)	100.0	1.00						
sumac	FV3 - Dist. to escape cover (m)	100.0	0.60						
	EV1 - % herbaceous cover	80.5	1.00			0.84			
	EV2 - Avg herb. height (cm)	22.9	0.00						
	EV3 - % shrub canopy cover	36.7	1.00						
	EV4 - Avg shrub height (m)	0.7	0.70						
	EV5 - Dist. to roost (m)	100.0	1.00						
	RV1 - % shrub canopy cover	36.7	1.00					0.33	
	RV2 - Avg shrub height (m)	0.7	1.30						
	RV3 - Dist. to escape cover (m)	100.0	0.60						
S - 4	FV1 - % herbaceous cover	45.7	1.00	0.00					
Basin saddle	FV2 - Dist. to roost (m)	200.0	1.00						
	FV3 - Dist. to escape cover (m)	200.0	0.00						
	EV1 - % herbaceous cover	45.7	0.91			1.00			
	EV2 - Avg herb. height (cm)	20.0	0.00						
	EV3 - % shrub canopy cover	88.3	1.00						
	EV4 - Avg shrub height (m)	1.4	1.00						
	EV5 - Dist. to roost (m)	200.0	1.00						
	RV1 - % shrub canopy cover	88.3	1.00					0.00	
	RV2 - Avg shrub height (m)	1.4	0.80						
	RV3 - Dist. to escape cover (m)	200.0	0.00						
				0.14	0.04	0.81	0.24	0.11	0.03

California Quail model: HSI equations and analysis techniques

Relative area = Cover type acres divided by the total acres of habitat.
Only cover types used by quail were included as habitat types
Numbers in red (other than acre totals) represent data not collected to 95% CI

Riparian =	609 acres	35%
S. shrub =	545 acres	31%
T. shrub =	598 acres	34%
total acres =	1752	

Food

SI food = (FV1 x .75) x lesser of FV2 or FV3
Food Equivalent Optimal Area (EOA) = (Food SI) x (relative area).
These FEOA values are summed and applied to the Food EOA graph to derive an HSI value
Sum of F-EOAs = 0.29

Escape

SI escape = EV5 x larger of either (EV1 x EV2)1/2 , or (EV3 x EV4)1/2
Escape EOA = (Escape SI) x (relative area).
These EEOA values are summed and applied to the Escape EOA graph to derive an HSI value
Sum of E-EOAs = 0.68

Roost

SI roost = $(RV1 \times RV2)^{1/2}$ x RV3
Roost EOA = (Roost SI) x (relative area).
These REOA values are summed and applied to the Roost EOA graph to derive an HSI value
Sum of R-EOAs = 0.35

Overall HSI:

The lesser of the three HSI values is the overall HSI for the study area.
29% Food EOA = HSI of 0.73
68% Escape EOA = HSI of 1.0
35% Roost EOA = HSI of 1.0
Overall HSI = 0.73

0.73 x 1752ac = **1279 HU**

Table 14. Results and Data from Sharp-tailed grouse HSI Model Run

Good Grasslands (Grassland) - acres 8423 (73% relative area)

Transect	Variable	Variable Value	SI Value	HSI Value	Cover type HU's	**Total HU's**
G - 2	V3 - % grass cover	42.8	1.00	0.51	5,138	**6,307**
Buford	V4 - % forb cover	11.1	0.30			
Crest to creek	V5 - % herb cover from native spp	15.5	0.19			
	V6 - % herb cover from introd. spp	27.0	0.23			
	V7 - % area providing brood cover	0.73	1.00			
G - 3	V3 - % grass cover	70.7	1.00	0.57		
Tamrk saddle	V4 - % forb cover	7.8	0.23			
W of cabin	V5 - % herb cover from native spp	41.6	0.42			
	V6 - % herb cover from introd. spp	29.2	0.21			
	V7 - % area providing brood cover	0.73	1.00			
G - 4	V3 - % grass cover	57.4	1.00	0.69		
E side	V4 - % forb cover	6.8	0.21			
Hunt Camp Rdg	V5 - % herb cover from native spp	47.7	0.48			
	V6 - % herb cover from introd. spp	9.6	0.61			
	V7 - % area providing brood cover	0.73	1.00			
G - 5	V3 - % grass cover	44.4	1.00	0.70		
W side	V4 - % forb cover	10.7	0.31			
Hunt Camp Rdg	V5 - % herb cover from native spp	36.0	0.36			
	V6 - % herb cover from introd. spp	8.4	0.73			
	V7 - % area providing brood cover	0.73	1.00			
G - 8	V3 - % grass cover	58.3	1.00	0.67		
Tmrk - E side	V4 - % forb cover	9.0	0.27			
Joseph Crk	V5 - % herb cover from native spp	45.2	0.45			
SW of cabin	V6 - % herb cover from introd. spp	13.0	0.51			
	V7 - % area providing brood cover	0.73	1.00			
G - 10	V3 - % grass cover	43.3	1.00	0.50		
NE of Paradise	V4 - % forb cover	10.0	0.30			
Grass bird plot	V5 - % herb cover from native spp	13.7	0.17			
station 5	V6 - % herb cover from introd. spp	29.1	0.21			
	V7 - % area providing brood cover	0.73	1.00			
				0.61		

Agricultural (Pasture and Hayland) - acres 124 (1% relative area)

Transect	Variable	Variable Value	SI Value	HSI Value	Cover type HU's
GF - 1	V3 - % grass cover	100.0	1.00	0.22	27
Bufd wheat field	V4 - % forb cover	0.0	0.00		
	V5 - % herb cover from native spp	100.0	1.00		
	V6 - % herb cover from introd. spp	0.0	1.00		
	V7 - % area providing brood cover	0.01	0.02		
				0.22	

Table 14. Sharp-tailed Grouse Continued

Degraded Grasslands (Grassland) - acres 2929 (26% realtive area)

Transect	Variable	Variable Value	SI Value	HSI Value	Cover type HU's
DG - 1	V3 - % grass cover	73.9	1.00	0	1,142
Disturbed grass.	V4 - % forb cover	7.8	0.23		
	V5 - % herb cover from native spp	2.0	0.11		
	V6 - % herb cover from introd. spp	69.0	0.00		
	V7 - % area providing brood cover	0.26	0.51		
G - 6	V3 - % grass cover	37.6	0.90	0.57	
Tmrk ridge	V4 - % forb cover	9.2	0.28		
	V5 - % herb cover from native spp	37.3	0.37		
	V6 - % herb cover from introd. spp	1.0	0.99		
	V7 - % area providing brood cover	0.26	0.51		
G - 7	V3 - % grass cover	62.6	1.00	0.43	
Tmrk - E side	V4 - % forb cover	12.1	0.41		
Joseph Crk	V5 - % herb cover from native spp	29.2	0.29		
	V6 - % herb cover from introd. spp	33.0	0.18		
N of cabin	V7 - % area providing brood cover	0.26	0.51		
G - 9	V3 - % grass cover	70.9	1.00	0.4	
3/4 mi NE of	V4 - % forb cover	10.4	0.32		
Basin cabin	V5 - % herb cover from native spp	31.5	0.32		
	V6 - % herb cover from introd. spp	39.0	0.11		
	V7 - % area providing brood cover	0.26	0.51		
G - 11	V3 - % grass cover	30.5	0.51	0.51	
N of Buford Ridge	V4 - % forb cover	24.7	0.84		
ponds	V5 - % herb cover from native spp	22.6	0.23		
	V6 - % herb cover from introd. spp	8.0	0.68		
	V7 - % area providing brood cover	0.26	0.51		
G - 12	V3 - % grass cover	68.5	1.00	0.44	
2mi N of bottom	V4 - % forb cover	8.9	0.27		
Jackman rd	V5 - % herb cover from native spp	36.7	0.37		
	V6 - % herb cover from introd. spp	31.9	0.18		
	V7 - % area providing brood cover	0.26	0.51		
				0.39	

Sharp-tailed Grouse model (brood rearing only): HSI equations and analysis techniques

Brood rearing HSI equation

$$[\{(V3 + V4)/2\}(V5 \times V6)^{1/2} \times V7]^{1/3}$$

Table 15. Results and Data from Downy Woodpecker HSI Model Run

Riparian - acres 609

Transect	Variable	Variable Value	SI Value	SI Food (V1)	SI Repro. (V2)	Transect HSI	**Total HU's**
R - 1	V1 - Basal area (sq. ft/ acre)	15.8	0.30	0.30	0.00	0.00	**317**
Up Tamrk	V2 - # snags >6" dbh / acre	0.0	0.00				
R - 2	V1 - Basal area (sq. ft/ acre)	0.0	0.00	0.00	0.00	0.00	
Low Tmrk	V2 - # snags >6" dbh / acre	0.0	0.00				
R - 3	V1 - Basal area (sq. ft/ acre)	43.8	1.00	1.00	0.76	0.76	
Basin	V2 - # snags >6" dbh / acre	3.8	0.76				
R - 4	V1 - Basal area (sq. ft/ acre)	27.1	0.57	0.57	1.00	0.57	
Broady	V2 - # snags >6" dbh / acre	17.1	1.00				
R - 5	V1 - Basal area (sq. ft/ acre)	8.2	0.20	0.20	0.75	0.20	
Cttnwd	V2 - # snags >6" dbh / acre	3.5	0.75				
R - 6	V1 - Basal area (sq. ft/ acre)	39.4	0.83	0.83	1.00	0.83	
Buford	V2 - # snags >6" dbh / acre	16.9	1.00				
R - 7	V1 - Basal area (sq. ft/ acre)	55.0	1.00	1.00	0.60	0.60	
N Joseph	V2 - # snags >6" dbh / acre	3.0	0.60				
R - 8	V1 - Basal area (sq. ft/ acre)	40.0	0.84	0.84	1.00	0.84	
S Joseph	V2 - # snags >6" dbh / acre	9.0	1.00				
R - 9	V1 - Basal area (sq. ft/ acre)	41.0	0.85	0.85	1.00	0.85	
Rock	V2 - # snags >6" dbh / acre	6.3	1.00				
						0.52	

Downy Woodpecker model: HSI equations and analysis techniques

- HSI = lower of V1 or V2

Table 16. Results and Data from Mule Deer HSI Model Run

Riparian - acres 609, relative area 4%						
Transect	Variable	Variable Value	SI Value	SI Food	SI Cover	HSI
R - 1	V1 - % cover pref. shrubs <1.5m	34.20	1.00	0.42		0.15
Up Tamrk	V2 - # preferred shrub species	4.00	1.00			
	V3 - Avg. shrub height (cm)	140.00	1.00			
	V4 - % cover of shrubs <1.5m	39.20	1.00			
	V5 - % cover of palatable herb	1.97	0.15			
	V6 - Crops within 1.6 km (Y/N)	N	0.00			
	V7 - Aspect (degrees)	320.00	0.37			
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00			
	V9 - Topo diversity (A-E)	E	0.70			
	V10 - % evergreen canopy >1.5m	10.80	0.06			
R - 2	V1 - % cover pref. shrubs <1.5m	26.80	0.85	0.44		
Low Tmrk	V2 - # preferred shrub species	1.00	0.50			
	V3 - Avg. shrub height (cm)	190.00	1.00			
	V4 - % cover of shrubs <1.5m	37.30	1.00			
	V5 - % cover of palatable herb	30.90	1.00			
	V6 - Crops within 1.6 km (Y/N)	N	0.00			
	V7 - Aspect (degrees)	332.00	0.32			
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00			
	V9 - Topo diversity (A-E)	D	1.00			
	V10 - % evergreen canopy >1.5m	0.00	0.00			
R - 3	V1 - % cover pref. shrubs <1.5m	29.40	0.99	0.27		
Basin	V2 - # preferred shrub species	2.00	0.80			
	V3 - Avg. shrub height (cm)	160.00	1.00			
	V4 - % cover of shrubs <1.5m	44.40	1.00			
	V5 - % cover of palatable herb	0.00	0.10			
	V6 - Crops within 1.6 km (Y/N)	N	0.00			
	V7 - Aspect (degrees)	359.00	0.21			
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00			
	V9 - Topo diversity (A-E)	E	0.70			
	V10 - % evergreen canopy >1.5m	32.50	0.22			
R - 4	V1 - % cover pref. shrubs <1.5m	13.80	0.37	0.33		
Broady	V2 - # preferred shrub species	1.00	0.50			
	V3 - Avg. shrub height (cm)	180.00	1.00			
	V4 - % cover of shrubs <1.5m	37.50	1.00			
	V5 - % cover of palatable herb	0.00	0.10			
	V6 - Crops within 1.6 km (Y/N)	N	0.00			
	V7 - Aspect (degrees)	296.00	0.38			
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00			
	V9 - Topo diversity (A-E)	D	1.00			
	V10 - % evergreen canopy >1.5m	2.90	0.02			
R - 5	V1 - % cover pref. shrubs <1.5m	8.60	0.16	0.56		
Cttnwd	V2 - # preferred shrub species	3.00	1.00			
	V3 - Avg. shrub height (cm)	160.00	1.00			
	V4 - % cover of shrubs <1.5m	11.70	0.24			
	V5 - % cover of palatable herb	11.60	0.40			
	V6 - Crops within 1.6 km (Y/N)	N	0.00			
	V7 - Aspect (degrees)	244.00	0.92			
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00			
	V9 - Topo diversity (A-E)	D	1.00			
	V10 - % evergreen canopy >1.5m	0.59	0.01			

Table 16. Mule Deer Continued

Riparian - cont. Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
R - 6	V1 - % cover pref. shrubs <1.5m	6.30	0.12	0.15	
Buford	V2 - # preferred shrub species	1.00	0.50		
	V3 - Avg. shrub height (cm)	130.00	1.00		
	V4 - % cover of shrubs <1.5m	15.30	0.31		
	V5 - % cover of palatable herb	7.90	0.52		
	V6 - Crops within 1.6 km (Y/N)	Y	0.10		
	V7 - Aspect (degrees)	5.00	0.20		
	V8 - Road density (km rd/km^2 habitat)	1.24	0.65		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
R -7	V1 - % cover pref. shrubs <1.5m	22.80	0.71	0.22	
N Joseph	V2 - # preferred shrub species	1.00	0.50		
	V3 - Avg. shrub height (cm)	180.00	1.00		
	V4 - % cover of shrubs <1.5m	45.30	1.00		
	V5 - % cover of palatable herb	0.37	0.05		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	30.00	0.20		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
R - 8	V1 - % cover pref. shrubs <1.5m	20.00	0.60	0.17	
S Joseph	V2 - # preferred shrub species	0.00	0.05		
	V3 - Avg. shrub height (cm)	210.00	1.00		
	V4 - % cover of shrubs <1.5m	55.00	1.00		
	V5 - % cover of palatable herb	0.00	0.05		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	95.00	0.21		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
R - 9	V1 - % cover pref. shrubs <1.5m	28.10	0.92	0.24	
Rock	V2 - # preferred shrub species	2.00	0.80		
	V3 - Avg. shrub height (cm)	180.00	1.00		
	V4 - % cover of shrubs <1.5m	60.00	1.00		
	V5 - % cover of palatable herb	0.00	0.05		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	50.00	0.20		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	E	0.70		
	V10 - % evergreen canopy >1.5m	50.00	0.40		
				0.31	

Table 16. Mule Deer Continued

Short Shrub - acres 545, relative area 4%

Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
SS - 1	V1 - % cover pref. shrubs <1.5m	76.90	0.87	0.79	
Tamrk gate	V2 - # preferred shrub species	2.00	0.80		
	V3 - Avg. shrub height (cm)	40.00	0.30		
	V4 - % cover of shrubs <1.5m	77.50	0.95		
	V5 - % cover of palatable herb	72.00	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	230.00	0.96		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
SS - 2	V1 - % cover pref. shrubs <1.5m	50.00	1.00	0.33	
SE of tree farm	V2 - # preferred shrub species	2.00	0.80		
	V3 - Avg. shrub height (cm)	30.00	0.20		
	V4 - % cover of shrubs <1.5m	50.00	1.00		
	V5 - % cover of palatable herb	45.90	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	97.00	0.25		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
SS - 3	V1 - % cover pref. shrubs <1.5m	80.00	0.85	0.79	
E of Basin cabin	V2 - # preferred shrub species	3.00	1.00		
	V3 - Avg. shrub height (cm)	60.00	0.49		
	V4 - % cover of shrubs <1.5m	80.80	0.89		
	V5 - % cover of palatable herb	29.80	0.99		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	266.00	0.83		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
				0.64	

Table 16. Mule Deer Continued

Tall Shrub - acres 598, relative area 4 %

Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
S -1	V1 - % cover pref. shrubs <1.5m	43.10	1.00	0.37	
Rye shrub	V2 - # preferred shrub species	3.00	1.00		
	V3 - Avg. shrub height (cm)	100.00	1.00		
	V4 - % cover of shrubs <1.5m	50.00	1.00		
	V5 - % cover of palatable herb	87.60	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	42.00	0.20		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
S - 3	V1 - % cover pref. shrubs <1.5m	7.50	0.15	0.29	
Broady sumac	V2 - # preferred shrub species	1.00	0.50		
	V3 - Avg. shrub height (cm)	70.00	0.65		
	V4 - % cover of shrubs <1.5m	34.20	1.00		
	V5 - % cover of palatable herb	77.10	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	95.00	0.25		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
S - 4	V1 - % cover pref. shrubs <1.5m	51.70	1.00	0.53	
Basin saddle	V2 - # preferred shrub species	1.00	0.50		
	V3 - Avg. shrub height (cm)	140.00	1.00		
	V4 - % cover of shrubs <1.5m	51.70	1.00		
	V5 - % cover of palatable herb	37.90	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	311.00	0.42		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
				0.40	

Table 16. Mule Deer Continued

Conifer - acres 630, relative area 4%

Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
C - 2	V1 - % cover pref. shrubs <1.5m	61.30	0.99		0.85
2nd Buford pilot	V2 - # preferred shrub species	4.00	1.00		
	V3 - Avg. shrub height (cm)	70.00	0.65		
	V4 - % cover of shrubs <1.5m	61.30	0.99		
	V5 - % cover of palatable herb	70.80	1.00		
	V6 - Crops within 1.6 km (Y/N)	Y	0.10		
	V7 - Aspect (degrees)	10.00	0.20		
	V8 - Road density (km rd/km^2 habitat)	1.24	0.65		
	V9 - Topo diversity (A-E)	C	0.50		
	V10 - % evergreen canopy >1.5m	54.60	0.45		
C - 3	V1 - % cover pref. shrubs <1.5m	50.80	1.00		1.00
UpBrody bird plot	V2 - # preferred shrub species	3.00	1.00		
	V3 - Avg. shrub height (cm)	40.00	0.30		
	V4 - % cover of shrubs <1.5m	51.70	1.00		
	V5 - % cover of palatable herb	7.30	0.29		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	28.00	0.20		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	E	0.70		
	V10 - % evergreen canopy >1.5m	72.50	0.80		
C - 5	V1 - % cover pref. shrubs <1.5m	68.30	0.98		0.94
Brody Cr, S ridge	V2 - # preferred shrub species	2.00	0.80		
	V3 - Avg. shrub height (cm)	100.00	1.00		
	V4 - % cover of shrubs <1.5m	68.30	0.99		
	V5 - % cover of palatable herb	23.30	0.78		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	320.00	0.38		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	E	0.70		
	V10 - % evergreen canopy >1.5m	48.30	0.38		
					0.93

Open Conifer - acres 1189, relative area 8 %

Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
OC - 1	V1 - % cover pref. shrubs <1.5m	56.80	1.00		0.47
1st Buford pilot	V2 - # preferred shrub species	4.00	1.00		
	V3 - Avg. shrub height (cm)	100.00	1.00		
	V4 - % cover of shrubs <1.5m	56.90	1.00		
	V5 - % cover of palatable herb	54.20	1.00		
	V6 - Crops within 1.6 km (Y/N)	Y	0.10		
	V7 - Aspect (degrees)	40.00	0.20		
	V8 - Road density (km rd/km^2 habitat)	1.24	0.65		
	V9 - Topo diversity (A-E)	C	0.50		
	V10 - % evergreen canopy >1.5m	11.70	0.07		
OC - 5	V1 - % cover pref. shrubs <1.5m	50.00	1.00		0.77
Tmrk - N Hunt	V2 - # preferred shrub species	5.00	1.00		
Camp Ridge	V3 - Avg. shrub height (cm)	90.00	0.99		
	V4 - % cover of shrubs <1.5m	50.00	1.00		
	V5 - % cover of palatable herb	5.50	0.28		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	30.00	0.20		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	E	0.70		
	V10 - % evergreen canopy >1.5m	31.10	0.21		
					0.62

Table 16. Mule Deer Continued

Good Grasslands - acres 8423, relative area 56 %

Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
G - 2	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.21	
Buford	V2 - # preferred shrub species	0.00	0.05		
Crest to creek	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	44.70	1.00		
	V6 - Crops within 1.6 km (Y/N)	Y	0.10		
	V7 - Aspect (degrees)	249.00	0.89		
	V8 - Road density (km rd/km^2 habitat)	1.24	0.65		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
G - 3	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.13	
Tamrk saddle	V2 - # preferred shrub species	0.00	0.05		
W of cabin	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	71.50	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	122.00	0.41		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
G - 4	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.10	
E side	V2 - # preferred shrub species	0.00	0.05		
Hunt Camp Rdg	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	57.80	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	104.00	0.27		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
G - 5	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.22	
W side	V2 - # preferred shrub species	0.00	0.05		
Hunt Camp Rdg	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	45.80	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	220.00	1.00		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
G - 8	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.22	
Tmrk - E side	V2 - # preferred shrub species	0.00	0.05		
Joseph Crk	V3 - Avg. shrub height (cm)	0.00	0.05		
SW of cabin	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	64.90	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	233.00	0.97		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		

Table 16. Mule Deer Continued

Good Grass - cont.

Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
G - 10	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.14	
NE of Paradise	V2 - # preferred shrub species	0.00	0.05		
bird plot station 5	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	43.20	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	136.00	0.50		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	E	0.70		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
				0.17	

Agricultural - acres 124, relative area 1%

Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
GF - 1	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.08	
Bufd wheat field	V2 - # preferred shrub species	0.00	0.05		
	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	99.40	1.00		
	V6 - Crops within 1.6 km (Y/N)	Y	0.10		
	V7 - Aspect (degrees)	5.00	0.20		
	V8 - Road density (km rd/km2 habitat)	1.24	0.65		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
				0.08	

Degraded Grasslands - acres 2929, relative area 19 %

Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
DG - 1	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.17	
Disturbed grass.	V2 - # preferred shrub species	0.00	0.05		
	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	73.90	1.00		
	V6 - Crops within 1.6 km (Y/N)	Y	0.10		
	V7 - Aspect (degrees)	295.00	0.59		
	V8 - Road density (km rd/km^2 habitat)	1.24	0.65		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
G - 6	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.22	
Tmrk ridge	V2 - # preferred shrub species	0.00	0.05		
	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	39.30	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	220.00	1.00		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		

Table 16. Mule Deer Continued

Degraded Grass - cont.

Transect	Variable	Variable Value	SI Value	SI Food	SI Cover
G - 7	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.22	
Tmrk - E side	V2 - # preferred shrub species	0.00	0.05		
Joseph Crk	V3 - Avg. shrub height (cm)	0.00	0.05		
N of cabin	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	72.20	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	234.00	0.96		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
G - 9	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.20	
3/4 mi NE of	V2 - # preferred shrub species	0.00	0.05		
Basin cabin	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	71.20	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	254.00	0.86		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
G - 11	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.20	
N of Buford Ridge	V2 - # preferred shrub species	0.00	0.05		
ponds	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.00	0.05		
	V5 - % cover of palatable herb	71.20	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	254.00	0.86		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
G -12	V1 - % cover pref. shrubs <1.5m	0.00	0.05	0.08	
2mi N from bottom	V2 - # preferred shrub species	0.00	0.05		
Jackman road	V3 - Avg. shrub height (cm)	0.00	0.05		
	V4 - % cover of shrubs <1.5m	0.30	0.05		
	V5 - % cover of palatable herb	68.60	1.00		
	V6 - Crops within 1.6 km (Y/N)	N	0.00		
	V7 - Aspect (degrees)	92.00	0.21		
	V8 - Road density (km rd/km^2 habitat)	0.00	1.00		
	V9 - Topo diversity (A-E)	D	1.00		
	V10 - % evergreen canopy >1.5m	0.00	0.00		
				0.18	

Mule Deer model: HSI equations and analysis techniques

- Conifer & Open conifer provide thermal cover, all other cover types were assessed as forage habitat
- Optimal habitat: 60% forage and 40% cover , so Food and Cover SI's are divided by 0.6 and 0.4
  - Food SI = $\{[(V1 \times V2 \times V3 \times V4 \times V5^{1/5}) + V6] \times V7\}^{.625} \times V8$
    (Food SI) /0.6 = **Food Index**
  - Cover SI = (V9 x 0.8) + V10
    (Cover SI) / 0.4 = **Cover Index**
- HSI = lower of either Food Index or Cover Index

Table 17. Results and Data from Song Sparrow HSI Model Run

Riparian - acres 609

Transect	Variable	Variable Value	SI Value	HSI value	HU's	Total HU's
R - 1	V1 - % shrub cover	65.8	1.00	0.00	445	786
Up Tamrk	V2 - Avg shrub height (m)	1.4	0.99			
	V3 - Dist. to potable water (m)	2000.0	0.00			
R - 2	V1 - % shrub cover	74.1	1.00	0.00		
Low Tmrk	V2 - Avg shrub height (m)	1.9	1.00			
	V3 - Dist. to potable water (m)	1000.0	0.00			
R - 3	V1 - % shrub cover	78.8	1.00	1.00		
Basin	V2 - Avg shrub height (m)	1.6	1.00			
	V3 - Dist. to potable water (m)	0.0	1.00			
R - 4	V1 - % shrub cover	62.5	1.00	1.00		
Broady	V2 - Avg shrub height (m)	1.8	1.00			
	V3 - Dist. to potable water (m)	0.0	1.00			
R - 5	V1 - % shrub cover	22.4	0.60	0.77		
Cttnwd	V2 - Avg shrub height (m)	1.6	1.00			
	V3 - Dist. to potable water (m)	0.0	1.00			
R - 6	V1 - % shrub cover	25.6	0.70	0.78		
Buford	V2 - Avg shrub height (m)	1.3	0.82			
	V3 - Dist. to potable water (m)	0.0	1.00			
R - 7	V1 - % shrub cover	55.6	1.00	1.00		
N Joseph	V2 - Avg shrub height (m)	1.8	1.00			
	V3 - Dist. to potable water (m)	0.0	1.00			
R - 8	V1 - % shrub cover	72.5	1.00	1.00		
S Joseph	V2 - Avg shrub height (m)	2.1	1.00			
	V3 - Dist. to potable water (m)	0.0	1.00			
R - 9	V1 - % shrub cover	72.0	1.00	1.00		
Rock	V2 - Avg shrub height (m)	1.8	1.00			
	V3 - Dist. to potable water (m)	400.0	1.00			
				0.73		

Tall Shrub - acres 598

Transect	Variable	Variable Value	SI Value	HSI value	HU's
S -1	V1 - % shrub cover	63.9	1.00	0.05	341
Rye shrub	V2 - Avg shrub height (m)	1.0	0.64		
	V3 - Dist. to potable water (m)	700.0	0.05		
S - 3	V1 - % shrub cover	36.7	0.99	0.74	
Broady sumac	V2 - Avg shrub height (m)	0.7	0.55		
	V3 - Dist. to potable water (m)	100.0	1.00		
S - 4	V1 - % shrub cover	88.3	0.85	0.92	
Basin saddle	V2 - Avg shrub height (m)	1.4	0.99		
	V3 - Dist. to potable water (m)	300.0	1.00		
				0.57	

Song Sparrow model: HSI equations and analysis techniques

HSI = the lesser value between V3, or $(V1 \times V2)^{1/2}$

Table 18. Results and Data from Western Meadowlark HSI Model Run

Good Grasslands (Grassland) - acres 8423

Transect	Variable	Variable Value	SI Value	HSI	Cover type HU's	**Total HU's**
G - 3	V1 - % herbaceous cover	78.5	1.00	1.00	5643	**7697**
Tamrk saddle	V2 - % grass	70.7	1.00			
W of cabin	V3 - Avg herb. height (cm)	34.2	1.00			
	V4 - Dist. to perch (m)	6.6	1.00			
	V5 - % shrub cover <6m	0.0	1.00			
G - 2	V1 - % herbaceous cover	53.9	0.62	0.49		
Buford	V2 - % grass	42.8	0.39			
Crest to creek	V3 - Avg herb. height (cm)	31.4	1.00			
	V4 - Dist. to perch (m)	6.3	1.00			
	V5 - % shrub cover <6m	0.0	1.00			
G - 4	V1 - % herbaceous cover	61.2	0.85	0.64		
E side	V2 - % grass	57.4	0.68			
Hunt Camp Rdg	V3 - Avg herb. height (cm)	34.9	1.00			
	V4 - Dist. to perch (m)	41.1	0.71			
	V5 - % shrub cover <6m	0.0	1.00			
G - 5	V1 - % herbaceous cover	55.1	0.65	0.52		
W side	V2 - % grass	44.4	0.41			
Hunt Camp Rdg	V3 - Avg herb. height (cm)	33.8	1.00			
	V4 - Dist. to perch (m)	12.5	1.00			
	V5 - % shrub cover <6m	0.0	1.00			
G - 8	V1 - % herbaceous cover	67.3	1.00	0.87		
Tmrk - E side	V2 - % grass	58.3	0.77			
Joseph Crk	V3 - Avg herb. height (cm)	35.1	0.99			
SW of cabin	V4 - Dist. to perch (m)	13.8	1.00			
	V5 - % shrub cover <6m	0.0	1.00			
G -10	V1 - % herbaceous cover	53.3	0.61	0.49		
NE of Paradise	V2 - % grass	43.3	0.40			
Grass bird point	V3 - Avg herb. height (cm)	36.6	0.98			
count station 5	V4 - Dist. to perch (m)	8.0	1.00			
	V5 - % shrub cover <6m	0.0	1.00			
				0.67		

Agricultural (Pasture and Hayland) - acres 124

Transect	Variable	Variable Value	SI Value	HSI	Cover type HU's
GF - 1	V1 - % herbaceous cover	97.8	1.00	0.50	62
Bufd wheat field	V2 - % grass	100.0	1.00		
	V3 - Avg herb. height (cm)	57.7	0.51		
	V4 - Dist. to perch (m)	50.0	0.50		
	V5 - % shrub cover <6m	0.0	1.00		
				0.50	

Table 18. Western Meadowlark - continued

Degraded Grasslands (Grassland) - acres 2929

Transect	Variable	Variable Value	SI Value	HSI	Cover type HU's
DG - 1	V1 - % herbaceous cover	81.7	1.00	0.45	1992
Disturbed grass.	V2 - % grass	73.9	1.00		
	V3 - Avg herb. height (cm)	16.5	1.00		
	V4 - Dist. to perch (m)	79.2	0.20		
	V5 - % shrub cover <6m	0.0	1.00		
G - 6	V1 - % herbaceous cover	46.8	0.44	0.36	
Tmrk ridge	V2 - % grass	37.6	0.30		
	V3 - Avg herb. height (cm)	29.7	1.00		
	V4 - Dist. to perch (m)	22.0	1.00		
	V5 - % shrub cover <6m	0.0	1.00		
G - 7	V1 - % herbaceous cover	74.7	1.00	0.96	
Tmrk - E side	V2 - % grass	62.6	0.93		
Joseph Crk	V3 - Avg herb. height (cm)	30.4	1.00		
N of cabin	V4 - Dist. to perch (m)	27.2	1.00		
	V5 - % shrub cover <6m	0.0	1.00		
G - 9	V1 - % herbaceous cover	81.3	1.00	0.97	
3/4 mi NE of	V2 - % grass	70.9	1.00		
Basin cabin	V3 - Avg herb. height (cm)	29.1	1.00		
	V4 - Dist. to perch (m)	31.7	0.95		
	V5 - % shrub cover <6m	0.0	1.00		
G - 11	V1 - % herbaceous cover	55.2	0.68	0.35	
N of Buford	V2 - % grass	30.5	0.18		
Ridge ponds	V3 - Avg herb. height (cm)	30.5	1.00		
	V4 - Dist. to perch (m)	14.8	1.00		
	V5 - % shrub cover <6m	0.0	1.00		
G - 12	V1 - % herbaceous cover	77.4	1.00	1.00	
Joseph Crk	V2 - % grass	68.5	1.00		
2mi N from	V3 - Avg herb. height (cm)	28.3	1.00		
bottom Jckmn rd	V4 - Dist. to perch (m)	28.7	1.00		
	V5 - % shrub cover <6m	0.3	1.00		
				0.68	

Western Meadowlark model: HSI equations and analysis techniques

- HSI = $(V1 \times V2 \times V3 \times V4)^{1/2} \times V5$

Table 19. Results and Data from Yellow Warbler HSI Model Run

Riparian - acres 609

Transect	Variable	Variable Value	SI Value	SI Repro.	HSI	**Total HU's**
R - 1	V1 - % shrub cover	65.8	1.00	0.56	0.68	**414**
Up Tamrk	V2 - Avg shrub height (m)	1.4	0.74			
	V3 - % shrubs of hydrophytic spp.	35.0	0.43			
R - 2	V1 - % shrub cover	74.1	1.00	0.77		
Low Tmrk	V2 - Avg shrub height (m)	1.9	0.95			
	V3 - % shrubs of hydrophytic spp.	59.0	0.63			
R - 3	V1 - % shrub cover	78.8	1.00	0.64		
Basin	V2 - Avg shrub height (m)	1.6	0.80			
	V3 - % shrubs of hydrophytic spp.	44.0	0.51			
R - 4	V1 - % shrub cover	62.5	1.00	0.87		
Broady	V2 - Avg shrub height (m)	1.8	0.90			
	V3 - % shrubs of hydrophytic spp.	84.0	0.85			
R - 5	V1 - % shrub cover	22.4	0.38	0.38		
Cttnwd	V2 - Avg shrub height (m)	1.6	0.80			
	V3 - % shrubs of hydrophytic spp.	41.0	0.48			
R - 6	V1 - % shrub cover	25.6	0.44	0.45		
Buford	V2 - Avg shrub height (m)	1.3	0.65			
	V3 - % shrubs of hydrophytic spp.	67.0	0.70			
R - 7	V1 - % shrub cover	55.6	0.91	0.81		
Joseph North	V2 - Avg shrub height (m)	1.8	0.92			
	V3 - % shrubs of hydrophytic spp.	78.0	0.79			
R - 8	V1 - % shrub cover	72.5	1.00	0.88		
Joseph South	V2 - Avg shrub height (m)	2.1	1.00			
	V3 - % shrubs of hydrophytic spp.	76.0	0.77			
R - 9	V1 - % shrub cover	72.0	1.00	0.80		
Rock	V2 - Avg shrub height (m)	1.8	0.92			
	V3 - % shrubs of hydrophytic spp.	67.0	0.70			
				0.68		

Yellow Warbler model: HSI equations and analysis techniques

- HSI = Reproduction SI = $(V1 \times V2 \times V3)^{1/2}$

Appendix D
Common and Scientific Names for Plant Species Mentioned in the Text

Nomenclature of plants in Table 20 follows Hitchcock and Cronquist (1973), except for the grasses, which follows Hickman (1993).

Table 20. Common and Scientific Names for Plant Species Mentioned in the Text

Common Name	Scientific Name	Common Name	Scientific Name
Apple	*Pyrus malus*	Prairie junegrass	*Koeleria macrantha*
Balsamroot	*Balsamorhiza spp.*	Prickly currant	*Ribes lacustre*
Black cottonwood	*Populus trichocarpa*	Quaking aspen	*Populus tremuloides*
Black hawthorn	*Crataegus douglasii*	Raspberry	*Rubus idaeus*
Bluebunch wheatgrass	*Pseudoregneria spicatum*	Red osier dogwood	*Cornus stolonifera*
Buckwheat	*Eriogonum spp.*	Redstem ceanothus	*Ceanothus sanguineus*
Cascara	*Rhamnus purshiana*	Red threeawn	*Aristida longiseta*
Cheatgrass	*Bromus tectorum*	Reed canarygrass	*Phalaris arundinaceae*
Chokecherry	*Prunus virginiana*	Rocky Mountain maple	*Acer glabrum*
Common snowberry	*Symphoricarpos albus*	Rose	*Rosa spp.*
Diffuse knapweed	*Centaurea diffusa*	Rush skeletonweed	*Condrilla juncea*
Douglas-fir	*Pseudotsuga menziesii*	Sandberg's bluegrass	*Poa sandbergii*
Elderberry	*Sambucus cerulea*	Scotch thistle	*Onopordum acanthium*
Himalayan blackberry	*Rubus discolor*	Serviceberry	*Amelanchier alnifolia*
Idaho fescue	*Festuca ovina var. ingrata*	Smooth sumac	*Rhus glabra*
Intermediate wheatgrass	*Elytrigia intermedia*	Spirea	*Spirea betulifolia*
Kentucky Bluegrass	*Poa secunda*	Syringa	*Philadelphus lewisii*
Larch (tamarack)	*Larix occidentalis*	Thimbleberry	*Rubus parviflorus*
Lupine	*Lupinus spp.*	Thistle	*Circium spp.*
Medusahead	*Taeniatherum caput-medusae*	Water birch	*Betula occidentalis*
Ninebark	*Physocarpus malvaceus*	Wax currant	*Ribes cereum*
Oceanspray	*Holodiscus discolor*	White alder	*Alnus rhombifolia*
Oregon grape	*Berberis repens*	Willow	*Salix spp.*
Plum	*Prunus spp.*	Yellow starthistle	*Centaurea solstitialis*
Ponderosa pine	*Pinus ponderosa*		