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Defining old-growth Douglas-fir forests of central Montana and use of the northern goshawk (Accipiter gentilis) as a management indicator species

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DEFINING OLD-GROWTH DOUGLAS-FIR

FORESTS OF CENTRAL MONTANA AND USE OF

THE NORTHERN GOSHAWK (Accipiter gentilis)

AS A MANAGEMENT INDICATOR SPECIES

by

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Defining Old-growth Douglas-fir Forests of Central Montana and Use of the Northern Goshawk (*Accipiter gentilis*) as a Management Indicator Species (62 pages)

Director: Dr. E. Earl Willard E.E.W.

Old-growth Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) forest stands and Douglas-fir northern goshawk (*Accipiter gentilis*) nest stands were investigated in summers 1989 and 1990. Data were collected from 21 old-growth stands and 12 goshawk nest stands. Objectives of this study were to recommend refinements to an old-growth forest definition used by the Lewis and Clark National Forest (LCNF), to compare old-growth Douglas-fir stands with Douglas-fir goshawk nest stands in order to evaluate the appropriateness of the goshawk as a management indicator species (MIS) for old-growth Douglas-fir forests on the LCNF, and to examine the applicability of the nesting habitat portion of a goshawk habitat suitability model for the LCNF. Results indicated that old-growth Douglas-fir stands could be identified with minimum age and minimum dbh used as descriptors. Hence, simplification of old-growth definitions and development of definitions for each forest type were recommended for the LCNF. Differences between old-growth Douglas-fir stands and Douglas-fir goshawk nest stands were significant. The northern goshawk was a poor old-growth forest MIS on the LCNF. Land managers must identify a valid old-growth MIS or employ other methods in order to identify and manage old-growth forests. Index values produced by the goshawk habitat suitability model for each old-growth stand and goshawk nest stand verified that the model was successful in rating the nest stands higher than the old-growth stands. However, index values were virtually impossible to interpret so further refinement is necessary if the model is to be useful.

FORWARD

The chapters of this thesis are designed to be read independently. Because of this, the reader will encounter some redundancy in the methods and study area descriptions of these chapters.

Many people helped in making this project both possible and enjoyable. My thanks go to Dr. Earl Willard, my committee chairperson, for his guidance throughout the project. I am especially grateful for the advice, generosity, and friendship of Dr. Sallie Hejl. I thank the other members of my committee, Dr. Les Marcum and Dr. James Habeck, for their suggestions and review of the thesis.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter One:

CHARACTERIZATION OF OLD-GROWTH DOUGLAS-FIR FORESTS OF CENTRAL MONTANA

INTRODUCTION

No environmental issue in several decades has attracted more attention or created more controversy in the northwestern United States than harvesting the region's old-growth forests (Orians 1990). Loss of old-growth forests to human activity and manipulation has become an escalating concern to natural resource organizations and the general public. Despite this concern, old-growth forests have been virtually "liquidated" within private land holdings (Juday 1978, Debell and Franklin 1987, Orians 1990). Fortunately, examples of old-growth forests remain intact in national parks, wilderness areas, and some national forests (Debell and Franklin 1987, Greene 1988, Habeck 1988, Orians 1990). Conscientious management of the remaining old-growth forests is of vital importance because, if current harvesting practices continue, all existing old-growth forest stands not protected by national parks or wilderness areas will have been logged by the year 2010 (Orians 1990).

Old-growth forests serve many important functions. They provide habitat for a variety of plant, fish, and wildlife species; maintain water quality, soil productivity, and soil stability; and supply recreational opportunities (Juday 1978, Barrows 1984, Yuskavitch 1985, Habeck 1988, Greene 1988, Thomas et al. 1988, Franklin and Spies 1989, Miner 1989) . In addition, old growth is often recognized as having its own intrinsic value (Juday 1978, Barrows 1984, Yuskavitch 1985, Habeck 1988, Greene 1988, Thomas et al. 1988).

The term "old growth" is commonly used today, but little was known about old-growth forest ecosystems until the last decade. Much information addressing its structure, vegetative composition, site characteristics, and ecological role remains unknown (Spies and Franklin 1988). Such knowledge is essential to devise resource management prescriptions and forest management plans, which are required for all national forests by the 1976 National Forest Management Act.

Establishing a definition of old-growth forest has been of particular interest to the U.S. Forest Service in recent years. Old growth has been defined in many ways, but a clear definition that is universally accepted and applied has not been established (Hunter 1989). Developing a definition that is applicable to a large geographic area may be impossible. Recently, the U.S. Forest Service (1989) proposed a generic definition of old-growth forests: "Old-growth forests are ecosystems distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function". The definition also stresses that specific structural characteristics which make up an old-growth forest will vary widely according to forest type, climate, site conditions, and natural disturbance regime. In addition to the generic definition, site-specific working definitions and structure-oriented descriptions of old growth are possible and necessary for old-growth forest management (Thomas et al. 1979,1988; Alabeck 1982; Heinrickes 1983; Franklin and Spies 1984,1989).

Resource managers of the Lewis and Clark National Forest (LCNF) have incorporated the following definition of old-growth forest into their 1986 Forest Plan:

> Old-growth forest is widely considered to be an essential habitat component for a particular group of wildlife species. However, a standard definition of "old growth" is not available due to great variations in site productivity, species composition, stand history and other variables. Standard criteria used in timber management to classify mature and overmature stands such as age, volume, and culmination of mean annual increment are not good indicators of old-growth forest on the Lewis and Clark National Forest:
>
> An old-growth forest will normally contain the following characteristics;
>
> - One or more coniferous species which are climax or long-lived seral dominants on the site.
> - Two or more layers or age classes.
> - A combined overstory-understory tree canopy closure which averages 60 percent or more.
> - The dominant tree component generally exceeds 13 inches dbh, 50 feet in height, and has reached or is past full maturity with signs of decadence present and obvious.
> - At least 2 snags/acre of 10 inches dbh or greater.
> - Sparse understory shrub and herbaceous vegetation with logs and other down material common and well distributed through the stand.

The definition was based primarily on extrapolated and modified information derived from old-growth forest stands in Oregon and Washington (D. Godtel pers. comm.). This definition may have limited applicability to the LCNF (D. Godtel pers. comm.). The definition is general and untested.

Neither a working definition nor a structural description specific to the old-growth Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) community in central Montana had been created when this study began in 1989, even though this community is scheduled to receive substantial timber harvest in the next decade. Resource managers of the Lewis and Clark National Forest are interested in learning how to describe old-growth Rocky Mountain Douglas-fir forests of central Montana. The objective of this study is to recommend refinements to the current Forest Plan's ecological definition of old-growth Douglas-fir forests on the Lewis and Clark National Forest.

STUDY AREA

Field work was conducted on the Jefferson Division of the Lewis and Clark National Forest in central Montana during summers 1989 and 1990. Study sites were located in the Little Belt, Big Snowy, Castle, and Crazy Mountain ranges (Figure 1). These mountain ranges display varying topography, with elevations from 1,500 m to 2,800 m. Foothills are generally rolling grasslands with bands of Douglas-fir or ponderosa pine (See Appendix A for plant scientific names). Mid-elevation slopes are primarily vegetated with dense stands of lodgepole pine or Douglas-fir. Grassy benches or forest/grassland mosaics are common throughout the lower and middle elevations. Higher elevations generally have steep slopes with gentle to flat ridges. Limber pine, whitebark pine, Engelmann spruce, subalpine fir, and grassland are the dominant vegetation types of the upper elevations.

These mountain ranges are characterized by distinct fire histories that are illustrated by the fire-generated or fire-perpetuated forest types dominating the areas (Habeck 1988). Historically, lodgepole pine stands experienced stand-replacing fires, and ponderosa pine/ Douglas-fir stands along the forest-grassland ecotone have been maintained by low intensity fires (Habeck 1988). Fire disturbances may play a vital role in maintaining some old-growth forests of central Montana.

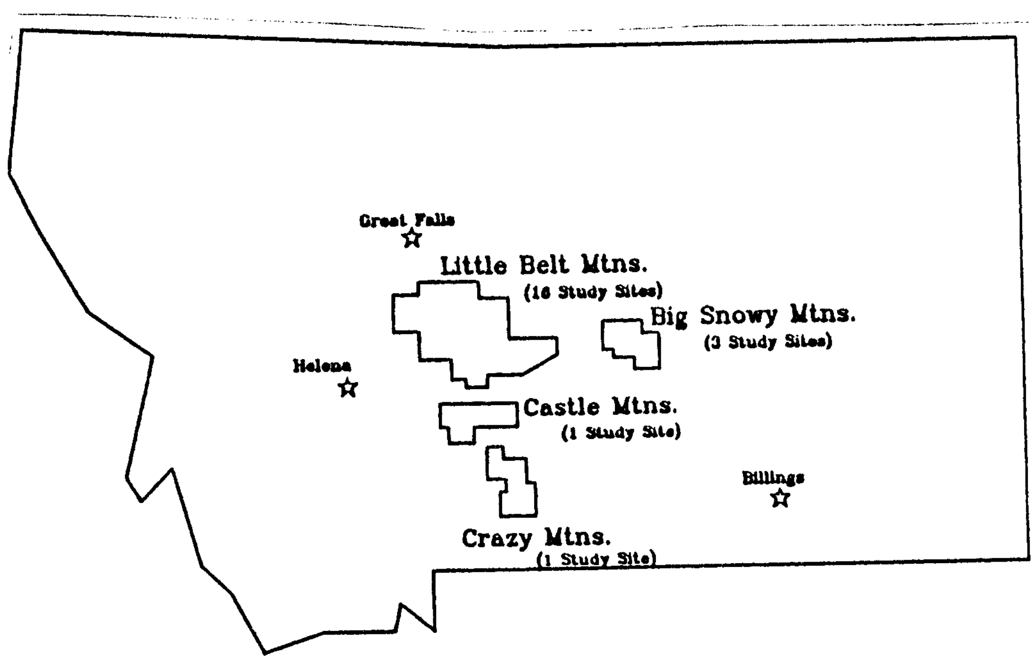

Figure 1. Study area with number of study sites in each mountain range.

METHODS

In summer 1989, I identified 50 old-growth Douglas-fir stands in my study area. Criteria for the stand to be considered a study site were: (1) stand was dominated by Douglas-fir, (2) dominant Douglas-fir trees were large diameter for this species in this geographic area [$\geq$ 25 cm diameter-at-breast-height(dbh)], (3) no timber harvesting had occurred in the stand, and (4) stands were at least 2 hectares (5 acres) in size. Data sources for identification of candidate old-growth Douglas-fir stands were aerial photographs, timber stand exam data, and locations from Forest Service field crews and other personnel.

In summer 1990, I randomly selected 25 old-growth Douglas-fir study stands to be sampled from the 50 which met the criteria. Time and weather permitted me to sample only 24 of these study sites. Nineteen study stands were located in the Little Belt, three in the Big Snowy, one in the Castle, and one in the Crazy Mountains (Figure 1). Each old-growth study site was sampled with a series of five fixed-radius plots. Plot locations were determined by a random sampling design (example in Figure 2). A line transect with five evenly spaced points bisected each sample stand as determined by use of aerial photographs. Transect length and distance between points varied with the dimensions of each stand. Stand sizes were calculated by using orthophoto quads and Digitablet 2400 by Numonics. The transect was located so that a majority of the stand fell within its reaches. The starting point of the transect was determined by choosing a random distance from 0 to 100 meters. All random distances came from a random numbers table. Once the random starting point was determined, five evenly spaced points were placed on the transect after the starting point. From each of the five points, a perpendicular, random distance (-50 to 50 m) to a sample plot center was taken. Positive and negative values corresponded to right and left directions from the transect point. Only random numbers which selected plots within the old-growth stand were used. The transect approach attempted to reduce the likelihood of concentrating the sample plots in specific areas of the stands. Therefore it allowed me the opportunity to sample portions of the entire stand.

The stands were sampled using circular plots with radii of 11.3 m (area = 0.04 ha) and 4.6 m (area = 0.007 ha). Primary old-growth characteristics were measured on the 0.04 ha plots and secondary old-growth characteristics were measured on the 0.007 ha plots. Three 0.007 ha plots were nested concentrically inside the first, third and fifth plots of the 0.04 ha plots (Figure 2).

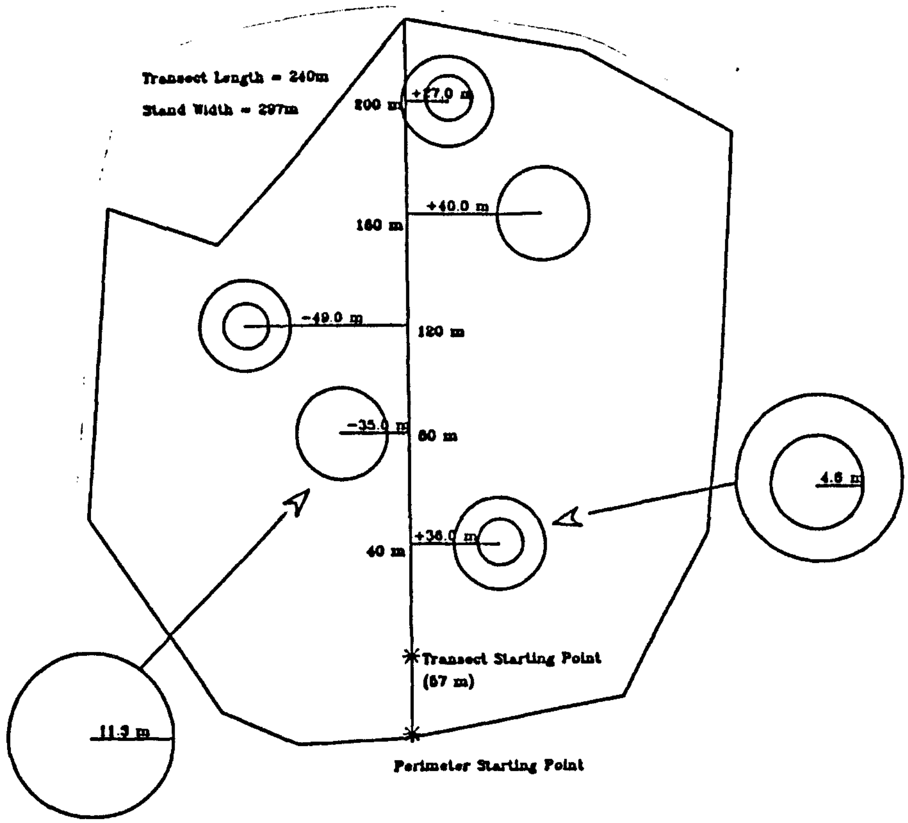

Figure 2. Example of the plot sampling design.

Physiographic data was taken at plot center of each 0.04 ha plot (elevation, slope, aspect, and habitat type (Pfister et al. 1977).)

Trees, snags, and downed logs were considered primary old-growth stand components. Trees (>20 cm dbh), snags ($\geq$ 10 cm dbh), and downed logs (>10 cm bottom diameter) were measured and characterized on the 0.04 ha plot. Species (if possible), height and dbh were recorded for trees and snags. Heights were estimated after a few heights were measured at each plot. I recorded percent canopy cover and descriptions of snags and logs such as snag condition (after Cline et al. 1980, see Appendix B), and log condition (after Thomas et al. 1979, see Appendix

C). The two largest (>20 cm dbh) Douglas-fir trees in each of the 0.04 ha plots were cored and aged. If two large Douglas-fir trees were not located in the plot, large trees (>20 cm dbh) closest to the plot were used. Volume of downed logs (>10 cm bottom diameter) in the 0.04 ha plots was estimated by measuring log length and the log's top and bottom diameters. Volume was calculated using the frustrum of a cone formula (J. Brown pers. comm.).

Small trees, seedlings, shrubs, tree canopy, and ground cover types were considered secondary old-growth components. Trees (0-20 cm dbh), seedlings (>50 cm tall) and shrubs (>50 cm tall) were tallied by species on the 0.007 ha plots. Tree canopy, seedling, shrub, and ground cover were calculated, on the first, third, and fifth 0.04 ha plots, using a method developed by Hejl (1989). Seven points, placed at 0.0, 3.9, 6.0, 7.5, 8.7, 9.8, and 10.8 m intervals, were located in each cardinal direction (N, E, S, and W) from plot center. The type of cover and species were noted after sighting upward and downward from each point. Percent cover was calculated by multiplying the number of points blanketed by each cover type by four. Ground cover types were litter, rock, soil, downed wood, grass, forb, water, and other.

Overall mean values, 95% confidence intervals, and ranges were calulated using the averages for each variable by stand (N = 21).

RESULTS

Age Data

A total of 126 trees were aged. The ages ranged from 70 to 456 years. Overall mean live tree age was 268 years with a 95% confidence interval of 231.7 to 304.3. Diameter (dbh) of the aged trees averaged 48 cm with a 95% confidence interval of 17.8 to 20.2. Seven of the 24 stands had mean ages less than 200 years. Four of these stands had small diameter trees that were aged, but those trees with dbhs $\geq$ 36 cm were over 200 years. Large, old trees were common on these four stands but were missed on the sample plots. The other three stands had trees $\geq$ 36 cm dbh that were aged (except one 33 cm dbh tree) and most of these were less than 200 years. Because these latter three stands contained large diameter, young trees, they were not considered old growth and were not included in the overall analysis. Appendix D presents summary statistics from these three forest stands. Appendix E presents summary data, using mean values, from the 21 old-growth study stands.

Physiographic Data

Old-growth stand elevations averaged 1990 m and ranged between 1,695 m and 2,265 m. Stand slope averaged 32% and ranged from 7 to 80%. Old-growth stand orientations were well distributed between each primary compass direction: north, east, south, and west. Recorded habitat types (Pfister et al. 1977) varied widely, covering the range within the Pseudotsuga menziesii series but included other climax series habitat types as well. A complete list of all recorded plant species is in Table 1 (See Appendix A for scientific names).

Primary Old-Growth Stand Components

Live trees. A total of 1,395 trees (> 20 cm dbh) were sampled on the study sites, 1,217 (87%) of which were Douglas-fir. Stem diameters (dbhs) ranged from 20.0 cm to 94.0 cm. Mean dbh was 36.0 cm, with a 95% confidence interval of 34.5 to 37.5 (Table 2). Large tree densities, by stand, ranged between 85 and 205 per 0.4 hectare (0.4 ha = 1.0 acre). Average large tree density was 130 per 0.4 ha with a 95% confidence interval of 116.5 to 143.5. Mean percent canopy cover was calculated for each old-growth stand. Mean canopy cover ranged from 41% to 77% with an overall mean of 55%. A 95% confidence interval for mean canopy cover was 50.2% to 59.8%.

Table 1. List of recorded plant species and numbers in each measured group. Species are listed according to prevalence.

Plant Species		Large[a]	Small[b]	Seed[c]	Shrub[d]	Note[e]
		Classification				
Tree Species						
Douglas-Fir		1217	382	677	---	---
Lodgepole Pine		64	13	17	---	---
Engelmann Spruce		52	10	26	---	---
Subalpine Fir		35	39	175	---	---
Ponderosa Pine		21	0	8	---	---
Limber Pine		6	4	6	---	---
Western Redcedar		0	9	6	---	---
Mountain Maple		0	0	48	---	---
	Total	1395	457	963		
Shrub Species						
Common Snowberry		---	---	---	876	---
Common Juniper		---	---	---	267	---
Mountain Gooseberry		---	---	---	193	---
White Spiraea		---	---	---	67	---
Buffaloberry		---	---	---	56	---
Wood's Rose		---	---	---	42	---
Blue Huckleberry		---	---	---	23	---
Mountain Snowberry		---	---	---	16	---
Chokecherry		---	---	---	10	---
Ninebark		---	---	---	4	---
Elderberry		---	---	---	1	---
	Total				1555	
Other Recorded Species						
Creeping Oregon Grape		---	---	---	---	X
Kinnikinnick		---	---	---	---	X
Red Raspberry		---	---	---	---	X
Twinflower		---	---	---	---	X
Dogwood		---	---	---	---	X

[a] Trees > 20 cm dbh.
[b] Trees 0-20 cm dbh.
[c] Seedlings 50 cm $\geq$ 0 $\leq$ 137 cm in height.
[d] Shrubs $\geq$ 50 cm in height.
[e] Plant species noted but numbers were not counted.

Snags. A total of 481 coniferous snags ($\geq$ 10 cm dbh) were sampled. Stem diameters (dbhs) ranged from 10 cm to 89 cm. Mean snag dbh was 28 cm with a 95% confidence interval of 24.4 to 31.6 (Table 2). Snag heights ranged between 1.2 m and 27.0 m. Snag heights averaged 8.2 m with a 95% confidence interval of 7.7 to 8.7. Snag densities, by stand, ranged between 15.0 and 105.0 snags per 0.4 ha (Table 2). Average snag density was 45.0 per 0.4 ha with a 95% confidence interval of 35.0 to 55.0.

Snag decomposition classes used were described by Cline et al. (1980) (Appendix B). Of snags recorded on each old-growth stand, an average of 25% were assigned to decomposition class 1, 24% to class 2, 23% to class 3, 21% to class 4, and 7% to class 5.

Downed logs. A total of 2,167 downed logs (> 10 cm bottom diameter) were tallied across all stands. Mean log density, calculated by stand, was 195.0 per 0.4 ha with a 95% confidence interval of 151.0 to 239.0 (Table 2). Log densities ranged from 35.0 to 385.0 per 0.4 ha. Average downed log volume, again calulated by stand, was 100.0 m^3 per 0.4 ha. The 95% confidence interval was 72.0 to 128.0. Average downed log volumes ranged between 4.0 and 166.0 m^3 per 0.4 ha.

Downed log decomposition classes used were described by Thomas et al. (1979) (Appendix C). Of downed logs measured on each old-growth study site, an average 3% were assigned to decomposition class 1, 13% to class 2, 40% to class 3, 25% to class 4, and 17% to class 5.

Secondary Old Growth Components

Tree canopy. The number of canopy layers was not measured in this study. However, the occurrence of two or more canopy layers can be noted for an old-growth stand based on the assumption that when small and large diameter trees occur together, two or more canopy layers are present in the stand. Therefore, those sample stands with at least 10 small trees (0-20 cm dbh) and 10 large trees [> 36 cm dbh (mean tree dbh)] recorded were tallied as old-growth forest stands with more than one canopy layer. A total of 13 of 21 (62%) sample old-growth stands exhibited more than one canopy layer.

Shrubs. Mean percent shrub cover, calulated by stand, was 16% with a 95% confidence interval of 10.6 to 21.4 (Table 2). Percent shrub cover ranged between 0.0 and 51.0%. A total of 1,555 shrubs (≥ 50 cm in height) were tallied on the study sites. Using mean shrub densities for each sample stand, shrub density averaged 715.0 per 0.4 ha. The 95% confidence interval was 287.4 to 1,142.6. Densities ranged between 41.0 to 4,235.0 per 0.4 ha.

Small trees. A total of 457 small trees (0-20 cm dbh) were tallied. Small tree densities, by stand, averaged 206 small trees per 0.4 ha (Table 2). The 95% confidence interval for small tree density was 31.4 to 380.6. Densities ranged from 0.0 to 1,787.5 small trees per 0.4 ha.

Seedlings. A total of 963 seedlings (50 to 137 cm in height) were tallied across the stands. Average seedling density, by stand, ranged from 0.0 to 2,213.8 per ha (Table 2). Mean seedling density was 413.0 per 0.4 ha with a 95% confidence interval of 168.2 to 657.8.

Ground cover. A total of 1,532 ground cover recordings were taken, 502 (34%) were recorded as litter, 436 (29%) as forb, 233 (15%) as downed wood, 216 (14%) as grass, 110 (7%) as other (moss, lichen, and seedlings), 27 (2%) as rock, and 8 (1%) as soil.

Table 2. Primary and secondary old-growth study stand components.

	N	$\bar{X}$	95% CI	Range
Live trees				
dbh[a]	21	36.0	36.0 ± 1.5	20.0-94.0
height[b]	21	17.0	17.0 ± 0.2	6.0-34.0
age[c]	21	268.0	268.0 ± 36.3	70.0-456.0
no./0.4 ha[d]	21	130.0	130.0 ± 13.5	85.0-205.0
Snags				
dbh	21	28.0	28.0 ± 3.6	10.0-89.0
height	21	8.2	8.2 ± 0.5	1.2-27.0
no./0.4 ha	21	45.0	45.0 ± 10.0	15.0-105.0
Downed logs				
no./0.4 ha	21	195.0	195.0 ± 44.0	35.0-385.0
vol/log	21	0.8	0.8 ± 0.15	0.02-11.6
vol/0.4 ha[f]	21	100.0	100.0 ± 28.0	4.0-166.0
Trees				
canopy cover[e]	21	55.0	55.0 ± 4.8	41.0-77.0
Shrubs				
cover	21	16.0	16.0 ± 5.4	0.0-51.0
no./0.4 ha	21	715.0	715.0 ± 427.6	41.0-4,235.0
Small trees				
no./0.4 ha	21	206.0	206.0 ± 174.6	0.0-1,787.5
Seedlings				
no./0.4 ha	21	413.0	413.0 ± 244.8	0.0-2,213.8

[a] All diameters were measured in centimeters.
[b] All heights were measured in meters.
[c] Age was in years.
[d] All densities were in numbers per 0.40 ha (1.0 acre).
[e] Covers were expressed in percentages.
[f] Volume was expressed in square meters per 0.4 ha.

Comparison of Old Growth Study Results and Old Growth Specifications Currently Used

All 21 of the old-growth study sites fulfilled the currently used old-growth criteria of containing one or more dominant coniferous species which are climax or long-lived seral dominants. However, a total of 13 of the 21 (62%) old-growth sites displayed two or more canopy layers or age classes. Therefore, single canopy layered old-growth Douglas-fir stands were not uncommon, as 38% (8/21) of the study stands had single canopy layers.

The tree canopy closure for the old-growth sample stands averaged 55%, which fell short of the $\geq$ 60% parameter of the currently used old-growth specifications. In fact, only 7 of 21 stands (33%) had mean canopy closures of 60% or more.

A total of 48% of the measured trees exceeded 33 cm (13 inches) dbh and 52% were greater than or equal to 15 m (50 feet) in height. Overall, approximately 50% of the old-growth sample stands met the currently used criteria where dominant trees generally exceeded 33 cm (13 inches) dbh and 15 m (50 feet) in height.

Indicated by the densities of snags and downed logs, decadence was present and obvious in all 21 old-growth stands. Fifty-two percent of the recorded snags were classified in decomposition classes three, four, and five (Appendix B). Eighty-eight percent of the recorded logs were classified in decomposition classes three, four, and five (Appendix C).

All sample old-growth stands except 3 (14%) had at least two snags per 0.4 ha (1.0 acre) of 25cm (10 inches) dbh or greater. In fact the old-growth stands averaged 20 snags per 0.4 ha of this size class with a 95% confidence interval of 15.0 to 25.0.

Contrary to currently used old-growth specifications, a variety of shrubs were common and herbaceous plants were very common throughout the old-growth study sites.

Downed logs, woody debris, and litter were common throughout all of the old-growth stands. Table 3 contains the comparison of the currently used old-growth standards and those derived from this study.

Table 3. Comparison of values used in current LCNF old-growth definition and those resulting from this study.

Variable	Currently Used Value	Study Results
Climax or long-lived seral dominants	$\geq$ 1 species present	$\geq$ 1 species present
Canopy layers or age classes	$\geq$ 2	13/24 (54%) stands
Canopy closure	$\bar{X} \geq 60\%$	$\bar{X} = 55\%$
Dominant trees		
dbh	$\bar{X} \geq$ 13 inches	$\bar{X} =$ 14 inches
height	$\bar{X} \geq$ 50 feet	$\bar{X} =$ 56 feet
decadence	present and obvious	present and obvious
Snags	2 $\geq$ 10 in. dbh/acre	$\bar{X} =$ 5 snags 10 in. dbh/acre
Shrubs and herbaceous veg.	sparse	common
logs and downed material	common and well distributed	common and well distributed

All old-growth sample stands fully met the following parameters of currently used old-growth criteria: presence of one or more coniferous species which are climax or long-lived seral dominants, dominant trees exceed 33 cm dbh and 15 m in height, signs of decadence present and obvious, at least 2 snags per 0.4 ha of 25 cm dbh or greater, and logs and other downed material common and well distributed. Parameters not met were two or more layers or age classes, tree canopy closure that averages 60 percent or more, and sparse understory shrub and herbaceous vegetation.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Old-growth forests are difficult to define. When establishing a usable definition, one needs to consider the variables that are likely to have ecological significance as well as being easily measured. With a basic understanding of a specific forest type, land managers need to consider the logical criteria on which to base a area and forest type specific old-growth definition. Important factors that must be addressed are the number of descriptors to be included in the definition and how narrow or flexible they are.

As expected, there are good aspects and bad aspects to old-growth definitions that are narrow or flexible. One advantage of a definition with flexible descriptors would be that old-growth forests could be "created" in areas where they are rare or nonexistent by allowing existing forests to develop into old growth with time (Hunter 1989). In this manner, those stands meeting the minimum requirements of a flexible definition can be preserved and allowed to evolve into a "true" old-growth stand. Another advantage of a flexible definition is that forest stands representing early, middle, and late old growth stages could be identified and preserved. A disadvantage of a flexible definition is that the amount of remaining old growth in an area may be over-estimated. This may lead land managers to believe that current harvest rates are acceptable when in fact they might be too high for sustained yield management practices.

Advantages and disadvantages of old-growth definitions with narrow descriptors also occur. Possibly the "best" old-growth stands will be identified and preserved when implementing a narrow definition, therefore eliminating or reducing over-estimation errors. A disadvantage of a narrow definition is that representative stands of early, middle, and late old-growth stages may not be preserved. Consequently, the number and variety of plant and animal species that inhabit or utilize old-growth forest ecosystems would possibly be reduced. Narrow definitions may also reduce the possibility of "creating" old-growth stands (Hunter 1989) in areas where they are rare or nonexistent. Obviously, care must be taken when creating old-growth forest definitions.

After working with several different Forest Service and private industry data gathering crews, I firmly support the simplistic approach of data gathering designs, especially after utilizing information stemming from different sources. The primary advantage of this approach is that it reduces biased information, especially since in most cases the information is supplied by individuals with varying backgrounds.

Undoubtedly it is difficult, if not impossible, to link a specific list of criteria to encompass all old-growth forest stands found in even a small area. Fortunately all the old-growth study sites had two parameters in common: they all supported large diameter, old trees. With this fact in mind, I propose that old-growth Douglas-fir forest definition on the Lewis and Clark National Forest be based primarily on the number of live trees of a specific dbh per unit area. These dominant trees must be at least 200 years.

The principal justification for such reasoning is that all structural characteristics of old-growth forests were linked to age, and the presence of large diameter trees was a reflection of age (≥ 200 years) in this study. Therefore if large, old trees are present, other old-growth structural attributes will theorectically evolve with time. Development of large diameter trees in central Montana is truly the time-consuming factor. Second, a major purpose of old growth definitions is to provide a standard criteria for land managers to identify old-growth stands and subsequently to formulate old-growth management strategies. Finally, a usable definition should be as simple as possible in order to limit implementation costs, bias, and confusion.

On the LCNF, old-growth forest definitions should be broken down by forest types and when necessary site conditions which can be deliniated through habitat types. For the Douglas-fir forest type (Table 4) further breakdown is unnecessary because there were no pronounced structural differences between old-growth Douglas-fir forests representing different Habitat Types (site conditions) in this study. Lower values from the 95% confidence intervals, calculated for the variables measured in this study, were used to define old-growth Douglas-fir forests. Sample old-growth stands averaged 74 trees $\geq$ 34 cm dbh (low CI value for live tree dbh) per 0.4 hectare with a 95% CI of 62 to 86. Tree ages averaged 268 years with a 95% confidence interval of 232 to 304. Therefore, old-growth Douglas-fir forests will contain a minimum of 62 live trees $\geq$ 34 cm dbh per 0.4 hectare and dominant trees (largest trees in the stand) are $\geq$ 200 years. Table 4 displays the proposed old-growth Douglas-fir forest definition for the LCNF.

Inclusion of other structural attributes in the definition are important in determining whether an old-growth stand is in early, middle, or late stages of development. When possible, management of old-growth forests in all stages of maturation is desirable because plant and animal species associated with old-growth ecosystems are likely to be linked to specific developmental stages and attributes.

Table 4. Minimum values for components included in the Douglas-fir forest type old-growth definition.

Site[a] Cond	For[b] Type	No.[c] TPH.dbh	Age[d]
All	DF	62$\geq$34cm	$\geq$200

[a] Old-growth forest component values may need further breakdown by site condition in some forest types. Ex. Lodgepole pine (LP) types.
[b] Described by dominant overstory species present.
[c] Minimum number of trees per 0.4 hectare of stated dbh.
[d] Minimum age of dominant live trees.

Again it is important to stress that old-growth forest ecosystems are extremely complex and thus difficult to define. This complexity compounds the difficulties of defining old-growth forests. Nevertheless, functional definitions are necessary for determining the amount of old-growth forests that remain in an area and subsequent management practices that will ensure their preservation.

Complicated definitions using a wide array of variables have been implemented in the past and newly formulated definitions continue with this trend. These definitions have provided limited success to the old-growth inventory process being initiated in central Montana as well as elsewhere. Undoubtedly the definitions can be simplified as the proposed old-growth Douglas-fir forest definition outlined in this paper suggests. Before more irreversable destruction and fragmentation occurs in these unique, complex forest ecosystems, usable definitions must be devised and agreed upon by land managers.

Chapter 2:

USEFULNESS OF THE NORTHERN GOSHAWK AS A MANAGEMENT INDICATOR SPECIES FOR OLD-GROWTH DOUGLAS-FIR FORESTS OF CENTRAL MONTANA

INTRODUCTION

Indicators were first used in the 1910s by plant ecologists who worked with soil productivity and agricultural crops (Patton 1987). Recently, the indicator species concept was introduced to the wildlife profession as Management Indicator Species (MIS) by the 1976 National Forest Management Act (NFMA) (Patton 1987).

The Lewis and Clark National Forest (LCNF), as well as all other National Forests, was required by the implementing regulations of NFMA to use MIS to monitor and manage old-growth forest ecosystems. The indicator species concept, in short, implies that an indicator species having restrictive habitat requirements is assumed to represent other species utilizing the same habitats. It is generally thought that by managing habitats for the health and viability of the indicator species, other species utilizing these same habitats will also be protected and maintained (Blosser 1987). An MIS is essentially a single species representative or surrogate of a community (Patton 1987, Landres et al. 1988).

The MIS approach has received considerable criticism. Landres et al. (1988) pointed out that community responses to change can not be extrapolated from one community member to another. Few if any species groups within a community utilize habitat or respond to change so similarly that one species could be used as an indicator of others within its group (Verner 1984). Landres et al. (1988) stated that if use of the MIS concept is unavoidable, "it must be justified by research on populations of the species involved, over an extensive area and time."

The Lewis and Clark National Forest employs the Northern Goshawk (Accipiter gentilis) as a management indicator species for old-growth forests. The Northern Region, USDA Forest Service of which the LCNF is a part developed a goshawk habitat model, based on that of Hayward et al. (1983), which provided an index rating of habitat value (USDA Forest Service 1990). This model was developed for application in boreal forests of western Montana and northern Idaho. The variables considered by this model for goshawk nesting/cover habitat are: overstory tree size, canopy closure, size of nest stand, and slope. Canopy closure was judged to be the most important variable and slope the least important variable (USDA Forest Service 1990). This model has been reviewed by goshawk researchers, but has not been verified in the field.

The objectives of this study were (1) to compare old-growth Douglas-fir stands with Douglas-fir goshawk nest stands in order to evaluate the appropriateness of the goshawk as a MIS for old-growth Douglas-fir forests on the LCNF, and (2) to examine the applicability of the nesting habitat portion of the goshawk habitat model for the LCNF.

STUDY AREA

Field work was conducted on the Jefferson Division of the Lewis and Clark National Forest in central Montana. Study sites were located in the Little Belt, Big Snowy, Castle, and Crazy Mountain ranges (Figure 3). These mountain ranges display varying topography, with elevations from 1,500 m to 2,800 m. Foothills are generally rolling grasslands with bands of Douglas-fir or ponderosa pine (See Appendix A for plant scientific names). Mid-elevation side slopes are primarily vegetated with dense stands of lodgepole pine or Douglas-fir. Grassy benches or forest/grassland mosaics are common throughout the lower and middle elevations. Higher elevations generally have steep side slopes with gentle to flat ridges. Limber pine, whitebark pine, Engelmann spruce, subalpine fir, and grassland are the dominant vegetation types of the upper elevations.

These mountain ranges are characterized by distinct fire histories that are exemplified by the fire-generated or fire-perpetuated forest types dominating the areas (Habeck 1988). Historically, lodgepole pine stands have experienced stand-replacing fires, and ponderosa pine / Douglas-fir stands along the forest-grassland ecotone have been maintained by low intensity fires. Fire disturbances may play a vital role in maintaining some old-growth forests of central Montana.

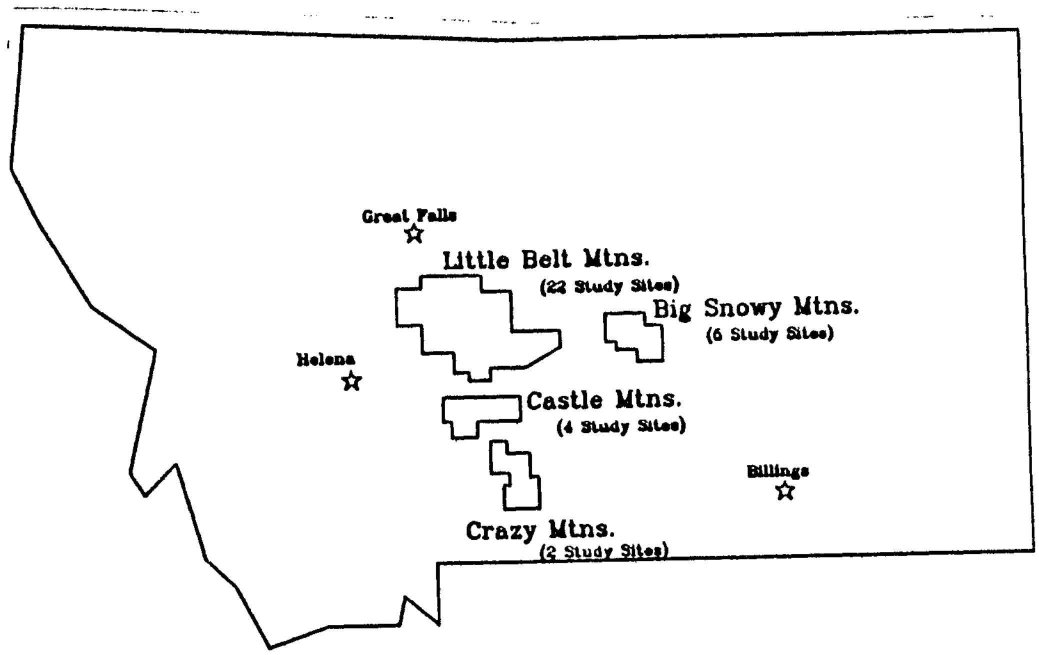

Figure 3. Study area with number of study sites in each mountain range.

METHODS

In summer 1989, I identified 50 old-growth Douglas-fir stands in my study area. Criteria for the stand to be considered a study site were: (1) stand is dominated by Douglas-fir, (2) dominant Douglas-fir trees are large diameter [≥ 25 cm diameter-at-breast-height(dbh)], (3) no timber harvesting has occurred in the stand, and (4) stands are at least 2 hectares (5 acres) in size. Data sources for identification of candidate old-growth Douglas-fir stands were aerial photographs, timber stand exam data, and references from Forest Service field crews and other personnel. Also in summer 1989, I surveyed 10 previously identified and 2 newly indentified northern goshawk nest stands. If a forest stand contained at least one confirmed northern goshawk nest site, the stand was classified as a goshawk nest stand. I surveyed the nest stands to confirm that their dominant live tree components were Douglas-fir and that they contained at least one old or new goshawk nest site.

In summer 1990, I randomly selected 25 old-growth Douglas-fir study stands to be sampled from the 50 which met the criteria. Time and weather permitted me to only sample 24 of these study sites. I also sampled the 12 northern goshawk nest stands. Twenty-five study stands were located in the Little Belt, five in the Big Snowy, four in the Castle, and two in the Crazy Mountains (Figure 3). Each old-growth study site and goshawk nest stand were sampled with a series of five fixed-radius plots. Plot locations were determined by a random sampling design. A line transect with five evenly spaced points bisected each sample stand as determined by use of aerial photographs. Transect length and distance between points varied with the dimensions of each stand. Stand sizes were calculated by using orthophoto quads and Digitablet 2400 by Numonics. The transect was located so that a majority of the stand fell within its reaches. The starting point of the transect was determined by choosing a random distance from 0 to 100 meters. All random distances came from a random numbers table. Once the random starting point was determined, five evenly spaced points were placed on the transect after the starting point. From each of the five points, a perpendicular, random distance (-50 to 50 m) to a sample plot center was taken. Positive and negative values corresponded to right and left directions from the transect point. Only random numbers which selected plots within the study stands were used. The transect approach attempted to reduce the likelihood of concentrating the sample plots in specific areas of the stands. Therefore, it allowed me the opportunity to sample portions of the entire stand.

The stands were sampled using circular plots with radii of 11.3 m (area = 0.04 ha) and 4.6 m (area = 0.007 ha). Primary stand characteristics were measured on the 0.04 ha plots and secondary stand characteristics were measured on the 0.007 ha plots. Three 0.007 ha plots were nested concentrically inside the first, third and fifth plots of the 0.04 ha plots (Figure 4).

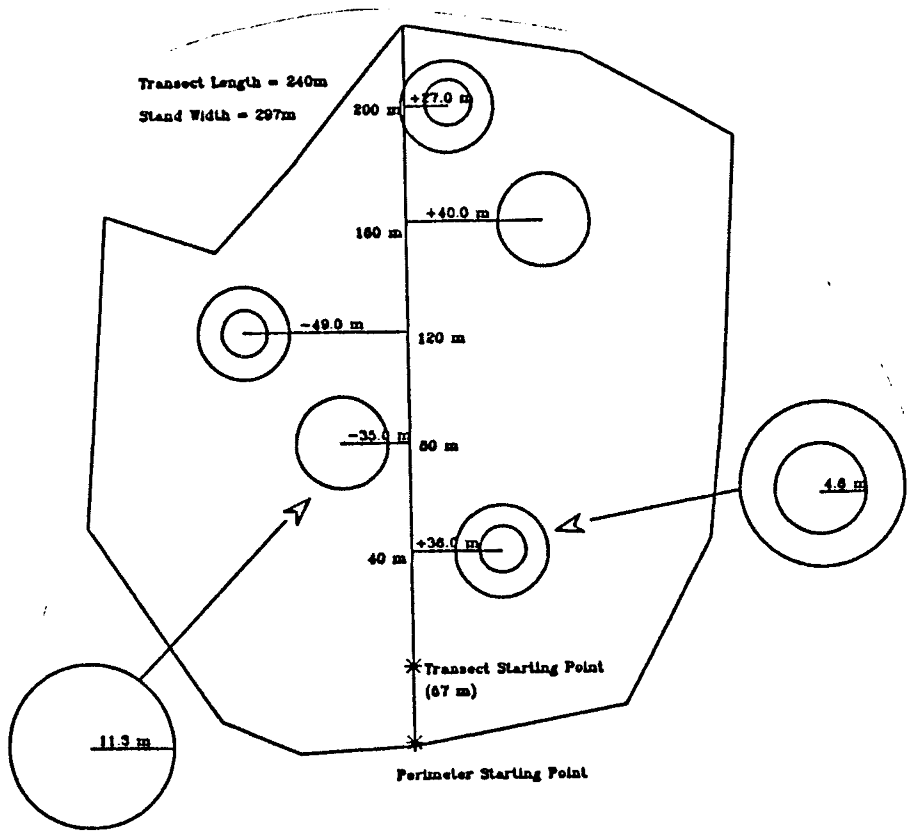

Figure 4. Example of the plot sampling design.

Physiographic data was taken at plot center of each 0.04 ha plot (elevation, slope, aspect, and habitat type (Pfister et al. 1977).)

Trees, snags, and downed logs were considered primary stand components. Trees (>20 cm dbh), snags ($\geq$ 10 cm dbh), and downed logs (>10 cm bottom diameter) were measured and characterized on the 0.04 ha plot. Species (if possible), height and dbh were recorded for trees and snags. Heights were estimated after a few heights were measured at each plot. I recorded percent canopy cover and descriptions of snags and logs such as snag condition (after Cline et al. 1980, see Appendix B), and log condition (after Thomas et al. 1979, see Appendix C). The two largest (>20 cm dbh) Douglas-fir trees in each of the 0.04 ha plots were cored and aged. If two large Douglas-fir trees were not located in the plot, large trees (>20 cm dbh) closest to the plot were used. Volume of downed logs (>10 cm bottom diameter) in the 0.04 ha plots was estimated by measuring log length and the log's top and bottom diameters. Volume was calculated with the frustrum of a cone formula (J. Brown pers. comm.).

Small trees, seedlings, shrubs, tree canopy, and ground cover types were considered secondary old-growth components. Trees (0-20 cm dbh), seedlings (>50 cm tall), and shrubs (>50 cm tall) were tallied by species on the 0.007 ha plots.

Tree canopy, seedling, shrub, and ground cover were calculated, on the first, third, and fifth 0.04 ha plots, using a method developed by Hejl (1989). Seven points, placed at 0.0, 3.9, 6.0, 7.5, 8.7, 9.8, and 10.8 m intervals, were located in each cardinal direction (N, E, S, and W) from plot center. The type of cover and species were noted after sighting upward and downward from each point. Percent cover was calculated by multiplying the number of points blanketed by each cover type by four. Ground cover types were litter, rock, soil, downed wood, grass, forb, water, and other.

T tests were used to test the hypothesis that mean values of the measured variables that were derived from the old-growth stands were equal to the mean values from the goshawk nest stands.

Mean values of overstory tree size, canopy closure, size of nest stand, and slope from each study stand were applied to the nesting/cover portion of the goshawk habitat model. Subsequently a single index value was generated for each stand. Index values were calculated as follows:

nesting/cover value = [(2 * V(cc)) + V(dbh) + V(acres) + V(slope)] / 5

where V(cc) = percent canopy closure
V(dbh) = diameter of overstory trees
V(acres) = nest stand acres
V(slope) = average slope of stand

V(cc): canopy closure

% Closure:	0 - 39	40 - 70	> 70
Value:	0.0	0.4	1.0

V(dbh): overstory tree size

Average DBH:	5 - 9	10 - 14	15 - 20	> 20
Value:	0.0	0.4	0.8	1.0

V(acres): size of nest stand

Acres	21 - 50	51 - 100	101 - 150	151 - 200	201 - 250	> 250
Value:	0.1	0.3	0.6	0.8	0.9	1.0

V(slope): average slope within nest stand

Percent Slope:	< 20	21 - 30	31 - 40	41 - 50	51 - 60	> 60
Value:	1.0	0.9	0.7	0.5	0.1	0.0

Possible index values range between 0.0 and 1.0 where 1.0 theoretically represents optimum goshawk nest habitat.

A t test was used to test the hypothesis that mean index values for the two stand types were equal.

RESULTS

Comparison of Old-Growth Stands and Goshawk Nest Stands

Physiographic Data

Twenty-one previously verified old-growth Douglas-fir stands and twelve Douglas-fir goshawk nest stands encompassed essentially the same range of elevations; elevations of old-growth stands averaged 1,991 m and nest stands 1,810 m. Stand slopes averaged 32% for old growth and 28% for goshawk nest stands. Recorded habitat types for both stand types varied widely, covering the range within the Psuedotsuga menzeisii series found in central Montana but included other climax series habitat types as well. Stand orientations presented a marked contrast between old-growth Douglas-fir and Douglas-fir goshawk nest stands. All sample nest stands were on northerly aspects, whereas old growth stands were equally distributed among the primary compass directions. Appendix E presents summary data, using mean values, from each old-growth stand and goshawk nest stand.

Primary Stand Components

Live trees. A total of 1,395 live trees (>20 cm dbh) were sampled on the old-growth study sites and 1,121 live trees were sampled on goshawk nest sites. Eighty-seven percent of the measured trees were Douglas-fir on the old-growth stands and 82% were Douglas-fir on the nest stands. Of the measured live trees, 28% were ≥ 43 cm dbh on the old-growth stands, whereas only 10% were ≥ 43 cm dbh on the goshawk nest stands (Figure 5).

Mean live tree dbh was 36 cm for old-growth stands and 31 cm dbh for nest stands (Table 5). The t-test determined that these mean live tree dbhs were significantly different at the 1% level. Mean live tree ages were also calculated for each study stand. Using mean values from each stand, overall mean live tree age was calculated at 268 years for old-growth stands and 203 years for goshawk nest stands (Table 5). Mean live tree ages were significantly different at the 1% significance level. Overall live tree density was 130 per 0.4 ha for old growth and 190 per 0.4 ha for goshawk nest stands (Table 5). Difference in tree density between stand types was statistically significant at the 1% level

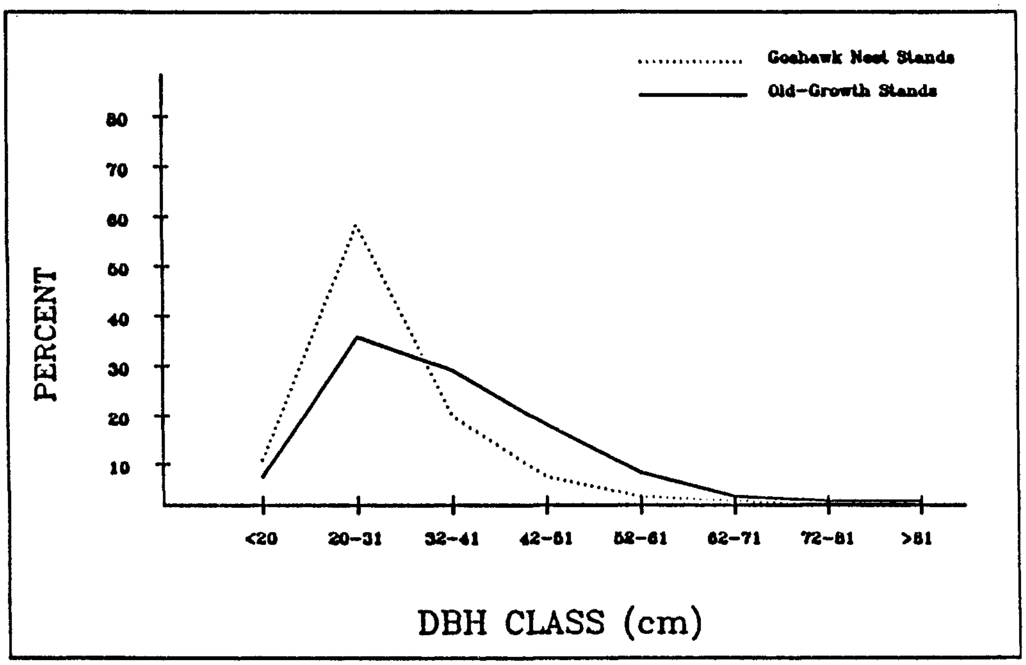

Figure 5. Diameter (dbh) distribution (% frequency by stand) of live trees.

Table 5. Comparison of primary and secondary components of old-growth stands and goshawk nest stands.

	N	95% Confidence Intervals: Old Growth	Nest Stand	N	p-values
Live trees					
dbh	21	36.0 ± 1.5	31.0 ± 0.5	12	0.000
age	21	268.0 ± 36.3	203.0 ± 16.0	12	0.010
no./0.4 ha[a]	21	130.0 ± 13.5	190.0 ± 10.0	12	0.001
Snags					
dbh	21	28.0 ± 3.6	18.0 ± 0.8	12	0.000
no./0.4 ha	21	45.0 ± 10.0	65.0 ± 5.0	12	0.003
Downed logs					
no./0.4 ha	21	195.0 ± 44.0	250.0 ± 20.0	12	0.066
vol/log	21	0.8 ± 0.15	0.4 ± 0.03	12	0.000
vol/0.4 ha	21	100.0 ± 28.0	65.0 ± 21.0	12	0.038
Trees					
canopy cover	21	55.0 ± 4.8	72.0 ± 3.0	12	0.000
Shrubs					
% cover	21	16.0 ± 5.4	21.0 ± 5.0	12	0.333
no./0.4 ha	21	715.0 ± 427.6	1,361.0 ± 330.0	12	0.154
Small trees					
no./0.4 ha	21	206.0 ± 174.6	96.0 ± 27.5	12	0.207
Seedlings					
no./0.4 ha	21	413.0 + 244.8	165.0 + 68.8	12	0.087

[a] All densities were in numbers per 0.4 hectare (1.0 acre).

Snags. A total of 481 coniferous snags (≥10 cm dbh) were sampled on the old-growth study sites and 392 on the goshawk nest sites. Of the measured snags, 48% were ≥ 23 cm dbh on the old growth sites while only 17% were ≥ 23 cm dbh on the goshawk nest sites (Figure 6).

Mean snag dbh was 28 cm on old-growth sites and 18 cm dbh on nest sites (Table 5). Difference in snag dbh between the two stand types was statistically significant at the 1% level. Using mean values by stand, old-growth forest stands averaged 40 snags per 0.4 ha and goshawk nest stands averaged 65 snags per 0.4 ha (Table 5). These values differed significantly at the 1% significance level.

Snag decomposition classes used were described by Cline et al. (1980) (Appendix B). Of snags recorded on each old-growth study site, an average 25% were assigned to decomposition class 1, 24% to class 2, 23% to class 3, 21% to class 4, and 7% to class 5. On each goshawk nest stands, an average of 37% of the recorded snags were assigned to decomposition class 1, 23% to class 2, 18% to class 3, 19% to class 4, and 2% to class 5. No distinct differences were seen in the distribution of the snags, from the two stand types, in the decomposition classes.

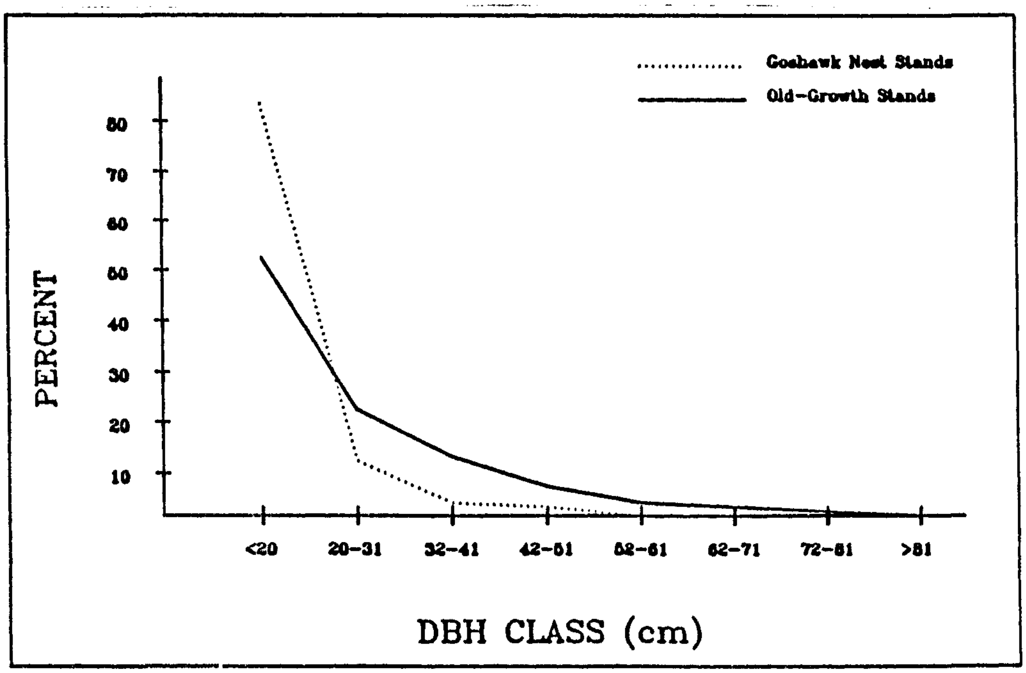

Figure 6. Diameter (dbh) distribution (% frequency by stand) of snags.

Downed logs. A total of 2,167 downed logs were measured on the old-growth study stands and 1,490 on the goshawk nest stands. Of the measured logs, 45% were $\geq$ 23 cm bottom diameter on the old-growth sites while only 25% were $\geq$ 23 cm bottom diameter on the goshawk nest sites (Figure 7).

Downed log density averaged 195 per 0.4 ha on old-growth stands and 250 per 0.4 ha on goshawk nest stands (Table 5). Differences between these mean log density values were nearly significant at the 5% level. Mean volume per downed log was 0.8 m^3 per log on old-growth sites and 0.4 m^3 per log on nest sites (Table 5). Difference in volume per log between the stand types was significant at the 1% significance level. Total log volume averaged 100.0 m^3 per 0.4 ha on the old-growth stands and 65.0 m^3 per 0.4 ha on the goshawk nest stands (Table 5). The difference was significant at the 5% level.

Downed log decomposition classes used were described by Thomas et al. (1979) (See Appendix C). Of downed logs measured on each old-growth site, an average 3% were assigned to class 1, 13% to class 2, 40% to class 3, 25% to class 4, and 17% to class 5. On each goshawk nest stand, an average of 3% of the recorded downed logs were assigned to class 1, 13% to class 2, 46% to class 3, 25% to class 4, and 13% to class 5. No significant difference was seen in the distribution of logs, from the two stand types, in the downed log decomposition classes.

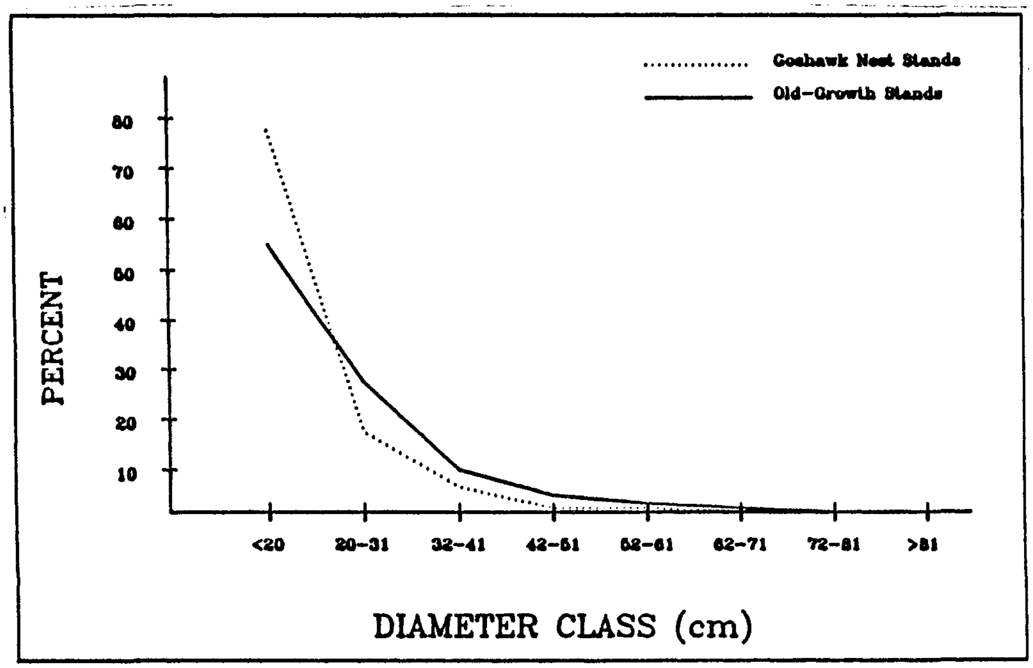

Figure 7. Bottom diameter distribution (% frequency by stand) of downed logs.

Secondary Stand Components

Percent canopy cover had a mean value of 55% for old-growth sites and 72% for nest sites (Table 5). This difference was significant at the 1% significance level. Neither shrub cover, shrub density, small tree density, or seedling density differed between the two types of stands (Table 5).

A total 1,532 ground cover recordings were taken on the old-growth study sites and 735 recordings were taken on the goshawk nest sites. Of these recordings, 502 (34%) were recorded as litter, 436 (29%) as forb, 233 (15%) as downed wood, 216 (14%) as grass, 110 (7%) as other (moss, lichen, and seedlings), 27 (2%) as rock, and 8 (1%) as soil on the old growth sites. On the goshawk nest stands, 342 (47%) recordings were litter, 154 (21%) forb, 135 (18%) downed wood, 49 (7%) grass, 46 (6%) other (moss, lichen, and seedlings), 6 (1%) rock, and 3 (0.04%) soil. No significant difference was seen between the these distributions.

Application of the Goshawk Habitat Model

Index values for old-growth study stands ranged from 0.26 to 0.76, with a mean value of 0.46. Index values for goshawk nest stands ranged from 0.38 to 0.70, with 0.58 as the mean value. Mean index values for the two stand types differed significantly ($p = 0.009$) (Table 6). This difference suggested that the goshawk habitat model was successful in rating the nest stands higher than the old-growth stands.

Table 6. Mean index values, using the goshawk habitat model, generated from old-growth stands and goshawk nest stands.

Stand Type	N	$\bar{X}$	95% CI	p-value
Old Growth	21	0.47	0.47 $\pm$ 0.05	0.009
Nest Stands	12	0.58	0.58 $\pm$ 0.07	

However, a critical problem with the model was that many stands within each type produced the same index value even though the forest stands were notably structurally different. For example, old-growth stands BRPK, INBB, SDPT, and TRCB produced the same 0.44 index value Table 7). Stands from each group had replicated index values (Table 7).

Table 7. Index values, using the goshawk habitat model, for the old-growth stands and goshawk nest stands.

STD ID	%CC	Tree dbh[a]	acres	slope[b]	Index Value
Old Growth					
BRPK	47	13	25	23	0.44
CEMN	77	13	22	7	0.70
CYMN	43	14	42	40	0.40
GNMN	55	16	26	30	0.52
INBA	64	15	58	13	0.58
INBB	48	13	32	21	0.44
KSGH	52	13	7	22	0.42
KYCK	63	14	42	35	0.40
LGCK	65	13	234	50	0.52
LYBY	55	16	26	27	0.52
MRGA	41	13	11	28	0.42
MRGC	43	13	27	37	0.40
MTPA	43	16	52	40	0.52
NLCK	60	13	11	41	0.32
RKRE	49	15	47	22	0.52
SDHE	45	14	6	53	0.26
SDPT	56	15	35	26	0.44
TRCA	49	16	21	41	0.44
TRCB	55	16	24	65	0.34
WLCA	61	14	68	41	0.40
WLCB	73	15	30	28	0.76
Nest Stands					
BNFT	84	11	28	19	0.70
CNCK	76	12	16	31	0.62
DYGH	71	10	13	45	0.58
ETRK	64	13	3	13	0.44
FGSF	72	10	66	48	0.64
LECK	53	14	6	37	0.38
NLCA	69	12	45	9	0.46
NLCB	73	12	13	18	0.68
PEGH	79	11	34	27	0.68
TDGH	81	13	7	25	0.66
WBCK	68	14	36	26	0.44
WLCK	77	12	7	24	0.66

[a] Tree dbh was expressed in inches.
[b] Slope was expressed in percent.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Addressing the applicability of the goshawk habitat model to the LCNF is difficult. Obviously more field testing is necessary in order to refine the model so that it includes the most meaningful variables and assigns accurate, interpretable index values. Researchers should apply the model to established goshawk nest stands to aid in refining the model and to create a ranking system where certain ranges of index values receive, for example, poor, moderate, or good rankings. As it stands, there is no way to differentiate between potentially good and poor goshawk nest stands. Also the model must be adjusted for geographic areas in order to compensate for the notable differences between "eastside" and "westside" forests. If wildlife managers desire to manage habitat for the northern goshawk, they must identify the hawk's needs and requirements, and prescribe management techniques accordingly.

On the other hand, the data provided strong evidence that old-growth Douglas-fir stands and Douglas-fir goshawk nest stands were structurally different. First, stand orientation showed a marked contrast between the two forest stand types. Goshawk nest stands were all located on north aspects whereas old-growth stands were found on all aspects. If land managers were only to manage north facing stands for the goshawk, as the data and MIS concept suggest, plant and animal species that occupy stands on other aspects may be neglected or mismanaged. Obviously old-growth stands are located on all aspects and should be managed accordingly.

Another notable difference concerned live trees. Old-growth forest stands supported older, larger dbh live trees with open canopies while goshawk nest stands had younger, smaller dbh live trees with dense canopies.

Snag characteristics were also dissimilar between the two stand types. Old-growth stands supported fewer and larger snags while nest stands had smaller dbh snags but more snags per hectare. Past research reinforces the fact that large snags can potentially provide for a wider variety of animal species, especially birds (Thomas et al. 1979, Bull 1987). Sole management of goshawk habitat may have diminishing effects on animal species dependant on snags.

Data related to downed logs also supported evidence of differences between old-growth stands and gohawk nest stands. Old-growth stands contained larger logs and more total downed log volume per hectare. Nest stands had smaller logs and more logs per hectare. Like larger snags, larger downed logs may potentially support a greater diversity of plant and animal species (Franklin et al. 1981).

In short, old-growth Douglas-fir stands are significantly different than Douglas-fir goshawk nest stands when comparing characteristics normally associated with old-growth stands as well as other characteristics. This information should be recognized and contemplated when devising management plans based on MISs for special interest ecosystems such as old-growth forests which are being depleted on a daily basis.

Clearly the northern goshawk is not a good choice as a management indicator species for old-growth Douglas-fir forests on the Lewis and

Clark National Forest. Since Douglas-fir forests represent a substantial amount of the LCNF's timber base, another old-growth MIS could be implemented or other old-growth manangement techniques could be employed. In any case, as Landres et al. (1988) stated, if use of MIS is unavoidable, it must be backed by extensive research.

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APPENDIX A

PLANT SCIENTIFIC NAMES (Hitchcock and Cronquist 1973)

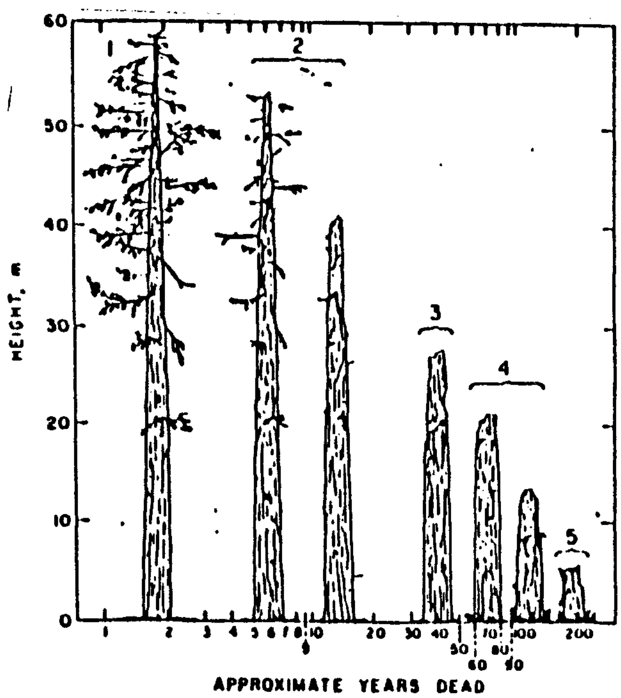
Common Name	Scientific Name
Tree Species	
Douglas-fir	Pseudotsuga menziesii
lodgepole pine	Pinus contorta
Engelmann spruce	Picea engelmannii
subalpine fir	Abies lasiocarpa
ponderosa pine	Pinus ponderosa
limber pine	Pinus flexilis
western redcedar	Thuja plicata
Rocky mountain maple	Acer glabrum
Shrub Species	
common snowberry	Symphoricarpos albus
common juniper	Juniperus communis
mountain gooseberry	Ribes montigenum
white spiraea	Spiraea betuliolia
buffaloberry	Shepherdia canadensis
Wood's rose	Rosa woodsii var. woodsii
blue huckleberry	Vaccinium globulare
mountain snowberry	Symphoricarpos oreophilis
chokecherry	Prunus virginiana
ninebark	Physocarpus malvaceus
elderberry	Sambucus racemosa
Other Recorded Species	
Oregon grape	Berberis repens
kinnikinnick	Arctostaphylos uva-ursi
red raspberry	Rubus idaeus
twinflower	Linnaea borealis
dogwood	Cornus (spp.)

APPENDIX B

Snag Condition: Physical characteristics and stages of deterioration (Cline et al. 1980).

Snag characteristic	Stage of deterioration 1	2	3	4	5[a]
Limbs and branches	All present	Few limbs, no fine branches	Limb stubs only	Few or no stubs	None
Top	Pointed	Broken			
Diameter, broken top	..... Increasing at decreasing rate				
Height	..... Decreasing at decreasing rate				
Bark remaining %	100	..... Variable			>20
Sapwood presence	Intact	..... Sloughing			Gone
Sapwood condition	Sound, incipient decay, hard, original color	Advanced decay, fibrous, firm to soft, light brown	Fibrous, soft, light to reddish brown	Cubical, soft, reddish to dark brown	
Heartwood condition	Sound, hard, original color	Sound at base, incipient decay in outer edge of upper bole, hard, light to reddish brown	Incipient decay at base, advanced decay throughout upper bole, fibrous, hard to firm, reddish brown	Advanced decay at base, sloughing from upper bole, fibrous to cubical, soft, dark reddish brown	Sloughing, cubical, soft, dark brown, OR fibrous, very soft, dark reddish brown, encased in hardened shell
Estimated age at which snags reach a deterioration stage:					
9–18 cm dbh[b]	0–4	5–8	9–16	>17	Fallen
19–47 cm dbh[c]	0–5	6–13	14–29	30–60	>60
47 cm dbh[d]	0–6	7–18	19–50	51–125	>125

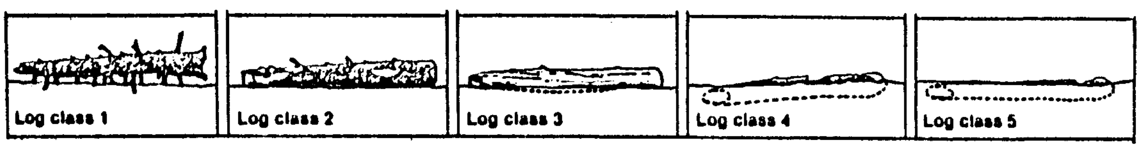
[a] Mostly remnant snags.
[b] Characteristic in Douglas-fir forests <80 years old; mean dbh 11.5 ± 3 (SE) cm.
[c] Characteristic in Douglas-fir forests 80–200 years old; mean dbh 32.0 ± 7 cm.
[d] Characteristic in Douglas-fir forests >200 years old; mean dbh 67.0 ± 41 cm.



APPENDIX C

Log Condition: Physical characteristics and stages of deterioration (Thomas et al. 1979).

Log characteristics	Log decomposition class				
	1	2	3	4	5
Bark	intact	intact	trace	absent	absent
Twigs<3 cm (1.18 in)	present	absent	absent	absent	absent
Texture	intact	intact to partly soft	hard, large pieces	small, soft, blocky pieces	soft and powdery
Shape	round	round	round	round to oval	oval
Color of wood	original color	original color	original color to faded	light brown to faded brown or yellowish	faded to light yellow or gray
Portion of log on ground	log elevated on support points	log elevated on support points but sagging slightly	log is sagging near ground	all of log on ground	all of log on ground



APPENDIX D

Primary and secondary old-growth stand components from three old-growth stands not included in analysis.

	N	$\bar{X}$	95% CI	Range
Live trees				
dbh	3	38.0	38.0 ± 1.5	8.0-24.0
height	3	17.0	17.0 ± 0.6	8.0-26.0
age	3	178.0	178.0 ± 23.3	84.0-254.0
no./0.4 ha	3	105.0	105.0 ± 26.5	30.0-220.0
Snags				
dbh	3	20.0	20.0 ± 2.0	10.0-43.0
height	3	10.0	10.0 ± 0.6	2.0-21.0
no./0.4 ha	3	45.0	45.0 ± 29.0	0.0-180.0
Downed logs				
no./0.4 ha	3	50.0	50.0 ± 26.0	10.0-180.0
vol/log	3	0.7	0.7 ± 0.2	0.06-7.0
vol/0.4 ha	3	24.0	24.0 ± 19.0	1.0-120.0
Trees				
canopy cover	3	60.0	60.0 ± 28.3	47.0-69.0
Shrubs				
cover	3	11.0	11.0 ± 31.0	1.0-25.0
no./0.4 ha	3	316.0	316.0 ± 483.0	110.0-495.0
Small trees				
no./0.4 ha	3	110.0	110.0 ± 109.0	55.0-138.0
Seedlings				
no./0.4 ha	3	330.0	330.0 + 630.0	110.0-605.0

[a] All diameters were measured in centimeters.
[b] All heights were measured in meters.
[c] Age was in years.
[d] All densities were in numbers per 0.4 ha (1.0 acre).
[e] Covers were expressed in percentages.
[f] Volume was expressed in square meters per 0.4 ha.

APPENDIX E

Summary data from each old-growth stand and goshawk nest stand.

Old-Growth Stands:

STAND ID	LOCATION	LEGAL LOCATION
BRPK	BEAR PARK	T11N, R10E, SEC 34, SW 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,985 M	23%	10	NW	PSME/ARUV

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
14 M	33 CM	394	47%	115/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
6 M	23 CM	60/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.7	245/0.4 HA	92

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
358/0.4 HA	17%	206/0.4 HA	4,180/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
CEMN	CASTLE MOUNTAIN	T9N, R9E, SEC 19, SE 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
2,024 M	7%	9	W	PSME/CARU

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
13 M	33 CM	236	77%	190/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
6 M	31 CM	30/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.8	145/0.4 HA	64

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
138/0.4 HA	1%	28/0.4 HA	151/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
CYMN	CRAZY MOUNTAIN	T6N, R10E, SEC 2, SW 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,936 M	39%	17	NW	PSME/SYAL

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
13 M	36 CM	235	43%	140/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
7 M	31 CM	50/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.9	300/0.4 HA	151

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
4,125/0.4 HA	23%	96/0.4 HA	69/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION		
GNMN	GREEN MOUNTAIN	T12N, R7E, SEC 36, SE 1/4		
ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
2,083 M	30%	11	W	PSME/SYAL
TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
14 M	41 CM	357	55%	140/0.4 HA
SNAG HGT	SNAG DBH	SNAG DENSITY		
6 M	31 CM	35/0.4 HA		
VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)		
1.2	215/0.4 HA	141		
SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY	
1,238/0.4 HA	33%	275/0.4 HA	825/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
INBA	IRON BUTTE	T11N, R6E, SEC 3, NE 1/4		
ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,913 M	13%	24	N	PSME/SYAL
TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
23 M	38 CM	184	64%	110/0.4 HA
SNAG HGT	SNAG DBH	SNAG DENSITY		
8 M	43 CM	20/0.4 HA		
VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)		
1.2	115/0.4 HA	81		
SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY	
179/0.4 HA	7%	110/0.4 HA	96/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
INBB	IRON BUTTE	T11N, R6E, SEC 3, NW 1/4		
ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,906 M	21%	13	NW	PSME/CARU
TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
20 M	33 CM	223	48%	95/0.4 HA
SNAG HGT	SNAG DBH	SNAG DENSITY		
10 M	25 CM	35/0.4 HA		
VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)		
1.1	105/0.4 HA	62		
SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY	
1,293/0.4 HA	9%	0.0/0.4 HA	41/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
KSGH	KENT'S GULCH	T10N, R10E, SEC 11, NW 1/4		
ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,740 M	22%	3	SE	PSME/SYAL
TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
14 M	33 CM	221	52%	165/0.4 HA
SNAG HGT	SNAG DBH	SNAG DENSITY		
9 M	18 CM	70/0.4 HA		
VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)		
0.6	385/0.4 HA	133		
SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY	
234/0.4 HA	37%	0.0/0.4 HA	275/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
KYCK	KINNEY CREEK	T12N, R7E, SEC 18, SE 1/4		
ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,896 M	35%	17	SW	PSME/CARU
TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
22 M	36 CM	182	63%	90/0.4 HA
SNAG HGT	SNAG DBH	SNAG DENSITY		
8 M	31 CM	15/0.4 HA		
VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)		
0.9	80/0.4 HA	38		
SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY	
193/0.4 HA	1%	69/0.4 HA	124/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
LGCK	LOGGING CREEK	T16N, R5E, SEC 36, SW 1/4		
ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,739 M	50%	95	NW	ABLA/LIBO
TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
18 M	33 CM	215	65%	170/0.4 HA
SNAG HGT	SNAG DBH	SNAG DENSITY		
9 M	20 CM	35/0.4 HA		
VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)		
0.3	100/0.4 HA	19		
SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY	
894/0.4 HA	16%	15/0.4 HA	440/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
LYBY	LUCKY BOY	T10N, R11E, SEC 7, NE 1/4		
ELEVATION	**SLOPE**	**HECTARES**	**ASPECT**	**HABITAT TYPE**
2,064 M	28%	11	W	PSME/LIBO
TREE HGT	**TREE DBH**	**TREE AGE**	**%CANOPY COVER**	**TREE DENSITY**
15 M	41 CM	385	55%	160/0.4 HA
SNAG HGT	**SNAG DBH**	**SNAG DENSITY**		
8 M	33 CM	45/0.4 HA		
VOL/LOG (M^3)	**LOG DENSITY**	**TOTAL LOG VOL/0.4 HA (M^3)**		
1.1	270/0.4 HA	159		
SHRUB DENSITY	**%SHRUB COVER**	**SMALL TREE DENSITY**	**SEEDLING DENSITY**	
69/0.4 HA	17%	1,788/0.4 HA	894/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
MRGA	MILLER GULCH	T11N, R7E, SEC 8, SW 1/4		
ELEVATION	**SLOPE**	**HECTARES**	**ASPECT**	**HABITAT TYPE**
1,843 M	29%	5	N	PSME/LIBO
TREE HGT	**TREE DBH**	**TREE AGE**	**%CANOPY COVER**	**TREE DENSITY**
17 M	33 CM	191	41%	135/0.4 HA
SNAG HGT	**SNAG DBH**	**SNAG DENSITY**		
11 M	20 CM	45/0.4 HA		
VOL/LOG (M^3)	**LOG DENSITY**	**TOTAL LOG VOL/0.4 HA (M^3)**		
0.7	195/0.4 HA	73		
SHRUB DENSITY	**%SHRUB COVER**	**SMALL TREE DENSITY**	**SEEDLING DENSITY**	
1,746/0.4 HA	51%	69/0.4 HA	399/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
MRGC	MILLER GULCH	T11N, R7E, SEC 19, SE 1/4		
ELEVATION	**SLOPE**	**HECTARES**	**ASPECT**	**HABITAT TYPE**
1,773 M	36%	11	E	PSME/SYAL
TREE HGT	**TREE DBH**	**TREE AGE**	**%CANOPY COVER**	**TREE DENSITY**
19 M	33 CM	197	43%	85/0.4 HA
SNAG HGT	**SNAG DBH**	**SNAG DENSITY**		
9 M	23 CM	15/0.4 HA		
VOL/LOG (M^3)	**LOG DENSITY**	**TOTAL LOG VOL/0.4 HA (M^3)**		
0.9	85/0.4 HA	42		
SHRUB DENSITY	**%SHRUB COVER**	**SMALL TREE DENSITY**	**SEEDLING DENSITY**	
894/0.4 HA	31%	138/0.4 HA	69/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
MTPA	MONUMENT PEAK	T14N, R5E, SEC 2, NW 1/4		
ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
2,067 M	37%	21	NW	ABLA/LIBO
TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
15 M	41 CM	300	43%	115/0.4 HA
SNAG HGT	SNAG DBH	SNAG DENSITY		
9 M	23 CM	105/0.4 HA		
VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)		
0.6	225/0.4 HA	80		
SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY	
151/0.4 HA	3%	563/0.4 HA	2,214/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
NLCK	NEIL CREEK	T12N, R17E, SEC 27, SE 1/4		
ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
2,164 M	42%	5	S	ABLA/CACA
TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
12 M	33 CM	338	60%	205/0.4 HA
SNAG HGT	SNAG DBH	SNAG DENSITY		
6 M	23 CM	90/0.4 HA		
VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)		
0.9	275/0.4 HA	137		
SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY	
110/0.4 HA	16%	69/0.4 HA	41/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
RKRE	RIMROCK RIDGE	T13N, R5E, SEC 8, NW 1/4		
ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
2,039 M	22%	19	N	PSME/SYAL
TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
20 M	38 CM	260	49%	115/0.4 HA
SNAG HGT	SNAG DBH	SNAG DENSITY		
6 M	25 CM	75/0.4 HA		
VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)		
0.8	320/0.4 HA	152		
SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY	
1,361/0.4 HA	20%	41/0.4 HA	83/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
SDHE	STUD HORSE	T11N, R7E, SEC 14, SE 1/4		
ELEVATION	**SLOPE**	**HECTARES**	**ASPECT**	**HABITAT TYPE**
1,900 M	53%	3	SW	PSME/SYAL
TREE HGT	**TREE DBH**	**TREE AGE**	**%CANOPY COVER**	**TREE DENSITY**
14 M	36 CM	263	45%	115/0.4 HA
SNAG HGT	**SNAG DBH**	**SNAG DENSITY**		
8 M	23 CM	25/0.4 HA		
VOL/LOG (M^3)	**LOG DENSITY**	**TOTAL LOG VOL/0.4 HA (M^3)**		
0.7	140/0.4 HA	55		
SHRUB DENSITY	**%SHRUB COVER**	**SMALL TREE DENSITY**	**SEEDLING DENSITY**	
1,114/0.4 HA	21%	14/0.4 HA	69/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
SDPT	SAND POINT	T12N, R10E, SEC 23, SW 1/4		
ELEVATION	**SLOPE**	**HECTARES**	**ASPECT**	**HABITAT TYPE**
1,906 M	26%	14	NE	PIEN/LIBO
TREE HGT	**TREE DBH**	**TREE AGE**	**%CANOPY COVER**	**TREE DENSITY**
22 M	38 CM	354	56%	130/0.4 HA
SNAG HGT	**SNAG DBH**	**SNAG DENSITY**		
11 M	20 CM	35/0.4 HA		
VOL/LOG (M^3)	**LOG DENSITY**	**TOTAL LOG VOL/0.4 HA (M^3)**		
0.9	345/0.4 HA	183		
SHRUB DENSITY	**%SHRUB COVER**	**SMALL TREE DENSITY**	**SEEDLING DENSITY**	
275/0.4 HA	13%	124/0.4 HA	1,031/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
TRCA	TIMBER CREEK	T12N, R18E, SEC 33, NW 1/4		
ELEVATION	**SLOPE**	**HECTARES**	**ASPECT**	**HABITAT TYPE**
2,253 M	40%	9	S	ABLA/CACA
TREE HGT	**TREE DBH**	**TREE AGE**	**%CANOPY COVER**	**TREE DENSITY**
12 M	41 CM	394	49%	150/0.4 HA
SNAG HGT	**SNAG DBH**	**SNAG DENSITY**		
6 M	48 CM	40/0.4 HA		
VOL/LOG (M^3)	**LOG DENSITY**	**TOTAL LOG VOL/0.4 HA (M^3)**		
1.6	255/0.4 HA	236		
SHRUB DENSITY	**%SHRUB COVER**	**SMALL TREE DENSITY**	**SEEDLING DENSITY**	
193/0.4 HA	8%	220/0.4 HA	110/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION
TRCB	TIMBER CREEK	T12N, R18E, SEC 32, NW 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
2,237 M	65%	10	E	ABLA/GATR

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
13 M	41 CM	406	55%	95/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
6 M	38 CM	35/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
1.4	105/0.4 HA	87

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
193/0.4 HA	8%	69/0.4 HA	96/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
WLCA	WHITETAIL CREEK	T11N, R10E, SEC 30, SW 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
2,152 M	40%	12	SE	PSME/CARU

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
19 M	36 CM	201	61%	170/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
8 M	25 CM	65/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
1.2	205/0.4 HA	141

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
96/0.4 HA	11%	151/0.4 HA	0.0/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
WLCB	WHITETAIL CREEK	T11N, R10E, SEC 19, NE 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
2,171 M	28%	28	NE	ABLA/VASC

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
23 M	38 CM	228	73%	140/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
13 M	25 CM	50/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.9	245/0.4 HA	117

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
41/0.4 HA	7%	179/0.4 HA	550/0.4 HA

Goshawk Nest Stands:

STAND ID	LOCATION	LEGAL LOCATION		
BNFT	BELDON FLAT	T12N, R11E, SEC 1, NW 1/4		
ELEVATION	**SLOPE**	**HECTARES**	**ASPECT**	**HABITAT TYPE**
1,644 M	19%	11	NW	PSME/SYAL
TREE HGT	**TREE DBH**	**TREE AGE**	**%CANOPY COVER**	**TREE DENSITY**
12 M	28 CM	220	84%	250/0.4 HA
SNAG HGT	**SNAG DBH**	**SNAG DENSITY**		
7 M	18 CM	85/0.4 HA		
VOL/LOG (M^3)	**LOG DENSITY**	**TOTAL LOG VOL/0.4 HA (M^3)**		
0.3	210/0.4 HA	33		
SHRUB DENSITY	**%SHRUB COVER**	**SMALL TREE DENSITY**	**SEEDLING DENSITY**	
83/0.4 HA	1%	165/0.4 HA	0.0/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
CNCK	CABIN CREEK	T13N, R6E, SEC 28, NE 1/4		
ELEVATION	**SLOPE**	**HECTARES**	**ASPECT**	**HABITAT TYPE**
1,879 M	31%	7	NW	PSME/LIBO
TREE HGT	**TREE DBH**	**TREE AGE**	**%CANOPY COVER**	**TREE DENSITY**
10 M	31 CM	216	76%	170/0.4 HA
SNAG HGT	**SNAG DBH**	**SNAG DENSITY**		
10 M	23 CM	48/0.4 HA		
VOL/LOG (M^3)	**LOG DENSITY**	**TOTAL LOG VOL/0.4 HA (M^3)**		
0.8	195/0.4 HA	83		
SHRUB DENSITY	**%SHRUB COVER**	**SMALL TREE DENSITY**	**SEEDLING DENSITY**	
4,235/0.4 HA	41%	179/0.4 HA	316/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION		
DYGH	DRY GULCH	T10N, R15E, SEC 34, SE 1/4		
ELEVATION	**SLOPE**	**HECTARES**	**ASPECT**	**HABITAT TYPE**
1,705 M	47%	5	N	PIEN/PHMA
TREE HGT	**TREE DBH**	**TREE AGE**	**%CANOPY COVER**	**TREE DENSITY**
11 M	25 CM	270	71%	185/0.4 HA
SNAG HGT	**SNAG DBH**	**SNAG DENSITY**		
6 M	15 CM	65/0.4 HA		
VOL/LOG (M^3)	**LOG DENSITY**	**TOTAL LOG VOL/0.4 HA (M^3)**		
0.3	320/0.4 HA	48		
SHRUB DENSITY	**%SHRUB COVER**	**SMALL TREE DENSITY**	**SEEDLING DENSITY**	
756/0.4 HA	17%	14/0.4 HA	674/0.4 HA	

STAND ID	LOCATION	LEGAL LOCATION
ETRK	ELEPHANT ROCK	T10N, R10E, SEC 8, SE 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,808 M	13%	1	N	PSME/SYAL

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
15 M	33 CM	220	64%	190/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
7 M	18 CM	60/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.6	215/0.4 HA	68

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
2,048/0.4 HA	44%	14/0.4 HA	28/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
FGSF	FLAGSTAFF	T9N, R10E, SEC 7, NE 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,653 M	51%	27	N	PSME/SYAL

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
10 M	25 CM	190	72%	180/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
6 M	15 CM	70/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.3	295/0.4 HA	46

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
440/0.4 HA	12%	96/0.4 HA	14/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
LECK	LAKE CREEK	T11N, R7E, SEC 25, NE 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,870 M	37%	2	NE	PSME/LIBO

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
15 M	36 CM	217	53%	125/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
10 M	20 CM	35/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.6	245/0.4 HA	81

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
1,608/0.4 HA	9%	14/0.4 HA	28/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
NLCA	NIEL CREEK	T12N, R17E, SEC 34, NW 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,815 M	9%	18	NW	PSME/SYAL

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
13 M	31 CM	130	69%	185/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
7 M	18 CM	65/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.4	130/0.4 HA	31

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
853/0.4 HA	33%	193/0.4 HA	770/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
NLCB	NIEL CREEK	T12N, R17E, SEC 35, SW 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,876 M	17%	5	NW	PSME/SYAL

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
14 M	31 CM	129	73%	245/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
8 M	15 CM	75/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.4	295/0.4 HA	71

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
275/0.4 HA	40%	28/0.4 HA	14/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
PEGH	PASTURE GULCH	T8N, R10E, SEC 3, NW 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,827 M	26%	14	N	PSME/LIBO

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
15 M	28 CM	294	79%	270/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
8 M	20 CM	75/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.6	260/0.4 HA	82

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
495/0.4 HA	4%	138/0.4 HA	0.0/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
TDGH	TOWNSEND GULCH	T8N, R10E, SEC 2, SE 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,825 M	24%	3	NE	PSME/SYAL

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
12 M	33 CM	238	81%	170/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
6 M	18 CM	80/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.3	230/0.4 HA	31

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
509/0.4 HA	8%	55/0.4 HA	41/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
WBCK	WEST COMB CREEK	T7N, R10E, SEC 29, NW 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,895 M	26%	15	N	PSME/SYAL

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
14 M	36 CM	127	68%	115/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
8 M	15 CM	95/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.4	395/0.4 HA	80

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
3,355/0.4 HA	25%	14/0.4 HA	28/0.4 HA

STAND ID	LOCATION	LEGAL LOCATION
WLCK	WHITETAIL CREEK	T11N, R10E, SEC 31, NE 1/4

ELEVATION	SLOPE	HECTARES	ASPECT	HABITAT TYPE
1,951 M	24%	3	NE	PSME/LIBO

TREE HGT	TREE DBH	TREE AGE	%CANOPY COVER	TREE DENSITY
14 M	31 CM	178	77%	190/0.4 HA

SNAG HGT	SNAG DBH	SNAG DENSITY
9 M	15 CM	50/0.4 HA

VOL/LOG (M^3)	LOG DENSITY	TOTAL LOG VOL/0.4 HA (M^3)
0.6	225/0.4 HA	72

SHRUB DENSITY	%SHRUB COVER	SMALL TREE DENSITY	SEEDLING DENSITY
1,636/0.4 HA	24%	192/0.4 HA	96/0.4 HA
