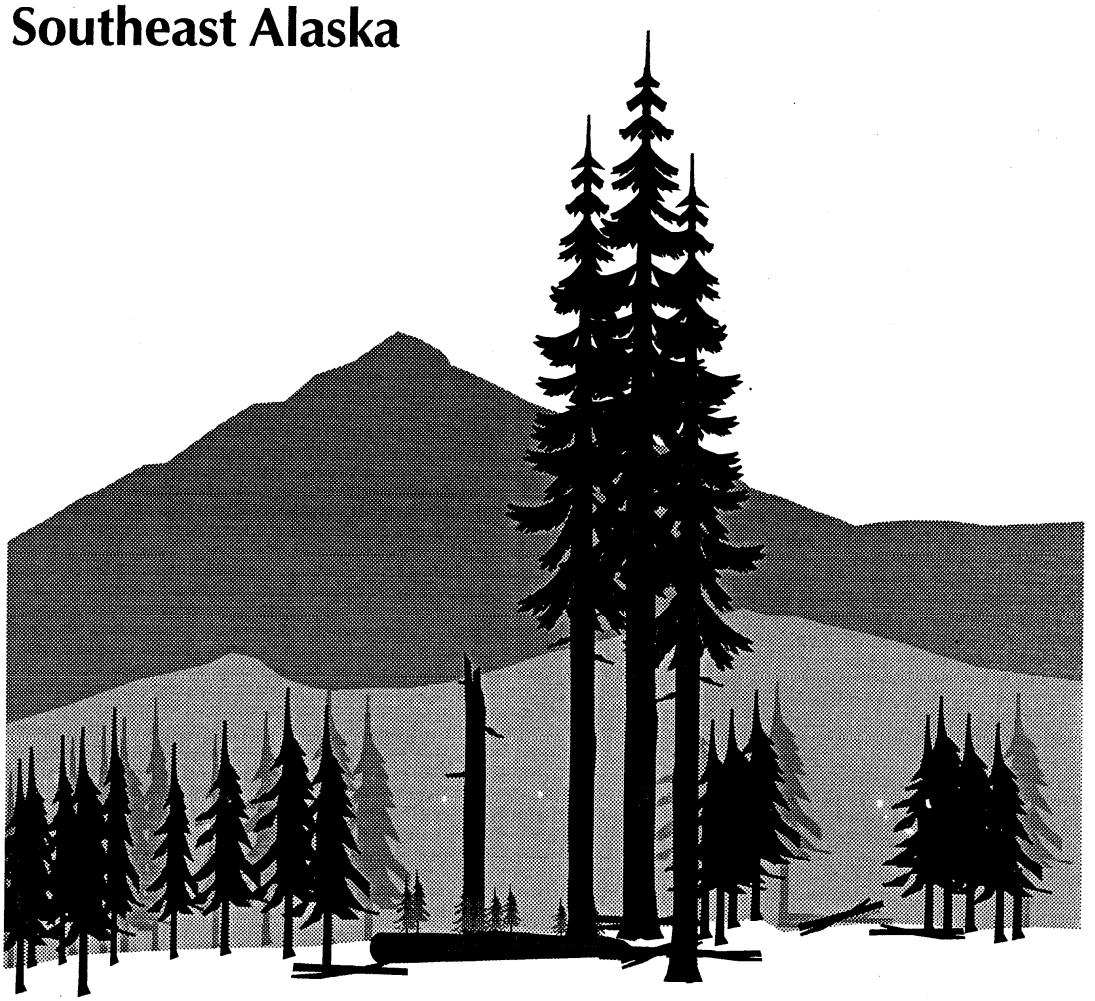
713 RJ-G-10-g

Contract No. 53-0109-0-00-00304

Effectiveness of Silvicultural Modifications of Young-Growth Forest for Enhancing Wildlife Habitat on the Tongass National Forest, Southeast Alaska



ENSERCH ENVIRONMENTAL CORPORATION
formerly the Environmental Division of Ebasco Services Incorporated

JLM511 1204

FINAL REPORT

EFFECTIVENESS OF SILVICULTURAL MODIFICATIONS OF YOUNG-GROWTH FOREST FOR ENHANCING WILDLIFE HABITAT ON THE TONGASS NATIONAL FOREST, SOUTHEAST ALASKA

Prepared for:

USDA Forest Service, Region 10

Prepared by:

Dominick A. DellaSala
Kathleen A. Engel
David P. Volsen
Randal L. Fairbanks

Enserch Environmental Corporation
(formerly the Environmental Division of Ebasco Services Incorporated)
Bellevue, WA 98004-4405

Joan C. Hagar
William C. McComb

Oregon State University
Department of Forest Science
Corvallis, OR 97331

and

Kenneth J. Raedeke

Raedeke Associates, Inc.
Seattle, WA 98115

August 1994

G:\WP16\USFS\06036A • 8-10-94

JLM511 1205

CONTENTS

ACKNOWLEDGEMENTS x

1.0 INTRODUCTION 1-1

2.0 STUDY AREA AND EXPERIMENTAL DESIGN 2-1

3.0 EFFECTS OF SILVICULTURAL MODIFICATIONS OF TEMPERATE RAINFOREST ON BREEDING BIRD COMMUNITIES IN SOUTHEAST ALASKA 3-1
- 3.1 INTRODUCTION 3-2
- 3.2 METHODS 3-4
  - 3.2.1 Vegetation Sampling 3-5
  - 3.2.2 Breeding Bird Sampling 3-6
  - 3.2.3 Statistical Analysis 3-7
- 3.3 RESULTS 3-8
  - 3.3.1 Vegetation Characteristics 3-8
  - 3.3.2 Avian Community Indices 3-10
  - 3.3.3 Breeding Bird Abundance 3-11
  - 3.3.4 Breeding Bird Abundance and Vegetation Characteristics 3-13
- 3.4 DISCUSSION 3-13
  - 3.4.1 Young Growth 3-13
  - 3.4.2 Old Growth vs. Young Growth 3-16
- 3.5 CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS 3-18

4.0 EFFECTS OF SILVICULTURAL MODIFICATIONS OF TEMPERATE RAINFOREST ON WINTERING BIRD COMMUNITIES IN SOUTHEAST ALASKA 4-1
- 4.1 INTRODUCTION 4-1
- 4.2 METHODS 4-3
  - 4.2.1 Vegetation Sampling 4-4
  - 4.2.2 Winter Bird Sampling 4-4
  - 4.2.3 Statistical Analysis 4-5

JLM511 1206

603_0302
Page 3 of 107

CONTENTS (continued)

4.3 RESULTS 4-6
4.3.1 Vegetation Characteristics 4-6
4.3.2 Winter Bird Abundance 4-6
4.4 DISCUSSION 4-8
4.5 CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS 4-11

5.0 PRELIMINARY HABITAT CAPABILITY MODEL FOR A NEOTROPICAL MIGRANT ASSOCIATED WITH OLD-GROWTH, COASTAL TEMPERATE RAINFOREST IN SOUTHEAST ALASKA 5-1
5.1 INTRODUCTION 5-1
5.2 SPECIES SELECTION 5-2
5.3 PACIFIC-SLOPE FLYCATCHER LITERATURE REVIEW 5-3
5.3.1 Breeding Range and Systematics 5-3
5.3.2 Habitat Use 5-4
5.4 PACIFIC-SLOPE FLYCATCHER HABITAT MODEL 5-6
5.4.1 Model Development 5-6
5.4.2 Habitat Model 5-7
5.4.3 Habitat Capability 5-8
5.5 CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS 5-9

6.0 EFFECTS OF SILVICULTURAL MODIFICATIONS OF YOUNG-GROWTH FOREST ON FORAGE AVAILABILITY AND WINTER/SPRING HABITAT USE OF SITKA BLACK-TAILED DEER, PRINCE OF WALES ISLAND, SOUTHEAST ALASKA 6-1
6.1 INTRODUCTION 6-1
6.2 METHODS 6-4
6.2.1 Vegetation Sampling 6-4
6.2.2 Deer Pellet-group Counts 6-6
6.2.3 Winter Track Surveys and Snow Cover Estimates 6-6
6.2.4 Statistical Analysis 6-7
6.3 RESULTS 6-8
6.3.1 Vegetation Characteristics 6-8
6.3.2 Forage Species 6-10
6.3.3 Deer Pellet-group Counts 6-14
6.3.4 Snow Coverage and Winter Deer Track Counts 6-14

JLM511 1207

603_0302
Page 4 of 107

CONTENTS (continued)

6.4 DISCUSSION 6-16
6.4.1 Deer Forage and Pellet-group Counts 6-16
6.4.2 Snow Coverage and Deer Winter Track Counts 6-20
6.5 CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS 6-20

7.0 OVERVIEW AND SUMMARY 7-1
7.1 MANAGEMENT INDICATOR SPECIES 7-1
7.2 BREEDING BIRDS 7-2
7.3 WINTERING BIRDS 7-3

8.0 RECOMMENDATIONS FOR FUTURE STUDIES 8-1

9.0 LITERATURE CITED 9-1

APPENDIX A - INCIDENTAL OBSERVATIONS (1992-93)
APPENDIX B - STUDY STAND MAPS
APPENDIX C - WINTER BIRD DETECTIONS
APPENDIX D - MIGRATORY STATUS OF FOREST BIRDS

JLM511 1208

603_0302
Page 5 of 107

FIGURES - APPENDIX B

B-1 Location of non-treated (C), gapped (G), thinned (T), and old-growth (O) stands in geographic areas 1-5, Prince of Wales Island, southeast Alaska. Site codes include geographic locations (1-5) and stand types (C, G, T, O). B-1

B-2 Location of non-treated (C), gapped (G), thinned (T), and old-growth (O) stands within Craig Quads D3 and D4. Site codes include geographic locations (1-5) and stand types (C, G, T, O). B-2

B-3 Location of stand 1-C (Non-treated). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-3

B-4 Location of stand 1-G (Gapped). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-4

B-5 Location of stand 1-T (Thinned). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-5

B-6 Location of stand 1-O (Old Growth). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-6

B-7 Location of stand 2-C (Non-treated). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-7

B-8 Location of stand 2-G (Gapped). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-8

JLM511 1209

603_0302
Page 6 of 107

FIGURES (continued)

B-9 Location of stand 2-T (Thinned). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-9

B-10 Location of stand 2-O (Old Growth). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-10

B-11 Location of stand 3-C (Non-treated). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-11

B-12 Location of stand 3-G (Gapped). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-12

B-13 Location of stand 3-T (Thinned). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-13

B-14 Location of stand 3-O (Old Growth). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-14

B-15 Location of stand 4-C (Non-treated). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-15

B-16 Location of stand 4-G (Gapped). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-16

B-17 Location of stand 4-T (Thinned). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-17

JLM511 1210

603_0302
Page 7 of 107

FIGURES (continued)

B-18 Location of stand 4-O (Old Growth). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-18

B-19 Location of stand 5-C (Non-treated). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-19

B-20 Location of stand 5-G (Gapped). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-20

B-21 Location of stand 5-T (Thinned). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-21

B-22 Location of stand 5-O (Old Growth). Transect segments (dashed line) have letter codes and bird count stations along transects have numbered codes. B-22

JLM511 1211

603_0302
Page 8 of 107

TABLES

3-1 Vegetation characteristics ($\bar{x} \pm$SE) of non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 3-9

3-2 Mean ($\pm$SE) breeding bird abundance (summed over 4 stand visits, 5 sampling stations/stand, and 2 breeding seasons) for non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 3-12

4-1 Vegetation characteristics ($\bar{x} \pm$SE) of non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 4-7

4-2 Mean ($\pm$SE) winter bird abundance (summed over 4 stand visits, and 5 sampling stations/stand, and 2 winters) for non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 and 1992-93 4-9

5-1 Life form and habitat association of neotropical migrants, Prince of Wales Island, southeast Alaska 5-4

5-2 Capability of habitats to support breeding Pacific-slope flycatchers in southeast Alaska - preliminary models 5-8

6-1 Vegetation characteristics ($\bar{x} \pm$SE) of non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 6-9

6-2 Mean ($\pm$SE) percent cover of fern, forb, and shrub layers in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 6-10

6-3 Mean ($\pm$SE) percent cover of forb species considered forage of Sitka black-tailed deer in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 6-11

JLM511 1212

603_0302
Page 9 of 107

TABLES (continued)

6-4 Mean (±SE) percent cover and height of shrub species considered forage of Sitka black-tailed deer in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 6-12

6-5 Mean (±SE) percent cover and height of tree seedlings/saplings (< 5-cm dbh) considered forage of Sitka black-tailed deer in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 6-13

6-6 Mean (±SE) number of Sitka black-tailed deer pellet groups/1500 m, deer winter tracks/100 m, snow depth, and snow cover in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska 1991-93

ACKNOWLEDGEMENTS

The authors of this study spent a considerable amount of time researching the effects of timber-harvest practices on wildlife of the Tongass National Forest. We have come to appreciate the vast areas of undisturbed tracts of coastal temperate rainforest, the enormous biological wealth supported by these forests, and the complexities of natural resource management on the Tongass National Forest. Articles in local newspapers and Congressional testimony appearing during the time of this study reflected the controversy between timber management and the need to conserve biological diversity. We hope that this study provides some insight into managing young even-aged forests to enhance the suitability of such forests as habitat for wildlife and to help resolve some of the conflict regarding large-scale conversion of old-growth forest to young growth.

Several individuals contributed in many ways to the successful completion of this project. We benefitted greatly from discussions and/or reviews of this report by P. Alaback, C. Crocker-Bedford, M. Brown, E. Campbell, C. Ford, R. Flynn, M. Kirchhoff, L. Suring, P. Tierney, and J. Whitney. In particular, we are grateful to E. Campbell for providing opportunities to exchange ideas with other coworkers in southeast Alaska and for obtaining the necessary funds to complete this project. We are also grateful for the dedicated work and contributions of D. Vesley who endured many long hours in the difficult terrain and weather conditions of southeast Alaska and provided invaluable assistance with data entry. We are especially grateful to J. and C. Hedges for making us feel a part of their family in Coffman Cove, Alaska, and for help with various logistical problems. This study was funded by the USDA Forest Service, Region 10.

JLM511 1214

1.0 INTRODUCTION

The Tongass National Forest (i.e., the "Forest") encompasses approximately 7% of Alaska's total land mass and is the largest of the 156 U.S. National forests (USDA Forest Service 1991 Chpt 1: 9). The Forest spans most of coastal southeast Alaska, from the Yakutat forelands south to the Dixon Entrance, and includes some of the most expansive areas of coastal temperate rainforest remaining in North America today. Approximately 23% of the 6.8 million ha comprising the Forest are currently designated for timber production (USDA Forest Service 1991 Chpt 2: 19). Clearcut logging, with reliance on natural regeneration and seeding from adjacent forests, is the most widely used regeneration system in the Sitka spruce (*Picea sitchensis*) - western hemlock (*Tsuga heterophylla*) association (Ruth and Harris 1979, USDA Forest Service 1991 Chpt 3: 318). Consequently, considerable amounts (approximately 143,158 ha) of old growth (>150 years, Capp et al. 1992:11, plot sensitivity analysis method) have been replaced by extensive areas of even-aged forests <40 years old (USDA Forest Service 1991 Chpt 3: 30).

About 5,621 ha of young (15-25 years) spruce-hemlock stands on the Forest have been treated silviculturally by the Forest Service over the last decade to enhance habitat for select species of wildlife. Precommercial thinning and the creation of 0.05-ha gaps within the overstory canopy of dense, young forests are 2 standard methods that have been used to accomplish this goal. An additional 24,282 ha have also been precommercially thinned, primarily to enhance young forests for timber production. The purpose of the habitat enhancement treatments has typically been to maintain and encourage shrub and herbaceous plant growth in the understory layer of young spruce-hemlock forests, primarily for the benefit of Sitka black-tailed deer (*Odocoileus hemionus sitkensis*). Information describing the response of other wildlife species to these treatments, however, is lacking, and baseline data on wildlife community composition in the older forests of southeast Alaska is limited.

The main objective of this study was to evaluate the effectiveness of 2 silvicultural modifications (gapping and thinning) of young-growth forest for enhancing and/or maintaining habitat quality for select Management Indicator Species (MIS) and for species of breeding and wintering birds. To accomplish this objective, we described the occurrence and abundance of various wildlife species in non-harvested (i.e., old growth) forest adjacent to young-growth stands. Old-growth forest was studied to (1) identify

JLM511 1215

bird species composition and abundance associated with various characteristics of old-growth forest, (2) describe conditions in the young-growth forests prior to clearcut logging, and (3) determine whether the silvicultural modifications of young-growth stands were effective in accelerating the development of important structural characteristics present in old growth.

Some species of neotropical migrant (i.e., long-distance migrant) birds have declined drastically in North America; these declines have been partially attributed to habitat loss on breeding grounds, such as southeast Alaska (Finch 1991). Therefore, we identified a neotropical migrant that appeared to be associated with old-growth forest in southeast Alaska, and developed a preliminary habitat-based model that may eventually be used to monitor changes in habitat capability of managed stands on the Forest for supporting thi species after timber harvest.

More specific objectives of this study included the following:

(1) compare the occurrence and abundance of select MIS, and breeding and wintering birds, between silviculturally modified and non-treated young-growth forest stands;

(2) compare the occurrence and abundance of select MIS, breeding and wintering birds, and neotropical migrants, between young- (treated and non-treated) and old-growth forest;

(3) identify habitat characteristics that may account for differences in occurrence and abundance of avian species between young- and old-growth forest;

(4) identify a neotropical migrant bird associated with old-growth forest in southeast Alaska and develop a model that can be used to predict effects of timber management activities on habitat capability for the species; and

(5) provide management recommendations for select MIS and other wildlife species associated with young- and old-growth forest on the Tongass National Forest.

During the first year of study, we completed an Annual Report that provided a detailed literature review of the distribution and habitat use of 13 MIS of the Tongass National

JLM511 1216

Forest (DellaSala et al. 1992). Results of this report were used to determine the likelihood of occurrence of the 13 MIS in our study area and the need to include these species in our field studies. The 13 MIS evaluated included the following: red squirrel (*Tamiasciurus hudsonicus*), black bear (*Ursus americanus*), brown bear (*U. arctos*), marten (*Martes americana*), river otter (*Lutra canadensis*), Sitka black-tailed deer, mountain goat (*Oreamnos americanus*), gray wolf (*Canis lupus*), Vancouver Canada goose (*Branta canadensis fulva*), bald eagle (*Haliaeetus leucocephalus*), red-breasted sapsucker (*Sphyrapicus ruber*), hairy woodpecker (*Dendrocopus villosus*), and brown creeper (*Certhia familiaris*). Based on this review, and 2 years of field studies in our study area, most of these 13 MIS either use young growth only occasionally or do not occur in our study area. Information on the MIS that were observed infrequently in the study area is provided in the Annual Report (DellaSala et al. 1992) and in Appendix A of this report. Other MIS, such as Sitka black-tailed deer, red-breasted sapsucker, and brown creeper, were observed commonly during field studies and are thus discussed herein.

This report represents the final stages of a 2-year field investigation designed to address the above-stated objectives. The report is divided into 8 Chapters based on taxonomic groups and study objectives. Chapter 2 provides a description of the study area for the wildlife studies discussed in Chapters 3 through 6. Chapters 3 through 6 were prepared as separate sections reflecting the major objectives of the study and refer to previous chapters only when necessary to limit redundancy. A summary and overview of the major findings of the study are provided in Chapter 7 and recommendations for future studies are provided in Chapter 8. These chapters were prepared as semi-independent documents formatted for future publication in peer-reviewed journals.

JLM511 1217

2.0 STUDY AREA AND EXPERIMENTAL DESIGN

The study area was located on the northern portion of Prince of Wales Island (i.e., the "Island"), approximately 35 km northwest of Ketchikan, Alaska (56°01' N, 132°51' W, Appendix B-1). The Island is part of the Alexander Archipelago and is located on the southern tip of the Forest in the Ketchikan Administrative Area. Prince of Wales Island is the third largest (approximately 5,778 km^2) island in the United States. The Island is surrounded by numerous smaller mountainous islands and fjords. Clarence Strait separates the Island from the mainland by a minimum distance of 9 km.

Climate on the Island is characterized by a unique combination of moderate temperatures and high rainfall resulting from the warm Alaska Current. In general, the climate is increasingly colder and drier moving from south to north (DeMeo 1989). Notably, these localized differences in climate influence site productivity and distribution of over 37 major plant associations on the Island (DeMeo 1989). Summer conditions at sea-level typically range from 9°C and 107 mm of rainfall in May to 13°C and 43 mm of rainfall in August (mean monthly averages for 1908-1987, Alaska State Climate Center, University of Alaska). Winter conditions typically range from 4°C and 109 mm of snowfall in December to 3°C and 223 mm of snowfall in February. Winter weather conditions on the Island varied considerably between 1991-92 and 1992-93. The winter of 1991-92 (i.e., "mild winter") was characterized by mean monthly temperatures that were about 1° to 4°C above the 29-year average (climatic records on file with the Ketchikan, Alaska, weather station, approximately 30 km southeast of the study area), with snowfall present in the study area only during a 6-day period in February and averaging less than 7-cm-deep (range = 0 to 25 cm, snow depths were recorded at 15 sampling stations in each stand). In contrast, the winter of 1992-93 (i.e., "harsh winter") was characterized by mean monthly temperatures of approximately 1°C below the 29-year average, with snowfall averaging above 20 cm (range = 12 to 89 cm) from January through mid-February.

The topography of Prince of Wales Island is dominated by rugged mountains with peaks rising to 608-915 m above sea level (asl). Vegetation was comprised of a mosaic of riparian hardwoods, saltwater estuaries, muskegs, alpine meadows, and coastal temperate rainforest (see Chapter 3 for definition of temperate rainforest). Western hemlock and Sitka spruce were the dominant conifers below 457 m asl and the predominant forest-types over most of the commercial-forest land base (USDA Forest

JLM511 1218

Service 1991). Although the Island had been heavily logged and had an extensive road system relative to other areas on the Forest, large (>4,000 ha) semi-contiguous patches of old growth remained in several locations.

The predominant plant association in young-growth (20 years) forests in the study area was the *Tsuga heterophylla/Vaccinium* association (DeMeo 1989, DellaSala et al. 1992). Additional plant associations present in young-growth forests included *Picea sitchensis/Rubus spectabilis*, *Tsuga heterophylla/Thuja plicata/Vaccinium*, and mixed conifer/*Vaccinium/Lysichitum americanum*. Old-growth forests were characterized by plant associations that were primarily components of the western hemlock series (DeMeo 1989). Characteristic associations in descending order of abundance included *Tsuga heterophylla/Vaccinium/Lysichitum americanum*, *T. heterophylla/Vaccinium/ Opholopanax horridum*, *T. heterophylla/Thuja plicata/Vaccinium/L.americanum*, and *T. heterophylla/Vaccinium/Dryopteris austriaca*. Other vegetation associations that occurred as inclusions within these areas were mixed conifer/*Vaccinium/Fauria crista-galli* and *Pinus contorta/Empetrum nigrum*. Thus, old-growth forests in our study area most closely resembled the western hemlock and western hemlock/western redcedar (*Thuja plicata*) old-growth forest types reported in the Regional guidelines (Capp et al. 1992). Based on the age criteria provided in the Regional guidelines (Capp et al. 1992:11, plot sensitivity analysis) for these forest types and tree-diameter distributions, old-growth stands in our study area were at least 150 years old. Additional information on plant associations is available in DellaSala et al. (1992).

Dominant tree species in both the young- and old-growth forests included western hemlock, Sitka spruce, western redcedar, and Alaska cedar (*Chamaecyparis nootkatensis*). Red alder (*Alnus rubra*) was associated with scarified soils and streambeds, and shore pine (*Pinus contorta*) was common in small, patches of muskeg that occurred in some stands. Dominant shrub species included devil's club (*Oplopanax horridum*), stink currant (*Ribes bracteosum*), trailing currant (*R. laxiflorum*), thimbleberry (*Rubus parviflorus*), salmonberry (*R. spectabilis*), red elderberry (*Sambucus racemosa*), blueberries (*Vaccinium* spp.), and rusty menziesia (*Menziesia ferruginea*). Crowberry (*Empetrum nigrum*) and Labrador tea (*Ledum groenlandicum*) occurred in patches of muskeg. Common herbaceous species included goldthreads (*Coptis* spp.), bunchberry (*Cornus canadensis*), deer cabbage (*Fauria crista-galli*), bedstraws (*Galium* spp.), yellow skunk cabbage (*Lysichitum americanum*), rattlesnake root (*Prenanthes alata*), and five-leaf bramble (*Rubus pedatus*). Common ferns included

deer fern (*Blechnum spicant*), lady fern (*Athyrium filix-femina*), spinulose shield fern (*Dryopteris austriaca*), and oak fern (*Gymnocarpium dryopteris*).

For statistical purposes, the study area was divided into 5 geographic areas (i.e., "blocks", Appendix B-1) based on localized differences in topography and plant associations. Dividing the area into geographic blocks allowed us to sample the variation in plant associations across the Island while controlling for the variations in a number of stand characteristics that were unrelated to silvicultural modifications. Blocks were separated by 3-13 km. Four sample stands, representing 1 of each of 4 stand types, were located within each block (n = 20 sample stands). The 4 stand types studied included (1) non-treated, young growth (i.e., "non-treated"), (2) precommercially thinned, young growth (i.e., "thinned"), (3) canopy-gapped, young growth (i.e., "gapped"), and (4) old growth. Sample stands within each geographic block were separated by ≤ 1 km and were selected to represent general characteristics (e.g., elevation, slope, aspect, and dominant plant association) of the block that were unrelated to silvicultural modifications.

All young-growth stands were clearcut harvested approximately 20 years prior to this study. Non-treated young-growth stands averaged 70 ha in size (range = 50-95 ha). Dominant vegetation in non-treated, young-growth stands resulted from natural reseeding of hemlock and spruce following harvest. Thinned stands averaged 63 ha in size (range = 35-106 ha) and were treated in 1987-88 by thinning trees along 3.7- x 3.7-m or 4.3- x 4.3-m spacing grids. Thinning resulted in dense piles of slash that were scattered throughout the stand. Gapped stands averaged 59 ha in size (range = 36-83 ha). Gaps were created in 1988-89 by clearing trees along the perimeter of existing, natural gaps or by creating new openings by tree removal. Individual canopy gaps averaged 0.05-ha and gap density (gaps/ha) ranged from 0.60 to 0.86. Old-growth stands met the Regional criteria (Capp et al. 1992) and averaged about 75 ha (range = 39-106 ha). Maps depicting the location of all stands are provided in Appendix B.

Boundaries for each stand were delineated based on obvious changes in major vegetation types, landscape features (e.g., ridge lines, streams), and disturbance history, as determined by aerial photographs and stand maps supplied by the USDA Forest Service. Stand boundaries were mapped from current (1991) aerial photos (1:24,000), transferred onto base maps using a zoom transfer scope, and digitized for analysis using the Geographic Information System (GIS) ARC/INFO software. The GIS database for the

study area was provided by the USDA Forest Service and was matched against aerial photos for all data layers used in the analyses.

JLM511 1221

3.0 EFFECTS OF SILVICULTURAL MODIFICATIONS OF TEMPERATE RAINFOREST ON BREEDING BIRD COMMUNITIES IN SOUTHEAST ALASKA

Key words: temperate rainforest, old growth, young growth, breeding birds, canopy gaps, precommercial thinning, southeast Alaska

Abstract - During 1991 and 1992, we compared vegetation characteristics and breeding bird communities in temperate rainforest of southeast Alaska among 4 forest stand types: non-treated young growth (20 years), precommercially thinned young growth, young growth with 0.05-ha openings (i.e., gaps) created in the overstory canopy, and old growth (>150 years). The main objective of this study was to evaluate the effectiveness of 2 silvicultural modifications (gapping and thinning) of young-growth forests for maintaining and/or enhancing habitat quality for breeding bird communities in southeast Alaska. Of 16 bird species studied, only dark-eyed junco (Junco *hyemalis*) abundance was highest (Ps $\leq$ 0.05) in thinned stands, while numbers of fox sparrows (*Passerella iliaca*) and Wilson's warblers (*Wilsonia pusilla*) were lowest (Ps $\leq$ 0.05) in gapped stands. Dark-eyed junco abundance was related positively (P = 0.008) to percent forb cover, and fox sparrow abundance was related inversely (P = 0.02) to the number of canopy gaps in young-growth stands. Species richness, equitability, and diversity of breeding bird communities were statistically similar (Ps > 0.05) among stand types, although the composition of breeding bird communities was more similar among young-growth stand types than between young- and old-growth stand types. Pacific-slope flycatchers (*Empidonax difficilis*), golden-crowned kinglets (*Regulus satrapa*), red-breasted sapsuckers (*Sphyrapicus ruber*), and brown creepers (*Certhia americana*) were more (Ps $\leq$ 0.05) abundant in old growth than in young-growth stand types. In old-growth stands, numbers of Pacific-slope flycatchers were related inversely (P = 0.04) to canopy cover, and numbers of golden-crowned kinglets were related positively (P < 0.0001) to density of trees >55-cm dbh. In contrast, orange-crowned warblers (*Vermivora celata*), Swainson's thrushes (*Catharus ustulatus*), fox sparrows, and Wilson's warblers were least (Ps $\leq$ 0.05) abundant in old growth. Differences in breeding bird communities between young- and old-growth forest stand types were attributed to the presence of specific structural characteristics (i.e., snags, large-diameter trees) lacking in young-growth stands. We suggest retention of residual patches of old-growth in logged areas to facilitate dispersal of forest birds between old- and young-growth temperate rainforest.

JLM511 1222

3.1 INTRODUCTION

The Pacific Coast of North America supports some of the largest tracts of coastal temperate rainforest worldwide (Alaback 1988, 1991, Samson et al. 1989, Beebe 1991, Kirk and Franklin 1992). Temperate rainforests along the Pacific Coast are dominated by Sitka spruce and western hemlock and occur along a narrow coastal band extending northward from the Olympic Peninsula in Washington State (46°N) to southeast Alaska (61°N, Alaback 1991). These forests occur within a distinct climatic zone characterized by high annual precipitation (>1,400 mm), cool (midsummer isotherm <16°C) and frequently overcast summers, dormant seasonal periods, and infrequent fires (Alaback 1988, 1991). At least 10% of the annual precipitation occurs during the summer months.

Temperate rainforests along the Pacific Coast provide habitat for 290 species of vertebrates (Taylor 1979), influence regional climatic patterns (Waring and Franklin 1979, Alaback 1991), and play an integral role in the economies of local timber-dependent communities and many Pacific Rim nations (Samson et al. 1989). Consequently, considerable controversy exists regarding the simultaneous management of these remaining temperate rainforests for maintenance of ecological functions and species diversity and for timber production.

The Tongass National Forest (i.e., the "Forest") in southeast Alaska encompasses one of the few remaining contiguous tracts of old growth (>150 years, Capp et al. 1992:11, plot sensitivity analysis method) temperate rainforest worldwide. In 1954, approximately 2.2 million ha of temperate rainforest on the Forest was considered productive old growth (USDA Forest Service 1991). Extensive logging on the Forest began in the late 1950's and has reduced productive old growth by approximately 7%. Another 23% reduction is anticipated by the year 2150 (USDA Forest Service 1991). Large-scale replacement of old-growth by young-growth forests is believed to account for widespread changes in the abundance of many resident and some neotropical migratory bird species in the Pacific Northwest (Raphael et al. 1988). In general, as old-growth forests are harvested and replaced by young forests, bird species associated with early seral stages have increased while those associated with more mature forest stages have declined (Raphael et al. 1988). Young forests managed intensively for timber production in southeast Alaska typically do not acquire structural attributes (e.g., large trees and snags) associated with late-seral species of birds within commercial forest harvest rotations (≤100 years). Consequently, affected breeding bird

communities may benefit from silvicultural modifications of young-growth forest that accelerate development of important forest attributes (e.g., large-diameter and tall trees). Nyberg et al. (1987) recommended that land managers consider managing younger forests to produce habitat conditions required by wildlife associated with old growth.

Most young-growth forests managed for timber production in this region are characterized by relatively little structural complexity in both the understory and overstory vegetation layers as compared to virgin old-growth conditions (Alaback 1982a,b). Sparse understory layers in young forests result from shading by the dense conifer overstory that develops 15-25 years following logging and may affect understory composition for up to 160 years post-harvest (Alaback 1982a,b, Tappeiner and Alaback 1989). In few young-growth forests, residual old-growth components (large trees and snags) remain from logging operations, thus increasing the structural complexity of these relatively homogeneous habitats.

A variety of silvicultural modifications, including precommercial thinning and creation of openings within the dense overstory canopy (i.e., "gapping"), of 15- to 20-year-old forests have been used to both maintain understory vegetation considered beneficial for wildlife (primarily deer *Odocoileus* spp.) and to maximize diameter growth rates of remaining crop trees (Alaback and Tappeiner 1991). Precommercial thinning involves the cutting of small unmerchantable trees to specific stocking densities and retention of cut material on site as "slash". Such thinning is designed to delay crown closure, increase growth rates of potential crop trees by removing nearby competing stems, and extend understory layers over longer periods of the rotation (Kessler 1982, Crawford and Frank 1987). Light (trees thinned to 2.4 x 2.4 m) to moderate (trees thinned to 3.7 x 3.7 m) thinnings are most effective in retaining understory layers, but the peak response is reached within 5 years and is limited to ≤ 10 years post-thinning (Alaback and Herman 1988, pers. comm. P. Alaback). In our study, precommercial thinning was conducted 3-5 years prior to the study, and thus our results were obtained just prior to and during peak vegetative response.

In contrast, gapping of young-growth overstory canopy is designed to retain understory layers by providing increased light levels for light-dependent forbs and shrubs (Alaback and Herman 1988). Natural canopy openings in coastal conifer overstory are generally characterized by productive and diverse understory layers (Alaback and Herman 1988, Alaback and Tappeiner 1991), are known to be important for establishment of Sitka spruce and other *Picea* spp. (Stewart 1986), and may thus influence overall plant species

composition within a young-growth forest (Spies and Franklin 1989). Our study was conducted 2-4 years post-gapping.

Despite widespread application of thinning and gapping in young-growth forests, no studies assessing the effects of such modifications on breeding bird communities have been published. Furthermore, the effects of large-scale harvest of old-growth temperate rainforest on vegetative and avian communities in this region have not been compared in a replicated, multi-year study.

The main objective of this study was to evaluate the effectiveness of 2 silvicultural modifications (gapping and thinning) of young-growth forests for enhancing and/or maintaining habitat quality for breeding bird communities in southeast Alaska. To accomplish this, we (1) compared breeding bird species composition and abundance among thinned, gapped, and non-treated young-growth stands; (2) compared breeding bird species composition and abundance between young- and old-growth stands; and (3) identified vegetation characteristics related to the occurrence and abundance of breeding bird species in these different stands.

3.2 METHODS

We collected vegetation and avian information from 20 stands on Prince of Wales Island during June 1991 and 1992. The Island was divided into 5 geographic areas (i.e., "blocks"), based on obvious differences in vegetation composition and topography (see Appendix B-1). Four sample stands, representing 1 of each of 4 stand types, were positioned within each geographic block (n = 20 sample stands). The 4 stand types studied included: (1) non-treated, young growth (i.e., "non-treated"), (2) precommercially thinned, young growth (i.e., "thinned"), (3) canopy-gapped, young growth (i.e., "gapped"), and (4) old growth (>150 years) (see Chapter 2 for detailed description of forest stands). Sample stands within each geographic block were separated by ≤1 km and were selected to represent general characteristics (e.g., elevation, slope, aspect, and dominant plant association) of the block that were unrelated to silvicultural modifications. Vegetative characteristics and winter bird communities were sampled at 5 stations positioned randomly within each study stand. Sampling stations were from 150 to 300 m apart and were >50 m from stand boundaries.

3.2.1 Vegetation Sampling

Vegetation and avian communities were sampled at 5 stations positioned randomly within each stand. Sampling stations were 150-300 m apart and were ≥50 m from stand boundaries. The number of stations sampled in each stand was based on minimum sample sizes required to yield stable density estimates for breeding bird communities (Morrison et al. 1981).

One nested, circular plot was positioned in each of 4 cardinal directions, at random distances of 10-40 m from the center of each sampling station. In old-growth stands, each nested plot consisted of a 10-m-radius, a 5-m-radius, and 2 2-m-radius plots. In young-growth stands, each nested plot consisted of a 5-m-radius plot and 2 1-m-radius plots. Plots with smaller radii were used in young growth because of the denser tree spacing than in old growth. At each plot, we measured 13 vegetation variables: stem densities (stems/ha) of conifers in 3 size classes, small (6- to 35-cm diameter at breast height [dbh]), medium (36- to 55-cm dbh), and large (>55-cm dbh); stem densities of hardwoods (small size class only); snag (standing dead trees >2-m tall) densities; number of tree species; tree and shrub heights (m); percent conifer canopy cover; and percent cover of shrubs, forbs, and slash in 2 depth categories: <50-cm and >50-cm deep. Ten-m radius plots in old growth and 5-m-radius plots in young growth were used to record tree and snag densities, dbh in 10-cm classes, tree height, and percent tree-canopy cover. Tree-canopy cover was estimated by sighting through an ocular tube (James 1971) for the presence of vegetation from 5 sample points (4 cardinal points plus plot center) located within each plot. Average tree-height estimates were obtained by measuring the height of the 2 dominant trees nearest to the plot center using a clinometer. Five-m radius plots in both old- and young-growth stands were used to estimate percent shrub cover and shrub height. Vegetation recorded in the small (1- or 2-m radius) plots included percent forb cover and percent slash cover in each depth class.

We mapped locations of other pertinent vegetation features of each stand, including canopy gaps and patches of residual trees. Stand features were mapped from current (1991) aerial photos using a zoom transfer scope or from the GIS database provided by the USDA Forest Service. Canopy gaps were mapped from aerial photos of young-growth stands. No distinction was made between natural and artificial gaps and only gaps ≥0.05 ha were mapped. Residual trees were considered those trees remaining after harvest of old-growth that were >15 m taller than the surrounding

regenerating trees. Residual trees were easily identifiable on aerial photos as isolated clumps of older trees within some young-growth stands. Residual tree clumps were mapped as polygons; area of clumps was calculated using the GIS. Mapped locations of canopy gaps and residual tree clumps were verified opportunistically while walking between sampling stations. Once verified, the GIS was used to calculate distances from each sampling station to the nearest stream and canopy gap.

3.2.2 Breeding Bird Sampling

Breeding birds were surveyed at each of the 20 stands from 1 June to 23 June in 1991 and 1992. Surveys were conducted from sunrise to 6 hours after sunrise. No surveys were conducted during high winds or moderate rainfall. All stands were visited 4 times during 1-week intervals each year. Stands within geographic blocks were surveyed on the same day to minimize potential biases associated with temporal variation in avian detectability.

Breeding bird abundance was determined by counting all birds detected (i.e., seen or heard) during an 8-min count period within 100-m radius of the center of each sampling station. An abundance estimate was calculated as the number of detections summed over 4 visits to each of the 5 sampling stations within each stand. To test whether bird species were equally detectable among stand types, we also estimated the horizontal distance from the sampling station to each bird detection.

The same 3 skilled observers conducted surveys each year. Observers were trained in distance estimates and recognition of avian vocalizations and each had >5 years experience in conducting bird surveys. In addition, distance estimates and species identifications were verified periodically among observers. Careful selection of skilled observers and continuous training is known to reduce observer error to acceptable levels (Kepler and Scott 1981). Observer survey schedules and the order in which sampling stations were visited were rotated systematically to further minimize potential observer biases and any potential biases associated with temporal activity patterns in avian species (Robbins 1981, Kessler and Milne 1982).

Species richness (total number of species), species diversity (Shannon and Weaver 1949), equitability (Smith 1980), total abundance, and proportional similarity (Brower et al. 1984: 167) were used as avian community indices and were compared among stand types. Equitability, or "evenness", expresses the degree of equality of individual

JLM511 1227

abundance estimates of species for a given community (Smith 1980: 589). The equitability index ranges from 0 to 1, with 1 representing equal distribution of abundance among different species within a community. The proportional similarity index reflects the proportion of species occurring within a given stand plot that also occurred in another stand. This index ranges from 0 (no overlap in community composition) to 100% (complete overlap) and was calculated as follows: $Ps = 1 - S\ p_i - q_i/2$, where p_i is the proportion composition of species *i* for a given stand and q_i is the proportion composition of that species in different stand. Proportional similarity indices were used in comparisons among young-growth stand types and between young- and old-growth stand types. Community indices were derived for species that were observed at least twice in the study area, and only those species that were detected at least 30 times were used in comparisons of individual species detection rates among stand types. Experience indicates that at least 30 detections are needed for statistical comparisons of species abundance.

3.2.3 Statistical Analysis

Individual stands served as the experimental units for statistical analyses. All vegetation variables measured at the nested, circular vegetation plots were averaged among the 4 plots at each sampling station. The means calculated for the vegetation variables at each station were then averaged among the 5 sampling stations to provide overall mean estimates for each stand. Habitat variables were then compared among the 4 stand types using Analysis of Variance (ANOVA), blocking on the 5 geographic areas.

Horizontal distances from observers to individual bird detections were compared among stand types using a One-Way ANOVA. Species richness, species diversity, equitability, total abundance, and abundance of each bird species were compared among stand types and between years using Split-plot ANOVA. Year served as the whole plot, stand type as the subplot, and geographic area as the blocking variable. For each year, the stand type-by-geographic block error term was used to test both the stand type effect and the stand type-by-year interaction. Significant stand type-by-year interactions were examined by comparing abundance among stand types for each year separately using One-way ANOVA.

If necessary to improve normality and/or stabilize variances, vegetation and abundance variables were transformed using either arcsine (for all percentages) or square-root transformations (Zar 1984: 239, 241). The ANOVA models were assumed to be robust

JLM511 1228

enough to compensate for departures from normality and/or variance homogeneity (Neter and Wasserman 1983); however, the non-parametric Friedman's test was used if transformations did not adequately improve normality or variance homogeneity. If results of the ANOVA models were significant ($P \leq 0.05$), Tukey's HSD analysis was then used to identify differences between specific stand-type means. The power of statistical tests (Zar 1984:43) was calculated for non-significant results using alpha=0.05.

Relationships between breeding bird abundance and selected vegetation characteristics were determined for both young- and old-growth stand types by relating the abundance of each species to specific stand attributes using correlation (old-growth stands) and multiple regression (young-growth stands). We limited this analysis to only those species of birds demonstrating significant stand type effects. A Pearson correlation matrix was calculated for the abundance of each bird species in old-growth stands and each of the vegetation variables within the various layers. Stepwise regression (forward selection) was used to identify variables within each vegetation layer that best explained variability in individual bird species abundance among young-growth stand types. Variables differing among stand types were then used in a final regression model to relate bird abundance to specific vegetation variables. All analyses were run on SYSTAT (Wilkinson 1990). The level of significance used was $P \leq 0.05$. Marginal significance was assigned to $0.05 < P < 0.10$.

3.3 RESULTS

3.3.1 Vegetation Characteristics

Several vegetation characteristics differed among stand types, and these differences were generally related to either a young-growth modification (i.e., thinning, gapping) or to overall differences in stand age (i.e., old growth vs. young growth).

Young Growth - Seven of the 15 vegetation variables measured differed (Ps ≤ 0.10) among young-growth stand types (Table 3-1). Six vegetation variables differed consistently between thinned stands and at least 1 of the other young-growth stand types. In general, thinned stands were characterized by lower densities of small conifers and lower percent canopy cover, higher snag densities, and higher percentages of slash cover >50-cm deep, shrub cover, and forb cover than the other young-growth stand types. Two vegetation variables (i.e., gap density and distance to gaps) differed between

JLM511 1229

JLM511 1230

Table 3-1. Vegetation characteristics ($\bar{x}\pm$SE) of non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (> 150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92.

	Stand Type[1/]			
Vegetation Characteristic	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Tree Layer				
Small (5- to 35-cm dbh) conifer/ha[2/]	1,117.9±75.2A	1,117.9±233.0A	435.4±30.0B	411.6±36.9B
Medium (36- to 55-cm dbh) conifer/ha	1.3±1.3A	2.5±2.5A	0[3/]	60.2±4.5B
Large (>55-cm dbh) conifer/ha[3/]	0	0	0	52.8±9.4
Hardwoods (10- to 30-cm dbh)/ha[2/]	45.8±34.5A	85.3±70.5A	17.8±12.0A	2.9±2.9A
No. tree species	3.2±0.4A	3.2±0.4A	2.8±0.6A	3.8±0.5A
Conifer canopy cover (%)[2/]	62.4±4.9A	58.2±9.0B	38.4±5.2AB	86.2±8.2C
Tree height (m)	7.1±0.2A	7.3±0.5A	8.0±0.3A	29.1±1.9B
Dead Tree Layer				
Snags/ha[2/]	6.4±2.8A	8.9±2.5A	25.5±7.8C	78.6±10.4B
Slash in piles <50-cm deep (%)[2/]	7.9±1.4A	11.1±2.2A	12.4±1.6A	8.4±3.7A
Slash in piles >50-cm deep (%)[2/]	7.7±1.1A	8.5±1.0A	17.4±3.2B	7.0±1.2A
Ground Cover Layer				
Shrub cover (%)[2/]	47.5±5.3A	43.3±3.0A	66.2±6.1B	45.2±4.7A
Shrub height (m)	1.3±0.04A	1.2±0.07A	1.1±0.1A	1.3±0.06A
Forb cover (%)[2/]	11.2±2.2A	16.4±2.4AB	22.9±5.0B	21.9±3.9B
Prominent Stand Features				
No. canopy gaps/ha[4/]	0.04±0.02A	0.73±0.04B	0.09±0.03A	0.14±0.06A
Distance to gap (m)[4/]	288.4±56.7A	54.6±10.7B	191.0±40.8AB	162.6±55.8AB

1/ Means sharing the same letters did not differ significantly ($P > 0.05$); underlined letters indicate means that differed marginally ($0.05 < P < 0.10$) (ANOVA, Tukey's HSD-test).
2/ Untransformed means.
3/ No statistical analysis was conducted.
4/ Canopy gaps were ≥ 0.05 ha.

G:\WP16\USFS\06036T • 8-10-94

gapped stands and at least 1 of the other young-growth stand types: gapped stands were characterized by higher gap densities and lower distances to gaps. Young-growth stand types were also characterized by relatively few residual tree clumps. Sixteen residual tree clumps were identified within 4 young-growth stands: 11 relatively small ($\bar{x}$ = 0.2 ha, range = 0.05-1.3 ha) clumps occurred in 1 thinned stand, 1 large (0.6 ha) clump occurred in another thinned stand, 3 ($\bar{x}$ = 0.4 ha, range = 0.1-0.6 ha) clumps occurred in a gapped stand, and 1 (0.3-ha) clump occurred in a non-treated stand.

Young Growth vs. Old Growth - Eight of the 15 vegetation variables measured differed (Ps $\leq$ 0.05) between old- and young-growth stand types (Table 3-1). Old-growth stands were characterized by lower densities of small conifers, higher densities of medium and large conifers, greater percent conifer canopy cover and tree heights, and greater snag densities than any of the young-growth stand types. Approximately 43% of the 245 snags found in old growth were $\geq$40-cm dbh, and 20% were $\geq$15-m tall. In contrast, only 6% of 32 snags observed in all young-growth stand types were $\geq$40-cm dbh and 6% were $\geq$15-m tall. In addition, relative to non-treated stands, old-growth stands had higher percent forb cover.

3.3.2 Avian Community Indices

Mean ($\pm$ SE) numbers of birds detected differed (P = 0.001) among stand types during both years; however, species richness and species diversity were similar (Ps > 0.05) among stand types. Numbers of birds detected were lowest for old growth (127.8 $\pm$ 8.4) relative to non-treated (157.6 $\pm$ 6.8), gapped (158.8 $\pm$ 6.3), and thinned (162.4 $\pm$ 8.2) stands. Differences in equitability among stand types differed (P = 0.03) between years; only a marginal difference (P = 0.07) in equitability was detected among stand types in 1991, and no difference (P = 0.10) in equitability among stand types was detected in 1992. Follow-up comparisons of stand type means for equitability in 1991 did not differ (Ps > 0.05).

Overlap in the composition of breeding bird communities was substantially greater among young-growth stand types than between young- and old-growth stands. Mean ($\pm$ SE) percent similarity was greatest between non-treated vs. gapped (76.3% $\pm$ 2.5), gapped vs. thinned (75.5% $\pm$ 1.5), and non-treated vs. thinned (74.9% $\pm$ 1.6) stands, and lowest for old growth vs. thinned (45.1% $\pm$ 2.2), non-treated (50.4% $\pm$ 2.9), and gapped (52.2% $\pm$ 2.2) stands.

JLM511 1231

3.3.3 Breeding Bird Abundance

Eight breeding bird species accounted for >75% of the total detections recorded (n = 6,076): winter wren (17.5%), orange-crowned warbler (14.2%), Swainson's thrush (12.7%), dark-eyed junco (8.1%), Townsend's warbler (7.8%), Pacific-slope flycatcher (5.2%), varied thrush (5.1%), and hermit thrush (5.1%). Mean detection distances of individual bird species did not differ (Ps > 0.05) among stand types. Detection distances varied by <15 m among stand types for individual bird species and thus detectability of birds did not appear to be related to overall differences in stand characteristics (e.g., old vs. young growth, silviculturally treated vs. non-treated young growth).

Young Growth - Abundance of several bird species differed among stand types. Abundance of 3 of 16 bird species differed (Ps ≤ 0.05) among young-growth stand types (Table 3-2). Among young-growth stand types, fox sparrows were least (Ps ≤ 0.05) abundant in gapped stands and dark-eyed juncos were most abundant (Ps ≤ 0.05) in thinned stands. In addition, fewer (Ps ≤ 0.05) Wilson's warblers were detected in gapped than in non-treated stands.

Numbers of American robins, hermit thrushes, and Townsend's warblers differed (Ps ≤ 0.05) among stand types, but these differences did not follow any predictable pattern related to silvicultural modifications (Table 3-2). In addition, numbers of Steller's jays, chestnut-backed chickadees, varied thrushes, and song sparrows were similar (Ps > 0.05) among stand types. Statistical power associated with comparisons of these species among stand types was lowest for song sparrows (0.10), followed by varied thrushes (0.16), Steller's jays (0.24), and then chestnut-backed chickadees (0.38). Differences in abundance of winter wrens among stand types differed (P = 0.004) between years. During 1991, mean (± SE) numbers of winter wrens were lower (P ≤ 0.05) in gapped (12.2 ± 2.3) than in thinned (21.8 ± 2.4) stands; however, during 1992, wren abundance was lower (Ps ≤ 0.05) in old growth (24.2 ± 2.3) than in non-treated (37.6 ± 2.8), gapped (39.0 ± 2.0), and thinned (41.8 ± 2.5) stands.

Young Growth vs. Old Growth - Abundance of 8 of the 16 bird species differed (Ps ≤ 0.05) between young- and old-growth stand types. Red-breasted sapsuckers, Pacific-slope flycatchers, and golden-crowned kinglets were more (Ps ≤ 0.05) abundant in old growth than in each of the young-growth stand types (Table 3-2). Although brown creepers were too rare (<30 total detections) for statistical analysis, all 22

JLM511 1232

Table 3-2. Mean (±SE) breeding bird abundance (summed over 4 stand visits, 5 sampling stations/stand, and 2 breeding seasons) for non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92.[1/]

Species	Stand Type[2/]			
	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Red-breasted sapsucker (*Sphyrapicus ruber*)	0.5±0.4B	1.5±0.5B	0.3±0.1B	5.4±1.3A
Pacific-slope flycatcher (*Empidonax difficilis*)	1.8±0.5B	3.8±1.2B	3.4±0.8B	22.3±2.3A
Stellar's jay (*Cyanocitta stelleri*)	2.4±1.0A	1.8±0.5A	3.2±1.0A	0.9±0.4A
Chestnut-backed chickadee (*Parus rufescens*)	3.9±1.2A	4.2±0.9A	3.5±0.9A	6.9±1.4A
American robin[3/] (*Turdus migratorius*)	1.0±0.5AB	4.1±1.2A	3.0±1.1AB	0.5±0.3B
Varied thrush (*Ixoreus naevius*)	9.2±2.0A	7.7±2.4A	5.3±1.2A	9.0±2.0A
Hermit thrush (*Catharus guttatus*)	7.3±1.6AB	10.8±1.7A	4.9±1.3B	8.0±1.3AB
Swainson's thrush (*Catharus ustulatus*)	25.8±1.3B	24.3±2.5B	20.9±2.3B	6.1±1.1A
Golden-crowned kinglet (*Regulus satrapa*)	2.2±0.9B	2.2±1.2B	1.6±0.6B	9.2±2.2A
Orange-crowned warbler (*Vermivora celata*)	25.5±2.4B	29.3±1.9B	28.7±1.9B	2.5±0.7A
Townsend's warbler (*Dendroica townsendi*)	12.1±1.7AB	11.3±0.8AB	7.3±1.2B	16.8±3.6A
Wilson's warbler (*Wilsonia pusilla*)	6.1±2.1A	1.0±0.3B	2.7±0.9AB	0.1±0.1B
Dark-eyed junco (*Junco hyemalis*)	8.2±2.2BC	14.0±3.0B	22.7±4.5A	4.4±1.3C
Fox sparrow (*Passerella iliaca*)	11.3±2.3A	3.8±1.6B	13.1±1.9A	0B
Song sparrow (*Melospiza melodia*)	0.8±0.4A	3.2±1.5A	2.0±0.9A	0.4±0.3A

1/ Includes only species with a minimum of 30 total detections and those with no stand type-by-year interaction.
2/ Means sharing the same letter did not differ significantly ($P > 0.05$) (ANOVA, Tukey's HSD-test).
3/ Friedman's test; Tukey's HSD-test, $P \leq 0.05$.

G:\WP16\USFS\06036T • 8-10-94

JLM511 1233

creepers detected were recorded in old growth. In contrast, orange-crowned warblers and Swainson's thrushes were more (Ps $\leq$ 0.05) abundant in the 3 young-growth stand types than in old growth. Wilson's warblers and fox sparrows were also more (Ps $\leq$ 0.05) abundant in non-treated stands than in old growth.

3.3.4 Breeding Bird Abundance and Vegetation Characteristics

Only 5 of the 15 vegetation variables measured were statistically associated with differences in bird species abundance among stand types: percent forb cover, total conifer densities (all size classes combined), number of canopy gaps, percent canopy cover, and density of large trees. Dark-eyed junco abundance was related positively to percent forb cover (r^2 = 0.44, P = 0.008, df = 1,13). Juncos were most abundant in thinned stands, where forb cover was greatest. Hermit thrush numbers were related positively to total conifer densities in young-growth stand types (r^2 = 0.36, P = 0.02, df = 1,13), as evidenced by higher numbers of thrush detections in gapped stands. Fox sparrow abundance was lowest in gapped stands and was related inversely to the number of canopy gaps (r^2 = 0.33, P = 0.02, df = 1,13). No significant (Ps > 0.05) relationships were identified between abundance of Wilson's warblers and the 15 vegetation characteristics measured.

Pacific-slope flycatcher abundance was correlated inversely (r = -0.90, P = 0.04, n = 5) to percent canopy cover in old growth and golden-crowned kinglet abundance was correlated positively (r = 0.99, P < 0.0001, n = 5) to density of trees >55-cm dbh. No significant (Ps > 0.05) relationships were identified between red-breasted sapsuckers and the 15 vegetation variables measured; numbers of brown creepers detections were too low for statistical analysis.

3.4 DISCUSSION

3.4.1 Young Growth

Of the 16 bird species detected, numbers of only 3 species appeared to be influenced by the silvicultural modifications. Based on abundance, dark-eyed juncos appear to benefit from thinning, while fox sparrows and Wilson's warblers appear to be negatively affected by gapping. This finding is consistent with that of Mannan and Meslow (1984) who found higher numbers of dark-eyed juncos in thinned as compared to unthinned stands in northeast Oregon. Similarly, Medin (1985) and Artman (1990) reported that

JLM511 1234

junco numbers tend to increase following reductions in canopy cover. Higher numbers of dark-eyed juncos in thinned stands may have been due to the relatively low conifer densities and low canopy cover resulting in higher forb cover in thinned stands. Juncos nest and forage on the ground (Brown 1985, Tobalaske et al. 1991); thus, higher forb cover in thinned stands may provide greater foraging and nesting opportunities for this species relative to non-treated and gapped young-growth stands.

Numbers of fox sparrows and Wilson's warblers were negatively associated with gapping, but the reasons for this apparent negative response to gapping remains unclear. Although, fox sparrows are obligate shrub nesters (Verner and Larson 1989), no association was found between numbers of fox sparrows and either shrub cover or tree densities in this study. Furthermore, although fox sparrow abundance has been positively related to total crown volume (sum of shrub and tree volumes) (Verner and Larson 1989), total crown volume at the stand level appeared virtually unaffected by gapping, since gapped stands had some of the highest densities of small-size conifers and the percent shrub cover in gapped stands was similar to that recorded in non-treated stands. Similarly, although numbers of Wilson's warblers were lowest in gapped stands, no associations were identified between Wilson's warbler abundance and the vegetation characteristics we measured. Thus, factors other than those we measured may be important to fox sparrows and Wilson's warblers and may influenced by gapping.

Hermit thrush abundance appeared to be associated positively with conifer density in young-growth stands. Other studies have shown that hermit thrushes use dense thickets for shading on hot days (Verner and Larson 1989). Although we detected fewer hermit thrushes in thinned stands, which had low conifer densities, this difference was only significant between thinned and gapped stands, not between thinned and non-treated stands. Non-treated stands had conifer densities similar to those recorded in gapped stands.

Similarities in breeding bird communities among young-growth stand types may have resulted from (1) high variability among sample stands (i.e., within-stand type vs. between-stand type variability), (2) relatively low statistical power associated with the high variances of some variables, (3) positioning of sampling plots within stands, (4) time-related lags in vegetative response following treatment, (5) insufficient alteration of vegetative structure by the silvicultural modifications, and/or (6) omission of other important habitat variables (i.e., microclimate) from our sampling that may have influenced bird communities. Greater stand-type differences may have been revealed by

increasing the number of stand replicates, and sampling intensity within stands, which would provide greater statistical power. In addition, differences among gapped stands may have been more apparent if more sampling plots had been positioned within individual canopy gaps. However, selectively positioning sampling plots within gaps would have presented a biased sampling design. Vegetation plots could also have been centered on individual bird locations (i.e., territories or nest sites) and compared with random sites. Larson and Bock (1984) indicated that bird-centered vegetation plots generally resulted in many more statistically significant habitat associations than correlations of bird abundances with habitat features measured at the plot level. However, stand-level correlations never produced results that conflicted with bird-centered correlations. Again, access in our stands and the difficulty in locating birds in dense foliage of young growth and tall tree canopies of old growth prevented use of bird-centered sample plots.

A longer period between silvicultural modification and sampling, may have revealed more differences related to the silvicultural modifications. Our study was conducted 3-5 years following thinning and 2-4 years following gapping. As such, our results most likely represent the period just prior to and during peak response of understory layers to the silvicultural modifications (Alaback and Herman 1988, P. Alaback, pers. comm). Although a longer post-treatment period may have been beneficial, distinguishing effects of silvicultural modifications from successional events influencing understory characteristics in these stands would have been difficult. Furthermore, Alaback and Herman (1988) report that vegetation response to thinning is limited to ≤ 10 years, for as forest canopies close, vegetation response diminishes. Thus, effects attributed to thinning in this study are probably short-lived events, necessitating repeated thinnings on 10-year intervals to sustain understory benefits for ground-nesting species (e.g., dark-eyed juncos) over longer periods of the commercial forest rotation age.

Although thinning and gapping altered some vegetation or stand characteristics, these modifications may not have been substantial enough to alter the relatively homogenous structure that still characterized these stands. Both breeding bird density and species richness are known to be correlated strongly with vegetation structure (see Verner and Larson 1989 for a review). Thus, additional modifications of structural characteristics in young-growth stands may be necessary as enhancement for bird species that utilize young-growth forest. We recommend thinning trees along variably spaced grids designed to produce 2-storied forest canopies (McComb et al. 1993). Such variable-spaced thinning would create clumps of unthinned trees surrounded by thinned

areas that would eventually produce a 2-storied canopy appearance in these stands as well as increase horizontal patchiness (McComb et al. 1993). Spies (1991) also suggested that variable-spaced thinning enhances horizontal and vertical structure. Such treatment may provide additional nesting opportunities for birds that position nest sites in the tree canopy and within understory vegetation layers.

3.4.2 Old Growth vs. Young Growth

Species richness, equitability, and diversity of breeding bird communities were similar between old growth and the 3 young-growth stand types; however, breeding bird communities were less similar between old growth and young growth than among the 3 young-growth stand types alone. Differences in composition of bird communities between old- and young-growth stand types were attributed primarily to differences in the abundance of 8 species: Pacific-slope flycatchers, golden-crowned kinglets, red-breasted sapsuckers, brown creepers, orange-crowned warblers, Swainson's thrushes, fox sparrows, and Wilson's warblers. Other studies found that abundance of Pacific-slope flycatchers, golden-crowned kinglets, red-breasted sapsuckers, and brown creepers were lowest in early seral stages (shrub/forb stage) following clearcut harvesting (Kessler and Kogut 1985) and were highest in older forest age classes (Franzreb and Ohmart 1978, Mannan and Meslow 1984, Kessler and Kogut 1985, Rosenberg and Raphael 1986, Manuwal and Huff 1987, Raphael et al..1988, Sakai and Noon 1991).

Although we did not measure abundance across a successional gradient following logging, and although abundance is not always a reliable indicator of habitat quality (VanHorne 1983), based on abundance estimates alone, Pacific-slope flycatchers, golden-crowned kinglets, red-breasted sapsuckers, and brown creepers appear to be positively associated with old-growth. Abundances of these old-growth associates were attributed to the presence of specific structural characteristics that were most prevalent in old-growth stands. For instance, Pacific-slope flycatchers nest in large-diameter trees and snags, and forage in open areas within old-growth stands (Beedy 1991, Sakai 1987, Sakai and Noon 1991). Although canopy coverage was highest in old-growth stands in our study, flycatchers were associated with relatively open tree canopies. The presence of multiple tree size classes in old-growth stands may have provided flycatchers with a range of canopy coverages that encompassed areas with both continuous and broken tree canopies. The combination of large-diameter trees and multiple tree layers was nearly absent in young-growth stands which were characterized by relatively uniform tree

JLM511 1237

layers. Higher abundance of golden-crowned kinglets in old growth was attributed to density of trees >55-cm dbh. Young-growth stands lacked trees in these size classes and thus were used infrequently by kinglets.

Our results confirm the status of the red-breasted sapsucker as a Management Indicator Species of old-growth habitat in southeast Alaska (Suring et al. 1988a). Although red-breasted sapsucker numbers were associated with old growth in our study area, none of the vegetation variables we measured was correlated with sapsucker abundance. Lack of significant associations between specific vegetation variables and sapsucker abundance in old growth may have resulted from insufficient sample sizes within old-growth stands, and/or associations with other vegetation characteristics, especially those at finer-scales, not measured in our study. Other studies have shown that red-breasted sapsuckers nest in trees with advanced decay in the heartwood (Miller et al. 1979, Erskine and McLaren 1972) that are either live or have been dead for less than 3 years (Bull et al. 1986). Thus, low snag densities in young-growth stands probably at least partially explain the low use of young-growth stands by sapsuckers. When snags occur in sufficient densities, as in old-growth stands, the availability of snags with specific structural characteristics may be especially important in determining sapsucker abundance.

Although brown creepers were rarely observed, all 22 detections of brown creepers were recorded in old growth. These results confirm the status of the brown creeper as a Management Indicator Species of old-growth habitat in southeast Alaska (Suring et al. 1988b). Brown creepers forage primarily along the bark crevices of large (approximately 50-cm dbh) trees (Morrison et al. 1987) and nest between the bark and trunk of dead or dying trees (Davis 1978, Raphael and White 1984, Franzreb 1985) available in old-growth stands. Such external bark structure tends to be correlated with tree diameter and age (Jackson 1979). Young-growth stands were probably not used by creepers because of a lack of such large-diameter trees that provide essential foraging and nesting habitat.

Timber management on Prince of Wales Island is expected to reduce the amount of old growth by 70% over the next 150 years (USDA Forest Service 1991:3-30). Such large-scale reductions in old-growth temperate rainforest on coastal islands are especially significant, since island systems are not as resilient to perturbations as mainland areas (MacArthur and Wilson 1967, Diamond 1975, Temple 1985) and tend to support endemic subspecies of resident birds (Cowan 1989). Evidence from studies of island biogeography and land bird communities in northern latitudes suggests that the ability of

JLM511 1238

birds to colonize oceanic islands depends on regional population abundance, availability of suitable habitat, and specific autecological responses (Haila 1983, Haila and Jarvinen 1983). In general, flexibility in habitat utilization is an important determinant of colonization propensity in land bird communities (Haila et al. 1983). The species of old-growth associates we studied tended to specialize on specific structural attributes lacking in young-growth forests (e.g., large-diameter trees, snags, etc.) and thus populations of these species are expected to be particularly vulnerable over the next 150 years. In addition, populations of rare species are expected to turnover frequently in island systems (Haila 1983). Although we have no data on regional populations of brown creepers, a rare species in our study area, the tendency of creepers to specialize on structural attributes found primarily in old growth combined with the low abundance of creepers on the Island may make this species especially vulnerable to the effects of long-term reductions in of old growth.

In contrast, the results of this study suggest that 4 bird species benefit from the availability of young-growth forest: orange-crowned warblers, Swainson's thrushes, fox sparrows, and Wilson's warblers. Although none of the specific vegetation variables measured in young growth were correlated with the abundance of these species, each species either nests or forages in dense understory vegetation (Sidle 1985) and is common in early forest seral stages in southeast Alaska (Kessler and Kogut 1985).

3.5 CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Results of this study suggest that abundance of a number of bird species associated with old-growth forest in southeast Alaska declines in response to clearcut logging, and that neither thinning nor gapping of the resultant young-growth stands appears to enhance habitat quality for these species. Thus, to manage such species, we recommend (1) long-term conservation of existing intact blocks of old-growth temperate rainforest as breeding and foraging habitat, and (2) retention of residual clumps of old-growth structural components (i.e., large-diameter trees and snags) in young-growth stands to provide dispersal habitat. Only 4 of the 15 young-growth stands we studied contained residual tree components. Wetmore et al. (1985) found that bird species composition in residual tree components left within clearcuts was similar to unlogged old-growth (>150 years) in mountain hemlock (Tsuga mertensiana) - Engelmann spruce (*Picea engelmannii*) stands of British Columbia. Similarly, Raphael et al. (1988) indicated that retention of large relic trees in young Douglas-fir (*Pseudotsuga menziesii*) stands of northwestern California provided habitat for some bird species that were more typical of

JLM511 1239

old-growth stands. Thus, we suggest retention of residual clumps of larger tree size classes in young-growth stands to provide important structural components lacking in standard clearcut stands which may be more beneficial to breeding of old growth associate species of birds than either gapping or thinning. Residual tree clumps could also be combined with variable-spaced thinning grids in young-growth stands to provide additional structure lacking in standard clearcuts.

When possible, residual old-growth clumps should approximate territory sizes of the old-growth associates. However, retention of much smaller clumps, and even individual reserve trees, would also be beneficial. The number of clumps retained within individual logging units should be based on the size of the unit, with large units receiving multiple clumps spaced close enough to allow dispersion of old-growth associates into adjacent old-growth stands. Residual clump sizes and positioning should also be adjusted to minimize potential loss due to windthrow. Occasional high-velocity winds are a primary disturbance feature of temperate rainforests in this region (Ruth and Harris 1979, Alaback and Juday 1989, Alaback 1991, Alaback and Tappeiner 1991) that could limit the long-term suitability of residual old-growth components as habitat for breeding birds in young growth. Retention of residual trees clumps would function primarily as (1) dispersal habitat, (2) foraging habitat, (3) escape cover, and (4) perching habitat for old-growth associates. Notably, such clumps should not be considered suitable breeding habitat for old-growth associates due to lack of "interior" conditions, and thus should not be viewed as replacement habitat or mitigation for harvesting of large intact blocks of old-growth, temperate rainforest.

In addition to residual clumps, leaving reserve trees along the edges of clearcuts, as proposed in the Etolin Island Implementation Analysis in the Stikine Area (Iverson and Strauss 1991) and in the recent Polk Inlet DEIS in the Ketchikan Area (USDA Forest Service 1993), would provide additional structural diversity in future second-growth stands. This practice, referred to as "feathering edges" (Iverson and Strauss 1991) or "Type A and Type B clearcuts" (USDA Forest Service 1993), can be implemented using most logging systems and with limited timber volume reduction if conducted within a 50- to 100-ft zone along unit boundaries with directional felling and yarding. This practice would be particularly suitable for implementation in blowdown prone areas, because such "feathering" is believed to help channel wind over the canopy at the edge of a clearcut in an old-growth stand, as compared with an abrupt edge usually maintained. Elimination of this abrupt edge may reduce impacts due to loss of interior

JLM511 1240

old-growth habitat in the adjacent old-growth stand by buffering the abrupt ecotone (Iverson and Strauss 1991).

Our results may underestimate the differences in overall breeding bird community composition and abundance between young-growth and old-growth temperate rainforest of southeast Alaska, because our conclusions and management recommendations are restricted to those species of birds with relatively small home ranges that breed in the coastal temperate rainforest of southeast Alaska. Thus, we did not address bird species with relatively large home ranges, such as the northern goshawks (*Accipiter gentilis atricapillus*) and marbled murrelets (*Brachyramphus marmoratus*), that nest almost exclusively in old-growth forests (Quinlan and Hughes 1990, Crocker-Bedford 1990a,b, Paton et al. 1992), nocturnal species such as owls, or species associated with the old-growth/water edges (e.g., Vancouver Canada goose [*Branta canadensis fulva*], Lebeda and Ratti 1983). These species were observed as flyovers in the area. In addition, because 2 of the 5 old-growth stands we studied were characterized by considerable openings (e.g., muskeg) in the forest canopy (see Appendix B), they may not represent optimal habitat for old-growth associates, particularly forest interior species. Because all 5 old-growth stands occurred within landscapes characterized by alternating old growth and regenerating forests, old-growth associates may also have been responding to habitat fragmentation at the landscape level. Additional studies are needed with larger sample sizes of old-growth stands to assess the contribution of landscape-level effects on the abundance and distribution of old-growth associates.

4.0 EFFECTS OF SILVICULTURAL MODIFICATIONS OF TEMPERATE RAINFOREST ON WINTERING BIRD COMMUNITIES IN SOUTHEAST ALASKA

Key words: coastal temperate rainforest, old growth, young growth, wintering birds, canopy gaps, precommercial thinning, southeast Alaska

Abstract - We compared vegetation characteristics and wintering forest bird communities in temperate rainforest during the relatively mild winter of 1991-92 and harsh winter of 1992-93 among 4 forest stand types: non-treated young-growth stands (20 years), precommercially thinned young-growth stands, young-growth stands with 0.05-ha openings (i.e., "gaps") created in the overstory canopy, and old-growth (>150 years) stands. Our purpose was to determine if abundance and/or composition of wintering bird communities differed among young-growth stand types and between young- and old-growth stands during mild and harsh winter conditions. Wintering bird abundance and composition were statistically similar (Ps > 0.05) among young-growth stand types during both winters. However, old growth supported more species of birds than young growth (Ps ≤ 0.05) during both winters, and higher numbers of some bird species during the harsh winter (1992-93). Golden-crowned kinglets were more ($P \leq 0.05$) abundant in old growth than in all young-growth stand types during the harsh winter. This result was attributed to greater snow cover in young-growth stands and less snow in tree canopies of old-growth stands where kinglets foraged. Almost all (38 of 39) detections of brown creepers occurred in old growth, and this was attributed to greater availability of roosting and foraging areas in old growth as compared to young-growth stands. Our data suggest that, during harsh winters in southeast Alaska, old growth provides critical wintering bird habitat especially for species, such as golden-crowned kinglet, that forage in the forest canopy.

4.1 INTRODUCTION

The wintering period is a critical time for resident bird species in northern latitudes because of constraints imposed on winter survival by food availability and climatic conditions (Rottenberry 1978, Rottenberry et al. 1979, Raphael and White 1984, Yahner 1986, Morrison et al. 1986, Manuwal and Huff 1987). Forest structure such as canopy height, vegetation layering, crown thickness, and snag availability, are important features for wintering birds (Morrison et al. 1985, 1986, Manuwal and Huff 1987).

JLM511 1242

Forests of different ages may differ in these important structural characteristics, resource levels, and microclimatic conditions, and may thus vary in quality for certain species of birds (Manuwal and Huff 1987). Thus, timber management activities that alter important forest structural characteristics may affect wintering birds through associated changes in food resources or microclimatic conditions.

Over half of the world's temperate rainforest occurs in northern latitudes ranging from 46°N to 61°N (Alaback 1991, Kirk and Franklin 1992, Alaback and Weigand 1992). Temperate rainforests in this region are dominated by the Sitka spruce/western hemlock association and are characterized by high annual precipitation (>1,400 mm), cool frequently overcast summers, infrequent fires, and dormant seasonal periods (Alaback 1991). The dormant seasonal period in this region occurs from November through April (Waring and Franklin 1979) and is characterized by wide variances in temperature and precipitation associated with proximity to coastal areas and elevation (Alaback 1991). In general, proximity to the coast ameliorates the effects of winter conditions and makes these areas climatically more suitable to wintering birds relative to other temperate forests (Waring and Franklin 1979).

Northern temperate rainforests have experienced extensive modification through clearcut logging and a variety of related silvicultural practices. Extensive areas of old growth (>150 years old, Capp et al. 1992:11, plot sensitivity analysis method) have been converted to young forests, drastically altering the structural characteristics of non-harvested forests. Because avian community composition is closely tied to habitat structure (see Verner and Larson 1989 for a review), such habitat alteration has important implications for bird species wintering in the temperate rainforest ecosystem.

Young forests (15-25 years) managed for timber production in southeast Alaska are generally characterized by sparse understory layers, dense tree crowns, and relatively few snags and downed logs (Alaback 1982a,b, Tappeiner and Alaback 1989). Uniform tree canopies, characteristic of most young forests in this region, also tend to intercept less snowfall relative to the multilayered tree canopies of old growth (Kirchhoff and Schoen 1987). Consequently, silvicultural practices that influence canopy structure in young-growth forests may influence their suitability as habitat for wintering birds. In southeast Alaska, precommercial thinning and creation of small (0.05-ha) canopy openings (i.e., canopy gaps) within the overstory of young growth are used to restore impoverished understory layers that result from shading by the dense tree canopies (Kessler 1982, Alaback 1982a,b, USDA Forest Service 1991). These silvicultural

modifications, however, are used primarily as habitat enhancement for species (e.g., Sitka black-tailed deer) that nest or forage in the understory during the breeding season (Kessler 1982, Alaback and Tappeiner 1984). Moreover, both modifications involve structural changes of the forest canopy that could affect the forest microclimate. Despite the widespread application of these silvicultural modifications of young growth, few studies have been published that address the effects of these practices on wintering bird communities in northern latitudes. We describe wintering bird populations in non-treated young-growth, precommercially thinned young-growth, canopy-gapped young-growth, and old-growth forest stands in the temperate rainforest ecosystem of southeast Alaska. Our data allowed us to test 2 main hypotheses: (1) abundance and/or composition of wintering bird communities do not differ among young-growth stand types, and (2) abundance and/or composition of wintering bird communities do not differ between young- and old-growth stand types. Moreover, because winter conditions in southeast Alaska can vary substantially between years, we determined whether interannual variation in winter conditions affected winter bird use in young- and old-growth stands.

4.2 METHODS

We collected vegetation and winter bird information from 20 stands on the Island from December to February 1991 and 1992. For statistical purposes, the study area was divided into 5 geographic areas (i.e., "blocks", Appendix B-1) based on localized differences in topography and plant associations. Dividing the area into geographic blocks allowed us to sample the variation in plant associations across the Island while controlling for the variations in a number of stand characteristics that were unrelated to silvicultural modifications. Blocks were separated by 3-13 km. Four sample stands, representing 1 of each of 4 stand types, were located within each block (n = 20 sample stands) (see Appendix B-1). The 4 stand types studied included (1) non-treated, young growth (i.e., "non-treated"), (2) precommercially thinned, young growth (i.e., "thinned"), (3) canopy-gapped, young growth (i.e., "gapped"), and (4) old growth (>150 years) (see Chapter 2 for detailed description of forest stands). Sample stands within each geographic block were separated by ≤1 km and were selected to represent general characteristics (e.g., elevation, slope, aspect, and dominant plant association) of the block that were unrelated to silvicultural modifications. Vegetative characteristics and winter bird communities were sampled at 5 stations positioned randomly within each study stand. Sampling stations were from 150 to 300 m apart and were >50 m from stand boundaries.

JLM511 1244

4.2.1 Vegetation Sampling

Vegetation was sampled at each sampling station during the 1991 breeding bird season as part of a related study on breeding bird communities (see Chapter 3). Only those characteristics that were not likely to change appreciably between summer and winter were presented in this study, primarily for descriptive purposes.

One circular plot was positioned in each of 4 cardinal directions, at random distances of 10- to 40-m from the center of each station. Plots in old-growth stands were 10-m-radius while those in young-growth stands were 5-m-radius. At each plot, we measured 7 vegetation variables: conifer stem density (stems/ha) in 3 size classes, small (6- to 35-cm diameter-at-breast height [dbh]), medium (36- to 55-cm dbh), and large (>55-cm dbh); snag (standing dead trees >2-m tall) densities; number of tree species; percent conifer-canopy cover; and tree height (m). Conifer-canopy cover was estimated by sighting through an ocular tube (James 1971) for the presence of vegetation from 5 sample points (plot center plus 4 cardinal points) located within each vegetation plot. Average tree height was measured for the 2 trees nearest plot center using a clinometer. Canopy gaps were mapped from current (1991) aerial photos using a zoom transfer scope and were digitized for analysis using the GIS ARC/INFO software. No distinction was made between natural and artificial gaps, and only gaps ≥ 0.05 ha were mapped. Canopy gap locations were verified opportunistically while walking between bird count stations. Once verified, the GIS was used to calculate distance from bird count stations to the nearest canopy gap.

4.2.2 Winter Bird Sampling

Winter birds were surveyed at sampling stations during 4 1-week visits between December and February of 1991-92 and 1992-93. Numbers of stand visits each year were limited by high costs and access problems associated with conducting wintering bird surveys in southeast Alaska. Surveys were conducted from sunrise (0730-0830) to about 5 hours after sunrise. No surveys were conducted during heavy precipitation or high winds. All stands within the same geographic block were visited on the same day to minimize biases associated with temporal variation in avian detectability.

Winter bird abundance was estimated by counting all birds detected (i.e., seen or heard) during a 10-min observation period conducted within a 100-m radius plot centered on each sampling station. An abundance estimate was calculated as the number of

JLM511 1245

detections summed over 4 stand visits to each of the 5 sampling stations within each stand. To test whether bird species were equally detectable among stand types, we also estimated the horizontal distance (i.e., detection distance) from the sampling station to each bird detection.

The same 3 skilled observers conducted surveys each year. Observers were trained in distance estimates and recognition of avian vocalizations and each had >5 years experience in conducting bird surveys. In addition, distance estimates and species identifications were verified periodically among observers. Careful selection of skilled observers and continuous training is known to reduce observer error to acceptable levels (Kepler and Scott 1981). Observer survey schedules and the order in which sampling stations were visited were rotated systematically to further minimize potential observer biases and any potential biases associated with temporal activity patterns in avian species (Robbins 1981, Kessler and Milne 1982).

4.2.3 Statistical Analysis

Individual stands served as the experimental units for statistical analyses. All vegetation measurements were averaged for the circular plots at each sampling station. The means calculated for all vegetation variables at each station were then averaged among sampling stations to provide a mean estimate for each stand. Vegetation variables were compared among stand types using an ANOVA, blocking on the 5 geographic areas.

Horizontal distances from sampling stations to individual bird detections were tested for differences among stand types using a One-way ANOVA. Species abundance was compared among stand types and between years using Split-plot ANOVA. Year served as the whole plot, stand type as the subplot, and geographic area as the blocking variable. The stand type-by-year interaction also was included in the model. Significant stand type-by-year interactions were examined by comparing stand types for each year separately using One-way ANOVA.

If necessary to improve normality and/or stabilize variances, vegetation variables were transformed using either square-root or arcsine transformations (for all percentages) (Zar 1984:239, 241). The ANOVA models were assumed to be robust enough to tolerate moderate deviations from normality and/or variance homogeneity (Neter and Wasserman 1983); however, a non-parametric Friedman's test was used if transformations did not adequately improve normality or variance homogeneity. If results of the ANOVA's

JLM511 1246

were significant ($P \leq 0.05$), Tukey's HSD was used to locate differences between specific stand type means. All analyses were run on SYSTAT (Wilkinson 1990). The level of significance used was $P \leq 0.05$. Marginal significance was assigned to $0.05 < P < 0.10$.

4.3 RESULTS

4.3.1 Vegetation Characteristics

Several vegetation characteristics differed among stand types; these differences were generally either related to a particular silvicultural modification (i.e., thinning or gapping) or to overall differences in stand age (i.e., old growth vs. young growth).

Young Growth - Five of the 9 vegetation variables measured differed (Ps ≤ 0.10) among young-growth stand types (Table 4-1). Three vegetation variables in thinned stands differed consistently from at least 1 of the other young-growth stand types. Thinned stands were characterized by lower densities of small conifers, lower percent canopy cover, and higher snag densities. Two vegetation variables in gapped stands differed consistently from at least 1 of the other young-growth stand types; gapped stands were characterized by higher gap densities and lower distances to gaps.

Young Growth vs. Old Growth - Six of the 9 vegetation variables measured differed (Ps ≤ 0.05) between young- and old-growth stand types (Table 4-1). Old-growth stands were characterized by lower densities of small conifers, higher densities of medium and large conifers, greater percent canopy cover and tree heights, and greater snag densities than the 3 young-growth stand types. Notably, approximately 43% of the 245 snags found in old growth were ≥40-cm dbh, and 20% were ≥15-m tall. In contrast, only 6% of 32 snags observed in all young-growth stand types were ≥40-cm dbh and 6% were ≥15-m tall.

4.3.2 Winter Bird Abundance

We recorded 1,037 detections during both winters, 598 in 1991-92 and 439 in 1992-93 (Appendix C). During both years, 4 species accounted for 85% of the total detections: golden-crowned kinglets comprised the majority (52.1%) of the total detections, followed by winter wrens (18.9%) and chestnut-backed chickadees (10.3%), and then brown creepers (3.7%).

JLM511 1247

Table 4-1. Vegetation characteristics ($\bar{x} \pm$SE) of non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92.

	Stand Type[1/]			
Vegetation Characteristic	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Small (6- to 35-cm dbh) conifer/ha[2/]	1,117.9±75.2A	1,117.9±233.0A	435.4±30.0B	411.6±36.9B
Medium (36- to 55-cm dbh) conifer/ha	1.3±1.3A	2.5±2.5A	0[3/]	60.2±4.5B
Large (>55-cm dbh) conifer/ha	0	0	0	52.8±9.4[3/]
No. tree species	3.2±0.4A	3.2±0.4A	2.8±0.6A	3.8±0.5A
Conifer canopy cover (%)[2/]	62.4±4.9A	58.2±9.0B	38.4±5.2AB	86.2±8.2C
Tree height (m)	7.1±0.2A	7.3±0.5A	8.0±0.3A	29.1±1.9B
Snags/ha[2/]	6.4±2.8A	8.9±2.5A	25.5±7.8C	78.6±10.4B
No. canopy gaps/ha[4/]	0.04±0.02A	0.73±0.04B	0.09±0.03A	0.14±0.06A
Distance to gap (m)[4/]	288.4±56.7A	54.6±10.7B	191.0±40.8AB	162.6±55.8AB

1/ Means sharing the same letter did not differ significantly ($P > 0.05$); underlined letters were marginally different ($0.05 < P < 0.10$) (ANOVA, Tukey's HSD-test).
2/ Untransformed means.
3/ No statistical tests performed.
4/ Canopy gaps were ≥0.05 ha.

JLM511 1248

Mean detection distances of individual species were similar (Ps > 0.05) among stand types. Detection distances for individual species varied by <10 m among stand types; therefore, detectability was not likely influenced by stand type.

In general, wintering bird abundance and composition were statistically similar (Ps $>$ 0.05) among young-growth stand types and among all stand types combined during 1991-92. Numbers of species were greater (Ps ≤ 0.05) in old growth than in young-growth stand types and this pattern was consistent ($P = 0.91$) between years. Differences in total numbers of detections among stand types, however, differed ($P =$ 0.001) between years: numbers of detections were similar (Ps > 0.05) among stand types in 1991-92, but were higher (Ps ≤ 0.05) in old growth than in young-growth stand types during 1992-93.

Mean ($\pm$ SE) numbers of chestnut-backed chickadee detections were similar ($P = 0.53$) among stand types during both years, but were greater ($P = 0.04$) in 1991-92 ($3.5 \pm$ 0.7) than in 1992-93 (1.8 ± 0.5). In contrast, mean number of detections of golden-crowned kinglets and winter wrens among stand types differed between years (Ps < 0.01). During 1991-92, mean numbers of golden-crowned kinglets detected were similar (Ps > 0.05) among stand types, but during 1992-93 numbers of kinglets were greater (Ps ≤ 0.05) in old-growth than in young-growth stand types (Table 4-2). Likewise, during 1992-93 mean numbers of winter wren detections were similar (Ps $>$ 0.05) among stand types, but in 1991-92 numbers were lower (Ps ≤ 0.05) in old-growth than in young-growth stand types. Numbers of brown creeper detections in young-growth stand types were too few for statistical comparison. Notably, however, 38 of the 39 creepers detected were recorded in old growth.

4.4 DISCUSSION

Similar to other northern latitudes (Kricher 1975, Rotenberry et al. 1979, Yahner 1986), the wintering bird community we studied was characterized by relatively few species and low numbers of wintering birds. Harsh winter conditions relative to other temperate forests, the northern location of our study area, the extent of old-growth habitat fragmentation in our study area, and island biogeographic factors may have limited species richness and abundance of birds wintering in our study area. Some bird species are reluctant to cross oceanic barriers (Haila and Jarvinen 1983), and thus Clarence Strait, as well as numerous small mountainous islands and fjords that separated the

JLM511 1249

Table 4-2. Mean (±SE) winter bird abundance (summed over 4 stand visits, 5 sampling stations/stand, and 2 winters) for non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (> 150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92 and 1992-93.

		Stand Type[1/]			
Species	Year	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Golden-crowned kinglet (*Regulus satrapa*)	1991-92	10.0±1.0A	11.8±1.0A	10.4±2.8A	16.8±3.0A
	1992-93	7.4±1.3A	8.2±1.5A	11.8±1.1A	31.6±2.3B
Winter wren (*Troglodytes troglodytes*)	1991-92	9.8±0.7A	9.8±1.6A	9.2±0.9A	3.0±0.8B
	1992-93	1.6±0.5A	1.8±0.5A	2.4±1.0A	1.6±0.8A
Chestnut-backed chickadee (*Parus rufescens*)	1991-92	2.4±0.8A	1.6±0.7A	4.4±1.9A	5.6±1.7A
	1992-93	1.4±0.6A	1.6±0.7A	1.8±0.7A	2.6±0.9A
Total abundance	1991-92	28.8±3.8A	28.0±1.5A	29.8±4.0A	33.0±2.8A
	1992-93	12.2±2.5A	14.2±1.0A	18.0±2.5A	43.2±4.3B
Total no. species	1991-93[2/]	4.1±0.5A	4.8±0.2A	4.5±0.5A	6.5±0.4B

1/ Means sharing the same letter did not differ significantly ($P > 0.05$) (ANOVA, Tukey's HSD-test).
2/ Pooled means.

JLM511 1250

Island from the mainland, may limit the number of bird species present on the Island. In addition, avian species richness declines with increasing latitude from south to north (Pianka 1966); thus, the Island may lie outside the extreme most limits of the northern distribution of many forest bird species.

The thinning and gapping of young-growth stands appeared to have no effect on winter bird communities. Although winter wrens were more abundant in young-growth than old-growth stands, this pattern was not consistent between years. Numbers of winter wren detections were low in the second year when snow levels were deepest. Snow cover may limit foraging opportunities for this ground-foraging species, which during winters of high snowfall, may occur in more southern latitudes.

Relative to young growth, old growth supported more species and higher numbers of brown creepers during both winters, and during the second winter, old growth supported more golden-crowned kinglets and higher numbers of birds overall. Our results from the second year of study are consistent with those of Manuwal and Huff (1987) who found that birds wintering in Douglas-fir/western hemlock stands of the western Washington Cascades were twice as abundant in old growth (250-500+ years) than in either young (42-75 years) or mature (105-165 years) stands. They attributed these differences to greater availability of roost sites and tree cones, and more-suitable microclimatic conditions in old growth relative to younger forests.

Our results also confirm the status of the brown creeper as a Management Indicator Species of old-growth habitat in southeast Alaska (Suring et al. 1988b), particularly during the winter (contrast with Chapter 3 results). Although brown creepers were observed rarely during the winter in our study area, 38 of 39 detections were recorded in old growth.

The most important features to birds wintering in old growth were probably the large dominant trees, dense tree canopy, multilayered canopy, and snags. Morrison et al. (1986) found bird species wintering in mixed-conifer forests of the Sierra Nevada Mountains used areas characterized by high, heavy canopy cover that apparently provided thermal protection from wind and precipitation. For species, such as the brown creeper, that forage for insects along bark crevices (Morse 1970), the thick furrowed bark structure of old trees probably provides more suitable foraging sites relative to young growth. Brown creepers are known to forage in trees with deeply furrowed barks that provide suitable prey (Jackson 1979, Morrison et al. 1985). Such

JLM511 1251

external bark structure tends to be correlated positively with tree diameter and age (Jackson 1979). In addition, large snags are important as roosting sites for creepers (Walsberg 1986), and were relatively uncommon in young-growth stands.

For species, such as the golden-crowned kinglet, that forage for insects in tree canopies (Airola and Barrett 1985, Manuwal and Huff 1987, Tobalaske et al. 1991), greater canopy cover in old-growth stands may have provided thermal protection and foraging opportunities especially during the harsher winter. We observed particularly low numbers of golden-crowned kinglets in young growth following storms that coated tree branches with ice and snow. Kinglets were observed foraging primarily in multilayered tree canopies of old growth that appeared to have less snow covering on branches than trees in young stands.

4.5 CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Our results suggest that land managers consider old-growth, temperate rainforest as essential wintering habitat for resident birds. Resident species of birds in northern latitudes must endure harsh winter conditions, and winter survivability is believed to regulate population size in birds (Lack 1966, 1968, Fretwell 1969, 1972). Thus, populations of species associated year-round with old-growth, temperate rainforest in southeast Alaska, such as brown creepers and golden-crowned kinglets (see Franzreb and Ohmart 1978, Mannan and Meslow 1984, Kessler and Kogut 1985, Rosenberg and Raphael 1986, Manuwal and Huff 1987, Raphael et al. 1988, Chapter 3 this study), may be particularly vulnerable to intensive harvest of old growth in this system. In addition, because oceanic islands are known to support fewer species of birds and are more vulnerable to local population extinctions relative to mainland areas (MacArthur and Wilson 1967, Diamond 1975, Temple 1985), species populating such areas as Prince of Wales Island may be less tolerant of habitat perturbations. Furthermore, the ability of birds to colonize northern forested islands following disturbance is related to regional abundances on the mainland and autecological mechanisms (i.e., habitat selection) (Haila 1983, Haila et al. 1983). Thus, long-term reductions in old growth occurring Island-wide may limit the ability of old-growth associates to colonize the Island from mainland areas due to a lack of sufficient old-growth, temperate rainforest habitat.

Results of this study also identify the need to further monitor habitat use by wintering birds in the temperate rainforest habitats of southeast Alaska over a wide range of winter conditions to further define the relationships suggested by this research.

5.0 PRELIMINARY HABITAT CAPABILITY MODEL FOR A NEOTROPICAL MIGRANT ASSOCIATED WITH OLD-GROWTH, COASTAL TEMPERATE RAINFOREST IN SOUTHEAST ALASKA

Key words - coastal temperate rainforest, habitat capability model, neotropical migrant, old growth, Pacific-slope flycatcher, southeast Alaska, timber management

Abstract - We determined the migratory status of 35 species of forest birds and relative use of old growth and young growth by neotropical migrant birds in southeast Alaska. Of the 35 forest bird species, 14 were residents, 13 were short-distance migrants, and 7 were neotropical migrants. Neotropical migrants included Wilson's warbler, orange-crowned warbler, Swainson's thrush, Townsend's warbler, rufous hummingbird, tree swallow, and Pacific-slope flycatcher. Of these 7 species, the Pacific-slope flycatcher was the only neotropical migrant associated with old-growth (average tree age meeting the minimum diameter is > 150 years) forests in southeast Alaska. Literature on Pacific-slope flycatcher habitat use was reviewed from studies conducted in northwestern California, western Washington, and other areas; however, only limited data were available for southeast Alaska. Based on these studies, a preliminary habitat capability model was developed. Additional studies are needed to verify habitat relationships for this species in southeast Alaska, and as a prerequisite to model refinement.

5.1 INTRODUCTION

Neotropical migrants are migratory landbirds that breed in North America and winter in neotropical areas (i.e., south of the United States, Finch 1991). Because these species migrate over considerable distances, they are particularly vulnerable to the cumulative effects of multiple land-use actions that traverse international boundaries (Morton and Greenberg 1989, Askins et al. 1990). Population declines have been reported in some species of neotropical migrants and have been attributed primarily to: (1) predation on the breeding grounds (see Bohning-Gaese et al. 1993 for a review), (2) nest parasitism by the brown-headed cowbird (*Molothrus ater*) (Brittingham and Temple 1983, Temple and Cary 1988), (3) direct reduction and increased fragmentation of breeding habitat (Whitcomb et al. 1977, Terborgh 1989), and (4) deforestation on the wintering grounds (Terborgh 1989, Robbins et al. 1989). Such factors may act individually or in

JLM511 1253

combination (e.g., fragmentation and increased cowbird parasitism; Brittingham and Temple 1983) to influence population status of neotropical migrants.

Although many neotropical migrants that breed in forested habitat have distinct species-specific habitat requirements on the wintering grounds (Lynch 1989, Finch 1991), approximately half of these species winter exclusively in forests (Askins et al. 1990). Population declines in neotropical migrants have been most dramatic in the eastern deciduous forests where this group comprises up to 92% of the forest bird species, including species that occupy the interior of forest patches, and species that are sensitive to habitat fragmentation (Whitcomb et al. 1977). In contrast, only 29% of the forest bird species in the Pacific Northwest are neotropical migrants; however, those species that forage by sallying from the forest canopy (e.g., flycatchers, *Empidonax* spp) have declined substantially (Raphael et al. 1988).

Based on the above, an integrative management program, spanning multinational jurisdictions, is paramount to maintaining viable populations of forest-dwelling neotropical migrants. Conservation of neotropical migrants at local and regional levels is consistent with this strategy and with population viability goals as specified under the National Forest Management Act (1976) and in National Forest plans (e.g., USDA Forest Service 1991).

In intensively managed temperate rainforests of southeast Alaska, a predictive model for determining timber-related impacts to neotropical migrants is essential for maintaining viable populations of this group, particularly in light of anticipated long-term reductions in old growth. Development of such a model necessitates an understanding of factors regulating population size, geographic distribution, and habitat use, including specific use of various forest seral stages. The primary objectives of this study were to: (1) identify a neotropical migrant associated with old-growth, temperate rainforest in southeast Alaska, (2) determine factors influencing distribution and habitat use by this species, and (3) develop a habitat-based model to predict effects of timber management on this species.

5.2 SPECIES SELECTION

The selection of a neotropical migrant for predictive modeling was based on the following criteria: (1) the species must be a long-distance migrant that winters primarily south of the conterminous United States, (2) the species must be associated with

JLM511 1254

old-growth forests of southeast Alaska, and (3) information on habitat use should be available for the species in southeast Alaska or other comparable areas within the species range.

The migratory status of 35 forest-breeding bird species in southeast Alaska was evaluated during a 2-year study of forest bird communities on Prince of Wales Island (see Chapter 3), and by a review of the available literature on migratory habits of these species (American Ornithologists' Union 1983, Armstrong 1991). Information on habitat use and avian community composition for the 35 bird species was obtained from breeding bird surveys and vegetation sampling performed in 15 young-growth (20 years) and 5 old-growth sites (> 150 years) on Prince of Wales Island (see Chapter 3). Of the 35 forest bird species occurring in our study area, 14 (38.9%) were residents, 13 (37.1%) were short-distance migrants, and 7 (19.4%) were neotropical migrants (migratory status of all forest birds observed in our study area is indicated in Appendix D). Although short-distance migrants may winter in neotropical areas in more southerly portions of their range, those species occurring in our study area probably winter in Alaska, British Columbia, and the conterminous United States, and thus did not meet our criteria as neotropical migrants.

Neotropical migrants occurring in our study area included: Wilson's warbler, orange-crowned warbler, Swainson's thrush, Townsend's warbler, rufous hummingbird, Pacific-slope flycatcher, and tree swallow, (Table 5-1). Three of these species, orange-crowned warbler, Wilson's warbler, and Swainson's thrush, nest or forage primarily in the understory of young-growth forest. Two species, Pacific-slope flycatcher and Townsend's warbler, nest or forage in the overstory; however, only the Pacific-slope flycatcher was consistently more abundant in old-growth forests relative to young growth in our study area (see Chapter 3). Therefore, the Pacific-slope flycatcher was chosen as the neotropical migrant on which to base the predictive model.

5.3 PACIFIC-SLOPE FLYCATCHER LITERATURE REVIEW

5.3.1 Breeding Range and Systematics

The Pacific-slope flycatcher is widely distributed in western North America, breeding from southeastern Alaska and northwestern and central British Columbia south to southwestern California and the mountains of northern and southern Baja California (Bent 1942: 247, American Ornithologists' Union 1983: 525). The winter range of this

JLM511 1255

Table 5-1. Life form and habitat association of neotropical migrants, Prince of Wales Island, southeast Alaska.

Species	Life Form[1/]	Habitat Association[2/]	
		Young Growth	Old Growth
Wilson's warbler (*Wilsonia pusilla*)	6	X	
Orange-crowned warbler (*Vermivora celata*)	6	X	
Swainson's thrush (*Catharus ustulatus*)	7	X	
Townsend's warbler[3/] (*Dendroica townsendi*)	10	X	X
Rufous hummingbird (*Selasphorus rufus*)	11	X	
Pacific-slope flycatcher (*Empidonax difficilis*)	11		X
Tree swallow[4/] (*Tachycineta bicolor*)	14		

1/ Life form: 6=nests on ground, feeds in shrubs or trees or in the air; 10=nests in conifers, feeds in trees or shrubs or in the air; 11=nests in trees, feeds in trees or shrubs or on ground or in the air; 14=nests in natural hole, feeds on ground or water or in the air.
2/ Based on results of this study (Chapter 3).
3/ Detected in approximately equal numbers in old growth and young growth (Chapter 3).
4/ Primarily associated with riparian areas (Brown 1985).

species includes southern Baja California, and northwestern Mexico south to the Isthmus of Tehuantepec (American Ornithologists' Union 1983: 525).

Until recently, the Pacific-slope and the Cordilleran flycatchers (*E. occidentalis*) were considered conspecific (western flycatcher). However, recent information on vocalization patterns and allozyme frequencies in the Siskiyou region of northern California where these flycatchers are sympatric, suggests that they are biologically distinct species (Johnson and Marten 1988).

5.3.2 Habitat Use

The Pacific-slope flycatcher is considered common in open coniferous forests of southeast Alaska and accidental along the southcoastal region (Armstrong 1991: 227).

JLM 511 1256

The species is associated with riparian, old-growth areas in southeast Alaska (Kessler and Kogut 1985) and is known to nest close to water (Bent 1942: 247, Johnson 1980, however see Sakai and Noon 1991 and McGarigal and McComb 1992). Nest sites of this species have been reported in live trees, snags, exposed root wads of fallen trees, and on rock ledges near streams (Bent 1942, Armstrong 1991, Sakai and Noon 1991).

Structural characteristics of Pacific-slope flycatcher nest sites vary in association with specific seral stages. Nest sites in young (30-90 years) Douglas-fir/tan oak (*Lithocarpus densiflorus*) forests of northwestern California were characterized by higher shrub cover, greater densities of large (>50 cm dbh) Douglas-fir and Pacific madrone (*Arbutus menziesii*) than random sites (Sakai and Noon 1991). Average nest-tree heights and dbh were approximately 24-m tall and 55-cm dbh, respectively, and canopy cover near nest sites averaged about 92%. In mature (91-199 years) forests, Pacific-slope flycatcher nest sites were characterized by lower mid-canopy bole heights, higher ground cover in the understory layer, and greater densities of small (1- to 10-cm dbh) Pacific madrone than random sites. Nest sites in old growth (>200 years) were characterized by lower mid-canopy bole heights, more closed tree canopies, and higher densities of large (>50-cm dbh, >15-m tall) snags than random sites.

Several studies have reported Pacific-slope flycatchers nesting in higher density in older forests than in younger seral stages (Franzreb 1977, Franzreb and Ohmart 1978, Kessler and Kogut 1985, Sakai 1987, Raphael et al. 1988, Chapter 3 this study). Sakai (1987) measured flycatcher densities using variable circular plots located in young (30-90 years), mature (91-199 years), and old-growth (>200 years) Douglas-fir/tan oak forests of northwestern California. Flycatcher densities were highest in old-growth (130 birds/100 ha), followed by mature- (80 birds/100 ha), and young- growth (10 birds/100 ha) sites. Raphael et al. (1988) determined flycatcher densities using variable circular plots located in sapling (0-20 years), pole/sawtimber (21-80 years), and mature sites (>100 years) in Douglas-fir forests of northwestern California. Flycatcher densities were highest in mature (169 birds/ha) and pole/sawtimber (121 birds/100 ha) stages, and were substantially lower in the sapling (1.6 birds/100 ha) stage.

In western Washington, Manuwal and Huff (1987) calculated an index of bird abundance by using a point count method in young (42-75 years), mature (105-165 years), and old-growth (250-500+ years) Douglas-fir/western hemlock forests. Pacific-slope flycatcher detection rates were highest in old growth (0.69 detections/8 min count), lowest in

mature forests (0.33 detections/8 min count), and intermediate in young forests (0.52 detections/8 min count).

In southeast Alaska, Kessler and Kogut (1985) calculated a relative index of flycatcher abundance based on bird counts conducted along transects through a range of seral stages on Kosciusko and Prince of Wales Island. Flycatchers were considered uncommon in sapling/shrub (11-17 years), common in pole (30 years) and young sawtimber (75 years), common in upland old growth, and abundant in riparian old growth (Kessler and Kogut 1985). In addition, we measured flycatcher abundance using fixed radius (100-m) plots located in 15 young-growth (20 years) and 5 old-growth sites on Prince of Wales Island (Chapter 3 this study). Flycatchers were approximately 6 to 12 times more abundant in old-growth than in young-growth sites. Furthermore, although our sample size was small, we determined that flycatcher abundance was inversely correlated (r = -0.90, P = 0.04, n = 5) with canopy cover in old-growth stands. The relationship between flycatcher detections and several measures of riparian habitat were also evaluated in each stand. No significant relationships were detected; however, this outcome may be related to the lack of accurate stream mapping within the stands. Our observations during surveys suggested that there was some degree of correlation between flycatcher abundance and proximity to streams.

5.4 PACIFIC-SLOPE FLYCATCHER HABITAT MODEL

5.4.1 Model Development

Most habitat capability models developed for MIS of the Tongass National Forest are based on suitability criteria derived from density estimates and habitat relationships in various seral stages and timber volume classes. For instance, suitability indices developed to evaluate brown creeper habitat in southeast Alaska range from 0 for noncommercial forests (timber volume 0-8,000 board feet/acre) where densities of this species are low, to 1 for high volume sites (timber volume +30,000 board feet/acre) where creeper densities are high (Suring et al. 1988b). This relationship between brown creeper density and timber volume is based on a quantitative study conducted in southeast Alaska (Hughes 1985). Data on such associations are most reliable when they are specific to southeast Alaska and when model relationships have been field tested.

The neotropical migrant model we developed for the flycatcher was based primarily on 2 studies conducted on this species in southeast Alaska: Kessler and Kogut's (1985)

study of flycatcher abundance across different seral stages on Prince of Wales and Kosciusko Islands and this study (Chapter 3). However, neither study quantified the relationship between this species and timber volume; Kessler and Kogut (1985) provided only qualitative information on flycatcher abundance across various seral stages and we provided quantitative information on flycatcher abundance for only two seral stages (see Chapter 3). Therefore, the model was supplemented with information on the habitat requirements and density of this species in different seral stages from the Douglas-fir/tan oak forests of northwestern California (Raphael et al. 1988, Sakai 1987, Sakai and Noon 1991) and the Douglas-fir/western hemlock forests of western Washington (Manuwal and Huff 1987). This model should, thus, be considered preliminary. Further study in southeast Alaska is needed to validate and refine this model before application, particularly with regard to the relationship between flycatcher density and timber volume and the value of riparian habitats.

5.4.2 Habitat Model

Our preliminary Pacific-slope flycatcher habitat model is presented in Table 5-2. The model was based on four assumptions. First, flycatcher density increases with forest age, being highest in old growth, lower in younger forests, and zero at the seedling/sapling stage. This assumption is supported by this study, Kessler and Kogut (1985), Manuwal and Huff (1987), Raphael et al. (1988), and Sakai (1987). Second, Pacific-slope flycatchers show some affinity for stream riparian habitats. This relationship may not be as strong as the seral stage association, but is supported by field observations in this study, Kessler and Kogut (1985), and other observations (Bent 1942, Johnson 1980). We speculate that riparian habitats associated with lakes and muskegs are less selected by the Pacific-slope flycatcher, possibly due to competition with the olive-sided flycatcher (*Contopus borealis*). This speculation is supported by the findings of Kessler and Kogut (1985). The olive-sided flycatcher was often observed using habitats associated with lakes and muskegs in our study. Third, flycatcher density is inversely related to timber volume in old-growth forests containing volumes greater than 8,000 board-feet/acre. This assumption is supported by the relationship between canopy cover and flycatcher density observed in this study and Bent (1942), and is based on the assumption that timber volume is correlated with canopy cover in old-growth stands. Fourth, flycatcher densities are relatively high in deciduous forest types (Bent 1942, Brown 1985). We assume further that this is particularly true for the black cottonwood type; abundance is expected to drop in the red alder type due to competition with the alder flycatcher (*Empidonax alnorum*).

JLM511 1259

Table 5-2. Capability of habitats for supporting breeding Pacific-slope flycatchers in southeast Alaska - preliminary model.

Habitat	Suitability Index	Number per 100 ha (#/sq mi)*
Old-growth forest		
Western Hemlock, Sitka spruce, cedar, W. hemlock/spruce		
Riparian (stream)**		
30,000+bf/ac***	0.8	80 (207)
8-30,000 bf/ac	1.0	100 (259)
Noncommercial	0.5	50 (130)
Upland & Riparian (non-stream)		
30,000+bf/ac	0.6	60 (155)
8-30,000 bf/ac	0.8	80 (207)
Noncommercial	0.3	30 (78)
Subalpine	0.0	0 (0)
Black cottonwood	0.8	80 (207)
Red alder	0.5	50 (130)
Clearcut (0-25 yrs)	0.0	0 (0)
Second-growth forest (25-75 yrs)		
Riparian	0.2	20 (52)
Upland	0.1	10 (26)
Second-growth forest (75+ yrs)		
Riparian	0.5	50 (130)
Upland	0.3	30 (78)
Nonforest	0.0	0 (0)
Other	0.0	0 (0)

* See section on Habitat Capability

** The riparian zone width, needs to be determined by field study.

*** bf/ac = board-feet/acre; 30,000+ bf/ac refers to volume classes 6 and 7, 8-30,000 bf/ac refers to volume classes 4 and 5, and noncommercial refers to volume class 3 (< 8,000 bf/ac) from the Tongass National Forest forest land classification system.

5.4.3 Habitat Capability

Sakai (1987) recorded flycatcher densities ranging from 10 to 130 per 100 ha (26-337 flycatchers per sq mi), and Raphael et al. (1988) measured densities ranging from 1.6 to 169 per 100 ha (4-438 flycatchers per sq mi) in northwestern California. Beaver and Baldwin (1975) reported densities ranging from 12 to 69 birds per 100 ha (31-177 flycatchers per sq mi) in Colorado. No information is available regarding densities of

JLM 511 1260

Pacific-slope flycatchers in southeast Alaska, thus we have assumed that maximum flycatcher density is 100 birds per 100 ha (259 birds per sq mi) for the preliminary model.

5.5 CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Prior to broad-scale application of the preliminary flycatcher model presented here, we recommend that a quantitative study of flycatcher population densities be conducted in various habitat types in southeast Alaska. The available database on habitat selection and abundance of this species in southeast Alaska is limited. Our study was not designed to gather information on forest bird communities across various seral stages, riparian areas, or timber volume classes, nor to obtain specific information on nest-site selection by Pacific-slope flycatchers. However, flycatcher densities should be measured in various seral stages, in various volume classes within the old-growth seral stage, and in riparian versus non-riparian habitats. It is also important to identify how far from a stream the riparian zone influence occurs. Stream riparian habitats should be separated from riparian habitats associated with lakes and muskegs because of likely density differences associated with interspecific competition. Information could also be collected on nest-site selection using specialized sampling procedures (e.g., nest-centered vegetation plots, Larson and Bock 1984).

6.0 EFFECTS OF SILVICULTURAL MODIFICATIONS OF YOUNG-GROWTH FOREST ON FORAGE AVAILABILITY AND WINTER/SPRING HABITAT USE OF SITKA BLACK-TAILED DEER, PRINCE OF WALES ISLAND, SOUTHEAST ALASKA

Key Words - Sitka black-tailed deer, precommercial thinning, canopy gaps, old-growth forest, forage, winter habitat, spring habitat, southeast Alaska

Abstract - During 1991 and 1992, we compared availability of forage (forbs, shrubs, tree seedlings/saplings), winter snow conditions, and deer use (pellet-group counts and winter track counts) for Sitka black-tailed deer on Prince of Wales Island, among 4 forest stand types: non-treated young growth (20 years), precommercially thinned young growth, young growth with 0.05-ha openings (i.e., "gaps") created in the overstory canopy, and old growth (>150 years). Our purpose was to determine if 2 silvicultural modifications (gapping and thinning) of young growth were effective for maintaining or enhancing habitat quality for deer after logging of old-growth forest in southeast Alaska. Of 16 plant (6 forb, 6 shrub, and 4 tree) species considered important deer forage in our study area, only 1 species, bunchberry, was associated positively with a silvicultural modification. Both bunchberry (Ps $\leq$ 0.05) and deer spring use (pellet-group counts, P = 0.02) were higher in thinned stands relative to the other 3 stand types. Deer pellet-group counts, winter track counts, and forage species, however, were similar (Ps > 0.05) between gapped stands and each of the other stand types. Although, mean snow depths were similar (Ps > 0.05) among stand types during a relatively mild winter of 1991, mean snow depths were lowest (Ps $\leq$ 0.05) in old growth during the harsher winter studied in 1992. Regardless, deer winter track counts were similar (Ps > 0.05) among stand types. We recommend retention of islands of old-growth forest within logging units to serve as source pools for forb and shrub propagules and as potential bedding sites for deer in young-growth forests.

6.1 INTRODUCTION

The Sitka black-tailed deer is at the northern limit of its distribution in Alaska, and may therefore be subject to extreme environmental conditions (Wallmo 1981). Deer are an MIS of the Tongass National Forest that utilize low elevation old growth (>150 years, Capp et al. 1992: 11, plot sensitivity analysis) for foraging and thermal cover, and to reduce energetic expenditures during winter (Suring et al. 1991). A variety of habitats

JLM511 1262

and elevations are used by deer in the summer to obtain forage (Klein and Olson 1960, Hanley et al. 1984, Suring et al. 1991). During the summer, deer maximize their intake of succulent, nutrient and energy-rich forage to regain lost weight, resume body growth, nurse fawns, and store fat for the winter (Schoen et al. 1982). Summer forage quality varies considerably over the foraging range of deer and in relation to successional changes in understory vegetation following clearcut logging. Residual shrubs, tree seedlings, and understory biomass reach peak levels within 5 years of logging in Sitka spruce - western hemlock forests that are characterized by relatively well-drained soils (Alaback 1982a,b). Elevated forage biomass in recent clearcuts provides forage, especially in areas where logging slash has been removed (Hanley et al. 1984). However, digestible nitrogen content of young plants is low and may limit forage quality (Hanley et al. 1985, Hanley and McKendrick 1985). In addition, this pulse in forage biomass is short-lived (15-20 years), as conifer overstories begin to shade-out understory vegetation (Alaback 1982a,b). Forage biomass typically remains at levels below that of old-growth forests for up to 160 years after logging (Alaback 1982a,b, Hanley et al. 1984). Thus, widespread conversion of old-growth forest to young growth in portions of southeast Alaska has significantly altered the quality of deer forage habitat throughout the commercial forest rotation age (100 years).

A variety of silvicultural modifications, including precommercial thinning and creation of openings (i.e., "gaps") within the overstory of young-growth (15-20 years) stands, has been used to maintain understory vegetation beneficial for deer use and to maximize diameter growth of residual crop trees (Alaback and Tappeiner 1991). Precommercial thinning involves the cutting of small unmerchantable trees to specific stocking densities, with the resulting debris being retained in the stand as "slash". Such thinning is designed to retard crown closure, increase growth rates of potential crop trees by removing nearby competing stems, and extend the duration of understory layers over longer periods of the rotation (Kessler 1982, Crawford and Frank 1987). Light (trees thinned to 2.4 x 2.4 m) to moderate (trees thinned to 3.7 x 3.7 m) thinning is most effective in retaining understory layers, but this response is limited to ≤ 10 years post-thinning (Alaback and Herman 1988). Moreover, thinning contributes to existing slash conditions by adding a second input of debris.

Gapping of young forest overstories is designed to retain understory layers for deer by providing increased light levels for light-dependent forbs and shrubs (Alaback and Herman 1988). Natural canopy openings in coastal conifer overstory are generally characterized by productive and diverse understory layers (Alaback and Herman 1988,

JLM511 1263

Alaback and Tappeiner 1991), are important for establishment of Sitka spruce and other *Picea* spp. (Stewart 1986), and may thus significantly influence overall plant species composition within a young-growth forest stand (Spies and Franklin 1989). Although gapping and thinning of young-growth forest are designed to increase deer forage, the effects of these silvicultural modifications on the quality of deer winter range are poorly understood.

Winter is a critical period for deer populations in southeast Alaska. Severe winter conditions may restrict deer habitat use, reduce mobility and home range size, reduce forage availability, greatly increase energy expenditures, and adversely influence population mortality and recruitment rates (Jones and Bunnell 1984, Nyberg et al. 1985, McNay and Doyle 1987). Snow depth appears to exert the greatest influence on habitat selection by deer (Jones and Bunnell 1984). High-volume old-growth forest <300 m elevation represents the most important deer habitat during high-snow winters primarily because of the snow-intercept properties of older stands (Kirchhoff and Schoen 1987, Schoen and Kirchhoff 1990). Because of uniform tree canopies, young-growth forests typically intercept less snowfall than the multi-layered canopies characteristic of old-growth forests (Wallmo and Schoen 1980, Kirchhoff and Schoen 1987). Both gapping and thinning of young-growth forest may influence deer use during winter by opening conifer overstories and thus changing microclimatic and snow-interception properties of young-growth stands. Nyberg et al. (1986) recommended that, to serve as winter range in coastal British Columbia, young forests should be more patchily distributed among blocks of old growth than most intensively managed stands, and in some patches trees should be maintained at lower densities than normal.

The objectives of our study included the following: (1) compare the availability of deer forage species among silviculturally modified young-growth stands, non-treated young-growth stands, and old-growth stands, (2) compare deer use between young-growth and old-growth stands during spring and winter, and (3) compare characteristics of young-growth and old-growth stands used by deer during spring and winter. Related effects of silvicultural modifications on availability of forage species for black bear were also examined where they overlapped with deer forage species. Black bear occurred throughout our study area (see DellaSala et al. 1992, Appendix A this study), and use some of the same forage species as deer. Notably, because our study was conducted 3-5 years post-thinning and 2-4 years post-gapping, our results represent the period just prior to and during the peak vegetation response to the silvicultural modifications (Alaback and Herman 1988, pers. comm. P. Alaback).

JLM511 1264

6.2 METHODS

We collected vegetation and deer use information from 20 stands on Prince of Wales Island during the spring (April to May), summer (June), and winter (December to February) of 1991 and 1992. For statistical purposes, the study area was divided into 5 geographic areas (i.e., "blocks", Appendix B-1) based on localized differences in topography and plant associations. Dividing the area into geographic blocks allowed us to sample the variation in plant associations across the Island while controlling for the variations in a number of stand characteristics that were unrelated to silvicultural modifications. Blocks were separated by 3-13 km. Four sample stands, representing 1 of each of 4 stand types, were located within each block (n = 20 sample stands) (see Appendix B-1). The 4 stand types studied included (1) non-treated, young growth (i.e., "non-treated"), (2) precommercially thinned, young growth (i.e., "thinned"), (3) canopy-gapped, young growth (i.e., "gapped"), and (4) old growth (>150 years) (see Chapter 2 for detailed description of forest stands). Sample stands within each geographic block were separated by ≤1 km and were selected to represent general characteristics (e.g., elevation, slope, aspect, and dominant plant association) of the block that were unrelated to silvicultural modifications.

Deer habitat use was described along a 1500-m transect that "zig-zagged" through the interior of each stand. Transects were mapped on aerial photos (see Appendix B3 to B22) and then positioned with a compass and hip chain within each stand. All transects were permanently marked using PVC pipe and flagging for repeated visits. Transects were used to conduct deer pellet-group counts and deer-track surveys. In addition, 5 sampling stations were positioned at random distances of 150-300 m along each transect and were permanently marked for repeated sampling. Sampling stations were used to describe general stand characteristics and availability of specific forage species used by deer.

6.2.1 Vegetation Sampling

Vegetation data were collected in June 1991 within nested, circular plots positioned in each of 4 cardinal directions, at random distances of 10-40 m from the center of each sampling station. At each plot, we measured 11 vegetation variables: conifer stem density (stems/ha) in 3 size classes, small (6- to 35-cm diameter at breast height [dbh]), medium (36- to 55-cm dbh), and large (>55-cm dbh); hardwood stem density (small size class only); number of tree species; tree and shrub height (m); percent cover and

JLM 511 1265

height of tree seedlings/saplings (<5-cm dbh); percent cover of ferns, forbs, and shrubs; conifer-canopy cover; and slash in 2 depth categories, <50-cm and >50-cm deep. In old-growth stands, each nested plot consisted of a 10-m-radius and 2 2-m-radius plots. In young-growth stands, each nested plot consisted of a 5-m-radius plot and 2 1-m-radius plots. Plots with smaller radii were used in young growth because of the denser tree spacing relative to old growth. Ten-m-radius plots in old growth and 5-m-radius plots in young growth were used to record tree densities in 10-cm-dbh classes, tree height, and percent tree-canopy cover. Total shrub cover was also recorded in the 5-m-radius plots. Tree-canopy cover was estimated by sighting through an ocular tube (James 1971) for the presence of vegetation from 5 points (plot center and 4 cardinal points) located within each plot. Average tree height estimates were obtained by measuring the height of the 2 dominant trees nearest plot center using a clinometer. Vegetation recorded in the small (1- or 2-m-radius) nested plots included percent cover of important forage forbs and shrubs, fern cover, slash cover, cover and height of tree seedlings/saplings, and shrub heights.

Based on the diet of deer in southeast Alaska (Hanley et al. 1984, Hanley and McKendrick 1985) and plant species occurrences in our study area, we estimated percent cover for 6 forb species: fern-leaf goldthread (*Coptis asplenifolia*), foam flower (*Tiarella trifoliata*), five-leaf bramble, bunchberry, deer heart (*Maianthemum dilatatum*), and yellow skunk cabbage. Skunk cabbage is also considered an important forage of black bear in southeast Alaska (Modafferi 1982, Suring et al. 1991). Cover and height estimates were provided for 6 shrub species: blueberries (*Vaccinium* spp.), currants (*Ribes* spp.), salmonberry, devil's club, rusty menziesia, and elderberry. Blueberries are considered the most important shrub species that serves as forage for deer in southeast Alaska (Hanley and McKendrick 1985); salmonberry and blueberries are considered important forage for bears in southeast Alaska as well (Modafferi 1982, Suring et al. 1991). Cover and height estimates were also provided for seedlings/saplings of 4 tree species known to be used by deer as forage (Hanley et al. 1984, Hanley and McKendrick 1985): western redcedar, Sitka spruce, western hemlock, and red alder.

To further describe general stand characteristics, we mapped the location of canopy gaps from aerial photos of stands. No distinction was made between natural and artificial gaps and only gaps ≥0.05 ha were mapped. Mapped locations of canopy gaps were verified opportunistically while walking between sampling stations. Once verified, the GIS was used to calculate distance from sampling stations to the nearest canopy gap.

JLM511 1266

6.2.2 Deer Pellet-group Counts

A relative index of deer use was obtained from pellet-group counts (Neff 1968, Fairbanks 1979) conducted in each study plot from 25 April to 12 May 1991 and from 22 April to 30 April 1992. Although, pellet-group counts have been used to estimate deer abundance and habitat use in southeast Alaska (Doerr and Sandburg 1986, Kirchhoff and Pitcher 1988, Mankowski and Peek 1989, Kirchhoff 1990), a number of problems have been identified with using pellet-group counts as an index to relative habitat value for deer. Such problems include habitat-specific in defecation rates, pellet persistence times, and differences in observability of pellet groups (Kirchhoff 1990, Fuller 1991). Since our study is likely affected by these factors as well, analysis of deer pellet groups was conducted with recognition that small differences in use identified between stands may be inconclusive.

Deer pellet groups were counted within 0.5 m on either side of the 1500-m transects in each study stand. Pellet groups were counted only if the center of the pellet group occurred within the transect belt. Pellet groups were not removed prior to the survey, and all identifiable pellet groups were counted regardless of age. Pellet-group counts were expressed as the total number of pellet groups occurring along the 1500-m transect within each stand.

6.2.3 Winter Track Surveys and Snow Cover Estimates

To gather information on deer use during the critical winter period, tracks were counted when snow was present and stands were accessible. Based on a recent study of black-tailed deer (*Odocoileus hemionus*) in managed forests of western Washington (Raedeke and Major 1989), winter track counts compared favorably to other more expensive methods, including radio-telemetry, for demonstrating habitat-use patterns of wintering deer. Winter track counts were performed along the same 1500-m transects as the pellet-group surveys. Although our study was initially designed to conduct winter track surveys during 3 periods each winter, the unusually mild winter in southeast Alaska during 1991-92 limited our ability to conduct track surveys to 1 period when snow was present. Heavy snowfall in 1992-93 also limited track surveys to 1 period when stands were accessible. Track counts were performed from 18 to 24 February 1992 and from 12 to 16 January 1993. Tracks were counted only if they crossed the transect. Care was taken to avoid multiple counting of the same set of tracks that crossed the transect repeatedly. All stands within the same geographic block were

surveyed on the same day to ensure that changing weather conditions did not affect the relative visibility of tracks or the time since last snowfall between stands within the same geographic block.

Snow cover estimates were obtained for each of the sample stands using 2 methods. First, to compare average snow depth among stand types, we took 3 snow-depth measurements using a calibrated probe along 50 m of the transects nearest the vegetation sampling stations. Snow-depth sampling stations were marked with flagging for repeated measurements. One of the 3 measurements was taken at the center of the vegetation sampling station; the remaining 2 were spaced at 15-m intervals along the transect. Thus, 15 snow-depth measurements (3 measurements per station x 5 stations per stand) were taken in each stand. Second, because total snow cover is influenced primarily by canopy coverage, which differed greatly among stand types, snow cover had to be estimated along each transect so that track counts could be compared among stand types. This was accomplished by estimating the percentage of each transect that was snow covered. To aid in accuracy of snow-cover estimates, transects were divided into segments along which percent snow-cover was estimated. Transect segments ranged from 50-300 m in length and corresponded to inflection and end points along each transect (see Appendix B). Total snow cover was then expressed as the weighted average of percent snow-cover estimates obtained from the transect segments. Winter-track counts were also standardized according to the percent of the transect cover by snow.

6.2.4 Statistical Analysis

Individual stands served as the experimental units for statistical comparisons. All vegetation measurements were averaged for the nested, circular plots at each sampling station. The means calculated for vegetation variables at each station, and other prominent stand features (e.g., canopy gaps), were then averaged among sampling stations to provide a mean estimate for each stand. Vegetation variables were compared among stand types using a Randomized Block ANOVA, blocking on the 5 geographic areas. The model assumes that the blocking factor is fixed and therefore the possibility of any interactions between the geographic blocks and the stand types was not considered (Neter and Wasserman 1983). Means calculated for deer pellet-group counts and track counts were compared among stand types using a Split-plot ANOVA procedure. Year served as the whole plot, stand type as the subplot, and geographic area the blocking variable. The interaction term used in this model was the stand type-

JLM511 1268

by-year interaction; no geographic block-by-stand type nor block-by-year interaction term was calculated. Significant stand type-by-year interactions were examined by comparing stand types for each year separately using One-way ANOVA.

When necessary to improve normality and/or stabilize variances, vegetation and deer use variables were transformed using either arcsine (for all percentages) or square-root transformations (Zar 1984: 239, 241). The Friedman's test was used if transformations were ineffective and as a validation of the Randomized Block ANOVA model. The Randomized Block ANOVA was assumed to be robust enough to withstand limited departures from normality or variance homogeneity when the test results were consistent with the Friedman's test. If results of the Randomized Block ANOVA were significant ($P \leq 0.05$), Tukey's HSD analysis was then used to locate differences between specific stand types.

Because of reliability/accuracy problems associated with the use of deer pellet-group counts for estimating relative habitat use by deer, significance probabilities for pellet-group comparisons were $P \leq 0.01$. For consistency, we also used significance probabilities of $P \leq 0.01$ for the deer winter-track counts. All other statistical tests were run using significance probabilities of $P \leq 0.05$. Marginal significance was assigned to $0.05 < P < 0.10$, excluding pellet-group analyses. All analyses were run on SYSTAT (Wilkinson 1990).

6.3 RESULTS

6.3.1 Vegetation Characteristics

Several of the 11 vegetation variables measured differed among stand types; these differences were generally either attributed to a young-growth modification (i.e., thinning, gapping) or to overall differences in stand age (i.e., old growth vs. young growth).

Young Growth - Five of 11 vegetation variables measured differed (Ps ≤ 0.10) among the 3 young-growth stand types (Table 6-1). Three vegetation variables in thinned stands differed consistently from one or more of the other young-growth stand types. Thinned stands were characterized by lower densities of small conifers (Ps ≤ 0.05), lower percent canopy cover (Ps ≤ 0.10), and higher percentages of slash cover >50-cm deep (Ps ≤ 0.05). Two vegetation variables in gapped stands differed (Ps $\leq$

JLM 511 1269

Table 6-1. Vegetation characteristics ($\bar{x}\pm$SE) of non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92.

	Stand Type[1/]			
Vegetation Characteristic	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Small (6- to 35-cm dbh) conifer/ha[2/]	1,117.9±75.2A	1,117.9±233.0A	435.4±30.0B	411.6±36.9B
Medium (36- to 55-cm dbh) conifer/ha	1.3±1.3A	2.5±2.5A	0[3/]	60.2±4.5B
Large (>55-cm dbh) conifer/ha	0	0	0	52.8±9.4[3/]
Hardwoods (10- to 30-cm dbh)/ha[2/]	45.8±34.5A	85.3±70.5A	17.8±12.0A	2.9±2.9A
No. tree species	3.2±0.4A	3.2±0.4A	2.8±0.6A	3.8±0.5A
Conifer canopy cover (%)[2/]	62.4±4.9A	58.2±9.0B	38.4±5.2AB	86.2±8.2C
Tree height (m)	7.1±0.2A	7.3±0.5A	8.0±0.3A	29.1±1.9B
Slash in piles <50-cm deep (%)[2/]	7.9±1.4A	11.1±2.2A	12.4±1.6A	8.4±3.7A
Slash in piles >50-cm deep (%)[2/]	7.7±1.1A	8.5±1.0A	17.4±3.2B	7.0±1.2A
No. canopy gaps/ha[4/]	0.04±0.02A	0.73±0.04B	0.09±0.03A	0.14±0.06A
Distance to gap (m)[2/, 4/]	288.4±56.7A	54.6±10.7B	191.0±40.8AB	162.6±55.8AB

1/ Means sharing the same letter did not differ significantly ($P > 0.05$); underlined letters indicate means that differed marginally ($0.05 < P < 0.10$) (ANOVA, Tukey's HSD-test).
2/ Untransformed means.
3/ No statistical analysis was conducted.
4/ Canopy gaps were $\geq$ 0.05 ha.

JLM511 1270

0.05) from at least 1 of the other 2 young-growth stand types: gapped stands were characterized by higher gap densities and lower distances to gaps.

Young Growth vs. Old Growth - Five of the 11 vegetation variables measured differed (Ps $\leq$ 0.05) between old-growth and young-growth stand types (Table 6-1). Old-growth stands were characterized by lower densities of small conifers, higher densities of medium and large conifers, greater percent canopy cover and tree heights than the young-growth stand types.

6.3.2 Forage Species

Young Growth - Cover estimates for the combined deer forage layers for ferns were similar (Ps $>$ 0.05) among young-growth stand types; however, thinned stands had greater (Ps $\leq$ 0.05) forage and shrub cover estimates than other young-growth stand types (Table 6-2). Cover estimates for all individual forb species, except bunchberry, were below 10% among young-growth stand types. Cover estimates differed among stand types for only 1 of 6 forb species (Table 6-3). Mean percent cover of bunchberry was greater ($P \leq 0.05$) in thinned stands than in non-treated stands.

Table 6-2. Mean ($\pm$SE) percent cover of fern, forb, and shrub layers in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth ($>$150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92.

	Stand Type[1/, 2/, 3/]			
Forage Layer	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Fern (%)	4.3$\pm$0.8A	3.0$\pm$0.5A	4.0$\pm$1.3A	1.7$\pm$0.4A
Forb (%)	11.2$\pm$2.2A	16.4$\pm$2.4AB	22A$\pm$5.0B	21.9$\pm$3.9B
Shrub(%)	47.5$\pm$5.3A	43.3$\pm$3.0A	66.2$\pm$6.1B	45.2$\pm$4.7A

1/ Based on combined percent cover estimates for all species considered as deer forage.
2/ Means sharing the same letter did not differ significantly (P $>$ 0.05) (ANOVA, Tukey's HSD-test).
3/ Untransformed means.

Cover and height of all 6 forage shrubs were statistically similar (Ps $>$ 0.05) among all young-growth stand types (Table 6-4). Percent cover of seedlings/saplings of 2 of the 3 conifer species identified was statistically similar (Ps $>$ 0.05) among young-growth stand types. Percent cover of western hemlock, however, was greater ($P \leq 0.05$) in gapped vs. thinned stands. In addition, the height of conifer seedlings/saplings differed

JLM511 1271

Table 6-3. Mean (±SE) percent cover of forb species considered forage of Sitka black-tailed deer in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92.

	Stand Type[1/, 2/]			
Species	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Fern-leaf goldthread (*Coptis asplenifolia*)	0.5±0.5A	0.4±0.1A	0.1±0.1A	1.0±0.5A
Foam flower (*Tiarella trifoliata*)	0.6±0.3A	0.3±0.2A	0.4±0.2A	0.6±0.3A
Five-leaf bramble (*Rubus pedatus*)	1.0±0.4A	1.6±0.6A	2.5±1.1A	2.9±0.8A
Bunchberry (*Cornus canadensis*)	6.9±1.5A	12.2±1.6AB	18.1±4.4B	6.6±1.5A
Skunk cabbage (*Lysichitum americanum*)	0.7±0.4A	2.3±1.0AB	1.4±1.1A	7.1±2.2B
Deer cabbage (*Maianthemum dilatatum*)	1.2±0.7A	0.3±0.1A	0.3±0.2A	0.5±0.3A

1/ Means sharing the same letter did not differ significantly ($P > 0.05$) (ANOVA, Tukey's HSD-test).
2/ Untransformed means.

(Ps ≤ 0.05) among young-growth stand types (Table 6-5). Mean height of western redcedar was marginally greater (Ps ≤ 0.10) in gapped stands as compared to thinned and non-treated stands; mean height of Sitka spruce was lower ($P \leq 0.05$) in thinned stands as compared to non-treated stands, and mean height of western hemlock was lower (Ps ≤ 0.05) in thinned as compared to gapped and non-treated stands. Red alder occurred sporadically among young-growth stand types, averaging between 0.1 and 1.4% coverage, and was thus too rare for statistical comparisons.

Young Growth vs. Old Growth - Between gapped and old-growth stands, percent coverages of ferns, forbs, and shrubs were similar (Ps > 0.05) (Table 6-2). Between non-treated and old-growth stands, fern and shrub cover percentages were also similar (Ps > 0.05); however, forb cover was lower ($P \leq 0.05$) in non-treated stands. Between thinned and old-growth stands, fern and forb cover were similar (Ps > 0.05) in fern and forb cover, but shrub cover was higher ($P \leq 0.05$) in thinned stands.

JLM511 1272

Table 6-4. Mean (±SE) percent cover and height of shrub species considered forage of Sitka black-tailed deer in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92.

		Stand Type[1/]			
Species	Variable	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Currant (*Ribes* spp.)	Cover (%)[2/]	0.3±0.2AB	0.5±0.2A	0.5±0.1A	0.1±0.1B
	Height (cm)[2/]	11.4±6.9AB	8.9±2.7AB	13.7±2.5A	1.0±1.0B
Salmonberry (*Rubus spectabilis*)	Cover (%)[2/]	9.5±3.4A	5.4±1.6AB	8.0±3.9AB	0.1±0.1B
	Height (cm)	97.9±8.2A	88.2±26.4A	64.6±18.2AB	10.5±8.5B
Devil's club (*Oplopanax horridum*)	Cover (%)[2/]	1.2±0.3A	0.5±0.3A	1.8±0.8A	1.7±0.7A
	Height (cm)	66.9±14.2A	38.6±19.3A	41.5±22.8A	47.5±12.5A
Rusty menziesia (*Menziesia ferruginea*)	Cover (%)[2/]	2.7±1.1A	7.9±2.2A	8.5±2.6A	4.9±1.2A
	Height (cm)	56.5±22.0A	104.4±18.3A	84.0±23.3A	142.6±24.6A
Blueberry (*Vaccinium* spp.)	Cover (%)[2/]	29.6±4.9A	31.5±4.2A	36.4±5.4A	26.9±4.3A
	Height (cm)	120.3±9.0A	116.9±5.2A	115.9±6.9A	118.4±8.6A
Elderberry (*Sambucus racemosa*)	Cover (%)[2/]	0.2±0.1A	0.1±0.1A	0.1±0.1A	0A
	Height (cm)	28.4±12.4A	9.6±7.0A	4.8±4.8A	0A

1/ Means sharing the same letter did not differ significantly ($P > 0.05$); underlined letters indicate means that differed marginally ($0.05 < P < 0.10$) (ANOVA, Tukey's HSD-test).
2/ Untransformed means.

JLM511 1273

Table 6-5. Mean (±SE) percent cover and height of tree seedlings/saplings (< 5-cm dbh) considered forage of Sitka black-tailed deer in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (> 150 years) conifer forest stands on Prince of Wales Island, southeast Alaska, 1991-92.

		Stand Type[1/]			
Species	Variable	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Western redcedar	Cover (%)[2/]	0.8±0.5A	0.9±0.3A	0.2±0.1A	0.4±0.3A
(*Thuja plicata*)	Height (cm)[2/]	22.7±15.5A	73.4±26.3B	14.4±12.5A	9.4±5.0A
Sitka spruce	Cover (%)[2/]	2.6±1.0A	4.0±1.2A	1.4±0.4A	1.2±0.5A
(*Picea sitchensis*)	Height (cm)[2/]	134.5±25.2A	120.4±20.2AB	56.6±4.1BC	50.4±10.3C
Western hemlock	Cover (%)[2/]	16.0±4.9A	17.7±5.4AC	3.8±1.2AB	11.5±2.4A
(*Tsuga heterophylla*)	Height (cm)	175.3±7.7A	183.4±7.5A	83.0±6.8B	79.3±3.6B

1/ Means sharing the same letter did not differ significantly ($P > 0.05$); underlined letters indicate means that differed marginally ($0.05 < P < 0.10$) (ANOVA, Tukey's HSD-test).
2/ Untransformed means.

JLM511 1274

Two of 6 forb species (bunchberry and skunk cabbage) differed (Ps $\leq$ 0.05) between young growth and old-growth stands (Table 6-3). Mean percent cover of bunchberry was higher in thinned than in old-growth stands, and mean percent cover of skunk cabbage was higher in old growth than in thinned and non-treated stands.

Mean percent cover and/or height of 2 of 6 shrub species (currant and salmonberry) differed marginally (Ps $\leq$ 0.10) among stand types (Table 6-4). Mean percent cover of currant was greater (Ps $\leq$ 0.05) in gapped and thinned stands as compared to old-growth stands, and mean height of currant was marginally greater ($P \leq 0.10$) in thinned stands than in old growth. In addition, mean percent cover of salmonberry was greater (Ps $\leq$ 0.05) in non-treated than in old-growth stands. Mean height of salmonberry was also greater (Ps $\leq$ 0.05) in non-treated and gapped stands than in old-growth stands.

Although percent cover of conifer seedlings/saplings was similar (Ps $>$ 0.05) among stand types, mean height of conifer seedlings/saplings differed marginally (Ps $\leq$ 0.10) (Table 6-5). Mean height of western redcedar was marginally lower ($P \leq 0.10$) in old growth than in gapped stands. Mean height of Sitka spruce was greater (Ps $\leq$ 0.05) in non-treated and gapped as compared to old-growth stands. Mean height of western hemlock was lower (Ps $\leq$ 0.05) in old growth relative to non-treated and gapped stands.

6.3.3 Deer Pellet-group Counts

The mean number of deer pellet groups/1500 m of transect differed among stand types ($P = 0.001$); this pattern was consistent for both years ($P = 0.19$). Thus, pellet-group counts for each stand type were pooled across years (Table 6-6). Although numbers of pellet groups were similar (Ps $>$ 0.05) among young-growth stand types, thinned stands had higher ($P = 0.02$) numbers of pellet groups than old-growth stands.

6.3.4 Snow Coverage and Winter Deer Track Counts

Differences in mean percent snow cover and mean snow depth among stand types differed ($P = 0.03$) between years. Both the mean percent snow cover and mean snow depth were statistically similar (Ps $>$ 0.05) among all stand types in 1991 and were similar (Ps $>$ 0.05) among young-growth stand types in 1992 (Table 6-6). Mean snow

JLM511 1275

Table 6-6. Mean (±SE) number of Sitka black-tailed deer pellet groups/1500 m, deer winter tracks/100 m, snow depth, and snow cover in non-treated, canopy-gapped, and precommercially thinned young-growth (20 years), and old-growth (>150 years) conifer forest stands on Prince of Wales Island, southeast Alaska 1991-93.

		Stand Type[1/, 2/]			
Variable	Year	Non-treated (n=5)	Gapped (n=5)	Thinned (n=5)	Old Growth (n=5)
Deer pellet groups/1500 m	1991	35.6±12.7A	58.4±17.5A	49.6±9.6A	27.0±9.1A
	1992	20.8±7.0A	30.6±10.3AB	50.4±6.2B	7.8±1.8A
	1991-92[3/]	28.2±7.3A	44.5±10.6A	50.0±5.4AB	17.4±5.4AC
Deer tracks/100 m	1991-92	1.1±0.7A	1.0±0.6A	3.9±1.5A	2.5±2.0A
	1992-93	1.3±0.5A	2.4±1.5A	3.8±0.4A	6.0±1.6A
	1991-93[3/]	1.2±0.4A	1.8±0.8A	3.8±0.6A	4.4±1.2A
Snow depth (cm)	1991-92	2.5±1.2A	3.6±1.9A	1.8±1.0A	1.3±0.7A
	1992-93	21.2±2.1A	23.3±3.5A	25.2±2.5A	12.0±2.1B
Snow cover (%)	1991-92	75.1±16.8A	71.7±20.1A	50.0±18.0A	26.9±19.6A
	1992-93	96.9±1.5A	98.8±0.4A	98.9±0.4A	92.9±3.6A

1/ Means sharing the same letter did not differ significantly ($P > 0.01$ for deer tracks and pellet groups; $P > 0.05$ for snow cover and snow depth) (ANOVA, Tukey's HSD-test).
2/ Untransformed means.
3/ Pooled means.

II M511 1978

depth, however, was lower (Ps $\leq$ 0.05) in old growth than in the 3 young-growth stand types in 1992. During 1992, snow depths recorded in old-growth stands were about 1/2 those recorded in each of the young-growth stand types.

Mean numbers of deer tracks/100 m of transect were statistically similar (P = 0.16) between years and thus means for individual stands were pooled across years. Differences in mean number of deer tracks were significant (F = 3.5, P = 0.02) among stand types (Table 6-6). The higher mean number of deer tracks in old growth and thinned stands relative to non-treated stands was marginally significant (Ps $\leq$ 0.10). Mean number of deer tracks was statistically similar (Ps > 0.05) between gapped stands and each of the other 3 stand types.

6.4 DISCUSSION

6.4.1 Deer Forage and Pellet-group Counts

Although we recognize that problems exist with the use of pellet-group counts for quantifying deer use, we believe that our findings are strong enough to suggest that thinning young-growth stands may be an effective deer habitat enhancement measure for the following reasons: (1) high pellet-group counts (and low P-value [0.02]) in thinned stands compared to old-growth stands; (2) high ranking of pellet-group counts in thinned stands relative to the other 3 stand types, and the consistency of this pattern for both years; and (3) the marginally higher winter track counts in thinned stands relative to non-treated stands, and the consistency of this pattern for both years.

Based on pellet-group counts, Doerr and Sandburg (1986) also observed higher deer use of precommercially thinned stands (thinned 18 years prior to study) relative to non-treated stands in 34-year-old clearcuts just north of Prince of Wales Island. In contrast, Mankowski and Peek (1989) did not observe significant deer use within precommercially thinned 15- to 20-year-old clearcuts on northern Prince of Wales Island; they noted that extremely high levels of slash resulting from thinning apparently excluded deer use from these stands. Notably, slash from thinning had largely decomposed by the time of Doerr and Sandburg's (1986) study was conducted. Although observed slash cover was higher on thinned stands relative to non-treated stands in our study, slash cover was apparently not high enough to exclude deer. Hanley et al. (1984) and Mankowski and Peek (1989) report that slash > 25-cm-deep can significantly impair deer movements. They recommend the placement of slash in piles to facilitate movement of deer in

JLM511 1277

thinned stands. Although slash appeared not to be stacked in piles in the thinned stands we studied, numerous skid trails and old logging roads bisected these stands and may have facilitated deer movement.

Based on the results of deer forage comparisons, thinning was apparently effective in enhancing deer forage in young-growth stands, by increasing total forb and shrub layers, and by increasing 1 of 6 forb species that is highly important deer forage. Thinned stands were characterized by higher levels of bunchberry relative to non-treated stands. Higher levels of bunchberry in precommercially thinned stands relative to unthinned stands were also reported by (Doerr and Sandburg 1986). Bunchberry is a significant component of deer diets in southeast Alaska (Hanley et al. 1984) and is of major importance in determining the quality of deer winter range (Hanley and McKendrick 1985). Furthermore, Yeo and Peek (1989) found bunchberry to be the plant species most highly correlated with preferred deer habitat.

None of the 6 shrub forage species quantified was significantly associated with thinning. This finding conflicts with that of Doerr and Sandburg (1986) who found significantly higher blueberry coverage in thinned relative to unthinned stands. Because our study was conducted only 3-5 years after thinning, versus 18 years post-thinning as in the Doerr and Sandburg (1986) study, sufficient time may not have elapsed for effects of thinning on shrub layer to become apparent. Alaback and Tappeiner (1984) noted that, within 5 years following thinning of stands with established understories, woody shrub production tends to increase markedly over other understory layers.

In contrast to other forage species, of the 4 tree forage species quantified, western hemlock seedlings/saplings appeared to be negatively effected by thinning. This finding conflicts with that of Alaback and Herman (1988) who found that extreme thinning (trees thinned to 6.1-m-spacing) in young spruce-hemlock stands in the central Oregon Coast Range stimulated the development of a secondary hemlock layer. This discrepancy between our study and Alaback and Herman (1988) may be because thinning in our study was not intense enough to stimulate a secondary hemlock layer and/or because the time elapsed since thinning occurred may not have been long enough for a secondary layer to develop. In contrast to Alaback and Herman (1988), thinning in our study area was considered moderate (trees thinned to 3.7-m-spacing) to heavy (4.3-m-spacing), and both percent cover and height of hemlock was lower in thinned stands relative to the other young-growth stand types.

Gapping of young-growth forests apparently had relatively little influence on deer forage species and no significant influence on deer use (based on pellet-group counts) of young-growth stands. Western redcedar was the only forage species that apparently benefitted from gapping. This finding concurs with those of Spies and Franklin (1989) who found that small gaps formed in otherwise dense overstories were necessary to maintain shade-tolerant species such as western redcedar. They concluded that shade-tolerant species were able to persist in canopy openings characterized by variable light levels due to shading from lateral tree branches.

In our study, vegetation plots were located randomly along transects bisecting the interior of each study stand, thus no special effort was made to position plots within individual canopy gaps. Studies of canopy gaps elsewhere, however, have been based on sample plots located directly within canopy gaps. DeMeo (1989) studied 60 artificially created canopy gaps (0.04-ha) in young (26-35 year) spruce-hemlock stands on Prince of Wales Island. He found mean deer browse was greater in gaps than in adjacent young growth, but was still significantly lower than in old-growth stands.

Lack of significant differences in availability of most deer forage species among stand types may have been due to the following: (1) high variability associated with most cover estimates, (2) abundance of forage species prior to silvicultural modifications, (3) differences in site productivity among forest stands, (4) time-related lags in vegetative response following silvicultural modification; and/or (5) lack of response to silvicultural modifications. Increasing sampling intensity within stands and adding more stand replicates would provide greater statistical power and perhaps reveal more differences in cover estimates of forage species than we detected. In particular, forb species were not uniformly distributed in our study stands and thus greater sampling would be required to produce stable variances associated with cover estimates. Although we made every effort to select stands to be as similar as possible in gross vegetative characteristics and physiography, differences in site productivity may have inhibited our ability to detect effects of silvicultural modifications.

Because our study was conducted 3-5 years following thinning, our results represent the period just prior to and during peak vegetation response to thinning (Alaback and Tappeiner 1984, Alaback pers. comm.). Additional years of study would have overlapped more closely with the peak in vegetation response and may have revealed more detectable patterns in vegetation layers related to the silvicultural modifications.

Alaback and Herman (1988) found that where shade-tolerant overstory trees such as *Tsuga* spp. can effectively colonize the understory, heavy thinning (trees thinned to 4.9- x 4.9-m) did not significantly change shrub and herb productivity in western hemlock-Sitka spruce forests of the central Oregon Coast Range. Periodic light (trees thinned to 2.4- x 2.4-m) to moderate (3.7- x 3.7-m) thinnings were more effective at encouraging forb and shrub diversity in their study than less frequent, but heavier, thinnings. The thinning grids we studied (trees thinned to 3.7- x 3.7-m and 4.3- x 4.3-m) correspond to the moderate to heavy thinning grids used by Alaback and Herman (1988) in *Tsuga*-dominated stands of the Oregon Coast Range, and thus thinning in our stands may have been too severe to stimulate development of forage species. In addition, Alaback and Herman (1988) suggest that some form of forest floor disturbance, such as low-intensity fire or soil mixing, may be necessary immediately following site disturbance to reduce the density of older hemlock seedlings and to create microsites for a wider range of plant propagules. Although we agree with the potential value of site preparation as a means of producing microsites for propagule development, fire is not part of the natural disturbance regime in southeast Alaska (Alaback and Juday 1989, Alaback 1991, Alaback and Tappeiner 1991) and western hemlock seedlings/saplings were negatively associated with thinning in our study. Moreover, any soil disturbance would need to be conducted away from streams and unstable slopes to avoid problems with soil instability and would need to be limited to control potential stimulation of red alder development which would inhibit potential conifer regeneration.

Alaback and Herman (1988) hypothesized that because of the reproductive limitations of many perennial forb and shrub species, the best understory development will likely occur when pockets of viable understory clones are maintained throughout the forest development cycle through the use of periodic thinning or gapping of young stands. While we agree that maintenance of understory clones throughout commercial forest rotations encourages forb development, such forb development may be better accomplished by leaving small islands of old growth that can act as population source areas for dispersal of forbs and shrubs into adjacent regenerating forests. Such use of leave-tree islands may be especially important in regenerating forests dominated by shade tolerants such as *Tsuga* spp. Dominance by shade-tolerants limits forb and shrub regeneration even in the presence of thinning and gapping (Alaback and Herman 1988).

JLM511 1280

6.4.2 Snow Coverage and Deer Winter Track Counts

The winter of 1992-93 was characterized by greater snow depths and a more continuous distribution of snowfall relative to 1991-92. In contrast to young-growth stand types, old-growth stands were characterized by an extensive canopy layer that intercepted snowfall. Consequently, snow depths were significantly lower in old-growth than in the young-growth stands in 1992-93, and although not statistically different, both snow depth and snow coverage were lower in old-growth stands in 1991-92 as well. Although overall snow depth in old growth was approximately half that recorded in young-growth stands, deer winter-track counts were similar between old- and young-growth stands. This lack of difference in apparent deer use may be due to the relatively low snowfall recorded in our area during our years of study. Snow levels in our study area averaged <30 cm, even during the winter of 1992-93. Suring et al. (1991) indicated that snow depths >30 cm impede deer movements and increase energetic costs associated with locomotion. Thus, snow depths may not have been deep enough to preclude deer movements in our study stands, especially in old growth. Moreover, all but 3 of the 20 stands we studied were <245 m asl and thus were within the elevation range considered to be high quality deer winter range in southeast Alaska (Suring et al. 1991). Our results may have been different if stands occurred at higher elevations with increased snow levels and lower deer use.

6.5 CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Based on the results of this study, thinning was apparently an effective enhancement of young-growth forest for deer habitat. Bunchberry, an important deer forage species, was the only forage species that had significantly higher cover in thinned stands, and deer use was higher in thinned stands. Alaback and Herman (1988) indicated that the effectiveness of precommercial thinning in retaining understory layers was limited by rapid canopy closure following thinning and by the abundance of forage species in stands prior to thinning. They concluded that periodic thinning was necessary to prevent canopy closure in young stands with productive overstories. Thus, we recommend that managers considering the use of precommercial thinning in young-growth stands to maintain deer forage evaluate stands based on the following criteria: (1) site productivity and abundance of forage species (especially bunchberry) prior to stand harvest and thinning; (2) the costs of repeated treatments required to maintain deer forage in a young-growth stand; and (3) the importance and costs of slash treatment to increase access by deer to forage within manipulated stands. Slash treatment may be

especially critical in stands that lack suitable travel corridors for deer. The use of light to moderate, repeated thinning, is likely to be more cost-effective for maintaining deer forage species over a longer time period than heavy thinning conducted less frequently. We believe that variable-spaced thinning, which has been recommended as a means of producing greater horizontal and vertical structure (Spies 1991, McComb et al. 1993), should be investigated for enhancing deer winter range. Nyberg et al. (1986) recommended that a pattern of small patches of dense canopy interspersed with more open patches, would provide an optimum mix of shallow snow and abundant food for coastal British Columbia young-growth stands being managed as deer winter range. Because this study was conducted only 3-4 years following thinning, we also recommend the establishment of permanent vegetation plots and the continued use of seasonal deer surveys to determine whether vegetation responses and deer use changes over time.

Gapping of young-growth stands apparently had little effect on most deer forage species and deer use. However, because vegetation plots were not centered within canopy gaps our results regarding the effectiveness of canopy gapping are inconclusive. Therefore, we recommend the establishment of permanent vegetation plots within canopy gaps and the continued use of seasonal deer surveys to determine whether vegetation responses and deer use changes over longer periods of time in gapped stands.

We also recommend experimenting with the use of old-growth islands as population source areas for forb and shrub species. Old-growth islands that contain pockets of forb and shrub species may prove useful for long-term retention of forb and shrub layers throughout a stand. Such islands could be retained as clumps within regenerating stands where they could serve as source areas for colonization of regenerating forests by forbs. In addition to their value as forage areas, old-growth islands may also provide limited thermal and hiding cover for deer in young stands. We frequently observed evidence of deer "bedding" sites within residual tree clumps in young-growth stands. These islands could be left as part of logging prescriptions and incorporated with leave-tree requirements for other wildlife species (e.g., residual trees for old-growth associated forest birds, Chapter 3). However, such leave-tree islands should not be considered as replacement or mitigation for logging of intact blocks of old growth that provide essential thermal cover for deer in southeast Alaska (Suring et al. 1991). We believe that optimum prescription for a young-growth stand may include a combination of repeated, variable-spaced thinning and retention of old-growth islands. The thinned areas would consist primarily of light to moderate thinning, interspersed with small patches of no thinning and heavy thinning. Old-growth islands would be interspersed to

the extent practicable. The structural diversity expected to result should provide a mixture of areas with forage, cover, snow-free bedding, and forage plant seed sources, in proximity to each other.

JLM511 1283

7.0 OVERVIEW AND SUMMARY

7.1 MANAGEMENT INDICATOR SPECIES

Use of young growth and old growth by 13 MIS of the Tongass National Forest was evaluated by (1) conducting a literature review of their habitat use and distribution (DellaSala et al. 1992), (2) providing information on species observed incidentally over 2 years of summer and winter field studies (DellaSala et al. 1992, Appendix A this report), and (3) collecting field data on habitat use and abundance of MIS commonly observed in the study area. Relatively common MIS for which we provided habitat and/or abundance data in young growth and old growth included brown creeper, red-breasted sapsucker, and Sitka black-tailed deer. Brown creepers occurred primarily in old-growth stands during both the summer and winter. During the 2 years of this study, we detected a total of 61 brown creepers (22 in summer, 39 in winter), all but 1 of these detections was recorded in old growth. Low use of young growth by creepers was attributed to a lack of suitable nest sites, roosting cavities, and foraging sites (e.g., thick-furrowed tree barks) relative to old growth. Red-breasted sapsuckers were more abundant in old growth than in young growth during both breeding seasons. Although we did not detect any specific associations between sapsucker abundance and the vegetation characteristics we measured, young-growth stands were characterized by relatively low numbers of snags and sapsuckers.

Sitka black-tailed deer were detected year-round in both young- and old-growth stands, and black bear were observed sporadically throughout the study area. Thinning of young-growth stands apparently resulted in higher bunchberry cover, which probably explained the high use of thinned stands by deer. No other forage species was positively associated with thinning of young-growth stands. Periodic ($\leq$10 years) light to moderate thinning of young growth and the use of variable-spaced thinning was recommended to retain forage layers throughout the commercial forest rotation (100 years). In addition, we recommended that managers consider the use of old-growth islands as population source areas for forb and shrub species. Old-growth islands that contain pockets of forb and shrub species may prove useful in retaining forb and shrub levels over commercial forest rotations and for providing source propagules for forage species to colonize regenerating forests. Such islands could be left as clumps within regenerating stands and may function as bedding sites for deer in young-growth forest. Old-growth islands could be left as part of logging prescriptions and incorporated with

JLM511 1284

leave-tree requirements for other wildlife species (e.g., old-growth-associated forest birds).

Gapping of young-growth stands had little effect on most forage species of deer and black bear. However, this study was conducted 2-4 years following gapping and most of our vegetation sampling plots were not positioned within canopy gaps. Thus, we recommended positioning of sample plots within canopy gaps as well additional monitoring of gapped stands to determine if time-related lags in vegetation communities related to gapping masked our ability to detect vegetation response.

7.2 BREEDING BIRDS

We detected few consistent patterns in the abundance of breeding bird species among young-growth stand types and the association of bird species with vegetation characteristics. Of 16 bird species studied, the dark-eyed junco was the only species that appeared to benefit from thinning of young growth; fox sparrow and Wilson's warbler were negatively associated with gapping. Junco abundance in thinned stands was attributed to higher forb cover that was presumably related to the effects of reduced conifer stem densities and more open canopy conditions. Based on results of young-growth comparisons, we conclude that precommercial thinning and creation of artificial canopy gaps in young-growth stands currently were ineffective habitat enhancement techniques for all but 1 species of breeding bird and may have negative impacts on 2 species.

Differences in composition of avian communities between old growth and young growth were attributed primarily to differences in the abundance of 8 species. Four species were positively associated with old growth: Pacific-slope flycatcher, golden-crowned kinglet, red-breasted sapsucker, and brown creeper. These species tend to reach their highest densities in old growth in other locations; utilize structural features more typical of old-growth stands for nesting, feeding, or roosting; and were considered to be vulnerable to logging of old growth in southeast Alaska. In particular, golden-crowned kinglet abundance was positively associated with large (>50-cm-dbh) trees and Pacific-slope flycatcher abundance was negatively associated with percent canopy cover. Concerns were raised regarding the long-term (150-year) reductions in old-growth forest expected to occur Island-wide and the ability of old-growth associated species to colonize the Island from mainland areas. Regional abundance of forest birds combined with autecological mechanisms may limit the ability of old-growth forest bird

JLM511 1285

communities to respond to large-scale reductions of old-growth forest. Rare species, like brown creeper, may be particularly vulnerable to long-term logging effects due to low island populations and the tendency of this species to specialize on structural attributes (e.g., large-diameter trees and snags) lacking in standard clearcuts.

Four species were positively associated with young growth and included: orange-crowned warbler, Swainson's thrush, fox sparrow, and Wilson's warbler. These species tend to nest or forage on the ground or in shrubs and occur in young growth in other areas of their range.

Since most of the differences in stand characteristics and bird communities were attributed to differences between old growth and young growth, we recommend the retention of more structural features that resemble old-growth stands in young-growth stands. Retention of residual components in young growth may prove more beneficial to breeding bird communities than either thinning or gapping. Residual tree clumps are likely to function primarily as dispersal habitat for old-growth associates and should not be viewed as replacement or mitigation for logging of intact blocks of old-growth, temperate rainforest.

7.3 WINTERING BIRDS

The winter bird community of temperate rainforest in southeast Alaska that we studied was characterized by relatively few species and few individuals. Of the 4 prominent wintering bird species (brown creeper, winter wren, golden-crowned kinglet, chestnut-backed chickadee), no species was associated with any of the young-growth stand types. However, our data suggest that harsh winters in southeast Alaska may negatively influence abundance of overwintering birds and may result in greater use of old growth by some species. Old growth supported higher numbers of all species and higher numbers of golden-crowned kinglets than young growth during the second (harsher) winter. Old growth also supported more species and more brown creepers during both winters than young growth. Higher golden-crowned kinglet abundance in old growth was attributed to the presence of snow-free branches that provided foraging opportunities for kinglets following snow and ice storms. Higher use of old growth by brown creepers was attributed to greater availability of roosting and foraging sites relative to young growth. These results suggest that land managers should consider the value of old-growth, temperate rainforests as critical habitat for resident birds. Species, such as brown creepers and golden-crowned kinglets, that are associated with old growth

year-round may be particularly vulnerable to proportional shifts in availability of old growth due to intensive timber management.

JLM511 1287

8.0 RECOMMENDATIONS FOR FUTURE STUDIES

Based on the results of our study, we identified several additional research topics that would strengthen the findings of our study and provide further information on the effectiveness of young-growth treatments for wildlife. Recommendations for additional studies include the following:

(1) Investigate the feasibility of other types of silvicultural modifications, such as alternative thinning grids (i.e., variable-spaced thinning) and retention of residual old-growth components in young-growth stands, as enhancement measures for wildlife habitat;

(2) Monitor or model silvicultural modifications over longer periods of the rotation age to determine whether vegetation responses and resultant wildlife responses change over time and whether treated stands acquire important structural characteristics (e.g., tall and large trees) more rapidly than non-treated stands;

(3) Develop a monitoring program to track changes in composition and abundance of breeding and wintering birds that utilize old growth and young growth; and

(4) Collect field data to further refine the neotropical migrant model.

The Forest Service is currently experimenting with alternative thinning practices in southeast Alaska to increase structural diversity within young-growth stands. For instance, experimental stands near Wrangell and on Prince of Wales Island have been precommercially thinned by varying the spacing between remaining trees. Variable spacing results in stands with greater structural complexity by leaving clumps of unthinned trees and large areas where trees have been thinned. However, the effects of this thinning regime on deer and bear forage have not been studied. In addition, wildlife response to variable-spaced thinning may be limited initially to species associated with young growth. In general, young-growth associates are less likely to be impacted negatively by logging operations, and thus regional populations of this group tend to be stable or increasing (see Rosenberg and Raphael 1986, Raphael et al. 1988). In contrast, old-growth associates are generally impacted negatively by logging, require

structural features more characteristic of old-growth stands, and have been experiencing regional population declines (e.g., Rosenberg and Raphael 1986, Raphael et al. 1988, Chapter 3 this study). Therefore, variable-spaced thinning of young-growth stands, at least initially, may have limited value as habitat enhancement for species associated with old growth. However, it is unknown whether such treatments would accelerate development of desired structural attributes (e.g., greater tree dbh and heights) so that such attributes are present within the rotation age of treated stands.

The Forest Service should explore the feasibility of applying a stand growth-yield model to determine whether silvicultural treatments accelerate development of important structural characteristics (e.g., tree dbh, height) over time. Since our study stands were treated approximately 2 to 5 years prior to fieldwork, our conclusions of the effectiveness of young-growth treatments were limited to a short period of time post-treatment. We recommend application of growth-yield models to predict the likelihood of treated stands to develop desired structural characteristics over time, and that modeling efforts be employed prior to extensive use of variable-spaced thinning programs and the continued use of existing precommercial thinning practices as enhancement for wildlife habitat on the Tongass National Forest.

One of the primary findings of this study was the lack of significant differences in structural characteristics and avian community composition in silviculturally treated and non-treated young-growth stands. Lack of structure in these stands was further demonstrated by the low number of residual old-growth components in young growth. Although our study was not designed to specifically determine use of residual clumps by avian species, we observed several species of raptors, songbirds, woodpeckers, and some of the old-growth associates (e.g., Pacific-slope flycatcher, golden-crowned kinglet, red-breasted sapsucker) using residual tree clumps as feeding and perching sites. Thus, we recommend a follow-up study to investigate avian use of residual components in young-growth stands. The follow-up study could be used to develop specific recommendations on the density and spatial distribution of leave trees and snags for young-growth stands and is consistent with current Forest Service policy on ecosystem management. Such studies should be coordinated with breeding bird monitoring efforts currently in progress on the Thorne Bay District. We recommend including a representative sample of stands with residual tree components at different stocking densities and distributed at various distances from large patches of old growth. Breeding birds could be surveyed using spot-mapping or nest-search techniques within residual clumps or by using bird count stations centered in residual clumps and at

JLM511 1289

random locations within areas lacking such clumps. The number of bird sampling stations should be determined by computing sample size estimates necessary to produce stable abundance estimates. Sample size determination could be based on the number of samples required to produce an error bound (or 95% confidence interval) on the population variance so that it is within 20-40% of the population mean. We recommend using the variance and mean abundance estimates provided in our study to compute sample sizes needed to obtain reliable population estimates. Stands with suitable residual tree components could be located using current aerial photographs. For instance, we observed several young-growth stands within the Staney Creek drainage that were comprised of residual tree components that could be used in such a study. If a sufficient number of suitable study sites is lacking, such sites could be experimentally created during logging operations to increase sample sizes. Experimental manipulations should be based on well-designed study objectives that include considerations for (1) adequate sample sizes, (2) various stocking densities and spatial patterns of residual clumps, (3) suitable controls, (4) comparable plot ages, and (5) defendable survey designs for determining breeding bird abundance. Such a study should be replicated in several locations on the Tongass National Forest in order to quantify a greater range of variability in use of residual old-growth components by avian species.

A long-term monitoring program is needed to track changes in breeding bird composition in young-growth and old-growth, temperate rainforest in southeast Alaska. The need for such a monitoring effort will become increasing apparent as vast amounts of structurally diverse temperate rainforest are converted to even-aged stands. In addition, our results indicate the need for long-term studies of winter birds which appear to rely on old growth as critical habitat, especially during harsh winters. We recommend the establishment of permanent plots or census routes for monitoring breeding and wintering birds in representative locations of managed and virgin watersheds on the Tongass National Forest. Monitoring efforts could be coordinated with regional surveys currently underway for federal candidate species (e.g., northern goshawk, marbled murrelet). Our study stands could serve as a basis for a long-term monitoring program to track population changes in forest bird communities and changes in structural characteristics following silvicultural modification.

9.0 LITERATURE CITED

Airola, D.A., and R.H. Barrett. 1985. Foraging and habitat relationships of insect-gleaning birds in a Sierra Nevada mixed-conifer forest. Condor 87:205-216.

Alaback, P.B. 1982a. Dynamics of understory biomass in Sitka spruce-western hemlock forests of southeast Alaska. Ecol. 63:1932-1948.

_____. 1982b. Long-term community structural changes during secondary succession in southeast Alaska. Pages 70-79 *in* J.E. Means (ed.). Succession and stand development research in the Northwest. Proc. Symp. March 26, 1981. Corvallis, OR.

_____. 1988. Endless battles, verdant survivors. The ecology of Alaska's coastal rainforests. Natural History 97:44-51.

_____. 1991. Comparative ecology of temperate rainforests of the Americas along analogous climatic gradients. Revista Chilena de Historia Natural 64:399-412.

_____, and F.R. Herman. 1988. Long-term response of understory vegetation to stand density in *Picea-Tsuga* forests. Can. J. For. Res. 18:1522-1530.

_____, and G.P. Juday. 1989. Structure and composition of low elevation old-growth forests in research natural areas of southeast Alaska. Natural Areas Journal 9:27-39.

_____, and J.C. Tappeiner II. 1984. Response of understory vegetation to thinning in the Sitka spruce-western hemlock forests of southeastern Alaska. Oregon State Univ., Corvallis. 37pp.

_____, and J.C. Tappeiner II. 1991. Response of western hemlock (*Tsuga heterophylla*) and early huckleberry (*Vaccinium ovalifolium*) seedlings to forest windthrow. Can. J. For. Res. 21:534-539.

JLM511 1291

603_0302
Page 88 of 107

_____, and J. Weigand. 1992. Coastal temperate rain forests: definition and global distribution with particular emphasis on North America. Ecotrust Report, Portland, Oregon. 11pp.

American Ornithologists' Union. 1983. Check-list of North American Birds. 6th edition. American Ornithologists' Union. Allen Press, Inc. Lawrence, KS.

Armstrong, R.H. 1991. Guide to the Birds of Alaska. Alaska Northwest Books. Bothell, WA. 342 pp.

Artman, V.L. 1990. Breeding bird populations and vegetation characteristics in commercially thinned and unthinned western hemlock forests of Washington. M.S. thesis, Univ. Washington, Seattle. 55pp.

Askins, R.A., J.F. Lynch, and R. Greenberg. 1990. Population declines in migratory birds in eastern North America. Current Ornithology 7:1-57.

Beaver, D.L., and P.H. Baldwin. 1975. Ecological overlap and the problem of and sympatry in the Western and Hammond's Flycatcher. Condor 75:1-13.

Beebe, S.B. 1991. Conservation in temperate and tropical rain forests: The search for an ecosystem approach to sustainability. Pages 595-603 *in* Trans. 56th North Am. Wild. and Nat. Resour. Conf. 1991. Wildlife Management Institute, Washington, D.C.

Beedy, E.C. 1991. Bird communities and forest structure in the Sierra Nevada of California. Condor 83:97-105.

Bent, A.C. 1942. Life histories of North American flycatchers, larks, swallows, and their allies. U.S. Natl. Mus. Bull. 179 pp.

Böhning-Gaese, K., M.L. Taper, and J.H. Brown. 1993. Are declines in North American insectivorous songbirds due to causes on the breeding range? Conservation Biology 7:76-86.

Brittingham, M.C., and S.A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31-35.

JLM511 1292

Brower, J.E., J.H. Zar, and C.N. VonEnde. 1984. Field and laboratory methods for general ecology. Wm. C. Brown Publishers, Dubuque, Iowa. 237pp.

Brown, E.R. (ed.) 1985. Management of wildlife and fish habitats in forests of western Oregon and Washington. USDA For. Serv. Publ. No. R6-F&WL-192-1985. 302pp.

Bull, E.L., S.R. Peterson, and J.W. Thomas. 1986. Resource partitioning among woodpeckers in northeastern Oregon. USDA For. Serv. Res. Note PNW-444. 19pp.

Capp, J., B.V. Zee, P. Alaback, J. Boughton, M. Copenhagen, and J. Martin. 1992. Ecological definitions for old-growth forest types in the Alaska region. Final Report. USDA For. Serv. Alaska Region R10-TP-28. 56pp.

Cowan, I.M. 1989. Birds and mammals on the Queen Charlotte Islands. Pages 175-186 *in* G.G.E. Scudder and N. Gessler (eds.). The outer shores. Proceedings of the Queen Charlotte Islands First International Symposium. University of British Columbia, British Columbia.

Crawford, H.S., and R.M. Frank. 1987. Wildlife habitat responses to silvicultural practices in spruce-fir forests. Pages 92-100 *in* R.E. McCabe (eds.). Trans. 52nd North Am. Wildl. and Nat. Resour. Conf. Wildlife Management Institute, Washington, D.C.

Crocker-Bedford, D.C. 1990a. Status of the Queen Charlotte goshawk. USDA For. Serv., Tongass National Forest, Ketchikan, Alaska. 16pp.

_____. 1990b. Goshawk reproduction and forest management. Wildl. Soc. Bull. 18:262-269.

Davis, C.M. 1978. A nesting study of the brown creeper. Living Bird 17:237-263.

DellaSala, D.A., R.L. Fairbanks, D. Volsen, K. Barker, W. McComb, J. Hagar, and K. Raedeke. 1992. Annual Report 1991. Tongass National Forest evaluation of young-growth treatments for wildlife. 85pp.

JLM511 1293

DeMeo, T. 1989. Preliminary forest plant association management guide. Ketchikan Area, Tongass National Forest, Alaska. 163pp.

Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. Biol. Conserv. 7:129-146.

Doerr, J.G., and N.H. Sandburg. 1986. Effects of precommercial thinning on understory vegetation and deer habitat utilization on Big Level Island in southeast Alaska. For. Sci. 32:1092-1095.

Erskine, A.J. and W.D. McLaren. 1972. Sapsucker nest holes and their use by other species. Can. Field Nat. 86:357-361.

Fairbanks, R.L. 1979. An evaluation of the pellet group survey as a deer and elk census method in western Washington. M.S. thesis, Univ. Washington, Seattle. 96pp.

Finch, D.M. 1991. Population ecology, habitat requirements, and conservation of neotropical migratory birds. USDA For. Serv. Gen. Tech. Rept. RM-205. 26pp.

Franzreb, K.E. 1977. Bird population changes after timber harvesting of a mixed conifer forest in Arizona. USDA Forest Service Res. Paper RM-84. Fort Collins, CO. 26 pp.

_____. 1985. Foraging ecology of brown creepers in a mixed-coniferous forest. J. Field Ornithol. 56:9-16.

_____, and R.D. Ohmart. 1978. The effects of timber harvesting on breeding birds in a mixed-coniferous forest. Condor 80:431-441.

Fretwell, S.D. 1969. Dominance behavior and winter habitat distribution in juncos (*Junco hyemalis*). Bird-Banding 40:1-25.

_____. 1972. Populations in a seasonal environment. Princeton, New Jersey, Princeton Univ. Press.

JLM511 1294

Fuller, T.K. 1991. Do pellet counts index white-tailed deer numbers and population change? J. Wildl. Manage. 55:393-396

Haila, Y. 1983. Colonization of islands in a north-boreal Finnish lake by birds. Ann. Zool. Fennici 20:179-197.

_____, and O. Jarvinen. 1983. Land bird communities on a Finnish island: species impoverishment and abundance patterns. Oikos 41:255-273.

_____, O. Jarvinen, and S. Kuusela. 1983. Colonization of islands by land birds: prevalence functions in a Finnish archipelago. J. Biogeogr. 10:499-531.

Hanley, T.A., R.G. Cates, B. VanHorne, and J.D. McKendrick. 1985. Forest stand-age-related differences in apparent nutritional quality of forage for deer in southeastern Alaska. Symposium on plant-herbivore interactions. Snowbird, UT. pp. 9-17.

_____, and J.D. McKendrick. 1985. Potential nutritional limitations for black-tailed deer in a spruce-hemlock forest, southeastern Alaska. J. Wildl. Manage. 49:103-114.

_____, O.C. Wallmo, J.W. Schoen, and M.D. Kirchhoff. 1984. Habitat relationships of Sitka black-tailed deer. USDA For. Serv. Alaska Region Admin. Doc. No. 151. 32pp.

Hughes, J.H. 1985. Characteristics of standing dead trees in old-growth forests on Admiralty Island, Alaska. M.S. Thesis, Washington State University, Pullman, Washington.

Iverson, C., and R. Strauss. 1991. Incorporation of new perspectives in the Etolin Island implementation analysis proposed action alternatives. *In* M. Copenhagen (ed.), Proceedings of the New Perspectives Workshop. July 17-20, 1990. Petersburg, Alaska.

Jackson, J.A. 1979. Tree surfaces as foraging substrates for insectivorous birds. Pages 69-93 *in* J.G. Dickson, R.N. Connor, R.R. Fleet, J.A. Jackson, and J.C.

JLM511 1295

Kroll (eds.). The role of insectivorous birds in forest ecosystems. Academic Press, New York, N.Y.

James, F.C. 1971. Ordination of habitat among breeding birds. Wilson Bull. 83:215-236.

Johnson, N.K. 1980. Character variation and evolution of sibling species in the *Empidonax difficilis-flavescens* complex (Aves:Tyrannidae). Univ. Calif. Publ. Zool. 112:1-150.

_____, and J.A. Marten. 1988. Evolutionary genetics of flycatchers. II. Differentiation in the *Empidonax difficilis* complex. Auk 105:177-191.

Jones, G.W., and F.L. Bunnell. 1984. Response of black-tailed deer to winters of different severity on northern Vancouver Island. Pages 385-390 *in* W.R. Meehan, T.R. Merrell, Jr., and T.A. Hanley (eds.). Fish and wildlife relationships in old-growth forests: Proc. Symp. Amer. Inst. Fish. Res. Biol., Reintjes Publ., Morehead City, N.C.

Kepler, C.B. and J.M. Scott. 1981. Reducing bird count variability by training observers. Pages 366-371 *in* C.J. Ralph and J.M. Scott (eds.). Estimating numbers of terrestrial birds. Studies in Avian Biology Vol. 6. Allen Press, Inc., Lawrence, KS.

Kessler, W.B. 1982. Wildlife and second-growth forests of southeast Alaska: Problems and potential for management. USDA For. Serv., Admin. Doc. 110. Juneau, AK. 36pp.

_____, and T.E. Kogut. 1985. Habitat orientations of forest birds in southeastern Alaska. Northwest Sci. 59:58-65.

_____. and K.A. Milne. 1982. Morning versus evening detectability of southeast Alaskan birds. Condor 84:447-448.

Kirchhoff, M.D. 1990. Evaluations of methods for assessing deer population trends in southeast Alaska. Alaska Dept. of Fish and Game. Fed. Aid in Wildl.

JLM511 1296

Restoration., Final Rept. Job IIB-2.9 W-22-6, W23-1, W23-2, and W-23-3. Juneau. 35pp.

_____, and K.W. Pitcher. 1988. Deer pellet-group surveys in southeast Alaska 1981-1987. Alaska Dept. of Fish and Game, Fed. Aid in Wildl. Restoration, Final Rept. Job 2.9, Objective 1 W-22-6, W23-1. 113pp.

_____, and J.W. Schoen. 1987. Forest cover and snow: Implications for deer habitat in southeast Alaska. J. Wildl. Manage. 51:28-33.

Kirk, R., and J. Franklin. 1992. The Olympic Rain Forest: an ecological web. University of Washington Press. Seattle and London.

Klein, D.R., and S.T. Olson. 1960. Natural mortality patterns of deer in southeast Alaska. J. Wildl. Manage. 24:8-88.

Kricher, J.C. 1975. Diversity in two wintering bird communities: possible weather effects. Auk 92:766-777.

Lack, D. 1966. Population studies of birds. Oxford, Clarendon.

_____. 1968. Bird migration and natural selection. Oikos 19:1-9.

Larson, D.E., and C.E. Bock. 1984. Determining avian habitat preference by bird-centered vegetation sampling. Pages 37-43 *in* J. Verner, M.C. Morrison, and C.J. Ralph (eds.). Modeling habitat relationships of terrestrial vertebrates. Univ. of Wisconsin Press, Madison.

Lebeda, C.S., and T.J. Ratti. 1983. Reproductive biology of Vancouver Canada geese on Admiralty Island, Alaska. J. Wildl. Manage. 47:297-306.

Lynch, J.F. 1989. Distribution of overwintering nearctic migrants in the Yucatan Peninsula. I. General patterns of occurrence. Condor 91:515-544.

MacArthur, R.H., and E.O. Wilson. 1967. The theory of island biogeography. Princeton Press, Princeton, NJ.

JLM511 1297

Mankowski, J.D., and J.M. Peek. 1989. Habitat use of Sitka black-tailed deer in logged and unlogged forests, Prince of Wales Island, southeast Alaska. USDA For. Serv. Admin. Study 85-0501. Univ. of Idaho, Moscow. 27pp.

Mannan, R.W., and E.C. Meslow. 1984. Bird populations and vegetation characteristics in managed and old-growth forests, northeastern Oregon. J. Wildl. Manage. 48:1219-1238.

Manuwal, D.A., and M.H. Huff. 1987. Spring and winter bird populations in a Douglas-fir forest sere. J. Wildl. Manage. 51:586-595.

McComb, W.C., T.A. Spies, and W.H. Emmingham. 1993. Douglas-fir forests: managing for timber and mature-forest habitat. J. For. 91:31-42.

McGarigal, K., and W.C. McComb. 1992. Streamside versus upslope breeding bird communities in the central Oregon Coast Range. J. Wildl. Manage. 56:10-23.

McNay, R.S. and D.D. Doyle. 1987. Winter habitat selection by black-tailed deer on Vancouver Island: a job completion report. B.C. Minist. Environ. and Parks and B.C. Minist. For. IWIFR-34. Victoria. 90pp.

Medin, D.E. 1985. Breeding bird responses to diameter-cut logging in west-central Idaho. USDA For. Serv. Res. Paper INT-355. 12pp.

Miller, E., A.D. Partridge, and E.L. Bull. 1979. The relationship of primary cavity nesters and decay. Trans. Annual Meeting Northeast Sec. Wildl. Soc. 36:60-68.

Modafferi, R.D. 1982. Black bear movements and home range study. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Restoration, Final Rept., Proj. W-17-10, W-17-11, W-21-1, W-21-2, Job 17.2R. Juneau. 73pp.

Morrison, M.L., R.W. Mannan, and G.L. Dorsey. 1981. Effects of number of circular plots on estimates of avian density and species richness. Pages 405-408 *in* C.J. Ralph and J.M. Scott (eds.). Estimating numbers of terrestrial birds. Studies in Avian Biology Vol. 6. Allen Press, Inc., Lawrence, KS.

JLM511 1298

_____, I.C. Timossi, K.A. With, and P.N. Manley. 1985. Use of tree species by forest birds during winter and summer. J. Wildl. Manage. 49:1098-1102.

_____, K.A. With, and I.C. Timossi. 1986. The structure of a forest bird community during winter and summer. Wilson Bull. 98:214-230.

_____, K.A. With, I.C. Timossi, W.M. Block, and K.A. Milne. 1987. Foraging behavior of bark-foraging birds in the Sierra Nevada. Condor 89:201-204.

Morse, D.H. 1970. Ecological aspects of some mixed-species foraging flocks of birds. Ecol. Monogr. 40:119-168.

Morton, E.S. and R. Greenberg. 1989. The outlook for migratory songbirds: "Future shock" for birders. American Birds 43:187-183.

Neff, D.J. 1968. The pellet-group count technique for big game trend, census, and distribution: a review. J. Wildl. Manage. 32:597-614.

Neter, J.W., and W. Wasserman 1983. Applied linear statistical models, regression, analysis of variance, and experimental designs. Richard D. Irwin, Inc. Homewood, IL.

Nyberg, J.B., F.L. Bunnell, D.W. Janz, and R.M. Ellis. 1986. Managing young growth forests as black-tailed deer winter ranges. Land Management Report No. 37. B.C. Ministry of Forests, Victoria. 49 pp.

_____, J.B., D. Doyle, and L. Peterson. 1985. Deer movements and habitat use during winter: working plan. B.C. Minist. For. IWIFR-18. Victoria. 81pp.

_____, A.S. Harestad, and F.L. Bunnell. 1987. "Old growth" by design: managing young forests for old-growth wildlife. Pages 70-81 *in* Trans. 52nd N.A. Wildl. and Nat. Res. Conf., Quebec City, Quebec.

Paton, P.W., C.J. Ralph, and R.A. Erickson. 1992. Use of inland site in northwestern California by marbled murrelets. Pages 109-116 *in* H.R. Carter and M.L. Morrison (eds.). Proc. of the Western Foundation of Vertebrate Today.

JLM511 1299

Pianka, E.R. 1966. Latitudinal gradients in species diversity: a review of concepts. Am. Natur. 100:33-46.

Quinlan, S.E., and J. Hughes. 1990. Location of a marbled murrelet tree nest site in Alaska. Condor 92:1068-1073.

Raedeke , K.J., and D. Major. 1989. Winter distribution and habitat use by deer in the Bear Creek drainage. Final Rept. to Washington Dept. of Wildlife and USDA For. Serv.

Raphael, M.G., K.V. Rosenberg, and B.G. Marcot. 1988. Large-scale changes in bird populations of Douglas-fir forests, northwestern California. Pages 63-83 *in* Jackson, J.A. (ed.). Bird Conservation 3. Univ. Wisconsin Press, Madison.

_____, and M. White. 1984. Use of snags by cavity-nesting birds in the Sierra-Nevada. Wildl. Monogr. 86. 66 pp.

Robbins, C.S. 1981. Effect of time of day on bird activity. Studies in Avian Biology 6:275-286.

_____, J.R. Sauer, R. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proc. Nat. Acad. Sci. 86:7658-7662.

Rosenberg, K.V. and M.G. Raphael. 1986. Effects of forest fragmentation on vertebrates in Douglas-fir forests. Pages 263-272 *in* J. Verner (ed.). Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. Univ. of Wisconsin Press, Madison.

Rotenberry, J.T. 1978. Components of avian diversity along a multifactorial climatic gradient. Ecol. 59:693-699.

_____, R.E. Fitzner, and W.H. Rickard. 1979. Seasonal variation in avian community structure: differences in mechanisms regulating diversity. Auk 96:499-505.

JLM511 1300

Ruth, R.H., and A.S. Harris. 1979. Management of western hemlock-Sitka spruce forests for timber production. USDA For. Serv. Gen. Tech. Rept. PNW-88, 197pp.

Sakai, H.F. 1987. Response of Hammond's and western flycatchers to different aged Douglas-fir sites in northwestern California. M.S. thesis, Humboldt State Univ., Arcata, CA. 109pp.

_____, and B.R. Noon. 1991. Nest-site characteristics of Hammond's and Pacific-slope flycatchers in northwestern California. Condor 93:564-574.

Samson, F.B., P. Alaback, J. Christner, T. DeMeo, A. Doyle, J. Martin, J. McKibben, M. Orme, L. Suring, K. Thompson, B.G. Wilson, D.A. Anderson, R.W. Flynn, J.W. Schoen, L.G. Shea, and J.L. Franklin. 1989. Conservation of rainforests in southeast Alaska: Report of a working group. Pages 122-133 *in* Trans. 54th North Am. Wildl. and Nat. Resour. Conf. Wildlife Management Institute, Washington, D.C.

Schoen, J.W., and T.A. Hanley. 1982. Seasonal distribution and habitat use by Sitka black-tailed deer in southeastern Alaska. Vol. III. Alaska Dept. Fish and Game. Fed. Aid Wildl. Rest. Proj. Prog. Rept. Proj. W-21-1, Job 2.6R and 2.7R. 51pp.

_____, and M.D. Kirchhoff. 1990. Seasonal habitat use by Sitka black-tailed deer on Admiralty Island, Alaska. J. Wildl. Manage. 54(3):371-378.

Shannon C.E., and W. Weaver. 1949. The mathematical theory of communication. Univ. Illinois Press, Urbana, IL.

Sidle, W.B. 1985. Habitat management for forest birds in southeast Alaska. Wildlife and Fisheries Habitat Management Notes. USDA Forest Service, Alaska Region Administration Document 146. Juneau, Alaska.

Smith, R.L. 1980. Ecology and field biology. Harper and Row Publishers, Inc. Third edition. New York, NY.

JLM511 1301

Spies, T.A. 1991. Trends in ecosystem management at the stand level. Pages 628-639 *in* Transactions of the 56th North American Wildlife and Natural Resources Conference.

_____, and J.F. Franklin. 1989. Gap characteristics and vegetation response in coniferous forests in the Pacific Northwest. Ecol. 70:543-545.

Stewart, G.H. 1986. Forest development in canopy openings in old-growth *Pseudotsuga* forests of the western Cascade Range, Oregon. Can. J. For. Res. 16:558-568.

Suring, L.H., E.J. Degayner, R.W. Flynn, M.D. Kirchhoff, J.R. Martin, J.W. Schoen, and L.C. Shea. 1991. Habitat capability model for Sitka black-tailed deer in southeast Alaska: winter habitat. USDA For. Serv. Juneau, AK.

_____, R.W. Flynn, J.H. Hughes, M.L. Orme, and D.A. Williamson. 1988a. Habitat capability model for red-breasted sapsuckers in southeast Alaska: breeding habitat. USDA For. Serv. Draft.

_____, R.W. Flynn, J.H. Hughes, M.L. Orme, and D.A. Williamson. 1988b. Habitat capability model for brown creepers in southeast Alaska: winter habitat. USDA For. Serv. Draft. Juneau, AK.

Tappeiner II, J.C., and P.B. Alaback. 1989. Early establishment and vegetative growth of understory species in the western hemlock-sitka spruce forests of southeast Alaska. Can. J. Bot. 67:318-326.

Taylor, T. 1979. Species list of Alaska birds, mammals, fish, amphibians, reptiles, and invertebrates. USDA For. Serv., Alaska Region Rept. No. 82. 102pp.

Temple, S.A. 1985. Why endemic island birds are so vulnerable to extinction. Bird Conserv. 2:3-6.

_____, and J.R. Cary. 1988. Modelling dynamics of habitat-interior bird populations in fragmented landscapes. Conservation Biology 2:340-347.

Terborgh, J.W. 1989. Where have all the birds gone? Princeton University Press, Princeton, NJ.

Tobalske, B.W., R.C. Shearer, and R.L. Hutto. 1991. Bird populations in logged and unlogged western larch/Douglas-fir forest in northwestern Montana. USDA Forest Service Res. Paper INT-442. Ogden, UT. 12 pp.

USDA Forest Service. 1991. Tongass Land Management Plan: Supplement to the Draft Environmental Impact Statement. USDA Forest Service Tongass National Forest R10-MB-149.

_____. 1993. Polk Inlet draft environmental impact statement, Ketchikan Pulp Company long-term timber sale contract. USDA Forest Service, Tongass National Forest, R10-MB-237a. Prepared by Ebasco Environmental, Bellevue, Washington.

VanHorne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47:893-901.

Verner, J., and T.A. Larson. 1989. Richness of breeding bird species in mixed-conifer forests of the Sierra Nevada, California. Auk 106:447-463.

Wallmo, O.C. 1981. Mule and black-tailed deer distribution and habitats. Pages 1-25 *in* O.C. Wallmo (ed.). Mule and black-tailed deer of North America. Wildl. Manage. Inst., Univ. Nebraska Press, Lincoln.

_____, and J.W. Schoen. 1980. Response of deer to secondary forest succession in southeast Alaska. Forest Science 26:448-462.

Walsberg, G.E. 1986. Thermal consequences of roost-site selection: the relative importance of three modes of heat conservation. Auk 103:1-7.

Waring, R.H., and J.F. Franklin. 1979. Evergreen coniferous forests of the Pacific Northwest. Science 204:1380-1386.

JLM511 1303

Whitcomb, B.L., R.F. Whitcomb, and D. Bystrak. 1977. Island biogeography and "habitat island" of eastern forest: III. Long-term turnover and effects of selective logging on the avifauna of forest fragments. Am. Birds 31:17-23.

Wilkinson, L. 1990. SYSTAT: The system for statistics. Evanston, IL. SYSTAT, Inc.

Yahner, R.H. 1986. Structure, seasonal dynamics, and habitat relationships of avian communities in small even-aged forest stands. Wilson Bull. 98:61-82.

Yeo, J.J., and J.M. Peek. 1989. Habitat selection by Sitka black-tailed deer in logged forests of southeastern Alaska. Job completion report, USDA Forest Service. Ketchikan. 41 pp.

Zar, J.H. 1984. Biostatistical analysis. Second edition. Prentice-Hall, Inc., Englewood Cliffs, NJ.

JLM511 1304

APPENDIX A - INCIDENTAL OBSERVATIONS (1992-93)

APPENDIX A - INCIDENTAL OBSERVATIONS (1992-93)

Incidental observations of MIS and other wildlife were recorded during the breeding season of 1992 and wintering season of 1992-93; similar observations were provided in the Annual Report for 1991 (DellaSala et al. 1992). The hairy woodpecker, Vancouver Canada goose, bald eagle, Sitka black-tailed deer, gray wolf, and black bear were observed occasionally in the study area. However, these species did not occur in high enough numbers for statistical comparisons among sites.

The hairy woodpecker was observed on 5 occasions during the breeding season of 1992, once in a thinned site and on 4 occasions in old growth. In addition, this species was observed on 2 occasions in old growth during the winter of 1992-93. Vancouver Canada goose were frequently observed during the summer and winter in a saltwater marsh adjacent to the Staney Creek Cabin old-growth site (site number 2-O, see Appendix B10). During the winter, we observed 4 bald eagles perched in tall (> 20 m) snags and hemlocks in young growth. Eagles were also occasionally observed perched in residual old-growth trees in young growth outside the study area.

Sitka black-tailed deer were observed commonly throughout the study area and were regularly observed on logging roads, along stand boundaries, canopy gaps, and within each of our study stands. Evidence of deer use (browse, pellets, tracks) was present year-round throughout the study area (see Chapter 6). The gray wolf was observed in an old-growth stand during the winter and was heard howling on 2 occasions, once in a gapped stand and once in the vicinity of Staney Creek outside the study stands. Evidence of wolf use (tracks, scat) was present in most stands year-round. Wolf sign was primarily observed on logging roads within and outside study stands. Black bear were observed on 2 occasions in a thinned stand during the breeding season. Evidence of bear use (tracks, scat) was frequently observed along logging roads within and outside study stands and along transects within most stands. An unconfirmed den site was located in a 4-m tall, large (>50-cm dbh) snag in a non-treated stand. Evidence of digging and scat was located near the base of a large cavity in this snag.

In addition to the MIS observed incidentally in the study area, great blue heron, marbled murrelet, blue grouse, and pygmy owl were also observed. The great blue heron was commonly observed in a salt marsh adjacent to the Staney Creek Cabin old-growth site (site number 2-0) during the summer and winter. We recorded 100 detections of

marbled murrelets during the summer of 1992 and winter of 1992-93; all but 6 of these detections were recorded during the summer. All murrelet detections recorded were observations of birds flying overhead and thus specific locations and use of study stands could not be determined. A blue grouse was observed in a non-treated stand (site number 2-N, see Appendix B7) and a pygmy owl was heard calling in an old-growth stand during the breeding season. In addition, an unconfirmed spruce grouse sighting was recorded in a thinned stand (site number 1-T, see Appendix B5) during April 1991 (not reported in the Annual Report). Spruce grouse are of special concern due to the limited distribution of this species on Prince of Wales Island and in southeast Alaska (pers. comm. J, Gustafson, ADF&G, Ketchikan, AK, 3 May 1993).

Notably, over the 2 years of this study, bald eagles, other raptors, woodpeckers, and Pacific-slope flycatchers, were observed on several occasions using residual old-growth components in young-growth stands. Residual trees and snags were much taller than the surrounding regenerating trees and provided perching and feeding sites for these species in young growth.

JLM511 1307

APPENDIX B - STUDY STAND MAPS

G:\WP16\USFS\06052A • 8-9-94

JLM511 1308

APPENDIX B - STUDY STAND MAPS

This appendix provides detailed maps for each forest stand. These maps were prepared from the GIS (ARC/INFO) database, current (1991) aerial photographs, and handdrawn field maps of sampling stations used to collect data on bird and vegetation characteristics. Figure B1 is an enlargement of the entire study area depicting Forest Service roads, contour lines, and significant landscape features. This figure was developed by digitizing locations of study stands from stand maps and overlaying these locations onto the GIS datalayers provided by the Forest Service. Figures B2 and B3 provide stand location maps within Forest Service Quads D3 and D4 (Craig District). These maps illustrate general locations of stands, Forest Service roads, contour lines, lakes and shorelines, and significant landscape features. Figures B4-B22 contain more detailed information on each stand, including locations of canopy gaps, residual tree clumps (trees taller than pole size), permanent streams, Forest Service roads, contour lines, stand transects, and sampling stations. These figures were produced by mapping transect and sample station locations in the field, transferring locations onto base maps using a zoom transfer scope, and digitizing them for GIS analysis. GIS maps were appended to color xerox photocopies of aerial photos of each stand. Stand transects on photos and GIS maps were labeled with letter codes corresponding to different positions along the transect and sampling stations were given numbers. Sampling stations on the color aerial photos were given a prefix code corresponding to VCP (variable circular plot - sampling station) numbers. Sampling stations on the GIS plots were given numbered codes only (i.e., VCP was left out).

Stand transects appearing on the GIS generated maps and on adjacent aerial photos in Figures B4-B22 were positioned within the interior of stands and followed a "zig-zag" configuration to provide maximum coverage of each stand. Transect lengths were also established within stands to accomplish multiple study objectives. For instance, we needed a total transect length of 1500-m to ensure adequate coverage of stands for deer track and pellet-group surveys. Therefore, the 1500-m transects were configured to the size and shape of each stand, and sampling stations used in the bird and vegetation studies were then spaced at random distances of 150- to 300-m along these transects. Consistent transect configurations among stands was not possible due to the irregular shape of stands, access problems, and multiple study objectives. In addition, because current aerial photos of the study area were not available in the first year of this study, the size and shape of each stand were not fully known when transects were positioned.

JLM511 1309

Therefore, some transect configurations may not have provided maximum coverage for a given stand even though our intention was to do so during the early stages of the study.

Locations of canopy gaps and residual trees appearing on the GIS plots (Figs. B4-B22) were mapped from aerial photos and were ground-truthed opportunistically while walking between sampling stations. Stream locations were based on the GIS database and were matched against aerial photos to improve accuracy. Although we noticed several situations where the GIS road layer did not match aerial photos, we made no attempt to correct road locations on the GIS, since they were not used in either the deer or bird analyses. Therefore, road locations appearing on GIS-generated maps (Figs. B1-B22) may not reflect ground locations. Only those road locations appearing on color aerial photos were ground-truthed.