Habitat Relationships of Birds and Young-Growth Douglas-fir in Northwestern California

by

Bruce G. Marcot

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Ninety-one species of birds were surveyed in grass/forb, early and late shrub/sapling, pole, an3 medium sawtimber stages of young-growth Douglas-fir in northwestern California; patterns of bird distribution and abundance were related to habitat conditions and even-age silvicultural treatments. Seven species (band-tailed pigeon, western wood pewee, dusky flycatcher, western bluebird, fox sparrow, purple finch, and evening grosbeak) have probably increased in population size or distribution since extensive clearcutting in the study area began in the early 1950's. Six species (Hammond's flycatcher, chestnut-backed chickadee, red-breasted nuthatch, brown creeper, golden-crowned kinglet, and hermit warbler) are restricted to forest stages and probably have decreased in

population size or distribution. Abundances of various species were associated with presence of a forest 'overstory, hardwood stem density, deciduous foliage volume, height and patchiness of shrub cover, number of plant species, and snag density. Slope angle and distance to permanent water or to the next nearest similar habitat type explained some variation in abundance of a few species. The grass/forb stage-had the lowest number of bird species and lowest total density, while the late shrub/sapling stage had the highest; species composition varied markedly across the young-growth stages. Cluster analysis defined shrub stage specialists and forest stage specialists. Seasonal patterns of permanent resident species suggested that the shrub stage specialists are most limited in distribution during winter, and that their winter distributions may reflect optimal ("source") habitat. In contrast, forest stage specialists showed no seasonal changes of distribution, or were more restricted in distribution during the breeding season.

All phases of the clearcutting system, including site preparation, stocking control, intermediate treatments, and final harvest, greatly affect stand conditions. No one stand condition, young-growth stage, or silvicultural treatment provided best habitat for all bird species. Simplification of forest stand structure by reduction or elimination of hardwoods, snags, and large diameter softwoods, could lead to low within-stand but high between-stand diversity of vegetation and bird assemblages. Even-age silvicultural systems, however, can integrate management objectives for timber production and bird habitat.

APPROVED:

Professor of Fisheries and Wildlife in charge of major

Head of Department of Fisheries and Wildlife

Dean of Graduate School

Date thesis is presented November 20, 1984

Thesis typed by Bruce G. Marcot

Ode to the Niche

(An Ecologist's Nightmare)

With hypervolumetric grin,
I grow more Hutchinsonian
Despite intense investigation
Of axial proliferation.

Each bird I see expands in place
To seventeen-dimension space;
And should it light on forest floor,
Then axes sprout a dozen more!

Euclid would approve with glee
How territoriality
Of bunting perched upon a stone
Is asymptote to hypercone.

And should competing species brawl
A tesseract defines the sprawl;
Yet meaning loses in the end;
We've lost the zero origin!

- Bruce G. Marcot

DEDICATION

This thesis is affectionately dedicated to my parents, Guy and Olga Marcot, for all the support, love, and friendship they have given me for 31 years. In the end, the studies of wildlife ecology and management are bound to personal dicta and ethics, and I am grateful for the best guidance and role models a son could have.

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PREFACE

This report marks the completion of a 5-year Administrative Study funded by the Pacific Southwest Region, USDA Forest Service, in cooperation with Oregon State University, Corvallis, and represents one of several papers from the study that are in preparation, in press, or already published.

The study was initiated in 1979 under the impetus of the California Wildlife Habitat Relationships (WHR) Program of the U.S. Forest Service, following the lead of Thomas (1979). Under the WHR Program, the Pacific Southwest Region (California) of the Forest Service was divided into four ecological zones. In each zone, existing information on amphibians, reptiles, birds, and mammals was summarized into written accounts of life histories, maps of species' distributions, and matrices showing species' use of habitats (vegetation types with successional and structural stages). Eventually, much of this information was coded for retrieval on computers, forming the basis for several WHR models that predicted species occurrences and relative abundances as a function of conditions of habitat.

The models began to be used by Forest Service personnel at the District level to assess impacts on wildlife from harvesting timber. Personnel at the Forest level employed the model to assess wildlife use of existing habitat conditions, and to assess results of different planning alternatives. It was recognized, however, that validation of the models was a crucial stage in their use. The present study was devised in response to the need for validation. Consistent with the original study objectives, three main foci of the study have resulted.

The first focus involves summary and interpretation of field data on species abundance and relationships of species with habitat conditions. Specifically, this thesis summarizes the field data on the distribution of birds in young-growth Douglas-fir, and on the relationships and opportunities between even-age timber management and bird management. The present paper was prepared in manuscript style for anticipated submission as a Wildlife Monograph. Several of the Appendices will be deleted for final publication, but are included in this dissertation as a repository of data summaries.

Closely related to the objectives of this thesis was a paper, already published, detailing the associations of cavity-nesting birds and snag presence in Douglas-fir clearcuts:

1. Marcot, B. G. 1983. Snag use by birds in Douglas-fir clearcuts. Pp. 134-139 in J. W. Davis. G. A. Goodwin, and R. A. Ockenfels, eds. Snag habitat

management: Proceedings of the symposium. USDA Forest Service Gen. Tech. Rept. RM-99.

Second, the results of the present study are being used to validate a WHR model that was developed for the North Coast/Cascades Zone of the Pacific Southwest Region; three papers to date report on procedures of model use and validation:

2. Marcot, B. G. 1983. Use of a habitat/niche model for old growth management: a preliminary discussion. Pp. 390-402 in R. M. DeGraff, ed. Management of western forests and grasslands for nongame birds. USDA Forest Service Gen. Tech. Rept. INT-86.

3. Marcot, B. G., M. G. Raphael, and K. H. Berry. 1983. Monitoring wildlife habitat and validation of wildlife-habitat relationships models. N. Amer. Wildl. Nat. Resourc. Conf. 48:315-329.

4. Raphael, M. G., and B. G. Marcot. 1985. Validation of a wildlife-habitat relationships model: vertebrates in a Douglas-fir sere. Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. 7-11 October 1984, Fallen Leaf Lake, California.

Third, results of the validation efforts will spur extensions to the existing WHR model and the exploring of new model forms; one paper from this study has reported on a potentially new approach:

5. Marcot, B.G. 1985. Use of expert systems in wildlife-habitat modeling. Wildlife 2000: Modeling Habitat Relationships of Terrestrial Vertebrates. 7-11 October 1984, Fallen Leaf, California.

The three foci of the original study objectives - description of species distributions from the empirical surveys, validation of the existing wildlife-habitat models, and extensions to new model forms - explicitly address information needs about young-growth Douglas-fir as originally identified by National Forest managers. The next objective is to integrate the three foci with results from similar studies being conducted on National Forest land in California, Oregon, and Washington. Specifically, one objective is to better understand the abundances of birds in mature and old-growth forest habitats in light of their abundances in young-growth habitats, as discussed in this thesis. Another objective is to compare results of model formulation and validation in young-growth habitat among different geographic locations. Results of these comparisons will be presented elsewhere.

HABITAT RELATIONSHIPS OF BIRDS AND YOUNG-GROWTH DOUGLAS-FIR IN NORTHWESTERN CALIFORNIA

INTRODUCTION

Much of the Douglas-fir (scientific names of plant species are in Appendix 1) region of the Pacific Northwest is being rapidly altered to young-growth conditions from the harvesting of timber. In the future, many timber stands will be managed on relatively short rotations, thus reducing the land base supporting older stands of timber. During the last 30 years in western Oregon and Washington, net volume of sawtimber softwood has been reduced 21 percent, net volume of large diameter softwood has been reduced 34 percent, and annual lcss and removal of Douglas-fir sawtimber has averaged 3 times annual growth (Harris 1982). Conversion of large areas from mature forest to young-growth stands of shrubs and sapling or pole softwoods is continuing to dramatically alter the structure and quality of habitat for wildlife.

Specifically, even-age timber management of Douglas-fir forest has the potential to remove snags and hardwood trees, to reduce horizontal heterogeneity of vegetation within stands, and to simplify much of the vertical vegetation structure important to some forest birds (e.g., Willson 1974, Beedy 1981). The regeneration of forest stands after clearcutting results in a temporal series of various mixes of plant species and vegetation structures. Insofar as stand conditions are guided by intensive silvicultural treatments -- such as site preparation, planting of seedlings, control of brush, and thinning of trees -- the temporal series is predictable as to type and duration and is regarded as a special case of secondary succession (Thornburgh 1982).

In the Pacific Northwest, major differences in the distribution and abundance of bird species were found among different age or structural classes of clearcuts or in young-growth compared with forested stages of the managed, secondary sere (Hagar 1960, Mannan 1977, Mannan et al. 1980, Marcot 1983, Morrison and Meslow 1983). Similar effects on the distribution and abundance of birds from clearcut logging were reported in Alaska (Kessler 1979), Arizona (Szaro and Balda 1979), Maine (Titterington et al. 1979), Minnesota (Niemi and Hanowski 1984), Texas (Strelke and Dickson 1980), Utah (DeByle 1981), Virginia (Conner et al. 1975, 1979; Maurer et al. 1981), and elsewhere.

The goals of this study were to quantify the seasonal and overall distribution and abundance of forest birds within young-growth Douglas-fir forest; to relate bird distribution and abundance to habitat structure; and to quantify relationships between bird abundance, habitat structure, and even-age timber management. These goals were addressed through the following study objectives: 1) to conduct year-around surveys of birds in Douglas-fir forest at replicated study sites representing an early successional sequence following clearcut timber harvesting, 2) to describe habitat conditions by sampling vegetation and habitat structure at the bird count points, 3) to quantitatively relate bird species distribution and abundance to habitat conditions, 4) to summarize the results of the habitat surveys in terms of timber stand management objectives, and 5) to relate bird distribution and abundance with stand conditions as influenced by various phases of even-age timber management. The primary audience for whom this document is intended is forest ecologists in the broadest sense, including wildlife managers and silviculturists.

ACKNOWLEDGMENTS

The study was funded by USDA Forest Service, Pacific Southwest Region, under the auspices of the California Wildlife-Habitat Relationships Program, and was conducted under a Cooperative Research Agreement with the Cooperative Wildlife Research Unit, Oregon State University, Corvallis. Forest Service personnel instrumental in helping initiate the Agreement included John Capp, Hal Salwasser, and Robert Nelson. Dean Carrier, Joe Harn, Jack Kahl, William Laudenslayer, Jeff Mattison, Dick Nute, C. J. Ralph, Edward Toth, and many Forest Service personnel lent logisitic support.

My sincere thanks to my two main mentors, E. Charles Meslow and Jack Ward Thomas, for their unfailing support and encouragement throughout the course of this work. The hiatus between pure research and management application is difficult to span, and their guidance helped keep me on course. The other members of my doctoral committee, W. Scott Overton and John Tappeiner, also provided unique and outstanding challenges, and I thank them for all their help and continued interest. I am grateful to John Crawford for his review of the manuscript and for acting as substitute during the final exam.

The study design benefitted greatly from suggestions by Hal Salwasser and Martin Raphael. Linda Doerflinger and Alan Seigel helped conduct pilot bird surveys in 1980. The study owes much to Richard Lundquist and Valen Castellano, who conducted subsequent bird surveys and who suffered through difficult field conditions. Vicky Meretsky headed the habitat survey crews and provided invaluable assistance in many phases of the vegetation surveys. Valen Castellano, Wendy Cole, Craig Foster, Leslie Haness, Valerie Hiller, Debrah Kimbrell, Gina Kurtovich, Richard Lundquist, Patricia Manley, Grace McLaughlin, John McWilliams, C. Ogan, Rema Sadak, Carrie Sakai, Howard Sakai, John Shannon, and Roy Sutcliffe helped conduct habitat surveys. Vicky Meretsky, Leslie Haness, Patricia Manley, and Tom Nelson helped identify plant species.

The Oregon State University Computer Center provided a grant to help fund development of the bird density estimation program. Special thanks to Fred Ramsey for kindly providing the algorithm for calculating effective areas from bird survey data, and to David McIntire for making available the AIDONE and AIDN programs used to calculate indices of bird species diversity and habitat niche breadth. Steve Jeffrey and Muopopa Tshibuabua provided valuable programming assistance. Valen Castellano, Laura Kunioka, Anne Lee, Kirstin Meslow, and Edward Vandehee helped enter and verify data.

The manuscript benefitted from discussions with Andrew Carey, William Laudenslayer, Patrick McIntire, Barry Noon, Martin Raphael, David Solis, and Edward Toth. My thanks to all. I also gratefully acknowledge the Department of Fisheries and Wildlife support staff at Oregon State University for their assistance throughout the project. My thanks to Ruth Brandt for drafting the figures and to LaVon Mauer for typing some of the tables and appendices.

Finally, the study has ended on the happiest note thanks to the support, confidence, and encouragement from Carrie Sakai.

METHODS

Study Area

Fifty-five vegetation stands representing young-growth Douglas-fir were the sites of this study on the Lower Trinity and Big Bar Ranger Districts of the Six Rivers and Shasta-Trinity National Forests, respectively, in northwestern California (Fig. 1). The study stands were between 670 and 1370 m elevation. All study stands were within the Mixed Evergreen Forest with Chinquapin or Rhododendron (Kuchler 1977) and Douglas-fir-Tanoak-Madrone (USDA Forest Service 1981) vegetation types. Stands were chosen based on general physiognomic characteristics and winter accessibility.

Much of the commercial timber land on the two National Forests is dominated by Douglas-fir (USDA Forest Service 1981). The general study area has undergone substantial timber harvesting since the early part of the twentieth century on private land and since the 1950s on Forest Service land. For example, on the Six Rivers National Forest during the period 1950-1980, the annual timber harvest increased from 2 million board feet to a high of 265 million board feet in 1964, and averaged 156 million board feet during 1970-1979 (USDA Forest Service 1980).

The general study area is characterized by warm dry summers and cool wet winters (Fig. 2). Average monthly precipitation was as high as 25–40 cm during November to January, and as low as 0–2 cm during July and August. February and March 1983 appeared slightly wetter than normal. Mean minimum monthly temperatures varied less over the year than did mean maximum monthly temperatures; minimums ranged between 0–4 C during winter and 7-11 C during summer, and maximums ranged between 7–13 C during winter and 30–35 C during summer.

Field Surveys

Selection of Study Stands

Vegetation stands were selected to represent young-growth physiognomic conditions under even-age timber management following clearcutting. Five secondary successional stages were recognized: grass/forb, early shrub/sapling, late shrub/sapling, pole, and medium sawtimber. The stands selected represented two developmental sequences: natural and silvicultural. In this report, the grass/forb, early shrub/sapling, and late shrub/sapling stages are referred to as "shrub stages," collectively. The grass/forb stage was defined as being recently cut, containing mostly grass and herbaceous species, and containing $\leq$ 20% woody vegetation cover; thus, shrubs were present on most grass/forb sites, but with low total ground cover. Similarly, the pole and medium sawtimber stages are referred to as "forested stages," collectively. Since little clearcutting had been conducted on public land in the study area prior to the 1950s, the forested stages were necessarily selected from natural stand conditions. Although most study stands in the forested stages developed following wildfires, they were chosen to represent the general physiognomic conditions that would result from intensive timber management.

The shrub stages were clearcut, burned, planted with seedling Douglas-fir, and, except for the grass/forb stage, sprayed with herbicides (2,4-D or 2,4,5-T; Table 1). The predominant cover on most of the shrub stage stands was provided by species of deciduous and evergreen shrub and broad-leaf hardwood trees. Some of the late shrub/sapling stage stands contained planted ponderosa pine or naturally seeded white fir.

Study stands of the forested stages were selected on the basis of their even-age appearance and modal diameter at breast height (dbh) of softwood stems. The pole stage represented a modal stem dbh of 13-28 cm and the medium sawtimber stage represented a modal stem dbh of 29-53 cm (stem size classes from Timber Stand Classification System, Six Rivers National Forest, USDA Forest Service.)

Habitat Surveys

Vegetation and habitat characteristics were measured around each of the bird count points. Three fixed-area plots were each set at random distances between 15 and 77 m from the bird count points (Fig. 3); the 15 m minimum assured that no plots would overlap, and the 77 m maximum assured that vegetation would be sampled within the 90 m distance that most birds were detected. Compass direction from the count point to the first plot was chosen randomly, and the directions to the two other plots were then located at increments of 120 degrees. New random distances were chosen if a plot landed in riparian influence zones, in anomalously large, bare ground disturbed areas, on roads or associated disturbed areas, or in anomalously large rock outcrops or log piles. The fixed area plots were aligned at right angles to the line which extended between their centers and the bird count point. In shrub stages, each fixed area plot consisted of a 2 x 30 m belt transect, three of which therefore totaled 0.018 ha at each bird count point. In forested stands, each plot was an 11.3-m radius half or full circle, in pole and medium sawtimber stands respectively. Total area surveyed thus was 0.06 ha at bird count points in pole stands and 0.12 ha at bird count points in medium sawtimber stands.

Within each fixed-area plot, foliage volume was measured as a function of height on a continuous basis with a modification of the HTVOL procedure of Mawson et al. (1976). The HTVOL procedure entailed visually estimating plan and profile shapes and sizes of all vegetation, excluding stems, greater than 10 cm tall. The HTVOL algorithm computes foliage volumes of each individual plant, tallying volumes by species and growth form (evergreen, deciduous), along any number of height strata defined *a posteriori*. For analysis, height strata increments of 0.2 m in the shrub stands, and 2 m in forested stands, were selected. The fixed area plots also allowed estimates of tree crown size, vegetation height, number of plant species within different height strata, and tree and snag stem densities and basal areas by dbh class.

In addition to the three fixed-area plots, in the forested stands a circular plot 30 m radius was centered on the bird count points. Within this larger, 0.28-ha plot, diameters of all tree and snag stems at least 40 cm dbh were measured.

A total of thirty 1 m^2 square mini-plots were placed systematically along each 30-m transect line (see Fig. 3). Within the mini-plots, estimates were made of percent cover of the following items: moss, bare rock, bare soil, litter, and vegetation under 10 cm tall. Percent cover estimates were used to calculate average percent cover and percent frequency of occurrence of each cover item. Litter depth was also measured at one corner of each mini-plot.

Volume and mass of woody debris were calculated with a modification of Brown's (1974) technique. In alternate, 1-m transect segments along each 30-m line at each fixed-area plot, "hits" with down wood were tallied according to three size classes: 0-0.6, 0.7-2.5, and 2.6-7.6 cm diameter. A total of forty-five 1-m segments were used at each bird count point for down wood tallies. Additionally, "hits" of logs over 7.6 cm diameter were made along the three 30-m transects.

A total of 48 canopy closure measurements were made around each bird count point with a spherical densiometer (Lemmon 1957). Densiometer readings were taken at ground level in the shrub stages and at elbow height in the forested stages; thus, the readings represent density of different vegetation strata in shrub and forested stages, and should be interpreted with this difference in mind. Slope aspect (degrees azimuth) and slope angle were measured at each plot with compass and clinometer, respectively.

Bird Surveys

Birds were counted with the variable circular plot (VCP) method (Reynolds et al. 1980). VCP count points were located within each stand at least 180 m from any stand edge and usually no closer than 360 m from any next nearest VCP point within the same stand, unless the two points were separated visually and aurally by a ridge. The number of VCP points totaled 89 over all stands, and ranged from 14 to 23 points per successional stage (Table 2).

VCP counts were taken mostly between sunrise and 10:00. Uncommonly, counts were taken after 10:00 on north-facing slopes, during winter, or in a small number of other cases when conditions necessitated late morning counts. In any one season, each point was visited on two consecutive or near-consecutive mornings. During each morning visit, six consecutive 10-min counts were made; thus, a total of 12 VCP counts were made per count point per season. A decision was made from initial test surveys conducted during summer 1980 to replicate counts at individual points rather than to attempt to survey from many points within a stand, because most stands were too steep and/or cluttered with woody debris to allow timely traversing between more than just a few points. One estimate of density of each species was derived from a mean of the twelve 10-min counts taken at each point during each season. The sampling frame I used for counting birds was adequate for detecting most bird species at each count point (unpub. data from 1980 trial runs). Bird densities were subsequently estimated for each VCP count point rather than by stand because of the heterogeneous vegetation structure within most stands, and because stands were originally mapped as units of vegetation based on silvicultural rather than ecological criteria.

Each count consisted of recording species of all individual birds seen or heard and estimating to the nearest meter across-ground distance. Other information recorded included visual or aural cue (call, song, drum, wing sounds), and stand boundary if the bird was perceived to be near the edge of the stand.

Bird surveys were conducted year-round, weather and access permitting. Counts were aborted or delayed during periods of precipitation. Five avian counting seasons were delineated: breeding (15 Apr - 30 Jun), summer (post-breeding dispersal; 1 Jul - 15 Sep), fall (16 Sep - 30 Nov), winter (1 Dec - 28 or 29 Feb), and spring (1 Mar - 14 Apr). Pilot surveys were conducted from June through September 1980 to establish the sampling frame and to conduct methodological tests. Regular surveys were conducted from July 1981 through March 1983. A total of 486 count-point visits were made and 5832 ten-minute VCP bird counts were conducted during the regular surveys (Table 3).

A series of field training sessions and methodological tests were conducted during pilot surveys and twice yearly throughout the study in both shrub/sapling and forested stands. The tests included simultaneous bird surveys and tests of species identification and distance estimation. The tests ensured that all observers were equally able to identify birds by sight and sound and equally able to estimate distances from visual or aural cues. Results (unpub. data) highlighted the need for such testing and suggested that, after initial training, observer skills of bird identification and distance estimation were adequate for subsequent data analysis.

Bird survey data were gathered by 3 primary observers. Hearing ability may greatly influence the results of bird surveys (Cyr 1981, Ramsey and Scott 1981b), especially in forested habitats where as many as 90 percent of all detections are made aurally. High frequency hearing was specifically important for detecting species such as brown creeper and golden-crowned kinglet, which typically call in the 6 to 8 khz frequency range. A standard pure-tone hearing test was administered to all 3 observers at the Speech and Hearing Clinic at Oregon State University at Corvallis. Results of the tests indicated that all 3 observers had good to excellent hearing ability in the frequency range tested (up to 8 khz).

Data Analysis

Classification of Habitat Stages

Study sites were initially categorized from map and field reconnaissance according to a successional series defined *a priori*. The vegetation and habitat survey data were further analyzed with discriminant function analysis to reclassify sites and to identify vegetation and habitat variables that accounted for the site classification schema. Highly correlated variables ($r \geq 0.75$) were first eliminated from the analyses, with the more ecologically meaningful or interpretable variable being retained. Both direct and stepwise discriminant function analyses, with a minimum Wilk's lambda criterion to discriminate groups, were employed with the SPSS statistical package (Nie et al. 1975).

Additionally, vegetation and habitat variables were converted to principle component scores with the principle factoring with iteration option of the SPSS package. Again, highly correlated variables were first eliminated from the analysis. Factor scores were orthogonally rotated with the Varimax criterion (Kaiser 1958; SPSS option discussed in Kim 1975) to simplify factor structure and ease interpretation. Site-specific scores of each statistically significant factor were first interpreted by back-correlating with the original vegetation and habitat variables and were then correlated with site-specific estimates of densities and richness values (number of bird species). In this way, habitat characteristics that correlated significantly with bird abundance and richness could be identified. Bird survey data from different seasons and years were assessed separately to qualitatively test for consistency of the associations.

Estimation of Bird Densities

Densities of bird species were calculated following the technique of Ramsey and Scott (1981a) and the algorithm described by Wildman (1984). Effective detection distance of each bird species was calculated for each combination of season and successional stage (pole and medium sawtimber stages were combined), years combined, where the number of distance estimates totaled at least 15.

Bird Distribution and Abundance

Three indices were used to describe the degree of suitability of scccessional stages for bird species: mean density, coefficient of variation of density, and percent occurrence. In this report, high habitat suitability is defined empirically as corresponding to those stages with high densities and low variations of density of birds among replicate count points. Temporal variations in densities, as well as demographic and dispersal information, were not included in this operational definition, but are important for discerning relative quality of different habitats and viability of populations (Van Horne 1983).

Coefficients of variation (CV = SD/mean) of species densities were used to describe the variability of species' abundance levels within successional stages.

Comparing CV values of a species across successional stages within a season gave some insight into the degree of suitability of different stages. High CV values reflected high within-stage variation of density estimates among VCP count points, owing to either a species' absence at some of the count points or to its higher densities at some count points and not at others. I interpreted low CV values as reflecting a higher degree of habitat suitability than high CV values (Van Horne 1983), although I did not partition the relative proportions of density variations as contributed by habitat quality and by pure error (chance variation).

Percent occurrence was calculated as the percent of VCP count points of a given stage surveyed during a given season at which a species was detected at least once. High values of percent occurrence were interpreted as reflecting a greater degree of habitat suitability than low values.

Stepwise multiple linear regression (Draper and Smith 1981) was used to formulate equations predicting breeding and winter densities of each bird species from vegetation and habitat variables. I used the SPSS statistical package (Nie et al. 1975) to conduct regression analyses. Avian density values were first transformed (log[x+1]) to better meet the underlying distribution assumptions of least-squares estimation. Because of the great number of regression equations generated, it was unfortunately infeasible to search for better fits with polynomial and interaction terms, which may additionally explain some species distributions (Meents et al. 1983). A measure of the percent of total variation explained by a regression equation was the adjusted coefficient of determination (adj. R^2), which was computed as

$$\text{adj. } R^2 = R^2 - \frac{K - 1}{N - K}(1 - R^2)$$

where N is the number of cases, R^2 is the unadjusted coefficient of determination from the regression, and K is the number of coefficients estimated (including constant) (Cohen et al. 1981).

The above regression analyses were used to investigate associations of bird species densities with vegetation and habitat variables at the level of alpha (within-habitat) diversity. A further analysis investigated additional influence on species density from topographic and physiographic variables at the level of beta (between-habitat) diversity. The question posed may be stated as, could topophysiographic characteristics of the study sites account for any of the variations in bird density that were not explained by on-site, vegetation and habitat characteristics? To investigate this possibility with bird data from shrub and forested stages during breeding and winter seasons in 1982, I regressed density estimates of each bird species against all principle component factor scores that were derived from vegetation and habitat variables (Appendix 2); stored the values of the residuals (i.e., the unexplained variation); and then regressed, step-wise, the residuals against the topophysiographic variables (Appendix 2) while looking for significant values of partial correlations.

Community Composition Parameters and Classification of Bird Communities

Sample estimates of bird species richness, total density, and diversity (Shannon-Weiner information diversity index, Shannon and Weaver 1949) were calculated for each combination of site and season with the AIDONE and AIDN computer programs of Oregon State University at Corvallis.

The AIDN programs calculated taxonomic (Euclidean) distance measures (DIST) between all pairs (m,n) of successional stages from site-specific estimates of bird densities. The formula used was

$$DIST_{mn} = \sum_{j=1}^{S} (p_{mj} - p_{nj})^2$$

where p_{mj} and p_{nj} are proportions of the jth species in successional stages m and n, respectively.

Habitat niche breadth was estimated for each species in each season by using Levins' (1968) formula:

$$B_j = \exp\left[- \sum_{i=1}^{k} \frac{p_{ij}}{R_j} \ln \frac{p_{ij}}{R_j} \right] \qquad (1)$$

where $R_j = \sum_{ij}^{k} p_{ij}$, B_j = habitat niche breadth of the jth species, k = number of collections (sites sampled) in a given season, and p_{ij} = proportion of the jth species in the ith collection. Unweighted mean habitat niche breadth for the ith collection, $\bar{B}_i$, was calculated as the mean over all species observed in the collection (S_i):

$$\bar{B}_i = \frac{1}{S_i} \sum_{j=1}^{S_i} B_j . \qquad (2)$$

Further, since $1 \leq B_j \leq k$, and since k varied among seasons, equations (1) and (2) were standardized by dividing by k (Levins 1968). Thus, with a moderate to large number of collections,

$$0 \simeq k^{-1} \leq \left[\frac{B_j}{K} \text{ or } \frac{\bar{B}_i}{k} \right] \leq 1.$$

In this way, species-specific measures of habitat niche breadth and measures of unweighted mean habitat niche breadth over all species were rescaled to vary between 0 and 1, and could thereby be compared between seasons. Also, rescaled niche breadth values may be interpreted, in a sense, as proportions of maximum possible distribution; a value of 1.0 occurs only when a species is equally distributed (equally abundant) at all sites, and values progressively less than 1.0 occur as a species' distribution becomes increasingly unequal across sites.

Similarity of habitat niche breadth among permanent resident bird species was calculated by AIDN as

$$ESIMI_{ij} = \frac{\sum_{h=1} p_{ih} \; p_{jh}}{SD_i \; SD_j}$$

where $ESIMI_{ij}$ is the similarity between species i and j; p_{ih} and p_{jh} are proportions, respectively, of species i and j in the hth collection; and SD_i and SD_j are sample standard deviations of densities of species i and j, respectively. ESIMI is analogous to a simple correlation coefficient (S. Overton, D. McIntire, pers. comm.) between species, and varies in the interval [0,1].

Measures of mean community overlap (MCO) among resident bird species in each season were calculated for the ith species as

$$MCO_i = \frac{1}{S-1} \sum_{j=1}^{S-1} ESIMI_{ij} \qquad i \neq j,$$

as a modification of Cody's (1974) formula. Mean community overlap essentially measured the average similarity of abundance of each resident species with abundances of all other permanent resident species across all study sites. Species with high overlap values in a particular season occurred commonly, on the average, with other permanent residents; species with low overlap values occurred less commonly with other residents, or had more restricted distributions across sites or successional stages.

Bird communities were classified (r-type classification) with density data from each season with a hierarchical clustering algorithm. The purpose of classification is to describe assemblage-level patterns of the similarities of species abundances. Classification groups species into clusters based on their site-specific densities. The properties common to a group of species in a particular cluster are then used to describe that set of species as a whole.

In employing classification, density estimates were first transformed [log(x+1)] to reduce the controlling influence on classification patterns from the more abundant bird species. The Bray-Curtis dissimilarity index (Bray and Curtis 1957) was calculated for each species. I used the Lance-Williams' Flexible Method (Lance and Williams 1967) as a cluster fusion strategy with the beta parameter chosen as -0.25 to provide a moderate and interpretable clustering intensity. Dendrograms were drawn showing cluster fusion levels and similarity of bird species.

RESULTS AND DISCUSSION

PART ONE: ECOLOGICAL RELATIONSHIPS

Habitat Surveys

The young-growth successional sequence was marked (in part) by changes in plant species composition, foliage volume, size distribution of softwood and hardwood stems, ground cover characteristics, and down wood and litter.

Plant Species Composition

A total of 189 plant species was identified from all vegetation surveys, including 46 trees and shrubs and 143 grasses and forbs. Seven of the tree and shrub species were coniferous evergreen, 23 were broadleaf deciduous, and 16 were broadleaf evergreen.

Grass/forb stage. The grass/forb stage, as well as the early and late shrub/sapling stages, showed high between-site variability in plant species composition. Grass/forb sites were dominated by a variety of species, including low canyon live oak shrubs (averaging 24% of total foliage volume), bull thistle (16%), low tanoak shrubs (10%), berries (7%), and golden chinquapin shrubs (4%); groudsel, skeleton weed, and California harebell (each $\leq$ 2%) were also common. The more frequently encountered grass and forb species included willow herb, fescues, dogbane, draperia, and cheat grass (each $\leq$ 1%).

Shrub/sapling stages. In early and late shrub/sapling stages, tanoak (averaging 19% of total foliage volume), Douglas-fir (15%), Pacific madrone (10%), deerbrush (8%), tobacco brush (8%), canyon live oak (5%), gooseberry (3%), mountain whitethorn (1%), and blue elderberry (1%)contributed seasonally and heavily to foliage volumes and percent cover. Plant species presence and foliage volumes differed substantially by site.

Forested stages. Forest stages were dominated mostly by Dougas-fir (averaging 71% of total foliage volume), with subdominants of tanoak (7%), California black oak (6%), and Pacific madrone (5%). Tree species encountered less frequently included ponderosa pine (3%), sugar pine (2%), canyon live oak (2%); and bigleaf maple, Jeffrey pine, white fir, and insence cedar (each ≤ 1%). Oregon white oak (<1%) appeared infrequently in the understory of medium sawtimber stands.

Foliage Volume and Canopy Structure

Foliage volume. Estimates of total foliage volume varied substantially by successional stage (Table 4). Total foliage volume in the late shrub/sapling stage was 1.6 times as great as in the early shrub/sapling stage and 9.3 times as great as in the grass/forb stage. Total foliage volume averaged 1.9 times as great in the medium sawtimber stage as in the pole stage. The proportion of total foliage volume found in the 0.1–2 m height stratum decreased across the five successional stages and averaged 99, 73, 61, 2, and 1 percent in the grass/forb through medium sawtimber stages, respectively.

Evergreen foliage, especially of softwood trees, accounted for the significantly smaller proportion, of deciduous foliage in the overstory of forested stages as compared to the shrub stage. Most of the foliage in the pole stage occurred below 40 m high, whereas foliage in the medium sawtimber stage sometimes extended to 56 m (Fig. 4).

Foliage closure. Percent closure of understory and overstory foliage was less in shrub than in forested stages. Densiometer estimates of percent foliage closure averaged 68 (S.E. = 3), 71 (S.E.= 3), 81 (S.E.= 2), 90 (S.E. = 1), and 93 (S.E. = 1) percent, respectively, in the grass/forb through medium sawtimber stages.

Foliage patchiness. The degree of understory and overstory foliage patchiness declined across the successional sequence, concomitant with the increase of percent closure of foliage. Foliage patchiness was measured by the coefficient of variation of densiometer measurements of overstory and understory foliage closure, and decreased from an average of 1.11 in the grass/forb stage to 0.04 in the medium sawtimber stage (Fig. 5). Patchiness differed significantly among the three shrub stages and between shrub and forested stages, but not significantly between the two forested stages ($P < 0.05$, ANOVAs, Student's *t*).

Tree crown sizes. Crown sizes of 9 species of trees increased as stem diameter increased (Fig. 6). Species with wide crowns were ponderosa pine, sugar pine, Douglas-fir, Pacific madrone, and canyon live oak which occurred in dominant or codominant crown positions in the overstory canopy of the forested stands. Bigleaf maple, Oregon white oak, and California black oak were broad-leaf deciduous hardwoods that frequently occurred in the understory. Tree species with fast-spreading crowns in the 1-12 and 13-27 cm dbh classes included big-leaf maple, tanoak, and Oregon white oak, which were prevalent in the understory.

Size Distribution of Stems

~~Live stem~~ density. I calculated density of live stems at least 1 cm dbh from vegetation plots at each VCP bird count point. Total stem density averaged 20 stems/ha in the grass/forb stage, 384 stems/ha in the early shrub/sapling stage, and 1250 stems/ha in the late shrub/sapling stage (Fig. 7). Pole stands averaged 1710 stems/ha and medium sawtimber stands averaged 1066 stems/ha. In all stages, the majority of stems occurred in the 1-12 cm dbh class, with the late shrub/sapling stage showing the greatest variation in stem density between VCP bird count points.

Total numbers of softwood stems over all dbh classes (Fig. 7) averaged 0, 229, 435, 1390, and 537 stems/ha in grass/forb through medium sawtimber stages, respectively; total number of softwood stems 13 cm dbh and larger averaged 0, 7, 14, 510, and 237 stems/ha. Medium sawtimber stands averaged a greater proportion of density of softwood stems in the larger dbh classes than did pole stands.

Total numbers of hardwood stems over all dbh classes (Fig. 7) averaged 20, 155, 815, 320, and 529 stems/ha in grass/forb through medium sawtimber stages, respectively; total numbers of hardwood stems 13 cm dbh and larger averaged 4, 4, 26, 150, and 215 stems/ha. Grass/forb stands contained no softwood stems measuring at least 1 cm dbh. The bloom of dense hardwood shrubs in the subsequent shrub stages was reflected by the percentage of all live stems that were hardwoods: 40 percent in early shrub/sapling and 65 in late shrub/sapling stages. The proportion and total density of hardwood stems increased from early to late shrub/sapling stages. Pole stands averaged 19 percent of all stems as hardwoods, and medium sawtimber stands averaged 50 percent.

Many of the stems 40 cm dbh and larger in the forested stands were residual trees from earlier stands.

Most of the forested stands probably developed their present, more or less even-age structures following wildfires in 1910-1930 (Lower Trinity and Big Bar Ranger District Fire Atlases). Many large diameter softwoods, especially Douglas-fir and ponderosa pine, had fire scars on the lowest 2-5 m of the trunks, and survived along with large, old California black oaks and Pacific madrones. In pole stands, the high density of stems in all dbh classes, and especially in the 1-12 cm dbh class, attested to the highly stocked regeneration of both softwoods and hardwoods in those stands.

Live stem basal area. Total stem basal area averaged 0.1, 0.9, 2.6, 52.8, and 49.9 m^2/ha in grass/forb through medium sawtimber stages, respectively (Fig. 8). Total basal area of softwood stems of all diameters averaged 0, 0.7, 0.8, 38.7, and 33.8 m^2/ha in grass/forb through medium sawtimber stages, respectively. The few, large remnant softwoods present in both pole and medium sawtimber stages contributed greatly to total average stand basal area in the 53+ cm dbh class; however, pole stands exhibited a mode of basal area in the 13-27 cm dbh class (Fig. 8).

Estimates of average basal area in each of the forested stages derived from the three half- or full-circle plots at each VCP bird count point, compared closely with estimates derived from the larger single, 0.28-ha circular plots centered on each count point. However, despite the close agreement on stage-wide averages, the two methods agreed much less closely on a VCP point-by-point basis. At any given point, the I-plot method surveyed 4.7 times the area as did the 3-plot method in pole stands, and 2.3 times the area as did the 3-plot method in medium sawtimber stands. Also, the 1-plot method sampled a different section of each stand at the VCP bird count points than did the 3-plot method (Fig. 3). Because substantially greater area was surveyed, the I-plot method gave more precise stand-specific estimates of density and basal area of the larger stems than did the 3-plot method; and, conversely, the 3-plot method provided some insight into within-stand variations of stem density and basal area, whereas the I-plot method did not. Estimates of basal area, as well as of density, at each VCP bird count point from both survey methods were retained for all subsequent analyses.

Snag density and basal area. The three shrub stages contained a few scattered live trees and snags that were retained during clearcutting from the original stands, but these residual live trees and snags were seldom encountered in the fixed-area vegetation survey plots. Where present in the shrub stands, snags over 13 cm dbh and over 1.8 m in height ranged 2-10 per ha within 200 m of the VCP bird count points. Snags in all successional stages were most commonly Douglas-fir, Pacific madrone, tanoak, or California black oak.

A greater average density, and a greater proportion of all snags, of the over-52 cm dbh class were found in pole as compared with medium sawtimber stands (Table 5), reflecting again the wildfire-induced origins of the pole stands and the residua of earlier, pre-fire trees. Basal area of snags over 40 cm dbh was slightly greater in pole as compared with medium sawtimber stands (Table 5).

Ground Cover Characteristics

The grass/forb stage was distinguished from early and late shrub/sapling stages by having a lower average percent ground cover of green vegetation under 10 cm tall and higher amounts of bare soil and rock (Fig. 9). Among the 3 shrub stages, percent green vegetation cover was significantly correlated with number of years since the stands were clearcut ($r = 0.42$, $p < 0.001$, $n = 52$). Pole and medium sawtimber stages were similar in percent ground cover characteristics, with the medium sawtimber stage having slightly greater green vegetation cover. Most of the ground in both forested stages was covered with litter.

Percent occurrence of each cover item in the mini-plots (Fig. 9) may be viewed as indices of patchiness at a scale relative to the sampling design. For example, although average percent ground cover of litter increased substantially over the 5 successional stages, percent occurrence of litter remained high, because litter was more or less evenly distributed throughout the surveyed areas. Green vegetation < 10 cm tall was evenly and densely distributed in the 3 shrub stages (percent occurrence of green vegetation was equally high), but was less evenly or less densely distributed in forested stages; further, green vegetation was much more patchily distributed in pole stands than in medium sawtimber stands, as evidenced by the much lower average percent occurrence.

Down Wood and Litter

~~Down wood mass and volume~~. Down wood mass at VCP bird count points averaged highest in early and late shrub/sapling stages and lowest in medium sawtimber stages (Table 6). The proportion of total mass that occurred in the smaller down wood size class (<= 7.6 cm diameter) was lower in stands that had been burned (Table 1) as site preparation for seedling planting as compared with stands that had not been burned. Estimates of average down wood volume varied significantly across the five successional stages (ANOVA, $F = 2.50$, $p = 0.05$, $df = 4,84$), but were not significantly correlated with number of years since clearcutting in the 3 shrub stages ($r = -0.02$, $p > 0.50$, $n = 52$).

Down wood volume showed the same trends among successional stages as did down wood mass (Table 6). Down wood volume was highly significantly correlated with down wood mass ($r = 0.98$, $p < 0.001$, $n = 89$); therefore, down wood volume was excluded from subsequent assessments of bird-habitat relationships.

Litter depth. Litter depth measurements around VCP bird count points averaged 2.3, 2.2, 4.8, 6.0, and 3.9 cm in grass/forb through medium sawtimber stages, respectively. Estimates of average litter depth differed significantly across the five successional stages (ANOVA, $F = 19.40$, $p < 0.001$, $df = 4,84$). The substantially greater average depth in late shrub/sapling as compared with grass/forb or early shrub/sapling stages correlated highly with various measures of shrub foliage volume and density (e.g., the correlation between litter depth and total foliage volume was $r = 0.52$, $p < 0.001$, $n = 52$). Among the 3 shrub stages, litter depth correlated significantly with number of years since clearcutting ($r = 0.43$, $p < 0.001$, $n = 52$).

Seasonal Changes of Vegetation

Deciduous foliage. The three shrub stages exhibited greater seasonal changes of total foliage volume than did the two forested stages, because of the high proportion of deciduous foliage volume. The bulk of deciduous foliage volume in most forested stands occurred between ground level and the mode of evergreen foliage volume; in some stands, however, deciduous foliage was represented by large, remnant hardwoods, and was restricted to the upper canopy position.

Plant growth phenology. The *a posteriori* defined five avian seasons corresponded with various stages in the cycle of plant growth. During the avian breeding season, most leaf growth started (April) and continued until leaves were fully grown (late May). During the avian summer season, plant seeds developed, ripened (mid-July to mid-August), and disseminated (late August to early September). During the avian fall season, leaves began abcission (September), dried, and began to drop (October). During the avian winter season, deciduous plants were leafless. Finally, during the end of the avian spring season (late March to April), leaf growth began.

Stand Physiographic Characteristics

Physiographic characteristics of the 55 study stands differed among the *a priori* defined successional stages (Table 7). This resulted from topographic, physiographic, and size characteristics of the shrub stage study stands, which in turn were influenced by existing and past

National Forest guidelines and policies for clearcutting. For example, the shrub stages were all under 26 ha in contiguous area and bordered no more than 8 adjacent stands. In contrast, the (unharvested) forested stages ranged as large as 86 contiguous ha and bordered as many as 14 adjacent stands. The forested stands varied considerably in size and physiographic characteristics.

Additionally, the most recently clearcut stands (grass/forb stage) were generally the smallest, steepest, and highest in elevation of all stages, as recent timber harvesting has focused on clearcutting small timber stands occurring on upper slopes and ridgelines. Such trends in recent harvesting accounted for the observed negative correlation between area and elevation ($r = -0.44$, $p < 0.001$, $n = 55$ stands) over all stands. However, slope and elevation of all stands were not significantly correlated ($r = 0.17$, $p = 0.20$, $n = 55$).

Stand shape. The relationship between stand area and boundary length was captured in the stand shape index of Patton (1975) (Table 7). In general, the index ranges in the interval $[1, \infty)$, attaining a value of 1 when the stand in question is perfectly circular, and exceeding 1 as stand shape deviates more markedly from circularity. As was anticipated, the more "block-shaped" clearcut stands had lower shape index values than forested stands.

Slope aspect. Present and past timber harvesting in the study area, and criteria for selecting the study stands, resulted in a non-random distribution of average aspects (slope azimuth) of the study stands. Forty-eight of the 52 VCP bird count points in the shrub stages were situated on slopes facing north (between 270 and 89 degrees azimuth) for a non-random mean aspect orientation (Rayleigh's R = 33.60, $p < 0.001$, df = 52). In contrast, 25 of the 36 VCP bird count points in the forested stages were situated on slopes facing south (between 90 and 269 degrees azimuth) for a non-random mean aspect orientation (Rayleigh's R = 16.30, $p < 0.001$, df = 37). The mean aspect of VCP bird count points in shrub stands was 0 degrees azimuth (S.E. = 54), whereas the mean aspect of VCP bird count points in forested stands was 152 degrees azimuth (S.E. = 77). Throughout this paper, I have assumed that the effects of aspect on bird distribution and abundance occurred primarily through the influence of aspect on vegetation and habitat characteristics of the stands. For example, greater foliage volumes of canyon live oak were found on south-facing slopes than on north-facing slopes, and greater foliage volumes of big-leaf maple were found on north-facing slopes than south-facing slopes. Accordingly, aspect was not explicitly included as a habitat variable in subsequent analyses.

Distance to water. Mean distance from the stands to the nearest permanent water, as represented on U.S. Forest Service (USFS) topographic maps (scales 1:12,000 or 1:24,000) as permanent streams or rivers, differed among the stages (Table 7). In some stands, ephemeral seeps, springs, streams, and small ponds occurred during winter and spring seasons from the highly seasonal pattern of precipitation (Figure 2). Therefore, distance to permanent water may incompletely describe year-long proximity of the various stands to open water or water-influenced vegetation.

Distance to nearest similar habitat. Distance from each study stand to the nearest contiguous or non-contiguous stand having the same USFS vegetation designation was measured from orthographic maps (scales 1:12,000 or 1:24,000) and USFS timber type map overlays updated from field reconnaissance. Most stands were in close proximity to stands of the same type class and averaged 245 m distance over all 55 stands (Table 7). The close proximity is explained by the highly mosaic nature of stand structures and age classes under natural conditions in the general study area, a result of both natural conditions (high topographic relief and high diversity of soil and substrate types) and past forest management activities (clearcutting and associated activities).

Classification of Habitat Stages

Direct discriminant function (DF) analysis of summertime vegetation and habitat variables, excluding topophysiographic variables (Appendix 2), was conducted separately with data from shrub stages and forested stages. Results of the analyses suggested that no particular stands required relabelling; classification success was 100 percent, not surprisingly, because a large number of vegetation and habitat variables was included in DF analyses and because g *priori* classification of stages was based upon salient vegetation and habitat characteristics.

Shrub stages. The grass/forb, early shrub/sapling, and late shrub/sapling stages formed more or less a continuum of stand structure, as evidenced by a plot of 52 case-specific DF scores (Fig. 10). Average stand conditions, as shown by the wide separation of group centroids, reflected my *a priori* conceptions of the three stages. The shrub stages differentiated from one another vegetationally along two main DF gradients. The first gradient (84 percent of total explained variation; see Table 8) differentiated the grass/forb stage and represented changes during the initial 10 or so years following clearcutting and burning, during which vegetation height and low foliage volume increase and percent bare soil cover decreases (Figs. 4,9). The second gradient (16 percent of total explained variation) differentated the early and late shrub/sapling stages and represented changes occurring after 10 years, especially increasing litter accumulation and decreasing bare rock and stump cover.

Principle component factor analysis of vegetation and habitat variables from the three shrub stages (52 VCP bird count points total) resulted in 5 significant factors from breeding and summer data, 6 factors from spring and fall data, and 5 factors from winter data (Appendix 3). The first factors in all three seasons' data sets represented shrub volume development, corresponding well with the first discriminant function of the same data set. Factors 1 and 2 accounted for 48 and 22 percent of total explained variation, respectively, averaged across seasons, meaning that on the average 70 percent of the variation in vegetation among the shrub stages was attributed to relatively few vegetation variables (shrub volume, stem density, and litter deposition).

Forested stages. Pole and medium sawtimber stages differed significantly on the basis of vegetation, as revealed by a plot of 37 case-specific DF scores (Fig. 10). The pole stage differentiated from the medium sawtimber stage on the basis of a greater density and basal area of softwood stems in the 13-27 cm dbh class and a smaller average diameter of Douglas-fir stems, as shown by the single DF axis (see Table 8). DF classification matched and amplified the vegetation variables used in the *a priori* classification of sites.

Factor analysis of vegetation and habitat variables from the forested stages (37 VCP count points total) resulted in 8 significant factors from breeding and summer data, 9 factors from spring and fall data, and 10 factors from winter data (Appendix 3). The first two factors consistently represented low vegetation cover and foliage volume, and density and basal area of large diameter softwoods, and on the average accounted for 26 and 21 percent of total explained variation, respectively.

Summary: Habitat Surveys

In general, stand physiographic, vegetation, and habitat characteristics served to distinguish the five *a priori* defined successional stages. Physiographic characteristics reflected recent timber harvesting practices on National Forest land within the study area; the most recent clearcuts (grass/forb stage) were smaller in area and often occurred on steeper, north-facing slopes. All study stands occurred in areas of high topographic relief and mosaic-like patterns of surrounding stand conditions and age classes.

Shrub stages showed high between-site variability in plant species composition, and contained a number of dominant species of fast-growing deciduous and evergreen broadleaf shrubs. Foliage volume was approximately one and one-half times greater in the early shrub/sapling stage, and nine times greater in the late shrub/sapling stage, than in the grass/forb stage, and approximately twice as great in the medium sawtimber stage as compared with the pole stage. A greater proportion of foliage volume was comprised of deciduous foliage in the shrub stages than in the forested stages. Overstory and understory foliage closure was progressively higher, and foliage cover patchiness was progressively lower, across the successional sequence. In the forested stages, dominant or codominant overstory trees with wide crowns included ponderosa pine, sugar pine, Douglas-fir, Pacific madrone, and canyon live oak; bigleaf maple, Oregon white oak, and California black oak frequently occurred in the understories.

Total stem density was 19 times greater in the early shrub/sapling stage, and 63 times greater in the late shrub/sapling stage, than in the grass/forb stage, and 1.6 times greater in the pole stage than in the medium sawtimber stage. Many of the softwood, hardwood, and dead (snag) stems $\geq$ 40 cm dbh in the pole and medium sawtimber stands were probably left from earlier, pre-wildfire stands, and contributed greatly to estimates of total stand basal area; none of these vegetation elements were silviculturally planned inclusions. Pole stands generally contained significantly higher densities of snags 13-40 cm dbh as compared with medium sawtimber stands.

Burned stands contained a significantly lower proportion of total down wood in the small diameter (< 7.6 cm) category than did unburned or forested stands. Discriminant function classification and principle component factor analysis of vegetation and habitat variables suggested that the shrub sites represented a continuum of stand structure, distinguished by an increase in' vegetation height, the development of shrub volume, a decrease in the patchiness of ground vegetation, and an accumulation of litter. Pole stands differentiated from medium sawtimber stands on the basis of a greater density and basal area of softwood stems 13-27 cm dbh, a lower total vegetation height, and a lower mean diameter of Douglas-fir stems. The classification of sites into habitat stages helped quantify the contributions of various vegetation and habitat variables and also served to underscore the _a priori_ defined criteria on which study sites were originally selected.

Patterns of Bird Distribution and Abundance

Species Densities by Successional Stage and Season

Ninety-one species of birds were encountered during surveys over all seasons (Appendix 4). Families that were especially well represented included woodpeckers (7 species), flycatchers (5 species), and new-world warblers (9 species).

Effective detection areas (EFFAR) of a given species by season and successional stage often were greater in the open, grass/forb stage than in the other stages, which were more visually and aurally constraining (Appendix 5). Estimates of EFFAR were well correlated among the principle observers ($r = 0.55$, $P < 0.001$, $n = 55$) and showed low between-observer bias. Species-specific estimates of EFFAR for all successional stages combined were significantly and positively correlated between summer 1981 and 1982 ($r = 0.63$, $P < 0.001$, $n = 59$ between-year comparisons), between fall 1981 and 1982 ($r = 0.61$, $P < 0.001$, $n = 59$), and between winter 1982 and 1983 ($r = 0.91$, $P < 0.001$, $n = 8$). Similar results were obtained when successional stages were not combined. Therefore, species-specific values of EFFAR in different seasons and stages were estimated from data with years combined, which served to increase sample size (number of detection distances to individual birds of a given species) and thus the reliability of the EFFAR estimates.

Species-specific estimates of mean density often differed significantly among the five successional stages within a season. For example, during the breeding 1982 season, 41 of 48 species showed significant differences in mean density among stages (ANOVAs, all F's $>$ 2.70, $p <$ 0.05, df = 4,67). During winter 1982 and winter 1983, 14 of 22 species (ANOVAs, all F's $>$ 3.20, $p <$ .05, df = 4,27) and 13 of 23 species (ANOVAs, all F's $>$ 2.70, $p <$ 0.05, df = 4,27), respectively, showed significant differences in mean density across the five successional stages. Species not showing significant differences across successional stages were abundant and ubiquitous across the stages (dark-eyed juncos), or often occurred in relatively low abundances throughout the stages (e.g., acorn woodpeckers).

Breeding season densities. Each successional stage had species occurring at highest density during the breeding season (Table 9, Appendix 6). In general, 32 species showed significantly higher densities (ANOVAS, $p <$ 0.05) in the three shrub stages than in the two forested stages, and 21 species showed significantly higher densities in forested than in shrub stages. Eighteen species were observed too infrequently for estimation of effective detection distances and densities in any successional stage.

During the breeding season, species found with highest mean densities in the grass/forb stage included western wood pewee (scientific names given in Appendix 4), house wren, western bluebird, and lazuli bunting*. (Asterisks [*] mark species found almost solely in the denoted stage). Species with highest mean density in the early shrub/sapling stage included northern flicker, scrub jay*, Bewick's wren, wrentit, yellow-rumped warbler, black-throated gray warbler, song sparrow*, and dark-eyed junco. Species with highest mean densities in the late shrub/sapling stage were Anna's hummingbird, calliope hummingbird*, bushtit*, hermit thrush, warbling vireo, MacGillivray's warbler, Wilson's warbler, black-headed grosbeak, chipping sparrow, and fox sparrow. Species showing higher mean densities in shrub than in forested stages, but with nearly less equal densities in early and late shrub/sapling stages, included mountain quail, olive-sided flycatcher*, dusky flycatcher*, orange-crowned warbler*, Nashville warbler, rufous-sided towhee*, purple finch, and lesser goldfinch*.

Species with highest mean densities in the pole stage were red-breasted sapsucker, hairy woodpecker, and mountain chickadee. Species with highest mean densities in the medium sawtimber stage included acorn woodpecker, Hammond's flycatcher*, western flycatcher, brown creeper, winter wren*, golden-crowned kinglet, American robin, solitary vireo, hermit warbler, and pine siskin. Species with higher mean densities in forested than in shrub stages, but that showed more or less equal densities in pole and medium sawtimber stages, were Steller's jay, common raven, chestnut-backed chickadee, red-breasted nuthatch*, western tanager, and evening grosbeak*.

Seasonal changes in density patterns. Several bird species showed marked shifts of densities among successional stages among seasons. Warbling vireos, for instance, were most abundant in shrub stages during the breeding season and in forested stages during summer (post-breeding). Conversely, acorn woodpeckers and western tanagers were most abundant in the forest stages during the breeding season, but showed substantially greater densities in shrub stages than in forested stages during the summer season.

Band-tailed pigeons and northern flickers were most abundant in shrub stages during the breeding and summer seasons and in forested stages during the fall and winter seasons. Steller's jays, winter wrens, American robins, pine siskins, and evening grosbeaks were most abundant in forested stages during the breeding and summer seasons and in shrub stages during fall and winter seasons.

Shifts of habitat use may be explained by at least 4 phenomena working independently or in concert: dispersing or wandering juveniles may have used habitats in different frequencies as compared with breeding adults; birds may have invaded shrub habitats during the winter for cover and food (winter wrens); birds may have left shrub habitats during winter because of the reduction of cover or food resources in the more exposed stages (band-tailed pigeons, northern flickers); and birds may have invaded shrub habitats supplying fruits or seeds during late summer and fall (pine siskins, evening grosbeaks). Additionally, seasonal changes in elevational or latitudinal distributions of birds may have influenced patterns of habitat use.

Yearly changes in density patterns. I compared mean densities of each species within each successional stage between years. Densities rarely differed between years because of high variations of densities among replicate stands of each successional stage. Only 5 of a total of 143 between-year comparisons were significantly different between summer 1981 and summer 1982 (unpaired t-tests, $p < 0.05$). Common ravens, sharp-shinned hawks, and downy woodpeckers were more abundant in 1982 than in 1981 in the pole stage. Mountain quail, however, were more abundant in the pole stage during 1981 than during 1982. Olive-sided flycatchers were more abundant in the early shrub/sapling stage during 1982 than during 1981.

Only 3 of 130 between-year comparisons during fall 1981 and 1982 showed significant differences ($P < 0.05$) in mean densities. Estimates of mean density of downy woodpeckers in pole stages were higher in fall 1982 than in fall 1981. Pygmy owls were more abundant in both pole and medium sawtimber stages in fall 1982 than in fall 1981. Only 1 of 64 between-year comparisons during winter 1982 and 1983 showed significant differences in mean density levels: northern flickers were more abundant in the pole stage during 1983 than 1982. No differences were found between spring or breeding seasons. In summary, within-stage estimates of mean density, were seldom significantly different between years for a given season. Differences that were observed may have been real or artifacts of improving ability to detect species by call notes. Improving observer ability seems the likely cause, as 8 of 9 between-year differences were increases in density estimates over time.

Hagar's (1960:116) surveys of birds in clearcuts ranging 1 to 7 years old and in "virgin forest" areas were conducted during 1955-1957, 26 years prior to the present study, and in several geographical locations identical to those used in the present study. Many distributional patterns of birds over habitats and seasons reported by

Hagar were replicated in the present study, including the seasonal occurrence of varied thrushes, winter wrens, golden-crowned sparrows, and white-crowned sparrows; the 'affinities of spotted (rufous-sided) towhees, Calavaras (Nashville) warblers, Tolmie (MacGillivray's) warblers, and other species to later, shrubby stages of clearcuts, and the winter preference by Steller's jays of brushy clearcuts.

However, several species exhibited altered patterns of distribution and/or abundance relative to Hagar's surveys. Hagar reported that fox sparrows were absent during the breeding season, but were common in brushy clearcuts from October to April. Similarly, Grinnell and Miller (1944) showed a gap in the distribution of fox sparrows in northwestern California in the location of my study sites on the Six Rivers National Forest. As recently as 1975, Yocum and Harris (1975:59) reported that the species was a rare inland breeder in "localized areas" in northwestern California. In contrast, during the breeding season, densities of fox sparrows in the present study averaged as high as 27.3 birds/40 ha in the late shrub/sapling stage (Table 9), where they occupied one-third of all shrub/sapling stage sites surveyed (Appendix 7). Clearly, this species has invaded a new breeding range in response to the greater amount of clearcutting since the 1950's.

Hagar (1960:124) also reported that western bluebirds were "occasionally seen on cutovers in late fall and winter," whereas I found local densities averaging 18.3 and 22.9 birds/40 ha during breeding and summer seasons, respectively, in the grass/forb stage (Table 9). Hagar noted that purple finches and evening grosbeaks were residents during winter in the forest canopy, whereas I found these 2 species present also in the shrub stages throughout the year. Hagar reported that the western wood pewees were common in the forest and did not invade logged areas, whereas I found highest densities, averaging up to 8.7 birds/40 ha in the grass/forb stage during breeding and summer seasons. Hagar reported that band-tailed pigeons were common during winter on the edges of cutovers, as I also found them, but I observed that the species invaded the shrub stages during summer and especially fall for perching and foraging, averaging up to 86.9 birds/40 ha during fall.

Hagar did not mention dusky flycatchers in his report, whereas I found this species as abundant as 25.9 birds/40 ha and occupying 81 percent of study sites in the late shrub/sapling stage during the breeding season. This species has clearly expanded its local range by invading clearcut habitats.

All of these species have probably increased in local density, total population size, distributional range, seasonal occurrence, or types of habitats (successional stages) used since the mid-1950's, and will continue to show overall population increases as long as shrub stage habitat is increasingly available in the general study area. Species that are restricted to forest stages and that have probably decreased in total population sizes since Hagar's study, given the amount of forest area converted to shrub stage habitat, include brown creeper, golden-crowned kinglet, Hammond's flycatcher, chestnut-backed chickadee, red-breasted nuthatch, and hermit warbler.

Total area occupied by, and distributional patterns of, different successional stages - young-growth as well as mature or old-growth - have been greatly influenced by timber harvesting in the study area during the past 30 years. Currently, many forested stands have been harvested and converted to shrub/sapling stages, probably to the benefit of bird species highly associated with shrub stages, and to the detriment of species highly associated with forested stages. Probably the most pronounced detrimental effect has been on bird species highly associated with mature or old-growth stages, which were not included in this study. In the next 20 years, most of the existing shrub stages will advance to the pole stage, and much of the existing mature and old-growth forest area will likely be converted to shrub/sapling stages. Once again, the avifauna may shift according to the new proportions and distributional patterns of successional stage habitats, which may include an increase in late shrub/sapling and pole stages and a further decrease in mature or old-growth stages (Rosenberg, Raphael, and Marcot, in prep.)

Variation of densities within successional stages. In general, during the breeding season, successional stages in which a species had highest values of mean density usually also had lowest CV values (Appendix 8). That is, stages in which a species averaged the greatest abundance were also stages in which the same species had lowest within-stage variation of abundance. Modal density and lowest CV values often reinforced one another as indices of greater habitat suitability. For example, dusky flycatchers had the highest mean density and the lowest CV in the early shrub/sapling stage during the 1982 breeding season. Similar trends of high density matching low CV occurred with most other species, including brown creepers in the medium sawtimber stage and Wilson's warblers in the late shrub/sapling stage (Table 10).

Matches of high density with low CV were less common, however, during non-breeding seasons. For example, during winter 1983, American robins had highest mean density in the pole stage but lowest CV in the medium sawtimber stage (Table 10). Overall, non-breeding distributions of birds often expanded to include stages not as fully or at all occupied during the breeding season; a number of species appeared at consistently low abundance levels within additional successional stages during fall and winter as compared with the breeding season. Habitat suitability is probably better indexed by lower variation of numbers (i.e., CV values as used here) than by greater mean density (Van Horne 1983).

The grass/forb and medium sawtimber stages averaged higher CV values across species and seasons than the other stages. I interpreted this to mean that species presence and densities were less consistent among VCP count points, and that habitat suitability was on the average lower, in the grass/forb and medium sawtimber stages than in the other stages. Across all stages, the summer and fall seasons consistently averaged higher CV values of species densities, and winter, spring, and breeding seasons averaged lower CV values, than other seasons. That is, species were less consistently distributed within stages during periods of post-breeding dispersal and fall migration than during winter residency, spring migration, and breeding.

Patterns of species dominance. In the 3 shrub stages, the dark-eyed junco was consistently one of the two most abundant species among seasons. During the breeding season, house wren (in the grass/forb stage) and Nashville warbler (early and late shrub/sapling stages) were the second most abundant species in the shrub stages. During the summer (post-breeding) season, lesser goldfinch and house wren (grass/forb), wrentit and rufous-sided towhee (early shrub/sapling), and bushtit and Wilson's warbler (late shrub/sapling) were the second most abundant species in 1981 and 1982, respectively. During fall, winter, and spring, winter wren was the most consistently abundant species in the shrub stages; various other species also shared high abundance levels, including dark-eyed junco, fox sparrow, and American robin. Hagar (1960) had similarly reported that dark-eyed juncos were generally the most numerous of all birds in Douglas-fir clearcuts, reaching maximum numbers in 3-6 year old clearcut sites, and that numbers in clearcuts were highest during winters with abundant Douglas-fir seeds.

In the two forested stages, chestnut-backed chickadee was consistently one of the two most abundant species across all seasons, followed by golden-crowned kinglet (fall through spring) and dark-eyed junco and brown creeper (summer). During the breeding season, hermit warbler was the most abundant species in the forested stages.

Species dominance was calculated as the percent of total abundance of the two most abundant species, with all surveys within each successional stage pooled. Among all seasons, the late shrub/sapling stage nearly consistently showed the lowest dominance by the two most abundant species and the grass/forb stage showed the highest (Fig. 11). The lower degree of dominance in the late shrub/sapling stage than in all other stages corresponded with the consistently higher number of species observed in that stage. Conversely, the higher degree of dominance in the grass/forb stage than in all other stages corresponded with consistently lower numbers of species. This inverse relationship between dominance and richness, however, is basically a numerical relationship, and may not reflect biological attributes of bird assemblages.

Dominance levels of the two most abundant species within each successional stage showed regular patterns among seasons (Fig. 11). The lowest degree of dominance occurred during the breeding season in the forested stages, during the summer season in early and late shrub/sapling stages, and during the fall season in the grass/forb stage. The highest degree of dominance occurred during the winter season in the forested stages and during the spring season in the three shrub stages.

Percent occurrence. Trends of species' densities among successional stages were reinforced by similar trends of percent occurrence (Appendix 7). For example, during the breeding season, Wilson's warbler had the highest estimated density, highest percent occurrence, and lowest CV of density, which suggested that the late shrub/sapling stage was the most suitable habitat (Table 10). However, during non-breeding seasons, the successional stages with the highest percent occurrence were not always stages with highest mean density. Again, divergence of modal density and modal percent occurrence among the successional stages suggested that non-breeding distributions of a number of species expanded or shifted among stages.

Associations of Species Densities with Habitat Factors

Estimates of site-specific densities were correlated with site-specific vegetation and habitat principle component factor scores. For this analysis, the original labels of successional stages were in essence stripped from each study site, thereby allowing the vegetation and habitat conditions at each VCP count point to potentially form a continuum of stand structure. However, study sites originally belonging to the 3 shrub stages were pooled for assessment, and those belonging to the 2 forested stages were pooled.

A total of 2,867 correlations were made (Table 11). Significant (i.e., $P < 0.05$) correlations indicated real associations between a habitat factor and the abundance of a species, although some associations were probably not causal. I allowed for Type I errors when I tested the correlations for significance. Type I errors led to a certain percentage of correlations being judged significant when in fact they did not represent causal associations. To lessen the chances of incurring Type I errors, only those correlations that were significant at $P < 0.01$ may be considered. Type I errors should have occurred randomly among the combinations of species, seasons, stages, and years.

When a correlation between a species and a particular habitat component occurred consistently among different years or successional stages, I judged this as evidence against a Type I error. However, I judged the occurrence of conflicting results, such as a positive correlation coefficient in one stage or year and a negative in another stage or year, for a given species in a particular season, as supporting the possibility of a Type I error (Meslow and Keith 1971). Where recognized, non-causal associations were discounted and not discussed in the text, although results of the correlations were not edited from Table 11.

Garsd (1984) and others recommended the use of partial correlation for identifying and avoiding the problems of spurious correlation that is associated with Type I error. For this reason, I subjected the same data sets of species abundance to multiple regression, which accounted for partial correlation of habitat and species variables. The signs of the multiple regression coefficients, being the same as the signs of partial correlations between habitat and species variables, indicated the contribution (positive or negative) of each habitat variable to the abundance of a species.

Coniferous and hardwood factors. The first principle component factor in all seasons and stages represented shrub foliage volume (Appendix 3). In general, species that were significantly correlated with the first factor in both shrub and forested stages were species often found at higher density levels in the late shrub/sapling stage than in the grass/forb or early shrub/sapling stages and at higher density levels in medium sawtimber than in pole stages. Conversely, species negatively correlated with the first factor were species that were found at higher density levels in the grass/forb stage than in the early or late shrub/sapling stages. Shrub foliage volume essentially explained much of the commonly observed patterns of species having densities bimodally distributed in late shrub/sapling and medium sawtimber stages.

In the 3 shrub stages, factors representing density of sapling and small pole-size softwood stems reflected shrub and tree development (number of years since clear-cutting) and the degree to which coniferous evergreen foliage and stems had developed on a given site. Species showing significant positive associations with such shrub and conifer components included American kestrel, acorn woodpecker, olive-sided flycatcher, Steller's jay, scrub jay, wrentit, hermit thrush, American robin, solitary vireo, hermit warbler, and black-throated gray warbler. Acorn woodpecker, Steller's jay, scrub jay, wrentit, and American robin also showed high negative associations with factors representing hardwood stem density or deciduous foliage volume.

Additional species in the 3 shrub stages not during the breeding season showing high negative associations with hardwood, broadleaf, or deciduous foliage components included golden-crowned kinglet, varied thrush, cedar waxwing, Hutton's vireo, and fox sparrow. However, cedar waxwings were observed foraging on Sambucus fruits in the fall season. Species showing consistently high positive associations with hardwcod, broadleaf, or deciduous foliage components in the 3 shrub stages included bushtit, MacGillivray's warbler, western tanager, golden-crowned sparrow, and dark-eyed junco; these species would likely benefit from high hardwood stem density or high deciduous foliage volume, which may afford preferred food and foraging or nesting substrates.

In the 2 forested stages, factors representing large softwood stems also represented stands of older ages and stands with greater shrub foliage volume. Species associated during at least one season with factors representing large softwood stems (cf. Figs. 22g,23b) included pygmy owl, pileated woodpecker, western flycatcher, winter wren, golden-crowned kinglet, varied thrush, cedar waxwing, solitary vireo, and Hutton's vireo. Species positively associated during at least one season with factors representing deciduous tree foliage volume (cf. Fig. 22h) or hardwood stem density (cf. Figs. 23d,23f) in the 2 forested stages were band-tailed pigeon, acorn woodpecker, downy woodpecker, ruby-crowned kinglet, American robin, varied thrush, Hutton's vireo, warbling vireo, and western tanager. Many species which were negatively associated during at least one season with factors representing deciduous tree foliage volume (cf. Fig. 22g) or hardwood stem density (cf. Figs. 23c,23e) were those positively associated with factors representing large softwood stems, and included red-breasted sapsucker, hairy woodpecker, Steller's jay, common raven, chestnut-backed chickadee, red-breasted nuthatch, white-breasted nuthatch, yellow-rumped warbler, pine siskin, and evening grosbeak; additionally, mountain quail, purple finch, and lesser goldfinch were negatively associated with deciduous foliage factors (cf. Fig. 22g).

Some univariate relationships of bird densities and hardwood vegetation variables in forested stages are shown in Figure 12. For example, density of warbling vireos was positively associated with density of hardwood stems $\geq$ 40 cm dbh. Other variables that significantly contributed to variation of warbling vireo density may be discerned from the multiple regressions (Table 12), and included density of small softwood stems, basal area of small softwood and pole-size hardwood stems, and low deciduous foliage volume. Hairy woodpeckers, red-breasted nuthatches, hermit warblers, and yellow-rumped warblers were negatively associated with various hardwood vegetation variables (Fig. 12).

A number of studies have reported greater bird species richness in deciduous or mixed conifer-deciduous forest than in pure conifer forests (Beedy 1981, Winkler and Dana 1977, Winternitz 1976, Salt 1957). Beedy (1981) reported that the presence of black oaks in mixed conifer sites in the Sierra Nevadas of California was one factor that significantly affected bird species diversity and accounted for the presence of solitary vireos and yellow, black-throated gray, and Wilson's warblers. In the forested stages surveyed in the present study, at least 8 bird species benefitted from the presence of deciduous or hardwood trees (listed above; see also Table 11, Figs. 22h,23d,23f), and a number of other species occurred in the forested stages because of the presence of low (< 2 m) deciduous or hardwood shrubs (Table 11, Figs. 22f,23d).

Shrub patchiness factors. Several principle component factors may be interpreted as representing the degree of patchiness or across-ground heterogeneity of shrub and near-ground vegetation cover (Table 11, Appendix 3 Low patchiness reflected more continuously distributed cover of shrub and near-ground vegetation, whereas high patchiness reflected a more fragmented vegetation cover with shrubs interspersed with areas of open ground.

In the 3 shrub stages, Anna's hummingbirds, chestnut-backed chickadees, Townsend's solitaires, black-throated gray warblers, black-headed grosbeaks, rufous-sided towhees, and golden-crowned sparrows were positively associated with a high degree of patchiness, Species consistently associated with a low degree of patchiness, and thus with a more continuous across-ground distribution of shrub and low vegetation cover, included acorn woodpecker, northern flicker, western flycatcher, scrub jay, Bewick's wren, ruby-crowned kinglet, American robin, wrentit, yellow-rumped warbler, fox sparrow, and pine siskin. High patchiness species were those whose primary foraging substrate is open ground (e.g., golden-crowned sparrows) or shrubs (Anna's hummingbirds) and which therefore may require a moderate spacing of shrubs and bare ground to facilitate foraging efforts. The low patchiness species were those with no consistent pattern of foraging substrate, but included species that typically associate with or forage within dense brush (wrentits), tree foliage (yellow-rumped warblers), or on the ground but within dense shrub cover (fox sparrows).

In the 2 forested stages, shrub patchiness was associated with the volume and proportion of deciduous foliage and the patchiness of canopy foliage. Stands with discontinuous canopy cover allowed direct sunlight to reach lower canopy and forest floor levels, which induced shrub growth; such stands had a more continuous shrub layer and a lower degree of shrub patchiness. Species showing a high association with shrub patchiness in the forested stages, thus representing stands with more closed or continuous canopies, were species that usually nested and foraged well off the ground: band-tailed pigeons, hairy woodpeckers, chestnut-backed chickadees, red-breasted nuthatches, brown creepers, and purple finches.

These 6 species were most likely responding to the more closed canopy conditions than to the across-ground distributions of shrub volume per se.

On the other hand, in the forested stages, species negatively associated with shrub patchiness, and therefore positively associated with stands having a more broken canopy and a more continuous across-ground distribution of shrub volume, included some species that often nested or foraged in the subcanopy or in vegetation close to the forest floor: northern flickers, Steller's jays, winter wrens, hermit thrushes, American robins, cedar waxwings, yellow-rumped warblers, and dark-eyed juncos. All 8 of these species were also commonly found in the three shrub stages, reflecting their generalized use of shrub cover despite the presence of overstory tree structure.

Roth (1976) suggested that increased patchiness of vegetation explains why shrubland habitats have more bird species than grassland habitats; and that decreased patchiness explains why closed-canopy forests have fewer bird species than some shrubland habitats despite their having more vegetation layers or volume. Species richness patterns reported in post-clearcutting stages by Kessler (1979), Conner and Adkisson (1975), and Hagar (1960), as well as those observed in the present study, agree with Roth's suggestion. In the present study, patchiness of shrubs and low vegetation accounted for some of the variation in density of some bird species. Karr and Roth (1971) noted similarly that highest bird species richness occurred with the presence of shrub and early tree layers, and that development of forest structure after that coincided with lower levels of bird species richness. Both the addition of vertical structure (MacArthur et al. 1962, Willson 1974) and higher values of across-ground patchiness of vegetation (Roth 1976) accounted for the greater bird species richness observed in the shrub/sapling stages than in either the grass/forb or forest stages.

Snags. In each season in the forested stages, at least one principle component factor clearly represented snag density. During non-winter seasons, acorn woodpeckers, northern flickers, and hairy woodpeckers, which are primary cavity excavator species, showed positive and significant associations with snag components, as did American kestrels and brown creepers, which are secondary cavity users. During the winter, band-tailed pigeons, chestnut-backed chickadees, mountain chickadees, brown creepers, and winter wrens showed positive associations with snag components. As was observed, band-tailed pigeons commonly use snags as perch sites (Neff 1947). Steller's jays and Hutton's vireos, which are not known to select snags, showed positive associations with snag densities; such associations were probably not causal.

The retention of snags and live trees in clearcut areas was highly associated with presence and abundance of some primary and secondary cavity-nesting birds (Marcot 1983, Morrison and Meslow 1983, Conner et al. 1975). In the 3 shrub stages, detection rates (number of birds observed per count) of woodpeckers and secondary cavity nesters averaged 1.8 times higher where snags were retained during clearcutting compared with areas where snags were absent (Marcot 1983).

Seasonal variations. Several species showed rather consistent shifts of associations with habitat factors over different seasons. For example, in the forested stages during the fall seasons, ruby-crowned kinglets and varied thrushes were significantly and negatively associated with density of large diameter hardwood stems, but showed significant, positive associations during the winter season. In this case, the different habitat associations were probably related to the fact that both of these species move to lower elevations and tend to inhabit forest stands with a greater proportion of hardwoods during winter. Thus, seasonal variation at the finer level of resolution (i.e., association with specific habitat components) can be accounted for, at least in some cases, by seasonal variation at a coarser level of resolution (i.e., migration status, or association with elevation and successional stages). It remains unclear, however, which level of resolution provides the proximate cues for habitat selection. Rice et al. (1980:1411) reported similarly that many bird species in southwest riparian areas changed habitat use among seasons, and that such shifts in habitat preference "outside the breeding season have important implications for habitat preservation and environmental quality assessment decisions." Further, they found that migratory dispersal patterns of species led to changes in demography and niche attributes, as also suggested by the results of the present study.

Another example of seasonal variation of habitat associations was found with hermit thrushes and dark-eyed juncos. These species were significantly and negatively associated with shrub patchiness in the shrub stages during the breeding or summer (post-breeding) seasons, and were positively associated during fall. The reverse pattern of association was found with Hutton's vireos. Purple finches showed a significant and positive association with shrub patchiness in the shrub stages during fall, but a negative association during winter. These shifts of habitat association may have reflected real changes in affinities to structure of shrub distribution, whereby requirements during one (e.g. breeding) season differed from requirements during other (e.g. post-breeding) seasons. For example, the greater affinities of purple finches with less patchy and more continuously distributed shrub cover during winter than during fall may have associated with a need for greater thermal cover during winter. Alternate explanations include the possibility that measures of shrub patchiness in the shrub stages were actually indexing other habitat characteristics that were not formulated into predictor variables in this study but which were variables with which some species were more directly associated.

In summary, many species did not change habitats among seaons and consistently associated with the same successional stages and habitat components whenever the species was observed in the surveys, such as the association of hermit thrushes with shrub foliage volume. With other species, seasonal changes in elevational distribution (ruby-crowned kinglets, varied thrushes) or habitat structure requirements (purple finches) may have accounted for the observed shifts of habitat associations, but mechanisms of habitat selection remain unclear.

Prediction Equations of Bird Densities

Vegetation and habitat variables. Results of multiple linear regressions provided equations that related species density to vegetation and habitat variables (Table 12). Habitat associations probably were strongest and regressions were most interpretable and useful if derived from surveys conducted outside of such periods of strong movement as post-breeding dispersal and fall and spring migration; thus, I present results based on breeding and winter surveys only.

Regression equations of many species often accounted for less than 50 percent of observed variation of densities. The predictor variables that entered into the regression equations often concurred with the vegetation and habitat principle component factors that associated highly with bird species densities. For example, in the shrub stages during the breeding season, Bewick's wrens were positively and significantly correlated with the principle component factor representing shrub foliage volume, and negatively correlated with the factor representing litter accumulation and patchiness of low green vegetation cover (Table 11). Similarly, the multiple regression equation of Bewick's wren density included vegetation and habitat variables (with positive coefficients) representing low foliage volume and softwood density, and a variable (with a negative coefficient) representing litter cover.

Multiple regression formulae provided a detailed view of the microhabitat characteristics of each species and accounted for partial correlations between predictor (vegetation and habitat) variables. Doubtless, predictor variables often were proxy for other characteristics of a species' microhabitat that were not sampled explicitly. For example, in the shrub stages during winter 1982, a habitat variable representing number of shrub and tree species over 2 m tall entered into the regression equation of ruby-crowned kinglet density. This habitat variable may be proxy for total twig and foliage surface area from which ruby-crowned kinglets glean insects, or for the degree of thermal and wind cover afforded by foliage of various heights and densities in a shrub stage stand.

Topophysiographic variables. The proportions of variation of bird densities (i.e., adjusted R^2 values from the regressions) that were further explained by topophysiographic variables were as high as 0.62 with winter wrens in forested stages during the breeding season (accounted for by slope position and slope angle variables), and averaged 0.25 across all species, stages, and seasons. Most species (71 percent of all species so tested) showed no such additional associations with topophysiographic conditions as they were measured (Table 13). However, many of the results of this analysis seemed reasonable. For instance, density of song sparrows was accounted for, in part, by proximity to permanent water and thus to phreatophytic vegetation. Slope position accounted for variations in densities of acorn woodpeckers, winter wrens, wrentits, hermit warblers, and golden-crowned kinglets during the breeding season; hermit warblers and acorn woodpeckers occurred in higher densities in the upper slope, higher elevation areas, whereas the other 3 species occurred in higher densities in the lower slope, lower elevation areas.

Distance to the nearest habitat patch of a similar designation accounted for some of the unexplained variation of bird densities in the shrub stages (western wood pewees, warbling vireos, and western tanagers during the breeding season, and chestnut-backed chickadees, cedar waxwings, and evening grosbeaks during the winter season) but not in the forested stages (Table 13). Precisely how much this indicated the effects on bird distribution from patterns of the configuration and isolation of different shrub stage patches across the managed forest landscape would require closer scrutiny than the present study affords.

Influence of Migration Status on Distribution and Abundance

One life history attribute of birds that had a direct influence on distribution and abundance was migration status. I devised a system for classifying the migration status of bird species encountered in this study to help explain seasonal changes in patterns of distribution (Table 14, Appendix 4). I classified species as elevational migrants, latitudinal migrants, permanent residents, and nomads. Elevational migrants were subclassified into those species moving downslope during late fall and winter seasons and those moving upslope during post-breeding. Latitudinal migrants were subclassified into 3 groups depending upon latitudes of breeding and wintering. The migration class into which a given species was placed was relevant to my study area, and may differ depending on other geographical points of reference.

Not including the 18 rarely observed species, most species were latitudinal migrants (35 species, 48 percent of total), followed by permanent residents (32 species, 44 percent), elevational migrants (5 species, 7 percent), and nomads (1 species, 1 percent) (Table 14). Most of the latitudinal migrants bred and summered in the study area and migrated to lower latitudes in the fall; some latitudinal migrants moved south from higher latitudes during fall, replacing locally breeding individuals; and a few bred at higher latitudes and only wintered in the study area. Analogous patterns occurred with elevational migrants.

Each migration class had a more or less unique distribution of occurrence among seasons. The highest potential number of species (73 species) found in the study area during any one season occurred during fall, and the lowest potential number of species (45 species) was during spring. Field observations concurred with these patterns (Table 14).

Eighteen additional species were observed rarely (< 5 detections per season; Appendix 4) during the surveys, and most were observed during summer, fall, or winter seasons. A quick review of the migration status of these species (Appendix 4) explains their general pattern of seasonal occurrence: 9 species are elevational migrants that breed in the lower elevation bottomlands and move upslope briefly to the study stands during post-breeding dispersal (e.g., Brewer's blackbird, western meadowlark, and starling), or that breed at higher elevations and occur sporadically in the study stands (white-headed woodpecker and Lincoln's sparrow). Additionally, 4 species (2 owls, northern goshawk, and golden eagle) occur nocturnally or are uncommon and range over very wide areas, and 3 species (northern phalarope, great blue heron, and mallard) occurred in ephemeral ponds and are associated closely with aquatic habitats. Only 2 of the 18 species are latitudinal migrants (barn swallow and yellow warbler) and usually occur in lower elevation bottomlands.

As is often found in north temperate coniferous forests, most of the latitudinal migrants were species: that breed and summer in the study area and move to lower latitudes during fall; that are insectivorous foliage gleaners, flycatchers, or hawkers; that were commonly observed in early successional (shrub stage) habitat; and that commonly build open nests in foliage or on branches of shrubs or trees. In contrast, many of the permanent residents were species: that represent a wider variety of dietary characteristics and foraging substrates than do the latitudinal migrants; that were observed in both early (shrub) and more mature (forested) successional habitat; and that represent a wide variety of nesting substrates, including snags and branches of trees.

A total of 23 species was observed during surveys (and all but 4 during the breeding season) that nest in cavities in trees (primary, secondary, or natural cavity users). All except 6 of these species were primarily permanent residents; the 6 include 4 latitudinal migrants (violet-green swallow, house wren, Vaux's swift, and winter wren) and 2 primarily elevational migrants (red-breasted sapsucker and white-headed woodpecker). That most cavity-nesting species are permanent residents is probably of selective advantage for exploiting local resources on a year-long basis.

The migration status of a species has implications for how effective habitat management activities can be for those species that have winter ranges that differ from breeding ranges or for species that winter off-site from habitat management areas (Wilcove and Terborgh 1984). Rappole et al. (1983) listed Townsend's warbler as a species likely to show declines in the next decade because preferred wintering habitat is decreasing. Neotropical migrants are especially vulnerable to alteration of wintering habitat (Rappole et al. 1983). For example, Aldrich and Robbins (1970) noted that numbers of solitary vireos have decreased despite increases of available habitat, probably because of alteration of migration or wintering habitat.

Summary: Bird Distribution and Abundance

Most of the 91 bird species observed during surveys showed significant differences of densities across the 5 successional stages. During the breeding season, each successional stage had certain species that occurred at highest density. Ten species showed seasonal shifts of abundance patterns across successional stages, perhaps because of dispersing or wandering juveniles or post-breeding adults, or perhaps in response to seasonal changes in available resources or interspecific interactions. Most species showed little between-year variation in mean density within successional stages, given the within-stage variation of densities between replicate study sites.

Several species apparently increased in local density, total population size, distributional range, seasonal occurrence, or range of habitats (successional stages) used since extensive cleatcutting in the study area began in the early 1950's. These species include band-tailed pigeon, western wood pewee, dusky flycatcher, western bluebird, fox sparrow, purple finch, and evening grosbeak. Species restricted to forest stages that have probably decreased in population size over the last 30 years are Hammond's flycatcher, chestnut-backed chickadee, red-breasted nuthatch, brown creeper, golden-crowned kinglet, and hermit warbler.

During the breeding season, most species that had a highest mean density in a particular successional stage also showed highest percent occurrence and lowest coefficient of variation of density in that stage, suggesting high habitat suitability. As measured by within-stage variation of densities, species were less consistently distributed across study stands within successional stages during summer and fall, than during winter through breeding seasons.

A number of different species numerically dominated each successional stage. During the breeding season, the most abundant birds in the shrub stages were rufous-sided towhees, Nashville warblers, and dark-eyed juncos, and in the forested stages were hermit warblers, chestnut-backed chickadees, dark-eyed juncos, and brown creepers. The late shrub/sapling stage showed the lowest dominance by the 2 most abundant species, and the grass/forb stage showed the highest. In each successional stage, the lowest degree of species dominance occurred during breeding through fall seasons and the highest occurred during winter and spring.

Correlations of bird densities with vegetation and habitat principle component factors revealed that shrub foliage volume accounted for the bimodal densities of many species in the late shrub/sapling and medium sawtimber stages. Presence and density of deciduous foliage and hardwood stems, and the across-ground patchiness of shrub cover, accounted for the abundance patterns of a number of other species. Species positively associated with shrub patchiness were species that often foraged on open ground or in shrubs; species negatively associated with shrub patchiness included species that often foraged within dense shrub foliage, within tree foliage, or on the ground but within dense shrub cover. Seasonal changes in habitat affinities of a few species may have related to changes in species' requirements or to elevational distributions.

Interpretations of multiple linear regressions predicting density of bird species as a function of vegetation and habitat variables usually concurred with the interpretations of associating bird densities with vegetation and habitat principle component factor scores. Most regressions accounted for less than 50 percent of the variation of estimated species' densities. Little additional variation in bird densities was consistently accounted for from topophysiographic variables, with a mean of 25 percent of additional variation accounted for in only 29 percent of all species assessed. However, results suggested that abundance patterns of a few bird species in shrub stages were influenced by slope angle and distance to permanent water or to the next nearest similar habitat type. Further studies would be necessary to more precisely determine the influence of landscape patterns of habitat patches on bird distribution and abundance.

The majority of the 73 commonly observed bird species were locally-breeding latitudinal migrants, followed in order of abundance by permanent residents, elevational migrants, and one nomadic species. Most of the 18 rarely observed species bred primarily in bottomland habitats and moved upslope briefly during summer and early fall. The latitudinal migrants were often open-nesting, insectivorous aerial- or foliage-gleaners, and were commonly observed during surveys in early successional (shrub stage) habitat. In contrast, permanent residents included most cavity nesters and were observed more or less equally throughout all successional stages.

Community Composition Parameters and Patterns

Bird Species Richness, Total Density', and Diversity

Bird species richness. In each of the successional stages, species richness (number of species) at VCP count points reached a maximum during the breeding season (Fig. 13). Lowest richness values occurred during winter or spring seasons. Low richness values during spring were expected, because many latitudinal migrants did not appear in the study area until the breeding season. The 3 shrub stages showed greater variation in species richness over all seasons that did the 2 forested stages, in part owing to the latitudinal migrant species that added to the mean number of species more in the shrub stages than in the forested stages, during breeding through fall seasons.

The highest values of mean species richness occurred in the early and late shrub/sapling stages during the breeding season, and the lowest occurred in the grass/forb stage during the winter season. Doubtless, the low richness levels during winter in the grass/forb stage were related to the lack of cover found on most grass/forb study sites. Species richness during the breeding season increased dramatically from that during the spring migration season, in all successional stages. The increase may have been in part because of the greater detectability during the breeding than during the spring season of the more vocal and territorial species. However, patterns of expected species presence based on migration status (Table 14, Appendix 4) concurred with the low spring richness levels, suggesting that the increases in richness levels from spring to breeding seasons were real.

More species attained their highest density in the late shrub/sapling stage than in all other stages, throughout all seasons except spring (Fig. 14). In contrast, fewest species had highest densities in the grass/forb stage in all seasons except spring. During the breeding season, grass/forb and pole stages had the lowest number of species with modal density values, but this pattern completely reversed during spring. During summer, modal species richness declined in the medium sawtimber stage but increased in all other stages, as compared to richness levels during the breeding season.

Many of these patterns of modal species richness across successional stages and seasons can be explained by migration movements of individual species and by the shifts of individual species' densities among successional stages across the seasons. An example of the latter is winter wren, which averaged highest density in the medium sawtimber stage during breeding and summer seasons, and in the shrub/sapling stages throughout the rest of the year.

Regressions of species richness against vegetation and habitat principle component factor scores revealed that species richness in the 3 shrub stages consistently and positively associated with shrub and tree foliage volume in both breeding and winter seasons. Foliage volume accounted for 28, 48, and 54 percent (adjusted R^2's) of the variation of species richness in the shrub stages during breeding 1982, winter 1982, and winter 1983 seasons, respectively. No other vegetation and habitat factor significantly entered into the stepwise regression equations of species richness.

In the two forested stages, the only vegetation and habitat factor that accounted for species richness per se was during the breeding season. Density of large hardwood stems accounted for 30 percent of the variation of, and was negatively correlated with, species richness in the forested stages.

Species richness was significantly and consistently associated with percent slope (negative correlations) and stand area (positive correlations) in the 3 shrub stages during breeding and winter seasons. These associations arose because grass/forb stands usually had lower numbers of species, and, owing to recent timber harvest practices, were situated on steeper, upper ridge slope positions and were smaller in area than the early and late shrub/sapling stands. Excluding the grass/forb stage, associations between species richness and slope or area became nonsignificant. Thus, what first appeared as strong species-slope and species-area relationships were explainable, at least within the range of stand sizes surveyed in this study, by the non-random "allocation" of successional stages to particular slope locations.

In the forested stages, no topophysiographic variables significantly associated with species richness during the winter seasons, and only slope angle significantly (simple $r = -0.41$, $P = 0.03$, $n = 26$) associated with species richness during the breeding season. Species richness was negatively associated with distance to next nearest similar habitat type only during winter 1983 in the 3 shrub stages ($r = -0.71$, $P < 0.001$, $n = 17$). The lack of consistency of this association across other seasons or stages suggested a weak relationship of species richness with distance to nearest similar habitat.

Total density. Mean total density of all species at VCP count points was generally lower in the grass/forb stage than in all other stages throughout all seasons (Fig. 15). Lowest total density was observed in the grass/forb stage during winter. Highest total density occurred during fall migration in the early and late shrub/sapling stages. Overall, the grass/forb stage had lowest total densities of all successional stages throughout most seasons.

Total densities were lower in the forested stages than in the shrub stages during the breeding season, but were higher during winter. Again, this pattern suggests that different successional stages or cover types may play different ecological roles, so to speak, at different times of the year. For example, many permanent resident species had higher densities in forested stages than in shrub stages during the winter, but the shrub stages provided suitable breeding habitat for many of the latitudinal and elevational migrant species. The successional stage which often held the lowest number of species and the lowest total species densities -- the grass/forb stage -- had the highest number of modally abundant species only during spring migration.

Species diversity. Bird species diversity (Shannon and Weaver 1949) was generally highest during breeding or summer seasons and lowest during winter or spring seasons; and was generally higher or equal in the early and late shrub/sapling stages as compared with the forested stages, and lowest in the grass/forb stage (Fig. 16). As with species richness, diversity values in all stages increased steeply from spring to breeding seasons. Since the Shannon-Weiner diversity index is sensitive to both species richness (Fig. 13) and species dominance (Fig.

14), the similarity of patterns between species richness and species diversity is not surprising.

Classification of Bird Assemblages

Similarity of bird assemblages among successional stages. Much of the above discussion on patterns of species richness, density, and diversity needs to be viewed in light of bird species composition of the different successional stages. Not surprisingly, the most similar stages in terms of species composition and species-specific densities were the early and late shrub/sapling stages, and also the pole and medium sawtimber stages (Table 15). The least similar stages often were the grass/forb as compared with either the pole or medium sawtimber stages. The grass/forb stage showed a monotonic or near-monotonic decrease in similarity with the early shrub/sapling through the medium sawtimber stages, respectively, through all seasons.

The 3 shrub stages were more similar to one another during summer and fall seasons, than during winter through breeding seasons, especially during spring. Contrariwise, the 2 forested stages generally were more similar to one another during the winter and breeding seasons than during spring and summer seasons. The greatest similarity in bird assemblages between the shrub and forested stages occurred during breeding and summer seasons, and the greatest dissimilarity occurred between winter and spring. All of these patterns suggested that species composition among, and similarity between, stages varied strongly by season, and that any one season does not necessarily reflect patterns of species distribution and similarity in other seasons.

Classification of bird assemblages. Cluster classification of bird species by season (Fig. 17) revealed the following patterns: In each season, species associated more with shrub stages consistently segregated from species associated more with forest stages. For example, during the breeding season, the two main clusters of shrub and forest species differentiated at a relatively low degree of similarity. The shrub species cluster further split into species found predominantly in grass/forb and early shrub/sapling stages and species found predominantly in the late shrub/sapling stage. The forest species cluster further split into species found in both shrub and forest stages and species found only in the forest stages. At even lower dissimilarity levels, these clusters further differentiated according to within-stage distributional patterns. For instance, calliope hummingbirds, chipping sparrows, fox sparrows, and mountain chickadees became a distinct cluster, as these four species were commonly observed in the same stands of the late shrub/sapling stage.

Classifications of species across the seasons suggested that the bird assemblages observed at count points in forest stages were more alike than the bird assemblages observed at count points in shrub stages. Also, dissimilarity levels were higher (similarity was lower) between shrub and forest species clusters during breeding and summer seasons than during other times of the year. As evidenced by changes of dissimilarity levels over seasons, bird assemblages tended to vary more in shrub stages than in forest stages. This is not surprising, considering the greater proportion of total density contributed by latitudinal migrants in the shrub stages than in the forest stages during summer and fall.

Cody (1974) defined "core species" in a classification as those species that initiate a cluster or join it at high similarity levels, thereby typifying a particular cluster. Core species typically are commonly occurring species, and show lar

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eyed junco, and fox sparrow during both winter seasons (Fig. 17g,h; no grass/forb species cluster was evident during the winter seasons). The core species of the grass/forb species cluster generally showed negative associations with total shrub foliage volume and with density of sapling or pole size softwoods and hardwoods, whereas the core species of the late shrub/sapling species cluster showed positive associations with total shrub foliage volume and vegetation height (Table 11).

In the forest species cluster, core species included chestnut-backed chickadee, solitary vireo, hermit warbler, and western tanager during the breeding season (Fig. 17b); and chestnut-backed chickadee, brown creeper, golden-crowned kinglet, and winter wren during both winter seasons (Fig. 17g,h). These forest core species typically showed positive associations with density of medium to large diameter softwood stems, and negative associations with foliage volume of vegetation < 2 m tall and with density of small to medium diameter hardwood stems (Table 11). Additionally, during the winter season, forest core species were positively associated with volume of down wood and density of snags > 40 cm dbh.

Federal legislation -- specifically, the National Forest Management Act of 1976 -- mandated the use of wildlife "indicator species" in National Forest planning and monitoring. Selection of species to "indicate" habitat conditions and population levels of other species is problematic (Mannan et al., in press). However, while alternative approaches are being tested, such as the use of ecological guilds, core species as defined above may help objectively define a set of species that represent or typify habitat stages and a variety of microhabitat components (e.g., snag density) found therein. Importantly, different species may take the role of core species during different seasons, and all such species may need to be considered in toto. Still, the inference that population levels of core species will reflect specific habitat conditions or population levels of other species would require explicit field validation.

At the other extreme in a classification, "fringe" species (sometimes called "singletons") are those that join clusters at low similarity levels or tag onto clusters as specialists. Fringe species typically are unrepresentative of other species, show low community overlap, and may be uncommon in abundance. Fringe species would be poor candidates for use as indicator species. Fringe species included bushtit, band-tailed pigeon, pine siskin, and mountain chickadee in the shrub stages, and common raven, Hammond's flycatcher, red-breasted nuthatch, and varied thrush in the forested stages.

Habitat Niche Breadth and Mean Community Overlap of Resident Species

Habitat niche breadth. Habitat niche breadth -- the distributional pattern of a species across study sites and successional stages -- was lowest during summer and highest during spring, as averaged over all species by season (Fig. 18). This pattern suggested that, on the average, species had the most restricted distributions across study stands and successional stages during summer, and the widest distribution during spring migration. However, seasonal patterns of habitat niche breadth differed greatly between species.

Among permanent residents, species highly associate? with shrub stages generally had lowest measures of habitat niche breadth during winter, and highest measures during breeding, summer or fall (Fig. 19). Conversely, species highly associated with forest stages had rather equable measures of habitat niche breadth across seasons, such as chestnut-backed chickadee, or had lowest measures during breeding or summer and highest measures during winter, such as golden-crowned kinglet.

The contrasting seasonal patterns of habitat niche breadth between shrub stage specialists and forest stage specialists were accounted for by the distributions of species among seasons and stages. Shrub stage specialists were more restricted in distribution during winter than non-winter seasons. For example, dark-eyed juncos and purple finches had lowest densities during the winter, and were more or less restricted during this time to the early and late shrub/sapling stages. On the other hand, forest stage specialists were either more or less equally abundant throughout seasons (e.g., brown creepers) or they increased in abundance and increased the number of successional stages used during winter as compared with non-winter seasons (e.g., golden-crowned kinglets). Higher abundances of golden-crowned kinglets during winter may have occurred because of the addition to local populations from individuals moving into the area from higher elevations.

Mean habitat niche breadth was significantly ($P < 0.05$) and negatively correlated with bird species richness at each VCP count point in all seasons (average $r \approx -0.65$) except spring (spring $r = -0.17$, $P = 0.3$, $n = 23$). Significant negative correlation between niche breadth and species richness traditionally has been interpreted as suggesting niche packing (McNaughton and Wolf 1970), whereby a higher number of species present on a site causes a narrowing of species-specific use along some resource gradient(s), reflected in lower values of the niche breadth measure.

Values of mean habitat niche breadth were regressed against species richness of all but the spring season

(Fig. 20). All regression lines had negative and nearly identical slopes, and suggested that species' abundances were more equitably distributed across study sites when species richness was low as compared to when species richness was high. The regression line of winter 1982 was substantially steeper than the other seasons', owing in part to the high values of mean habitat niche breadth and low values of species richness in the grass/forb stage study site during that season. Vagaries of sampling, weather, or species occurrence may have influenced the relatively high values of mean habitat niche breadth in those grass/forb sites. Eliminating the grass/forb stage from the winter 1982 regression analysis decreased the slope of the line to closely match those from the other seasons.

The spring season was unusual in several respects. The spring season was the shortest in duration of all 5 avian seasons, had the lowest species richness levels in most of the successional stages, and averaged the highest levels of habitat niche breadth averaged over all species. Several common species, notably winter wren and golden-crowned kinglet, seemed less tied to specific sites and successional stages and therefore had broader distributions during spring than during other seasons. However, a number of species, especially permanent residents and late latitudinal migrants, probably did not recognize spring as a distinctly separate season, and their spring patterns of distribution and abundance are better interpreted as those of late winter. Further, the narrow time band of the spring season allowed smaller sample sizes than other seasons, which may have led to imperfect measures of species richness and density.

As pointed out by Rice et al. (1980), Fretwell (1972) concluded that it may be of adaptive advantage for a species to change or narrow the range of habitats used prior to a season of limited resources. From this generalization, the prediction may be made that resident bird species facing winter resource shortages may show decreased use of habitats during late summer or fall. Rice et al. (1980) supported this hypothesis with their analysis of birds in the Lower Colorado River Valley. Likewise, the average trend in the present study was for species to have narrowest habitat niche breadths during summer.

More specifically, however, the trend of permanent residents highly associated with shrub stages to have lowest measures of habitat niche breadth during winter did not follow Fretwell's (1972) generalization, assuming that the winter season was the most resource-restricted. Seasons may have been too broadly defined in the present study to facilitate detecting narrower habitat niche breadths immediately before the winter season (viz., during late fall).

Mean community overlap. Mean community overlap -- the similarity of the distribution pattern of a species as compared with all other species -- among those shrub stage specialists that were permanent residents was low during winter and spring seasons and high during breeding through fall (Fig. 21), more or less repeating the pattern of habitat niche breadth over seasons (Fig. 19). An exception was fox sparrow, which had highest mean community overlap during spring 1982 because of its ubiquitous occurrence in the early shrub/sapling stage during that season.

In contrast, mean community overlap among permanent resident forest stage specialists was fairly constant over seasons (Fig. 21). During winter and spring, levels of mean community overlap of the forest stage specialists were much higher than levels of overlap of the shrub stage specialists.

The following interpretation is one explanation of the patterns presented here of habitat niche breadth and mean community overlap of permanent resident species. Shrub stage specialists and forest stage specialists appeared to be very different ecologically. Shrub stage specialists were most widely distributed during breeding through fall seasons. However, during winter and, in some cases, spring, distributions of shrub stage specialists changed in two ways: the range of sites or successional stages in which they were found with any regularity narrowed (mean habitat niche breadths decreased), and they occupied different stands within successional stages (mean community overlap decreased). These changes in distribution may have been in response to the severity of the winter habitats and a decrease in available resources in the shrub stage sites. Also, narrowing of sites used by permanent resident shrub stage specialists may have been related to greater separation of foraging behavior among species during winter than during summer, as reported by Lewke (1982) in floodplain habitat in southeastern Washington. Forest stage specialists, however, were distributed among study sites equally throughout seasons or showed more restricted distributions during the breeding season than during winter; they did not further differentiate during winter compared to non-winter seasons as to sites they occurred on.

Shrub stage specialists retracted in distribution to more optimal habitats ("sources," sensu Wiens and Rotenberry 1981) during winter and invaded suboptimal habitats ("sinks") as weather ameliorated and resource levels increased. In contrast, forest stage specialists either found no substantial changes in resource levels or severity of habitat over seasons, or were most restricted in distribution during the breeding season. Restrictions of distributions during the breeding season may have been related to the presence of latitudinal migrant species or to greater interspecific vying for resources in the breeding season than in other seasons in the forest stages. If this interpretation is correct, then why shrub stage specialists did not also restrict their distributions during the breeding and summer seasons in response to the presence of latitudinal migrants, as did the forest stage specialists, needs explanation. One possible explanation is that resource levels in the shrub stages during breeding and summer seasons were high enough to support both migrants and permanent residents without exclusion of species.

Identifying "source" and "sink" habitats for managing various bird species may eventually aid in identifying adequate configurations of different habitat (successional or structural stage) patches across the landscape. Additional information must be acquired on species-specific dispersal, wandering, and migration (especially elevational) distances.

Summary: Bird Community Structure

Highest levels of species richness occurred during the breeding season, and lowest levels occurred during winter or spring seasons. The grass/forb stage was generally the least rich of all stages. The shrub stages had a greater seasonal variation of species richness than did the forest stages. Bird species richness was positively associated with shrub and tree foliage volume in the shrub stages during both breeding and winter seasons. Species richness was negatively associated with density of large hardwood stems in the forest stages during the breeding season, and was not consistently associated with any vegetation or habitat variable during the winter seasons. Species richness was not consistently associated with any topophysiographic variable in shrub or forest stages, once effects from recent timber harvest policy on slope location of study sites were accounted for.

Total density of all bird species was lowest in the grass/forb stage and highest in the shrub/sapling stages. Total densities were lower in the forest stages than in the shrub stages during the breeding season, but were higher during winter. Patterns of species diversity closely followed patterns of species richness across seasons and successional stages.

The two shrub/sapling stages and the two forested stages were more similar in bird species composition than were any other pair-wise combinations of stages. The 3 shrub stages were most similar to one another during summer and fall seasons, and the 2 forested stages were most similar to one another during winter and breeding seasons.

Classification of bird assemblages resulted in clusters representing predominantly shrub- and forest-dwelling species in each season. Bird assemblages varied more in shrub than in forest stages. "Core species" -- species that initiate a given cluster or join it at high levels of similarity -- included western wood pewee and Lazuli bunting in the grass/forb species cluster; and dark-eyed junco, Nashville warbler, MacGillivray's warbler, and rufous-sided towhee in the shrub/sapling species cluster during the breeding season, and wrentit, dark-eyed junco, and fox sparrow during the winter season. Core species in the forest species cluster included chestnut-backed chickadee, solitary vireo, hermit warbler, and western tanager during the breeding season; and chestnut-backed chickadee, brown creeper, golden-crowned kinglet, and winter wren during winter. The various sets of core species showed associations with a variety of vegetation and habitat attributes, and may prove useful, with proper field validation, as indicator species until other monitoring approaches can be devised and tested.

Seasonal patterns of habitat niche breadth and mean community overlap of permanent resident species suggested that shrub stage specialists are most limited in distribution during winter, and that their winter distributions may reflect optimal (source) habitat. In contrast, forest stage specialists showed no seasonal changes of distributions, or were more restricted in distribution during the breeding season than during other seasons.

PART TWO: TIMBER MANAGEMENT RELATIONSHIPS

The purpose of this section is to describe the effects of even-age timber management on conditions of Douglas-fir stand structure, and to describe bird species presence and abundance in terms of stand structure in young-growth stages resulting from even-age management. A distinction is drawn here between forest management, timber management, and silviculture. Forest management is the planning and execution of activities across a large area to meet generally more than one management goal, such as wildlife management, recreation, or timber management. Timber management has the specific objective of producing commercial wood fiber. Silviculture is vegetation management in the broadest sense, the objectives of which may include, but are not restricted to, timber management.

Influence of Even-Age Timber Management on Stand Structure

The central aim of intensive timber management is to increase the production of wood fiber of desirable tree species over that available under natural conditions. Many characteristics and processes of natural forest development are modified in the course of achieving this goal. The most commonly applied silvicultural system for intensive timber management in the Douglas-fir region of the Pacific Northwest is the even-age system, one application of which involves the clearcutting and replanting of an entire stand at one time. Other applications of the even-age system include variants of the shelterwood method (Smith 1962), but the shelterwood method is used infrequently on Douglas-fir forest land in the general study area. Two main phases of the even-age system substantially alter vegetation stands as compared with most natural forest conditions. The two phases are 1) site preparation for planting of conifer seedlings and stocking control of pre-commercial size trees, which affect stand characteristics of grass/forb and shrub/sapling stages (Table 16); and 2) intermediate treatments and final harvest of commercial size trees, which affect stand characteristics of pole and sawtimber stages (Table 17).

Depending on type and intensity, all methods of site preparation, intermediate treatments, and final harvest considered here can have minor to major impact on the structure and plant species composition of grass/forb and subsequent shrub/sapling stages. However, on-the-ground application can be directed so as to mitigate for potential undesirable impacts on bird species. The purpose here is to discuss typical or potential impacts.

Effects of Site Preparation and Stocking Control

Site preparation. After the final harvest (clearcutting), site preparation prepares for regeneration of a forest stand. Site preparation is mainly used to reduce or eliminate down wood, reduce plant competition, prepare a mineral soil seedbed, or create a favorable microclimate for conifer seedlings (Stewart 1978). Methods of site preparation include mechanical, chemical, prescribed burning, or some combination. All methods can be used directly after clearcutting depending on soil, topographic, and other conditions of the site, or to reclaim brushfields for growing conifers. Mechanical and chemical methods can also be used in existing conifer plantations for interplanting or replanting.

Usually some sort of site preparation is necessary for initial regeneration of conifer stocks. Down wood is often piled and burned or broadcast burned. Existing shrubs that have sprouted or otherwise regrown since the time of harvest may be mechanically cleared (scarification) or sprayed with herbicides prior to burning (brown and burn), depending on shrub density. Similar and more intensive treatments may be applied to reclaim brushfields for planting (Stewart 1978). While site preparation may produce a cleared grass/forb site, it hastens the (usually artificial) introduction of conifer seedlings and may also quickly produce an early shrub stage by stimulating seed germination of species such as ceanothus and manzanita or sprouting of such hardwood shrubs as bigleaf maple, Pacific madrone, and tanoak.

Scarification tends to severely reduce plant density and foliage volume, and may eliminate any hardwood trees and snags that were left standing after clearcutting. Complete or near-complete scarification of the soil increases soil erosion potential on steep slopes, and may act to maintain grass/forb conditions for a longer period of time than would less intensive site preparation methods.

The use of chemicals (herbicides) for initial planting or for release of conifer regeneration may, in the short run, reduce deciduous and broad-leaf shrub and hardwood foliage volume and increase foliage patchiness, open areas, and grass cover. Snags and standing residual trees, however, may first be felled to facilitate aerial application. Morrison (1982) reported that, on National Forest land in the Coast Range in Oregon, only minor effects of phenoxy herbicide treatment were evident during the second growing season following spraying except for the severe reduction of red alder (Alnus rubra) foliage, and that most deciduous plants recovered by 4 years after spraying. Also, vegetation under 1 m tall was unaffected. Morrison's study area, however, lacked most of the hardwood or broad-leaf shrub species that are common in the mixed conifer-hardwood region of my study area.

Controlled burning temporarily reduces tree and shrub densities, and permanently reduces down wood mass and volume. Depending on type and intensity, prescribed burning can consume nearly all small diameter down wood and leave all logs (Morris 1970). Specific references on the effects of burning on vegetation can be found in Stewart (1978).

Stocking control. Stocking control is used to adjust the density of desirable conifer species after initial site preparation and planting of seedlings and before trees reach commercial size. Two main stocking controls are conifer release (Table 16) and pre-commercial thinning (Table 17). Release (mechanical or chemical) is used to reduce shrub competition, freeing trees to grow to dominant crown positions. Release at least temporarily reduces hardwood and broad-leaf foliage volume and height and percent canopy closure of shrub and hardwood cover, and may increase patchiness of shrub cover.

Pre-commercial thinning reduces conifer stem density and total basal area, total foliage volume, and percent canopy closure, in order to increase the average size of softwood stems and hasten the growth of commercial timber. It may also be used to regulate species composition of both conifers and hardwoods and remove diseased trees.

Effects of Thinning, Salvage, and Final Harvest

Intermediate treatments. The objectives of thinning and salvage of an even-aged stand are to provide growing space for trees by reducing crown competition for light and space; and to salvage trees damaged by insects, frost, disease, wind, or other agents, or that would otherwise be lost through competition. By thinning, total yield may be increased because mortality is salvaged, thereby providing a commercial product and possibly making the stand more resistant to insects and disease.

Four main methods of commercial thinning differ according to crown class (position) or stem dbh of trees removed (Table 17). All 4 methods at least temporarily reduce softwood total density, total basal area, and total foliage volume. Low thinning (thinning from below) removes trees in the lower crown and dbh classes and may increase average dbh of softwood stems, decrease height diversity of the vertical foliage profile, and not affect percent closure of the canopy foliage. Crown thinning (thinning from above) reduces or removes trees in the upper crown and dbh classes and may enhance diversity of the foliage profile and increase patchiness of the canopy foliage. Selection thinning removes crown dominant trees to stimulate growth of trees of lower crown classes, and may decrease diversity of the foliage profile and patchiness of canopy foliage. Mechanical thinning removes codominant trees in dense young stands regardless of tree characteristics, and decreases percent canopy closure, may increase canopy patchiness, and maintains average diameter of softwood stems, stem size and age distributions, and diversity of the foliage profile (Smith 1962).

Fuelwood and salvage cutting may influence stand structure in a variety of ways, depending on type and intensity. The most important potential impacts are the removal of hardwood and broad-leaf trees, and the reduction of the number of medium to large diameter hard snags and sound down logs in a stand.

Final harvest. Clearcutting, under the most intensive timber management objectives, removes all overstory and understory trees and increases shrub foliage volume and height, total number of plant species, and down wood mass, volume, distribution, and mean diameter. Dell and Ward (1971) reported that down wood 10 cm and larger in diameter on clearcuts in old-growth Douglas-fir ranged 67-448 metric tons/ha depending on age and species composition of the logged stands; and Howard (1971) reported that total "logging residue" volume on National Forest land in the Douglas-fir region of western Oregon and western Washington averaged 221 m^3/ha. These reported values correspond well with this study's averages of 53-81 metric tons/ha of wood over 7.6 cm diameter, and 198-281

m^3/ha of all size classes, in the 3 shrub stages (Table 6).

Comparison with Study Stand Conditions

Intensive even-age timber management tends to produce forests that have few large snags and large trees, low densities of understory trees, usually a single canopy layer (low tree height diversity), low patchiness of canopy foliage, and uniform spacing between trees (Mannan 1982), as well as low density of hardwood and broad-leaf trees and a low number of tree species. Some characteristics of the pole and medium sawtimber stands in this study were similar to "ideal" even-age forests, and some deviated markedly, although all forest stands in this study qualified as "even-age" following the criteria given by Smith (1962). Outlining similarities and differences is important for understanding how well the analyses of bird relationships in the forested stages represented relationships that would occur under intensive timber management situations.

Throughout this section, I refer to intensive timber management as an objective for forest management; other objectives are feasible. The purpose is to present a means of deducing potential impacts on bird species as consequences of strategies for forest management. I present not a prediction but only a hypothetical projection of what could occur under one scenario of forest management. Current forest management direction, by plan or by accident, may produce young-growth stands with characteristics different than the "intensive timber managment" scenario presented here.

Conifer trees. Most of the pole and sawtimber stands in this study were naturally stocked and less productive as compared to stand conditions under intensive even-age timber management. Pole stands in this study averaged 66 yrs old (S.E. = 3, n = 292 softwood increment cores), live Douglas-fir stems over 12 cm dbh averaged 25 cm dbh (S.E. = 1.3), and density of all softwood stems over 12 cm dbh averaged 510/ha. Medium sawtimber stands averaged 78 yrs old (S.E. = 4, n = 233 cores,), live Douglas-fir stems over 12 cm dbh averaged 37 cm dbh (S.E. = 3.9). and density of all softwood stems over 12 cm dbh averaged 237/ha. In contrast, under intensive even-age management with multiple commercial thinnings, a typical pole-size stand of Douglas-fir of the same average dbh as in this study would be only half as old and density of softwood stems would be slightly greater (Curtis et al. 1982:110-111). When the same intensively managed stand grew to an average dbh to compare with this study's medium sawtimber conditions, the stand would be about two-thirds as old and would be about 8 percent denser (Curtis et al. 1982).

Total basal area of softwood stems averaged 35.8 and 32.7 m^2/ha in pole and medium sawtimber stands, respectively, in this study. However, because of the presence of "residual," large-diameter softwoods, averages of 40 and 64 percent of total softwood basal area were contributed by softwoods over 53 cm dbh in pole and medium sawtimber stages, respectively. Comparable, intensively managed stands of the same average dbh would measure about 34 and 43 m^2/ha softwood basal area, respectively (Curtis et al. 1982), but little if any of this would be from trees over 53 cm dbh. Diameter frequency distributions of softwood stems would be more peaked and much less broad in intensively managed even-age stands (Smith 1962) than in the observed stands (Fig. 7), and would be highly regulated by intermediate treatments during a stand rotation.

Hardwood trees. Under intensive management conditions, many hardwood trees would be removed to maximize use of growing space. In some of the study stands, however, hardwood trees contributed heavily to total stem density (Fig. 7) or total basal area (Fig. 8).

Foliage volume profile. Foliage volume profiles in the present study (Fig. 4) compared fairly well with probable profiles of intensively managed stands, showing a highly modal peak and little deciduous foliage in the middle and upper canopy positions. However, less evergreen foliage would be expected in upper canopy positions in the medium sawtimber stages under intensively managed conditions, because dominant, very large diameter softwoods would be absent. Also, the study stands showed moderate between-stand variation in foliage volume profiles, whereas under managed conditions between-stand variation would be relatively low.

The study stands had low canopy foliage patchiness (Fig. 5); intensively managed conditions would also produce low canopy foliage patchiness (Mannan 1982).

Snags. Under conditions of intensive timber management, none of the large "residual" softwood or hardwood snags observed in the present study would be present and fewer medium diameter softwood snags would be present. Mannan (1982) reported that the density of snags 31+ cm dbh averaged about 8.4/ha in old-growth stands and about 1.4/ha in managed stands. Snag density in the present study (Table 5) compared more closely with natural stand conditions than with managed stand conditions.

Summary: Even-Aged Timber Management and Stand Structure

All phases of the clearcutting system of even-age silvicultural management of Douglas-fir greatly affect stand conditions as compared with natural forest conditions. Site preparation and stocking control generally reduce density of hardwood trees, total foliage volume, canopy closure, shrub cover, number of plant species, snag density, and down wood mass and volume, and may increase patchiness of remaining canopy foliage and shrub cover.

Intermediate treatments generally reduce total stem density, basal area, and total foliage volume. Four main methods of commercial thinning differently affect mean diameter, size, and age distributions of softwood stems; foliage volume profile; and patchiness and percent closure of canopy foliage. Low thinning and selective thinning create more uniform stand conditions than the other thinning methods, crown thinning may create more diverse stand conditions, and mechanical thinning more or less maintains most stand conditions.

Final harvest(clearcutting) usually results in increases of shrub foliage volume, height, and cover, total number of plant species, and down wood mass, volume, distribution, and mean diameter; and decreases of all other stand characteristics considered here.

Pole and medium sawtimber stands selected for this study reflected stand conditions under intensive even-age silvicultural management, except for the study stands being older in age(suppressed conditions) and having "remnant" softwood and hardwood trees and snags in the large (53+ cm) dbh class. Total softwood stem density, foliage volume profiles, percent canopy closure, and patchiness of canopy foliage of the study stands matched well with conditions expected in an intensively managed stand.

Relationships of Birds and Even-Age Stand Structure

Bird Abundance and Structural Components

The variety of stand structures encountered in this study represented a fair portion of the range of conditions that may be expected from even-age silvicultural management of a Douglas-fir forest. For example, during clearcutting, live and dead "residual" trees may or may not be left standing; down wood and brush may be piled and burned, broadcast burned, or left on site; grasses and forbs or hardwood and deciduous shrubs of various species may dominate a site; conifer plantations may subsequently require replanting, release, or pre-commercial thinning; and resultant stands may be entered for thinning, weeding, salvage, or other intermediate treatments, or not at all until final harvest.

Each combination of stand treatments may produce different habitat conditions. Different bird species occurred in highest abundance under different stand conditions, but no single stand condition, successional stage, or variation in the even-age system provided best habitat for all species. Thus, the potential range of site-specific conditions must be considered when relating bird abundance to even-age management. To simplify this assessment, I will confine discussion to birds in the breeding season only and will focus on two major characteristics of stand structure influenced by silvicultural treatments: structure of foliage volume and size distribution of tree stems.

Structure of foliage volume. Between-site variation of stand conditions in the 3 shrub stages owed largely to time since clearcutting and to differences in final harvest, site preparation, and stocking control. Resulting grass/forb and shrub/sapling sites varied by total foliage volume and percent of total foliage volume in deciduous and evergreen classes. Although densities of each bird species correlated with unique combinations of vegetation and habitat characteristics, and in no case did such characteristics totally account for variations of bird abundances between sites, some generalizations may be made about suitability of stand conditions for various species.

Examples of the ranges of foliage volume profiles in the shrub stages are shown in Figure 22, along with bird species associated with each general stand structure, as revealed by the correlations of bird densities with vegetation factor scores (Table 11). The foliage volume profiles in Figure 22 are drawn from individual study stands and, as case studies, represent a range of conditions of shrub stage vegetation structure For example, a site with relatively high volumes of deciduous shrub foliage (Fig. 22d) would benefit red-breasted sapsucker, house wren, MacGillivray's warbler, Wilson's warbler, and western tanager.

Insofar as silvicultural practices influence shrub foliage volume and proportion of deciduous foliage in the shrub stages (Table 16), they may enhance or depress abundances of associated species. For instance, suppression release may produce conditions favorable for species associated with evergreen foliage volume (Fig. 22c), but may at least temporarily reduce conditions favorable for species associated with deciduous foliage volume (Fig. 22d). However, care must be taken to identify how inflexible a species may be to changes in conditions of habitat or environment. For example, some western wood warblers have been shown to alter their mean foraging height or use different foraging substrates in different seasons (Hutto 1981) or in the presence or absence of deciduous foliage shrub cover (Morrison 1981). As observed in the present study, some species such as winter wren and purple finch may change habitat affiliation over seasons for a variety of possible reasons. Habitat conditions required by a species over all seasons must be taken into account in setting objectives for habitat management.

In forest stages, as in shrub stages, different foliage volume profiles may generally be associated with suitable conditions for different species of birds (Fig. 22). Presence of foliage volume in the < 2 m stratum, or dominance of the canopy by deciduous or evergreen foliage, may benefit different groups of species. As intermediate treatments affect stand structure and plant composition (Table 17), associated bird species may be affected in predictable ways. For example, salvage cutting has the potential to reduce or remove canopy hardwoods, thus lowering abundances of species associated with deciduous or broad-leaf tree foliage volume, such as Hutton's vireo and western tanager (Fig. 22h); but if a more open canopy stimulated growth of low shrub foliage, another set of species may benefit, including hermit thrush, Wilson's warbler, and black-headed grosbeak (Fig. 22f).

Size distribution of tree stems. Intermediate stand treatments influence density and frequency distributions of stems by diameter class and growth form, which in turn may be related to bird abundance (Table 17, Fig. 23). The frequency distributions of stems shown in Figure 23 were selected from individual study stands, and represent the range of conditions encountered in this study. As an example, crown and selection thinnings may decrease the average diameter of softwood trees in a stand; species associated with stands containing higher densities uf large diameter softwoods, such as Hammond's flycatcher and brown creeper, may decrease in abundance (Fig. 23b). Stand treatments that induce or maintain an understory of small to medium diameter hardwood shrubs and trees would probably benefit winter wrens and Wilson's warblers (Fig. 23d); species associated with low foliage volume in forest stages may also benefit (Fig. 22f).

Effects on bird abundance from altering other vegetation and habitat characteristics of shrub and forest stages, such as percent closure of canopy foliage, patchiness of shrub cover, and snag density, may also be discerned from species-habitat relationships outlined above (Tables 16 and 17).

Bird Assemblages in Managed Stands

The structural characteristic across the young-growth successional sequence that had the greatest influence on bird species composition and richness was the presence or absence of the tree layer, as also reported in other forest types such as spruce-fir forest in Maine (Titterington et al. 1979). The forest stands used in this study represented understocked, post-fire conditions of even-age structure. Under intensive silvicultural treatment to maximize softwood production, densities of hardwood trees, snags, large diameter softwoods, and possibly shrubs may be lower than average levels observed in the study stands, although their presence afforded the opportunity to assess how they may influence patterns of bird species abundance. As discussed above, abundances of a number of bird species correlated significantly with densities of these vegetation factors.

The overall result of intensive even-age timber management is probably the simplification of stand structure and composition. The even-age forest stand, characterized by dense and single-layered canopy foliage, and uniform spacing of conifers of more or less equal diameters and heights, has often been reported to typically contain the lowest bird species richness and diversity over the managed forest sere (James and Wamer 1982, Beedy 1981, Kessler 1979, Conner and Adkisson 1975, Karr and Roth 1971), as discussed by Meslow (1978). I also found that the pole stage was characterized by relatively low bird densities and a low number of modally abundant bird species during the breeding season, especially after the influences from large hardwood stems, deciduous foliage, and snags were discounted.

Application of intensive even-age management over a wide forest area, however, may result in various levels of habitat diversity at different scales. Although within-stand (alpha) diversity of vegetation structure and avifaunal composition would generally be low, between-stand (beta) diversity may be high if stands are managed in staggered cutting sequences (e.g., Roach 1974, Hall and

Thomas 1979, Salwasser and Tappeiner 1981, Harris and Marion 1981, Mealey et al. 1982). In contrast, natural stand conditions, tending toward uneven-age structure, lend to high alpha diversity and low beta diversity.

Summary: Birds and Stand Structure

Vegetation structure and composition of shrub and forest stages in the young-growth successional sequence are largely determined by specific combinations of silvicultural treatments. No one stand condition, successional stage, or combination of treatments provided best habitat for all bird species. Each phase of the clearcutting system, including site preparation, stocking control, intermediate treatments, and final harvest, can be seen as altering specific stand characteristics, which can in turn be used to predict bird species responses.

In the shrub stages, foliage volume density and percent deciduous foliage, as well as shrub patchiness and presence of snags and live residual trees, can be manipulated by final harvest, site preparation, and stocking control, and related to bird abundance. In the forest successional stages, presence of foliage volume in the 0.1-2 m stratum, presence of deciduous foliage in the canopy, and density of small and large softwood and hardwood tree stems can be manipulated by intermediate treatments and significantly associated with bird abundance.

A major result of intensive even-age management is the simplification of forest stand structure, in part by the reduction in density of hardwood trees, snags, large diameter softwoods, and possibly shrubs. All of these components in an even-age forest stand, however, associated significantly and positively with abundances of a number of bird species. The homogeneous even-age forest that lacks these components typically has the lowest bird species richness, diversity, or density over the managed forest sere, and few species occur in highest numbers under such conditions.

Large-scale application of even-age forest management with different stands staggered in cutting and regeneration sequences would result in low within-stand diversity of vegetation structure and avifaunal composition, but high between-stand diversity as different species occupy successive stages of the sere. In contrast, natural, uneven-age stand conditions generally have high within-stand and low between-stand levels of vegetation and bird diversity.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

The distribution of birds among young-growth stages of Douglas-fir varied in response to stand structure and successional stage, which in turn were largely determined by the history of even-age silvicultural treatments. Each successional stage and stand structure component accounted for abundance of a unique set of species, and no one stage or component provided best habitat conditions for all species. Densities and habitat associations of birds in mature and old-growth successional stages were not investigated in this study.

Variations of bird species richness and density suggested that the habitat roles played by the various shrub and forest stages differed by season. Among permanent resident species of birds, shrub stage specialists were limited in distribution during winter to optimal or "source" habitats. In contrast, forest stage specialists showed no seasonal restriction of distribution, or were more restricted during the breeding season than during other seasons. As a result, patterns of habitat use in one season (e.g., breeding) may not reflect year-long requirements. Seasonal changes in abundance patterns, suggesting changes in habitat requirements, must be accounted for when managing habitat for birds in young-growth Douglas-fir.

Bird species composition must be considered when managing young-growth habitat; emphasis should not focus solely on overall species richness, density, and diversity. For example, the grass/forb stage generally had lowest levels of bird species richness, number of modally abundant species, total bird density, and bird species diversity, but had highest numbers of 3 species (western wood pewee, western bluebird, and Lazuli bunting) which were absent or nearly absent in all other stages surveyed.

The major component distinguishing bird composition among the young-growth stages was presence or absence of a forest overstory, which separated predominantly shrub stage species from predominantly forest stage species. Habitat components in the shrub stages that further differentiated bird abundance included total shrub foliage volume, percent deciduous foliage, presence and density of hardwood stems, height and patchiness of shrub cover, number of plant species, presence of snags, and down wood mass and volume. In the forest stages, bird abundance was influenced by these same habitat components as well as by foliage volume in the 0.1-2 m stratum, foliage volume profile, percent closure and patchiness of canopy foliage, and mean diameter, density, basal area, and size distribution of softwood stems. These are all habitat components that are greatly modified during intensive even-age timber management.

A central concern over large scale application of intensive even-age management is its potential for simplifying the structure and composition of forest stands, and its regional history of converting large areas of mature forest to conditions of shrub stages and single-species conifer plantations. In the Douglas-fir region of northwestern California, the widespread conversion of forest stages to shrub stages since the early 1950's has probably caused distributional shifts or increases of band-tailed pigeons, western wood pewees, dusky flycatchers, western bluebirds, fox sparrows, purple finches, and evening grosbeaks. However, species more or less restricted to forest stages -- Hammond's flycatchers, chestnut-backed chickadees, red-breasted nuthatches, brown creepers, golden-crowned kinglets, and hermit warblers -- are probably experiencing concomitant decreases in distribution or abundance. Future changes of total area, proportions, and landscape patterns of successional stages may induce different shifts of bird distribution and abundance.

Viewed another way, the promise for maintaining habitat conditions for the majority of shrub and forest bird species lies in carefully crafting silvicultural prescriptions within the even-age silvicultural system.

Smith (1962) defined a silvicultural system as a flexible and comprehensive program of silvicultural treatment applied during the entire cycle of stand growth. Specific stand treatments are only part of a series of logical steps designed to help create and maintain well-defined stand conditions, which in turn derive from overall management objectives and landowner goals. In this context, specific management objectives for bird habitat and even-age timber management may be blended to produce silvicultural prescriptions for stand treatments to meet both needs. Essential to this process is a detailed understanding of how each silvicultural treatment may influence key components and stages of the young-growth habitat, and an understanding of the relationships of bird abundance to such habitat components and successional stages.

Successful merging of wildlife and timber management objectives in the even-age managed forest may depend on how well stand conditions that are favorable to birds can be specified as objectives and created through silvicultural treatments. For example, one objective may be to create conditions favorable for forest bird species associated with deciduous broad-leaf foliage in the canopy (Fig. 22g). One strategy to achieve this objective could be to retain a mix of various species of hardwood trees in 0.1-ha plots scattered throughout a stand, such that hardwood stem density averages at least 50/ha (e.g., to be able to maintain warbling vireos at least at 50 percent of their maximum observed breeding density; see Fig. 12), allowing deciduous and broad-leaf foliage to penetrate the canopy. Appropriate prescriptions for the silvicultural system to create such stand conditions would include retaining 0.1-ha hardwood groups during final harvest, site preparation, release and precommercial thinning, and during subsequent stocking controls and intermediate treatments.

The patterns of bird numbers and relationships to habitat factors presented in this report are specific to young-growth Douglas-fir, but the patterns are probably general to many mixed conifer-hardwood forest types found throughout the western U.S. Many of the effects on bird distribution and abundance from even-age timber management are also applicable to other forest types, and results from this study may provide a general framework for considering relationships between timber management and bird habitat management.

A more precise understanding than this study provides of the breeding and foraging ecology of individual species would help to detail suitable habitat conditions and structures of vegetation for management use. Specifically, attention should be placed on bird species in 2 main categories: those that occur predominantly in older, mature forest stages (e.g., Hammond's flycatchers, hermit warblers, brown creepers, golden-crowned kinglets); and those that are strongly associated with vegetation elements that are likely to be reduced within or excluded from intensively managed stands, such as associates of hardwoods and deciduous foliage (e.g., western tanagers, Hutton's vireos), snags (primary and secondary cavity-nesting species), and shrub foliage in forest stages (hermit thrushes, Wilson's warblers, black-headed grosbeaks).

Table 1. Timing of silvicultural activities on young-growth Douglas-fir study stands, northwestern California. Values are mean number of years since activity (as of 1981) and number of stands (n) incurring treatment activity.

Successional stage		Regeneration activity: Clear-cut	Burn	First plant	Spray\a
Grass/forb (13 stands)	yrs:	4.9	2.7	1.8	(a.n.c.)\b
	n:	13 (100%)	11 (85%)	13 (100%)	0 (0%)
Early shrub/ sapling (10 stands)	yrs:	14.4	9.0	8.3	4.2
	n:	10 (100%)	8 (80%)	10 (100%)	5 (50%)
Late shrub/ sapling (14 stands)	yrs:	16.3	14.0	14.1	7.5
	n:	14 (100%)	5 (36%)	14 (100%)	11 (79%)
Pole (10 stands)	yrs:	30.0	29.0	24.7	27.0
	n:	1 (10%)	1 (10%)	1 (10%)	1 (10%)
Medium sawtimber (8 stands)	yrs:	(a.n.c.)	(a.n.c.)	(a.n.c.)	(a.n.c.)
	n:	0 (0%)	0 (0%)	0 (0%)	0 (0%)

\a Aerially-applied 2,4-D or 2,4,5-T herbicides.
\b a.n.c. = activity not conducted.

Table 2. Number of variable circular plot bird count points (number of study stands in parentheses) by successional stage of young-growth Douglas-fir, northwestern California.

Successional stage	No. count points
Grass/forb	14 (13)
Early shrub/sapling	15 (10)
Late shrub/sapling	23 (14)
Pole	18 (10)
Medium sawtimber	19 (8)
TOTAL	89 (55)

Table 3. Numbers of variable circular plot (VCP) bird surveys conducted July 1981 through March 1983. Values are total numbers of VCP count points visited; in parentheses are total numbers of 10-minute VCP surveys.

Season	Grass/ forb	Early shrub/ sapling	Late shrub/ sapling	Pole	Medium sawtimber	Total
	Successional stage					
Summer 1981	3 (36)	15 (180)	14 (168)	13 (156)	7 (84)	: 52 (624)
Fall 1981	14 (168)	15 (180)	23 (276)	16 (192)	17 (204	: 85 (1020)
Winter 1982	9 (108)	0 (0)	9 (108)	7 (84)	14 (168)	: 39 (468)
Spring 1982	2 (24)	6 (72)	4 (48)	6 (72)	5 (60)	: 23 (276)
Breed. 1982	12 (144)	13 (156)	21 (252)	12 (144)	14 (168)	: 72 (864)
Summer 1982	14 (168)	15 (180)	22 (264)	18 (216)	19 (228)	: 88 (1056)
Fall 1982	14 (168)	15 (180)	23 (276)	18 (216)	19 (228)	: 89 (1068)
Winter 1983	3 (36)	11 (132)	3 (36)	10 (120)	5 (60)	: 32 (384)
Spring 1983	6 (72)	0 (0)	0 (0)	0 (0)	0 (0)	: 6 (72)
Total	77 (924)	90 (1080)	119 (1428)	100 (1200)	100 (1200)	: 486 (5832)

Table 4. Deciduous, evergreen, and total foliage volumes (m^3/ha, mean with one standard error shown in parentheses) among young-growth Douglas-fir stands by successional stage, northwestern California.

Successional stage	Height stratum (m)	Deciduous	Evergreen[a]	Total
Grass/forb (n = 14)	< 2	352 (105)	982 (253)	1334 (277)
	Total	352 (105)	1002 (263)	1354 (281)
Early shrub/ sapling (n = 15)	< 2	1301 (404)	4326 (617)	5627 (812)
	Total	1387 (402)	6305 (1129)	7692 (1275)
Late shrub/ sapling (n = 23)	< 2	2007 (289)	5631 (542)	'7638 (532)
	Total	3259 (630)	9327 (1326)	12586 (1330)
Pole (n = 16)	< 2	152 (98)	739 (313)	891 (324)
	Total	3382 (1019)	33000 (3040)	36381 (3327)
Medjum sawtimber (n = 20)	< 2	157 (62)	824 (211)	981 (227)
	Total	5366 (1113)	63993 (14056)	69359 (14210)

[a] Includes broad-leaf evergreen species such as _Quercus chrrsolepus_ and _Lithocarpus densiflora_.

Table 5. Density and basal area of snags (means with standard errors in parentheses) at bird count points in forested study stands of young-growth Douglas-fir, northwestern California.

Successional stage	Snag stem diameter class (cm dbh)			
	13-52\a	> 40\b	> 52\a	Total
Pole (n=18 stands)				
Snag density (n/ha)	8.0 (1.8)	7.0 (1.8)	3.1 (0.8)	11.1
Snag basal area (m\2/ha)	n.c.	3.1 (0.8)	n.c.	
Medium sawtimber (n=19 stands)				
Snag density (n/ha)	12.6 (3.5)	6.0 (2.0)	2.2 (0.8)	14.8
Snag basal area (m\2/ha)	n.c.	2.2 (0.8)	n.c.	

\aEstimates derived from the 3-plot vegatation sampling method, covering a total of 0.06 ha and 0.12 ha at each bird count point in pole and medium sawtimber stands, respectively.

\b Estimates derived from the 1-plot vegetation sampling method, covering 0.28 ha centered at each bird count point.

n.c. = not calculated.

Table 6. Down wood mass and volume by wood diameter class and successional stage of young-growth Douglas-fir, northwestern California. (See Table 2 for number of bird count points sampled within each successional stage.)

Successional stage		Down wood diameter class ≤ 7.6 cm	> 7.6 cm	Total
DOWN WOOD MASS (Metric tons/ha)				
Grass/forb	mean:	14.8	53.4	68.2
	S.E.:	2.4	13.5	14.4
Early shrub/ sapling	mean:	9.7	81.4	91.1
	S.E.:	1.4	13.7	13.4
Late shrub/ sapling	mean:	7.9	74.7	82.7
	S.E.:	1.0	11.2	11.4
Pole	mean:	11.9	52.4	64.2
	S.E.:	1.0	19.9	19.9
Medium sawtimber	mean:	10.4	29.5	36.4
	S.E.:	1.1	6.4	4.9
DOWN WOOD VOLUME (m^3/ha)				
Grass/forb	mean:	35	163	198
	S.E.:	6	41	43
Early shrub/ sapling	mean:	23	258	281
	S.E.:	4	42	41
Late shrub/ sapling	mean:	19	246	265
	S.E.:	3	37	38
Pole	mean:	27	171	198
	S.E.:	2	66	66
Medium sawtimber	mean:	24	98	122
	S.E.:	3	21	21

Table 7. Physiographic characteristics of study stands, northwestern California. See Table 2 for number of stands surveyed in each successional stage.

Successional stage		Elevation (m)	Area (ha)	Boundary length (m)	Shape index\a	Number of adjacent stands	Distance to permanent water (m)	Distance to nearest stand of same type (m)
Grass/forb	mean:	1114	9.5	1309	1.20	3.3	382	390
	S. E.:	309	0.8	76	0.03	0.4	150	85
Early shrub/sapling	mean:	1012	17.2	2043	1.39	4.6	1890	37
	S.E.:	320	1.3	149	0.06	0.5	642	24
Late shrub/sapling	mean:	1044	17.6	1948	1.32	4.6	611	200
	S.E.:	279	1.4	119	0.04	0.4	100	136
Pole	mean:	967	22.3	2343	1.46	5.7	575	481
	S. E. :	306	7.5	456	0.08	0.7	152	112
Medium sawtimber	mean:	789	38.5	3519	1.58	7.3	370	51
	S.E.:	279	7.0	597	0.12	1.1	198	35
ANOVA	F value:	6.48	6.46	7.13	4.61	5.53	4.44	3.46
	P value\b:	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02

\a Shape index from Patton (1975).
\b ANOVAs based on DF1 = 4, DF2 = 50.

Table 8. Statistical summary of discriminant functions (breeding and summer seasons only) and the first two principle component factors (see Appendix 3) from shrub and forested successional stages of young-growth Douglas-fir, based on habitat and vegetation variables (see Appendix 2).

Discriminant function	Percent total variation	Eigenvalue	χ^2	Significance	d.f.
SHRUB STAGES (3 groups)					
1	84	10.99	138.24	0.000	46
2	16	2.17	43.84	0.004	22
FORESTED STAGES (2 groups)					
1	100	29.36	56.32	.004	31

	Principle factor	Percent total variation	Eigenvalue
SHRUB STAGES (52 cases)			
Breeding, Summer	1	51	4.13
	2	24	1.93
Spring, Fall	1	43	5.86
	2	21	2.83
Winter	1	51	5.49
	2	22	2.37
Mean	1	48	
	2	22	
FORESTED STAGES (37 cases)			
Breeding, Summer	1	24	3.72
	2	21	3.20
Spring. Fall	1	25	5.15
	2	23	4.63
Winter	1	28	7.27
	2	20	5.28
Mean	1	26	
	2	21	

Table 9. Mean bird densities (n/40.5 ha) by season and successional stage of young-growth Douglas-fir, northwestern California, years combined.

Species	Breeding (15 April - 30 June 1982) Grass/ forb	Early shrub/ sapling	Late shrub/ sapling	Pole	Medium sawtimber
Turkey vulture		P			
Sharp-shinned hawk		P	P	P	
Cooper's hawk		P	P		
Red-tailed hawk		P	P	P	P
American kestrel		P	P		P
California quail	P				
Mountain quail	P	3.0	4.3	0.8	0.2
Band-tailed pigeon		P	P		
Western screech owl					P
Anna's hummingbird	73.8		135.7	P	
Calliope hummingbird			29.8	P	
Rufous hummingbird	P	P	P		
Allen's hummingbird	P	P	P		
Acorn woodpecker		0.4	P	2.6	3.8
Red-breasted sapsucker		P	2.8	11.3	1.4
Downy woodpecker			P	P	P
Hairy woodpecker	P		P	5.3	1.9
White-headed woodpecker	P				
Northern flicker	P	1.9	0.9	P	P
Pileated woodpecker		P		P	P
Olive-sided flycatcher	1.0	1.4	2.2	P	P
Western wood pewee	4.5	P	0.5	P	
Hammond's flycatcher	P				15.1
Dusky flycatcher	5.6	21.5	25.9	P	
Western flycatcher	1.3	P	P	15.5	33.8
Steller's jay	0.9	5.4	6.1	10.9	11.3
Scrub jay		1.2	P		P
Common raven		P	P	0.6	0.3
Mountain chickadee	0.4	0.8	1.9	10.9	
Chestnut-backed chickadee	2.3	2.3	2.7	49.4	47.9
Bushtit		P	47.0		
Red-breasted nuthatch	P	P	P	8.4	4.7
White-breasted nuthatch			P	P	P
Brown creeper	P	P	P	24.5	35.5
Bewick's wren		8.5	1.1	P	
House wren	83.6	21.9	21.2	P	
Winter wren	P	P	P		7.7
Golden-crowned kinglet		P	P	0.4	9.0
Western bluebird	18.3	3.1	P		P
Townsend's solitaire	P	P	P	P	P
Hermit thrush	P	2.4	8.5		3.3
American robin	P	P	1.1	3.4	5.5
Wrentit		25.1	16.3		
Solitary vireo		1.1	2.4	8.3	18.9
Hutton's vireo		P	P	P	P
Warbling vireo	1.3	P	12.4	1.6	2.2
Orange-crowned warbler	P	11.6	14.8		
Nashville warbler	7.5	127.5	132.3	14.9	10.7
Yellow warbler	P	P			
Yellow-rumped warbler	7.7	27.2	0.9	8.3	1.8
Black-throated gray warbler	P	16.1	3.0	4.6	2.1
Hermit warbler	0.7	1.8	0.8	82.7	107.5
MacGillivray's warbler	1.9	29.0	38.1	P	P
Wilson's warbler	P	6.4	39.6	2.3	4.4

Table 9. Continued.

Species	Breeding (15 April - 30 June 1982)				
	Grass/ forb	Early shrub/ sapling	Late shrub/ sapling	Pole	Medium sawtimber
Western tanager	P	0.7	3.5	16.2	15.6
Black-headed grosbeak	2.1	5.5	28.8	17.1	18.9
Lazuli bunting	22.7	P	P		
Green-tailed towhee		P	P		
Rufous-sided towhee	P	40.9	32.8	P	P
Chipping sparrow	P	P	3.2	P	P
Fox sparrow	P	2.4	27.3		
Song sparrow		4.9	P		
Dark-eyed junco	65.6	96.1	54.8	41.2	60.9
Brown-headed cowbird	P	P	P		
Purple finch	1.2	26.3	22.6	2.0	2.9
Red crossbill	P			P	P
Pine siskin	2.5	4.4	4.5	4.3	10.5
Lesser goldfinch	P	2.5	4.3		P
Evening grosbeak	P	P	P	0.9	0.3

Table 9. Continued.

Species	Summer (I July-15 September, 1981 and 1982)				
	Grass/ forb	Early shrub/ sapling	Lace shrub/ sapling	Pole	Medium sawtimber
Turkey vulture	P	P	P	P	P
Sharp-shinned hawk	P	P	P	0.1	1.2
Cooper's hawk		P	P	P	
Red-tailed hawk		P	P	0.2	0.5
American kestrel		0.4	P		P
Mountain quail	0.8	10.0	14.9	0.7	
Band-tailed pigeon	8.6	7.9	4.9	1.6	
Northern pygmy awl		P	P	P	
Vaux's swift	P	P			
Anna's hummingbird	P	P	P		
Rufous hummingbird		P	P		
Allen's hummingbird	P	P	P		
Acorn woodpecker	P	5.4	0.4	0.2	2.0
Red-breasted sapsucker	P	P	P	13.9	P
Downy woodpecker		P	P	0.02	0.3
Hairy woodpecker	P	P	P	1.2	1.9
White-headed woodpecker	P				
Northern flicker	P	1.7	1.1	0.3	0.5
Pileated woodpecker	P		P	0.1	0.4
Olive-sided flycatcher	1.2	0.2	1.2	P	P
Western wood pewee	8.7	1.5	0.7	P	P
Hammond's flycatcher				P	
Dusky flycateher	P	9.8	10.1	P	
Western flycatcher	1.7	1.0	2.9	6.8	14.1
Violet-green swallow	9.3	12.6	P	P	
Steller's jay	3.2	6.3	24.8	6.9	9.9
Scrub jay		3.9	P		
Common raven	P	1.2	P	0.1	0.4
Mountain chickadee	P	2.7	2.0	1.3	
Chestnut-backed chickadee	2.2	11.2	7.5	112.1	105.3
Bushtit	1.1	27.1	61.1	P	
Red-breasted nuthatch	P	P	2.3	18.9	16.9
White-breasted nuthatch	P	P	P	0.7	0.1
Brown creeper	P		P	41.1	56.2
Bewick's wren	P	3.8	P		
House wren	27.4	9.9	18.8	P	
Winter wren	P	P	P	1.5	2.6
Golden-crowned kinglet			P	32.0	19.5
Western bluebird	22.9	5.9	P	P	
Townsend's solitaire	P	P	6.5	P	
Hermit thrush		16.3	7.0	4.1	9.2
American robin	2.2	7.8	10.8	3.7	1.6
Wrentit	P	34.3	37.7	P	
Cedar waxwing		P	12.1		
Solitary vireo	P	1.4	1.0	4.3	3.0
Hutton's vireo	P	1.5	4.1	5.3	4.5
Warbling vireo	P	0.2	P	4.7	4.2
Orange-crowned warbler		P	P	P	
Nashville warbler		11.7	24.0	P	
Yellow-rumped warbler		1.6	P	3.4	0.6
Black-throated gray warbler	P	6.8	22.8	1.5	0.4
Hermit warbler	P	P	P	38.9	37.2
MacGillivray's warbler	1.1	19.8	24.6	P	P
Wilson's warbler	1.9	11.7	40.2	5.0	8.2

Table 9. Continued.

	Summer (I July-15 September, 1981 and 1982)				
Species	Grass/ forb	Early shrub/ sapling	Late shrub/ sapling	Pole	Medium sawtimber
Western tanager	3.2	14.3	34.3	5.9	5.6
Black-headed grosbeak	1.4	20.4	21.8	3.0	1.3
Lazuli bunting	P	P			
Green-tailed towhee		10.5	6.9		
Rufous-sided towhee	1.0	39.0	41.3	P	P
Chipping sparrow	P	P	2.0	P	P
Fox sparrow	P	14.3	21.1	P	
Song sparrow	0.8	0.2		P	
Golden-crowned sparrow		P			
Dark-eyed junco	168.4	179.5	194.4	89.2	16.5
Brown-headed cowbird			P		
Purple finch	13.6	10.9	29.6	1.7	0.3
Red crossbill		P	P	1.1	0.3
Pine siskin	45.4	13.7	3.7	3.6	2.8
Lesser goldfinch	20.5	16.0	5.0	1.0	0.4
American goldfinch	P	P			
Evening grosbeak	P	P	P	P	P
Brewer's blackbird			P		

Table 9. Continued.

Species	Grass/ forb	Early shrub/ sapling	Late shrub/ sapling	Pole	Medium sawtimber
	Fall (16 September–30 November, 1981 and 1982)				
Great blue heron		P			
Mallard		P			
Turkey vulture			P		
Sharp-shinned hawk	P	P	P	P	
Cooper's hawk	P	P		P	
Northern goshawk	P		P		
Red-tailed hawk	P	P	P	P	
Red-shouldered hawk		P			
American kestrel	P		P		
Mountain quail	P	8.5	1.5	P	
Northern phalarope		P			
Band-tailed pigeon	3.0	80.1	86.9	15.3	16.0
Northern pygmy owl	P	P	P	0.1	0.2
Vaux's swift	P	P	P		
Anna's hummingbird	P	P	P	P	
Acorn woodpecker	P	1.2	0.6	1.0	1.7
Red-breasted sapsucker	P	P	P	P	P
Downy woodpecker	P		P	0.5	0.8
Hairy woodpecker	P	P	P	1.3	1.1
Northern flicker	1.5	1.0	1.3	1.7	2.5
Pileated woodpecker	P	P	P	0.3	0.5
Olive-sided flycatcher				P	
Western wood pewee			P		
Western flycatcher		P		P	P
Violet-green swallow		P	P	P	P
Steller's jay	3.1	9.9	16.1	22.7	28.4
Scrub jay		1.9	2.9	P	P
Common raven	2.3	P	0.5	0.7	0.9
Mountain chickadee	P	P	P	P	
Chestnut-backed chickadee	5.7	9.3	17.1	203.5	181.4
Bushtit	P	17.4	41.2	P	P
Red-breasted nuthatch	P	P	P	17.6	12.3
White-breasted nuthatch	P		P	P	
Brown creeper	P				
Bewick's wren	P	8.6	3.3	49.2	46.1
House wren	P	P	P	P	P
Winter wren	17.9	50.8	77.6	22.4	14.0
Golden-crowned kinglet	11.8	58.9	64.3	219.0	183.1
Ruby-crowned kinglet	4.9	31.9	37.6	15.9	18.3
Western bluebird	0.7	2.9	1.0	P	P
Townsend's solitaire	P	P	0.6	P	P
Hermit thrush	P	6.0	19.0	2.1	3.1
American robin	12.9	105.2	43.6	5.6	9.5
Varied thrush	0.5	2.8	2.0	2.4	6.0
Wrentit	0.5	18.3	18.0	P	P
Cedar waxwing	3.1	17.6	36.5	2.9	10.1
Solitary vireo		P		P	P
Hutton's vireo		4.5	2.2	6.6	8.5
Warbling vireo		P		P	

Table 9. Continued.

	Fall (16 September–30 November, 1981 and 1982)				
Species	Grass/ forb	Early shrub/ sapling	Late shrub/ sapling	Pole	Medium sawtimber
Orange-crowned warbler		P	P	P	
Nashville warbler		P		P	
Yellow-rumped warbler	25.4	8.8	5.0	4.3	5.0
Black-throated gray warbler	P	P	P	P	P
Townsend's warbler			P	P	P
Hermit warbler			P	P	P
MacGillivray's warbler		P	P	P	
Wilson's warbler		P	P	P	P
Western tanager	P	P	P	P	P
Green-tailed towhee		P	P		
Rufous-sided towhee	P	15.9	19.6	P	
Chipping sparrow	P				
Pox sparrow	5.1	149.8	78.6	P	P
Song sparrow	2.4	3.2	P	P	
Lincoln's sparrow		P			
Golden-crowned sparrow	9.5	P	16.1		
White-crowned sparrow		P	P		
Dark-eyed junco	149.2	134.3	173.4	33.2	26.8
Western meadowlark		P	P		
Starling		P			
Brewer's blackbird		P	P	P	P
Purple finch	3.6	3.8	11.5	4.2	4.5
Red crossbill	P	P	P	P	
Pine siskin	41.7	16.9	6.8	6.8	6.0
Lesser goldfinch	11.0	4.3	6.3	0.9	0.8
Evening grosbeak	P	4.5	5.4	0.6	0.4

Table 9. Continued.

Species	Winter (1 December-28 February, 1982 and 1983)				
	Grass/ forb	Early shrub/ sapling	Late shrub/ sapling	Pole	Medium sawtimber
Sharp-shinned hawk				P	P
Red-tailed hawk	P	P	P	P	
Mountain quail			P	P	
Band-tailed pigeon		26.3	2.3	15.3	34.2
Acorn woodpecker			P	0.2	0.7
Red-breasted sapsucker	P	P		P	
Downy woodpecker				P	P
Hairy woodpecker	P	P	P	P	P
White-headed woodpecker		P			
Northern flicker	P	P	P	0.2	0.4
Pileated woodpecker				P	P
Steller's jay	P	11.4	13.3	2.5	3.3
Scrub jay		1.6	P		
Common raven	P	P	P	0.5	0.4
Mountain chickadee	P	P	P	3.5	
Chestnur-backed chickadee	P	13.4	12.0	113.4	85.7
Bushtit		14.6	19.0		P
Red-breasted nuthatch		P		9.2	1.2
White-breasted nuthatch				P	
Brown creeper				22.1	25.9
Bewick's wren		P			
Winter wren	35.6	76.3	145.1	25.4	21.7
Golden-crowned kinglet	10.6	P	143.3	331.9	371.8
Ruby-crowned kinglet	P	P	12.4	14.3	15.7
Western bluebird	P		P	P	P
Townsend's solitaire	P	P		P	P
Hermit thrush		P		P	P
American robin	4.1	7.6	191.1	18.2	6.0
Varied thrush	P	1.0	3.4	4.6	2.8
Wrentit	P	19.7	3.2		
Cedar waxwing		22.1	11.1	12.1	1.7
Hutton's vireo			P	4.0	4.2
Yellow-rumped warbler	P				P
Townsend's warbler			P	P	P
Rufoue-sided towhee		P	P		
Fox sparrow		15.9	57.8	P	
Song sparrow	P	P	P		
Dark-eyed junco	P	37.7	18.3	P	P
Purple finch	P	P	1.4	P	P
Red crossbill	P	P		P	
Pine siskin	1.8	P	12.4	1.4	1.4
Lesser goldfinch		P	P		P
Evening grosbeak	P	P	5.3	3.4	2.9

Table 9. Continued.

Species	Spring (1 March-14 April, 1982 and 1983)				
	Grass/ forb	Early shrub/ sapling	Late shrub/ sapling	Pole	Medium sawtimber
Turkey vulture	P				
Red-tailed hawk	P	P		P	
Band-tailed pigeon	5.8			P	
Northern pygmy owl	P			P	P
Acorn woodpecker		P	P		P
Red-breasted sapsucker		P	P	P	P
Downy woodpecker				P	
Hairy woodpecker	P			P	P
Northern flicker	P	P		0.7	0.4
Violet-green swallow		P			P
Steller's jay	P	4.2	23.9	4.8	2.9
Common raven	P	P	P		P
Cheatnut-backed chickadee	P	P	P	95.3	143.1
Bushtit		P	P	P	
Red-breasted nuthatch		P		P	
White-breasted nuthatch					P
Brown creeper	P			39.6	36.6
Bewick's wren	P	11.0	P	P	
House wren		P			
Winter wren	43.2	95.4	16.9	97.1	33.8
Golden-crowned kinglet	P	30.0	P	230.6	150.8
Ruby-crowned kinglet	P	P		P	P
Western bluebird	22.5	P			
Townsend's solitaire	1.9				
Hermit thrush		P	P	P	P
American robin	36.4	11.1		0.8	0.8
Varied thrush				P	P
Wrentit	P	10.2	58.4	P	
Cedar waxwing	9.3				
Hutton's vireo	P	2.8	P	9.3	8.2
Townsend's warbler					P
Rufous-sided towhee	P	P			
Pox sparrow	P	84.4	P		
Dark-eyed junco	183.2	41.9	P	27.7	22.9
Purple finch	P				
Pine siskin	P	P		15.0	4.3
Evening grosbeak	P	P	P	P	

Table 10. Examples of mean bird densities (n/40.5 ha; Appendix 6), coefficients of variation of density (CV; Appendix 8), and percent occurrence at bird count points (Appendix 7) of selected species within successional stages of young-growth Douglas-fir, northwestern California.

SEASON. YEAR Species	Grass/ forb	Early shrub/ sapling	Late shrub/ sapling	Pole	Medium sawtimber
BREEDING 1982					
Brown creeper\a					
mean density:	P\b	0.0	0.0	47.9	65.1
CV density:	---	---	---	1.53	0.70
% occurrence:	17	8\c	5\c	75	93
Dusky flycatcher					
mean density:	P	19.5	16.6	P	0.0
CV density:	2.13	0.86	1.01	---	---
% occurrence:	33	77	81	8	0
Wilson's warbler					
mean density:	2.3	16.3	45.4	7.3	11.2
CV density:	---	1.63	0.91	1.07	1.85
% occurrence:	17	38	90	75	50
WINTER 1983					
American robin					
mean density:	11.2	7.6	25.3	29.3	17.8
CV density:	1.45	1.14	1.73	1.63	0.80
% occurrence:	\d	73	\d	90	100
Pine siskin					
mean density:	1.7	P	1.7	0.3	0.3
CV density:	0.87	---	1.73	3.16	2.24
% occurrence:	\d	64	\d	20	20
Cedar waxwing					
mean density:	0.0	22.1	36.1	20.6	6.3
CV density:	---	2.73	1.73	1.61	2.24
% occurrence:	\d	73	\d	50	20

\a Scientific names appear in Appendix 4.
\b P = present in successional stage but numbers detected too low (< 15) for estimation of density.
\c Present at bird count points but not observed during formal bird surveys.
\d Number of bird count points too few for reliable estimation of percent occurrence.

Table 11. Results of simple correlations of site-specific bird densities with principle component factor (Appendix 3) scores derived from vegetation and habitat variables, young-growth Douglas-fir, northwestern California.

SHRUB STAGES	1 Foliage volume			2 Stem density			3 Low vegetation patchiness			4 Pole softwood density			5 Down wood		
Species	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982
American kestrel		-	-		(-)	(-)		(-)	-		*	(-)		(-)	(-)
Mountain quail	**	+	*	(-)	(-)	+	-	-	-	-	(-)	(-)	(-)	(**)	(-)
Band-tailed pigeon		-	(-)		-	(-)		(-)	(-)		(-)	(-)		-	-
Vaux's swift		-			-			(**)			-			-	
Anna's hummingbird	-			(*)			*			(-)			-		
Calliope hummingbird	-			(-)			-			(-)			(*)		
Acorn woodpecker	+	+	+	(-)	(-)	(-)	(-)	(*)	(-)	*	*	*	(-)	(-)	(-)
Red-breasted sapsucker	+			-			-			(+)			-		
Northern flicker	*	-	*	-	(-)	-	(-)	(**)	-	(-)	+	(-)	(-)	-	(-)
Olive-sided flycatcher	-	-	-	*	-	(-)	(-)	+	+	(-)	-	(-)	(-)	-	(-)
Western wood pewee	(**)	(*)	(**)	(*)	(-)	(-)	(+)	(-)	(-)	-	(-)	(-)	-	-	(-)
Dusky flycatcher	*	-	+	-	(-)	-	(-)	-	(-)	-	-	-	(-)	(+)	(+)
Western flycatcher	(**)	-	+	(-)	(-)	-	(*)	+	-	(-)	-	(-)	-	(-)	-
Violet-green swallow		-	(-)		-	(-)		(**)	-		-	-		(-)	-
Steller's jay	*	**	**	*	(-)	-	-	(-)	-	(-)	(-)	-	-	(-)	-
Scrub jay	+	+	+	(-)	(-)	-	(*)	(*)	(*)	*	**	*	(-)	(-)	(-)
Common raven		(-)			(-)			-			(-)			(+)	
Mountain chickadee	-	(-)	-	(-)	-	-	(-)	-	(-)	(-)	(+)	(-)	(+)	(-)	(*)
Chestnut-backed chickadee	-	-	**	-	-	-	(-)	-	-	+	+	-	(-)	-	-
Bushtit	-	-	*	-	(+)	(-)	-	+	(-)	(-)	-	(-)	(*)	(-)	(-)
Red-breasted nuthatch		-	(+)		**	(-)		-	(-)		(*)	(-)		-	-
Bewick's wren	*	(-)	-	-	(-)	-	(+)	(*)	(-)	-	+	-	(-)	(-)	-
House wren	(**)	-	(*)	(**)	(-)	(*)	(-)	-	-	(*)	(-)	(*)	-	(+)	(-)
Western bluebird	(**)	-	(*)	(-)	-	(*)	(**)	(*)	(+)	-	(-)	-	-	(-)	-
Townsend's solitaire		-	*		(-)	(-)		-	-		(-)	(-)		(*)	(-)
Hermit thrush	**	+	**	**	-	-	(-)	-	(*)	*	*	(-)	-	-	(-)
American robin	-	-	-	(-)	(-)	-	+	(+)	(-)	(-)	(-)	(-)	(-)	-	(-)
Wrentit	*	*	*	**	**	**	(-)	(-)	-	**	-	**	(-)	-	-
Cedar waxwing		-	-		(-)	**		-	-		(-)	(+)		(-)	-
Solitary vireo	*	+	*	-	(-)	**	-	(-)	(+)	(-)	(-)	(-)	(-)	-	(-)
Hutton's vireo		*	*		-	-		*	(+)		(-)	-		-	(-)
Warbling vireo	*	-		-	(-)		-	(-)		+	(-)		-	-	
Orange-crowned warbler	**			-			(-)			*			(-)		

Table 11. Continued

SHRUB STAGES	I Foliage volume			2 Stern density			3 Low vegetation patchiness			4 Pole softwood density			5 Down wood		
Species	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982
Nashville warbler	**	-	+	-	-	(-)	-	-	-	-	*	(-)	-	(-)	(*)
Yellow-rumped warbler,	(-)	(-)	(-)	-	(-)	-	(*)	-	(**)	(-)	(-)	(-)	-	(-)	(-)
Black-throated gray warbler	+	-	-	+	-	*	-	**	-	*	(-)	(-)	-	-	*
Hermit warbler	-			**		.	(-)			+			-		
MacGillivray's warbler	**	(-)	**	-	(-)	-	-	-	-	(-)	-	(*)	-	(**)	(-)
Wilson's warbler	**	•	**	-	-	**	-	-	-	-	(*)	-	-	-	-
Western tanager	**	-	**	(-)	(-)	(-)	+	-	-	(-)	(*)	-	(-)	*	(-)
Black-headed grosbeak	**	-	*	(-)	(+)	(-)	-	(*)	-	-	-	(+)	*	-	(-)
Lazuli bunting	(**)			(*)			-			(+)			(-)		
Green-tailed towhee	**	(-)	-		(-)	(-)		-	(-)		(-)	(-)		(-)	(+)
Rufous-sided towhee		**	**	+	-	(-)	(-)	(-)	-	*	-	(-)	-	(*)	-
Chipping sparrow	*		-	(-)		(-)	+		-	(-)		(-)	(-)		(-)
Fox sparrow	-	-	-	-	-	-	-	-	(-)	(-)	•	(-)	(*)	(-)	(*)
Song sparrow	-	-	(+)	-	-	(-)	(+)	-	(-)	-	-	(-)	-	-	-
Dark-eyed junco	(-)	(-)	(-)	(**)	(+)	(*)	(*)	-	-	(-)	(-)	(**)	+	-	-
Purple finch	-	-	-	(-)	-	(-)	(-)	-	-	(-)	(-)	(-)	-	(+)	-
Pine siskin	-	(**)	(+)	-	-	(-)	(-)	(*)	(-)	-	-	(-)	+	-	(*)
Lesser goldfinch	-	(**)	-	(-)	(-)	-	-	(+)	(-)	-	-	+	(-)	-	(-)

Table 11. Continued

SHRUB STAGES	1 Foliage volume			2 Sapling softwood density			3 Medium hardwood basal area			4 Down wood			5 Low vegetation patchiness			6 Pole hardwood density		
Species	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982
American kestrel		(*)			(-)			-			(-)			-			-	
Mountain quail	-	+	-	(-)	(-)	(-)	(-)	(-)	-	-	-	-	-	(-)	(-)	-	(+)	(-)
Band-tailed pigeon		*	*		-	(-)		(-)	(*)		(-)	(-)		-	(-)		(-)	(-)
Acorn woodpecker		*	-		-	(-)		(*)	(-)		t	(-)		(-)	(-)		(-)	(+)
Northern flicker		(+)	(-)		(-)	(-)		-	-		-	(+)		-	-		(-)	+
Steller's jay	+	**	**	+	+	-	(**)	(*)	(**)	(-)	-	(-)	(+)	-	-	*	-	*
Scrub jay		-	-		(-)	(-)		(**)	(**)		-	*		(-)	-		*	**
Common raven		(-)	(*)		**	(-)		(-)	*		(-)	(-)		(-)	-		(-)	-
Chestnut-backed chickadee		*	*		*	-		(-)	+		-	(-)		+	*		-	(-)
Bushtit		+	-		-	(-)		(-)	-		(+)	(-)		(-)	(-)		(+)	*
Bewick's wren	(-)	*	*	(-)	(-)	(-)	-	-	(+)	**	+	**	-	-	(*)	(-)	(-)	(-)
Winter wren	(-)	**	+	(-)	-	*	*	-	(-)	-	-	-	-	(-)	(-)	(-)	(-)	+
Golden-crowned kinglet	-	**	-	(-)	-	-	(-)	(**)	(**)	-	-	(-)	-	(-)	-	(+)	-	**
Ruby-crowned kinglet		**	**		-	**		(-)	**		-	(-)		(*)	-		-	*
Western bluebird	(*)	(-)	(-)	(-)	-	(-)	+	(-)	-	-	-	-	+	(*)	(-)	-	(-)	(-)
Townsend's solitaire		-	-		(-)	(-)		-	(-)		-	-		(-)	*		-	*
Hermit thrush		**	**		+	(-)		(-)	-		-	-		*	*		*	-
American robin	(-)	+	-	(-)	+	+	-	(*)	(-)	(+)	**	-	-	(*)	(*)	(-)	(-)	(-)
Varied thrush		**	**		+	**		(**)	(**)		*	-		-	(-)		(-)	-
Wrentit	-	**	●	-	*I	(-)	(*)	(**)	(**)	-	-	-	(*)	(*)	(+)	*	*	*
Cedar waxwing		+	**		(-)	**		(-)	(*)		-	-		-	-		(+)	-
Hutton's vireo	-	**	+	(-)	**	(-)	(-)	(**)	-	-	t	-	-	(*)	(-)	(*)	(-)	(-)
Yellow-rumped warbler		(**)	(*)		(-)	(-)		+	-		*	+		-	+		(+)	(+)
Rufous-sided towhee		**	**		-	(-)		-	(-)		-	(-)		**	(-)		-	(-)
Fox sparrow	(-)	**	**	(-)	+	+	-	(**)	(**)	-	-	*	-	(**)	(-)	(-)	(-)	-
Song sparrow		(-)	(-)		(-)	(-)		(-)	-		-	*		(-)	(-)		(-)	-
Golden-crowned sparrow		+	(-)		-	(-)		(-)	**		(-)	-		(-)	*		-	-
Dark-eyed junco	(-)	(-)	-	(-)	-	(-)	-	*	+	(+)	-	(**)	*	+	-	(-)	(-)	(-)
Purple finch		●	*I		**	-		(-)	(-)		(-)	(-)		(-)	*		-	-
Pine siskin		(*)	(-)		-	(-)		+	(-)		-	●		-	(+)		(-)	(-)
Lesser goldfinch		(+)	-		(-)	(-)		*	-		-	-		(-)	-		(-)	-
Evening grosbeak		*	-		●	(-)		*	-		(-)	(-)		-	(-)		(-)	(-)

Table 11. Continued

SHRUB STAGES	1 Foliage volume		2 Litter desposition		3 Pole softwood density		4 Low vegetation patchiness		5 Down wood	
Species	Win. 1982	Win. 1983	Win. 1982	Win. 1983	Win. 1982	Win. 1983	Win. 1982	Win. 1983	Win. 1982	Win. 1983
Band-tailed pigeon	-	(-)	-	-	+	**	(-)	(-)	(-)	*
Steller's jay	**	**	-	(*)	(-)	-	(+)	-	+	-
Scrub jay		*		(**)		+		-		-
Chestnut-backed chickadee	-	+	-	(-)	-	(-)	(+)	-	-	-
Bushtit	-	+	(-)	(-)	-	-	(-)	-	-	-
Winter wren	**	-	*	-	-	(-)	(+)	-	-	(-)
Golden-crowned kinglet	+	-	-	-	+	(-)	(-)	-	-	(-)
Ruby-crowned kinglet	+	-	*	-	-	-	(-)	-	-	(+)
American robin	*	-	-	-	*	(-)	(*)	(-)	(-)	(-)
Varied thrush	+	-	-	(-)	+	-	(-)	-	(-)	-
Wrentit	*	**	-	(-)	-	-	(+)	(*)	+	-
Cedar waxwing	-	-	-	+	(-)	(-)	(-)	-	-	(+)
Fox sparrow	+	-	-	-	(-)	-	(-)	-	-	(-)
Dark-eyed junco	*	-	-	(-)	+	-	(-)	(-)	-	-
Purple finch	*		-		*		(*)		-	
Pine siskin	*	(-)	+	-	-	(-)	(-)	-	-	-
Evening grosbeak	*		-		-		(-)		-	

Table 11. Continued

FOREST STAGES	1 Low foliage volume			2 Large softwoods			3 Small-medium hardwood density			4 Canopy, deciduous foliage volume		
Species	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982
Sharp-shinned hawk			(-)			-			(-)			-
Red-tailed hawk		(-)	-		(+)	**		-	-		-	(-)
Mountain quail	(-)	-	(-)	(*)	(*)	(-)	(-)	(-)	(-)	(-)	(**)	-
Band-tailed pigeon			(-)			(-)			(-)			-
Acorn woodpecker	*	-	+	(-)	-	(-)	(-)	-	-	(-)	-	-
Red-breasted sapsucker	(-)		(-)	(-)	-	(-)	(-)	-	-	(-)	-	-
Downy woodpecker			-			-			(-)			*
Hairy woodpecker	(-)	-	(-)	(-)	(-)	(-)	(-)	-	(+)	(*)	-	-
Northern flicker		-	-		(-)	-		+	(-)		(-)	
Hammond's flycatcher	+			-			-			(-)		
Western flycatcher	-		(-)	*		-	-		-	-		-
Steller's jay	(-)	-	*	-	-	(-)	(-)	-	-	-	-	-
Common raven	(+)		-	-		-	(-)		(-)	(**)		-
Mountain chickadee	(+)	(-)	(-)	(+)	(*)	(*)	-	-	-	(-)	(-)	(-)
Chestnut-backed chickadee	-	(+)	(-)	-	+	-	(-)	(*)	(*)	-	-	(-)
Red-breasted nuthatch	(-)	(-)	(*)	(*)	(-)	-	(+)	(+)	(+)	(-)	(**)	(-)
White-breasted nuthatch		(-)	+		(-)	(+)		(+)	(-)		(**)	(-)
Brown creeper	(-)	(+)	(-)	-	-	+	-	(-)	(-)	-	-	(-)
Winter wren	-	(-)	(-)	*	-	(-)	*	(-)	*	(-)	-	-
Golden-crowned kinglet	(-)	(-)	(+)	-	-	-	-	-	(**)	-	-	-
Hermit thrush	-	**	*	-	(*)	-	-	-	-	(-)	(*)	-
American robin	(-)	(-)	(-)	-	(-)	(-)	(+)	(*)	(-)	-	-	-
Solitary vireo	-	(-)	(-)	**	-	-	(-)	(*)	(**)	*	(**)	-
Hutton's vireo		(*)	(-)		+	-		(-)	(-)		*	(-)
Warbling vireo	(+)	**	(-)	-	(*)	(*)	-	(-)	+	(-)	(-)	(-)
Nashville warbler	(-)			(*)			-			-		
Yellow-rumped warbler	(-)		-	(*)		(-)	(+)		(*)	(-)		(+)
Black-throated gray warbler	(-)	-	-	(*)	(-)	(*)	(-)	-	(-)	(-)	(-)	(-)
Hermit warbler	(-)	-	-	-	-	(-)	(-)	-	(-)	(-)	-	(-)
Wilson's warbler	(-)	-	**	**	(-)	-	+	-	-	(-)	(-)	(-)
Western tanager	(-)	-	(-)	(-)	(-)	-	(+)	*	(-)	+	-	*
Black-headed grosbeak	(-)	**	**	(-)	(*)	(**)	(-)	(-)	(-)	-	(-)	-
Dark-eyed junco	(-)	**	(+)	+	(**)	(-)	(-)	-	(**)	(-)	(-)	(-)
Purple finch	-	-	(-)	(-)	(+)	(**)	(-)	-	(-)	(-)	-	(*)
Red crossbill		**	-		(*)	-		(-)	(-)		(-)	-
Pine siskin	+	-	-	(-)	-	(-)	+	-	(**)	-	(-)	-
Lesser goldfinch		**	-		(**)	(-)		-	(-)		(**)	(-)
Evening grosbeak	(-)			(-)			(+)			(+)		

Table 11. Continued

FOREST STAGES	5 Medium – large softwood density			6 large hardwood density			7 Down wood			8 Large snag density		
Species	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982	Bre. 1982	Sum. 1981	Sum. 1982
Sharp-shinned hawk			(-)			-			-			-
Red-tailed hawk		(+)	+		(-)	-		(-)	-		-	-
Mountain quail	-	-	-	(*)	(-)	-	-	(-)	-	(-)	(**)	(-)
Bend-tailed pigeon			-			*			-			-
Acorn woodpecker	(-)	(-)	(+)	(-)	-	-	(-)	(+)	(*)	(-)	**	(-)
Red-breasted sapsucker	-		(*)	(*)		(+)	(-)		**	(*)		(-)
Downy voodpecker			(-)			(-)			(-)			(-)
Hairy woodpecker	(-)	(*)	(*)	(*)	(-)	-	-	(-)	(-)	(*)	*	-
Northern flicker		+	(-)		(-)	(-)		(-)	(+)		-	-
Hammond's flycatcher	(-)			*			-			(-)		
Western flycatcher	(-)		(-)	**		(-)	(-)		-	*		(-)
Steller's jay	-	(-)	-	(-)	-	(-)	(-)	-	(-)	(-)	-	*
Common raven	-		(-)	(-)		-	(-)		(-)	(-)		-
Mountain chickadee	(+)	(-)	(-)	(+)	(-)	(+)	**	(-)	-	(-)	-	-
Chestnut-backed chickadee	(**)	(-)	(+)	-	-	**	(-)	(-)	(-)	(-)	(-)	(-)
Red-breasted nuthatch	(-)	(-)	(-)	(*)	(*)	-	-	(-)	(-)	(-)	(*)	-
White-breasted nuthatch		-	-		(*)	(-)		(*)	(+)		(*)	-
Brown creeper	(-)	-	(-)	(-)	*	-	*	(-)	(-)	-	(-)	-
Winter wren	-	(-)	(-)	(-)	+	+	-	-	-	-	(-)	(-)
Golden-crowned kinglet	-	-	-	(-)	+	-	-	-	-	-	-	(-)
Hermit thrush	(*)	-	(-)	*	(-)	-	-	-	*	(-)	(-)	-
American robin	(+)	-	(*)	-	**	(-)	(-)	-	(-)	-	(*)	(+)
Solitary vireo	-	-	-	-	(-)	(-)	-	(+)	(-)	-	(+)	(-)
Hutton's vireo		-	-		-	(*)		-	+		(-)	-
Warbling vireo	(**)	-	(-)	+	-	-	(-)	*	+	-	-	(-)
Nashville warbler	(-)			(-)			(**)			(-)		
Yellow-rumped warbler	(-)		(-)	(**)		(-)	*		-	(*)		(-)
Blsck-throated gray warbler	-	(-)	(-)	(-)	-	(-)	-	(*)	(+)	-	(-)	-
Hermit warbler	(-)	-	(+)	+	-	-	-	-	*	-	-	(-)
Wilson's warbler	-	(+)	(-)	(+)	(-)	*	-	(-)	+	-	(-)	-
Western tanager	(-)	-	-	(+)	(-)	(+)	-	(-)	-	-	(-)	(-)
Black-headed grosbeak	(-)	-	-	-	-	(-)	(+)	*	-	(-)	-	-
Dark-eyed junco	(-)	-	-	-	-	-	(-)	-	-	(-)	(-)	(*)
Purple finch	(+)	(-)	-	-	(+)	(+)	-	-	+	(-)	-	(-)
Red crossbill		-	(-)		-	-		*	-		-	(-)
Pine siskin	(*)	(-)	-	(-)	(-)	-	-	(-)	(-)	-	-	(-)
Lesser goldfinch		-	(-)		(-)	(-)		-	(-)		(-)	(-)
Evening grosbeak	(-)			+			(*)			-		

Table 11. Continued

FOREST STAGES	1 Low vegetation volume			2 Large softwood density			3 Diameter Douglas-fir stems			4 Down wood			5 Small-medium hardwood density		
Species	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982
Band-tailed pigeon		(*)	(-)		(-)	(-)		(-)	-		(-)	(-)		+)	*
Northern pygmy owl		-	(-)		(-)	+		**	(-)		(-)	(-)		|+)	(-)
Acorn woodpecker		+	+		(-)	(-)		(-)	(-)		(-)	(-)		-	-
Downy woodpecker		(-)	-		(-)	-		+	(-)		-	(+)		-	(-)
Hairy woodpecker		(-)	(*)		**	(-)		-	(-)		(-)	-		(+)	(*)
Northern flicker	*	*	(-)	(-)	*	-	(*)	-	(-)	**	-	(-)	**	-	-
Pileated woodpecker		-	-		*	(-)		-	-		-	(-)		(-)	(-)
Steller's jay	**	**	-	(-)	-	(-)	(+)	-	(-)	**	-	-	-	-	-
Common raven		-	-		-	-		(-)	(-)		-	(+)		-	+
Chestnut-backed chickadee	(-)	(+)	(-)	**	-	(-)	(-)	+	-	(*)	(-)	-	-	(+)	(**)
Red-breasted nuthatch		-	(**)		(-)	(-)		-	(-)		(-)	-		(-)	(*)
Brown creeper	(**)	(*)	(-)	-	+	-	-	(-)	(-)	(*)	(-)	-	**	(-)	-
Winter wren	(-)	(-)	-	(-)	(-)	*	(-)	(-)	-	-	**	-	**	(*)	-
Golden-crowned kinglet	(-)	(-)	(-)	-	-	+	(+)	(-)	-	+	-	(-)	.	(-)	(-)
Ruby-crowned kinglet		-	+		-	-		(-)	*		-	(-)		(+)	(-)
Hermit thrush		**	**		-	(-)		-	(-)		+	**		-	-
American robin	(-)	**	-	(-)	-	-	-	(+)	(-)	(-)	-	(-)	-	-	(-)
Varied thrush		+	-		*	(-)		(-)	-		-	(-)		(-)	-
Cedar waxwing		*	-		(-)	(-)		(-)	*		**	(-)		(-)	+
Hutton's vireo	(-)	-	-	(-)	**	-	(-)	(-)	-	(-)	(-)	*	(*|	(-)	(*)
Yellow-rumped warbler		-	*		(-)	(-)		-	(+)		*	(*)		(-)	(-)
Dark-eyed junco	(-)	**	*	-	-	-	(-)	(-)	(+)	(-)	**	*	(-	(-)	(-)
Purple finch		(*)	(-)		(-)	(-)		(-)	(-)		-	(-)		(+)	-
Pine siskin	-	(+)	(-)	(*)	-	(-)	(-)	-	(-)	-	-	(-)	(*)	(-)	(-)
Lesser goldfinch		-	-		-	(-)		(-)	(+)		(*)	-		(-)	(-)
Evening grosbeak		(-)	-		(*)	-		(+)	-		(-)	-	|	-	-

Table 11. Continued

FOREST STAGES	6 Canopy cover			7 Snag density			8 large hardwood density			9 Deciduous foliage volume		
Species	Spr. 1982	Fall 1981	Fell 1982	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fall 1981	Fall 1982	Spr. 1982	Fell 1981	Fall 1982
Bsnd-tailed pigeon		(-)	(*)		(-)	(+)		(-)	-		-	(-)
Northern pygmy owl		-	-		(-)	-		(-)	-		(-)	-
Acorn woodpecker		(-)	-		-	+		(-)	(-)		**	**
Downy woodpecker		(-)	-		(-)	(-)		+	-		-	(+)
Hairy woodpecker		(-)	-		-	(-)		(-)	(-)		-	-
Northern flicker	(-)	(+)	-	(**)	(-)	(*)	(-)	(-)	(-)	(-)	-	(-)
Pileated woodpecker		-	*		-	(*)		(-)	-		(*)	(-)
Steller's jay	(+)	(-)	-	(-)	(-)	(-)	(-)	+	(+)	-	*	(*)
Common raven		(+)	(-)		-	(-)		(-)	-		(-)	-
Chestnut-backed chickadee	(-)	(-)	(-)	-	-	(-)	(-)	-	-	(+)	(-)	(-)
Red-breasted nuthatch		-	(-)		(-)	(-)		-	-		-	(*)
Brown creeper	-	(+)	(-)	-	(-)	*	-	-	-	(-)	(-)	(-)
Winter wren	-	-	(-)	(-)	-	-	*	(-)	+	(+)	(*)	-
Golden-crowned kinglet	(-)	-	-	(+)	-	(-)	-	(*)	(-)	(-)	(-)	*
Ruby-crowned kinglet		-	*		-	(+)		(*)	-		(-)	+
Hermit thrush		-	-		-	(-)		(-)	(-)		+	-
American robin	*	-	+	(-)	(-)	(-)	*	(-)	(-)	(-)	-	-
Varied thrueh		-	-		-	-		(*)	-		-	*
Cedar waxwing		(-)	-		(-)	(-)		(-)	*		-	-
Button's vireo	(-)	(-)	-	(-)	*	+	(-)	-	(-)	-	-	-
Yellow-rumped warbler		(-)	(-)		-	(-)		-	-		-	(-)
Dark-eyed junco	-	-	(-)	-	(-)	(*)	(-)	(-)	-	(-)	-	(-)
Purple finch		-	(-)		-	(-)		(-)	-		(-)	+
Pine siskin	(-)	-	(-)	(-)	-	(-)	(-)	(*)	(-)	+	-	(-)
Lesser goldfinch		+	-		(-)	-		(-)	-		-	+
Evening grosbeak		(-)	+		(-)	(+)		(-)	(-)		-	-

Table 1. Continued

FOREST STAGES Species	1 Low vegetation cover Winter 1982	Winter 1983	2 Large softwoods Winter 1982	Winter 1983	3 Large hardwoods Winter 1982	Winter 1983	4 Stand growth rate Winter 1982	Winter 1983	5 Small-medium hardwood density Winter 1982	Winter 1983
Band-tailed pigeon		-		-		(+)		-		-
Acorn woodpecker	+	-	(+)	())	-	-	(-)	(-)	(-)	-
Northern flicker	*	(-)	(+)	-	+	-	(-)	(-)	-	-
Steller's jay	+	-	(-)	(-)	-	-	(-)	-	(*)	-
Common raven	(-)	+	-	(-)	(-)	-	-	(-)	-	(-)
Mountain chickadee	·	(-)		(-)		(-)		-		-
Chestnut-backed chickadee	-	(*)	-	-	(-)	(-)	-	-	(+)	(-)
Red-breasted nuthatch	+	(-)	(-)	-	-	(-)	(-)	-	(+)	(*)
Brown creeper	(-)	(-)	-	-	(-)	(-)	+	-	-	(-)
Winter wren	*	(+)	(+)	*	-	(-)	(-)	-	(-)	-
Golden-crowned kinglet	(+)	-	+	(-)	(-)	-	-	(-)	(-)	(-)
Ruby-crowned kinglet	-	+	(-)	(-)	+	*	-	(*)	(*	(-)
American robin	**	(-)	(*)	-	-	(-)	-	-	(-)	-
Varied thrush	(-)	-	(-)	-	-	*	(-)	(*)	(-	-
Cedar waxwing		(+)		-		(-)		-		+
Hutton's vireo	(+)	(-)	-	-	(-)	(-)	-	-	-	(-)
Pine siskin	-	-	(-)	())	-	-	(-)	-	(+	(-)
Evening grosbeak	+	-	(-)	())	-	(-)	(-)	-	(**	-

Table 11. Continued

FOREST STAGES	6 Diameter Douglas-fir stems		7 Down wood		8 Snag density		9 Medium softwood density		10 Large snag density	
Species	Winter 1982	Winter 1983	Winter 1982	Winter 1983	Winter 1982	Winter 1983	Winter 1982	Winter 1983	Winter 1982	Winter 1983
Band-tailed pigeon		-		-		*		-		-
Acorn woodpecker	(-)	(-)	(-)	(-)	(-)	-	(-)	(-)	(-)	(-)
Northern flicker	(-)	-	(-)	-	(-)	(-)	(-)	(-)	(-)	-
Steller's jay	(-)	(-)	(-)	-	(+)	-	(-)	(-)	(-)	(-)
Common raven	(-)	(-)	(-)	(-)	(-)	-	(-)	(-)	(-)	-
Mountain chickadee		-		-		+		-		-
Cheatnut-backed chickadee	-	+	-	+	-	-	-	+	-	+
Red-breasted nuthatch	(-)	-	(-)	-	(+)	(-)	(-)	-	(-)	-
Brown creepe	-	-	-	-	+	-	-	-	+	-
Winter wren	(+)	-	(-)	+	*	(-)	(-)	-	(-)	-
Golden-crowned kinglet		(-)	*	(-)	-	(-)	-	(-)	*	(-)
Ruby-crowned kinglet	(-)	(*)	(-)	(*)	-	(-)	(-)	(*)	(-)	(*)
American robin	(-)	-	(+)	-	(-)	-	(+)	-	(-)	-
Varied thrush	-	(*)	(-)	-	(-)	-	(-)	(*)	(-)	(*)
Cedar waxwing		-		-		-		-		t
Hutton's vireo	-	-	-	-	(-)	(-)	-	(-)	-	-
Purple finch	(-)	(-)	(+)	(-)	(+)	-	(-)	(-)	(+)	(-)
Evening grosbeak	(-)	-	(-)	-	(-)	(-)	(-)	-	(-)	-

** $P < 0.01$
* $P < 0.05$
+ $0.05 < P < 0.10$
- $P > 0.10$
blank Species absent or insufficient number of detections for estimation of density.
( ) Negative correlation

Table 12. Results of stepwise multiple linear regression of estimated bird densities (n/40.5 he) on vegetation and habitat variables, from breeding and winter 1982 seasons in shrub and forested stages of young-growth Douglas-fir. northwestern California. Bird densities were first transformed (log[x+1]). All equations are significant (F tests, $P \leq 0.05$). Mnemonics of habitat variables are described in Appendix 2.

Season, Year Successional stages	Adjusted R^2	Prediction error\a
BREEDING 1982		
SHRUB STAGES		
Acorn woodpecker = 0.075 + 0.00003(FVOLLO) + 0.003(SOILOCC) - 0.0001(DENHW1) + 0.094(BASW2) - 0.003(LITTOCC)	0.55	0.076
American robin = 0.023 + 0.0005(FVOLDLO)	0.09	0.220
Anna's hummingbird = -1.286 + 0.045(NOSPP10) - 0.0002(FVOLELO) + 0.133(VEGHT) + 0.029(LITTCOV)	0.50	0.748
Bewick's wren = 0.768 + 0.084(NOSPP2M) - 0.023(LITTCOV) + 0.0001(FVOLDLO) + 0.312(BASW2) - 0.00005(FOLHIGH)	0.51	0.301
Black-headed grosbeak = 0.203 + 0.085(VEGHT) + 0.001(FVOLDTO)	0.49	0.419
Black-throated gray warbler = -0.031 + 0.010(NOSPP2M) + 0.287(BASW1) - 0.107(BAHW1)	0.43	0.398
Bushtit = 0.454 + 0.260(LITTDEP) - 0.025(LITTCOV) + 0.023(DENHW3)	0.36	0.547
Calliope hummingbird = -0.401 + 0.023(NOSPP10)	0.10	0.615
Chestnut-backed chickadee = 0.258 + 0.006(DENSW2)	0.10	0.393
Chipping sparrow = -0.350 + 0.066(LITTDEP) + 0.012(NOSPP10)	0.25	0.306
Dark-eyed junco = 1.758 - 0.0001(FVOLETOT) + 0.297(BASW2) + 0.002(WOODMASS)	0.34	0.382
Dusky flycatcher = 0.293 + 0.0001(FVOLELO)	0.34	0.596
Fox sparrow = -0.445 + 0.022(GRNCOV) + 0.002(DENSW1) - 0.896(BASW1) - 0.091(DENHW3)	0.21	0.542
Hermit thrush = 0.081 + 0.00005(FOLTOTAL) + 0.016(CANCOV) + 0.113(BAHW1) - 0.013(LITTOCC) - 0.175(BASW2)	0.75	0.258
Hermit warbler = 0.182 + 0.205(BASW1) - 0.002(DENHW2)	0.31	0.200
House wren = 1.753 - 0.0002(FVOLELO)	0.34	0.655
Lazuli bunting = 0.253 - 0.087(VEGHT) + 0.013(SOILOCC)	0.54	0.379
Lesser goldfinch = 0.623 - 0.015(SOILCOV)	0.15	0.378
MacGillivray's warbler = 0.348 + 0.128(NOSPP2M) + 0.0001(FVOLDLO)	0.45	0.528
Mountain quail = 0.036 + 0.0001(FVOLLO) - 0.075(BAHW1)	0.41	0.285
Nashville warbler = 1.867 + 0.120(NOSPP2M) - 0.016(SOILOCC)	0.57	0.444
Northern flicker = -0.197 + 0.041(NOSPP2M) - 0.0001(DENHW1) + 0.008(GRNCOV)	0.29	0.218
Olive-sided flycatcher = -0.426 + 0.131(BAHW3) + 0.015(CANCOV) - 0.065(LITTDEP)	0.26	0.262
Orange-crowned warbler = -0.189 + 0.00008(FOLTOTAL) - 0.0003(DENSW1)	0.50	0.468
Pine siskin = 0.407 + 0.178(BASW1)	0.07	0.398
Purple finch = -0.295 + 0.022(GRNCOV) + 0.0002(FVOLELO) - 0.0001(FOLTOTAL)	0.31	0.553
Red-breasted sapsucker = -0.171 + 0.098(LITTDEP) + 0.022(DENHW3) - 0.202(BAHW1) + 0.318(BAHW2)	0.45	0.239
Rufous-sided towhee = 0.189 + 0.152(NOSPP2M) - 0.019(SOILCOV) + 0.017(GRNCOV)	0.70	0.403
Scrub jay = 0.184 + 0.158(BASW2) - 0.0001(DENHW1) + 0.030(NOSPP2M) - 0.008(NOSPP10)	0.47	0.135

Table 12. Continued

Song sparrow = -0.225 + 0.012(GRNCOV) - 0.088(LITTDEP) + 0.094(NOSPP2M) - 0.00005(FVOLLO) + 0.002(WOODMASS)	0.44	0.252
Solitary vireo = -0.410 + 0.100(VEGHT) + 0.004(DENHW2) - 0.00005(FOLHIGH)	0.48	0.221
Steller's jay = 0.231 + 0.115(VEGHT) - 0.0001(FVOLLO)	0.35	0.298
Warbling vireo = 0.731 + 0.213(BAHW1) + 0.0001(FVOLDTOT)	0.45	0.402
Western bluebird = 3.556 - 0.027(LITTOCC) - 0.015(GRNCOV) - 0.020(NOSPP10) - 0.0001(DENHW1)	0.52	0.334
Western flycatcher = 0.378 - 0.023(NOSPP2M) - 0.007(GRNCOV)	0.24	0.162
Western tanager = -0.373 + 0.068(VEGHT) - 0.141(BAHW1) + 0.011(NOSPP10) + 0.198(BAHW2)	0.53	0.230
Western mood pewee = -0.307 + 0.022(SOILCOV) + 0.002(WOODMASS)	0.44	0.250
Wilson's warbler = -0.980 + 0.0001(FVOLLO) + 0.144(LITTDEP) + 0.019(GRNCOV)	0.58	0.500
Wrentit = -0.051 + 0.0001(FVOLELO) - 0.0001(FVOLDTO) + 0.111(NOSPP2M)	0.53	0.472
Yellow-rumped warbler = 2.112 - 0.029(CANCOV)	0.16	0.552
FOREST STAGES		
Acorn woodpecker = -0.344 + 0.115(NOSPP2M)	0.14	0.443
American robin = 0.0134 + 0.020(MOSSOCC) - 0.011(CBASW40) + 0.019(GRNCOV)	0.55	0.275
Black-throated gray warbler = 0.178 + 0.101(BASW1)	0.32	0.350
Bleck-headed grosbeak = 1.101 - 0.012(CDENSN40) + 0.010(CBASW40)	0.24	0.286
Brown creeper = 3.066 - 0.0092(DENHW3) - 0.051(BAHW5) - 0.273(NOSPP2M) - 0.0003(DENSW1) + 0.0008(DENHW1)	0.66	0.341
Chestnut-backed chickadee = 1.546 - 0.0073(DENSW3) + 0.0003(FVOLELO) + 0.025(BASW2) + 0.0099(DENHW4) - 0.0009(DENHW2)	0.78	0.200
Common raven = 3.131 - 0.055(CANCOV) + 0.0021(CDSW40) + 0.0006(DENHW2)	0.60	0.107
Dark-eyed junco = 2.728 - 0.0083(WOODMASS) - 0.147(NOSPP2M) - 0.0035(DENHW3) - 0.222(BAHW5) + 0.079(DENHW5)	0.71	0.273
Evening grosbeak = -1.780 + 0.019(SOILCOV) + 0.0003(FVOLDLO) + 0.0026(CDHW40) + 0.022(LITTCOV) + 0.0001(FVOLELO)	0.58	0.135
Golden-crowned kinglet = -0.253 + 0.0097(CBASW40) + 0.0035(DENHW2) - 0.062(BAHW3)	0.55	0.356
Hammond's flycatcher = 1.852 - 0.0017(DENSW2) - 0.029(MOSSOCC) - 0.0061(DENSW3) - 0.0009(FVOLDLO) + 0.014(DENHW5)	0.62	0.337
Hairy woodpecker = -0.853 + 0.162(LITTDEP) + 0.026(NOSPP10)	0.32	0.390
Hermit thrush = -0.013 + 0.609(BAHW4) - 0.081(DENHW4) - 0.006(DENSW5) + 0.0083(MEANDBH) - 0.0008(DENSW3)	0.65	0.208
Hermit warbler = 1.641 + 0.010(SOILOCC) + 0.002(CDENSW40) + 0.000002(FVOLETOT) - 0.013(GRNCOV)	0.42	0.190
Mountain chickadee = -1.417 + 0.216(LITTDEP) + 0.0043(WOODMASS) + 0.0077(GRNOCC)	0.71	0.253
Mountain quail = -0.168 + 0.062(LITTDEP)	0.23	0.177
Nashville warbler = 3.554 + 0.045(LITTCOV) + 0.440(BAHW1) + 0.0003(DENSW1) + 0.0139(VEGHT)	0.69	0.299
Pine siskin = 0.501 - 0.044(BASW4) + 0.001(DENHW1) + 0.021(DENSN2)	0.42	0.382
Red-breasted nuthatch = 0.603 + 0.0002(DENSW1)	0.19	0.335
Red-breasted sapsucker = 5.541 - 0.016(MOSSOCC) - 0.080(CANCOV)	0.32	0.468
Solitary vireo = 0.999 + 0.007(DENSW5) - 0.002(DENHW2)	0.39	0.375
Steller's jay = 3.141 - 0.023(LITTCOV) - 0.059(NOSPP2M) - 0.002(CDENSW40)	0.44	0.188
Warbling vireo = -0.319 + 0.0076(CDHW40) + 0.033(BAHW2) + 0.020(BASW1) + 0.0003(FVOLDLO) - 0.0005(DENSW1)	0.81	0.146

Table 12. Continued

Western flycatcher = -6.465 - 0.177(LITTDEP) + 0.128(CANCOV) + 0.020(SOILOCC) 0.013(VEGHT)	0.70	0.309
Western tanager = 1.251 - 0.003(CDENHW40)	0.12	0.309
Wilson's warbler = -1.564 + 0.015(CBASN40) - 0.0018(DENSN1) + 0.027(LITTCOV)	0.55	0.273
Winter wren = -0.132 + 0.013(CBASN40) + 0.0010(DENHW1)	0.92	0.143
Yellow-rumped warbler = 0.433 + 0.0003(DENSW1) - 0.00004(FVOLDTOT)	0.46	0.377
WINTER 1982		
SHRUB STAGES		
American robin = 4.912 + 0.163(NOSPP2M) - 0.021(DENHW2) - 0.020(SOILOCC)	0.83	0.422
Band-tailed pigeon = 0,072 + 1.119(BASW1) - 0.002(DENSW1)	0.61	0.226
Bushtit = -1.551 + 0.353(VEGHT) - 0.0002(FVOLELO) + 0.017(SOILOCC)	0.32	0.404
Chestnut-backed chickadee = 0.274 + 0.240(LITTDEP) - 0.010(DENHW2) - 0.027(NOSPP10)	0.62	0.341
Cedar waxwing = 0.027 + 0.0007(DENHW1) - 0.486(BAHW1)	0.74	0.169
Dark-eyed junco = -0.789 + 0.091(NOSPP2M)	0.42	0.401
Evening grosbeak = -0.329 + 0.252(VEGHT) - 0.0002(FVOLELO) + 0.0006(DENSW1)	0.77	0.210
Fox sparrow = 0.754 + 0.150(NOSPP2M) - 0.035(NOSPP10)	0.46	0.518
Golden-crowned kinglet = 0.605 + 0.206(LITTDEP)	0.27	0.733
Pine siskin = 0.280 + 0.107(NOSPP2M)	0.54	0.378
Purple finch = -0.162 + 0.094(LITTDEP)	0.55	0.194
Ruby-crowned kinglet = 0.532 + 0.125(NOSPP2M) - 0.026(GRNCOV) + 0.011(DENHW2)	0.81	0.246
Steller's jay = -0.332 + 0.239(VEGHT) - 0.0001(FVOLETO) + 0.0002(DENHW1)	0.88	0.195
Varied thrush = -0.177 + 0.102(LITTDEP)	0.28	0.354
Winter wren = 1.233 + 0.113(NOSPP2M)	0.48	0.438
Wrentit = -0.136 + 0.079(VEGHT)	0.43	0.312
FOREST STAGES		
Acorn woodpecker = 0.150 - 0.0016(CDSW40) + 0.056(NOSPP2M) + 0.0085(BAHW5) - 0.0066(MOSSOCC)	0.70	0.128
American robin = 0.292 + 0.0002(FVOLELO) - 0.004(DENSW5)	0.41	0.256
Common raven = 0.058 + 0.050(BASW1)	0.32	0.140
Evening grosbeak = 1.836 + 0.0003(DENSW1) - 0.225(LITTDEP) - 0.016(MOSSOCC)	0.42	0.325
Northern flicker = -0.458 + 0.021(NOSPP10) + 0.011(BAHW5) - 0.021(BASW4) + 0.0017(CDSW40) + 0.0038(SOILOCC)	0.79	0.065
Golden-crowned kinglet = 2.784 - 0.0068(CBASN40) + 0.0058(MEANDBH) - 0.085(LITTDEP)	0.64	0.121
Hutton's vireo = -0.092 + 0.0012(DENHW1) + 0.074(BASW3) - 0.0003(FVOLELO) + 0.0040(CDHW40)	0.76	0.182
Pine siskin = 8.832 - 0.140(CANCOV) - 0.040(SOILCOV) + 0.236(BAHW1) -0.0002(FVOLELO)	0.43	0.232
Red-breasted nuthatch = 4.878 - 0.016(MOSSOCC) - 0.057(LITTCOV) - 0.0079(CBAHW40)	0.73	0.172
Ruby-crowned kinglet = -5.623 + 0.031(DENSN2) + 0.094(SOILCOV) + 0.096(CANCOV)	0.49	0.403
Steller's jay = 0.114 + 0.0002(FVOLELO) + 0.0002(DENSW1)	0.43	0.290
Varied thrush = 0.372 - 0.0042(DENSW5) + 0.0021(CDHW40) - 0.093(BAHW1)	0.53	0.154
Winter wren = 1.186 - 0.005(DENHW3)	0.22	0.520
Wrentit = -0.063 + 0.008(CDENSW40)	0.21	0.680

\a Values given are standard errors of predicted (estimated) densities (SEE), based on the transformed density estimates. SEE values were computed as:

$$SEE = \frac{SSres}{n - 2}$$

where SSres = sums of squares of residuals, and n = number of bird count points from which individual estimates of bird densities were calculated, for a given season, year, and set of successional stages (see Table 3) (Draper and Smith 1981). Small prediction errors mean that density of a given bird species was tightly associated with the given habitat variables, whereas large prediction errors suggest a loose association.

Table 13. Results of analysis designed to discern effects on bird species densities from topophysiagraphic variables, once vegetation and habitat variables are taken into account(see text for explanation of analysis), in young-growth Douglas-fir. northwestern California.

	Shrub stages		Forested stages	
	Breeding 1982	Winter 1982	Breeding 1982	Winter 1982
Total no. bird species tested	36	16	29	15
No. species with significant partial correlation with topophysiographic variables	14(39%)	4(25%)	8(28%)	2(13%)
Mean adjusted R^2 of regressions\a	0.18	0.37	0.30	0.25
Topophysiographic variables\b (no. times entered into equations)				
SLOPE (percent slope)	5	0	3	1
DISWAT (distance to nearest permanent water)	4	1	1	1
DISHAB (distance to nearest similar habitat)	3	3	0	0
TOPO (slope position)	2	0	4	0
AREA (study stand size)	1	0	1	0
NOEDGES (no. adjacent stands)	1	0	0	0

a\ Proportion of variation in species densities that was not accounted for by on-site vegetation and habitat variables, that is explained by topophysiagraphic variables.

b\ See Appendix 2.

Table 14. Classification of migration status of bird species observed in stands of young-growth Douglas-fir, northwestern California.

Migration class	Code	No. spp.\b	Percent of total	Seasons present\a Sp	B	Su	F	W
Elevational migrants								
Downslope movement, winter								
Breed at studied elev.. move lower in winter . . .	El	2	3	X	X	X	X	
Breed at higher elev., move into area during winter	E2	2	3	X			X	X
Upslope movement, **post-**breeding								
Breed in bottomlands, move upslape during past-breeding.	E3	1	1			X	X	
Latitudinal migrants								
Displacement migrants	L1	6	8	X	X	X	X	Y
Neotropical migrants and lower-latitude nearctic migrants	L2	25	34		X	X	X	
High latitude **nearctic** migrants	L3	4	5				X	X
Permanent residents	PR	32	44	X	X	X	X	X
Nomads.	NOM	1	1	----		any	-----	
	Predicted no. spp. per **season:\c**			45	69	70	73	47
	Total no. spp. observed:							
			1981:			68	65	
			1982:	39	71	71	72	42
			1983:	(21)\d				41

\a Seasons: Sp = spring, B = breeding. Su = summer (post-breeding dispersal), F = fall. W = winter.
\b Excluding rarely observed species (< 5 observations per season).
\c Based on total list of all species observed in field surveys.
\d Spring 1983: only **grass/forb** plots surveyed (n = 6 plots).

Table 15. Euclidean distance measures of bird assemblages based on site-specific species densities, by season and successional stage of young-growth Douglas-fir, northwestern California (G = grass/forb, E = early shrub/sapling, L = late shrub/sapling, P = pole, S = medium savtimber). Lover values denote greater similarity of bird assemblages between stages, higher values denote greater dissimilarity.

Season	Stage	G	E	L	P
Summer 1981	E	.066			
	L	.087	.012		
	P	.287	.256	.259	
	S	.457	.422	.425	.029
Fall 1981	E	.186			
	L	.130	.037		
	P	.449	.281	.253	
	S	.379	.247	.216	.051
Winter 1982	E	--			
	L	.154	--		
	P	.391	--	.329	
	S	.396	--	.352	.002
Spring 1982	E	.225			
	L	.712	.462		
	P	.479	.272	.619	
	S	.584	.393	.662	.080
Breeding 1982	E	.188			
	L	.220	.024		
	P	.256	.159	.154	
	S	.251	.170	.166	,009
Summer 1982	E	.110			
	L	.151	.014		
	P	.228	.120	.115	
	S	.350	.177	.157	.029
Fall 1982	E	.067			
	L	.044	.008		
	P	.286	.262	.238	
	S	.256	.227	.200	.012
Winter 1983	E	.348			
	L	.415	.080		
	P	.913	.373	.428	
	S	.882	.312	.396	.033

Table 16. Potential immediate impacts (first 2-3 yrs) on selected characteristics of Douglas-fir stand structure of main methods of site preparation and release conducted during intensive timber management, following clearcut final harvest. Impacts are coded as positive (+), negative (-), or none (0), and compare characteristics before and after activities.

	Site preparation				Release	
Stand structure characteristics	Mechanical (scarification)	Drown-and-burn	Broadcast burn	Pile-and-burn	Manual	Chemical (herbicides)
Hardwood, deciduous trees						
-Average diameter	-	-	-	0,-	0,-	0,-
-Total stem density	-	-	-	0,-	0,-	0,-
-Total stem basal area	-	-	-	0,-	0,-	0,-
-Size, age distribution	-	-	-	0,-	0,-	0,-
Foliage volume (all species)						
-Total foliage volume	-			0,-	-	-
-Vertical profile (foliage height diversity)	-			0,-	-	-
-Percent deciduous and broad-leaf	-			0,-	-	-
Canopy foliage (trees only)						
-Percent closure	-	-	-	0,-	-	-
-Patchiness	-	-	-	0,-	+	+
Shrub cover						
-Total foliage volume	-	-	-	0,-	-	-
-Height	-	-	-	0,-	-	-
-Patchiness	-	+	+	0,+	-?	+?
No. plant species						
-Trees, shrubs	-	-	-	0,-	-	0,-
-Grass, forbs	-\a	-\a	-\a	0,-	-	0
Snags						
-Mean diameter, density, basal area	-	-	0,-	0,-	0,-	0,-
Down wood						
-Mass/Volume	-	-	-	-	0	0
-Spatial distribution	-	0	0	-	0	0
-Mean diameter	-	0,+	0,+	0,-	0	0

\a Immediate effect; + after 1-2 years (Morrison 1970, Dyrness 1973, Stewart 1978).

Table 17. Potential immediate impacts (first 2-3 yrs) on selected characteristics of Douglas-fir stand structure from intermediate treatments and final harvest (clearcutting) conducted during intensive timber management. Impacts are coded as positive (+), negative (-), or none (0), and compare characteristics before and after activities.

Stand structure characteristic	Pre-commercial thinning	Method of commercial thinning: Low	Crown	Selection	Mechanical	Fuelwood, salvage cutting	Final harvest (clearcutting)
Softwood trees							
-Average diameter	0,+	+	-	-	0	-,0,+	-
-Total stem density	-	-	-	-	-	0,-	-
-Total stem basal area	-	-	-	-	-	0,-	-
-Size, age distribution	0,-	-	?	-	0	-,0,+	-
Hardwood, deciduous trees							
-Average diameter	0	0	0	0	0	0,-	-
-Total stem density	0	0	0	0	0	0,-	-
-Total stem basal area	0	0	0	0	0	0,-	-
-Size, age distribution	0	0	0	0	0	0,-	-
Foliage volume (all species)							
-Total foliage volume	-	-	-	-	-	0,-	-
-Vertical profile (foliage height diversity)	0,+?	-	+	-	0	0,+?	-
-Percent deciduous and broad-leaf	0,+	0,+	0,+	0,+	0,+	0,-	-
Canopy foliage (trees only)							
-Percent closure	-	0	-	-	-	0,-	-
-Patchiness	+	0	+	-?	0,+	0,+	-
Shrub cover							
-Total foliage volume	0	0	0	0	0	0,-	+
-Height	0	0	0	0	0	0	+
-Patchiness	+	0	0	0	0	0,+	-
No. plant species							
-Tree,shrub,grass,forb	0	0	0	0	0	0	+
Snags							
-Mean diameter, total density, total basal area	0	0	0	0	0		-
Down wood							
-Mass, volume, spatial distribution, mean diameter	0	0	0	0	0	-	+

Figure 1. Location of young-growth Douglas-fir study sites, northwestern California. 1 = Grass/forb, 2 = Early shrub/sapling, 3 = Late shrub/sapling, 4 = Pole, 5 = Medium sawtimber. Township and range locations are based on Humboldt Base Line Meridian.

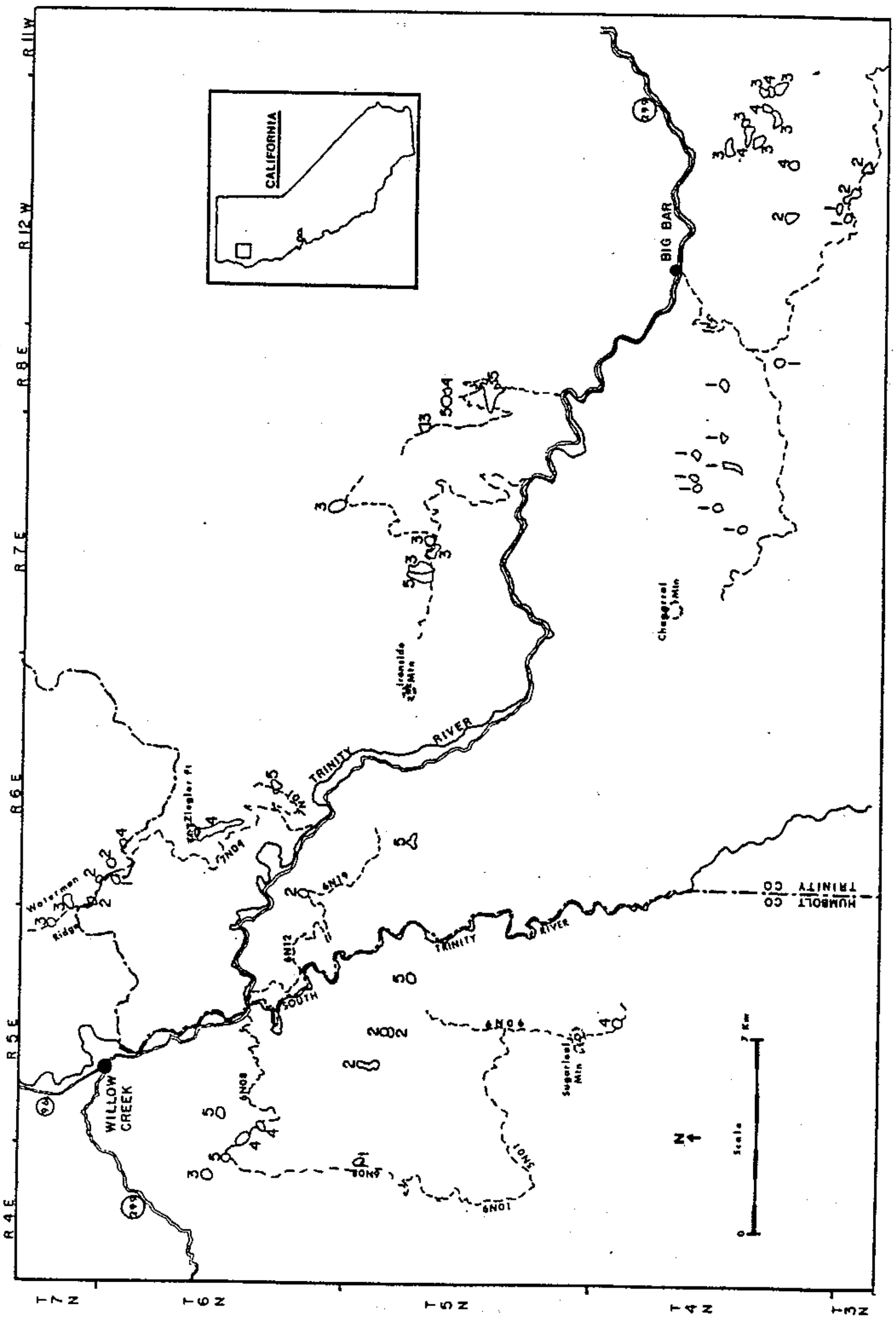

CALIFORNIA
BIG BAR
WILLOW CREEK
TRINITY RIVER
SOUTH TRINITY RIVER
HUMBOLT CO
TRINITY CO
Waterman Ridge
Ironside Mtn
Chaparral Mtn
Sugarloaf Mtn
R 11 W
R 12 W
R 8 E
R 7 E
R 6 E
R 5 E
R 4 E
T 7 N
T 6 N
T 5 N
T 4 N
T 3 N
Scale

Figure 1.

Figure 2. Monthly average precipitation and minima and maxima temperatures, Willow Creek, northwestern California. Thirty-nine year 75 % tolerance interval of monthly precipitation is shown as shaded region. Data from Lower Trinity Ranger District office, Six Rivers National Forest.

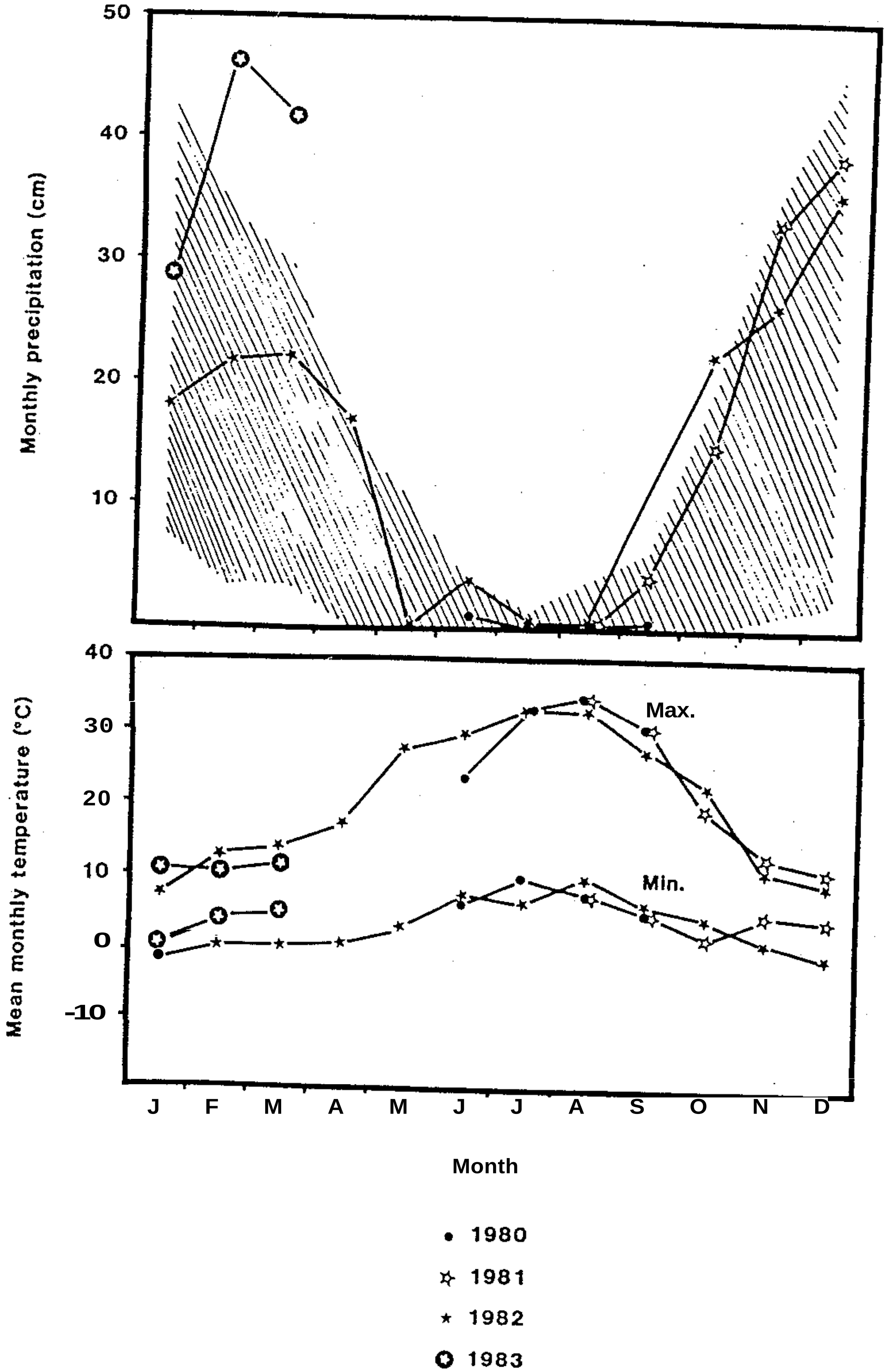

50
40
30
20
10
Monthly precipitation (cm)
40
30
20
10
0
-10
Mean monthly temperature (°C)
Max.
Min.
J
F
M
A
M
J
J
A
S
O
N
D
Month
1980
1981
1982
1983

Figure 2.

Figure **3.** Vegetation sampling design at bird count points, northwestern California.

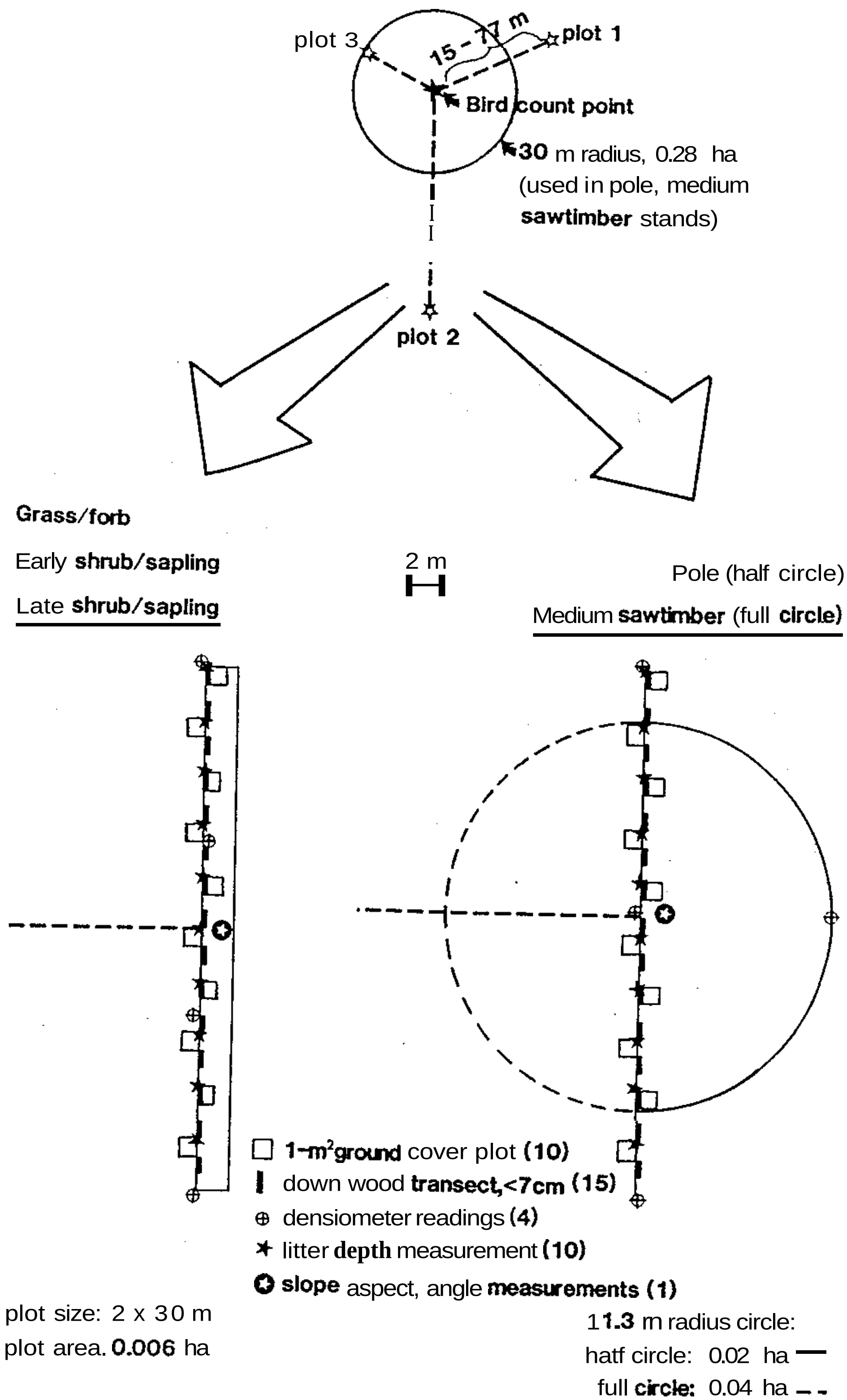
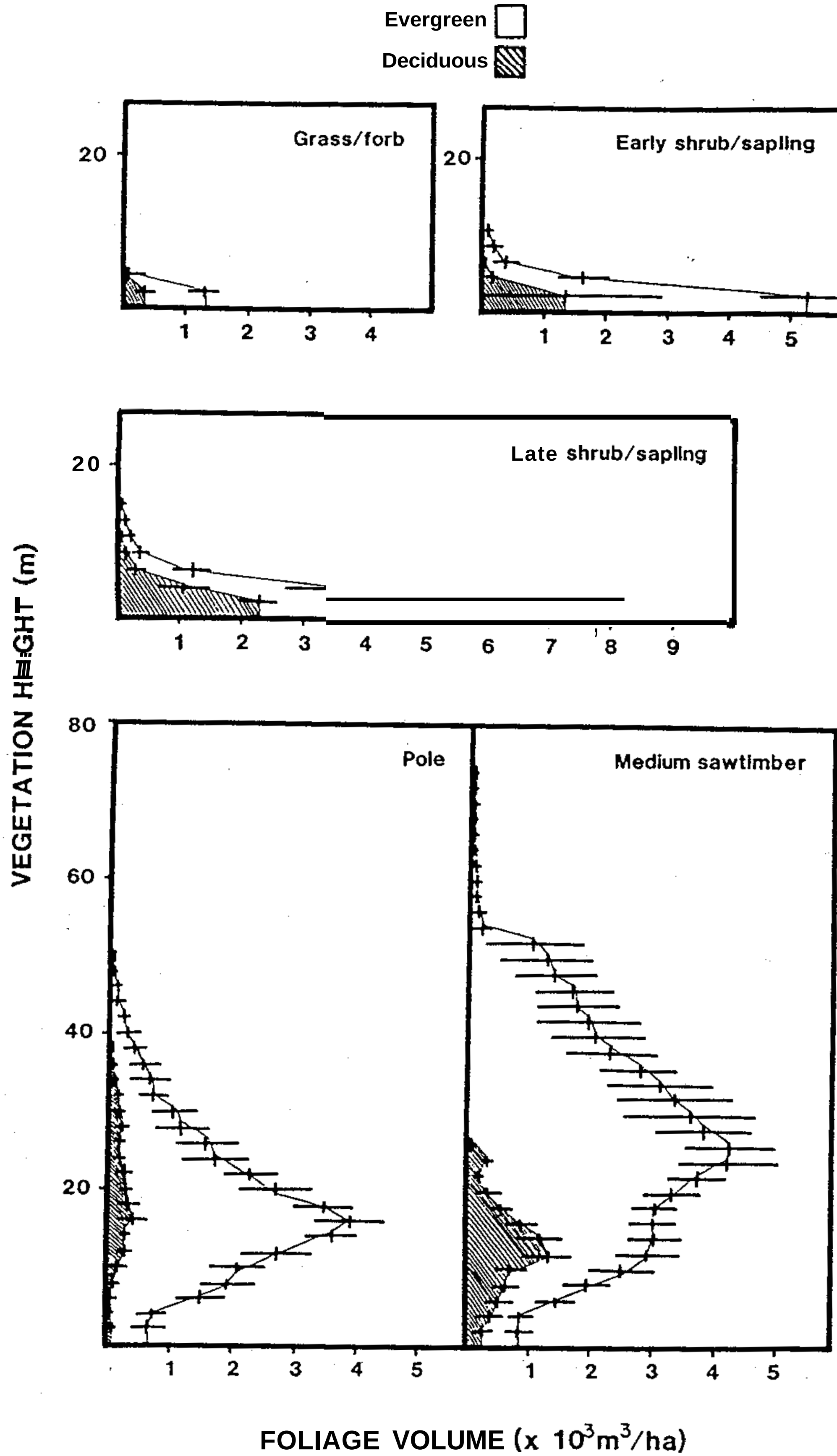

plot 3
15 - 17 m
plot 1
Bird count point
30 m radius, 0.28 ha
(used in pole, medium
sawtimber stands)
plot 2
Grass/forb
Early shrub/sapling
Late shrub/sapling
2 m
Pole (half circle)
Medium sawtimber (full circle)
1-m² ground cover plot (10)
down wood transect, <7cm (15)
densiometer readings (4)
litter depth measurement (10)
slope aspect, angle measurements (1)
plot size: 2 x 30 m
plot area. 0.006 ha
11.3 m radius circle:
hatf circle: 0.02 ha
full circle: 0.04 ha

Figure 3.

Figure 4. Foliage volume as a function of 2-m height intervals across successional stages of young-growth Douglas-fir, northwestern California. Vertical bars denote mean values and horizontal bars denote one standard error. See Table 2 for stand sample sizes.



Evergreen
Deciduous
Grass/forb
Early shrub/sapling
Late shrub/sapling
Pole
Medium sawtimber
VEGETATION HEIGHT (m)
FOLIAGE VOLUME (x 10³m³/ha)

Figure 4.

Figure 5. Patchiness of overstory and understory foliage, expressed as coefficient of variation (CV) of densiometer readings of percent canopy closure, by successional stage of young-growth Douglas-fir, northwestern California. Horizontal bars denote mean values, vertical bars denote one standard error.

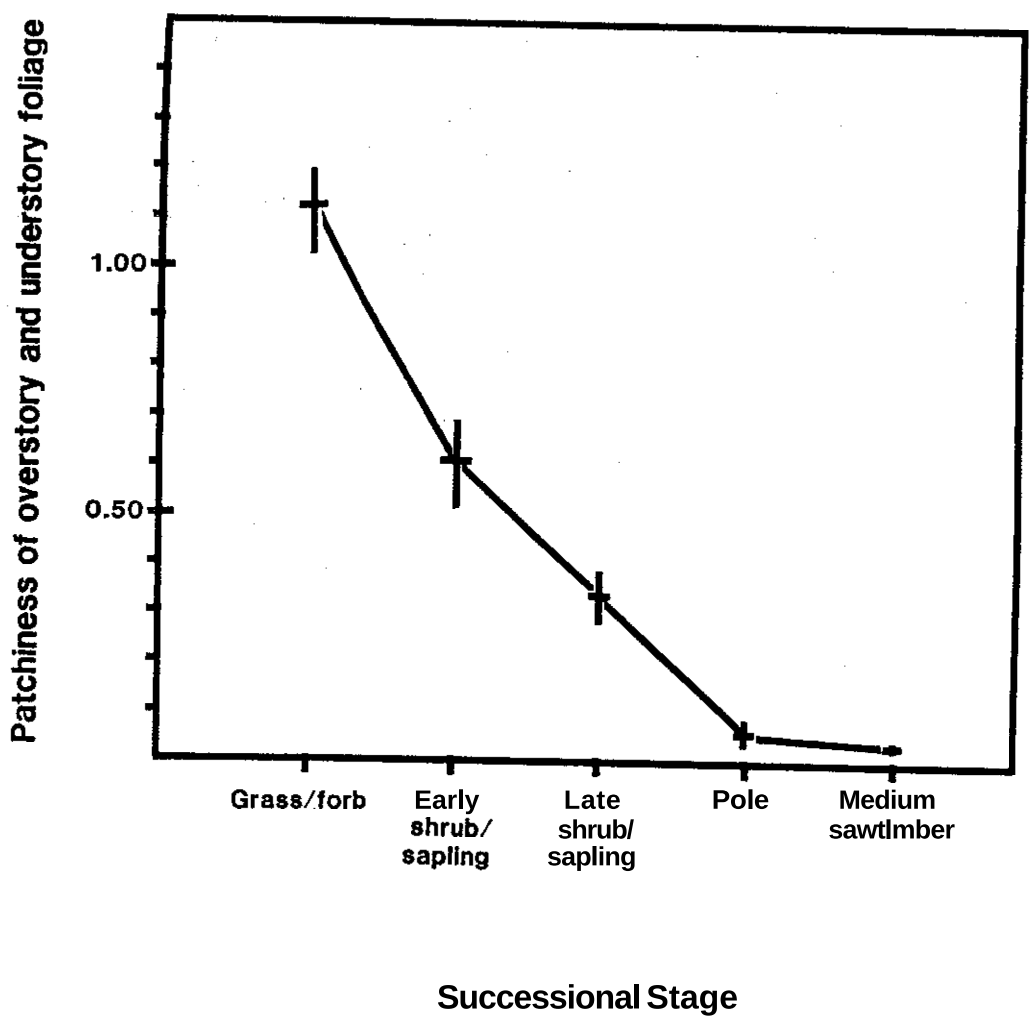
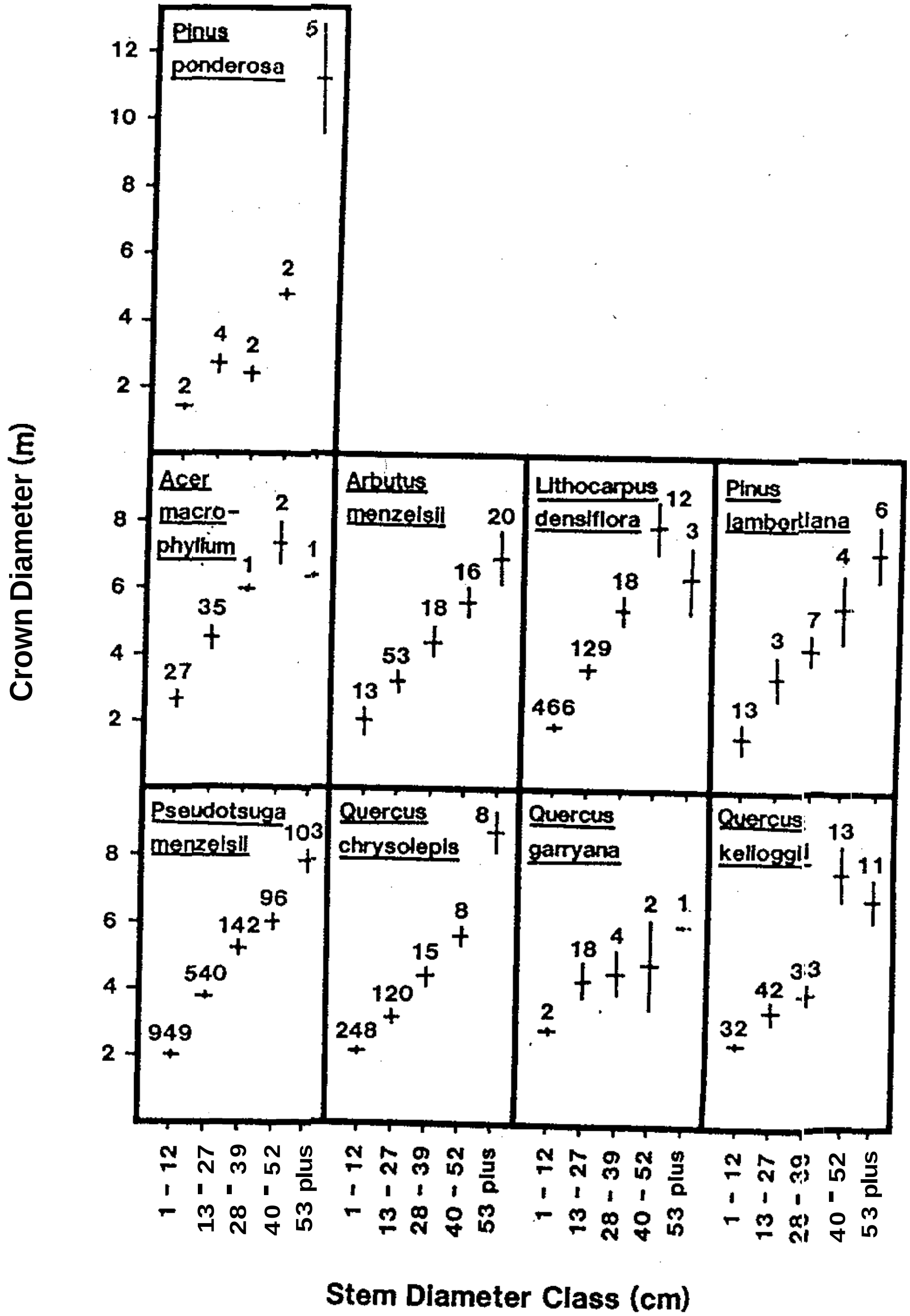

Patchiness of overstory and understory foliage
1.00
0.50
Grass/forb
Early shrub/ sapling
Late shrub/ sapling
Pole
Medium sawtlmber
Successional Stage

Figure 5.

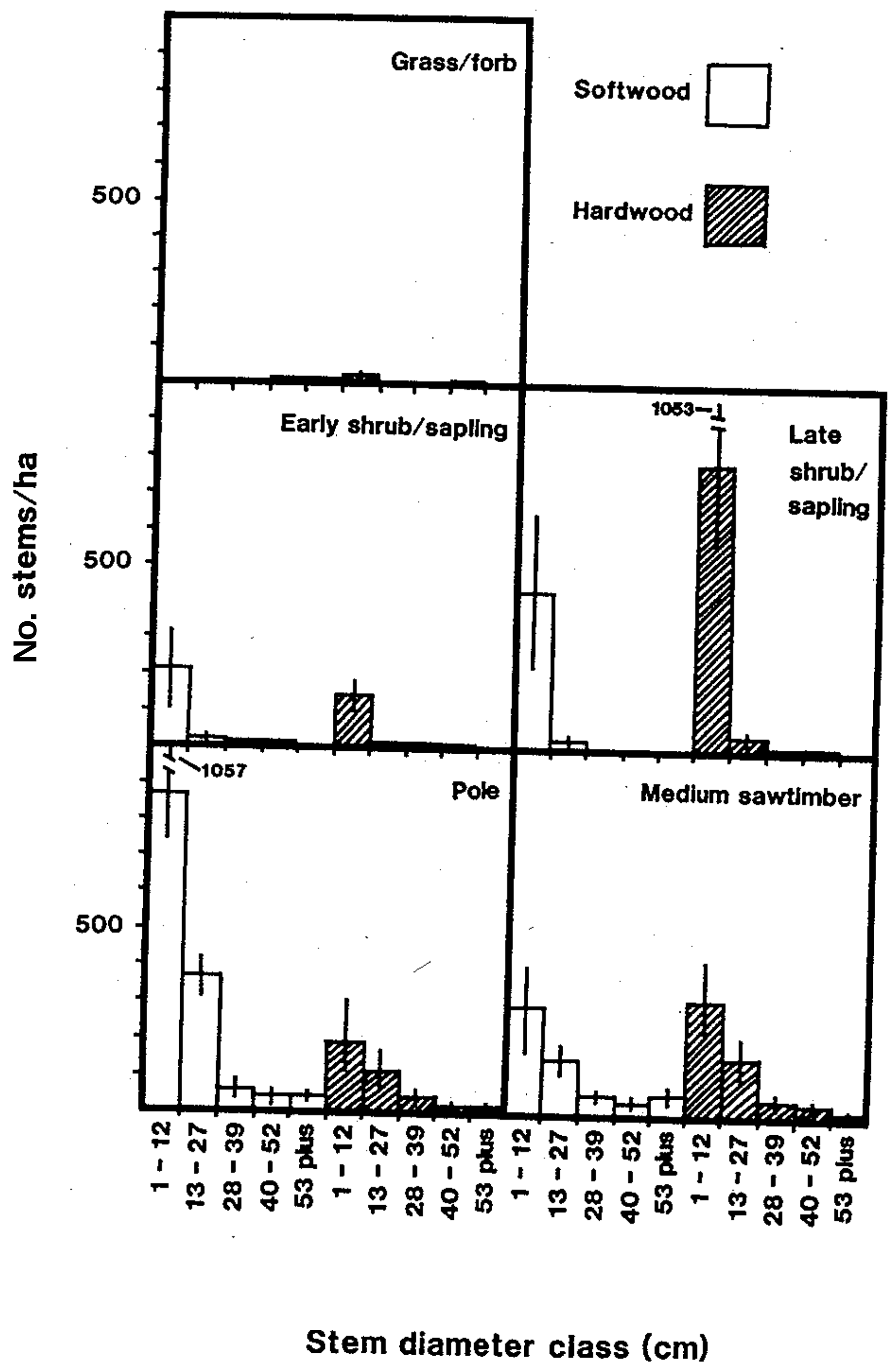
Figure 6. Crown diameters of 9 overstory tree species by diameter at breast height (dbh) class, from Douglas-fir pole and medium sawtimber stands combined, northwestern California. Horizontal lines denote mean values, vertical lines denote one standard deviation, and integers are number of trees measured. A total of 3,249 tree crowns were measured.



Crown Diameter (m)
Pinus ponderosa
Acer macro-phyllum
Arbutus menzeisii
Lithocarpus densiflora
Pinus lambertiana
Pseudotsuga menzeisii
Quercus chrysolepis
Quercus garryana
Quercus kelloggii
Stem Diameter Class (cm)
1 - 12
13 - 27
28 - 39
40 - 52
53 plus

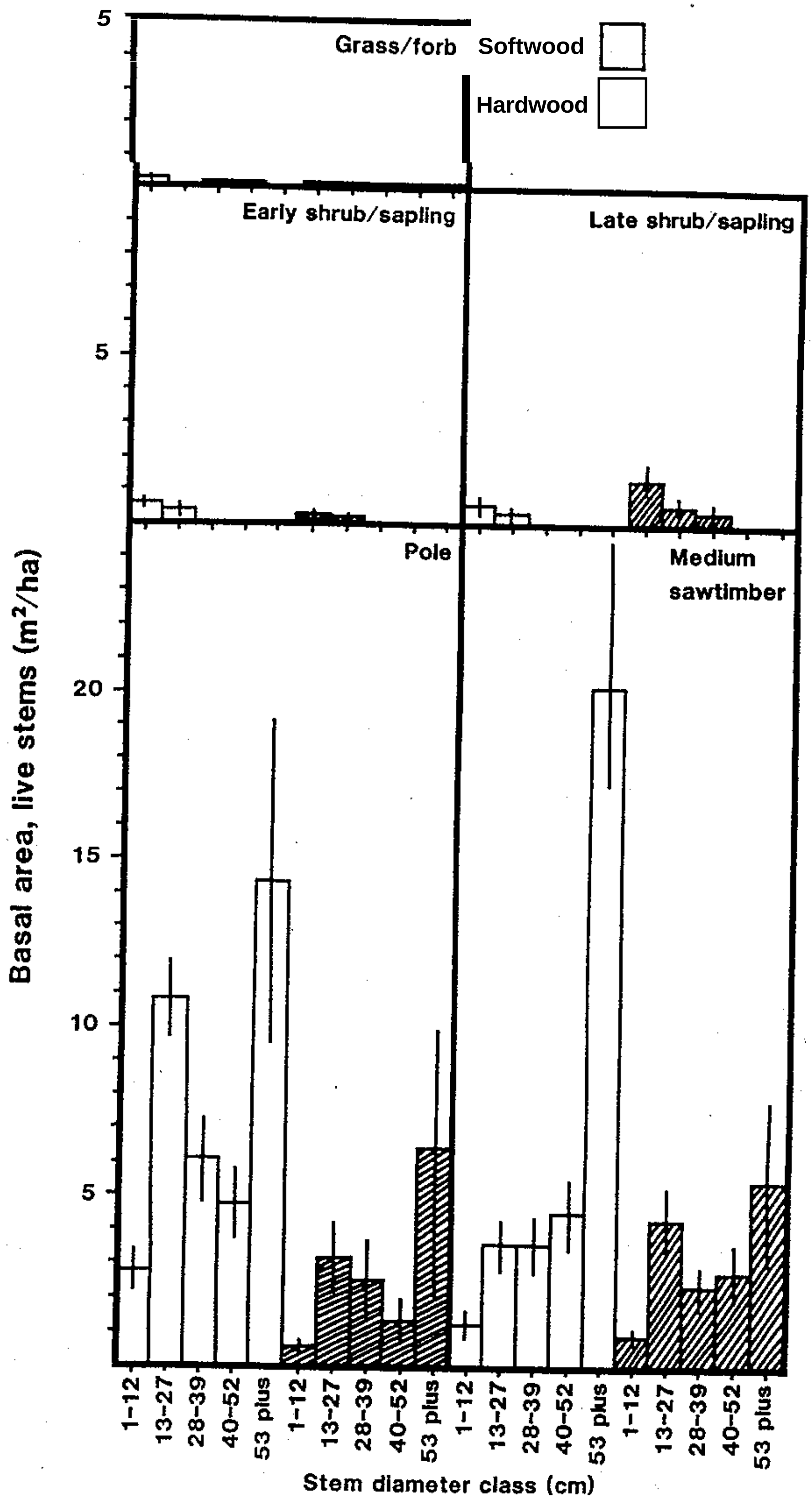
Figure 6.

Figure 7. Live stem density by successional stage and diameter at breast height class, young-growth Douglas-fir, northwestern California. Bars denote mean values, vertical lines denote one standard error.


Grass/forb
Softwood
Hardwood
Early shrub/sapling
Late shrub/ sapling
Pole
Medium sawtimber
1053
1057
500
500
500
No. stems/ha
1 - 12
13 - 27
28 - 39
40 - 52
53 plus
Stem diameter class (cm)

Figure

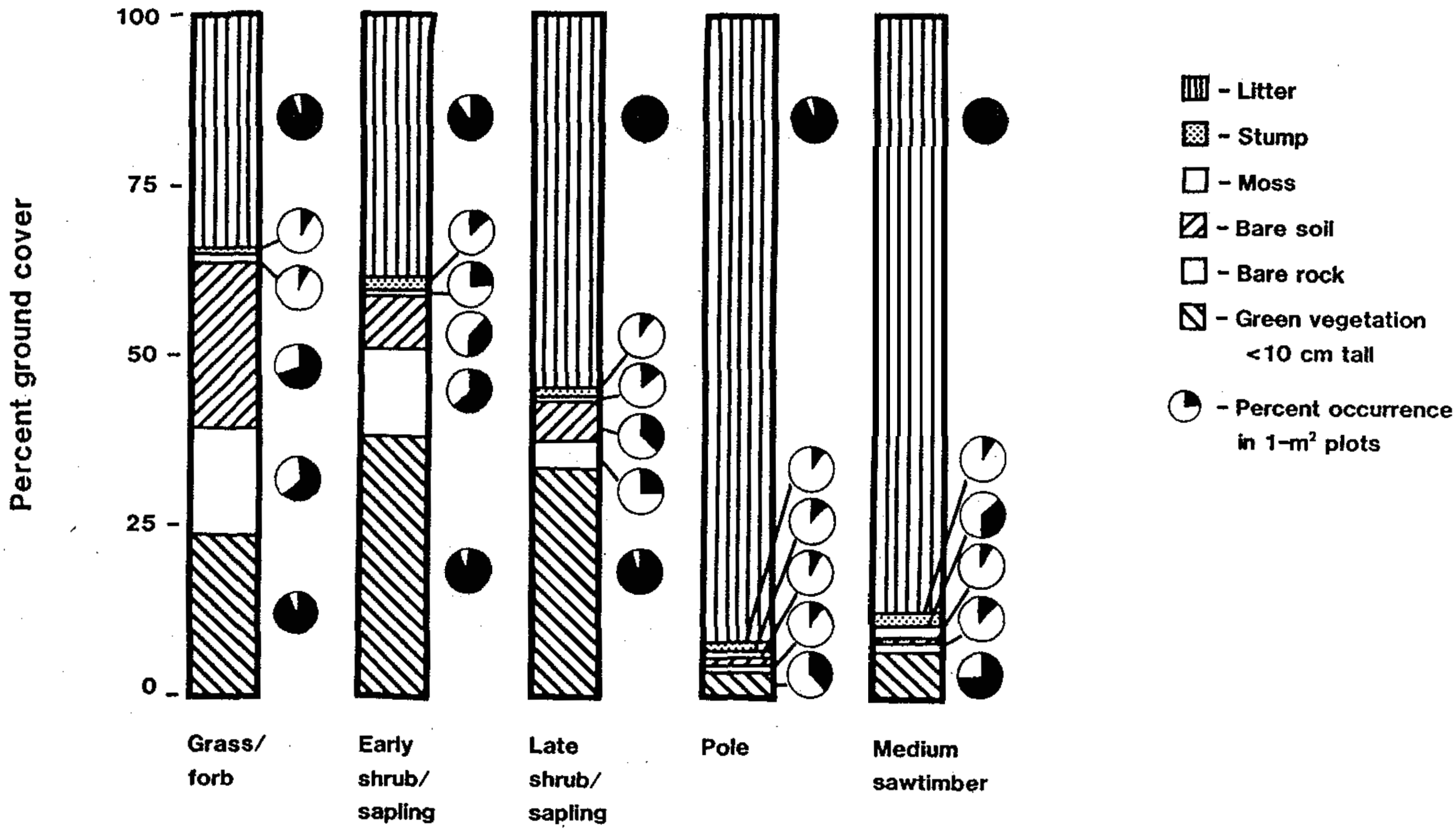
Figure 8. Live stem basal area by successional stage and diameter at breast height class, young-growth Douglas-fir, northwestern California. Bars denote mean values, vertical lines denote one standard error.



Grass/forb
Softwood
Hardwood
Early shrub/sapling
Late shrub/sapling
Pole
Medium sawtimber
Basal area, live stems (m²/ha)
5
5
20
15
10
5
1-12
13-27
28-39
40-52
53 plus
Stem diameter class (cm)

Figure 8.

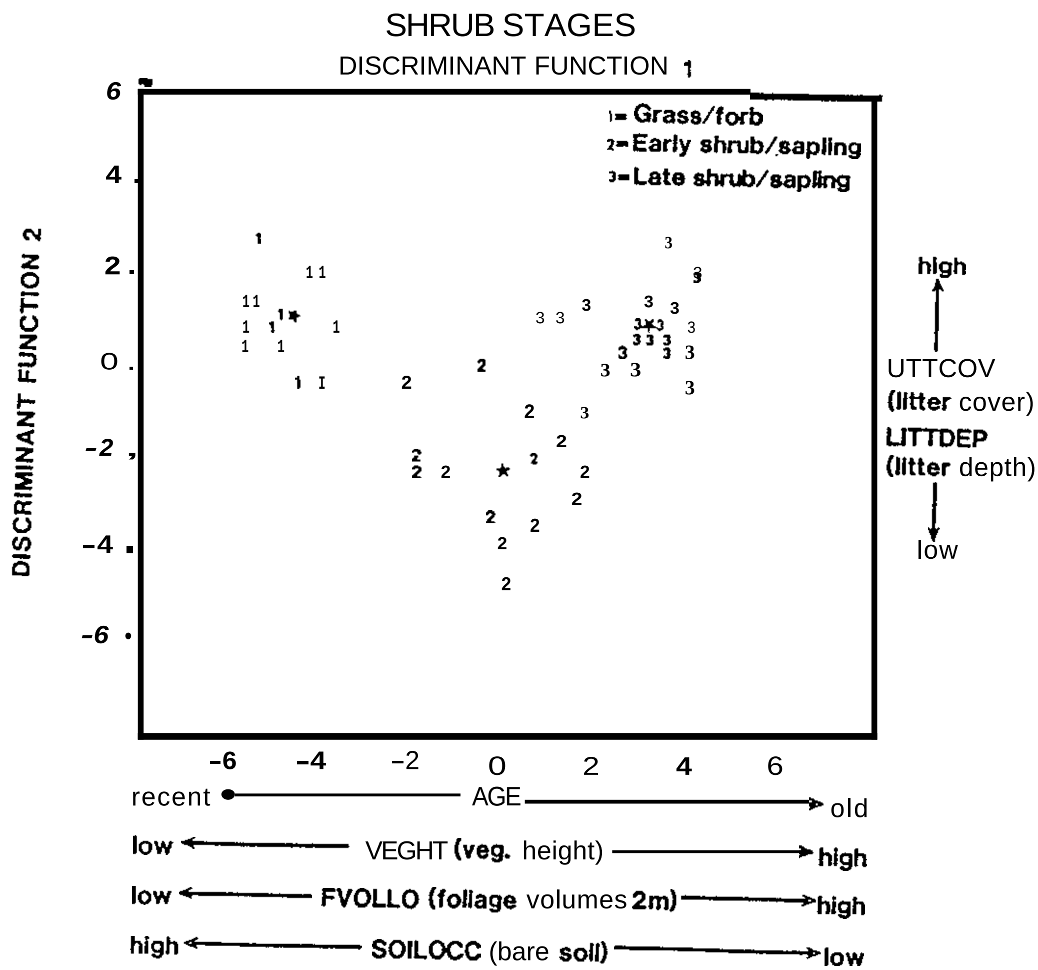
Figure 9. Mean values of percent ground cover and percent occurrence in 1-m^2 vegetation plots at bird count points of 6 ground cover categories, by successional stage of young-growth Douglas-fir, northwestern California.



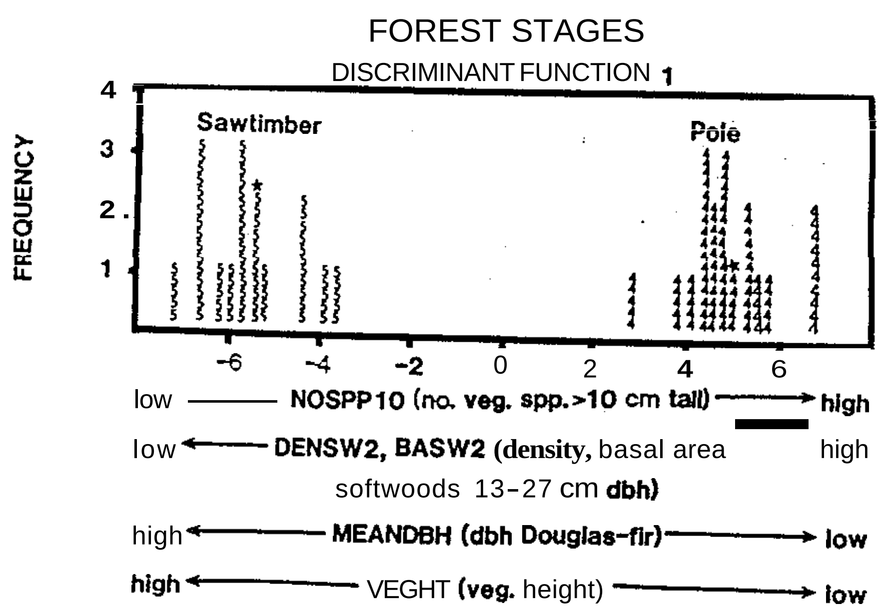
Percent ground cover
100
75
50
25
0
Grass/ forb
Early shrub/ sapling
Late shrub/ sapling
Pole
Medium sawtimber
- Litter
- Stump
- Moss
- Bare soil
- Bare rock
- Green vegetation <10 cm tall
- Percent occurrence in 1-m² plots

Figure 9.

Figure 10. Plot of cases, discriminant function analyses of the 3 brush and 2 forested stages of young-growth Douglas-fir, based on vegetation and habitat variables (Appendix 2). * = Group centroid. Axes are labeled with variables having greatest correlation.



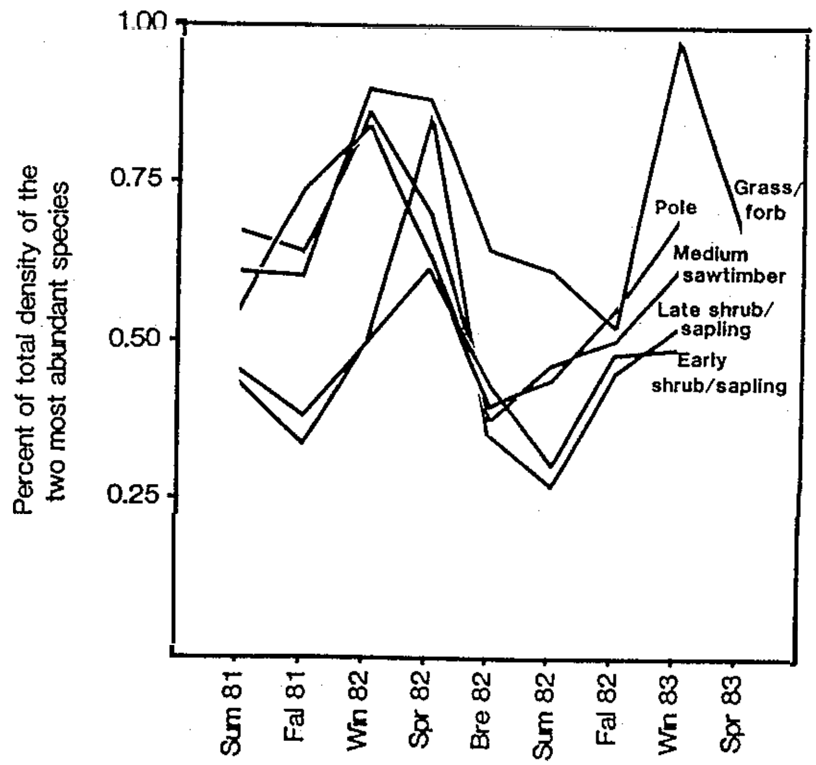
SHRUB STAGES
DISCRIMINANT FUNCTION 1
DISCRIMINANT FUNCTION 2
1= Grass/forb
2= Early shrub/sapling
3= Late shrub/sapling
high
UTTCOV (litter cover)
LITTDEP (litter depth)
low
recent AGE old
low VEGHT (veg. height) high
low FVOLLO (foliage volumes 2m) high
high SOILOCC (bare soil) low



FOREST STAGES
DISCRIMINANT FUNCTION 1
FREQUENCY
Sawtimber
Pole
low NOSPP10 (no. veg. spp.>10 cm tall) high
low DENSW2, BASW2 (density, basal area softwoods 13-27 cm dbh) high
high MEANDBH (dbh Douglas-fir) low
high VEGHT (veg. height) low

Figure 10.

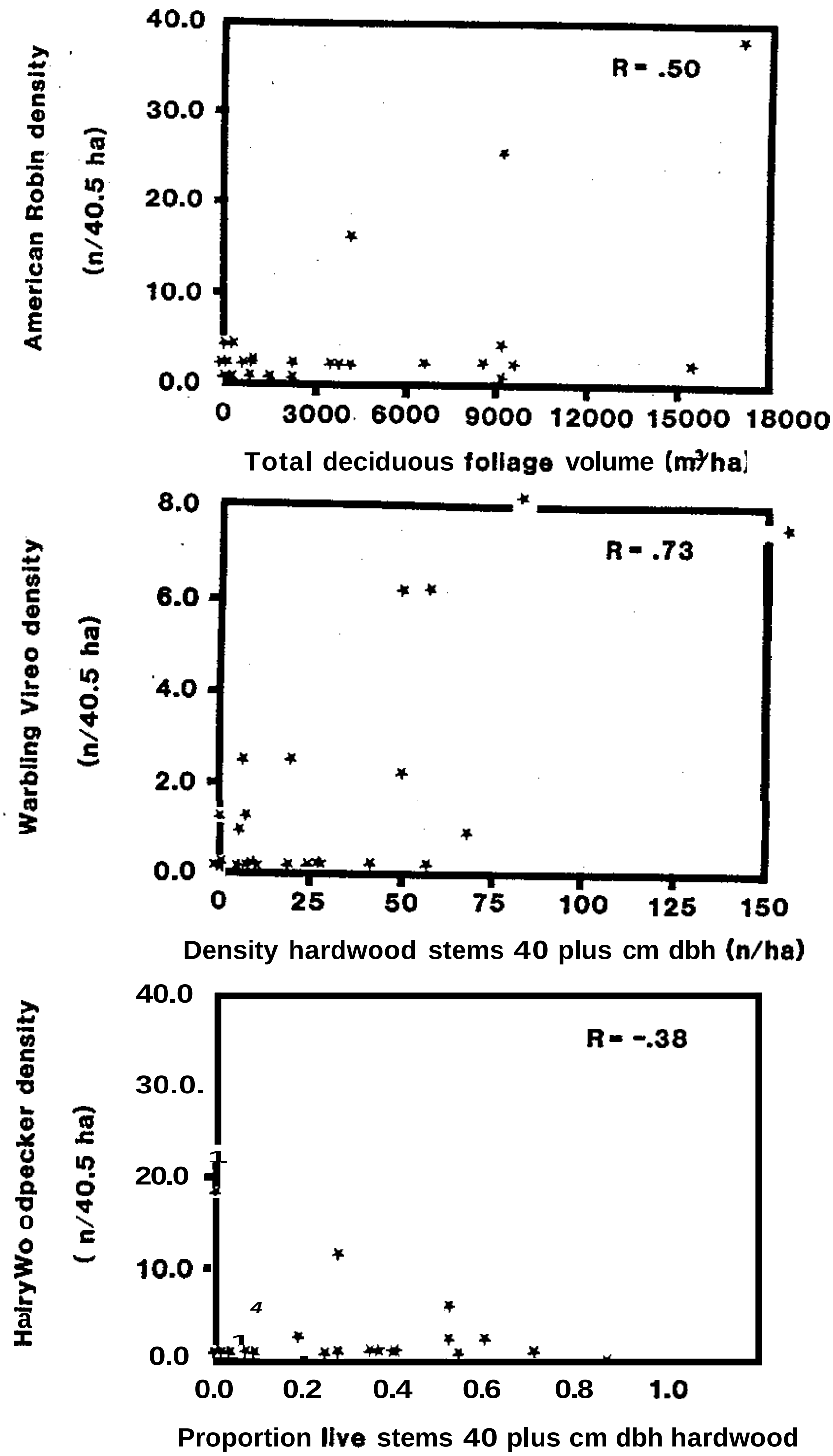
Figure 11. Percent of total density of the two most abundant bird species by season and successional stage of young-growth Douglas-fir, northwestern California.



1.00
0.75
0.50
0.25
Percent of total density of the two most abundant species
Grass/ forb
Pole
Medium sawtimber
Late shrub/ sapling
Early shrub/sapling
Sum 81
Fal 81
Win 82
Spr 82
Bre 82
Sum 82
Fal 82
Win 83
Spr 83

Figure 11.

Figure 12. Densities of six selected bird species plotted as functions of hardwood vegetation variables in pole and medium sawtimber stages of even-age Douglas-fir during the breeding season. Each point represents a stand.



American Robin density
(n/40.5 ha)
40.0
30.0
20.0
10.0
0.0
R= .50
0
3000
6000
9000
12000
15000
18000
Total deciduous foliage volume (m³/ha)
Warbling Vireo density
(n/40.5 ha)
8.0
6.0
4.0
2.0
0.0
R= .73
0
25
50
75
100
125
150
Density hardwood stems 40 plus cm dbh (n/ha)
Hairy Woodpecker density
(n/40.5 ha)
40.0
30.0
20.0
10.0
0.0
R= -.38
0.0
0.2
0.4
0.6
0.8
1.0
Proportion live stems 40 plus cm dbh hardwood

Figure 12.

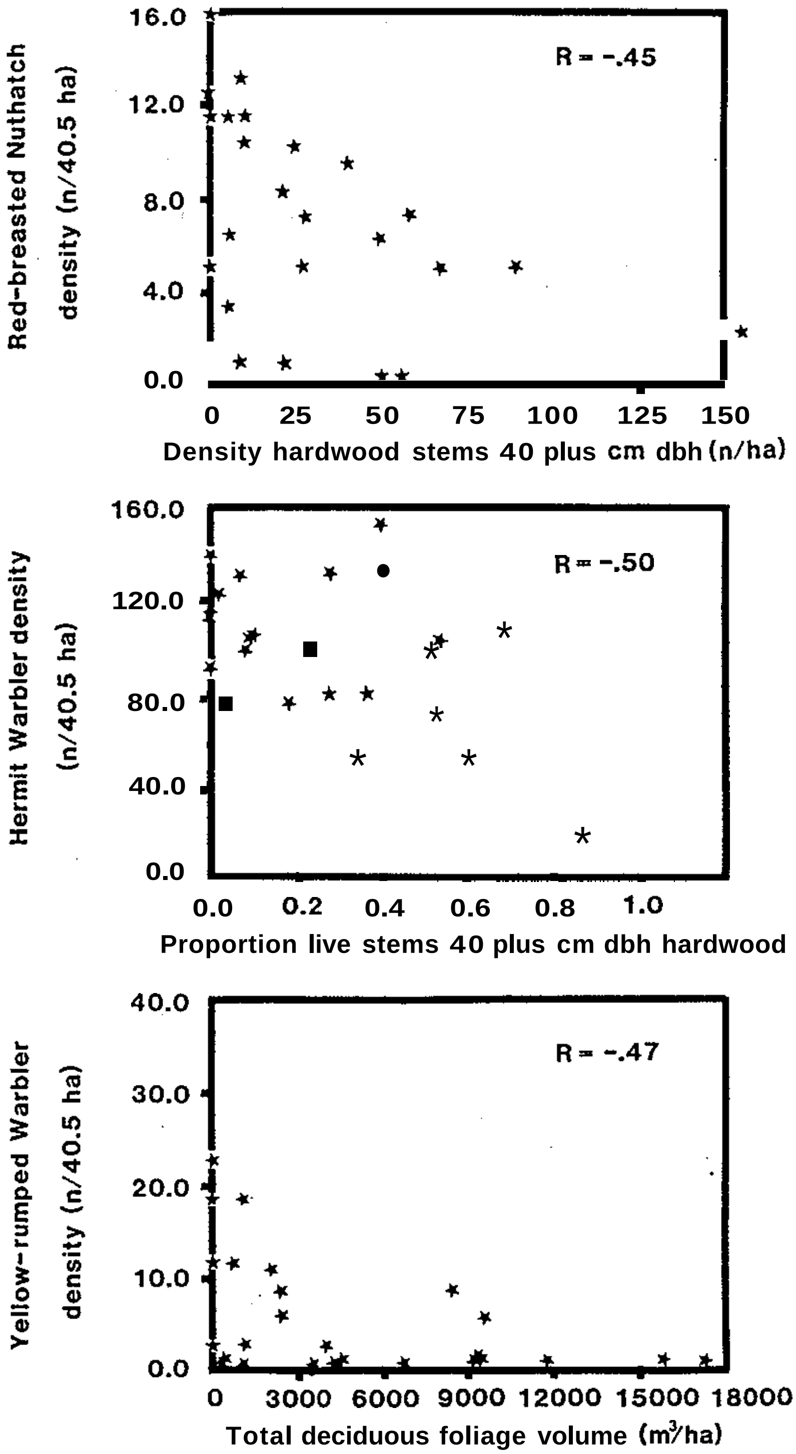


Figure 12. Continued

Figure 13. Number of bird species detected at bird count points during surveys, by season and successional stage of young-growth Douglas-fir, northwestern California. Horizontal bars denote mean values, vertical bars denote one standard error. Sample sizes (no. bird surveys) are shown in Table 3.

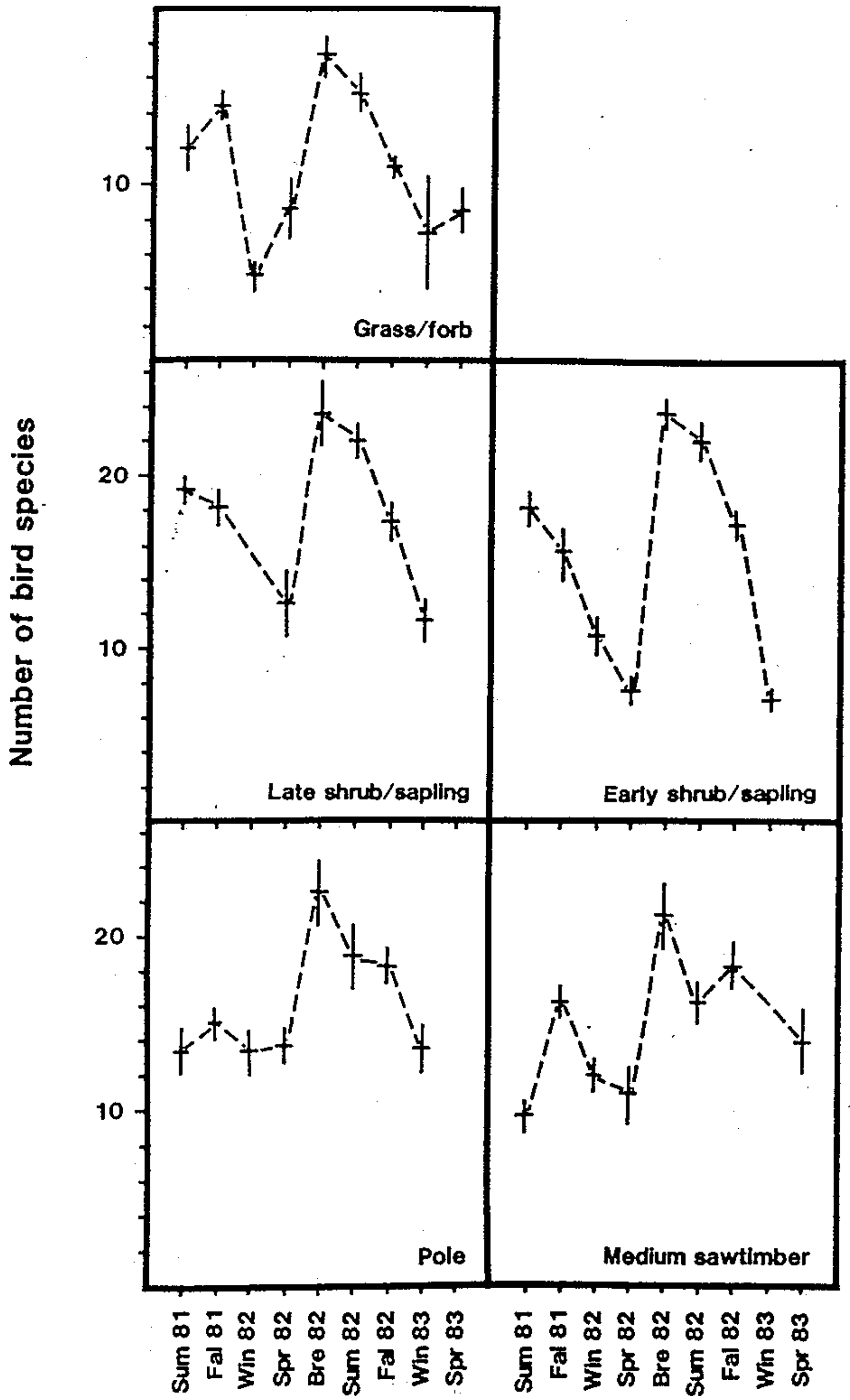
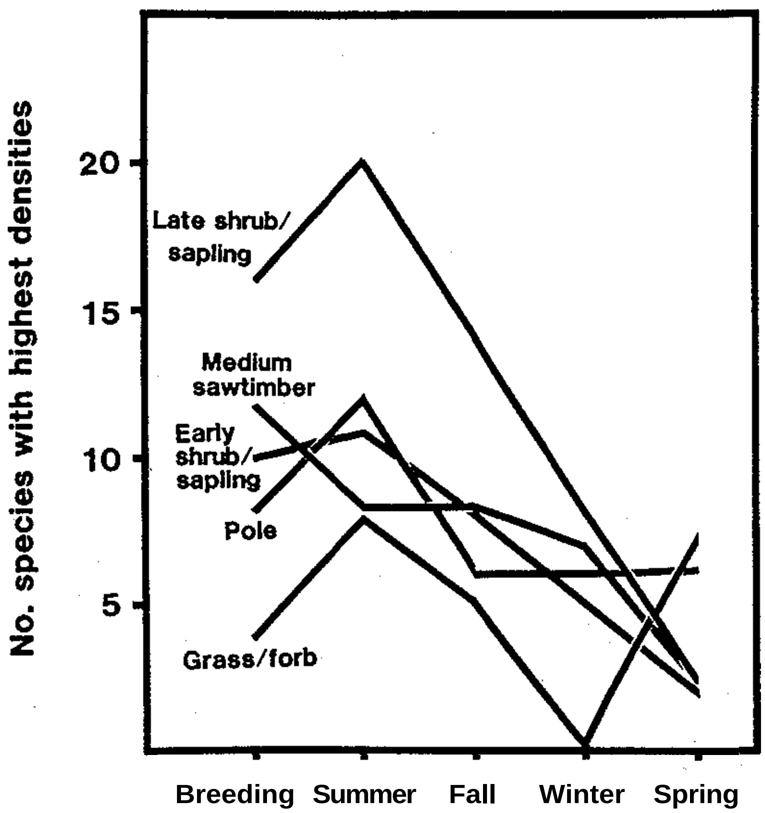

Number of bird species
10
Grass/forb
20
10
Late shrub/sapling
Early shrub/sapling
20
10
Pole
Medium sawtimber
Sum 81
Fal 81
Win 82
Spr 82
Bre 82
Sum 82
Fal 82
Win 83
Spr 83

Figure 13.

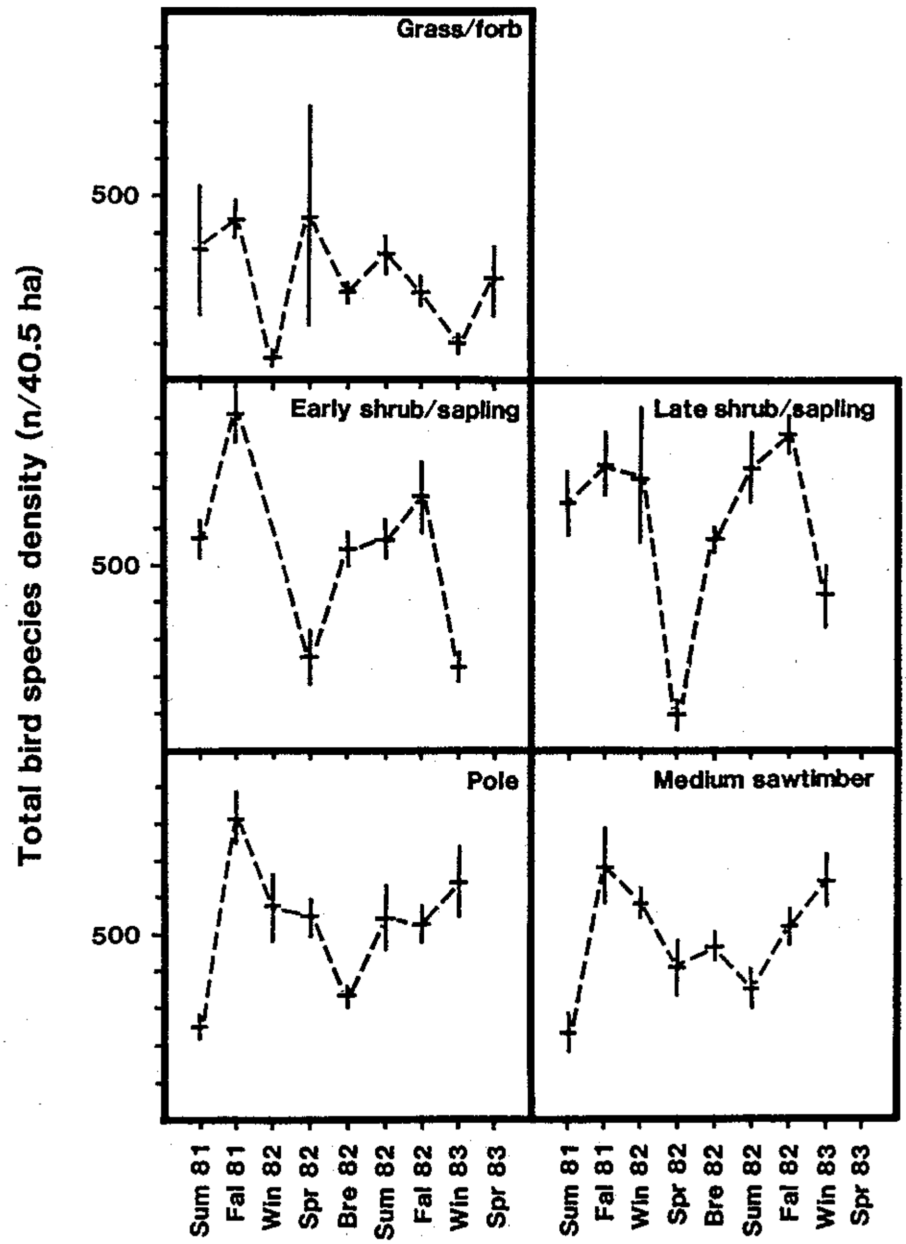
Figure 14. Number of bird species with highest (modal) densities across successional stages by season, years combined. See Table 9 for density values.



No. species with highest densities
20
15
10
5
Late shrub/ sapling
Medium sawtimber
Early shrub/ sapling
Pole
Grass/forb
Breeding
Summer
Fall
Winter
Spring

Figure *14.*

Figure 15. Total bird species density at bird count points by season and successional stage. Horizontal bars denote mean values, vertical bars denote one standard error. Sample sizes (no. bird surveys) are shown in Table 3.



Total bird species density (n/40.5 ha)
Grass/forb
Early shrub/sapling
Late shrub/sapling
Pole
Medium sawtimber
500
500
500
Sum 81
Fal 81
Win 82
Spr 82
Bre 82
Sum 82
Fal 82
Win 83
Spr 83

Figure 15.

Figure 16. Bird species diversity by successional stage and season. Diversity index used is Shannon-Weiner (Shannon and Weaver 1949),

$$H' = -\sum_{i=1}^{S} p_i \ln p_i ,$$

where S is the total number of species detected at a given count point and p_i is the proportion of total bird density of the ith species.

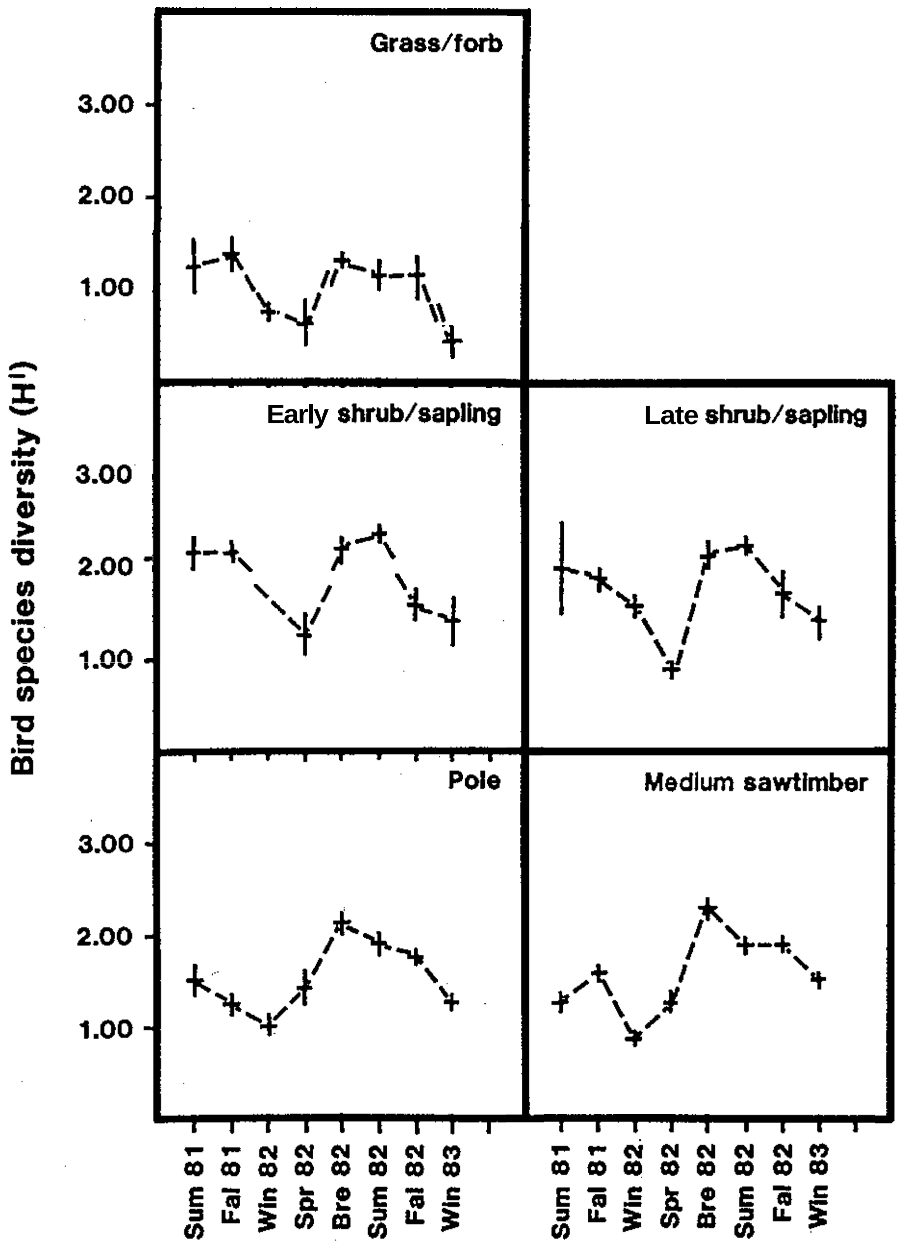

Grass/forb
Early shrub/sapling
Late shrub/sapling
Pole
Medium sawtimber
Bird species diversity (H')
3.00
2.00
1.00
Sum 81
Fal 81
Win 82
Spr 82
Bre 82
Sum 82
Fal 82
Win 83

Figure 16.

Figure 17. Cluster classifications of bird species by season, based on site-specific species densities. In most seasons, species found predominantly in forest stage habitats segregated'in the classification from species found predominantly in grass and shrub stage habitats. "Mixed" refers to broad occurrence in both shrub and forested stages. Asterisks (*) denote core species in breeding and winter seasons, as discussed in the text. See Appendix 4 for species name codes.

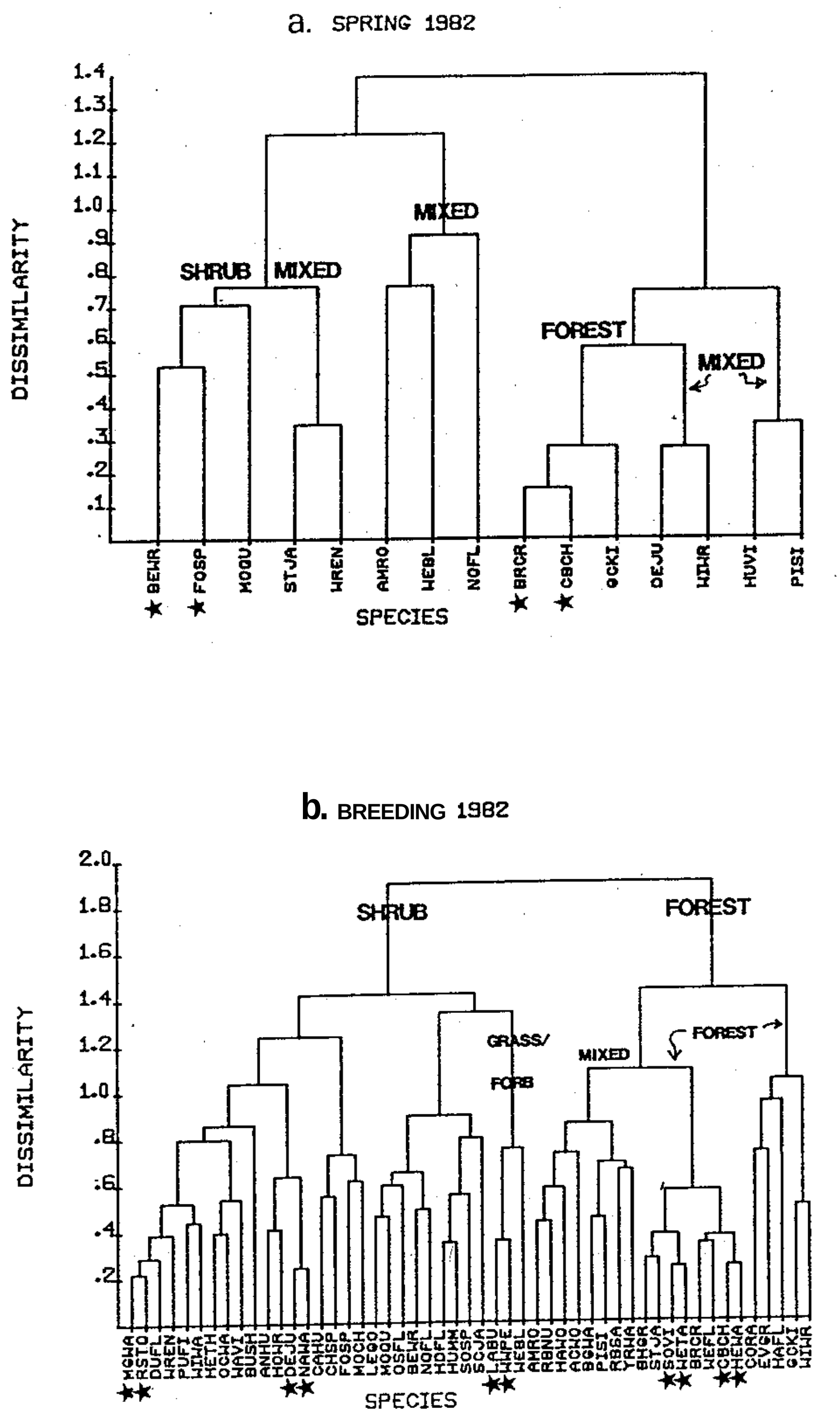

a. SPRING 1982
DISSIMILARITY
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
SHRUB
MIXED
MIXED
FOREST
MIXED
BEWR
FOSP
MOQU
STJA
WREN
AMRO
WEBL
NOFL
BRCR
CBCH
GCKI
DEJU
WIWR
HUVI
PISI
SPECIES
b. BREEDING 1982
DISSIMILARITY
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
SHRUB
FOREST
GRASS/
FORB
MIXED
FOREST
MGWA
RSTO
DUFL
WREN
PUFI
WIWA
WETH
OCWA
WAVI
BUSH
ANHU
HOWR
DEJU
NAWA
CAHU
CHSP
FOSP
MOCH
LEGO
MOQU
OSFL
BEWR
NOFL
HOFL
HUHM
SOSP
SCJA
LABU
WWPE
WEBL
AMRO
RBNU
HAWO
ACWO
BGWA
PISI
RBSA
YRWA
BHGR
STJA
SOVI
WETA
BRCR
WEFL
CBCH
HEWA
CORA
EVGR
HAFL
GCKI
WIWR
SPECIES

Figure 17.

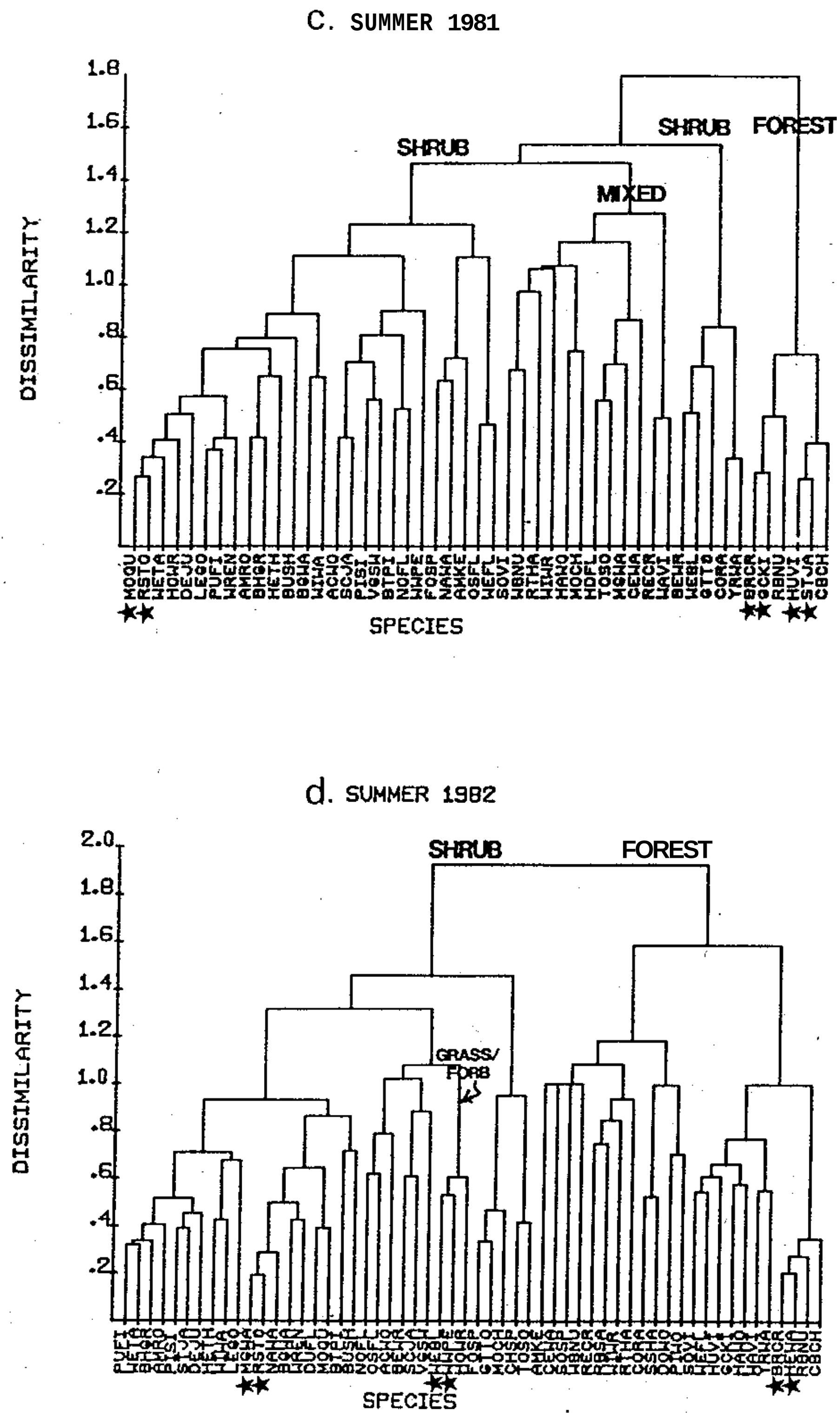
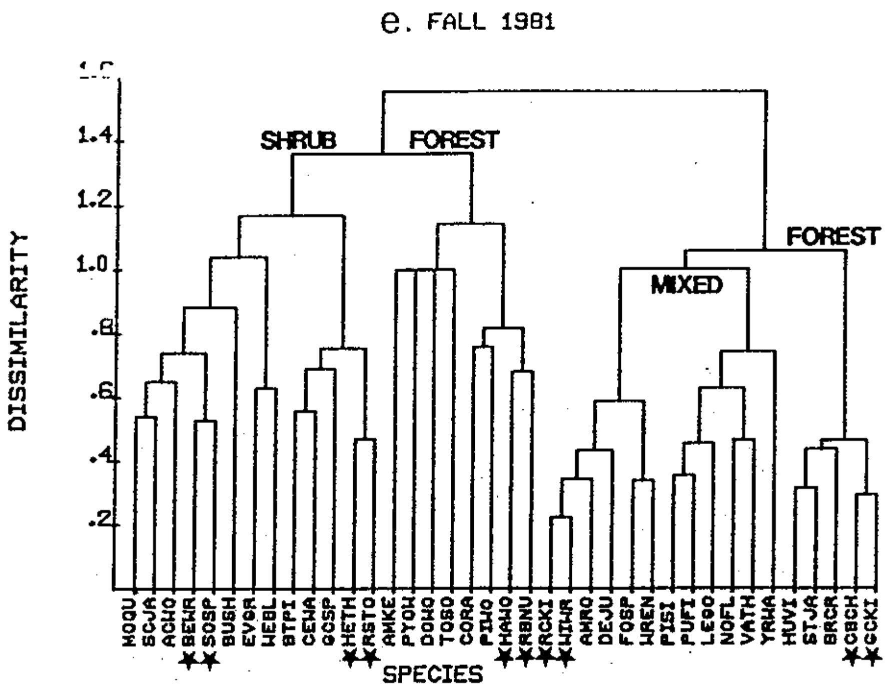


Figure 17. Continued



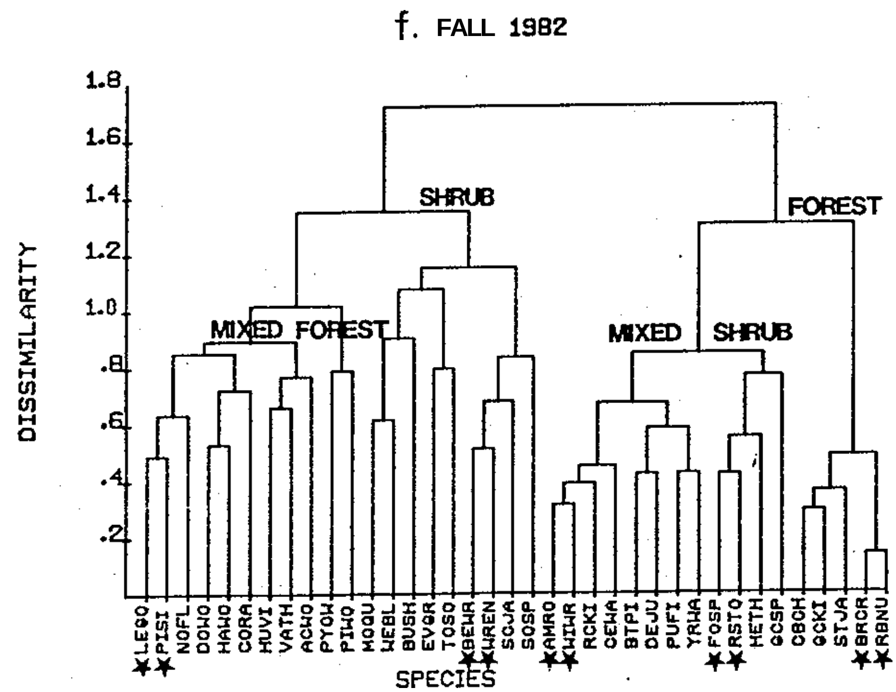
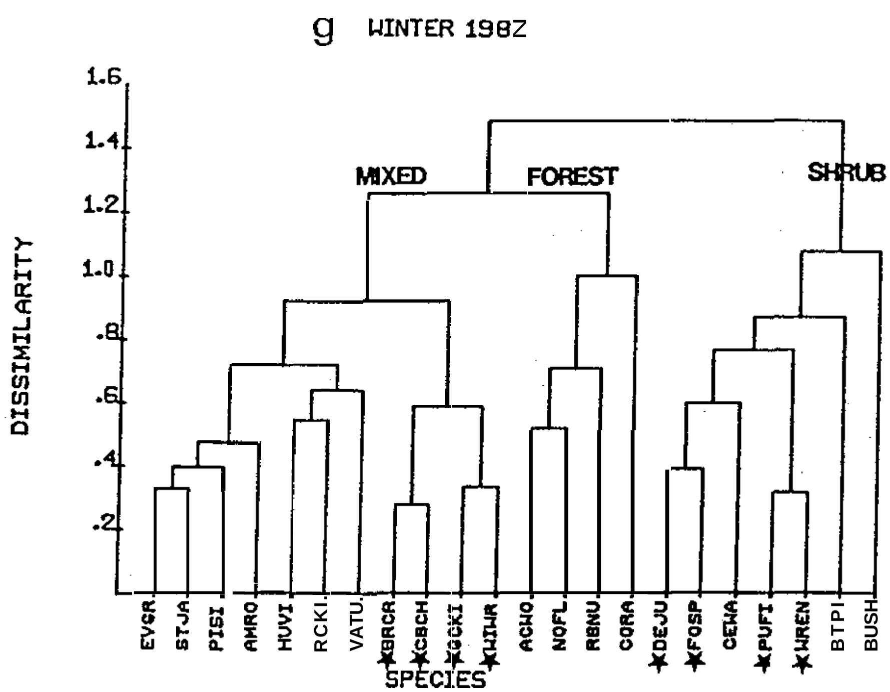


Figure 17. Continued



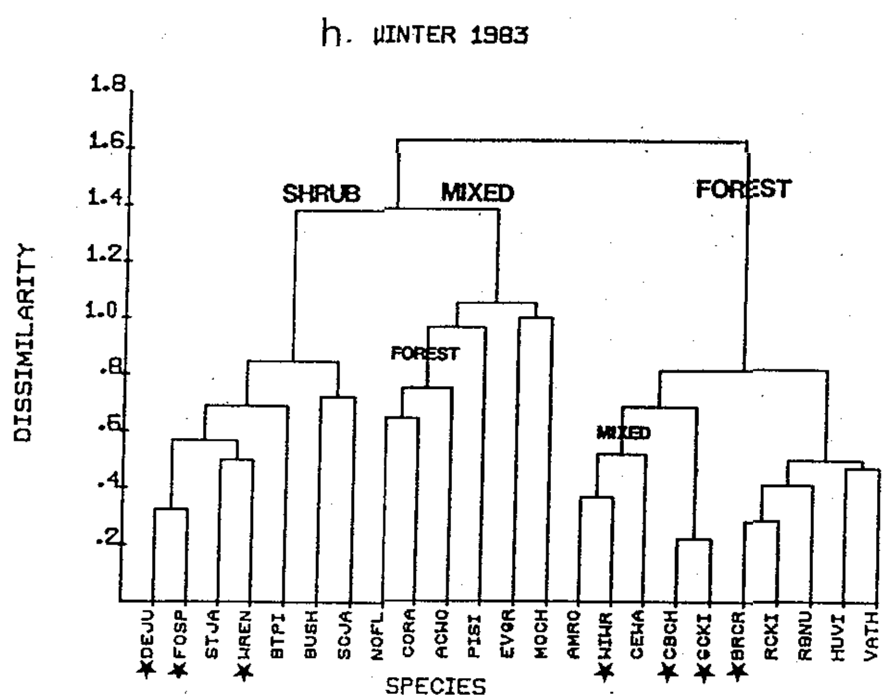
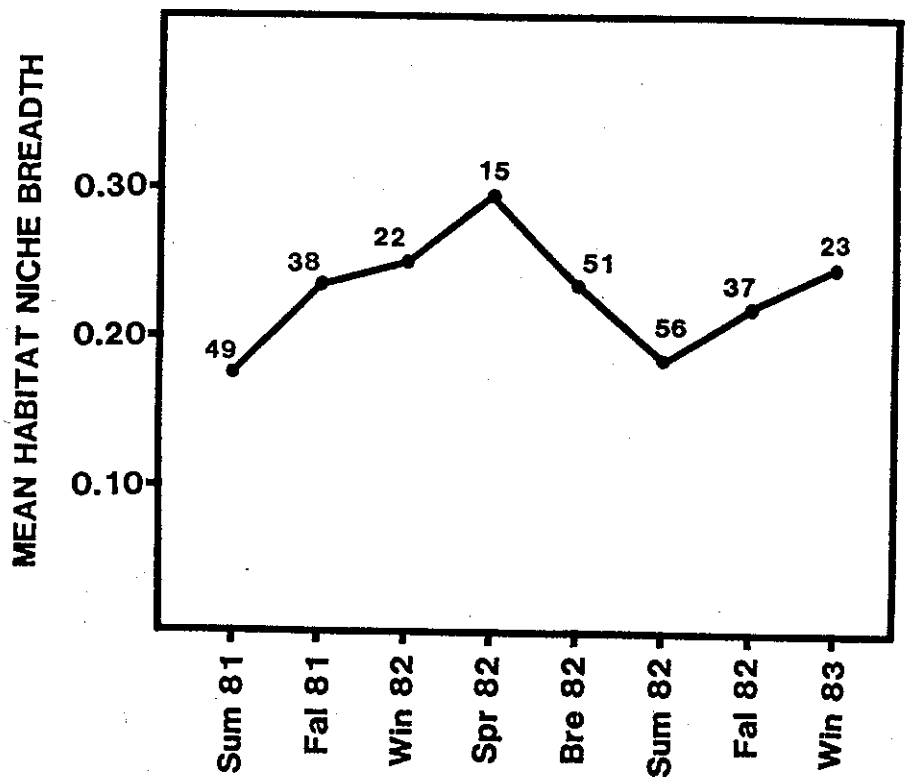


Figure 17. Continued

Figure 18. Mean habitat niche breadth of all species, by season, scaled to range between approximately zero and one. Integers above points are number of species observed whose density estimates contributed to mean niche breadth measures. See text for description of calculations used.



MEAN HABITAT NICHE BREADTH
0.30
0.20
0.10
49
38
22
15
51
56
37
23
Sum 81
Fal 81
Win 82
Spr 82
Bre 82
Sum 82
Fal 82
Win 83

Figure 18.

Figure 19. Habitat niche breadth of 10 permanent resident species, by season, scaled to range between approximately zero and one. See text for description of calculations used.

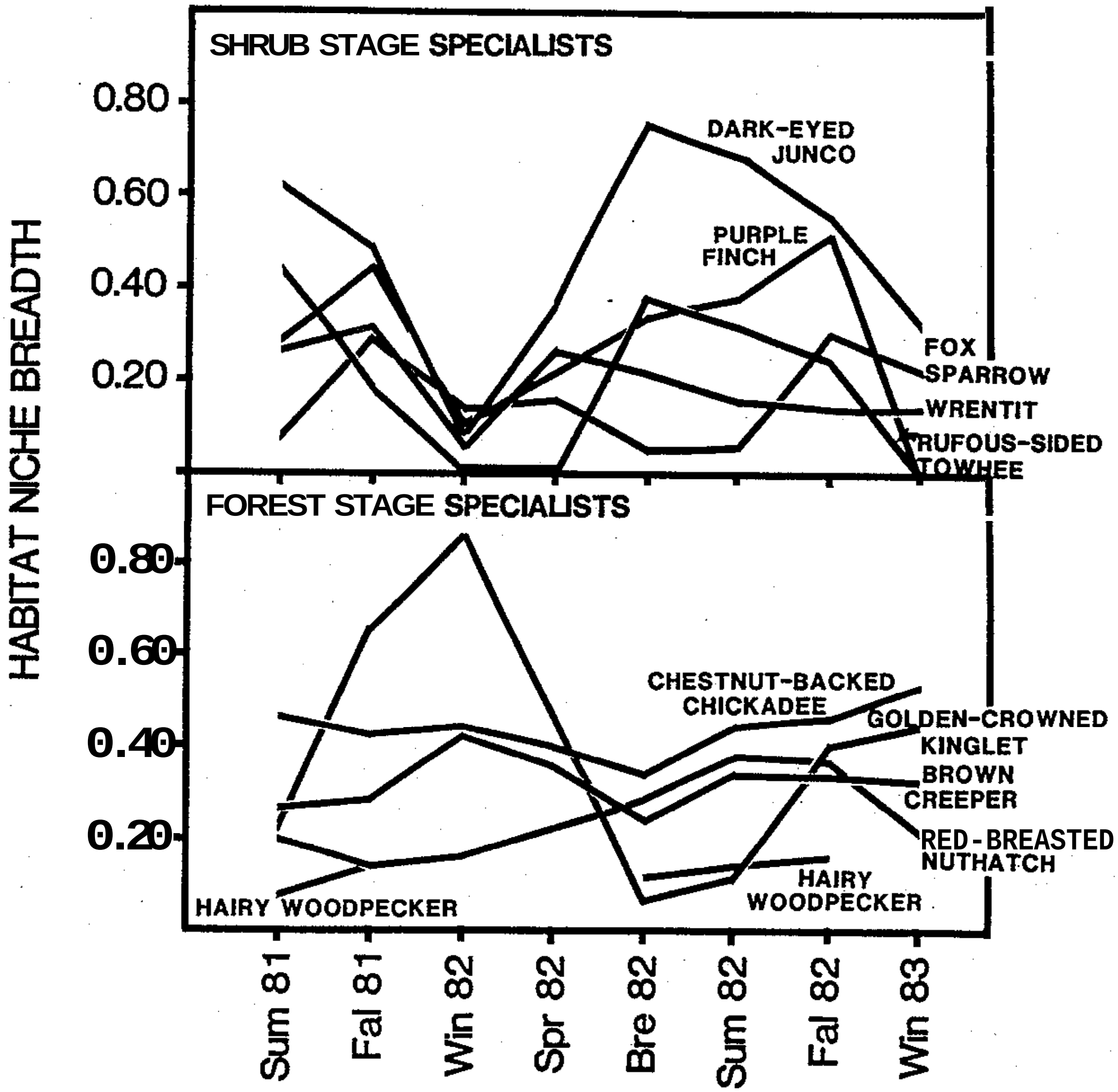

SHRUB STAGE SPECIALISTS
HABITAT NICHE BREADTH
0.80
0.60
0.40
0.20
DARK-EYED JUNCO
PURPLE FINCH
FOX SPARROW
WRENTIT
RUFOUS-SIDED TOWHEE
FOREST STAGE SPECIALISTS
0.80
0.60
0.40
0.20
CHESTNUT-BACKED CHICKADEE
GOLDEN-CROWNED KINGLET
BROWN CREEPER
RED-BREASTED NUTHATCH
HAIRY WOODPECKER
HAIRY WOODPECKER
Sum 81
Fal 81
Win 82
Spr 82
Bre 82
Sum 82
Fal 82
Win 83

Figure 19

Figure 20. Linear regression lines of unweighted mean habitat niche breadth versus number of bird species observed at count points, by season. All regressions are significant (F-tests, $P < 0.05$), and all slopes are significantly different than zero (t-tests, $P < 0.05$). See text for description of niche breadth index used.

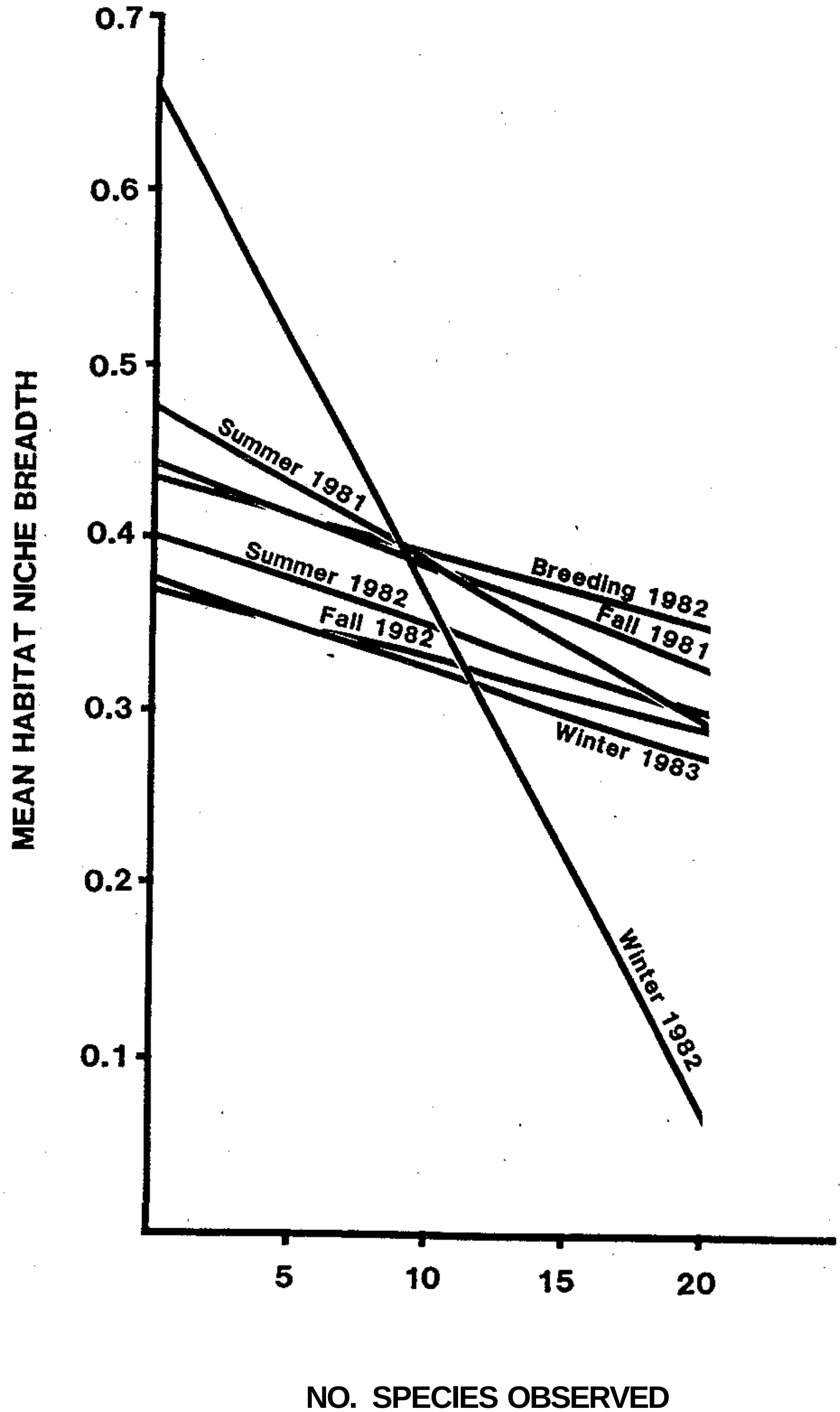

MEAN HABITAT NICHE BREADTH
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Summer 1981
Breeding 1982
Fall 1981
Summer 1982
Fall 1982
Winter 1983
Winter 1982
5
10
15
20
NO. SPECIES OBSERVED

Figure *20.*

Figure 21. Mean community overlap among resident bird species, by season. Overlap values range from zero (no overlap in distribution over study sites) to one (complete overlap). See text for description of calculations used.

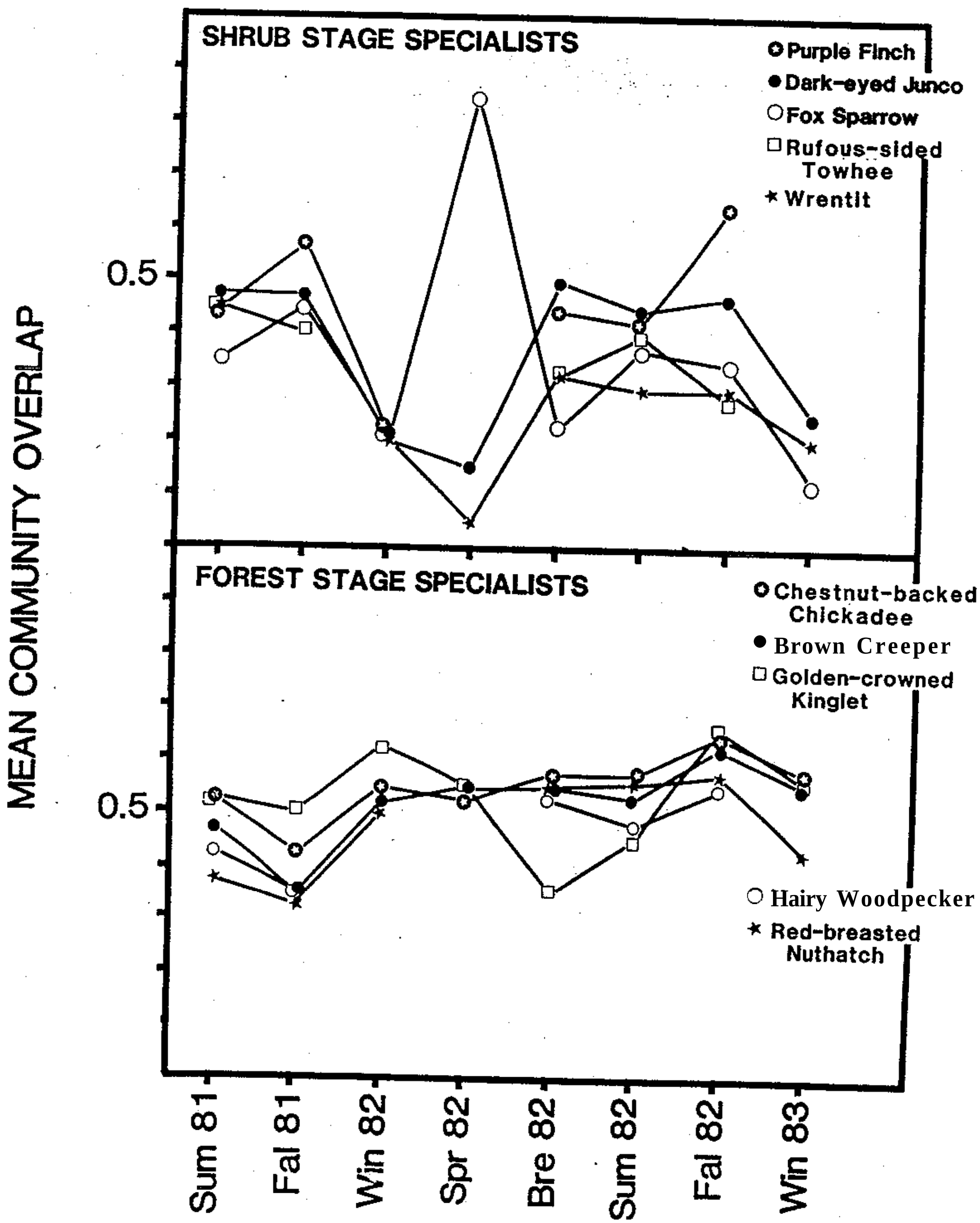
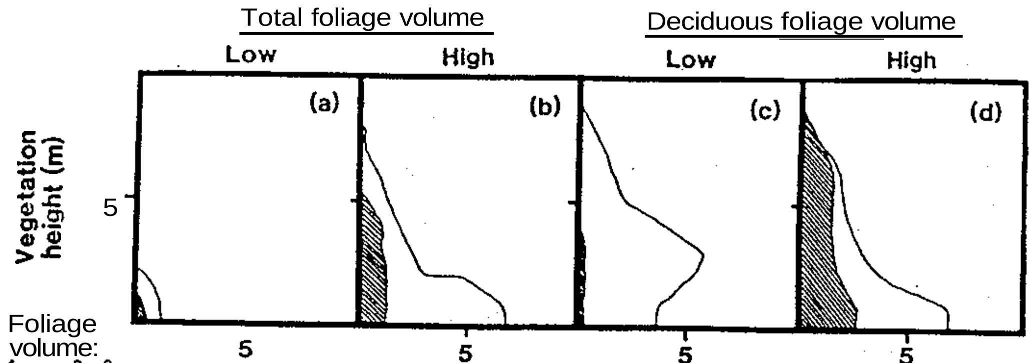

SHRUB STAGE SPECIALISTS
Purple Finch
Dark-eyed Junco
Fox Sparrow
Rufous-sided Towhee
Wrentit
0.5
FOREST STAGE SPECIALISTS
Chestnut-backed Chickadee
Brown Creeper
Golden-crowned Kinglet
Hairy Woodpecker
Red-breasted Nuthatch
0.5
MEAN COMMUNITY OVERLAP
Sum 81
Fal 81
Win 82
Spr 82
Bre 82
Sum 82
Fal 82
Win 83

Figure 21.

Figure 22. Examples of site-specific foliage volume profiles with associated species of birds found in high abundance, during breeding and summer seasons. Hatched areas represent summertime deciduous foliage volume, unhatched areas represent evergreen foliage volume. Values following species names are values of simple correlations of breeding bird density with factor scores of principle components representing the particular habitat characteristic; values are not given for species associated with deciduous foliage volume in shrub stages because no principle component specifically represented that particular characteristic.

SHRUB STAGES

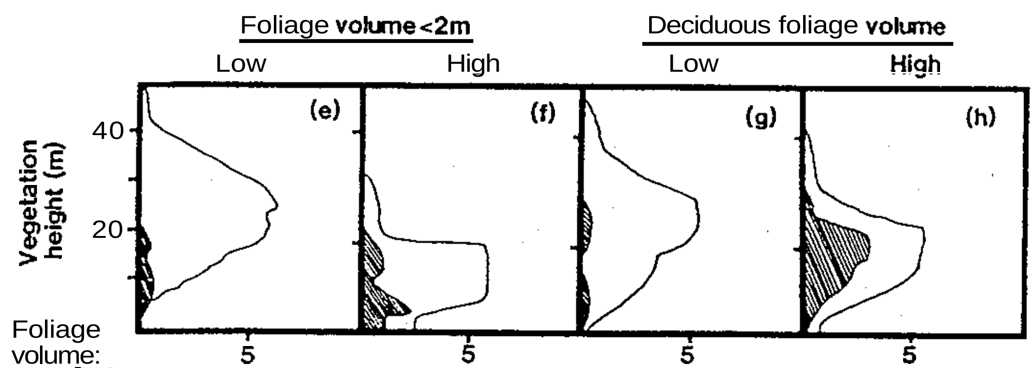


Associated species:

(a)	(b)	(c)	(d)
Western wood pewee -0.49	Mountain quail 0.32	Acorn woodpecker	Red-breasted sapsucker
Western flycatcher -0.03	Steller's jay 0.43	Scrub jay	House wren
House wren -0.23	Bushtit 0.19	Hermit thrush	MacGillivray's warbler
Western bluebird -0.34	Bewick's wren 0.10	Wrentit	Wilson's warbler
Lazuli bunting -0.53	Solitary vireo 0.29	Orange-crowned warbler	Western tanager
	Hutton's vireo 0.35	Nashville warbler	
	Warbling vireo 0.25	Black-throated gray warbler	
	Black-headed grosbeak 0.35	Rufous-sided towhee	
		Fox sparrow	

Evergreen
Deciduous

FOREST STAGES



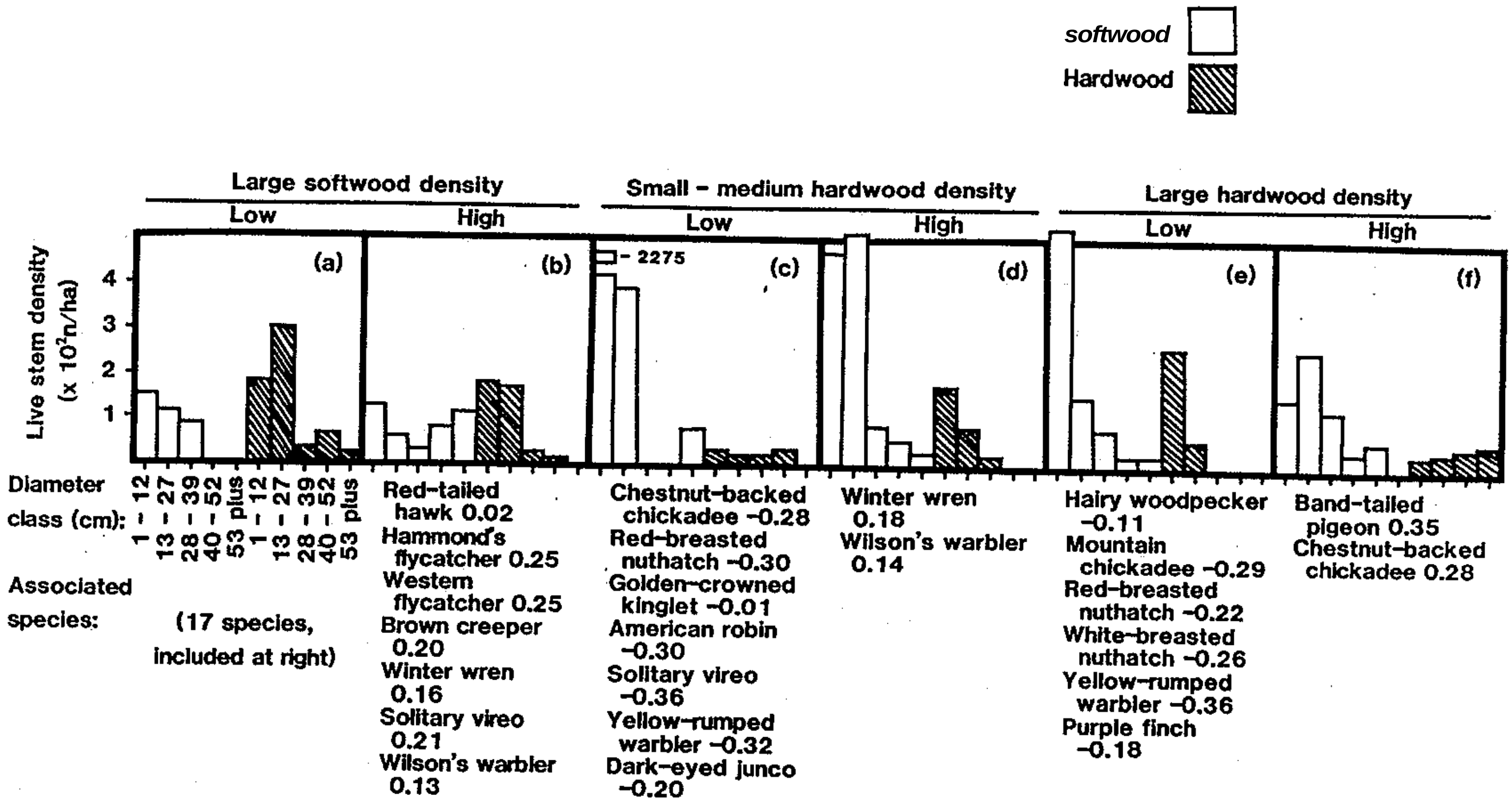
Associated species:

(e)	(f)	(g)	(h)
(none)	Steller's jay 0.15	Hairy woodpecker -0.08	Downy woodpecker 0.35
	Hermit thrush 0.45	Common raven -0.29	Hutton's vireo 0.21
	Warbling vireo 0.18	Red-breasted nuthatch -0.35	Western tanager 0.25
	Wilson's warbler 0.19	Hermit thrush -0.22	
	Black-headed grosbeak 0.34	Yellow-rumped warbler -0.26	
	Dark-eyed junco 0.19	Purple finch -0.15	

Figure 22.

Figure **23.** Examples of site-specific stem frequency distributions with associated species of birds found in high abundance, in forest stages during breeding and summer seasons. Values following species names are values of simple correlations of breeding bird density with factor scores of principle components representing the particular habitat characteristic.

Figure 23



softwood
Hardwood
Large softwood density
Low
High
Small - medium hardwood density
Low
High
Large hardwood density
Low
High
(a)
(b)
(c)
(d)
(e)
(f)
- 2275
Live stem density
(x 10²n/ha)
4
3
2
1
Diameter class (cm):
1 - 12
13 - 27
28 - 39
40 - 52
53 plus
1 - 12
13 - 27
28 - 39
40 - 52
53 plus
Associated species:
(17 species, included at right)
Red-tailed hawk 0.02
Hammond's flycatcher 0.25
Western flycatcher 0.25
Brown creeper 0.20
Winter wren 0.16
Solitary vireo 0.21
Wilson's warbler 0.13
Chestnut-backed chickadee -0.28
Red-breasted nuthatch -0.30
Golden-crowned kinglet -0.01
American robin -0.30
Solitary vireo -0.36
Yellow-rumped warbler -0.32
Dark-eyed junco -0.20
Winter wren 0.18
Wilson's warbler 0.14
Hairy woodpecker -0.11
Mountain chickadee -0.29
Red-breasted nuthatch -0.22
White-breasted nuthatch -0.26
Yellow-rumped warbler -0.36
Purple finch -0.18
Band-tailed pigeon 0.35
Chestnut-backed chickadee 0.28

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APPENDICES

Appendix 1. Common and scientific names of plant species mentioned in this report. Nomenclature fallows Munz and Keck (1968).

Common name	Scientific name
Berries	Rubus leucodermis, R. parviflorus, R. ursinus
Big-leaf maple	Acer macrophyllum
Blue elderberry	Sambucus caerulea
Bull thistle	Cirsium vulgare
California black oak	Quercus kelloggii
California harebell	Campanula prenanthoides
Canyon live oak	Quercus chrysolepis
Cheat grass	Bromus tectorum
Deerbrush	Ceanothus integerrimus
Dogbane	Apocynum androsaemifolium
Douglas-fir	Pseudotsuga menzeisii
Draperia	Draperia systyla
Fescue	Festuca occidentalis
Golden chinquapin	Castanopsis chrysophylla var. minor
Gooseberry	Ribes lobii, R. roezlii, R. sanguineum
Groundsel	Senecio vulgaris, S. spp.
Incense cedar	Calocedrus decurrens
Jeffery pine	Pinus jefferyi
Mountain whitethorn	Ceanothus cordulatus
Oregon white oak	Quercus garryana
Pacific madrone	Arbutus menzeisii
Ponderosa pine	Pinus ponderosa
Prickly lettuce	Lactuca serriola
Skeleton weed	Stephanomeria virgata
Sugar pine	Pinus lambertiana
Tanoak	Lithocarpus densiflora
Tobacco brush	Ceanathus velutinus
White fir	Abies concolor
Willow herb	Epilobium paniculatum

Appendix 2. Vegetation and habitat variables measured around each bird count point, northwestern California.

Mnemonic	Description
STAND STRUCTURE VARIABLES	
FVOLDLO	Foliage volume, deciduous, 0.1 to 2 m (m\3/ha).
FYOLDTOT	Foliage volume, deciduous, 0.1+ m (m\3/ha).
FVOLELO	Foliage volume, evergreen. 0.1 to 2 m (m\3/ha).
FVOLETOT	Foliage volume, evergreen, 0.1+ m (m\3/ha).
FVOLLO	Foliage volume, deciduous and evergreen, 0.1 to 2 m (m\3/ha).
FOLHIGH	Foliage volume, deciduous and evergreen, > 2 m (m\3/ha).
FOLTOTAL	Foliage volume, deciduous and evergreen, 0.1+ m (m\3/ha).
VEGHT	Total vegetation height (m) measured with clinometer.
CANCOV	Vegetation cover (%) estimated with spherical densio-meter. Model C (Lemmon 1956).
MEANDBH	Mean diameter (cm) at breast height (dbh), Douglas-fir, 12+ cm dbh.
DENSW1-5	Live stem density, softwoods, 1-12, 13-27, 28-39, 40-52, and 53t cm dbh (n/ha).
DENHWI-5	Live stem density, hardwoods, 1-12, 13-27, 28-39, 40-52, and 53+ cm dbh (n/ha).
DENSN1-2	Stem density. snags, 13-52 and 53+ cm dbh (n/ha).
BASW1-5	Live stem basal area, softwoods, 1-12, 13-27, 28-39, 40-52, and 53+ cm dbh (m\2/ha).
BAHW1-5	Live stem basal area, hardwoods, 1-12. 13-27. 28-39. 40-52, and 53+ cm dbh (m\2/ha).
CDENSW40	Live stem density, softwoods, 40+ cm dbh (n/ha). Measured from single 0.28-ha circular plor.
CDENHW40	Live stem density, hardwoods. 40+ cm dbh (n/ha) Measured from single 0.28-ha circular plot.

Appendix 2. Continued

CDENSN40	Stem density, snags. 40+ cm dbh (n/ha). Measured from single 0.28-ha circular plot.
CBASW40	Live stem basal area, softwoods. 40+ cm dbh (m\2/ha). Measured from single 0.28-ha circular plot.
CBAHW40	Live stem basal area, hardwoods, 40+ cm dbh (m\2/ha). Measured from single 0.28-ha circular plot.
CBASN40	Stem basal area, snags, 40+ cm dbh (m\2/ha). Measured from single 0.28-ha circular plot.
NOSPP10	Number of plant species 10+ cm tall.
NOSPP2M	Number of plant species 2+ m tall.

GROUND COVER VARIABLES

LITTDEP	Litter depth (cm).
GRNCOV	Ground cover (%), green vegetation < 10 cm tall.
ROCKCOV	Ground cover (I), bare rock.
SOILCOV	Ground cover (%), bare soil.
MOSSCOV	Ground cover (I), moss.
STMPCOV	Ground cover (Z), stump.
LITTCOV	Ground cover (I), litter.
GRNOCC	Percent occurrence, green vegetation < 10 cm tall.
ROCKOCC	Percent occurrence, bare rock.
SOILOCC	Percent occurrence, bare soil.
MOSSOCC	Percent occurrence, moss.
STMPOCC	Percent occurrence, stump.
LITTOCC	Percent occurrence, litter.
WOODMASS	Down wood mass (metric tons/ha).
WOODVOL	Down wood volume (m\3/ha).

Appendix 2. Continued

TOPOPBYSIOGRAPHIC VARIABLES

ELEV	Elevation (m).
AREA	Stand area (ha).
DISTWAT	Distance from stand boundary to nearest permanent water (km).
DISHAB	Distance from stand boundary to next nearest stand of the same designation (km).
TOPO	Topographic position of stand (1 = bottom slope, 2 = mid-slope, 3 = upper slope, 4 = ridge, 5 = bottom slope to ridge, 6 = isolated summit).
BOUNDLEN	Stand boundary length (m).
NOEDGES	Number of adjacent stands.
SLOPE	Percent slope. Measured with clinometer.

Appendix 3. Summary and interpretation of vegetation and habitat factors from principle component factor analysis.

SEASON, STAGE Factor	Interpretation	Associated variables\a
BREEDING. SUMMER Shrub Stages		
Factor 1	Foliage volume.	+ NOSPP2M,FVOLDTOT,FVOLETOT, VEGHT,CANCOV - (none)
Factor 2	Stem density.	+ DENSW1,DENHW1 - NOSPP10
Factor 3	Litter accumulation; low vegetation patchiness.	+ LITTOCC - (none)
Factor 4	Density of pole softwoods.	+ DENSW2 - GRNOCC
Factor 5	Down wood.	+ WOODHASS - (none)
Forested Stages		
Factor 1	Foliage volume and low plant diversity.	+ NOSPP2M,NOSPP10,FVOLDLO, FVOLELO,DENHW1 - (none)
Factor 2	Large softwoods.	+ VEGHT,MEANDBH,DENSW5, FVOLETOT - LITTDEP
Factor 3	Density of small, medium diam. hardwoods.	+ DENHW1-3 - (none)
Factor 4	Canopy cover, deciduous foliage volume.	+ CANCOV,FOLDTOT - SOILCOV
Factor 5	Density of medium, large softwood stems.	+ DENSW3-5 - DENHW4
Factor 6	Density of large hardwood stems.	+ DENHW5 - DENSW1
Factor 7	Down wood.	+ WOODMASS - (none)
Factor 8	Density of large snags.	+ DENSN2 - (none)

Appendix 3. Continued

SPRING, FALL\b

Shrub Stages

Factor 1	Foliage volume development.	+ VEGHT,FVOLETOT,FVOLDTOT, NOSPPZM - SOILCOV
Factor 2	Density of sapling softwoods.	+ DENSW1,BASW1 - (none)
Factor 3	Basal area, medium diameter hardwoods.	+ BAHW3 - (none)
Factor 4	Down wood.	+ WOODMASS - LITTOCC,NOSPP10
Factor 5	Low vegetation patchiness.	+ LITTCOV - GRNCOV,GRNOCC
Factor 6	Density of pole size hardwoods.	+ DENHW2 - (none)

Forested Stages

Factor 1	Low vegetation cover.	+ GRNOCC,GRNCOV,FVOLELO - (none)
Factor 2	Large diameter softwoods.	+ DENSW5,BASW5 - (none)
Factor 3	Diameter of Dougas-fir stems.	+ MEANDBH - DENSW1-2
Factor 4	Down wood.	+ WOODMASS,NOSPP2M - LITTOCC
Factor 5	Density of small to medium hardwood stems.	+ DENHW1-3 - (none)
Factor 6	Canopy cover.	+ CANCOV - SOILCOV
Factor 7	Snag density,	+ DENSN1-2 - DENSW3
Factor 8	Density of large hardwood stems.	+ DENHW4-5 - (none)
Factor 9	Deciduous foliage volume.	+ FVOLDTOT,FVOLDLO - DENSW4

Appendix 3. Continued

WINTER\b
Shrub Stages

Factor 1	Shrub volume development.	+ FVOLETOT,VEGHT,NOSPP2M - SOILCOV
Factor 2	Litter deposition.	+ LITTOCC,LITTCOV,LITTDEP, NOSPP10 - (none)
Factor 3	Density of sapling softwoods.	+ DENSW1,BASW1 - (none)
Factor 4	Low vegetation patchiness.	+ (none) - GRNCOV,GRNOCC
Factor 5	Down wood.	+ WOODMASS - (none)

Forested Stages

Factor 1	Low vegetation cover.	+ GRNCOV,GRNOCC,FVOLELO,NOSPP10, NOSPP2M - CDSW40,CBASW40,LITTOCC
Factor 2	Large softwoods.	+ DENSW5,BASW5,VEGHT - (none)
Factor 3	Large hardwoods.	+ CDHW40,CBAHW40,DENHW5,DENHW4 - (none)
Factor 4	Stand growth rate.	+ BAGRTHHA\c,DGRTHTR\c, SOILCOV - CANCOV
Factor 5	Density of small to medium diameter hardwoods.	+ DENHW1-3 - (none)
Factor 6	Diameter of Douglas-fir stems.	+ MEANDBH - DENSW1-2
Factor 7	Down wood.	+ WOODMASS - LITTOCC
Factor 8	Snag density.	+ DENSN1-2 - (none)
Factor 9	Density of medium diameter softwood stems.	+ DENSW3-4 - (none)
Factor 10	Density of large snags.	+ CDSN40 - NOSPP2M

Appendix 3. Continued

\a See Appendix 2. + = variables(s) loaded positively and significantly onto factor, - = variables(s) loaded negatively and significantly onto factor.

\b Variables associated with deciduous foliage volume were set to 0.5 of their summertime estimated values far factor analysis of spring and fall seasons, and were excluded from factor analysis of winter season.

\c BAGRTHHA = mean stand basal area growth rate (m\2/ha/y) of conifer stems; DGRTHTR = mean diameter growth rate per tree (cm/y) of conifer stems. Determined from increment cores.

Appendix 4. Bird species encountered during surveys in young-growth Douglas fir forest, northwestern California.

Mnemonic\a	Species\b		Migration class\c
GBHE	Great blue heron\f	Ardea herodias	E3?,O\e
MALL	Mallard\f	Anas platyrhynchos	O
TUVU	Turkey vulture	Cathartes aura	L2
SSHA	Sherp-shinned hark	Accipiter striatus	L1,E1?
COHA	Cooper's hawk	Accipiter cooperi	L1,E1?
NOGO	Northern goshawk\f	Accipiter gentilis	E1?
RTHA	Red-tailed hawk	Buteo jamaicensis	PR\d
RSHA	Red-shouldered hawk\f	Buteo lineatus	E3
AMKE	American kestrel	Falco sparverius	PR
GOEA	Golden eagle\f	Aquila chrysaetos	PR
CAQU	California quail\f	Callipepla californica	E3
MOQU	Mountain quail	Oreortyx pictus	E1,PR\d?
NOPH	Northern phalarope\f	Lobipes lobatus	O
BTPI	Band-tailed pigeon	Columba fasciata	L1
WSOW	Western screech owl\f	Otus kennicottii	PR
NPOW	Northern pygmy owl	Glaucidium gnoma	PR
NSOW	Northern saw-whet owl\f	Aegolius acadicus	PR,E1(some)
VASW	Vaux's swift	Chaetura vauxi	L2
ANHU	Anna's hummingbird	Calypte anna	E3
CAHU	Calliope hummingbird	Stellula calliope	L2
RUHU	Rufous hummingbird	Selasphorus rufus	L2
ALHU	Allen's hummingbird	Selasphorus sasin	L2
ACWO	Acorn woodpecker	Melanerpes formicivorus	PR
RBSA	Red-breasted sapsucker	Sphyrapicus ruber	PR\d,L1
DOWO	Downy woodpecker	Picoides pubescens	PR
HAWO	Hairy woodpecker	Picoides villosus	PR
WHWO	White-headed woodpecker\f	Picoides albolarvatus	E2,NOM(winter)
NOFL	Northern flicker	Colaptes auratus	PR
PI40	Pileated woodpecker	Dryocopus pileatus	PR
OSFL	Olive-aided flycatcher	Contopus borealis	L2
WWPE	Western wood pewee	Contopus sordidulus	L2
HAFL	Hammond's flycatcher	Empidonax hammondi	L2
DUFL	Dusky flycatcher	Empidonax oberholseri	L2
HDFL	Hammond's or dusky flycatcher		
WEFL	Western flycatcher	Empidonax difficilis	L2
VGSW	Violet-green swallow	Tachycineta thalassina	L2
BASW	Barn swallow\f	Hirundo rustica	L2
STJA	Steller's jay	Cyanocitta stelleri	PR\d
SCJA	Scrub jay	Aphelocoma coerulescens	PR
CORA	Common raven	~~Corvus corax~~	PR
MOCH	Mountain chickadee	Parus gambeli	PR
CBCH	Chestnut-backed chickadee	Parus rufescens	PR
BUSH	Bushtit	Psaltriparus minimus	PR
RBNU	Red-breasted nuthatch	Sitta canadensis	PR

Appendix 4. Continued

WBNU	White-breasted nuthatch	*Sitta carolinensis*	PR\d
BRCR	Brown creeper	*Certhia americana*	PR
BEWR	Bewick's wren	*Thryomanes bewickii*	PR
HOWR	House wren	*Troglodytes aedon*	L2
WIWR	Winter wren	*Troglodytes troglodytes*	L1
GCKI	Golden-crowned kinglet	*Regulus satrapa*	PR
RCKI	Ruby-crowned kinglet	*Regulus calendula*	E2
WEBL	Western bluebird	*Sialia mexicana*	PR\d
TOSO	Townsend's solitaire	*Myadestes townsendi*	PR\d
HETH	Hermit thrush	*Catharus guttatus*	L1,E1(some)
AMRO	American robin	*Turdus migratorius*	L1
VATH	Varied thrush	*Ixoreus naevius*	E2,L1
WREN	Wrentit	*Chamaea fasciata*	PR
CEWA	Cedar waxwing	*Bombycilla cedrorum*	L3,NOM(winter)
SOVI	Solitary vireo	*Vireo solitarius*	L2
HUVI	Hutton's vireo	*Vireo huttoni*	PR
WAVI	Warbling vireo	*Vireo gilvus*	L2
OCWA	Orange-Frowned warbler	*Vermivora celata*	L2
NAWA	Nashville warbler	*Vermivora ruficapilla*	L2
YEWA	Yellow warbler\f	*Dendroica petechia*	L2
YRWA	Yellow-rumped warbler	*Dendroica coronata*	PR\d
BGWA	Black-throated gray warbl r	*Dendroica nigrescens*	L2
TOWA	Townsend's warbler	*Dendroica townsendi*	L3
HEWA	Hermit warbler	*Dendroica occidentalis*	L2
MGWA	MacGillivray's warbler	*Oporornis tolmiei*	L2
WIWA	Wilson's warbler	*Wilsonia pusilla*	L2
WETA	Western tanager	*Piranga ludoviciana*	L2
BHGR	Black-headed grosbeak	*Pheucticus melanocephalus*	L2
LABU	Lazuli bunting	*Passerina amoena*	L2
GTTO	Green-tailed towhee	*Pipilo chlorurus*	L2
RSTO	Rufous-sided towhee	*Pipilo erythrophthalmus*	PR\d
CHSP	Chipping sparrow	*Spizella passerina*	L2
FOSP	For sparrow	*Passerella iliaca*	PR\d
SOSP	Song sparrow	*Melospiza melodia*	PR
LISP	Lincoln's sparrow\f	*Melospiza lincolnii*	E2
GCSP	Golden-crowned sparrow	*Zonotrichia atricapilla*	L3
WCSP	White-crowned sparrow	*Zonotrichia leucophrys*	L3
DEJU	Dark-eyed junco	*Junco hyemalis*	PR\d
WEME	Western meadowlark\f	*Sturnella neglecta*	E3
STAR	Starling\f	*Sturnella vulgaris*	E3
BHCO	Brown-headed cowbird\f	*Molothrus ater*	E3
BRBL	Brewer's blackbird\f	*Euphagus cyanocephalus*	E3
PUFI	Purple finch	*Carpodacus purpureus*	PR,L1?
RECR	Red crossbill	*Loxia recurvirostra*	NOH
PISI	Pine siskin	*Carduelis pinus*	PR,L1?
LEGO	Lesser goldfinch	*Carduelis psaltria*	E1(most), PR\d(some)

Appendix 4. Continued

AMGO	American goldfinch\f	Carduelis tristis	E3
EVGR	Evening grosbeak	Coccothraustes vespertinus	PR\d

\a Bird mnemonics follow convention set by Klimkiewicz and Robbins (1978).
\b Species names after American Ornithologists' Union (1983).
\c See Table 14 for descriptions of migration classes.
\d Present year-long in study area but are elevationally displacement migrants.
\e 0 = use other, special habitats within general study ares (aquatic habitats).
\f Rarely observed species (< 5 observations per season).

Appendix 5. Effective detection areas (EFFAR; ha) estimated for bird species (years combined) by successional stage (pole and medium sawtimber combined into "forest") in young-growth Douglas-fir. northwestern California. EFFAR valves may be used in conjunction with estimates of species-specific densities to back-calculate the original mean number of detections made of each species during surveys at count points in the ith successional stage and the jth season, as follows:

$$\text{Mean no. birds counted}_{ij} = \frac{(\text{species density}_{ij})\ (\text{EFFAR}_{ij})\ (12\ \text{counts/survey})}{40.5\ \text{ha}}$$

For example, in summer 1981, the original mean number of brom creepers counted during field surveys in the medium sawtimber stage can be baek-calculated from their density (32.1 brown creepers/40.5 ha, from Appendix 6) and EFFAR (0.54 ha. from this Appendix). as:

$$\text{Mean 5.14 brom creepers counted per survey} = \frac{(32.1\ \text{creepers}/40.5\ \text{ha})\ (0.54\ \text{ha})\ (12\ \text{counts/survey})}{40.5\ \text{ha}}$$

	Breeding				Summer			
		Shrub/sapling				Shrub/sapling		
Species	Grass/ Forb	Early	Late	Pole & medium sawtimber	Grass/ Forb	Early	Lace	Pole 6 medium sawtimber
Sharp-shinned hawk								2.49
Red-tailed hawk								3.93
American kestrel						5.15		
Mountain quail		5.28	4.97	7.09	4.31	2.28	1.16	2.65
Band-railed pigeon					2.38	2.26	2.89	0.33
Anna's hummingbird	0.08		0.09				0.03	
Calliope hummingbird			0.21					
Acorn woodpecker		14.51		1.53		2.11	10.06	4.25
Red-breasted sapsucker			1.75	0.50				0.22
Downy woodpecker								4.34
Hairy woodpecker				1.14				1.96
Northern flicker		5.85	5.70			5.03	5.72	8.31
Pileated woodpecker								5.55
Olive-sided flycatcher	10.29	6.74	5.20		3.70	12.69	5.47	
Western wood pewee	6.16		6.33		1.98	3.99	6.24	
Hammond's flycatcher				0.51				
Dusky flycatcher	1.26	0.98	1.01			1.47	1.08	
Hammonds's or Dusky flyc.		1.26	1.01			1.47	1.08	
Western flycatcher	3.78			1.45	2.40	3.59	0.85	0.95
Violet-green swallow					0.47	3.19		
Steller's jay	9.07	4.65	4.66	2.96	4.26	4.59	2.15	4.17
Scrub jay		6.19				3.49		
Common raven				7.97		4.45		4.23
Mountain chickadee	2.20	1.02	1.21	1.29		2.42	1.64	2.66
Chestnut-backed chickadee	2.20	1.02	1.21	0.70	2.81	1.02	0.93	0.61
Bushtit			0.41		1.09	0.39	0.39	
Red-breasted nuthatch				4.27			1.27	1.75
White-breasted nuthatch								2.49
Brown creeper				0.70				0.54
Bewick's wren		1.16	2.16			0.92		
House wren	1.04	0.99	0.85		1.43	1.09	0.49	
Winter wren				0.75				0.78
Golden-crowned kinglet				0.72				0.34
Western bluebird	0.60	2.49			0.59	2.39		
Townsend's solitaire							0.46	
Hermit thrush		3.82	4.28	3.69		0.42	0.73	0.72
American robin			4.09	2.31	3.75	2.98	1.33	1.72
Wrentit		1.27	1.77			0.85	0.59	
Cedar waxwing							0.73	

Appendix 5. Continued

Species	Breeding: Grass/ Forb	Breeding: Shrub/sapling Early	Breeding: Shrub/sapling Late	Breeding: Pole 6 medium sawtimber	Summer: Grass/ Forb	Summer: Shrub/sapling Early	Summer: Shrub/sapling Late	Summer: Pole 6 medium sawtimber
Solitary vireo		5.16	1.99	2.26		3.31	3.64	2.03
Hutton's vireo						3.16	1.42	2.14
Warbling vireo	5.14		1.34	5.22				0.98
Orange-crowned warbler		0.58	0.89					
Nashville warbler	3.00	0.80	0.74	1.44		0.52	0.27	
Yellow-rumped warbler	0.89	0.64	4.66	2.51		0.63		1.22
Black-throated gray warbler		1.03	2.94	1.84		0.30	0.16	0.36
Hermit warbler	9.18	3.91	6.10	1.46				0.30
MacGillivray's warbler	2.38	0.93	1.00			0.92	0.56	
Wilson's warbler		1.50	0.82	1.58	1.66	0.54	0.24	0.46
Western tanager		6.20	4.05	3.07	2 6 5	1 4	0.76	2.43
Black-headed grosbeak	5.11	3.54	1.90	2.10	2.47	0.84	0.83	1.06
Lazuli bunting	1.87							
Green-railed towhee						0.68	0.42	
Rufous-sided towhee		1.13	1.19		3.33	1.13	0.74	
Chipping sparrow			1.55				0.98	
Fax sparrow		3.42	0.63			0.59	0.43	
Song sparrow		2.31			2.22			
Dark-eyed junco	1.02	0.50	0.67	0.56	0.52	0.47	0.29	0.37
Purple finch	3.64	0.84	0.79	3.16	0.89	1.61	0.73	2.45
Red crossbill								1.01
Pine siskin	3.18	3.11	3.47	1.51	1.46	1.26	2.08	1.93
Lesser goldfinch		3.06	1.59		2.04	2.09	2.13	2.49

Appendix 5. Continued

Species	Fall Grass/Forb	Fall Shrub/sapling Early	Fall Shrub/sapling Late	Fall Pole & medium sawtimber	Winter Grass/Forb	Winter Shrub/sapling Early	Winter Shrub/sapling Late	Winter Pole & medium sawtimber
Mountain quail		1.31	5.45					
Band-tailed pigeon	6.23	0.82	0.82	0.73		4.92	2.89	0.79
Northern pygmy owl				15.34				
Acorn woodpecker		5.33	10.46	3.85				6.79
Downy woodpecker				3.17				
Hairy woodpecker				3.46				
Northern flicker	2.09	4.43	5.25	4.40				6.33
Pileated woodpecker				5.87				
Steller's jay	5.30	3.52	2.93	1.78		1.94	2.19	3.94
Scrub jay		5.60	1.04			4.05		
Common raven	5.01		5.05	4.66				6.74
Mountain chickadee								1.72
Chestnut-backed chickadee	1.16	0.68	0.51	0.26		0.80	0.75	0.52
Bushtit		0.83	0.33			0.88	0.37	
Red-breasted nuthatch				1.78				2.97
Brown creeper				0.48				0.61
Bewick's wren		0.66	0.45					
Winter wren	0.89	0.49	0.28	0.71	0.87	0.43	0.30	0.54
Golden-crowned kinglet	0.40	0.30	0.26	0.32	0.61		0.21	0.28
Ruby-crowned kinglet	0.70	0.36	0.25	0.40			0.50	0.50
Western bluebird	4.89	3.20	3.33					
Townsend's solitaire			3.75					
Hermit thrush		1.29	0.54	0.57				
American robin	1.78	1.69	2.20	1.97	1.81	4.50	0.49	3.46
Varied thrush	4.36	3.34	3.80	1.64		5.14	1.74	3.67
Wrentit	3.33	1.31	0.71			0.64	1.33	
Cedar waxwing	4.68	0.92	1.11	0.38		3.41	1.34	1.49
Hutton's vireo		1.02	1.25	1.28				1.28
Yellow-rumped warbler	1.29	0.60	1.05	0.39				
Rufous-sided towhee		0.98	0.85					
Fox sparrow	0.50	0.48	0.48			0.60	0.36	
Song sparrow	1.64	0.68						
Golden-crowned sparrow	1.00		0.26					
Dark-eyed junco	0.86	0.48	0.34	0.29		0.66	0.46	
Purple finch	2.62	2.47	1.89	2.31			2.32	
Pine siskin	1.63	3.28	3.25	1.63	2.72		2.63	2.70
Lesser goldfinch	1.42	1.96	2.22	3.14				
Evening grosbeak		1.08	0.73	2.89			2.84	2.06

Appendix 5. Continued

Species	Spring			
	Grass/ Forb	Shrub/sapling Early	Shrub/sapling Late	Pole & medium sawtimber
Mountain quail		4.34	11.74	
Band-tailed pigeon	1.96			
Northern flicker				8.33
Steller's jay		6.36	2.15	5.11
Chestnut-backed chickadee				0.75
Bushtit			0.05	
Brown creeper				1.05
Bewick's wren		0.87		
Winter wren	0.83	0.46	0.80	0.62
Golden-crowned kinglet		0.30		0.30
Western bluebird	1.03			
Townsend's solitaire	4.89			
American robin	3.11	1.73		12.58
Wrentit		0.83	0.26	
Cedar waxwing	4.09			
Hutton's vireo		4.77		3.04
Fox sparrow		0.34		
Dark-eyed junco	0.35	0.47		0.65
Pine siskin				0.94

Appendix . Birds species densities (n/40.5 ha) by successional stage, season, and year, in young growth Douglas fir northwestern California. See Table 3 in text for number of bird count points of each stage surveyed.

Bird Species	Summer 1981									
	Grass/Forb		Early Shrub Sapling		Late Shrub/Sapling		Pole		Medium Sawtimb	
	Mean	S.D	Mean	S.D.	Mean	S.D.	Mean	S D	Mean	S.D.
Turkey vultur			P	-	P	-			P	-
Sharp-shinned hawk	P	-	P	-	P	-				
Cooper's hawk			P	-	P	-				
Red-tailed hawk			P	-	P	-	0.1	0.2	P	-
American kestrel			0.7	2.35	P	-			P	-
Mountain quail	0.5	0.91	3.0	8.66	23.5	23.79	[illegible]	1.5		
Band-tailed pigeon			1.5	23.17	8.0	13.94	P	-		
Northern pygmy owl			P	-	P	-	P	-	P	-
Vaux's swift			P	-						
Anna's hummingbird	P	-	P	-	P	-				
Calliope hummingbird										
Rufous hummingbird			P	-						
Allen's hummingbird										
Acorn woodpecker			7.7	12.91	0.1	0.23			[illegible]	0.35
Red-breasted sapsucker			P	-		-	P	-	P	-
Downy woodpecker										
Hairy woodpecker	P	-	P	-	P	-	0.7	1.65	2.0	3.78
Northern flicker	P	-	2.8	2.59	1.0	0.88	0.4	0.70	0.6	0.51
Pileated woodpecker					P	-	0.2	0.46	0.2	0.46
Olive-sided flycatcher					0.6	1.73			P	-
Western wood pewee	5.7	9.84	1.8	4.5	0.6	1.59	P	-		
Hammond's flycatcher										
Dusky flycatcher										
Hammond's or Dusky Flyc			P	-	P	-				
Western flycatcher			0.1	0.33	2.8	6.50	P	-		
Violet-green swallow			20.7	55.61	P	-				
Barn swallow			P	-						
Steller's jay	3.2	4.19	7.9	6.78	17.0	15.28	6.7	3.[illegible]7	10.9	4.9[illegible]
Scrub jay			3.4	5.75	P	-				
Common raven			2.4	8.60	P	-				
Mountain chickadee			2.3	9.00	1.8	4.11	0.8	2.46		
Chestnut-backed chickadee	3.0	7.72	16.1	25.07	19.4	14.70	109.0	80.51	133.6	90.00

Appendix 6. Continued.

	Summer 1981									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.U.
Bushtit			27.7	59.98	57.3	97.37	P	–		
Red-breasted nuthatch	P	–	P	–	21	4.32	11.7	14.11	3.3	4.69
White-breasted nuthatch			P	–			12	2.40	0.2	0.51
Brown creeper					P	–	31.7	38.23	32.1	21.98
Bewick's wren	P	–	27	4.70	P	–				
House wren	24	4.09	81	11.21	231	26.55				
Winter wren			P	–	P	–				
Golden-crowned kinglet					P	–	30.5	37.24	45.4	64.80
Western bluebird			79	17.89	P	–				
Townsend's solitaire			P	–	26	5.46	P	–		
Hermit thrush			96	16.13	25	4.20	0.7	1.76	P	–
American robin	24	2.75	51	9.91	47	7.37	4.2	5.36		
Varied thrush										
Wrentit			45.0	39.10	41.7	61.91				
Cedar waxwing					19.8	55.61				
Solitary vireo			P	–	0.3	0.77	0.5	1.84		
Hutton's vireo			2.1	2.34	8.2	5.65	7.4	4.43	9.0	3.61
Warbling vireo			0.4	1.37	P	–	0.8	2.87		
Orange-crowned warbler			P	–	P	–	P			
Nashville warbler			1.7	5.18	2.7	5.32	P			
Yellow warbler										
Yellow-rumped warbler			0.7	2.77						
Black-throated gray warbler			3.8	9.19	4.5	8.98	0.7	2.60		
Townsend's warbler										
Hermit warbler					P	–	P	–		
MacGillivray's warbler	6.2	10.68	0.7	2.06	2.2	5.07	P	–		
Wilson's warbler			7.1	22.52	32.1	37.99	1.7	4.40		
Western tanager	7.6	6.62	16.6	17.68	23.8	15.05	4.6	5.12		
Black-headed grosbeak	0.9	1.59	19.0	22.80	3.5	5.72	1.5	3.58		
Lazuli bunting										
Green-tailed towhee			6.3	14.71	10.3	17.67				
Rufous-sided towhee	0.7	0.58	37.0	24.80	36.5	26.60				

Appendix 6. Continued.

	Summer 1981									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pale		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Chipping sparrow					0.3	0.92				
Fox sparrow			1.1	2.37	2.8	7.30				
Song sparrow	P	-	0.3	0.92			P	-		
Golden-crowned sparrow										
White-crowned sparrow										
Dark-eyed junco	155.8	131.74	209.2	169.90	267.7	226.41	36.5	67.13	2.6	4.45
Brown-headed cowbird										
Brewer's blackbird					P	-				
Purple finch			9.9	14.12	19.2	31.46	0.5	0.90		
Red crossbill			P	-			0.3	0.93		
Pine siskin	79.4	129.54	16.1	19.24	0.4	0.95	0.7	1.52	1.8	3.03
Lesser goldfinch	95.4	146.64	19.6	19.39	7.9	7.98	1.2	1.45		
American goldfinch			P	-						
Evening grosbeak			P	-						

Appendix 6. Continued.

	Pall 1981									
	Grass/Forb		Early Shrub/Sapling		late Shrub/Sapling		Pole		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Great blue heron			P	-						
Turkey vulture					P	-				
Sharp-shinned hawk	P	-	P	-	P	-	P	-		
Northern goshawk	P	-								
Red-tailed hawk	P	-	P	-	P	-			P	-
Red-shouldered hawk			P	-						
American kestrel	P	-								
Mountain quail	P	-	14.3	30.06	1.8	2.80	P	-	P	-
Northern phalarope			P	-						
Band-tailed pigeon	0.2	0.50	18.1	60.49	25.2	69.4	6.7	14.51	P	-
Northern pygmy owl	P	-	P	-	P	-			0.1	0.19
Northern saw-whet owl									P	-
Vaux's swift	P	-								
Anna's hummingbird					P	-				
Acorn woodpeckec	P	-	1.7	2.76	1.1	2.43	0.9	3.73	1.4	2.89
Red-breasted sapsucker	P	-			P	-	P	-	P	-
Downy woodpecker							0.1	0.27	0.3	0.60
Hairy woodpecker	P	-	P	-	P	-	0.8	1.14	1.5	1.73
Northern flicker	1.6	1.67	1.0	1.54	1.0	1.16	1.3	1.42	2.6	1.65
Western flycatcher							P	-	P	-
Violet-green swallow					P	-				
Barn swallow					P	-			P	-
Steller's jay	3.4	2.77	10.6	8.59	14.3	9.86	18.4	15.62	29.9	16.41
Scrub jay			1.6	2.41	3.8	11.93	P	-	P	-
Common raven	1.2	1.80	P	-	0.7	1.34	0.5	0.69	0.7	1.34
Mountain chickadee	P	-	P	-	P	-				
Chestnut-backed chickadee	5.6	7.08	10.6	9.90	13.2	19.03	219.1	183.20	225.3	152.28
Bushtit			32.5	59.50	61.8	149.69	P	-	P	-

Appendix 6. Continued.

Bird Species	Fall 1981 Grass/Forb Mean	Grass/Forb S.D.	Early Shrub/Sapling Mean	Early Shrub/Sapling S.D.	Late Shrub/Sapling Mean	Late Shrub/Sapling S.D.	Pole Mean	Pole S.D.	Medium Sawtimber Mean	Medium Sawtimber S.D.
Red-breasted nuthatch	P	-			P	-	2.1	4.2[a]	7.[illegible]	7.33
White-breasted nuthatch	P	-					P	-		
Brown creeper							50.1	34.65	40.1	22.62
Bewick's wren	P	-	8.9	11.01	5.5	17.40				
Winter wren	13.3	19.03	73.9	51.18	115.8	127.19	39.0	38.65	13.4	15.88
Golden-crowned kinglet	22.3	25.76	107.3	94.11	95.9	83.28	368.5	216.4	269.9	347.27
Ruby-crowned kinglet	8.3	14.82	58.8	53.32	50.5	55.69	29.5	36.19	19.9[a]	42.08
Western bluebird	1.0	1.50	2.5	5.81	0.7	1.52				-
Townsend's solitaire	P	-			0.9	2.46	P	-		
Hermit thrush	P	-	1.7	2.14	17.1	22.23	1.1	3.222	3.5	4.71
American robin	20.4	21.79	110.6	123.08	23.1	06.66	7.0	8.97	8.9	8.24
Varied thrush	0.8	1.49	4.7	4.35	2.5	3.13	3.2	4.44	7.7	7.92
Wrentit	0.9	2.51	26.5	25.64	25.8	37.29	P	-	P	-
Cedar waxwing	1.9	4.82	5.3	20.33	10.7	28.92	3.9	15.54		
Solitary vireo							P	-	P	-
Hutton's vireo	P	-	8.2	7.99	3.8	5.26	9.4	6.81	14.1	8.02
Warbling vireo							P	-		
Orange-crowned warbler					P	-				
Yellow-rumped warbler	27.1	53.46	9.0	24.77	0.8	2.21	0.5	2.16	1.5	4.57
Black-throated gray warbler					P	-			P	-
Townsend's warbler							P	-	P	-
Wilson's warbler					P	-	P	-	P	-
Rufous-sided towhee	P	-	8.5	10.15	15.9	23.79				
Fox sparrow	2.9	9.06	223.1	176.53	101.2	143.17	P	-		
Song sparrow	2.8	10.45	5.3	12.92	P	-	P	-		
Lincoln's sparrow			P	-						
Golden-crowned sparrow	3.1	4.67	P	-	15.8	26.82				
Dark-eyed junco	192.9	125.53	105.0	74.34	124.1	116.62	18.2	44.77	22.6	35.03
Western meadowlark			P	-	P	-				
Starling			P	-						
Brewer's blackbird			P	-						
Purple finch	5.1	4.64	5.0	6.15	9.5	12.20	2.6	2.75	1.5	2.94
Pine siskin	77.7	125.43	22.4	21.36	11.3	15.52	7.1	9.65	11.1	23.15
Lesser goldfinch	17.4	36.16	3.7	4.01	7.0	9.59	0.7	0.85	1.0	1.04
Evening grosbeak			9.0	22.38	10.5	25.54	1.2	2.22	0.1	0.57

Appendix 6. Continued.

	Winter 1982									
	Grass/Forb		Early Shrub/Sapling[a]		Late Shrub/Sapling		Pole		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Sharp-shinned hawk							P	-	P	-
Red-tailed hawk	P	-			P	-	P	-		
Mountain quail					P	-	P	-		
Band-tailed pigeon					3.1	7.10				
Acorn woodpecker					P	-	0.5	1.32	0.7	1.73
Downy woodpecker							P	-		
Hairy woodpecker	P	-			P	-	P	-	P	-
Northern flicker	P	-			P	-	0.1	0.20	0.5	0.68
Pileated woodpecker									P	-
Steller's jay	P	-			15.1	12.25	3.5	5.45	3.1	3.90
Scrub jay					P	-				
Common raven	P	-			P	-	0.6	0.56	0.5	0.77
Mountain chickadee	P	-								
Cheatnut-backed chickadee	P	-			15.0	31.10	86.2	83.85	76.0	54.33
Bushtit					18.2	54.73			P	-
Red-breasted nuthatch							2.3	4.69	1.2	1.97
White-breasted nuthatch							P	-		
Brown creeper							24.5	17.16	26.5	23.79
Winter wren	25.9	15.39			149.7	87.00	20.5	23.03	18.8	21.37
Golden-crowned kinglet	14.1	11.10			189.3	234.94	361.9	160.37	420.2	170.78
Ruby-crowned kinglet	P	-			15.0	24.29	17.4	31.39	6.8	10.59
Western bluebird					P	-				
Townsend's solitaire	P	-								
Hermit thrush									P	-
American robin	1.7	2.87			246.4	339.43	2.5	2.51	1.8	2.42
Varied thrush					4.3	7.81	1.1	0.64	1.3	2.16
Wrentit					4.2	5.08				
Hutton's vireo					P	-	3.8	3.68	3.8	4.10
Yellow-rumped warbler	P	-							P	-
Townsend's warbler					P	-	P	-	P	-
Rufous-sided towhee					P	-				
Fox sparrow					29.2	51.66	P	-		
Song sparrow					P	-				
Dark-eyed junco	P	-			7.3	9.71	P	-	P	-
Purple finch	P	-			1.9	2.06	P	-	P	-
Red crossbill							P	-		
Pine siskin	1.9	3.68			15.8	14.33	3.0	3.30	1.8	2.76
Lesser goldfinch					P	-			P	-
Evening grosbeak	P	-			7.0	7.98	7.7	8.86	4.0	4.88

Appendix 6. Continued.

Bird Species	Spring 1982									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Turkey vulture	P	-								
Red-tailed hawk			P	-			P	-		
American kestrel										
Mountain quail			2.1	3.29	1.5	2.65	P	-	P	-
Band-tailed pigeon							P	-		
Northern pygmy owl							P	-	P	-
Anna's hummingbird										
Allen's hummingbird										
Acorn woodpecker			P	-	P	-			P	-
Red-breasted sapsucker			P	-	P	-	P	-	P	-
Downy woodpecker							P	-		
Hairy woodpecker	P	-					P	-	P	-
Northern flicker	P	-	P	-			0.7	0.76	0.4	0.57
Violet-green swallow			P	-					P	-
Steller's jay			4.2	3.60	23.9	10.28	4.8	8.99	2.9	5.42
Scrub jay			P	-						
Common raven			P	-	P	-			P	-
Mountain chickadee			P	-						
Chestnut-backed chickadee			P	-	P	-	95.3	67.49	143.1	57.93
Bushtit			P	-	P	-	P	-		
Red-breasted nuthatch			P	-			P	-		
White-breasted nuthatch									P	-
Brown creeper	P	-					39.6	23.94	36.6	16.17
Bewick's wren	P	-	11.0	10.53	P	-	P	-		
House wren			P	-						
Winter wren	65.1	17.25	45.4	65.13	16.9	25.54	97.1	53.71	33.8	34.08
Golden-crowned kinglet			30.0	68.12	P	-	230.6	114.45	150.8	124.67
Ruby-crowned kinglet			P	-			P	-	P	-
Western bluebird	16.4	9.27	P	-						
Hermit thrush			P	-	P	-	P	-	P	-
American robin	4.9	6.91	11.1	24.26			0.8	0.87	0.8	0.90
Varied thrush							P	-	P	-

Appendix 6. Continued.

	Spring 1982									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Wrentit	P	-	10.2	6.68	58.4	34.35	P	-		
Hutton's vireo	P	-	2.8	4.59	P	-	9.3	9.22	8.2	3.73
Orange-crowned warbler			P	-						
Townsend's warbler									P	-
Rufous-sided towhee	P	-	P	-						
Fox sparrow	P	-	84.4	113.48	P	-				
Song sparrow	P	-	P	-			P	-		
Dark-eyed junco	347.1	477.30	41.9	52.26	P	-	27.7	28.94	22.9	25.06
Pine siskin	P	-	P	-			15.0	17.06	4.3	6.42
Lesser goldfinch					P	-				
American goldfinch										
Evening grosbeak	P	-	P	-	P	-	P	-		

Appendix 6. **Continued.**

Bird Species	Grass/Forb Mean	Grass/Forb S.D.	Early Shrub/Sapling Mean	Early Shrub/Sapling S.D.	Late Shrub/Sapling Mean	Late Shrub/Sapling S.D.	Pole Mean	Pole S.D.	Medium Sawtimber Mean	Medium Sawtimber S.D.
	Breeding 1982									
Turkey vulture	P	-	P	-						
Sharp-shinned hawk			P	-	P	-	P	-	P	-
Cooper's hawk			P	-	P	-				
Red-tailed hawk	P	-	P	-	P	-	P	-	P	-
American kestrel			P	-	P	-			P	-
California quail	P	-								
Mountain quail	P	-	3.0	3.05	4.3	5.69	0.8	1.06	0.2	0.64
Band-tailed pigeon			P	-	P	-				
Western screech owl									P	-
Anna's hummingbird	73.8	85.70	P	-	135.7	157.98	P	-		
Calliope hummingbird					29.8	63.33	P	-		
Rufous hummingbird	P	-	P	-	P	-				
Allen's hummingbird	P	-	P	-	P	-				
Acorn woodpecker			0.4	1.03	P	-	2.6	5.47	3.8	10.75
Red-breasted sapsucker	P	-	P	-	2.8	6.06	11.3	17.82	1.4	3.91
Downy woodpecker					P	-	P	-	P	-
Hairy woodpecker	P	-	P	-	P	-	5.3	8.15	1.9	3.60
White-headed woodpecker	P	-								
Northern flicker	P	-	1.9	2.37	0.9	1.12	P	-	P	-
Pileated woodpecker			P	-			P	-	P	-
Olive-sided flycatcher	1.0	0.97	1.4	1.43	2.2	3.56	P	-	P	-
Western wood pewee	4.5	4.25	P	-	0.5	0.85	P	-		
Hammond's flycatcher	P	-							15.1	31.41
Dusky flycatcher	5.6	11.89	21.5	18.55	25.9	26.2	P	-		
Hammond's or Dusky flyc.			17.9	23.11	1.6	5.14				
Western flycatcher	1.3	2.07	P	-	P	-	15.5	18.68	33.8	16.3
Steller's jay	0.9	0.74	5.4	4.60	6.1	6.61	10.9	7.31	11.3	7.12
Scrub jay			1.2	2.26	P	-			P	-
Common raven			P	-	P	-	0.6	1.01	0.3	0.53

Appendix 6 Continued.

Bird Species	Breeding 1982									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Mountain chickadee	0.4	0.69	0.8	2.75	1.9	4.86	10.9	26.63		
Chestnut-backed chickadee	2.3	4.11	2.3	3.67	2.7	6.14	49.4	36.90	47.9	30.52
Bushtit			P	-	47.0	133.98				
Red-breasted nuthatch	P	-	P	-	P	-	8.4	4.16	4.7	4.11
White-breasted nuthatch					P	-	P	-	P	-
Brown creeper	P	-	P	-	P	-	24.5	37.49	35.5	24.70
Bewick's wren			8.5	10.98	1.1	1.92	P	-		
House wren	83.6	43.83	21.9	27.22	21.2	27.26	P	-		
Winter wren	P	-	P	-	P	-			7.7	15.43
Golden-crowned kinglet			P	-	P	-	0.4	1.35	9.0	16.49
Western bluebird	18.3	42.24	3.1	5.52	P	-			P	-
Townsend's solitaire	P	-	P	-	P	-	P	-	P	-
Hermit thrush	P	-	2.4	3.35	8.5	9.62			3.3	7.63
American robin	P	-	P	-	1.1	1.89	3.4	4.68	5.5	11.12
Wrentit			25.1	23.76	16.3	11.73				
Solitary vireo	P	-	1.1	1.35	2.4	4.00	8.3	7.49	18.9	9.99
Hutton's vireo			P	-	P	-	P	-	P	-
Warbling vireo	1.3	2.92	P	-	12.4	20.07	1.6	2.71	2.2	2.91
Orange-crowned warbler	P	-	11.6	28.51	14.8	26.02				
Nashville warbler	7.5	9.08	127.5	69.39	132.3	69.36	14.9	14.14	10.7	12.53
Yellow warbler	P	-	P	-						
Yellow-rumped warbler	7.7	15.14	27.2	55.51	0.9	1.45	8.3	8.22	1.8	2.67
Black-throated gray warbler	P	-	16.1	21.67	3.0	2.98	4.6	5.88	2.1	3.04
Hermit warbler	0.7	0.77	1.8	2.27	0.8	1.03	82.7	34.79	107.5	37.99
MacGillivray's warbler	1.9	3.22	29.0	22.17	38.1	25.17	P	-	P	-
Wilson's warbler	P	-	6.4	10.47	39.6	36.10	2.3	2.49	4.4	8.19
Western tanager	P	-	0.7	0.72	3.5	4.10	16.2	7.79	15.6	11.15
Black-headed grosbeak	2.1	1.95	5.5	5.73	28.8	23.44	17.1	9.63	18.9	9.71
Lazuli bunting	22.7	25.04	P	-	P	-				
Green-tailed towhee			P	-	P	-				
Rufous-sided towhee	P	-	40.9	30.30	32.8	18.41	P	-	P	-

Appendix 6. Continued.

	Breeding 1982									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Chipping sparrow	P	-	P	-	3.2	4.05	P	-	P	-
Fox sparrow	P	-	2.4	5.58	27.3	68.48				
Song sparrow			4.9	7.07	P	-				
Dark-eyed junco	65.6	25.78	96.1	86.89	54.8	45.12	41.2	43.22	60.9	43.30
Brown-headed cowbird	P	-	P	-	P	-				
Purple finch	1.2	1.74	26.3	48.31	22.6	31.31	2.0	2.08	2.9	3.62
Red crossbill	P	-					P	-	P	-
Pine siskin	2.5	4.21	4.4	6.10	4.5	7.78	4.3	5.43	10.5	17.10
Lesser goldfinch	P	-	2.5	3.69	4.3	5.39			P	-
Evening grosbeak	P	-	P	-	P	-	0.9	1.68	0.3	0.67

Appendix 6. Continued

	Summer 1982									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Turkey vulture	P	-	P	-			P	-		
Sharp-shinned hawk			P	-	P	-	0.1	0.32	1.7	7.14
Cooper's hawk							P	-		
Red-tailed hawk	P	-			P	-	0.2	0.56	0.7	1.78
American kestrel			0.04	0.17					P	-
Mountain quail	0.8	1.88	11.0	15.54	9.4	10.96	0.1	0.41		
Band-tailed pigeon	10.4	39.04	4.2	7.72	2.9	4.79	2.8	12.05		
Vaux's swift	P	-								
Anna's hummingbird	P	-	P	-	P	-				
Rufous hummingbird			P	-	P	-				
Allen's hummingbird	P	-	P	-	P	-				
Acorn woodpecker	P	-	3.0	7.67	0.6	1.11	0.4	1.87	1.4	2.64
Red-breasted sapsucker	P	-	P	-	P	-	23.9	86.5		
Downy woodpecker			P	-	P	-	0.04	0.18	0.4	1.02
Hairy woodpecker	P	-			P	-	1.5	2.04	1.8	2.18
White-headed woodpecker	P	-								
Northern flicker	P	-	0.5	0.78	1.2	1.28	0.3	0.57	0.5	0.68
Pileated woodpecker	P	-			P	-	0.1	0.33	0.5	0.81
Olive-sided flycatcher	1.5	2.42	0.4	0.41	1.5	2.06	P	-		
Western wood pewee	9.3	12.63	1.1	2.06	0.7	1.80			P	-
Hammond's flycatcher							P	-		
Dusky flycatcher	P	-	19.5	23.37	16.6	25.63	P	-		
Western flycatcher	2.0	4.00	1.9	2.50	2.9	4.61	11.7	14.71	19.3	28.48
Violet-green swallow	11.3	42.22	4.4	16.65	P	-	P	-		
Steller's jay	3.2	4.49	4.6	4.22	29.8	19.88	7.1	3.43	9.5	6.25
Scrub jay			4.3	6.64	P	-				
Common raven	P	-	P	-	P	-	0.2	0.46	0.6	1.84
Mountain chickadee	P	-	3.0	6.62	2.1	5.51	1.6	5.00		
Chestnut-backed chickadee	0.9	1.50	6.2	10.38	P	-	114.3	83.21	94.9	90.51

Appendix 6. Continued

Bird Species	Summer 1982									
	Grass/Forb		Early Shrub/Sapling		late Shrub/Sapling		Pole		Medium Sawtimber	
	Mean	S.D.	Mean	S.D.	Mean	SD	Mean	S.D.	Mean	S.D.
Bushtit	1.3	4.97	26.5	41.95	62.2	106.28				
Red-breasted nuthatch	P	-	P	-	2.4	4.63	24.1	11.74	21.9	10.55
White-breasted nuthatch	P	-	P	-	P	-	0.3	0.99	0.1	0.31
Brown creeper	P	-					47.9	30.47	65.1	35.00
Bewick's wren	P	-	4.9	10.34						
House wren	32.7	29.40	11.6	17.65	16.0	24.36	P	-		
Winter wren	P	-	P	-			2.6	11.22	3.6	7.39
Golden-crowned kinglet					P	-	33.1	74.20	9.9	17.82
Western bluebird	27.8	38.72	3.9	6.55	P	-	P	-		
Townsend's solitaire	P	-	P	-	9.0	12.99	P	-		
Hermit thrush			23.0	40.85	9.9	10.06	6.5	19.77	12.6	22.86
American robin	2.1	2.88	10.0	12.91	14.7	19.21	3.3	4.20	2.2	2.16
Wrentit	P	-	23.6	31.43	35.1	42.43				
Cedar waxwing			P	-	7.2	29.65				
Solitary vireo	P	-	2.8	4.09	1.4	1.93	7.1	6.69	4.1	9.21
Hutton's vireo	P	-	0.9	2.74	1.5	2.98	4.0	5.42	2.8	5.11
Warbling vireo	P	-	P	-	P	-	7.5	11.35	5.8	12.56
Orange-crowned warbler			P	-	P	-	P	-		
Nashville warbler	P	-	21.5	35.27	37.5	84.52	P	-		
Yellow-rumped warbler			2.5	5.68	P	-	4.9	6.48	0.8	3.52
Black-throated gray warbler	P	-	9.8	14.65	34.5	58.78	2.1	5.14	0.5	2.15
Hermit warbler	P	-	P	-	P	-	66.9	64.51	50.9	82.53
MacGillivray's warbler	P	-	38.8	32.55	38.9	34.78	P	-	P	-
Wilson's warbler	2.3	5.40	16.3	19.02	45.4	53.67	7.3	19.17	11.2	19.47
Western tanager	2.2	2.84	12.0	10.70	41.0	37.48	6.9	7.69	7.6	12.65
Black-headed grosbeak	1.5	1.97	21.7	20.98	33.4	35.72	4.1	4.98	10.8	2.87
Lazuli bunting	P	-	P	-						
Green-tailed towhee			14.6	30.16	4.8	11.00				
Rufous-sided towhee	1.0	2.95	39.0	30.86	44.4	33.46	P	-	P	-
Chipping sparrow	P	-	P	-	3.0	6.58	P	-	P	-
Pox sparrow	P	-	27.5	54.53	32.8	102.01	P	-		
Song sparrow	1.0	3.66	P	-			P	-		

Appendix 6. Continued

Bird Species	Summer 1982									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Dark-eyed junco	171.1	[illegible]	[illegible]	103.67	147.8	124.77	127.2	155.26	[illegible]	19.75
Brown-headed cowbird					P	-				
Purple finch	16.5	[illegible]	11.9	[illegible]	36.2	≥ 9.3	2.6	3.16	0.4	0.78
Red crossbill			P	-	P	-	1.7	4.9	0.4	1.53
Pine siskin	[illegible]	[illegible]	11.3	8.78	5.8	733	5.7	8.27	3.1	3.67
Lesser goldfinch	[illegible]	[illegible]	12.4	20.16	3.1	511	0.9	1.80	0.6	1.45
American goldfin h	P	-								
Evening grosbeak	P	-	P	-	P	-	P	-	P	-

Appendix 6. Continued

	Fall 1982									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Mallard			P	-						
Sharp-shinned hawk	P	-	P	-	P	-	P	-	P	-
Cooper's hawk	P	-	P	-			P	-		
Northern goshawk					P	-				
Red-tailed hawk			P	-	P	-	P	-	P	-
American kestrel					P	-				
Mountain quail	P	-	2.6	6.82	1.2	1.66	P	-	P	-
Band-tailed pigeon	5.7	11.15	142.14	224.41	148.5	201.23	22.9	33.32	30.4	74.98
Northern pygmy owl										
Northern pygmy owl			P	-			0.1	0.12	0.2	0.37
Anna's hummingbird	P	-	P	-	P	-	P	-		
Acorn woodpecker			0.6	1.80	0.1	0.22	1.1	4.75	1.9	3.71
Red-breasted sapsucker	P	-	P	-	P	-	P	-	P	-
Downy woodpecker	P	-			P	-	0.9	1.31	1.2	1.98
Hairy woodpecker	P	-	P	-	P	-	1.7	2.08	0.8	1.27
Northern flicker	1.4	2.27	0.9	0.79	1.5	2.06	2.1	2.79	2.4	2.22
Pileated woodpecker	P	-	P	-	P	-	0.4	0.86	0.5	0.75
Olive-sided flycatcher							P	-		
Western wood pewee					P	-				
Western flycatcher			P	-					P	-
Violet-green swallow			P	-	P	-	P	-	P	-
Steller's jay	2.7	3.50	9.1	6.72	17.8	11.06	26.6	20.72	27.1	19.30
Scrub jay			2.2	3.79	2.0	7.17				
Common raven	3.3	1.33	P	-	0.2	0.43	0.8	1.46	1.0	1.33
Mountain chickadee	P	-	P	-	P	-	P	-		
Chestnut-backed chickadee	5.8	12.96	7.9	18.55	20.9	32.47	189.7	125.31	142.1	67.65
Bushtit	P	-	2.2	8.40	20.5	69.98	P	-		
Red-breasted nuthatch	P	-	P	-	P	-	31.4	16.49	16.9	11.05
White-breasted nuthatch					P	-	P	-		
Brown creeper	P	-					4.8	27.91	51.4	35.32
Bewick's wren			8.2	8.43	1.0	2.58				
House wren	P	-	P	-	P	-	P	-		
Winter wren	22.5	33.41	27.6	49.46	39.3	47.28	7.7	9.67	14.5	11.48
Golden-crowned kinglet	1.2	3.06	10.5	30.50	32.7	51.16	86.1	100.60	105.5	85.97
Ruby-crowned kinglet	1.4	3.98	5.0	13.66	24.7	28.97	3.8	9.69	16.9	17.79
Western bluebird	0.1	1.20	3.2	7.01	1.2	3.49	P	-	P	-

Appendix 6. Continued

	Fall 1982									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Townsend's solitaire	P	-	P	-	0.3	0.83	P	-	P	-
Hermit thrush	P	-	10.3	31.43	20.9	26.49	3.0	7.11	2.8	6.65
American robin	5.3	8.74	99.7	237.76	64.1	154.54	4.7	8.25	10.1	15.28
Varied thrush	0.1	0.28	0.9	2.02	1.4	2.61	1.7	2.76	4.4	5.91
Wrentit	0.1	0.27	10.1	13.99	10.1	16.86				
Cedar waxwing	4.3	9.51	29.8	63.95	62.3	90.26	2.0	6.50	19.2	43.03
Solitary vireo			P	-			P	-	P	-
Hutton's vireo	P	-	0.7	1.86	0.2	1.05	4.1	5.59	3.5	3.94
Warbling vireo			P	-			P	-	P	-
Orange-crowned warbler			P	-	P	-	P	-		
Nashville warbler			P	-			P	-		
Yellow-rumped warbler	23.73	48.81	8.6	16.72	9.2	18.68	7.7	17.02	8.2	15.12
Black-throated gray warbler	P	-	P	-	P	-	P	-	P	-
Townsend's warbler					P	-			P	-
Hermit warbler					P	-	P	-	P	-
MacGillivray's warbler			P	-	P	-	P	-		
Wilson's warbler			P	-	P	-	P	-	P	-
Western tanager	P	-	P	-	P	-	P	-	P	-
Green-tailed towhee			P	-	P	-				
Rufous-sided towhee	P	-	23.2	23.59	23.3	29.11	P	-		
Chipping sparrow	P	-								
Fox sparrow	7.2	17.25	76.4	76.37	55.9	51.21			P	-
Song sparrow	1.9	6.07	1.0	2.78			P	-		
Lincoln's sparrow			P	-						
Golden-crowned sparrow	15.9	30.14	P	-	16.4	43.27				
White-crowned sparrow			P	-	P	-				
Dark-eyed junco	105.4	126.59	163.5	180.12	222.7	166.80	46.65	71.30	30.6	52.08
Western meadowlark			P	-						
Brewer's blackbird			P	-	P	-	P	-		
Purple finch	2.1	4.12	2.6	3.03	13.4	13.17	5.6	6.40	7.1	7.45
Red crossbill	P	-	P	-	P	-	P	-		
Pine siskin	5.6	9.35	11.4	25.39	2.2	2.86	6.6	8.65	1.4	2.19
Lesser goldfinch	4.1	7.43	4.9	7.81	5.6	8.31	1.07	1.65	0.6	1.20
Evening grosbeak	P	-			0.2	0.96	0.1	0.38	0.6	1.53

Appendix 6. Continued

Bird Species	Winter 1983									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Red-tailed hawk			P	-	P	-				
Band-tailed pigeon			26.3	38.28			26.1	80.92	129.9	128.33
Acorn woodpecker									0.8	1.09
Red-breasted sapsucker			P	-			P	-		
Downy woodpecker									P	-
Hairy woodpecker							P	-	P	-
White-headed woodpecker			P	-						
Northern flicker	P	-	P	-			0.3	0.37	0.2	0.29
Pileated woodpecker							P	-		
Western flycatcher							P	-		
Steller's jay			11.4	12.91	7.7	4.63	1.8	3.39	3.8	4.40
Scrub jay			1.6	2.34						
Common raven	P	-	P	-			0.4	0.61	0.3	0.45
Mountain chickadee			P	-	P	-	5.9	18.62		
Chestnut-backed chickadee			13.4	19.77	3.0	5.20	132.4	114.90	112.9	82.69
Bushtit			14.6	25.08	21.3	36.86				
Red-breasted nuthatch			P	-			14.1	10.70	1.1	2.54
White-breasted nuthatch							P	-		
Brown creeper							20.5	18.64	24.3	36.82
Bewick's wren			P	-						
Winter wren	64.7	32.30	76.3	77.23	131.3	65.92	28.8	26.71	30.0	22.27
Golden-crowned kinglet			P	-	5.4	9.28	311.0	198.37	236.3	121.31
Ruby-crowned kinglet	P	-	P	-	4.5	7.79	102.2	10.46	40.5	43.74
Western bluebird	P	-					P	-	P	-
Townsend's solitaire	P	-	P	-			P	-	P	-
Hermit thrush			P	-			P	-	P	-
American robin	11.2	16.26	7.6	8.63	25.3	43.75	29.3	47.70	17.8	14.26
Varied thrush	P	-	1.0	2.12	0.7	1.12	7.0	6.28	6.8	6.84
Wrentit	P	-	19.7	26.59	P	-				
Cedar waxwing			22.1	60.43	36.1	62.53	20.6	33.18	6.3	14.18
Hutton's vireo							4.2	4.16	5.3	7.46

Appendix 6. Continued

	Winter 1983									
	Grass/Forb		Early Shrub/Sapling		Late Shrub/Sapling		Pole		Medium Sawtimber	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Yellow-rumped warbler									P	-
Rufous-sided towhee			P	-						
Fox sparrow			15.9	19.29	143.8	140.73	P	-		
Song sparrow	P	-	P	-						
Dark-eyed junco	P	-	37.7	34.48	51.4	31.98	P	-	P	-
Purple finch			P	-			P	-	P	-
Red crossbill	P	-	P	-			P	-		
Pine siskin	1.7	1.43	P	-	1.7	2.96	0.3	0.79	0.3	0.56
Lesser goldfinch			P	-						
Evening grosbeak			P	-			0.3	1.04		

Appendix 6. Continued

	Spring 1983									
	Grass/Forb		Early Shrub/Sapling[a]		Late Shrub/Sapling[a]		Pole[a]		Medium Sawtimber[a]	
Bird Species	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Red-tailed hawk	P	-								
Band-tailed pigeon	7.8	18.98								
Northern pygmy owl	P	-								
Hairy woodpecker	P	-								
Northern flicker	P	-								
Steller's jay	P	-								
Common raven	P	-								
Chestnut-backed chickadee	P	-								
Brown creeper	P	-								
Winter wren	35.9	24.18								
Golden-crowned kinglet	P	-								
Ruby-crowned kinglet	P	-								
Western bluebird	24.6	33.34								
Townsend's solitaire	2.5	2.21								
American robin	46.9	68.94								
Cedar waxwing	12.4	30.32								
Hutton's vireo	P	-								
Dark-eyed junco	128.6	138.09								
Purple finch	P	-								
Pine siskin	P	-								
Evening grosbeak	P	-								

[a] Stage not sampled.

Appendix 7. Percent occurrence of bird species at count points by successional stage, season, and year, in young-growth Douglas-fir, northwestern California. See Table 3 in text for number of bird count points of each stage surveyed.

	Summer 1981					
Bird Species	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber	X^2
Turkey vulture	n/a[a]	33	14		14	36.11**
Sharp-shinned hawk		27	21			48.50**
Cooper's hawk		13	7			23.60**
Bed-tailed hawk		20	29		14	13.56**
American kestrel		27	7		14	33.17**
Mountain quail		87	100	69		92.91**
Band-tailed pigeon		80	64	8		125.89**
Northern pygmy owl		7	7	8	14	3.78≠
Vaux's swift		13				39.00**
Anna's hummingbird		7	14			25.67**
Rufous hummingbird		7				21.00**
Acorn woodpecker		53	36		57	55.48**
Red-breasted sapsucker		27	14	8	14	12.24**
Hairy woodpecker		47	7	23	43	34.53**
Northern flicker		87	79	62	100	9.24*
Pileated woodpecker			14	15	29	29.03**
Olive-sided flycatcher			21		14	37.80**
Western wood pewee		40	21	8		53.03**
Hammond's or Dusky flycatcher		7	36			82.12**
Western flycatcher		20	29	15		27.63**
Violet-green swallow		47	7			113.26**
Barn swallow		7				21.00**
Steller's jay		100	100	92	100	0.49≠
Scrub jay		40	7			93.34**
Common raven		20	7			39.52**
Mountain chickadee		13	29	15		28.67**
Chestnut-backed chickadee		80	93	100	100	2.86≠
Bushtit		20	57	8		89.73**
Red-breasted nuthatch		53	36	92	43	33.46**
White-breasted nuthatch		7		46	43	71.25**
Brown creeper			7	85	100	167.88**
Bewick's wren		40	36			76.42**
House wren		60	71			132.85**
Winter wren		20	14	8		20.86**
Golden-crowed kinglet			7	77	57	120.76**
Western bluebird		27	14			48.24**
Townsend's solitaire		40	21	23		38.38**
Hermit thrush		47	29	23	14	20.63**
American robin		67	50	62		63.08**
Wrentit		73	57	8		112.48**
Cedar waxwing			21			63.00**
Solitary vireo		20	14	8		25.27**
Hutton's vireo		73	93	100	100	5.34≠
Warbling vireo		7	7	15		15.55**
Orange-crowned warbler		27	21	8		32.14**
Nashville warbler		20	29	8		60.84**
Yellow-rumped warbler		7				21.00**
Black-throated gray warbler		27	36	23		32.79**
Hermit warbler			7	8		15.13**
MacGillivray's warbler		27	29	15		30.13**
Wilson's warbler		40	64	31		62.24**
Western tanager		93	100	92		95.53**

Appendix 7. Continued

Bird Species	Grass/ Forb	Early Shrub/ Sapling	late Shrub/ Sapling	Pole	Medium Sawtimber	X^2
	Summer 1981					
Black-headed grosbeak	n/a	60	43	31		57.34**
Green-tailed towhee		27	36			65.57**
Rufous-sided towhee		100	100	8		177.85**
Chipping sparrow			14			42.00**
Fox sparrow		20	14			36.12**
Song sparrow		27		8		55.63**
Golden-crowned sparrow		7				21.00**
Dark-eyed junco		100	100	62	57	20.72**
Brewer's blackbird			7			21.00**
Purple finch		80	71	31		90.57**
Red crossbill		7		8		15.13**
Pine siskin		67	21	23	29	40.00**
Lesser goldfinch		100	86	54	29	45.54**
American goldfinch		7				21.00**
Evening grosbeak		7				21.00**

Appendix 7. Continued

	Fall 1981					
Bird Species	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber	χ^2
Great blue heron		7				28.00**
Turkey vulture			4			16.00**
Sharpshinned hawk	29	33	17	6		47.65**
Northern goshawk	7					28.00**
Red-tailed hawk	21	27	17		12	27.09**
Red-shouldered hawk			9			36.00**
American kestrel	14					56.00**
Mountain quail	36	53	70	19	18	51.19**
Northern phalarope		7				28.00**
Band-tailed pigeon	29	27	43	19	6	29.87**
Northern pygmy owl	7	7	9		18	20.34**
Northern saw-whet owl					6	24.00**
Vaux's swift	7					28.00**
Anna's hummingbird			9			36.00**
Acorn woodpecker	14	40	48	6	35	44.45**
Red-breasted sapsucker	21		4	13	18	28.82**
Downy woodpecker				13	24	63.68**
Hairy woodpecker	43	13	9	44	59	55.69**
Northern flicker	79	73	61	75	94	7.42≠
Pileated woodpecker	7	7	4	13	53	100.05**
Western flycatcher				6	6	18.00**
Violet-green swallow			4			16.00**
Steller's jay	100	93	91	88	100	1.24≠
Scrub jay		40	13	6	6	76.62**
Common raven	71	47	39	38	35	18.70**
Mountain chickadee	7	7	4			13.67**
Chestnut-backed chickadee	64	73	70	100	100	14.68**
Bushtit		40	30	13	12	53.05**
Red-breasted nuthatch	21		22	38	82	115.93**
White-breasted nuthatch				19		52.85**
Brawn creeper				100	100	300.00**
Bewick's wren	14	60	22			126.92**
House wren			9		6	24.00**
Winter wren	57	100	91	75	71	14.58**
Golden-crowned kinglet	64	93	100	100	94	9.99*
Ruby-crowned kinglet	43	100	70	69	47	31.47**
Western bluebird	50	33	17		12	67.55**
Townsend's solitaire	36		17	19		63.14**
Hermit thrush	43	67	57	13	47	36.55**
American robin	93	100	74	69	82	7.96+
Varied thrush	50	93	65	50	82	21.76**
Wrentit	14	80	78	6	6	162.52**
Cedar waxwing	21	7	30	6		47.41**
Solitary vireo				13	6	34.95**
Hutton's vireo	36	73	52	94	100	41.69**
Warbling vireo				6		24.00**
Orange-crowned warbler			13			52.00**
Yellow-rumped warbler	64	27	13		12	90.05**
Black-throated gray warbler			9		6	24.00**
Townsend's warbler				25	29	81.74**
Wilson's warbler			9	6	12	21.33**
Rufous-sided towhee	14	60	57			137.89**
Fox sparrow	14	100	61	6		204.44**
Song sparrow	7	40	9	6		80.42**
Lincoln's sparrow		7				28.00**
Golden-crowned sparrow	36	27	35			67.82**
Dark-eyed junco	100	100	96	25	65	55.27**

Appendix 7. Continued

Bird Species	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber	X^2
	Fall 1981					
Western meadowlark		7	4			18.55**
Starling			4			16.00**
Purple finch	71	67	70	69	41	10.18*
Pine siskin	100	93	91	63	65	14.26**
Lesser goldfinch	86	67	70	50	65	9.78*
Evening grosbeak	7	47	30	31	6	50.69**

Appendix 7. Continued

Bird Species	Grass/ Forb	Early Shrub/ Sapling[b]	Late Shrub/ Sapling	Pole	Medium Sawtimber	χ^2
	Winter 1982					
Sharp-shinned hawk				14	7	25.67**
Red-tailed hawk	lI		1I	14		12.67**
Mountain quail			22	14		39.56**
Band-tailed pigeon			22			66.00**
Acorn woodpecker			22	14	21	21.67**
Red-breasted sapsucker	11					33.00**
Downy woodpecker				14		42.00**
Hairy woodpecker	33		22	29	29	2.22≠
Northern flicker	11		11	14	57	65.58**
Pileated woodpecker					14	42.00**
Steller's jay	11		LOO	57	86	73.02**
Scrub jay			II			33.00**
Common raven	56		22	71	43	26.96**
Mountain chickadee	11					33.00**
Chestnut-backed chickadee	22		33	86	86	64.37**
Bushtit			11		7	19.78**
Red-breasted nuthatch				29	57	104.23**
White-breasted nuthatch				29		87.00**
Brown creeper				86	93	179.55**
Winter wren	89		100	100	93	0.93
Golden-crowned kinglet	89		100	100	100	0.93≠
Ruby-crowned kinglet	II		67	86	57	55.11**
Western bluebird			11			33.00**
Townsend's solitaire	22					66.00**
Hermit thrush					14	42.00**
American robin	44		78	86	50	19.77**
Varied thrush			56	86	71	79.45**
Wrentit			78			234.00**
Cedar waxwing			22			66.00**
Hutton's vireo			33	71	79	87.40**
Yellow-rumped warbler	II				7	19.78**
Townsend's warbler			II	14	21	19.91**
Rufous-sided towhee			11			33.00**
Fox sparrow			67	14		150.36**
Sang sparrow			11			33.00**
Dark-eyed junco	II		89	14	14	135.56**
Purple finch	22		78	29	14	69.73**
Red crossbill				14		42.00**
Pine siskin	44		100	86	71	22.89**
Lesser goldfinch			22		14	39.56**
Evening grosbeak	78		89	86	64	4.73

Appendix 7. Continued

Bird Species	Spring 1982					
	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber	X^2
Red-tailed hawk	n/a	17		33		60.24**
Mountain quail		67	50	17	20	45.43**
Band-tailed pigeon				17		51.00**
Northern pygmy owl				17	20	37.49**
Acorn woodpecker		50	50		20	60.00**
Red-breasted sapsucker		17	50	17	20	29.77**
Downy woodpecker				17		51.00**
Hairy woodpecker				50	40	92.22**
Northern flicker		67		67	40	69.17**
Violet-green swallow		33			20	59.38**
Steller's jay		83	100	100	60	12.56**
Scrub jay		33				99.00**
Common raven			25		20	46.11**
Chestnut-backed chickadee		17	50	100	100	74.41**
Bushtit		17	50	17		62.57**
Red-breasted nuthatch		17		33		60.24**
White-breasted nuthatch					20	60.00**
Brown creeper				83	100	186.16**
Bewick's wren		67	25	17		89.28**
House wren		17				51.00**
Winter wren		100	75	100	80	5.85≠
Golden-crowned kinglet		33	25	100	100	78.65**
Ruby-crowned kinglet		50		17	20	59.62**
Western bluebird		67				201.00**
Hermit thrush		17	25	17	20	2.16≠
American robin		50		67	60	62.30**
Varied thrush				50	20	95.71**
Wrentit		83	100	17		143.56**
Hutton's vireo		33	50	83	100	41.94**
Orange-crowned warbler		17				51.00**
Townsend's warbler					40	120.00**
Rufous-sided towhee		67				201.00**
Fox sparrow		100	75			182.14**
Song sparrow		33		17		60.24**
Dark-eyed junco		100	75	83	60	10.48*
Pine siskin		67		83	40	83.22**
Lesser goldfinch			25			75.00**
Evening grosbeak		33	25	50		48.07**

Appendix 7. Continued

Bird Species	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber	X^2
	Breeding 1982					
Turkey vulture	8	23				64.65**
Sharp-shinned hawk		8	5	8	7	8.07+
Cooper's hawk		8	5			21.23**
Red-tailed hawk	42	8	10	25	7	49.41**
American kestrel		8	14		14	27.33**
California quail		8				32.00**
Mountain quail	33	85	95	50	21	73.04**
Band-railed pigeon		8	19			51.70**
Northern screech owl					7	28.00**
Anna's hummingbird	67	46	62	17		87.64**
Calliope hummingbird			29	8		85.30**
Rufous hummingbird	17	23	5			48.67**
Allen's hummingbird	8	38	29			81.60**
Acorn woodpecker		23	19	25	21	23.14**
Red-breasted sapsucker	42	23	29	58	14	35.63**
Downy woodpecker			14	8	7	24.28**
Hairy woodpecker	50	8	19	50	36	43.17**
White-headed woodpecker	8					32.00**
Northern flicker	25	77	52	25	21	58.10**
Pileated woodpecker		8		25	36	74.84**
Olive-sided flycatcher	83	62	62	17	29	57.42**
Western wood pewee	92	31	33	8		158.50**
Hammond's flycatcher	17				21	58.05**
Dusky flycatcher	33	77	81	8		143.79**
Hammond's or Dusky flyc.		46	19			125.54**
Western flycatcher	50	31	33	75	100	60.05**
Steller's jay	92	100	95	100	100	0.57#
Scrub jay		46	10		14	102.29**
Common raven		31	19	42	57	63.58**
Mountain chickadee	42	8	14	17		61.78**
Chestnut-backed chickadee	58	46	38	92	100	46.06**
Bushtit		38	48			131.91**
Red-breasted nuthatch	42	23	10	100	86	118.10**
White-breasted nuthatch				8	14	37.09**
Brown creeper	17	8	5	75	93	172.00**
Bewick's wren		69	43	8		158.08**
House wren	83	69	71	33		91.27**
Winter wren	17	8	14		21	22.50**
Golden-crowned kinglet		8	10	8	50	103.47**
Western bluebird	58	46	10	17	21	55.57**
Townsend's solitaire	42	62	14	25	29	39.34**
Hermit thrush	8	54	57		29	90.85**
American robin	58	62	43	92	79	21.72**
Wrentit		77	52			205.61**
Solitary vireo	25	69	67	92	93	44.00**
Hutton's vireo		23	14	33	29	35.09**
Warbling vireo	67	31	62	50	50	14.88**
Orange-crowned warbler	17	23	48			89.39**
Nashville warbler	75	100	100	75	93	7.33*
Yellow warbler	8	8				24.00**
Yellow-rumped warbler	42	46	43	58	57	4.85**
Black-throated gray warbler	17	62	71	75	43	42.60**
Hermit warbler	75	62	71	100	100	14.92**
MacGillivray's warbler	33	85	75	17	29	97.54**
Wilson's warbler	17	38	90	75	50	62.56**

Appendix 7. Continued

Bird Species	Breeding 1982					
	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber	X^2
Western tanager	58	62	81	100	100	20.06**
Black-headed grosbeak	75	69	95	92	100	8.39+
Lazuli bunting	92	8	19			254.49**
Green-tailed towhee		23	5			70.93**
Rufous-sided towhee	8	92	95	33	29	122.05**
Chipping sparrow	8	46	57	17	7	78.59**
Pox sparrow	8	31	33			74.81**
Song sparrow		46	5			158.90**
Dark-eyed junco	100	100	100	100	100	0.00≠
Brow-headed cowbird	8	23	14			42.67**
Purple finch	58	85	71	67	57	7.68≠
Red crossbill	8			8	7	15.48**
Pine siskin	75	77	86	67	79	2.46≠
Lesser goldfinch	17	69	76		36	108.11**
Evening grosbeak	17	38	38	42	36	11.37*

Appendix 7. Continued

Bird Species	Summer 1982					
	Grass/ Forb	Early Shrub/ Sapling	late Shrub/ Sapling	Pole	Medium Sawtimber	χ^2
Turkey vulture	14	13		6		27.76**
Sharp-shinned hawk		7	18	6	11	21.10**
Cooper's hawk				6		24.00**
Red-tailed hawk	29		14	17	21	28.07**
American kestrel		7			11	28.22**
Allen's hummingbird	21	7	18			42.48**
Mountain quail	36	73	73	11		119.82**
Band-tailed pigeon	7	53	50	6		116.50**
Northern pygmy owl						20.00**
Vaux's swift	7					28.00**
Anna's hummingbird	21	27	50			89.24**
Rufous hummingbird		7	9			24.63**
Acorn woodpecker	7	20	40		47	58.92**
Red-breasted sapsucker	29	27	9	17	5	25.93**
Downy woodpecker		20	9	6	16	24.78**
Hairy woodpecker	14	7	14	44	47	55.98**
White-headed woodpecker	7					28.00**
Northern flicker	43	53	68	33	58	14.31**
Pileated woodpecker	7		5	17	47	93.21**
Olive-sided flycatcher	36	73	73	11		119.82**
Western wood pewee	79	47	27		11	119.54**
Hammond's flycatcher				17		68.00**
Dusky flycatcher		67	73	11		158.08**
Western flycatcher	36	47	36	67	63	17.24**
Violet-green swallow	7	13	9	11		12.50*
Steller's jay	79	93	100	100	95	3.18≠
Scrub jay		40	14			112.30**
Common raven	7	7	9	22	26	23.30**
Mountain chickadee	14	20	23	22		22.84**
Chestnut-backed chickadee	43	47	73	100	100	41.78**
Bushtit	7	53	36			120.35**
Red-breasted nuthatch	57	40	41	100	100	54.46**
White-breasted nuthatch	21	13	18	11	11	5.46≠
Brown creeper	14			89	100	243.23**
Bewick's wren	7	40				128.43**
House wren	100	67	68	6		156.28**
Winter wen	29	13		6	32	49.38**
Golden-crowned kinglet			5	39	37	98.94**
Western bluebird	50	47	14	6		94.15**
Townsend's solitaire	43	27	36	11		53.73**
Hermit thrush		53	68	33	42	66.40**
American robin	71	93	86	50	68	15.29**
Wrentit	14	67	64			157.79**
Cedar waxwing		13	9			34.82**
Solitary vireo	14	60	45	78	63	45.27**
Hutton's vireo	14	20	45	56	53	39.82**
Warbling vireo	21	33	41	56	32	18.39**
Orange-crowned warbler		7	5	6		12.56*
Nashville warbler	14	87	77	11		176.48**
Yellow-rumped warbler		27	14	61	21	83.79**
Black-throated gray warbler	21	47	59	22	21	37.53**
Hermit warbler	14	20	32	89	68	94.60**
MacGillivray's warbler	21	100	86	28	5	148.46**
Wilson's warbler	36	67	77	33	37	33.44**

Appendix 7. Continued

Bird Species	Summer 1982					
	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber	χ^2
Western tanager	50	87	100	78	79	17.09**
Blaek-headed grosbeak	50	73	86	61	37	23.86**
Lazuli bunting	14	7				37.33**
Green-tailed towhee		27	18			72.00**
Rufous-sided towhee	29	87	91	11	5	154.51**
Chipping sparrow	7	13	32	II	5	34.06**
Fox sparrow	7	33	18	6		53.03**
Song sparrow	7	27		6		61.75**
Dark-eyed junco	100	100	100	72	89	5.6%
Brown-headed cowbird			5			20.00**
Purple finch	57	93	91	61	26	46.63**
Red crossbill		33	23	22	II	35.89**
Pine siskin	79	100	82	78	79	4.13#
lesser goldfinch	57	80	59	33	16	50.41**
American goldfinch	7					28.00**
Evening grosbeak	7	20	23	II	5	19.15**

Appendix 7. Continued

Bird Species	Fall 1982					
	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber	χ^2
Mallard		7				28.00**
Sharp-shinned hawk	29	33	30	6	5	37.34**
Cooper's hawk	7	7		6		13.50**
Northern goshawk			9			36.00**
Red-tailed hawk			9	6	5	8.37+
American kestrel			4			16.00**
Mountain quail	7	20	48	11	5	68.29**
Band-tailed pigeon	50	80	83	50	26	39.11**
Northern pygmy owl		7		22	32	66.62**
Vaux's swift		7	9			24.63**
Anna's hummingbird		13	22	11		24.64**
Acorn woodpecker		20	17	11	42	53.00**
Red-breasted sapsucker	7	20	17	28	11	15.98**
Downy woodpecker	36		9	56	32	75.16**
Hairy woodpecker	14	13	9	61	63	94.25**
Northern flicker	50	73	70	72	79	7.08≠
Pileated woodpecker	14	7	9	22	47	53.47**
Olive-sided flycatcher				6		24.00**
Western wood pewee						16.00**
Western flycatcher					5	18.83**
Violet-green swallow		40	17	11	11	55.87**
Steller's jay	71	87	100	100	95	6.55≠
Scrub jay		40	9			122.53**
Common raven	50	27	22	39	53	19.55**
Mountain chickadee	21	20	17	17		19.60**
Chestnut-backed chickadee	50	20	61	100	100	350.61**
Bushtit	7	7	26	6		42.04**
Red-breasted nuthatch	29	33	39	100	100	88.55**
White-breasted nuthatch			4	6		16.00**
Brown creeper	21			100	100	241.47**
Bewick's wren		53	13			159.61**
House wren	29	27	17	11		33.86**
Winter wren	43	27	57	61	89	38.32**
Golden-crowned kinglet	21	13	57	83	100	104.61**
Ruby-crowned kinglet	21	13	57	17	68	73.20**
Western bluebird	29	33	22	17	5	22.68**
Townsend's solitaire	14	40	22	22	16	18.46**
Hermit thrush	14	47	78	28	21	70.35**
American robin	64	73	74	44	89	15.85**
Varied thrush	14	27	43	33	63	37.56**
Wrentit	7	67	52			161.38**
Cedar waxwing	29	40	57	17	32	25.09**
Solitary vireo	7	13		44	11	76.67**
Hutton's vireo	14	13	17	44	63	66.19**
Warbling vireo		13		6	5	23.92**
Orange-crowned warbler		20	39	6		85.54**
Nashville warbler		7		6		19.69**
Yellow-rumped warbler	50	40	52	33	37	6.44≠
Black-throated gray warbler	7	47	22	39	21	36.94**
Townsend's warbler			4		5	13.78**
Hermit warbler			9	22	11	39.67**
MacGillivray's warbler		47	26	11		91.93**
Wilson's warbler		67	35	28	5	106.59**
Western tanager		20	13	39	5	44.81**

Appendix 7. Continued

	Fall 1982					
Bird Species	Grass/ Forb	Early Shrub/ Sapling	late Shrub/ Sapling	Pole	Medium Sawtimber	χ^2
Green-tailed towhee		20	17			56.11**
Rufous-aided towhee	14	80	70	6		169.18**
Chipping sparrow	7					28.00**
Fox sparrow	21	87	87		5	190.10**
Song sparrow	21	27		6		57.67**
Lincoln's sparrow		7				28.00**
Golden-crowned sparrow	50	33	30			85.63**
White-crowned sparrow		13	17			46.33**
Dark-eyed junco	100	100	100	67	79	10.61*
Western meadowlark		7				28.00**
Brewer's blackbird		7		6	5	12.56*
Purple finch	57	87	97	61	84	15.14**
Red crossbill	7	20	9	11		22.26**
Pine siskin	57	67	65	67	42	7.64*
Lesser goldfinch	57	73	70	50	37	15.21**
Evening grosbeak	7		4	11	21	28.81**

Appendix 7. Continued

Bird Species	Winter 1983					
	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber	χ^2
Red-tailed hawk	n/a	9	n/a			n/a
Red-shouldered hawk						
Band-tailed pigeon		55		30	60	
Western screech owl						
Acorn woodpecker					40	
Red-breasted sapsucker		18		20		
Downy woodpecker				20	60	
Hairy woodpeeker				40	40	
Whice-headed woodpecker		9				
Northern flicker		36		50	60	
Pileated woodpecker				30		
Steller's jay		82		50	80	
Scrub jay		36				
Common raven		18		50	40	
Mountain chickadee		27		10		
Chestnut-backed chickadee		45		100	100	
Bushtit		36				
Red-breasted nuthatch		27		90	20	
White-breasted nuthatch				10		
Brown creeper				90	80	
Bewick's wren		27				
Winter wren		100		70	100	
Golden-crowned kinglet		64		100	100	
Ruby-crowned kinglet		36		80	80	
Western bluebird				40	20	
Townsend's solitaire		27		40	20	
Hermit thrush		36		20	20	
American robin		73		90	100	
Varied thrush		64		90	100	
Wrentit		55				
Cedar waxwing		73		50	20	
Hutton's vireo				60	80	
Yellow-rumped warbler					40	
Rufous-sided towhee		45				
Pox sparrow		82		10		
Song sparrow		9				
Dark-eyed junco		91		80	60	
Purple finch		36		70	40	
Red crossbill		18		30		
Pine siskin		64		20	20	
Lesser goldfinch		9				
Evening grosbeak		9		20		

Appendix 7. Continued

Bird Species	Spring 1983					
	Grass/ Forb	Early Shrub/ Sapling[b]	late Shrub/ Sapling[b]	Pole[b]	Medium Sawtimber[b]	χ^2
Red-tailed hawk	17					n/a
Band-tailed pigeon	17					
Northern pygmy owl	17					
Hairy woodpecker	50					
Northern flicker	50					
Steller's jay	50					
Common raven	33					
Chestnut-backed chickadee	33					
Brown creeper	17					
Winter wren	100					
Golden-crowned kinglet	17					
Ruby-crowned kinglet	17					
Western bluebird	100					
Townsend's solitaire	83					
American robin	100					
Cedar waxwing	17					
Hutton's vireo	17					
Dark-eyed junco	100					
Purple finch	17					
Pine siskin	83					
Evening grosbeak	17					

[a] n/a = percent occurrence not calculated because of small number of count points surveyed.

[b] Stage not sampled.

Appendix 8. Coefficients of variation (S.D./mean) of bird densities by successional stage, season, and year, in young-growth Douglas-fir, northwestern California. See Table 3 in text for number of bird count points of each stage surveyed.

Bird Species	Summer 1981				
	Grass/ Forb	Early Shrub/ Sapling	Lace Shrub/ Sapling	Pole	Medium Sawtimber
Red-called hawk				3.61	
American kestrel		3.33			
Mountain quail	1.73	1.46	1.01	1.00	
Band-tailed pigeon		2.02	1.74		
Acorn woodpecker		1.66	2.35		1.81
Hairy woodpecker				2.50	1.92
Northern flicker		0.92	0.91	1.63	0.88
Olive-sided flycatcher			2.80		
Western wood pewee	1.73	2.63	2.75		
Hammond's flycatcher			3.03		
Western flycatcher		2.64	2.29		
Violet-green swallow		2.69			
Steller's jay	1.32	0.86	0.90	0.48	0.45
Scrub jay		1.68			
Common raven		3.54			
Mountain chickadee		3.87	2.33	3.15	
Chestnut-backed chickadee	0.96	1.56	0.76	0.74	0.68
Bushtit		2.09	1.64		
Red-breasted nuthatch			2.07	1.21	1.42
White-breasted nuthatch				2.09	2.65
Brown creeper				1.20	0.67
Bewick's wren		1.75			
House wren	1.73	1.39	1.15		
Winter wren				3.61	
Golden-crowned kinglet				1.22	1.43
Western bluebird		2.26			
Townsend's solitaire			2.09		
Hermit thrush		1.67	1.64	2.44	
American robin	1.15	1.72	1.56	1.27	
Wrentit		0.87	1.49		
Cedar waxwing			2.81		
Solitary vireo		3.87	2.89	3.61	
Hutton's vireo		1.13	0.69	0.60	0.40
Warbling vireo		3.87		3.61	
Nashville warbler		3.00	1.99		
Yellow-rumped warbler		3.87			
Black-throated gray warbler		2.45	1.98	3.61	
MacGillivray's warbler	1.73	2.80	2.36		
Wilson's warbler		3.18	1.18	2.60	
Western tanager	0.87	1.07	0.63	1.11	1.50
Black-headed grosbeak		1.20	1.64	2.42	
Green-tailed towhee		2.34	1.71		
Rufous-sided towhee	0.87	0.64	0.73		
Pox sparrow		2.07	2.60		
Dark-eyed *junco*	0.85	0.81	0.85	1.84	1.71
Purple finch		1.42	1.64	1.69	
Red crossbill				3.61	
Pine siskin	1.63	1.20	2.67	2.26	1.73
Lesser goldfinch	1.54	0.99	1.01	1.26	2.65

Appendix 8. Continued

Bird Species	Fall 1981				
	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber
American kestrel	3.74	3.87			
Mountain quail		2.11	1.53		
Band-tailed pigeon	2.60	3.34	2.75	2.18	
Northern pygmy owl					2.89
Acorn woodpecker		1.68	2.28	4.00	2.00
Downy woodpecker				4.00	2.39
Hairy woodpecker				1.44	1.56
Northern flicker	1.04	1.52	1.15	1.14	0.64
Pileated woodpecker				3.25	1.60
Steller's jay	0.81	0.81	0.69	0.85	0.55
Scrub jay		1.50	3.13		
Common raven	1.49		1.84	1.38	1.97
Chestnut-backed chickadee	1.26	0.94	1.44	0.84	0.68
Bushtit		1.83	2.42		
Red-breasted nuthatch				2.00	1.03
Brown creeper				0.69	0.56
Bewick's wren		1.29	3.14		
Winter wren	1.43	0.69	1.10	0.99	1.18
Golden-crowned kinglet	1.16	0.88	0.89	0.59	1.23
Ruby-crowned kinglet	1.79	0.91	1.10	1.23	2.12
Western bluebird	1.45	2.36	2.29		
Townsend's solitaire			2.85		
Hermit thrush		1.22	1.30	2.90	1.35
American robin	1.26	1.08	1.59	1.29	0.93
Varied thrush	1.92	0.94	1.27	1.38	1.02
Wrentit	2.89	0.97	1.44		
Cedar waxwing	2.60	3.87	2.70	4.00	
Hutton's vireo		0.98	1.40	0.72	0.57
Yellow-rumped warbler	1.64	2.75	2.64	4.00	3.00
Rufoue-sided towhee		1.20	1.50		
Fox sparrow	3.13	0.79	1.41		
Song sparrow	3.74	2.44			
Golden-crowned sparrow	1.49		1.70		
Dark-eyed junco	0.65	0.71	0.92	2.46	1.55
Purple finch	0.92	1.23	1.29	1.07	1.90
Pine siskin	1.62	0.96	1.38	1.36	2.09
Lesser goldfinch	2.03	1.09	1.38	1.16	1.03
Evening grosbeak		2.50	2.45	1.90	4.12

Appendix 8. Continued

Bird Species	Winter 1981				
	Grass/ Forb	Early Shrub/ Sapling[a]	Lace Shrub/ Sapling	Pole	Medium Sawtimber
Band-tailed pigeon			2.28		
Acorn woodpecker				2.65	2.32
Northern flicker				2.65	1.37
Steller's jay			0.81	1.54	1.25
Common raven				0.87	1.70
Chestnut-backed chickadee			2.07	0.97	0.71
Bushtit			3.00		
Red-breasted nuthatch				2.06	1.61
Brown creeper				0.70	0.90
Winter wren	0.60		0.58	1.12	1.34
Golden-crowned kinglet	0.79		1.24	0.44	0.41
Ruby-crowned kinglet			1.62	1.81	1.57
American robin	1.73		1.30	1.00	1.33
Varied thrush			1.81	0.60	1.64
Wrentit			1.20		
Cedar waxwing			2.68		
Hutton's vireo				0.98	1.09
Fox sparrow			1.17		
Dark-eyed junco			1.32		
Purple finch			1.06		
Pine siskin	1.91		0.90	1.09	1.55
Evening grosbeak			1.14	1.15	1.23

Appendix 8. Continued

Bird Species	Fall 1982				
	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber
Mountain quail		2.65	1.40		
Band-tailed pigeon	1.97	1.58	1.35	1.46	2.47
Northern pygmy owl				2.47	1.86
Acorn woodpecker		3.04	2.65	4.24	1.92
Downy woodpecker				1.39	1.61
Hairy woodpecker				1.20	1.54
Northern flicker	1.64	0.88	1.36	1.34	0.92
Pileated woodpecker				2.24	1.55
Steller's jay	1.36	0.74	0.62	0.78	0.71
Scrub jay		1.71	3.63		
Common raven	2.21		2.09	1.91	1.34
Chestnut-backed chickadee	2.23	2.34	1.55	0.66	0.48
Bushtit		3.87	3.42		
Red-breasted nuthatch			4.80	0.53	0.66
Brown creeper				0.58	0.69
Bewick's wren		1.15	2.64		
Winter wren	1.49	1.80	1.20	1.26	0.79
Golden-crowned kinglet	2.54	2.91	1.56	1.17	0.82
Ruby-crowned kinglet	2.89	2.73	1.18	2.59	1.05
Western bluebird	2.70	2.17	3.04		
Townsend's solitaire			3.04		
Hermit thrush		3.05	1.27	2.40'	2.37
American robin	1.66	2.38	2.41'	7	1.51
Varied thrush	2.54	2.30	1.93	1.61	1.33
Wrentit	3.74	1.38	1.66		
Cedar waxwing	2.20	2.15	1.45	3.29	2.25
Hutton's vireo		2.80	2.23	1.36	1.13
Yellow-rumped warbler	2.06	1.94	2.02	2.21	1.84
Rufous-sided towhee		1.02	1.25		
Chipping sparrow					
Fox sparrow	2.39	1.00	0.92		
Song sparrow	3.17	2.80			
Golden-crowned sparrow	1.89		2.64		
Dark-eyed junco	1.20	1.10	0.75	1.53	1.70
Purple finch	1.95	1.15	0.99	1.14	1.05
Pine siskin	1.66	2.23	1.29	1.32	1.54
Lesser goldfinch	1.82	1.58	1.48	1.54	1.94
Evening grosbeak			4.80	2.91	2.76

Appendix 8. Continued

	Spring 1982				
Bird Species	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber
Mountain quail		1.58	1.76		
Northern flicker				1.12	1.42
Steller's jay		0.85	0.43	1.86	1.86
Chestnut-backed chickadee				0.71	0.40
Brown creeper				0.60	0.44
Bewick's wren		0.96			
Winter wren	0.27	0.68	1.51	0.55	1.01
Golden-crowned kinglet		2.27		0.50	0.83
Western bluebird	0.57				
American robin	1.41	2.19		1.08	1.20
Wrentit		0.66	0.59		
Hutton's vireo		1.62		1.00	0.45
Fox sparrow		1.34			
Dark-eyed junco	1.37	1.25		1.05	1.10
Pine siskin				1.14	1.49

Appendix 8. Continued

Bird Species	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber
	Breeding 1982				
Mountain quail		1.02	1.32	1.34	3.13
Anna's hummingbird	1.09		1.16		
Calliope hummingbird			2.12		
Acorn woodpecker		2.29		2.13	2.84
Red-breasted sapsucker			2.20	1.58	2.70
Hairy woodpecker				1.53	1.89
Northern flicker		1.26	1.28		
Olive-sided flycatcher	1.02	1.03	1.64		
Western wood pewee	0.89		1.86		
Hammond's flycatcher					2.08
Dusky flycatcher	2.13	0.86	1.01		
Western flycatcher	1.63			1.20	1.48
Steller's jay	0.79	0.66	1.08	0.67	0.63
Scrub jay		1.86			
Common raven				1.79	1.59
Mountain chickadee	1.81	3.61	2.61	2.44	
Chestnut-backed chickadee	1.79	1.60	2.31	0.75	0.64
Bushtit			2.85		
Red-breasted nuthatch				0.50	0.87
Brown creeper				1.53	0.70
Bewick's wren		1.29	1.72		
House wren	0.52	1.24	1.29		
Winter wren					2.00
Golden-crowned kinglet				3.46	1.82
Western bluebird	2.31	1.76			
Hermit thrush		1.37	1.13		2.29
American robin			1.66	1.37	2.01
Wrentit		0.94	1.38		
Solitary vireo		1.22	1.65	0.90	0.53
Warbling vireo	2.22		1.62	1.68	1.31
Orange-crowned warbler		2.45	1.76		
Nashville warbler	1.21	0.54	0.52	0.83	1.17
Yellow-rumped warbler	1.96	2.04	1.61	0.99	1.46
Black-throated gray warbler		1.34	1.01	1.28	1.45
Hermit warbler	1.13	1.27	1.30	0.42	0.35
MacGillivray's warbler	1.70	0.76	0.66		
Wilson's warbler		1.63	0.91	1.07	1.85
Western tanager		1.01	1.18	0.48	0.71
Black-headed grosbeak	0.91	1.04	0.81	0.56	0.51
Lazuli bunting	1.10				
Rufous-sided towhee		0.74	0.56		
Chipping sparrow			1.26		
Fox sparrow		2.30	2.51		
Song sparrow		1.43			
Dark-eyed junco	0.39	0.90	0.82	1.05	0.71
Brewer's blackbird					
Purple finch	1.40	1.84	1.39	1.06	1.24
Pine siskin	1.70	1.38	1.71	1.27	1.62
Lesser goldfinch		1.50	1.24		
Evening grosbeak			4.58	1.86	2.09

Appendix 8. Continued

Bird Species	Summer 1982 Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber
Sharp-shinned hawk				4.24	4.17
Red-tailed hawk				2.91	2.62
American kestrel		3.87			
Mountain quail	2.24	1.42	1.17	2.91	
Band-tailed pigeon	3.74	1.85	1.64	4.24	
Acorn woodpecker		2.57	2.03	4.24	1.86
Red-breasted sapsucker				3.62	4.36
Downy woodpecker				4.24	2.76
Hairy woodpecker				1.33	1.21
Northern flicker		1.59	1.06	1.79	1.39
Pileated woodpecker				2.47	1.48
Olive-sided flycatcher	1.61	0.97	1.33		
Western wood pewee	1.36	1.92	2.77		
Dusky flycatcher		1.22	1.54		
Western flycatcher	1.89	1.29	1.60	1.26	1.45
Violet-green swallow	3.74	3.81			
Steller's jay	1.42	0.92	0.67	0.49	0.65
Scrub jay		1.54			
Common raven				2.07	3.38
Mountain chickadee		2.23	2.69	3.08	
Chestnut-backed chickadee	1.59	1.68	1.43	0.73	0.95
Bushtit	3.74	1.58	1.71		
Red-breasted nuthatch	3.74		1.94	0.49	0.48
White-breasted nuthatch				3.29	4.36
Brown creeper				0.64	0.54
Bewick's wren		2.11			
House wren	0.90	1.53	1.53		
Winter wren				4.24	2.03
Golden-crowned kinglet				2.24	1.79
Western bluebird	1.38	1.70			
Townsend's solitaire			1.44		
Hermit thrush		1.77	1.02	3.04	1.82
American robin	1.40	1.29	1.31	1.29	1.00
Wrentit		1.33	1.21		
Cedar waxwing			4.15		
Solitary vireo		1.47	1.35	0.94	2.25
Hutton's vireo		3.21	1.97	1.34	1.81
Warbling vireo				1.52	2.17
Nashville warbler		1.63	2.25		
Yellow-rumped warbler		2.27		1.32	3.75
Black-throated gray warbler		1.50	1.70	2.47	4.36
Hermit warbler				0.96	1.62
MacGillivray's warbler		0.86	0.88		
Wilson's warbler	2.32	1.17	1.18	2.61	1.74
Western tanager	1.30	0.89	0.91	1.12	1.66
Black-headed grosbeak	1.34	0.97	1.07	1.22	1.56
Green-tailed towhee		2.07	2.32		
Rufous-sided towhee	2.91	0.79	0.75		
Chipping sparrow			2.21		
Fox sparrow		1.99	3.11		
Song sparrow	3.74				
Dark-eyed junco	0.69	0.69	0.84	1.22	0.91
Purple finch	2.56	0.95	0.82	1.24	2.14
Red crossbill				2.93	4.36
Pine siskin	2.25	0.78	1.28	1.44	1.17
Lesser goldfinch	1.39	1.63	1.66	1.99	2.54

Appendix 8. Continued

Bird Species	Winter 1983				
	Grass/ Forb	Early Shrub/ Sapling	Late Shrub/ Sapling	Pole	Medium Sawtimber
Band-tailed pigeon		1.45		3.11	0.99
Acorn woodpecker					1.37
Northern flicker				1.17	1.37
Steller's jay		1.13	0.60	1.88	1.17
Scrub jay		1.47			
Common raven				1.54	1.48
Mountain chickadee				3.16	
Chestnut-backed chickadee		1.47	1.73	0.87	0.73
Bushtit		1.71	1.73		
Red-breasted nuthatch				0.76	2.24
Brown creeper				0.91	1.51
Winter. wren	0.50	1.01	0.50	0.93	0.74
Golden-crowned kinglet			1.73	0.64	0.51
Ruby-crowned kinglet			1.73	0.86	1.08
American robin	1.45	1.14	1.73	1.63	0.80
Varied thrush		2.09	1.73	0.90	1.00
Wrentit		1.35			
Cedar waxwing		2.73	1.73	1.61	2.24
Hutton's vireo				0.99	1.41
Fox sparrow		1.22	0.98		
Dark-eyed junco		0.92	0.62		
Pine siskin	0.87		1.73	3.16	2.24
Evening grosbeak				3.16	

Appendix 8. Continued

	Spring 1983				
Bird Species	Grass/ Forb	Early Shrub/ sapling[a]	Late Shrub/ sapling[a]	Pole[a]	Medium Sawtimber[a]
Band-tailed pigeon	2.45				
Winter wren	0.67				
Western bluebird	1.36				
Townsend's solitaire	0.87				
American robin	1.47				
Cedar waxwing	2.45				
Dark-eyed junco	1.07				

[a] Stage not sampled.