METHODOLOGIES FOR A COMPREHENSIVE WILDLIFE SURVEY AND HABITAT ANALYSIS IN OLD-GROWTH DOUGLAS-FIR FORESTS

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ABSTRACT.

The management of old-growth forest stands for wildlife requires identifying the wildlife species using such stands and also requires information on the features of stands that define the habitat of each species. The USFS (Region 5) and U.C. Berkeley have recently begun a cooperative study to develop such information for old-growth Douglas-fir in northwestern California. These studies required the development of sampling methods suitable for a wide variety of taxa (all vertebrates except fishes) over a large number of sites. All sampling is centered on 1 to 5 sample points located within each study stand, depending on stand size. Twelve ten-minute bird censuses are run at each point during each of 4, 3-month periods per year, using the variable-radius circular plot technique. small mammals, reptiles, and amphibians are sampled at each point using combinations of live-traps and pitfalls. Larger mammals are surveyed using baited, smoked aluminum track plots, and we are attempting to survey bats using collapsible bat-traps. We measure vegetation characteristics on 3 to 4, 0.04 ha circular elements randomly located near each sample point. Using these methods, we have identified 55 bird species, 19 mammals, 9 reptiles, and 7 amphibians in our preliminary surveys, as well as 94 plant taxa. Our methods may prove suitable for other studies including wildlife monitoring, elucidation of wildlife-habitat relationships, and general wildlife ecology research.

INTRODUCTION

Acreage of old-growth tree stands is decreasing rapidly on public and private lands due to intensive timber management to meet demands for wood products. Older stands have a large volume of commercially valuable timber; forest management policies based on wood production dictate that older stands should be harvested and replaced with younger, more vigorous stands.

But the Forest Service is legally required to provide suitable habitat for all wildlife species on National Forest lands, including those species dependent on old growth stands. To meet this objective, current Region 5 policy requires each forest to maintain a minimum allocation of 5% of the land area occupied by each plant community in an old-growth state. The recommended minimum size of each old-growth stand is 40 acres. Old-growth under these guidelines, is defined to include stand size classes 4 and 5 ("large saw timber" or old-growth sawtimber"). Each stand should contian a minimum of 1 snag greater than 11 inches

DBH plus 0.5 snag greater than 16 inches DBH per acre. At least half of the stand should have a crown canopy closure of at least 70% (USFS, FSM 4/80 R-5 Supp. 231, pp. 2045.14 -- 8-11). National forests in Oregon and Washington have developed similar guidelines, as has the Bureau of Land Management in western Oregon (Mannon and Meslow 1979).

Land managers do not know, at the present time, whether these guidelines are sufficient to meet the habitat requirements of wildlife associated with old-growth forests. Data on the presence and abundance of wildlife species in old-growth stands, and on the features of old-growth stands that influence wildlife, are lacking for California's forests. The present study, initiated in October 1979 as a cooperative effort between Region 5 and U.C. Berkeley, is designed to help fill this gap in our knowledge. The objectives of this study are to:

1) Evaluate methodologies to inventory wildlife in old-growth stands;
2) Conduct a thorough inventory of wildlife species (including birds, mammals, reptiles and amphibians) present in old-growth stands;
3) Describe the structural characteristics of old-growth stands as they relate to wildlife populations; and
4) Develop models to predict the effects of silvicultural treatments in old-growth on wildlife populations.

The purpose of this report is to describe the results of our sampling methodology evaluation (objective 1). We hope that other investigators will contribute to this effort so that we might eventually present a truly comprehensive sampling frame suitable to meet a wide variety of forest wildlife inventory and monitoring goals.

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STUDY AREA

All surveys were conducted on the Six Rivers, Klamath, and Shasta-Trinity National Forests in northwestern California. Studies were limited to forests dominated by Douglas-fir (see Tables for scientific names) tanoak and madrone at elevations less than 1100 m.

PRELIMINARY STUDIES

BIRD CENSUS

Of the many techniques available for censusing birds, the variable circular-plot method (Reynolds et al. 1980) is most suited for censusing a large number of plots in rough terrain. Because the method is so new, however, little information exists to guide researchers toward appropriate study design. Therefore, we initiated several experimental censuses to evaluate optimum procedures.

Time Per Station---We selected 3 study plots, 1 in each of 3 timber strata (D3, D4, D5) and, standing at 1 point, tallied all bird species detected during 10-minute intervals over a 3-hour period on each of 2 days. Additional species were detected on 2 of the plots nearly 3 hours after the start of the census (Figure 1) but most species were detected in the first hour.

we anticipate sampling up to 5 points per plot, depending on stand size, and we intend to census all points within a plot on 1 day. It would take 15 hours to census 5 points for 3 hours each, and 5 hours at 1 hour per point. In order to sample all plots (45 total) we must census 2 per day. Therefore, even 1 hour per point is prohibitive if censuses are to be completed during morning hours.

Our next experiment, then, involved tests of the number of half-hour censuses necessary to maximize the number of species detected. Nine sample points were chosen, 3 in each of 3 timber strata. Each point was censused 6 times for a half-hour and numbers of species were tallied. The results of this study (Figure 2) show that 4 censuses are adequate to record nearly every species ultimately recorded over all 6 periods.

A third experiment was designed to examine the tradeoffs involved in censusing a point on 2 days for 1 hour each day versus 4 days at a half-hour per day. Spending only 2 days per point is advantageous because it reduces total travel time to and from points. However, we found that 15% more species were detected when censusing over 4 different days.

The results of these experiments led us to the decision to sample each point on 4 days for a half-hour per day. During each half-hour all observations will be tallied during 3 successive 10-minute intervals. Thus, each point will be censused 12 times.

<u>Number of Sample Points</u>---Larson and Verner (1978) used only 1 sample point per plot in their variable circular plot censuses. Reynolds et al. (1980) recommended using up to 30 points per plot. Morrison et al. (personal communication) found that 2-6 stations were adequate to calculate bird density and diversity in homogeneous forest stands. The appropriate number of sample points is a function of inter-point variability, stand size, time, and budgetary constraints.

To examine inter-point variability, we censused 2 independent points in 1 plot and compared the number of species detected on each point to the total number of species on both points. We recorded 41 bird species on the plot, and 36 species on each point. Only 31 of the species (76%) occurred on both points.

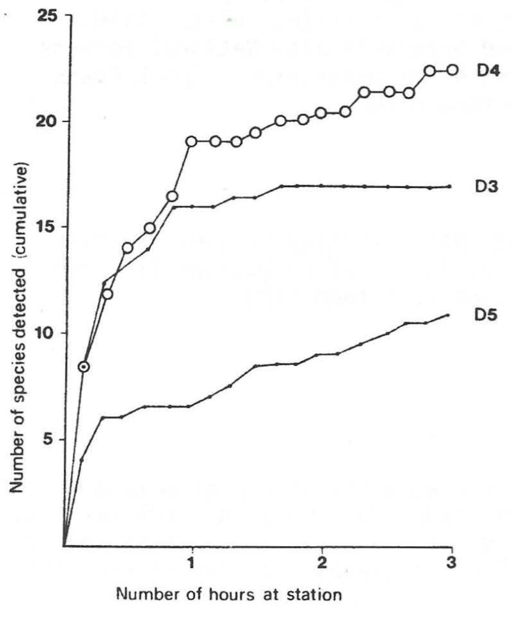

Figure 1. Cumulative number of bird species detected as a function of census duration (average over 2 censuses), by timber strata.

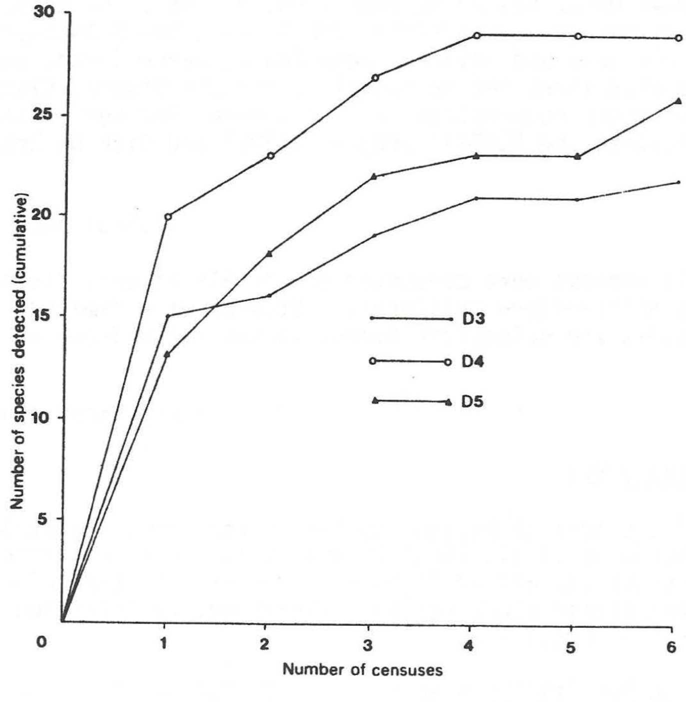

Figure 2. Cumulative number of bird species detected in relation to number of half-hour censuses, by timber strata.

To minimize the probability of detecting the same bird from 2 neighboring points we found that points should be located a minimum of 360 m apart. This distance corresponds to about 10 ha per sample point. Therefore, plots of 10 ha or smaller can support only 1 sample point. Larger plots should have more points, preferably 1 per 10 ha, but other constraints will limit the total number. We feel that 5 points is the maximum number we can visit on any day; this value falls close to the recommendations of Morrison et al. The number of points chosen per plot will, therefore, vary between 1 and 5 depending on total stand size.

Observer Differences---Observers differ in hearing acuity, interest, and ability. To test for the effects of such differences, we censused 1 plot using 2 different teams of observers alternated each day for 3 days. Overall, 41 bird species were detected but only 29 species (70%) were recorded by both teams. Team A detected 4 species not recorded by Team B, and B detected 8 species not recorded by A. These results demonstrated the necessity to rotate teams among sample points, and that 2 independent teams achieve a more thorough census than 1 team. Therefore, we decided to use at least 2 teams for all census work, and to rotate teams among all points.

Results of Preliminary Censuses---Using census methods developed as a result of these experiments, we censused 3 plots (3 points per plot) representing 3 timber strata (Table 1) and recorded 4,000 observations. These data were keypunched and analyzed using CIRPLT, a computer program developed for circular plot data. The D3 plot supported the fewest species (23) and lowest density. The D4 and D5 plots contained comparable numbers of species (29 and 27, respectively) and densities (Table 1).

Table 1. Density of birds (number of detections per 40 ha) censused on old growth study plots, August 1980.

Species	Timber Strata D3	D4	D5
Band-tailed Pigeon (*Columba fasciata*)			+[1]
Common Flicker (*Colaptes auratus*)	+	+	+
Pileated Woodpecker (*Dryocopus pileatus*)			+
Red-Breasted Sapsucker (*Sphyrapicus varius*)		+	+
Hairy Woodpecker (*Dendrocopos villosus*)	+	+	
Hammond's-Dusky Flycatcher (*Empidonax* sp.)			+
Western Flycatcher (*Empidonax difficilis*)	34	19	243
Steller's Jay (*Cyanocitta stelleri*)	1	6	2
Scrub Jay (*Aphelocoma coerulescens*)		+	+
Common Raven (*Corvus corax*)	1	+	+
Chestnut-backed Chickadee (*Parus rufescens*)	157	51	63

Table 1. (continued)

Species	Timber Strata D3	Timber Strata D4	Timber Strata D5
Red-breasted Nuthatch (*Sitta canadensis*)	11	13	14
Brown Creeper (*Certhia familiaris*)	9	112	+
Winter Wren (*Troglodytes troglodytes*)	+		
American Robin (*Turdus migratorius*)	+	+	
Hermit Thrush (*Catharus guttata*)	1	+	6
Golden-crowned Kinglet (*Regulus satrapa*)	10	50	+
Solitary Vireo (*Vireo solitarius*)	+	+	+
Hutton's Vireo (*Vireo huttoni*)	7	2	2
Warbling Vireo (*Vireo gilvus*)	+	+	
Nashville Warbler (*Vermivora ruficapilla*)	+	+	+
Hermit Warbler (*Dendroica occidentalis*)	+	+	2
Black-throated Gray Warbler (*Dendroica nigrescens*)			+
MacGillivray's Warbler (*Oporornis tolmiei*)		+	
Wilson's Warbler (*Wilsonia pusilla*)	+		
Western Tanager (*Piranga ludoviciana*)	+	2	1
Black-headed Grosbeak (*Pheucticus melanocephalus*)	+	+	+
Evening Grosbeak (*Hesperiphona vespertina*)		+	+
Purple Finch (*Carpodacus purpureus*)	+	+	+
Pine Siskin (*Spinus pinus*)	+	+	+
Red Crossbill (*Loxia curviostra*)		+	+
Rufous-sided Towhee (*Pipilo erythrophthalmus*)		+	

Table 1. (continued)

Species	Timber Strata D3	D4	D5
Dark-eyed Junco (*Junco hyemalis*)	8	65	+
Chipping Sparrow (*Spizella passerina*)		+	+
Song Sparrow (*Melospiza melodia*)		+	
TOTAL	243	324	337

[1]+ indicates density less than 1 bird per 40 ha.

MAMMAL LIVE-TRAPPING

Three trap grids were established, 1 each in a D3, D4, and D5 stand. Each square grid consisted of 100 traps, spaced 20 m apart in 10 rows with 10 traps per row. All traps were checked once daily for 8 days after they were set. All captured animals were marked by toe-clipping and released. One of 3 different baits (horsefeed, crushed walnuts, peanut butter and oats) was randomly assigned to each trap, with nearly equal frequency on each plot. Of 114 captures, 46 were with peanut butter, 43 with walnuts, and 25 with horsefeed. Walnuts and peanut butter were equally effective, but walnut costs more per trap and requires more handling time. Therefore, peanut butter and oats will be used in all subsequent small mammal live-trapping.

Five species were captured among all plots after 800 trap-nights of effort (Table 2). The deer mouse was the only species captured with sufficient frequency to permit population and density estimation. Data for this species were analyzed using CAPTURE, a computer program developed by Otis et al. (1978). Estimated population size did not differ among plots but density was significantly higher on the D4 plot (Table 2). Even though sampled population estimates were similar on these plots, densities differ because the animals on the D4 plot was smaller than that on the other plots.

We examined the relationship between estimated population size and its standard error with the number of trapping days (Figure 3). The results suggest that 5 days of trapping is optimum.

Because of the effort required to layout and run these grids, it is not feasible to place a grid on each sample point in each plot. Instead, 1 point will be randomly chosen on each plot for grid placement. If 5 grids can be run at once, it will take 9 weeks to finish all grids. Currently, we plan to run the grids for 2 9-week periods (winter, summer) each year.

PITFALL TRAPS

Pitfall traps offer a number of advantages over conventional live traps; they allow multiple recaptures, do not require constant monitoring, and may catch a greater diversity of vertebrates, including herps (Williams, in press). Our preliminary studies were designed to develop the best methodology for using such traps in north coast forests.

Table 2. Results of live trapping on 3 study plots (800 trap-nights per plot).

Statistic	Timber Strata D3	D4	D5
Number of captures			
Deer mouse (*Peromyscus maniculatus*)	25	24	17
Pinyon mouse (*P. truei*)		1	
W. Red-backed mouse (*Clethrionomys occidentalis*)			1
Dusky-footed wood rat (*Neotoma fuscipes*)	1	3	
Townsend chipmunk (*Eutamias townsendii*)		2	
Estimated population (N ± 2 S.E.)[a]	25 ± 2	32 ± 10	22 ± 8
Estimated density (N/ha ± 2 S.E.)[a]	3 ± 1	9 ± 3	3 ± 1

[a]Values for deer mice only.

Trap Design---Two-gallon plastic buckets were sunk to ground level and covered by square plywood tops supported 3-5 cm above the bucket. A total of 36 buckets was placed in each of 3 timber strata. We tested 3 factors; the number of buckets per station (1, 2, or 3), presence of drift fences (with or without 10 cm tall by 6 m long fences), and medium in buckets (dry, water only, or formalin covered with mineral oil). Six stations were established at 20 m intervals along 3 randomly oriented lines in each of 3 plots (D3, D4, D5 strata). Treatments were randomly assigned so that each plot had all possible combinations of trap design (18 possible combinations). Unfortunately, the D5 plot was rendered unexpectedly inaccessible due to a road closure, so our results apply only to the 2 other plots.

Preliminary summaries of capture frequencies (Table 3) show nearly equal capture rates with 1, 2, or 3 buckets (which allow captured animals to hop out) captured fewer animals. Of the 2 liquid media, water seems to be the more effective. None of these observed differences are, however, statistically significant (3-way ANOVA, $p > 0.10$).

A total of 41 animals of 8 species were captured after 360 station-nights of effort (Table 4). Capture frequencies and number of species captured were nearly equal among the 2 plots.

Trapping Duration---Although all traps were monitored a total of 20 days, all species were captured by day 10 and nearly all individuals were catpured by day 15 (Figure 4).

These results indicate that traps should consist of 1 water-filled bucket without drift fences, and should be run for 15 days. We will continue these experiments, however, to determine whether these results hold during the wet season when amphibians are more active. Pitfall trap lines will consist of 10 traps spaced at 20 m intervals along randomly oriented lines bisecting each sample point.

Table 3. Number of captures (mammals and herps) in relation to pit trap design. Data polled over 2 study plots.

Factor	Number of captures
Number of buckets per station	
1	16
2	10
3	15
Drift fences	
With	24
Without	17
Medium in buckets	
Dry	8
Water only	20
Formalin and oil	13

Table 4. Summary of catch of mammals and herps in pitfall traps.

Species	Timber Strata D3	Timber Strata D4
Trowbridge Shrew (*Sorex trowbridgii*)	4	2
Deer Mouse (*Peromyscus maniculatus*)	11	13
Western Red-backed Mouse (*Clethrionomys occidentalis*)	2	
Painted Salamander (*Ensatina eschscholtzi picta*)	1	1
Western Toad (*Bufo boreas*)	1	
Northern Alligator Lizard (*Gerrhonotus coeruleus*)	3	1
Western Skink (*Eumeces skiltonianus*)		1
Sharp-tailed Snake (*Contia tenuis*)		1
TOTAL	22	19

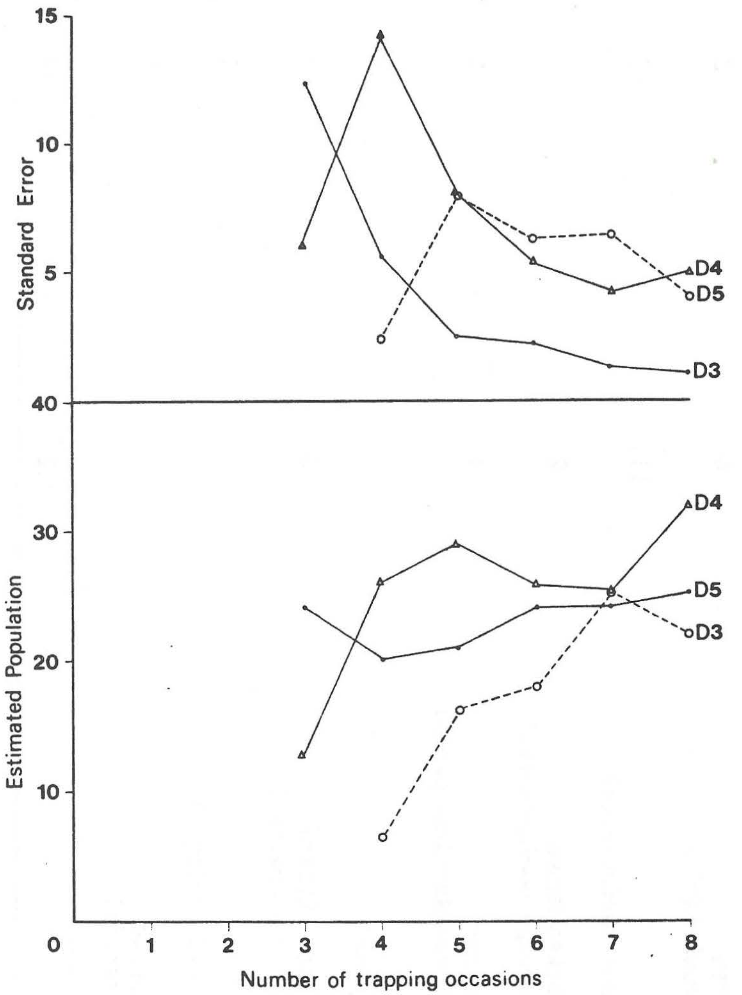

Figure 3. *Peromyscus maniculatus* population estimates and standard errors in relation to days of trapping on 3 old-growth plots, by timber strata.

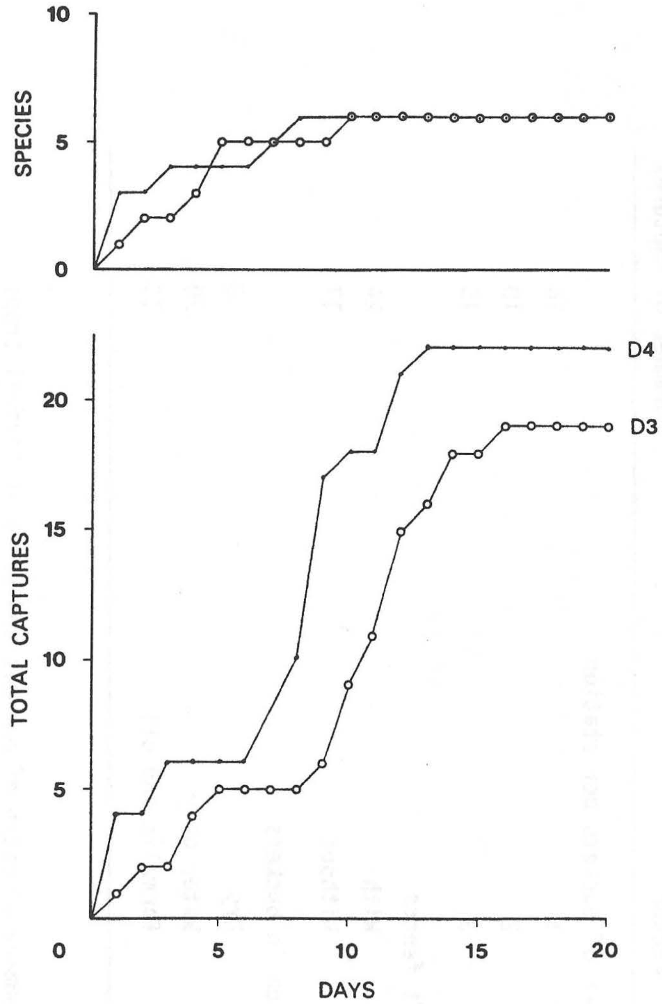

Figure 4. Cumulative number os species and individuals captured in pitfall traps over time, by timber strata.

TRACK PLOTS

Track plots, consisting of square-meter smoked aluminum plates baited with cat food (Barrett, in press), were placed at each of 3 sample points in 3 plots. These were used to document the presence of larger mammals. Seven species were recorded overall, 4 on the D3 plot and 5 each on the D4 and D5 plots (Table 5). All species were recorded by day 11 during a 15 day experimental run (Figure 5). Because of a road closure, the D5 plot was run only 3 days. With the exception of the deer mouse, all species were previously unrecorded on these plots. The track plots are thus an effective addition to the sampling regime.

Table 5. Animal tracks recorded on track plots in each timber type (3 plots per type run for 15 days each.

Species	D3	D4	D5*
Deer mouse (*Peromyscus maniculatus*)	X	X	X
Northern flying squirrel (*Glaucomys sabrinus*)		X	
Douglas Squirrel (*Tamiasciurus douglasii*)			X
Gray squirrel (*Sciurus griseus*)			X
Marten (*Martes americana*)	X	X	X
Black bear (*Ursus americanus*)	X	X	X
Spotted skunk (*Spilogale putorius*)	X	X	

*Plots run only 3 days in this type.

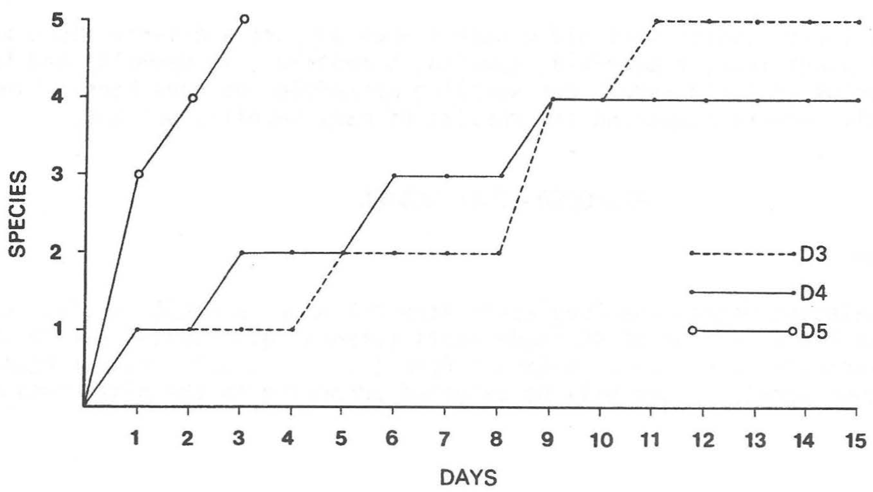

Figure 5. Number of mammal species detected on track plots over time, by timber strata. The D5 plot was sampled only 3 days.

BAT TRAPS

Two collapsible bat traps (Constantine 1958, Tidemann and Woodside 1978) were installed on 1 plot to evaluate their efficacy as a monitoring tool. Traps were placed along natural corridors where bats might be expected to fly and were run with and without 15-watt black lights used to attract flying insects. Only 1 bat was captured after 30 nights of operation. These are not encouraging results, but we will continue to search for methods to survey this little understood but potentially important group.

VEGETATION ANALYSIS

Methods---Complete vegetation analyses were conducted on 3 points in each of 3 plots representing D3, D4, and D5 strata. Four 0.04 ha sample elements were located at random distances from the sample point along 4 cardinal directions (Figure 6). All trees and shrubs greater than 2 m in height were measured within each element. Measurements included plant species, DBH, height, height to crown, crown profile and plan (Mawson et al. 1976), crown radius, and condition (live or dead). The crown measurements were used to compute foliage volume using the computer program HTVOL (Mawson et al. 1976). A 30 m transect line was also placed in a random direction bisecting the sample element. This line was used to measure the total dead and down weight (Brown 1974), to measure duff and litter depth, and to tally larger intersected logs. In addition, understory plants less than 2 m tall were tallied along a 1 m strip on either side of the transect line.

Results---Table 6 shows mean values of selected measurements calculated from the 12 elements sampled in each strata. Notice in particular the number of snags, and litter and duff depth on the 3 strata: there is a clear progression from D3 to D5. Also, the D5 stand has a significantly higher total dead and down volume and density of decay class 5 (Maser et al. 1979) logs.

Another interesting pattern, not evident from total foliage volume alone, is seen in Figure 7. The D3 is basically a single layer canopy with nearly all foliage occurring between 10 and 30 m. The D4 stand shows a double layer with greatest volumes at 25 and 40 m. The D5 stand is more strongly double layered, with layers centered at 15 and 50 m.

Characteristics of the understory vegetation sampled along the element transects are summarized in Table 7. These transects were run in September, after most annuals had dried. We attempt to run these transects at least twice, one during spring, to include more of these ephemeral species.

We have maintained a log of all plant species encountered on the old growth study areas and have initiated a herbarium collection. To date, plants of 94 taxa have been noted (Raphael 1980).

It is apparent from these studies that old growth stands support a diverse flora and fauna. We have recorded 94 plant taxa, 6 amphibian species, 9 reptiles, 19 mammals, and 55 bird species during 6 months of field work. Our sampling methodologies have been refined as a result of an intensive effort comparing the results of many sampling options.

PROPOSED STUDY DESIGN

STUDY PLOT SELECTION

All plots will be selected within the Douglas-fir/tan oak/madrone CALVEG series (Ericksen, N. D.). Our goal is the selection of 45 study plots (stands) distributed evenly among the Six Rivers, Shasta-Trinity, and Klamath National Forests. To assure a representation of stand sizes and timber strata, plots will be selected according to the distribution shown in Table 8.

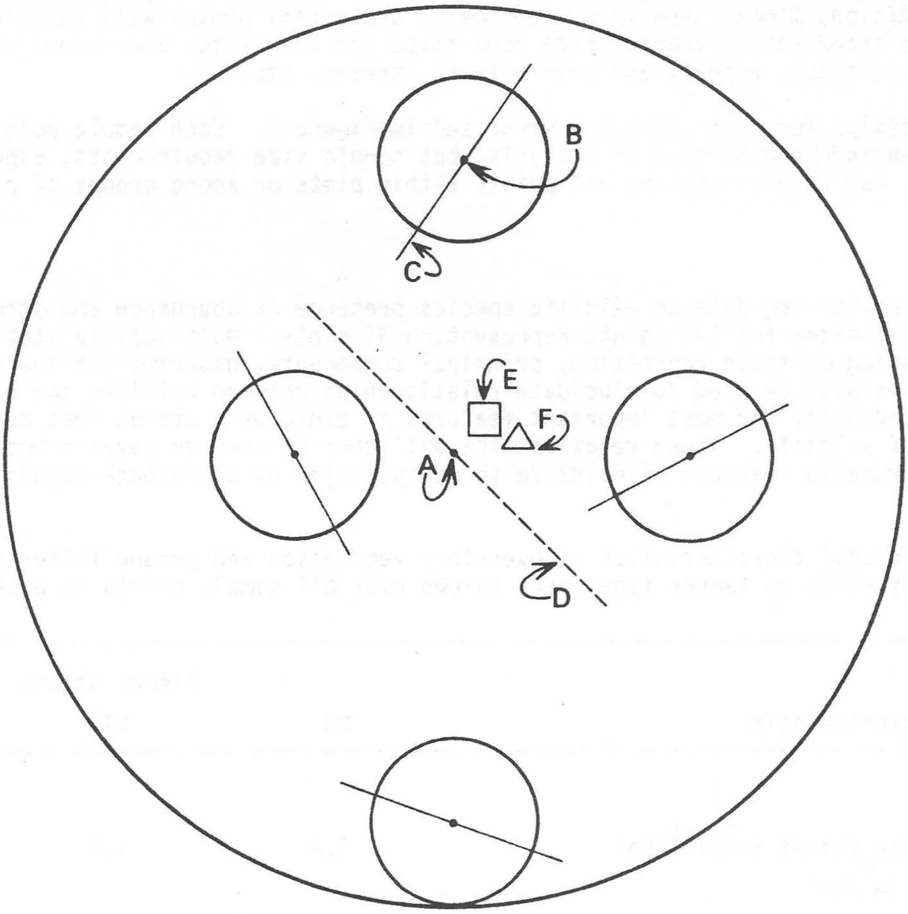

Figure 6. Sampling frame at each sample point (not drawn to scale). A = Point center -- site of bird census, center of live-trapping grid; B = Center of 0.04 ha element -- used for vegetation analysis (4 per point); C = Transect line through element center -- used for dead and down inventory, understory density estimates; D = Pitfall trap line; E = Track plot; F = Bat trap.

Criteria for plot selection, in addition to CALVEG series and size, include accessibility, freedom from other management conflicts, and availability of adequate map and photo information. All plots will be cleared through the appropriate personnel in each district and suprevisor's office with the understanding that forest management goals have priority over our study goals.

SAMPLING METHODS

Bird censuses (and censuses of vocal diurnal mammals) will be conducted on all sample points on 4 days during each of 4, 3-month periods over each of 3 years. Owls will be surveyed using recorded or voice calls on at least 2 nights per sample point on each plot during spring and summer each year. Data will be analyzed using CIRPLT or TRANSECT (Burnham et al. 1980).

Mammal and herp trapping using methods described above, will be conducted at least twice per year over 3 years. In addition, surveys for mammal sign, such as tree nests of *Glaucomys* and *arborimus*, scat, rodent burrows, etc. will be conducted on each sample element during vegetation analyses. Other opportunistic sightings will be recorded onto wildlife observation sheets developed for this purpose.

Vegetation measurements will be gathered at each sample element using methods described above. In addition, timber type maps, topo maps, and aerial photos will be used to map plots, measure stand sizes, characterize edge shape and diversity, and record physiographic features such as slope, aspect, and proximity of streams, etc.

The sampling design for each point is summarized in Figure 6. Each sample point is designed to represent an independent unit of analysis, but sample size requirements, especially for bird censuses, may require pooling all points within plots or among groups of plots.

DATA ANALYSES

We anticipate collecting data on wildlife species presence or abundance and structural features of vegetaiton for 135 points representing 45 plots. Multivariate statistical methods, including multiple regression, principal components, discriminant analysis, and cluster analysis will be used to elucidate relationships between wildlife and habitat features, and to identify the most important features of old-growth stands that define requirements of wildlife. These relationships will then be used to develop models describing the probable response of wildlife to manipulation of old-growth stands.

Table 6. Structural characteristics of overstory vegetation and ground litter on old-growth study plots by timber type (mean values over all sample points in each strata).

Characteristic	Timber Strata D3	D4	D5
Live Trees			
Total foliage volume ($m^3 x 10^5$/ha)	1.4	1.1	1.1
Basal area (m^2/ha)			
Douglas-fir (*Pseudotsuga menziesii*)	30.9	56.0	12.7
Tan oak (*Lithocarpus densiflora*)	1.5	2.8	17.9
Madrone (*Arbutus menziesii*)	2.5	0.8	2.9
Other	2.8	2.1	0.0
Density (stems/ha)			
< 53 cm DBH	626	338	1023
≥53 cm DBH	95	130	62
Snags			
Density (stems/ha)	43	76	152
Mean DBH (cm)	19.8	22.5	9.3
Dead and down volume (metric tons/ha)	58	50	117
Log density (no./ha)			
Decay class[1] 1	10	17	6
2	16	16	4
3	29	56	12
4	19	27	29
5	2	6	14
Litter depth (cm)	4.9	5.3	8.4
Duff depth (cm)	3.8	4.3	6.1

[1]Maser et al. (1979).

Table 7. Density of plants in understory layer[1] by timber strata (no/dm^2).

Species	Timber Strata D3	D4	D5
Equisetum sp.	0.1	7.3	
Pteridium aquilinum	11.3		
Pteridaceae sp.	0.1	0.7	5.8
Polystichum munitum	4.7	5.1	0.2
Woodwardia fimbriata		0.7	
Pseudotsuga menziesii	1.8	1.8	7.8
Lidocedrus decurrens	1.1	0.2	
Mahonia sp.	1.9	6.5	19.7
Achyls triphylla	0.1		1.5
Vancouveria planipetala	30.3	36.8	6.1
Oxalis sp.			1.1
Viola sp.		20.5	
Montia sp.	6.9		
Arbutus menziesii		1.9	0.7
Pyrola picta	1.3		2.4
Chimaphila umbellata	9.2	6.8	34.6
Pityopus californicus			0.3
Apocynum sp.			1.1
Gilia spp.	0.3		
Boschniakia strobilacea			0.6
Whipplea modesta	0.8	6.7	5.5
Ribes spp.	2.0	0.8	0.1
Holodiscus discolor	1.1	0.6	
Fragaria californica		6.1	
Rubus ursinus	44.1	11.7	0.8
Rosa sp.	3.6	2.0	1.9
Corylus cornuta	44.1	11.7	0.8
Lithocarpus densiflora	3.6	2.0	1.9
Quercus kelloggii		0.1	
Quercus garryana	0.1		
Quercus chrysolepis	9.4	2.8	
Rhamnus sp.	2.4		
Acer macrophyllum	3.3	1.0	
Rhus diversiloba	12.2	0.1	1.5
Cornus sp.		0.1	
Galium spp.	23.4	101.0	8.1
Lonicera sp.	8.1		
Campanula spp.	12.8	0.1	4.9
Adenocaulon bicolor		6.1	
Compositae	7.2	62.9	
Smilacina racemosa		0.1	
Smilacina stellata		1.5	
Iris sp.	2.1	3.5	0.3
Cypripedium sp.		0.1	
Eburophyton austinae		0.1	
Goodyera oblongifolia	1.1	6.9	0.3
Corallorhiza mertensiana			0.8
Graminae spp.	35.5	176.0	1.8
TOTAL	146	350	164

[1]Plants less than 2 m tall.

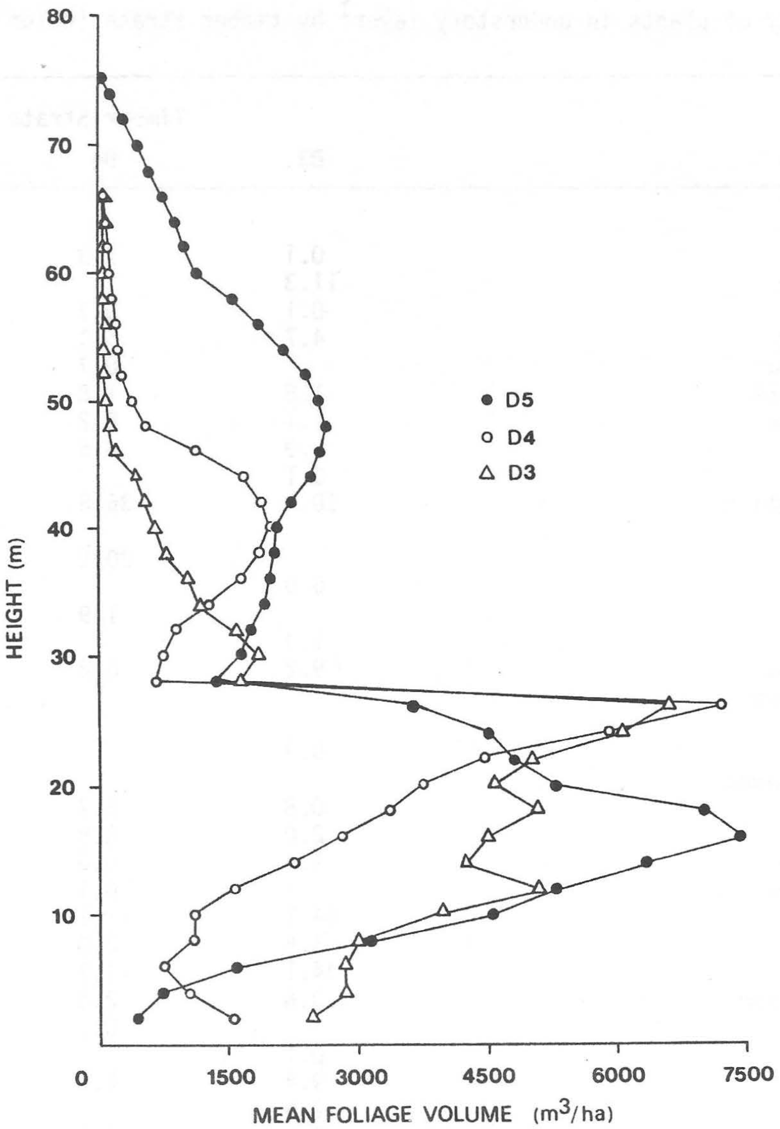

Figure 7. Vertical distribution of foliage volume by timber strata. Values averaged over 12 elements per strata.

Table 8. Proposed distribution of study plots and sample points by stand size and timber type (stratum).

Median size of plot (ha)	Number of sample points per plot	Number of plots in each stratum D3	D4	D5	Total points
10	1	3	3	3	9
20	2	3	3	3	18
40	3	3	3	3	27
60	4	3	3	3	36
>80	5	3	3	3	45
TOTALS		15	15	15	135

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