A NATIONAL STUDY OF THE CONSEQUENCES OF FIRE AND FIRE SURROGATE TREATMENTS

Study plan

Blodgett Forest Research Station
Study Site

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Prepared and Assembled by the
Blodgett Forest FFS Research Team

Special Thanks to Frieder Schurr
For Map Preparation

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I.   DEFINITIONS FOR TERMS USED IN THE BLODGETT FOREST STUDY SITE PROTOCOLS

1. **Compartment**- Blodgett Forest is divided into several sub-units ranging from a few to over 70 acres in size. Each sub-unit has a unique number and assigned set of silvicultural treatments or research uses. The sub-units are called compartments. For the purposes of this study, a treatment unit is a compartment which has been assigned as one of the 4 fire surrogate study treatments (mechanical only, mechanical plus fire, fire only, control).

2. **Existing 1/10th acre matrix plots**- this term refers to 1/10th acre plots which were established in the matrix area on a 6 chain grid prior to the densification to a 3 chain grid for the Fire and Fire Surrogate Study. Most of these plots were established in the 1970's. They are numbered 1-50. The numbering sequence starts at "1" in each individual compartment or treatment unit.

3. **Grid point**- a grid point is defined as the plot center of a 1/10th acre plot. The 1/10th acre plots are established on a 3 chain by 3 chain (60 m by 60 m) grid.

4. **Group selection unit**- defined as the area of the treatment unit which is within a group opening. The edge of the group is defined by the drip-line of surrounding residual trees.

5. **Group selection unit 1/10th acre plots**- this term refers to 1/10th acre plots which are established in group selection units. These plots are established in the centers of group openings within 1-year of harvest.

6. **Matrix area**- this term is used to describe the areas within the treatment units that are **not** in group selection units.

7. **New 1/10th acre matrix plots**- this term refers to 1/10th acre plots established in the matrix area for the purpose of taking measurements on the Fire and Fire Surrogate Study. They are numbered in sequence starting with 101. The numbering sequence starts at "101" in each individual compartment or treatment area.

8. **1/100th acre regeneration sub plot**- this term describes a 1/100th acre (radius of 11.7 ft; 3.6 m) plot nested in both new and existing 1/10th acre plots. The 1/100th acre plot is used only for the purpose of inventorying regeneration which is less than 4.5 in (11.4 cm) in diameter at breast height.

9. **Plot center**- Refers to the PVC post marking the geometric center of a existing, new, or group selection 1/10th acre plot. Plot centers are on a 3 chain by 3 chain (60 m by 60 m) grid.

10. **Treatment Area**- For the purposes of this study, a treatment unit is a "compartment" (see definition above) which has been assigned as one of the 4 fire surrogate study treatments (mechanical only, mechanical plus fire, fire only, control. There are 12 treatment units at Blodgett Forest Research Station (4 treatments x 3 replicates)

II.   PLOT ESTABLISHMENT GUIDELINES

BACKGROUND

This section describes the procedure for establishing new 1/10th acre plots and re-establishing existing 1/10th acre plots for the Fire and Fire Surrogate Study. These plots will be used over the next 4 years for data collection before and after Fire Surrogate Study treatments. It is important that these plots be established with accuracy and consistency to insure ease of relocation and ensure random measurements in the future.

MAP PREPARATION

A 100-foot buffer was mapped around the entire treatment unit using Arc-Info. Within this area, new plots were established from existing 1/10th acre plots on a 3-chain grid. Existing plots are numbered from 1-50; new plots are numbered sequentially starting at 101. GPS'd features including roads, watercourses, group selection units, and boundaries were mapped as well. See **appendix 1** for all area and treatment unit maps. Special thanks to Frieder Schurr, Blodgett Forest Assistant Manager, for map preparation

FIELD PROCEDURE

New 1/10th acre plots (use these instructions to establish new 1/10th acre plots numbered 101 and up in the Fire Surrogate Study Units). Important note- always establish new plots from an existing 1/10th-acre plot, i.e. minimize establishing new plots from other new plots.

1. Look at the compartment plot map and plot description to determine which existing permanent plot(s) the new plots should be established from.
2. Locate the existing plot post. If in place, go on to #3, if not, go to #9
3. From the existing plot post, use the compass to sight the line to the new plot. It is best to sight on a tree, snag at a far distance.
4. Go 3-chains (198 feet) to the new plot.
5. Once you go 198 feet, check the percent slope using the clinometer. Find the corresponding slope distance on the pink card and compensate using the appropriate slope distance. (Example, if you go a slope distance 198 feet and read a 24% slope, the correct slope distance should be 203.4 feet- add 5.4 feet and set the plot post).
6. Once the plot post is set, check that plot center is greater than 37.2 feet from any landing, road cut/fill/surface, or group and that the plot center is not within the 100 foot buffer area. If the plot center location is o.k., attach the appropriate plot tag and fill out the plot location form as shown in the attached sample form. Use the appropriate symbol to mark the plot on the map (see section of "plot symbols"). If the plot center needs to be offset, then go to #7. If the plot location is o.k., go back to #1 to locate the next plot.

Offsetting new 1/10th acre plots (use these instructions to offset new 1/10th acre plots).
NEVER OFFSET EXISTING 1/10TH ACRE PLOTS! Note the appropriate symbol on the
map and record the required information on the plot location form.

7. Use the 8-sided die to randomly determine which direction to offset the plot. The compass direction(s) corresponding to the numbers on the die are listed on the bottom of the plot location form.
8. Go 37.2 feet in the direction "rolled" to the offset plot location. Once the plot post is set, check that plot center is greater than 37.2 feet from any landing, road cut/fill/surface, or group and that the plot center is not within the 100 foot buffer area. If the new plot center location is o.k., attach the appropriate plot tag and fill out the plot location form as shown in the attached sample form. Use the appropriate symbol to mark the plot on the map (see section of "plot symbols"). If the plot center needs to be offset, then go back to #7.

IMPORTANT- DO NOT EVER USE AN OFFSET PLOT TO LOCATE NEW PLOTS- ALWAYS GO BACK TO AN EXISTING 1/10TH ACRE PLOT OR THE LOCATION THE NEW PLOT WAS OFFSET FROM TO LOCATE THE NEXT PLOT!

Re-establishment of existing 1/10th acre plots (use these instructions to re-establish existing 1/10th acre plots numbered 1-50 and up in the Fire Surrogate Study Units)

9. If plot post is not in place, locate the witness trees using the provided witness tree list.
10. Re-locate the plot using the azimuths and distances on the witness tree list.

Establishing new 1/10th acre plots in group selection units

In group selection units, place a standard 1/10 acre plot in the center of the group where the two widest perpendicular axis of the group intersect.

1/10TH ACRE PLOT DIAGRAM

Each 1/10th acre plot will have a 4 foot tall PVC pipe at the plot center. A tape will be used to delineate the 1/10th and 1/100th acre plots for tree measurements. 2 fuel transects will be established at random azimuths from the plot center. 3 residual witness trees will be tagged with a nail at their base. From these trees, the distance and azimuth to the plot center will be recorded and used for plot re-establishment.

1/10th acre plot
37.2 foot radius

Radius 37.2 feet

1/100th acre
regeneration plot (11.8
ft radius)

Plot center, 4' PVC
post w/tag
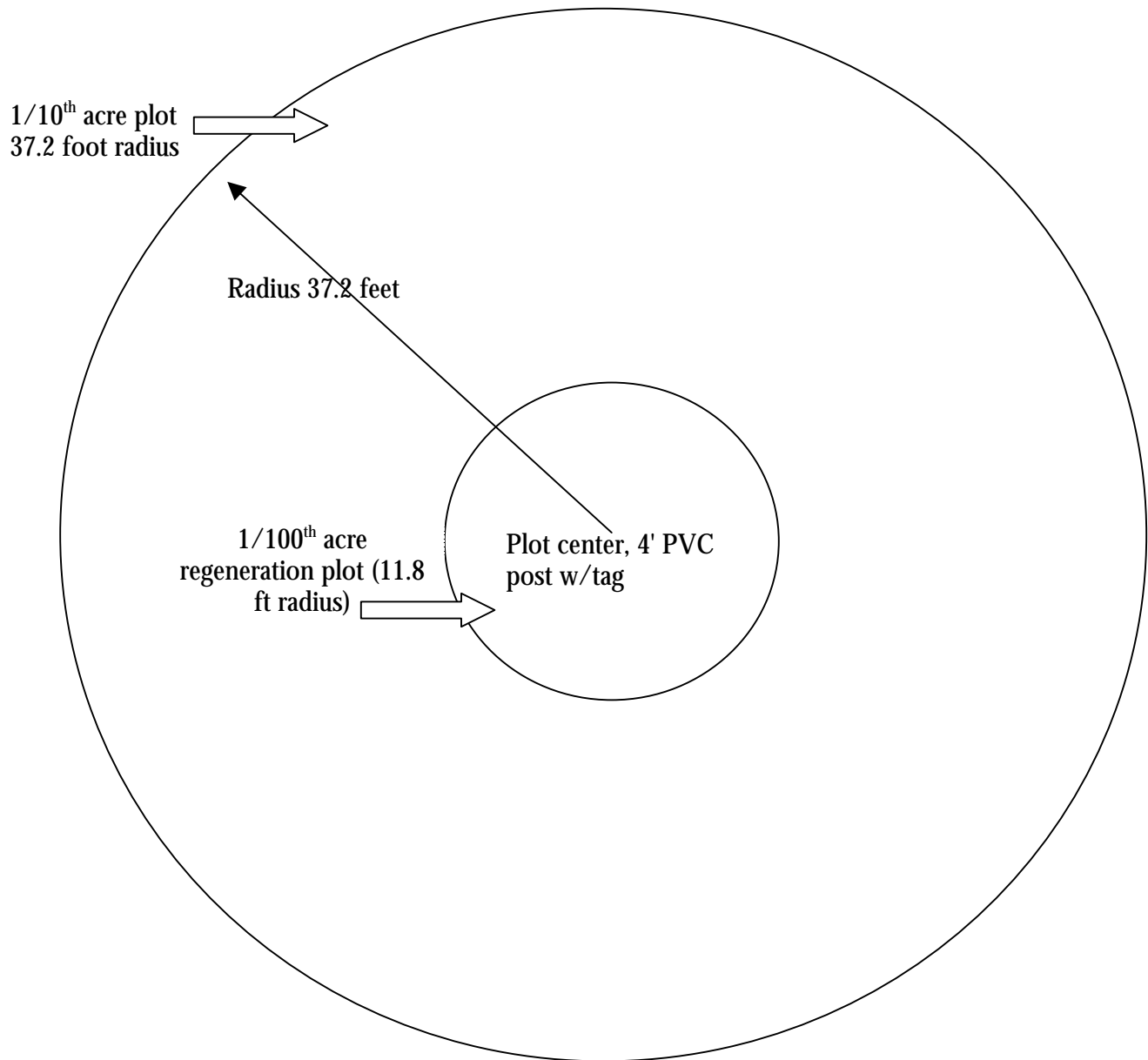
III. TREATMENT UNITS

As described in the vegetation protocols section, Blodgett Forest is divided into several discrete "compartments". Each compartment is assigned a silvicultural and/or management objective which is carried out on a regular entry schedule. For the Fire and Fire Surrogate Study, 12 random compartments were selected for use as treatment units. The compartments (referred to as treatment unit from now on) all have group selection as their silvicultural method. Each treatment unit ranges in size from 40-70 acres and has or will have 3 age classes of group selection units. The identification number of the treatment unit will correspond to its given compartment number within the Blodgett Forest numbering system. The treatment unit number will be followed by the following treatment abbreviations (i.e. "570 MF"):

- Mechanical = "M"
- Control = "C"
- Mechanical plus fire = "MF"
- Fire only = "F"

Treatments were assigned randomly to group selection compartments. Treatment units are summarized in the table below.

Table P-1. *Treatment units and corresponding acreage's.*

Treatment	Treatment Unit Number	Total Treatment Unit Area Acres (hectares)
Control	40	44 (18)
Control	60	59 (24)
Control	590	48 (19)
Mechanical only	190	58 (24)
Mechanical only	350	34 (14)
Mechanical only	490	72 (29)
Fire only	60	59 (24)
Fire only	340	43 (17)
Fire only	400	43 (17)
Mechanical plus fire	180	42 (17)
Mechanical plus fire	380	54 (22)
Mechanical plus fire	570	31 (13)

IV. BLODGETT FOREST VEGETATION TREATMENT PLAN

INTRODUCTION

The purpose of this plan is to describe the desired future conditions for Blodgett Forest and overview vegetation treatments available to reach those conditions. Treatment units are summarized as well.

DESIRED FUTURE CONDITIONS

The primary goal of vegetation treatments at Blodgett Forest is to reach the desired future conditions which meet the following national post-treatment requirements (the "80/80 rule):

> **"Each non-control treatment shall be designed to achieve stand and fuel conditions such that, if impacted by a head fire under 80th percentile weather conditions, at least 80 percent of the basal area of overstory (dominant and codominant) trees will survive. The definition of 80th percentile weather conditions will be based on an analysis of fire season conditions, calculated for mid-afternoon, over a period of 10 to 20 years at the closest fire weather station. The prescription to implement the treatment will be developed based on fire behavior modeling (e.g., FARSITE) and predicted fire effects. Effects will be predicted using techniques such as FOFEM (First Order Fire Effects Model) and/or other modeling efforts that may include expert opinion."**

Table VT-1 describes the "desired future conditions" for the matrix areas of all treated units. Desired future conditions are in development for new and existing plantation areas.

VT-1. *Desired future conditions for treated stands in the Fire and Fire Surrogate Study.*

	Basal area (all species in ft²/acre)	Overstory crown cover (%)	Percent of overstory crowns that can touch and adjacent tree (%)	Maximum percentage of stand that can have a multi-layered canopy (%)	Average height to live crown base (meters)	Snags/acre (greater than 12" DBH)	LWD per acre (at least 12" DBH and 10' long)	Surface fuel load (tons/ac)	Average percent cover of duff and litter	Average depth of duff and litter (cm)
Minimum	100	35	0	0	1	0	0	5	NA	NA
Average	125	45	15	15	3	1	2	10	75	5-8
Maximum	150	60	20	20	NA	2	3	12	NA	NA

VEGETATION TREATMENTS AVAILABLE AT BLODGETT FOREST RESEARCH STATION

Vegetation treatments are categorized by "mechanical treatments", "non-mechanical treatments", "fire related treatments", and "chemical treatments". Mechanical treatments include all treatments which require motorized or manual specialized equipment or for actual vegetation manipulations. Non-mechanical treatments include treatments which may be implemented without specialized additional tools (making burn piles). Fire related treatments include all treatments which utilize fire in some way for implementation. Chemical treatments include those which utilize herbicides for implementation (i.e. brush control). Table VT-2 summarizes treatments by type and their applicability on treatment units. Utilized treatments will be implemented in the matrix and plantation areas of the treatment units. Treatments in plantation will vary with several factors including fuel loading, tree density, plantation age, and species mix.

Table VT-2. *Vegetation treatments available for use at Blodgett Forest.*

Treatment	Mechanical	Fire Only	Mechanical Plus Fire
"x" = denotes applicability for treatment type			
Mechanical Treatments			X
a. Chainsaw falling of trees	X		X
b. Tractor and skidder yarding	X		X
c. Mechanical harvesting of trees (market depending)	X		X
d. Biomass Chipping (market depending)	X		X
e. Rotary mastication	X		X
f. Grapple piling with mechanical grapple	X		X
g. Pruning	X		X
Non-Mechanical Treatments			
a. Piling of downed woody debris by hand	X		X
Fire Related Treatments			
a. Broadcast burning		X	X
b. Pile burning	X		?
Chemical Treatments			
a. Herbicide control of vegetation	?		?

IMPLEMENTATION OF TREATMENTS

Mechanical treatments

Mechanical treatments will be implemented on both mechanical (190, 350, & 490) and mechanical plus fire (180, 380, 570) treatment units. Initial treatment will consist of a commercial harvest in the summer of 2001. All trees to be harvested will be marked prior to the commencement of harvest activities. As previously stated, the desired future conditions are primarily defined by those which will meet the "80/80 guidelines". To meet the desired future conditions, the marking prescription is driven primarily by crown spacing, removal of diseased & damaged trees, removal of trees of low vigor, and minimum basal area requirements. Essentially, the prescription is a thin from below with an emphasis on the removal of suppressed, intermediate, and co-dominant trees of relatively low vigor with crowns that touch crowns of trees of higher vigor. Secondarily, dominant trees of relatively lower vigor with overlapping crowns will be removed to meet crown spacing guidelines. Finally, dominant trees of relatively high vigor with overlapping crowns will be removed to meet basal area and crown cover requirements.

Further treatments on mechanical only treatment units may include reduction of live and dead aerial fuels utilizing a rotary masticator. This treatment may then be followed by piling and burning of non-merchantable biomass and surface fuels. Both mastication and piling will target areas of high fuel loading or dense standing live vegetation with the objective(s) of meeting the desired future conditions on mechanical only units.

Implementation of biomass and/or mechanical harvest (i.e. cut to length) systems will depend greatly on operator availability and market prices for products produced. Implementation of pruning will depend on research needs and forest management guidelines.

Fire related treatments

Fire related treatments will consist primarily of pile burning (on mechanical only units) and broadcast burning on fire only and mechanical plus fire units. All broadcast burns for these 6 treatment units are scheduled for implementation in the fall of 2002. Broadcast burns will be used to meet desired future conditions listed in table VT-1. Due to the logistics and extent of planned burning, line construction will be initiated in 2001. Table VT-3 summarizes estimated line construction needs and construction times by treatment unit.

Table VT-3. *Estimated line construction needs and construction times by treatment unit.*

Treatment Unit	Number of plantations in unit	Estimated chains of plantation line (1)	Estimated chains of boundary line (2)	Total chains of line	Estimated required crew hours for line construction (3)	Location of boundary fire line construction needs
60 (F)	11	167	36	203	25	60/70 boundary
340 (F)	6	91	61	152	19	340/350, 340/400, 340/western property line
400 (F)	9	136	36	172	22	400/390, 400/350 boundaries
180 (MF)	6	91	93	184	23	180/170, 180/eastern and northern property lines
380 (MF)	10	152	9	161	20	380/330 boundary
570 (MF)	4	61	41	102	13	570/600, 570/562, 570/western property line
Totals	**46**	**697**	**276**	**973**	**122**	-

(1) Assumes an average size of 1.5 acres per plantation with approximately 1000 linear feet of line to construct for each 1.5 acre plantation.
(2) Estimated using treatment unit maps in the appendix.
(3) Assumes a 20-person crew cutting line at a rate of 8 chains per hour. Rate derived from Appendix A-20 of the National Wildfire Coordinating Group, 1989 (Fire line Handbook, NWCG Handbook 3). Assumes line is constructed in light to medium logging slash. Estimates do not account for transportation time.

V.   FUELS ASSESSMENT PROTOCOLS

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METHODS

Aerial, Surface, and Ground Fuels

Surface fuel sampling is done using the procedures in the Handbook for Inventorying Downed Woody Material, by James K. Brown, a USDA Forest Service publication, and the Log Decomposition Classes was taken from FSH 2509.18 - Soil Management Handbook, R5 Supplement # 2509.18-95-1. The following is a summary of the procedure.

Selection Random Azimuths
Randomly pick two azimuth bearings. Record these azimuths on the data sheet.

Assessment of 0" to 3" fuels:
Run a tape from plot center to 37.2' along one of the azimuths above. Use a go-no-go gauge with 0.25", 1", and 3" openings to record the number of downed woody particles intersecting the transect from the ground to a maximum height of 6'. Particles must be severed from the original source of growth and their central axes must be above the duff layer. Do not count needles, grass, bark or cones.
> a. 0 to .24": number of particles less than .25" diameter from plot center to 6'.
> b. .25 to .99": number of particles between .25" and 1" diameter from plot center to 6'.
> c. 1" to 3: number of particles between 1" and 3" diameter from plot center to 10'.
> d. Pieces larger than 3" in diameter from plot center to 37.2 feet. For each piece record diameter in inches and if the piece is sound or rotten.

Assessment of Duff and Litter:
Use a trowel to expose 2 vertical planes, at 1' and 3', of duff and litter, down to the mineral soil. If a tree or stump occurs at 1' or 3', offset 1' to the right. Measure the depths of the

duff (visibly decomposing organic material) and litter (freshly fallen needles, leaves, bark, cones, and twigs) layers with a ruler to the nearest 0.1".

Calculation of Fuel Loads

Ground and surface fuel loads will be calculated by using equations developed for Sierra Nevada forests (van Wagtendonk et al. 1996; van Wagtendonk et al. 1998). Coefficients required to calculate all surface and ground fuel loads will be arithmetically weighted by the basal area fraction (percent of total basal area by species) of each 0.1 acre plot within the10 ha unit. This methodology will produce accurate estimates of fuel loads (van Wagtendonk et al. 1996; van Wagtendonk et al. 1998). Previously many fuel inventories assumed that the fuel particles being inventoried had similar properties to those found in the northern Rocky Mountains (Brown 1974). Van Wagtendonk's comprehensive work in quantifying Sierra Nevada fuel properties, both surface and ground, allow custom fuel load equation to be developed for the Blodgett site.

Assessment of 1', 2', and 3' Fuel Height:

At 1', 2', and 3', measure, to the nearest 0.1", from the bottom of the litter layer to the highest dead particle (not to exceed 72") intersecting a 1' wide vertical plane perpendicular to the transect. Fuel particles must be severed from the original source of growth.

Record of Fuel Species

- a. If the litter and debris is mostly from trees and:
  - i. If one tree species comprises >75% of the litter and fuel, use the tree species code listed in Table V-1**.** "List of codes used for conifers, hardwoods, and unknown trees at Blodgett Forest Research Station" in the vegetation section of the protocols.
  - ii. If no single species comprises >75%, **MC**.

- b. If the litter and debris is mostly not from trees, use one of the following codes:
  - i.   **ES** = evergreen shrub
  - ii.   **DS** = deciduous shrub
  - iii.   **GF** = grass or forb

Timing and location of measurements

At each 1/10th acre plot center, wildland fuels will be inventoried before and after treatments. Fuels will be inventoried in the summer and fall of 2001, 2003, and 2004. Compartments that receive the broadcast burn treatment in the fall of 2002 will be re-inventoried for fuel load within 4 weeks of the fire to determine consumption of surface and ground fuels.

FUELS REFERENCES

Brown, J.K. 1974. Handbook for inventorying downed wood material. USDA Forest Service, General Technical Report INT-16.

Van Wagtendonk, J.W., J. M. Benedict, and W. S. Sydoriak. 1998. Fuel bed characteristics of Sierra Nevada conifers. Western Journal of Applied Forestry 13(3): 73-84.

Van Wagtendonk J.W., J.M. Benddict, and W.M. Sydoriak. 1996. Physical properties of woody fuel particles of Sierra Nevada conifers. International Journal of Wildland Fire 6(3): 117-123.

VI. WILDLIFE ASSESSMENT PROTOCOLS

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INTRODUCTION: BIRDS

The avian component of the study will estimate treatment effects on avian species occurrence, relative abundance, nest productivity and feeding behavior. Avian studies will include point counts, nest productivity, and functional response of bark gleaners and woodpeckers, pre-treatment (Year 1) and post-treatment (Years 2 and 3). Treatments will occur during the fall of the 1st year after all wildlife sampling has been completed.

This document provides a list of hypotheses describing how the response variables (bird abundance, nest productivity and foraging behavior) may be affected by each of the three treatments relative to a control. Second, it describes the overall sampling design, and how and why it varies from the proposed national protocol (Zack and Laudenslayer 2000). Finally, detailed protocols are given to instruct field crews for each job. Data forms are from the Mission Creek FFS Study Plan (Lehmkuhl and Gaines 2000), from which this document has extensively drawn upon.

Research Question and Predicted Responses

The basic research question to be addressed in this study is: What are the initial (2 year) effects of prescribed fire and thinning on avian abundance, nest productivity and foraging behavior?

The predicted responses of the most common avian species at Blodgett Forest to the 3 treatments are shown in the following tables. Predicted responses were developed from the literature and previous experience with wildlife surveys at Blodgett Forest since 1976 (Airola and Barrett 1981, Airola and Barrett 1985, Dahlsten et al. 1985, Morrison et al., 1985, Lehmkuhl and Gaines 2000). The predicted responses of the avian species to each of the treatments are shown in Table W-1. It is expected that less than 20% of all the bird species known to occur at Blodgett Forest will provide adequate data for statistical analysis.

Table W-1. *Estimated treatment effects on bird species at Blodgett Forest rated on a 3-point scale: - negative, 0 neutral, + positive.*

Response variable: Bird abundance.

Bird Species	Thin Only	Burn Only	Thin and Burn
American Robin	+	+	+
Brown Creeper	-	-	-
Dark-eyed Junco	-	+	0
Hairy Woodpecker	-	+	+
Mountain Chickadee	-	+	-
Red-breasted Nuthatch	-	-	-
Solitary Vireo	0	+	+
Townsend's Solitaire	-	0	0
Western Tanager	-	+	0
Yellow-rumped Warbler	0	+	+

Response Variable: Nest Productivity

Bird Species	Thin Only	Burn Only	Thin and Burn
Ground nesters	-	-	-
Cavity nesters	-	-	-
Depression nesters	0	0	0
Foliage nesters	+	+	+

Response Variable: Foraging Habitat

Bird Species	Thin Only	Burn Only	Thin and Burn
Red-breasted Nuthatch	-	-	-
Mountain Chickadee	-	-	-
Hairy Woodpecker	-	+	+

PROTOCOLS FOR AVIAN SPECIES ABUNDANCE

Point counts will be used to quantify bird occurrence and relative abundance (Reynolds et al. 1980, Buckland 1987, Ralph et al. 1993, Bibby et al. 2000). From mid-March to mid-May field crews will flag routes to the study stands and routes to be used to traverse all the points in the stand. At least two weeks will be devoted to developing birding identification skills (sight and sound) specific to the study area. In mid-May the point counts will be initiated and continue until the July 4th holiday. The breeding season at Blodgett Forest extends only six weeks.

METHODS

Point counts will be conducted at four $1/10^{th}$ acre plot centers per treatment unit for a total of six visits to each of the 12 study stands (total of 4 point counts x 12 treatment units x 6 visits = 288 counts per breeding season). Sample points will be located at least 180 meters apart (90 meter radius). This is a deviation from the national protocol, which called for 100-meter radii because of the size and shape of the compartments at Blodgett Forest and the overriding goal of at least 4 point-count stations per treatment unit.

Each point count will begin within ½ hour of the official sunrise. Once at the point, the observer will wait 2-4 minutes then count birds for 10 minutes. The observer will be quiet and move as little as possible once at the point. Detections of birds will be recorded at 10-meter increments out to 80 meters. Birds detected flying directly overhead will be recorded as "10" because first detection was directly overhead. All measurements will be as horizontal distance.

A complete count of all 4 sampling points will be completed before the second visit is made to any plot. A random number will be used to determine the sequence of sampling. Standard four-letter codes for each bird species will be recorded (Pyle, 1997).

This work will require at least 5 qualified observers, the wildlife field crew leader (Ph.D. student) plus 4 field technicians (B.S. degree). Undergraduate students will not be out of school early enough to accomplish this work. Field technicians should have had some experience in point count work, preferably in the Sierra Nevada Mixed Conifer type. The wildlife field crew leader will have had experience doing point counts at Blodgett Forest and will be expected to train the rest of the crew starting in April 2001.

PROTOCOLS FOR FUNCTIONAL RESPONSE OF WOODPECKERS AND OTHER BARK-GLEANING BIRDS

This portion of the avian studies will assess changes in the foraging behavior of woodpeckers and other bark gleaning species (chickadees, nuthatches, creepers) in response to the 3 treatments. The objectives of this portion of the study are: 1) Quantify the foraging activities of woodpeckers and bark-gleaners, and 2) Quantify the selection of foraging habitat by woodpeckers and bark-gleaners.

METHODS

We will use focal animal sampling techniques (Airola and Barrett 1985, Martin and Bateson 1986) to quantify the foraging activities of woodpeckers and other bark-gleaning species. A list of the species most likely to provide useable data is given in Table W-1.

Observations of the focal bird species activities and habitat selection will be made during a 2-hour sampling period beginning directly after completion of the point counts each day. Observations will be completed prior to 1400 hours. Each of the 12 sample plots (compartments) will be sampled for a total of 12 hours for a grand total of 144 hours of foraging observations in each of 3 years across all study stands.

Observations of bird foraging activities and habitat use will be made along transects that traverse the plot centers within each stand. Transects will be started at one corner of the stand and a different starting point and route will be used for each sampling period. We will sample an individual species once while foraging, then move on to another species, or move at least 200m before making another observation on the same species (the same individual will never be sampled twice in one day). We will collect data from bark-gleaners only when they are foraging in trees. Observations will be made while walking along a transect until one of the target species is heard or seen. Once a visual detection is made:

1. Wait for the bird to engage in some form of foraging behavior.
2. Once foraging, record the variables (see attached data sheets) as if taking a "snapshot" at the time the foraging activity is initially detected.
3. Record the type of foraging activity.
4. Do not collect data on the first species until at least one other species has been sampled **OR** observations of the same species are separated by at least 200 meters.
5. Never collect data on the same individual more than once.
6. When more than one species is detected at the same time, choose the woodpecker (rarest) species.
7. At the time of detection record the habitat variables of that location (see data sheet). These data will be pooled for each species by plot and compared to equivalent data for the plot as a whole from the vegetation portion of the study to estimate habitat preference.

Bark Gleaner Observation Form

Site _____Unit _____   Time Start _____ Time End _____
(1 hr session)

Date _____ *Observer* _____

BIRD SPECIES CODE		RANDOM TREE		RANDOM TREE		RANDOM TREE		RANDOM TREE
FORAGING BEHAVIOR		███		███		███		███
SEX		███		███		███		███
Tree Species								
Tree dbh								
Tree height								
Horizontal Strata		███		███		███		███
Vertical Strata		███		███		███		███
Fire Effects								
% bark (nearest 10%)								
Bark condition								
Beetle exit holes near breast ht								
Hard or Soft Snag								

NOTES:

BIRD SPECIES CODE		RANDOM TREE		RANDOM TREE		RANDOM TREE		RANDOM TREE
FORAGING BEHAVIOR		███		███		███		███
SEX		███		███		███		███
Tree Species								
Tree dbh								
Tree height								
Horizontal Strata		███		███		███		███
Vertical Strata		███		███		███		███
Fire Effects								
% bark (nearest 10%)								
Bark condition								
Beetle exit holes near breast ht								
Hard or Soft Snag								

BARK GLEANERS AND BARK PROBERS DATA

Behavior and Habitat Variables

Behavior: (while foraging) **GL** glean from bark surface**; PR** probe in crevice; **H** Hammer**; PK** peck (softer than hammer)**; CH** chisel (sideways hammering)**; FL** flake (breaking off small pieces of bark**; PY** pry**; PU** pull
Tree Species: Use a four-letter code (make sure to standardize and report codes)
Tree dbh: in cm
Tree height: : in meters, use clinometer
Vertical Strata: LB, UB, LC, UC, or TS (below)
Horizontal Strata: BO, SD, LD, SL, ML, LL, BT, or CN (below)
Fire Effects: 1 none**, 2** trunk only, **3** lower leaves only, **4** half of tree's leaves, **5** nearly all or all leaves
%Bark: to nearest 10%
Bark Condition: 1 tight, **2** loose
Beetle exit holes (at breast ht): 0 none**, 1** few (< 10 evident)**, 2** many (> 10 evident)
Hard Snag (decay class 1-2**), Soft Snag (**decay class 3-5**)**

Foraging Habitat Codes

Code	Location	Definition
(Vertical strata)		
LB	Lower bole	Lower half of the portion of the trunk lacking live foliage, or lower half of a snag
UB	Upper bole	Upper half of the portion of the trunk lacking live foliage, or upper half of a snag
LC	Lower crown	Lower half of crown of live tree
UC	Upper crown	Upper half of crown of live tree
TS	Top of snag	Top 0.25 m of a snag
(Horizontal strata)		
BO	Bole	Main trunk of a tree or a snag
SD	Short-dead branch	Dead branch < 1 m long
LD	Long-dead branch	Dead branch > 1 m long
SL	Small-live branch	Living branch < 4 cm in diameter at location used by bird
ML	Medium-live branch	Living branch 4-8 cm in diameter at location used by bird
LL	Large-live branch	Living branch > 8 cm in diameter at location used by bird
BT	Branch tip	Tips of living branches
CN	Cone	Cone of a coniferous tree

PROTOCOLS FOR AVIAN NEST PRODUCTIVITY

Standardized methods will be used to assess avian productivity (Martin and Geupel 1993, Ralph et al. 1993). Nest searches will begin in early May and continue until July 4th or as long as necessary to record fledging of all nests monitored.

METHODS

Nest searches will be conducted in at least two of the three replicates of each treatment (including controls), and nests will be monitored until the fate (fledging young or failure) has been determined. One person will be assigned to nest search on 3-4 treatment units. The searchers will work alternating days on these stands for the entire nest season. Some nest searching can be combined with point counts and foraging observations, but additional visits will be necessary. Ideally, nests will be located early during nest construction to provide the best estimates of nest success. Often the most effective way of finding nests is to locate and follow females, although males may provide some cues. Nest searchers will be trained by the wildlife field crew leader in the cues to look for to aid in finding nesting birds. Training will begin in April 2001. Treatment units will be thoroughly searched for nests following routes that traverse through all parts of the plot (compartment). Once a nest is found, flagging will be used (10-15 meters away) to indicate the bird species and nest number. A photograph and a detailed drawing (using the attached form) will be made so that the nest can be relocated for subsequent monitoring.

Nest monitoring will record the number of days that a nest was active, and whether or not a nest is successful. Nests will be checked from a distance, whenever possible, and all efforts will be made to minimize disturbance. When transitions are expected (onset of incubation, hatching, fledging) nests should be checked at least every 2 days. Otherwise, on average nests will be checked every 3-4 days, keeping careful track of the stage of each nest. Species-specific literature on clutch sizes, incubation, and nestling periods will be used to estimate when incubation, hatching or fledging is likely to occur so that more frequent visits can be made during these times. Dead-end paths will be avoided when checking nests by entering along one path and exiting along another so that predators have difficulty determining the exact nest location. Active nests will not be visited if predators are nearby. If no activity is observed at the nest, spend as much time as feasible, up to 30 minutes, to confirm that the parents aren't just temporarily away from the nest. The total time spent trying to determine if a nest is active will be recorded. Nest monitoring will follow nest progress through termination. Nests that appear inactive will be confirmed by inspection. Use the nest check forms to record observations as accurately and thoroughly as possible.

FFS NATIONAL STUDY: NEST DISCOVERY AND MONITORING

Location: _____

Nest ID #: _____   Species: _____   Unit #: _____

Observer: _____   Date of Discovery: _____   Time: _____

Location of Flagging from 1/10th ace plot center : ___ ___ : _____° @ _____ m in _____

Location of Nest from Flagging: ___° @ _____ m in _____   Search method: _____
(PB, F, SS, NBC, L,

PY, YB)

Text:
(include how nest was found
with notes on bird behavior)   Drawing:

Mo	Day	Time	Min @ nest	Obs	Stage	Nest cont. seen?	# Eggs	# Yng	Min age yng	Max age yng	# CB eggs	# CB yng	Comments

INTRODUCTION: MAMMALS

Mammal studies will quantify the effects of 3 treatments on small mammal abundance pre-treatment (Year 1) and post-treatment (Years 2 and 3). Treatments will be accomplished during the fall of the 1st year.

Insectivores, mice, chipmunks and squirrels are the primary focus of the mammal study. This document describes the overall sampling design, and how and why it varies from the proposed national FFS protocol (Zack and Laudenslayer 2000). Detailed protocols are given for each trapping method to instruct field crews. Sampling schedules and a data form are provided. Safety considerations are discussed. Hypothesized treatment effects on species abundances are listed in Table W-2.

Table W-2. *Estimated treatment effects on small mammals at Blodgett Forest rated on a 3-point scale: negative -, neutral 0, positive +.*

Species		Treatment			
Common Name	Scientific Name	Thin	Burn	T+B	Control
Trowbridge Shrew	*Sorex trowbridgii*	-	-	-	0
Broad-footed Mole	*Scapanus latimanus*	-	-	-	0
Long-eared Chipmunk	*Tamias townsendii*	-	-	-	0
Calif. Ground Squirrel	*Spermophilus beecheyi*	+	+	+	0
Western Gray Squirrel	*Sciurus griseus*	-	-	-	0
Douglas Squirrel	*Tamiasciurus douglasii*	-	-	-	0
Flying Squirrel	*Glaucomys sabrinus*	-	-	-	0
Deer Mouse	*Peromyscus maniculatus*	+	-	-	0
Brush Mouse	*Peromyscus boylii*	+	-	-	0

METHODS

Overview

At the Blodgett Forest FFS site, we have attempted to follow the national protocols as closely as possible, but have had to make some changes as described below.
A 6 x 6 grid with 60m spacing will used to sample small mammals. One Sherman live trap and one Tomahawk live trap will be placed within 5m of each 1/10th acre plot marker in locations most likely to capture animals.   Pit traps provide very little information at Blodgett Forest, therefore we will not use them. Camera traps will be used on a subset of the 1/10th acre plots.

Trap spacing

The FFS national protocol calls for trapping on a 6 x 6 grid with 50m spacing using pitfall, Sherman (9in), and Tomahawk live traps (Zack and Laudenslayer 2000). The basic grid dimension for the Blodgett Forest site will be modified to 6 x 6 with 60 m spacing and a 30m buffer zone between the grid and the treatment unit boundary. This spacing will allow use of both existing and new 1/10th acre plots as plot centers. This in turn will allow the use

of available vegetation and wildlife change data available for the existing 1/10th acre plots and collected for new 1/10th acre plots.

Trap Types & Trapping Duration

 Many thousands of pitfall trap days of effort have been expended at Blodgett Forest with almost no captures of any kind. The cost of installing pit traps does not justify the effort as Sherman and Tomahawk traps have proven to adequately sample the existing small mammal fauna. Traps will be run for 10 days, being checked morning and evening as per the national protocol. In addition, 2 Trailmaster camera traps will be run for 20 days in each treatment unit. Camera traps have successfully documented most mammals occurring at Blodgett Forest, from shrews to bears, without needing to capture or handle them. Many bird species are also detected.

Sherman Traps
Layout:

- 6 x 6 grid with 60m spacing. One trap per grid point.

Trap placement:

- Runways and other likely locations for trapping within 5m of grid points.

Duration:

- Concurrent with Tomahawk trapping – 10 days total (work 10 days on, 4 days off).

Bait:

- Bait will be a mixture of whole oats, peanut butter, and molasses (same as for Tomahawk trapping).

Sherman Trapping Procedure
 Pre-trapping:

- Make sure you have a complete set of your personal trapping equipment. Check off each item on the equipment check list.
- Make especially sure you have a compass, stand maps, water, lunch, and insect repellent.
- Check that each vehicle has a first-aid kit (including bee sting kit) and radio if available.
- Be sure of the safety procedures regarding travel in the woods and diseases potentially picked up from handling small mammals: re-read the safety section of this protocol to refresh your memory when starting a trapping session.

Checking Traps:

- Traps will be checked every 12 hours for 10 consecutive days.
- Crew will be rotated among the treatment units to reduce bias associated with individuals. People set traps at different sensitivities and locations, so we want to distribute this variation evenly among all the plots.
- Follow disease safety precautions in handling traps. Don't stick your nose near traps, or blow onto them or on animals. Keep the wind at a right angle to you and the animal if possible.
- There are a lot of traps to check, so work the trap grid quickly, but don't sacrifice careful and thorough examination of traps and animals, or safety moving through the woods.

Removing and Handling Animals:

- Remove animal from trap carefully in zip-loc bags. Mark each capture with an indelible marking pen on the top of the head, neck or back. Record location, date, species, sex, age, reproductive status and any other relevant comments (e.g. killed by weasel, trap damaged or sprung by bear, etc.).
- Record all sprung or stuck traps. That information will be used later to adjust trapping effort.
- Make notes on any changes in the condition of the trap site (e.g. recent wind-throw or other disturbance, human intrusion, etc.).
- Rebait, set, and position traps. Replace damaged traps with fresh ones.
- Reflag trap positions if hard to find.
- Back at the truck, all crew members will dispose of rubber gloves and wash their hands before moving to the next plot. Bag any moralities and place in a freezer as soon as possible.

Post-Trapping Handling Of Traps and Collected Animals

At the end of each trapping period, traps will be removed from the treatment units, cleaned and disinfected. Follow the guidelines in the attached document on hanta virus safety protocol for details on cleaning and disinfecting traps. Soiled traps should be double bagged for transportation in the back of a pickup to avoid contamination of vehicle passenger cabins. Dead animals will be double bagged and put in a cooler for transport to a freezer. Put the cooler outside the passenger cabin of vehicles, do not use the cooler for food or water storage.   Be sure to wash your hands with the soap provided, and bag and isolate potentially contaminated equipment or clothes.

Tomahawk Traps
Layout

We will place one Tomahawk trap on each grid point of the 6 x 6 layout. Place the trap on a flattened surface next to a log, stump or tree within 5 m of the grid point. Ensure that the trap is firmly placed and does not wobble or move with slight hand pressure.

Trap design:

- Cover the trap with bark or other material to protect it from direct sun, rain and wind.

Trap adjustment

Adjust the trigger mechanism with pliers as needed to ensure the trap will spring with a slight pressure. Set the trap treadle at an angle of 10-20 degrees from the bottom of the trap. Make sure the door closes completely and locks into place.

Bait

Bait will be a mixture of oats, peanut butter, and molasses. The purpose of the bait is not only to attract the animals, but to provide food during their confinement and reduce the risk of death from hypothermia. Place a small handful (about 1 heaping tablespoon) of bait in the back of the trap. Be sure that the angle of the trap is not so severe that the bait slides forward and interferes with the treadle.

Tomahawk Trapping Procedure
Pre-trapping:

- Make sure you have a complete set of your personal trapping equipment. Check off each item on the equipment check list.
- Make sure you have a compass, stand maps, water, lunch, and insect repellent.
- Check that each vehicle has a first-aid kit (including bee sting kit) and Forest Service radio.
- Be sure of the safety procedures regarding travel in the woods and diseases potentially picked up from handling small mammals: reread the safety section of this protocol to refresh your memory when starting a trapping session.

Trapping Schedule:

- We will trap a stand for 10 days.
- Traps will be opened on Monday, baited, and tested to ensure proper working order.

Checking Traps:

- Traps will be checked every 12 hours for 10 consecutive days.
- Crew will be rotated among the plots (compartments) to reduce bias associated with individuals. People set traps at different sensitivities and locations, so we want to distribute this variation evenly among all the plots.
- Each trap should be checked even if the door is open to ensure that the mechanism is in proper working order and bait is present. Sometimes the treadle gets jammed and needs to be freed, or the bait is stolen by small mammals that do not trip the door closed. Reach in the trap and trip the door by pressing down on the treadle, check for bait, then reset the mechanism. Test the treadle action once to make sure it works, then reset.

- Follow disease safety precautions in handling traps. Don't stick your nose near traps, or blow onto them or on animals. Keep the wind at a right angle to you and the animal if possible.
- Plan to replace traps that have captured skunks.
- There are a lot of traps to check, so work the trap grid quickly, but don't sacrifice careful and thorough examination of traps and animals, or safety moving through the woods.

Removing and Handling Animals:

- You must be familiar with identifying the species, sex, and age of the animals that will be found in the traps. There will be training with keys, and in the field with live animals prior to the regular trapping session. We will initially have people working in pairs so you can exchange information and learn from each other. The first days of trapping are hectic with learning how to handle and identify animals.

- Data will be collected on every animal that is caught in the traps. Study the data sheets so you are familiar with what needs to be recorded.   Fill out the header information on each data sheet no matter if it is a continuation of a first page with the same information. The subsequent columns have spaces for trap station, trap placement, species, capture code, age, sex, and condition.   Record this information in a methodical and thorough manner with legible printing in pencil. Make sure you are using Rite 'N Rain paper if the weather is damp.

- Remove animals by placing the cloth of a trapping cone over the entrance of the trap. Make sure the fit is tight and the cloth is secure, or else the animal will escape and data will be lost. Hold the cage of the cone out in front of the trap and tap the end of the cage where the animal is hiding. When the animals moves into the cone, twist the cloth to trap the animal, then begin processing.

Data Collection Procedures

  Check the ear tag numbers, if an old capture, immediately after removing the animal from the trap. This will allow for recording of some data if the animal manages to escape before the full examination is done. Animals are ear tagged on both ears following the procedures in the attached appendix: read these instructions carefully before tagging. Place the tag on the rear margin of the ear with the numbers facing forward.   Be sure that the tags in each ear are identically numbered. If you capture an animal with 1 tag (the other begin ripped out, etc.), then replace the absent tag with a new tag with a different number and record carefully on the data sheet. Tags come in numbered pairs, so put the second tag not used on the animal in your pocket and later throw out so that it is not used later on another animal, thus confusing the identity of individuals.

Examine the animals to determine species, age, sex, and reproductive condition. Some species will be easy to identify, but others may take careful examination and reference to keys. If you catch something unusual that you cannot identify, take a photograph and make notes as to its pelage color, appearance, weight, body length, tail length, etc. for later identification. If possible, let others see it.

The data-coding sheet will have codes for the age classes of the different species. Recording reproductive condition will be most important in the spring when animals are reproductively active.   Refer to the attached appendices on assessing reproductive conditions in males and females.

Hypothermic or injured animals may be encountered in traps, and it is your responsibility to care for these animals and ensure their recovery and release. Carry a dropper bottle of sugar water and a sick-animal bag.   Quickly record information on the animal then administer the juice or sugar water and keep it warm in the bag. You may need to continue checking traps while the animal warms up. If the animal recovers, return it to the grid point where it was captured.

Dead animals will be placed in a zip-loc bag. Using a marking pen, record the location, date, species and probable cause of death. Place dead animals in a freezer as soon as possible.

When in doubt, make notes in the comment field or footnoted at the bottom of the data sheet on the condition of the animal or trap (killed by weasel, trap damaged, trap door stuck open overnight, trap sprung by bear, etc.), or changes in the condition of the trap site (e.g. recent wind-throw or other disturbance, human intrusion, etc.).

Post-Trapping Handling Of Traps and Collected Animals:

 At the end of each trapping period, traps will be removed from the stands, cleaned and disinfected. Follow the guidelines in the attached document on hanta virus safety protocol for details on cleaning and disinfecting traps. Soiled traps should be double bagged for transportation in the back of a pickup to avoid contamination of vehicle passenger cabins. Dead animals will be double bagged and put in a cooler for transport to a freezer. Put the cooler outside the passenger cabin of vehicles, do not use the cooler for food or water storage.   Be sure to wash your hands with the soap provided, and bag and isolate potentially contaminated equipment or clothes.

Camera Traps
Layout.

We will deploy one Trailmaster camera trap (Kucera and Barrett 1993) on each of two 1/10th acre plot centers in each treatment unit. Place the Trailmaster transmitter 3m WNW and the receiver 3m WSW of the plot center marker (CFI PVC pipe) using 1x3in wooden stakes. A bait station will be located between the transmitter and receiver, directly W of the plot center marker. The camera will be attached to the center marker itself and focused on the bait station.

Bait

Bait will be a mixture of oats, peanut butter, and molasses plus a chicken back. Place 1 heaping tablespoon of the peanut butter mix on the bottom of an overturned paper plate. Place the chicken in a cotton sock to protect it from flys and place it next to the peanut

butter mix. Make sure the bait is situated exactly 2cm below the Trailmaster trigger beam and midway between the transmitter and receiver.

Trapping Procedure

Check the camera traps every other day and add new bait and film as necessary. Record the number of events at each check.

Table W-3. *Mammals known to occur at Blodgett Forest.*

Common Name	Scientific Name	Code (for field data forms)
Trowbridge's Shrew	*Sorex trowbridgii*	TRSO
Broad-footed Mole	*Scapanus latimanus*	SCLA
Snowshoe Hare	*Lepus americana*	LEAM
Black-tailed Jackrabbit	*Lepus californicus*	LECA
Long-eared Chipmunk	*Tamias quadrimaculatus*	TAQU
California Ground Squirrel	*Spermophilus beecheyi*	SPBE
Western Gray Squirrel	*Sciurus griseus*	SCGR
Douglas Squirrel	*Tamiasciurus douglasii*	TADO
Northern Flying Squirrel	*Glaucomys sabrinus*	GLSA
Deer Mouse	*Peromyscus maniculatus*	PEMA
Brush Mouse	*Peromyscus boylii*	PEBO
Dusky-footed Woodrat	*Neotoma fuscipes*	NEFU
Porcupine	*Erethizon dorsatum*	ERDO
Coyote	*Canis latrans*	CALA
Gray Fox	*Urocyon cinereoargenteus*	URCI
Black Bear	*Ursus americanus*	URAM
Ringtail	*Bassariscus astutus*	BAAS
Raccoon	*Procyon lotor*	PRLO
Long-tailed weasel	*Mustela frenata*	MUFR
Western Spotted skunk	*Spilogale gracilis*	SPGR
Striped Skunk	*Mephitus mephitus*	MEME
Mountain Lion	*Felis concolor*	FECO
Bobcat	*Lynx rufus*	LYRU
Mule Deer	*Odocoileus hemionus*	ODHE

HERPTOFAUNA

While several species of amphibians and reptiles occur at Blodgett Forest, only the Western Fence Lizard (*Sceloporus occidentalis*) is sufficiently common and readily detectable to have any hope of demonstrating a response to the proposed treatments. It is likely that this species will benefit from any thinning of the forest canopy. Thousands of hours of pit trapping, camera trapping, cover board deployment, and time-area counting have clearly demonstrated that time-area counts of Western Fence Lizards provide the only data useful for any statistical analysis. All the other herptofauna are so rare or so difficult to detect that it is unreasonable to attempt to incorporate them into this study. Therefore we propose to focus the wildlife work at Blodgett Forest on birds and mammals only.

Table W-4. <u>Outline of Wildlife Methods at Blodgett Forest</u>: Wildlife research will be conducted in four of the five years of study.

Measurement	Season	Scale	Effort	"Output"
Bird Point Counts	May-June	Every 180 m	12 plots 6 repeat visits	Abundance and diversity
Bird Nest Productivity	May-July	Where found on sampled plots	2 plots each treatment (= 8 plots total)	Young/nest per nesting species
Bird Foraging Behavior	May-July	Sampling foraging "bark gleaners"	12 plots (total 144 hours observation/yr)	Foraging response to "treated" trees
Mammal Trapping	July-August	6X6 grid, 60 m apart, with Sherman and Tomahawk trap at each station	All plots, sampled one time/yr (10day-night periods)	Abundance and diversity
Camera Trapping	July-August	2 Trailmasters per plot	All plots (20 days/yr)	Abundance and diversity

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VII. PROPOSED ADDITIONAL WILDLIFE PROTOCOL (NEST BOXES)

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INTRODUCTION

In the methods section of the wildlife protocol there is a section on bird nest productivity. We would like to propose a variance to this protocol, which we believe, is a much more efficient method of understanding the effect of treatments on bird productivity. The addition of 10 nesting boxes per compartment would give precise productivity measurements for secondary cavity nesting bird species (mountain chickadees, chestnut-backed chickadees, and red-breasted nuthatches). The use of the nesting boxes by small mammals such as deer mice and flying squirrels in addition to the bird species mentioned above and the activity of bird predators such as snakes and weasels could be quantified. The diet of the birds could be monitored in the different treatments and quantified with the use of cameras, and the survival of the nestlings recorded. Nest boxes are an excellent tool for making these comparisons and we have a large database (more than 20 years) with this type of information at Blodgett Forest to use as a background. There is a large body of published information available for comparison (Mc Callum et al, 1999, Brennan et al, 1999a, Brennan et al, 1999b, Dahlsten et al 1992, Grundel et al 1991, Dahlsten et al, 1990, Dahlsten et al 1979, Copper et al 1978)

The site level hypotheses we wish to address are the following:
1) Treatments will have no effect on abundance or the productivity of secondary cavity nesting birds.

2) Treatments will have no effect on the diet of nestlings of secondary cavity nesting birds.
3) There will be no treatment effects on the predators (snakes, weasels etc.) of secondary cavity nesting birds or on the other occupants (eg. flying squirrels) in potential nesting sites.

METHODS

Nesting frequency and productivity habits will be determined by visiting artificial nest boxes set up in the 12 plots (of 4 treatment types) on the forest. Boxes will be placed between 50 and 100 m apart (at or near subplot points) within each. Data will be collected by compartment on number of boxes used by each species, eggs/nest, nestlings fledging, predation or other mortality, and measurements of size of adults. Prey items fed to nestlings will be identified using video or single-frame cameras on active nests.

Table E-2. *Data to be collected using nest boxes*

VARIABLE	UNIT	HOW MEAS.	PLOT SIZE	PERM/TEMP?
Species of adult bird or mammal in box	Counts	Visual	12 study plots, 10 boxes each	Permanent
Adult bird characteristics	mm, gm	Scale, calipers	"	"
Nestling	Counts	Visual	"	"
Predation	Counts	Visual	"	"
Bird diet	Insect category/unit time/nest	Camera/ video	Active bird nests of each sp. in each plot	Temp. on selected perm. boxes

Frequency of Measurements
Box checks will be made weekly during breeding season (from mid April to July, approx.). Camera units will be used during period of nestling feeding on three active nests of each species in each treatment if available. Video cameras will be used during period of nestling feeding for 2 hr periods at selected times and days.

ANALYSIS
1) Abundance will be tested with Chi-squared analysis after several nesting seasons have occurred. Productivity of nests will be determined using ANOVA by treatment type and plot.
2) Mean numbers of each prey item category will be analyzed by bird species and treatment type using ANOVA.
3) Predation numbers by type (snake, weasel, etc.) will be tested with Chi-squared analysis over treatment types after several nesting seasons have occurred.

Table E-3. Summary table for Wildlife Protocol

Summary table for Wildlife Protocol

Variable Measured	Compartment	# of 0.1 acre plots	When measurement will take place
sp. of bird or mammal in box	All 12	10 plots	Weekly during breeding season
adult bird characteristics	All 12	10 plots	Weekly during breeding season
number of nestlings	All 12	10 plots	Weekly during breeding season
type of predation	All 12	10 plots	Weekly during breeding season
nestling diet	All 12 (if available)	10 plots	Weekly during breeding season

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VIII. VEGETATION ASSESSMENT PROTOCOLS

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INTRODUCTION

The vegetation component of the Fire and Fire Surrogate Study has been designed for the long term because forest response to treatment occurs at four levels that demand long-term research and monitoring (Franklin 1989): (i) slow processes, such as forest succession; (ii) sensitivity to rare episodic events, such as weather extremes and insect outbreaks; (iii) high intra- and inter-annual variability, such as changes in reproduction, growth, and death driven by both "normal" and changing climatic regimes; and (iv) complex phenomena where multivariate analysis is required to separate pattern from noise, a consequence of the interactions of the preceding three characteristics.

Stand Structure and Composition, both because trees are keystone life forms which create or greatly influence habitat for all other forest organisms, and because trees have great amenity and commodity value to humans.

Stand Function (e.g., aboveground productivity) because productivity tells us the rate at which future forest products are produced, the rate at which carbon and other elements are being sequestered, and the rate at which new fuels are being generated.

Stand Stability and Resilience, because forests have great amenity and commodity value to humans. Forest stability and resilience can be viewed as components of the vaguer term "forest health." Stability and resilience are more easily inferred from stand structure and function than directly measured.

Shrub and Herb Layer Structure and Composition, because understory vegetation is important as habitat and food sources for other forest organisms, and because the understory plants are important components of the aesthetics for which humans often visit such sites.

Shrub and Herb Layer Function, because the plants that comprise these understory strata are important in the fuel complex and in fixing atmospheric nitrogen that subsequently supports productivity in the tree layer.

Vegetation Type and Annual Vegetation Inventory at the Blodgett Forest Study Site.

At the Blodgett Forest Research Station Study Site, the dominant vegetation type is the mixed conifer series (classification by Sawyer and Keeler-Wolf, 1995). Dominant overstory tree species include ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), incense cedar (*Calocedrus decurrens*), sugar pine (*Pinus Lambertiana*), and California black oak (*Quercus kelloggii*). Hardwoods and shrubs that dominate the understory and recently cleared areas include tan oak (*Lithocarpus densiflora*), chinquapin (*Chrysolepis sempervirens*),manzanita (*Arctostaphylos spp.*), deer brush (*Ceanothus integerrimus*), and cut-leaf blackberry (*Rubus laciniatus*). Nomenclature follows Hickman (1993).

Quantification of vegetation composition and structure occurred at Blodgett Forest as early as 1935 by Henry Vaux, a professor in then School of Forestry (Rambeau, personnel comm.). The vegetation inventory has evolved into a complex vegetation sampling system, with all data integrated into a database managed on site at Blodgett Forest. Since 1975, Blodgett Forest has utilized a vegetation inventory system based permanent $1/10^{th}$ acre (radius of 37.2 ft; 11.3 m) plots on a 6-chain by 6-chain (120 m x 120 m) square grid. New plots are also established each year in group openings to monitor growth and dynamics of plantation development. Once a plot is established, it is scheduled for re-measurement every five years using the Blodgett Forest Inventory Protocols (Blodgett Forest Research Station, 2000). Plots are also measured before and after any manipulative treatments (harvesting, thinning, burning, mastication, etc.). Information obtained from plots is used for research, management decision making, and monitoring.

For the purpose of the Fire and Fire Surrogate Study, the existing Blodgett Forest permanent plot grid was densified from a 6-chain (120 m) grid to a 3-chain grid. This densification created 4 categories of plots, which are defined below. These terms will be used to describe the plots throughout the protocol.

1. ***"Existing 1/10th acre matrix plots"***- this term refers to 1/10th acre plots which were established prior to the densification for the Fire and Fire Surrogate Study. Most of these plots were established in the 1970's. They are numbered 1-50. The numbering sequence starts at "1" in each individual compartment or treatment unit.

2. ***"New 1/10th acre matrix plots"***- this term refers to 1/10th acre plots established for the purpose of taking measurements on the Fire and Fire Surrogate Study. They are numbered in sequence starting with 101. The numbering sequence starts at "101" in each individual compartment or treatment unit.

3. ***"Group Selection Unit 1/10th acre plots"***- this term refers to 1/10th acre plots which were established in group selection units. These plots are established in the center of group openings within 1-year of harvest.

4. **"1/100th acre regeneration sub plot"**- this term describes a 1/100th acre (radius of 11.7 ft; 3.6 m) plot nested in both new and existing 1/10th acre plots. The 1/100th acre plot is used only for the purpose of inventorying regeneration which is less than 4.5 in (11.4 cm) in diameter at breast height.

Important Note: The Fire and Fire Surrogate Study will be using existing Blodgett Inventory matrix and group 1/10th acre plots. These plots make up approximately 20% of the all Fire Surrogate Study plots. In order to maintain continuity of the Blodgett Forest Inventory system, we will measure these plots as they have been measured over the last 30 years. This requires additional qualitative assessments which are described in the "vegetation appendix section". These protocols are followed with the note **"(existing 1/10th matrix and group plots only)"**.

METHODS

Categories Used for the Measurement of Core Vegetation Variables

The core variables to be measured for vegetation have been divided into 4 general categories (listed below). The measurement protocols for the core variables are summarized on the following pages.

1. **Baseline plot information**- This category includes information that will be recorded by the vegetation crew for each plot including, slope, aspect, elevation, canopy cover, and percent exposed soil.

2. **Live trees**- This category includes all size and age classes for Douglas-fir, ponderosa pine, sugar pine, white fir, incense cedar, black oak, tan oak, and all other conifers and hardwoods listed in table 1 on page 6.

3. **Snags**- This category includes all standing snags greater than 4.5 in (11.6 cm) DBH and greater than 4.5 ft (1.37 m) at breast height.

4. **Stumps**- This category includes all stumps on the 1/100 acre subplot greater than 8 inches (20.3 cm) diameter and greater than 4.5' tall and those stumps greater than 20 inches 50.8 cm) in diameter and less than 4.5 ft tall on the 1/10 acre plot (including subplot).

5. **Woody shrubs, herbaceous monocots, dicots, ferns, ground cover, and seedlings less than 2 years of age** - This category includes all woody shrubs and all herbaceous monocots, dicots, and ferns found within study sites at Blodgett Forest Research Station. This category also include seedling less than 2 years of age of coniferous and hardwood tree species.

Protocols Used for the Measurement of Core Vegetation Variables, by Category

Each category of vegetation is listed below with a set of core variables and their measurement protocols. At the end of the section, a table summarizes the scale of assessment including of which type of plot, the number of plots, and the timing of measurement each core variable will be assessed. Core variables for live trees, snags, and stumps were derived directly from the current Blodgett Forest Research Station Inventory Protocols (Blodgett Forest Research Station, 2000). **Note:** As stated in the introduction, in order to maintain the consistency of the existing Blodgett Inventory system, several additional variables will only be measured on existing matrix and group 1/10th unit acre plots. These variable will **not** be measured on new 1/10th-acre plots. These variables are noted "**(existing 1/10th matrix and group plots only)**" and described in the "vegetation appendix" section.

CORE VARIABLES TO BE MEASURED FOR BASELINE PLOT INFORMATION

Baseline plot information
1. Witness tree establishment
2. Slope
3. Aspect
4. Elevation
5. Canopy cover
6. Percent exposed soil within 1/10th acre plot

FIELD PROTOCOLS FOR ASSESSING CORE VARIABLES FOR BASELINE PLOT INFORMATION

Witness tree establishment

A. Mark 3 witness trees.
1. Choose witness trees to:
    a. Maximize triangulation (try to choose trees more than 100° apart).
    b. Be among the largest trees on the plot.
    c. Be close to plot center.
2. Blaze a 3" wide area (not through the cambium) at the base of the witness tree, facing plot center.
3. Drive an aluminum nail, pointing to plot center, into the blaze only as far as necessary to secure the nail. Leave room for growth, and do not go through the cambium unless necessary.
4. Measure the azimuth and distance from plot center to the head of the nail. Record in the COMMENTS column of the Tree, Snag, and Stump Inventory section of the inventory template in the following form: WITNESS AZ __ DIST __'.

Slope

Measure uphill and downhill with a clinometer to the nearest 1%, and record the average.

Aspect

Taken to the nearest intercardinal using a hand compass, ex: N, NW, W, SW, S, SE, E, NE

Elevation

Elevation to the nearest 10' from a map ex: 4350, 4500.

Canopy cover

Canopy density measured using a sight tube. Take 5 shots, at 1 pace intervals from plot center, in each cardinal direction for a total of 20 shots. Do not take a shot at plot center. Multiply the number of hits by 5 to get density.
Percent exposed soil

Percent exposed soil within 1/10th acre plot

See soils protocols section "Exposed Mineral Soil".

CORE VARIABLES TO BE MEASURED FOR LIVE TREES, SNAGS, AND STUMPS

Core Variables assessing Stand Structure and Composition for trees greater than 4.5 inches (11.4 cm) in diameter at breast height (4.5 ft (1.37 m) on 1/10th acre plots and for trees less than 4.5 inches (11.4 cm) in diameter but greater than 4.5 feet (1.37 m) in height. Variables with a "*" denotes measurement on existing and group 1/10th acre plots only.

Live Trees

1. Tree number
2. 1/100th acre regeneration inventory of trees less than 4.5 inches (11.4 cm) DBH
3. Species
4. Status
5. Diameter at breast height
6. Total height*
7. Crown Class*
8. Height to crown base*
9. Damage and disease*
10. Quality of foliage*
11. Comments

Core variables to be measured for snags greater than 4.5 inches (11.4 cm) in diameter at breast height (4.5-ft (1.37 m)) and stumps.

Snags

1. Snag number
2. Status
3. Species
4. Diameter at breast height
5. Total height*
6. Apparent cause of death*
7. Wood hardness*
8. Limb condition*
9. Presence or absence of tree top*
10. Number of visible nesting holes*
11. Evidence of woodpecker feeding*
12. Estimated percentage of bark remaining*
13. Estimated years dead*
14. Comments

Stumps

1. Stump number
2. Status
3. Species
4. Diameter at top face*
5. Total height*
6. Apparent cause of death*
7. Wood hardness*
8. Extent of sapwood decomposition*
9. Extent of heartwood decomposition*
10. Number of visible nesting holes*
11. Evidence of woodpecker feeding*
12. Estimated percentage of bark* remaining*
13. Estimated years dead
14. Comments

Field protocols for assessing core variables for trees, snags, and stumps

Determining tree, snag, or stump number and tagging procedure

Live trees, snags, and stumps of measurable size (live trees >4.5 inches (1.37 m) at breast height or live trees on the 1/100th acre plot >4.5 ft (1.37 m) in height, snags >4.5 inches (1.37 m) at breast height, and stumps on the 1/100th acre subplot >8" diameter and <4.5' tall or stumps on the 1/10th acre plot >20" diameter and <4.5' tall) will be numbered sequentially starting with north and continuing in a clockwise direction. If a tree forks below breast height, it will count as 2 trees. For trees >4.5" DBH, an aluminum nail and numbered tag will be driven into the bark plate of the tree at 4.5-ft (1.37 m) facing plot

center. For trees <4.5 in DBH, the tag will be loosely attached using a zip tie on the branch nearest 4.5 ft from the ground facing plot center. Room will be allowed for growth on both nailed and "zip tied". Steel nails and tags will be used on "mechanical plus fire" and "fire only" treatment units to minimize the chance of tag melting and data loss.

    a. For trees from a past inventory: Replace tags as needed. Do not renumber trees. Remove tagless nails from the tree.

    b. For ingrowth (trees which were not "measurable" at the last inventory): Assign new numbers, continuing where the previous numbering left off. Do not use previously used numbers.
      i. 1/100 acre subplot: trees > 4.5 ft (1.37 m) tall
      ii. 1/10 acre plot (including subplot): trees > 4.5" DBH.

    c. For snags: dead trees >4.5" DBH and >4.5' tall. If the living tree number can be determined, use the same number. Otherwise, assign a new number, continuing where the previous number left off and note in comments.

    d. For Stumps: If the living tree number is known, the same number will be used, otherwise, it will be ignored. Put the tag on the top of the stump.
      i. 1/100 acre subplot: >8" diameter and <4.5' tall
      ii. 1/10 acre plot (including subplot): >20" diameter and <4.5' tall

    e. Overlooked trees: Trees too big to be in-growth and were therefore missed in the previous inventory. Number these trees sequentially, starting with north and continuing clockwise, starting with number 101.

1/100th acre regeneration tally of trees less than 4.5 inches (11.4 cm) DBH and greater than 4.5 ft (1.37 m) tall

Seedlings (<4.5' tall and >2 years old) on the 1/100 acre subplot (11.8 ft radius) will be tallied by species and height class. Height classes include: <1', 1-3', 3-5',…, 23-25', and >25'.

Assessing tree, snag, or stump status

One of the following appropriate status codes will be used for each tree, snag, or stump of measurable size.

      D = dead tree (snag)
      DM = dead tree (snag), marked and **not** cut
      L = living tree
      LM= living tree, marked and **not** cut
      S = site tree
      X = fallen tree (no longer measured); or a tree not found. Insert a comment if tree is not found.
      Z = stump

Recording species

The following the two letter codes below will be used to record species of trees, snags, or stumps. These two letter codes will be converted to 4 letter codes (**ge**nus, **sp**ecies) in the database.

Table V-1. *List of codes used for conifers, hardwoods, and unknown trees at Blodgett Forest Research Station*

Conifers	Hardwoods	Unknown/Other
DF = Douglas-fir	AL = alder spp.	HW = hardwood
GS = giant sequoia	BO = CA black oak	MC = conifer
IC = incense-cedar	CH = chinquapin	XX = unknown
LP = lodgepole pine	DW = dogwood	
NM = nutmeg	MA = maple spp.	
PP = ponderosa pine	MD = madrone	
SP = sugar pine	TO = tanoak	
WF = white fir	LO = live oak	
YW = Pacific yew		

Measurement of diameter at breast height and stump diameter **(stump diameters on existing 1/10th matrix and group plots only)**:

Diameter at breast height (4.5 ft; 1.37 m) will be measured to the nearest 0.1"
A.   For trees and snags

    a.   Tagged: measure at the level of the tag making sure that the tape is level around the whole bole of the tree.
    b.   Untagged: measure at breast height (4.5' from the uphill side). Put on a tag.

B.   For stumps: measure the diameter of the top of the stump in inches.

Measurement of height **(existing 1/10th matrix and group plots only)**
Tree, snag, or stump height will be measured to the nearest 1' from the uphill side. Measurements will be taken using a Hagloff hypsometer. Heights on new $1/10^{th}$-acre plots will be determined using regression analysis as described in Bell & Dilworth (1988).

Height to crown base
Average height to crown base for the $1/10^{th}$ acre plot will be estimated to the nearest meter.

CORE VARIABLES FOR ASSESSING CANOPY COVER, STRUCTURE AND COMPOSITION OF WOODY SHRUBS, HERBACEOUS PLANTS, GROUND COVER, AND SEEDLINGS LESS THAN 2 YEARS OF AGE.

Herbaceous plants include all herbaceous monocots, dicots, and ferns found on study sites at Blodgett Forest Research Station. Ground cover includes bare mineral soil, woody litter, leaf litter, wood, moss, and rock.

Canopy Cover

1. Canopy cover analysis utilizing hemispherical photographs.

Woody Shrubs

1. Identification and recording of all species in the 1/10th acre plot.
2. Identification of all species, fixed area time search (Battles et. al., in press)
3. Average height of all species in the 1/10th acre plot
4. Percent cover using an ocular estimate
5. Percent cover using "line point sampling" (Battles et. al., in press)

Herbaceous monocots, dicots, ferns, ground cover, course woody debris, and seedlings less than 2 years of age

1. Identification and recording of all species in the 1/10th acre plot
2. Identification of all species, fixed area time search (Battles et. al., in press)
3. Percent cover using "line point sampling" (Battles et. al., in press)
4. Assessment of seedlings less than 2 years of age.
5. Assessment of course woody debris.
6. Average height of all species in the 1/10th acre plot.*
7. Percent cover using an ocular estimate*

Field protocols for assessing core variables for canopy cover, structure and composition of woody shrubs, herbaceous plants, ground cover, and seedlings less than 2 years of age.

Identification and recording of all species

All vegetation inventory technicians will be taught to identify the common woody plants of Blodgett Forest. Lists of vascular plants as well as extensive research (Battles et. al., in press) on plants present at Blodgett Forest are readily available. On all plots, cover of species will be categorized as rare (<5% cover), common (5%-25% cover) or abundant (>25% cover). We will use a quantitative method for assessing percent cover (described below) to obtain more detailed cover information. All species present will be recorded on all 1/10th acre plots. When recording plant species names, the following procedure will be used.

   i.   Record the first 2 letters of the genus followed by the first 2 letters of the species. This is followed by a number if there are multiple plant with the same code. Ex: greenleaf manzanita is *Arctostaphylos patula* is ARPA, woolly yarrow is *Eriophylum lanatum* is ERLA-6

   ii.   If the genus but not the species is known, record the first 3 letters of the genus followed by a hyphen. Bedstraw (Velcro plant), *Gallium spp.*, is GAL-

   iii.   If you the family but not the genus is known, record the first 3 letters of the family followed by a Z. Sunflower family, *Asteraceae*, is ASTZ

   iv.   If both the genus and species cannot be identified in the field ("b" and "c" above), a sample will be collected in a Ziploc bag and labeled with a unique number, compartment, plot, and date. Plants will be later identified in the lab and displayed to aid in future identification.

Assessment of percent cover using "line point sampling"

Protocols for the assessment of percent cover using "line point sampling" are derived from Battles et. al. (in press). al. (in press). Five $1/10^{th}$ acre plots will be randomly selected in each compartment. 2 plots will be in the matrix area, and the remaining within 3 in groups of different age classes. From the plot center, 10 meter transects will be run in cardinal directions (N, S, E, and W). Along each transect, a point sample will be taken every 10-cm for a total of 400 points. At each point, "hits" will be classified into the 9 categories listed below. This information will be used to determine percent cover of the listed categories.

1. Shrub
2. Herbaceous plant
3. Grass
4. Fern
5. Rock
6. Moss
7. Litter
8. Bare mineral soil
9. Wood (dead)

Identification of all species, fixed area time search

Protocols for the Identification of all species using a fixed area time search are derived from Battles et. al. (in press). A 30-m radius circular plot will be established from each of the plot centers also used in the above section "Assessment of percent cover using line point sampling". Within each circular plot, trained technician(s) will conduct a search for a total of 1 person hour (2 technicians for 1/2 hour or 1 technician for 1 hour). Within the search time, the presence of all identifiable vascular plants will be recorded. Unknown plants will be bagged and collected for later identification. This information will be used to derive species lists within matrix and group areas across all treatments.

Canopy cover assessment using hemispherical photos

To assess structure and understory light conditions, three hemispherical photo will be taken along the same N-S transect used for the "Assessment of percent cover using line point sampling" described above. Sample points will be located at plot center, 5 m due north from center and 5 m due south from center. Photographs will be taken at approximately 1-m height following protocols described in Battles (1999). Data from BFRS weather stations will be used to parameterize the above-canopy radiation model. Software provided by Frazer et. al. (1999) will be used to estimate canopy closure, total transmitted radiation, and the extent of exposure to direct beam radiation (i.e., sunflecks). The precision error associated with these results is typically less than 4% of the mean.

Assessment of seedlings less than 2 years of age

Seedlings less than 2 years of age will be surveyed using 1 m^2 circular plots located 5 m from the plot center in cardinal directions (NSEW). A pin will be used to establish a plot center and a cable cut to 5.64 cm used to establish the 1-m2 plot. Within the plot, all seedling less than years of age will be tallied by species. Unidentifiable species of seedlings will be tallied as "unknown seedling". Seedling surveys will be carried out as late as possible in the season (preferably August).

Assessment of course woody debris

(**Note**: at the the Clemson meeting in November, 2000, the status of these protocols was unclear. We would like to have corresponding papers and assurance of use at the national level before implementing this CWD protocol)

The following protocols are recommended for estimating the structural aspects of CWD as potential wildlife and insect habitat. Sample plots will be established on at least every other grid point on all experimental units. At each sampled grid point, a strip-plot (4 meters by20 meters) will be established with the respective woody fuel transect line serving as the strip-plot center line. Within each strip-plot only logs or parts of logs that are at least 1m in length and have a large end diameter 15cm or greater will be measured and counted. The small end (>7.62cm) and large end diameters will be measured on all qualifying logs or parts of logs that fall within the boundaries of the strip-plot. If a piece extends outside the strip-plot, diameters are measured at the line of intercept of the strip-plot boundary and CWD piece. Piece lengths are the lengths of the CWD within the strip-plot area an are recorded. The length of the entire piece must be measured to determine the midpoint of the CWD. If the midpoint is within the strip-plot, the piece is given an additional rating of ``1" for the Indicator Variable. If the midpoint falls outside the strip-plot the piece is given a rating of ``0" for the Indicator Variable.

In addition the species (if possible) and decay class of each log will be recorded. The following 5 decay classes will be used to rate the CWD (from Thomas 1979):

Decay Class 1 Bark is intact; twigs are present; wood texture is sound; log is still round; original wood color.

Decay Class 2 Bark is intact; twigs are absent; wood texture is sound or becoming soft; log is still round; original wood color.

Decay Class 3 Bark is falling off; twigs are absent; wood texture is hard; log is still round; original color of wood is faded.

Decay Class 4 Bark is absent; twigs are absent; texture of wood is soft, blocky Pieces; shape of log is oval; wood has faded to light yellow or gray.

Decay Class 5 Bark is absent; twigs are absent; wood texture is soft and powdery; shape of log is oval; wood has faded to light yellow or gray.

MEASUREMENT PLAN AND SCHEDULE

Specific types of plots and the measurement schedule for all core variables are listed on the following pages. Due to time and financial constraints we intend to sample heights only on existing $1/10^{th}$ acre matrix plots and group selection unit $1/10^{th}$ acre plots and develop a regression equation to compute heights on new $1/10^{th}$-acre matrix plots. These savings in

time in height measurements will allow us to complete a more detailed assessment of understory species composition and dynamics. The stump inventory will only occur on existing $1/10^{th}$ acre matrix plots and on all group selection unit $1/10^{th}$ acre plots. The following table describes the core variables and their measurement schedule by category (trees, snags, and stumps; woody shrubs, herbaceous monocots, dicots, ferns, and ground cover).

Table 3. *Blodgett Forest Study Site Measurement Plan and Schedule*

Core Variable by Category	Plot type and Measurement of Core Variable (y = yes, will be measured, n = no, will not be measured)				Measurement Year and Season (spring, summer, fall, winter)			
	"Existing 1/10th acre matrix plot"[1]	*"New 1/10th acre plot"[2]*	*"Group Selection Unit 1/10th acre plots"[3]*	*"1/100th acre regeneration sub-plot"[4] **	*2001*	*2002*	*2003*	*2004*
Core Variables in the Category "Live Trees"								
1. Tree number	y	y	y	y	Summer			Summer
2. 1/100th acre regeneration tally of trees less than 4.5 inches (11.4 cm) DBH	n	n	n	y	Summer			Summer
3. Species	y	y	y	y	Summer			Summer
4. Status	y	y	y	y	Summer			Summer
5. Diameter at breast height	y	y	y	y*	Summer			Summer
6. Total height	y	n	y	y*	Summer			Summer
7. Crown Class	y	n	y	y*	Summer			Summer
8. Height to crown base	y	n	y	y*	Summer			Summer
9. Damage and disease	y	n	y	y*	Summer			Summer
10. Quality of foliage	y	n	y	y*	Summer			Summer
11. Comments	y	y	y	y	Summer			Summer

Core Variable by Category	Plot type and Measurement of Core Variable (y = yes, will be measured, n = no, will not be measured)				Measurement Year and Season (spring, summer, fall, winter)			
	"Existing 1/10th acre matrix plot"[1]	*"New 1/10th acre plot"[2]*	*"Group Selection Unit 1/10th acre plots"[3]*	*"1/100th acre regeneration sub-plot"[4]* *	*2001*	*2002*	*2003*	*2004*
Core Variables in the category "Snags"								
1. Snag number	y	y	y	n	Summer			Summer
2. Status	y	y	y	n	Summer			Summer
3. Species	y	y	y	n	Summer			Summer
4. Diameter at breast height	y	y	y	n	Summer			Summer
5. Total height	y	n	y	n	Summer			Summer
6. Apparent cause of death	y	n	y	n	Summer			Summer
7. Wood hardness	y	n	y	n	Summer			Summer
8. Limb condition	y	n	y	n	Summer			Summer
9. Presence or absence of tree top	y	n	y	n	Summer			Summer
10. Number of visible nesting holes	y	n	y	n	Summer			Summer
11. Evidence of woodpecker feeding	y	n	y	n	Summer			Summer
12. Estimated percentage of bark remaining	y	n	y	n	Summer			Summer
13. Estimated years dead	y	n	y	n	Summer			Summer
14. Comments	y	y	y	n	Summer			Summer

Core Variable by Category	Plot type and Measurement of Core Variable (y = yes, will be measured, n = no, will not be measured)				Measurement Year and Season (spring, summer, fall, winter)			
	"Existing 1/10th acre matrix plot"[1]	*"New 1/10th acre plot"[2]*	*"Group Selection Unit 1/10th acre plots"[3]*	*"1/100th acre regeneration sub-plot"[4] **	*2001*	*2002*	*2003*	*2004*
Core variables in the category "stumps"								
1. Stump number	y	n	n	n	Summer			Summer
2. Status	y	n	n	n	Summer			Summer
3. Species	y	n	n	n	Summer			Summer
4. Diameter at top face	y	n	n	n	Summer			Summer
5. Total height	y	n	n	n	Summer			Summer
6. Apparent cause of death	y	n	n	n	Summer			Summer
7. Wood hardness	y	n	n	n	Summer			Summer
8. Extent of sapwood decomposition	y	n	n	n	Summer			Summer
9. Extent of heartwood decomposition	y	n	n	n	Summer			Summer
10. Number of visible nesting holes	y	n	n	n	Summer			Summer
11. Evidence of woodpecker feeding	y	n	n	n	Summer			Summer
12. Estimated percentage of bark remaining	y	n	n	n	Summer			Summer
13. Estimated years dead	y	n	n	n	Summer			Summer
14. Comments	y	n	n	n	Summer			Summer

Core Variable by Category	Plot type and Measurement of Core Variable (y = yes, will be measured, n = no, will not be measured)				Measurement Year and Season (spring, summer, fall, winter)			
	"Existing 1/10th acre matrix plot"[1]	*"New 1/10th acre plot"[2]*	*"Group Selection Unit 1/10th acre plots"[3]*	*"1/100th acre regeneration sub-plot"[4] **	*2001*	*2002*	*2003*	*2004*
Core variables in the category "Woody shrubs, herbaceous monocots, dicots, ferns, ground cover, and seedling less than 2 years of age"								
1. Identification and recording of all species	y	y	y	n	Summer		Summer	Summer
2. Identification of all species, fixed area time search (Battles et. al., in press)	on 2 existing or new 1/10th acre plots/treatment unit	on 2 existing or new 1/10th acre plots/treatment unit	on 3 groups of different age classes per treatment type	n	Summer		Summer	Summer
3. Average height	y	n	y	n	Summer		Summer	Summer
4. Percent cover using an ocular estimate	y	n	y	n	Summer		Summer	Summer
5. Percent cover using "line point sampling"	on 2 existing or new 1/10th acre plots/treatment unit	on 2 existing or new 1/10th acre plots/treatment unit	on 3 groups of different age classes per treatment type	n	Summer		Summer	Summer

6. Assessment of seedlings less than 2 years of age.	y	y	n	n	Summer		Summer	Summer

1. ***"Existing 1/10th acre matrix plots"*** - this term refers to 1/10th acre plots which were established prior to the densification for the Fire and Fire Surrogate Study. Most of these plots were established in 1975?. They are numbered 1-50. The numbering sequence starts at "1" in each individual compartment.
2. ***"New 1/10th acre matrix plots"*** - this term refers to 1/10th acre plots established for the purpose of taking measurements on the Fire and Fire Surrogate Study. They are numbered in sequence starting with 101. The numbering sequence starts at "101" in each individual compartment.
3. ***"Group Selection Unit 1/10th acre plots"*** - this term refers to 1/10th acre plots which were established in group selection units. These plots are established in the center of the group opening within 1-year of harvest.
4. **"1/100th acre regeneration plot"** - this term describes a 1/100th acre (radius of 11.7 (3.6 m) plot nested in both new and existing 1/10th acre plot. The 1/100th acre plot is used only for the purpose of tallying regeneration that is less than 4.5 ft (1.37 m) in height.

*denotes protocols used only on 1/100th acre plots imbedded in existing 1/10th acre plots.

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VEGETATION APPENDIX: ADDITIONAL PROTOCOLS TO BE TAKEN ON EXISTING MATRIX AND GROUP 1/10TH ACRE PLOTS

The following are the procedures used for inventory of existing Blodgett Forest matrix and group 1/10th acre plots. These measurements will be taken to insure the continuity of the Blodgett Forest Inventory during the Fire and Fire Surrogate study period.

Assessment of percent cover using an ocular estimate (existing 1/10th matrix and group plots only)

Estimates of percent cover can often vary between untrained observers. All vegetation technicians will be trained by the site manager to estimate percent cover within 10%. Percent cover will be estimated for all species occurring on existing 1/10th acre plots. On all plots, cover of species will be categorized as rare (<5% cover), common (5%-25% cover) or

abundant (>25% cover). We will use a quantitative method for assessing percent cover (described below) to obtain more detailed cover information.

Assessment of average height estimate (existing 1/10th matrix and group plots only)
Average height of herbaceous and woody plants will be assessed using a height pole or tape for each species on existing 1/10th acre plots. Average heights will be measured to the nearest 0.5-ft.

Classification of Crown class (existing 1/10th matrix and group plots only)
Crown class will be noted using the following crown class codes.

> ***PreDominant (code "P")***: Tree much older than the main stand; residual from a previous stand.
> ***Dominant (code "D")***: Receives direct light from top and sides for most of the day; crown above the main canopy.
> ***Codominant (code "C")***: Receives direct light from above and sometimes the sides; crown in the upper canopy.
> ***Intermediate (code "I")***: Light from above only; most of the crown is in the main canopy.
> ***Suppressed (code "S")***: Only indirect light; crown is below the main canopy level; slow growing.
> ***Understory (code "U")***: Below the main canopy; may or may not receive direct light, trees much younger than the above crown class; not a suppressed tree.

Apparent cause of death (existing 1/10th matrix and group plots only)
The following codes ("C"-"W") will be used to record the apparent cause of death for measurable trees, snags, and stumps.

> C = Cut and left on the plot
> D = Dead at last inventory (even if it changed from a snag to a stump)
> F = Fire
> H = Harvesting damage (broken top, skinned bole, etc.; was there a harvest since the last inventory?)
> L = Lightning
> M = Missing
> N = Natural (insects, disease, suppression, weather damage, etc.)
> P = Physical damage (broken top, etc. not from harvesting)
> R = Cut and removed
> S = Deliberately created snag (girdled, poisoned, etc.)
> U = Other; you must make a comment regarding the condition of the stump or snag
> W = Wind-throw; broken or uprooted below 4.5'; includes snags from previous inventories which have since fallen or broken

Height to the crown base (existing 1/10th matrix and group plots only)

The height to the base of the crown of live trees will be measured to the nearest 1 foot using a Hagloff hypsometer. The height to crown base will be defined as the vertical distance from the uphill base of a tree to where the lower branches of the compressed crown attach to the bole.

Wood hardness (snags and stumps) (existing 1/10th matrix and group plots only)

The average relative wood hardness of snags and stumps will be rated on a scale from 1 to 5, 1 being the hardest and 5 the softest. "1" is comparable to a live tree of the species and "5" comparable to rotten, almost disintegrated wood.

Damage and disease (existing 1/10th matrix and group plots only)

Apparent damage and disease will be noted for live trees. The following codes ("A"-"Z") will be used.

A = annosus root rot (*Heterobasidion annosum* or *Fomes annosus*)
B = butt scar
C = frost crack or lightning scar
D = bark beetles other than *Ips* spp. (*Dendroctonus* spp. or *Scolytus* spp.)
E = *Elytroderma deformans*, Elytroderma needle cast on ponderosa pine (new code in 1998)
F = forked top
G = gall other than western gall rust
H = healthy, no obvious damage
I = pine engraver beetles (*Ips* spp.)
J = pistol butt
K = crook
L = leaning or partially knocked over.
M = leafy and dwarf mistletoe (*Phoradendron* spp. and *Arceuthobium* spp.)
  (1) Rate each third of the crown by the following:
      0 = No visible infection
      1 = Light infection; half or less of the branches are infected; little or no brooming.
      2 = Heavy infection; more than half of the branches are infected; heavy brooming.
  (2) Add the ratings of each third to obtain the rating for the tree.
  (3) Record M in the Damage & Disease column.
  (4) In the comments column record:
      (a) M + tree rating, ex: M2, M6
      (b) If a bole infection is visible, Mbole.
N = white speck or red ring rot (*Phellinus pini* or *Fomes pini*)
O = base girdling
P = brown cubical butt rot (*Phaeolus schweinitzii* or *Polyporus schweinitzii*)
Q = rot in black oak (*Quercus kelloggii*) (new code in 1998)
R = rusts including incense-cedar rust, western gall rust, and white pine blister rust
S = sweep
T = top broken out

U = unknown foliage insect (new code in 1998)
V = blackstain root disease (*Leptographium wagnerii* or *Verticicladiella wagnerii*)
W = wood borers (*Buprestidae*, *Cerambycidae*, or *Siricidae*)
Z = skinned bole above breast height

Condition of limbs (existing 1/10th matrix and group plots only)\
The following codes ("A"-"E") will be used to record the condition of the limbs of standing snags of measurable size.

A = brown foliage present
B = foliage gone but small twigs present
C = small twigs gone but larger branches present
D = branch stubs present
E = no branches present

Extent of sapwood decomposition (existing 1/10th matrix and group plots only)
The following codes ("A"-"E") will be used to record the decomposition state of the sapwood for stumps of measurable size.

A = fresh, hard stumps; little decomposition
B = hard stumps; bark beginning to separate from sapwood
C = intact, soft stumps with bark present, some wood still hard
D = intact to fractured cubical wood and bark
E = mostly soft, fractured cubical wood

Quality of foliage (existing 1/10th matrix and group plots only)
The following codes will be used to generally describe the foliage condition of live trees of measurable size.
Normal (code "N"): foliage color and retention
Pale (code "P"): yellowing, or chlorotic foliage
Short (code "S"): needle length for the species
Thin (code "T"): or sparse crown for the species, poor needle retention, "lion's tailing" of pines

Presence or absence of treetop (existing 1/10th matrix and group plots only)
The Presence (Y) or absence (N) of top will be recorded for snags of measurable size.

Extent of Heartwood decomposition (existing 1/10th matrix and group plots only)
The decomposition stage of the heartwood will be recorded for stumps of measurable size using codes "A"-"E".

A = fresh, hard stumps; little decomposition
B = hard stumps; bark beginning to separate from sapwood
C = intact; soft stumps with bark present; some wood still hard

D = intact to fractured cubical heartwood and bark
E = mostly soft, fractured cubical heartwood

Number of visible nesting holes (existing 1/10th matrix and group plots only)
The number of visible nesting holes will be noted for measurable snags and stumps.

Evidence of woodpeckers (existing 1/10th matrix and group plots only)
Sign (Y) or no sign (N) of woodpecker feeding on snags and stumps will be recorded where observed on measurable snags and stumps

Estimated percentage of bark remaining (existing 1/10th matrix and group plots only)
The estimated percent of measurable stumps or snags still covered with bark will be recorded to the nearest 5%.

Estimated years dead (existing 1/10th matrix and group plots only)
The estimated years since death for measurable snags and stumps will be determined using previous data and harvest knowledge to estimate when possible. The following codes will be used.

Table V-2. Codes used to record years dead for standing snags at Blodgett Forest Research Station

Code	Years dead	Foliage condition
0	0	green, yellow, or orange
1	1	brown and most foliage still on branches
2	2-3	sparse brown
4	3+	no foliage; small twigs gone
9	unknown	

IX. SOILS AND FOREST FLOOR ASSESSMENT PROTOCOLS

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INTRODUCTION

As per the National Study protocol, the spatial pattern of the soil and forest floor sampling will be guided by the design of the subplots for vegetation analysis, whereas the degree of replication within and around each subplot will be determined by the magnitude of the underlying variability in each site. Forest floor and mineral soil will be sampled at all $1/10^{th}$-acre matrix plots and group selection unit $1/10^{th}$-acre plots.

Soil and forest floor sampling will take place in the pre-treatment year (yr 01, 2001), the immediate post-treatment year (yr 03, 2003) and year 04 (2004).

METHODS: FOREST FLOOR

Field Procedures

At each $1/10^{th}$-acre plot, the forest floor will be sampled from 6 pits using a 15cm $\times$ 15cm plot frame and clippers. This destructive sampling will be systematically offset from the vegetation census area to minimize impacts of litter removal, trampling and other disturbances to the vegetation sampling area. Two layers will be sampled at each pit: the L

layer and the F+H layer. These two layers correspond to the layers used in assessing the forest floor as fuel (van Wagtendonk et al. 1998). The bulk density values obtained from the fuels sampling will be applied to the forest floor material that is collected for chemical analysis. Live vegetation will be cut at the base if necessary to exclude it from the forest floor sample. As per van Wagtendonk et al.'s (1998) fuel sampling method, woody material at the forest floor surface will not be collected with the L layer. Each sample will be placed in a labeled paper bag and returned to the laboratory for processing. The total number of forest floor samples to be collected in each sampling year is 4320 (2 layers × 6 pits × 30 1/10th-acre plots × 12 treatment units).

Lab Procedures

Sample compositing

In general, the extent to which the samples from a given site are composited prior to analysis depends on the spatial variability in nutrient content within that site. Based on previous research in these forest stands, we intend to composite the 6 samples from a given 1/10th-acre plot down to 1-2 samples for chemical analysis; however, in highly variable sites or treatments (e.g. just after mechanical harvesting), analyzing all 6 samples independently may be required. Analysis of spatial autocorrelation in forest soils from a hardwood site in Ohio indicate that the chemical properties of mineral soil samples are spatially autocorrelated at ranges up to 10m (Boerner et al. 1998); thus compositing samples taken within this range does not cause the loss of ecologically-relevant information, at least in this hardwood site.

Analysis of forest floor material from similar stands, adjacent to the FFS treatment units, indicate that these stands have met the compositibility criterion described in the National Study protocols: the standard error of the mean (SEM) of the composited samples shall not exceed 20% of the magnitude of the mean of those samples. If the standard error does exceed 20% of the magnitude of the mean, too much compositing has been done. In each of 4 stands, 12 samples were collected per forest floor layer and analyzed for total C and total N. For both C and N, for each layer in each stand, the SEM of the 12 samples was less than 5% of the mean (Greinke, unpublished data).

Each forest floor sample will be air-dried and ground through a Wiley Mill to pass a 20-mesh screen. For each set of samples to be composited, the samples will be homogenized and subsamples of equal mass will be combined to form the composite.

C and N

The composite samples will be homogenized and a 2-g subsample from each will be ball milled to pass a 60-mesh screen for total C and total N determinations by combustion technique (Nitrogen/Carbon Analyzer, Carlo-Erba, Milan, Italy).

METHODS: MINERAL SOIL

Field Procedures

Sampling for chemical analyses and P.S.A

At each 1/10th-acre plot, mineral soil will be collected from the same 6 locations used to sample the forest floor. At each pit, a 0-15cm sample will be collected. We expect each sample to contain only A-horizon material based on personal experience and soil survey data (Rogers 1974). Samples will be placed in labeled plastic bags and stored on blue ice in ice-chests for transport to the laboratory. The total number of soil samples to be collected in each sampling year is 2160 (1 horizon $\times$ 6 pits $\times$ 30 1/10th-acre plots $\times$ 12 treatment units).

Exposed Mineral Soil

The vegetation crews will search each quadrat (NE, SE, SW, NW) of each 1/10th-acre plot for areas of exposed mineral soil. Using ocular assessment, each quadrat will be assigned a level of exposed mineral soil, expressed as a percent of ground cover, as follows: 0%, 1-25%, 26-50%, 51-75%, and 76-100%.

Compaction

Compaction will be measured along the perimeter of the 1/10th-acre plots. The preferred method will be to take penetrometer readings (Bradford 1986). Along the 71m perimeter, 7 readings will be taken at 10m intervals.

Soil Bulk Density

Bulk density samples will be collected by the core method (Blake and Hartge 1986) at the same locations used for the penetrability measures. The soils will be stored in labeled plastic bags for transport to the laboratory. The total number of soil bulk density samples to be collected per year is 2520 (7 samples $\times$ 30 1/10th-acre plots $\times$ 12 treatment units).

Lab Procedures

Soil bulk density samples

Soil bulk density samples will be oven-dried at 105°C to constant weight. The oven-dry weight will be recorded for bulk density calculations.

All other soils

All other soils will be air-dried in the lab, sieved to determine rock content (weight basis), and the <2mm fraction stored in plastic bags prior to analysis, as follows:

Sample Compositing

We intend to composite the 6 soil samples from each 1/10th-acre plot down to 1-2 samples, using the justifications described for forest floor compositing. In the same 4 stands described there, 12 samples of surface mineral soil were collected and analyzed. For each stand, the SEM of the 12 samples was less than 20% of the mean, as follows: pH: 1%; total C, total N, total P, organic P: <15%; Bray P: <20% (Greinke, unpublished data). For these

measurements, the compositing criterion described in the National Study protocol has been met. Based on these data, we intend to composite samples for the FFS study.

For each set of samples to be composited, the <2mm samples will be homogenized and subsamples of equal mass will be combined to form the composite.

Carbon and Nitrogen

A 2-g subsample from each soil sample will be ball milled to pass a 60-mesh screen for total C and total N determinations by combustion technique (Nitrogen/Carbon Analyzer, Carlo-Erba, Milan, Italy).

pH

Soil pH will be determined with a pH electrode, using a soil:solution ratio of 1:5. The suspension medium will be 0.01M $CaCl_2$ (Kalra and Maynard 1991).

CEC, Exchangeable cations

Cation exchange capacity will be determined using 1M NH_4OAc, and exchangeable Ca, Mg, and K will be determined using atomic absorption spectrometry (Thomas 1982).

Aluminum

Aluminum will be extracted with 2M KCl and determined using an ICP (Barnhisel and Bertsch 1982).

Phosphorus

Phosphorus will be extracted with 0.01M $CaCl_2$ and P content determined using colorimetric methods (Olsen and Sommers 1982).

Particle size analysis

The Bouyoucos hydrometer method will be used for particle size analysis (Gee and Bauder 1986). Na-hexametaphosphate will be used for chemical dispersion of the samples, followed by physical dispersion with an electrical mixer. Based on previous work, the expected organic C content of these soils is less than 5% (Greinke 2000). As such, no pretreatments for organic matter removal will be conducted.

Soil Nutrient Availability

Analysis of nutrient availability (i.e. N mineralization and nitrification) will be conducted at each of the 1/10th-acre plots. At each 1/10th-acre plot, 1 sample will be collected during the spring or early summer of each year using aerobic, *in situ* incubations for measurement of N mineralization and nitrification. This involves the following steps: (1) taking a soil sample from the plot, (2) separating the sample into five subsamples, (3) placing four of the subsamples into four separate polyethylene bags and returning them to the hole from which the sample came for a 20-30 day *in situ* incubation, and (4) returning the fifth subsample to the laboratory for immediate extraction with 2M KCl for subsequent analysis of NH_4 and NO_3 concentration by automated colorimetry (Keeney and Nelson 1982). After 20-30 days, the samples which have remained *in situ* in the polyethylene bags are recovered and extracted for inorganic N the same way. Of the four bags buried at each 1/10th-acre plot, we expect

to recover one or two that are free from bore holes and suitable for analysis. Net N mineralization is calculated as the difference in total inorganic N ($NH_4 + NO_3$) between the initial samples and those incubated *in situ* for 20-30 days. Net nitrification is calculated as the difference between the NO_3 in the initial samples and the incubated samples. Proportional nitrification is calculated as the net difference in NO_3 concentration between the initial and incubated samples divided by the total NH_4 available for nitrification (i.e. initial NH_4 + net N mineralization). Refer to Eno (1960) for basic design issues for this method, and Plymale et al. (1987) and Boerner et al. (2000) for examples from one of the network sites. The number of initial samples to be collected is 360 (1 sample × 30 1/10th-acre plots × 12 plots). The expected number of incubated samples collected is 720 (2 bags × 30 1/10th-acre plots × 12 treatment units).

Soil Biodiversity

The diversity of microbial communities will be assessed at each 1/10th-acre plot using the BiOLOG plate system (Garland and Mills 1991, Zak et al. 1994, Dobranic and Zak 1999). This method was chosen to quickly and effectively assess microbial functional diversity with relative ease and low cost. BiOLOG plate systems have been used routinely in our department, and we are equipped with a plate reader, permitting us to conduct the analyses in-house. In addition, this method has been selected for use at several FFS network sites, thus allowing for uniform comparisons across sites.

The initial samples collected for nutrient availability will be used to inoculate the BiOLOG plates. Depending on our resources, we will inoculate Gram (-) and/or Gram (+) plates using procedures described by Zak et al. (1994). We may also assess fungal diversity with BiOLOG plates, using a modification described by Dobranic and Zak (1999).

Sampling treatment effects on mycorrhizal community structure.

A total of 36 mycorrhizal plots will be established within the 80-90 year old forest compartments. These plots be distributed evenly among the treatments with each mycorrhizal plot located within a different 0.1 hectare plot. Mycorrhizal plots will be located under the canopy of mature Douglas-fir trees that are likely to survive the treatments. This host-delimited sample will help reduce spatial variation between plots, and the selection of Douglas-fir allows us to take maximum advantage of prior mycorrhizal data from Blodgett. A full set of core samples (36 X 3= 108) will be taken in late June or early July of 2001 prior to treatment. Post-treatment core samples (108/sample period) will be taken in each of the successive years in the same plots along parallel arrays spaced 10 cm apart.

Soil cores will be stored at 5° C and processed within 2 weeks of collection. Root samples will be wet sieved, washed to remove most of the soil, and stored frozen. Frozen samples will be thawed, placed in ethanol, and mycorrhizae will be sorted by color and shape, freeze-dried, weighed, and archived for later molecular analysis. DNA will be extracted from individual mycorrhizae, and the internal transcribed spacer region (ITS) will be amplified, and characterized by restriction fragment length polymorphisms and sequence analysis. Additional rRNA targets will be amplified and sequenced if ITS-based identification are insufficient. This basic approach results in identification for a high percentage of fungal species in similar previous studies (Bruns et al. 1998; Horton and Bruns 1998; Baar, et al. 1999; Taylor and Bruns 1999).

Total mycorrhizal biomass will be compared pre and post treatment by ANOVA to test for treatment effects on mycorrhizal abundance. Pre and post-treatment fungal community composition will be compared with principle component analysis to see if fire and fire-surrogate treatments have a similar directional effect on mycorrhizal community structure. Comparisons to control plots will allow us to examine year to year and spatial effects that are independent of treatment. In addition the similar sampling scheme will enable us to compare results between this Douglas-fir biased study and a similar white fir biased study that we are conducting with the USDA Forest Service at Teakettle experimental Forest.

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X. ENTOMOLOGY PROTOCOL

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INTRODUCTION

The fire-fire surrogate study will determine the effects of prescribed burning, thinning, and combined treatments in replicated stands on various parameters of each stand. The significance of treatment effects on entomological response variables, individually and in multi-way combinations with variables from other disciplines, will be statistically evaluated. In this study plan, we provide protocols for establishing insect conditions prior to treatment, and for re-evaluating those conditions after treatment. The data collected will feed into the national database, and be available for use by other disciplines in the project. Protocols for coarse woody debris are described in the vegetation section.

The site level hypotheses we wish to address are the following:

1. Treatments (fire, fire and mechanical, mechanical and control) will have no effect on:

a. subsequent attack, tree mortality or morbidity due to primary bark beetles in the genera *Ips*, *Dendroctonus* and *Scolytus*.
         b. the activity of secondary bark beetles such as twig beetles, *Pityophthorus* spp.
2. The landing rates of bark beetles and associated insects on trees will not be related to:
         a. Bark beetle associated tree mortality on local and treatment wide scales
         b. Scorching of individual trees within the burned plots
         c. Activity levels of bark beetles (to be determined by mark-recapture studies independently of the treatment areas).
3. Treatments will not increase the activity of:
         a. ground dwelling spiders, carabids or other arthropod predators associated with coarse woody debris.
         b. the beetle vectors (eg. *Hylastes* and *Steremnius*) of *Leptographium wageneri*, the pathogen that causes black stain root disease. To be done in cooperation with Matteo Garbelotto in the PATHOLOGY section.
4. Treatments will have no effect on the interactions between bark beetles, secondary insects and primary cavity nesting birds. To be done in cooperation with Reg Barrett in the WILDLIFE section.

METHODS

Null Hypothesis:

1a. Treatments (fire, fire and mechanical, mechanical and control) will have no effect on subsequent attack, tree mortality or morbidity due to primary bark beetles in the genera *Ips*, *Dendroctonus* and *Scolytus*.

Before the applications of the treatments all of the 1/10-acre study plots will be censused for bark beetle activity and associated mortality. The vegetation group will have recorded information on species, size and location of all trees in these plots. At each successive grid point we will scan 180 degrees for trees that are clearly in decline or devoid of needles. As such trees are found, we will record bark beetle species responsible for mortality, fading stage (color i.e. lime or light green, straw colored, yellow, red, or gray {old dead}), and evidence of pitch tubes and frass. In addition to this national protocol, we will then scan the full plot 1/10-acre plot for the same data. This census will be repeated in May/June of each year following treatment.

In addition to identifying dates of attack and insect species, fire injury to the root, stem, and crown, mechanical injuries, and other factors that would dispose the tree to insect infestation will be rated, as will evidence of frass and pitch tubes.

Using data gathered prior to treatment, differences in tree mortality between the treatment areas will be determined using hierarchical log-linear analysis and analysis of variance, as appropriate. After burning and mechanical treatments have occurred, differences among treatments will be incorporated into the analytical procedures.

Null Hypothesis:

1b. Treatments (fire, fire and mechanical, mechanical and control) will have no effect on the activity of secondary bark beetles such as twig beetles, *Pityophthorus* spp., in pines.

At each of the plot centers, lower branches of the three conifers (with the exception of incense cedar) closest to the plot center with DBH greater than 4" will be examined for evidence of attack by *Pityopthorus* spp. When presence of *Pityopthorus* spp. is noted, the number of lower branch tips with *Pityopthorus* present will be recorded. Using data collected during the vegetation survey of tree diameter and location relative to the plot center, *Pityopthorus* spp. data will be spatially referenced for GIS analysis. Data on *Pityophthorus* spp. will be collected annually in May/June.

Null Hypothesis:

2a. The landing rates of bark beetles and associated insects on trees will not be related to bark beetle associated tree mortality on local and treatment wide scales

Bark beetle landing rates on ponderosa pine were monitored at Blodgett Forest between 1997 and 1999. The main bark beetle taxa that landed on ponderosa pines were (in decreasing order of abundance) *Hylastes* spp., *Gnathotrichus* spp., *Ips latidens*, *Dendroctonus brevicomis*, *I. paraconfusus*, and *D. ponderosae*. In addition, some of the bark beetle predators were collected from these traps, including *Enoclerus* spp. (Coleoptera: Cleridae) and *Temnochila* spp. (Coleoptera: Trogositidae). In the fire/fire surrogate study, we will determine the relationship between bark beetle landing rates and bark beetle associated tree mortality, as well as variation in landing rates among treatments. In each of the 12 treatment areas, we will attach wire mesh sticky traps (1' x 2' of 3mm wire mesh, treated with tanglefoot and carbaryl) to 2 groups of 5 ponderosa pines. Groups will be located between randomly selected quartets of matrix 1/10-acre plots. Each tree will have four traps attached to it, two at the base, and two 4-5m above the ground. An initial landing rate measurement will be collected prior to mechanical treatments in July 2001. After this time, insects will be removed from traps in late June and late October of each year. In addition to the bark beetles, we will remove all bark beetle predators and subsample the traps for bark beetle parasites. We will also collect any *Steremnius* spp. (Coleoptera: Curculionidae) from the traps to provide additional data on the activity of this vector of the pathogen that causes black stain root disease. Relationships among the landing rates of primary bark beetles, secondary bark beetles, bark beetle predators and bark beetle parasites will be determined. In addition, these landing rates will be related to bark beetle associated tree mortality on spatial scales from the local 1/10 care plot matrix data to the area wide matrix plot data. Differences in landing rates among treatments will be tested using ANOVA following square root transformation of the data.

Null Hypothesis:

2b. The landing rates of bark beetles and associated insects on trees will not be related to scorching of individual trees within the burned plots

We will determine the effects of fire scorching on the landing rates of the bark beetles and their associated fauna on ponderosa pines and white firs. In all plots that are burned as part of the treatment protocols (6 plots) we will select five fire scorched trees of each species. For each of these trees, an unscorched or minimally scorched tree will be selected as a negative control. Landing rates of bark beetles will be monitored as detailed above, with the exception that the traps will be monitored every month after the prescribed burn. Differences in landing rates between scorched and unscorched trees of each species in areas with and without mechanical treatment will tested using ANOVA. Paired t-tests may also be used to detect differences in landing rates between scorched and unscorched trees.

Null Hypothesis:

> **2c. The landing rates of bark beetles and associated insects on trees will not be related to activity levels of bark beetles (to be determined by mark-recapture studies independently of the treatment areas).**

Independently of the treatment areas in the fire-fire surrogate study, we will determine the relationships between bark beetle landing rates and the level of bark beetle activity as determined by mark-recapture studies. This relationship will indicate whether the landing rates detected in the fire-fire surrogate study are indicative of bark beetle activity in the treatment and control areas.

Null Hypothesis:

> **3. Treatments will not increase the activity of:**
>   **a. ground dwelling spiders, carabids or other arthropod predators associated with treatments effects on coarse woody debris.**
>   **b. the beetle vectors (eg. *Hylastes* and *Steremnius*) of *Leptographium wageneri*, the pathogen that causes black stain root disease. To be done in cooperation with Matteo Garbelotto in the PATHOLOGY section.**

We will use pitfall traps to examine the effects of fire and fire surrogate treatments on insects and spiders that utilize leaf litter and coarse woody debris. We will collect all spiders (Araneae), all ground beetles (Coleoptera: Carabidae), and beetles in the genera *Hylastes* (Coleoptera: Scolytidae) and *Steremnius* (Coleoptera: Curcurlionidae) caught in the traps. Pitfall traps have been used extensively to sample these taxa, although specific study designs vary (see Andersen and Muller 2000, Apigian and Wheelwright 2000, Brennan et al 1999, Churchill and Arthur 1999, Fahy and Gormally 1998, Niemela et al 2000, and Nystrand and Granstrom 2000 for similar recent applications).

Pitfall traps used in this study will consist of 10 cm deep plastic cups with approximately 5 cm of a 1:1 ethylene glycol:water mixture in the bottom as a killing agent and preservative. The traps will be buried into the ground with the lip level with the soil surface. The traps will be covered by squares of plastic held several inches above the traps on wire to act as rain guards.

Every month from April to October we will randomly select five 1/10th acre plots within each of the twelve compartments for sampling. We will place five pitfall traps within each

plot, for a total of 300 traps for the entire study. Trap location within the plots will be determined by setting up a transect line through the center of the plot along a randomly selected azimuth. Five points along this line will then be chosen at random for the traps. Additional sampling for *Hylastes* and *Steremnius* will involve selecting individual ponderosa pines that have been confirmed to have black stain root disease within the plots and placing 8 pitfall traps at random azimuths and distances (up to 3 m) away from the trees. Up to 5 trees / compartment will be sampled.

Traps will be placed and left open in the field for 72 hours. The traps will then be removed and the contents stored in vials of 70% ethanol for later identification. Spiders will be identified to the family level and beetles will be identified to species.

Differences between treatments in the number of beetles that may vector *L. wageneri* (eg. *Hylastes* and *Steremnius*) captured in pitfall traps in the randomly selected 1/10th acre plots, and near black stain root disease-affected pines, will be tested using ANOVA. Similar analyses will test differences between treatments in the number of ground dwelling spiders, carabids and other arthropod predators captured in pitfall traps.

Null Hypothesis:
   4.   Treatments will have no effect on the interactions between bark beetles, secondary insects and primary cavity nesting birds. To be done in cooperation with Reg Barrett in the WILDLIFE section.

In addition to the national protocol for woodpecker scaling and excavation, we will survey the bole of bark beetle killed trees using binoculars for scaling and excavation as well as evidence of frass and pitch tubes.

Bole segments showing woodpecker scaling or excavation may be continuous or discontinuous. Each bole segment displaying woodpecker scaling or excavation will be recorded as a range of feet by entering the starting and ending vertical heights of the scaling or excavation on the bole. For example, a dead tree may exhibit scaling at a bole height beginning at 15' and ending at 45' (15-45') and beginning again at 55' and ending at 65' (55-65'). A range beginning with a zero indicates that woodpecker scaling begins at the base of a tree. The length of bole segment(s) should be ocularly estimated to the nearest 5 feet. To calibrate the observer's eye, ocular estimates should be regularly checked against clinometer or Relaskop measurements of the same tree. The base of the tree will be examined for woodpecker activity associated with *Dendroctonus valens*, the red turpentine beetle.

Table E-1. *Summary table for Entomology Protocol*

Summary table for Entomology Protocol			
Variable Measured	Compartment	# of 0.1 acre plots	When measurement will take place
For Bark Beetle killed trees:			
Tree ID number	all 12	All	once / year, May/June
Tree fading stage	all 12	All	once / year, May/June
Bark beetle sp.	all 12	All	once / year, May/June
Fire scorching to root, stem and crown	6 burned	All	once / year, May/June
Mechanical injury	6 thinned	All	once / year, May/June
Evidence of frass and pitch tubes	all 12	All	once / year, May/June
For Pityopthorus spp. Survey:			
Number of lower branch tips with Pityopthorus present	all 12	All	once / year, May/June
Tree ID number	all 12	All	once / year, May/June
Fire scorching to root, stem and crown	6 burned	All	once / year, May/June
For Wood Pecker Survey:			
Woodpecker scaling extent on bole	all 12	All	once / year, late summer
Woodpecker excavation extent on bole	all 12	All	once / year, late summer
Tree ID number	all 12	All	once / year, late summer
Within subsample rectangle:			
Woodpecker Scaling	all 12	All	once / year, late summer
Woodpecker Excavation	all 12	All	once / year, late summer
Dendroctonus exit holes	all 12	All	once / year, late summer
Buprestid exit holes	all 12	All	once / year, late summer
Cerambycid exit holes	all 12	All	once / year, late summer
For Pitfall Traps:			
Hylastes sp.	all 12	5 plots	monthly, April through October

Steremnius sp.	all 12	5 plots	monthly, April through October
Carabid sp.	all 12	5 plots	monthly, April through October
Spider families	all 12	5 plots	monthly, April through October

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XI. PATHOLOGY PROTOCOLS

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PATHOLOGY: NATIONAL PROTOCOLS

It is recognized that sites will vary with respect to preeminent disease problems, including root diseases and, in particular, above-ground diseases such as dwarf mistletoe, rusts, and various canker and foliar diseases. These above-ground diseases should be addressed, if desired, on an individual site basis because few inferences can be made on treatment effects over the entire suite of study sites with respect to these localized conditions.

The following protocol, however, addresses the need for a consistent pathological variable that can be measured across all treatments and sites, given constrained budget levels. Because all trees have roots and grow in soil, fire and other treatments can directly impact this component relative to disease causing microorganisms, notwithstanding direct above-ground effects such as crown scorch and bole scorch that are being addressed by another discipline. Furthermore, there is a critical need for information regarding below-ground pathological processes and potential effects of fire and other disturbances on these processes. Therefore, as a starting point, a rudimentary below-ground pathology protocol is presented that relies, in principal, upon above-ground symptomatology and root sampling.

THE PROTOCOL

An initial survey of all treatment plots will be conducted in order to mark trees that have pre-existing symptoms so as not to confuse these with subsequent treatment effects. This survey will follow the current entomology plan that involves 100% inventory of all 1/10th acre plots on all treatment units. In the case of pathology, observations will consist largely of above-ground crown symptoms based upon a rating scale developed by TRB. Four symptom classes are recognized ranging from healthy to moribund. Determinants involved in these crown symptom classes are based upon foliar color, needle/leaf size, and internode length, with color being the primary character defining symptomatic trees. These symptom

classes and their application to this study will be specified through on-site training by TRB personnel.

The pre-treatment data collection will include all trees over 10 cm in diameter. Symptomatic trees will be tagged with fire-resistant metal tags that are numbered sequentially. Tags will be placed on trees via aluminum nail at the highest point that can be practically and safely reached (approximately six feet) above ground level. If plot grid points are monumented, then tags should face in the direction of grid center. Data will be obtained on all treatment plots and replicates on each study site. Data collection on all symptomatic, putative root diseased trees will consist of recording the above mentioned crown symptoms, dbh, crown position, and signs of other distress agents (such as bark beetle pitch tubes, exit holes, etc.). Because hardwoods are different than conifers relative to expectations for diseases and for manifestations of symptoms, a different protocol will be developed for this ecosystem. Nonetheless, the hardwood site pre-treatment examination will be conducted for signs of *Armillaria* root disease.

Pre-treatment data collection for pathology involves woody root samples taken from symptomatic trees via careful excavation of lateral roots that are near the soil surface. A minimally invasive procedure will be used that involves the sampling of intact root tissue by means of an increment hammer. This cautionary method is crucial in that minimal tissue disruption is essential--excessive wounding will cause anomalous insect attraction. Such undesirable impacts would confound interpretation of treatment effects relating to entomological data. To minimize these potential confounding effects, the pretreatment survey will be conducted in the following manner.

Entomology crews who, following the entomology protocol and trained in this pathology protocol, will identify trees that are symptomatic (i.e. potentially root diseased trees). Such trees will be identified by tagging with the above described numbered tags in addition to recording their distance and azimuth from the plot grid point. Root samples will not be taken from identified symptomatic trees until and unless the insect flight season has passed. Thus, root samples from identified, symptomatic trees will be obtained during late fall or after insect flights have ceased.

Several samples of wood per root will be obtained by coring the excavated (or exposed) root from the root collar to approximately one meter distally along the root. **(Note: There is concern by the entomology researchers of how the exposure of this root material will effect rates of insect attack, particularly in *D. valens* in *Pinus ponderosa*. It is suggested that this sampling be done after the trees are dead).** At least two such woody roots having a minimum diameter of about five cm will be sampled per symptomatic tree. Roots from a few (two to three) healthy, asymptomatic, randomly selected trees in each treatment plot will also be sampled. These trees will also be tagged with the above described numbered tags. While it is necessary to tag all symptomatic trees during the sampling of each $1/10^{th}$ acre plot, root samples from all these trees are not necessary, particularly if there are large numbers of symptomatic trees in a plot or the disease can be readily identified by symptom characteristics (e.g., black-stain root disease). In the event of a large number of symptomatic trees, a sub-sample of trees will then be obtained that is consistent with good judgement, logistic capability, and statistical validity. As a preliminary

general rule, about 20% of symptomatic trees would be sampled in such cases, although this percentage sample can vary depending upon the amount of symptomatic trees observed. Also, prior knowledge of root diseases on sites, past history, and existing conditions will also be important factors used in the interpretation of symptoms and sampling intensity. To provide consistency and analytical validity for the overall meta-analysis, these issues will be resolved on site in conference with TRB personnel.

Extracted cores from all trees will be stored in ice chests or similar thermally protected implement. Isolations will be conducted according to standard lab techniques using specific media specified by TRB. Emerging relevant fungi from wood samples will be subcultured and identified. A copy of all data will be provided to TRB for analyses.

Post treatment sampling will be similarly conducted. During the second and fourth years post-treatment, treatment plots will be observed and sampled relative to crown symptoms. Newly symptomatic trees will be tagged, noted, and root samples taken and analyzed as above.

Regarding other diseases that may be present in stands or diseases that are regional in nature (e.g., dwarf mistletoe, rusts), the sites having arrangements with other pathology groups can develop their protocols to address these issues. Such protocols will be incorporated into site study plans that are available for review by SMIC members upon request.

PATHOLOGY: ADDITIONAL PROPOSED SITE LEVEL PROTOCOLS

INTRODUCTION, FIRST ADDITIONAL PROPOSED STUDY

Wounding appears as one of the most significant variables that may affect this study. It appears that because of the low intensity of the prescribed burns only trees with relatively small diameters and not fire adapted will be susceptible to fire scars. I propose here to look at the effects of treatments on the fungal microbial component that will invade these wounds. Such fungi are responsible for decay, wood alterations, and diseases. The information will be also very valuable from a wood ecology perspective, providing us with data on the micro-ecological effects of the various treatments.

Hypothesis
The hypothesis we are testing here is that there may be a difference in wood inhabiting fungi (number of species or relative abundance of species) that enter trees in wounds created by the different treatments.

METHODS

Tree Species
We will look at three most important fire-susceptible species at Blodgett

(incense cedar, *Calocedrus decurrens,* will be excluded)

1. Ponderosa pine (*Pinus ponderosa)*
2. White fir (*Abies concolor)*
3. Douglas-fir (*Pseudotsuga menziesii*)

Size of Trees

For each species fire wounds caused by low intensity prescribed fires are most likely for trees up to a certain diameter. We will only look at wounds in trees up to 18 inches in diameter. There may be wounds on trees of larger size, but these wounds may be considered as rare events, and would fall out of the objective of this study.

Wound Location

We will study wounds found up to 50 cm from the soil line. Wounds will be divided in two groups:

a. On root flares, root collar
b. Above root collar

Wound Sampling

Three samples will be collected per wound, when possible. Samples will be collected in a longitudinal (vertical order), equally spaced to represent sample from the top portion , the middle portion, and the basal portion of the scar. Distance among sampling points will vary according to the size of the scar; this variability will allow for each sampling to represent the full array of microhabitats represented by a scar. Wounds that are wider than 2.5 cm will be sampled with at least two sampling lines (one sampling line of three samples for each 2.5 cm will be the rule). A subset of the wounds may be resampled after 1 and 2 years to check for progression of decay in each wound, and shifts

Sampling Technique

A 10-cm wood core taken with a Pressler wood corer will represent the sample taken at each sampling point. The wood core will be extracted and placed in a sealed container in the field (normally we use taped large drinking straws). Once in the lab, each core will be sprayed with a benomyl solution in order to cut down on the contaminant mycoflora. Wood decay fungi are resistant to benomyl. Wood cores will be placed in a moist chamber an after a week all visible fungal structures (spores or hypae) will be subcultured. Isolates will be pooled together, and identification will be aided by comparison of DNA sequences from isolated organisms and known sequences deposited in GENBANK.

Based on the specific taxa isolated on our first sampling, we will design taxon-specific primers that will allow us to determine composition of wood-inhabiting fungi directly from the wood. We will use direct PCR from wood extracts in this approach. We will save core samples from the first year sampling to compare results obtained with the two approaches.

Sampling Scheme

To test this hypothesis, we will look at wound-related fungi in the Fire, Mechanical, and Fire plus Mechanical treatments. A minimum of 30 wounds per tree species per treatment block would be necessary (a total of 90 wounds per treatment per host species).

Question

Will we have this number of wounds created under "normal" harvest and burn operations?

Proposal

Would it be possible to cause 30 such wounds in a subplot in each treatment block. The wounds could then be standardized, of course I am talking of really fairly small wounds (5-10 com wide) on trees up 18" DBH. If this is not possible, we will utilize trees "naturally" scarred during mechanical and fire operations.

Analysis

Community comparisons among treatments will be performed with standard statistical and ordination techniques

INTRODUCTION, SECOND ADDITIONAL PROPOSED STUDY, PART I

There are three known mechanisms for spread of root diseases:

1. Through spores infecting stumps and standing trees
2. Through root contacts and grafts
3. Through structures growing through the soil (e.g. rhizomorphs)

While point c will be hard to experimentally test, we will use data on rhizomorphs from the general study.

We propose to conduct two studies to experimentally test the effects of the treatments on means of spread of Annosus root disease caused by the pathogen Heterobasidion annosum.

EFFECT OF TREATMENTS ON THE AIRSPORA

Basidiospores of Heterobasidion annosum are essential in both establishing and expanding new infection centers. Such basidiospores are produced by basidiocarps (fruit bodies) that are likely to be affected by both fire and mechanical treatment. These basidiocarps are in fact sometimes inconspicuous and often at the duff and root crown level, where the impact of both mechanical and prescribed burn may be maximum. We have also recently determined that in Blodgett there are two biological species (soon to be officially recognized as different species) of the pathogen: the fir biological species (S) is widespread on white and red fir, the P biological species is more rare but it has been detected both in the airspora (spores

trapped in the air) and in pine plantations. In our study we will use molecular techniques to potentially determine the differential effects of the treatment not only on overall basidiospore production, but also on the two different biological species. We have recently submitted a paper to the Canadian Journal of Botany, in which we provide what we think is compelling evidence that 99% of the spores trapped in a stand are originated in that stand. We do not thus believe that the confounding effect (background spore level due to spores coming in from other forests.

Because our data indicates that 2 km is a sufficient barrier, but we have no data at the lower scale, we will only replicate our study twice using the northernmost and the southernmost treatment blocks for each treatment. This will eliminate any possibility of crossing of spores from one treatment into the other. Sampling transects will also be placed in order to minimize such risk.

Hypothesis Tested
The treatment will affect spore production, a major inoculum source for the pathogen Heterobasidion annosum

METHODS

Spores will be caught using the wood disk exposure method, this method has been already widely used at Blodgett. It consists in placing a disk of uncontaminated and surface sterilized pine wood in a petri dish. The dish is opened and disks exposed for a period of 4 hours (this has been determined to be an optimal time for Blodgett). In the lab, colonies are counted and recorded, under the assumption that each colony corresponds to one spore. Colonies are then subcultured and the biological species of the fungus determined with molecular methods.

Sampling Scheme
Three traps will be placed at each sampling point. Sampling points will be placed at regular intervals (50 m) along transects. A minimum of two transects will be placed in each treatment block. Transects will be perpendicular to each other and either in a NS or in a EW direction. Multiple transects may be required in order to obtain equal number of sampling points in both directions, without changing the spacing between the sampling points.

Analysis
We will look at differences among treatments in both number of spores caught and type of spores (S vs. P) caught. We will perform three spore catches per year and thus we will be able to follow the effects as time progresses on spore production

SECOND STUDY PART II

INTRODUCTION

Because fungal growth in roots and root contact mediated fungal contagion plays a major role in many root diseases (including Annosus root disease) it is important to determine the effects of fire and wounding on such growth. While some information on this aspect can be gathered by the general pathology protocol, we feel that a more controlled experiment, may provide us with important information. We propose to inoculate tree roots (white fir) and stump roots (ponderosa pine) with the pathogen in order to standardize conditions.

Hypothesis

Treatments may affect fungal growth in shallow roots and hence affect root diseases.

METHODS

Inoculation Technique

It is minimally invasive, we will place a dowel colonized by the fungus on roots **(Note, concerns for the potential of this technique have additional effects on insect attack is acknowledged and has been voiced at the site level)**, at 10 cm from the root collar in the distal direction (away from the tree), wounds are 5 mm wide , and the bark is replaced on top of the wound, sealed with grafting wax, and the root is tagged and covered with soil. We have never observed attractiveness of such inoculations to beetles
We will use the S group of the pathogen. We have several strains from Blodgett that we can use, we will use two different strains. We will inoculate white fir trees and ponderosa pine stumps. Standing white firs are the most common infection courts for the pathogen. Pine stumps are the most common infection courts for this host species. Also the S group commonly infects pine stumps. With this approach we will not have to inoculate the P group, which appears to still be rare or limited to plantations at Blodgett.

Inoculations will be performed in the Fall of the year 2001. We would inoculate thirty trees and thirty stumps in each treatment block. Two different inoculation schemes will be followed based on recommendations by the reviewers. a) Thirty white fir trees and ponderosa pine stumps will be randomly inoculated in each treatment block b) Three subplots will be identified in each treatment block. Each subplot will contain 10 white fir trees and 10 ponderosa pine stumps that will be inoculated. In each subplot small basal wounds will be simulated by using the relative treatment.

Sampling

Cores will be taken from the roots after 1 and 2 years, at regular intervals from the inoculation point. Cores will be checked for H. annosum presence and the fungus will be subcultured. Effect of treatment on fungal growth will be assessed by calculating extent of root colonization by each isolate. Somatic compatibility tests will be performed to ensure the isolates collected in the sampling phase are the same used in the inoculation.

Analysis
Standard statistical analysis such as ANOVA will be used to compare growth among treatments.

INTRODUCTION, THIRD ADDITIONAL PROPOSED STUDY
Conducted in cooperation with Don Dahlsten, Entomologist

Blackstain disease caused by the ascomycete Leptographium wagenerii is present at Blodgett, both on Douglas-fir and on Ponderosa pine. One of the most interesting aspects of this disease is the potential vectoring by insects. Root feeders of the genus Hylastes are reputed responsible for transmitting the disease. Evidence for insect vectoring is stronger for the Douglas-fir than for Ponderosa pine.

I propose to trap Hylastes spp. insects in the four treatments according to the method and design proposed by Don Dahlsten. I will look for the presence of the pathogen using molecular techniques in order to determine phoresy values. It would be useful to have a complete trapping on all the selected blocks before treatment to determine baseline values.

XII. TREATMENT COSTS AND UTILIZATION

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INTRODUCTION

There are economic costs and benefits associated with reducing fuel loadings whether this happens through uncontrolled wildfires, prescribed natural fire, prescribed burning, mechanical removals of coarse fuels, or some other means. If silvicultural cutting (thinning, improvement cuts, regeneration harvest, etc.) is part of the management strategy then materials removed might help offset treatment costs. A better understanding of these costs and benefits will enable management to make more informed decisions regarding the most appropriate action with regards reducing fuel loadings.

Objectives

1.   Quantify the costs of fire and fire surrogate treatments.
2.   Over the life of the study, quantify the economic consequences on utilization of fire and fire surrogate treatments.
3.   Validate and existing harvesting model.

Quantify the costs of fire and fire surrogate treatments

All costs associated with prescribed burning should be recorded including all personnel

involved in both planning and burning operations. All equipment used including vehicles (cars, trucks) should be recorded. Although all actual cost data should be recorded, the size of the compartments is too small to be representative of normal prescribed burning areas and therefore it is felt that <u>expert opinion</u> may be a more appropriate costing method.

Costing of mechanical methods will be more intensive at the Blodgett site compared to the other ten sites involved in the F&FS study, principally due it being readily accessible from UC Davis. The table below divides the main elements of mechanical methods into individual components along with potential data sources.

Table T-1. *Components of mechanical harvest methods*

Element	**Component**	**Potential Data Source**
Machine	Purchase price + finance	Contractor or Manufacturer (make, model & options)
	Depreciation	Equipment sales or standard 20% after five years
	Consumables	Contractor or estimate
	Repair	Contractor or estimate
	Machine capacity (size, speed)	Manufactures data, work study
	Annual working hours	Contractor or standard 1600 hours
	Time on site	Operator Logs, Vibration sensing data loggers
	Cost to move machine	Supervisor
	Production while on site	Machine Logs, Machine printout
Operator	Experience	Supervisor
	Pay & Benefits	Supervisor
	Hours (productive & unproductive)	timesheet & Vibration sensing data loggers
	Set up time	time spent pre-planning on timesheet
Supervision & Planning	Supervision	Salary + on-cost / per hour
	Planning	Salary + on-cost / per hour
Miscellaneous	Haulage	Contractors price per ton
	Facilities (roading, shelter, electricity)	Roading costs, hire costs

Most machine-related costs can be calculated using standard figures as long as there is an accurate record of the machine make and model and productive & unproductive hours on the site. Dataloggers have been developed at UC Davis which moniter machine vibration to calculate productive and unproductive time on site. The dataloggers will require data to be downloaded once a week, plus an accurate record of which machine the datalogger is fitted and on which compartment it is working. A data logger should be fitted to each machine that is working on the Blodgett study sites. The dataloggers require no input by the operators

other than recording when the machine moves from a compartment. In addition to the data loggers, occasional time-motion studies will be conducted by UC Davis researchers. This will be principally to verify the accuracy of the data loggers.

Data loggers will not be fitted to timber trucks, chippers or chainsaws. An accurate record must be kept of each operator and machine that works on the site. Ideally accurate information on operator wages would be useful, but as a minimum the hours worked on the site will be required.

Records should be kept of supervision time and any other cost related factors such as roading.

Agreements to allow monitoring of operating times and to provide scale records by compartment must be built into harvest contracts (or formally agreed upon in advance with purchasers) by the site manager.

Over the life of the study, quantify the economic consequences on utilization of fire and fire surrogate treatments.

In addition to the cost data, information will be required on the volumes cut and burned. The principle source for this data will be before and after plots conducted by the Vegetation group of the F&FS study. Weighbridge tickets or volume records and product specifications must be collected on all loads of timber and chips removed from site by truck. If available income figures for each product cut should be recorded.

Utilization researchers will develop estimates of the economic consequences with the volume, value and cost data.

Validate an existing harvesting model.

UC Davis has an existing harvesting cost model, ST Harvest. Estimates from the model for similar conditions will be compared with the compartment level cost data. This comparison will act as a validation of the existing model.

Certain site information is needed as input to the model. The site manager will supply accurate topographic maps of all units, with compartment boundaries and landing locations indicated, to UC Davis. These will be used to calculate compartment areas, and to estimate average skidding, forwarding or yarding distances and ground slopes. Indications should be given of ground softness and roughness.

XIII. APPENDIX

Blodgett Forest Treatment Area Map

Maps of individual treatment units

Blodgett Forest Research Station

FIRE-FIRE SURROGATE UNITS

LEGEND

- Control Units
- Fire Only Units
- Mechanical Only Units
- Mechanical and Fire Units
- Group Openings

	Paved Roads		Class I Streams
	Graveled Roads		Class II Streams
	Seasonal Roads		Section/Ownership
	Seasonal Low Use Roads		Gate

40 Ft Contours

FEET

0   1000   2000   3000
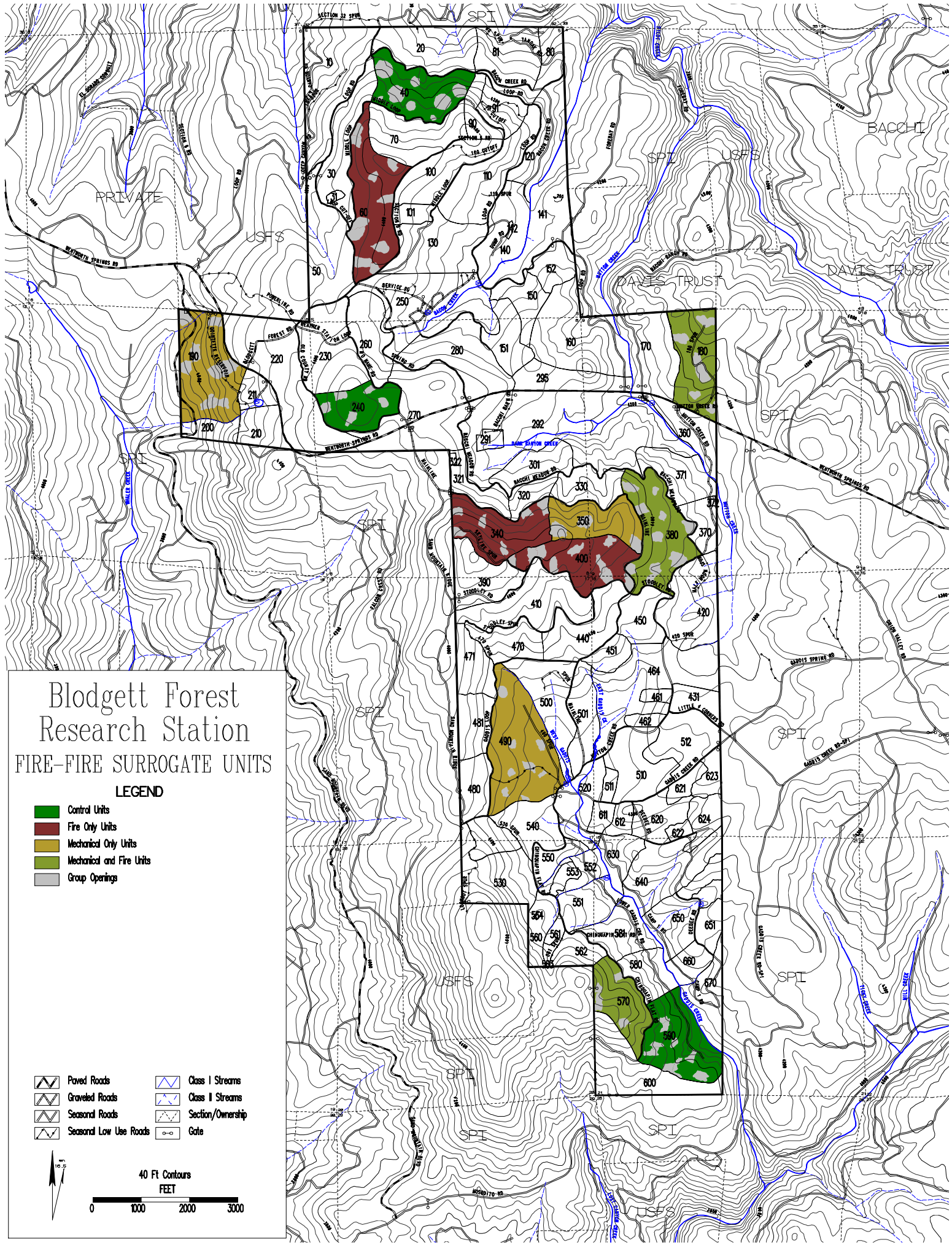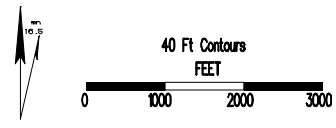
BLODGETT FOREST – COMPARTMENT 40 (Group Selection Research)
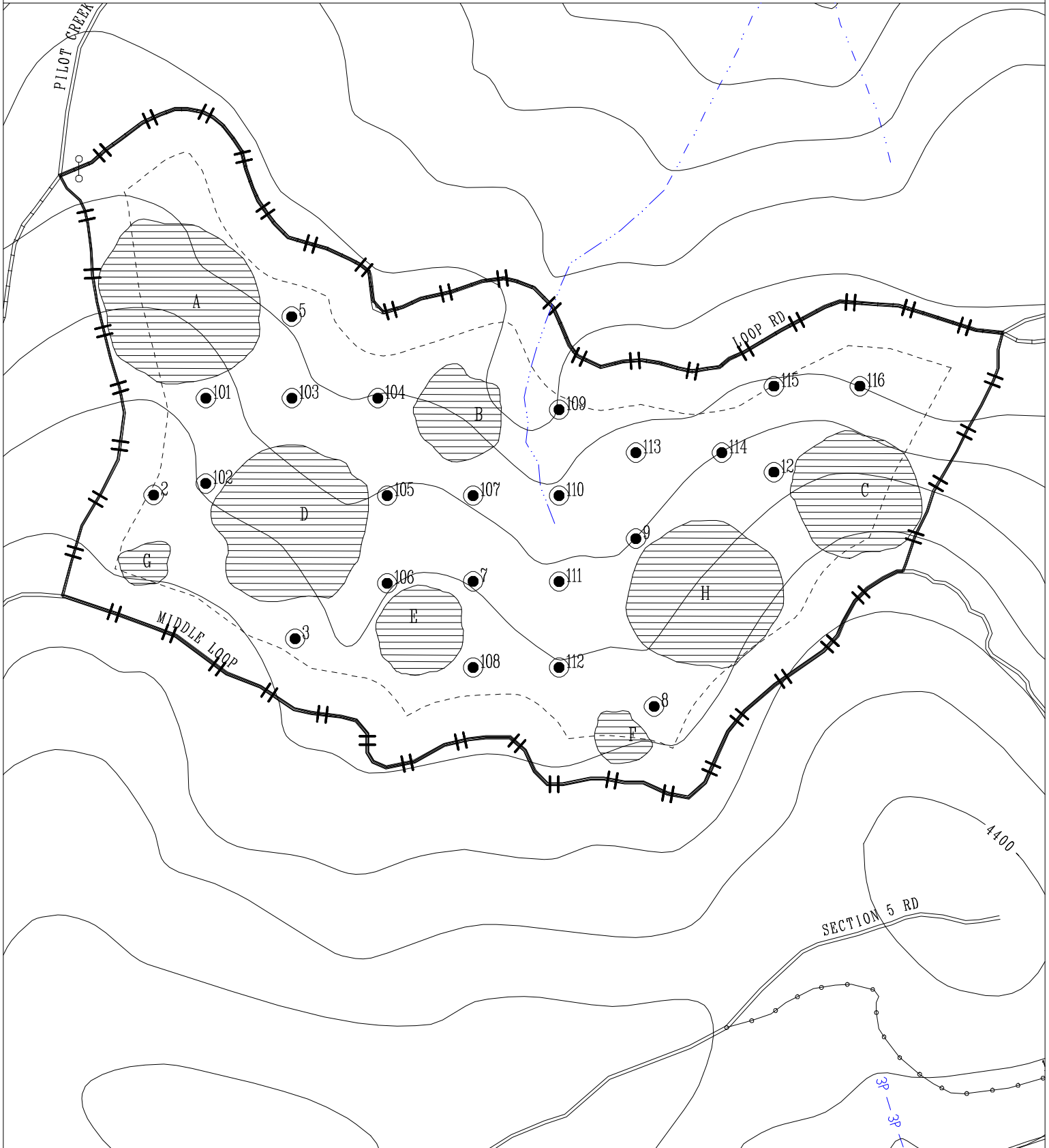
PILOT CREEK

LOOP RD

MIDDLE LOOP

A
5
101 103 104 B 109 115 116
102 113 114
2 D 105 107 110 12 C
G 9
106 7 111 H
E
3
108 112
8
F

4400

SECTION 5 RD

3P
3P

Roads:

Paved Permanent
Graveled Permanent
Seasonal
Seasonal Low Use
New Seasonal
Compartment Boundary
Property Boundary
40 ft Contours

Watercourses:

Class I
Class II
Class III
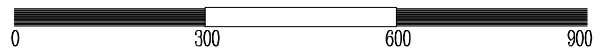3P   3P   3P   Class IIIP (Potential)
Class IV

1996 groups
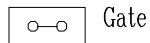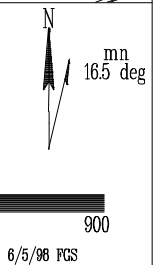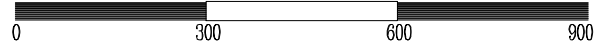
○—○ Gate

Township 12N, Range 12E

Sec 7, Mount Diablo B&M

1 inch = 300 feet

N
mn
16.5 deg

0   300   600   900

6/5/98 FGS

Roads:

Paved Permanent
Graveled Permanent
Seasonal
Seasonal Low Use
New Seasonal
Compartment Boundary
Property Boundary
40 ft Contours

Watercourses:

Class I
Class II
Class III
Class IIIP (Potential)
Class IV

1975 groups

1989 groups

1999 groups

Gate

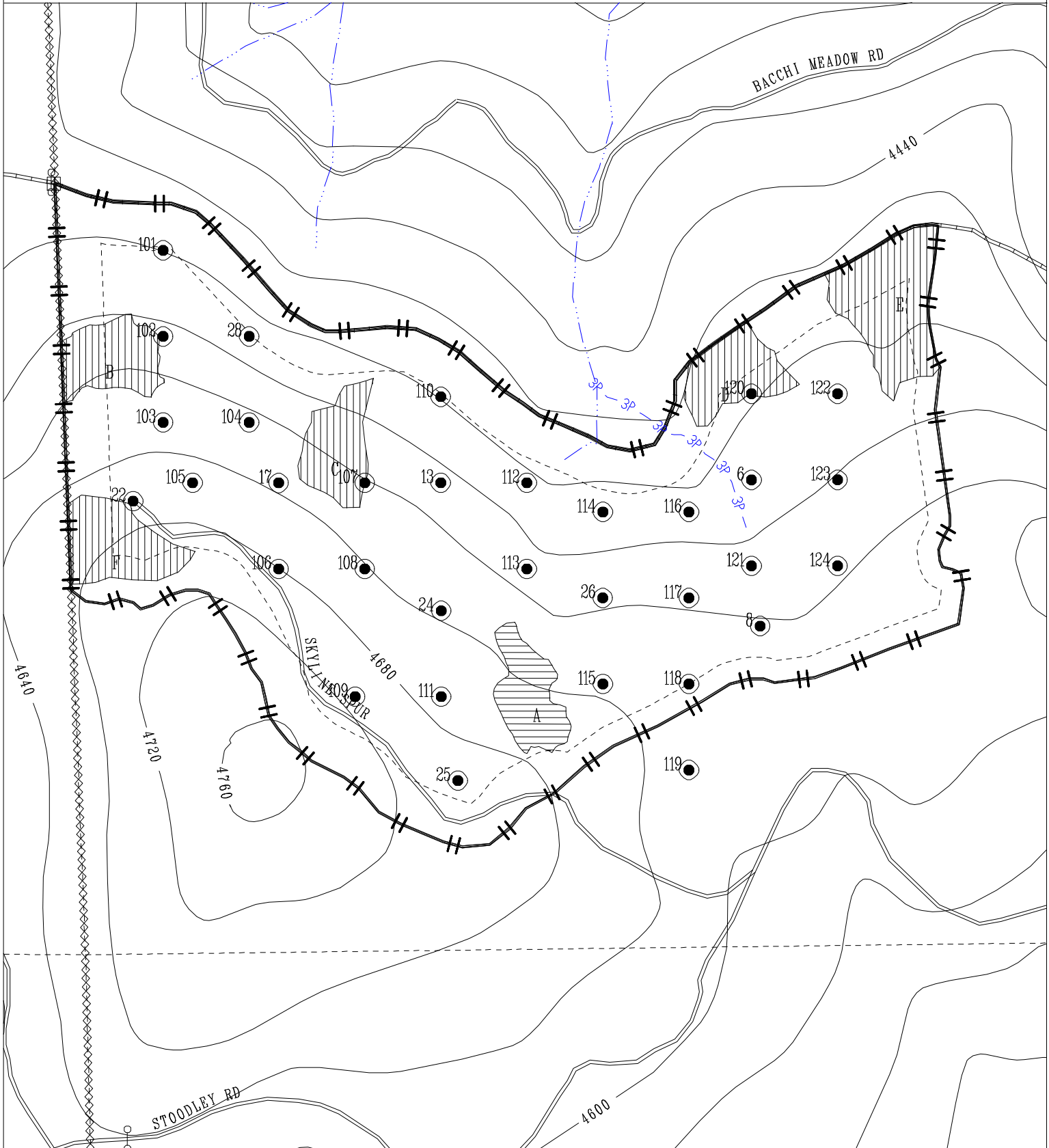Township 12N, Range 12E
Sec 5, Mount Diablo B&M

N
mn
16.5 deg

1 inch = 400 feet

0   400   800   1200

11/15/2000 PGS

4280

4240

4360

101 102 103 C

10

104 18 105

108

D 106 107

180 SPUR

109 22 110 8

112 113 114
A

6

115 23

E 118

116 117

119 13 120

4

121 122 F 123 124

B

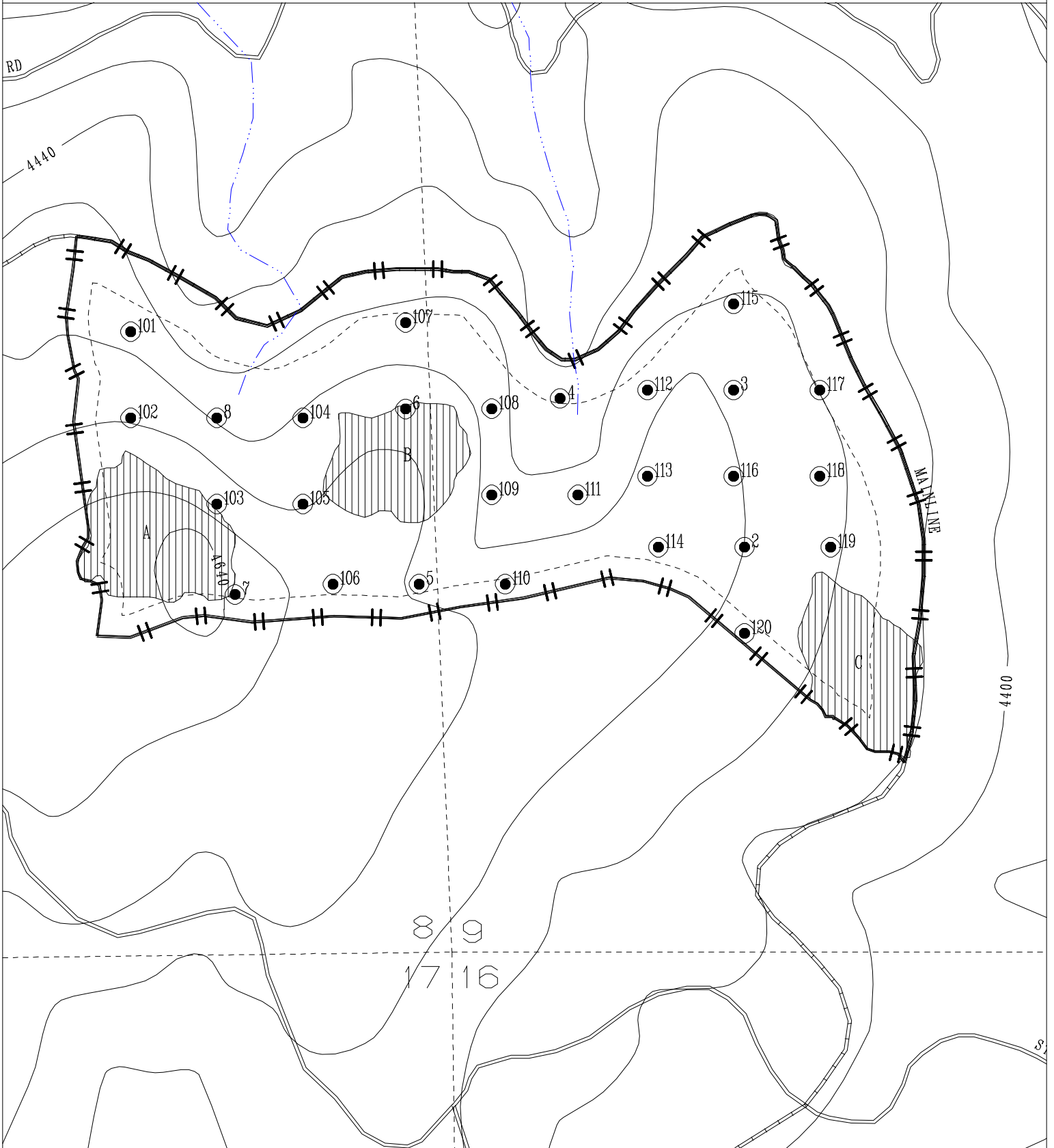180 SPUR

WENTWORTH SPRINGS RD

3P 3P

3P

3P

WENTWORTH St

MUTTON CREEK RD
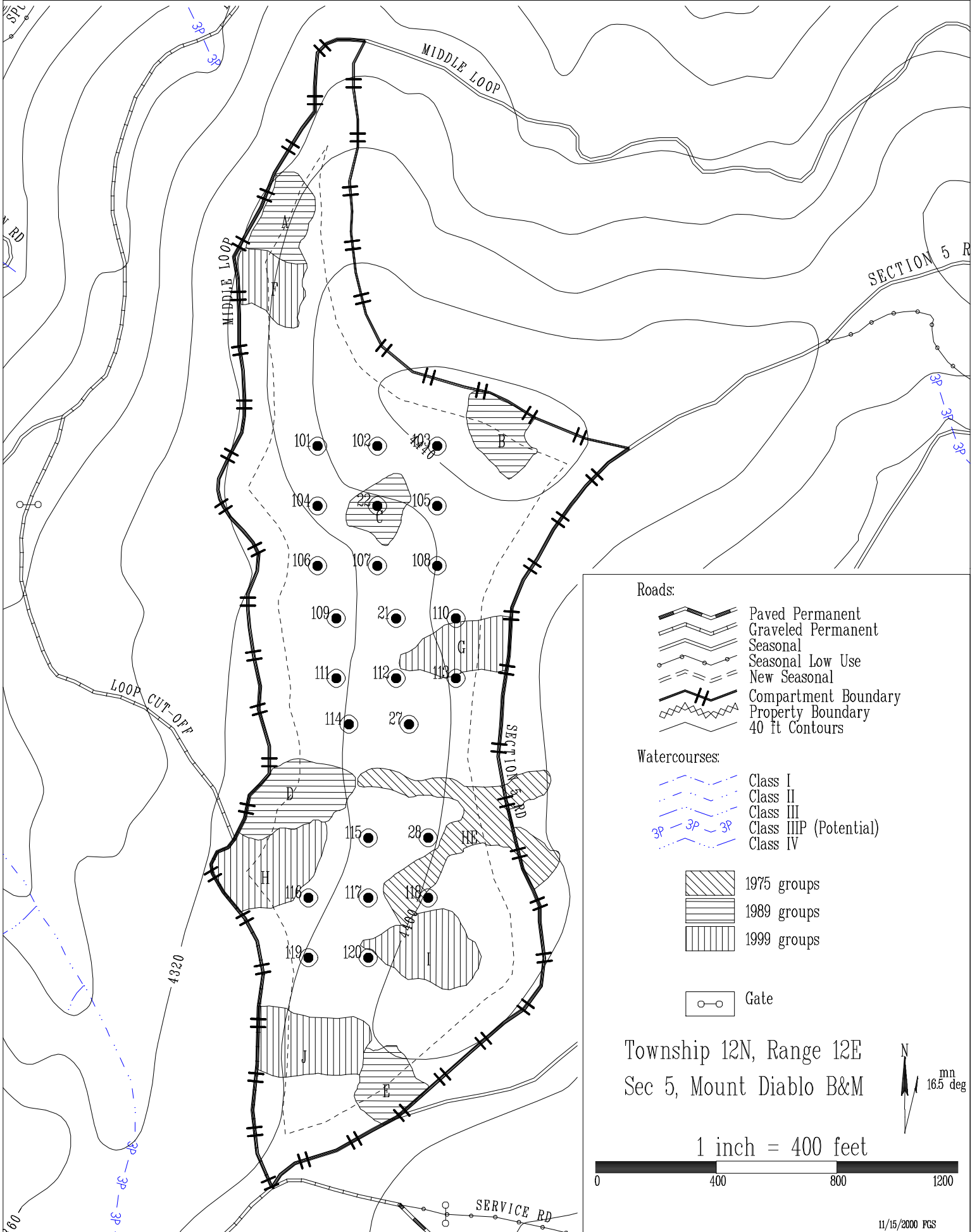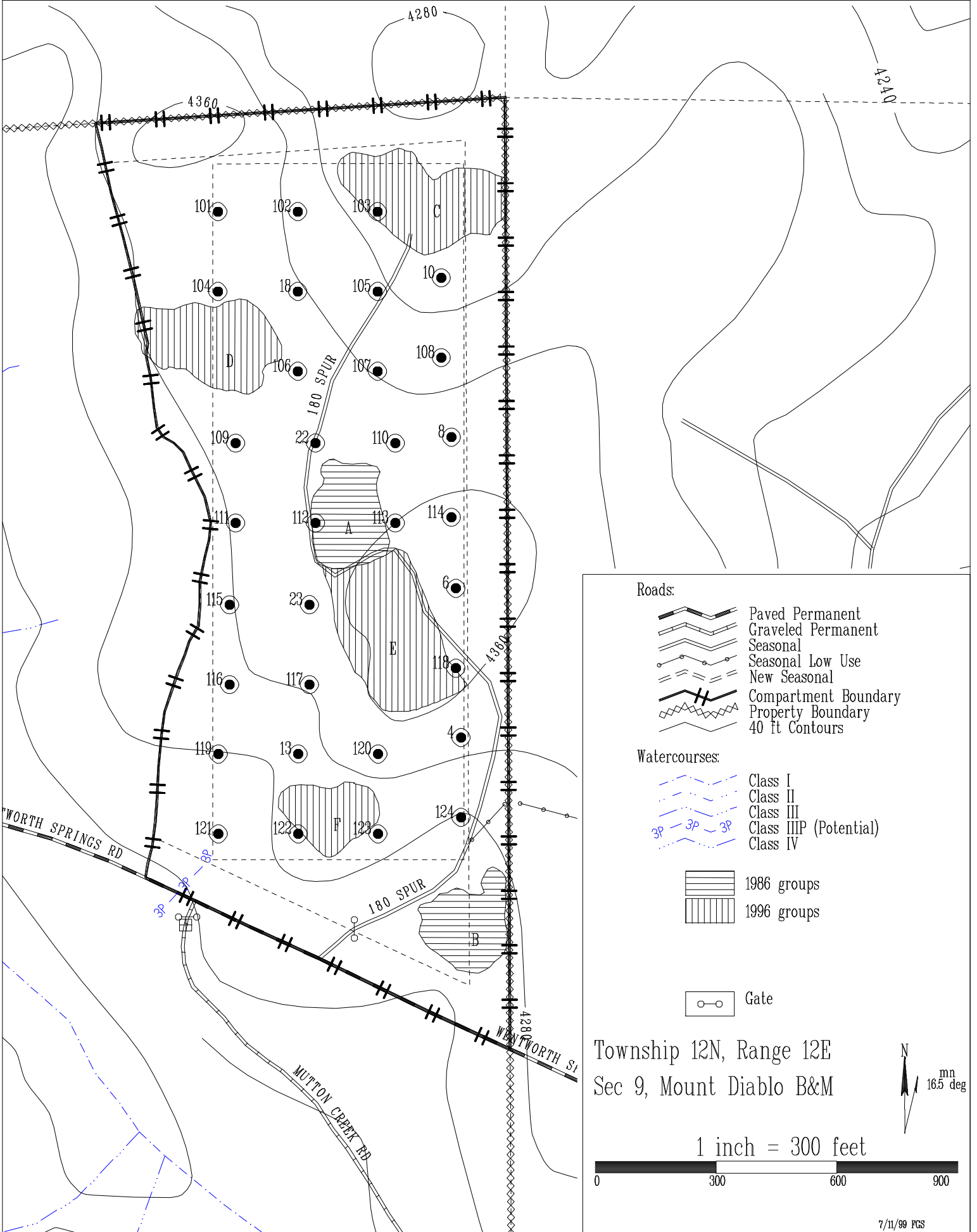
Roads:

Paved Permanent
Graveled Permanent
Seasonal
Seasonal Low Use
New Seasonal
Compartment Boundary
Property Boundary
40 ft Contours

Watercourses:

Class I
Class II
Class III
3P 3P 3P Class IIIP (Potential)
Class IV

1986 groups
1996 groups

Gate

Township 12N, Range 12E
Sec 9, Mount Diablo B&M

N
mn
16.5 deg

1 inch = 300 feet

0   300   600   900

7/11/99 FGS
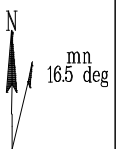
BLODGETT FOREST – COMPARTMENT 190 U (Group Selection)
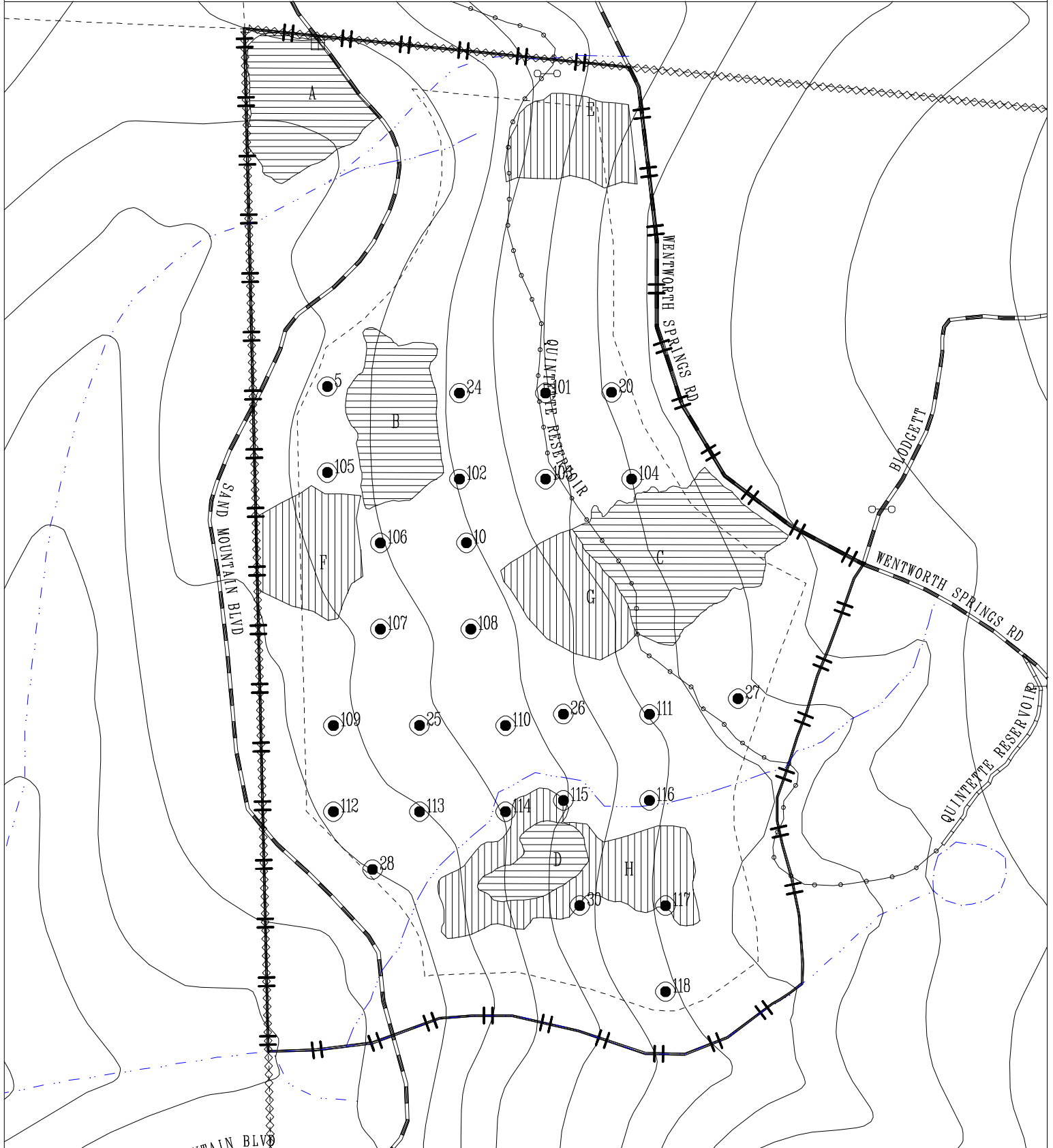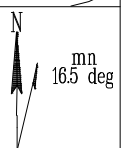
Township 12N, Range 12E
Sec 7, Mount Diablo B&M

1 inch = 300 feet

Roads:
Paved Permanent
Graveled Permanent
Seasonal
Seasonal Low Use
New Seasonal
Compartment Boundary
Property Boundary
40 ft Contours

Watercourses:
Class I
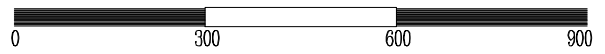Class II
Class III
Class IIIP (Potential)
Class IV

1989 groups
1999 groups

Gate

N
mn
16.5 deg

0   300   600   900

6/5/2000 FGS
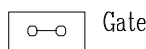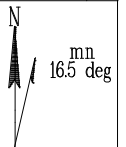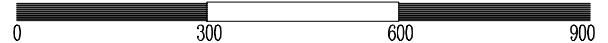
BLODGETT FOREST – COMPARTMENT 240 U (Group Selection)
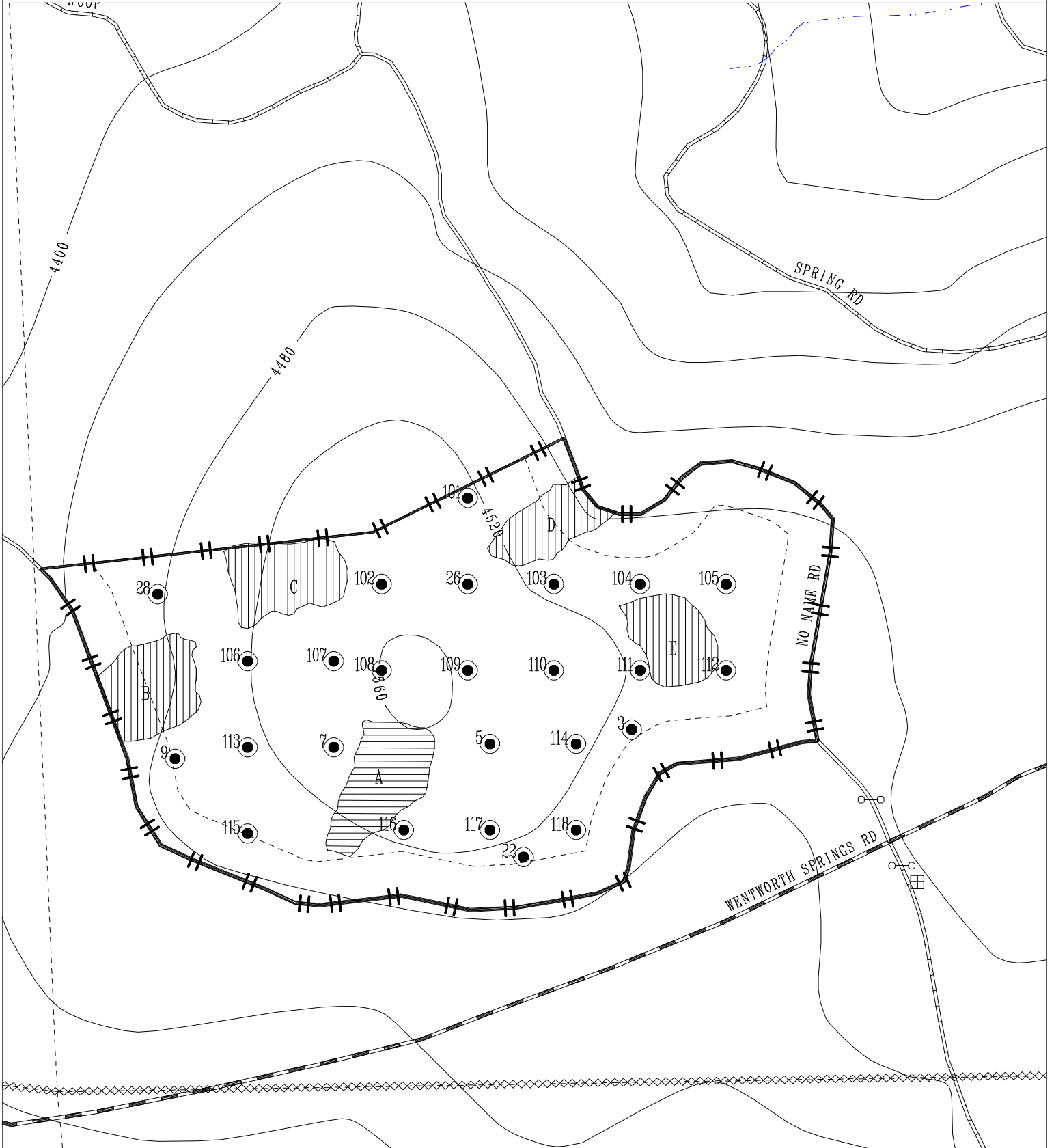
Roads:

Paved Permanent
Graveled Permanent
Seasonal
Seasonal Low Use
New Seasonal
Compartment Boundary
Property Boundary
40 ft Contours

Watercourses:

Class I
Class II
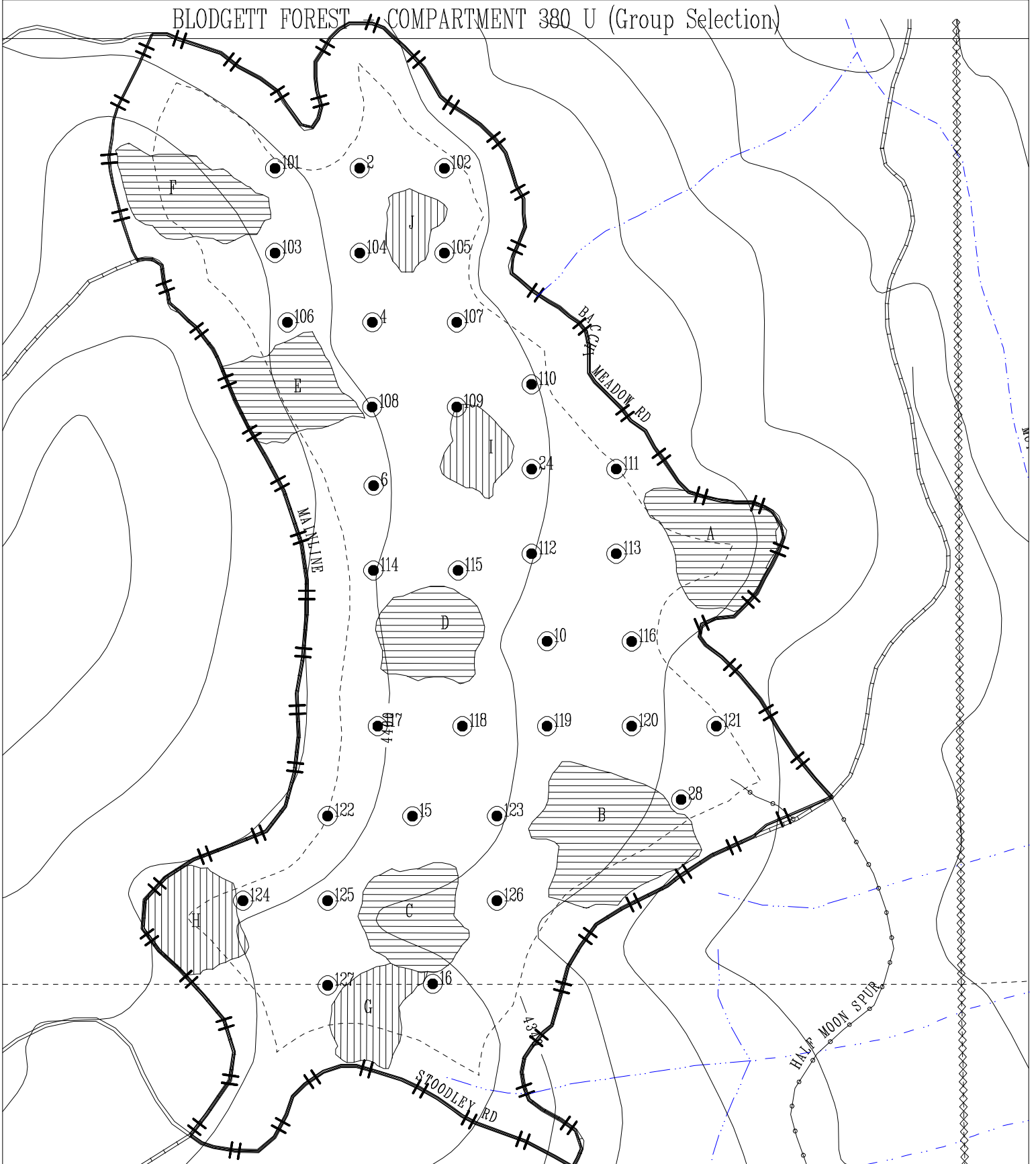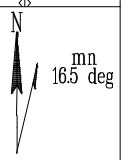Class III
Class IIIP (Potential)
Class IV

1984 groups

1998 groups

Gate

Township 12N, Range 12E

Sec 8, Mount Diablo B&M

1 inch = 300 feet

0   300   600   900

6/14/2000 FGS

BLODGETT FOREST – COMPARTMENT 340 U (Group Selection)

BACCHI MEADOW RD

4440

101

102   28

B

103   104   110

105   17   C107   13   112

22   114   116

F   106   108   113   121   124

24   26   117   8

SKYL   409   PUR   111   A   115   118   119

4680

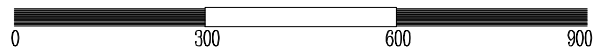4640   4720   4760   25

120   122
E
6   123

4600

STOODLEY RD

Roads:
- Paved Permanent
- Graveled Permanent
- Seasonal
- Seasonal Low Use
- New Seasonal
- Compartment Boundary
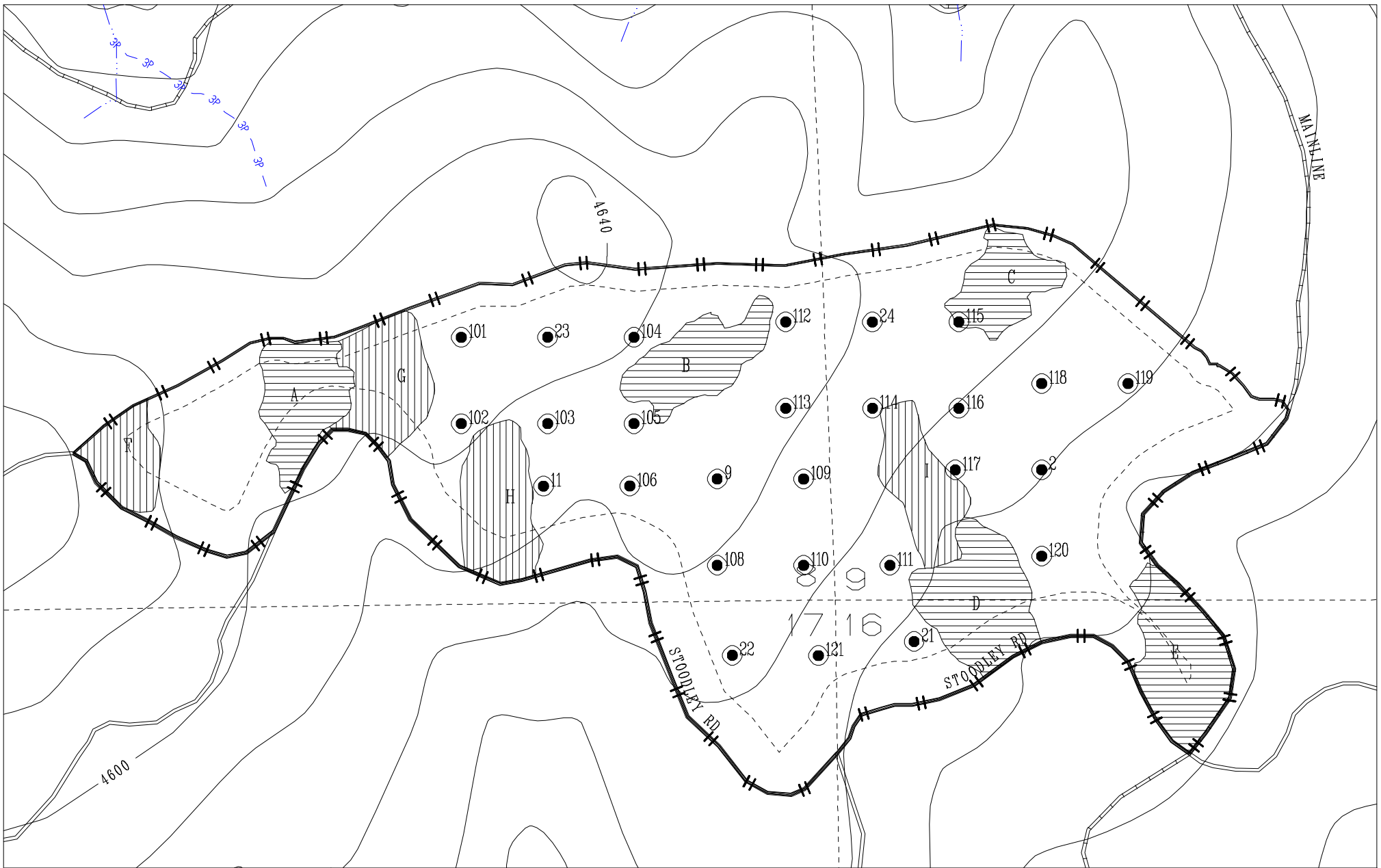- Property Boundary
- 40 ft Contours

Watercourses:
- Class I
- Class II
- Class III
- 3P — Class IIIP (Potential)
- Class IV

1986 groups

1998 groups

Gate

Township 12N, Range 12E, Sec 8,9
Mount Diablo Base & Meridian

1 inch = 300 feet

0   300   600   900

mn
16.5 deg

N

7/9/96 FGS

RD

4440

4440

101

107

115

102 8 104 6 108 4 112 3 117

B 109 113 116 118

A 103 105 111

7 106 5 110 114 2 119

120

C

MAINLINE

4400

8 9

17 16

Roads:

Paved Permanent
Graveled Permanent
Seasonal
Seasonal Low Use
New Seasonal
Compartment Boundary
Property Boundary
40 ft Contours

Watercourses:

Class I
Class II
Class III
3P 3P 3P Class IIIP (Potential)
Class IV

1992 groups

○—○ Gate

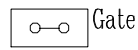Township 12N, Range 12E

Sec 8&9, Mount Diablo B&M

1 inch = 300 feet

N
mn
16.5 deg

0   300   600   900

4/27/99 FGS

F

101   2   102

J

103   104   105

106   4   107

E

108   110
109

I   24   111

6   A

112   113

114   115

D

10   116

117   118   119   120   121

28

B

122   15   123

124   125   126
H   C

127   16

G

BACON MEADOW RD

MAINLINE

STOODLEY RD

HALF MOON SPUR

Township 12N, Range 12E

Sec 21, Mount Diablo B&M

1 inch = 300 feet

N

mn
16.5 deg

Roads:

Paved Permanent
Graveled Permanent
Seasonal
Seasonal Low Use
New Seasonal
Compartment Boundary
Property Boundary
40 ft Contours

Watercourses:

Class I
Class II
Class III
3P   3P   3P   Class IIIP (Potential)
Class IV

1985 groups

1995 groups

Gate

0   300   600   900

11/19/98 FGS

BLODGETT FOREST

COMPARTMENT 400

(Group Selection)

Roads:

Paved Permanent
Graveled Permanent
Seasonal
Seasonal Low Use
New Seasonal
Compartment Boundary
Property Boundary
40 ft Contours

Watercourses:

Class I
Class II
Class III
Class IIIP (Potential)
Class IV

1989 groups
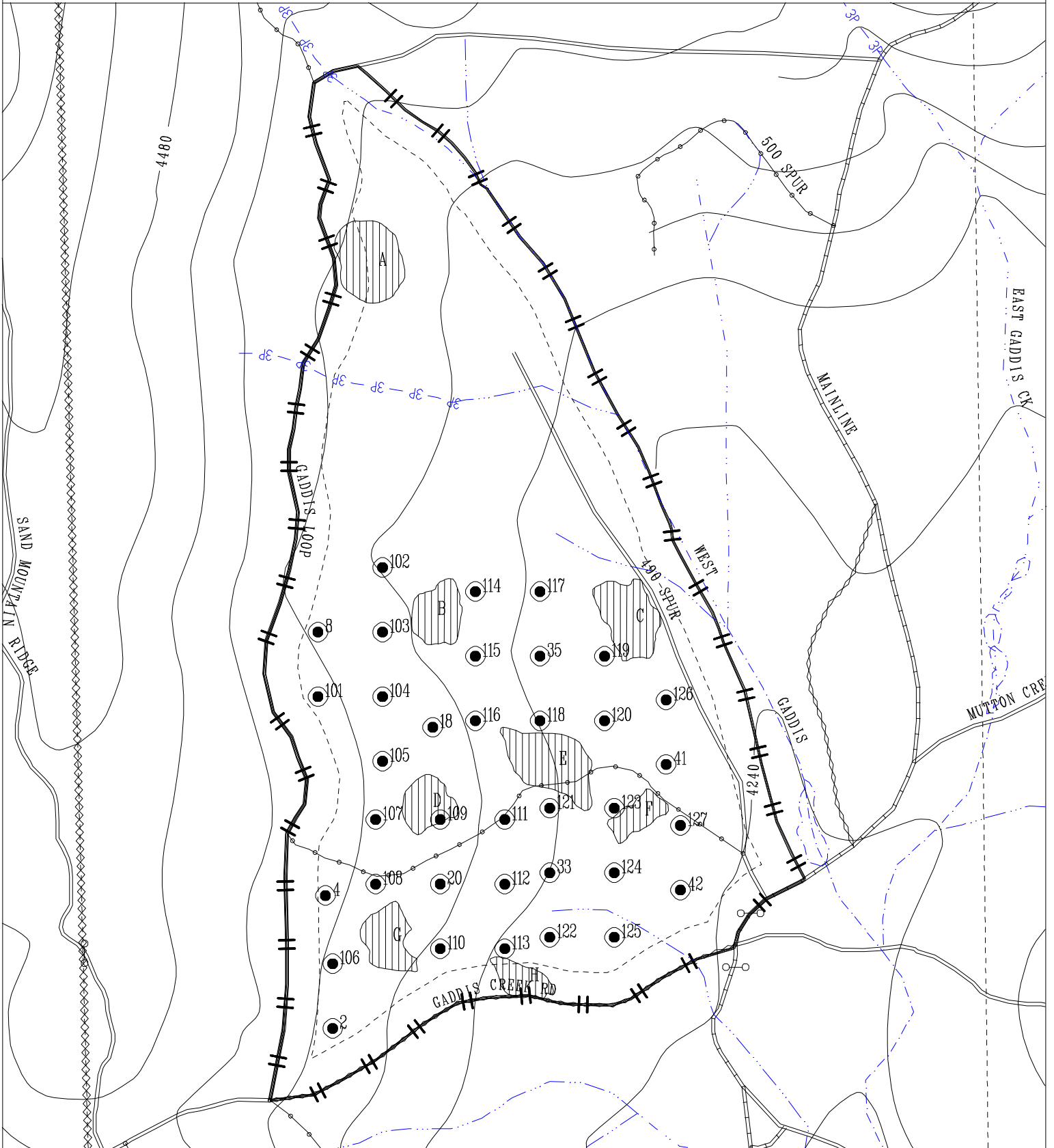1999 groups

Gate

Township 12N, Range 12E
Mount Diablo B&M
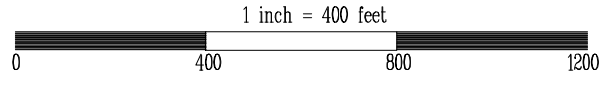
1 inch = 300 feet

0   300   600   900

6/5/98 FGS

N
mn
16.5 deg

MAINLINE

STOODLEY RD

STOODLEY RD

4640

4600

17 16

A B C D E F G H I

101 23 104 112 24 115
102 103 105 113 114 116 118 119
11 106 9 109 117 2
108 110 111 120
22 121 21

BLODGETT FOREST – COMPARTMENT 490 U (Group Selection)

SAND MOUNTAIN RIDGE

4480

GADDIS LOOP

500 SPUR

MAINLINE

EAST GADDIS CK

WEST 490 SPUR

GADDIS 4240

MUTTON CREEK

A

- 102
- 114
- 117
- B
- 8
- 103
- C
- 115
- 35
- 119
- 101
- 104
- 126
- 18
- 116
- 118
- 120
- 105
- E
- 41
- D
- 107
- 109
- 111
- 121
- 123 F
- 127
- 4
- 108
- 20
- 112
- 33
- 124
- 42
- G
- 110
- 113
- 122
- 125
- 106
- H
- 2

GADDIS CREEK RD

Roads:

- Paved Permanent
- Graveled Permanent
- Seasonal
- Seasonal Low Use
- New Seasonal
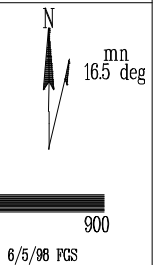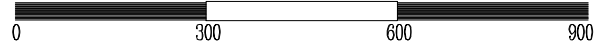- Compartment Boundary
- Property Boundary
- 40 ft Contours

Watercourses:

- Class I
- Class II
- Class III
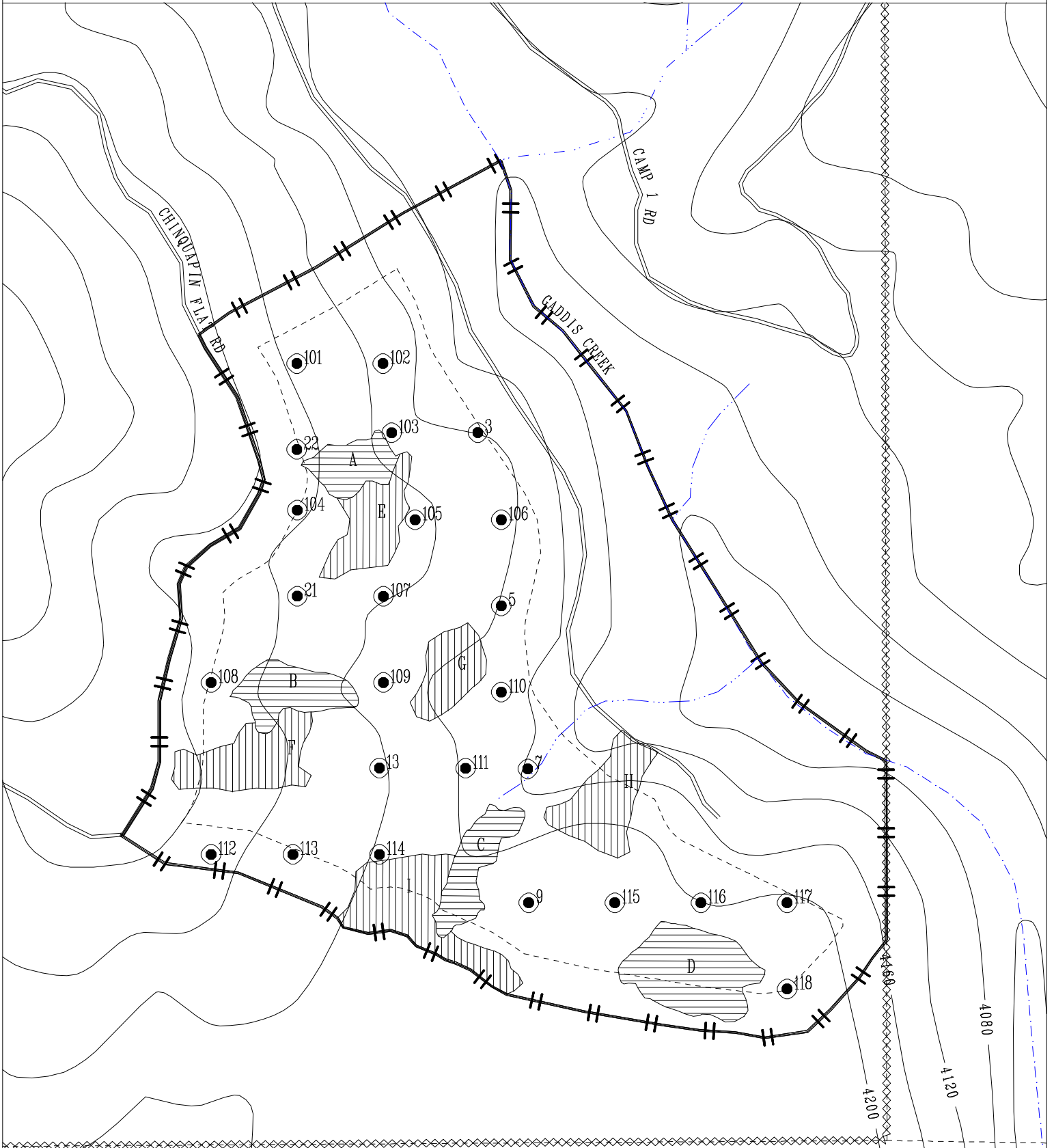- 3P — Class IIIP (Potential)
- Class IV
- 1992 groups

1 inch = 400 feet

0   400   800   1200

mn
16.5 deg

BLODGETT FOREST – COMPARTMENT 570 U (Group Selection)
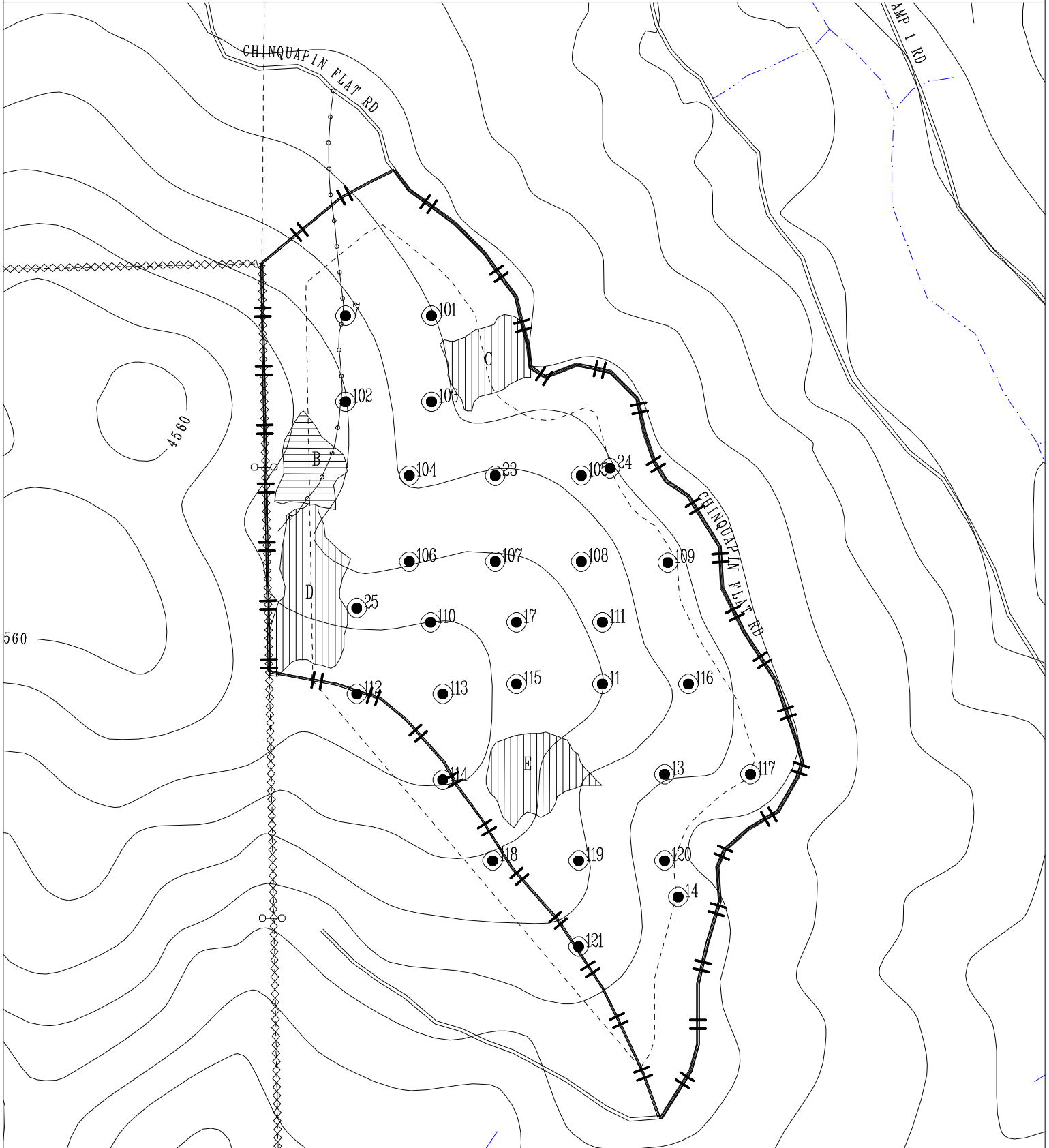
CHINQUAPIN FLAT RD

AMP 1 RD

CHINQUAPIN FLAT RD

4560

560

C
B
D
E

7
101
102
103
104
23
105
24
106
107
108
109
25
110
17
111
112
113
115
11
116
114
13
117
118
119
120
14
121

Township 12N, Range 12E

Sec 21, Mount Diablo B&M

1 inch = 300 feet

N
mn
16.5 deg

0   300   600   900

6/5/98 FGS

BLODGETT FOREST – COMPARTMENT 590 U (Group Selection)

CAMP 1 RD

CHINQUAPIN FLAT RD

GADDIS CREEK

101 102

22 103 3

A

104 E 105 106

21 107 5

108 B 109 G 110

F

13 111 7

C H

112 113 114

I

9 115 116 117

D

118

4080

4120

4160

4200

Township 12N, Range 12E

Sec 21, Mount Diablo B&M

1 inch = 300 feet

N
mn
16.5 deg

Roads:
Paved Permanent
Graveled Permanent
Seasonal
Seasonal Low Use
New Seasonal
Compartment Boundary
Property Boundary
40 ft Contours

Watercourses:
Class I
Class II
Class III
3P   3P   3P   Class IIIP (Potential)
Class IV

1989 groups

1996 groups

Gate

0   300   600   900

10/5/98 FGS