Progress Report: Forest Fertilization Effects on the Understory Community

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Most forest soils in the Intermountain Northwest have nutrient deficiencies of some kind, especially nitrogen. (Cole and Gessel 1991; Gessel, Turnbull, and Tremblay 1960) Overstory conifer trees respond favorably following fertilization in the Intermountain Northwest (Moore, Mika, Ploeg, Vander 1991). However, knowledge of fertilization effects on understory vegetation growth in mixed-conifer stands in the Intermountain Northwest is minimal. The effects of overstory density on understory vegetation response to fertilization in the Intermountain Northwest is also limited. Information about whether fertilization of understory vegetation causes species composition, species diversity, and wildlife habitat to change through time in mixed-conifer stands in the Intermountain Northwest is scarce. Knowledge of the long term effects of fertilization treatments on understory vegetation characteristics in the Intermountain Northwest is lacking.

There are many factors that influence productivity of forest plants; i.e. genetics, climate, nutrition, soil water. (Gessel, Trumbull, Tremblay 1960; Klinka et. al. 1996) Nutrition is the only factor that is economically feasible to manipulate for understory vegetation. Plants require 13 essential nutrient elements to grow; nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, boron, zinc, iron, copper, molybdenum, manganese, and chlorine. Carbon, hydrogen, and oxygen are obtained from water and air, while the others must usually be obtained from the soil. (Gessel et. al. 1960; Harris 1992) Many forest soils in the Intermountain Northwest are deficient in many soil-borne nutrients. Fertilization can be used to remedy this problem. Site specific fertilization may allow for the deficiencies to be overcome and for increased growth of the overstory species as well as the understory species in a forest stand. (Gessel et. al. 1960)

Several studies have shown that understory species respond to fertilization in mature forest stands. Understory biomass responded with a 17 percent increase following nitrogen fertilization in a ponderosa pine forest in Northeastern Oregon. (Riegel, Miller, and Krueger 1991) Yield of pinegrass increased significantly following nitrogen fertilization in a mixed stand of Douglas-fir and lodgepole pine in southern British Columbia (Freyman and van Ryswyk 1969). They also found that pinegrass yield increased significantly after applications of a nitrogen fertilizer and a nitrogen and sulphur fertilizer in an aspen stand and a lodgepole stand in southern British Columbia. Shrubs were also found to show a slight increase in yield after both the nitrogen and the nitrogen and sulphur fertilizations, while the forbs showed a slight increase in yield only with the nitrogen and sulphur application. Total live shoot biomass increased due to a multi-nutrient fertilizer of nitrogen, potassium, and phosphorus in mature jack pine in northern lower Michigan. (Abrams and Dickmann 1983) A multi-nutrient nitrogen, potassium, and phosphorus fertilization significantly increased vegetative cover and herbage production in maritime pine stands in northern Greece (Papanastasis, et. al. 1995). Increases in growth followed nitrogen fertilization of 18, 25, and 125 pounds per acre for grasses, herbs, and shrubs in white spruce stands in southwestern Yukon. (Nams, Folkard, and Smith 1993) Repeated nitrogen fertilization showed no significant differences in percent cover in a second-growth mature Douglas-fir site located near Seattle, Washington. Greater levels of nitrogen fertilization (50 #, 100 #, 150#, 200 #, 250 #) further decreased percent cover of the understory (Prescott et. al. 1993). They also found that a sulphur only treatment produced the greatest change in percent cover, while nitrogen with sulphur increased percent cover more than nitrogen alone (except 50 #) in a Douglas-fir dominated stand near Parksville, British Columbia. It can be inferred from these studies that understory vegetation production will change in mixed conifer stands in the Intermountain Northwest as a result of fertilization.

Nitrogen fertilization has also been shown to change understory composition and species diversity in mature forests. In a mature 130-year-old Scots pine stand in Sweden, 40 new understory plant species established themselves after fertilization (Kellner and Marshagen 1991). Repeated nitrogen fertilization drastically changed understory composition, and changed species diversity in a second-growth Douglas-fir forest located near Seattle, Washington (Prescott et. al. 1993). They also found that nitrogen fertilization changed species composition and decreased diversity with greater nitrogen application rates, and sulphur increased diversity alone and in combination with nitrogen and changed species composition in a Douglas-fir dominated stand near Parksville, British Columbia.

Several studies have shown that increased overstory density decreases understory growth. This is due to competition for light, water, and nutrients (Jameson 1967; Nabuurs 1996). Alaback and Herman (1988) found that percent cover increased for many understory species and composition changed as overstory density decreased in western hemlock and Sitka spruce stands near Otis, Oregon. Increased canopy cover decreased understory vegetation cover in Douglas fir, grand fir, Pacific silver fir, Sitka spruce, western hemlock, western redcedar, and Port-Orford-cedar stands on south-western Vancouver Island (Klinka et. al. 1996). Herbage production decreased as basal area per acre increased in a ponderosa pine forest in northern Arizona (Jameson 1967). Understory production and species diversity decreased with increasing basal area in ponderosa pine stands in the Black Hills of South Dakota (Uresk and Severson 1989). Composition changed in relation to trees per acre in a ponderosa pine stand near Bend, OR (Busse, Cochran, and Barrett 1996). In this study, I want to see if different basal areas coupled with fertilization affects understory vegetation growth in the Intermountain Northwest. It is possible that forest managers can manipulate overstory density and/or canopy cover to change understory vegetation growth. (Klinka et. al. 1996; Alaback and Herman 1988)

Understory vegetation's growth response to fertilization may be affected by an increase in overstory tree growth. Several studies have shown that tree foliar biomass increases following fertilization. (Turner 1977, Turner and Olson 1976) This is a result of both increases in needle production and retention of older needle age classes. (Turner 1979) Fertilization might show better results in less dense stands. Thinnings coupled with fertilization could be a management objective to increase biodiversity, aesthetics, wildlife habitat, etc. One negative concern may be the impact on fuel loads.

Wildlife use understory vegetation in forest stands for a variety of reasons including cover, nesting, and food. (Stubbendieck, Hatch, and Butterfield 1997; Alaback and Herman 1988) Many forest stands are also grazed by livestock. Fertilizer application affects yield, palatability, and nutritive value on grasslands. (Raymond and Spedding 1965) There is usually a high positive correlation between protein and animal preference. (Freyman and van Ryswyk 1969) Nitrogen (Freyman and van Ryswyk 1969), and nitrogen and sulphur fertilization applications (Geist 1976; Geist, Edgerton, and Strickler 1974) have been shown to increase the protein content of understory vegetation. If understory production, and protein, can be increased through fertilization, then more wildlife could be supported. (Idaho Wildlife 1990) Therefore, if biomass, percent cover, species diversity index values, and nutritive values increase in fertilized areas then wildlife habitat on a general scale can be said to be improved. This statement is based on the fact that increased biomass and percent cover means there will be more biomass available for food and cover. If the nutritive values increase, then wildlife will benefit from more nutrition. If diversity increases, then more wildlife species could be supported. Naturally, there are too many wildlife species to analyze any one in particular for this study.

Fertilization may not produce statistically significant responses in understory vegetation growth until several years after application. This study is an attempt to quantify affects a short time after application and to establish monitoring plots. The IFTNC plans to use these study areas for a long-term assessment. Understory vegetation may show more response immediately after fertilization or more response several years after fertilization.

METHODS

There are a total of five study sites located throughout the Intermountain Northwest near the following towns; Potlatch, Idaho (University of Idaho Experimental Forest), Bovill, Idaho (Potlatch), Goldendale, Washington (Boise Cascade), New Meadows, Idaho (Boise Cascade), and Wallowa, Oregon (Boise Cascade). All sites have control and multinutrient treatments. In addition, Bovill also has nitrogen, and nitrogen and potassium treatments. One hundred meter transects were layed out with quadrats located every 10 meters for a total of 11 quadrats. New Meadows and Goldendale have eight transects; 4 per treatment. Bovill has two transects per treatment for a total of eight. These three sites only have one overstory stand type (Bovill – mixed conifer, New Meadows – ponderosa pine, Goldendale – ponderosa pine/Douglas-fir). Wallowa has two different overstory types; a ponderosa pine plantation and a mixed conifer stand. Both of these have two transects, one in the control area and one in the fertilized area. Potlatch has three overstory stands; a ponderosa pine plantation, a Douglas-fir plantation, and an older cedar stand. Each stand type has a transect for both control and fertilized areas.

Four life forms were sampled: graminoids. forbs. shrubs, and understory trees. The quadrats are 1/300 th of an acre in size. Sampling was conducted in June, July, and August of 1997. Aerial photographs were used to help determine the exact boundaries of the fertilized areas. Boundaries were then marked for each treatment at each study site. Each vegetation plot center was marked with a painted PCV pipe. Variable radius tree plots were established centered on the vegetation plots. Each measured tree was marked with blue paint at the d.b.h. measurement point. At the Potlatch location, six one-tenth acre tree growth monitoring plots were established using the procedures of the IFTNC. All other sites will have permanent plots established by the respective cooperator.

Two separate sampling methodologies were used at each non-destructive sample plot: first, the Inland Northwest Growth and Yield Cooperative / USDA Forest Service sampling methods was used to more completely describe the understory vegetation community (see attached field form and procedures); and second, a combination of destructive (clipping and weighing) and non-destructive (occular estimates) plots were used to estimate annual production.

The need to estimate the amount of herbage in a pasture or forest quickly and accurately is recognized by most researchers. (Haydock and Shaw 1975) Although measuring yield directly by clipping is accurate, the limitation is usually that only a limited number are economically feasible and the method is destructive. (Haydock and Shaw 1975; Tucker 1980; Erixson 1993) In order to account for all the vegetation variability in plots it is better to have many samples of lower precision than few samples of high precision. (Haydock and Shaw 1975; Wilm et. al. 1944) Therefore, to reduce the amount of vegetation destruction and time of sampling we have decided to use the comparative yield method to estimate biomass (visual estimation procedure).

Methodology of the comparative yield method is taken from Haydock and Shaw 1975. Initially, five reference quadrats were selected which constitute the yield scale against which the yields of sample quadrats are rated. Two quadrats (standards 1 and 5) were placed on low and high yielding areas such that rarely would the dry matter yield of a sample quadrat lie outside this range. Then a position in the site was selected that had a dry matter yield half-way between those for 1 and 5. Then standards 2 and 4 were selected that had yields half-way between 1 and 3, and 3 and 5 respectively. Tucker (1980) examined five different methods to estimate yield and found that this method is the most reliable. This method provides for a greater number of sample plots compared to using the clipping method. Occular estimates result in a loss of individual quadrat precision; however, due to larger sample sizes the precision of the overall estimate of site annual production may actually increase. (Wilm et. al. 1944)

The quadrats were then sampled along the transect lines with ocular estimation of the yield rating placing it into one of the five categories of the scale. After all plots had been rated, the intensive quadrats were harvested and the regression equation of dry matter yield on scale rating was calculated. Forbs and grasses were clipped at ground level. The reference unit method was used to determine the production of shrubs and understory trees. The reference unit method uses a clipped twig from the perimeter of the plot which represents between 30 and 100 percent of the average above ground production. This twig then becomes the reference unit to which all other twigs are compared. Live annual production of each shrub is ocularly estimated to the nearest one percent of its relative weight to the reference unit (Erixson 1993). Several researchers have found that this method is nearly as accurate as clipping and weighing. (Andrew et. al. 1979; Kirmse and Norton 1985; Erixson 1993). The only concern is errors associated with mental fatigue. (Kirmse and Norton 1985) All clipped biomass production was then oven dried at 70 degrees Centrigrade for 48 hours. (Erixson 1993) The yield for any sample was then obtained by substituting the rating in this equation. A different scale rating and regression line was developed for each study site.

Percent cover and vertical layering procedures are taken from O'Brien and Van Hooser 1983. (Partly to provide data for INGY - Inland Northwest Growth and Yield Cooperative - models: see attached field form for this sampling methodology)

Data Collection of Understory Plants

Part I. This part provides individual species information. For each of the four plant groups - understory trees, shrubs, forbs, and graminoids - (overstory trees were also sampled for this part of the study) up to four species occurring with a crown canopy cover of at least 5 percent were recorded. Crown canopy cover was defined as the area of ground surface covered by the canopy of a plant.

Canopy coverage for each species recorded was visually estimated and assigned one of the following coverage classes (Daubenmire 1959):

Crown canopy cover class codes	Percent crown canopy coverage
1	5
2	6-25
3	26-50
4	51-75
5	76-95
6	96-100

The vertical diversity of vegetation on a plot is described by the assignment of one of three vegetational layers to each species recorded:

Layer 1 - (0-1.5 ft)
Layer 2 - (1.6 - 6 ft)
Layer 3 - (6.1+ ft)

Confining the species list to only the predominantly occurring plants makes the procedure fast and easy and still provides a picture of the basic composition of the understory vegetation.

Part II. This part provides plant group information. For each of the three layers previously referred to, a cover class was assigned to any of the four plant groups occuring on the plot. This data, combined with the overstory tree data, provides a vegetational profile of the plot. This part contains the species from Part I as well as other species that do not have a minimum 5 percent of cover on a plot.

Aluminum rings with a garbage bag inside them were established during the Potlatch fertilization in the fall of 1997. They were located at all six plot centers, and located on the fertilization line between the ponderosa pine plantation and the Douglas-fir plantation. Two more were established on a logging road separating the two plantations; one in the fertilized area and another in the control area. The last ring was established along the fertilized line near the older growth cedar stand. These were established to determine how different nutrients in an operational fertilization were distributed. The bags were collected immediately following the fertilization. They were then sent to an lab to analysis nutrient content.

Nutrient analysis studies were conducted for New Meadows, ID, Goldendale, WA, and Enterprise, OR. Oven-dried vegetation, seperated by life form, from each of the five biomass reference quadrats per site, and treatment were ground using coffee grinders in preparation for nutrient concentration analysis. Not all life forms were represented per site and treatment combination. These samples were then sent to an outside laboratory for tissue analysis.

WORK REMAINING

Field Work

A second field season will be conducted in 1998. The same methods will be used to quantify understory vegetation characteristics. Percent cover will be measured by individual species and by life form by layer similar to 1997. New production reference quadrats will be found. Once again forbs and grasses will be clipped at ground level. Shrub biomass will be estimated using the reference unit method. Ratings will then be applied to each quadrat. This will result in new annual biomass production equations developed for each study site by treatment and overstory type. Tissue nutrient analyses once again will be conducted for all the reference quadrats for Boise Cascade lands. Basal area and DBH will again be measured. Measurements will be conducted twice at each study site. Sampling will start in June and last until mid-August. Goldendale, Washington will be measured first, Potlatch, Idaho second, Bovill, Idaho third, Enterprise, Oregon fourth, and New Meadows, Idaho fifth. The sequence will repeat for the second measurement cycle.

Two additional sampling procedures will be conducted to better characterize the vegetation as well as provide data for INGY (Methods taken from the INGY Installation and Data Collection Procedures bulletin). Vertical sample lines are extended at each painted PVC pipe (plot center). A 3-D convex polygon is visually constructed for individual shrubs and forbs plants. The upper and lower intersection points of this polygon with the vertical sample line are recorded. The second procedure deals with grasses. A 6 inch by 6 inch square frame is placed at the left tip (direction defined by starting at quadrat one and moving to quadrat eleven) of each painted PVC pipe (plot center). Within this square, projected leaf area (percent cover of the frame) and average blade height of grasses (all species treated as one) are recorded.

Data Analysis and Report Writing

Summaries and statistical analyses will be conducted on data collected from the summers of 1997 and 1998. There will be three major data analyses. The first one is the effects of fertilization on production. The first component will be percent cover by individual species. All species occuring on a quadrat, with cover greater than five percent, will be summed by height layer. All quadrats on each transect per site, treatment, and overstory combination will be summed and divided by eleven to get an estimate for the transect as a whole. T-tests will be conducted on a site-by-site basis to see if there is a treatment effect. These methods will also be used to see if there is a treatment effect using the life form data. The second component is annual biomass production. Scale ratings will be inserted into regression equations constructed from the relationship between reference quadrat ratings and annual biomass production weight in grams. This will result in a estimate of the annual biomass production for each quadrat. These values will be summed by transect. T-tests will be conducted to see if there is a site specific difference. Data will be examined between 1997 and 1998 to see if there was more of an response at Enterprise, Oregon, New Meadows, Idaho, and Goldendale, Washington. Potlatch, Idaho and Bovill, Idaho will only have a one year response. Data can be compared by treatment versus control as well as by "prior" characteristics to "after" characteristics following fertilization in each treatment area.

The relationship between understory production and overstory density will be the second major data analysis. The first component will relate overstory density to understory percent cover (all species with cover greater than 5 percent and summed by life form and height layer). The second component will relate overstory density to understory percent cover by life form as a whole by height layer. Finally, annual biomass production by plot (using the regression equations from above) will be related to overstory density. This will be conducted by use of regression equations.

Tissue nutrient analysis will be the final major data analyis. All treatment observations by site, treatment, and overstory type will be compared to see if there is a difference between mixed fertilization and control for the nutrients applied to the site. For Goldendale, Washington and New Meadows, Idaho the nutrients analyzed will be nitrogen, potassium, boron, copper, zinc, molybdenum, and sulfur. For Enterprise, Oregon the same nutrients will be analyzed as well as phosphorus. T-tests will be used for each site to see if a significant treatment affect occurred.

It is hoped that this master's thesis will be completed by December of 1998. The defense should be some time in December.

APPENDIX A: LITERATURE CITED

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APPENDIX B: STUDY SITE SUMMARY SHEETS

(1) Basal area
(2) Average DBH
(3) Percent cover by individual species
(4) Percent cover by life form
(5) Annual biomass production

Installation New Meadows, Idaho
Region: C Idaho
Legal Description: T19NR1E Sec 34 (Tr 7 & 8)
T18NR1E Sec 9 (Tr 1-6)

Ownership: Boise Cascade
Meridian: Boise

Treatment Regime (lbs/acre): (Nitrogen 200,Potassium 200,Sulphur 80,Boron 10,Copper 10,Zinc 10, Molybdenum 1)
Year Fertilized: 1998

Elevation 4100
Aspect
Slope

Vegetation series
Abies grandis/Acer glabrum Physocarpus malvaceus phase (Tr 7 & 8)
Pseudotsuga menziesii/Symphoricarpos albus Pinus ponderosa phase (Tr 1-6)

Parent material
Soil depth
Ash depth

VEGETATION CHARACTERISTICS

Transect	1	2	3	4	5	6	7	8
Treatment	Multinutrient	Control	Multinutrient	Control	Multinutrient	Control	Multinutrient	Control
Slope (%)								
Aspect (%)								
Basal area	81.82	105.45	76.36	72.73	74.55	65.45	52.73	65.45
Average DBH	13.62	9.48	11.51	11.53	12.12	12.47	13.8	13.71
Percent cover (1st session)								
(based on average of individual species by plots)								
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	N/A	N/A	N/A	N/A	N/A	N/A	4.09	2.73
Tree1(T1)	N/A	N/A	N/A	N/A	N/A	N/A	1.36	N/A
Shrub3(S3)	N/A	N/A	N/A	N/A	N/A	6.82	3.41	1.36
Shrub2(S2)	N/A	N/A	1.36	20	1.36	15.68	5.45	N/A
Shrub1(S1)	8.18	5.45	23.18	19.09	19.77	31.36	35.45	13.64
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	4.77	N/A	N/A	4.09	10.91	1.36	14.32	1.36
Forb1(F1)	53.86	45.68	17.73	35.45	27.95	15	55.91	40.23
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A	1.36	N/A
Grass1(G1)	30	27.95	34.77	12.27	34.77	30	37.5	28.32
Percent cover (2nd session)								
(based on average of individual species by plots)								
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	N/A	N/A	N/A	N/A	N/A	N/A	8.18	1.36
Tree1(T1)	N/A	N/A	N/A	N/A	N/A	N/A	1.36	1.36
Shrub3(S3)	N/A	N/A	N/A	N/A	N/A	4.77	1.36	1.36
Shrub2(S2)	N/A	N/A	23.64	N/A	N/A	8.18	4.09	N/A
Shrub1(S1)	10.91	6.82	22.5	24.55	18.36	34.77	33.41	14.32
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	1	N/A	5.45	N/A	9.55	N/A	12.95	1.36
Forb1(F1)	35.45	27.27	28.64	12.27	23.86	5.45	47.05	28.64
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A	2.73	N/A
Grass1(G1)	23.18	32.05	10.91	34.77	33.64	30.68	40.91	23.18

Installation New Meadows, Idaho

Percent cover (1st session)
(based on average of life form by plots)

Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	N/A	N/A	N/A	N/A	N/A	N/A	5 45	2 73
Tree1(T1)	2 5	N/A	0 45	1 14	0 68	0 23	1 59	0.23
Shrub3(S3)	N/A	N/A	N/A	N/A	N/A	6 82	3 41	N/A
Shrub2(S2)	N/A	N/A	19 55	1 36	1 36	15 23	6 14	N/A
Shrub1(S1)	9 77	4 32	12 27	15 91	13 68	19 77	23 86	12 27
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0 23
Forb2(F2)	4 77	N/A	2.73	N/A	8.18	1 59	13 41	1 36
Forb1(F1)	37.73	19 09	15	12 73	14 55	12 73	33 41	21.14
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	1.59	0 23	0 45	0 68	0 91	0 45	1.82	0.23
Grass1(G1)	24 09	27 27	11 36	27 27	21 82	29 32	29.32	23 18

Percent cover (2nd session)
(based on average of life form by plots)

Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	N/A	N/A	N/A	N/A	N/A	N/A	8 86	1.36
Tree1(T1)	0 23	N/A	0 45	1 14	0 68	0 23	1.36	1 59
Shrub3(S3)	N/A	N/A	N/A	N/A	N/A	4 77	1.36	1.36
Shrub2(S2)	N/A	N/A	23 64	N/A	0 23	9 32	4 77	N/A
Shrub1(S1)	9 55	6 82	17 05	15 68	14 32	25 45	25 23	12 27
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0 23
Forb2(F2)	3 18	N/A	4 09	N/A	8 18	N/A	13 86	1 36
Forb1(F1)	18 64	13 64	15	10 45	15 91	7 05	31 36	16 82
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	4 55	0 45	0 45	0 68	1 36	0 45	4 09	0 23
Grass1(G1)	12 5	26 18	11 36	27 27	27 5	27 27	33 64	19 09

Biomass (ap - annual production, ln - natural log)

1st session - Dry weight	1	2	3	4	5	6	7	8
Mixed: lnap = 0 377 + 4 085 *(lnclass) (R^2 = 0 915)	123 48		78 35		38 49		260.74	
Control: lnap = -0 344 + 4 006 *(lnclass) (R^2 = 0 956)		41 23		38 34		93 37		32 77

2nd session - Dry weight	1	2	3	4	5	6	7	8
Mixed: lnap = 0.369 + 4.263 *(lnclass) (R^2 = 0 968)	11.52		75 66		45 66		108.40	
Control: lnap = 0.352 + 4.173 *(lnclass) (R^2 = 0.979)		12 41		20.76		35 13		22.59

1st session - Green weight	1	2	3	4	5	6	7	8
Mixed: lnap = 1.605 + 4.045 *(lnclass) (R^2 = 0.922)	502.93		318.36		157.59		1058.43	
Control: lnap = 1.125 + 3.732 *(lnclass) (R^2 = 0.965)		134 07		124 49		265 91		107.68

2nd session - Green weight	1	2	3	4	5	6	7	8
Mixed: 1.435 + 4.125 *(lnclass) (R^2 = 0.979)	26 29		181.17		107 67		257.77	
Control: 1.354 + 4.001 *(lnclass) (R^2 = 0.979)		30 62		50 19		83 34		54 58

Installation Goldendale,Washington
Region C Washington — Ownership Boise Cascade — Treatment Regime (lbs/acre) (Nitrogen 200, Potassium 200, Boron 5, Copper 10, Zinc 10, Molybdenum 1, Sulfur 60)
Legal Description T5NR14E Sec 12 (Tr 1 & 3) — Meridian Willamette — Year Fertilized 1996
T5NR14E Sec 13 (Tr 2,4,5-8)

Elevation 2200 — Vegetation series — Parent material
Aspect — Habitat type — Soil depth
Slope — Ash depth

VEGETATION CHARACTERISTICS

Transect	1	2	3	4	5	6	7	8
Treatment	Control	Control	Control	Control	Multinutrient	Multinutrient	Multinutrient	Multinutrient
Slope (%)								
Aspect (%)								
Basal area	54 55	65 45	60	65 45	67 27	70 91	72 73	56 36
Average DBH	12 58	12 99	11 8	10 82	13 19	13 69	11.93	12 55
Percent cover (1st session)								
(based on average of individual species by plots)								
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	2 73	1 36	N/A	6 82	1 36	N/A	1 36	N/A
Tree1(T1)	N/A	4 09	N/A	2 73	2 73	N/A	N/A	1 36
Shrub3(S3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1 36
Shrub2(S2)	N/A	2 73	6 82	N/A	N/A	N/A	2 73	2 73
Shrub1(S1)	43 41	27 27	28 86	15 23	21 82	17 05	5 45	26 36
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	1 36	N/A	N/A	N/A	N/A	N/A
Forb1(F1)	17 73	23 18	38 18	20 45	23 86	32 73	21 14	25 91
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	3 41	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	18 41	5 45	2 73	2 73	4 09	4 09	10 23	4 09
Percent cover (2nd session)								
(based on average of individual species by plots)								
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	2 73	2 73	N/A	6 82	2 73	N/A	2.73	N/A
Tree1(T1)	1 36	2 73	N/A	2 73	1 36	N/A	N/A	1.36
Shrub3(S3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1 36
Shrub2(S2)	1 36	2 73	8 18	N/A	N/A	N/A	2.73	2 73
Shrub1(S1)	41 14	27 95	26 82	12 95	38 41	25 23	7 5	22 05
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb1(F1)	20 45	23 18	39 55	19 09	21 82	36 14	23 18	25 91
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	3 41	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	18 41	6 82	1 36	2 73	3 41	6 14	7.5	2 73

Installation Goldendale, Washington

Percent cover (1st session)
(based on average of life form by plots)

Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	1 36	1 36	N/A	5 45	1 36	N/A	1 82	0 23
Tree1(T1)	N/A	2 95	1 59	0 45	2 05	0 45	0 91	2 05
Shrub3(S3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1 36
Shrub2(S2)	N/A	2 73	8 64	1 59	N/A	N/A	2 73	2 73
Shrub1(S1)	32 95	21 59	22 73	11 82	22 05	11 59	3 86	25 45
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb1(F1)	12 27	13 64	25 91	13 86	19 09	25 23	17 95	17 05
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	21 36	6 82	5	12 27	10 45	6 36	11 14	7 73

Percent cover (2nd session)
(based on average of life form by plots)

Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	1 36	2 73	N/A	6 82	1 36	N/A	1 36	N/A
Tree1(T1)	2 05	2 73	1 82	3 18	2 05	0 45	0 91	2 95
Shrub3(S3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1 36
Shrub2(S2)	2 73	1 36	8 41	N/A	N/A	N/A	2 73	2 73
Shrub1(S1)	26 14	22 05	22 73	9 32	36 36	20 68	7 73	18 64
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb1(F1)	12 95	13 86	25 91	11 36	15	19 09	18 64	17 95
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	21 36	7 05	3 86	7 95	7 73	11 82	8 86	9 77

Biomass (ap - annual production, ln - natural log)

	1	2	3	4	5	6	7	8
1st session-Dry weight								
Mixed lnap = 1 359 + 2 228*lnclass (R^2 = 0 987)					42 62	33 90	15 45	41 02
Control lnap = -0.0646 + 2.940*lnclass (R^2 = 0 965)	83 60	36 81	46 53	16 06				

	1	2	3	4	5	6	7	8
2nd session-Dry weight								
Mixed lnap = 0.08354 + 4 800*lnclass (R^2 = 0 962)					193 61	102 96	40 11	192 99
Control lnap = 0.462 + 4 133*lnclass (R^2 = 0 964)	181 77	106 19	85 93	37 22				

	1	2	3	4	5	6	7	8
1st session-Green weight								
Mixed lnap = 3 509 + 2 029*lnclass (R^2 = 0 994)					291 91	234 99	114 76	274 03
Control lnap = 3 105 + 2 151*lnclass (R^2 = 0 984)	340 98	153 74	190 92	62 77				

	1	2	3	4	5	6	7	8
2nd session-Green weight								
Mixed lnap = 1.047 + 4 723*lnclass (R^2 = 0 981)					460 64	245 88	96 29	458 40
Control lnap = 1.390 + 3.984*lnclass (R^2 = 0.983)	382 41	225 58	182 68	79 6				

Installation Bovill, Idaho

Region N Idaho
Legal Description T41NR2E Sec 19 (Tr 1 & 2)
T41NR2E Sec 20 (Tr 3-8)

Ownership Potlatch
Meridian Boise

Treatment Regime (lbs/acre)
Tr 1 & 2 Mixed (Nitrogen 200, Potassium 100, Copper 10, Sulfur 80, Boron 5)
Tr 3 & 4 Control
Tr 5 & 6 Nitrogen (200)
Tr 7 & 8 Nitrogen + Potassium (Nitrogen 200, Potassium 100)
Year fertilized 1997

Elevation 3500
Aspect
Slope

Vegetation series Thuja plicata
Habitat type Pachistima

Parent material
Soil depth
Ash depth

VEGETATION CHARACTERISTICS

Transect	1	2	3	4	5	6	7	8
Treatment	Multinutrient	Multinutrient	Control	Control	Nitrogen	Nitrogen	N/K	N/K
Slope (%)								
Aspect (%)								
Basal area	127 27	109 09	56 36	47 27	76 36	69 09	49 09	63 64
Average DBH	11 9	8 64	8 64	10 86	10 52	11 36	12 45	11 33

Percent cover (1st session) (based on average of individual species by plots)	1	2	3	4	5	6	7	8
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	11 59	6 82	9 55	8 18	8 18	4 09	12 27	4 09
Tree1(T1)	6 82	N/A	2 73	4 09	N/A	1 36	N/A	N/A
Shrub3(S3)	7 05	3 41	12 73	N/A	1 36	N/A	7 05	N/A
Shrub2(S2)	7 5	4 09	30	43 64	14 32	28 64	40 68	10 91
Shrub1(S1)	49 09	23 86	41 59	54 55	34 09	48 41	53 18	48 41
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	N/A	N/A	N/A	2.73	2 73
Forb1(F1)	55 91	36 82	40 23	52 5	57 27	47 73	48 41	39 55
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	N/A	N/A	N/A	2 73	N/A	N/A	N/A	N/A

Percent cover (2nd session) (based on average of individual species by plots)	1	2	3	4	5	6	7	8
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	18 36	4.09	6 14	6.82	13.64	6.82	6.82	N/A
Tree1(T1)	2 73	1.36	2 73	1.36	1 36	N/A	1.36	5.45
Shrub3(S3)	8 18	14 19	3 41	1.36	1.36	N/A	7.05	N/A
Shrub2(S2)	8 86	2 73	14 09	15	8 86	19 32	31.36	12.95
Shrub1(S1)	40.23	19 09	32 05	49 77	34 09	57.95	45	38.18
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb1(F1)	37.5	23 18	49 09	49 09	50 45	48 36	44.32	38 86
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Installation Bovill, Idaho

Percent cover (1st session) (based on average of life form by plots)	1	2	3	4	5	6	7	8
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	11.82	7.5	7.05	7.05	5.45	4.09	10.91	4.32
Tree1(T1)	7.73	0.45	1.82	3.64	0.68	2.27	1.82	0.68
Shrub3(S3)	7.05	9.09	12.73	N/A	1.36	N/A	7.05	N/A
Shrub2(S2)	6.14	2.73	25.45	25.45	6.82	25.45	40.45	11.59
Shrub1(S1)	27.27	17.27	27.27	31.36	19.77	26.14	29.32	23.86
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	N/A	N/A	N/A	2.73	2.73
Forb1(F1)	29.32	22.73	30	31.36	31.36	17.73	29.55	24.09
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	0.91	1.14	1.36	4.09	1.82	1.14	0.45	0.68

Percent cover (2nd session) (based on average of life form by plots)	1	2	3	4	5	6	7	8
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	18.41	5.45	9.09	10.45	13.64	7.05	12.95	5.45
Tree1(T1)	7.05	0.45	2.05	4.55	2.95	0.68	3.41	0.45
Shrub3(S3)	8.18	5.68	3.41	1.36	1.36	N/A	7.05	N/A
Shrub2(S2)	7.5	2.73	12.95	16.36	8.18	18.64	26.14	12.95
Shrub1(S1)	29.77	20.91	31.59	42.27	23.41	35.91	33.86	30.23
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	N/A	N/A	N/A	4.77	N/A
Forb1(F1)	29.77	23.18	27.5	33.41	33.64	35.45	29.55	27.27
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	2.5	0.91	1.14	2.73	0.68	2.5	0.68	1.82

Biomass (ap - annual production, ln - natural log)

1st session-Dry weight	1	2	3	4	5	6	7	8
Tr1&2: lnap = -0.440 + 3.760*lnclass (R^2 = 0.993)	20.11	N/A						
Tr3&4: lnap = 0.806 + 3.075*lnclass (R^2 = 0.987)			N/A	45.62				
Tr5&6: lnap = -0.502 + 3.798 * lnclass (R^2 = 0.993)					10.94	27.45		
Tr7&8: lnap = -0.321 + 3.976 * lnclass (R^2 = 0.984)							87.09	30.52

2nd session-Dry weight	1	2	3	4	5	6	7	8
Tr1&2: lnap = -2.064 + 4.435*lnclass (R^2 = 0.926)	12.59	2.05						
Tr3&4: lnap = -1.430 + 1.560*class (R^2 = 0.971)			10.85	24.64				
Tr5&6: lnap = -1.350 + 4.380 * lnclass (R^2 = 0.982)					12.07	29.30		
Tr7&8: lnap = 1.071 + 2.350 * lnclass (R^2 = 0.983)							55.36	36.18

1st session-Green weight	1	2	3	4	5	6	7	8
Tr1&2: lnap = 1.008 + 3.672*lnclass (R^2 = 0.979)	77.91							
Tr3&4: ap = -186.6 + 188.8*class (R^2 = 0.984)		N/A	N/A	289.69				
Tr5&6: lnap = 0.971 + 3.774 * lnclass (R^2 = 0.982)					46.80	27.45		
Tr7&8: lnap = 1.087 + 3.877 * lnclass (R^2 = 0.967)							313.64	112.62

2nd session-Green weight	1	2	3	4	5	6	7	8
Tr1&2: lnap = 0.668 + 3.955*lnclass (R^2 = 0.978)	110.66	21.77						
Tr3&4: lnap = 0.851 + 4.023*lnclass (R^2 = 0.991)			77.94	168.27				
Tr5&6: lnap = 1.197 + 3.698 * lnclass (R^2 = 0.992)					80.87	169.96		
Tr7&8: lnap = 0.0698 + 3.956 * lnclass (R^2 = 0.984)							433.25	266.92

Installation Potlatch, Idaho

Region N Idaho	Ownership University of Idaho (Experimental forest)	Treatment Regime (lbs/acre) Mixed (Nitrogen 200, Potassium 100, Copper 10, Sulfur 80, Boron 5)
Legal Description T40NR4W Sec 1	Meridian Boise	Year Fertilized 1997
Elevation 3200	Vegetation series Thuja plicata	Parent material
Aspect	Habitat type Clintonia uniflora	Soil depth
Slope		Ash depth

VEGETATION CHARACTERISTICS

Transect	1	2	3	4	5	6
Treatment	Multinutrient	Control	Control	Multinutrient	Control	Multinutrient
Slope (%)						
Aspect (%)						
Basal area	203 64	250 91	16 82	21 36	42 27	45 91
Average DBH	12 98	15 3	2 53	3 31	4 85	4 43
Percent cover (1st session)						
(based on average of individual species by plots)						
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	N/A	N/A	1 36	2 73	N/A	N/A
Tree1(T1)	N/A	1 36	N/A	N/A	N/A	N/A
Shrub3(S3)	N/A	N/A	1 36	12 27	1 36	N/A
Shrub2(S2)	6 14	3 41	41 59	11 59	22 5	24 55
Shrub1(S1)	9 55	4 09	38 86	53 18	27 95	30 68
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	N/A	N/A	N/A
Forb1(F1)	16 36	9 55	60 23	68 86	55 91	47 05
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	N/A	1 36	8 18	14 32	15 68	30
Percent cover (2nd session)						
(based on average of individual species by plots)						
Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	N/A	1 36	2 73	2 73	N/A	N/A
Tree1(T1)	N/A	2 73	N/A	N/A	N/A	N/A
Shrub3(S3)	N/A	3 41	4 77	14 77	1 36	N/A
Shrub2(S2)	8 86	N/A	38 86	16 36	23 86	37 5
Shrub1(S1)	8 18	9 55	40 91	51 14	32 05	40 91
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	1 36	N/A	5 45
Forb1(F1)	15	9 55	78 18	68 18	65 45	62 73
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	1 36	1.36	8 18	12 27	23 18	26 59

Installation Wallowa, Oregon
Region NE Oregon
Legal Description T3NR41E Sec 4 (Tr 3 & 4)
T3NR41E Sec 2 (Tr 1)
T3NR41E Sec 11 (Tr 2)

Ownership Boise Cascade
Meridian Willamette

Treatment Regime
Year Fertilized

Elevation 4000 (Tr 3 & 4)/ 3700 (Tr 1 & 2)
Aspect
Slope

Vegetation series Abies grandis
Habitat type

Parent material
Soil depth
Ash depth

VEGETATION CHARACTERISTICS

Transect	1	2	3	4
Treatment	Multinutrient	Control	Control	Multinutrient
Slope (%)				
Aspect (%)				
Basal area	54 29	62 86	37 33	34 67
Average DBH	7 94	7 88	5 89	6 17
Percent cover (1st session)	1	2	3	4
(based on average of individual species by plots)				
Tree3(T3)	N/A	N/A	N/A	N/A
Tree2(T2)	3 21	N/A	2	4
Tree1(T1)	N/A	N/A	N/A	1
Shrub3(S3)	1 07	1 07	1	1
Shrub2(S2)	41 25	41 96	9	14 5
Shrub1(S1)	23 57	33 75	23 5	27 5
Forb3(F3)	N/A	N/A	N/A	N/A
Forb2(F2)	17 32	13 93	18 67	3
Forb1(F1)	51 43	51 43	58 5	54 5
Grass3(G3)	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A
Grass1(G1)	20 36	3 75	19	27 5
Percent cover (2nd session)	1	2	3	4
(based on average of individual species by plots)				
Tree3(T3)	N/A	N/A	N/A	N/A
Tree2(T2)	3 21	N/A	2	6
Tree1(T1)	N/A	N/A	1	N/A
Shrub3(S3)	1 07	1.07	1	1
Shrub2(S2)	39 11	39 64	10	9
Shrub1(S1)	31.07	26.79	29	34
Forb3(F3)	N/A	N/A	N/A	N/A
Forb2(F2)	8 57	19 29	5 5	3
Forb1(F1)	49.29	49 82	55 5	57 5
Grass3(G3)	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	1
Grass1(G1)	19.29	2.14	16	31 5

Installation Wallowa, Oregon

Percent cover (1st session) (based on average of life form by plots)	1	2	3	4
Tree3(T3)	N/A	N/A	N/A	N/A
Tree2(T2)	1 25	N/A	2	5 17
Tree1(T1)	N/A	N/A	0 33	1
Shrub3(S3)	1 07	1 07	1	1
Shrub2(S2)	28 75	33 21	7 5	16
Shrub1(S1)	17 32	18 21	14 83	19 17
Forb3(F3)	N/A	N/A	N/A	N/A
Forb2(F2)	20 68	20 36	16 67	4
Forb1(F1)	37 5	34 29	38 33	39 33
Grass3(G3)	N/A	N/A	N/A	N/A
Grass2(G2)	1 82	0 36	1 33	6 33
Grass1(G1)	21 43	11 25	18 5	31 5

Percent cover (2nd session) (based on average of life form by plots)	1	2	3	4
Tree3(T3)	N/A	N/A	N/A	N/A
Tree2(T2)	3 21	N/A	2	4 17
Tree1(T1)	N/A	N/A	1	2 5
Shrub3(S3)	1 07	N/A	1	1
Shrub2(S2)	31 25	31 61	8 5	14 5
Shrub1(S1)	26 25	29 46	22 5	19
Forb3(F3)	N/A	N/A	N/A	N/A
Forb2(F2)	9 11	14 11	5	4 33
Forb1(F1)	30	35 89	34 5	39 33
Grass3(G3)	N/A	N/A	N/A	N/A
Grass2(G2)	6 61	0 36	4 33	9
Grass1(G1)	15 54	7 5	15	25 67

Biomass (ap - annual production, ln = natural log)	1	2	3	4
1st session-Dry weight				
Tr 1: lnap = -1.540 + 1.581*class (R^2 = 0 975)	112 7			
Tr2: lnap = 0.942 + 3.974*lnclass (R^2 = 0.999)		169 03		
Tr3: lnap = 0.148 + 3.391 * lnclass (R^2 = 0.969)			109 77	
Tr4: lnap = 0.0819 + 3.781 * lnclass (R^2 = 0 973)				269 51
2nd session-Dry weight	1	2	3	4
Tr 1: lnap = -0 633 + 1.650*class (R^2 = 0.991)	48 03			
Tr2: lnap = 0.768 + 3.781*lnclass (R^2 = 0.992)		95 96		
Tr3: lnap = 1.124 + 3 511 * lnclass (R^2 = 0.927)			51 12	
Tr4: lnap = 0.217 + 3.406 * lnclass (R^2 = 0.977)				103 71
1st session-Green weight	1	2	3	4
Tr 1: lnap = -0 110 + 4.888*lnclass (R^2 = 0 987)	697.70			
Tr2: lnap = 0 01857 + 4 666*lnclass (R^2 = 0.993)		697 94		
Tr3: lnap = 3.558 + 2.393 * lnclass (R^2 = 0.987)			563 57	
Tr4: lnap = 0 211 + 4.561 * lnclass (R^2 = 0.991)				1342 17
2nd session-Green weight	1	2	3	4
Tr 1: lnap = 1.433 + 1.378*class (R^2 = 0 986)	225 16			
Tr2: lnap = 2.448 + 3 244*lnclass (R^2 = 0.995)		369 56		
Tr3: lnap = 0.339 + 4.187 * lnclass (R^2 = 0.975)			253 39	
Tr4: lnap = 1.560 + 4.165 * lnclass (R^2 = 0.960)				411 29

Installation Potlatch, Idaho

Percent cover (1st session)
(based on average of life form by plots)

Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	N/A	0 23	0 23	4 09	1 36	N/A
Tree1(T1)	N/A	1 59	N/A	2 05	N/A	N/A
Shrub3(S3)	N/A	N/A	1 36	11 14	N/A	N/A
Shrub2(S2)	4 77	3 41	32 5	10 91	20 68	19 77
Shrub1(S1)	6 36	6 36	25 23	40 23	22 73	29 32
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	N/A	N/A	0 23
Forb1(F1)	12 73	6 82	42 27	44 32	32 95	29 32
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	0 45	1 36	15	19 09	26 82	25 23

Percent cover (2nd session)
(based on average of life form by plots)

Tree3(T3)	N/A	N/A	N/A	N/A	N/A	N/A
Tree2(T2)	N/A	1 36	2 73	1 36	N/A	N/A
Tree1(T1)	0 45	2 73	N/A	0 23	N/A	N/A
Shrub3(S3)	N/A	3 41	4 77	13 41	1 36	N/A
Shrub2(S2)	6 14	N/A	31 59	12 95	21 59	29 32
Shrub1(S1)	4 54	6 36	32 5	31 36	25 23	31 36
Forb3(F3)	N/A	N/A	N/A	N/A	N/A	N/A
Forb2(F2)	N/A	N/A	N/A	1 36	N/A	5 45
Forb1(F1)	9 09	7 95	60 23	42 05	44 32	44 32
Grass3(G3)	N/A	N/A	N/A	N/A	N/A	N/A
Grass2(G2)	N/A	N/A	N/A	N/A	N/A	N/A
Grass1(G1)	2 05	1 59	11 59	11 59	23 18	29 32

Biomass

	1	2	3	4	5	6
1st session-Dry weight						
Cedar: lnap = -0 137 + 0 819*class (R^2 = 0 963)	1 61	1 48				
D fir: lnap = 2 559 + 0.799*class (R^2 = 0 982)			76 24	114 14		
Pondo pine: lnap = 0.09948 + 3 124 * lnclass (R^2 = 0 971)					62 95	67 15

	1	2	3	4	5	6
2nd session-Dry weight						
Cedar: lnap = -1 615 + 1.325*class (R^2 = 0 907)	5 63	3 33				
D fir: lnap = 0.125 + 4 023*lnclass (R^2 = 0 964)			197 37	176 29		
Pondo pine: lnap = -1 511 + 1 508 * class (R^2 = 0 972)					50 30	53 40

	1	2	3	4	5	6
1st session-Green weight						
Cedar: lnap = -0 246 + 3 056*lnclass (R^2 = 0 976)	25 32	13 99				
D fir: lnap = 4 444 + 1.630*lnclass (R^2 = 0 996)			279 58	289 24		
Pondo pine: ap = -142 + 159 2 * class (R^2 = 0 970)					256 00	281 33

	1	2	3	4	5	6
2nd session-Green weight						
Cedar: lnap = -0 177 + 4 107*lnclass (R^2 = 0 893)	35 96	19 35				
D fir: lnap = 3 224 + 1 117*class (R^2 = 0 957)			575 70	513 85		
Pondo pine: lnap = -0.189 + 4 465 * lnclass (R^2 = 0 984)					228 69	258 38

APPENDIX C: TISSUE NUTRIENT ANALYSIS SUMMARY FOR 1997

NUTRIENT ANALYSIS DATA FOR SUMMER OF 1997 FOR BOISE CASCADE LANDS.

		Al	B	Ca%	Cu	Fe	K%	Mg%	Mn	Mo	N%	Na	P%	Zn
1 Enter	Mx Forb 1	541	35.6	1.17	8.52	279	3.69	0.192	215	1.67	1.64	220	0.5	45.1
3EnterMx	Forb Ctrl 1	373	27.2	2.55	6.52	319	4.31	0.211	135	2.99	1.83	101	0.588	79.8
3EnterMx	Forb Ctrl 2	15.1	6.71	0.324	3.35	21.5	2.18	0.116	29.9	0.246	0.71	38.4	0.064	26.1
5EnterMx	Shrub Ctrl1	30.7	27.9	0.919	5.99	47.9	1.18	0.152	75.1	0.524	2.23	32.1	0.321	86.2
5EnterMx	Forb Ctrl 1	158	24.4	0.875	7.26	154	4.46	0.213	65.3	1.66	2.69	72.6	0.388	150
4EnterMx	Forb Ctrl 1	32.1	12.2	0.499	4.95	43.6	2.99	0.108	29.7	0.96	1.27	37.2	0.254	123
4EnterMx	Shrub Ctrl1	35	33.2	1.41	5.91	58.6	1.06	0.219	127	0.99	2	22.1	0.396	146
3EnterMx	Shrub Fert1	257	28.8	1.56	7.2	215	2.5	0.172	162	1.72	1.78	90.1	0.364	66
5EnterMx	Shrub Fert1	80.1	58.1	1.41	4.73	88.5	1.3	0.147	97.7	1	2.09	31.4	0.24	85.3
4EnterMx	Grass Fert1	15.7	4.02	0.186	1.72	30.9	1.86	0.042	27.2	1	0.909	29.8	0.193	40.4
4EnterMx	Shrub Fert1	49.7	34.8	1.13	6.81	56.2	1.29	0.167	92.5	0.628	1.88	51.8	0.316	84
3EnterMx	Shrub Ctrl1	25.6	22.4	0.848	6.09	43.2	1.81	0.212	214	1.86	2.08	30.1	0.368	47.5
4EnterMx	Forb Fert 1	14.1	13.7	0.28	4.72	26	1.81	0.096	22.4	1.01	1.47	21.5	0.097	17.9
4EnterMx	Forb Ctrl 2	204	14.1	0.77	2.77	197	2.81	0.096	112	0.764	0.802	69.4	0.454	70.4
3EnterMx	Forb Fert 1	519	25.8	1.67	9.3	362	4.41	0.18	124	2.28	2.06	184	0.428	40
2EnterMx	Grass Ctrl2	17.5	4.37	0.208	0.636	32.9	1.36	0.064	86.4	1	0.913	20.1	0.154	20
4EnterMx	Forb Fert 2	52.6	10.9	0.424	2.14	57	2.09	0.155	83.9	1.46	0.87	44.3	0.159	56.6
3EnterMx	Grass Fert2	13.5	2.69	0.159	0.431	24.4	0.869	0.066	62.4	0.459	0.591	21.9	0.073	10.9
2EnterMx	Forb Ctrl 1	179	20.7	1.19	6.43	173	4.35	0.254	68.4	2.7	1.72	87.6	0.445	45.6
1EnterMx	Forb Fert 2	261	32.4	1.19	4.28	209	3.49	0.164	118	1.07	1.62	87.3	0.349	27.2
2EnterMx	Forb Fert 1	165	21.2	0.96	5.38	162	3.24	0.14	84.5	0.896	1.51	64.6	0.321	21.9
5EnterMx	Grass Fert1	46.1	13.3	0.283	6.07	69.1	3.62	0.074	63.5	2.29	1.12	57.6	0.295	27.2
2EnterMx	Forb Fert 2	110	14.2	0.725	4.36	79.9	2.37	0.123	78.2	1.02	1.21	76.9	0.195	27.5
4EnterMx	Shrub Fert2	64.4	41.4	1.35	5.11	69.5	1.05	0.122	116	0.808	1.37	41	0.285	126
4EnterMx	Shrub Ctrl2	33.9	26.9	0.879	5.99	46.9	0.789	0.129	82	0.497	1.1	40.4	0.198	84.2
5EnterMx	Shrub Ctrl2	49	47.9	1.06	5.88	59.3	1.07	0.149	77.1	0.519	1.5	53.1	0.278	94.9
5EnterMx	Shrub Fert2	48.4	57.1	1.32	3.68	55.3	0.837	0.172	117	0.454	1.5	34.9	0.178	60.4
5EnterMx	Forb Ctrl 2	122	24.6	1.73	3.05	99.5	2.63	0.151	70.6	2.03	1.4	66.5	0.523	39.8
5EnterMx	Grass Fert2	16.8	2.95	0.205	0.723	21.7	1.13	0.035	49.5	1	0.813	29.3	0.166	33.1
1EnterMx	Forb Ctrl 1	390	23.1	1.14	6.19	322	5.55	0.258	126	1.21	1.82	107	0.426	57.6
2EnterMx	Grass Fert1	22	8.43	0.229	5.16	43.3	2.47	0.069	41.2	1.18	1.33	59.1	0.233	36.4
5EnterMx	Forb Fert 1	81.5	34	0.605	5.85	93.6	3.54	0.132	64.4	3	2.08	41	0.252	30.4
3EnterPn	GrassFert2	36.5	8.13	0.461	1.11	48.4	2.36	0.108	101	2.89	0.931	27.3	0.199	43.5
3EnterPn	PineGrass 1	12.6	7.52	0.226	0.826	33.5	1.18	0.066	44.5	6.18	1.11	19.5	0.158	19.7
2EnterPn	PineGrass 1	14.7	5.74	0.151	1.64	33.3	1.91	0.053	75.9	1.39	1.37	20.5	0.201	15.7
4EnterPn	Shrub Ctrl2	42.2	38.8	1.18	6.23	57.2	1.65	0.132	131	1.94	1.55	22.4	0.251	112
3EnterPn	Forb Fert2	90.6	20.8	0.899	4.79	77.8	2.19	0.086	81	0.944	0.781	47.7	0.206	23.9
4EnterPn	Shrub Fert2	10.7	22.4	0.623	6.08	15.9	1.21	0.112	51	0.854	0.526	41.9	0.198	24.7
5EnterPn	Forb Ctrl1	10.9	11.8	0.237	5.01	19	1.38	0.141	12.5	0.842	1.25	23.8	0.079	13.8
5Pnd	shrubPine Ctrl1	56.6	23.6	1.34	5.1	60.6	1.29	0.217	104	1.07	1.74	39.3	0.313	102
2EnterPn	ForbCtrl 2	9.29	13.1	0.563	7.14	15.5	1.06	0.11	55.1	2.79	0.334	18.5	0.13	44.1
1Pnd Pin	ForbFert 1	169	35.2	1.25	7.18	126	3.87	0.117	205	1.92	2.3	92.5	0.329	38.9
5Pnd Pin	ForbFert 2	65.7	36.2	0.778	9.36	63.3	3.05	0.166	84.1	4.93	1.37	42.6	0.366	61.8
4Pnd Pin	GrassFert 1	17.2	6.91	0.182	2.49	33.3	2.45	0.072	44.1	2.74	0.96	40.4	0.195	32.1
4Pnd Pin	Forb Fert 1	23.5	19.2	0.424	5.97	40.4	2.45	0.141	32.5	2.01	1.4	22.8	0.175	27.3
5Ent	shrubFruitFert2	10.1	14.1	0.333	3.1	24.6	2.02	0.135	14.7	0.507	0.917	23	0.299	12
5Pnd Pin	Grass Ctrl1	13	3.56	0.22	1.36	30.9	1.94	0.099	37.4	6.78	1.08	41.7	0.245	13.7

4PndPine	CntrlGrass1	42.4	5.11	0.244	4.42	48	2.71	0.087	78.8	2.61	0.835	54.8	0.281	107
4PndPine	CntrlForb1	29.3	15.2	0.736	8.28	43.4	2.47	0.186	53.8	2.68	1.58	39.2	0.259	148
5PndPine	FertGrass1	14.2	4.32	0.219	1.84	35.2	1.9	0.072	50	5.33	1.21	43	0.216	412
5EnterPn	CntrlGrass2	19.9	4.71	0.186	0.94	37.9	1.06	0.074	47.1	3.85	0.851	85.6	0.12	40.2
3EnterPn	CntrlGrass2	57.7	6.27	0.383	1.27	52.3	1.14	0.077	104	0.926	0.98	129	0.148	323
3PndPine	CntrlShrub1	19.6	23.5	1.02	5.69	34.3	1.83	0.208	33.6	3.04	1.47	107	0.43	136
1PndPine	FertGrass1	9.06	5.66	0.125	2.06	25.3	1.74	0.052	50	2.94	0.88	50.5	0.14	1280
5EnterPn	CntrlShrub2	37.5	62.3	1.97	4.34	64.2	2.8	0.251	71.4	1.5	1.67	61.1	0.128	48.6
2EnterPn	FertForb2	11.3	8.09	0.295	3.61	26.1	1.54	0.16	21.8	0.424	0.723	18.7	0.032	84.9
1PndPine	CntrlGrass1	103	1.77	0.12	0.948	58	1.24	0.046	84.4	2.28	0.716	121	0.179	626
2PndPine	CntrlGrass 1	51.5	5	0.372	1.76	48.7	2.31	0.084	72.7	1.47	0.98	56.4	0.262	50.9
3EnterPn	dCntrlForb2	10.7	15.1	0.708	8.91	21.5	1.13	0.145	84.3	9.84	0.483	27.1	0.108	87.9
3PndPine	CntrlGrass1	14.9	2.69	0.141	1.15	31.2	1.57	0.05	28.6	1.64	0.916	34.3	0.189	20.9
5PndCntr	lGrassFlowr2	17.8	12	0.209	1.53	42.2	0.58	0.098	58.5	8.05	0.97	67.5	0.115	35.8
2PndPine	CntrlForb1	179	22.3	1.1	6.21	119	2.45	0.229	129	1.93	1.73	74	0.382	32.6
5PndPine	EnterShrub1	25.3	23.2	1.33	4.46	49.5	6.07	0.231	26	0.866	3.28	44.7	0.362	27.3
5GoldCnt	rlGrass2nd	57.8	4.6	0.325	0.849	49.9	1.09	0.103	124	1.87	1.01	29.2	0.145	116
3GoldFer	tForb2nd	40.3	27.4	0.592	4.97	37.6	2.48	0.142	91.8	0.672	1.07	47.3	0.09	130
5GoldFer	tForbFlower2	61.8	26.8	0.581	10.6	66.4	2.86	0.166	67.6	2.01	1.85	44.1	0.252	332
5GoldFer	tShrub2nd	39.4	18.3	1.23	3.6	47.2	1.04	0.232	78.9	1.01	1.67	21.7	0.153	116
3GoldFer	tForbFlower2	96.8	53	0.594	8.7	80.3	2.66	0.22	174	0.805	1.89	39.2	0.199	140
2GrassGo	ldFert2nd	20.4	81	0.162	3.73	44.3	2.57	0.068	93.2	1.48	1.87	29.5	0.111	33.4
5GoldCnt	rlShrub2nd	25.2	11.9	0.98	3.71	38.3	1.3	0.139	67.8	1.18	1.67	22.6	0.193	44.2
4GoldFer	tShrub2nd	23.2	11.9	0.638	2.55	24.6	0.811	0.163	74.7	1.2	0.908	38.8	0.109	27.8
2GoldCnt	rlGrass2nd	75.4	5.25	0.482	1.42	108	0.607	0.057	102	1.39	0.675	28.2	0.133	814
3GoldCnt	rlForb2nd	73.8	20.1	0.87	3.38	77.9	1.72	0.196	77.4	1.27	1.73	29.1	0.155	83.8
5GoldFer	tForb2nd	457	58.4	0.846	7.31	204	3.4	0.164	102	2.39	1.33	86.8	0.145	33.7
3GoldFer	tGrass2nd	73.2	28.9	0.215	2.56	55.9	1.67	0.051	74.6	0.738	1.21	45.6	0.095	27.2
4GoldCnt	rlShrub2nd	68.7	12.2	0.73	2.61	66.6	0.7	0.172	67.4	0.722	0.629	27.7	0.126	71.8
4GoldFer	tForb2nd	53.6	75.2	0.97	5.86	57.9	2.25	0.277	161	1.33	1.6	32.7	0.138	24.2
2MeadowF	ertForb2nd	60.2	16.4	0.548	2.98	43.3	1.34	0.143	75	0.743	0.683	84.4	0.038	334
3MeadowF	ertGrass2nd	11.3	4.85	0.137	0.99	28.1	1.21	0.031	89.6	0.473	0.468	30.9	0.075	309
4MeadowC	ntrlGrass2nd	66	4.34	0.356	0.841	63.9	1.31	0.075	167	0.897	0.98	62.5	0.12	247
5MeadowC	ntrlShrub2nd	59.7	44.2	2.09	5.24	63	0.762	0.174	150	0.6	1.71	35.2	0.227	228
5MeadowF	ertForb1st	25.3	29.6	0.504	3.88	31.7	3.15	0.07	68.2	1.89	1.22	43.8	0.129	42.4
5MeadowC	ntrlGrass2nd	37.5	6.47	0.336	0.737	48.8	1.34	0.089	49.3	0.627	1.13	21.3	0.149	241
4MeadowF	ertShrub2nd	55.7	49.9	1.56	4.87	58.3	0.61	0.223	149	0.737	1.24	51.2	0.173	500
2MeadowF	ertForbFlow2	128	26.2	0.831	4.65	90.1	0.455	0.13	88.9	1.51	1.03	152	0.053	53.4
3MeadowC	ntrlGrass2nd	29.4	4.29	0.303	0.769	35.6	1.36	0.065	194	0.561	1.28	20.5	0.149	141
2MeadowC	ntrlGrass2nd	35.3	8.2	0.294	0.715	41	1	0.087	251	0.253	0.907	113	0.098	61.5
5MeadowF	ertShrub2nd	56.3	85.1	1.51	5.32	60.2	2.39	0.146	127	3.02	2.05	38.5	0.229	146
5FertMea	dowForbFlow1	30.7	51.7	0.643	9.01	81	3.23	0.184	103	5.36	2.36	44	0.447	45.5
3MeadowF	ertShrub1st	17.1	20.7	1.98	7.31	62.7	1.53	0.299	189	0.855	2.9	27.7	0.221	37.7
1MeadowF	ertGrass1st	86.3	35.2	0.344	2.12	84.7	1.7	0.101	380	1.71	2.38	63.4	0.209	92.9
2MeadowF	ertForb1st	101	197	2.2	8.14	96.3	2.98	0.222	66.9	1.2	2.12	48.5	0.146	32.2
3MeadowF	ertGrass1st	25.9	31	0.403	1.59	58.9	2.6	0.144	194	0.742	2.19	32.5	0.16	80
2FertMea	dowGrass1st	22.9	21.2	0.452	3.34	45	1.68	0.068	90.1	2.5	1.77	48	0.113	148
2MeadowC	ntrlGrass1st	27	6.74	0.351	1.28	38.2	1.33	0.087	110	0.517	1.14	83.2	0.122	19.6
5MeadowS	hrubCntrl1st	78.5	35.5	2.41	6.98	88.5	1.48	0.265	173	0.743	2.16	52.4	0.385	132
4MeadowF	ertGrass1st	52.4	66.8	0.924	9.65	93.2	3.59	0.277	267	2.29	1.93	63.2	0.211	51.2
5MeadowF	ertGrass1st	55.1	3.67	0.392	0.97	45.9	2.04	0.077	83.7	0.934	2.14	36	0.231	18.5

4MeadowC	ntrlGrass1st	160	5 24	0 449	0 894	93 1	1.21	0.076	107	0.895	1.14	36.2	0.174	129
5MeadowC	ntrlGrass1st	25 9	21 6	0 419	9 86	52 3	2.89	0.117	113	4.09	1.25	25.6	0.218	49.8
4MeadowF	ertForb1st	29.6	23 8	0 433	4 62	61 1	2 61	0.101	393	2.14	3.59	34.4	0.181	59.4
4MeadowF	ertGrssFlow1	413	22 1	0 355	2 99	37 5	1.08	0.129	121	0.719	1.8	35.4	0.245	177
4MeadowC	ntrlShrub2nd	192	18 9	0.209	2 75	29 7	0.585	0.133	112	0.549	1.5	19.1	0.138	58.6
3MeadowF	ertGrssFlow2	28.3	5.24	0.134	2.82	55 6	0.221	0.039	146	1.27	0.668	28.5	0.09	33.9

Abbreviations

Enter - Enterprise, Oregon
Mx - mixed-conifer stand
Pn/Pnd - ponderosa pine plantation

Fert-fertilization
ctrl - control

Meadows - New Meadows

Gold - Goldendale