May 1976 Bulletin Number 14

College of Forestry, Wildlife and Range Sciences

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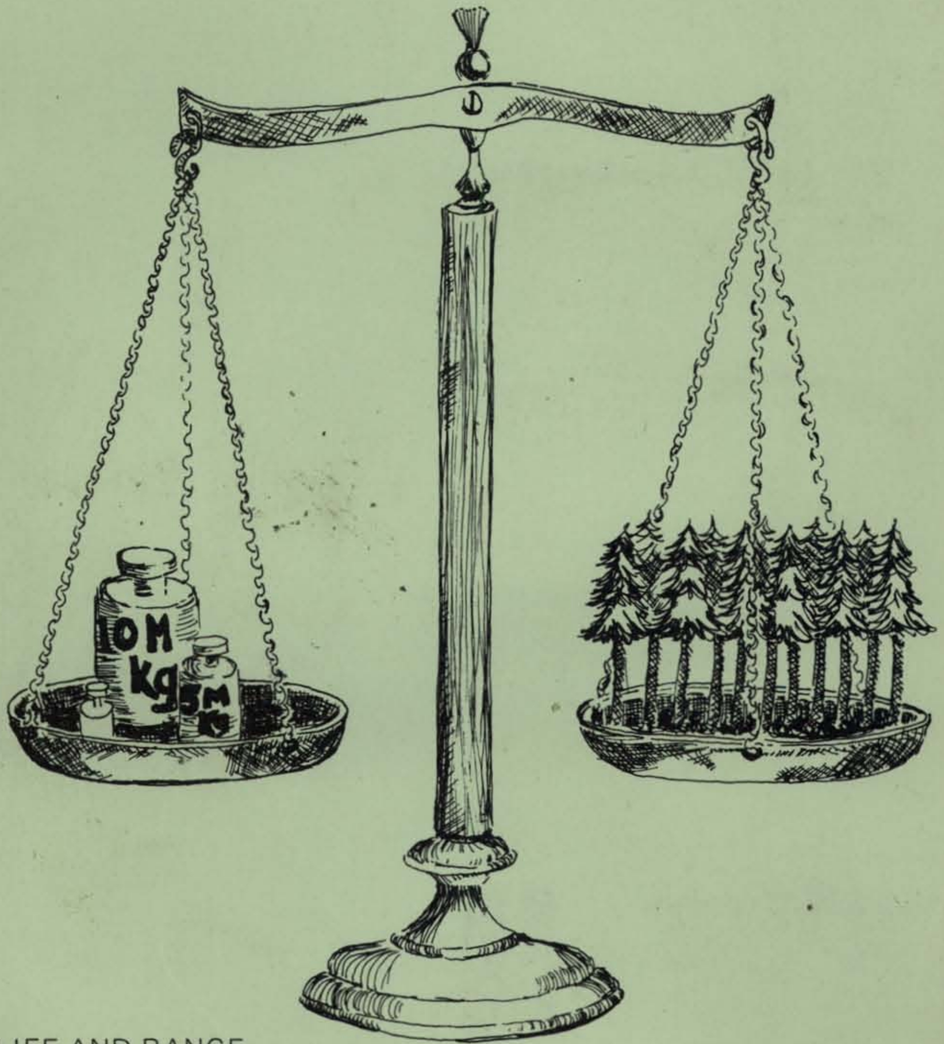

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INTRODUCTION

A floristically rich forest belt occurs at mid-elevations northern Idaho, defined by Daubenmire and ubenmire (1968) as the western hemlock series. The ies occurs within an environmental gradient that lies ween the colder, more moist subalpine fir series, and warmer, drier, Douglas-fir series. Five habitat types compass the environmental variation found in this ies. *Abies grandis/Pachistima myrsinites, Thuja icata/Pachistima myrsinites,* and *Tsuga erophylla/Pachistima myrsinites*[1] habitat types are und on well drained sites. *Thuja plicata/Oplopanax rridum and Thuja plicata/Athryium felix-femina* bitat types occupy relatively insignificant acreages of orly-drained soils. Grand fir/pachistima is the warmest d dryest of the types while hemlock/pachistima is the ldest and wettest. North of about 47°45' latitude, stern redcedar infrequently becomes climax. South of at general latitude, western hemlock occurrence minishes quite rapidly and is replaced by western dcedar. Daubenmire and Daubenmire (1968) defined ese associations by the presence of the *Pachistima* nion. This complex understory union consists of umerous shrub and forb species. The most constant enera are: *Adenocaulon, Clintonia, Coptis, Galium, innaea, Pachistima, Thallictrum,* and *Vaccinium.*

The objective of this study was to estimate the anding biomass and *potential* productivity of fully ocked stands within the grand fir/pachistima, western ed cedar/pachistima and western hemlock/pachistima abitat types found in northern Idaho. The estimates came from *existing* information relevant to the tree species and site characteristics of the western hemlock series. The study was limited to the coniferous tree portion of the stated habitat types. Primary production was estimated for the foliage, branchwood, peeled bole, bark, and roots by the accretion of live and dead biomass over a time interval.

Tree biomass information is essential to determine emphasis, priorities, and direction in research and management. Production estimates, on the ecosystem level, are required for comparison and analysis of changes brought about by man's alternative actions.

METHODS

Stand selection, equation selection, biomass determination, and productivity determination were the steps involved in carrying out the objectives.

Stand Selection

Stand selection criteria were:

(A) Location within the western hemlock series (Daubenmire and Daubenmire 1968);
(B) Uncut through the measurement period, and in accord with expected natural secondary successional trends;
(C) Near or at "normal stocking" for complete site occupancy;
(D) Even-aged and at the point of maximum mean annual increment, cubic-volume basis, the point of maximum biomass accumulation;
(E) No abnormal mortality and free of excessive pathological or entomological problems;
(F) A fixed radius sample plot located within its boundaries with a measurement record for all trees at the beginning and end of a known time, (5-11 years).

Selections were made from stands in which the Intermountain Forest and Range Experiment Station had established long-term growth and yield plots. To obtain

his study is one portion of the Intensive Timber Culture Program, onducted by the Forest, Wildlife and Range Experiment Station, niversity of Idaho and the Intermountain Forest and Range xperiment Station, USDA Forest Service. The author is grateful Mr. Glenn H. Deitschman, Mr. Charles A. Wellner, and Dr. David . Adams for their suggestions and guidance. Contribution No. 28, orest, Wildlife and Range Experiment Station, University of Idaho.

Hereafter referred to by common names.

Table 1. Stand information and descriptions for the plot sites selected for productivity estimation of the grand fir, western red cedar and western hemlock habitat types, northern Idaho.

Plot	Habitat Type[1/]	Stand Information: Location	Age @ T1	Period of Measurement T1	Period of Measurement T2	Site Index (WWP)[6/] (ft.)	Basal Area @ T1 (Sq M/ha)	Basal Area @ T1 (Sq ft/ac)	% Normal[6/] @ T1	Trees/AC @ T1 (T/ha)	Trees/AC @ T1 (T/ac)	Aspect	Slope %
W-12	GF/P	Hay Cr.[2/]	103	1925	1935	74	67.7	295	99	803	325	SE	55
W-18	GF/P	OroGrande Cr.	103	1925	1935	70	61.3	267	90	628	254	S	50
W-21	GF/P	OroGrande Cr.	103	1925	1935	73	62.2	271	90	699	283	W	40
15	GF/P	Phantom Cr.[3/]	105	1963	1973	50	53.5	233	79	1127	456	SW	20
W-9	WRC/P	Orofino Cr.	103	1925	1935	73	56.9	248	83	764	309	E	55
W-10	WRC/P	Hay Cr.	103	1925	1935	75	88.4	385	127	964	390	SE	40
W-11	WRC/P	Hay Cr.	103	1925	1935	77	63.8	278	92	598	242	SW	30
W-19	WRC/P	OroGrande Cr.	103	1925	1935	66	60.6	264	89	729	295	E	55
W-20	WRC/P	OroGrande Cr.	103	1925	1935	65	62.2	271	91	820	332	E	60
101	WH/P	Benton Flat[4/]	105	1964	1974	60	62.9	274	92	2609	1056	SE	10
105	WH/P	Benton Flat[4/]	110	1959	1970	55	51.4	224	74	1443	584	SE	10
161	WH/P	Benton Cr.[4/]	100	1953	1963	60	56.2	245	84	1868	756	SW	50
32	WH/P	Sands Cr.[5/]	20	1934	1939	65	11.2	49	104	6741	2728	E	50
148	WH/P	Fox Cr.[4/]	250+	1962	1972	65	49.8	217	62[7/]	259	105	NW	20

1/ GF/P = Grand fir/Pachistima; WRC/P = Western Red Cedar/Pachistima; WH/P = Western hemlock/Pachistima.
2/ The "W-plots" are located on the Clearwater National Forest, (latitude 40°35'; longitude 115°37').
3/ Fernan District, Idaho Panhandle N.F., (latitude 47°47'; longitude 116°30').
4/ Priest River Experimental Forest, (latitude 48°20'; longitude 116°50').
5/ Deception Cr. Experimental Forest, (latitude 47°45'; longitude 116°30').
6/ From Haig, 1932.
7/ Based on Haig's (1932) oldest age-class of 160 years.

ively standardized estimates of potential productivity, 12 stands chosen (Table 1) were normally stocked[2] even-aged at or near culmination of mean annual ement on a cubic-volume basis. Two additional stands e analyzed for stand age influences on biomass and luctivity. Stand No. 32 was immature, 20 years old, Stand No. 148 was over-mature, 250+ years old; both e within the western hemlock/pachistima habitat e[3] (Table 1). Normality comparisons were based on g's (1932) tables.

ation Selection

A search of the literature and information from the ntists engaged in forest biomass studies provided ession equations (Table 2) that are considered most licable to north Idaho. Equations of the form shown ow were sought to predict oven-dry tree component ghts[4] from known diameters and heights of the iferous tree species usually found within these habitat es:

$$Wc = f(dbh, ht)$$

or

$$Vc = f(dbh, ht)$$
$$Wc = C \times Vc \times Spg$$

ere:

Wc = tree component oven-dry weight in kilograms
Vc = tree component volume in cubic meters
dbh = diameter (o.b.) at 1.3 m (4.5 ft) above ground
ht = total height of tree
Spg = mean specific gravity of component from published sources
C = 1000.0, the weight in kilograms of 1 m^3 of water

ee components were defined as:

foliage = the weight of all live needles present.
branchwood = the weight of all branchwood present including the bark, excluding any portion of the main stem.
peeled bole = the weight of the main stem from ground line to top of tree, excluding the bark.
bark = the weight of the main stem bark from the ground line to the top of the tree.
roots = the weight of the below-ground portion of the tree.

[2]It is beyond the scope of this paper to discuss the advantages and isadvantages of using the normality concept. Excellent discussions re found in Nelson and Bennett (1965) and Smith (1965). No ttempt has been made to transform the study data to an "average ormal" value.

[3]Comparisons could only be made for the western hemlock/ achistima habitat type because of limited available data.

Biomass Determination

Total standing tree biomass, determined independently for each of the study plots, was calculated by summing the five component weights for each tree (1.5 cm dbh and larger), then adding these individual tree values for the plot totals. This determination was made twice, at T1, the beginning of the measurement period, and at T2, the end of the period.

Primary Productivity Determination

Productivity was also determined independently for each plot. Periodic annual productivity was measured for the period which bracketed the point at which mean annual increment maximized, in order to estimate the MAI point. Periodic annual productivity of the branchwood, peeled bole, bark, and roots was determined by summing the differences between beginning and ending biomass for each tree over the measurement period and dividing by the number of years in the period. Loss to the tree (i.e. bark loss, branchwood fall, and small root turnover) and respiration losses were not included.

Foliage productivity was handled separately because of the continual turnover of needle biomass. Periodic annual foliage productivity was determined by averaging tree foliage biomass for a given species during the measurement period and dividing by the average duration of needle retention for that species.[5] Annual foliage productivity was added to the annual productivity of the remaining components to arrive at total annual productivity. The procedure can be summarized as follows to arrive at the stand periodic annual producitvity in oven-dry kilograms/hectare/year:

$$\text{Productivity} = \sum_{i=1}^{n} \left[\{(bw_{2_i} - bw_{1_i}) + (pb_{2_i} - pb_{1_i}) + (b_{2_i} - b_{1_i}) + (r_{2_i} - r_{1_i})\}/Y + (f_{2_i} + f_{1_i})/2nL \right] /A$$

[4]Weights are expressed in kilograms/hectare.

[5]Average yearly needle durations used in this study are as follows: WWP=3 (Buchanan 1936); DF=3 (Mitchell 1974); GF=4, WRC=3 (Sargent 1933); WH=4, ES=5, PP=2, SAF=5, LPP=3 (USDA Forest Serv. 1965); WL=1.

Table 2. Sources of biomass equations employed for productivity estimates in the grand fir, western red cedar, and western hemlock habitat types, Northern Idaho.

Component	Species									
	WWP	WL	DF	GF	WH	WRC	LPP	ES	SAF	PP
Foliage	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)
Branchwood	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)	Brown (1975)
Peeled Bole	Stage[1/] (1966)	Stage[1/] (1966)	Stage[1/] (1966)	Stage[1/] (1966)	Stage[1/] (1966)	Stage[1/] (1966)	Stage[1/] (1966)	Stage[1/] (1966)	Stage[1/] (1966)	Stage[1/] (1966)
Bark	Young[2/] et al. (1965)	Faurot[1/3/] (1974) Smith-Kozak[4/] (1971)	Faurot[1/3/] (1974) Smith-Kozak[4/] (1971)	Young[2/] et al. (1965)	Kurucz (1969)	Kurucz (1969)	Faurot[1/3/] (1974) Smith-Kozak[4/] (1971)	Young[2/] et al. (1965)	Young[2/] et al. (1965)	Faurot[1/3/] (1974) Smith-Kozak[4/] (1971)
Roots	Young[2/] et al. (1964)	Rennie[2/] (1955)	Cole-Dice[5/] (1969)	Rennie[2/] (1955)	Young[2/] et al. (1964)	EIS[6/] (1970)	Johnstone[7/] (1971)	Young[2/] et al. (1964)	Rennie[2/] (1955)	Hanley[8/]

1/ Volume equations - converted to weight via specific gravity

2/ Local equations not available - equations used represent values obtained from other parts of the U.S. and may include values from other species within the same genera.

3/ Equations predict gross bark volume including fissures.

4/ Determined specific gravity constants from Pacific Northwest data base.

5/ Equations determined from Pacific Northwest data base.

6/ Equations determined from British Columbia data base.

7/ Equations determined from Alberta data base.

8/ Hypothetical equation.

ere:

bw = branchwood biomass
pb = peeled bole biomass
b = bark biomass
r = root biomass
f = foliage biomass
1_i = first observation on the ith tree
2_i = second observation on the ith tree
nL = average duration (years) of needle retention by species on the ith tree
Y = the number of years in the measurement period
A = plot area in acres
n = number of trees per plot

oductivity Assumptions

The productivity estimation was dependent on the rate tree growth, mortality, and ingrowth. These three aracteristics can be expressed as:

(A) $B_{2_i} \geq B_{1_i}$ (accretion)

(B) $B_{1_i} = O, B_{2_i} > O$ (ingrowth)

(C) $B_{1_i} > O, B_{2_i} = O$ (mortality)

here:

B_{1_i} = biomass at beginning of measurement period for ie ith tree
B_{2_i} = biomass at end of measurement period for the h tree

ituation A is documented in the previous section and ill not be duplicated here. Situation B, ingrowth, was andled as if all the biomass accumulated at the end of ie measurement period, therefore total productivity for ie ith tree equals B_{2_i}. Situation C, mortality, was andled as if no productivity occurred before the tree ied, therefore total productivity for the ith tree equaled ero.[6]

V-Plots

The "W-plots" (Table 1) were semi-permanent sample lots established in stands of the western white pine type in 925 and 1926 by the U.S. Forest Service. Unlike the other lots, trees had not been individually tagged, so records onsisted of periodic stand tallies by species and 1-inch 2.54 cm) dbh classes. These stand table data were ransformed into an equivalence of individual tree data ecords by allocating growth and mortality via a ystematic sequence, which included an assumption that o individual tree could grow more than two 1-inch (2.54 cm) classes during the 10-year measurement period; dbh was expressed as the mid-point of the class. Individual tree heights were developed from height/dbh curves for each plot.

RESULTS

Standing biomass and net primary productivity were each estimated as "total" and "above ground." Because of questionable applicability of the very diverse sources of the root equations used, the above-ground estimates are considered much more reliable.

Total standing biomass ranged from 322,900 to 793,100 kg per hectare with a mean of 495,500 kg per hectare at T1 (beginning of measurement period) and from 371,600 to 937,500 kg per hectare with a mean of 586,900 kg per hectare at T2 (end of measurement period) (Table 3). Note the small change in component percentage at the beginning and end of the measurement period (Table 3). The above-ground standing biomass for each of the study units with corresponding component percentages is expressed in Table 4.

Periodic annual productivity and component percentages are shown in Table 5 for total and above ground estimates, respectively. Total productivities ranged from 8,313 to 19,935 kg/hectare/year with a mean of 13,403 kg/hectare/year. Above-ground productivities ranged from 7,658 to 17,437 kg/hectare/year with a mean of 11,967 kg/hectare/year.

The young and old (study units 32 and 148, respectively) stands used for stand age comparisons had total standing biomasses and productivities as presented in Tables 3 and 5. Total standing biomass and productivity for the young stand was lower than the western hemlock/pachistima habitat type mean values, while the over-mature stand had a total standing biomass higher than the mean habitat value, but with a lower total productivity. Above-ground estimates resulted in the same trends as the total estimates (Tables 4 and 5).

DISCUSSION

Component Proportions

Total standing biomass and total productivity are shown separately by the five tree components (Fig. 1). Comparison of the average percentage shows foliage accounted for only a small portion of the stand weight (3 percent), but foliage accounted for 36 percent of the annual production. This difference is caused by the relatively short life span of the foliage; 1-5 years depending on the tree species. The other four components represent standing biomass accumulations over the life of the stand. A similar foliage relationship is also indicated in Fig. 1 for the above-ground stand components.

[6]No data were available to determine at what point during the easurement period an individual tree died.

Table 3. Total standing biomass for the selected plot sites, and percentage distribution by tree components.

Plot	Habitat Type	Standing Biomass T1	Standing Biomass T2	Components: Foliage	Branchwood	Peeled Bole	Bark	Roots
		(M Kg/hectare)		(Percent)[1]				
W-12	GF/P	490.9	658.0	3	7	70	6	14
W-18	GF/P	507.1	610.3	3	7	69	7	14
W-21	GF/P	544.5	662.0	3	7	70	8	12(13)
15	GF/P	344.2	390.0	6(5)	12	58(59)	8	16
W-9	WRC/P	487.9	585.2	3	7	69	6	15
W-10	WRC/P	793.1	937.5	3(2)	7	68	7	15(16)
W-11	WRC/P	621.3	730.4	3	7	71(70)	7	12(13)
W-19	WRC/P	500.1	618.4	3	7	70	6	14
W-20	WRC/P	529.1	631.7	3	7	69	7	14
101	WH/P	412.4	460.0	4	10	57	9	20
105	WH/P	347.3	388.0	3	9	59	9	20
161	WH/P	322.9	371.6	4	8	63	7	18
$\bar{X}$		491.7	586.9	3	8	66	7	16
32	WH/P	27.3	54.7	14(12)	10	32(39)	3(4)	41(35)
148	WH/P	399.8	432.8	3(2)	8	60	8	21(22)

[1] Percentages are the same for the beginning and end of measurement period, except where indicated by parentheses.

Table 4. Above-ground standing biomass for the selected plot sites, and percentage distribution by tree components.

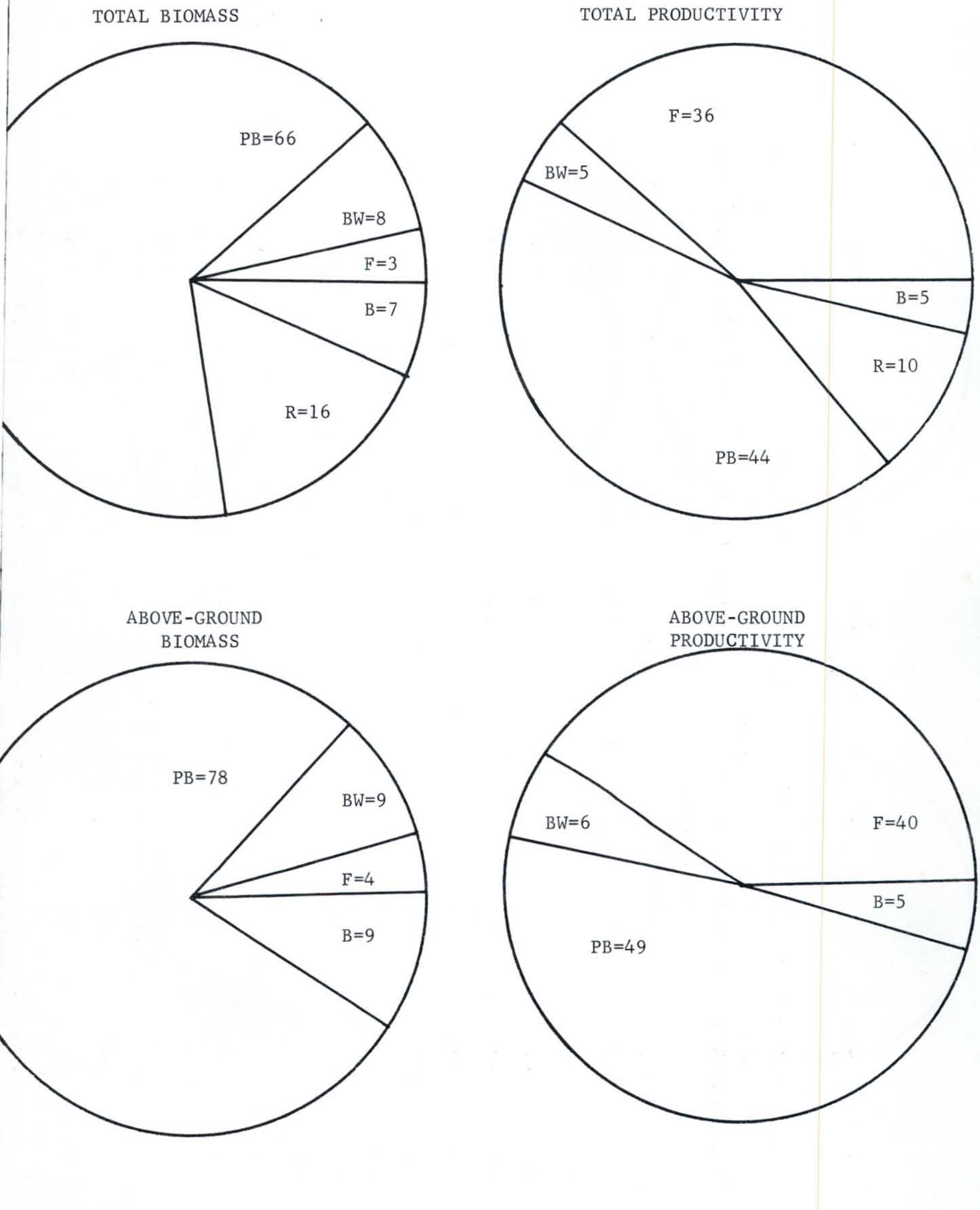
Plot	Habitat Type	Above Ground Biomass T1	Above Ground Biomass T2	Components Foliage	Components Branchwood	Components Peeled Bole	Components Bark
		(M Kg/ha)		(Percent)[1/]			
W-12	GF/P	467.7	566.9	3	8	81	8
W-18	GF/P	434.9	521.5	3	8	81	8
W-21	GF/P	477.6	578.1	4	8	80	8
15	GF/P	287.6	326.5	7	15(14)	69(70)	9
W-9	WRC/P	415.5	495.7	3	8	81	8
W-10	WRC/P	673.8	793.1	3	8	81	8
W-11	WRC/P	545.5	636.6	3	8	81	8
W-19	WRC/P	431.7	531.7	3	8	81	8
W-20	WRC/P	458.1	545.4	4	8	80	8
101	WH/P	328.3	367.9	5	12	72	11
105	WH/P	277.4	311.1	4	11	73	12
161	WH/P	264.9	305.9	6	9	77	8
$\overline{X}$		421.9	498.4	4	9	78	9
32	WH/P	16.1	35.5	24(18)	17(16)	54(60)	5(6)
148	WH/P	315.9	341.1	4(3)	10	76(77)	10

[1/] Percentages are the same for the beginning and end of the measurement period, except where indicated by parentheses.

Table 5. Periodic annual productivity for the selected plot sites, and percentage distribution by tree components over the measurement period.

Plot	Habitat Type	Total Productivity	Above-Ground Productivity	Components Foliage	Branchwood	Peeled Bole	Bark	Roots
		(M Kg/ha/yr)		(Percent)[1/]				
W-12	GF/P	15.2	13.4	25 (28)	5 (6)	53 (60)	5 (6)	12
W-18	GF/P	13.9	12.2	27 (31)	5 (6)	51 (58)	5 (5)	12
W-21	GF/P	16.0	14.3	29 (32)	5 (5)	51 (57)	5 (6)	10
15	GF/P	9.9	9.1	55 (59)	6 (6)	29 (31)	3 (4)	7
W-9	WRC/P	13.0	11.2	26 (31)	5 (6)	51 (58)	5 (5)	13
W-10	WRC/P	20.0	17.5	29 (33)	5 (6)	49 (56)	5 (5)	12
W-11	WRC/P	15.6	13.8	31 (35)	5 (6)	48 (54)	5 (5)	11
W-19	WRC/P	15.7	13.9	27 (30)	5 (6)	52 (59)	5 (5)	11
W-20	WRC/P	13.6	12.0	26 (29)	5 (6)	53 (59)	5 (6)	11
101	WH/P	10.8	10.0	57 (62)	4 (4)	28 (30)	4 (4)	7
105	WH/P	8.3	7.7	57 (62)	4 (4)	27 (30)	4 (4)	8
161	WH/P	9.1	8.3	48 (53)	4 (4)	36 (39)	4 (4)	8
$\bar{X}$		13.4	12.0	36 (40)	5 (5)	44 (50)	5 (5)	10
32	WH/P	6.3	4.7	23 (31)	9 (12)	39 (52)	4 (5)	25
148	WH/P	6.5	5.5	44 (52)	4 (5)	33 (38)	4 (5)	15

[1/] Component percentages without percentages are based on total productivity, those with parentheses are based on above-ground productivity.



g. 1. Average tree component percentages of standing biomass and productivity, "total" and ove-ground", for the 12 sampled north Idaho stands. F=foliage, BW=branchwood, PB=peeled e, B=bark, and R=roots.

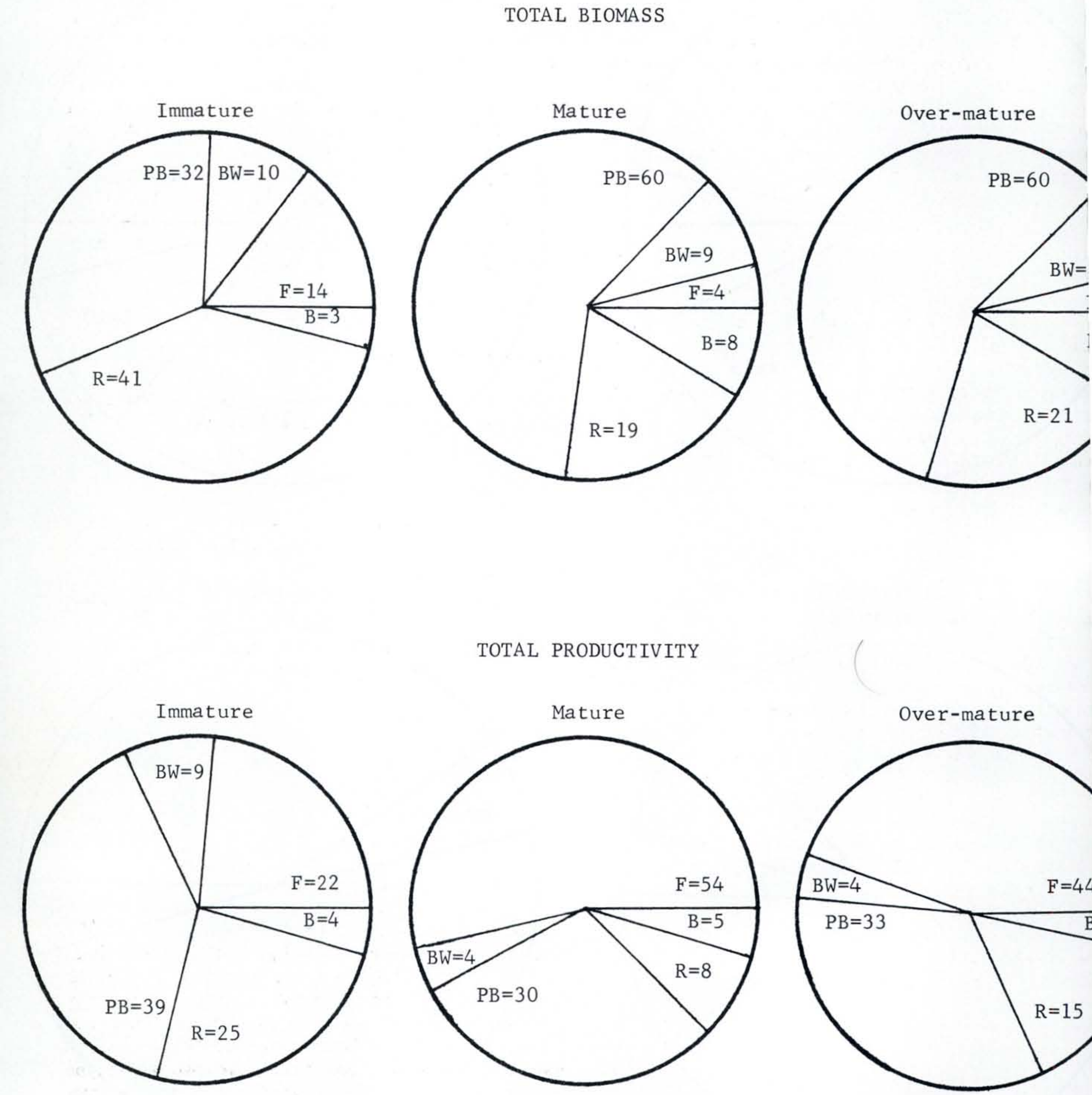


Fig. 2. Average tree component percentages of total standing biomass and productivity for stands of three age-classes; immature (20 years), mature (100 years), and overmature (250 all within the western hemlock/pachistima habitat type. F=foliage, BW=branchwood, PB=pee bole, B=bark, and R=roots.

nd Age Influence

Major age differences between even-aged stands of s type have an effect on the component percentages.[7] e most striking difference is the root biomass oportion of a young stand as compared to that of ture and over-mature stands (Fig. 2 and Table 5). Also, e large proportion of foliage biomass (14 percent) in e developing crowns of the young stand is in contrast the stable crowns of the over-mature stand (3 percent).

Comparison of productions among the three age oups shows a high proportion of the production is in liage compared to that component's relatively small oportion of total biomass. Annual production is lower the immature and over-mature stands compared to the ature stands (Table 5). These comparisons indicate the ossibility of maximizing mean annual increment on a eight basis close to the mean annual culmination point, ased on a cubic-volume basis. These comparisons were ade on a limited number of observations, and xtrapolation beyond these comparisons is not advised. pecies composition and site index should be kept niform to insure relevant comparisons.

pecies Composition Influence

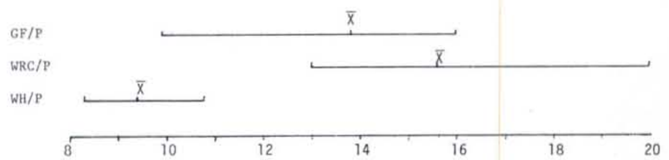
Species composition has an influence on biomass and roductivity. In general, the "W-plots" with a very high roportion of white pine have produced more than the ther stands (Table 6). In addition, the tree diameter of verage basal area is much greater for these plots. Dbh ifference is due to white pine dominance in the verstory and lack of cedar and hemlock in the nderstory. Crown competition factor (CCF) (Krajicek et l. 1961) also indicates differences between the "W-plots" nd the others. High CCF values (Table 6) for some plots ay indicate higher tree-to-tree competition and a stagnated" stand condition. Other factors such as site ndex, basal area, habitat type, measurement period,[8] and he introduction of white pine blister rust *(Cronartium ibicola,* Fisher) must also be accounted for in these omparisons.

Site Quality and Stand Density Influence

Site quality and stand density have an influence on productivity. Productivity is greater on those sites with high site index and basal area across the range of habitat types and species compositions. Multiple linear regression was used to describe the relationship between productivity and the independent variables, site index and basal area per hectare; correlation coefficient equaled 0.06 (Fig. 3). A multiple coefficient of determination of 0.857 and a standard error of the estimate of 1.42 M kg/hectare/year were obtained. The relationship between these variables and productivity helps explain the high productivities obtained on the "W-plots."

Habitat Type Influence

When the productivity ranges of the sample stands are grouped by habitat type they appear as follows:



Periodic Annual Productivity
(M kilograms/hectare/year)

The mean and standard deviations by habitat type are:

GF/P	$= \overline{X} = 13.75$ S = 2.71
WRC/P	$= \overline{X} = 15.58$ S = 2.74
WH/P	$= \overline{X} = 9.40$ S = 1.28

expressed as M kg/hectare/year.

The habitat type values obtained are inconsistent with the widely accepted but unpublished production theory about the types, where WH/P is greater than WRC/P, which is greater than GF/P. This inconsistency is brought about in part by variability in site index and basal area within and between habitat types. Species composition, stand stocking level, and stand history also affect the relative habitat type productivity rankings. Additionally, the warmer temperatures associated with the grand fir/pachistima habitat type may be more important than abundant moisture in the production of biomass. Additonal research is needed over a more diversified data base in order to identify the variables influencing the biomass production on these types and to provide a more discrete classification of habitats to minimize within-type variation.

[7] Comparisons were made between stands within the western emlock/pachistima habitat type only in order to hold constant any environmental variables.

[8] The 1925-1935 decade was a period of lower than average growth or white pine, (Leaphart and Stage 1971), indicating a conservative roductivity estimate during this period.

Table 6. Species composition compared to above-ground biomass and productivity for the selected plot sites by species.

Plot	Above-ground Biomass	Above-ground Productivity	Average DBH 1/	CCF 2/	WWP	WL	DF	GF	WH	WRC	Other Species
	(M Kg/ha)	(M Kg/ha/yr)	(centimeters)		Species Composition (Percent) 3/						
W-12	467.7	13.4	32.8	227	96 94	0 0	1 1	3 5	0 0	0 0	0 0
W-18	434.9	12.2	35.1	187	87 84	0 0	3 3	8 11	0 0	0 0	2 2
W-21	477.6	14.3	33.5	138	83 78	0 0	10 6	7 16	0 0	0 0	0 0
15	287.6	9.1	24.4	255	21 15	20 21	23 19	33 43	0 0	0 0	3 2
W-9	415.5	11.2	30.7	169	96 77	0 0	1 1	3 20	0 0	1 1	1 1
W-10	673.8	17.5	34.0	237	85 62	5 3	2 3	3 22	0 0	5 10	0 0
W-11	545.5	13.8	36.8	198	89 60	1 1	8 6	2 33	0 0	1 1	0 0
W-19	431.7	13.9	32.5	192	87 82	3 1	2 1	8 15	0 0	1 1	0 0
W-20	458.1	12.0	31.0	209	82 71	4 2	6 5	8 22	0 0	1 1	0 0
101	328.3	10.0	17.5	309	33 24	45 17	3 3	1 1	1 1	16 54	1 1
105	277.4	7.7	21.3	228	37 28	40 12	4 4	1 1	1 1	15 51	4 4
161	264.9	8.3	19.6	251	67 33	2 2	12 5	0 0	1 1	18 58	1 1
32	16.1	4.7	4.6	195	57 38	1 1	1 1	4 5	39 57	0 0	0 0
148	315.9	5.5	49.5	170	43 30	12 5	2 2	5 11	21 39	16 13	1 1

1/ Average basal area tree diameter.
2/ Crown competition factor (Krajicek, et al., 1961).
3/ Species percentage based on trees/acre and basal area/acre respectively.

mparisons to Other Forest Communities

The biomass and productivity estimates were mpared to 20 natural stands representative of a wide nge of coniferous forest types selected from the erature (Table 7). The format is similar to that used by t and Marks (1971). Limitations of available data cessitated comparing biomass and productivity for the ove-ground portion on a stand basis only. The average omass (421.9 M kg/hectare) and average productivity 2.0 M kg/hectare/year) from this study were within the blished range of values. In a very recent publication, son (1975) listed an above-ground biomass of 320 (M /hectare) and productivity of 12.0 (M kg/hectare/year) r "temperate forest, cool conifers, montane, valley ils." These values compare quite closely with the values tained in this study. The limited data available makes mparisons somewhat superficial; thus an accurate ranking of these forest types by productivity is not justified at this time. More valid comparisons should be possible when other sources of published data become available, and as further research is conducted in the western hemlock series.

CONCLUSION

Biomass and productivity of coniferous trees of three habitat types in northern Idaho were determined by empirical formulas. The estimates are useful as a standard for comparing stand-by-stand performance. Such estimates can also be used as a basis in evaluating silvicultural alternatives.

Additional research is needed to refine these estimations with actual productivity measurements on the diverse northern Rocky Mountain forest types.

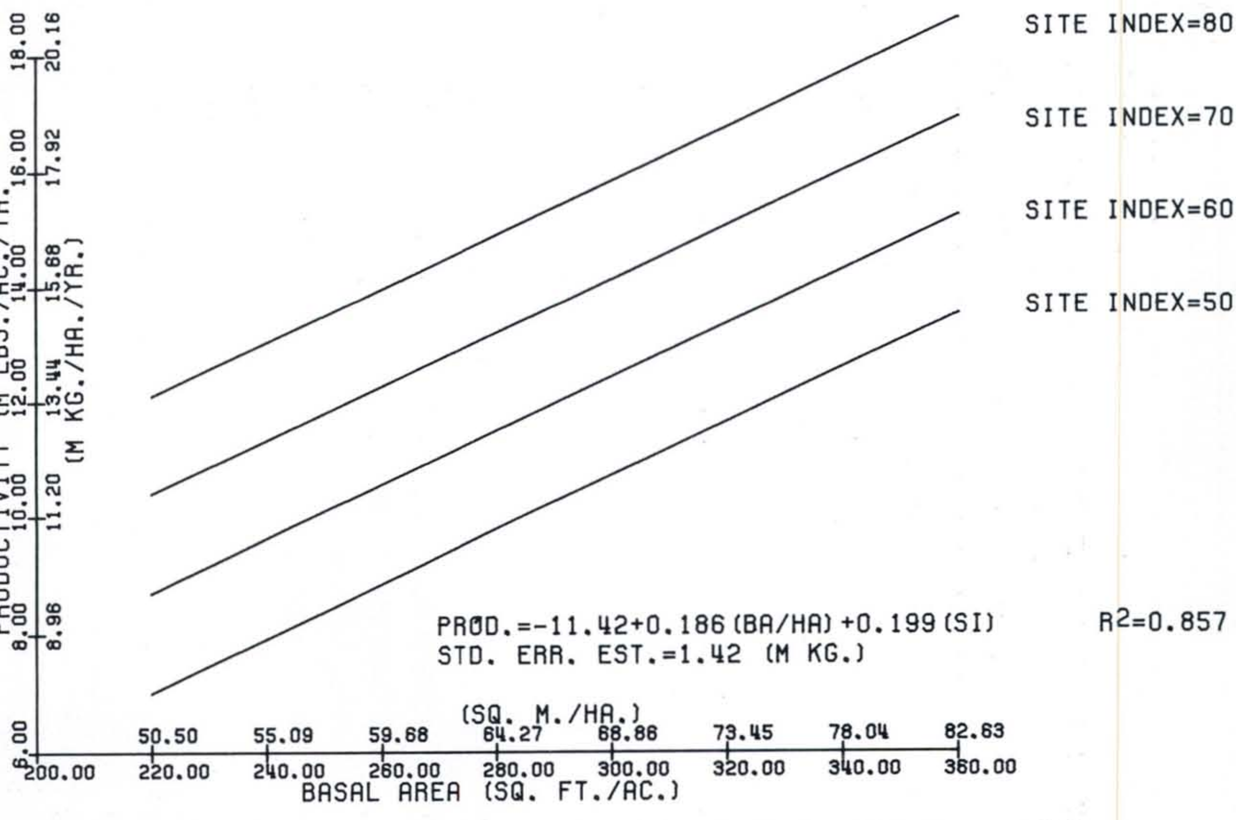


Fig. 3. Productivity estimated by basal area and site index, for the three habitat types studied.

Table 7. Summary of selected published biomass and productivity estimates from literature on even-aged, natural conifer stands.

Even-Aged Natural Stands Species or Type	Location	Age	Above-ground Biomass	Productivity[1/]	Reference
			(M kg/ha)	(M Kg/ha/yr)	
Temperate forest cool conifers - montane	North America	--	319.4	12.0	Olson, 1975
Giant and coastal - podsolic	Pacific NW Coast	--	699.7	25.0	Olson, 1975
Abies balsamea	New Brunswick	40-50	149.0	9.6	Baskerville, 1966
Abies balsamea	New Brunswick	40-50	167.0	10.5	Baskerville, 1966
Abies balsamea	New Brunswick	40-50	182.7	11.7	Baskerville, 1966
Abies balsamea	New Brunswick	40-50	200.1	12.6	Baskerville, 1966
Abies - *Tsuga*	Nepal	---	520.0	---	Yoda, 1968[3/]
Picea - *Abies*	Tennessee	---	341.0	10.2	Whittaker, 1966
Picea - *Abies*	Tennessee	---	310.1	9.4	Whittaker, 1966
Picea - *Abies*	Tennessee	---	300.0	14.0	Whittaker, 1966
Pseudotsuga menziesii	Washington	52	228.0	---	Riekerk, 1967[3/]
Pseudotsuga menziesii	Washington	75	264.0[2/]	---	Riekerk, 1967[3/]
Abies lasiocarpa	Arizona	106	356.2	8.6	Whittaker, 1975
Abies concolor	Arizona	124	360.7	11.1	Whittaker, 1975
Pseudotsuga - *Abies*	Arizona	321	783.0	10.8	Whittaker, 1975
Pseudotsuga menziesii	Arizona	252	437.0	8.3	Whittaker, 1975
Pinus contorta	Alberta	100	245.0	---	Johnstone, 1971
Pinus contorta	Alberta	100	194.4	---	Johnstone, 1971
Pinus contorta	Alberta	100	91.7	---	Johnstone, 1971

1/ Periodic annual increment.
2/ Unknown as to whether below ground mass included.
3/ Information obtained from Art and Marks (1971).

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