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Title: BIOMASS AND COMPOSITION OF THE UNDERSTORY VEGETATION IN SOME *ALNUS RUBRA* STANDS IN WESTERN OREGON

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Abstract approved:

The biomass and the composition of 15 stands of red alder (*Alnus rubra* Bong.) on river bottom sites in western Oregon was measured during August and early September, 1969. These stands ranged in age from two to 64 years. Biomass was found to vary from 134 k/ha (kilograms per hectare) for the very youngest stand to 7700 k/ha in one of the older stands. Net productivity for the first 64 years was estimated as 97 k/ha per year. Understory biomass was found to be a very small portion, up to 2.5%, of the biomass of the alder overstory for similar stands.

Composition was found to vary considerably as age of the overstory increased. Succession from a grass-herb dominated understory to a shrub-fern dominated understory was quantified. The findings appear to support an earlier prediction that lands now dominated

by red alder may be dominated by brush fields of _Rubus spectabilis_ in the future in the absence of a suitable conifer seed source.

Biomass and Composition of the Understory Vegetation in Some *Alnus rubra* Stands in Western Oregon

by

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A THESIS

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BIOMASS AND COMPOSITION OF THE UNDERSTORY VEGETATION IN SOME *ALNUS RUBRA* STANDS IN WESTERN OREGON

INTRODUCTION

Red alder (*Alnus rubra* Bong.) is a common seral species in the Coast Range of Oregon, where it is the second most abundant tree species. Furthermore, it owes its relative abundance to man's disturbance which has created the bare mineral soil and lack of plant competition necessary for its establishment.

Presently, this species has a low economic value relative to most of its associated species. Its uses include furniture, pulp and many specialty items. Some new innovations in its utilization include use as fodder (Smith, 1968).

Its potential value for pulp probably surpasses all other present uses of its wood. Furthermore, it has been predicted (Zavitkovski and Stevens, 1970) that this species may produce more pulp volume over short rotations than any other Northwest species and that it will assume a more prominent role in forest management in the Pacific Northwest in the future based on the relatively high primary productivity of this species at early ages.

Red alder is most important, however, for its non-destructive uses. Ecologically its role in nitrogen fixing and soil building have been given the most emphasis in the past and are truly important characteristics of this species. Secondary benefits that it provides include: game refuge and forage, stream water protection, and stream bank stabilization. Its importance in this last respect is pointed out by the very frequent occurrence of red alder along streams throughout its range.

It is important also because of the successional pattern which it establishes, which coupled with its relatively high abundance in western Oregon, makes this factor potentially very important to the land manager who must look ahead to timber, wildlife, and water uses on the lands now dominated by red alder.

Foreseeing the potentially greater economic importance of red alder and the need to know more about the ecology of this species and its ecosystem, a number of studies have been published recently which have added greatly to our knowledge of the ecology and productivity of red alder. The most significant of these is Biology of Alder edited by J.M. Trappe (1968) which presents the most current papers of principally an ecological nature. Current reports by Zavitkovski and Stevens (1970) and Zavitkovski and Newton (1969) provide the first data available describing the primary productivity and litter fall of this species.

The successional status of red alder has been noted in a number of places. Moreover, it is well known that red alder is a seral species. But the actual process of succession in a stand dominated by red alder which leads to the climax conifer species is rarely alluded to. Until now the most definitive published work was that of Newton *et al*. (1968) who predicted that alder may be replaced by brush fields dominated by *Rubus spectabilis*, *Acer circinatum*, or *Corylus cornuta*.

This study was intended to provide additional data on the primary productivity of the red alder community by estimating the contribution made by the understory vegetation and to provide synecological data on this community which would help explain the trends in biomass accumulation and the successional patterns which are believed to exist.

AREA OF STUDY

The study area lies in the Coast Range of Oregon between 44^{o} 15' and 44^{o} 30' latitude and 123^{o} 30' and 124^{o} 00' longitude and between 150 and 900 feet (46 and 274 meters) elevation (Figure 1; Table I) within the *Tsuga heterophylla* vegetation zone (Franklin and Dyrness, 1969). All stands were chosen on the alluvial plain of a major stream to ensure relative uniformity of site factors. Also, red alder dominates a recognizable community which is considered to be restricted to this habitat.

The disturbance factors which have created conditions suitable for red alder establishment in this habitat include logging, flood, agricultural clearing, road construction, and fire. Fire, however, is probably not as important a factor here as it is on more mesic upland sites.

Macroclimate is maritime with moderate temperatures. The January mean minimum is $-2^{o}C$ and the July mean maximum is $24^{o}C$. Total precipitation is about 210 cm, of which 40-50% comes in December, January, and February and 6% or less comes in June, July, and August (U.S.D.C., 1960).

Microclimate in the sampled stands is influenced greatly by the crown closure (Figure 17-A, B) of the red alder overstory, the relative absence of conifers, the diurnal shift in upstream and downstream

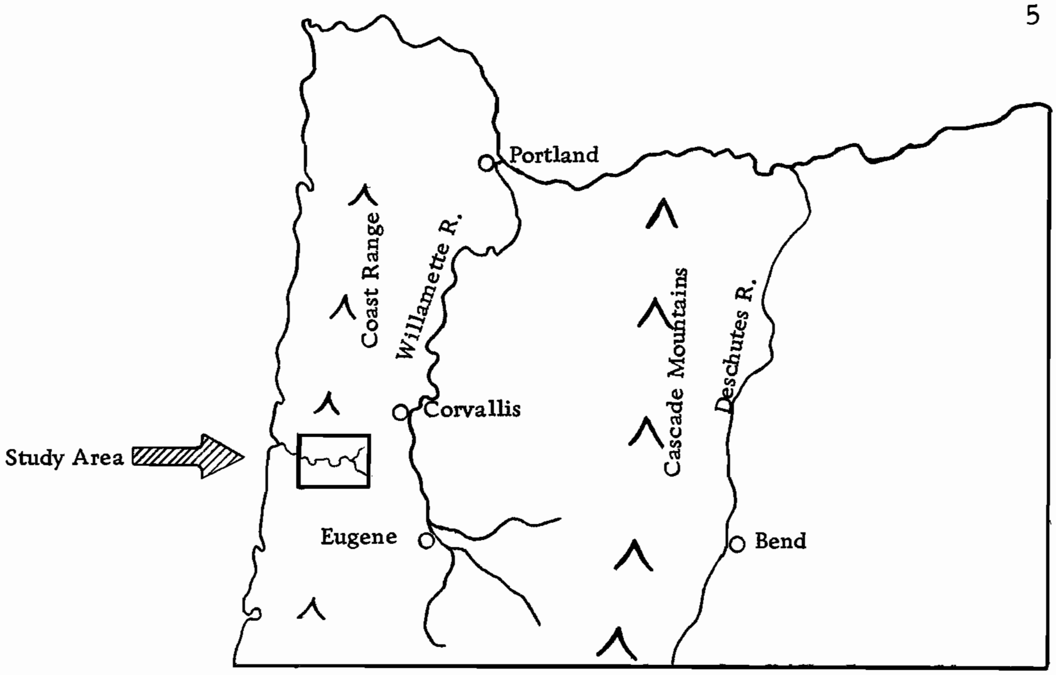


Figure 1. Location of study area in Northwest Oregon.

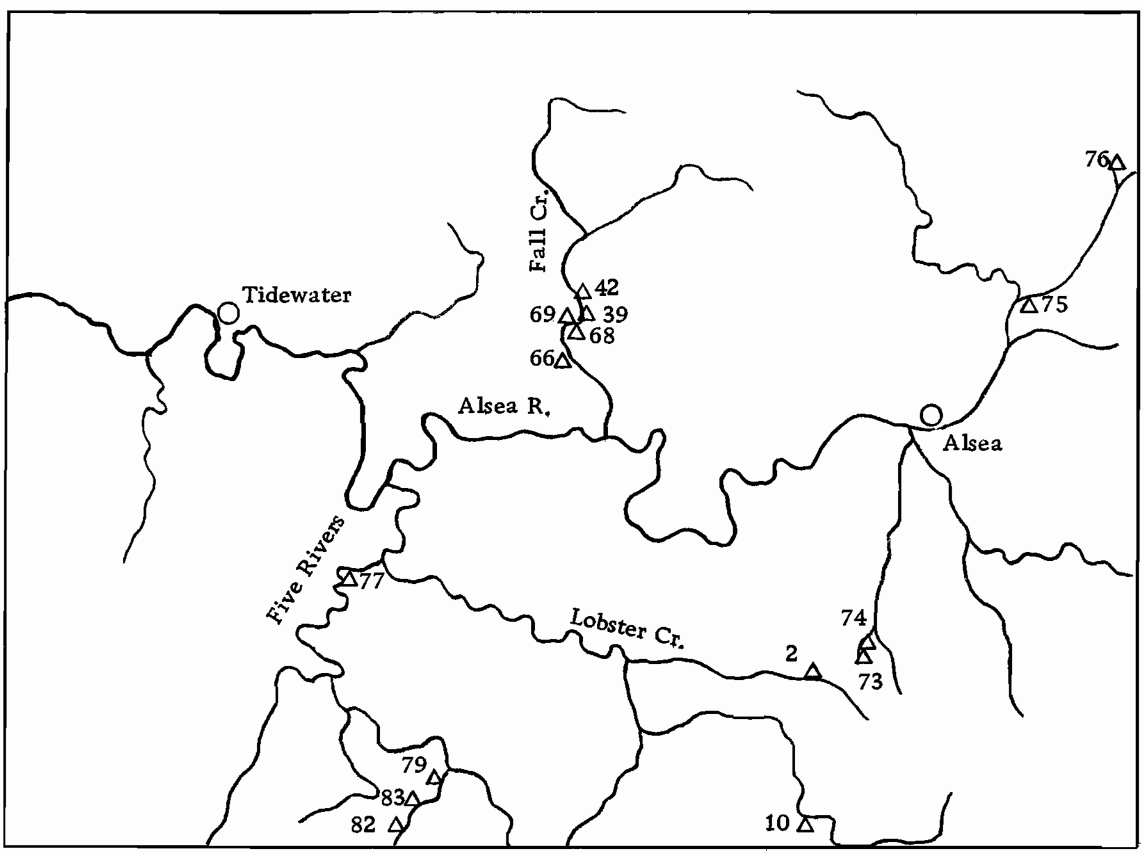


Figure 2. Location of stands in the study area.

Table I. Age, Elevation, and Location of Stands Studied.

Stand Number	Age	Elevation (Meters)	Location
76	2	274	Alder Creek, Adj. to Hwy 34.
83	4	95	Green R., Between 79 & 82.
66	9	61	1/2 mile above Fall Cr. Falls.
73	11	174	BLM Rd. 14-8-26.3, Bummer Cr.
82	13	88	Green R. above 83.
42	16	82	Fall Cr., near landing.
39	20	79	Fall Cr., 1/2 mile below 42.
2	24	207	Head of Little Lobster Cr.
10	25	195	Lobster Cr.
74	35	177	Bummer Cr., below 73.
69	39	76	Fall Cr., across from 68.
75	40	119	N. Fk. Alsea R.
77	49	46	Five Rivers, Above Maples Camp
79	51	91	Green R., Jct. Lower River Rd.
68	64	76	Adj. to Fall Cr. Hatch. Pond.

air flow, channelled and augmented wind in the stream bottoms, and the continual flow of water. This continual flow of water modifies both summer and winter temperatures and ensures that water is not a limiting factor except possibly during extreme drouth. Many other micro-environmental effects caused by the changing composition of the community are known to exist but are not explicitly recognized.

Soils under the sampled stands are alluvial, formed largely from the Tyee Formation fine sandstone (Baldwin, 1964). They have a characteristic mull humus layer (Zavitkovski and Stevens, 1970) with A and B horizons poorly developed especially in the younger stands, and deep C horizons. Soil texture is characteristically either gravelly or sandy. In a few cases, drainage appears to be restricted by a discontinuity of soil texture somewhere in the C horizon.

PROCEDURE AND METHODS

Eighty-seven nearly pure and well stocked stands of red alder were located in the Coast Range of Oregon. From these stands, fifteen were chosen on river-bottom alluvial soils in the Alsea River drainage, which were as evenly distributed as possible between ages two and 64. Minimum size of the stands was determined by the arrangement of the sample plots. Where possible, the largest stand available was used to minimize the effects of outside environmental factors.

Each of these stands was visited between August 1, and September 7, 1969, the period of maximum standing community biomass ("Terminal biomass," Mathews and Westlake, 1969; "Peak standing crop biomass," Malone, 1968). A starting point was located near the center of each stand, and from there a random distance and azimuth were generated which located the starting point of the sample plots.

The sample plot for crown coverage of the understory was designed after Daubenmire (1959), with the long axis of the plot on another random azimuth which would keep the entire plot within the stand. At ten meter intervals along this transect nested plots were established to determine above-ground biomass. Five meter intervals were used when it was judged that the variance of the shrub biomass was going to be too large.

One-meter square plots were used for shrubs and 50 cm by 50 cm plots for all else. All attached, above-ground plant material which fell within the plot was clipped, placed in paper bags by plot, labelled, and later dried at 70°C to equilibrium and then weighed to the nearest 0.1 gm. Percent crown coverage and species frequency were computed for each stand and are presented in Table II. Soil core samples were taken to estimate root biomass, but with unsatisfactory results.

Estimates of the percent crown closure of the overstory, and the percent of full sunlight passing through this canopy were also made in each of the stands.

Percent crown closure was estimated from below to the nearest five percent for the fully stocked portion of the stands.

Estimates of percent full sunlight were derived by using Ozalid paper light sensors described by Friend (1961)[1]. Five of these were placed in each stand as much above the level of the understory layers as possible. An additional five were placed throughout the Alsea drainage in open sunlight. From these readings full sunlight was derived. These data are presented in Figure 17-B. Figure 3 shows the placement of a petri dish containing the Ozalid paper on the ground where there is virtually no understory

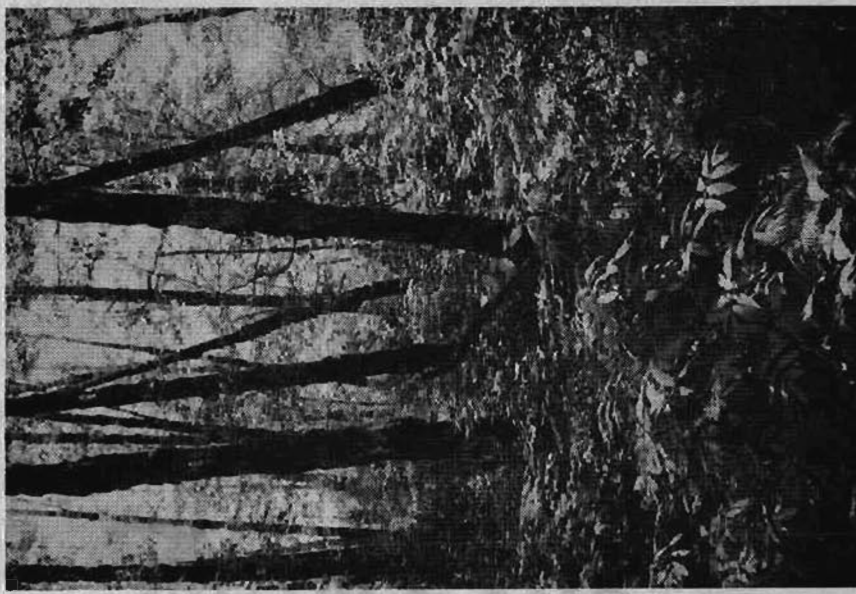
[1] These were calibrated against a Weston light meter by W. Emmingham, School of Forestry, Oregon State University, Corvallis.

Figure 3. Stand 83, age four years. Placement of light meter on ground where there is no shading from understory vegetation. Note the near-absence of understory vegetation in this very young stand.

Figure 4. Stand 82, age 13 years. Placement of a light meter on a post to elevate it above the understory vegetation. Height of the post is about one meter. Note the abundance of *Urtica dioica* in this "Grass-Herb" stand.

Figure 5. Stand 42, age 16 years. Representative of the "Grass-Herb" stage. Except for scattered *Sambucus racemosa* plants and ferns, the height of the ground cover rarely exceeds 20 cm.

Figure 6. Stand 79, age 51 years. Representative of the "Shrub-Fern" stage. The ground cover, dominated by *Sambucus racemosa* and *Rubus spectabilis* varies from two to four meters in height.



vegetation. Figure 4 shows a similar dish on top of a meter high staff in order to elevate it above the level of the vegetation.

DISCUSSION OF TERMS AND DEFINITIONS

Uniform definition of terms and goals is a prerequisite to making meaningful comparisons between similar studies. Furthermore, a lack of such uniformity has been the cause of many of the disputes and apparent contradictions in plant ecology. Therefore, to avoid misunderstanding I will define the possibly ambiguous terms pertinent to this paper.

The total product of photosynthesis is called gross production and is contrasted with net production which is gross production minus respiration losses. Comparative productivity studies are concerned with net production while gross production has significance in the theoretical sense. Net primary productivity is net production over a specified period of time.

Standing crop is the weight of plant material harvested at any one time and may include all components of the ecosystem or only a selected portion or may include only parts of selected plants. Biomass is also a weight on a unit area basis at a particular time but normally all parts of all plants and animals are included. Standing crop and biomass, therefore are not necessarily synonyms although many use them interchangeably especially when modified, such as in "root biomass" or "biomass of the overstory".

Terminal biomass is the total dry weight of plant material over a unit area of the ecosystem, all plants being harvested at the same time, presumably at maximum dry weight. Cumulative biomass, however, is the sum of the weights of the individual species each harvested at their maxima. Cumulative biomass is always greater than terminal biomass (Odum, 1960) but the two values converge at the theoretical possibility of a perfect monoculture. Conversely, standing crop biomass becomes less and less a measure of productivity as succession proceeds (Odum, 1960), since community biomass stabilizes as climax is approached and net productivity is approximately zero or may even be negative. While in seral stands, such as red alder, the positive slope of the community biomass curves approximates the net productivity for the community.

What is estimated in this study, therefore, is the terminal standing crop or terminal biomass of the above-ground portion of the understory. This represents only a portion of the ecosystem and excludes such components as roots, fungi, bacteria, lichens, liverworts, algae and all animals plus the alder overstory, which has already been studied (Zavitkovski and Stevens, 1970).

The term community may be used in either the concrete or the abstract sense and therefore needs some clarification. In the concrete sense, according to Daubenmire (p. 27, 1968), it refers to a "...piece of vegetation that is essentially homogeneous in all layers and differs from contiguous vegetation types by either quantitative or qualitative characters." It could also be called a "stand" (Daubenmire, 1968). The community in the abstract sense, however, refers collectively to all stands actual or potential

> . . . in which the dominants of corresponding layers are essentially the same, to the extent that any differences in composition are due to chance dissemination or to a transitory historic factor rather than to a fundamental dissimilarity in habitat potentialities (Daubenmire, p. 27, 1968).

If such a community is climax it is called an association. Moreover, any such abstract community which precedes a climax is called an associes (Daubenmire, 1968).

The Alnus rubra communities studied are concrete stands, whereas the results of the study are intended to describe the Alnus rubra/ Rubus spectabilis associes for part of its range in Oregon. Furthermore, an extrapolation of these data to stands outside of the study area should be done with caution. Since the associes is more abstract and wider ranging than the stand, its boundaries are not as easily recognized, and probably grade into other recognizable associes throughout the range of Alnus rubra.

RESULTS

Biomass

Above-ground, terminal biomass of the understory was found to vary from 134 k/ha (at age two) to 7700 k/ha (at age 51) (Figure 8-C). This maximum compares to some of the higher ground vegetation values from the literature (Tables IV and V), including a number of the annual field crops. Calculated as a percentage of the stand including the Alnus rubra component, using data of Zavitkovski and Stevens (1970), the above-ground biomass of the understory reached only 2.5% of the total above-ground community biomass by age 60 (Figure 7), but was increasing rapidly at that point. Moreover, if the prediction of Newton et al. (1968) is correct, that the A. rubra stand may be succeeded by a brush field, dominated by Rubus spectabilis, the percent would continue rapidly upward toward 100%.

Biomass of the herb portion increased linearly throughout the period, despite a marked change in composition (Figure 8-B). The shrub layer, however, was almost non-existent in the early stands, up to age 24, thereafter biomass increased rapidly and then showed some signs of leveling off in the area of 4000 to 5000 k/ha (Figure 8-A). Rubus spectabilis was by far the dominant shrub, accounting for 71 to 98 percent of the shrub cover in the older stands.

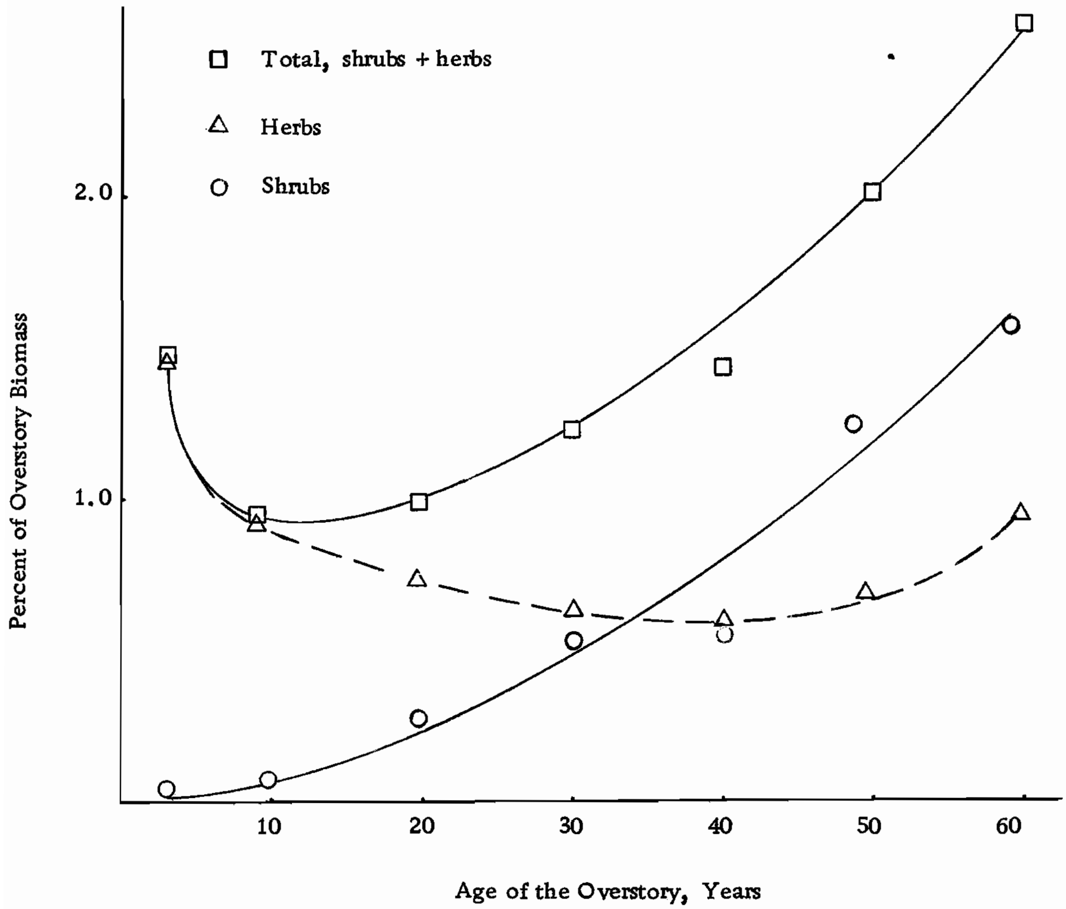


Figure 7. Understory biomass represented as percent of overstory biomass.

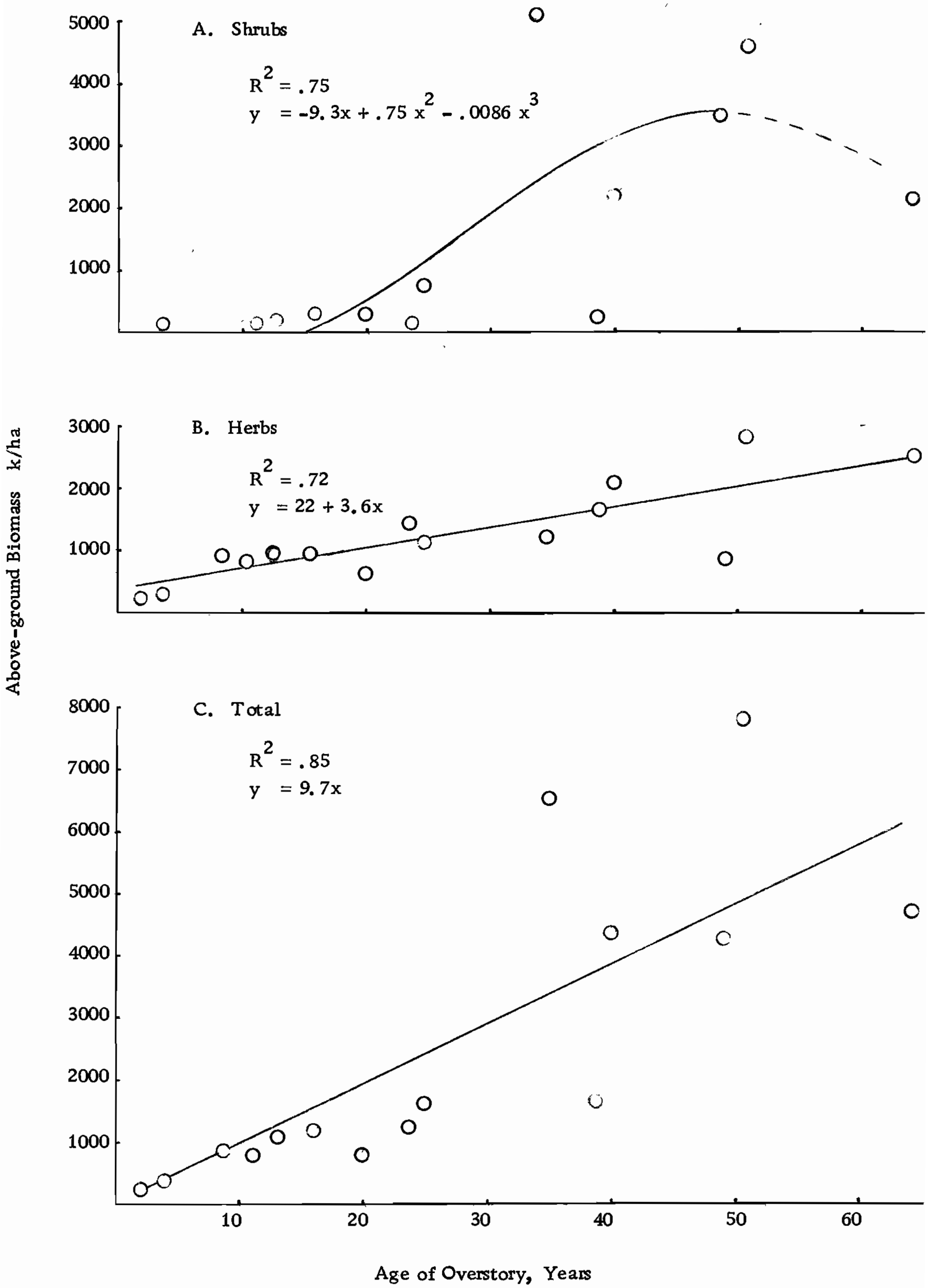


Figure 8. Above ground biomass of A. Shrubs, B. Herbs, and C. Total, by age of overstory.

Composition

For the relatively short age-span of the stands studied (2-64 years), marked and predictable changes in composition occurred as succession proceeded (Figures 9, 10, 11, 12 and Table II).

Table II presents crown coverage and frequency data for all understory species encountered and shows the gradual change in species dominance from young to old stands. A number of species were found in nearly all ages. A few of these showed no trend with time. These include Carex deweyana, the moss group as a whole, and to some extent Sambucus racemosa. Others such as Athyrium filix-femina, Polystichum munitum and Oxalis oregana are found in most age groups but increased in dominance with age. Most species were tallied in only part of the age-span studied. These were either too scarce to show a trend or they showed a period of peak dominance, usually flanked on both sides by periods of lesser dominance.

Histograms for the crown coverage of the most important species are shown in Figures 9, 10, 11, and 12. They show clearly the periods of maximum dominance of these species. Holcus lanatus, Stellaria media, Montia sibirica, Digitalis purpurea, Rubus ursinus, and Stachys mexicana are the major early dominants. Urtica dioica and Tolmeia menziesii appear as intermediate dominants or transition species between the grass-herb and the shrub-fern stages. The last

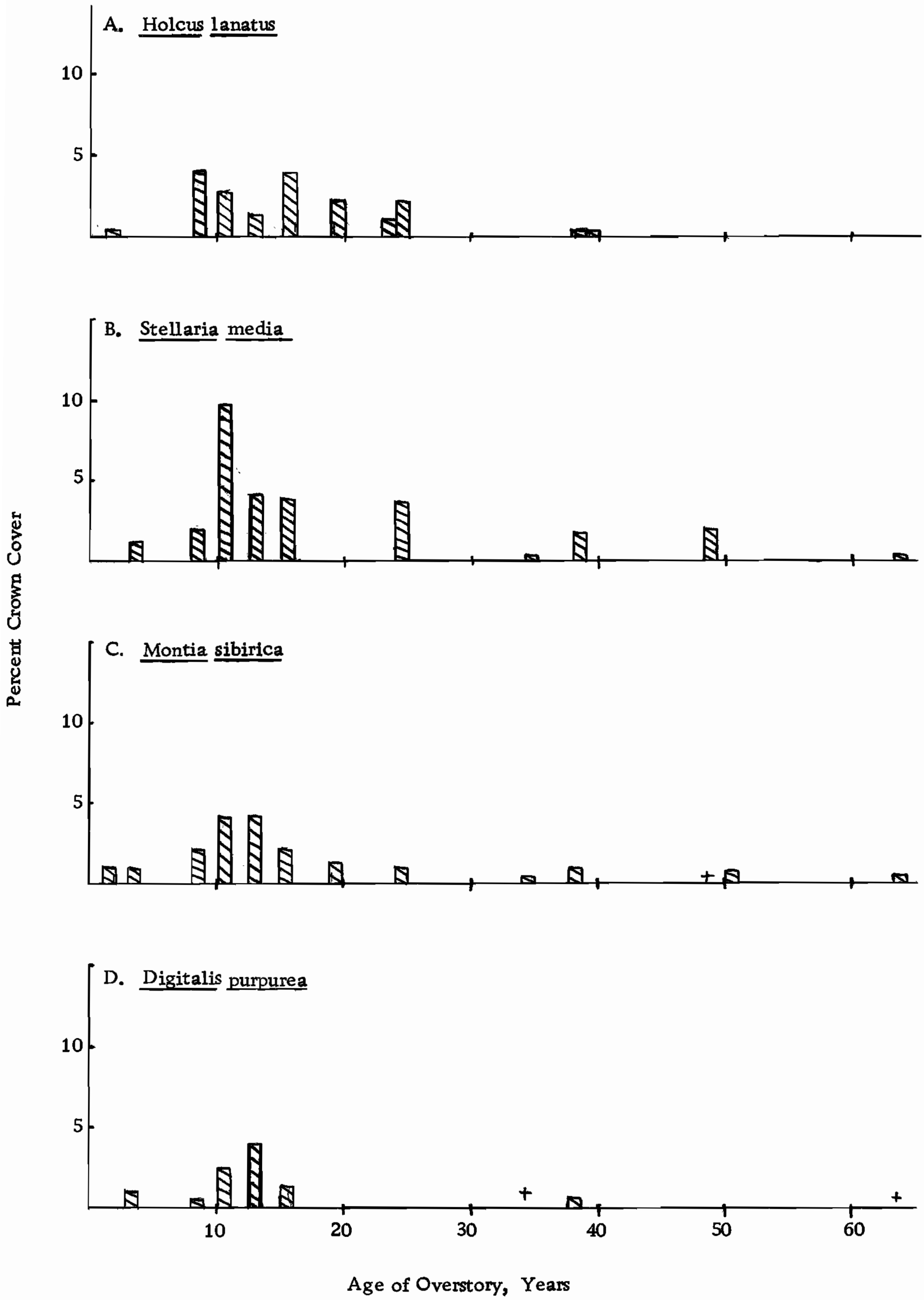


Figure 9. Percent crown cover of: A. Holcus lanatus, B. Stellaria media, C. Montia sibirica, D. Digitalis purpurea.

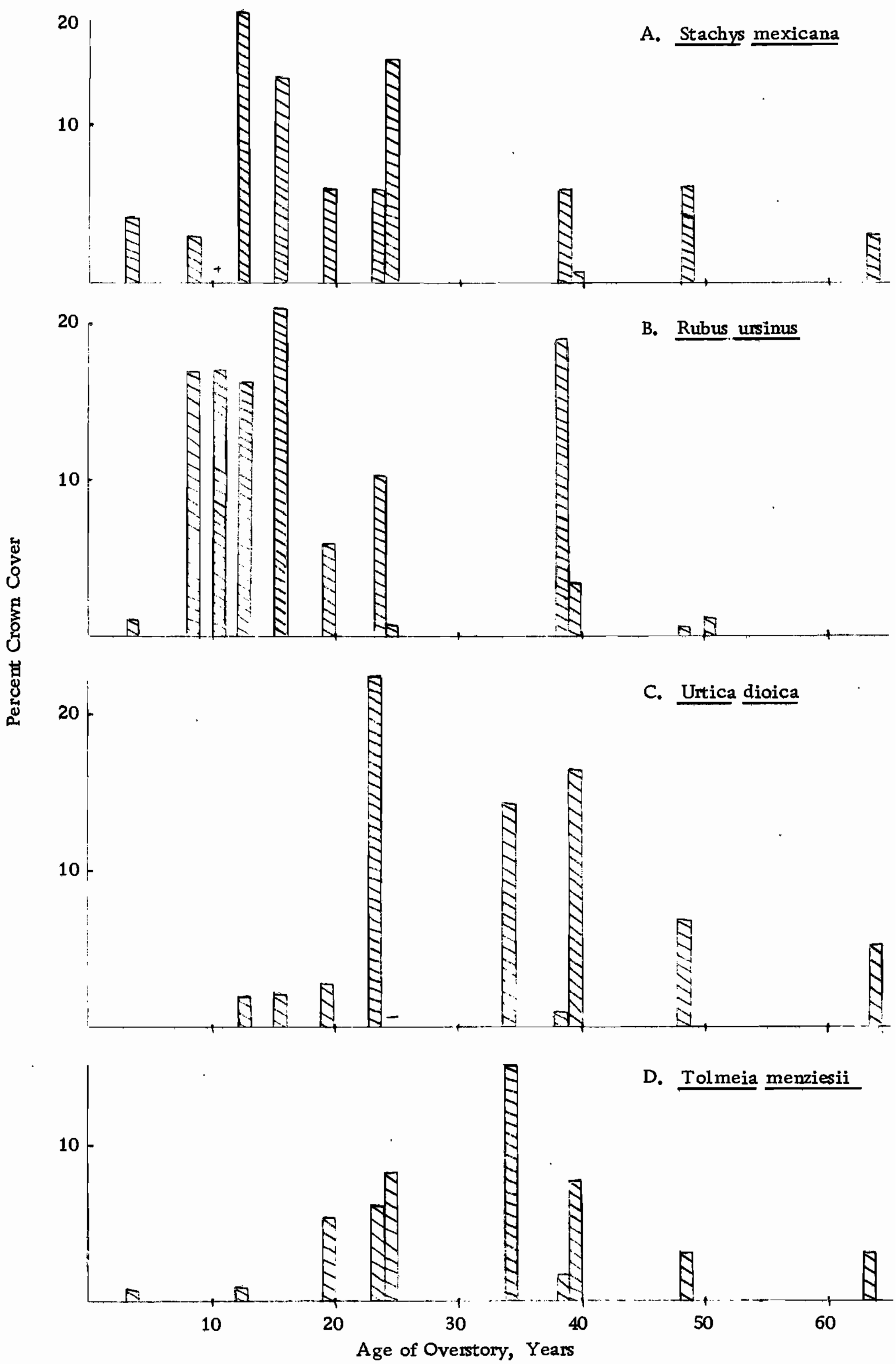


Figure 10. Percent crown cover: A. Stachys mexicana, B. Rubus ursinus, C. Urtica dioica, D. Tolmeia menziesii.

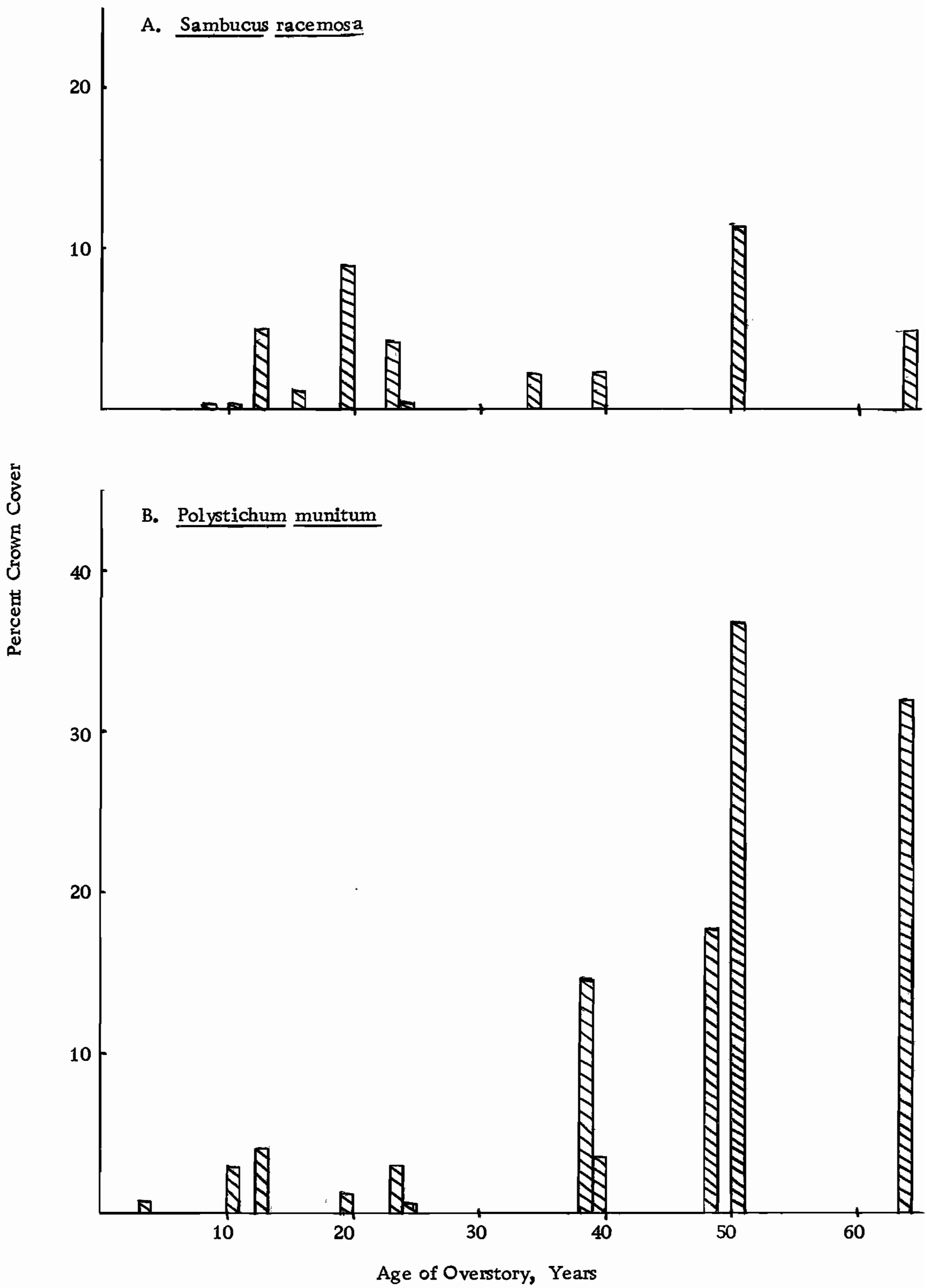


Figure 11. Percent crown cover for: A. Sambucus racemosa, B. Polystichum munitum.

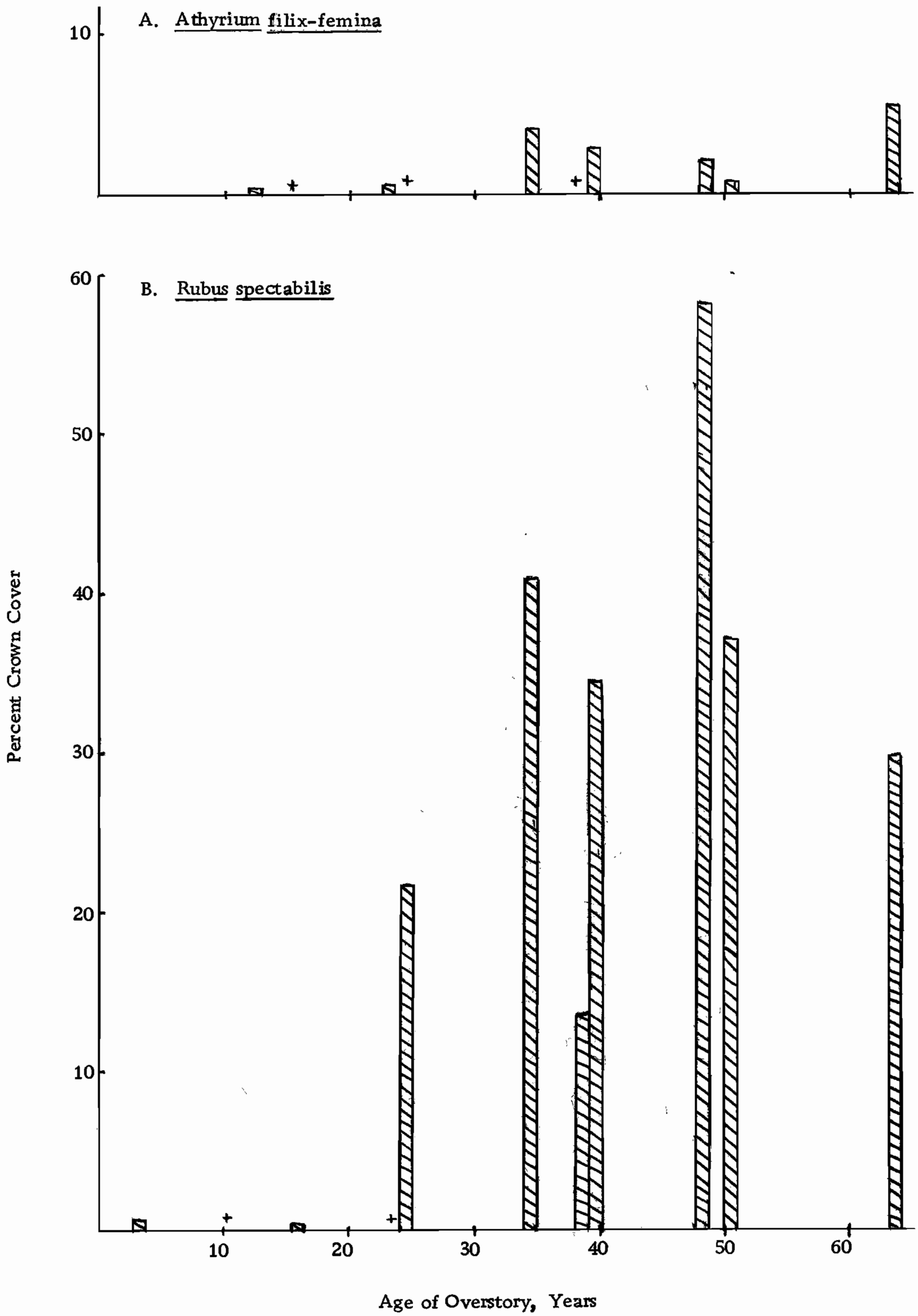


Figure 12. Percent crown cover for: A. Athyrium filix-femina, B. Rubus spectabilis.

three (Figures 11-A, 12-A, B), *Athyrium filix-femina*, *Polystichum munitum*, and *Rubus spectabilis* are clearly increasers in this community and appear to be the only species in a position to assume dominance of the site after the red alder is gone.

Cumulative histograms of all species encountered, broken down into life-forms, *e.g.* graminoids, ferns, herbs, and shrubs (Figures 13-A, B; 14-A, B) show the trends of these groups of species in the succession. They also show graphically why the early stands are called the grass-herb stage and the older stands are called the shrub-fern stage.

Total (*i.e.* cumulative for all species present) crown coverage was compiled and is shown in Figure 15. It shows a curvilinear trend levelling off at about 100% crown cover at about age 50. This is well below the 200 to 300 percent crown coverage found by other authors (Franklin and Pechanec, 1968a; Sharpe, 1956) for comparable stands. This difference is presumed to be due to the different times of data collection. Franklin and Pechanec collected data in early spring and Sharpe collected in July, while this study was done much later in the season when some of the spring species have disappeared or become rare and some others have declined in vigor, having passed through the flowering and fruiting stages. The data of these two similar studies, therefore, emphasize the crown cover of the early annuals and early herbaceous perennials which contribute

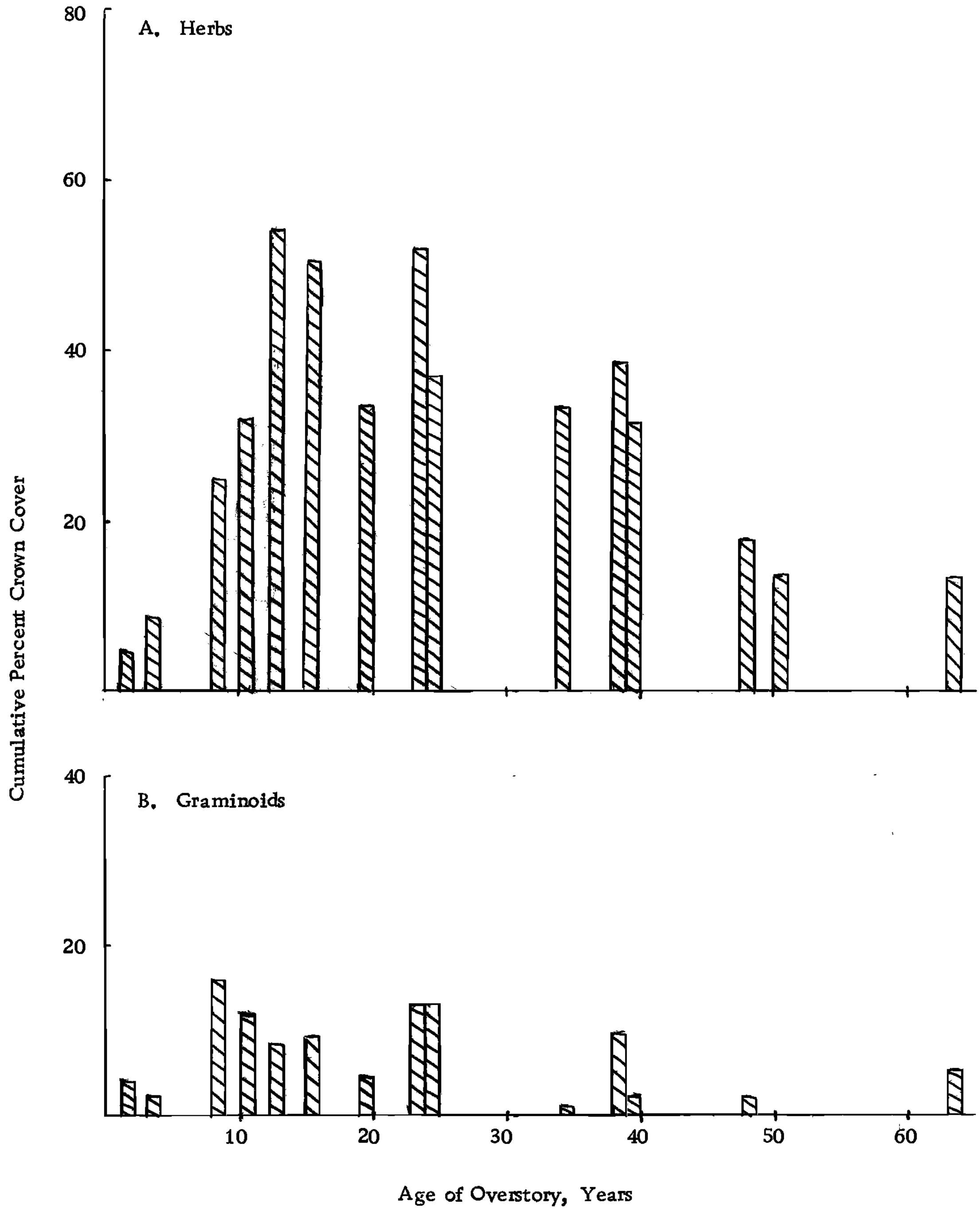


Figure 13. Total crown cover for: A. Herbs, B. Graminoids.

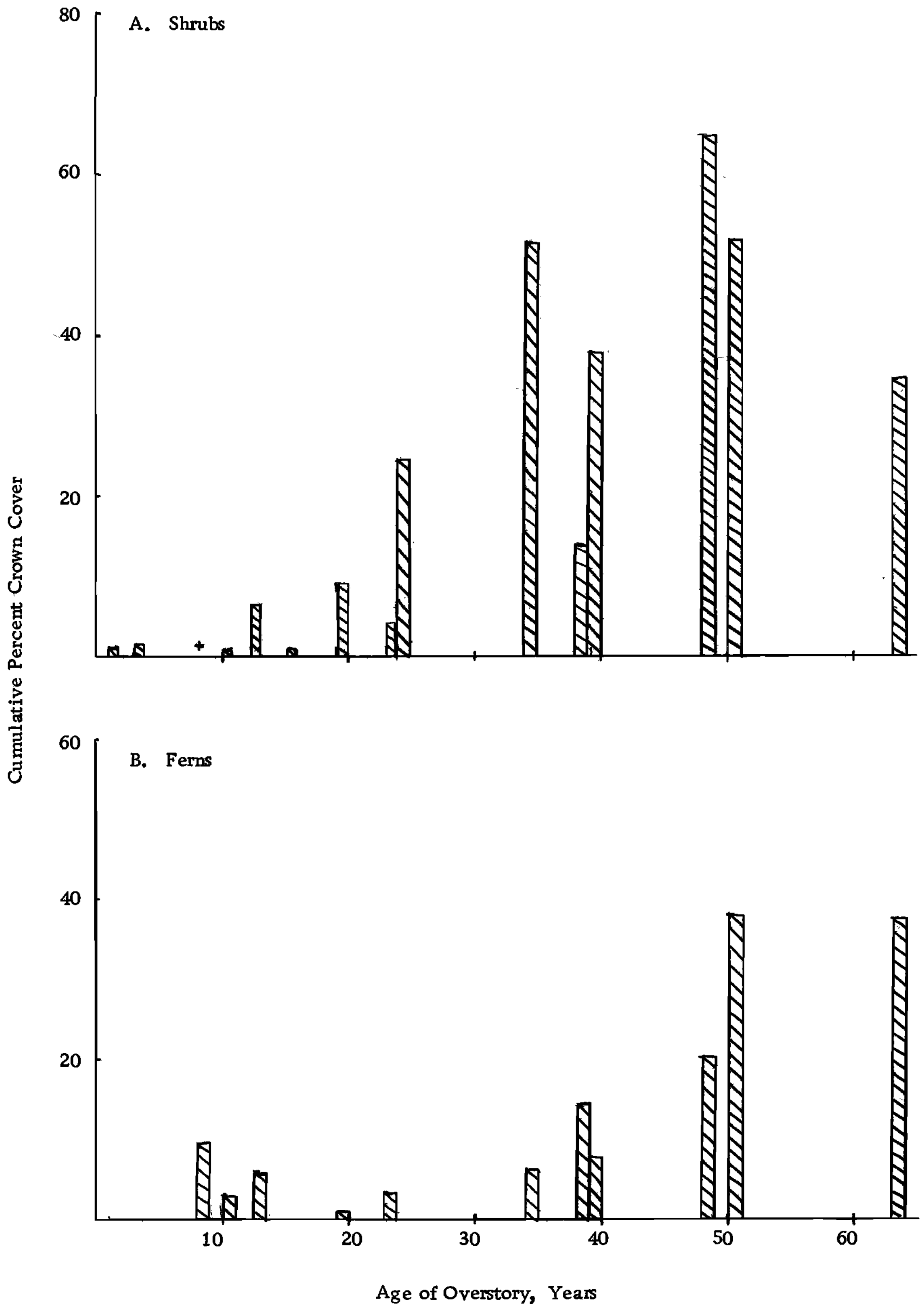


Table 14. Total crown cover for: A. Shrubs, B. Ferns.

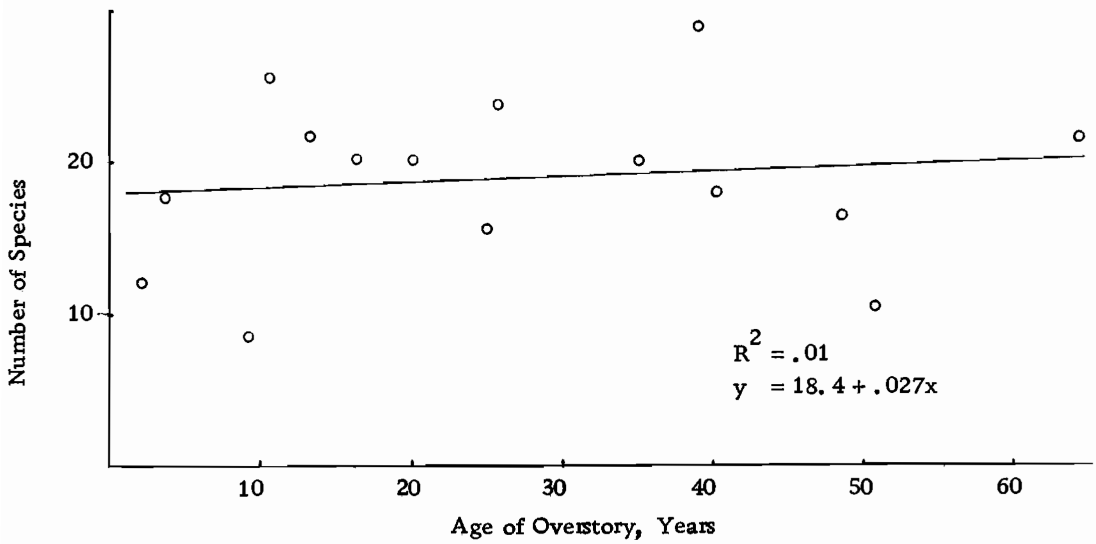


Figure 15. Number of species per plot.

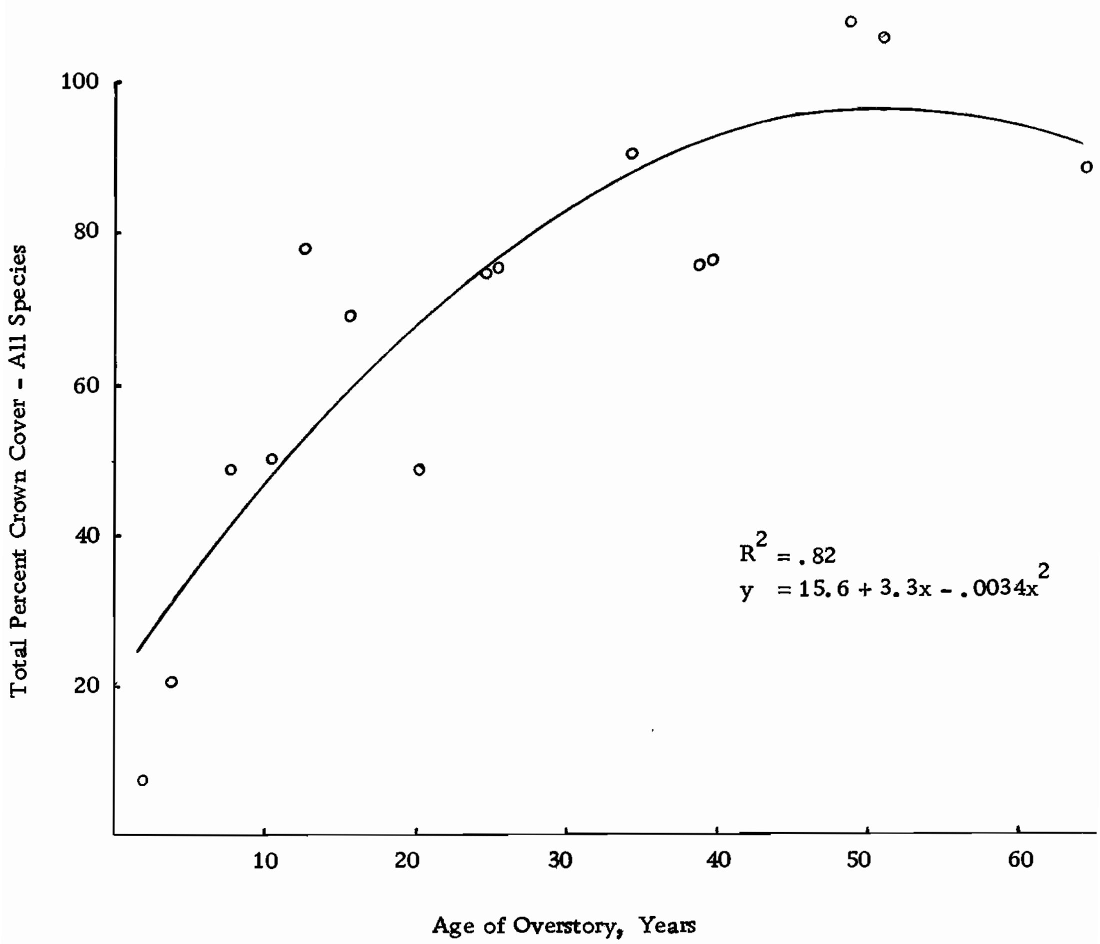


Figure 16. Total crown cover of all species per plot.

very little to the community biomass but may dominate the forest floor layer during certain seasons. Several species, e.g. Dicentra formosa, Cardamine pulcherrima, and Trillium ovatum, were present or even common in some of the stands visited during a reconnaissance in spring and early summer. These same species were rare or absent, however, during the data collection period. Some other species such as Montia sibirica and Stellaria media were noticeably lower in crown cover late in the season.

The total number of species per stand was tallied and showed no trend with time (Figure 16). However, if the 39 and 64 year old stands are moved to a position 20 years younger, which also makes them correspond more exactly with the expected biomass and composition for these ages, a curvilinear, increasing and then decreasing, trend becomes apparent.

Coniferous Reproduction

Conifer reproduction was noticeably scarce in these stands (Table II). Pseudotsuga menziesii seedlings were found in four of the younger stands, but not in any stands over 25 years. In all cases tested their ages were the same as that of the alder overstory. Their heights ranged up to one meter.

Only one stand (age 25) had any Tsuga heterophylla seedlings. These seedlings were found only on mossy, rotting logs along with

Table II. Percent Crown Cover and Frequency of Species Encountered.

Stand Age	2	4	9	11	13	16	20	24	25	35	39	40	49	51	64
SPECIES															
Herbs															
Ch-le	+/2														
Mi-mo	2/12														
Ep-an	2/18														
Se-si	+/4				6/26										
Ga-tr		+/2	2/12												
Ox-or	+/2	1/16		+/+	+/4	+/2				2/26	+/8			11/76	
Mo-si	+/4	+/4	1/42	2/64	2/48	1/42	1/24		1/18	+/6	+/14			+/4	+/10
St-md		1/12	1/38	5/52	2/22	2/20			2/50	+/8	1/10		1/26		+/10
Di-pu		2/12	1/10	5/16	8/30	3/20				+/2	1/6				+/2
Pr-vu			1/14	3/30	1/8	2/18	2/14								
Ru-ur		1/14	17/99	17/76	16/86	21/80	6/40	10/50	1/4		19/66	3/20	+/2	1/10	
St-mx		4/28	3/6	+/+	17/84	13/74	6/32	6/40	14/50		6/44	1/6	6/48		3/36
To-me		1/4			1/6		5/24	6/38	8/52	15/96	1/12	7/70	3/36		3/30
Vi-se				+/4		1/16	+/2			+/2	+/6		+/8	+/2	+/4
Ru-ob				+/+		+/4	+/2			+/2	+/+	+/+			
Di-fo				+/+					+/2		+/4				+/4
Ur-di					2/16	2/12	3/14	26/86		14/70	1/12	17/72	7/48		5/42
Ra-or						6/42	9/38	2/24			6/56	1/12			
Oe-sa						+/2		2/14	11/34	1/28					1/8
Pe-sp							1/10		1/4	1/4		1/8			
As-ca							1/2								
Ge-ma							+/4								
Os-ch								+/2		+/10	2/16				
Va-he											+/4				1/2
Ma-or											+/4		+/4		
Graminoids															
Je-ef	1/18	+/2													
Ag-te	+/2	1/22	+/+	5/38	3/38	5/46	+/2	+/2		+/6	1/16				
Ho-la	1/12	+/2	8/86	6/80	3/28	+/2	4/34	2/18	4/38		1/8	+/2			
Ca-de	2/22		2/6	+/6	1/10	4/40	1/10	6/24	2/20	+/4	+/2	1/6	2/12		4/18
El-gl			6/18	+/2	+/2		+/4	5/38	1/6		7/64	+/2			
Lu-pa		1/8			+/2				+/4	+/2					+/4
Gl-el		+/4			+/4				6/22						+/2
An-od				+/4											
Ca-ob									+/2		+/2				+/2

continued on next page

Table II Continued.

Stand Age	2	4	9	11	13	16	20	24	25	35	39	40	49	51	64
SPECIES															
Ferns and fern allies															
Pt-aq			9/42								+/4			1/4	
Moss	1/8	9/68	2/16	1/40	4/38	7/64	1/12	2/32	3/34	3/36	1/8	2/18	1/18	3/42	2/26
Eq-ar				+/+											+/4
Po-mu		+/12		3/16	4/22		1/4	3/8	1/8		15/18	4/28	37/92	18/56	32/64
At-fi					1/2	+/2		1/6	+/2	4/22	+/+	3/16	2/8	1/4	5/24
Shrubs															
Sal	1/4														
Ru-la		+/2			2/8										
Ri-la				+/+											
Rosa				+/2											
Ho-di				+/+											
Ru-pa		1/10							+/+		+/2	+/6			
Sa-ra			+/2	+/4	5/22	1/18	9/22	4/20	1/6	2/14		2/4		11/26	5/16
Ru-sp		1/6		+/2		+/6		+/+	22/56	41/92	14/40	35/84	58/98	37/60	30/76
Ac-ma									1/2				+/+		
Ph-ma										1/2					
Ac-ci										10/18					
Va-pa									+/+		+/4			4/14	
Rh-pu												+/2			
Conifers															
Ps-me		+/4	+/+	+/2				+/+							
Th-pl				+/+											
Ts-he									+/+						

Figure to left of slash is percent crown coverage, figure to right is percent frequency; "1" percent crown coverage represents a crown coverage of 0.5 - 1.0%; "+" to left of slash indicates less than 0.5 percent crown coverage and an "+" on both sides of slash indicates the species was in the stand but not tallied in the plot.

Vaccinium parvifolium and *Polystichum munitum*. A *Thuja plicata* seed source was seen nearby but the probable source of *T. heterophylla* seed was not seen. The relative wetness of the soil in this stand along with the understory competition may prohibit conifer seedling survival except on rotted logs and perhaps micromounds.

Only one stand (age 11) had any *Thuja plicata* seedlings. These small (about 10 cm high) seedlings were randomly scattered throughout the drier part of the stand along with similarly sized *P. menziesii* seedlings. This stand was found in an area where a *T. plicata* seed source was nearby. The absence of mature *T. plicata* and *T. heterophylla*, however, was apparent throughout the Alsea River drainage, which partially explains the absence of seedlings of these tolerant species from the understory of most red alder stands.

Flowering

Despite the low percent of full sunlight (Figure 17-A) that these understory plants receive, many (about 40% of the total number encountered) of the flowering plants were able to flower. These plants were often the community dominants. Two notable exceptions, however, were *Rubus spectabilis* which was often dominant in older stands but was never seen flowering or fruiting and *Sambucus racemosa* which was common in older stands and produced only an occasional depauperate fruit on an otherwise bare panicle.

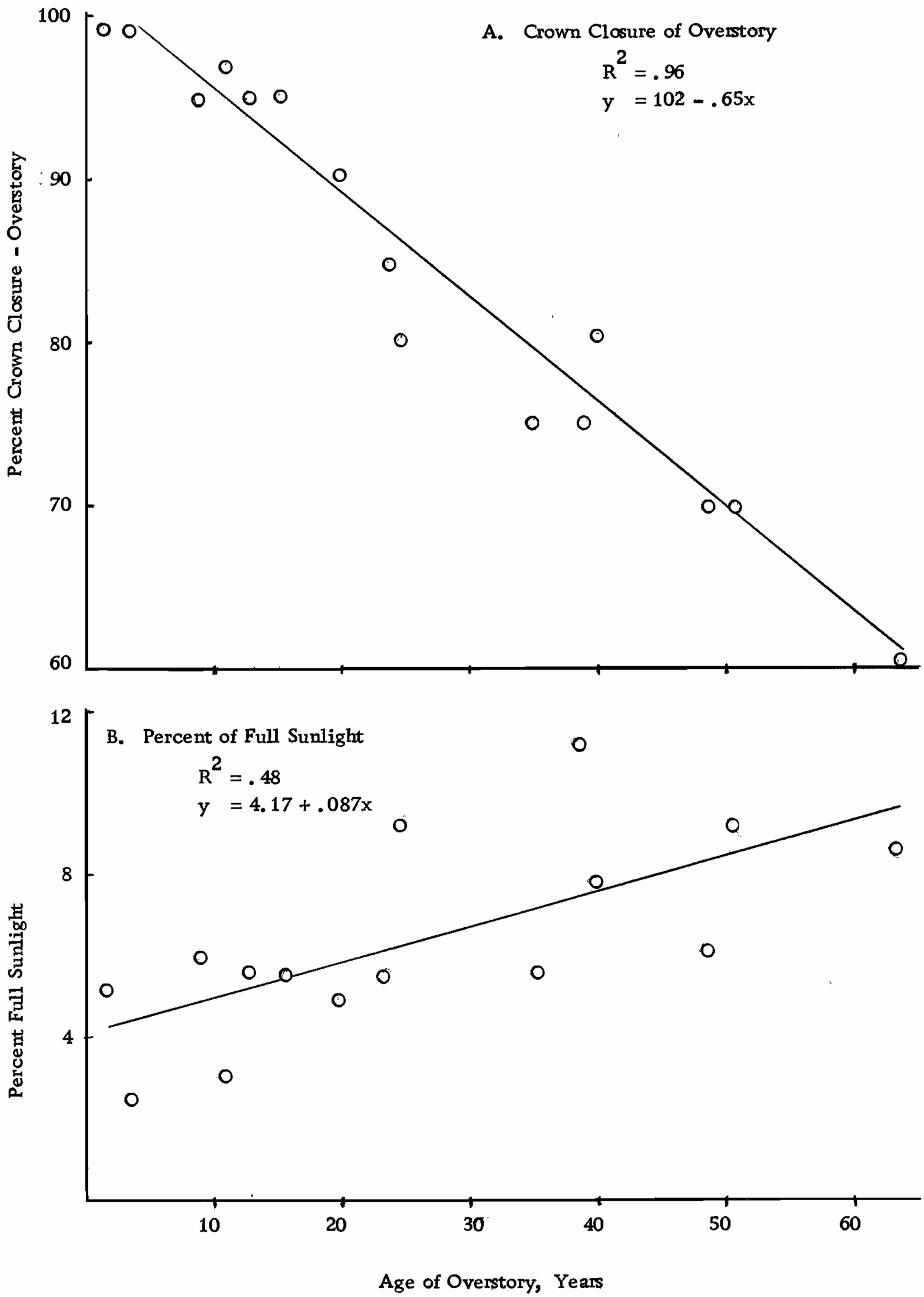


Figure 17. A. Percent crown closure of overstory,
B. Percent of full sunlight passing through the red alder canopy.

Good (1963) indicated that most plants in a pine-spruce-fir community in Minnesota require at least 12% full sunlight to reproduce while some were able to reproduce in as little as 5%. Although no count of viable seed was taken, 40% of these species appear to fit into her 5-12% class, which seems to be a figure higher than would have been expected. Perhaps the greater amount of sunlight early in the season permits many of these species to sufficiently begin or even to complete their flowering before the incoming light is reduced by the developing red alder canopy.

The Light Factor

The opening-up of the alder canopy and subsequent greater light penetration with age were estimated for each of the stands studied. It was thought that quantifying this one factor, the easiest to measure of all the ecologic factors, would add to the understanding of the productivity, composition, and succession of this community.

The percent crown closure for the alder canopy was estimated from below for each stand. These data are presented in Figure 17-A and show a significant ($R^2 = .96$) decrease in crown closure with time. Projecting this regression ($y = 102 - .65x$) to zero percent crown closure indicates that the canopy should have completely deteriorated by age 160 years, which is far in excess of 100 years, the maximum age for alder given by Fowells (1965). This indicates that for the time span of this study (2-64 years) the relationship is approximately linear but that it must be a near-linear portion of a curvilinear relationship and that the rate of canopy deterioration must begin to increase after age 60.

Ozalid paper light sensors were used to estimate the percent of full sunlight passing through the alder canopy. Five measurements which were taken in each stand on a partly cloudy day plus five control estimates of sunlight in the open from throughout the Alsea river drainage were used to compute an estimate of percent full sunlight for each stand (Figure 12-B). Extreme values were thrown out. This linear regression yielded a much less significant result ($R^2 = .48$) than was expected. This greater scattering of the data points is believed to be partially due to the partly cloudy weather conditions, incompletely or unevenly closed canopies, excessive amounts of sidelight, and to the partial obstruction of light by tall shrubs.

DISCUSSION

Biomass

The biomass of the understory vegetation of the Alnus rubra/ Rubus spectabilis associes has been shown to be an almost insignificant proportion of the biomass of the overstory, reaching only 2.5% by age 60. Furthermore, the biomass of this understory is higher than any found in the literature for comparable overstories (Table IV). This indicates that for many other communities, the understory vegetation in general comprises an insignificant proportion of the entire community biomass and might be ignored in productivity studies.

Some stands do not fit well into the biomass trends shown in Figure 8, particularly with respect to shrub biomass. Furthermore, light data (Figure 17) does not explain these anomalies.

Sampling error is certainly the cause of some of the scattering of the data, but there were no great differences between what was expected for a stand by visual estimation and the calculated biomass. The apparently low values for ages 24, 39, and 64 were predictable by visiting the stands. These three stands were in a position to be easily flooded. Actual flooding in these stands is not known but is speculated and considered very possible. The effect of flood water on the composition and subsequently the biomass of the vegetation is not known but would be expected to produce species more typical of younger aged stands due to this secondary disturbance. Such a disturbance might remove some or most of the existing vegetation and/or provide a fresh surface layer of alluvium. This would tend to encourage the pioneer understory species to come back and begin the succession over again. Such appears to be the case with these three stands, especially the 39 year old stand. Table II shows that the composition of these stands resembles younger aged stands more than it does that of comparably aged ones (see also Figures 9, 10, 11 and 12).

Each of these three stands, moreover, were close to areas where cattle are known to graze. Cattle have been seen in the 39 year old stand and cow dung was seen adjacent to the other two. Deer grazing is also considered a possible factor, but no reason is seen which would indicate that deer should favor these three stands over the others.

One stand, aged 35 years, had unusually high biomass, and was dominated by Rubus spectabilis more than what was expected for that age. This is a puzzling situation to explain in light of the other data of this study. If more were known about the autecology of R. spectabilis, the answer might be known. The role of R. spectabilis and its autecology will be more fully discussed later.

Comparisons with Other Communities: Biomass

One of the principal applications of biomass studies is the comparison of different communities' productivities. Numerous studies are now available for both wild and cultivated communities, many of which are presented in Tables III, IV, and V.

It should be pointed out that the data in Tables III, IV, and V are not all readily comparable since some values include roots and others do not, some represent cumulative biomass while others are terminal, and in the case of perennials, the age of the important species is usually not given.

Comparing the biomass of several deciduous stands, Ovington and Madgwick (1959) reported the highest biomass. It was for a birch stand at age 55 years, with 367,000 k/ha. The second highest biomass was reported by Zavitkovski and Stevens (1970) for red alder. It was 320,000 k/ha. Other figures include *Alnus incana* at 124,696 k/ha (Ovington, 1956), and *Populus davidiana* with 119,000 k/ha (Satoo *et al.*, 1956).

The lowest values found in the literature were for high elevation meadow communities such as the *Carex-Sibbaldia* community (Billings and Bliss, 1959) with 213 k/ha, the *Carex-Geum* turf with 65-598 k/ha (Paulsen, 1960), or the ridge cushion plant community with 276 k/ha (Bliss, 1956).

Table III. Biomasses of selected deciduous overstories.

Source	Community	Biomass k/ha
Ovington and Madgwick, 1959	Birch (Age 55)	367,000
Zavitkovski and Stevens, 1970	*Alnus rubra* (Age 60)	320,000
Ovington, 1956	*Alnus incana*	124,696
Satoo *et al.*, 1956	*Populus davidiana*	119,000

Table IV. Biomasses of understories with a deciduous overstory.

Source	Community	Biomass k/ha
Madgwick, 1965	*Fraxinus excelsior*	2,400
Ovington, 1955	*Betula alba*	2,194
"	*Alnus incana*	2,147
Bray, 1963	Aspen and cottonwood	1,670
"	Aspen	880
Smirnova and Sorogovets, 1966	Gray alder coppice	678
"	Alder and birch	732

Table V. Biomasses of selected communities which lack a tree layer.

Source	Community	Biomass k/ha
Bray *et al.*, 1959	Typha	46,400
"	*Zea mays*	13,900
Pearsall and Gorham, 1956	Bracken	10,100
Bray *et al.*, 1959	*Sorghastrum nutans*	9,300
"	*Zizania aquatica*	6,300
Kuramoto, 1968	Moist subalpine meadow	5,024
Bray *et al.*, 1959	*Setaria glauca*	4,700
Singh and Misra, 1969	Grassland	4,416
Kuramota, 1969	Tall sedge subalpine meadow	3,958
Hadley and Buccos, 1967	*Bromus-poa*	3,486
"	*Poa-andropogon-stipa*	3,380
Bliss, 1966	Heath	2,830
Hadley and Buccos, 1967	*Poa-melilotus*	2,536
Mathews and Westlake, 1969	*Conzya canadensis* (terminal)	2,320
"	" (cumulative)	5,020
Kuramoto, 1968	Mesic subalpine meadow	2,267
Malone, 1968	"Old field #1" (terminal)	2,190
"	" (cumulative)	3,980

Table V Continued.

Source	Community	Biomass k/ha
Odum, 1960	"Old field" (terminal)	2,025
"	" (cumulative)	2,700
Bliss, 1966	Snowbank	2,000
Klickoff, 1965	Saxifraga-Artemesia	1,930
"	Calamagrostis wet meadow	1,800
Mathews and Westlake, 1969	Conzya canadensis (terminal)	1,750
"	" (cumulative)	3,780
Klickoff, 1965	Carex dry meadow	1,500
Billings and Bliss, 1959	Sibbaldia-Agrostis	1,410
Bliss, 1956	Carex-Deschampsia wet meadow	1,124
Mathews and Westlake, 1969	Glyceria maxima (terminal)	850
"	" (cumulative)	2,930
Bliss, 1966	Heath-rush fellfield	740
Paulsen, 1960	Carex-Geum turf	598
Billings and Bliss, 1959	Geum-Salix meadow	400
Bliss, 1956	Cushion plants, Ridge	276
Billings and Bliss, 1959	Carex-Sibbaldia	213
Paulsen, 1960	Carex-Geum turf	65

Biomasses of the understory of comparable deciduous stands in the literature are mostly lower than that found in this study. Ovington (1955) found the biomass of the understory of *Alnus incana* was 2147 k/ha and for *Betula alba* was 2194 k/ha. Madgwick (1965) estimated the understory of an ash stand to be 2400 k/ha.

Smirnova and Sorogovets (1966) found surprisingly small values for the understories of gray alder and alder and birch communities (Table IV).

Numerous data are available for cultivated and wild fields (Table V). These data range rather consistently between 1000 k/ha and 5000 k/ha, with most being measured on a terminal standing crop basis. A few, however, which were reported by Bray *et al*. (1959) included roots and ran up to 46,400 k/ha. It should also be noted from Table V that cumulative biomasses are, on the average, about twice what the terminal biomasses are for the same species or type.

Composition

The composition of the 15 stands studied changed noticeably and predictably as the age of the overstory increased. This succession is important in several ways.

First, it indicates that a change in the soil and environment took place. These implied interrelationships between plants, soil, and environment are not completely known. A few have been studied to a degree on a piecemeal basis with respect to nitrogen fixation, and modification of other soil properties. What little is known about a few of the more important species is discussed later.

Second, it shows a case where the overstory or dominant layer of a community did not change in composition while the subordinate vegetation changed considerably. These stands are considered to represent one community in the abstract sense--the Alnus rubra/ Rubus spectabilis associes, yet the composition of a ten year old stand barely resembles the composition of a 50 year old stand.

Third, it shows the trend toward Rubus spectabilis' dominance of sites initially dominated by Alnus rubra which in turn indicates some of the problems which might be encountered when the alder is gone and the site should be producing trees, with their higher multiple use values, and not brush. Natural succession to a confier dominated community is dependent at this stage either upon another disturbance which might allow Douglas-fir to be established or to conifer establishment on downed logs. This process leaves much to chance. Succession to climax conifer forest from an advanced red alder community or a Rubus spectabilis dominated brush field would eventually occur, but might require a considerable waiting period by human standards. If these lands are to best supply human needs, the time to change this successional pattern is before the alder is gone, while there is some salvage value to the timber which might then cover the cost of scarification and conifer regeneration.

A search for brush fields dominated by Rubus spectabilis which would represent this stage in succession produced negative results. This does not negate the hypothesis that R. spectabilis replaces Alnus rubra as the community dominant, but rather indicates, perhaps, one of the ramifications of man's disturbance in altering the ecology of the earth and thus producing conditions unprecedented in the natural environment.

The composition of only one stand did not fit well into the pattern established by the other stands. This was the 39 year old stand, which was also one of the three stands which did not fit well into the shrub biomass data. Grazing and possibly flooding are the major causes which may explain this inconsistent composition. Rubus spectabilis may have been grazed by the cattle (and deer?) or was perhaps killed by flood. Cattle have actually been seen in this stand. Cattle grazing appears as the most important factor in explaining the inconsistent composition of this stand. The absence of R. spectabilis is very likely to modify the residual vegetation by its lack of competition. This would explain the slightly higher than expected crown coverage for a few grasses and herbs in this stand. Based on the percent crown coverage of several species in the stand, its "age" appears to be approximately 16-20 years. This indicates the time since a possible flood (or other unknown disturbance) initiated another secondary succession without killing the alder overstory.

Rubus spectabilis appears to be the most important understory species in the productivity and ecology of this community. More will be discussed about this key plant later.

Comparisons with Other Communities: Composition

A comparison was made between the composition of this study and that reported for several other comparable *Alnus rubra* studies. True to tradition, however, data were presented in nearly as many forms as there were authors. Table VI presents those species which occurred in my stands plus in at least two of the comparable studies.

Polystichum munitum was the only species (besides *Alnus rubra* itself) which was always present. Several others were noted in all but one study, *Rubus spectabilis*, *Sambucus racemosa*, *Rubus ursinus*, *Oxalis oregana* and *Galium triflorum*, still others were found in four of the six studies, *Athyrium filix-femina*, *Stachys mexicana*, and *Montia sibirica*. These are, with few exceptions, the most important species in the *Alnus rubra*/*Rubus spectabilis* associes in the Coast Range of Oregon. This comparison indicates that these species are well correlated with red alder over an even wider range than my study area.

These species are assumed to have independent environmental and edaphic requirements. The similar environmental conditions,

Table VI. Comparison of Important Species with Data from Several Other Red Alder Papers.

Species	a[1/]	b	c	d	e	f
Equisetum arvense	+	II			P	
Athyrium filix-femina	1	II	+		P	
Polystichum munitum	8	IV	14	A	P	64
Pteridium aquilinum	1		2			7
Luzula parviflora	1	II	+			
Carex deweyana	2	II	2			
Montia sibirica	1	V	37			33
Stellaria media	1	I				3[2/]
Osmorhiza chilensis	1	I	1			
Oxalis oregana	1	V	+	O		14
Rubus parviflorus	+		4			31
Rubus spectabilis	22	IV	40		P	24
Rubus ursinus	9	II	3	C		8
Galium triflorum	1	I	+	C		5
Sambucus racemosa	1	I	43		P	
Stachys mexicana	6		6			1
Symphoricarpos albus	1	II			P	
Vaccinium parvifolium	+		+	C		

1/ a - Average of 15 stands of this study; figures in percent crown coverage, + = less than .5%.
b - Sharpe (1956); constancy classes: I-rare, II-seldom, III-often present, IV-mostly present, V-abundant.
c - Franklin and Pechanec (1968a) percent crown cover;
d - Franklin and Dyrness (1969); abundance classes: A-abundant, O-occasional, C-common.
e - Douglas (1969) (P = present).
f - Bailey and Poulton (1968); percent crown cover.

2/ Identified as S. crispa.

however, which they appear to require, which are in part created or modified by red alder, allows them to be similarly distributed. Thus they are classified together as a recognizable and useful community, at least for the relatively small geographical area so far studied.

Discussion of Selected Important Species

Autecological data for herb and shrub species is noticeably lacking in the literature. However, with the limited material available, plus what was learned in this study, an analysis of the contribution of some of the more important species to the biomass, composition, and succession of the *Alnus rubra*/*Rubus spectabilis* associes is discussed.

Rubus spectabilis

Rubus spectabilis is the most important understory species in the older aged stands studied, where it represents about half of the cumulative crown coverage of the understory and about 75% of the understory biomass.

It occurs on a wide variety of habitats in the Pacific Northwest (Hitchcock *et al.*, 1961) and attains maximum size on rich, moist alluvial soils associated with *Picea sitchensis*, *Thuja plicata*, and *Alnus rubra* (U.S.D.A., 1937). It is often associated with red alder and may be the dominant understory species in many red alder communities (Newton et al., 1968; Franklin and Dyrness, 1969; Sharpe, 1956). It has been characterized as being relatively intolerant by Franklin and Pechanec (1968a) and conversely as being shade tolerant by Zavitkovski and Newton (1969). It grows well in the 6-12% full sunlight range in the stands studied here and was shown to germinate and grow in as low as 2.3% full sunlight by Ruth (1970), who also indicated that although light had little effect on germination of R. spectabilis it did affect growth. In his experiment greater light after thinning of the overstory allowed for much increased growth of existing plants. Since R. spectabilis can grow under low light intensities it should be classed as shade tolerant, yet it should be recognized that it does best under moderate light intensities and is less vigorous in high light intensities such as on clearcut or burned areas (U.S.D.A., 1937).

The rapid growth of new shoots and suckers (U.S.D.A., 1937; Hitchcock et al., 1961) of this species allows for a very rapid increase in biomass and percent crown cover under suitable conditions. Presumably light limits growth of R. spectabilis until the overstory of red alder has opened up to allow sufficient light penetration. Newton et al. (1968) have indicated that R. spectabilis is not a significant portion of the over-all alder community in stands younger than 25 years. That finding was clearly substantiated in this study

(Figure 12-B). Both biomass and percent crown cover of *R. spectabilis* increased rapidly after the 24th year which corresponds to the period (Figure 17-A) when the red alder canopy begins to deteriorate and drops to about 80% closed and the percent of full sunlight passing through the canopy increases to about 8% (Figure 17-B) and to the beginning of the period of maximum nitrogen and litter accumulation (Newton *et al.*, 1968; Zavitkovski and Newton, 1969).

Some members of the genus *Rubus*, *e.g. R. idaeus* (Smirnova and Sorogovets, 1966) are recognized as being nitrophyllous. It is also possible that *R. spectabilis* may require high levels of soil nitrogen.

Recent work by Virdi and Eaton (1969) has shown the close genetic similarity between *R. spectabilis* and *R. idaeus* on the west coast of North America. The fact that the beginning of rapid growth of *R. spectabilis* corresponds to the beginning of the period of maximum nitrogen accretion and litter production by red alder might be construed as support for this theory. The wide range of *R. spectabilis*, however, indicates that if nitrogen is important, that light and possibly other factors are probably just as important.

Grazing by wild and domestic animals may effect the composition and succession of a community, particularly in their preferential consumption of certain species. This is well documented in the field of range management.

The palatability of _R. spectabilis_ is rated as fair for cattle, and is rated as an important forage plant for game animals in many parts of the Northwest. Both deer and elk brouse freely on the leaves in the summer and on the twigs in autumn, winter, and spring (U.S.D.A., 1937). On the Olympic peninsula it has been sought so eagerly by elk that it has practically been eliminated from some areas (U.S.D.A., 1937; Sharpe, 1956).

Evidence of cattle grazing in some stands was found, _i.e._ for stands of ages 20, 24?, 39, and 64, where a marked decrease in the quantity of _R. spectabilis_ was noted compared to that which was expected for those ages. A commensurate and proportional increase in herbs was noted in these stands presumably due to the decreased competition by _R. spectabilis_ for light and moisture. In these stands, particularly ages 39 and 64, the possibility of repeated disturbance by flooding is also good and may compound and confound the effects of cattle and deer grazing.

Rubus spectabilis is a definite increaser throughout the life of the _Alnus rubra/Rubus spectabilis_ associes and is the most dominant plant in the older red alder stands besides _Alnus rubra_ itself. Evidence is strong that, baring further disturbance, _R. spectabilis_ will dominate lands now covered by the _Alnus rubra/Rubus spectabilis_ associes until _Tsuga heterophylla_ or _Thuja plicata_ become established, succeed, overtop, and eventually eliminate it completely, or until man takes steps to remove such weedy species and ensure alder re-establishment or conifer establishment.

Polystichum munitum

Polystichum munitum establishes itself early in the life of the *Alnus rubra*/*Rubus spectabilis* associes and increases to assume dominance of the herb layer in the later stages of this community. At this time it also represents the bulk of herb biomass (Figure 11-B).

Polystichum munitum is an extremely variable species throughout its range from Alaska to northwestern Montana, northern Idaho and extreme southern California. It is found in damp wooded slopes and stream bottoms chiefly in the humid transition zone in the Coast and Cascade Ranges (Hitchcock *et al.*, 1969) but is found in deep woods in the Canadian zone in eastern Washington and Idaho (St. John, 1963). It attains best development in the Coast Ranges from Santa Cruz peninsula to Washington.

In red alder stands it occurs with surprisingly high frequency at the base of the protected side of the red alder trees but may also be found on the protected side of logs. The more random location of *P. munitum* in the older stands is presumed to be partially due to the mortality of the "host" trees.

The distribution of young *P. munitum* plants is commonly associated with those mosses found at the base of red alder trees. Franklin and Pechanec (1968b) indicate that Eurhynchium oreganum and Isothecium speculiferum are the predominant mosses found there and that E. oreganum is the most abundant moss on well rotted logs as well. The causal agency for this pattern of distribution and the statistical proof of its validity, however, are not known. Sharpe (1956), however, notes P. munitum occurring only occasionally at the base of trees or on log habitats. His study, however, was largely restricted to older aged stands where this relationship is usually not very apparent.

Several studies have shown that stemflow is substantially richer in nutrient ions and has up to seven times the water depth of gross rainfall (Bollen et al., 1968). In a study of an individual red alder tree, Bollen et al. (1968) found that stemflow has a substantially greater concentration of nitrogen and dissolved solids and slightly lower pH than gross rainfall. These differences, however, were apparent in the soil only up to two feet from the base of the tree. It is suspected that the micro-environment created by the stemflow, both in added moisture and in soil modification encourages P. munitum to grow at the base of red alder trees.

The micro-niche created by the red alder tree at the base of its protected side is particularly suitable for both the establishment and development of the moss E. oregonum and the fern P. munitum.

Cooler temperatures caused both by higher moisture and protection from the sun, greater moisture because of protection from the sun and stemflow, lower amounts of smothering and acidic litter in the protected hollow and better nutrient status caused by greater proximity to the site of nitrogen fixation and stem flow may help create a habitat more suitable for _P. munitum_ germination and survival.

In another experiment, _P. munitum_ plants are doing well in a culture of only live moss and water. Possible nitrogen fixation by some species of mosses and lichens[2] may indicate an intimate nutritional relationship between mosses and some higher plants such as _P. munitum_.

The compounded effects by both _P. munitum_ and _E. oregonum_ are likely to mutually benefit each other by their contribution to shading, moisture conservation, and perhaps nutrient absorption. Later, as natural mortality claims many of the mother trees, _P. munitum_ is able to continue living where it is because of the continued site modification by its own perennial fronds, the influence of the other understory vegetation, the residual nutrients, and the much increased vigor of the adult plant.

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[2] H. Evans, Dept. of Botany and Plant Pathology, Oregon State University, Personal communication. Nov, 1969.

Urtica dioica

Urtica dioica is a species complex which ranges from Eurasia to North America, Mexico and South America and is divided into a number to races by Hitchcock *et al.* (1964). *U. dioica* L. ssp. *gracilis* var. *lyallii* (Wats.) C. L. Hitchc. is the recognized race in the Oregon Coast Range. It is always found in deep rich soil or near moisture from sea level to subalpine. It is a strongly rhizomatous perennial and is usually monoecious but is possibly occassionally, dioecious (Hitchcock *et al.*, 1964).

Smirnova and Sorogvets (1966) classify *U. dioica* as a nitrophyllous species based on early papers by Olsen (1921) and Tansley (1939) and on the tenuous evidence of Ivins (1952) where he simply sowed seeds of many different species together and then noted a correlation between the occurrence of *U. dioica* and nitrogen fixing legumes. Alternative explanations for this apparent nitrophylly have been suggested. Bates (1933, 1950) said that this relationship was due to better soil structure caused by some associated species which favored the penetration of *U. dioica* rhizomes. Osvald (1948) suggested possible allelopathic competition from toxic root exudates from grasses which then limited the areas in which *U. dioica* could grow to areas where the grasses didn't.

The data of my study do not substantiate either theory, since the occurrence of U. dioica corresponds to increasing levels of soil nitrogen (Newton et al., 1968) up to the point where shrub competition offsets the favorable nitrogen level. On the other hand, the increase in coverage of U. dioica (Figure 10-C) corresponds to the beginning of the decline in coverage of the grasses. If one had to choose one or the other of these two theories, the evidence here tends to support the nitrophylly hypothesis of Ivins (1952), Olsen (1921), and Tansley (1939).

Yet, the possibility that both factors might be at work is also worth considering, and in light of the complexity of the biological world, might be a better hypothesis than either of these two alone. A definitive answer must wait however until more research on the problem is done.

Urtica dioica is one of the species which is dominant during the transition period between the "grass-herb" stage and the "shrub-fern" stage. It is a major species in this associes where it constantly makes its presence felt even when present in low numbers.

SUMMARY AND CONCLUSIONS

The ability of red alder to establish itself on freshly disturbed sites has enabled it to dominate much of the Coast Range lands in Oregon. Furthermore, its presently low but potentially higher economic importance plus its site modification capabilities make it important that its yield and ecology be better understood.

Preliminary dry weight yield of the red alder itself has been shown by Zavitkovski and Stevens (1970), but nothing yet has been published about the biomass or productivity of the community as a whole.

The autecology of red alder has been given considerable attention lately particularly with respect to its ability to fix atmospheric nitrogen and to rebuild the soil following disturbance. The structure and composition of the community however have been almost completely neglected. There have been, however, a few references made to its successional status, although only one (Newton et al., 1968) drew any definite conclusions from their study.

The biomass of the understory vegetation for the community studied represents an almost insignificant contribution to the biomass of the community as a whole, increasing from near zero in the youngest stands to over 6000 k/ha in the older stands, yet it represents only 2.5% of the overstory biomass at age 60. Moreover, the understory is the second most important component of this community, which indicates that even smaller components of the community biomass might be ignored with little effect on the estimate of total community biomass.

The composition of the different aged stands showed a striking succession from an early grass-herb stage to a shrub-fern stage and pointed to the eventual dominance by _Rubus spectabilis_ after the red alder overstory dies. These changes are presumed to be influenced greatest by the changing light regime in the different layers of the community and to the soil modification by the alder and to a lesser extent by the understory itself.

The productivity of this alder community has been shown to be among the largest for comparable vegetation from the literature. These characteristics promise to make red alder a more important species in future land management decisions in Oregon.

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APPENDIX

APPENDIX

List of Plant Species and Symbols Used in the Text

All species names except mosses are from Hitchcock *et al*. (1955, 1959, 1961, 1964, and 1969). Mosses are from Lawton (1965).

Ac-ci	*Acer circinatum* Pursh (Vine maple)
Ac-ma	*Acer macrophyllum* Pursh (Bigleaf maple)
Ag-te	*Agrostis tenuis* Sibth. (Colonial bentgrass)
	Alnus rubra Bong. (Red alder)
An-od	*Anthoxanthum odoratum* L. (Sweet vernal grass)
As-ca	*Asarum caudatum* Lindl. (Wild ginger)
At-fi	*Athyrium filix-femina* (L.) Roth (Lady fern)
	Cardamine pulcherrima var. *tenella* (Pursh) C. L. Hitchc. (Spring beauty)
Ca-de	*Carex deweyana* Schw. (Dewey sedge)
Ca-ob	*Carex obnupta* Bail. (Slough sedge)
Ch-le	*Chrysanthemum leucanthemum* L. (Oxeye daisy)
	Corylus cornuta var. *californica* (DC.) Sharp (California hazel)
Di-fo	*Dicentra formosa* (Andr.) Walpers (Bleeding heart)
Di-pu	*Digitalis purpurea* L. (Foxglove)
El-gl	*Elymus glaucus* Buckl. (Blue wildrye)
Ep-an	*Epilobium angustifolium* L. (Fireweed)
Eq-ar	*Equisetum arvense* L. (Common horsetail)
	Eurhynchium oreganum (Sull.) J. & S.
Ga-tr	*Galium triflorum* Michx. (Sweetscented bedstraw)
Ge-ma	*Geum macrophyllum* Willd. (Largeleaf avens)
Gl-el	*Glyceria elata* (Nash) M.E. Jones (Tall manna grass)

Ho-la	*Holcus lanatus* L. (Common velvet grass)
Ho-di	*Holodiscus discolor* (Pursh) Maxim. (Ocean spray)
	Isothecium spiculiferum (Mitt.) Ren. & Card.
Ju-ef	*Juncus effusus* L. (Common rush)
Lu-pa	*Luzula parviflora* (Ehr.) Desv. (Common wood-rush)
Ma-or	*Marah oregana* (T. & G.) How. (Oregon wild cucumber)
Mi-mo	*Mimulus moschatus* Dougl. in Lindl. (Musk)
Mo-si	*Montia sibirica* (L.) How. (Miners lettuce)
Oe-sa	*Oenanthe sarmentosa* Presl. (Water parsley)
Os-ch	*Osmorhiza chilensis* H. & A. (Mountain sweetroot)
Ox-or	*Oxalis oregana* Nutt. ex T. & G. (Oregon oxalis)
Pe-sp	*Petasites speciosa* (Nutt.) Piper (Western coltsfoot)
Ph-ma	*Physocarpus malvaceus* (Greene) Ktze. (Ninebark)
Po-mu	*Polystichum munitum* (Kaulf.) Presl. (Sword fern)
Pr-vu	*Prunella vulgaris* L. (Healall)
Ps-me	*Pseudotsuga menziesii* (Mirb.) Franco (Douglas-fir)
Pt-aq	*Pteridium aquilinum* (L.) Kuhn (Bracken fern)
Ra-or	*Ranunculus orthorhynchus* Hook. (Bird foot buttercup)
Ra-un	*Ranunculus uncinatus* D. Donn (Woods buttercup)
Rh-pu	*Rhamnus purshiana* DC. (Cascara)
	Ribes bracteosum Dougl. ex Hool. (Stinking black Currant)
Ri-la	*Ribes lacustre* (Pers.) Poir. (Prickley currant)
Rosa	*Rosa* sp. (Wild rose)
	Rubus idaeus L. (Wild raspberry)
Ru-la	*Rubus lacinatus* Willd. (Evergreen blackberry)
Ru-pa	*Rubus parviflorus* Nutt. (Thimbleberry)
Ru-pr	*Rubus procerus* Muell. (Himalaya blackberry)
Ru-sp	*Rubus spectabilis* Pursh (Salmonberry)
Ru-ur	*Rubus ursinus* var. *macropetalous* (C. & S.) Brown (Trailing blackberry)

Ru-ob	Rumex obtusifolius L. (Bitterdock)
Sal	Salix sp. (Willow)
Sa-ra	Sambucus racemosa var. arborescens (T. & G.) Gray (Red elder)
Se-si	Senecio sylvaticus L. (Woodland groundsel)
St-co	Stachys cooleyae Heller (Colleys hedge nettle)
St-mx	Stachys mexicana Benth. (Great hedge nettle)
St-md	Stellaria media (L.) Cyrill. (Common chickweed)
Sy-al	Symphoricarpos albus (L.) Blake (Snowberry)
Th-pl	Thuja plicata Donn (Western redcedar)
	Trillium ovatum Pursh (Common trillium)
Ts-he	Tsuga heterophylla (Raf.) (Sarg.) (Western hemlock)
To-me	Tolmeia menziesii (Pursh) T. & G. (Youth-on-age)
Ur-di	Urtica dioica ssp. gracilis var. lyallii (Wats.) C. L. Hitchc. (Stinging nettle)
Va-pa	Vaccinium parvifolium Smith in Rees. (Red huckleberry)
Va-he	Vancouveria hexandra (Hook.) Morr. & Dec. (Inside-out-flower)
Vi-se	Viola sempervirens Green (Violet)