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Direct, nondestructive measurement of biomass and structure in living, old-growth Douglas-fir

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Abstract

Previous studies of biomass and structure of Douglas-fir have examined trees less than 100 years old. This paper describes methods for measuring older trees, illustrated by data from a tree 60 m tall and 450 years old.

Rock climbing techniques, modified for use on trees, are employed lo climb the main trunk. A movable spar provides access to lateral branches. The trunk is measured, the position of each branch system is located on it, and the branch systems are scored for 10 variables related to biomass and strucfure. An importance value, calculated for each branch system, is used in selecting a set of branch systems for detailed measurement. The data permit diagramatic reconslruction of the tree, or estimates of the distribution or total amount of component parts.

Introduction

The techniques described in this paper are of two kinds; technical climbing methods and methods of tree description and measurement which depend upon technical climbing to provide access to the top of the tree. In combination, these techniques are designed to provide quantitative descriptions of the biomass, surface area, and spatial distribution of the aboveground parts of individual trees.

The climbing techniques developed from a National Science Foundation-Undergraduate Research Participation study of epiphytes on old-growth Douglas-fir *(Pseudotsuga menxiesii).* Previous studies (Coleman, Muenscher, and Charles **1956;** Hoffman and Kazmierski **1969)** were limited to epiphytes within 2 m of the ground, but this study was designed to study the canopy populations as well. An initial attempt Lo use felled trees was unsuccessful because the surface of the trunk which hit the ground was destroyed and the branch systems with their epiphytes were shattered and scattered. The climbing techniques were developed as an alternative and proved to be practical, effective, and economical.

Five old-growth Douglas-firs have been rigged and climbed to date, but only one has been subjected to the measurement and analysis described herein. Previous studies of biomass in this species (Burger **1935;** Newbold **1967;** Reukema **1961)** have been limited to trees less than 100 years old, but the trees used in our study are 450 years old and large;

60-80m tall, l-1.5-m dbh, with their lowest branches 12-25 above the ground

Climbing trees of this height is dangerous. A fall would probably be fatal. But probably there is greater danger of injury to personnel under the tree in the event equipment orparts of branch systems are accidentally dropped upon them. We have worked through two seasons without injury.

The climbing techniques are described m detail to peremit others to adopt them. the rock-climbing techniques on which they are based are described in books on mountaineering (Blackshaw1970; Man ning1967) but may be unfamiliar to biologists.

The access technique, the methods of description and measurement and one application of the data, a diagramatic reconstruction of a tree, are treated in this paper Another paper in this symposium (Pike et al. 1972) describes the estimation of tree surface area and epiphyte biomass,

The Access Techniques

Access to the tree involves three steps: rigging, climbing, and use of the spar, each described below. Rigging and climbing techniques are modified from direct-aid rock-climbing techniques. Basic safety procedures, equipment, terminology, and philosophy have been adopted from mountaineering. Anyone without prior mountaineering experience who expects to adopt these techniques should consult one of the standard texts (Blackshaw 1970; Manning 1967). The specialized rope and hardware may be obtained from either mountaineering or yachting suppliers.

Basic equipment for all climbers includes: hard hat, heavy climbing shoes, and a harness of nylon webbing to which a belay rope is attached. The climber is always belayed—that is, she is protected by a safety rope held by another experienced climber. Climbing and belay ropes are 11 mm nylon "goldline" and the webbing used in making slings, stirrups, etc. is of nylon and 40-50 mm wide.

Rigging

Rigging involves an initial ascent and preparation of the tree for subsequent climbing. The ascent is slow, and requires exceptional agility and endurance. A team of three expenenced climbers, should rig the tallest trees in a day and a half.

The procedure used in ascending the tree and placing climbing and belay ropes is outlined in figures 1-4.

1

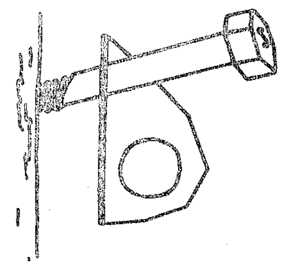

Figure 1. A lag screw is used to fasten a steel hanger to the tree.

2

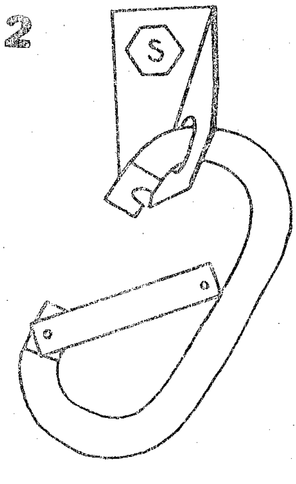

Figure 2. A carabiner is clipped into the hanger.

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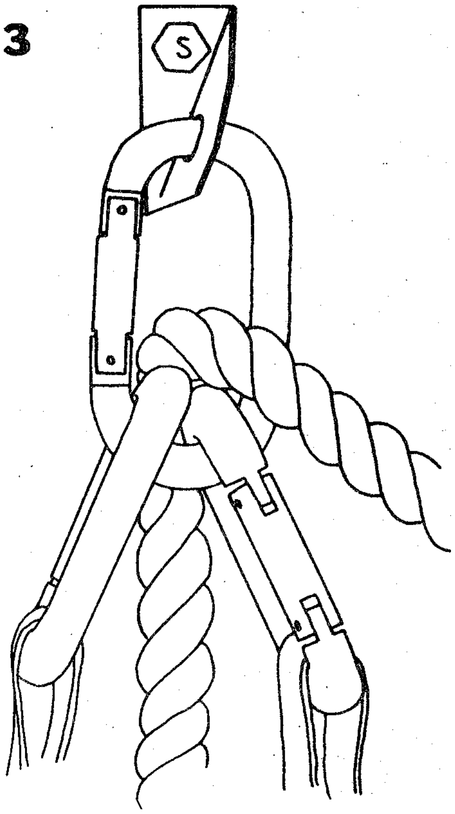

Figure 3. Two additional carabiners are used to fasten two climbing stirrups to the first carabiner. (Only the upper ends of the webbing stirrups are shown.) The belay rope is clipped through the carabiner.

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Figure 4. The climber ascends the climbing stirrups until the first carabiner is at her waist. Tension on the belay rope holds her in position while she drives the next lag screw.

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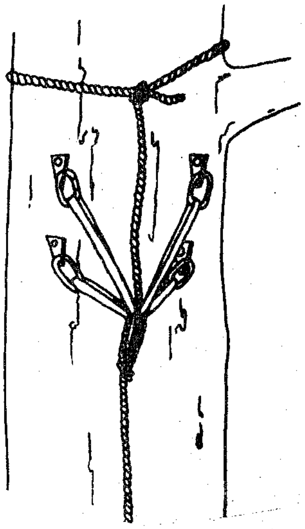

Figure 5. The climbing rope is fastened to the tree by four lag screws, hangers, and carabiners. A loop, tied near the end of the rope, is connected to the carabiners by two loops of webbing. The free end of the rope is tied around the tree using a bowline.

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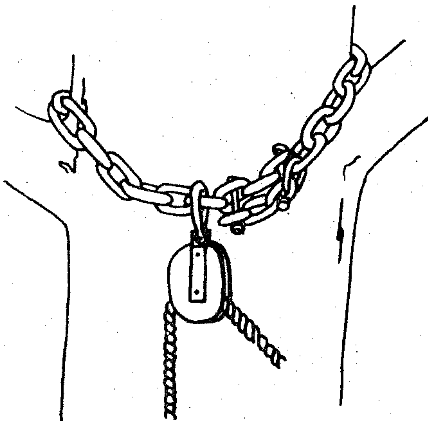

Figure 6. The belay rope runs through a block hung by heavy chain with welded links. The chain is fastened around the tree above a limb and secured by two 1 cm bolts with washers and lock nuts.

Lag screws, 8 by 150 mm, are used to attach equipment. They do not sag or “work out” of the thick, soft bark of Douglas-fir as nails do. The screws are driven with a hammer but may be tightened or removed with a wrench.

A climbing rope is attached near the top of the tree and subsequent ascents are made on this fixed rope. Figure 5 illustrates the usual method of attachment.

The block for the belay line is attached below the point at which the climb path is obstructed by branches. In climbing above this point the belay rope is carried up through carabiners placed during rigging. Below the block, on the open trunk, the climber is belayed from above through the block. Figure 6 illustrates the method of attachment for the block.

Climbing

Climbing requires mastery of unfamiliar skills, but no greater strength or agility than climbing a ladder, a 70-m ladder. An experienced climber, in good physical condition, can climb a 75-m tree in 20 minutes or less, depending upon the distribution of branches and the lean of the trunk. A clumsy, middle-aged man can clamber up with equal safety, but it takes longer.

The techniques involved in climbing the fixed rope are illustrated in figures **7-13.**

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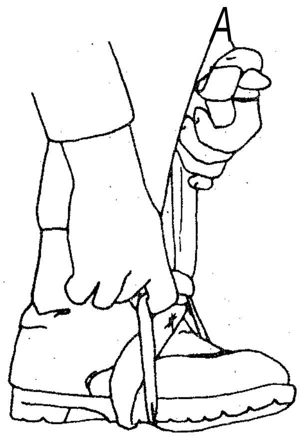

Figure 7. A band of rubber cut from a motorcycle innertube is fastened around the sling and over the toe of the boot to prevent the climber from accidentally stepping out of the sling.

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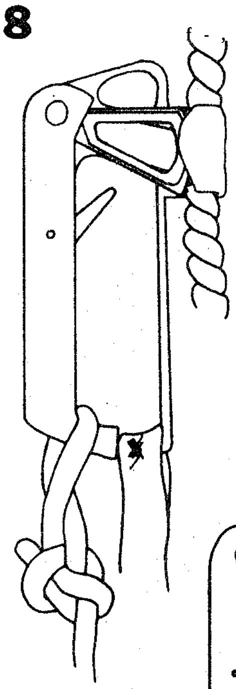

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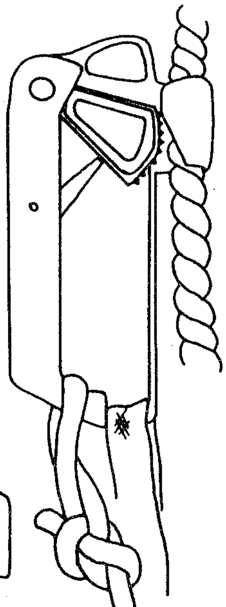

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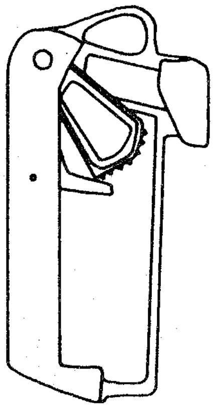
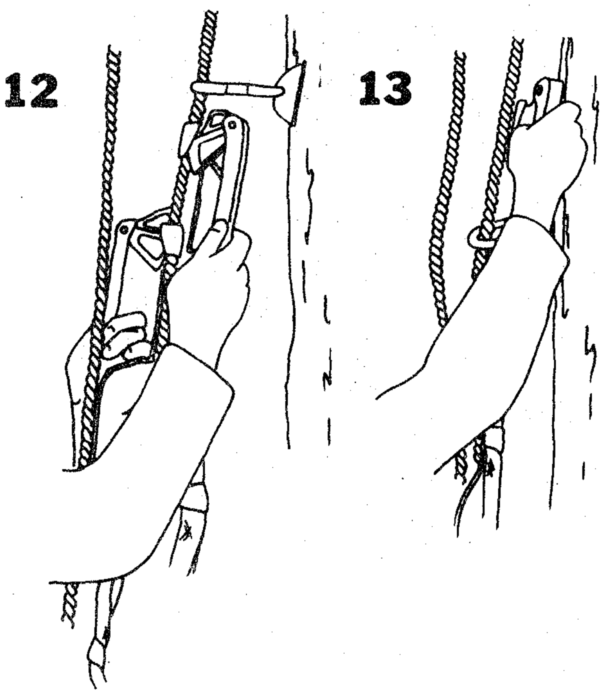


Figure 8. When weight is placed on the jumar, its toothed gate grips the rope so that the jumar can move neither up nor down.

Figure 9. When there is no weight on the jumar, its gate may be lowered and the jumar moved up or down the rope.

Figure 10. The jumar cannot be removed from the rope unless the safety catch is depressed to permit the gate to open fully.

Figure 11. The climber places her weight on one foot, thus locking the jumar on that side, while she moves the other jumar up or clown. She ascends or descends by shifting her weight from one foot to the other and moving the opposing jumars. She stands in webbing slings which hang from the jumars. The jumars are connected to each other by a short length of rope which passes through a carabiner clipped to her belay harness.



Figures 12 and 13. At those points at which the climbing rope is fastened by a carabiner, the jumars must be disconnected from the rope, one at a time, and moved around the carabiner.

Most of the carabiners used in rigging are removed once the tree is rigged, but a few are left in place to prevent the climbing rope from hanging away from the trunk.

Shouted instructions from climber to belayer are normally adequate during climbing, but once the climber enters the canopy conversation is severely impeded by distance and intervening foliage. A pair of small radio transceivers facilitates longer communications and permits the belayer to record data dictated by the climber.

The Spar

Use of a special boom, hereafter called "the spar," permits the climber to reach any point within 4 m of the trunk.

The spar is specially constructed of three lengths of mast-grade spruce laminated in a "tee" cross section. It is 4m long and together with its hardware and rigging it weighs 15 kg. It is awkward to maneuver into place, especially where there are branches close above the one to be sampled. Under normal

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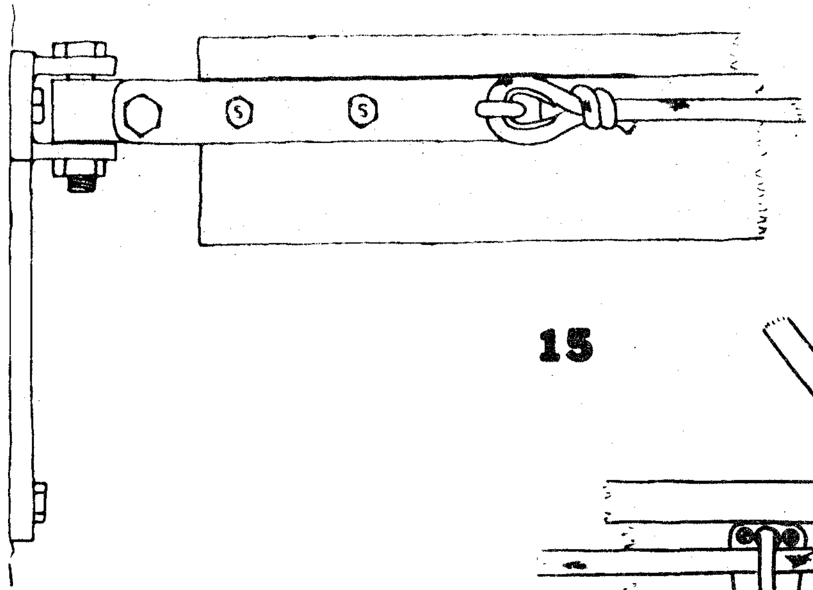

Figure 14. The inboard end of the spar. The hinge is of steel, 8 mm thick except for the central block, which is 36 by 36 mm. The top of the spar is a single piece of spruce, 22 mm high, 75 mm wide, and 4m long. The bottom is of twopieces, each 22mm thick, 100 mrn high, and 4 m long, glued face to face.

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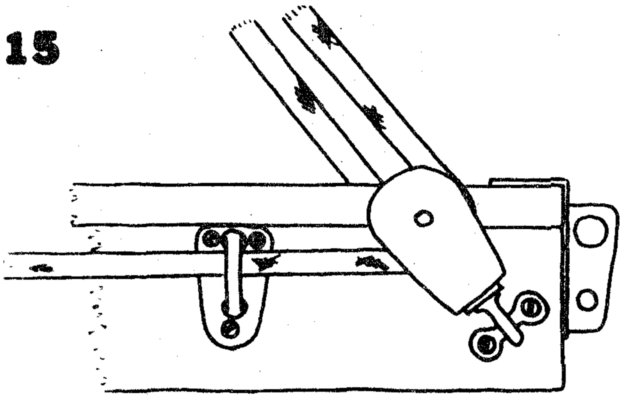

Figure 15. The outboard end of the spar. Mote that the supporting ropes are not fastened to the outboard end. They pass through blocks and guides on opposite sides of the spar and are secured at the hinge end.

circumstances it should be possible to raise the spar from the ground and have it ready for use in 2 hours or less; in difficult circumstances it may take a full day.

Figures 14-17 illustrate the construction and operation of the spar.

The ropes used to support the outboard end of the spar are of nylon, but, unlike those used in climbing, are of a special braid which minimizes stretching (Samson Yachtbraid). This prevents the spar from sagging out of position as the weight of the climber moves away from the tree.

Note that the ropes supporting the spar are fastened at the inboard end of the spar, not at the outboard end. The position at which the spar rests depends upon the relative tension on these ropes. Thus a climber on the spar may maneuver herself through 180" of arc, without returning to the trunk, by pulling on one or the other of the ropes running along the spar.

The climber sits in a "swing seat" suspended by loops of webbing. A climbing stirrup permits her to move along the spar by alternately sitting in the seat while she moves the stirrup and standing in the stirrup while she moves the seat.

In moving the spar, the ropes are coiled and the hinge is folded back along the spar and fastened. In placing it on the tree, it is hung, hinge downward, and maneuvered until the hinge is in place. The hinge is fastened to the tree with lag screws. Then the outboard end is lowered into place. In removing the spar the process is reversed.

The use of these three techniques in combination enables the climber to work with comparative freedom and safety for hours at a time if need be.

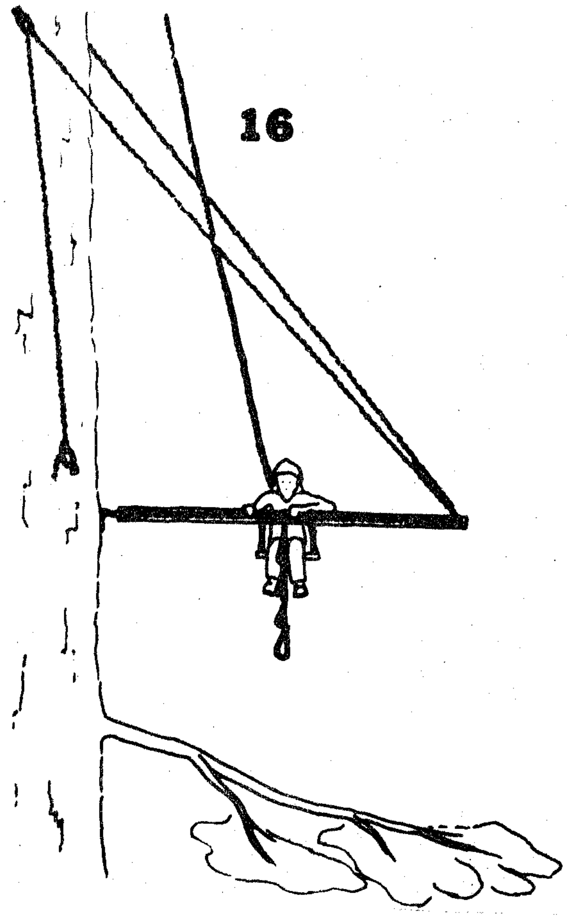

Figure 16. The spar in use. The suspending ropes pass upward through carabiners on opposite sides of the tree and are tied off near the inboard end of the spar. The spar is shown in the open but would normally be placed adjacent to a branch system.

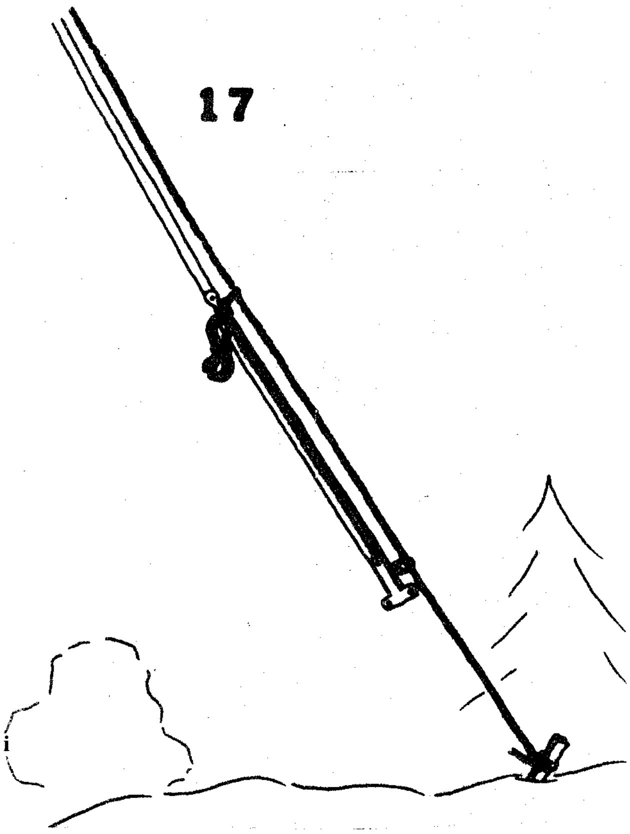

Figure 17. Raising the spar. A "trolley" of light nylon line is stretched from a clear area on the trunk to an open area on the ground. The spar is packaged, with its ropes coiled and hinge folded and clipped to the "trolley" with carabiners. A handline and pulley aid the climber in pulling the spar up into the tree.

Tree Description and Measurement

Description and measurement of a tree proceeds in two steps: an initial survey, in which the trunk and all of the branches are described, followed by detailed measurement of a sample set of branch systems. The tree is arbitrarily subdivided into components: the main trunk plus a number of branch systems. A branch system is defined as one or more branches, living or dead, arising from the same point on the trunk. Several branch systems may arise at the same height, but at different points around the circumference of the trunk. For examples of kinds of data recorded and calculated, the reader should refer to table 1 while reading the following sections.

Survey

As the tree is climbed, the trunk is marked off vertically in meters, by use of tape. At convenient intervals, 5 to 10 m, a benchmark is established and its height verified by transit from the ground. The diameter and inclination of the trunk are recorded at the benchmarks. It is not safe to climb above the point where the trunk is 10 cm or less in diameter, so we have treated the portion above that point as an exceptional branch system. When, through damage to the original leader, one or more secondary leaders have developed, they are treated in the same fashion as the main trunk.

Each branch system is numbered. The position of each branch system on the trunk is recorded by height and compass quadrant. Each branch system is scored for 10 variables. Most of these variables relate to the structure and biomass of the tree, but since this study began as a survey of epiphyte distribution, three variables relate to epiphyte load.

1. Number of Main Axes

A "main axis" is defined as a branch more than 4 cm in diameter, originating within 1 dm of the trunk. Six classes are recognized: no axes (i.e., no branch more than 4 cm in diameter), one axis, two axes, three axes, four axes, and five or more axes.

2. Extension from Trunk

The extension is measured as the horizontal distance from the trunk to the furthest tip of any part of the branch system. Five classes are recognized: 0-1 m, 1-3 m, 3-5 m, 5-10 m, and more than 10 m.

3. Total Length of Living Axes

An "axis" is any branch more than 4 cm in diameter. The total estimated here is of the length of all living axes within the branch system. Six classes are recognized: 0-1 m, 1-5 m, 5-10 m, 10-15 m, and more than 20 m.

4. Total Length of Dead Axes

The definition and classes are as in 3 above, except that here the branches are dead.

5. Area of Branchlets and Foliage

An estimate is made of the area of an imaginary figure formed by connecting the outer tips of all branchlets with the point of attachment to the trunk and projecting the outline on a horizontal plane. Six classes are recognized: 0-1 m^2, 1-2 m^2, 2-5 m^2, 5-10 m^2, 10-20 m^2, and more than 20 m^2.

6. Density of Branchlets and Foliage

Within the area delimited in 5 above, an estimate is made of the area occupied by branchlets and foliage. Six classes, expressed as percents of the total area, are recognized: 0 percent (no foliage), 0-20 percent, 20-40 percent, 40-60 percent, 60-80 percent, and 80-100 percent.

7. Maximum Diameter of Axis

The maximum diameter of the largest axis is measured to the nearest centimeter.

8. Lichen Cover: All Species

The lichen cover is estimated for all axes in the branch system. Only foliose and fruticose species are counted. The cover is expressed as a percent of the total surface area on all axes. Six classes are recognized: 0 percent lichens), 0-20 percent, 20-40 percent, 40-60 percent, 60-80 percent, and 80-100 percent.

9. Lichen Cover: *Lobaria* species

The cover is estimated and expressed for *Lobaria* species alone, using the same classes listed in 8 above.

10. Bryophyte Cover: All Species

The cover is estimated and expressed for all bryophytes using the same classes listed in 8 above.

The data from this survey are tabulated, with the branch systems arranged by number, in the order in which they occur on the tree. A sample group of branch systems is then selected for detailed measurement.

Sample Selection

The number of branch systems selected for detailed measurement (n) depends upon the complexity of the tree: two branch systems are selected in a small, uniform tree; three, in a normal tree; four or five, in a tree with more than one leader. In our example, five branch systems were selected and measured.

An importance value (u) is calculated for each branch system according to the following formula:

$$v = b^2 + b_1^2 + a d + l + m$$

where,

b = class number (1-6) of total length of living axes

b_1 = class number (1-6) of total length of dead axes

a = class number (1-6) of area of branchlets and foliage

d = class number (1-6) of density of branchlets and foliage

l = class number (1-6) of lichen cover, all species

m = class number (1-6) of bryophyte cover

The importance value is listed for each branch system, and both running totals and a grand total (V) are calculated. The grand total (2,111 in our example) is set equal to the number of branch systems to be selected (five in our example) and the running totals recalculated. For example, branch number 87 has an uncorrected running total of 28. The corrected total is: 28(5/2,111)=0.066. After this correction, each branch system is represented by an interval, proportional to its importance value, which is the difference between its corrected running total and that of the preceding branch system.

A random number is drawn: a three-place fraction of 1.000. In our example, the number drawn was 0.870. Those branch systems are selected which have intervals which include: the random number, 1+ the random number, 2 + the random number, etc. In our example, the numbers 0.87, 1.870, 2.870, 3.870, and 4.870 corresponded to branch system numbers 7, 33, 61, 93, and 116.

The branch systems selected in this way are measured in detail as described below.

Branch System Measurement

The measurement of each selected branch system is carried out in 10 stages. The first four stages occur in the field and require the use of the spar; the remaining stages occur in the laboratory.

1. Each axis is marked off in decimeter lengths and the total length of the main axes is recorded.
2. The diameter is recorded every 4 dm.
3. The transition points (4-cm diam) at which an axis becomes a branchlet are identified.
4. At one-fourth of the transition points the distal portion, consisting of branchlets and attached foliage, is cut off and lowered to the ground for further study.
5. The annual rings are counted at the cut end of the removed branch and the age of the sample is recorded.
6. The foliage-bearing portion of each sample is cut into lengths bearing a single year's needles.
7. A subsample of 20 of each year's needles is measured (length and width) while fresh.
8. The foliage and attached fragments of branchlet are dried at 85" and weighed. The weight of each year's foliage is recorded, as is the weight of its associated segments of branchlet.
9. The older branchlets, those without foliage, are cut into lengths representing approximately 1 year's growth and their lengths and diameters are recorded.
10. The segments of older branchlet are dried at 85" and weighed.

Analysis

Several types of information can be summarized from data accumulated by the techniques described. Two of these, surface area of the trunk and limbs and epiphyte biomass, are described in a paper by Pike et al.(1972). Analyses of wood and foliage biomass are being developed, but at present our results are incomplete since they are based on a single tree.

Another kind of analysis results in a diagram of the tree (fig. 18); a graphic summarization, to scale, of the structure of an individual tree. This diagram is an east-west vertical section. It serves both as a map for those working on the tree and as a chart of the distribution of branch systems and foliage.

Reconstruction of the trunk is based upon benchmark measurements of diameter, height, and inclination. A second leader, originating on the north side of the main trunk at the 40-m level, is drawn to the same scale but displaced to the right. Only those branch systems are shown which project to the east or to the west. From existing data one could draw a comparable north-south section displaying the remaining branch systems. Each branch system is shown in its correct position on the trunk and the length of the longest horizontal line indicates, to scale, the distance the entire branch system projected away from the trunk. However, the arrangement of axes and foliage within a branch system is symbolic rather than pictorial.

Living branch systems are represented by a parallelogram, representing foliage, usually accompanied by one or more solid lines, representing axes, Parallelograms without solid lines are branch systems in which no branch was more than 4 cm in diameter.

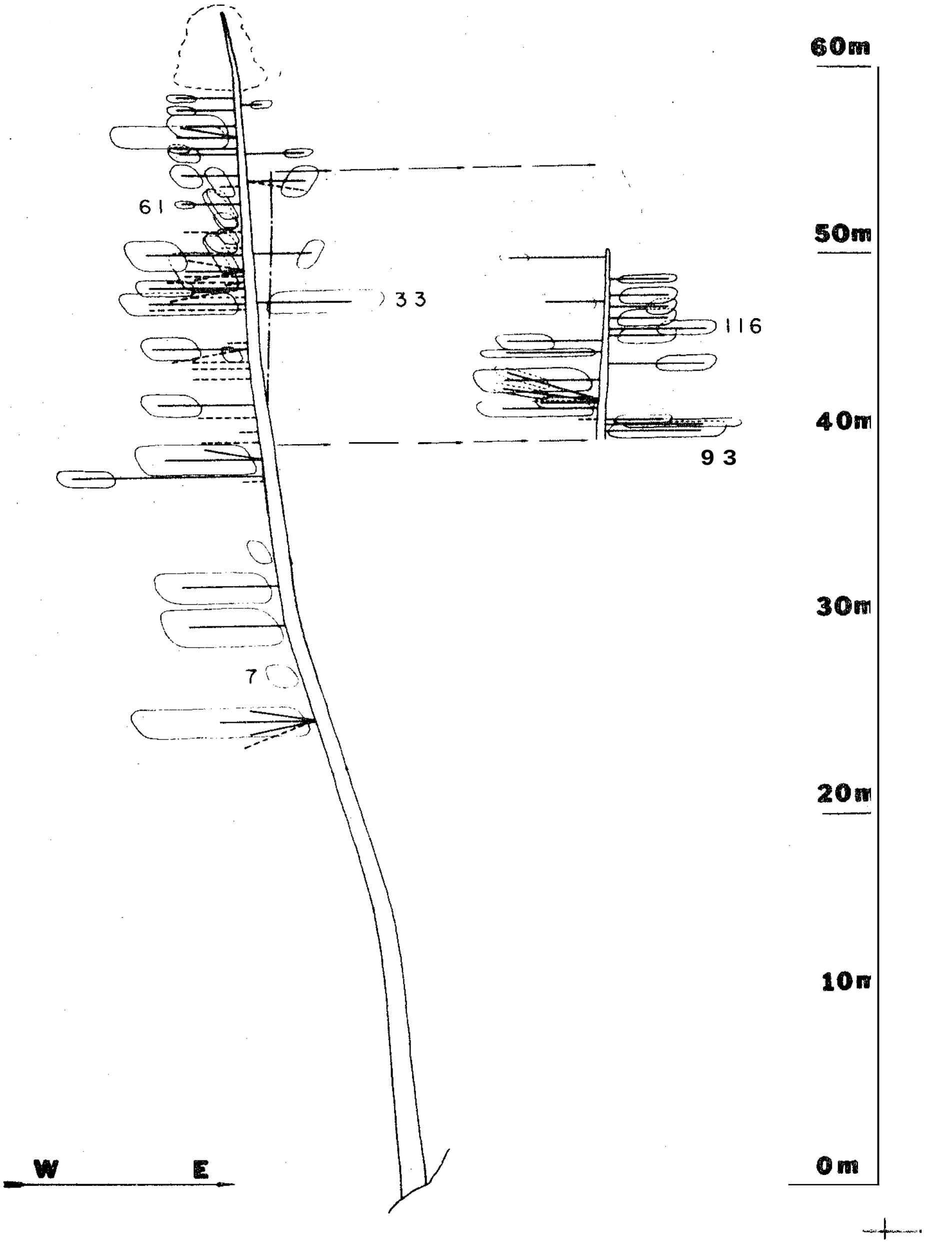

Figure 18. Semidiagrammatic reconstruction of Tree Number 1, Watershed 10. Only those branch systems extending to the east or west are shown. The second trunk is drawn to scale at the right height, but is displaced to the right. Solid horizontal lines represent living branches (axes) or branch systems more than 4 cm in diameter. The length of the line indicates, to scale, how far the whole branch system extends from the trunk. Dead branches are represented by dashed lines. The parallelograms represent branchlets and foliage. The length of a parallelogram represents the horizontal area covered by the branch system, and the height represents the density of branchlets and foliage within that area. Parallelograms without horizontal lines are branch systems with no branches more than 4 cm in diameter. Numbered branch systems are those selected for detailed measurement.

Dashed lines are dead branches. The area of a foliage parallelogram is a measure of the amount of foliage within the branch system. The length of a parallelogram is a function of the area of the branch system; the height of a parallelogram is a function of the density of foliage within the branch system.

Individual branch systems are easily identified. For example, those branch systems which were selected for detailed measuremeni (numbers 7, 33, 61, 93, and 116) are identified by number on the diagram.

Discussion

Although the access technique is still being improved, it is now very nearly routine for trees with a growth pattern similar to Douglas-fir. It could undoubtedly be modified for use in measuring large trees with different growth patterns. It would be particularly interesting to attempt to apply the method to trees of the upper canopy in lowland tropical wet forests.

We have not had adequate opportunity to evaluate the accuracy of our methods of description and measurement. The basic pattern seems satisfactory, but there will be changes made before we extend it to additional trees. We will increase the precision of initial estimates of lengths of axes. We need better methods for estimating foliage biomass. The importance value used in selecting branch systems combined values for foliage biomass with values for epiphyte load. This resulted in selection of a subset that was a poor compromise between the conflicting requirements for measurement of tree biomass and measurement of epiphyte biomass. In the future, separate importance values will be calculated for tree biomass and epiphyte biomass; and separate sets of branch systems will be selected and measured.

Acknowledgments

The authors are grateful to many people who contributed to the development of this project. DonKirk patrick taught US the ascent, technique and made the first ascent. Other climbers (Diane Nielsen, Tom Denison, Jane McCauley, and Karen Berliner), working with the authors, have helped in data taking and have made improvements in climbing methods. Dr. Jack Culver (Benton Boat Works) suggested improvements in the design of the spar, and James Ewanowski (Arboreal Constructions) built it. Sue Carpenter helped with the drawings. Dr. Scott Overton suggested the basic format of the sampling pattern and has guided its development.

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Literatare Cited

Blackshaw, A. 1970. Mountaineering. 552 p. Hammondsworth: Penguin Books.

Burger, H. 1935. Holz, Blattmenge und Zuwachs. 11. Die Douglasie. Mitt. Schweiz. Anst. forstl. Vers. 19: 21-72.

Coleman, B. B., W. C. Muenscher, and D. R. Charles. 1956. A distributional study of the epiphytic plants of the Olympic Peninsula, Washington. Am. Midland Nat. 56: 54-87.

Hartley, H. O. 1966. Systematic sampling with unequal probability and without replacement. J. Am. Statist. Assoc. 61: 739-748.

Hoffman, G. R., and R. G. Kazmierski. 1969. An ecological study of the epiphytic bryophytes on *Pseudotsuga menziesii* on the Olympic Peninsula, Washington. I. A description of the vegetation. Bryologist 72: 1-18.

Manning, H. (ed.). 1967. Mountaineering the frcedom of the hills. 2d ed, 486 p. Seattle: The Mountaineers.

Newbold, P. J. 1967. Methods for estimating the primary production of forests. I.P.P. Handbook #2. 62 p. Oxford, England: Blackwell Sci. Publ.

Pike, Lawrence H., Diane M. Tracy, Martha A. Sherwood, and Diane Nielsen. 1972. Estimates of biomass and fixed nitrogen of epiphytes from old-growth Douglas-fir. 1n Jerry F. Franklin, L. J. Dempster, and Richard Waring (eds.), Proceedings-research on coniferous forest ecosystems—a symposium, p. 177-187, illus. Pac. Northwest Forest & Range Exp. Stn., Portland, Oreg.

Reukema, D. L. 1961. Crown development and its effect on stem growth of six Douglas-firs. J. For. 59: 370-371.

Table 1.-Exemplary data for branch systems on tree #1-a Douglas-fir on Watershed 10,H.J. Andrews Experimental Forest

Branch #	Height -m-	Compass Direction	Main Branches #	Extension from Trunk -m-	Total Length of Branches: Live -m-	Total Length of Branches: Dead -m-	Maximum Diameter -cm-	Area of Branch System -m²-	Density of Foliage -%-	Lichen Cover: All Species -%-	Lichen Cover: Lobaria -%-	Bryophyte Cover -%-	Importance Value #	Running Totals #
88	59.1	TOP	1	1-3	1-5		30	2-5	10-20	40-60	40-60		15	15
87	59.1	S	1	1-3	1-5		6	1-2	20-40	0-20	0-20		13	28
86	58.8	W	1	1-3	1-5		6	1-2	0-20	0-20	0-20		11	39
85	58.5	E	1	0-1	0-1		5	0-1		0-20	0-20		5	44
84	58.2	W	1	1-3	1-5		5	1-2	0-20	0-20	0-20		11	55
83	58.2	N	1	1-3	1-5		8	0-1		0-20	0-20	0-20	9	64
82	58.2	S	i	0-1	0-1		5	0-1		0-20	0-20	0-20	6	70
81	57.6	S	2	1-3	1-5		. 6	2-5	20-40	0-20	0-20	0-20	17	87
22	41.1	W	1	1-3		1-5	Y	0-1		40-60	0-20	0-20	11	949
21	40.8	W	1	0-1		0-1	6	0-1		0-20			5	954
20	40.2	W	1	1-3		1-5	8	0-1				0-20	12	966
At this point the second trunk leaves the tree, 40m, N Compass														
19	39.3	W	2	3-5	5-10		7	5-10	60-80	0-20	0-20	0-20	33	999
18	38.4	W	1	5-10	5-10		8	2-5	20-40	20-40	0-20		22	1021
17	38.1	W	1	0-1		0-1	3	0-1		80-100			9	1030
2	20.4	N	5	3-5	10-15		8	10-20	40-60	0-20	0-20	20-40	41	1378
1	15.9	N	4	3-5	10-15	5-10	10	10-20	60-80	0-20		20-40	55	1433
Data far trunk 2 which left the tree between branch 19 h 20														
128	49.8	W	1	3-5	1-5		6	1-2	0-20	0-20	0-20	0-20	12	1445
127	49.5	N	1	3-5	1-5		6	1-2	0-20	0-20	0-20		11'	1456
93	40.5	E	1	3-5	1-5		12	5-10	20-40	0-20	0-20	20-40	21	2062
92	40.5	N	1	1-3	1-5		9	0-1		20-40	0-20	20-40	11	2073
91	40.2	N	1	0-1	0-1		9	0-1		0-20	0-20	0-20	6	2079
90	40.2	N	1	3-5	5-10		11	2-5	20 40	0-20	0-20	20-40	23	2102
89	39.9	N	1	1-3	1-5		7	0-1		0-20	0-20	0-20	9	2111