Swanson

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Second North American Dendroecological Fieldweek

H.J. Andrews Experimental Forest

August 16-25, 1991

Blue River, Oregon

Introduction

To explore and learn a lot about a small area in detail is a as valuable an experience as a general overview of a large area without detail. This years Dendroecological Fieldweek provided such an experience for those who participated. It was a chance for experts in the field of dendrochronology to demonstrate to others how tree-ring techniques may be used to examine various disparate subject areas in environmental research. At the same time, those who participated received a first-hand experience in conducting scientific experiments with tree-rings properly. Developing hypotheses, collecting samples, analyzing data, and discussing results are the significant activities emphasized during the Fieldweek.

The 1991 Dendroecological Fieldweek proved it's worth to the scientific community. It is now recognized as both a valuable educational and scientific program. During the nine days that this group worked together many new ideas and theories were shared and explored. From the development and construction of a new tool for non-destructive sampling, to the discovery of climatc sensitive western junipers growing on recent lava beds, Fieldweek participants proved that cooperation is the most effective single tool in science.

The future of the Fieldweek looks promising. Already plans are being made for next year's program. Continuing in the spirit of this newly created tradition, next years Fieldweek will be organized by the graduate students of the University of Arizona's, Laboratory of Tree-Ring Research. Student involvement in both the organizing and participation of the Fieldweek is paramount to preserving it's youthful and progressive approach to environmental research.

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Population and Growth Responses of *Populus trichocarpa* and *Alnus rubra* to Climate and Disturbance in a Riparian Environment in western Oregon

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I. Introduction

Disturbance-mediated processes are well documented in riparian environments, (e.g., Baker 1990), and dendrochronological techniques have been used extensively to date flood events, particularly in western Canada (Parker and Jozsa 1973, Gottesfeld and Gottesfeld 1990). Yet little information is available concerning the response of *Populus trichocarpa* and *Alnus rubra* to flooding and varying climate regimes in the western Cascades of Oregon. Both species are common in riparian environments in northwestern North America. *Populus trichocarpa* is a fast-growing, nutrient and water-demanding species which often grows to more than 100 cm diameter at breast height (1.4m; dbh), and to almost 200 years in age. *Alnus rubra* is also fast growing, but usually reaches diameters and ages of no more than 50 cm and 70 years, respectively. It is an important successional species throughout the western Cascades and Coast Range (Fowells 1965).

The main objective of this study was to determine the distribution, age structure, and growth characteristics of *Populus trichocarpa* and *Alnus rubra* growing along a profile perpendicular to the McKenzie River, Oregon. Because elevation rises in discrete overbank zones with increasing distance from the river, this profile may represent a gradient of decreasing available water and increasing disturbance frequency. If this is the case, distribution, age, and growth characteristics of trees should increase discretely with distance from, or elevation above, the river. Furthermore, stand-initiating flood events should be detectable from establishment dates of *Populus* and *Alnus* or from discrete changes in radial growth in these species.

II. Study site

The study site is the northern edge of an island located close by the southern bank of the McKenzie River at an elevation of 450 m a.s.l., 44 10' N, 122 20'W in the Willamette National Forest, Oregon. The McKenzie River is a fifth order stream approximately 100 m wide at the study site. Highest flow rates occur from November through May. We know of at least two major flood events which occurred in December 1964, and in the mid-to-late 1880s.

The 85 ha island, approximately 2000 m in length and 500 m in width, is dissected by a complex network of flood channels, most of which are dry during the summer drought and active from November to May. The surface consists of both erosional and depositional environments, and is underlain by cobbles beginning at depths from 5-50 cm.

Tree species include *Alnus rubra, Populus trichocarpa, Acer macrophyllum, Fraxinus latifolia, Cornus nutallii, Pseudotsuga menziesii, Calocedrus decurens, Thuja plicata, Abies grandis* and *Tsuga heterophylla*. Generally, *Alnus* is found closest to the river bank, then mixed hardwoods, dominated by *Populus*, at intermediate distance, and mixed hardwood-conifer forests furthest from the river's edge. The forest is extremely heterogeneous horizontally and vertically, and this heterogeneity has increased recently owing to a severe January 1990 storm, which caused numerous discrete areas of damage to all arboreal species except *Alnus*.

III. Methods

Three 10-meter-wide belt transects running from the river's edge southward toward the center of the island were located randomly, separated by distances of 58 meters. The transects were 145, 125 and 100 m long, and traversed the *Alnus* and *Alnus/Populus* communities, ending at the edge of old-growth mixed coniferous-deciduous forest. Elevation relative to the water level of the McKenzie River was measured along a center line, with special note made of breaks in the topography. Trees were located on the transects by measuring distance at a right angle from the center line.

Each stem over 10 cm was given an identification number and was measured for dbh. Additionally, canopy position (dominant, codominant, intermediate, or suppressed), canopy condition (normal, dying, topkill, broken) and degree (0-15%, 15-25%, 25-50%, 75-100%) and direction (0-360) of stem lean were noted. Thirty-five *Alnus* were cored on Transect 1, whereas, 27 of 29 *Populus* found on all three transects were cored. We extracted two cores per stem, noting bark thickness, and height and relative position at which each core was taken.

Cores were transported to the H.J. Andrews Experimental Forest in marked paper straws, and processed as described in Swetnam et al. 1985. In summary, they were dried, glued to wooden core mounts, and sanded with increasingly fine grade sand paper (100, 220, 400 grade). All cores were skeleton-plotted and crossdated. The 37 best crossdatable *Populus* cores were measured on a tree-ring measuring table connected to a microcomputer equipped with the TRIMS1-1 tree-ring measuring program ([c] Madera Software 1986). We used the program COFECHA (Holmes 1983) to assess the series intercorrelation of the cores and potential dating problems, and from this developed a master tree-ring chronology of the 10 best cores. Using ARSTAN, a time-series oriented tree-ring standardizing program (Cook 1985) we determined the tree and site summary tree-ring indices. Using PRECON (H.C. Fritts, Laboratory of Tree-Ring Research, University of Arizona, Tucson, personal communication), we developed climate-growth response models to determine if climatic response varied over the lifespan of the trees.

IV. Results and discussion

The cross-sectional profile of the three transects can be classified into four river overbank zones based on elevation and distance from the present river bank: a low-elevation zone adjacent to the McKenzie River, a higher-elevation zone beginning at what was probably a flood-stage river bank, a second low-elevation zone on either side of a flood-channel, and finally a second high-elevation zone that continues across the rest of the island, interrupted by several flood channels. The relief on the island varies from 0 to 3 m above summer river level. One hundred and eight-seven stem (500 stems/ha) with a total basal area of approximately 45 m^2/ha were found on the three transects. Stem maps clearly show *Alnus* occurring in the two low-elevation zones, and *Populus* in the two higher-elevation zones. Conifers were restricted to the second high-elevation zone farthest from the river bank.

Age and dbh increases with distance from the river bank for both *Populus* and *Alnus*, suggesting a gradient of decreasing disturbance frequency and severity. Overall growth rates (age/dbh), however, do not vary with distance from the river, suggesting that site quality is similar across the profile. Establishment dates appear to coincide with major flood events; 22 of the 35 *Alnus* stems aged on Transect 1 established within five years of the 1964 flood. Also notable is a cohort of *Populus* and *Alnus* that established as early as 1880, but for the most part during the early 20th century. These trees could be the remnants of a larger cohort of hardwoods that established after the late-1800s flood and have reached the end of their lifespan (Fowells 1965).

The master tree-ring chronology showed a series intercorrelation of 0.582 and a mean sensitivity of 0.251, indicating that the cores were in fairly close agreement and that the trees were responding in a similar fashion to climate. Overall, we found that tree growth is positively related to cool, wet late summers. By calibrating the series to the periods 1930 to 1955 (trees at younger ages) and 1955 to 1980 in PRECON, we found that climatic response of the trees was much stronger in the earlier period than the later period. Using deuterium/hydrogen ratios, T. Dawson and J. Ehleringer (personal communication; Department of Biology, University of Utah, Salt Lake City) found that in the riparian hardwood species *Acer negundo*, trees depended on surface water in the early part of their lives, but became relatively independent of annual climatic variations when root systems reached groundwater later in life. A similar model of surface water dependence, followed by groundwater usage would account for our observed change in climatic response by the *Populus* trees. However, because of the temporal restriction of 30 years and the limited number of sample cores, this conclusion must remain tentative. Further measurements and careful re-analysis of the remaining *Populus* and *Alnus* cores would help resolve this question, and this analysis is presently underway.

Summary.

1. Tree species occur in discrete elevational/distance zones.
2. Age increases with increasing distance from the river.
3. Dbh increases with increasing distance from the river.
4. Growth rates do not vary with distance from the river.
5. Periodic flooding appears to structure this community.
6. Trees were more responsive to climate in early years than in late years.

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DENDROCHRONOLOGICAL INVESTIGATIONS IN THE VICINITY OF COLLIER GLACIER

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Introduction

Volcanic and glacial history of the Cascade region for the last millenium is not well documented. Recent photographic evidence indicates that Collier Glacier has retreated from a position abutting Collier Cone in 1940 to a higher position 1.5 to 2.0 km south of Collier Cone by 1965. Although the extent of the Collier glacier during the so-called "Little Ice Age" is not well known, a glacially sculpted valley west of Collier Cone offers a potential pathway. Spatial distribution of old trees within this valley should provide insight into the presence and movement of the glacier prior to 1900. Additionally, growth characteristics of the trees closest to the glacier may reveal the influence of glacial microclimate. Furthermore, the high frequency of eruptions in this part of the central high Cascades, the dates of which are only poorly known or unknown may affect tree growth and allow recognition of absolute dates of these early historic and prehistoric eruptions. With these questions in mind, a group of six members from the Dendrochronological Fieldweek Workshop (August 16 to 24, 1991 at the H.J. Andrews Experimental Forest, Blue River, Oregon), sampled trees in the valley west of Collier cone.

Methods

Field work was conducted in the Three Sisters Wilderness Area on August 19 and 20, 1991. Four sites were chosen at increasing elevations progressively closer to Collier Cone. Mountain hemlock (*Tsuga mertensiana*) was sampled at sites A, B, and C while whitebark pine (*Pinus albicaulus*) was cored at site D. At each mountain hemlock site, six trees were cored at approximately breast height (1 - 1.5 meters above ground). If the tree provided an unsuitable core, a second core was taken or another tree was chosen. Cores of krummholtz whitebark pine were taken 25 cm above the ground. We selected for trees of maximum age based on tree diameter and avoided sampling trees growing in clumps. We unexpectedly discovered a fresh-appearing "boulder train" composed of a long, narrow ridge of unsorted sands, gravels, and boulders. This interesting feature prompted us to expand sampling to include flood-scarred trees at the terminal end of the "train" as well as a wedge of wood from a snag in the "train" center. In addition, we took cross sections from two 1.5 meter tall mountain hemlock saplings to estimate the tree ages at breast height. Photographs were taken of each site and of the over-all geography of the study area.

In the lab, each core was dried in an oven for two hours at 70 degrees F and air dried over night. We mounted, dried, and surfaced the cores. All samples were skeleton plotted to establish ring-width patterns for crossdating. We found no strong similarities to established chronologies from Oregon and California, therefore, we had to develop our own chronology. Important "marker" rings included narrow rings at 1972, 1962, 1953, 1943, 1916, 1899, 1880, 1866, 1862, 1840, 1820, 1810, 1801, 1775, 1742, 1715, 1710, 1668, 1640 and wide rings at 1905 and 1839. Each core was examined by at least two individuals during the dating process. We determined inside dates for each mountain hemlock core, dated damage to the trees associated with the "boulder train", and dated and measured whitebark pine ring widths.

RESULTS AND DISCUSSION

Inside tree dates from the lowest elevation site A range from 1598 to 1752. None of the cores reached the pith but 4 showed ring curvature. At site B, inside tree dates range from 1589 to 1732, one core that reached the pith dated to 1647, and 4 cores showed curvature. Inside tree dates at site C range from 1573 to 1717, 4 of which were near the tree center. Where curvature permitted, we estimated the number of rings from the inside of the core to the center of the tree. To estimate the number of years required for a tree to reach breast height, we averaged the ages of two hemlock sapling cross sections (52 and 54 years) with age measurements from two cored saplings (15 and 18 years). This value of 35 years was then added to the ages of all the trees from the three lower sites. Additional time could be added to reflect a time period between glacial retreat and invasion of the exposed land by trees ("ecesis"). Our observations of the treeless surface exposed over the past 40 years by the Collier Glacier retreat suggest a minimum of 40 years for this time period.

The oldest trees at sites A, B, and C are 450, 490, and 520 years respectively. Based on our sample size, we cannot state that there is a significant trend in tree ages with elevation in the valley. It appears the Collier Glacier could not have occupied this section of the valley during the "Little Ice Age" back to 1450. Because the ages at the highest elevation site are not different than those at the lowest elevation site, no rate of retreat or reestablishment of forest can be calculated.

Three of the six whitebark pines crossdated, the oldest of which was 222 years. These dates indicate that the trees were well established on Collier Cone before the glacial advance evident in the 1940 photos. Ring widths for whitebark pine crossdated with the mountain hemlock but tended to be more narrow. Ring-width measurements indicate a growth release during the 1950's and 1960's on 2 or possibly 3 of 3 cores measured. This release may represent the growth response of whitebark pine on Collier Cone to temperature amelioration due to glacial retreat. A larger whitebark pine sample is necessary to further test this response.

Cores from the scarred trees next to the "boulder train" date a possible flood event to 1955. In addition, the standing snag in the center of the "train" has a possible outer ring of 1920 or 1955 with an indication of injury 12 years prior. A small scale flood may have damaged the tree growing in the center of the channel and a later, larger scale movement of water may have killed the tree while damaging the trees on the periphery of the channel.

Yamaguchi (1983) demonstrated tephra eruptions at Mount St. Helens could be dated by the occurrence of an anomalous series of growth rings and was able to date eruptions at 1800 and 1480. We examined cores from the Collier sites for similar patterns of reduced growth that might reveal evidence of local volcanic eruptions within the Three Sisters area. Most of the mountain hemlock cores showed drastically reduced, or absent, radial growth in 1810, often followed by a narrow ring in 1811. Some of the 1810 rings of significant size have evidence of frost damage. This sequence may indicate a local eruption but coincident frost damage in 1810 in southern Sierra Nevada subalpine trees may point to a more widespread regional event. A map of deviations of reconstructed 1810 spring temperatures from the long-term average suggests it was warmer than average, perhaps providing conditions favorable to early growth and therefore susceptible to damage from late ice storms.

CONCLUSIONS

1. The valley which doglegs west from Collier Cone was not occupied by the glacier, except perhaps in it's extreme upper reaches, in the past 500-550 years.
2. Evidence for nearby tephra eruptions (Yapoah Cone and Three Sisters being the most probable sources) is lacking in our tree rings with the exception of the 1801, 1810-12, and 1916 years. Frost rings here and in high elevation Sierra Nevada trees suggest the 1810 event was at least regional in scale, however.
3. Krummholtz whitebark pine on Collier Cone crossdate with hemlock, are potentially quite old, and may be useful for monitoring microclimate associated with glacial movement.
4. Scarring of trees associated with the boulder train suggests flooding events in the early 1940's and mid-1950's.

The Difference in Climate Signal Between Douglas-fir and Incense Cedar Dendrochronologies in the Oregon Cascades

by

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Abstract

A high elevation site in the Oregon Cascades was used to test the growth response of two tree species as reflected in tree-ring chronologies, to variability in climate over a period of 100 years. The site -- a scoriacious basaltic lava flow -- was selected because it was expected to provide an environment in which either temperature or precipitation was limiting to tree growth. Therefore, both Douglas-fir and incense cedar were expected to exhibit a pronounced growth response, i.e. sensitivity, to climate. We hypothesized that incense cedar would be more sensitive to climatic factors than Douglas-fir based on higher variability in ring width increments of early cores. Tree-ring chronologies were constructed and analyzed using the latest dendrological techniques, including the statistical and modelling stength of COFECHA, ARSTAN, and PRECON. Results show that annual ring-width growth in Douglas-fir varies more with climatic factors than does incense cedar. Results also indicate that both species are less sensitive to climate on the lava flow than trees on an adjacent, more weathered lava flow. Neither a 2.5°C increase in temperature nor a 20% increase in precipitation -- a scenario predicted for the area by several global climate models -- changes growth in either species significantly at this site, as predicted by PRECON. However, the results of this study must be interpreted with caution. Sample size was small and time limitations precluded a more rigorous exploration of factors controlling variability in tree growth at this site.

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[1] Errors in grammer and spelling are the fault of this author.

Introduction

Climate is an important factor limiting the growth of trees. The growth response of trees to climate as recorded in tree-ring chronologies may vary in different species and between different environments. The climate signal as reflected in annual tree-ring widths is clearest in trees which grow under conditions where temperature and available soil moisture are limiting. Ring widths of these individuals vary most in response to climatic fluctuations in precipitation and temperature (Fritts, 1976), a characteristic called "sensitivity". Growth increment has the lowest resource priority over other necessary metabolic and growth functions, such that its size is an indication of remaining resources available after the needs of the tree have been met (Waring and Schlesinger, 1985). Small growth increments indicate years in which some resource required by the tree -- e.g., water, nutrients, or a temperature conducive to metabolic activity -- was limiting. Because different species use water and nutrients at different rates and may even have intrinsically different patterns of resource acquisition or assimilation, species will vary in their growth response to the same climatic conditions. Years in which climatic factors cause extreme growth limitations may be present regionally.

To assess how two associated species growing in the same environment respond to climate, 100-year tree-ring chronologies of Douglas-fir (*Pseudotsuga menziesii*) and incense cedar (*Calocedrus decurrens*) were compared to a 100-year climate record. These species occur together on a recent lava flow in the Oregon High Cascades Province (province description in Franklin and Dyrness, 1973).

Numerous Douglas-fir tree-ring chronologies have been constructed, but few chronologies exist for incense cedar. This void is surprising given the observation that incense cedar shows higher ring-width variability, characteristic of a climate-sensitive species. The existence of two adjacent lava flows of different ages on the site make possible the comparison between climate responses of trees growing on an older flow with a slightly developed soil and trees growing on a more recent flow without any soil development. A distinct boundary between the two flows made them easily identifiable. Both lava flows are probably younger than 10,000 years, although absolute dating of the flows was not attempted.

Methods

Site Description

The lava field is located in the Blue River District of the Willamette National Forest at 44°19'N, 122°00'W, along Oregon Highway 126 approximately 13 miles east of the junction with Highway 242. The flows are of scoriacious basalt extruded from volcanic vents probably during the late Pliocene and Pleistocene epochs, but possibly as late as upper Pleistocene and Recent (Franklin and Dyrness, 1973). The site is at 3000 feet elevation and it slopes gently west. Vegetation is sparse on both flows, though stand density is lower on the younger flow than on the older flow. On the younger flow, the widely-spaced trees have stunted and gnarled growth forms, some with broken tops. On the older flow, trees are much larger and crown shape is normal (Figure 1. Site sketch). Vegetation consists of an interesting association of trees: *Pseudotsuga menziesii, Calocedrus decurrens, Pinus monticola, Abies lasiocarpa*; shrubs: *Acer circinatum, Rubus parviflorum, Juniperus communis, Pachystima myrsinites, Arctostaphylos patula, A. nevadensis, Ceanothus velutinus, Castanopsis sempervirens, Rhamnus, Holodiscus, Corylus;* and herbaceous vegetation: *Epilobium, Erigonium, Phacelia, Cheilanthes and Sedum*. *Usnea* is present on many trees. Moss and lichen are frequent as groundcover in the older flow, as well as a covering of coarse woody debris, while the newer flow had virtually no ground cover.

Climate Data

Regional records of mean monthly precipitation and temperature were used in the analysis to determine whether tree growth was more strongly correlated to one or both of these climate variables. The climate records represented a mean of stations in a large-scale division defined by the National Climatic Data Center (~~Figure 2. Climatic map of Oregon~~). A continuous period between 1895 and 1983 represented by the division was compared to the same time period in the tree-ring record of each species.

Sampling Methods

Two cores were taken from each tree of the two species of trees sampled. A total of 40 trees were cored, 18 *P. menziesii* and 22 *C. decurrens*. Thirty-two trees from the younger flow and 8 from the older lava flow were cored. Trees were selected on the older flow well away from the transition zone to reduce edge effects.

All cores were mounted, dried, sanded and dated according to standard dendrochronological techniques (Swetnam et al., 1985). Skeleton plots were constructed to provide a crossdate reference while dating cores (Stokes and Smiley, 1968). Time constraints precluded the analysis of all cores. Therefore, 24 of the best cores were selected. The cores chosen included 8 *P. menziesii* and 11 *C. decurrens* from the younger flow, as well as 2 *P. menziesii* and 3 *C. decurrens* from the older flow. They were chosen based on the reliability of the increment sequence and the presence of variability in the ring-width series. Ring-width increment was measured with a Bannister Incremental Measuring Machine (BIMM). Measurements were converted to TRL format for use in later analysis.

Data Analysis

The accuracy of the ring-width measurements was verified using COFECHA, a computer-assisted quality control cross-dating program (Holmes, 1976). The program creates a master chronology of mean ring-widths from a group of trees (in this application from trees of the same species on the same flow) then flags suspect measurements based on correlation with the master chronology. Once verified as to their accuracy, the chronologies were standardized using ARSTAN (Cook et al, 1986). ARSTAN creates three types of indices. To create a standard index, ARSTAN removes the growth trend from the raw ring-width series with a user-defined function. For the purposes of this study, an 80-year rigid spline was used because the trees sampled were much older than the 100-year period analyzed and were no longer in the exponential phase of growth. ARSTAN also creates a residual index which removes the effects due to prior year's growth, i.e. autocorrelation between years. Finally, ARSTAN creates an index that reincorporates the site-specific average effects of autocorrelation. This study was concerned expressly with the standard and residual index types.

The index chronologies were analyzed with PRECON to determine whether tree-ring growth was related to monthly mean temperature or precipitation. PRECON is a statistical model based on empirically derived relationships between existing standardized tree-ring chronologies and monthly climatic data from nearby weather stations (Fritts et al, 1990). PRECON can be used to assess the ability of climate to predict tree growth and to determine the level of significance of the tree growth response to temperature and precipitation. Furthermore, climate trends can be manipulated by the user. This allows predictions to be made of tree growth response to future climatic change.

Results

Comparing P. menziesii and C. decurrens

Results from PRECON show that the response functions of climate variables temperature and precipitation are poor predictors of tree growth for both species at the young lava flow site. Actual growth tends to be more variable than predicted by the model (Figures 3,4). This could be due to the small number of samples analyzed of each species, about half the accepted minimum for dendrochronology. The general correlation between climate and tree growth is similar for *P. menziesii* and *C. decurrens*. Growth is positively correlated with cool, wet summers and warm, dry winters (Figures 5,6). Growth in *P. menziesii* is better predicted by climate variables than growth in *C. decurrens* (R^2_{PSME}=.32, R^2_{CADE}=0.18). Autocorrelation (prior year's growth) in both species accounts for more variation in growth than either temperature or precipitation. When the effect of autocorrelation is removed, significance is evident only in the tree growth response of *P. menziesii* to precipitation. Although tree growth response to temperature appeared consistent, it was not significant. *P. menziesii* growth showed a significant positive response to precipitation when it occured early in the growing season and during the prior year's growing season. *C. decurrens* growth was not as responsive as *P. menziesii* to precipitation but the response was not significant; however, the trend suggests that early fall precipitation is important for growth the following year in *C. decurrens*.

Temperature was not a significant factor in the growth of either *P. menziesii* or *C. decurrens*. However, the trend indicated an inverse relationship between prior summer and fall in both species. The inverse relationship with current summer temperature was stronger in *C. decurrens* than *P. menziesii*.

Comparing Old and Young Lava Flows

The comparison between old and young lava flows was made between uneven sample sizes: the old contained 5 trees and the young contained 19. The old lava flow sample consisted of both tree species. Given these limitations, analysis showed that climate explains 33% of the variation in growth, similar to the growth of *P. menziesii* on suggesting that growth in this species is responding to the same factors, although apparently not to climate. Other factors controlling growth may include exposure to dessicating conditions, mechanical damage like wind or snow, and fluctuations in nutrient inputs, e.g. due to litterfall or precipitation pulses.

Tree growth on the older lava flow appears to be more sensitive to climate than on the younger flow. Ring-width chronologies on this flow are more complacent, however. It is possible that potential factors causing variability in the tree-ring growth on younger flow are absent at this site, reducing noise in the response to climate. The higher density of trees growing on the older flow afforded greater protection from dessication and from mechanical damage, and the groundcover is more evenly distributed which may reduce the variability in the nutrient flux.

Conclusion

The results of this study must be interpreted in light of the small sample of trees used in the tree-ring chronologies. This may have reduced the accuracy of the master chronology. Given more time, at least twice as many samples should have been analyzed. With this in mind, the data showed a greater sensitivity of *P. menziesii* to temperature and precipitation than *C. decurrens*. In the Pacific Northwest, 32% of the variability being explained by climate is substantial. The response of *C. decurrens* to climate is negligible. Climate explains 33% of the variability in tree ring-width on the older flow, showing it to be a site more responsive to climate than the younger flow.

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the younger flow. The trend in growth response was similar to that of the younger flow: positive growth is correlated with warm, dry winters and cool, wet summers. The older flow is the only site where temperature correlated significantly with growth, in this case positive growth is correlated with warm, winter temperatures. Prior year's growth is significantly correlated with current year's growth, however the correlation is much weaker than either species on the younger flow.

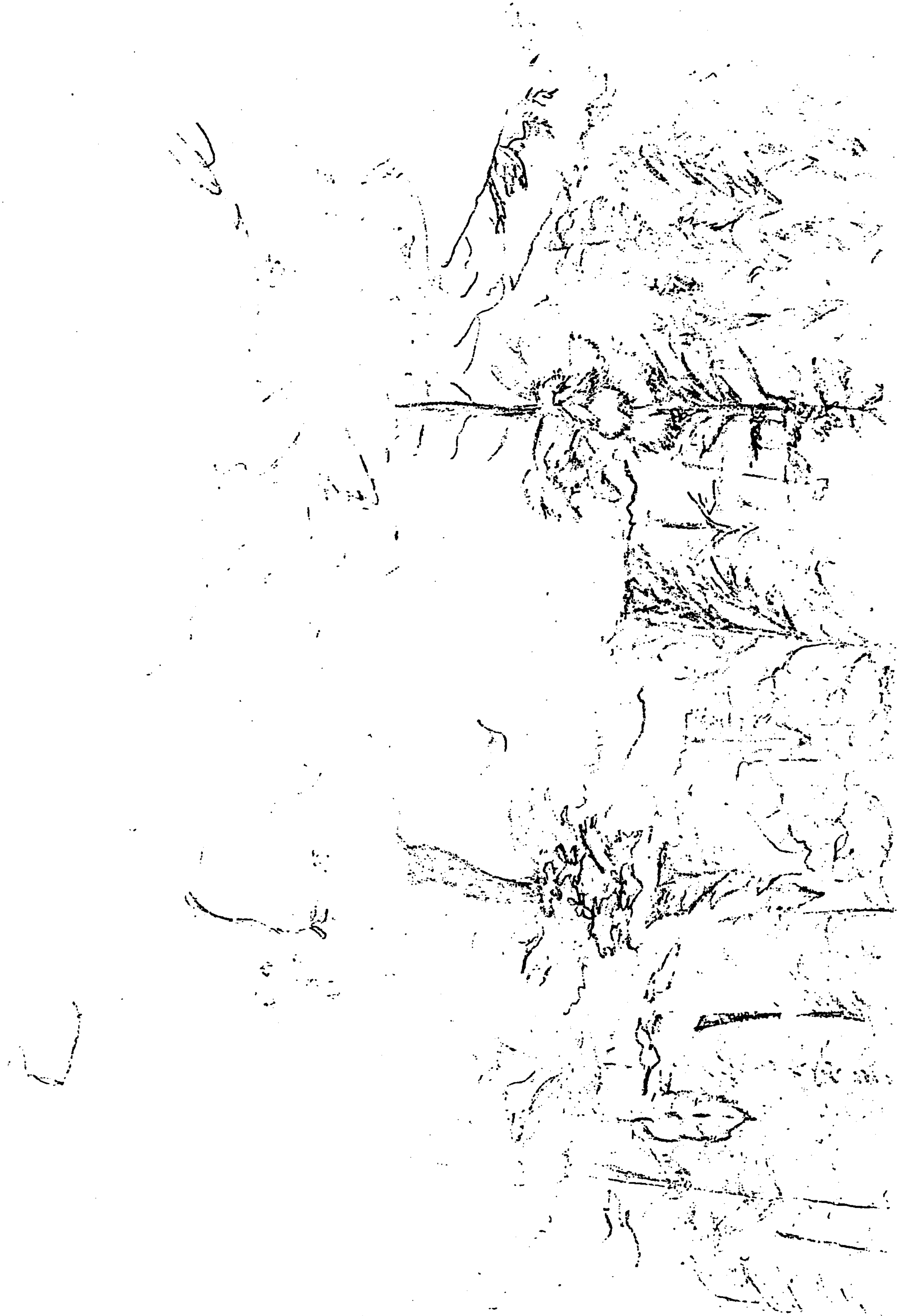
Climate Change

A climate change scenario predicted for the area by several general circulation models shows a step-function increase in precipitation of 20% and a temperature increase of 1.5°C to 3.5°C. We modelled tree growth response to the predicted scenario, using an average step-function temperature increase of 2.5°C concurrent with precipitation change in 1940. This change altered the growth only a small amount for incense cedar on the young flow (Figure 7) and a similarly small amount for both species on the older flow (Figure 8). This small effect could be a result of using an annual effect model for climate change. Temperature effects are correlated with growth positively in the winter and negatively in the summer. Thus the positive response of temperature is cancelled by the negative response in the annual model.

Discussion

That precipitation appears to be an important climatic variable for *P. menziesii* growth at this site, and the only statistically significant climate variable in the study, is consistent with the fact that the soil moisture requirements for *P. menziesii* are higher than for *C. decurrens*. *C. decurrens* is more tolerant of drought and temperature extremes, therefore might be expected to respond less to climate fluctuations. This is, indeed, the case. The positive growth response of both species to cool, wet summers is not surprising given that these conditions allow for photosynthesis in an otherwise hot, essentially lengthening the growing season. Warm, dry winters were positively correlated with increased ring-width in both species, though not significantly. There are several possible explanations for this trend. Dry winters will have reduced snowpacks. Lava may act as a black-body emitter, reradiating absorbed heat, melting snow and effectively increasing the length of the growing season. The same factors may favor winter photosynthesis.

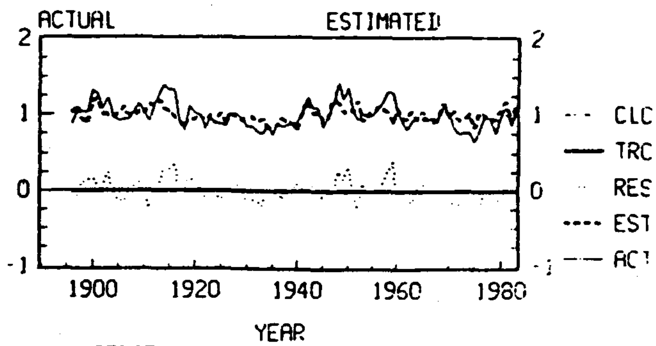
Incense cedar crossdated well among individuals on the younger lava flow,



Douglas-fir

Figure 3

FDF2.SXB N:ORT.MMT N.ORR.MPR ITRDB
TEM AND PRE, 1896-1983, JUL-AUG, ANNUAL
F= 3.50, SD Y,EST,RES= .168 .143 .139
RSQ= .32 CORRELATIONS 5 VARIABLES 0

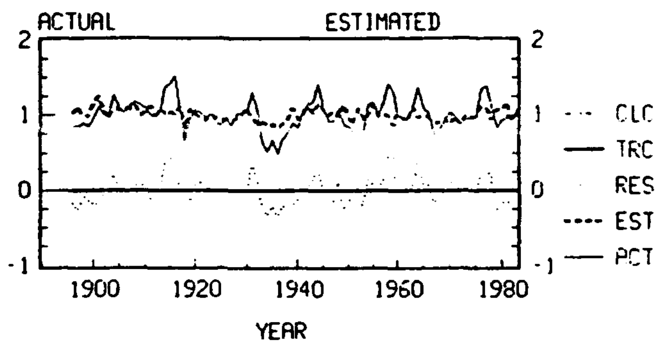


SERIES # 2, NO CHANGE -.04

Incense cedar

Figure 4

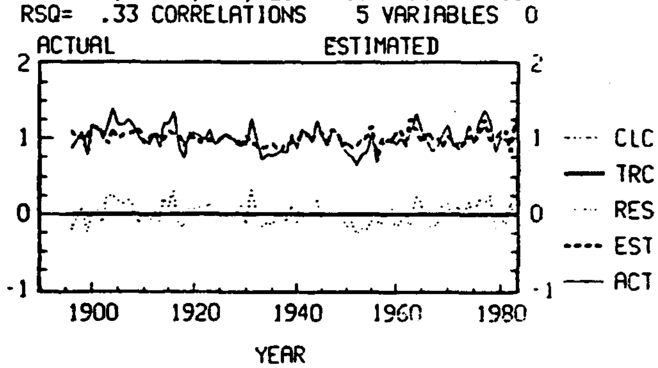
ficsidXB n:ORT.MMT n:ORR.MPR ITRDB
TEM AND PRE, 1896-1983, JUL-AUG, ANNUAL
F= 3.50, SD Y,EST,RES= .200 .184 .181
RSQ= .18 CORRELATIONS 3 VARIABLES 0



SERIES # 3, NO CHANGE -.04

Older Lava flow

foldsiXB n:orT.MMT n:orR.MPR ITRDB
TEM AND PRE, 1896-1983, JUL-AUG, ANNUAL
F= 3.50, SD Y,EST,RES= .164 .138 .134
RSQ= .33 CORRELATIONS 5 VARIABLES 0



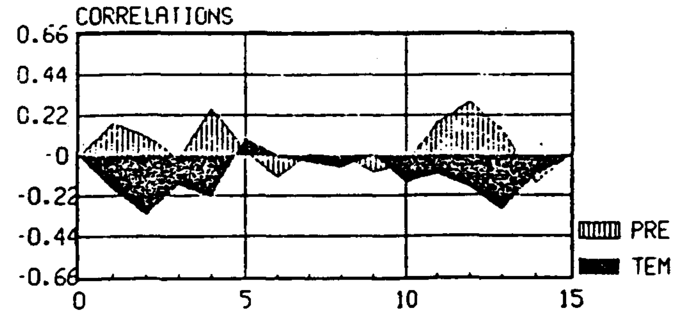
SERIES # 2, NO CHANGE -.04

Douglas-fir

Figure 5

see also 5a

FDF2.SXB N:ORT.MMT N:ORR.MPR DIV 4
ITRDB , TEM & PRE, 1896-1983
FOR JUL - AUG, N: 88
SIG SIMPLE R .22C



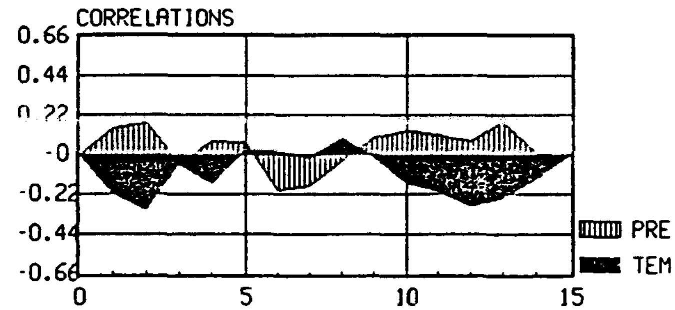
NO 1, 14 MONTHS, JUL - AUG

Incense Cedar

Figure 6

See also 6a

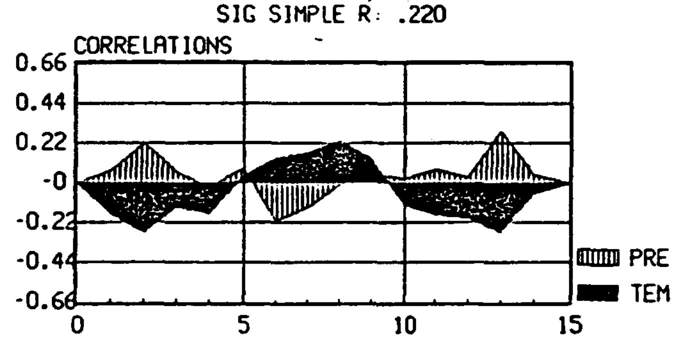
licstdXB n:ORT.MMT n:ORR.MPR DIV 4
ITRDB , TEM & PRE, 1896-1983
FOR JUL - AUG, N 88
SIG SIMPLE R .220



NO 2, 14 MONTHS, JUL - AUG

Older Lava Flow

foldstXB n:orT.MMT n:orR.MPR DIV: 4
ITRDB , TEM & PRE, 1896-1983
FOR JUL - AUG, N: 88
SIG SIMPLE R: .220

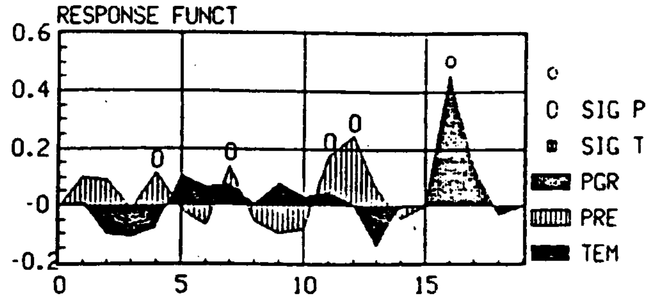


NO 1, 14 MONTHS, JUL - AUG

Douglas-fir

Figure 5a

FDF2.SXB N:ORT.MMT N:ORR.MPR DIV 4
TEM & PRE, 1896 - 1983 ,JUL - AUG, N= 88
20 REP, Rd:.850 +/-.031, Ri:.560 +/-.147
RSQ CL= .277, P GRO= .314, TOT= .591

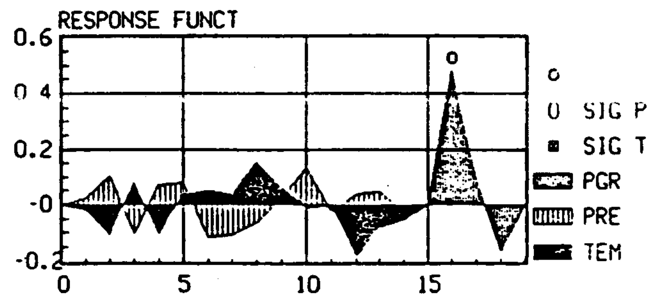


NO 5, 14 MONTHS, JUL - AUG
& 3 YEARS PRIOR GROWTH

Incense cedar

Figure 6a

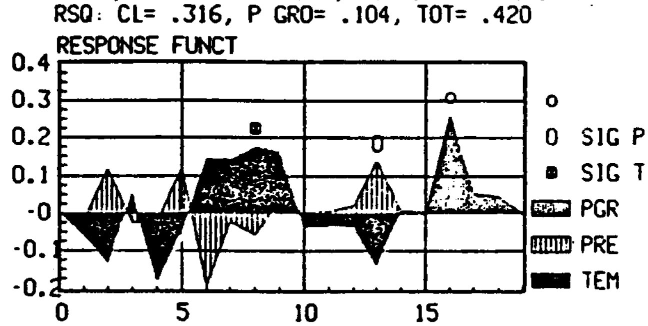
ficstdXB n:ORT.MMT n:ORR.MPR DIV 4
TEM & PRE, 1896 - 1983 ,JUL - AUG, N= 86
20 REP, Rd:.836 +/-.028, Ri:.406 +/-.180
RSQ: CL= .237, P GRO= .260, TOT= .497



NO 6, 14 MONTHS, JUL - AUG
& 3 YEARS PRIOR GROWTH

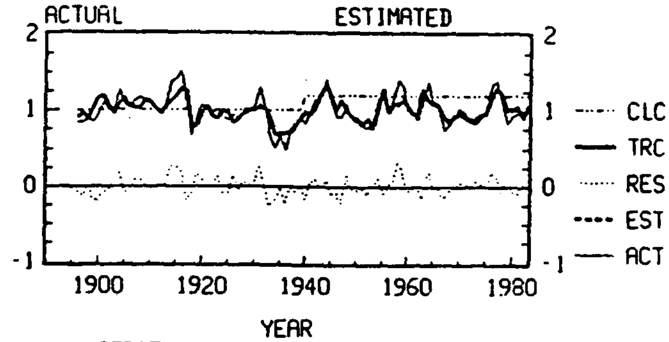
Old Lava Flow

foldstXB n:orT.MMT n:orR.MPR DIV 4
TEM & PRE, 1896 - 1983 ,JUL - AUG, N= 88
20 REP, Rd:.761 +/-.045, Ri:.370 +/-.119
RSQ: CL= .316, P GRO= .104, TOT= .420



NO 4, 14 MONTHS, JUL - AUG
& 3 YEARS PRIOR GROWTH

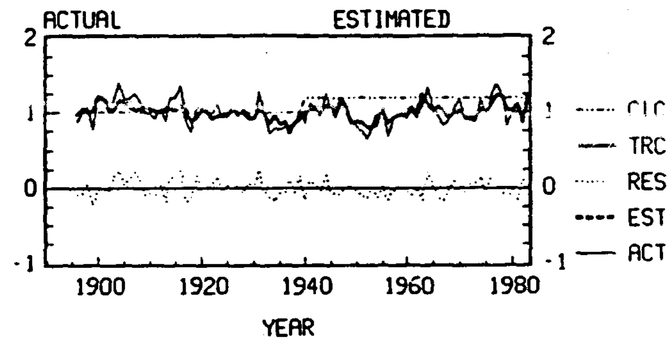
licsidXB n:ORT.MMT n:ORR.MPR ITRDB
TEM AND PRE, 1896-1983, JUL-AUG, ANNUAL
F= 3.50, SD Y,EST,RES= .200 .140 .121
RSQ= .65 RESPONSE FUNCT 31 ENTERED 0



SERIES # 8, PRE CHANGE .20

Figure 7

ioldsiXB n:orT.MMT n:orR.MPR ITRDB
TEM AND PRE, 1896-1983, JUL-AUG, SPRING
F= 3.50, SD Y,EST,RES= .164 .105 .115
RSQ= .51 RESPONSE FUNCT 31 ENTERED 0



SERIES # 7, PRE CHANGE .20

Figure 8

RECONSTRUCTION OF GAP HISTORY AND TREE RESPONSE IN AN OLD-GROWTH DOUGLAS-FIR FOREST

Juan Carlos Aravena, Peter Brown, Matthew Goslin, Randy Stoltmann, Bob Van Pelt, Nathan Poage, Malcolm Hughes

INTRODUCTION

The use of dendrochronology in studying the successional dynamics of mesic forests in the Pacific Northwest has received little attention. Complex endogenous signals due to multiple tree-tree interactions as well as stand-wide exogenous signals have made discerning patterns difficult. A variety of spatial patterns of mortality and decay conditions of logs and snags adds to this dilemma.

Successional drivers in old-growth forests of the Pacific Northwest are related to the creation and closure of small canopy gaps resulting from the death of one to many trees (Spies and Franklin 1989). Although most of these forests were established after catastrophic wildfire, small-scale disturbances are the most important factors in succession of mature and old-growth forests in this region during periods between stand replacement events.

Most gap related studies have looked at total tree ages to discern patterns of gap formation and closure rates as well as successional trends (i.e., Runkle 1981, Veblen 1985, Stewart 1986). These and other studies use ring counts for total age (i.e., not cross-dated) that may or may not represent actual age - particularly with suppressed understory trees. Lorimer (1980) used release patterns in ring width series for stand-wide patterns of disturbance in an Appalachian old-growth forest.

Detailed reconstruction of events leading to and following gap formation has not been successfully attempted in the Pacific Northwest. The goal of this study is to reconstruct the history of a small gap and to use dendrochronology to examine the response of living trees following the known death of canopy trees.

SITE DESCRIPTION

The study site is located on a gentle south facing slope at an elevation of approximately 808 meters in the McRae Creek watershed on the H.J. Andrews Experimental Forest in western Oregon.

The forest on the site is old-growth Douglas-fir/western hemlock in the TSHE/RHMA/BENE plant association. The dominant trees on the site are Douglas-fir 60 to 70 meters in height, up to 1.5 meters DBH and 400 to 500 years old (Franklin and Waring 1980). Western hemlock up to 50 meters tall is also present. Trees in the understory are primarily western hemlock, Pacific yew, Pacific dogwood and Pacific silver fir. Shrubs include rhododendron, vine maple and red and Alaska huckleberry.

Forest fires occurred in the site area in the years 1482, 1532, 1551, and 1566 (Teensma 1987).

Two adjacent gaps were selected in the forest more than 200 meters from the nearest forest edge.

The first gap is located on even ground on a flat to very gentle slope. A large wind thrown Douglas-fir dominates the center portion of the gap. There are also numerous other large downed trees in various stages of decay.

The second gap, to the east of the first, is located in a shallow depression, with the east side rising steeply to a ridge adjacent to a tributary of McRae Creek. This gap appears to be older than the first, featuring two pit/mound formations and fewer but more decayed downed trees.

FIELD MAPPING AND SAMPLING PROCEDURE

Gap mapping methods follow those of Runkle (1987, unpublished). The center of the first gap was located by measuring the intersection of the longest axis of the gap and the longest perpendicular to that. A north-south, east-west Cartesian grid was established with the gap center as origin. The extent of the canopy gap was mapped using a clinometer to sight vertically to the gap edge and assigning corresponding points on the ground Cartesian coordinates.

The location of all trees around the gap perimeter and all trees in the gap over 5 cm DBH were mapped. The gap perimeter was defined as the irregular polygon formed by drawing lines between adjacent trees whose foliage defined the canopy gap. These trees were tagged with identification numbers. Trees were located by measuring the distance from the gap center to the trees and taking compass bearings from the gap center to the trees.

Increment cores were taken from both the gap-facing and opposite sides of all these trees. Small trees, generally those within the gap, were cored right through the trunk.

The location of downed stems and stumps were mapped and decay classes assigned. Increment cores were taken from two of the more recent downed stems, as well as from dead snags and living trees which were damaged by the wind thrown trees when they fell.

During the course of mapping the first gap, it was noted that the two gaps were actually connected to form a roughly hourglass-shaped gap. The mapping and sampling procedure was repeated for the second gap.

LABORATORY METHODS

Increment cores were dried, subsequently straightened where necessary with a "low pressure steam generator," and then mounted. Once mounted they were sanded until individual tracheids were clearly visible. The cores were then counted under stereo microscopes.

Cores were skeleton plotted and cross-dated to form a master chronology plot spanning 438 years from 1553 to 1991. The 1991 ring had incomplete latewood. Some of the trees, particularly suppressed western hemlock and Pacific yew, could not be cross-dated due to reaction wood and wedged-out or missing rings.

Judging from the existing downed stems, significant gap forming events appear to have occurred in this stand in the last 50 years. To illustrate patterns of suppression and release, ring widths in the core samples were measured using a Bannister incremental measuring machine and the TRIMS software (Madera Software 1988) for the period from 1940 to 1991. Graphs of these patterns were generated.

RESULTS

The oldest dateable trees surrounding the gap dated back to the 1550's, indicating that this portion of the stand was established after the 1551 fire.

Core samples from dead snags and logs were cross-dated to provide the death dates of seven trees. The date of injury of tree #90 and the date of death of tree #23 were the same as the date of death of tree #8, 1978. The position of the stem of tree #8 indicated that it struck trees #23 and #90 while falling. Tree #23 was snapped off by the fall of tree #8 and formed its last ring in that year; tree #90 was injured and produced traumatic resin ducts at the beginning of the 1979 growth year.

In the western portion of the site, six dateable trees -- #9, 11, 12, 15, 18, and 90 -- surrounding the gap showed releases within three years after the 1978 event. In addition, three trees, surrounding and within the gap, which were ring-counted but undateable -- #7, 14, and 19 -- showed releases beginning 10 - 13 years before present. Tree #7 began an earlier dramatic release 28 years before present, corresponding with the death and fall of the an adjacent western red cedar (approximately 3 m south of tree #7) dated to 1962. The death of two other snags, trees #13 and 17, were dated to 1986 and 1951 respectively.

In the eastern portion of the site, six previously suppressed trees within the gap -- #42, 43, 44, 45, 46 and 47 -- showed releases beginning 10 - 15 years before present. Dated tree, #39, showed a release in 1982. Tree #47 also showed releases at 20 and 30 years before present. Tree # 25 began a release 54 years before present. Tree #10, which shared the border between gaps in the western and eastern portion of the site, began a gradual release around 50 years before present. Trees #7 and 9, whose releases were previously noted, also shared this boundary. The death of tree #33 dated to 1951 and the advanced stage of decay of fallen trees in the eastern portion of the site indicate that this portion of the gap was formed considerably earlier than the western section where the 1978 tree fall occurred.

In the case of trees in which two cores were taken, it was found that releases were often present in the core from one side of the tree, but not the other.

Several other pieces of evidence were used to confirm the sequence of gap-forming events. The present spatial pattern of trees and downed trees helped reconstruct these events. Changes in the morphology of previously suppressed trees due to release, particularly evident in the trees within the eastern gap, confirmed the dates of release found in tree rings. Changes in the morphology of trees damaged by fallen trees can also supplement tree-ring dating of these events. A suppressed Pacific yew in the western portion of the site, caused to lean by a fallen tree, exhibited vertical sucker growth occurring after the tree was pushed over. A ring count of a totally bodacious fungal fruiting body, which had changed the direction of its growth as a result of the falling of the tree on which it grew, offered further circumstantial evidence for dating the sequence of events.

CONCLUSIONS

It is possible to date the occurrence of recent gap formation. Three lines of evidence were used:

1) Death dates of fallen trees and snags,

2) Dates of injury in trees hit by dated fallen trees,

3) Release dates on dateable trees.

Cross-dating of dead and fallen trees provided direct evidence of the year of death of canopy trees. Supporting evidence was provided by dates of injury and release from surrounding living trees.

Cross-dating is a necessary procedure in dating dead trees and snags. Ring counts alone are not sufficient for dating living trees. The latter point was demonstrated by missing rings discovered in the cross-dating of two Douglas-firs. A large amount of wedged-out and suppressed rings in understory trees were also found, making it impossible to even cross-date cores taken from these trees. This is because of extreme variability of existing rings and the likelihood of missing rings.

Decay rates in the Pacific Northwest limit how far back dead trees can be dated, although release dates in living trees and the vertical layering of fallen dead stems can provide approximate relative dates.

Two additional questions were addressed in conjunction with the above study.

Are old-growth Douglas-firs influenced by neighboring trees?

This question addresses the hypothesis that the growth of old-growth Douglas-firs is negatively influenced by the number, size, and proximity of surrounding trees. The influence of neighboring trees on focals can be described by neighbor density (Peart, pers. comm.).

Neighbor density was defined in this study to be

SUM [(basal area neighbors) / (distance focal-to-neighbor)]

for all neighbors (DBH $\geq$25cm) growing $\leq$13m from an old-growth Douglas-fir.

The growth of focal trees was negatively correlated (R^2 = 0.1433) with neighbor density, suggesting that old-growth Douglas-firs are subject to inter-tree competition (Figure A). A potentially better (and future) measure of neighbor density might include the crown volumes of neighbors. Crown volume can be calculated accurately from the amount of sapwood present (Van Pelt, pers. comm.).

Is present growth a good predictor of future growth?

This question addresses the hypotheses that growth patterns are age dependent and that these patterns change as individuals grow older. Trees growing well during the early stages of the stem exclusion phase of stand development generally continue to do so throughout this phase (Oliver and Larson 1990). Does this pattern continue during the old-growth phase?

Douglas-firs that grew well during the stem exclusion stage of stand development (age 40-50) continued to do so twenty years later (R^2 = 0.0129; Figure B). However, the growth of the same trees during the old-growth stage (350 years later) was not correlated (R^2 = 0.0129) with earlier growth (Figure C).

Figure A. EFFECT OF NEIGHBORS ON GROWTH
(1982-1991)

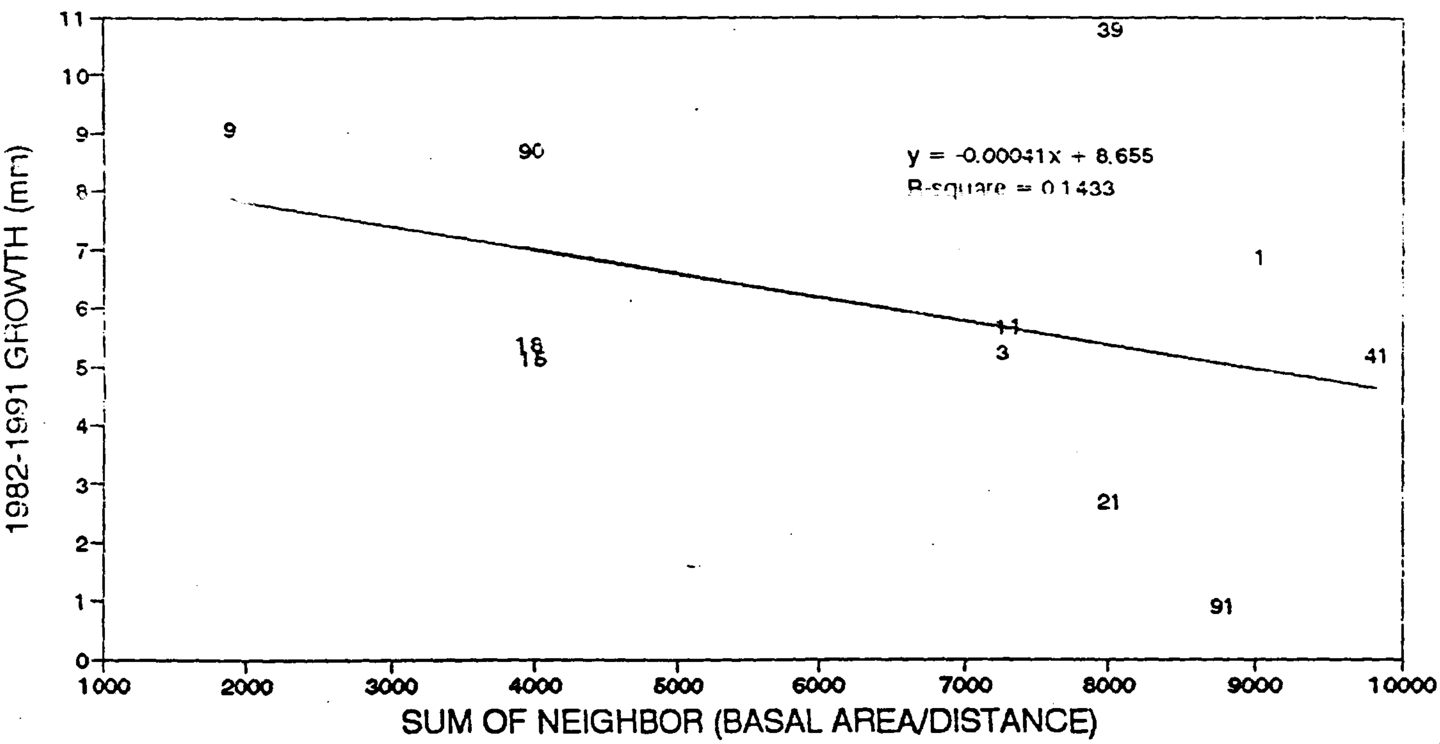


Figure B. 1591-1600 vs 1610-1619 GROWTH

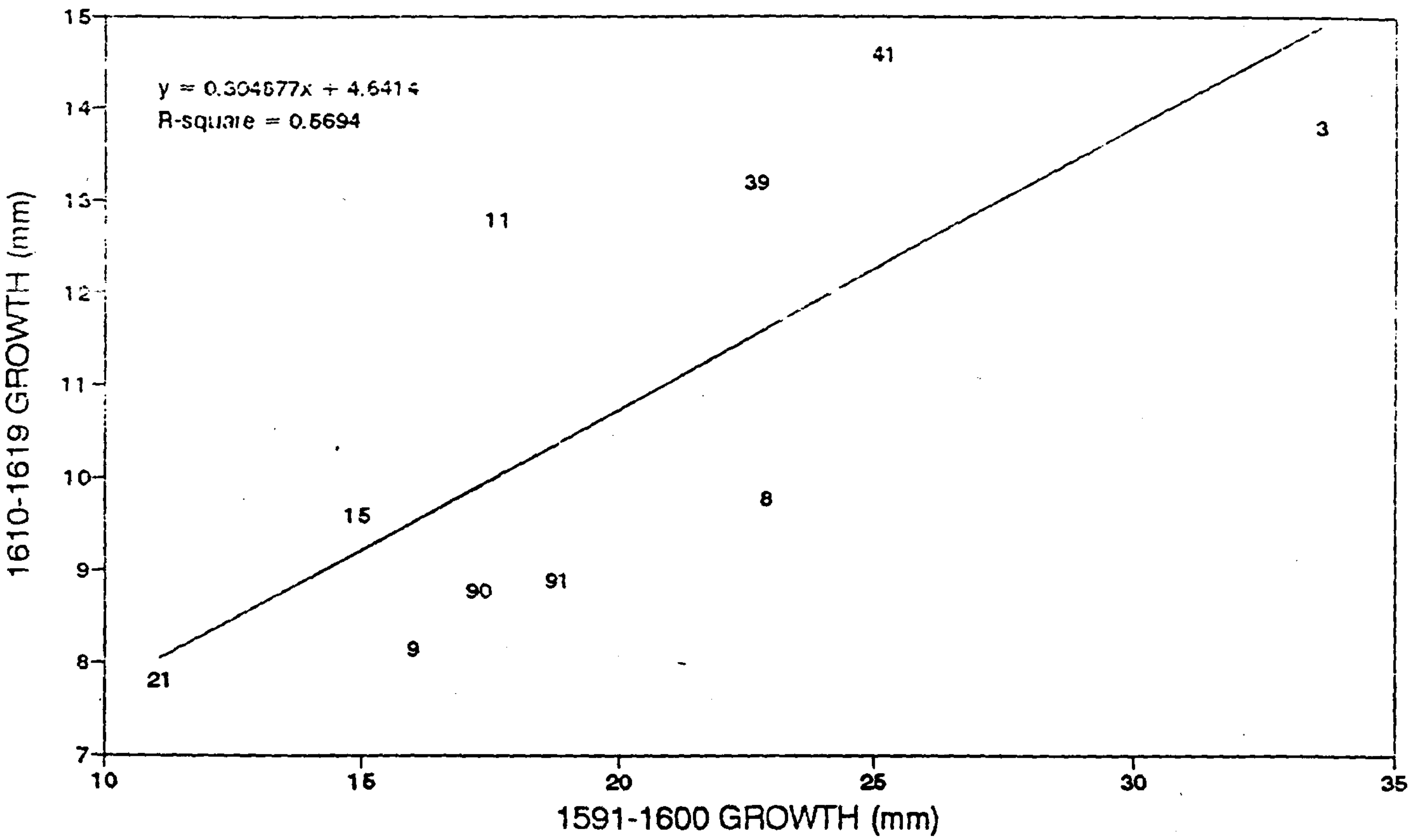
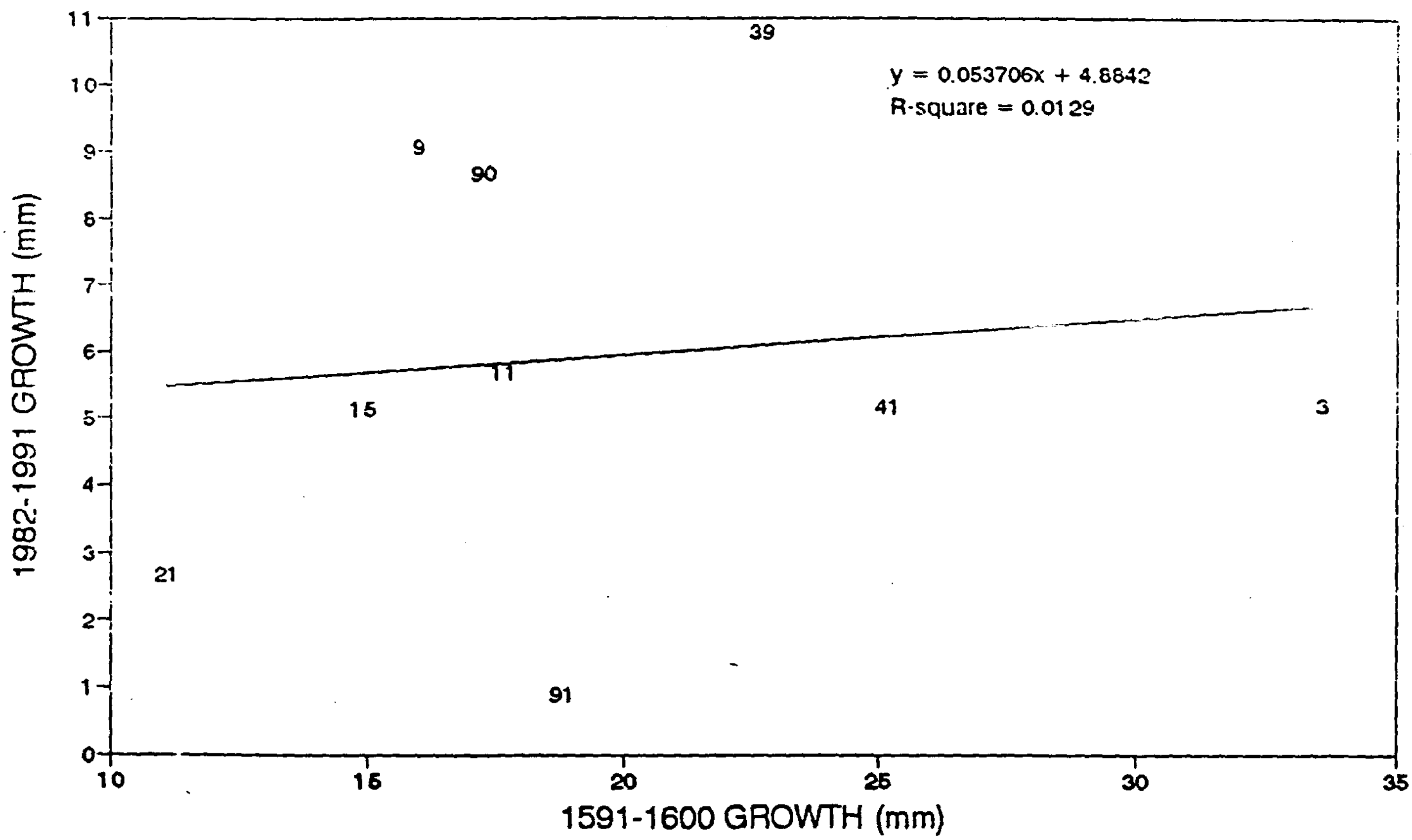


Figure C. 1591-1600 vs 1982-1991 GROWTH



Dating Barked Stripped Trees at Hidden Lake, Willamette National Forest, Oregon August, 1991

Marion Parker, Nancy Voorhis, Paul Krusic[1]

Performed during the 1991
Dendroecological Fieldweek H.J. Andrews Experimental Forest.

Introduction

Since the arrival of the white man to North America the plight of native Americans has been a continual battle in preserving their heritage and culture. Today native land claims and access to natural resources is one of many topical domestic issues facing both local and federal governments. Archaeological evidence of past and present native use is strong evidence in support of land claims. On many federal and private holdings, early Americans have been accustomed to gathering and harvesting natural resources for both their spiritual and domestic livelihood.

Today, the native North American cultures is severely eroding under the pressure to assimilate Anglo norms and mores. Preserving lands and customs deeply associated with a culture is the first step in thwarting it's demise. In this study, an area known for providing natural materials for primitive tool construction was examined to determine how recently native North American Indians had visited the site.

"Culturally-modified trees" (CMT's) are trees or dead-wood material that were altered by early inhabitants. For example, the inner bark of western red cedar was commonly used to make baskets while the tannin from western hemlock reportedly was used to preserve natural fiber products. Near Hidden Lake on the Blue River Ranger District of the Willamette National Forest, Oregon there is a large concentration trees stripped of their bark for such purposes.

[1] Prepared by: P.Krusic

Objectives

Forty-two culturally modified trees have been identified by US. Forest Service archaeologist Eric Bergland. A number of these CMT's had been previously dated using tree ring counts by Mr.Bergland and documented along with photographs and historical accounts from surviving natives regarding their activities in the area (Bergland, 1990). Members of the 1991 Dendroecological Fieldweek archeology group wanted to substantiate the dating of these bark stripping activities near Hidden Lake area and determine whether a new tool could be used to aid in dating CMT scars.

The goals of this study were, to build and test a device to assist in the non-destructive dating of bark-stripped trees and to obtain tree-ring dates from some of the many bark-stripped trees at Hidden Lake for Forest planners developing interpretive programs and trails for the area.

Methods

The first step was to develop and design a tool that could be brought into the field and used to reconstruct interior ring patterns of scared trees without destructive sampling. To relate exterior stem features with interior ring patterns would be to one's advantage when deciding exactly where to drill into the tree with an increment borer. To accomplish this chore a portable frame, similar to a shaper used by carpenters to copy intricate shapes, was built (fig.1). The Parker Measuring Frame (PMF), provided an accurately detailed trace of the trees circumference that was transcribed onto a full scale map. Increment cores, taken at strategic locations around the stem at the same height as the measuring frame, were used to transcribe growth patterns from ring curvature and size directly onto the stem map.

The second technique used to age CMT scars was to core directly through the callus growth near a wound in an attempt to intercept, inter-annual, trauma cells formed at the time of injury. Cross dating cores and identifying precisely the year in which the trauma cells were formed would provide the most accurate scar dates.

Of the seven trees examined in this study five distinctive scar types, relative to scar shape and species and species on which they are found, were defined.

Western red cedar:

Single bark strip, Type: 1;

Characterized by a clean axe cut along the base of the stem and torn bark up the stem 3-5 meters high.

Single bark strip, Type: 2;

Similar to Type 1 only the top and sometimes parallel sides of the scar were also cut with an axe resulting in a distinctly rectangular scar 1-1.5 meters high and 0.5-0.35 meters wide.

Tree-Girdle;

Characterized by a continuous series of axe scars that completely encircled a stem.

Western hemlock:

"D" Cut, Type:1

A backwards "D" shaped scar about 1 meter high and 0.5 meters wide.

"D" Cut, Type: 2

Same as Type: 1 only the bark within the axe cuts has been peeled away.

To age the scars made on cedars both the PMF and discriminate coring were used. The scars on the two hemlocks provided an interesting opportunity to compare growth rate changes both within and above the wound area. From tree #15, 'D' cut Type 1, one core through the center of the inscribed scar, and one outside the scar at the same height was taken. From tree #17 , 'D' Cut Type 2, another two cores were taken one directly above the top of the open scar face and another 10.0 cm. to the left of the scar in the living portion of the stem.

Results

Table (1), presents the results of the scar datings. The tree numbers used to identify individuals are those defined in Burgland, 1990. Dates given in column three are those determined also by Bergland, 1990. For only two trees, scar dates derived during this examination are questionable and deserve notation (tree 12, and A[2]) . Column five describes that technique used to date the scars.

Table 1.

tree #	Species	scar date [3]	Feildweek dates	Method used
2	Western red cedar	1911-16	not-dated	-
7	Western red cedar	not-dated	1946	core
12	Western red cedar	not-dated	1940-41	core
15	Western hemlock	not-dated	1946	PMF
16	Western red cedar	1935-40	1946	core/PMF
17	Western hemlock	not-dated	1943	core
A[2]	Western red cedar	not-dated	1957-67	core

[2] actual tree # unknown

[3] from Bergland, 1990

Once it was possible to relate exterior surface features to hidden, interior ring patterns, a diagrammatic picture of internal wound response to injury was developed (fig.2). This physiological response schematic was used as an aid in coring other trees for which cross-section reconstructions were not performed. Two distinctive features should be noted in this diagram. The first is the accelerated growth release in the callus wood as the tree attempts to quickly close its wound. Second is the resulting reduction in growth beginning about 90 degrees from either side of the wound edge and continuing 180 degrees in both directions. This distinct physical change in growth and the degree to which it is noticeable, is very likely related to the combination of wound size and tree vigor at the time of scarring. It appears to represent a change in carbohydrate allocation in response to injury.

Cores taken from cedars that did not intercept trauma cells were cross-dated and examined for synchronized reduction and release periods resulting from differential allocation priorities. Starting with a known date behind the scar face and counting outward to the beginning of both severe reduction and release periods (path'b' and path'c', fig1.) revealed the year of wounding in nearly all cases. In only one instance, tree #16, a core taken three centimeters from the scar edge intercepted trauma cells within the ring formed during the year of injury (fig.1, path 'a'). In this instance it was not only possible to determine exactly the year the wound was made, but also that time relative to the growing season growing.

Discussion

From discussion with those familiar with the growth of cedar in this area, latewood formation begins in early August. The trauma cells were found two to three cells after the commencement of latewood formation. This position corresponds, seasonally, to the time when those berries sought by Indians are ripe for harvest. This finding provided an unanticipated additional insight into the pragmatic nature of these native people. Since there are no know permanent settlements nearby, those who visited Hidden Lake for berry picking must have travelled some distance. Making their baskets on site reduced the amount of material carried during the journey in.

The cores taken from trees 15 and 17 showed dramatic contrasts in growth rates prior to and following injury. Recall that the scar made on tree #15, 'D' Type 1, did not remove bark from the stem, leaving some living tissue within the incised scar. One core from the center of this scar show a very dramatic reduction of growth beginning the year after wounding. Similarly, from tree #17, 'D' Type 2, one core extracted from immediately above the open scar face also showed a dramatic reduction in growth beginning the year after injury. In both cases the effect of wounding was that akin to a localized girdling of the stem. Growth within and above the scar continued, but at a drastically reduced rate.

Finally, It is interesting to note the close temporal grouping of scar dates. Ignoring the dates from trees #12 and "A", all scars were made within the 1940's.. Possibly a period of hard times for these people, representing a temporary return to subsistence survival practices.

Conclusion

Preserving our nations natural cultural heritage is a part of true stewardship for the land. Areas such as Hidden Lake on the Willamette National Forest hold in their natural splendor a cultural historic record. Tree-ring dating techniques can be used to unfold that history in a non-destructive manner. Leaving intact areas such as Hidden Lake for generations who follow is an investment in civilization both old and new.

References

Bergland E.O., Evidence For Native American Bark Containers From the Western Cascades of Oregon. Presented at the 43rd Annual Northwest Anthropological Conference, Eugene, Oregon. March 23, 1990.

Figure 1.

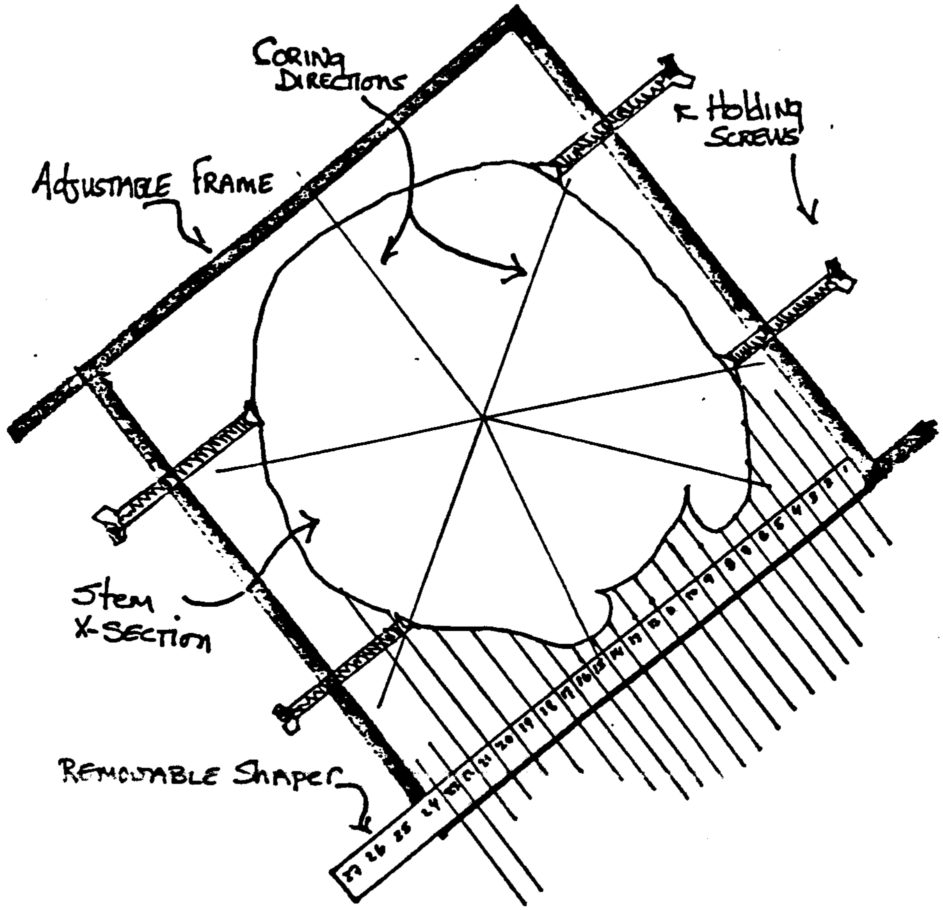
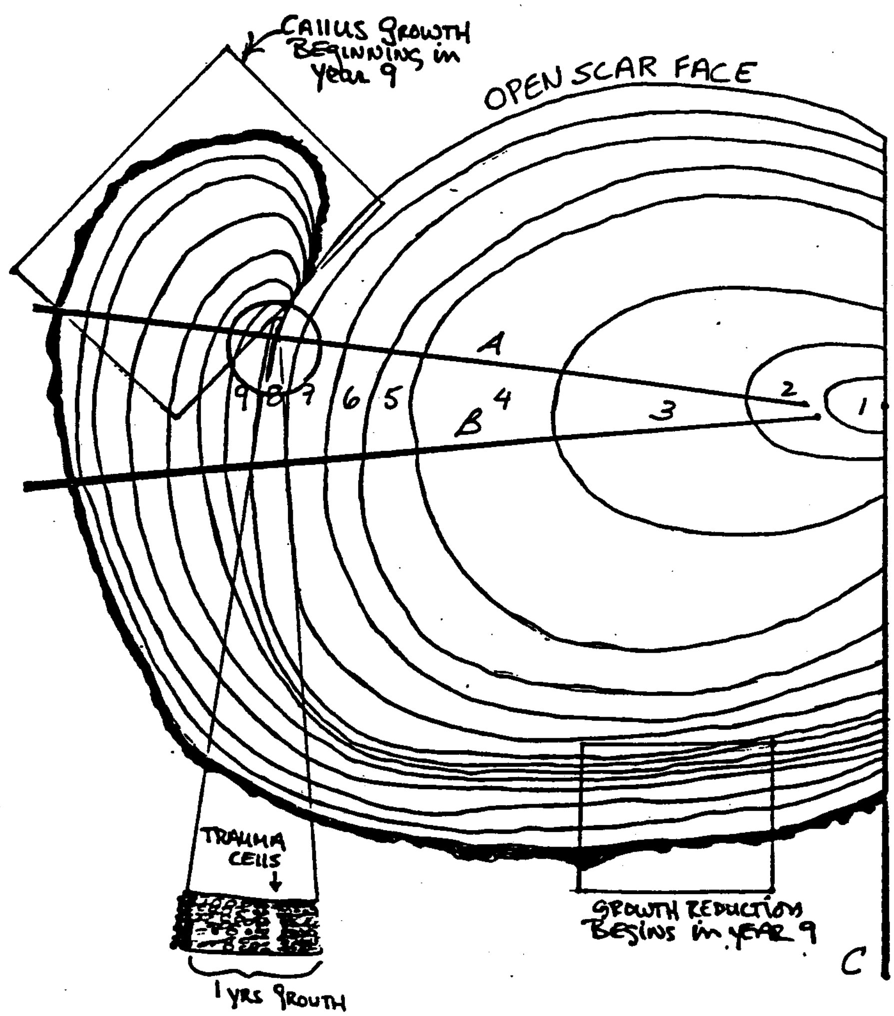


Figure 2.



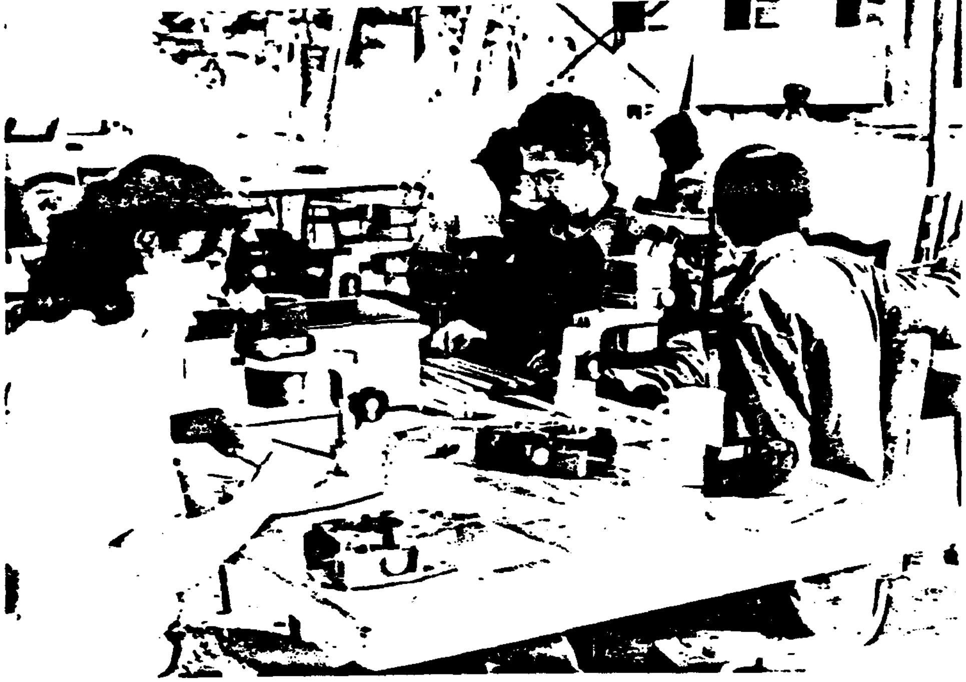
Acknowledgements

The organizers of this years 1991 Dendroecological Fieldweek wish to express their sincere appreciation to the many people and organizations that made this year's program the success it turned out to be. Special thanks go to Dr. "Sam" Sandberg; Program Coordinator, USDA FS Global Climate Change Program, PNW and Dr. Richard Birdsey; Program Coordinator, USDA FS NEFS, Global Climate Change Program, for their financial support. We also wish to thank the IBM corporation, GTSI, and the Digital corporation for their loan of computer hardware and software. Once again, like last year, we want to give recognition to Mr. John Peters; Project Leader, Forest Inventory and Analysis, NEFES, who recognized early the value of these projects and was a continual supporter of them.

Finally we wish to thank the five group leaders Hal Fritts, Malcolm Hughes, Elaine Sutherland, Marion Parker and Steve Leavitt who volunteered their time and experience. District Ranger Audrey Burditt, USFS Willamette Forest, Blue River Ranger District, Dr. Fred Swanson and all the people at the H.J. Andrews Experimental Forest who provided both logistical technical support to our group.

Thank you very much

PJK - Sept. 28, 1991



Members of the riparian study group, cross-dating and examining cores

Nancy Voorhis, UNH Earth Ocean Space Institute,

mounting cores

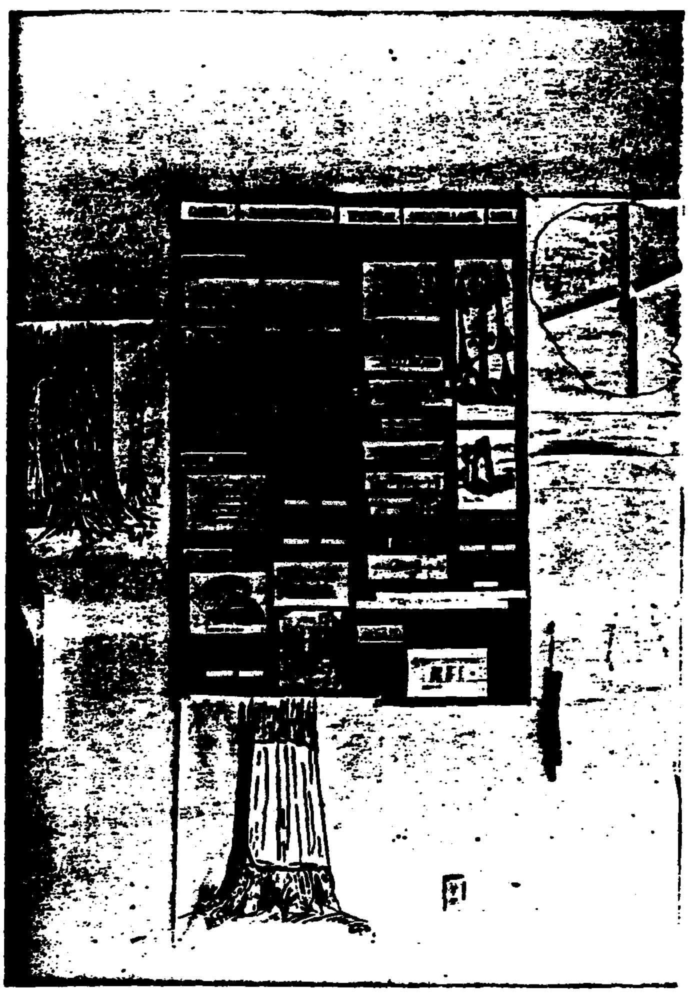
Gary Ahlstrand, NPS, Alaska, admiring innovative Fieldweek solutions.

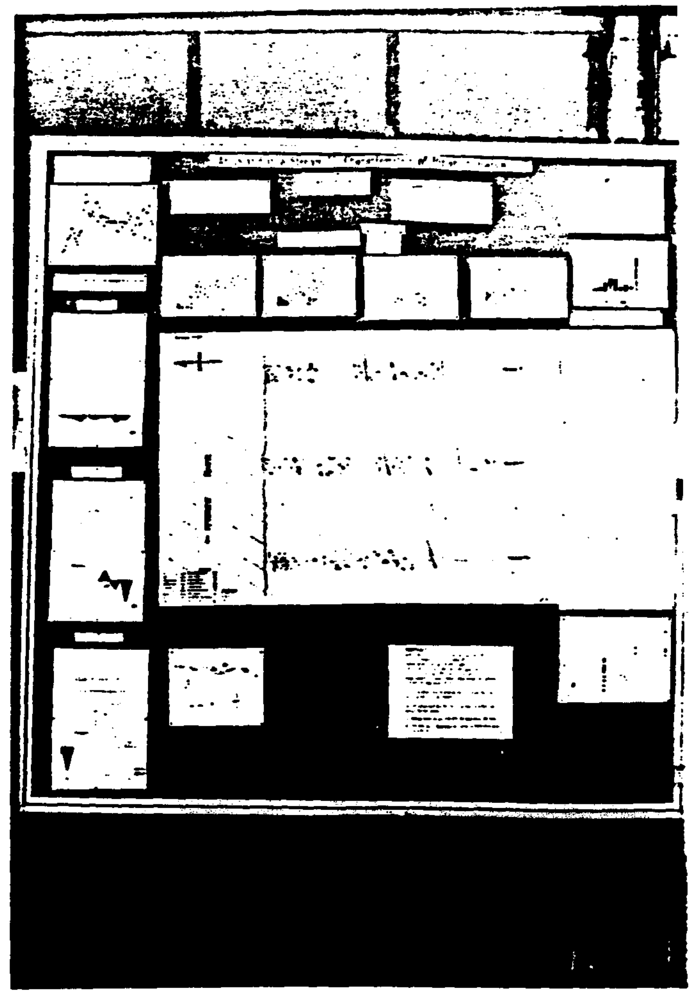
Juan-Carlos Aravena, Chile and Peter Brown, Tucson, mounting cores. In the foreground is the shaper portion of the Parker Measuring Frame.

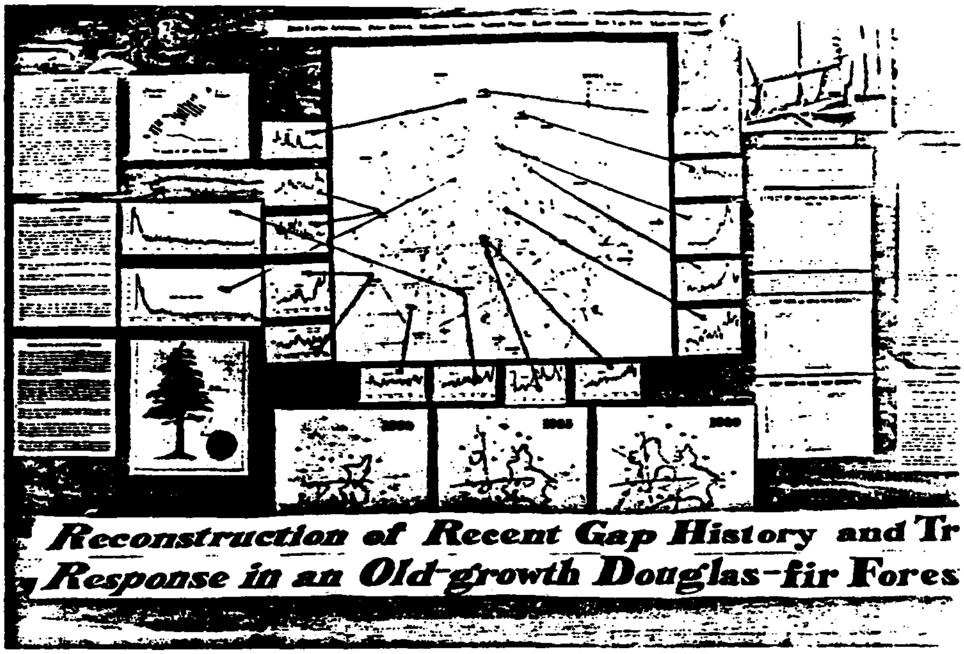
Hector Jimenez-Nunez, Chile, Henri Grissino-Mayer, Tucson and Cristina Paolazzi, Italy, analyzing tree-ring data

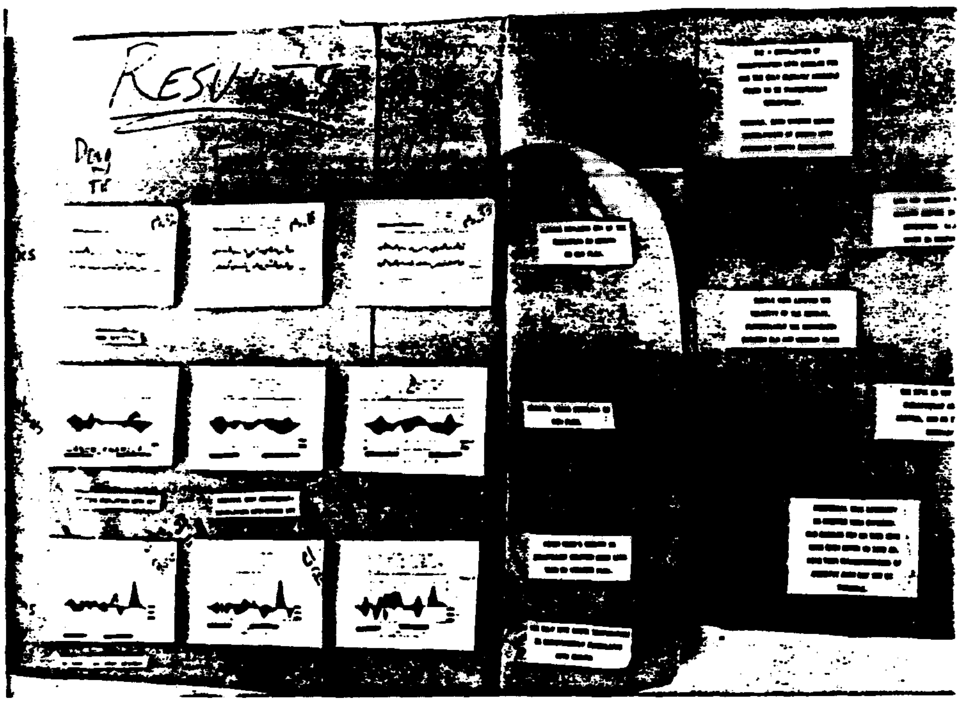
Malcolm Hughes; Director, Tree-Ring Lab Tucson, discussing group strategy with his "Gap Dynamics" Group

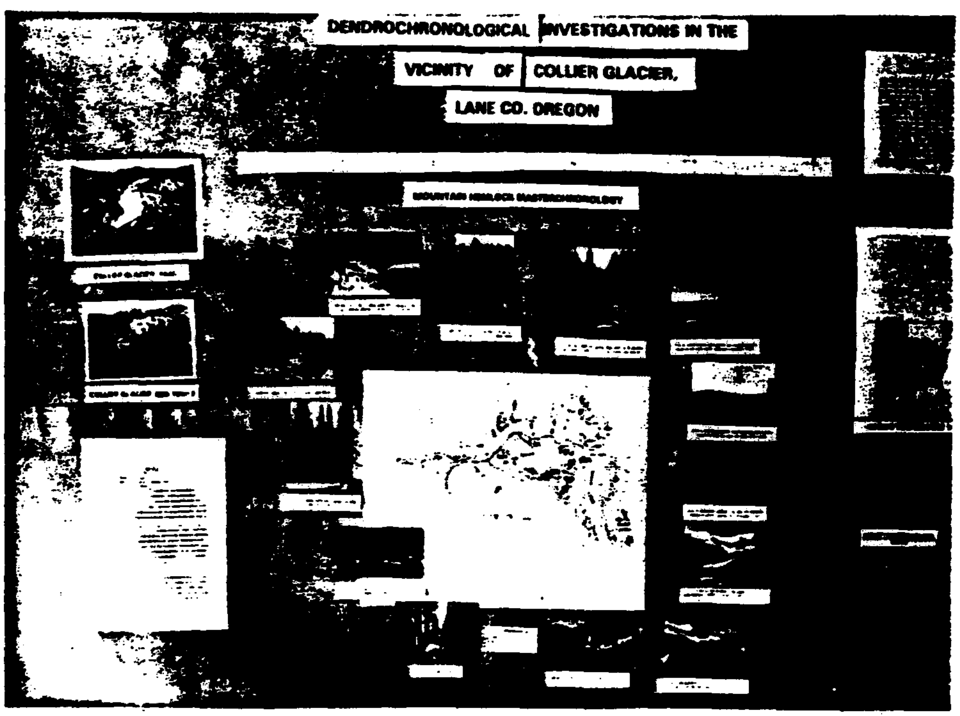
Posters prepared during the Fieldweek






Reconstruction of Recent Gap History and Tr
Response in an Old-growth Douglas-fir Fores




DENDROCHRONOLOGICAL INVESTIGATIONS IN THE
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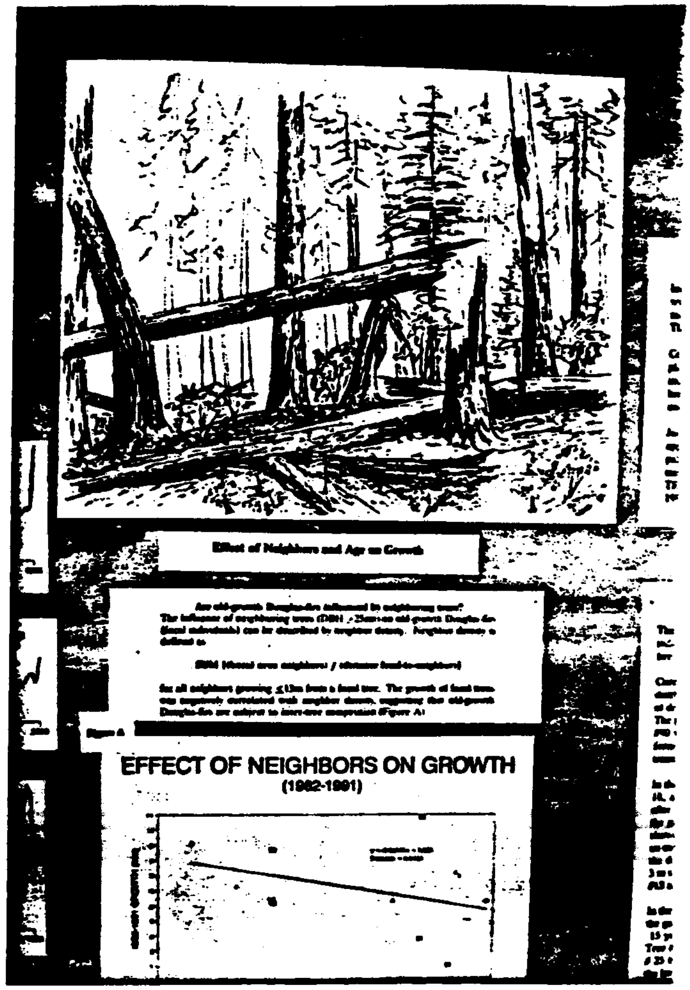

An example of some of the detail that went into the posters

1991 Dendroecological Fieldweek group photo less Malcolm Hughes and Art McKee