Forest Renewal BC Research Program

Final Report

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APPENDIX IV: FINAL REPORT ON PROGRESS TO DATE

Long Term Fire Histories in a Coastal Temperate Rainforest

SCBC Number: FR-98/99-307
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Report for the period April 1, 1996 – March 31, 2000

Abstract

The scarcity of stand-structural evidence of fire is a distinctive feature of the wetter coastal forests of British Columbia. Age-class data indicates that it has been many hundreds of years since the most recent fire in many areas, but stand origin dates are rarely available and fire may have been more common during earlier climatic periods. We employed two approaches to reconstruct fire history in a remote watershed on Vancouver Island: 1) point estimates of time-since-fire (TSF) from tree ages and radiocarbon dates on soil charcoal within a 700 ha low elevation area, and 2) spatially aggregated estimates of fire occurrence from an 1800-year lake sediment record of charcoal within the study area.

For a grid of 83 terrestrial sites, time-since-fire ranged from 1886 AD (64 years before present) to 12220 cal. years before present. Overall, hillslope sites had a significantly shorter median TSF than terrace sites (740 and 4410 years, respectively). The TSF distribution indicated that ca. 20% of the sites have not burned in 6000 years. These areas occur mainly on terraces or north-facing hillslopes that receive little direct solar radiation. Warm and dry summers during the early Holocene were probably necessary to overcome these site-level controls. 35% of the sites have burned in the last 600 years. These areas occur mainly on south-facing hillslopes, and usually contain a seral stand of Douglas-fir and in some locations an association of stunted western redcedar and dense shrub layer of salal. Recurrent fire on these sites was necessary to maintain Douglas-fir in the stand, and possibly contributed to the lower productivity of these sites. Fire intervals were detected at only 16 sites, which showed similar trends to TSF. Fire extent was very limited, rarely extending beyond 250 m.

The lake sediment record suggests fire intervals within a 250 ha area increased sharply at 1100 AD from decadal to centennial scales, coincident with a shift to cooler/wetter conditions found elsewhere in western North America. Comparison of the lake sediment record with the soil charcoal records near the lake provided evidence that fires were spatially restricted and burned the same areas repeatedly. These results suggest that topographic influences on fire susceptibility ensure that large areas do not burn during periods of higher fire frequency. This study significantly increases our knowledge regarding the spatial extent and long-term frequency of fire in coastal British Columbia.

Introduction

The lack of evidence of recent fire is a distinctive feature of coastal temperate rain forest of British Columbia (Canada) (Veblen and Alaback 1996). Late successional characteristics of these forests include a wide range of tree ages and sizes and the notable scarcity of Douglas-fir (*Pseudotsuga menziesii*), a long-lived seral species which establishes following fire and is dominant in most of the remainder of the Pacific Northwest region (Gagnon and Bradfield 1986; Lertzman et al. 1996; Veblen and Alaback 1996). Though there is little visible evidence of recent fire in coastal forests, the long-term frequency of fire has not been investigated in these systems. Periods of higher fire frequency in the Holocene, identified from paleoecological studies in other areas of the Pacific Northwest, may also have occurred in the coastal temperate rain forest (Cwynar 1987; Brubaker 1991; Brown and Hebda 1999).

In addition to gauging the sensitivity of fire regimes to climate change, fire history data studies add to fundamental data on the disturbance processes that drive forest dynamics. In the absence of evidence of other large disturbances, fire records may be used to infer the long-term presence of old-growth forest structure and its associated processes, such as species turnover through tree-fall gap-replacement (Lertzman et al. 1996). Measuring the frequency and spatial patterns of past fire provides an important benchmark to gauge modern (natural and anthropogenic) forest disturbances (e.g. Bergeron and Harvey 1997; Cissel et al. 1999). A management plan that applies a disturbance regime within the historical range of variability is currently the most defensible approach to developing ecosystem-based approaches to management (Scientific Panel 1995).

Forest fires can be though of as contiguous disturbances shaped by climatic and successional effects on fuel load and moisture, and have immediate effects at local (i.e. stand composition and structure) and regional (i.e. the landscape mosaic of age classes) scales (Chandler et al. 1983; Agee 1993). Characterizing a fire regime is difficult if fire frequency and extent vary over time, as is the norm where long-term records exist. For example, drought and fire weather are correlated with fire activity on scales of months (Skinner et al. 1999) to millennia (Long et al. 1998). In mountainous areas, climate interacts with topographic effects on fuel loads and moisture to influence the actual extent of the fire (Turner and Romme 1994). Furthermore, the role of stochastic processes such as ignition decreases at larger spatial scales relative to the role of climatic forcing (Johnson and Gutsell 1994). These scale-dependent properties of fire regimes suggest fire history studies must explicitly address temporal and spatial variability (Lertzman et al. 1998).

There are two main approaches to study the fire history of a watershed, and each is best at showing specific, different aspects of the fire regime. First, the stratigraphy of macroscopic charcoal particles in lake sediment records fire events over thousands of years, though this method aggregates evidence of fires spatially in the vicinity of the lake (Clark 1990). In contrast, tree-ring evidence of stand ages and fire scars is spatially explicit: it records fire dates at a specific point, though this method has a temporal depth limited by the ages of trees. Radiocarbon dates of soil charcoal may increase the temporal depth at some sites, but the poor stratigraphy and damaging effects of fire on soil usually limits this method to estimating the time of the last fire (Hopkins et al. 1993; Carcaillet 1998). No fire history method is particularly effective at estimating both the spatial pattern of disturbances and its long-term frequency. This characteristic property of fire history data being "censored" has resulted in the use of statistical models (e.g. Johnson and Gutsell 1994; Reed et al. 1998) or simulations (e.g. Turner et al. 1994; Boychuk et al. 1997) that often make unrealistic assumptions about the spatial and temporal distribution of fire events (Lertzman et al. 1998). However, utilizing both fire history methods in the same study area may indirectly provide information on the fire regime that is not estimable by either method alone (Clark 1990).

In this study we use point samples (from stand ages and soil charcoal) and a spatially aggregated sample (from a lake sediment core) to better understand the spatiotemporal dynamics of fire disturbance in a coastal temperate rain forest on the west coast of Vancouver Island. This area has large accumulations of coarse woody debris and would be very flammable during summer drought of sufficient magnitude (Agee 1993), though very few fires have occurred in historical times (Veblen and Alaback 1996). The few paleoecological studies from the west coast of Vancouver Island suggest fire frequency has varied considerably with climate change (Brown and Hebda 1999).

Our research objectives may be broken down into three broad groups. Because this study is the first to widely apply soil charcoal radiocarbon dating for fire history in the region, we first critically analyzed the accuracy soil charcoal dates. Next, we obtained soil charcoal dates from a large network of sites in a single watershed to determine the dates of the most recent fires, and the association of recent fire with terrain and vegetation types. Lastly, we used a lake sediment core to determine the dates of all fires within a portion the study area.

Our specific research objectives were to:

A1. Evaluate the reliability of using soil charcoal radiocarbon dates to determine the time-of-last-fire.

B1. Over a spatial network of sites in a low elevation forest, determine the distribution of time-since-fire (TSF) using tree-ring records and soil charcoal radiocarbon dates.

B2. Determine the relationship of TSF and fire intervals to forest vegetation type and topographic variables.

C1. Reconstruct a spatially aggregated estimate of fire frequency using a lake sediment charcoal record, and evaluate the relationship between fire frequency and climate change.

Study Area

This research was conducted in the Clayoquot River watershed, on the western edge of the Vancouver Island Range and 20 km from the outer west coast of Vancouver Island, British Columbia (49°15' N; 125°30' W). The 7700 ha, 12 km long watershed ranges in elevation from 15 m to ca. 1200 m. Unforested high elevation tundra and rock covers 16% of the watershed. The watershed contains many glacial features, including multiple terraces 10–60 m above the river and steep valley walls with slopes of 40% – > 60% and containing many small cliffs. The active floodplain is limited to the lower 4 km of river, and is constricted at several locations by alluvial fans from tributaries. Colluvial material is shallow (< 1 m) or absent on slopes above alluvial fans and terraces. Soils are mainly Ferro Humic Podzols (spodosols), classified in the Sugsaw, Reeses, and Hooper soil associations (Jungen 1985).

The study area was restricted to accessible low elevation areas within the watershed. In the biogeoclimatic ecosystem classification (BEC), the study area occurs in the submontane variant of the very wet maritime subzone of the Coastal Western Hemlock zone (CWHvm1), described as having a wet, humid climate with cool summers and mild winters featuring little snow (Meidinger and Pojar 1991). The study area is at the first rise in elevation to intercept Pacific moisture, and therefore receives a significant amount of orographic precipitation. Mean annual precipitation in the study area is 5400 mm, of which approximately 8% falls in June, July and August (Clayoquot Biosphere Project, unpublished data, 1993-1997). In contrast, significantly less precipitation occurs on the coast (3300 mm at Tofino, 25 km west) and further inland (1770 mm at Port Alberni, 48 km east). Mean temperatures in the study area are 14.5 and 4.9°C in July and December, respectively.

Methods

1. <u>Evaluate the reliability of soil charcoal radiocarbon dates</u>

Radiocarbon dates of charcoal do not date the time of fire, but rather date the time that the carbon in the wood was fixed from the atmosphere (i.e. "grew"). The difference in the age of charcoal and the age of the fire is known as "inbuilt age", and is a common limitation of the utility of radiocarbon dating. The potential effect of inbuilt age has implications for the comparison of two radiocarbon dates. For example, do two dates that differ by 250 years indicate there were two fires 250 years apart, or one fire that burned two pieces of wood that differed in age by 250 years? In forest of the Pacific Northwest, coarse woody debris comprises the majority of fuel in forest fires, and this fuel may be hundreds of years old at the time of fire. However, almost all other studies that utilize soil charcoal radiocarbon dates assume the inbuilt age is less than the standard error of the radiocarbon measurement (Hopkins et al. 1993; Carcaillet 1998).

We compared soil charcoal radiocarbon dates with the actual age of fire determined by tree-ring records. At locations in the Clayoquot Valley where the most recent fire may be determined by tree-ring dates, we also dated soil charcoal collected from the soil surface. A total of 26 radiocarbon dates were obtained from 16 locations where accurate tree-ring-based dates were also available.

2. Fire dates over a spatial network of sites

A network of 83 sites representing a range of forest types and topographic positions was sampled within a 700 ha low elevation area. At each site, the forest was first examined for evidence of recent fire, for instance as indicated by the presence of an even size structure or the presence of Douglas-fir. If an even size structure was found, at least seven trees were cored to age the fire. At the majority of sites, no such stand-level evidence of fire was found. In these cases, 3–5 soil cores were searched carefully in the field for charcoal, paying careful attention to charcoal in the O horizon. Any charcoal found at this time was bagged separately. An additional 3–5 soil cores were taken for later analysis in the laboratory, cutting the cores into 2–5 cm sections if the soil appeared undisturbed. The site was classified by the major vegetation type and as either terrace or hillslope.

In the laboratory, all soil cores were sieved to obtain the best charcoal for radiocarbon dating (total = 542 core sections). This involved soaking the soil in a warm KOH solution, sieving through a 0.5 mm screen, drying the large fraction, and picking charcoal out using a dissecting microscope. The upper-most piece of charcoal was submitted for radiocarbon dating at the Lawrence Livermore Center for Accelerator Mass Spectrometry in Livermore, California. At approximately half of the sites, additional dates were obtained at lower depths or from different soil cores. A total of 152 soil charcoal radiocarbon dates were obtained, of which only two were deemed unreliable because the sample size was very small and the dates were anomalous with regard to the local forest.

Fire records were analyzed to determine the degree that topography controls fire extent. Using Arc/Info GIS software, we computed the amount of direct and indirect solar radiation at each site using the SOLARFLUX program (Rich et al. 1995). This program uses a digital elevation model and the sunpath to compute the effects of slope, aspect, and hillshading on solar radiation. The amount of solar radiation at each site was expressed as the proportion of solar radiation received on a flat unobstructed surface.

3. Fire dates from a lake sediment charcoal record

We obtained a 3.2 m long sediment core from 38 m of water in the flat-bottomed lower basin of Clayoquot Lake. The core was split in the lab and 12 ml subsamples were taken every 1 cm. The core was dated with 10 radiocarbon dates on conifer needles at equal intervals down the core. In addition, the top 86 cm of the core was dated from 20 ^{210}Pb determinations. Charcoal particles in the 0.15–0.5 mm size fraction were counted from each 12 ml subsample. The charcoal record was expressed as accumulation rates (CHAR; particles cm^{-2} $year^{-1}$). Charcoal peaks were identified as the positive deviations from a background level of CHAR. Background CHAR levels were determined using a locally-weighted moving average on the minimum CHAR values that occur between peaks.

Results and Discussion

1. Evaluate the reliability of soil charcoal radiocarbon dates

The comparisons of soil charcoal radiocarbon dates and the actual time of fire suggests the age of wood at the time of fire (the inbuilt age) ranges between 0–700 years, though it is mainly confined to 100-400 years (Figure 1). It is interesting to note that most charcoal contained a certain amount of inbuilt age, and that inbuilt ages of 0 were relatively rare. The discrepancy between the radiocarbon dates and the actual dates of the fire confirms that old coarse woody debris is the most common fuel type in these forests.

In order to incorporate the error due to inbuilt into the interpretation of radiocarbon dates, we developed a method to adjust radiocarbon dates. This method uses the distribution of inbuilt ages (Figure 1) as the weights of a weighted moving average applied to a calibrated radiocarbon date. We wrote a computer program (CALIB READER) to compute this adjustment and graph the results (Figure 2). The adjustment of radiocarbon dates were run on dates from the remainder of the study to illustrate the potential effects of inbuilt age, though these results are not shown in this report.

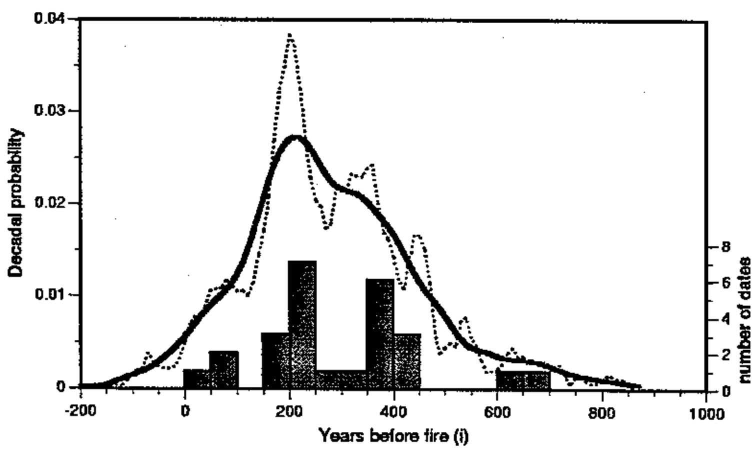


Figure 1. The range of inbuilt age that can be expected from soil charcoal radiocarbon dates from the Clayoquot Valley. Inbuilt age was measured as the difference between the radiocarbon date and the actual time of fire (determined from tree-rings). Each date was first calibrated from radiocarbon years to calendar years, which yields an irregularly shaped probability distribution. The dashed line represents the mean of all 26 calibrated radiocarbon dates. This curve was smoothed (solid blue line) to best show the overall potential inbuilt age in any single radiocarbon date.

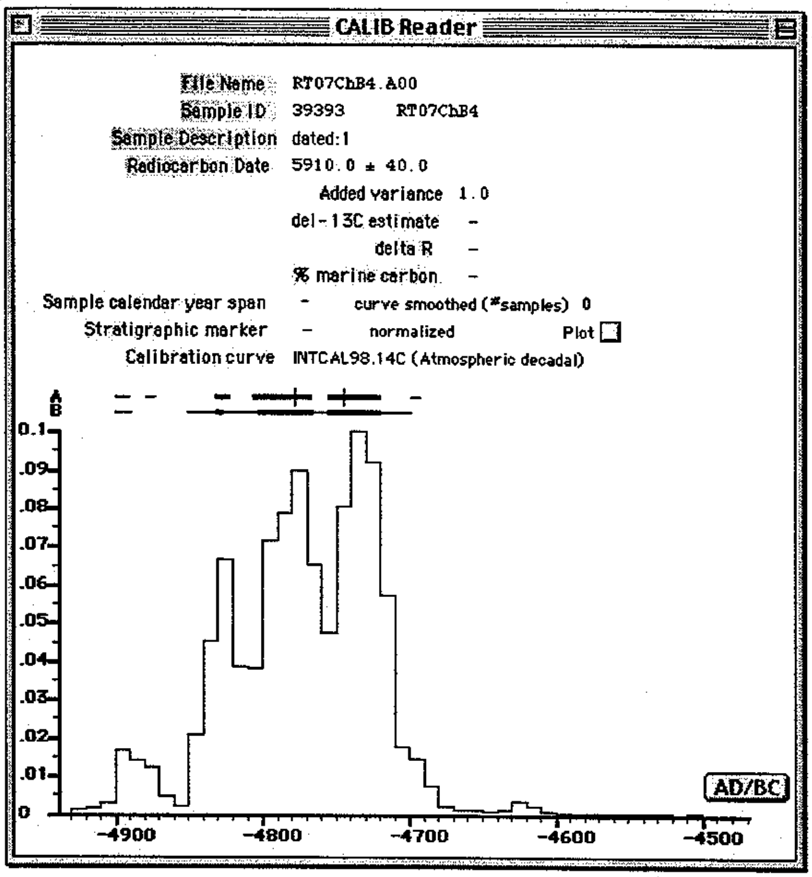


Figure 2a. Screen-shot from CALIB Reader, a computer program written to adjust radiocarbon dates for potential inbuilt age. Radiocarbon dates are first calibrated to calendar years with the program CALIB4.1 (Stuiver and Reimer 1993), which creates data files of the calibrated dates. CALIB Reader opens the CALIB data file and plots the calibrated probability distribution to the screen.

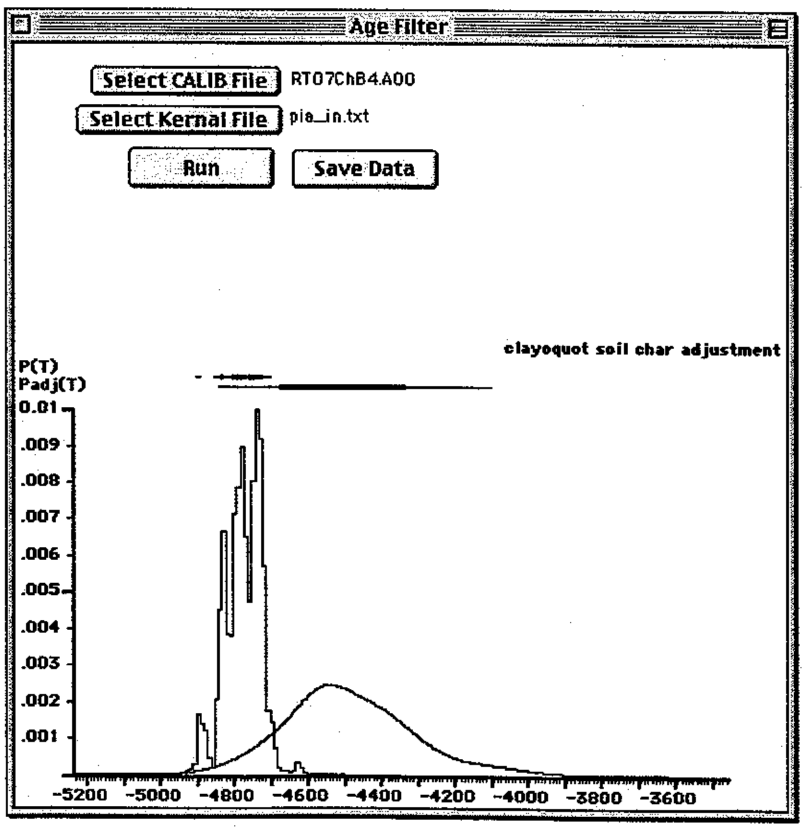


Figure 2b. The range of potential inbuilt ages (Figure 1) were used as weights (kernals) in a weighted moving average on the calibrated age probability distribution. The new distribution, Padj(T), reflects the uncertainty of a soil charcoal radiocarbon date to date a forest fire. X-axis is years AD/BC.

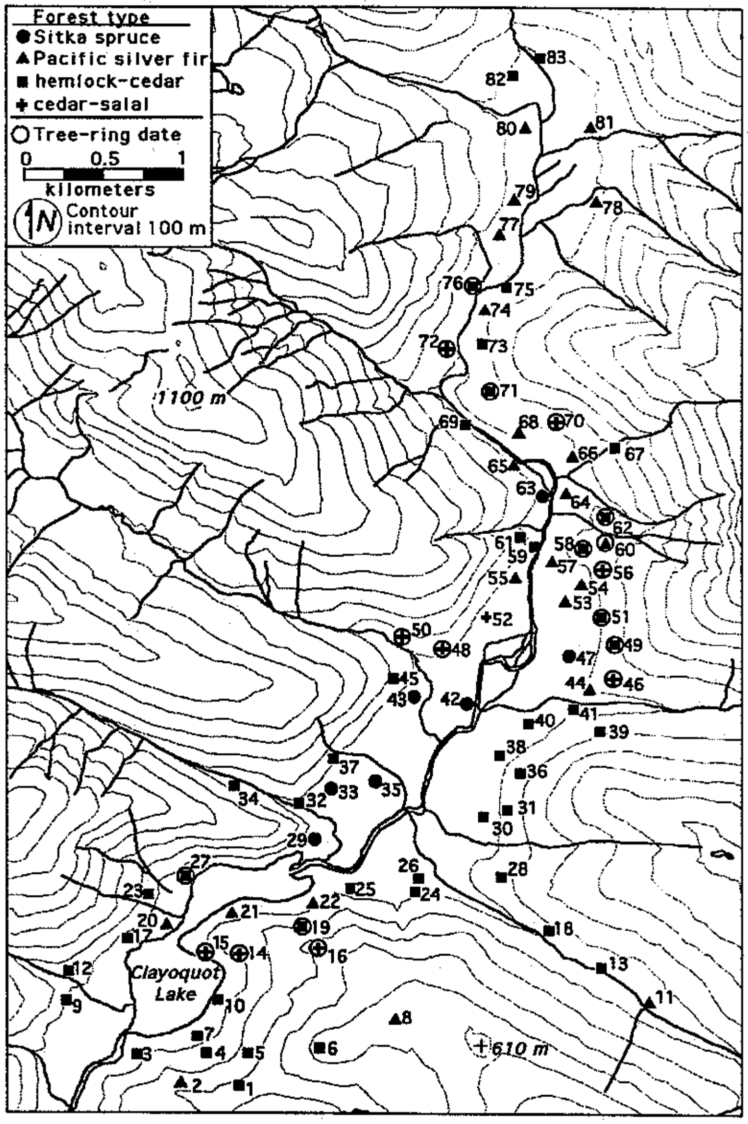
2. Fire dates over a spatial network of sites

The time-since-fire distribution shows that there is a near dichotomy between sites that were susceptible to fire in the last 1000 years, and sites that were resistant to fire for over 2000 years (Figure 3, Figure 4). 20% of the sites have not burned in the last 6000 years, and many sites have a time-since-fire between 9000 and 11,000 years BP (before present). Many other paleoecological studies from the Pacific Northwest have also found that this period, immediately following the transition from glacial to early Holocene climate, had the greatest summer warmth during the Holocene. These sites with a very long TSF were probably fire resistant at all times except during the early Holocene.

A second cluster of sites had time-since-fire between 2000 – 3000 years BP. The climatic history of this period is less well understood. A general trend of cooling beginning at 3000 year BP has been inferred from some pollen records, and a period of glacial advances in the British Columbia coast range have detected within this period (Pellatt and Mathewes 1997). However, those records integrate the long-term trend in climate, while fire weather can result from a drought of only one month—fire occurrence can be driven as much by short-term fluctuations in weather as by longer-term climate trends. Thus the combination of these other studies without fire evidence suggests that the clusters of sites with time-since-fire in the late Holocene probably result from a period of cool and moist climate punctuated by brief intervals of fire weather.

As expected, time-since-fire was negatively related to terrain insolation (Figure 5). Sites with high terrain irradiation all burned within the last 1000 years. These sites often supported Douglas-fir, a long-lived species dependent on fire to regenerate, and which is also currently very rare in the study area. The isolated occurrences of Douglas-fir suggest fires have recurred at these sites at intervals within its average life span (ca. 600 years). In contrast, most sites with less terrain irradiation and no Douglas-fir have not burned for several thousand years.

The median time-since-fire on terraces was significantly longer than on hillslopes (4410 and 740 years, respectively). Of the four main forest types, three had time-since-fire estimates that spanned the entire Holocene. However, the cedar–salal forest type consistently burned within the last 1000 years. This forest type is composed of stunted western redcedar and a dense understory of salal. Other research on Vancouver Island has found that this forest type results from low soil nutrition due to a combination of low soil turnover in very old forests and the ability of salal to compete for soil nitrogen (Keenan et al. 1996; Prescott et al. 1996). In the Clayoquot Valley cedar–salal forests, recurrent fire may have contributed to the stunted growth forms and salal understory by volatilizing soil nitrogen and causing erosion. Additional research is needed to address the role of fire in this forest type.



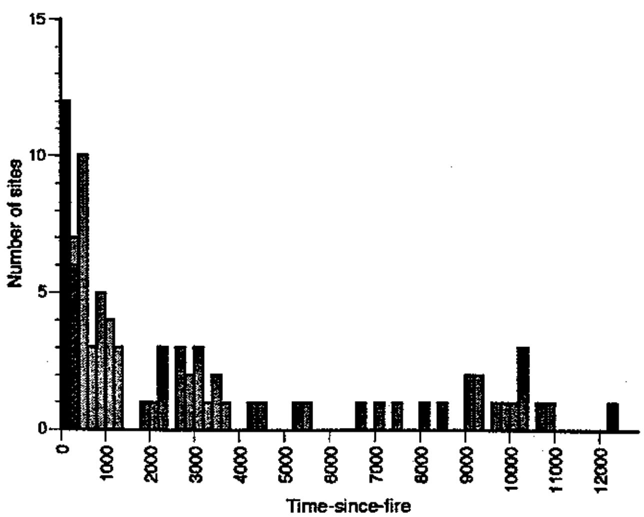


Figure 3 (above). The location of sample sites in the Clayoquot Valley on the west coast of Vancouver Island. Sites with tree-ring dates are noted by circles.

Figure 4 (left). The time-since-fire distribution from the 83 sites sampled in the Clayoquot Valley. Sites dated by tree-rings are shown with blue hatched bars; sites dated by radiocarbon dates are shown with red bars.

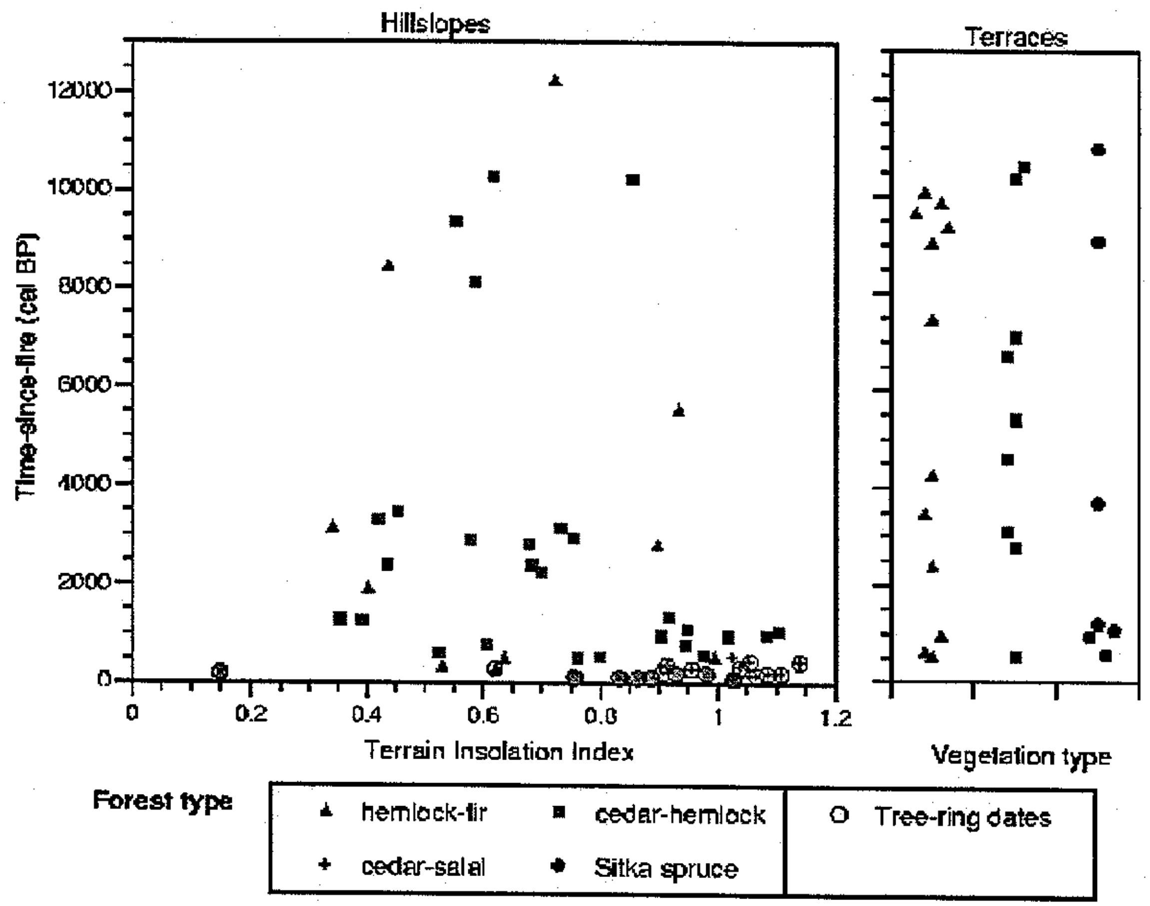


Figure 5. Time-since-fire relative to the terrain insolation index. The terrain insolation index is the proportion of August solar radiation received at a site relative to a flat surface with an unobstructed sky view. Index values > 1 indicate south-facing aspects, and values < 1 indicate north-facing aspects, hillshading, or both. Terrace sites were plotted separately from hillslope sites because terraces have a more moist understory and dense crowns than sites with a similar insolation index on hillslopes.

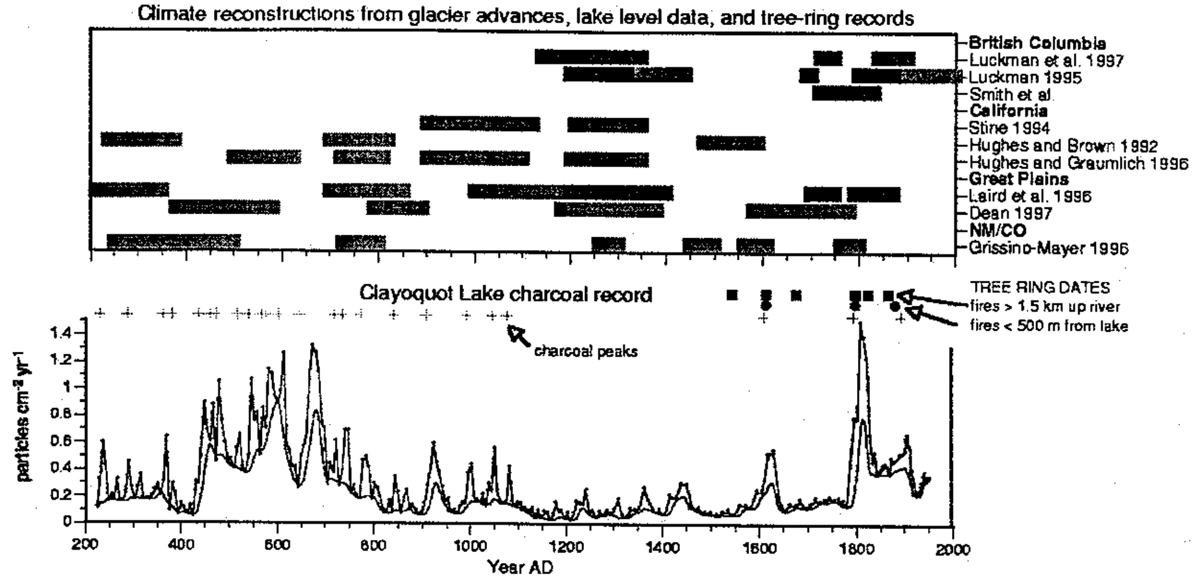


Figure 6. Top: Climate records of drought (red bars) and cool/wet conditions (blue hatched bars) from various locations in western North America, reconstructed from glacier advances, lake levels, lake salinity, and tree-ring records. Bottom: The charcoal record from Clayoquot Lake, showing times of local fires. Fires near the lake determined by tree-rings match charcoal peaks, though fires > 1.5 km up the Clayoquot River do not match charcoal peaks. A large shift in fire frequency occurred at ca. 1100 AD. Correspondence of fire frequency with other records of drought shows strong agreement with the large shift in fire frequency at 1100 AD. However, periods of maximum drought 200–1100 AD in California and the central United States do not match periods of highest fire frequency at Clayoquot Lake. The British Columbia records do not extend to before 1000 AD.

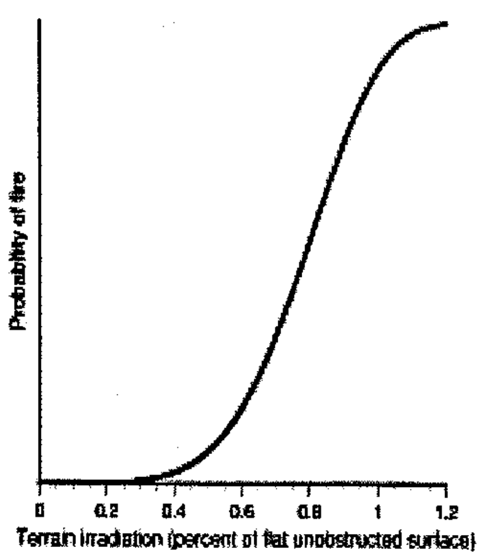


Figure 7. Schematic of a proposed non-linear relationship between the terrain irradiation index and the probability of fire (i.e. fire hazard). The terrain irradiation index is a measure of the amount of incoming solar radiation at a site relative to a horizontal unobstructed surface. This relationship suggests there is a threshold in the topographic control of fire occurrence.

3. Fire dates from a lake sediment charcoal record

Charcoal peaks in the lake sediment core matched fires detected near the lake, but not fires further upstream (Figure 6). This suggests that the Clayoquot River was not a major source of charcoal from outside the immediate catchment of the lake, and thus that the lake sediment core only records fires within a few hundred meters of the lake. The charcoal record shows that fire was more frequent before 1100 AD, with the shortest fire intervals (ca. 30 years) between 400 and 600 AD. In contrast, a long period of no fire (1100–1600 AD) and a period of very few fires (1700 AD –present) characterized the "Little Ice Age." This shift in fire frequency agrees with other climatic records from glacial advances, lake levels, and tree-rings.

Comparison of the lake sediment core and the soil charcoal records allows us to make inferences about the pattern of fire in space and time. The time-since-fire distribution revealed none of the temporal variation found in the sediment core: periods of higher fire frequency during the last 1800 years were not matched by more sites with time-since-fire dating from the same period. In fact, almost no sites had time-since-fire estimates during the period of highest fire frequency observed in the sediment core (ca. 1400-1800 years BP). In order for the loss of evidence on the landscape of these earlier fires, subsequent fires must have reburned the same areas. This suggests that fires during the last 1800 years had a very restricted extent, burning the same areas repeatedly and not burning other areas at all.[very interesting]

The strong bias of fire on the landscape probably resulted from topographic control of fire extent. We propose that, for late Holocene climates, there is a strong non-linear relationship between the amount of terrain irradiation and the probability that an area burns in a given period of time (Figure 7). Areas that receive more solar radiation above a threshold have a significantly greater chance of burning. This relationship is expected based on fuel moisture–fire hazard relationships, as certain thresholds of fuel moisture must be broken for fire to propagate (Chandler et al. 1983). In the Clayoquot Valley, such thresholds were probably never exceeded during the late Holocene over large proportions of the landscape.

Conclusions

- Fire frequency in the Clayoquot Valley study area was sensitive to climate change during the last 1800 years; small changes in climate have led to large changes in fire frequency.
- The spatial extent of fire is strongly affected by topography. Many north-facing slopes and terraces escaped fire for thousands of years, and all south-facing slopes have burned in the last 1000 years.
- Fire regimes did not vary among most forest types. The main exception is the cedar–salal association, which always burned in the recent past. These areas are more fire prone due to exposure on south aspects and the open canopy of stunted trees. These sites also support Douglas-fir, suggesting they have burned at centennial-scale intervals.
- The lake sediment core indicated there have been periods of higher fire frequency during the late Holocene. However, soil charcoal evidence of fire during the late Holocene was restricted to a set of susceptible sites. This suggests that periods of higher fire frequency did not translate into larger areas being affected by fire. Instead, late Holocene climate change affected fire frequency at only a subset of sites (i.e. "susceptible" sites).
- At many sites, early Holocene climate was required to overcome the topographic controls on fire extent that operated during the late Holocene. These extremely long fire intervals (>7000 years) are unprecedented with respect to most other forest types in the Pacific Northwest, as well as to most forest types world-wide. This supports the distinction of the "coastal temperate rain forest" from areas east of the Vancouver Island range, where legacies of past fire are ubiquitous.
- Forest managers that wish to pattern harvesting after the natural disturbance regime should recognize that stand-replacing fire disturbances have been absent for over 7000 years on certain landforms, especially terrace forest and north-facing slopes.

Application of results

This research will comprise the doctoral dissertation for Daniel Gavin, a team member on this project who conducted the majority of this research. The dissertation is organized into three chapters based on the three main research objectives in this report. These chapters are being written as stand-alone papers. The dissertation is expected to be complete in summer 2000. Tentative titles on the three papers are:

1. Estimation of inbuilt age in radiocarbon dates of soil charcoal for fire history studies.
2. Holocene fire history of a coastal temperate rain forest based on soil charcoal radiocarbon dates.
3. An 1800-year record of the temporal and spatial distribution of fire from the west coast of Vancouver Island, Canada.

Planned papers in addition to the dissertation include:

- Forest soil disturbance rates determined from soil charcoal radiocarbon dates.
  We have found that this set of radiocarbon dates allows us to draw inferences about soil disturbance and soil development.
- Ancient fires in ancient forests: the pattern of prehistoric fire in the coastal temperate rainforest of Clayoquot Sound, British Columbia.
  This paper is intended for a more general audience.

Other publications that have drawn on and were influenced by this research include:

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COMMUNICATION AND NETWORKING

Meetings

- Presentation at the 1996 Biennial meeting of the American Quaternary Association in Flagstaff, AZ, May 1996. (Gavin, Lertzman, Brubaker). Title: Long-term fire histories in a coastal temperate rain forest.
- Presentation at the 1996 Annual Meeting of the Ecological Society of America, Providence, Rhode Island (August 1996). (Gavin, Lertzman, Brubaker, Nelson).
  Gavin, D., K.P. Lertzman, L. Brubaker and E. Nelson. 1996. Long-term fire histories in a coastal temperate rainforest. Bulletin of the Ecological Society of America 77(3):157.
- Presentation at the 1997 Pacific Ecology Conference, Bamfield, BC. (February 1997). Title: Long-term fire histories in the Clayoquot river watershed, a coastal temperate rainforest.
- Presentation at the 1997 Annual Meeting of the Ecological Society of America, Albuquerque, NM (August 1997). (Gavin, Lertzman, Brubaker, Nelson).
  Gavin, D.G., K.P. Lertzman, L.B. Brubaker and E. Nelson. 1997. Holocene fire size and frequency in a coastal temperate rainforest. Bulletin of the Ecological Society of America 78(4):93.
- Presentation at the 1997 Third Annual Clayoquot Sound Science Symposium: "Research and Local Knowledge in the Planning Process." October 23-24, 1997, Tofino, B.C. Title: Natural disturbance regimes in a coastal temperate rainforest. Summary of our work placed our results in the context of other forest disturbance ecology research in the Clayoquot Sound area. Available online in Acrobat PDF format at: http://students.washington.edu/dgavin/charcoal.html.
- Presentation at the 1998 conference: Structure, Processes and Diversity in Successional Forests of Coastal British Columbia. (February 17-19, 1998) Sponsored by the Canadian Forest Service and the BC Ministry of Forests. (Lertzman, Gavin, Hallett, Brubaker, Lepofsky, Mathewes) Title: Long-Term Fire Histories and the Dynamics of Wet Coastal Forests.
- Guest lecture at the Long Beach Model Forest Rainforest Interpretive Center, Tofino. BC, August 4, 1998. (Gavin). Title: Ancient Fires in Ancient Forests: Understanding the Long-Term Role of Fire in the Coastal Temperate Rain forest.
- Presentation at the 1999 Annual Meeting of the Western Division of the Canadian Association of Geographers, Kelowna, BC. (March 13, 1999). (Gavin, Lertzman). Title: Holocene fire history of the temperate rain forest, Clayoquot Sound, Vancouver Island.
- Presentation at the 1999 Annual Meeting of the Ecological Society of America, Spokane, WA. August 10, 1999. (Gavin).
  Gavin, D.G. (1999) Holocene fire history in a coastal temperate rainforest, Vancouver Island. Abstracts, Ecological Society of America 84th Annual Meeting, August 8-12th, Spokane, WA, p. 252. (*winner of Edward S. Deevey Award for Excellence in Paleoecology*)
- Symposium co-organized by Ken Lertzman at the 1999 Annual Meeting of the Ecological Society of America, Spokane, WA.
  Implications of paleorecords for ecosystem management in northwestern North America.

- Presentation in the above symposium at the 1999 Annual Meeting of the Ecological Society of America, Spokane, WA. August 10, 1999. (Lertzman).
  Lertzman, K.P., B. Dorner, J. Fall and E.K. Heyerdahl. 1999. Linking paleoecology and forest management: applying lessons about forest landscapes in space and time. Ecological Society of America Annual Meeting Abstracts:326.

Workshops and presentations:

- Pacific Northwest Paleoecology Workshop, Seattle, WA (February 1997). Organized by co-investigator Linda Brubaker and Ken Lertzman. Forty participants from Oregon, Washington, and British Columbia.
- Talk on the dynamics of coastal temperate rainforests presented by Ken Lertzman at Oregon State University, March, 1997. The talk included the results of this study.
- Talk on the dynamics of coastal temperate rainforests presented by Ken Lertzman at the University of Northern British Columbia, April, 1997. The talk included the results of this study.
- Fire History Workshop. June 2-9, 1997, University of Oregon, Eugene, OR. Dan Gavin participated in this workshop on fire history methods organized by Dr. Cathy Whitlock at the University of Oregon.
- Presentation to the Department of Geography, University of Oregon, April 7, 1998. (Gavin).
- Vancouver Island Marmot Conservation Workshop, Nanaimo, June 16-19th, 1999. Sponsored by Environment Canada, Canadian Wildlife Service, B.C. Ministry of Environment, Lands and Parks, Royal British Columbia Museum.
- Structural Attributes of Fire-Maintained Ecosystems Workshop: Bringing Together Our Knowledge. Kamloops, Feb. 22-24, 2000. Organized by Southern Interior Forest Extension and Research Partnership. (Lertzman)
- Lertzman has participated in an ongoing series of workshops organized by MacMillan Bloedel (now Weyerhauser) Ltd. and TimberWest Forest Products Ltd. examining a variety of issues in ecosystem-based management and their efforts to adopt such an approach.

Budget Statement

A formal budget statement has been requested from the Finance Office at SFU and will be sent directly by them.