Fire history of spruce forests on the Kenai Peninsula, Alaska, on scales of decades to millennia, using fire scars, soil charcoal and lake sediments

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INTRODUCTION

The Kenai Peninsula has two distinct fire regimes: a high frequency regime in black spruce (*Picea mariana*) and a low frequency regime in white (*P. glauca*) and Lutz (*Picea* x *lutzii*) spruce. We examined these fire regimes on three different time scales, and estimated the mean fire return intervals and variances.

METHODS

Black spruce

We collected 1022 basal cross-sections from burn poles and 771 increment cores from living trees in the central Kenai lowlands. Burn area polygons were delimited as homogeneous stands containing fire scars of the same age, and fire return intervals were calculated from age differences of overlapping burn polygons.

White/Lutz spruce

In two areas we examined throw mounds from blown-over trees for soil charcoal and obtained radiocarbon dates on the charcoal. The Intensive study on the southern Kenai had been recently logged of spruce-bark-beetle-killed Lutz spruce and contained many blown-over residual trees. We drove along approximately 100 km of upland logging roads, and stopped every 0.8 km to search all throw mounds for fragments of soil charcoal within 100–150 m of the stopping point. These throw mounds provided access to exposed mineral soil where charcoal fragments could be collected if present. However, most throw mounds did not yield charcoal. At each stop we searched as few as 4–5 and as many as 40–50 throw mounds, using trowels to search both the organic and mineral soil layers.

In the Extensive study area, we sampled stands with 2 to 5 observers spread out and walking in agreed directions for several hours, examining each throw mound encountered. Ten areas were examined, all with mature upland forests of white and Lutz spruce, usually with a substantial component of birch (*Betula neoalaskana*).

For the Intensive study area we plotted calibrated dates against distance on each road, and visually defined clusters of dates that were close together in space and time in order to estimate mean fire intervals (MFI) and times-since-fire (TSF) among sites. The choice of spatial proximity for a cluster of dates represented a subjective judgment, based on the assumption that the scale of fires was on the order of several km^2 in size (Fig. 1). This choice determined the effective number of “sites” and hence the number of intervals that could be calculated. We assigned fire dates to the youngest date of each cluster, assuming that the older dates were biased by the presence of charcoal derived from the inner, older wood of the burned trees. For each site we calculated intervals between fires and the time since the last fire.

Sedimentary charcoal

To assess the entire post-glacial fire record, we conducted a high-resolution sedimentary charcoal study with a 9-meter core from Paradox Lake, an area of mixed white and black spruce forests. The core was dated with ^{210}Pb and ten ^{14}C dates, and a fire event frequency model was fitted to the charcoal abundance data. Charcoal was sampled at an average interval of 15 years, and for pollen an average of 260-650 years.

RESULTS AND CONCLUSIONS

Black spruce

We used 189 fire scars to date 10 fires from 1708 to 1898. Fire return intervals ranged from 18 to 166 years, with a mean fire return interval (MFI) of 79 ± 35 (SD) years. (De Volder 1999)

White/Lutz spruce

We used 121 radiocarbon-dated soil charcoal samples to estimate an MFI of 515 ± 355 (SD) years over the last 2500 years, at 22 sites. Charcoal older than 2500 years was excluded from the MFI calculation because of concern about long-term disintegration of charcoal fragments and consumption of older charcoal by more recent fires. Times-since-fire ranged from 90 to 1518 years, with a mean of 605 ± 413 (SD) years. (Berg and Anderson 2006)

Sedimentary charcoal

Charcoal was measured at 1-cm intervals to provide a 13,000 year record of fire activity at Paradox Lake. Fire frequency was lowest during the initial shrub tundra period with an MFI of 138 ± 65 years beginning 13,000 years before present (BP), increased after the arrival of birch, *Salix*, and *Populus* at 10,700 years BP to an MFI of 77 ± 49 years, and decreased slightly to an MFI of 81 ± 41 years after the arrival of white spruce at 8500 years BP. After black spruce arrived at 4500 years BP, fire activity declined to the present MFI value of 130 ± 60 years, presumably reflecting the onset of a cooler and wetter climate. (Anderson et al. in press)

The 130-year MFI estimated from sedimentary charcoal at Paradox Lake is considerably shorter than the 515-year MFI estimated from soil charcoal samples distributed over the central and southern Kenai Peninsula. This difference may be in part due to black spruce near Paradox Lake, but is more likely due to the fact that a lake can potentially accumulate charcoal from many fires distributed over a large area, whereas a soil charcoal sample represents a single fire at a single point on the landscape. Similar discrepancies have been reported in other studies comparing these two quite different methods (reviewed in Berg and Anderson 2006).

LITERATURE CITED

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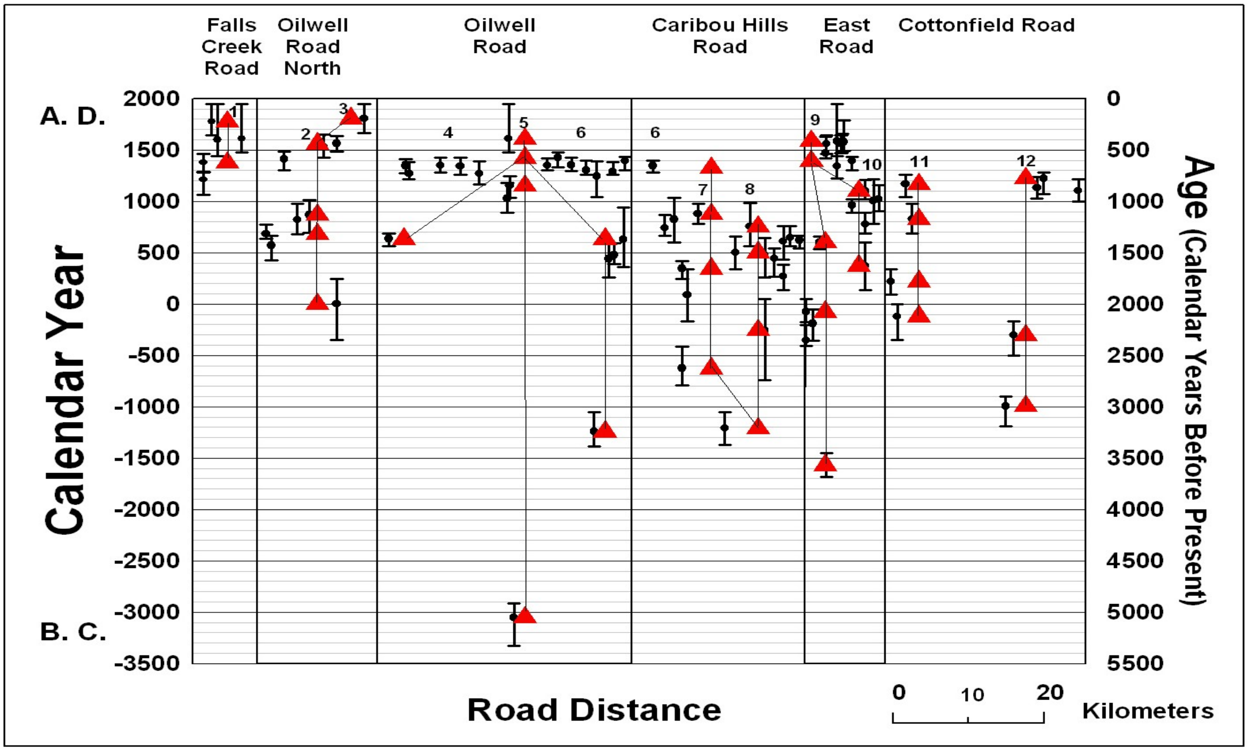

Fig. 1. Dates of fires estimated from soil charcoal samples (*n* = 82) excavated from the Intensive study area on the Kenai Peninsula, Alaska. Error bars (2 SD) were based on maxima and minima of calibrated age ranges. Solid triangles show estimated fire dates; connecting lines show intervals between estimated fire dates. Numbers 1–12 indicate site clusters. Dates are median calibrated years, not ^{14}C years. Road names are local logging roads along which samples were collected.

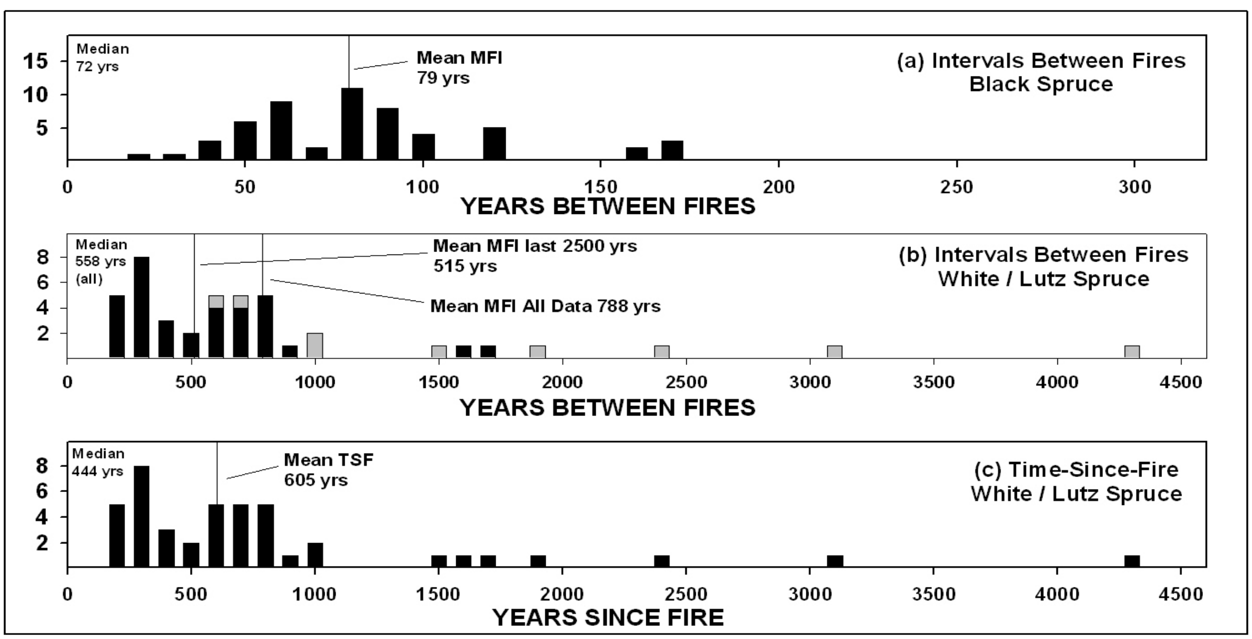

Fig. 2. Fire regimes on the Kenai Peninsula, Alaska: (a) Return intervals in black spruce forests (*n* = 17 burn areas, 55 intervals), (b) Return intervals of fires in white/Lutz spruce forests within the last 2500 years shown in black bars and of older fires in gray bars (*n* = 22 sites, 43 intervals), and (c) Times since last fire (*n* = 21 sites) in white/Lutz spruce forests.