A preliminary fire history for the Caribou-Poker Creeks Research Watershed, Alaska

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ABSTRACT

Fire history in a forested, 550 ha second-order basin (basin P6) of the Caribou-Poker Creeks Research Watershed near Fairbanks, Alaska, was reconstructed from 21 replicated dates from fire scars on black spruce trees and age structures of five post-fire stands of black spruce and paper birch. Forest vegetation in the research watershed is representative of the interior Alaskan taiga with black spruce common on permafrost-underlain north-facing slopes, and stands of hardwoods and spruce dominating warmer, south-facing slopes. Seventeen percent (~90 ha) of the P6 basin was burned by stand-initiating fires in 1902 and 1925. The remaining 83% of the basin has had no stand-initiating fires since ca. 1810, although less severe fires scarred trees in the basin in 1924, 1935, and 1964. The mean areally adjusted stand age in the basin is 167 yr. The timing of fires in the P6 basin and of three other fires dated in the 10,000 ha research watershed is associated with periods of mineral prospecting and extraction adjacent to the watershed.

INTRODUCTION

Wildfire is the most important disturbance in the boreal forest of interior Alaska with stand-initiating fires recurring at intervals of 29-300 yr (Dyrness et al. 1986). Through impacts on tree regeneration, soil temperature, and nutrient cycling, fire is a controlling influence on forested ecosystems in interior Alaska (Van Cleve and Viereck 1981, Viereck 1983, Van Cleve et al. 1991). Fires in Alaska can be large (50,000 to 200,000 ha) and the combustion of surface organic horizons provides a seedbed which facilitates recruitment of a new community (Dyrness et al. 1986). Post-fire succession on south-facing slopes typically involves the development of stands of paper birch (*Betula papyrifera*) or quaking aspen (*Populus tremuloides*) which are gradually replaced

by white spruce (*Picea glauca*, Dyrness et al. 1986, Van Cleve et al. 1991). On north-facing slopes, a hardwood stage is less important or missing, and black spruce (*Picea mariana*) is usually the mid- to late-successional dominant. Spruce stands can support hotter fires and more complete combustion of fuels than hardwood stands (Viereck and Foote 1985). Fires in black spruce communities on north-facing, permafrost dominated slopes are reported to be less severe but more frequent than fires in south-facing white spruce communities which have drier, shallower organic horizons and drier fuels (Van Cleve et al. 1991).

Previous studies of fire history and estimates of fire interval in interior Alaska are based on tree ages in post-fire stands (Heinselman 1981, Yarie 1981). No published account of fire history in Alaska has been based on dates of past fires recorded by fire scars (Arno and Sneck 1977). In anticipation of a planned experimental burn in the P6 basin of the Caribou-Poker Creeks Research Watershed near Fairbanks, Alaska, We used fire scars and tree ages to determine the history of past wildfires. Our objective was to produce a stand origin map (Heinselman 1973) of the P6 basin of the research watershed. The mosaic of forest patches in the boreal forest is produced by the history of overlapping past fires. If the fires which initiated each patch can be dated, aspects of the fire regime including the past fire frequency and mean time since the last fire can be estimated (Johnson 1992).

METHODS

Study site

The Caribou-Poker Creeks Research Watershed is 40 km north of Fairbanks, Alaska (65° 10' N, 147° 30' W). The 10,000 ha watershed is a complete hydrologic catchment including a fourth-order stream (Poker Creek) which exits the catchment at an elevation of 213 m. The highest point in the watershed is 825 m. Forests cover more than 95% of the watershed with only the highest ridges and parts of valley-bottom muskegs lacking trees. Permafrost is common in valley bottoms and on north-facing slopes where black spruce is the dominant tree. South-facing slopes are mostly permafrost-free and support stands of paper birch, quaking aspen, and black and white spruce.

The P6 basin is the 550 ha catchment of a second-order tributary of Poker Creek. The P6 creek is approximately 3.5 km in length and joins Poker Creek at an elevation of 271 m. The P6 basin is forested except for a narrow creek-side strip of shrubby wetland along most of the length of the creek, and a ridgetop alpine tundra community along a 683 to 755 m high ridge southeast of the basin. Approximately 75% of the basin is south of the creek on a generally north-facing slope. This slope supports a mosaic of black spruce stands which vary greatly in density and in proportion of codominant birch or aspen. Approximately half of the area of the south-facing slope north of the creek supports a nearly pure stand of paper birch. One quarter of this south-facing slope supports a closed-canopy stand of large (10 cm to 25 cm DBH) black spruce trees with

lesser areas where large (30 cm to 70 cm DBH) birch and aspen predominate. The ridge at the top of this south-facing slope supports a stand of smaller black spruce.

Tree ages

To select trees for age determination, sampling points were established in five forested stands in the P6 basin representing the dominant forest communities in the basin (Fig. 1). Trees (stems >3 cm DBH) were cored as close to the ground as possible, usually less than 30 cm above the root crown. In the black spruce community on the ridge north of the basin, six 4 X 4 m sampling plots were systematically located along a transect parallel to the ridgetop. All spruce trees in each plot were cored. In addition, seven other larger spruce which appeared to be remnants of an older cohort were cored. In the birch community on the south-facing slope all birch and aspen trees in one 16 X 16 m plot, and one additional large birch were cored. No spruce were present in the plot, so all black spruce within 5 m of the plot margins were also cored. In three black spruce stands on the north- or south-facing slopes, spruce stems were clumped as is typical when this species reproduces by layering. To avoid sampling the same individual more than once, four to seven sampling points were systematically located in each of these stands and the largest stem from each of the 3 or 4 clumps closest to the point was cored. The resulting age distribution should provide a more accurate record of the timing of early recruitment from seed. All field work was completed during the summer of 1992.

All cores were mounted on boards and sanded, and annual rings were counted under a dissecting microscope. Tree ages at core height were compiled into age frequency distributions to infer the approximate time of stand initiation. If this time corresponded to a dated fire year (see below), the stand was considered to have been initiated by a stand-initiating fire in that year.

Fire scars

Twenty-seven complete trunk sections from the base (generally 15 to 35 cm above the root crown) of living fire-scarred black spruce were collected from the P6 basin. Scars were present in all of the communities described above and were collected from each black spruce stand that was sampled for ages. Although fire scars were present on birch trees in the south-facing birch community, none was collected. During reconnaissance visits to three locations in the research watershed outside of the P6 basin, fourteen fire scars from living black spruce were collected. Trunk sections were sanded with progressively finer grit sandpaper and finished with 400 grit or finer paper. Fires scars were dated and tree age at stump height was determined by counting annual rings between the bark, the scar, and the pith under a dissecting microscope. Because fire dates have not yet been confirmed by crossdating ring widths (Madany et al. 1982), only fire dates that are recorded in two or more collected sections will be discussed here.

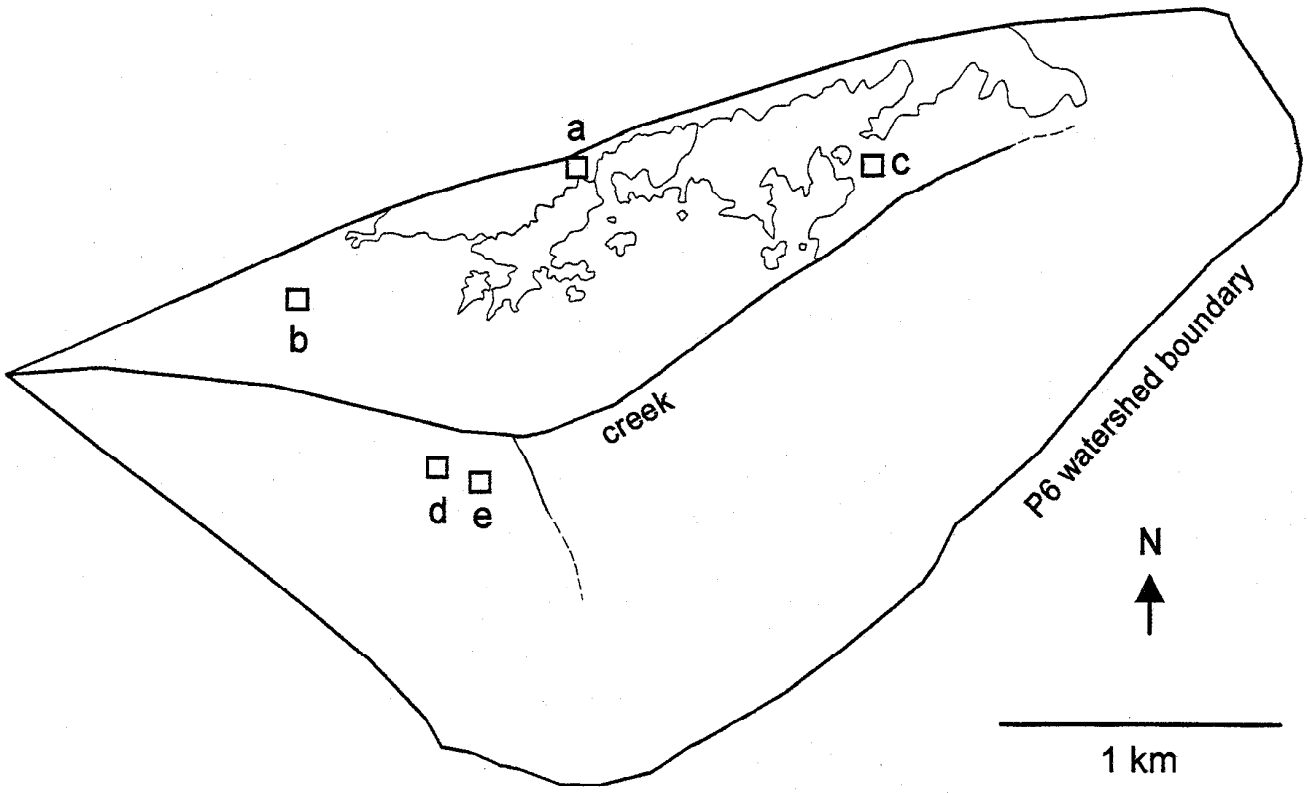


Fig.1. Locations of sampling points in the P6 basin. a = ridgetop black spruce; b = south-facing birch; c = south-facing black spruce; d = north-facing closed canopy black spruce; e = north-facing open muskeg black spruce. Margins of forest types north of the creek are also shown.

Stand origin map

Stand initiation dates determined from fire scars and tree age distributions for five study stands in the P6 basin were mapped onto 1969 black and white aerial photographs of the basin. Areas of the photographs with homogeneous pattern that ground observations had indicated represented homogeneous vegetation were outlined to produce a map of each forest patch. Patches for which stand initiation dates had been determined by both fire scars and corresponding age distributions were mapped as having experienced a stand-initiating fire in that year.

RESULTS

In the P6 basin, five fire years during the 20th century are recorded in two or more scars collected from 21 black spruce trees (Table 1, Fig. 2). Throughout the P6 basin, fire scars were found on 20 to 30 additional trees but no sections were collected from these trees. Outside of the P6 basin, three other fire years during the 20th century are recorded in two or more scars from 12 black spruce trees (Table 1, Fig. 2). None of the fire years documented in trees in the P6 basin was documented elsewhere in the research watershed. The earliest fire scar date in the P6 basin is 1902. The earliest fire scar date elsewhere in the research watershed is 1901. No tree had been scarred by more than one fire.

Pith dates from a systematic sample of 43 black spruce in the ridge top stand at the northern margin of the P6 basin indicate a pulse of recruitment between 1910 and 1940 (Fig.3). Four fire scars from older black spruce scattered throughout this stand date to 1902, suggesting a stand-initiating fire during that year. Pith dates from the fire-scarred trees and from seven other black spruce in this stand range from 1810 to 1888. These trees are survivors from the stand destroyed by the 1902 fire and suggest that that pre-fire stand was similar in composition to the post-fire stand and was at least 75 to 100 yr old when it burned. The area of the forest within the P6 basin that was destroyed by this fire is approximately 20 ha, or 4% of the basin (Fig. 4).

Pith dates from a systematic sample of 41 paper birch, 13 black spruce, and 3 aspen in the birch stand on the south-facing slope indicate a synchronous pulse of recruitment in all three species between 1930 and 1960 (Fig. 5). Although no fire scars were collected in this stand, four fire scars from black spruce at the eastern margin of this birch stand date to 1925, suggesting a stand-initiating fire during that year. Large birch scattered throughout the younger birch, one of which is at least 80 yr old, suggest that birch was an important component of the stand that burned in 1925. However, remnants of charred spruce stumps and downed logs are easy to find in this stand, suggesting that spruce may have been more important in the pre-fire stand than it is today. The area of the forest within the P6 basin that was destroyed by this fire is approximately 70 ha, or 13% of the basin (Fig. 4).

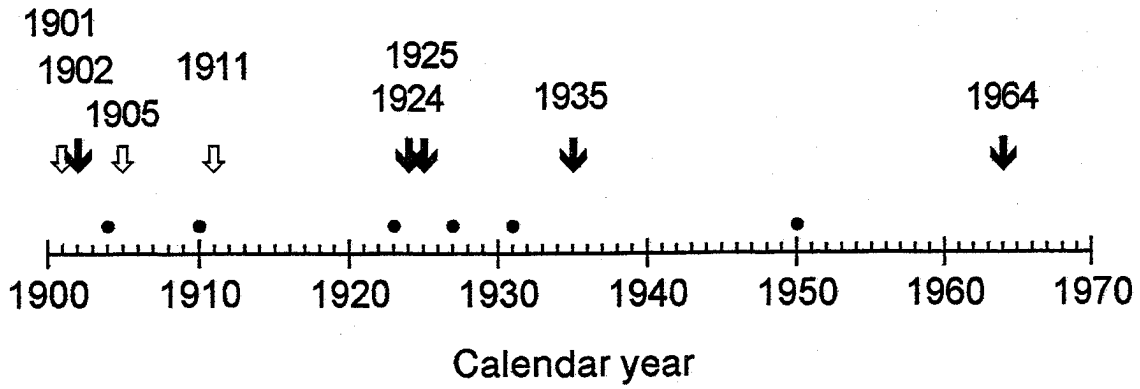


Fig. 2. Fire scar dates from the Poker-Caribou Creeks Research Watershed. filled arrows = replicated fire dates in the P6 basin; open arrows = replicated fire dates elsewhere in the research watershed; dots = fire dates from unreplicated scars.

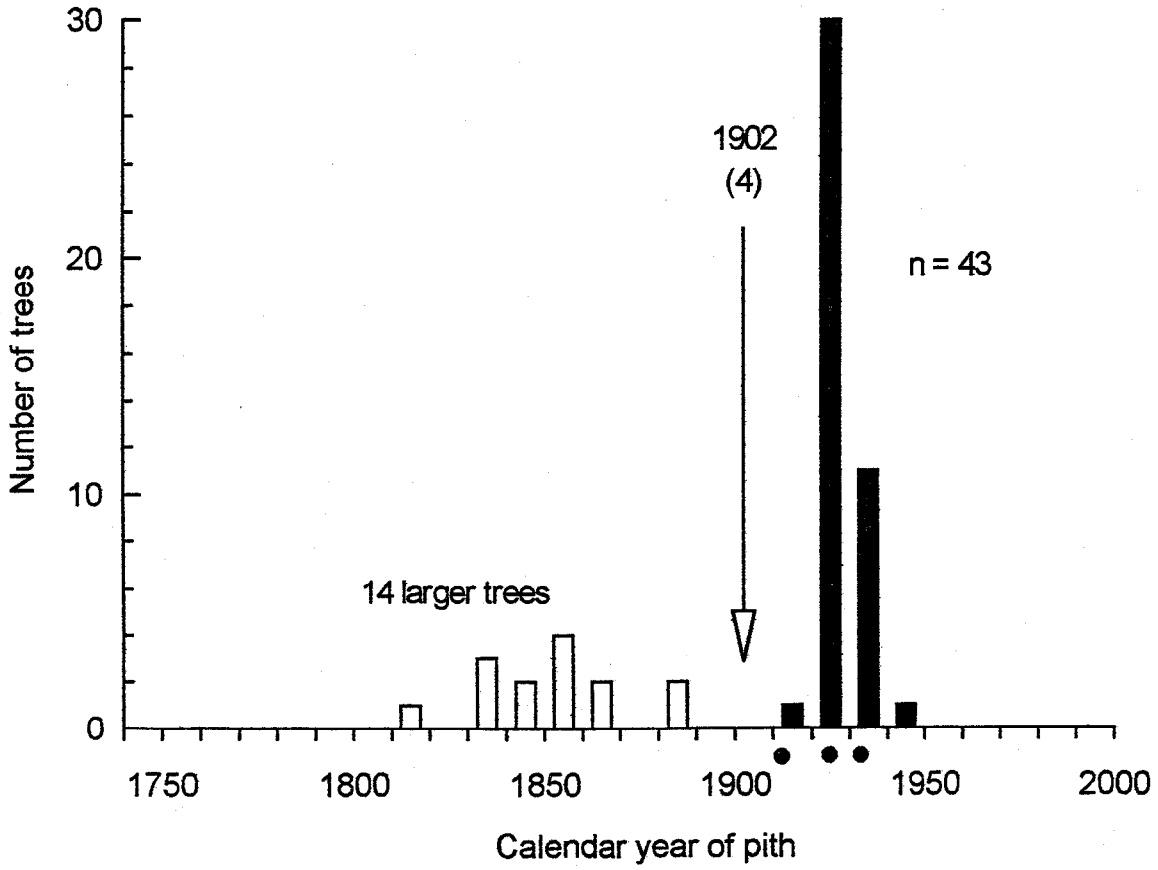
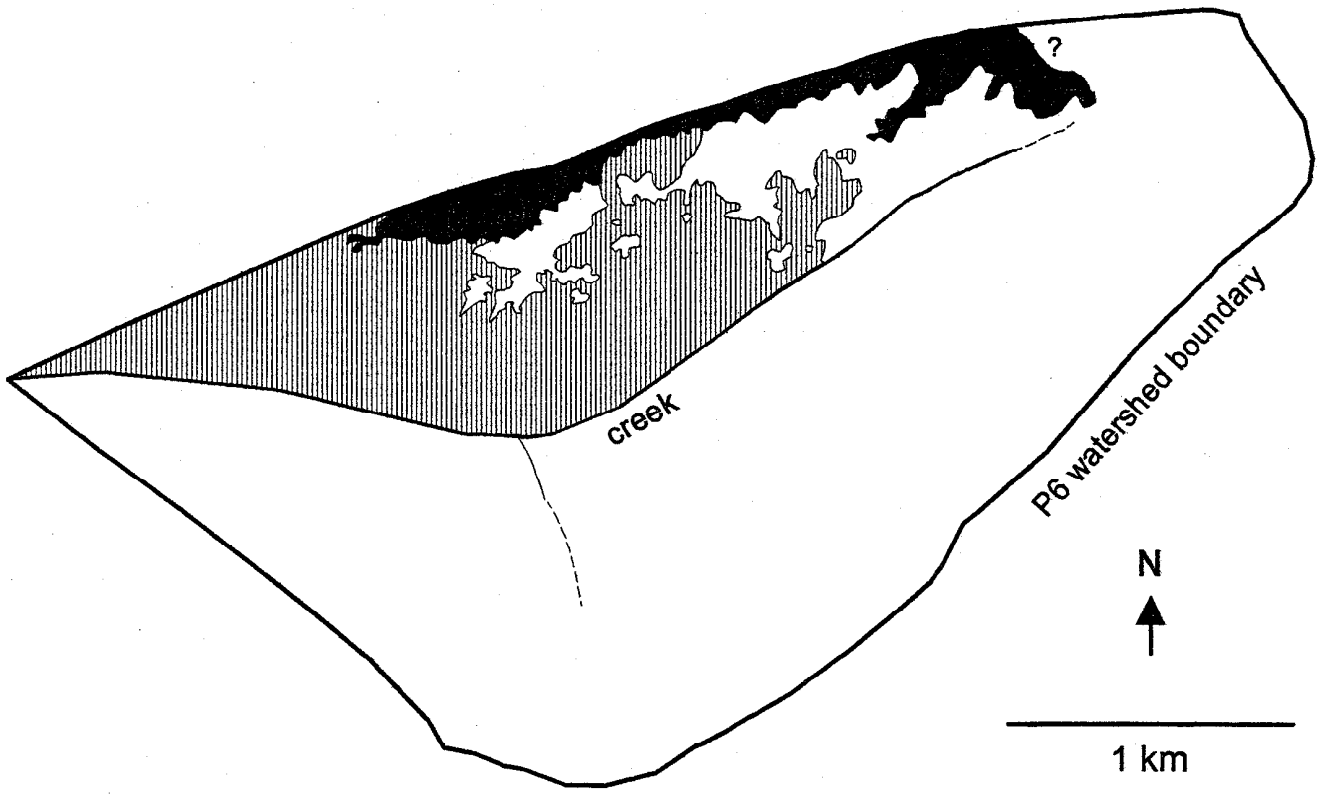


Fig. 3. Age distribution (10 yr classes of age above core height) of 43 black spruce in 6 sampling plots in the ridgetop black spruce stand (solid bars), and 14 larger spruce scattered throughout the stand (open bars), 4 of which were scarred by a 1902 fire (arrow), and 3 of which had fire scars with unique dates (dots).



Black spruce stand initiated after 1902 fire
(20 ha, 4% of basin)

Paper birch stand initiated after 1925 fire
(70 ha, 13 % of basin)

No stand-initiating fires since ca. 1810
(460 ha, 83% of basin)

Fig. 4. Stand origin map of the P6 basin. ? = boundary between stands is poorly known.

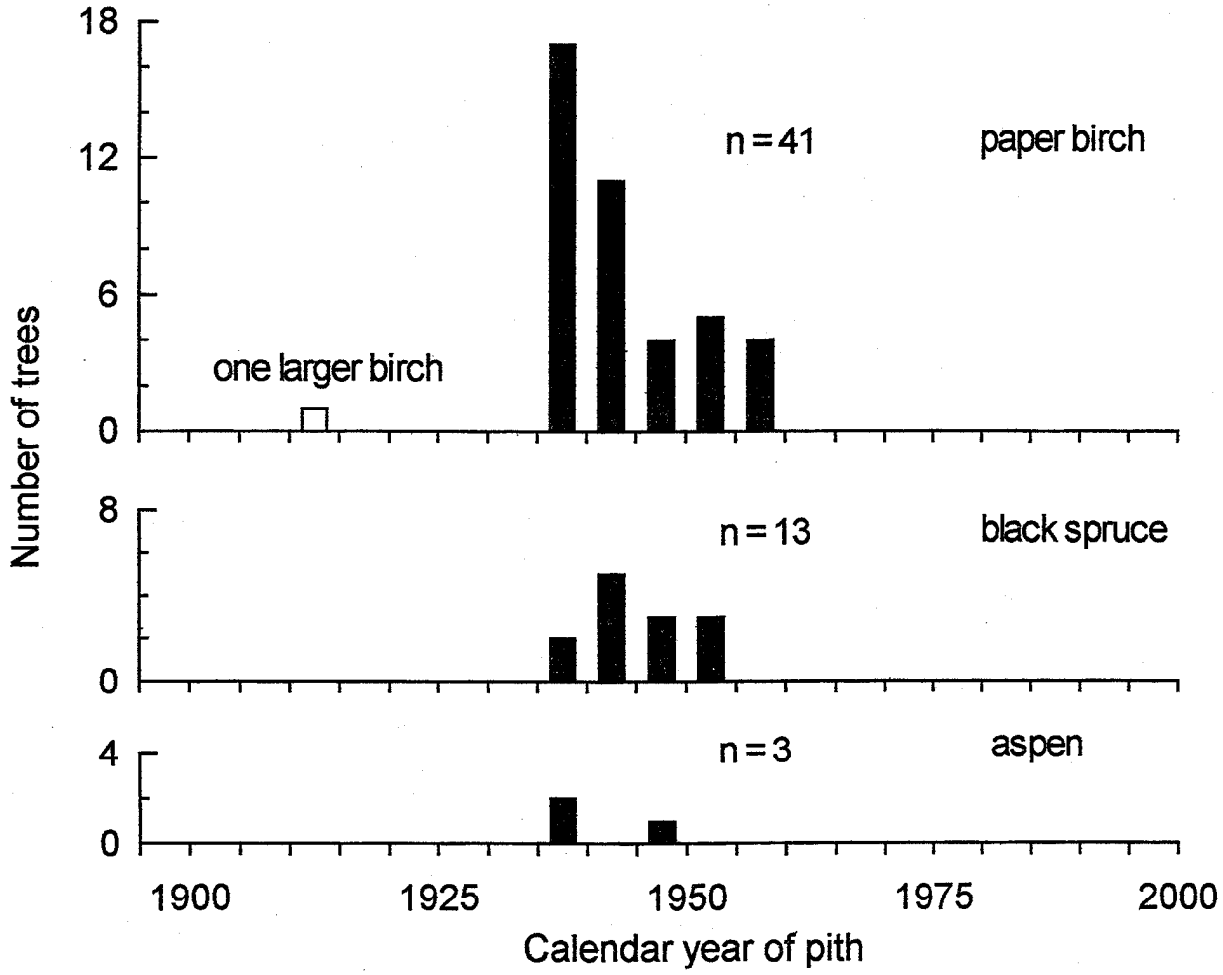


Fig. 5. Age distribution (5 yr classes of age above core height) of birch, black spruce, and aspen in study plots in the south-facing birch stand (solid bars) and one larger birch in the stand (open bar).

Pith dates from a systematic sample of 31 black spruce plus eight fire-scarred black spruce of similar age in the closed-canopy stand of large trees in the eastern part of the south-facing slope indicate a pulse of recruitment which began around 1810 (Fig. 6). None of the fire scars collected was dated to this period, although six younger scars in the stand indicate that recent fires burned to the edge of this stand in 1935 and burned

Table 1. Forest communities sampled for stand history reconstruction and fire scars. P6 = the P6 basin of the Poker Creek watershed; C3 = the C3 basin of the Caribou Creek watershed.

Location	Community	# plots	# trees aged	# dated fire scars	Pith date of oldest tree	Dates of replicated fire scars (n)
P6 north ridge	black spruce	6	57	7	1810	1902 (4)
P6 south-facing	birch	1	58	0	1914	
P6 south-facing	black spruce	7	50	7	1818	1925 (4), 1935 (2)
P6 north-facing	black spruce muskeg	7	21	0	1788	
P6 north-facing	closed-canopy black spruce	4	14	6	1748	1902 (2), 1925 (2), 1935 (1)
		other in P6:	11	7		1924 (4), 1964 (2)
		P6 totals:	211	27		(21)
C3 east-facing	black spruce		9	8	1766	1905 (7)
C3 north-facing	black spruce		2	2	1768	1911 (2)
Poker-Caribou confluence west-facing	black spruce		3	3	1807	1901 (3)
		other:	7	1	1733	
	Totals for entire watershed:		232	41		(33)

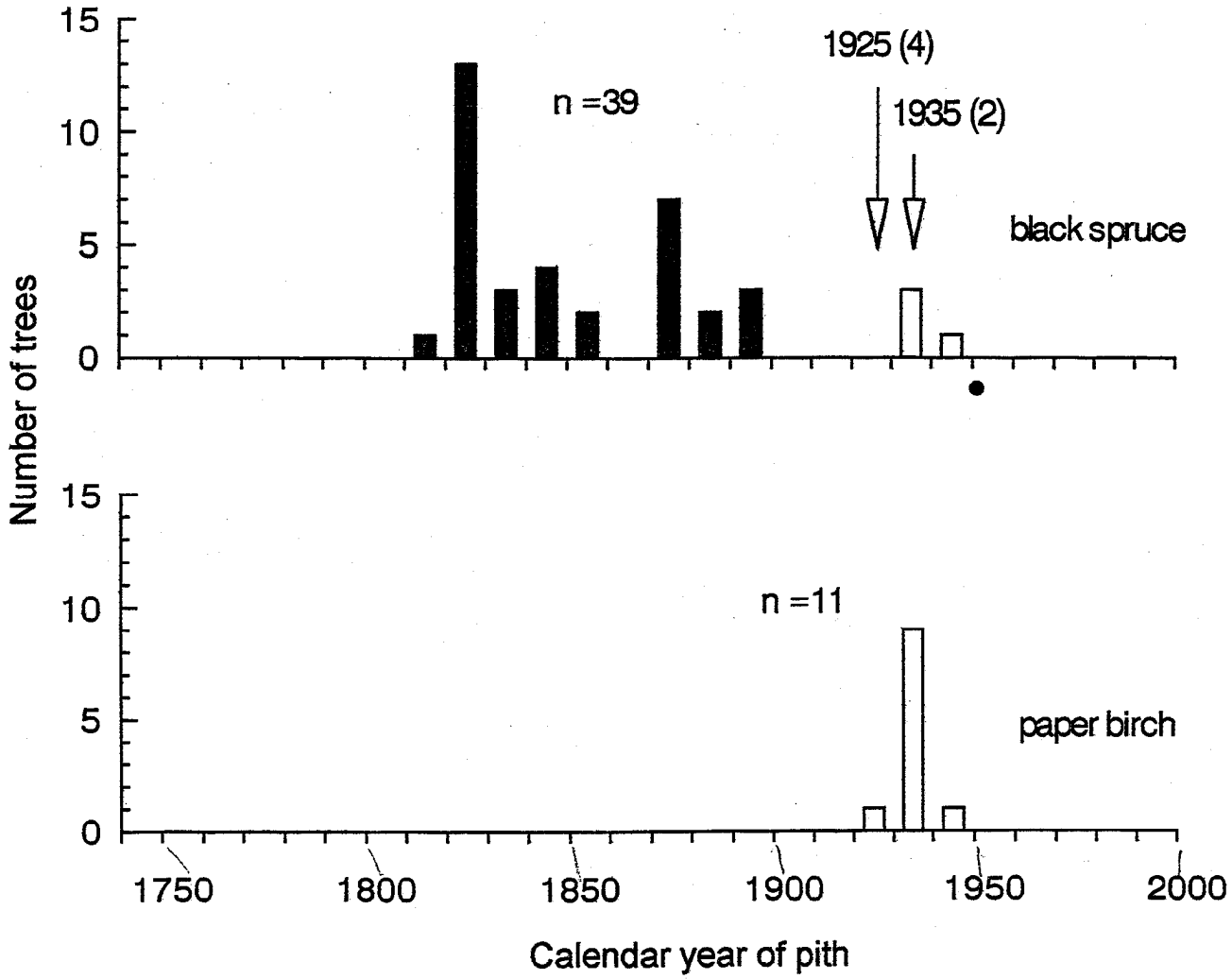


Fig. 6. Age distributions (10 yr classes of age above core height) of 31 black spruce at sampling points and 8 additional fire-scarred spruce in the south-facing black spruce stand (solid bars), and 4 spruce and 11 birch in an adjacent young stand (open bars). Replicated (arrows) and unique (dot) fire scars collected in this stand are shown. Sample size of fire scars in parentheses.

through part of the stand in 1925, apparently as a non-destructive ground fire. Pith dates from 11 birch and four black spruce in the young stand adjacent to the western margin of this stand suggest that the young trees are of the same cohort as trees in the western part of this south-facing slope (see above), and are part of the stand initiated after a 1925 fire (Fig 6).

Pith dates from a systematic sample of 21 black spruce from a sparsely stocked muskeg stand on the north-facing slope of the P6 basin suggest recruitment occurred between about 1780 and 1940 (Fig. 7). Pith dates from a systematic sample of 17 black spruce in an adjacent closed canopy stand indicate that a less prolonged period of recruitment occurred between about 1810 and 1880 (Fig 7). No fire scars suggest a date of a fire that could have initiated either of these stands. Neither of these age distributions suggests a pulse of recruitment typical of post-disturbance populations, although the small sample size prevents closer interpretation. Four fire scars at the margins of closed canopy stands suggest that the 1902 fire which initiated recruitment in the ridgetop black spruce stand, and the 1925 fire which initiated recruitment in the south-facing birch stand may have reached this north-facing slope. The absence of a recruitment pulse following these two fires suggests that these fires were non-destructive ground fires on this slope.

Stand-initiating fires have covered 17% of the P6 basin during the 20th century, at least 4% in 1902 and 13% in 1925. A minimum estimate of mean stand age (or mean time since last fire) can be made assuming that the remaining 83% of the basin burned in 1800. Adjusting each stand age for the area it covers today, the mean stand age in the P6 basin is 167 yr.

Fire scars in four black spruce trees from the eastern part of the north-facing slope in the P6 basin record a 1924 fire. Two fire scars in black spruce at the margins of the treeless creek-side wetland record a 1964 fire. No sampling of tree ages was done at these sites and there is no other evidence to suggest the extent or severity of these two fires.

Elsewhere in the research watershed, each of three sampling locations revealed a unique fire date which was not recorded in the P6 basin. On the west-facing slope above the confluence of Poker Creek and Caribou Creek, three fire-scarred black spruce record a 1901 fire. On the east-facing ridge north of the C3 basin, seven black spruce record a 1905 fire. On the north-facing slope near the mouth of the C3 basin, two black spruce record a 1905 fire. No sampling of tree ages was done at these sites and there is no other evidence to suggest the extent or severity of these three fires.

DISCUSSION

Approximately 83% of the P6 basin has not experienced a stand-initiating fire since at least 1810 (Fig. 4). Stand reconstructions in two out of the five stands studied suggest that black spruce recruitment began there in the first two decades after 1800. Although four black spruce sampled in two stands on the north-facing slope pre-date 1810, a recruitment gap around 1800 suggests that these stands may also have been

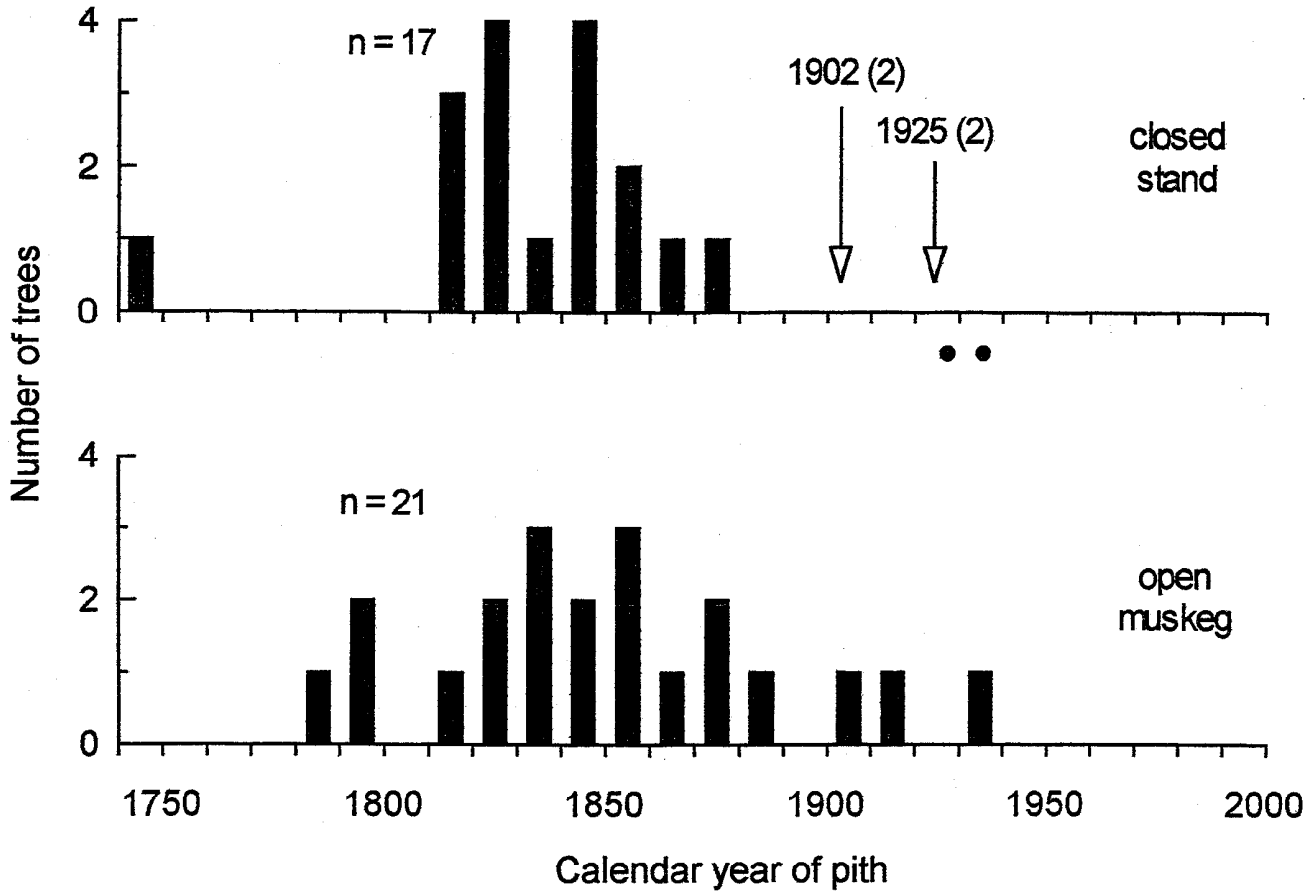


Fig. 7. Age distributions (10 yr classes of age above core height) of black spruce at sampling points in closed canopy (top) and muskeg (bottom) stands of black spruce on the north-facing slope. Replicated (arrows) and unique (dots) fire scar dates are shown. Sample sizes of fire scars are in parentheses.

affected by a fire around 1800 (Fig. 8). It is possible that a major fire at this time initiated new recruitment over a large part of the P6 basin. For the remainder of the 19th century, there is no evidence of fire in the P6 basin.

In 1902, a stand-initiating fire destroyed approximately 20 ha of black spruce forest on the top of the ridge at the northern margin of the P6 basin. The extent of this fire outside of the basin has not been investigated. In 1925, a stand-initiating fire destroyed approximately 70 ha of birch forest on the south-facing slope downhill from the ridgetop black spruce stand. This fire may also have affected an undetermined area outside of the P6 basin. It is possible that the 1902 ridgetop fire also reached into the area of the south-facing birch stand which burned in 1925. Most of the recruitment initiated there by a 1902 fire would have been killed by the 1925 fire, but an older cohort of birch on the south-facing slope which has not been adequately studied may be the remnants of that earlier recruitment. Both the 1902 and the 1925 fires apparently reached other areas of the P6 basin, but neither fire was severe enough there to initiate recruitment.

Fires in 1924, 1935, and 1964 scarred trees in the P6 basin but may not have disturbed biomass or organic matter sufficiently to initiate recruitment. The extent of these fires is not known, but may have been limited -- replicate scars for each of these fires were within 100 m of each other. Unreplicated scars record disturbances in five additional years between 1904 and 1931. Although these scars may be incorrectly dated because of missing or indistinct rings following the fire, some of these scars may accurately record small fires. Although the ecological significance of these fires may have been limited, ground fires can have important impacts on herb and shrub recruitment, wildlife, and nutrient cycling. The occurrence of these non-stand-initiating fires has been overlooked in previous fire history studies in Alaska which are based primarily on stand histories reconstructed from tree ages, and therefore detect only major fires.

Interior Alaska provides a unique opportunity to study fire regimes unaltered by European settlement. However, all of the fires documented in this study occurred after gold prospectors arrived in the Fairbanks area. In fact, the earliest fire documented burned in 1901, the first year prospectors are known to have explored within a few km of the study site (Cole 1991). The swarm of four fires between 1901 and 1911 encompasses the boom years that saw the population of Fairbanks grow from zero to 12,000 by 1903 and then decline to fewer than 5,000 as the easily recovered placer deposits were depleted. The richest active placer in the Fairbanks mining district was along Cleary Creek, immediately adjacent to the research watershed. A second swarm of fires between 1924 and 1935 may be associated with a second period of mining activity when power dredges began to work the deposits previously mined by hand. In the southwestern United States (Baisan and Swetnam 1990), the Great Lakes region (Heinselman 1973), and the northern Rocky Mountains (Barrett et al. 1991), grazing and fire suppression are responsible for a marked decline in fire frequency in the late 19th century. Results of this study suggest that the start of resource exploitation at the turn of the century was apparently responsible for a dramatic increase in fire frequency around Fairbanks.

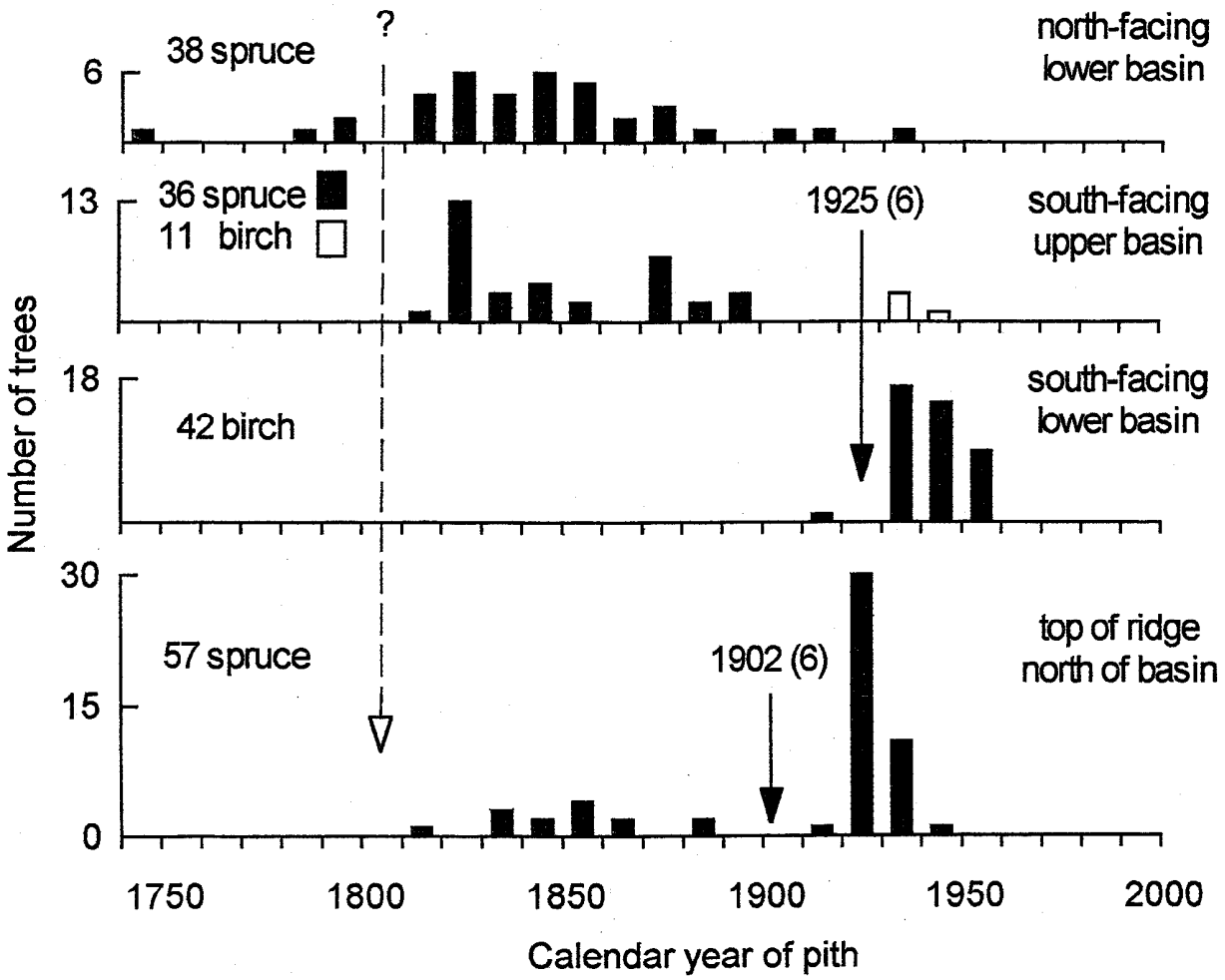


Fig. 8. Age distributions (10 yr classes of age above core height) of five study stands (two stands on north-facing slope have been combined at top). Dates of two stand-initiating fires are shown (solid arrows). Suggested approximate date of an earlier stand-initiating fire is also shown (open arrow). Composite sample sizes of fire scar dates are in parentheses.

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