Post-fire Forest Regeneration on the Western Kenai Peninsula, Alaska; a Forty-eight Year Record from Nine Permanent Plots

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INTRODUCTION

Disturbance by fire is the most immediate cause of the mosaic of successional stages that is so striking to the eye in northern landscapes (Viereck 1973, Van Cleve and Yarie 1986). In Interior Alaska this mosaic is created by frequent lightening-generated fires, and there are few forest stands more than 200 yr old (Viereck 1973). On the Kenai Peninsula in southern coastal Alaska lightening strikes are rare, and most fires are human-caused (KNWR 1988). Fire frequency appears to have accelerated substantially in the mid-19th century with the arrival of European settlers. Many black spruce burns north of the Kenai River date from 1835 to 1900 (DeVolder 1999). A series of large burns (106,000 ac) on the Benchlands between Skilak and Tustumena Lake (occurring in 1871, 1891, and 1910, according to trapper Andrew Berg, quoted in Palmer 1938) regenerated with thick willow, and gained the Kenai Peninsula an international reputation for trophy moose in the early 1900's. Two burns in 1926 in the Kasilof area (10-12,000 ac) and Slikok area (4000 ac) contributed important moose browse in the 1930's and 1940's (Spencer and Hakala 1964) .

In the later 20th century two large burns with quite different characteristics have dominated the western Kenai forest mosaic. The 1947 burn (310,000 ac) occurred during a summer of normal weather. It burned from June to August, predominantly in black spruce lowlands, and left many unburned patches of mixed hardwoods, white spruce and grass on moraine hills. These residual patches are quite visible from the air in the fall as yellow hardwoods in a sea of green black spruce. The 1969 burn (86,000 ac), by contrast, occurred during a second summer of drought and high temperatures, and it left few unburned residual patches. It was a severe mineral soil burn which effectively consumed the duff and litter of the forest floor, and created conditions for profuse hardwood regeneration that is still an important source of winter browse for moose and hares.

The 1947 and 1969 burns occurred primarily on the lands of the Kenai National Moose Range, established in the 1941, which subsequently became the Kenai National

Wildlife Refuge in 1981 with the passage of the Alaska National Interest Lands Conservation Act (ANILCA). Moose Range biologists understood the importance of early successional vegetation for moose winter survival, and in 1950 they set up nine permanent plots to monitor vegetation succession in the large 1947 burn. This work was initiated by John Hakala , then a graduate student who later became refuge manager (DATES___). The nine plots were set up along the old Sterling Highway (now Skilak Loop Road) between Sterling and the Kenai River, north of Skilak Lake (Fig. 1). The plots were chosen to represent a wide range of stand types and degrees of burn severity, and only two plots could be considered close replicates.

The 6.6' x 66' (0.010 acre or 10 milacre) plots were carefully censused and photographed by Hakala and co-workers in 1950, 1955, 1961, and 1965. A collapsible 10x10 grid measuring 6.6' on the side was used to count every stem, with numbers sometimes running into the thousands of stems. In 1950 every stem was mapped in the first and tenth milacre of each plot. In the surveys of 1955, 1961 and 1965 the mapping was simplified to listing the dominant and minor species in each of the 100 cells of the grid. In 1976 crews under the direction of John Oldemeyer censused 7 of the 9 plots using the original protocols, and in 1976-77 they surveyed the surrounding stands at all nine plots, using a forward random angle traverse of 25 1x5m subplots. Oldemeyer adapted this method after Daubenmire (1959), and used it for an extensive study of hardwood regeneration after disturbance, surveying 294 plots from 1975 to 1981 (Oldemeyer and Regelin 1984) . The present author censused the nine permanent plots in 1995, following the original protocols, and he also repeated the Daubenmire surveys of the surrounding stands.

At any point in time, it is possible to examine a wide variety of stand ages and conditions in the Kenai Peninsula forest mosaic, and to conceptually arrange these stands in a broad chronosequence of succession stages. This approach, however, can miss the unique features of each stand which determine its particular successional pathway. It can be plausibly argued that topography is the ultimate determinant of vegetation on the boreal landscape, as mediated through hydrology and soils (Van Cleve and Yarie 1986). On a shorter time scale, however, post-burn regeneration is most strongly determined by two factors: (1) pre-burn vegetation, and (2) burn severity, as regards the forest floor (Foote 1983, Viereck et al. 1979).

The pre-burn vegetation provides the living material for regeneration, be it seeds or vegetative resprouting. The burn severity determines the ground condition for regeneration. A severe mineral soil burn that consumes most of the duff and litter can effectively sterilize the soil, killing stems, roots, seeds in the soil, and soil mycorrhizae and other soil organisms (Ahlgren 1974). It can also provide a flush of nutrients from the burned organic matter (Viro 1974). The exposed mineral soil bed depends on dispersed seeds, and is often very effectively seeded by birch seeds blowing across the winter snow (Zasada 1971).

A lightly burned stand, on the other hand, may regenerate vegetatively, such as by root suckers from aspen or stump sprouts from birch or alder. Most of the root propagation of aspen, for example, occurs within 5-15cm (2-6") of the soil surface (Viereck 1973), below the zone of scorch for a light burn, but well within the reach of a severe burn (REF). It is also possible that a light burn can leave a thick grass sod which is not easily colonized by seedlings of any kind (Lieffers et al. 1993, 1994).

When one examines a stand many decades after a burn, careful analysis is needed to assess the pre-burn vegetation and especially the degree of burn severity. Unburned residual patches are the most obvious clue to the pre-burn vegetation, if one can argue that their very type was not the cause of their escape from burning, as might be the case with hardwoods. Profuse aspen suckering indicates a shallow burn, whereas thick birch regeneration suggests mineral soil exposure. The absence of either aspen or birch, however, allows no inference: on the Kenai either may have been initially present, but was subsequently consumed by moose or hares. The presence of living residual trees (perhaps with fire scars) within the burn indicates a shallow burning ground fire. Standing spruce burn poles whose branches were completely burned off (leaving charcoal nubs) but whose boles were not charred indicate a rapidly moving crown fire that killed green trees but did not undercut them by consuming the organic layer in which the trees were rooted. Dendrochronology can be used to date old burns by cross-dating uncharred burn poles to determine their death date (DeVolder 1999).

Permanent plots set up after a burn can preclude the necessity for such *ex post facto* exercise in deduction. Pre-burn vegetation and burn severity can be easily assessed within the first several years after a burn. Photographs can be taken, survey protocols described, plants vouchered, and materials archived for future surveys, as in the National Park Service Fire Monitoring Handbook protocols (1999). It is understood that different people will be reading the plots over a period of decades, and everything must be explicitly written down in a retrievable medium, such as a paper hard copy.

Our consideration of the permanent plots in this study can be enhanced by organizing the abundant plot data of Oldemeyer and Regelin (1984) into stem density chronosequences, based on time-since-burning as mentioned above. These chronosequences (for black spruce, white spruce, birch, aspen, and willow) show the general early rise and slow decline of stem densities as stands mature. When the trajectories of the permanent plots are graphed on top of the chronosequences, the reader can judge whether the permanent plots fall within the spectrum of regeneration density observed in the typical chronosequence plots.

THE STUDY AREA

The Kenai Peninsula lies in southcentral Alaska between Cook Inlet to the west and Prince William Sound to the east. The Kenai Mountains form a rugged spine of peaks, icefields and glaciers along the eastern side of the Peninsula, with elevations to 2000m, and the Kenai lowland forms a broad plateau extending westward 40 - 65km to Cook Inlet. This lowland plateau has experienced five major glaciations, the most recent being the Naptowne glaciation which consisted of four advances dating from 25,000yBP to 9,500yBP (Karlstrom 1964, Reger and Pinney 1997). The lowland geomorphology consists of hilly morainal belts, flat glacial lake beds, outwash plains, and multi-terraced river channels, with elevations generally ranging from 15 to 100m. Glacial deposits cover a thick sequence of the Tertiary Kenai Group siltstones, sandstones, and coals, which are exposed in coastal bluffs and are rarely visible inland (Calderwood and Fackler 1972, Swenson 1997). The Tertiary sediments lap onto Mesozoic graywacke, chert, and basalt of the McHugh Complex which form the Kenai Mountains (Bradley et al 1997).

On the coast the climate of the central Kenai Peninsula is moderately maritime The Kenai airport has a mean annual temp 33.7°F, total annual precipitation of 19.0" (NCDC 1998), and potential evapotranspiration 17.17" (Patric and Black 1968), although the climate grades to more continental toward the mountains. The Kenai airport reports an average of 88 frost-free days per year, with a range of 67 to 133 days (VERIFY - these figures from O&R 1984.)

The study plots lie 1-15 mi (2-24 km) west of the mountains and appear to fall within a rainshadow from weather coming westward over the mountains from Prince William Sound; the plots presumably experience less precipitation and higher potential evapotranspiration than the coastal Kenai airport meteorological station.

(ECOMAP category - need to get info on this. Forest Service?? Rob DeVelice?)

The forests of the Kenai lowland are transitional between coastal Sitka spruce rainforests and the white spruce - birch boreal forests of the arid Interior of Alaska. The study plots, however, are located 25-40 miles from Cook Inlet in a rainshadow of the mountains, and have a species composition and forest structure much more similar to the boreal forests of the Interior than to the coastal rainforests (Foote 1983, Viereck and Little 1972).

Plots HAK 1 - 5 are located within the 1963 reconnaissance survey soil survey of the KNMR (Rieger 1963). HAK 1 is mapped in the Naptowne Association, and HAK 2 - 5 are mapped in the Homestead Association. In both cases these soils are described as predominantly loess-derived silt loams overlying coarse glacial tills. The Naptowne silt loam commonly has 18-24" of silt loam, and the Homestead silt loam is 4-12" and is considered younger, less developed, and more droughty than the Naptowne silt loam. Both soils are classified as podzols. HAK 6 - 9 lie on the western slopes of the broad Kenai River valley between Hideout Mountain and Bear Mountain. This area is east of the 1963 soils survey area, and probably would have different soil associations. HAK 6 and 9, for example, have high pH values of 6.6 and 7, respectively, which would probably exclude them as podzols (REF). In a later survey Rieger et al. (1979) classified the hilly moraine area around Skilak Lake (the area of HAK 1 - 5) as the S05 phase of the Typic Cryorthod soil association, which has thin mantled soils formed over very gravelly glacial drifts.

Oldemeyer and Regelin (1984) report that most of the plots have a sand proportion of 70-75%, with silt 20-30%, and clay 5-10%, which classifies them as sandy loams. HAK 7 and HAK 9, however, have higher silt (~37%) and clay (~12%) values, and hence low sand values (~50%), and are classified as loams. None of the plots, however, has the required ≥50% silt value required for a silt loam, as described in the 1963 soil survey.

Decriptions of the stands are summarized in Tables 1 - 3.

METHODS

Re-survey of the permanent plots

Each permanent plot consists of a row of ten milacre (0.001 acre) subplots, aligned in a north-south direction, with overall dimensions of 6.6' x 66' and a total area of 0.01 acre (0.40 ha) (Fig. 2). Following the original protocol, a 6.6' x 6.6' collapsible wooden quadrat frame was used to count every stem and to estimate cover values for non-vascular taxa, dead wood, and leaf litter. String was used to create a 10x10 grid of 100 cells 0.66' (20cm) on the side, which greatly facilitated accurate counting and cover estimation. Clumps were counted for gramminoids and multi-stemmed shrubs, and several herbaceous taxa. Heights and diameter-at-breast-height was recorded for all tree species, and basal areas were calculated by summing the cross-sectional areas of all individuals ≥1.4 m tall (Appendices 1 - 7).

Resurvey with the Daubenmire protocol

In Oldemeyer's 1976-77 surveys, a set of 25 random Daubenmire plots were taken in the vicinity of each permanent plot. This protocol uses a forward random angle transect, and wanderes around a 1-2 acre area, providing a broader assessment of the forest stand than does the permanent plot itself. On occasion the transect was subjectively skewed so that it would include the vegetation on all sides of the permanent plot. Most of the 25 points lie within 100m of the plot.

At each point a 1x5m plot was laid out, stems ≥ 40cm in this plot were counted, DBH's taken, basal area measured with a Cruzall, and a height taken for each tree species. Herbaceous vegetation was sampled in a 20x50cm frame using seven cover classes (Appendices 8 - 11).

Plot Characterizations and chronologies

Plot descriptions were taken from the field data sheets prepared by John Hakala in 1950, C. J. Knös in 1955, R. V. Wade in 1961, R. V. Wade and others in 1965, John Oldemeyer in 1976, and the author in 1995. Soil data were collected under the direction of John Oldemeyer in 1976-77. We have on file at the KNWR headquarters 8x10" black-and-white glossy prints for the surveys of 1950, 1955, 1961, 1965, and 1995. For each plot two photos were taken from each end (Milacres 1 and 10).

A basal area dendrogram was prepared to exhibit similarities and dissimilarities among plots, and to group the plots into similar types for analysis and discussion, using the software PC-ORD (McCune and Medford 1997). The clustering algorithm "unpaired group means averaging" (UPGMA) provided a hierarchical tree of similarity relationships (Figs. 3 and 4).

For each census year the plots were qualitatively assessed according to the post-fire succession stage classification of Foote (1983). This classification was based on 130 post-fire stands of white and black spruce in the Interior, arranged in a chronosequence of stages: newly burned, moss-herb, tall shrub and sapling, dense tree, hardwood, and spruce. Succession stage was qualitatively determined by comparing the census photos and vegetation data with the photos and data in Foote (1983) (Fig. 5).

The present vegetation of the plots was classified to Level IV of the hierarchical Alaska Vegetation, following Viereck et al (1992) and DeVelice et al (1998), and Level V community types were assigned by the present author if they were not described in either of the above publications (Table 3).

A burn severity ranking was estimated on the basis of Hakala's 1950 description of the forest floor consumption and the 1950 photographs, with rank of 1 for the least severely burned plot HAK 3 to rank of 9 for the most severely burned plot HAK 6 (Table 1).

The numerical data of the six censuses (1950-1995) are summarized graphically in nine plot chronologies for the most common taxa (Figs. 6.1 - 6.9). Counts of stems are plotted, except where cover values were reported for moss and liverwort-lichen.

For some plots in 1955, 1961, and 1965 only cover values were estimated for grass and lowbush cranberry and these values are reported in the plot narratives in the Results section and in the Full Data Matrix (Appendix 2).

Most postburn aspen reproduction is by means of root suckers (REFS). Aspen seeds have a short viability period of two to four weeks (Perala 1990) and germinate best in mineral soil (McDonough 1979). In the censuses of 1950, 1961 and 1965 aspen seedlings were distinguished from root suckers on the plots where both were present (HAK 2 - HAK 4, Tables 4 and 5). On the other plots no aspen rootstock was present and it is reasonable to infer that increases (gains) in each milacre from one census to the next represent recruitment from seedlings, not from suckers (Appendix 4). These inferred values are minimum estimates, because a gain (birth) matched by a loss (death) would not change the count from one census to the next, and hence the birth (a new seedling) would not be detected. This inference also assumes that there are no counting errors in the data, and that the aspen seedlings were carefully distinguished from birch and alder seedlings. Inspection of the table of net gains (Appendix 4) shows clusters of gains in certain species in certain years that would be hard to explain by purely random data errors. The reported and inferred seedling events are summarized in Table 5.

Stem Density Chronosequences

Plots from Oldemeyer and Regelin (1984) were grouped by the four dominant tree species (black spruce, white spruce, birch, and aspen). Many of these stands were mixed spruce and hardwoods, but are grouped here according to the species with the greatest basal area, or the greatest stem density if basal areas were lacking. Stem densities for each species are graphed as a function of time-since-burning, with a single point representing the density of a single stand at its post-burn age when censused (Fig. 7). Mature plots were lumped together without estimation of stand ages. The graph of Salix includes all plots that had any Salix whatsoever (Fig. 8).

The trajectories of the permanent plots were overlaid on the chronosequence graphs for the appropriate species, e.g., HAK 1, 4, 5, and 7 are basically black spruce plots, which are overlaid on the black spruce chronosequence. A logarithmic scale is used for stem density because of the wide range of stem densities, which can easily vary by 1 or 2 orders of magnitude at a given post-burn year.

RESULTS

When reading the narratives of each plot below, it is instructive to keep the chronologies of the common species in view (Figs. 6.1 to 6.9), as well as Table 1 and

Fig. 4 which summarize the characteristic features of each plot. It should be noted in the discussion that follows, phrases such as "species X peaked in 1961" should be read as "species X peaked in the 1961 *census,* "as opposed to the censuses of other years. It is entirely possible, indeed likely, that species X peaked in some other year that was not censused.

HAK 1: Pure Black Spruce, lightly burned

The 1950 photos show lightly scorched standing black spruce (Picea mariana) burn poles of 1-2" DBH, with lush knee-high bluejoint grass (Calamagrostis canadensis), lupine (Lupinus nootkatensis) and fireweed (Epilobium angustifolium). Hakala suggested that the plot had been previously burned, and the stand was about 30y old, with an average height of 15-20'. Bunchberry (Cornus canadensis), Jacob's ladder (Polemonium spp.) and lowbush (mountain) cranberry (Vaccinium vitis-idaea) were also abundant. There were no aspen (Populus tremuloides) trees within 250yds, and both black spruce and willow (Salix spp.) shoots were visible in the immediate surroundings. See Fig. 6.1.

Black spruce recruitment had begun by 1955 (15 stems) and leveled off by 1961 in the 30's. Recruitment has continued by ones and twos in the milacre subplots each census, with a similar level of mortality (Appendices 4 and 5).

Willow counts began with 9 stems in 1950, and peaked at 27 in 1965. In 1961 and 1976 zero stems were counted, presumably due to moose browsing. Rose and Rubus were never observed.

Lowbush cranberry counts were 1524 in 1950, peaked at 14,301 in 1976, and were down to 2201 in 1995. For some plots in 1955 and 1961 lowbush cranberry stem counts were not made, and cover estimates were reported, and for HAK 1 cover values of 1% were reported for both 1955 and 1961.

Grass counts fluctuate, but appear to reach a low in 1995, as the tree overstory has increased to a canopy cover of 43%. Grass cover values were estimated in 1955 (20%) and in 1961 (48%). Counts of fireweed stems were generally high (200-400) but were lower (175) in 1995. Bunchberry generally increased from 700's in the first two censuses to a peak of 2126 in 1995. Lupine showed a rapid rise to 2092 stems in 1961, and then a steady decline to 3 stems in 1995.

Moss cover was 21% in 1950, with Ceratodon reported as the species, presumably growing on mineral soil exposed in the burn. In 1995 the moss cover was 93% with Pleurozium was dominant (84%), with traces of Aulacomium (4%), Ptilidium

(4%), Drepanocladus (2%), and Polytrichum (1%). Ceratodon was not observed in 1995.

Hardwood leaf litter cover in 1995 was 0%, with dead wood cover 1%.

In 1995 in the greater stand, black spruce basal area was 53 ± 19 ft^2/acre (12 ± 4 m^2/ha), as determined from 25 points with a Cruzall. Mean black spruce DBH was 4.4 ± 2.5cm (N = 71). The stocking of 39 black spruce stems on the 10 milacre (0.010 acre or 0.004 ha) plot represents 3900 stems/acre (9600 stems/ha).

Summary: HAK 1 was a lightly burned stand of young black spruce, which recolonized as pure black spruce, with a few willows as the shrub understory, and a typical Pleurozium - lowbush cranberry ground cover.

HAK 2: Mixed clonal Aspen-Black Spruce, lightly burned

HAK 2 was described in 1950 as a mixed aspen - black spruce stand 45-50 years old of height 25-30'. The ground was lightly burned with no mineral soil exposed. Aspen stems (all root suckers) numbered 445 in 1950, and declined steadily to 36 stems in 1995 (representing 110,000 and 8,900 stems/ha, respectively). The 1950 photos show profuse aspen sprouts 2-3' tall. Moose browsing on the aspen was moderate (24%) in 1950, heavy (100%) in 1955, and very light in 1961 (1%) when the stems were more than 8' tall. Stem height in 1995 in the greater stand was 27 ± 9' (SD) (8 ± 3m). See Fig. 6.2.

Black spruce has always been a minor component on this stand, with a maximum of 6 stems, and with 2 stems in 1995. Willows were reported only in 1965 (23 stems). Rose was abundant in the surrounding stand, Hakala reported in 1950, and 2 to 20 stems have been recorded at one time or another.

Lowbush cranberry counts have ranged from ~2000 to ~10,000, with 4204 stems in 1995; the 1955 cover estimate was 30%. Grass counts were generally low (20-59) and rose to 116 in 1995: grass cover was estimated as 1% in 1961 and 1965. Fireweed counts were low (72 to 165), falling to 36 in 1995. Bunchberry counts ranged from 600 to 2000. As on HAK 1, lupine peaked in 1961 (633 stems), and fell rapidly thereafter (0 in 1995).

Late arriving taxa include Geocaulon lividum, first recorded in 1976 with 672 stems and increasing to 2820 in 1995, Pyrola spp. which appeared in 1965 with 20 stems and increasing to 266 stems in 1995, and Lycopodium annotinum which was recorded in 1995 with 44 stems.

Ceratodon moss cover was 13% in 1950. In 1995 moss cover was scored as 57%, with Drepanocladus dominant (12% cover), Pleurozium (10%) second, and traces of Hylocomium (1%), Aulacomium (3%), Polytrichum (1%), Dicranum (1%), and Ptillium (0.1%). Ceratodon was not observed. (Brachythecium????)

Hardwood leaf litter cover in 1995 was 70%, with dead wood cover at 9%.

In 1995 in the greater stand, aspen basal area was 75 ± 37 ft^2/acre (17 ± 8 m^2/ha), with mean DBH at 5.7 ± 2.0cm (N = 70). Black spruce basal area was 28 ± 18 ft^2/acre (6 ± 4 m^2/ha), with mean DBH at 4.9 ± 2.5cm (N = 42). The 1995 stocking on the plot represent: aspen 3900 stems/ac (9600 stems/ha) and black spruce 200 stems/ac (500 stems/ha).

Summary: HAK 2 was a lightly burned young aspen - black spruce stand. Three years postburn the ground was covered with aspen suckers, which grew into a dense scrub, as shown in the photographs of 1950 through 1965. In 1995 the stand was predominantly aspen with a sparse understory of smaller black spruce (canopy cover 13%). The 1995 stand possessed a much more open appearance than the stands of 1965 and earlier. The herbaceous layer is now dominated by Pyrola, bunchberry, lowbush cranberry and moss.

HAK 3: Mixed clonal Aspen - BlackSpruce, lightly burned

Like HAK 2, HAK 3 was a young (55yr) aspen stand with an understory of black spruce (25yr). HAK 3 went through very similar succession beginning with hundreds of aspen root suckers in the early years whose numbers steadily declined exponentially to 40 in 1995 (representing 91,000 and 9,900 stems/ha, respectively). Hakala reported that the ground was lightly burned, and in the 1950 photographs the presence of fine branches on the burned black spruce and the lightly blackened aspen trunks confirm a light burn. See Fig. 6.3.

The plot is now virtually all aspen, with only one black spruce. Three willows were present in 1950, but had vanished by 1976. Rose and Rubus were never recorded.

Lowbush cranberry counts ranged from 146 to >9000 in 1976, with a 1995 count of about 3500; the 1955 cover estimate was 8%. Grass counts ranged from about 20 to 570 in 1976; grass cover was 10% in 1961 and 5% in 1965. Bunchberry ranged from about 800 to >3200 in 1965, with 1273 in 1995. As on HAK 1 and HAK 2, lupine peaked in 1961 (590 stems) and declined to 1 in 1995.

Late arriving taxa include crowberry, twin flower, and Pyrola spp., which were first recorded in 1976, and Lycopodium in 1995.

Ceratodon moss cover was 14% in 1950. In 1995 moss cover was 13% with Brachythecium dominant (4%), Drepanocladus (3%), and traces of Pleurozium (1%), Polytrichum (1%), and <1% of Dicranum, Ptilidium, Hylocomium, Aulacomium, Eurhynchium, Pohlia, and Thuidium. Ceratodon was not observed in 1995.

Hardwood leaf litter cover in 1995 was 97%, with dead wood cover 4%.

In 1995 in the greater stand, aspen basal area was 62 ± 32 ft^2/acre (14 ± 7 m^2/ha), with mean DBH at 5.9 ± 3.3cm (N = 60). Black spruce basal area was 25 ± 22 ft^2/acre (6 ± 5 m^2/ha), with mean DBH at 5.8 ± 5.1cm (N = 10). The 1995 stockings on the plot represent: aspen 4000 stems/acre (9900 stems/ha) and black spruce 100 stems/acre (250 stems/ha).

Summary: Like HAK 2, HAK 3 was a lightly burned young aspen - black spruce stand. With abundant root suckering, HAK 3 regenerated as an almost pure aspen stand. There is less moss in HAK 3, because of a nearly complete litter cover of dead leaves, due to the closed aspen canopy. Bunchberry and lowbush cranberry dominate the herbaceous layer.

HAK 4: Mixed Black spruce - Aspen, severely burned

This plot was heavily burned, according to Hakala. The 1950 Milacre 1 photo shows dense sprouting of aspen around a 6" DBH burned aspen with little remaining bark. Hakala estimated that the black spruce was 85yr old with average height of 15-20', and that the aspen was 80-85yr old, with average height of 25-30'. See Fig. 6.4.

No census data are available for 1976 for this plot (nor for HAK 6).

Black spruce seedlings (3) were present in1950, in 1955, peaked in 1965 at 44 stems, with 29 stems in 1995. In 1950 Hakala reported only 64 aspen stems (62 suckers, 2 seedlings); aspen peaked in the 1961census with 115 stems, and declined to 28 stems in 1995. Aspen suckering apparently continued at least until 1961, because the censuses of 1955 and 1961 showed increases of 30 and 29, respectively, in the milacre recruitment. Suckers were not distinguished from seedlings in 1955, but were distinguished in 1965, with 8 seedlings reported, leaving 21 stems as recent suckers (Table 5, Appendix 4). Several stems of birch and willow were present in each census year.

The low 1950 aspen recruitment of 64 stems contrasts strongly with lightly burned HAK 2 and HAK 3 plots, which had counts of 424 and 370, respectively. It is likely that the severe burn on HAK 4 killed many aspen roots.

Nevertheless, in 1950 the smaller number of stems on HAK 4 were distinctly taller (33.1") than those of HAK 2 (20.3") and HAK 3 (19.3") (Table 4).

Only 277 lowbush cranberry stems were counted in 1950, a further indication of a severe burn. Lowbush cranberry peaked in 1961 at 8208, with 3994 stems in 1995; lowbush cranberry cover in 1955 was 5%. Grass counts have been even, ranging 80-98, with covers of 8% (1961) and 4% (1965). Fireweed peaked in 1950 at 365 stems, and declined to 41 stems in 1995. Lupine appeared briefly in 1961 (10 stems) and 1965 (30 stems). Bunchberry increased from 835 in 1950 to 3657 in 1955, but decreased to 646 in 1995.

Geocaulon appeared late, in the 1995 census, but in large numbers (1088 stems).

Ceratodon moss cover was 35% in 1950 indicating substantial mineral soil exposure. In 1995 moss cover was scored as 29%, with Drepanocladus dominant (9%), Brachythecium (8%), Pleurozium (6%), and traces of Polytrichum (1%), Dicranum (0.2%), and Aulacomium (0.2%). Ceratodon and Hylocomium were not observed in 1995.

Hardwood leaf litter cover in 1995 was 85%, with dead wood cover 8%.

In 1995 in the greater stand, black spruce basal area was 18 ± 15 ft^2/acre (4 ± 3 m^2/ha), with mean DBH at 2.7 ± 1.8cm (N = 97). Aspen basal area was 38 ± 34 ft^2/acre (9 ± 8 m^2/ha), with mean DBH at 6.5 ± 4.0cm (N = 36). The 1995 stockings on the plot represent: black spruce 2900 stems/acre (7200 stems/ha) and aspen 2800 stems/acre (6900 stems/ha).

Summary: HAK 4 was a severely burned 85 year old black spruce and aspen stand. Aspen recruitment was primarily through suckers, which continued to proliferate at least until the 1961 census. In 1995 aspen was the canopy dominant species with black spruce subdominant with cover of 32%. Lowbush cranberry, bunchberry, and Drepanocladus formed the primary ground cover, with thick aspen leaf litter.

HAK 5: Pure Black Spruce, very severely burned

In 1950 Hakala described this plot as a heavily burned pure black spruce stand, with 70% mineral soil exposure. The 1950 Milacre 10 photo shows dense black spruce burn poles (2-3"DBH) with all branches burned off and soil with very little herbaceous cover other than fireweed (at 50% cover). Stand age was estimated to be 100yr, with DBH of 2-3". This contrasts with the photos of lightly burned HAK 1, 2, and 3 which had most poles still standing, with fine branches and bark intact. No aspen poles are visible in the 1950 photos of this plot. The site is located on a narrow moraine with about 20' of relief and is well-drained. See Fig. 6.5.

There were 4 black spruce seedlings in 1950, with this count increasing to 34 in 1976 and 1995. Aspen reproduction was entirely by seedlings in 1950, with Hakala reporting 43 first year seedlings (2-4" tall) and one second year seedling (14" tall) (Table 5). Aspen peaked at 77 stems in 1965 and declined to 13 stems in 1995. Birch peaked at 34 stems in 1965, with 10 stems in 1995. Willow stems varied from 12 to 28, with 12 stems in 1995. Rose and Rubus were never recorded.

No moose utilization was observed in 1950 or 1955, and only slight utilization in 1961. The census of in 1961, however, noted that the hardwoods were less than 4' tall on this plot, whereas they were well over 6' tall on HAK 2, 3, and 4. The surveyor attributed this to heavy moose utilization prior to 1961, but it was probably due to the fact that the hardwoods described (mostly aspen) were growing from seedlings, not from root suckers as in HAK 2 - 4. Aspen seedling recruitment continued until at least 1965 (Table 5, Appendix 4).

Lowbush cranberry was absent in 1950, indicating a very severe burn; it appeared in 1955 (0.3% cover), peaked in 1976 at 9382, and had 4315 stems in 1995.

Grass has been negligible on this plot, i.e., cover of 0.2% in 1961, 0.6% in 1965, and 2 clumps in 1995. Fireweed peaked in 1950 with 581 stems, with counts in the 100-200's until 1995 with 58. Bunchberry increased steadily from 114 in 1950 to 2283 in 1976, declining to 476 in 1995. Lupine peaked at 885 in 1965, but was absent in 1995.

Late appearing taxa were Ledum with two clumps in 1965, and Linnaea with 347 stems in 1976.

Moss cover was reported at 60% in 1950; no species name was reported but with 70% mineral soil exposed one would expect Ceratodon. Moss cover estimates very greatly over the years, from 3% to 72% with no apparent order; this suggests that theses estimates are overly subjective and are best taken as "order of magnitude" values. In 1995 moss cover was scored as 59% with Drepanocladus dominant at 12%, Pleurozium at 10%, Ptilidium at 3%, and traces of Polytrichum (1%), Aulacomium (0.4%), Ptillium (0.1%), and Hylocomium (0.4%).

Hardwood leaf litter cover in 1995 was 34%, with dead wood cover 28%.

In 1995 in the greater stand, black spruce basal area was 25 ± 15 ft^2/acre (6 ± 3 m^2/ha), with mean DBH at 3.5 ± 2.2cm (N = 81). Aspen was 22 ± 37 ft^2/acre (5 ± 9 m^2/ha), with mean DBH at 4.6 ± 3.4cm (N = 23). Birch was 12 ± 14 ft^2/acre (3 ± 3

m^2/ha), with mean DBH at 4.4 ± 2.6cm (N = 37). The 1995 stockings on the plot represent: black spruce (3400 stems/acre, 8400 stems/ha) and aspen (1300 stems/acre, 3200 stems/ha).

Summary: HAK 5 was a very severely burned 100 year old pure black spruce stand. Aspen regeneration was less intense on this plot than the previous plots, because there was no aspen in the original stand and all recruitment was through seedlings. Black spruce regeneration was abundant, like that of HAK 4, with a cover of 43% in 1995. Lowbush cranberry and Pleurozium are now the dominant ground cover; grass was never significant on this plot.

HAK 6: White Spruce, Cottonwood and Birch, very severely burned

This plot was and is very different from the black spruce and aspen plots described above (HAK 1- HAK 5). The plot was in a very severely burned mature white spruce, cottonwood and birch stand, with practically all of the trees burned and blown down, and a heavy cover of fireweed and liverwort-lichen on the burnt duff. The 1950 photos show only down dead wood and dense fireweed 2-3' tall. Down and rotten cottonwood boles of 2-3' diameter were still visible near the plot in the 1995 census. See Fig. 6.6.

HAK 6 is located mid-slope on a gentle slope of southeastern exposure, whereas HAK 1-5 and 7 are located on flat ground. HAK 8 and 9 are located mid-slope on gentle slopes of southerly exposure.

No census data are available for 1976 for this plot (nor for HAK 4).

Regeneration has been entirely birch and alder; no spruce (white or black), aspen or cottonwood regeneration was ever recorded in the plot, although white spruce was recorded in the 1995 Daubenmire plots in the greater stand. Hakala reported 171 birch seedlings 2-4" in height in 1950. Between 1955 and 1965 birch stem counts were in the 60's. In 1995 five live and seven dead birch stems were counted, with DBH's as large as 8.3" (21.1cm) and heights to 45' (14m).

Alder appeared with 2 stems by 1961, 34 stems in 1965, and 9 live and 21 dead stems in 1995. Willow was present from 1955 to 1965, but was not observed in 1995.

Raspberry (Rubus ideaus) appeared by 1961 (66 stems) and again in 1995 (15 stems). Rose appeared in 1965 (2) and 1995 (5).

This plot and HAK 9 have never reported lowbush cranberry or lupine, and this plot has never reported bunchberry.

Grass was not observed in 1950 and 1955 but was scored as 8% cover in 1961 and 20% in 1965, and counted as 174 clumps in 1995. In the greater stand in 1995 mean grass cover was 26.5%, which was by far the highest grass cover in all nine stands. Fireweed was very abundant in 1950 (2818 stems), but declined steadily to 525 in 1965, and to 0 in 1995.

Other taxa first appearing in the 1960's include bedstraw (Galium spp.) (1961), grass (1961), moss (1961), horsetail (Equisetum arvense) (1965), and violet (Viola spp.) (1965).

There was a 30 year gap between the censuses of 1965 and 1995 in this plot, and many new taxa were recorded in 1995: starflower (Trientalis europaea) (20), northern red currant (Ribes triste) (66), sweet cicely (Osmorhiza purpurea) (1499), baneberry (Actaea rubra) (34), bluebell (Mertensia paniculata) (11), devil's club (Echinopanax horridum) (3), horsetail (Equisetum scirpoides) (142), grove sandwort (Moehringia lateriflora) (307), cow parsnip (Heracleum lanatum) (58), and dandelion (Taraxacum spp.) (5).

In 1950 this was the first plot to report a significant "lichen" cover, with a value of 49%. This was most probably not lichen, but rather the liverwort Marchantia polymorpha which is a common early colonist of severely burned soils on the Kenai Peninsula. In subsequent discussion it is assumed that the "lichen" cover values reportrd in 1950 and probably 1955 actually represent Marchantia and not lichen. The slowly increasing lichen values from 1961 onward quite probably represent true lichen genera such as Cladina, Cladonia, and Sterocaulon.

The 1950 reported values of 0% Ceratodon and 0% mineral soil exposure suggest that the soil surface was effectively covered with Marchantia and fireweed, although a careful search under this dense cover would probably have revealed traces of Ceratodon and mineral soil.

Total moss cover was reported at 0% in 1950, and at 2% in 1995, with only Eurhynchium (2%), Drepanocladus (0.1%), and Plagiomnium insigne (0.3%) observed.

Hardwood leaf litter cover in 1995 was 95%, with dead wood cover 5%.

In 1995 in the greater stand, birch basal area was 41 ± 27 ft^2/acre (9 ± 6 m^2/ha), with mean DBH at 7.9 ± 4.7cm (N = 37). White spruce was 12 ± 21 ft^2/acre (3 ± 5 m^2/ha), with mean DBH at 10.4 ± 3.3cm (N = 5). Alder was 43 ± 48 ft^2/acre (10 ± 11 m^2/ha), with mean DBH at 7.7 ± 3.1cm (N = 19). The 1995 stockings on the plot were alder 900 stems/acre (2200 stems/ha) and birch 500 stems/acre (1200 stems/ha).

Birch and alder now dominate the canopy, above a well-developed cow parsnip (Heracleum) layer, with baneberry (Actaea), horsetail (Equisetum arvense), and grass as the ground cover. HAK 6 and HAK 9 are floristically very similar in sharing ten species not found on other plots, such as Heracleum, Moehringia and Osmorhiza. This may be a consequence of nitrogen enriched alder soils, or the high soil pH values in HAK 6 (pH 7) and HAK 9 (pH 6.6). The pH-values of spruce, aspen, or birch based soils in the other plots ranged from 3.8 to 4.8.

The recruitment pattern of tree species on HAK 6 is worth additional comment. First, cottonwood regeneration did not occur, in spite of the original canopy dominance, as well as the presence of residual survivors along the road, 100m down slope from the site.

Second, by 1950 there was limited birch seeding (175 seedlings 2-4" high), no alder, but extremely dense fireweed (2800 stems) and heavy liverwort ground cover (49%). The late appearance of alder (2 stems by 1961) and absence of cottonwood suggest that the initial period of open mineral soil was quite brief (perhaps the first post-fire season) and that seed sources for alder and especially cottonwood were lacking at that time. The fact that Hakala described the trees as down on the ground in 1950 suggests that the fire burned deeply around the tree bases, allowing the trees to fall over quickly. This phenomenon was observed in the late season 1994 Windy Point (Tustumena Lake) burn in hilltop cottonwood and white spruce stands, where every tree was down within one year.

Summary: HAK 6 was a very severely burned mature birch, cottonwood and white spruce stand, which regenerated as birch and alder, with a well-developed Heracleum layer, accompanied by Actaea, Equisetum arvense, and grass. HAK 6 and HAK 9 are floristically very similar.

HAK 7: Black Spruce, severely burned

In 1950 Hakala described this plot as situated in a heavily burned black spruce swamp. He estimated the stand age as 110yr at the time of the 1947 burn; this would date the stand to about the time of the 1835 fire, which were recently identified from fire scars near the south end of Mystery Creek Road, 5.5mi (9 km) to the NNW (DeVolder 1999). Hakala reported that no mineral soil was exposed but that the humus was heavily burned. The 1950 photos show heavily scorched black spruce burn poles (2" DBH) and a blackened ground surface with spotty Equisetum silvaticum. Ledum propagates from underground rhizomes and the abundance of Ledum in 1950 strongly suggests that the sod layer and Ledum rhizomes were not appreciably consumed (Viereck 1983).

It is quite possible that the water table has dropped slightly (c. 1') at this site, because it could not be described as a "swamp" in 1995. Water tables have fallen this much and more in many KNWR wetlands, and one sees recent spruce invasion into many wetland perimeters. Fifty meters south of the plot the soil is wet and one finds Sphagnum, Drosera, Equisetum fluviatile, and other wetland indicator species. These taxa have not been reported at anytime on the plot itself, however. A longterm drying of this plot since the 1960s is suggested by the steady decline in the counts of the "facultative wetland" species cloudberry Rubus chamaemorus (Reed 1988) from 311 in 1961, 179 in 1965, 151 in 1976, to 45 in 1995.

Taxa present in 1950 were Equisetum silvaticum (240), grass (27), abundant labrador tea (Ledum, 69), cloudberry (Rubus chamaemorus, 136), spirea (Spiraea Beauverdiana, 4), lowbush cranberry (142), black spruce (5), aspen first year seedlings (4), and Ceratodon moss at 6%. Fireweed was absent in 1950, but appeared and peaked in 1955 at 107 stems, and was absent in 1995. Equisetum silvaticum peaked in 1955 (969) but declined steadily to 0 in 1995.

Black spruce increased to a peak of 42 stems in 1976, and declined to 38 in 1995. Birch appeared in 1955 with 5 stems, peaked in 1965 (41), declined to 9 stems in 1976 and was gone by 1995. Dwarf birch (Betula nana) appeared in 1955 (1) and 1961 (10). Aspen has been present in low numbers at each census (3-10 stems). Ledum counts oscillated between 31 and 69, with 80 in 1995, but there is probably some variation in what different surveyors took as the unit to be counted. Ledum covers of 18% and 19% were reported in 1961 and 1965, respectively.

Willow appeared in 1955 (1) and showed 2-5 stems in subsequent counts. Blueberry appeared in 1961 (13), peaked in 1976 (178), and fell to 38 in 1995. Lowbush cranberry started with 142 stems in 1950, increased to 13% cover in 1955, peaked in 1976 at 29,144 stems (a record for all plots), declining to 3319 in 1995. Grass peaked in 1976 at 175, declining to 46 in 1995; grass cover was estimated in 1961 (7%) and 1965 (2%). No bunchberry was ever observed.

Late appearing taxa were crowberry (Empetrum nigrum) (1976, 36), Geocaulon (1995, 56), and Equisetum arvense (1995, 62).

Moss cover was reported at 6% in 1950 and peaked at 55% in 1961, with 21% in 1995, with Polytrichum dominant (14%), Pleurozium (3%), Ptilidium (2%), and traces of Aulacomium (1%), Dicranum (0.5%), Drepanocladus (0.1%), and Ceratodon (0.1%).

Hardwood leaf litter cover in 1995 was 0%, with dead wood cover 12%.

In 1995 in the greater stand, black spruce basal area was 17 ± 15 ft^2/acre (4 ± 3 m^2/ha), with DBH at 3.5 ± 2.1cm (N = 61). Black spruce stocking on the plot was 3800 stems/acre (9400 stems/ha).

Summary: HAK 7 was a moderately burned 110 year old dense lowland black spruce stand. The stand regenerated as an open black spruce woodland (17% cover), with a dense Ledum shrub layer (77% cover). The substantial Polytrichum ground cover (14%) suggests that the site is presently rather dry, at least on the surface. This plot had the lowest production of woody species of all nine plots, with a greater stand basal area of only 17 ft^2/acre of black spruce. The original burn charred the heavy sod layer, but apparently not to such an extent that mineral soil was effectively opened up for seedling recruitment.

HAK 8: Mixed White Spruce - Birch, moderately burned

This plot was situated in a mature (c.150yr) white spruce and birch stand. In 1950 Hakala reported that the area had been heavily burned in spots and bare mineral soil was exposed at 35% cover. The 1950 photos of Milacres 1 and 10 show fine branches and bark intact on the white spruce and birch, suggesting that the overstory was only moderately burned. See Fig. 6.8.

White spruce stem counts were highest in 1950 (168), and declined to 43 in 1995. Birch seedlings were counted at 2029 in 1950; this was the highest count for a tree species in all plots in all years. Birch declined steadily to 21 stems in 1995, with DBH's to 15.2cm and heights of 40'. Alder appeared in 1955 (6), peaked in 1965 (52), and declined in 1995 (6). Willow peaked in 1955 (82), declined to 1976 (10), and was absent in 1995. Aspen appeared in 1955 (13), declined, and was absent in 1995. Rose increased steadily to peak at 112 in 1965 and declined steadily to 18 in 1995. High bush cranberry (Viburnum edule) appeared in 1955 (2) and has been stable since 1965 (9-14). Raspberry was present in 1950 (48) but was gone by 1976.

Lowbush cranberry was counted at 167 in 1950, with cover of 11% in 1955; it rose steadily to 3314 in 1965, and declined to a minuscule 19 in 1995. Grass was reported only once, as 0.2% cover (1965). Fireweed peaked in 1950 (678) and has generally declined to 9 in 1995. Bunchberry counts ranged from 1025 to 3050 from 1950 to 1965, and declined to 58 in 1995.

Late arriving taxa include Geocaulon (1976, 45), and Linnaea (1965, 675).

Ceratodon moss cover was reported as 18% in 1950. In 1995 moss cover was 5% with Polytrichum dominant (5%), and traces of Pleurozium (0.3%), Drepanocladus (0.3%), Ptilidium (0.3%), and Aulacomium (0.1%).

Hardwood leaf litter cover in 1995 was 90%, with dead wood cover 19%.

In 1995 in the greater stand, birch basal area was 64 ± 27 ft^2/acre (15 ± 6 m^2/ha), with mean DBH at 8.2 ± 3.7cm (N = 46). White spruce was 48 ± 28 ft^2/acre (11 ± 6 m^2/ha), with mean DBH at 4.0 ± 2.9cm (N = 88). Alder was 14 ± 20 ft^2/acre (3 ± 5 m^2/ha), with mean DBH at 4.8 ± 1.3cm (N = 28). The 1995 stockings on the plot represent: birch 2100 stems/acre (5200 stems/ha), white spruce 4300 stems/acre (10,600 stems/ha), and alder 600 stems/acre (1500 stems/ha). HAK 8 appears to be a very productive plot when compared with the Oldemeyer and Regelin (1984) birch chronosequence. Its extremely profuse birch seedling regeneration of 500,000 stems/ha in 1950 was exceeded only by two plots ath the 1994 Windy Point burn (Fig. 7B).

Summary: this plot was a moderately burned birch and white spruce stand, which regenerated birch, white spruce, and alder, with thick hardwood leaf litter which appears to suppress growth of grass and an herbaceous layer.

HAK 9: Alder, lightly burned

This plot was placed in a burned alder thicket. In 1950 Hakala reported that all the alder stems were killed by the fire, but that numerous alder sprouts were coming up in the locality. The plot had about 75% cover with grass 4.5-5' tall. Stand age was estimated to be 30 yr. The presence of small branches (1-2 cm) in the 1950 Milacre 10 photo suggests that the burn was light to moderate, which is typical in this area for a stand dominated by alder and grass. The moist black loam soil has pH 7, the highest of all nine plots. See Fig. 6.9.

Alder counts started with 7 stems in 1950, peaked in 1965 at 59 stems, declined in 1995 to 14. Birch peaked at 12 stems in 1961, and was extinct by 1976. White spruce peaked at 130 in 1961, and declined to 6 in 1995. Willow appeared from 1955 (28) to 1965 (12) and then vanished. Black spruce never appeared, and only 2 aspen appeared briefly in 1955. Rose peaked in 1961 (137), and declined to 51 in 1995. Lowbush cranberry never appeared. Raspberry peaked in 1950 at 658, declined steadily to 38 in 1976, and rose to 199 in 1995. Devil's club appeared as 1 stem in 1955, and increased slowly to 9 stems in 1995.

This plot and HAK 6 have never reported lowbush cranberry or lupine. Grass has always been abundant on this plot, with counts ranging from 222 to 820, with no obvious trend; grass cover was estimated in 1961 (33%). Bunchberry first appeared in 1955 and increased to >300 since 1976. Viola first appeared in 1961 (185), peaked in 1976 (1281), and declined in 1995 (277). Fireweed declined steadily from 1950 (206) and was not present in 1995. Nettles (Urtica spp.) likewise declined from 1950 (112) and disappeared by 1976.

Late appearing taxa are Heracleum (1976, 51), Linnaea (1976, 475), Mertensia (1976, 58), Moehringia (1995, 386). Taxa first appearing in the 1995 census were the alder root parasite broomrape (Boschniakia, 22), enchanter's nightshade (Circaea alpina, 91), Equisetum scirpoides (66), grove sandwort (Moehringia latiflora, 386), sweet cicely (Osmorhiza purpurea, 291), northern red currant (Ribes triste, 72), and twisted stalk (Streptopus amplexifolius, 1).

Ceratodon moss cover was reported as 14% in 1950. Moss covers had single-digit values in the intermediate surveys, with 8% reported in 1995. Plagiomnium medium (7%) and Eurhynchium pulchellum (1%) were the most common moss taxa in 1995.

Hardwood leaf litter cover in 1995 was 81%, with dead wood cover 8%.

In 1995 in the greater stand, alder basal area was 96 ± 36 ft^2/acre (22 ± 8 m^2/ha), with mean DBH at 7.4 ± 3.1cm (N = 64). White spruce basal area was 21 ± 21 ft^2/acre (5 ± 5 m^2/ha), with mean DBH at 6.3 ± 6.5 (N = 17). The 1995 stockings on the plot represent: alder 1400 stems/acre (3500 stems/ha) and white spruce 600 stems/acre (1500 stems/ha).

Summary: this alder thicket replaced itself, probably by root or stump sprouting. As the alder canopy closed, fireweed and nettles disappeared, and bunchberry and Viola became abundant. Grass and Heracleum dominate the herbaceous layer today.

HAK 9 is similar to HAK 6: both appear to have rich alder (nitrogen-enhanced) soils with heavy hardwood leaf litter, southern exposures, a closed hardwood canopy, and an herbaceous layer dominated by grass and Heracleum. Soil pH in these two plots is markedly higher (6.6 - 7), compared to the other plots (3.8 - 4.8). Both plots lack substantial lowbush cranberry, moss, and lichen components, which are typical of the black spruce and aspen plots (HAK 1-5, 7). This upland vegetation is more typical of the southern Kenai (e.g., Kachemak Bay) than it is of the Kenai lowland, which is the primary domain of the 1947 Burn.

Aspen seedling reproduction

A total of 24 aspen seedlings were reported in the period 1950-1965 in the three plots experiencing vigorous root suckering (HAK 2, 3 and 4). HAK 2 and HAK 3 were lightly burned, and although HAK 4 was severely burned, enough aspen rootstock survived to produce root suckers, albeit at a much lower rate than for HAK 2 and HAK 3 (Table 5).

HAK 5 was very severely burned (70% mineral soil exposure in 1950) and had no original aspen. Hakala reported 44 seedlings in 1950, and at least 19, 18 and 29 seedlings were added in the next three censuses, respectively. These aspen seedlings on HAK 5 grew much more slowly than the root suckers on HAK 2-4, as is clearly shown in the photos, the stem diameter graph (Fig. 10), the stem height histograms (Appendix 6), and they ultimately produced much less basal area than the plots with root suckering (Fig. 4).

Evaluation of the earlier censuses

In a long-term study it is important to judge the quality of each census effort. Three generations of biologists conducted these surveys (1950-65, 1976, and 1995) and there appears to be some variation in the quality of data collection, as judged from existing records.

One must first ask if the plots were consistently relocated and scored in the correct order of milacres. Relocation was a concern in the 1995 census because many of the plots had missing stakes. Live stem counts for the tree species were tabulated by milacres for the years for which milacre data are available (Appendix 3). Visual inspection of the table shows remarkably consistent trends within each milacre on each plot for each species, from 1950 to 1965. Milacres with relatively high or low counts in 1950 remained relatively high or low in subsequent years, confirming that the plots were being consistently relocated and censused in the correct order.

In the thirty years from 1965 to 1995 there was a dramatic decline in stem counts for most species except black spruce which usually increased slightly, but there is a consistent pattern of relative highs and lows in the milacres over these years. HAK 3 is the most uncertain case: this plot had to be restaked in 1995 on the basis of one surviving stake. The 1950-1965 milacres in HAK 3 were homogeneously filled with thick aspen suckers, most of which were gone by 1995 (Fig. 6.3, Fig. 7C, Appendix 3). There were no black spruce, birch, or white spruce in the milacre data from any earlier census, so the stem counts neither confirm nor deny that HAK 3 was correctly relocated in 1995. Fortunately, this clonal aspen stand is very homogeneous, and the plot could probably be misplaced by tens of meters without changing the data significantly.

Inspection of the 8x10" black-and-white photos of the plots suggests that it must have been difficult to accurately count stems on many of the early plots, even with the finely divided sampling fame with 100 0.66' (8", 20cm) cells. In the early years HAK 6 was thickly covered with tall fireweed, whereas HAK 1 and HAK 9 had thick grass. HAK 2 and HAK 3 had large numbers of aspen suckers (200-400), and HAK 8 was covered with birch seedlings (>2800) . By 1961 on most plots there were many down trees, which were left in place. The physical difficulty of accurately censusing such large plots with thick vegetation and down woody debris is not to be minimized, and the general consistency of the milacre counts from one census to the next indicates that considerable effort was made to obtain accurate counts.

In 1950 and 1965 the height of every stem on every plot was recorded, indicating that special care was taken in these censuses. In 1955 heights were often not recorded, but in some cases were lumped into categories, such as 116 - 2' stems of birch on Milacre 1 of HAK 8. In 1961 aspen was measured in HAK 2 - HAK 4, but heights on other plots were reported unevenly. In 1976 only an average height was reported for each plot for each tree species.

The taxonomic skills of the census takers appear to have been adequate for the general categories employed, such as "lichen", "moss," and "grass." Some vascular binomials have changed with the publication of Hulten (1968) but there is nothing in the data to suggest an inaccurate or inconsistent scoring of the vascular taxa. As noted previously, it is odd that the liverwort Marchantia polymorpha was not reported in any of the plots, because it is a common postburn mineral soil colonist in this area. The very severely burned HAK 6 was scored with a mean 49% "lichen" cover in 1950, which was most likely Marchantia, not lichen

The primary data shortfall lies in the Oldemeyer census of 1976, where the only existing data are the plot total counts and average heights, with no data at all for plots 4 and 6. Lacking the milacre data it is impossible to assess the consistency of scoring with other years. One 1976 discontinuity with total counts of other years should be noted: lowbush cranberry counts in 1976 are greatly in excess of the typical counts on several of the plots. This is especially true of the 1976 HAK 1 count of 14,301 stems (compared to 1965 - 3170, and 1995 - 2201) and the HAK 7 count of 29,144 (compared to 1965 - 5095, and 1995 - 3319). Cranberry counts in 1976 were also high in HAK 3 and HAK 5, but were normal in HAK 2 and HAK 8. (See Figs. 6.1-8; Appendix 2). Lowbush cranberry is admittedly difficult to score consistently because of its multiple stem growth form. In any case there appears to be some inconsistency within the 1976 scoring, as well as between the 1976 scoring and that of 1965 and 1995.

DISCUSSION

The chronosequence graphs can assist the reader in distinguishing "the forest from the trees" in the complex detail of this study (Figs. 7 and 8). These graphs are designed to show how well the permanent plots conform to the general patterns of post-fire succession on the Kenai, as well as to exhibit some interesting specifics of the permanent plots.

Black spruce chronosequence

In the black spruce chronosequence (Fig. 7A) the four black spruce plots (HAK 1, 4, 5, and 7) track very closely together. Primary recruitment was effectively completed by 15 years postburn, although secondary recruitment continued by one and twos in the milacres through the 1995 census (Appendix 4). This ongoing low level recruitment (and corresponding mortality) will probably maintain constant population densities, but will widen the age distributions and reduce the appearance of these stands being even-aged.

On the longer time scale the four black spruce plots, having densities of 7-10,000 stems/ha, appear to be on a trajectory that will place them well within the range of 2,700 to 12,000 stems/ha for the mature plots on the black spruce chronosequence.

White spruce chronosequence

In the white spruce chronosequence (Fig. 7D) HAK 8 shows the general long-term density decline that one expects from a flush of seedlings colonizing mineral soil. The three center milacres (4, 5 and 6) of HAK 8 accounted for most of the 1950 recruitment of both white spruce and birch, and had high mineral soil exposures of 90, 50, and 90%, respectively, in contrast to the other milacres with exposures of 0 to 50%. Recruitment of white spruce and birch continued into the 1960's, in spite of the general precipitous declines in seedling numbers in most milacres. Indeed, there appears to have been a small recruitment pulse in both species in the 1960's (Appendix 4). Inspection of the photos shows that many of the trees were still standing in 1955, but that most were down by 1961. Treefall and uprooting may have created the mineral soil exposure for this delayed recruitment pulse, which can be seen in the graphs white spruce, birch, willow, rose, and alder in 1965 in Fig. 6.8.

The HAK 8 white spruce trajectory falls on the high side of the chronosequence (Fig. 7D), but two white spruce plots on the 1994 Windy Point burn initiated with even higher values (50,000 and 187,500 stems/ha) for seedlings at 3 years postburn. HAK 8 experienced only moderate burn severity, whereas the Windy Point plots had 80-100% mineral soil exposure. HAK 8 is proving to be a productive site with both white spruce and birch, as well as an alder component, and one would expect that its long range trajectory will be toward the high end of the mature white spruce densities, which range from 80 to 4000 stems/ha.

Birch chronosequence

In the birch chronosequence (Fig. 7B) total birch seedling counts decline rapidly in the first 10-15 years. Birch has a remarkable capacity to colonize exposed mineral soil, as shown by the extreme values of 16,280,000 stems/ha (based on a count of 1628 seedlings in a typical $1m^2$ quadrat) and 3,462,500 stems/ha (1385 seedlings in a 4 m^2 quadrat) at two plots in the 1994 Windy Point burn at 3 yrs postburn.

In 1950 Hakala scored HAK 8 with a mean of 35% exposed mineral soil, saying "the area has been heavily burned in spots and bare mineral soil exposed. These exposed areas are heavily covered with a dense growth of Birch (sp.) seedlings averaging 4-6 inches in height and 1 to 2 years in age." HAK 6 by contrast was scored with 0% mineral soil exposure in all milacres, and Hakala reported that "scattered throughout the plot are Birch seedlings from 2 to 4 inches in height and 1 to 2 years old." This plot had been "taken over completely by Epilobium angustifolium as an overstory with Lichen (sp.) covering the burnt duff." The 1950 photos for HAK 6 show that many of the trees were down, suggesting that the fire burned very deeply (as at Windy Point 1994) and that fireweed and "lichen" (i.e., liverwort) had out colonized the birch by virtue of their abundant propagules. This could explain why no mineral soil was exposed in 1950. Hakala counted 2818 stems of fireweed in HAK 6 and scored "lichen" cover at 49%, in contrast to HAK 8 with 678 stems of fireweed and "lichen" cover of 12%.

The 1950 photos of HAK 6 completely choked with fireweed 2-3' high, such as might occur in a fallow field or roadside edge. The 1950 photos of HAK 8 show much more sparse fireweed about 1' tall amidst standing trees. For these reasons, in Table 1 HAK 6 was assigned a burn severity of "very severe" and ranked 9 as the most severely burned plot. The patchy nature of the burning of HAK 8 suggested an assignment of "moderate" burn severity at a rank of 5, even though HAK 8 had consistently an order of magnitude more birch recruitment that HAK 6, contrary to what one would expect of a less severely burned plot.

Like the white spruce in HAK 8 discussed above, the birch in HAK 8 experienced a recruitment pulse in the 1960's with a gain of 85 seedlings from 1961 to 1965. HAK 6 experience a smaller recruitment pulse in this period, gaining 14 seedlings in 1961 and 8 in 1965 (Appendix 4).

Both HAK 6 and HAK 8 experienced moderate browsing in 1965 (30% and 28% moose utilization, resp., Appendix 7) and the long tails of stems (<100cm) in the stem height distributions presumably exhibit this browsing damage (Appendix 6).

Aspen Chronosequence

In the aspen chronosequence (Fig. 7C) there is a strong contrast between the lightly burned plots HAK 2 and HAK 3 and the more severely burned plots HAK 4 and HAK 5. The lightly burned plots produced profuse aspen root suckers in every milacre, indicating that parent trees had left viable rootstock in every milacre and that this rootstock was damaged only to the point of stimulating sucker development. Severely burned HAK 4 also responded with root suckers but at a much lower rate and very unevenly. The center Milacres 5 and 6 each produced 15 suckers, but Milacre 8 produced 0, and four other milacres each produced 4 or fewer suckers.

Burn severity on HAK 4 was rated as "severe" with 5% mineral soil exposure and 34.8% Ceratodon (fire moss) cover In 1950 Hakala described HAK 4 as being located "in a Black spruce and Scattered Aspen burn," whereas HAK 2 was located "in a mixed Aspen spruce stand," and HAK 3 was located "in a previous Aspen stand with an understory of black spruce." These observations clearly suggest that there was less aspen in HAK 4 than in HAK 2 and HAK 3; this observation coupled with the more severe burning of HAK 4 probably explains why there were only 62 suckers in HAK 4, whereas there were 442 and 370 in HAK 2 and HAK 3, respectively (Appendix 2).

In HAK 2 and HAK 3 the aspen sucker numbers declined exponentially (Figs. 6.2 and 6.3), and there were only occasional recruitments of 1 to several suckers (Appendix 4). In HAK 4, however, sucker recruitment continued until 1961, often recruiting 3 to 5 suckers per milacre between censuses (Fig. 6.4, Appendix 4).

HAK 5 is an especially interesting case because Hakala clearly documented its origin in aspen seedlings rather than in root suckers. He described the plot as having been "a pure black spruce stand," so there was no aspen rootstock available for suckering. In 1950 he reported 43 first year aspen seedlings 2-4" tall and 1 second year seedling 14" tall, as well as 4 birch and no alder seedlings.

Burn severity on HAK 4 was scored as "very severe" with 69.5% mineral soil exposure and 59.5% Ceratodon cover. These are by far the highest values for any plot (Table 1).

On HAK 4 and HAK 5 black spruce recruitment was slow but followed remarkably similar trajectories (HAK 4: 3, 24, 37, 44, 29; HAK 5: 4, 19,25,30, 34, for 1950-1995), indicating similar access to seed trees. Nevertheless, the sucker-generated aspen on HAK 4 grew much more rapidly than the black spruce and appears to have greatly suppressed the black spruce diameter growth. As shown in Fig. 10 the aspen are large on HAK 4 (~9cm DBH), and the black spruce are small (~2cm DBH) and contribute negligible basal area (Fig. 9). On HAK 5 by contrast the aspen and black spruce had to compete as seedlings from the beginning, and by 1995 the black spruce is winning, with larger stems (~4cm vs. 2cm) and most of the basal area (Fig. 9).

In the 1995 stem height histograms (Appendix 6) it is clear that the HAK 5 black spruce has substantially more trees >2m tall than does HAK 4, whereas on HAK 5 the aspen are <2.5m and on HAK 4 the aspen reach to 3.5m tall.

It would have been difficult to reconstruct the different developmental dynamics of HAK 4 and HAK 5, given only contemporary data, such as stand composition and structure, supplemented with tree-ring width measurements. With the permanent plot data we are privileged to know the initial conditions of the soil, seedling vs. sucker development, and recruitment and mortality in each of the ten compartments (milacres) of the plots. This is a remarkable amount of additional information.

Willow chronosequence

In the willow chronosequence (Fig. 8) stem densities typically span at least two orders of magnitude in the postburn intervals examined. Heavy moose browsing probably reduces willow numbers and stretches out the lower tails of these density distributions. On the permanent plots willows have generally been a minor component; on six of the nine plots willows have vanished entirely in at least one census period, presumably due to heavy moose browsing.

HAK 8 experienced a pulse of willow seedling recruitment in 1955 with 70 2" stems reported in Milacres 4, 5 and 6 which, the reader may recall, were the disturbed milacres that produced most of the initial white spruce and birch recruitment on this plot. Several willow seedlings were reported in other milacres in 1950, as well as in the surrounding area, so it is unclear why no willow seedlings were reported in Milacres 4, 5 and 6 in 1950 when birch and white spruce seedlings were so abundant (Appendix 3).

Herbaceous chronologies

Fireweed

Every plot experienced an initial flush of fireweed, although in greatly varying degrees. The black spruce plots with heavy graminoid sod that was not effectively consumed by fire (HAK 1, 2, 3, 4, and 7) had the least fireweed, with 1950 counts of 295, 99, 318, 365, and 0, respectively. Fireweed peaked in these plots in 1965. In 1950 the most severely burned plot (mixed white spruce - hardwood HAK 6) was choked with dense fireweed (2818 stems), the highest "lichen" (i.e., liverwort) value of 49%, and a flush of birch seedlings (171 stems); no other taxa were reported, not even Ceratodon moss.

Lupine

Like fireweed, lupine is a classic post-fire disturbed soil colonist. Only five plots (HAK 1,2,3,4, and 5) showed any lupine. Lupine peaked in the 1960's with maximum values of 2092, 633, 590, 30, and 885, respectively. The seeds of lupine are very heavy compared to the wind-borne seed of fireweed. The lack of nearby seed donors is the most likely cause of the complete absence of lupine on the four easternmost plots, which are all along the hilly eastern end of Skilak Loop Road (Fig. 1).

Moss

Most plots (except HAK 6) reported substantial Ceratodon moss in 1950 (range 5.7 - 59.5%) even though six od the nine plots reported mineral soil exposure as virtually zero (Table 1). Three years post-fire is adequate time for Ceratodon to become well-established on formerly exposed mineral soil. Moss cover shows a peak in 1955, which is undoubtedly a Ceratodon peak, followed by a decline in the 1960's. By 1995 moss has increased dramatically in the black spruce plots (HAK 1, 2, 4, 5, and 7) with values of 92, 57, 29, 59, and 21%, respectively, as Pleurozium, Hylocomium, and the liverwort Ptilidium become dominant, and Ceratodon is reduced to a trace (Appendices 11 - 12).

"Lichen"

Unfortunately, no voucher collections are available for the early surveys, and there is no way to assess what was being scored as "lichen." The very high lichen cover of 49% reported for the most severely burned plot HAK 6 suggests that the liverwort Marchantia polymorpha was (incorrectly) included under the rubric of "lichen."

A comparable example is the 1994 Windy Point burn. Four permanent FMH plots installed in 1994 reported mineral soil exposures of 60 to 99.2%. At three years post-fire (1997) our 50m line-intercept transects with 166 sampling points showed Ceratodon counts of 46, 16, 82, and 162, and Marchantia counts of 41, 5, 27, and 5, respectively. No lichens were recorded. At five years post-fire (1999) small Peltigera spp. fronds (5 - 10mm diameter) had appeared, with covers of 1 - 5% in some quadrats, but no fruticose lichens were observed.

Dyrness and Norum (1983) reported that the first two years post-fire in their severely burned black spruce - feathermoss plots in Interior Alaska were completely dominated by fireweed, Ceratodon, and Marchantia. In the boreal forest of Finland, Viro (1974) reported that lichens were slower to appear than other species, and only became apparent in the seventh year after burning and then increased rapidly. He also reported Ceratodon as the most common post-fire moss.

The black spruce plots (HAK 1, 2, 4, 5, and 7) show a slow long-term increase in lichen from the 1960's (or at least from 1976), owing to the rise of fruticose lichens such as Cladina spp. and Cladonia spp, and the foliose Peltigera spp. and Nephroma spp.

Corydalis sempervirens

Pale corydalis Corydalis sempervirens (L.) Pers. appears occasionally in burn areas on the Kenai Peninsula. The author has observed corydalis one year post-fire in five of fify-eight plots in the 1996 Hidden Creek burn, as well as along black-lined edges of Mystery Creek Road. He noted several plants in the 1987 Skilak Loop prescribed burn area in 1998. No instances of Corydalis have been recorded of corydalis on the Hakala plots, however.

Grass

The grass chronologies primarily represent Calamagrostis and should be interpreted very qualititatively. In plots sparsely populated with grass it makes sense to count individual clumps of grass, which are probably genetically distinct individuals; therefore low counts (< 100) in these surveys are probably dependable, as in HAK 2, 4, 5, 6, 7, and 8. As clumps enlarge through vegetative reproduction, it becomes more difficult to distinguish clumps and counting can become very subjective. With a continuous grass sod, counting is of no use whatsoever.

Estimation of grass percent cover equally weak, because a moderate density of clumps and a continuous sod can both be scored as 100% cover. In 1955, 1961 and 1965 some plots were scored with percent covers, with values ranging from 0.2 to 48%, in lieu of counting the clumps. With different surveyors making these estimates on different years such figures have little quantitative value. It is worth remarking however that none of the cover estimates were 100%.

Only HAK 1, 7 and 9 have consistentally shown substantial amounts of grass, according to reported values and the photos. The 1950 photos of HAK 1 show continuous knee-high grass cover on a lightly burned plot of young black spruce burn poles. The data suggest abundant grass through the 1970s, with grass decreasing at the present time as the black spruce canopy closes (_______% cover) and the Pleurozium-lowbush cranberry ground cover consolidates (total moss cover at 92% in 1995). HAK 7 apparently had a thick grass sod when it was burned, according to Hakala, but grass counts and covers have always been much lower than HAK 1 (Appendix 2). HAK 9 has by far the heaviest grass cover of all the plots, being a well-shaded alder thicket with rich moist organic soil. HAK9 was lightly burned and its original grass sod was probably not disrupted; it had the highest grass count in 1950 (391 clumps), followed by HAK1 (296), HAK4 (80), and HAK7 (27). In 1955 HAK9 reported 820 clumps, an all time record for all plots.

Summary

It is axiomatic that there are two basic factors that control what kind of vegetation regrows after a fire: the original vegetation composition and the burn severity. Of the three original pure black spruce stands, light to moderately burned HAK 1 and HAK 7 produced only black spruce; severely burned HAK 5 added aspen seedling recruitment with its 70% mineral soil exposure to yielded a mixed black spruce and aspen stand.

The original mixed black spruce and aspen stands (HAK 2, 3, and 4) have produced virtual carbon copies of themselves, regardless of burn severity, using vigorous root suckering in the lightly burned HAK 2 and HAK 3, and a reduced but still effective root suckering in the severely burned HAK 4.

The mixed white spruce and birch plots (HAK 6 and 8) both reproduced themselves, but added substantial alder components. In both plots, however, there are many dead alder stems, and alder appears to be substantially declining as it is over-topped by birch. The alder thicket (HAK 9) has reproduced itself with great vigor, having the highest basal area of any species in the nine plots (96 sq ft/acre), probably owing to its rich soil and southern exposure.

In conclusion, these nine plots appear to be replacing themselves quite faithfully. There have been no "type conversions" from conifers to hardwoods or grasslands, although aspen and alder have been added, at least temporarily, to some conifer stands. All of the black spruce stands (HAK 1-5, 7) were able to regenerate black spruce, regardless of the burn severity. Cottonwood is the one species that was eliminated from a plot, although not from the surrounding area. Grass has been a minor, and in most cases diminishing, component of these forest stands.

LUTZ (1956) MODEL OF SUCCESSION PATHWAYS IN VIERECK (1973, p474) SHOWS STANDS REPLACING THEMSELVES EARLY ON, THEN LATER GOING TO WHITE OR BLACK SPRUCE.

VIERECK (1984) SEES TWO TYPES OF PIMA SUCCESSION: PIMA-FEATHERMOSS (MESIC TO WET) AND OPEN PIMA-LICHEN WOODLANDS (WELL-DRAINED SITES). WE HAVE ONLY THE FIRST TYPE ON THESE PLOTS.

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LIST OF FIGURES, TABLES, AND APPENDICES

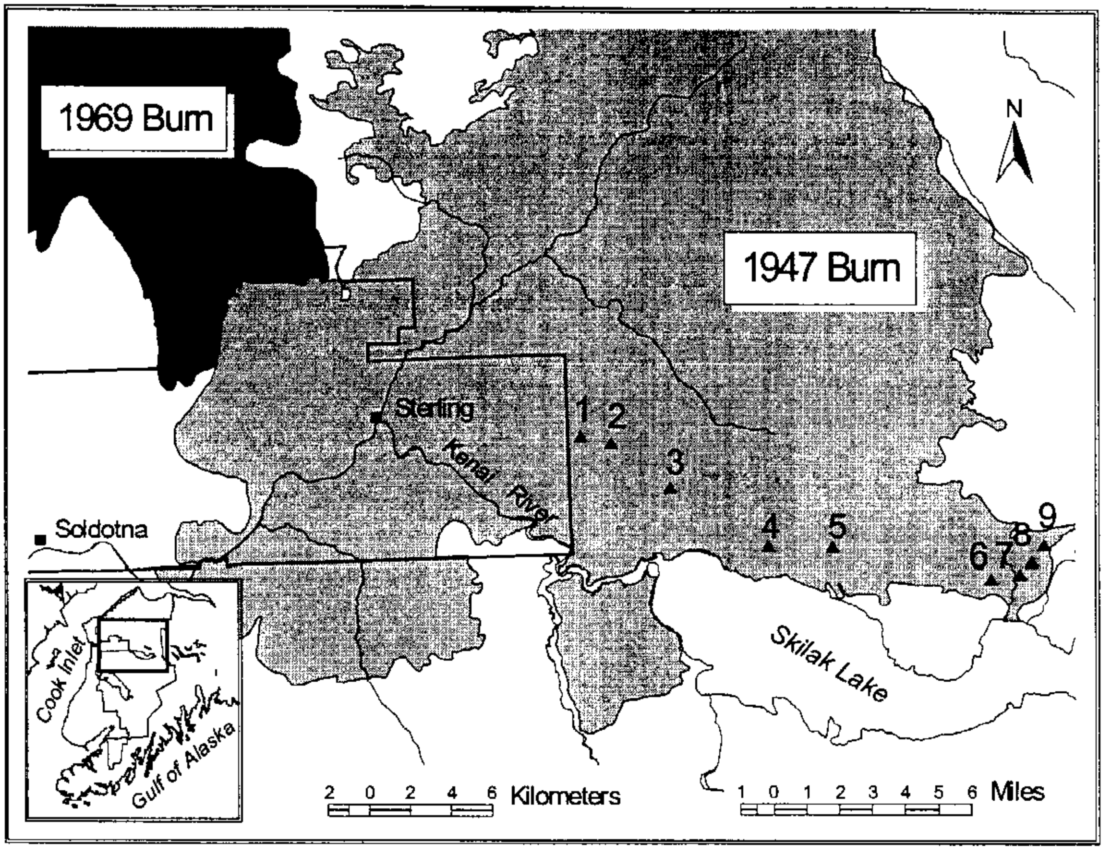

FIG. 1. MAP OF CENTRAL KENAI NATIONAL WILDLIFE REFUGE, SHOWING MAJOR BURNS AND PERMANENT PLOT LOCATIONS

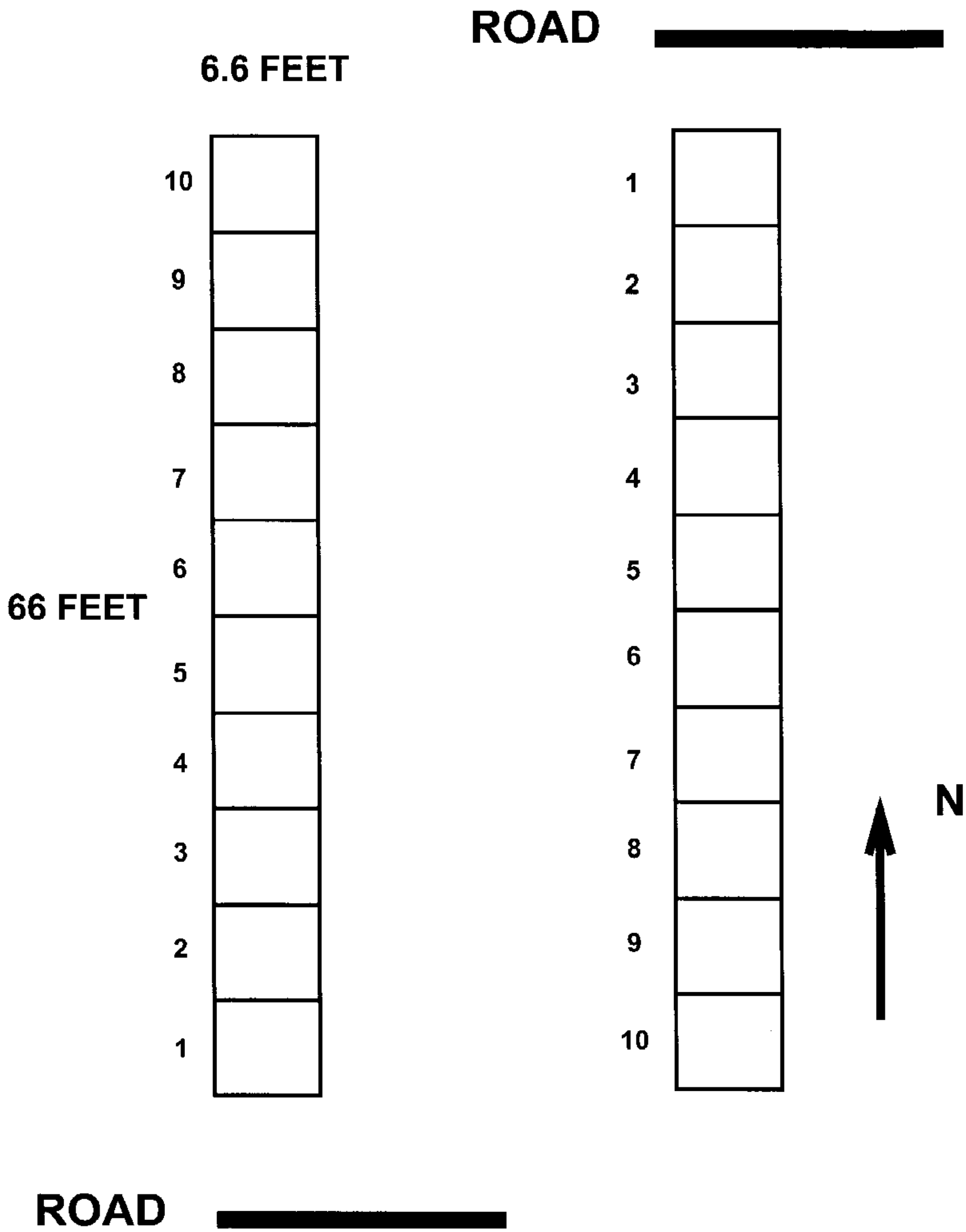

Fig. 2. 10 MILACRE PLOT LAYOUTS

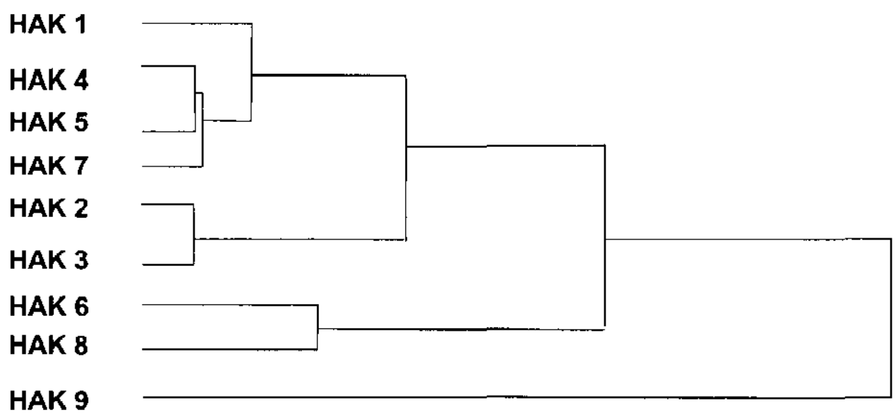

FIG. 3. STAND BASAL AREA DENDROGRAM

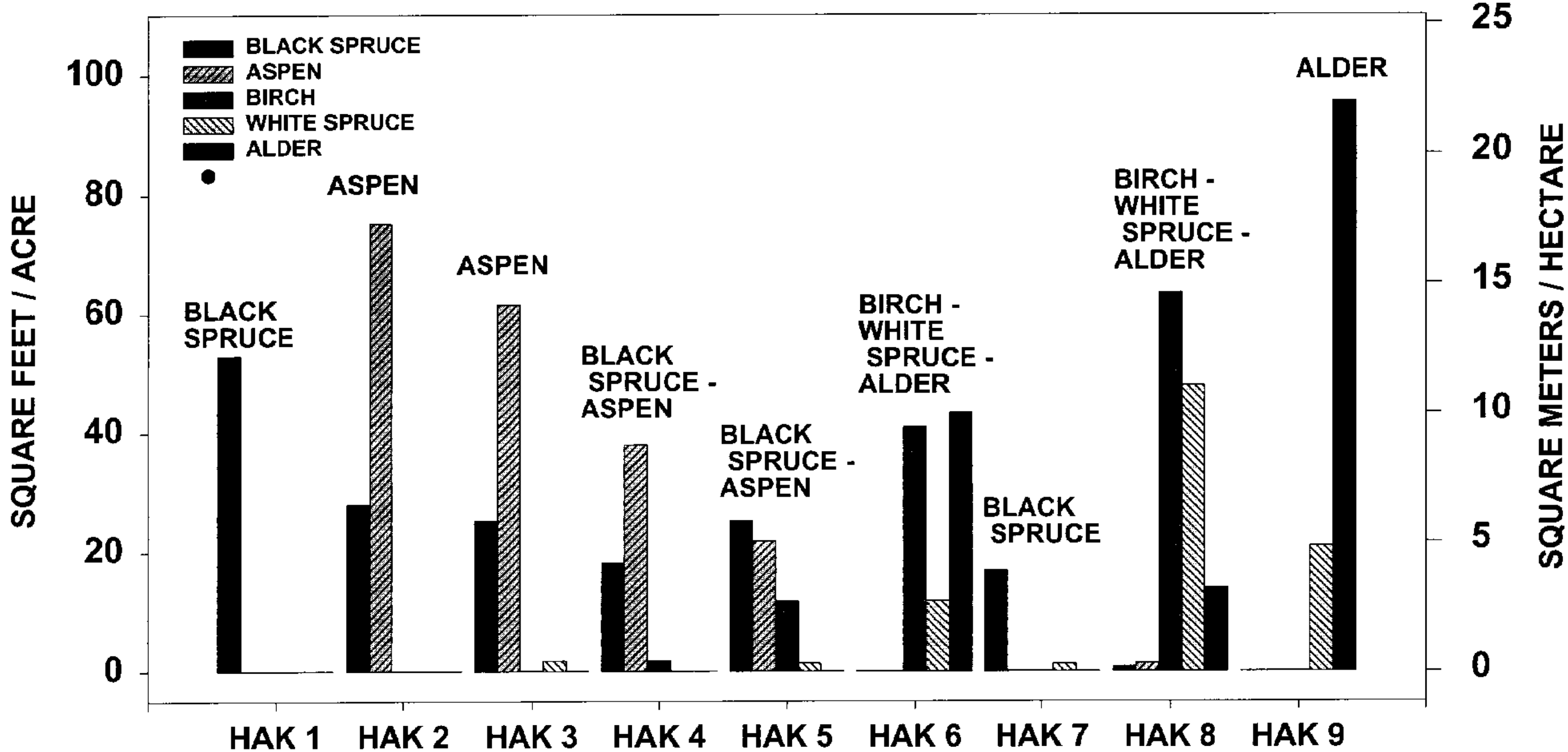

FIG. 4. STAND BASAL AREAS

F:\USERS\BERG\HAKALA\HAK_BA.JNB

E. BERG KNWR 4-20-99

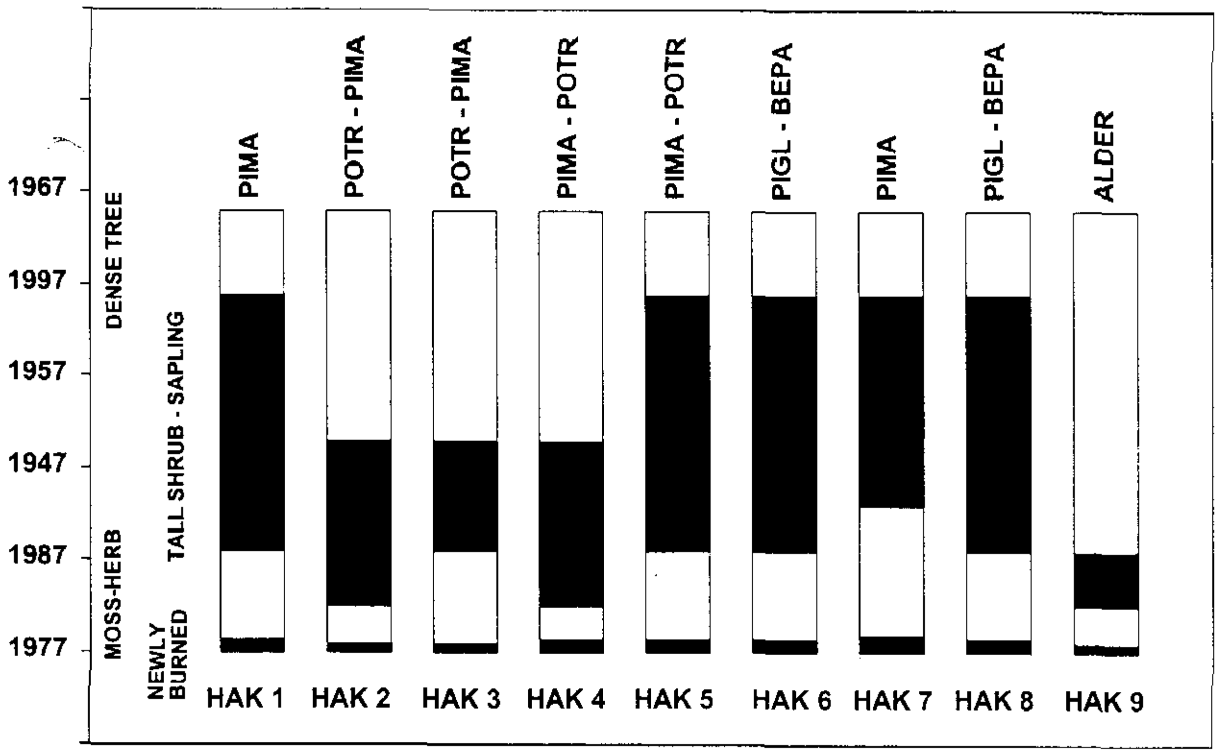

FIG. 5. DURATION OF SUCCESSION STAGES

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E. BERG KNWR 4-3-99

WILLOW STEM DENSITY

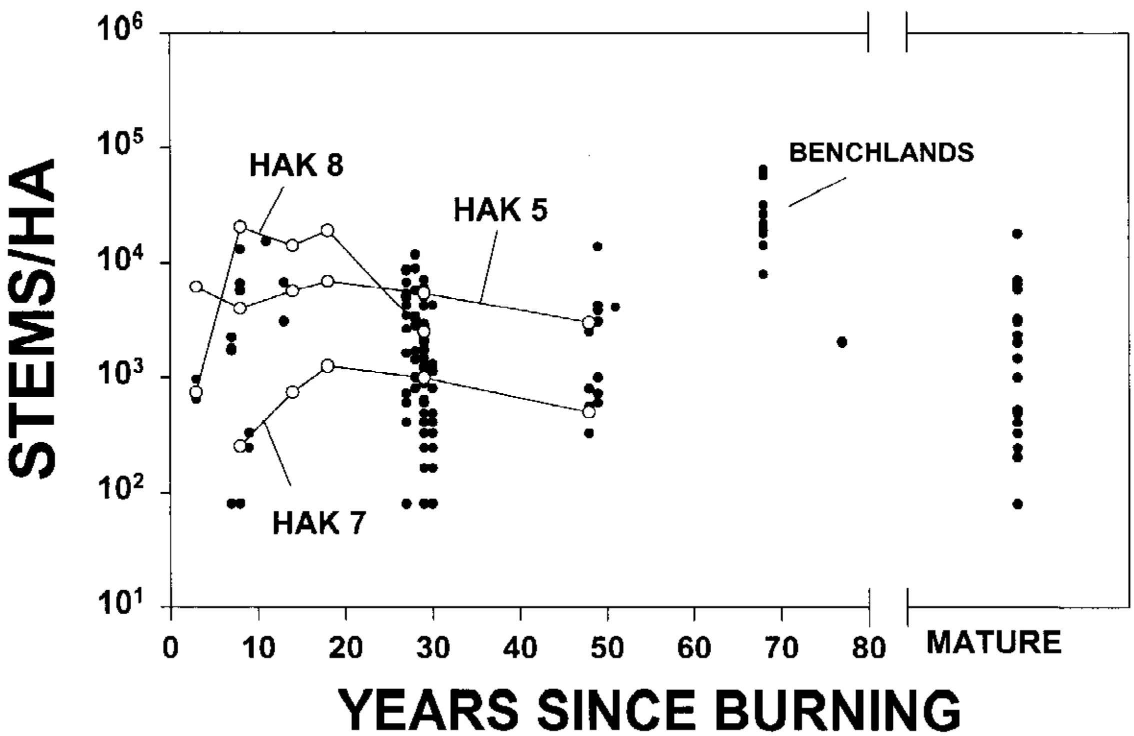

FIG. 8. STEM DENSITY CHRONOSEQUENCE

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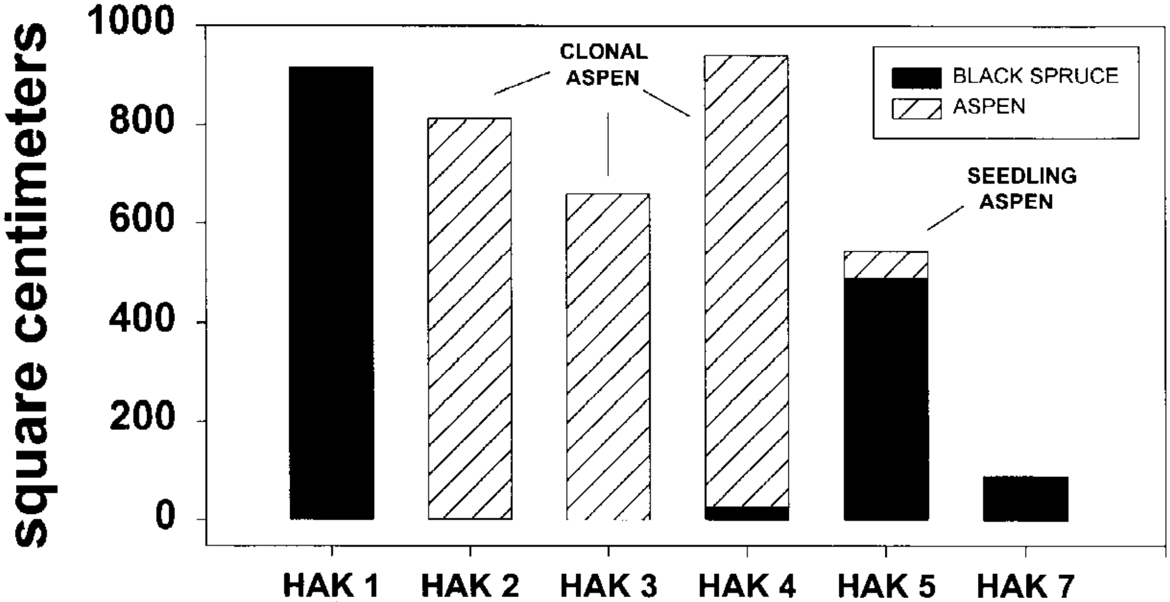

FIG. 9. ASPEN AND BLACK SPRUCE BASAL AREA

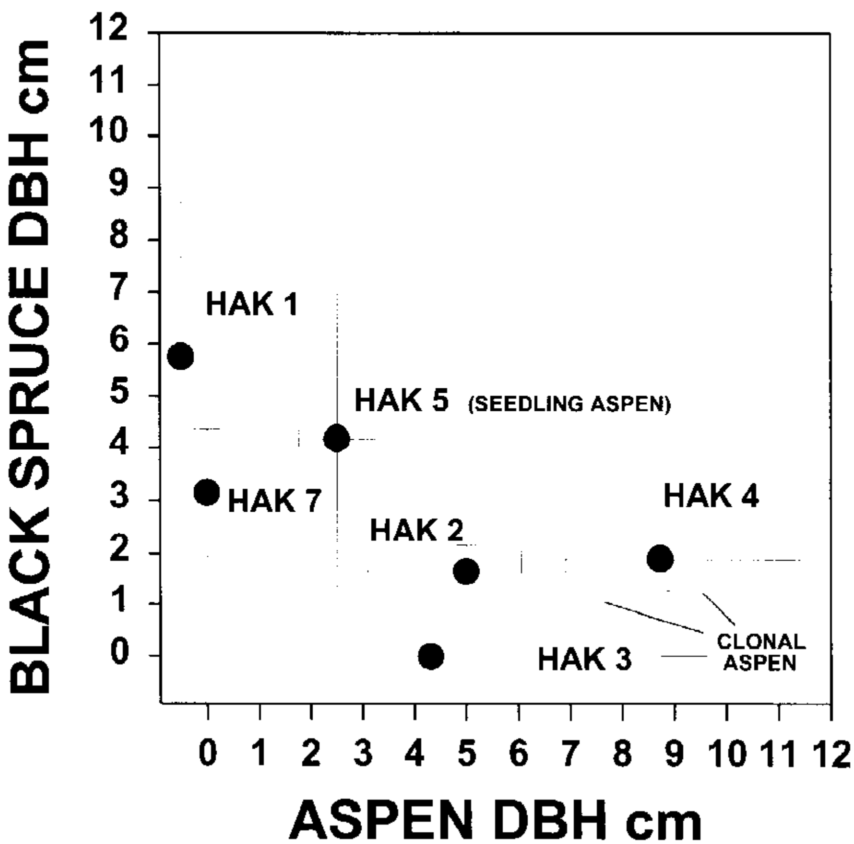

FIG. 10. ASPEN AND BLACK SPRUCE STEM DIAMETERS

PLOT #	HAK 1	HAK 2	HAK 3	HAK 4	HAK 5	HAK 6	HAK 7	HAK 8	HAK 9
ORIGINAL FOREST	PIMA	POTR PIMA	POTR PIMA	PIMA POTR	PIMA	PIGL BEPA POBA	PIMA	PIGL BEPA	ALDER
STAND AGE IN 1947	30y	50y	55y	85y	100y	Mature	110y	Mature	30y
1950 MINERAL SOIL	0%	0%	0%	5%	69.5%	0%	0.5% normal	34.5%	0%
1950 CERATODON	20.5%	13.0%	13.8%	34.8%	59.5%	0%	5.7%	18.0%	14.0%
BURN SEVERITY	LIGHT	LIGHT	LIGHT	SEVERE	VERY SEVERE	VERY SEVERE	SEVERE Mod	MOD	LIGHT
BURN SEVERITY RANKING	3	2	1	7	8	9	6	5	4
ASPECT	0	0	0	0	0	SE	0	S	S
SOIL pH	4.2	4.2	4.6	4.3	4.8	6.6	3.8	4.2	7
SOIL TYPE	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	LOAM	SANDY LOAM	LOAM
BASAL AREA sq ft / acre	PIMA 53	POTR 75 PIMA 28	POTR 62 PIMA 25	POTR 38 PIMA 18	POTR 22 PIMA 25	ALDER 43 BEPA 41 PIGL 12	PIMA 17	BEPA 64 PIGL 48 ALDER 14	ALDER 96 PIGL 21
BASAL AREA sq m / ha	PIMA 12	POTR 17 PIMA 6	POTR 14 PIMA 6	POTR 9 PIMA 4	POTR 5 PIMA 6	ALDER 10 BEPA 9 PIGL 3	PIMA 4	BEPA 15 PIGL 11 ALDER 3	ALDER 22 PIGL 5

POTR: ASPEN **PIGL:** WHITE SPRUCE **POBA:** COTTONWOOD
PIMA: BLACK SPRUCE **BEPA:** BIRCH

Table 1. Stand characteristics

Table 2. Summary of plots by present forest types

PRESENT FOREST TYPE	PLOT NUMBER
Black Spruce	1, 7
Aspen	2, 3
Mixed Black Spruce and Aspen	4, 5
Birch, White Spruce and Aspen Alder	6, 8
Alder	9

PLOT #	AVC CODE	AVC PAGE #	AVC: LEVEL IV	AVC: LEVEL V
HAK 1	I.A.1.k.	65	Closed Black Spruce Forest	Picea mariana / Vaccinium vitis-idaea / Pleurozium schreberi
HAK 2	I.C.1.d.	101	Closed Quaking Aspen - Spruce Forest	Populus tremuloides - Picea mariana / Vaccinium vitis-idaea / feathermoss
HAK 3	I.B.1.e.	89	Closed Quaking Aspen Forest	Populus tremuloides / Vaccinium vitis-idaea
HAK 4	I.C.1.d.	101	Closed Quaking Aspen - Spruce Forest	Populus tremuloides - Picea mariana / Vaccinium vitis-idaea / feathermoss
HAK 5	I.C.1.d.	101	Closed Quaking Aspen - Spruce Forest	Populus tremuloides - Picea mariana / Vaccinium vitis-idaea / Drepanocladus uncinatus
HAK 6	I.B.1.d.	88	Closed Paper Birch Forest	Betula papyrifera - Alnus crispa / Heracleum lanatum / Calamagrostis canadensis
HAK 7	I.A.2.f.	74	Open Black Spruce Forest	Picea mariana / Ledum decumbens / Polytrichyum spp.
HAK 8	I.C.1.a.	98	Closed Spruce - Paper Birch Forest	Betula papyrifera - Picea glauca / Alnus crispa
HAK 9	II.B.1.b.	114	Closed Tall Alder Scrub	Alnus crispa / Heracleum lanatum / Calamagrostis canadensis

Table 3. Classification of the plots, according to The Alaska Vegetation Classifcation of Viereck et al. (1992)

Table 4. Aspen reproduction in 1950.

Plot	Burn Severity	Mineral Soil %	Stems #	Moose Utililization	Mean Height	Mode of Reproduction
HAK 2	LIGHT	0	442	24%	20.3" / 52cm	ROOT SUCKERS
HAK 3	LIGHT	0	370	0	19.3" / 49cm	ROOT SUCKERS
HAK 4	SEVERE	5	62	0	33.1" / 84cm	ROOT SUCKERS*
HAK 5	VERY SEVERE	70	44	0	2.8" / 7cm	SEEDLINGS

*also two 4" seedlings

Table 5. Aspen seedling reproduction.

PLOT	1950	1955	1961	1965	TOTAL SEEDLING REPORTED	TOTAL SEEDLINGS INFERRED	TOTAL
HAK 1	0	0	0	0	0	0	0
HAK 2	0	ND	2*	2 (2")	4	-	4
HAK 3	8 (1")	ND	0	2 (2")	10	-	10
HAK 4	2 (4")	ND	0	8 (4-6")	10	-	10
HAK 5	43 (2-4"), 1 (14")	19	18	25 + 4 (2-4")	48	62	110
HAK 6	0	0	0	0	0	0	0
HAK 7	4 (1st yr)	2	5	2 (6-7")	6	7	13
HAK 8	0	13	0	4	1	16	17
HAK 9	0	2	0	0	2	0	2

ND - Suckers and seedlings not distinguished.

* These 2 stems were not clearly identified as seedlings on the 1961 data sheets, but they were listed as having heights of 3". The written commentary on HAK 2 in 1961 reported that "aspen seedlings (about 3 inches high) are coming in, but are widely scattered."

Stem counts on a plot can be converted to stems per acre by multiplying by 100

Table 6. Vascular plant species list

ACRU	Actaea rubra (Ait.) Willd. subsp. arguta
ALNUS	Alnus spp.
ANSPP	Angelica spp.
AQFO	Aquilegia formosa Fisch.
ARU-U	Arctostaphylos uva-ursi (L.) Spreng. var. uva-ursi
BENA	Betula nana L. subsp. exilis (Sukatsch.) Hult.
BEPA	Betula papyrifera Marsh. (includes B. kenaica Evans)
BORO	Boschniakia rossica (Cham. & Schlecht.) Fedtsch.
CARO	Campanula rotundifolia L.
CASPP	Carex spp.
CIAL	Circaea alpina L.
COCA	Cornus canadensis L.
ECHO	Echinopanax horridum (Sm.) Decne. & Planch.
EMNI	Empetrum nigrum L.
EPAN	Epilobium angustifolium L.
EPLA	Epilobium latifolium L.
EQAR	Equisetum arvense L.
EQSC	Equisetum scirpoides Michx.
EQSI	Equisetum silvaticum L.
ERSPP	Erigeron spp.
GASPP	Galium spp.
GELI	Geocaulon lividum (Richards.) Fern.
GEPR	Gentiana propinqua Richards subsp. propinqua
GRASS	Gramineae
HELA	Heracleum lanatum Michx.
LEPA	Ledum palustre L.
LIBO	Linnaea borealis L.
LICHEN%	Lichen
LUNO	Lupinus nootkatensis Donn
LYCO	Lycopodium spp.
MEPA	Mertensia paniculata (Ait.) G. Don var. paniculata
MOLA	Moehringia lateriflora (L.) Fenzl
MOSS%	Bryophytes
OSPU	Osmorhiza purpurea (Coult. & Rose) Suksd.
PAPA	Parnassia palustris L. subsp. neogaea (Fern.) Hult.
PELA	Pedicularis labradorica Wirsing
PIGL	Picea glauca (Moench) Voss
PIMA	Picea mariana (Mill.) Britt., Sterns & Pogg.
POBA	Populus balsamifera L. (includes subsp. balsamifera and subsp. trichocarpa)
POSPP	Polemonium spp
POTR	Populus tremuloides Michx.
PYSPP	Pyrola spp.
RILA	Ribes lacustre (Pers.) Poir.
RITR	Ribes triste Pall.
ROSA	Rosa spp.
RUCH	Rubus chamaemorus L
RUID	Rubus idaeus L. subsp. melanolasius (Dieck) Focke
SARA	Sambucus racemosa L. subsp. pubens (Michx.) House var. arborescens Gray
SASPP	Salix spp.
SHCA	Shepherdia canadensis (L.) Nutt.
SOSPP	Solidago spp.
SPBE	Spiraea Beauverdiana Schneid.
STAM	Streptopus amplexifolius (L.) DC.
TASPP	Taraxacum spp.
TREU	Trientalis europaea L. subsp. arctica (Fisch.) Hult.
URLY	Urtica Lyallii S. Wats.
VAUL	Vaccinium uliginosum L.
VAVI	Vaccinium vitis-idaea L. subsp. minus (Lodd.) Hult.
VIED	Viburnum edule (Michx.) Raf.
VISPP	Viola spp.

LAWTON PAGE # (MOSSES)	M OR LW	TAXON	WITHIN HAK #	OUTSIDE OF HAK #	VOUCHERED NEAR OR IN PLOT #	CENSUSED NEAR OR IN PLOT #	DATE VOUCHERED	VERIFIED BY DW?
268	M	Amblystegium serpens (Hedw.) B.S.G	9 (mil 10)	6, 9	6, 9		8/23/95, 9/6/95	YES
202	M	Aulacomium palustre (Hedw.) Schwaegr.		1, 2	1, 2		7/22/94	YES
294	M	Brachythecium reflexum (Starke) B.S.G.		9	9		Aug-95	YES
296	M	Brachythecium salebrosum (Web. & Mohr) B.S.G	4 (mil 4), 8		4, 8		8/21/95, 8/10/95	YES
167	M	Bryum caespiticium Hedw.		4, 9	4, 9		8/29/95	YES
	LW	Cephalozia lunulifolia (Dum.) Dum.		7	7		9/13/95	YES
49	M	*Ceratodon purpureus* (Hedw.) Brid.		5	1, 4. 5		9/5/95	YES
73	M	Dicranum acutifolium (Lindb. & Arn.) C. Jens		5	5		9/5/95	YES
78	M	Dicranum polysetum Sw.	3	6, 2	2, 3, 4, 6		8/26/95	YES
80	M	Dicranum tauricum Sapehin.		8	8		9/15/95	YES
81	M	Dicranum undulatum Brid.	7		7		8/5/95	YES
280	M	Drepanocladus uncinatus (Hedw.) Warnst.	5 (mil 6)	1, 2, 4	1, 2, 4, 5		8/2/95	YES
299	M	Eurhynchium oreganum (Sull.) Jaeg.		2	2, 6		7/29/94	YES
301	M	Eurhynchium pulchellum (Hedw.) Jenn.	4 (mil 1)		4,6,9		8/18/95	YES
261	M	Helodium blandowii (Web. & Mohr) Warnst.	3		3		8/25/95	YES
332	M	Hylocomium splendens (Hedw.) B.S.G.	2		2		7/26/95	YES
177	M	Leptobryum pyriforme (Hedw.) Wils.		6	6		9/6/95	YES
	LW	Lophozia bicrenata (Schmid.) Dum.		7	7		9/13/95	YES
	LW	Lophozia ventricosa (Dicks.) Dum. var. ventricosa		5	5		9/5/95	YES
	LW	Mylia anomala (Hook.) S. Gray		7	7		9/13/95	YES
82	M	Oncophorous wahlenbergii Brid.	4 (mil 1)		4		8/18/95	YES
196	M	Plagiomnium insigne (Mitt.) Koponen		9	6, 9		9/8/95	YES
318	M	Plagiothecium laetum B.S.G.		8	8,9		9/14/95	YES
286	M	Pleurozium schreberi (Brid.) Mitt.		1	1		7/22/94	YES
183	M	Pohlia cruda (Hedw.) Lindb.	3 (mil 1)	2	2, 3		8/25/95	YES
39	M	Polytrichum commune Hedw.	4	1	1, 4		8/18/95	YES
41	M	Polytrichum juniperinum Hedw.		7	7		9/13/95	YES
42	M	Polytrichum piliferum Hedw.		5	5		9/5/95	YES
	LW	Ptilidium ciliare (L.) Hampe		1	1		7/22/94	YES
	LW	Ptilidium pulcherrimum (G. Web.) Hampe	2 (mil 7)		2		7/26/95	YES
327	M	Ptilium crista-castrensis (Hedw.) De Not.		1	1		7/22/94	YES
330	M	Rhytidiadelphus triquetris (Hedw.) Warnst.	6		6		8/10/95	YES
	M	Sphagnum girgensohnii		7	7		9/13/95	NO
	M	Sphagnum recurvum (or nemorum)		7	7		9/12/95	NO

TABLE 7. Bryophyte species list

APPENDIX 1: PERMANENT PLOT PROTOCOL

A wooden frame was constructed of four 1x2" oak bars, measuring 6.6' on a side. This frame has an area of 0.001 acre or 1 milacre. A 0.75" hole at each end of an oak bar allowed the bar to slip over a rebar stake marking the corner of a milacre subplot.

Roofing nails were set at intervals of 0.66' along each oak bar to divide the bar into ten equal segments. When the four bars of the frame were in place on the rebar stakes, string was stretched to divide the frame into a suitable number of cells to facilitate counting the plants. For example, the string can be run back and forth in an east-west direction to make 10 long cells. The string can then be crossed in the middle in a north-south direction to make a grid of 20 cells, each 0.66' x 3.3'. This allowed accurate counting of dozens of stems within a single milacre, as well as estimation of cover values to within several percent..

Percent cover values were estimated for each of the following:

Foliose lichens (Peltigera, Nephroma, etc.)
Fruticose lichens (Cladonia, Cladina, Stereocaulon, etc.)
Leaf litter - hardwood or herbaceous leaves, not conifer needles.
Dead wood - only visible dead wood on the ground was considered, not probable dead wood under a thick moss cover, nor leaning dead wood.
Black spruce foliage.
Moss - a cover was estimated for all bryophytes collectively, and for all common bryophyte taxa separately.
Ledum spp.- also counted as clumps
Empetrum nigrum - also counted as clumps

Stem counts were made for the following taxa, with no attempt to identify genetic individuals:

Epilobium angustifolium
Geocaulon lividum
Cornus canadensis - both 4- and 6-leafed forms
Pyrola secunda and grandiflora
Vaccinium vitis-idaea - see below
Lycopodium annotinum - every upright stem was counted, not strands
Linnaea borealis - censused as strands
Equisetum arvense
Osmorhiza
Galium
Heracleum lanatum

Mertensia paniculata
Moehringia latifolia
Rubus - all species
Ribes - all species
Taraxacum spp.
Rosa acicularis
Actaea rubra
Boschniakia rossica
Circaea alpina
Trientalis europaea
Lupinus nootkatensis

Clumps were counted for the following taxa:

Grass
Ledum groenlandicum
Empetrum nigrum
Equisetum scirpoides
Viola spp.
Vaccinium uliginosum
Spiraea beauverdiana

Clumps were only counted if more than half of the clump was rooted within the plot. Clumps are probably genetic individuals (genets), which have many branches or sprouts (ramets).

Counts of abundant species were made with hand-operated Veeder-Root tally counter. Counts of Vaccinium vitis-idaea often numbered in the hundreds for each milacre subplot. These counts were made very roughly by pointing at a stem and clicking the counter. No more than 6 - 8 minutes were spent counting the V. vitis-idaea in a subplot, and the counts are probably accurate to only ± 20%. Similar limits apply to counts of Cornus and Geocaulon when they number in the hundreds per subplot.

For all live trees in the plot, a diameter-at-breast-height (DBH) was measured with a centimeter DBH tape, and height was estimated by eye, using a 2m pole graduated in decimeters. The presence of Spruce Broom Rust (Chrysomyxa arctostaphyli Diet.) on black spruce was recorded. Heights (but no DBH's) were estimated for standing dead trees. Fallen dead trees were not censused. Heights were estimated for every size of stem, from seedling to mature tree. Alder stems rooted within the plot were treated as trees: heights were recorded for both live and dead stems, and a DBH was measured on the largest live stem.

Willows were identified only to Salix spp. Birch was identified as Betula papyrifera Marsh: the Kenai birch B. kenaica Evans was not distinguished. Alder was only identified to the genus Alnus, although presumably the alder is Sitka alder Alnus crispa (Ait.) Pursh subsp. sinuata (Regel) Hult.. Cottonwood was identified as Populus balsamifera L.; subspecies balsam poplar balsamifera and black cottonwood trichocarpa (Torr. & Gray) Hult. were not distinguished. Taxonomic authorities for all taxa are cited on the species lists (Tables 6 and 7).

Bryophytes (mosses and liverworts) were recorded at least to the genus, and vouchered for species identification. Bryophytes were identified with the aid of Lawton (1971), Conrad (1979), and Vit, Marsh, & Bovey (1988), and were verified by Dr. David H. Wagner of the Northwest Botanical Institute, Eugene OR. Lichens were described only to the level of foliose (e.g., Peltigera, Nephroma) and fruticose (e.g., Cladonia, Cladina, Stereocaulon). Arboreal lichens were not inventoried.

Grasses were not identified to genus or species, unless flowers or a seed head was present, which was rarely the case. In most cases the dominant grass was Calamagrostis canadensis.

When there was doubt about identification at the species, subspecies, or variety level, the taxon was simply lumped with others at the next higher level. Nomenclature follows Viereck and Little (1972) for trees and shrubs, Hulten (1968) for other vascular plants, and Vitt, Marsh and Bovey (1988) for bryophytes.

The plots were photographed by L. Reinink-Smith in 1995 prior to surveying so as to avoid trampling effects in the photographs. She used a 35mm Nikon F90(N90) with a zoom lens and black-and white Kodak TMAX100 film. The photos were reproduced as 8x10" glossy prints, and added to the permanent collection of Hakala plot photos. Color slides were taken as the plots were surveyed.

APPENDIX 13. PERMANENT PLOT LOCATIONS

For each plot a reference metal fence post was set inside the woods beyond the road right-of-way. The plot is located due south of this post, if the plot is on the south side of Skilak Loop Road, and conversely the plot is due north of the post if the plot is on the north side of the road. These posts are not generally visible from the road. The 1950 plots were all marked with similar reference posts, but none could be located in 1995.

To find a plot, one would expect to use a vehicle odometer or GPS to get within 0.1 mile of the reference post, and then search for the post on foot. Missing rebar was replaced on all plots in 1995, and the original large sheet metal stakes were left in place. The rebar stakes have been driven down so that only a few inches are exposed, in hopes of reducing theft.

APPENDIX 14: ROAD MAP OF PERMANENT PLOT LOCATIONS

APPENDIX 15: ODOMETER MILEAGES

Using KNWR Chevy S-10 pickup #584 the following mileages were obtained in 1995:

0.0 mi KNWR boundary sign on Sterling Highway, 0.8 mi west of west entrance to Skilak Loop Road
0.35 HAK 1 (south of road)
0.8 West entrance of Skilak Loop Road
1.3 Bottenintnin Lake Road
1.41 HAK 2 (north of road)
3.8 HAK 3 (south of road)
6.3 Lower Skilak Lake Campground Road
7.6 HAK 4 (south of road)
8.35 RV dump station
9.7 HAK 5 (north of road)
10.6 Engineer Lake Road
11.65 Upper Skilak Lake Campground Road
15.05 Hidden Creek overlook
15.6 HAK 6 (north of road)
15.65 Hidden Creek trailhead
16.55 Hidden Creek
16.65 HAK 7 (south of road)
16.7 Hidden Lake Campground Road
17.15 HAK 8 (north of road)
17.8 HAK 9 (north of road)
17.85 Pot Hole Lake Fire sign
20.35 East Entrance of Skilak Loop Rd on Sterling Highway

Comparing odometer readings for various years shows substantial variation, e.g., for HAK-9 we have 17.1 (1950), 15.8 (1961), 14.9 (1976-77), and 17.8 (1995). To use a different odometer to locate these plots, it may be necessary to odometer the entire Skilak Loop Rd to obtain the total length L, and then multiply the above plot mileages by the ratio L/20.35 to rescale the mileages to the new odometer. For example, if the new odometer reads 22.3 miles for L, then its odometer reading for HAK-9 should be 17.8 x 22.3/20.35 = 19.5 mi.

APPENDIX 16: GPS COORDINATES

Geographic coordinates were measured with a handheld Trimble Scout GPS on Nov 3, 1995. These measurements were not post-processed, and are nominally accurate to ±100m at the 95% level. Coordinates are reported in both UTM and latitude-longitude, using the 1927 North American Datum (NAD27), Zone 5. Three to five satellites were used for each measurement. GPS measurements were taken on the plots, except for HAK 6 and HAK 8 where the closed forest canopy required taking readings on the road, 56m and 71m , respectively, south of the plots.

PLOT	NORTHING	EASTING	LATITUDE	LONGITUDE
HAK 1	6712128m	0633046m	60° 31.501 N	150° 34.557 W
HAK 2	6711735	0634532	60° 31.258	150° 32.983
HAK 3	6709653	0637413	60° 30.052	150° 29.856
HAK 4	6706727	0642175	60° 28.396	150° 24.738
HAK 5	6706673	0645345	60° 28.297	150° 21.407
HAK 6 road	6704820	0653044	60° 27.167	150° 13.105
HAK 7	6705641	0654446	60° 27.554	150° 11.494
HAK 8 road	6705907	0655051	60° 27.683	150° 10.821
HAK 9	6706834	0655600	60° 28.168	150° 10.182

APPENDIX 17: 1995 PLOT NARRATIVES

All paces are two-step paces.

HAK 1: A reference metal fence post was set on the south side of the Sterling Highway, 60m (32 paces) east of a north road to a microwave relay tower. This road is 0.6 mi east of Spruce Lane. The reference post is located 20.2m south of the center line of the Highway. The Milacre 1 post on the north end of the plot is 67.4m due south of the reference post. A 5' green metal fence post is near the plot, presumably installed by Oldemeyer as a starting point for the 1976 Daubenmire survey.

HAK 2: Plot is located about 120 paces southeast along Skilak Loop Road from the Bottenintnin Lake Road, then due north 30 paces. A reference metal fence post is on the road berm 20m due north of center of Skilak Loop Road. Plot is 38m due north of the reference post. An original large red sheetmetal stake marks Milacre 1 (south end of the plot). Only one rebar stake was found missing in 1995, and it was replaced. No Oldemeyer 1976 fence post was found.

HAK 3: A reference red metal fence post was set on the top of the road berm on the south side of Skilak Loop Road. A second metal fence post was set 85' due south at the top of the plot (Milacre 1). The only trace of this plot found in 1995 was a single red sheetmetal stake with a bullet hole in it, and a small rectangular pit that may have been a soil pit from Oldemeyer's 1976 survey. Using the original plot location description and the photos of 1950, 1955, 1961 and 1965, the plot was restaked on the assumption that the remaining sheetmetal stake was located at the south (Milacre 10) end of the plot. Fortunately the stand was quite uniform and the plot could have been moved 100' west or 400' east without appreciably changing the tree density or ground cover. There is no record of site vandalism in Oldemeyer's data, so it appears that the stakes were removed sometime after the 1976 survey. No Oldemeyer 1976 fence post was found. Plot was entirely restaked with 2' long ½" rebar painted dark red.

HAK 4: Plot is 20 paces east of a borrow pit path, on south side of Skilak Loop Road. A reference metal fence post was set 26m south of center of the Road. The original Milacre 1 stake (north end of plot) is 14m due south of the reference post. Only the 4 original large sheetmetal stakes were found in 1995; these stakes appeared to be in their proper places with respect to each other, so all rebar stakes were replaced on this assumption. No Oldemeyer 1976 fence post was found. No 1976 census data are available for this plot, although Oldemeyer & Regelin (1984) report a Daubenmire survey in 1977.

HAK 5: A reference red metal fence post was set 13m north of the center of the road and 6m into the woods. Plot is 17m due north of the reference post, on top of a steep 20' high moraine. All stakes were found in place in 1995. A metal fence post (presumably for Oldemeyer's 1976 Daubenmire survey) was found at the northeast end of the plot.

HAK 6: A reference green metal fence post was set on the north side of Skilak Loop Road, just inside of woods, 1.15 mi west of Hidden Lake Campground Road. The reference post is 14m north of the center of the road, on top of the berm beside a large double-trunk aspen. The Milacre 1 stake is 42m due north of the reference post. No 1976 census data are available for this plot, although Oldemeyer & Regelin (1984) report a Daubenmire survey in 1977.

HAK 7: A reference metal fence post was set 15m due south of the center of Skilak Loop Road, about 30m south of Hidden Lake Campground Road. The original Milacre 1 stake is 167m due south of the reference metal fence post. Plot is located on a flat area downhill from a terrace bench. It should be noted that Hidden Lake Campground Road was moved somewhat east from its original position along Hidden Creek, as shown on the 1950 USGS Kenai B-1 quadrangle map. In 1995 only one original rebar stake and five large red sheetmetal stakes could be found; these stakes appeared to be in their proper places with respect to each other, so the missing rebar stakes were replaced on this assumption. No Oldemeyer 1976 fence post was found.

HAK 8: A reference red metal fence post was set on top of the road cut on the north side of Skilak Loop Road, 25m north of the center of the road. The post is not visible from the road because of thick alders, and is about 20m above of the road, measured perpendicular to the road. The Milacre 1 stake is 46m due north of the reference post. All stakes were found intact in 1995, as well as a metal fence post (presumably from Oldemeyer's 1976 Daubenmire survey).

HAK 9: A reference red metal fence post was set 75 paces west of the Pot Hole Lake Fire sign at Mile 17.85 on Skilak Loop Road. The reference fence post was set on top of the road berm on the north side of the road, 14.5m from the center of the road. The Milacre 1 stake is 22.5m due north of reference post. Plot is heavily overgrown with alder, elderberry, and cowparsnip. In 1995 three rebar stakes were found in a pile, but the other stakes were intact, and the three stakes were replaced. No Oldemeyer 1976 post was found.

APPENDIX 18: 1994-95 PLOT VISITATION HISTORY

The dates here are useful references to the author's field notebooks and data sheets.

HAK 1: 7/18/94 initial visit, pictures, Daubenmire plots. 7/22/94 Daubenmire plots. 7/20/95 L. Reinink-Smith b&w photos. 7/25/95 grid counts. Revisit 8/24/95. 11/3/95 odometer and GPS location.

HAK 2: 7/27/94, 7/29/94 and 8/1/94 Daubenmire plots. 7/20/95 L. Reinink-Smith b&w photos. 7/26/95 and 7/27/95 grid counts. Revisit 8/24/95. 11/3/95 odometer and GPS location.

HAK 3: 8/3/94 initial finding of the single stake with a bullet hole. Daubenmire plots started. 6/21/95 searching general area for more well-defined plot. 6/27/98 searched with a group. 7/20/95 L. Reinink-Smith b&w photos. 8/25/95 restaking plot, color slides, grid counts. 8/26/95 grid counts. 8/27/95 and 8/28/95 Daubenmire plots. 11/3/95 odometer and GPS location.

HAK 4: 6/27/95 initial visit. 7/20/95 L. Reinink-Smith b&w photos. 8/18/95 and 8/21/95 grid counts. 8/29/95 and 8/31/95 Daubenmire plots. 11/3/95 odometer and GPS location.

HAK 5: 6/21/95 visit. 7/20/95 L. Reinink-Smith b&w photos. 7/28/95, 8/1/95, and 8/2/95 grid counts. 9/5/95 Daubenmire plots. 11/3/95 odometer and GPS location.

HAK 6: 6/21/95 initial visit. 7/20/95 L. Reinink-Smith b&w photos. 8/10/95 and 8/11/95 grid counts. 9/6/95 Daubenmire plots. 11/3/95 odometer and GPS location.

HAK 7: 7/20/95 L. Reinink-Smith b&w photos. 8/5/95 grid counts. 9/12/98 and 9/13/95 Daubenmire plots; the reference post was moved west (closer to Hidden Creek)

of its initial location so that it is now on a N-S line with the plot, consistent with the other plots. 11/3/95 odometer and GPS location.
HAK 8: 8/29/94 initial visit. 7/20/95 L. Reinink-Smith b&w photos. 7/9/95 grid counts. 9/14/95 and 9/15/95 Daubenmire plots; reference post is set. 11/3/95 odometer and GPS location.

HAK 9: 6/21/95 initial visit. 7/20/95 L. Reinink-Smith b&w photos. 8/22/95 grid counts. 9/7/95 and 9/8/95 Daubenmire plots. 9/12/95 reference post is set. 11/3/95 odometer and GPS location.

APPENDIX 2: PERMANENT PLOT 1950-2000 FULL DATA MATRIX

	1-1950	1-1955	1-1961	1-1965	1-1976	1-1995	1-2000	2-1950	2-1955	2-1961	2-1965	2-1976	2-1995	2-2000
ACRU														
ALNUS														
ANSPP														
AQFO														
ARU-U														
BENA														
BEPA										2	1			
BORO														
CARO														
CASPP														
CIAL														
COCA	768	643	1109	1110	1477	2126	2962	1021	868	636	1910	1152	1828	3824
DRDI														
ECHO														
EMNI												7		3
EPAN	295	238	365	395	339	175	74	99	72	92	165	113	36	27
EPLA														
EQAR														
EQSC														
EQSI														
ERSPP														
GASPP														
GELI					31							672	2820	3647
GEPR														
GRASS	296	20%COV	48%COV	217	306	173	105	20	59	1%COV	1%COV	45	116	144
HELA														
LEPA												5		
LIBO												7	10	120
LICHEN%				4.3	7.0	16.8	9.8				3.1	1.0	5.0	6.8
LUNO	734	435	2092	91	26	3	4	80	492	633	294	1		4
LYCO													44	74
MEPA														
MOLA														
MOSS%	20.5	53.0	1.1	7.6	15.9	92.2	92.8	13.0	27.5	10.2	9.7	5.7	56.5	69.3
OSPU														
PAPA														
PELA														
PIGL														
PIMA		15	34	35	29	39	43	1		6	4	6	2	8
POBA														
POSPP	231	48	105	128	2									
POTR								445	308	180	155	62	36	34
PYSPP											20	66	236	372
RILA														
RITR														
ROAC								2	20	7	7	7	5	5
RUCH														
RUID														
SARA														
SASPP	9	9		27		6	5				23			
SHCA														
SOSPP														
SPBE														
STAM														
TASPP														
TREU														
URLY														
VAUL		24		390	115	9	19					10		5
VAVI	1524	1%COV	1%COV	3170	14301	2201	14299	2390	30%COV	5200	10200	9428	4204	3705
VIED														
VISPP														

	3-1950	3-1955	3-1961	3-1965	3-1976	3-1995	3-2000	4-1950	4-1955	4-1961	4-1965	4-1976	4-1995	4-2000
ACRU							0					N/A		
ALNUS							0					N/A		
ANSPP							0					N/A		
AQFO							0					N/A		
ARU-U					14		0					N/A		52
BENA							0					N/A		
BEPA							0	1	3	6	6	N/A	2	1
BORO							0					N/A		
CARO							0					N/A		
CASPP							0					N/A		
CIAL							0					N/A		
COCA	850	779	1032	3287	2469	1273	677	835	3657	2340	3282	N/A	646	1600
DRDI							0					N/A		
ECHO							0					N/A		
EMNI					234	12	17					N/A		
EPAN	318	176	218	325	112	37	27	365	278	209	222	N/A	41	23
EPLA							0					N/A		
EQAR							0					N/A		
EQSC							6					N/A		
EQSI							0					N/A		
ERSPP							0					N/A		
GASPP							0					N/A		
GELI						104	505					N/A	1088	3074
GEPR							0					N/A		
GRASS	19	234	10%COV	5%COV	570	77	163	80	93	8%COV	4%COV	N/A	98	114
HELA							0					N/A		
LEPA							0					N/A		
LIBO					177	33	77					N/A		
LICHEN%				3.5	2.5	1.7	1.2	0.5		1.5	0.6	N/A	5.2	8.0
LUNO	82	348	590	552	10	1	0			10	30	N/A		
LYCO						322	33					N/A		
MEPA							0					N/A		
MOLA							0					N/A		
MOSS%	13.8	42.5	5.6	8.7	3.2	12.5	2.8	34.8	54.0	43.5	10.2	N/A	28.5	35.0
OSPU							0					N/A		
PAPA							0					N/A		
PELA				4			0					N/A		
PIGL							0					N/A		
PIMA						1	1	3	24	37	44	N/A	29	29
POBA							0					N/A		
POSPP	9		972				0					N/A		
POTR	371	213	191	169	100	40	32	64	89	115	76	N/A	28	17
PYSPP					9	28	73					N/A		
RILA							0					N/A		
RITR							0					N/A		2
ROAC							0					N/A		
RUCH							0					N/A		
RUID							0					N/A		
SARA							0					N/A		
SASPP	3	2	1	1			0	1	5	4	10	N/A	1	
SHCA							0					N/A		
SOSPP							0					N/A		
SPBE							0					N/A		
STAM							0					N/A		
TASPP							0					N/A		
TREU							0					N/A		
URLY							0					N/A		
VAUL							0					N/A		
VAVI	146	8%COV	735	2746	9145	3436	8840	277	5%COV	3000	8208	N/A	3994	5526
VIED							0					N/A		
VISPP							0					N/A		

	5-1950	5-1955	5-1961	5-1965	5-1976	5-1995	5-2000	6-1950	6-1955	6-1961	6-1965	6-1976	6-1995	6-2000
ACRU												N/A	34	38
ALNUS										2	34	N/A	9	2
ANSPP											23	N/A		
AQFO												N/A		
ARU-U												N/A		
BENA												N/A		
BEPA	4	19	19	34	18	10	7	171	62	64	68	N/A	5	6
BORO												N/A		
CARO												N/A		
CASPP												N/A		
CIAL												N/A		
COCA	114	586	730	901	2283	476	628					N/A		
DRDI												N/A		
ECHO												N/A	3	3
EMNI												N/A		
EPAN	581	251	158	197	193	58	33	2818	1600	740	525	N/A		
EPLA												N/A		
EQAR											110	N/A	83	98
EQSC												N/A	142	215
EQSI												N/A		
ERSPP												N/A		
GASPP										125	207	N/A	180	96
GELI												N/A		
GEPR											28	N/A		
GRASS			0.2%COV	0.6%COV	19	2	0			8%COV	20%COV	N/A	174	225
HELA												N/A	58	90
LEPA				2	1	1						N/A		
LIBO	3				347	21	80					N/A		
LICHEN%		0.2	0.6	3.0	6.7	11.9	18.0	48.5	4.5		0.3	N/A	0.9	0.1
LUNO	1	64	4	885	262		0					N/A		
LYCO												N/A		
MEPA												N/A	11	26
MOLA												N/A	307	758
MOSS%	59.5	72.0	17.3	62.0	3.0	58.5	61.6			5.0	7.7	N/A	1.6	0.9
OSPU												N/A	1499	387
PAPA									1	125	73	N/A		
PELA												N/A		
PIGL												N/A		
PIMA	4	19	25	30	34	34	34					N/A		
POBA				1								N/A		
POSPP												N/A		
POTR	44	52	50	77	75	13	5					N/A		
PYSPP		18		24	279	69	44			5	3	N/A		
RILA												N/A		
RITR							1					N/A	66	38
ROAC											2	N/A	5	1
RUCH												N/A		
RUID										66		N/A	15	10
SARA										1	1	N/A		
SASPP	25	16	23	28	22	12	5		3	15	13	N/A		
SHCA												N/A		
SOSPP										13	79	N/A		3
SPBE												N/A		
STAM												N/A		
TASPP												N/A	5	5
TREU												N/A	20	38
URLY												N/A		
VAUL												N/A		
VAVI		0.3%COV	77	849	9382	4315	1266					N/A		
VIED												N/A		7
VISPP											3	N/A	44	31

	7-1950	7-1955	7-1961	7-1965	7-1976	7-1995	7-2000	8-1950	8-1955	8-1961	8-1965	8-1976	8-1995	8-2000
ACRU														
ALNUS									6	5	52	34	6	2
ANSPP														
AQFO														
ARU-U														
BENA		1	10				1							
BEPA		5	27	41	9		0	2029	1689	289	319	74	21	14
BORO														
CARO														
CASPP		6												
CIAL														
COCA								1984	3050	1025	1321	572	58	28
DRDI														
ECHO														
EMNI					36	20	30							
EPAN		107	74	47	2			678	288	84	134	120	9	1
EPLA														
EQAR							10							
EQSC														
EQSI	240	969	575	191	126	62	114							
ERSPP														
GASPP														
GELI						56	135					45	104	16
GEPR														
GRASS	27	65	7%COV	2%COV	175	46	30				0.2%COV			
HELA														
LEPA	69	38	18%COV	19%COV	31	80	93							
LIBO											675	223	46	7
LICHEN%				0.1	4.3	9.0	20.5	11.5	1.0	0.1	1.8	3.6	2.0	1.6
LUNO														
LYCO														
MEPA														
MOLA														
MOSS%	5.7	35.1	55.0	45.0	14.9	20.9	16.1	18.0	23.5	5.5	4.2	2.0	4.9	6.9
OSPU														
PAPA														
PELA				1										
PIGL					1			168	121	146	161	89	42	23
PIMA	5	15	26	37	42	38	35						1	2
POBA		1							1		1			
POSPP														
POTR	4	3	8	8	10	6	4		13		4	1		
PYSPP									86		23	79	29	15
RILA				179							9			
RITR														
ROAC								14	23	87	112	45	18	11
RUCH	136	134	311	179	151	45	46							
RUID								48	9		2			
SARA														
SASPP		1	3	5	4	2	1	3	82	57	77	10		
SHCA											1	1		
SOSPP														
SPBE	4	40	209	275	231	30	25							
STAM														
TASPP														
TREU														
URLY														
VAUL			13	101	178	38	51							
VAVI	142	13%COV	2470	5095	29144	3319	1691	167	11%COV	1985	3314	952	19	6
VIED									2	2	9	14	13	
VISPP														9

	9-1950	9-1955	9-1961	9-1965	9-1976	9-1995	9-2000	FREQUENCY #PLOTS (MAX 9x7-2=61)
ACRU								3
ALNUS	7	20	49	59	10	14	16	18
ANSPP								2
AQFO				1				2
ARU-U								3
BENA								4
BEPA	1	6	12	4				38
BORO						22	16	3
CARO				42				2
CASPP								2
CIAL						91	7	3
COCA		14	43	82	351	321	334	47
DRDI							1	2
ECHO		1	1	2	3	9	9	9
EMNI								8
EPAN	206	206	168	53	21			54
EPLA								1
EQAR								5
EQSC						66	68	5
EQSI								8
ERSPP								1
GASPP		136	175	88	1281	130	58	10
GELI								13
GEPR								2
GRASS	391	820	33%COV	222	356	230	238	35
HELA	26	1			51	50	30	8
LEPA								10
LIBO					475	8	6	17
LICHEN%	16.5	4.0	0.2	0.5	0.4			43
LUNO								28
LYCO								4
MEPA					58	19	46	6
MOLA						386	195	5
MOSS%	14.0	4.0	1.6	2.3	7.0	8.2	9.0	59
OSPU						291	109	5
PAPA								4
PELA								3
PIGL	43	73	130	93	15	6	5	16
PIMA								36
POBA								5
POSPP								8
POTR		1						38
PYSPP			114	71	279			22
RILA	5	15	90	39	97	12	6	10
RITR						72	60	7
ROAC	4	5	137	117	111	51	35	25
RUCH								8
RUID	658	285	200	139	38	199	135	14
SARA			6	16				5
SASPP		28	2	12				40
SHCA								3
SOSPP				3				5
SPBE								8
STAM						1		2
TASPP					5		1	5
TREU								3
URLY	112	16	4	24				5
VAUL								13
VAVI								39
VIED					1		11	9
VISPP			185	166	1281	277	303	10

APPENDIX 3: MILACRE STEM COUNTS

	POTR											PIMA										
	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM
HAK 1																						
1950											0											0
1955											0	3	1	3	1	1	3		1	2		15
1961											0	3	3	6	2	2	5	1	2	7	3	34
1965											0	3	3	6	3	5	3	1	4	6	1	35
1995											0	4	2	7	4	3	5	1	4	8	1	39
HAK 2																						
1950	18	31	44	52	52	45	42	47	56	58	445		1									1
1955	24	22	20	38	44	33	33	34	24	36	308											0
1961	15	11	10	17	24	23	17	22	21	20	180		2		1	1	1		1			6
1965	14	12	10	17	19	24	15	16	11	17	155		2			1			1			4
1995	5	2	4	1	9	4	3	3	4	1	36		1						1			2
HAK 3																						
1950	45	32	32	35	48	41	40	38	30	30	371											0
1955	20	19	21	30	31	19	18	15	21	19	213											0
1961	13	21	27	19	23	15	17	15	30	11	191											0
1965	15	12	19	19	27	17	17	15	17	11	169											0
1995	5	7	8	6		1	1	5	2	5	40										1	1
HAK 4																						
1950	4	5	8	5	15	15	4		5	3	64						3					3
1955	10	8	12	13	13	12	4	4	8	5	89				2	3	14	2	2	1		24
1961	13	11	14	12	11	16	9	9	9	11	115	1	1	1	1	6	17		6	4		37
1965	7	4	8	11	10	10	5	5	8	8	76	2	1	1	4	6	16	3	6	5		44
1995	2	3	4	3	3	6	2		3	2	28	2	2		1	5	8	2	4	4	1	29
HAK 5																						
1950	19	10	2		2		2		9		44	2	2									4
1955	13	13	9		7	1	2	3	4		52	4	5	2		2		1	2	2	1	19
1961	5	6	5	2	6	4	4	6	11	1	50	5	4	3	2	4	1	1	3	2		25
1965	14	10	8	1	6	9	10	8	10	1	77	6	7	3	2	4	2	1	2	3		30
1995		1	1	1	4		2	1	3		13	6	6	3	2	4	2	1	1	8	1	34
HAK 6																						
1950											0											0
1955											0											0
1961											0											0
1965											0											0
1995											0											0
HAK 7																						
1950		4									4			2		3						5
1955		1			2						3	2	3	2		2		6				15
1961	2	4			2						8	4	7	3	3	5	3	1				26
1965	1	3			2		2				8	5	7	5	3	6	6	2	1	1	1	37
1995	3	2				1					6	5	5	4	5	6	4	2	3	2	2	38
HAK 8																						
1950											0											0
1955	1			3	2	7					13											0
1961											0											0
1965			1	1	1					1	4											0
1995											0											0
HAK 9																						
1950											0											0
1955	1		1								2											0
1961											0											0
1965											0											0
1995											0											0

	BEPA											PIGL										
	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM
HAK 1																						
1950											0											0
1955											0											0
1961											0											0
1965											0											0
1995											0											0
HAK 2																						
1950											0											0
1955											0											0
1961		2									2											0
1965		1									1											0
1995											0											0
HAK 3																						
1950											0											0
1955											0											0
1961											0											0
1965											0											0
1995											0											0
HAK 4																						
1950				1							1											0
1955	1					2					3											0
1961			1			4	1				6											0
1965		1				2	3				6											0
1995	1						1				2											0
HAK 5																						
1950		2	2								4											0
1955	6	4	2		4		1	1	1		19											0
1961	4	5	3	1	2		1	2	1		19											0
1965	6	11	3	2	6	1	1	1	2	1	34											0
1995		1	1	2	3		2			1	10											0
HAK 6																						
1950		17	32	25	8	9	8	9	22	41	171											0
1955			6	1	2		2	5	2	44	62											0
1961	1		8	3	7		3	3	5	34	64											0
1965	1		7	2	5		3	5	10	35	68											0
1995			1						1	3	5											0
HAK 7																						
1950											0											0
1955			1	3			1				5											0
1961	2	2		1	1	4	15	1	1		27											0
1965	13	2		1	1	6	16	1	1		41											0
1995											0											0
HAK 8																						
1950	76	90	50	350	550	750	80		50	33	2029	5	22	15	35	23	38	15		15		168
1955	116	63	69	357	670	335	12	11	41	15	1689	9	16	2	52	18	21	3				121
1961	40	20	25	100	15	25	11	8	25	20	289	13	19	15	45	28	13	5	2	2	4	146
1965	45	26	25	43	28	31	17	15	38	51	319	11	23	8	39	31	30	6	1	4	8	161
1995	4	2		2		1	3	2	3	4	21	6	6	14	4		2	5	3	2	1	43
HAK 9																						
1950				1							1	7	9	8	9	10						43
1955	1	1	2	1				1			6	31	11	17	12	1	1					73
1961		2	1	2	1			6			12	40	42	16	25	7						130
1965			1		1			2			4	35	22	13	17	5		1				93
1995											0			4		1					1	6

APPENDIX 4: MILACRE RECRUITMENT

	POTR											PIMA										
	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM
HAK 1																						
1950																						
1955												3	1	3	1	1	3		1	2		**15**
1961													2	3	1	1	2	1	1	5	3	**19**
1965															1	3			2			**6**
1995												1		1	1		2			2		**7**
HAK 2																						
1950																						
1955	6										**6**											
1961													2		1	1	1		1			**6**
1965		1				1					**2**											
1995																						
HAK 3																						
1950																						
1955																						
1961		2	6						9		**17**											
1965	2				4	2					**8**											
1995																					1	**1**
HAK 4																						
1950																						
1955	6	3	4	8				4	3	2	**30**				2	3	11	2	2	1		**21**
1961	3	3	2			4	5	5	1	6	**29**	1	1	1		3	3		4	3		**16**
1965												1			3			3		1		**8**
1995													1								1	**2**
HAK 5																						
1950																						
1955		3	7		5	1		3			**19**	2	3	2		2		1	2	2	1	**15**
1961				2		3	2	3	7	1	**18**	1		1	2	2	1		1			**8**
1965	9	4	3			5	6	2			**29**	1	3				1			1		**6**
1995																				5	1	**6**
HAK 6																						
1950																						
1955																						
1961																						
1965																						
1995																						
HAK 7																						
1950																						
1955					2						**2**	2	3					6				**11**
1961	2	3									**5**	2	4	1	3	3	3					**16**
1965							2				**2**	1		2		1	3	1	1	1	1	**11**
1995	2					1					**3**				2				2	1	1	**6**
HAK 8																						
1950																						
1955	1			3	2	7					**13**											
1961																						
1965			1	1	1					1	**4**											
1995																						
HAK 9																						
1950																						
1955	1		1								**2**											
1961																						
1965																						
1995																						

	BEPA											PIGL										
	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM
HAK 1																						
1950																						
1955																						
1961																						
1965																						
1995																						
HAK 2																						
1950																						
1955																						
1961		2									**2**											
1965																						
1995																						
HAK 3																						
1950																						
1955																						
1961																						
1965																						
1995																						
HAK 4																						
1950																						
1955	1					2					**3**											
1961			1			2	1				**4**											
1965		1					2				**3**											
1995	1										**1**											
HAK 5																						
1950																						
1955	6	2			4		1	1	1		**15**											
1961		1	1	1				1			**4**											
1965	2	6		1	4	1			1	1	**16**											
1995							1				**1**											
HAK 6																						
1950																						
1955										3	**3**											
1961	1		2	2	5		1		3		**14**											
1965								2	5	1	**8**											
1995																						
HAK 7																						
1950																						
1955			1	3			1				**5**											
1961	2	2			1	4	14	1	1		**25**											
1965	11					2	1				**14**											
1995																						
HAK 8																						
1950																						
1955	40		19	7	120			11			**197**	4			17							**21**
1961										5	**5**	4	3	13		10		2	2	2	4	**40**
1965	5	6			13	6	6	7	13	31	**87**		4			3	17	1		2	4	**31**
1995														6					2			**8**
HAK 9																						
1950																						
1955	1	1	2					1			**5**	24	2	9	3		1					**39**
1961		1		1	1			5			**8**	9	31		13	6						**59**
1965																		1				**1**
1995																					1	**1**

APPENDIX 5: MILACRE MORTALITY

	POTR											PIMA										
	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM
HAK 1																						
1950																						
1955																						
1961																						
1965																	2			1	2	5
1995													1			2						3
HAK 2																						
1950																						
1955		9	24	14	8	12	9	13	32	22	143		1									1
1961	9	11	10	21	20	10	16	12	3	16	128											
1965	1				5		2	6	10	3	27				1		1					2
1995	9	10	6	16	10	20	12	13	7	16	119		1			1						2
HAK 3																						
1950																						
1955	25	13	11	5	17	22	22	23	9	11	158											
1961	7			11	8	4	1			8	39											
1965		9	8						13		30											
1995	10	5	11	13	27	16	16	10	15	6	129											
HAK 4																						
1950																						
1955					2	3					5											
1961				1	2						3				1			2				3
1965	6	7	6	1	1	6	4	4	1	3	39						1					1
1995	5	1	4	8	7	4	3	5	5	6	48			1	3	1	8	1	2	1		17
HAK 5																						
1950																						
1955	6								5		11											
1961	8	7	4		1						20		1								1	2
1965				1					1		2								1			1
1995	14	9	7		2	9	8	7	7	1	64		1						1			2
HAK 6																						
1950																						
1955																						
1961																						
1965																						
1995																						
HAK 7																						
1950																						
1955		3									3					1						1
1961																		5				5
1965	1	1									2											
1995		1			2		2				5		2	1			2					5
HAK 8																						
1950																						
1955																						
1961	1			3	2	7					13											
1965																						
1995			1	1	1					1	4											
HAK 9																						
1950																						
1955																						
1961	1		1								2											
1965																						
1995																						

BEPA

	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM
HAK 1											
1950											
1955											
1961											
1965											
1995											
HAK 2											
1950											
1955											
1961											
1965		1									1
1995		1									1
HAK 3											
1950											
1955											
1961											
1965											
1995											
HAK 4											
1950											
1955				1							1
1961	1										1
1965			1			2					3
1995		1				2	2				5
HAK 5											
1950											
1955											
1961	2				2						4
1965								1			1
1995	6	10	2		3	1		1	2		25
HAK 6											
1950											
1955		17	26	24	6	9	6	4	20		112
1961								2		10	12
1965			1	1	2						4
1995	1		6	2	5		3	5	9	32	63
HAK 7											
1950											
1955											
1961			1	2							3
1965											
1995	13	2		1	1	6	16	1	1		41
HAK 8											
1950											
1955		27				415	68		9	18	537
1961	76	43	44	257	655	310	1	3	16		1405
1965				57							57
1995	41	24	25	41	28	30	14	13	35	47	298
HAK 9											
1950											
1955											
1961	1		1								2
1965		2		2				4			8
1995			1		1			2			4

PIGL

	MIL1	MIL2	MIL3	MIL4	MIL5	MIL6	MIL7	MIL8	MIL9	MIL10	SUM
HAK 1											
1950											
1955											
1961											
1965											
1995											
HAK 2											
1950											
1955											
1961											
1965											
1995											
HAK 3											
1950											
1955											
1961											
1965											
1995											
HAK 4											
1950											
1955											
1961											
1965											
1995											
HAK 5											
1950											
1955											
1961											
1965											
1995											
HAK 6											
1950											
1955											
1961											
1965											
1995											
HAK 7											
1950											
1955											
1961											
1965											
1995											
HAK 8											
1950											
1955		6	13		5	17	12		15		68
1961				7		8					15
1965	2		7	6				1			16
1995	5	17		35	31	28	1		2	7	126
HAK 9											
1950											
1955					9						9
1961			1			1					2
1965	5	20	3	8	2						38
1995	35	22	9	17	4		1				88

APPENDIX 6: STEM HEIGHT HISTOGRAMS (data need to be re-checked with 1995 notebooks and originial 1950-1965 data)

CENTIMETER	HAK 1 PIMA		HAK 2 POTR				HAK 3 POTR				HAK 4 POTR				HAK 4 PIMA			
BINS	1965	1995	1950	1961	1965	1995	1950	1961	1965	1995	1950	1961	1965	1995	1950	1961	1965	1995
1																		
1.5																		
2																		
2.5																		
3							8											
3.5																		
4																		
4.5																		
5																		
5.5					2				2									
6																		
6.5																		
7																		
7.5																		
8	1			2									2		3		1	
8.5																		
9																		
9.5																		
10											2							
15	7		4						1				2				5	
20	2		2		2		1				1		1				4	
25	4		18				21										5	
30	4		13				21				1						2	
35	1		27	1			35	2	1		1	18	1	2			11	3
40			46				38										1	
45			58				37				3						2	
50	1		55				52				1						11	
55			46				34				5							
60			29				17											
65	1	4	24	15	5		25	40	18		7	8	3	3			2	6
70			22				4											
75			19				8				5							
80	3		20				12				1							
85			14				16				2							
90			19				10				1							
95	2	1	19	45	8		27	68	30		7	21	9					8
100			3				4											
150	2	4	6	28	22		1	32	14		23	13	8					
200	4	3	1	32	37			44	58		2	23	22					6
250		1		29	23	4		5	25			10	6					3
300		2		14	5				10				1					1
350		1		11	17	7			9			2	2					1
400		3		2	18	6			1	3		10	4					
450		5		1	8							3						
500		2			6	2				7		3	5	3				
550		5			2					1		3	5					
600		1																
650		4				4				2		1	3	2				
700		1								2			1					
750						3								1				
800						8				11			1	4				
850										1								
900						2												
950						7				12				4				
1000										1								
1500		1				5												
2000																		
2500																		
3000																		
MEASURED	32	38	445	180	155	48	371	191	169	40	62	115	76	19	3	0	44	28
UNMEASURED	3	3																
TOTAL	35	39																

CENTIMETER BINS	HAK 5 POTR 1950	1955	1965	1995	HAK 5 PIMA 1950	1955	1965	1995	HAK 7 PIMA 1950	1965	1995
1											
1.5											
2											
2.5											
3					4				5		
3.5											
4											
4.5											
5											
5.5	26		3							1	
6											
6.5											
7											
7.5											
8	13		1							8	1
8.5											
9											
9.5											
10											
15	4		4				1			3	
20			2				2			4	2
25			7				5			3	2
30			1				2				
35		11	9				5	1		2	5
40	1									1	
45											
50			2				1			1	1
55											
60											
65		41	17	1			6	3		4	5
70											
75											
80										2	
85											
90											
95			11				5	2		3	1
100											
150			7	1			1	2		4	4
200			10	6			2	8		1	8
250			3	6				2			2
300											
350								1			3
400								5			2
450								4			
500								4			1
550								1			
600											
650											
700								1			
750											
800											
850											
900											
950											
1000											
1500											
2000											
2500											
3000											
MEASURED	44	52	77	14	4	0	30	34	5	37	37
UNMEASURED											
TOTAL											

CENTIMETER BINS	HAK 6 BEPA 1950	1955	1961	1965	1995	HAK 8 BEPA 1950	1955	1961	1965	1995	HAK 9 PIGL 1950	1961	1965	1995
1														
1.5									2					
2														
2.5														
3				1		28					3			
3.5														
4														
4.5														
5														
5.5	75			5		17			5		24		2	
6														
6.5														
7														
7.5														
8				1		11			8				3	
8.5														
9														
9.5														
10														
15	96			2		1064			36		16		12	
20				2		901			19				7	
25						6			10				8	
30						1			20				9	
35		62	3	2				133	19			97	14	
40						1							4	
45													1	
50									2				6	
55														
60														
65			19	2			1689	24	20			16	17	
70														
75														
80													1	
85														
90														
95			15	4				29	34			5	3	
100														
150			17	7				18	46			4	1	
200			10	25				2	80			1	4	
250				11					14	1			1	1
300				3					1	1				2
350				3					2	1				
400									1					1
450														
500										4				1
550														
600														
650					1					4				
700														
750														
800					1									
850														
900														
950										3				
1000														
1500					3					7				1
2000														
2500														
3000														
MEASURED	171	62	64	68	5	2029	1689	206	319	21	43	123	93	6
UNMEASURED														
TOTAL														

APPENDIX 7: MOOSE UTILIZATION PERCENTAGE 1950 - 1965

YEAR	PLOT	MIL 1	MIL 2	MIL 3	MIL 4	MIL 5	MIL 6	MIL 7	MIL 8	MIL 9	MIL 10	AVG	MAX	MIN
1950	HAK 1	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 2	85	75	50	20	5	0	0	0	0	0	24	85	0
	HAK 3	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 4	0	0	0	0	0	0	0	0	0	2	0	2	0
	HAK 5	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 6	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 7	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 8	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 9	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	HAK 1	0	0	0	0	0	0	100	100	6	100	31	100	0
	HAK 2	100	100	100	100	100	100	100	100	100	100	100	100	100
	HAK 3	100	100	100	100	100	100	100	100	100	100	100	100	100
	HAK 4	100	100	100	100	100	90	100	75	100	100	97	100	75
	HAK 5	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 6	0	0	0	0	0	0	0	0	0	80	8	80	0
	HAK 7	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 8	50	50	50	50	20	25	80	100	80	100	61	100	20
	HAK 9	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	HAK 1	0	0	0	0	0	0	100	50	0	100	25	100	0
	HAK 2	0	0	0	0	0	5	0	0	0	0	1	5	0
	HAK 3	0	0	0	0	1	0	0	0	0	0	0	1	0
	HAK 4	1	0	0	0	0	0	0	0	0	5	1	5	0
	HAK 5	2	0	0	0	0	0	0	0	10	0	1	10	0
	HAK 6	50	2	2	2	80	0	5	5	80	10	24	80	0
	HAK 7	0	0	0	100	20	0	0	0	0	100	22	100	0
	HAK 8	10	10	10	1	2	2	5	2	2	5	5	10	1
	HAK 9	0	0	2	1	0	0	0	2	20	0	3	20	0
1965	HAK 1	0	0	0	0	0	0	50	90	0	60	20	90	0
	HAK 2	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 3	0	0	0	0	0	0	0	0	0	0	0	0	0
	HAK 4	0	0	0	0	0	10	0	0	0	0	1	10	0
	HAK 5	50	50	40	10	10	1	5	50	40	0	26	50	0
	HAK 6	90	0	20	0	90	0	0	40	50	10	30	90	0
	HAK 7	0	30	0	0	20	0	10	0	0	0	6	30	0
	HAK 8	80	10	10	10	5	5	20	40	50	50	28	80	5
	HAK 9	0	0	0	0	0	0	0	100	0	0	10	100	0

SUMMARY OF AVERAGE PERCENT UTILIZATION

AVG %	HAK 1	HAK 2	HAK 3	HAK 4	HAK 5	HAK 6	HAK 7	HAK 8	AK 9
1950	0	24	0	0	0	0	0	0	0
1955	31	100	100	97	0	8	0	60.5	0
1961	25	1	0	1	1	24	22	4.9	2.5
1965	20	0	0	1	26	30	6	28	10

APPENDIX 8: Selections from the Kenai National Moose Range Annual Narratives

TO BE PREPARED

APPENDIX 9: DAUBENMIRE PLOT PROTOCOL

The basic tools of this survey are a 20x50cm wire frame with a 5m length of cord attached, a 2m story pole marked at decimeter intervals, clipboard and datasheets, field notebook, basal area gauge (Cruzall), and centimeter DBH tape.

A starting point is selected, usually the head of the subplot nearest the road (Milacre 1), and the steel pin at the end of the 5m cord is set in the ground. The cord is stretched down the plot for 5m, and the pin accompanying the frame is set, with the frame on the right hand side of the string. The cord forms one side of a 1 x 5m plot; the opposite side of the plot is delineated by eye, using the 1m mark on the story pole, which is placed on the right hand side of the string. The 20 x 50 cm frame thus samples a 0.1 m^2 area within the 5 m^2 of the 1 x 5 m plot.

The surveyor stands near the frame and swings the Cruzall in a 360° arc, counting trees which are equal to or larger than a chosen BAF window. It is convenient to keep two running counts (like a ping pong score), the first being the BAF 5 count and the second being the BAF 10 count. The first score will always be greater than the second, and ideally should be about double the second. This is done for each tree species.

To compute the basal area, one multiplies the tree count times the basal area factor (BAF 5 or 10, in this case). For example, 9 black spruce counted with the BAF 5 window yields a basal area of 45 square feet/acre for black spruce.

The surveyor then measures the height of each tree species nearest the frame corner of the 1 x 5m plot, within a distance of 3m. If no individual of a given species (e.g., willow) is found within 3m, a null value (dash) is entered on the data sheet. A null value is useful for presence/absence frequency calculations, e.g., it could be useful to know that only 2 (8%) of the 25 points showed willow, whereas 22 (88%) showed black spruce.

The next step is to take DBH's for all trees within the 1x5m plot, by species. This allows a second estimation of basal area, with the added information about whether the basal area is spread over many small trees or concentrated in a few large ones.

Next, all tree and shrub stems > 40 cm tall in the 1 x 5m plot are counted. Both live and standing dead stems are counted, with counts of dead stems circled on the data sheet.

The ground vegetation is surveyed in the 20 x 50 cm frame using 7 cover classes: 1 = 0%, 2 < 5%, 3 = 5-20%, 4 = 21-40%, 5 = 41-60%, 6 = 61-80%, and 7 ≥ 81%. For calculations the cover classes are converted into percents by using: class 2 = 2.5%, 3 = 12.5%, 4 = 30%, 5 = 50%, 6 = 70%, and 7 = 90%.

To move forward for the next subplot, the surveyor stands at the corner with the 20 x 50cm frame (the new starting point), faces forward and picks the nearest dominant tree species in 180-deg arc perpendicular to the present axis of the 1 x 5m plot. This tree determines the new bearing for the next leg of the traverse. The direction of the nearest dominant tree is considered "random," or at least not subjectively chosen. The surveyor then walks five two-step paces on the bearing of this tree (i.e., towards the tree or beyond it), sets the steel pin at the end of the 5m cord into the ground, and continues walking in the same direction while unwinding the 5m cord. At 5m point the cord is stretched tight and checked for alignment along the bearing from the previous plot, before setting the steel pin and the 20 x 50cm frame. Careful alignment with the random bearing is necessary to avoid subjectively placing the 1 x 5m plot in a convenient location. In thick vegetation it is useful to start by tying a piece of surveyors tape above the starting corner with the 20 x 50cm frame, so that one can sight back along the bearing to align the cord precisely with the starting point. See Fig. 11 for plot layout diagram.

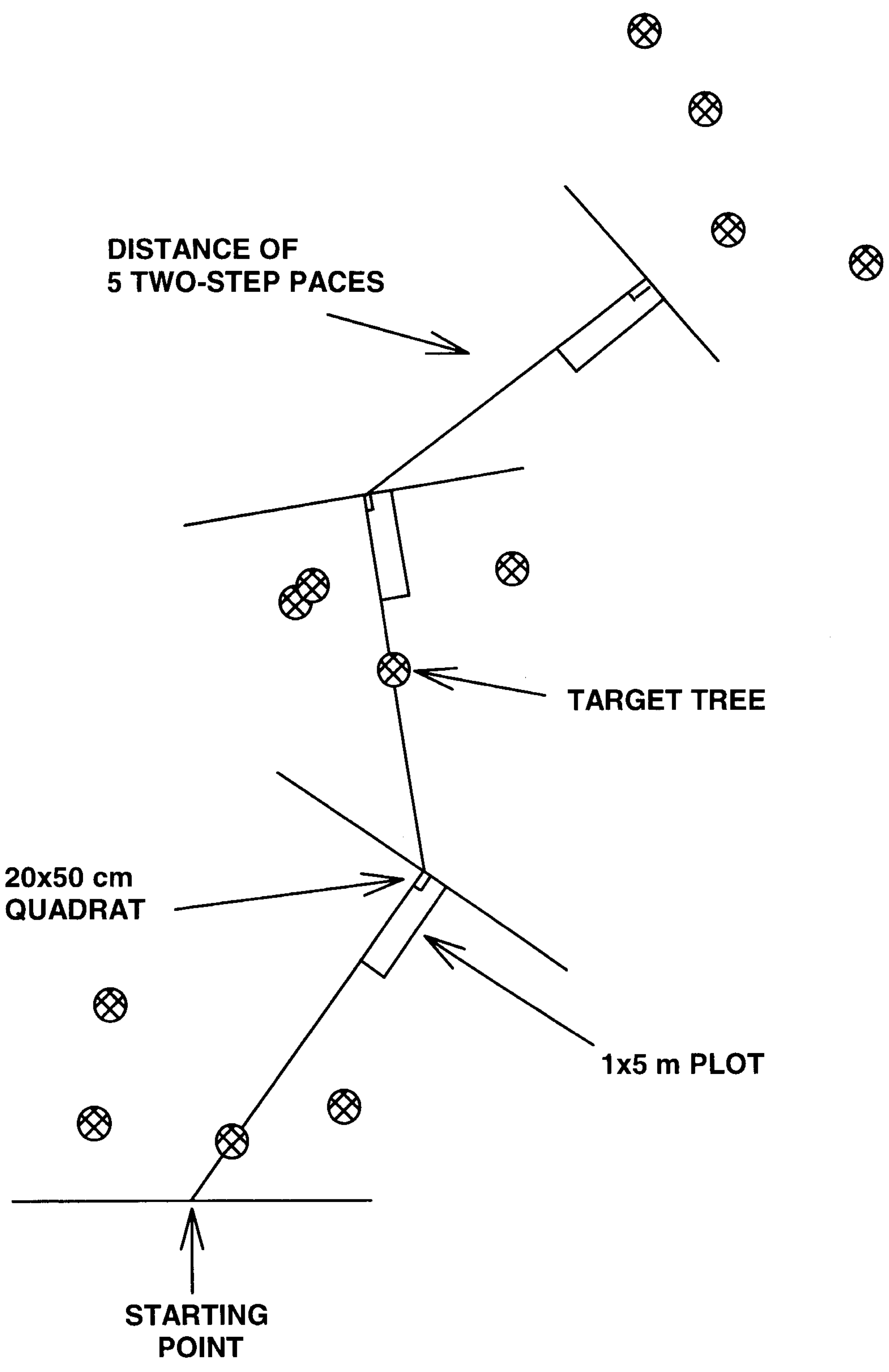

FIG. 11. DAUBENMIRE PLOT LAYOUT: FORWARD RANDOM ANGLE TRAVERSE

APPENDIX 10: 1995 DAUBENMIRE TREE SUMMARY

PLOT #	HAK 1 (SD)	HAK (SD)	HAK 3 (SD)	HAK 4 (SD)	HAK 5 (SD)	HAK 6 (SD)	HAK7 (SD)	HAK 8 (SD)	HAK 9 (SD)
BLACK SPRUCE									
BA sqft/ac	53 (19)	28 (18)	25 (22)	18 (15)	25 (15)		17 (15)	1 (2)	
BA sqm/ha	12 (4)	6 (4)	6 (5)	4 (3)	6 (3)		4 (3)	0.2 (.4)	
DBH cm	4.4 (2.5)	4.9 (2.5)	5.8 (5.1)	2.7 (1.8)	3.5 (2.2)		3.5 (2.1)	11.7	
N (DBH)	71	42	10	97	81		61	1	
STEMS/ACRE	2910 (1750)	1880 (2090)	420 (410)	4790 (5120)	4110 (2060)		2780 (2240)	30 (160)	60 (320)
STEMS/HA	7200 (4320)	4640 (5155)	1040 (1020)	11840 (12661)	10160 (5096)		6880 (5540)	80 (400)	160 (800)
HGT cm	517 (343)	462 (311)	450 (353)	216 (134)	221 (149)	582 (222)	261 (158)	600 (173)	
WHITE SPRUCE									
BA sqft/ac			2 (3)		1 (3)	12 (21)	1 (3)	48 (28)	21 (21)
BA sqm/ha			0 (1)		0 (1)	3 (5)	0 (1)	11 (6)	5 (5)
DBH cm		3.5 (.6)	10.9 (7.8)		4.1 (3.)	10.4 (3)	2.5	4.0 (2.9)	6.3 (6.5)
N (DBH)		4	4		9	5	2	88	17
STEMS/ACRE		30 (160)	130 (300)		320 (520)	130 (380)	60 (220)	3330 (3550)	550 (980)
STEMS/HA		80 (400)	320 (748)		800 (1291)	320 (945)	160 (554)	8240 (8762)	1360 (2430)
HGT cm		338 (75)	675 (236)		338 (156)	350 (165)	280 (78)	553 (326)	672 (644)
ASPEN									
BA sqft/ac		75 (37)	62 (32)	38 (34)	22 (37)			1 (7)	
BA sqm/ha		17 (8)	14 (7)	9 (8)	5 (9)			0 (2)	
DBH cm		5.7 (2.0)	5.9 (3.3)	6.5 (4.0)	4.6 (3.4)				
N (DBH)		70	60	36	23				
STEMS/ACRE		2230 (1550)	1970 (2160)	2070 (2410)	1360 (1380)		870 (1400)		
STEMS/HA		5520 (3842)	4880 (5325)	5120 (5946)	3360 (3401)		2160 (3460)		
HGT cm		820 (266)	801 (479)	495 (347)	311 (262)		56 (18)		
BIRCH									
BA sqft/ac				2 (4)	12 (14)	41 (27)		64 (27)	
BA sqm/ha				0 (1)	3 (3)	9 (6)		15 (6)	
DBH cm				3.4 (1.9)	4.4 (2.6)	7.9 (4.7)	2.6 (1.3)	8.2 (3.7)	
N (DBH)				5	37	37	5	40	
STEMS/ACRE	1040 (1800)	30 (160)		190 (353)	1170 (1260)	1130 (1955)	260 (800)	1520 (1176)	
STEMS/HA	2560 (4454)	80 (400)		480 (872)	2880 (3113)	2800 (4830)	640 (1977)	3760 (2905)	
HGT cm	116 (92)	1133 (115)		303 (170)	272 (141)	744 (202)	147 (85)	964 (180)	

PLOT #	HAK 1 (SD)	HAK (SD)	HAK 3 (SD)	HAK 4 (SD)	HAK 5 (SD)	HAK 6 (SD)	HAK7 (SD)	HAK 8 (SD)	HAK 9 (SD)
ALDER									
BA sqft/ac						43 (48)		14 (20)	96 (36)
BA sqm/ha						10 (11)		3 (5)	22 (8)
DBH cm						7.7 (3.1)		4.8 (1.3)	7.4 (3.1)
N (DBH)						19		28	64
STEMS/ACRE						710 (1430)		910 (1570)	2170 (1630)
STEMS/HA						1760 (3527)		2240 (3887)	5360 (4030)
HGT cm						711 (256)	40 (14)	633 (141)	795 (326)
WILLOW									
BA sqft/ac									1 (3)
BA sqm/ha									
DBH cm									
N (DBH)									
STEMS/ACRE	324 (522)		227 (549)	130 (383)	1004 (1264)		324 (809)		
STEMS/HA	800 (1291)		560 (1356)	320 (945)	2480 (3124)		800 (2000)		
HGT cm	135 (50)		160 (75)	135 (35)	147 (57)	160	70 (21)	520 (358)	180

KEY

BA sqft/ac	*BASAL AREA* square feet/acre (*CRUZALL BA5*)
BA sqm/ha	BASAL AREA square meters/hectare
DBH cm	MEAN DIAMETER AT BREAST HEIGHT centimeters
N (DBH)	NUMBER OF STEMS USED TO COMPUTE MEAN DBH
STEMS/ACRE	NUMBER OF STEMS/ACRE
STEMS/HA	NUMBER OF STEMS/HECTARE
HGT cm	MEAN STEM HEIGHT centimeters
(SD)	STANDARD DEVIATION centimeters

Stem heights were often measured outside of the 1x5m plots, especailly if stem density was low.
Hence, stem heights are sometimes reported, even if there were no occurrences of stems in any 1x5m plot, e.g., willow for plots 6, 8, and 9.

APPENDIX 11: 1995 DAUBENMIRE MEAN PERCENT COVER

MEAN PERCENT COVER IN 25 - 20x50cm QUADRATS PER PLOT

PLOT	HAK 1	HAK 2	HAK 3	HAK 4	HAK 5	HAK 6	HAK 7	HAK 8	HAK 9	FREQ (9 MAX)
ACRU	0	0	0	0	0	0.6	0	0	0.1	2
ARU-U	0	0	0	4.1	2.8	0	0	0	0	2
AULAC	0.6	7.5	0.6	0	1.6	0	1.6	0.8	0.2	7
BRACH	0	1	14.9	3.5	6.6	3.2	0	3.8	1.3	7
CERAT	0.1	0	0	0.3	0	0	0.1	0	0	3
CLRA	9.4	2.4	0.9	8.3	8.3	0.7	28.5	3.4	0	8
COCA	10.2	10.5	31.8	6.2	1.7	0	0.1	0.6	1.2	8
DDWOOD	NA	NA	4.9	13.5	19.6	38.5	6.1	21.1	14.4	7
DEGL	0	0	0	0	0	0	0	0	0.2	1
DICRN	0	0.1	0.2	2.3	1.3	0	6.1	0.3	0	6
DRDI	0	0	0	0	0	0.5	0	0	0	1
DREPA	1.6	8.3	1.3	4.7	5	0.2	0.5	2.3	0.1	9
EMNI	0	0	4.1	0	0	0	2	0	0	2
EPAN	1.6	0.8	4	0.2	0.7	0	0.1	0	0	6
EQAR	0	0	0	0	0	0.5	0.1	0	0	2
EQFL	0	0	0	0	0	0	0.2	0	0	1
EQSC	0	0	0	0	0	40.6	0	0	2.7	2
EURHY	0	0	0.1	0	0	2.2	0	0.1	2.1	4
GASP	0	0	0	0	0	0.2	0	0	2.3	2
GELI	0.5	23.1	4.6	5.7	1.8	0	0	0	0	5
GRASS	8.9	2.4	1.9	2.6	0.1	26.5	0.7	0	6.7	8
GYMNO	0	0	0	0	0.1	0	0	0	0	1
HELA	0	0	0	0	0	0.2	0	0	1	2
HYLOC	0	0	10.8	0.1	0.3	0	0	0.9	0.5	5
LEPA	0	0	1.2	0	0	0	30.7	0	0	2
LFLTCO	NA	NA	*80.4*	53.7	*55.5*	*83.7*	3	*79.3*	75.1	7
LIBO	0	0	30.9	5.3	7.8	0	0	0.2	0	4
LUNO	0.2	0	1.9	0	0	0	0	0	0	2
LYANN	0	0	3.6	0	0	0	0	0	0	1
LYCOMP	0	0.7	1.6	0	0	0	0	0	0	2
MEPA	0	0	0	0	0	1	0	0	0	1
MOLA	0	0	0	0	0	0.8	0	0	0.7	2
MOSSCO	76.6	78	48.1	39	49.2	7.3	53.1	12.8	7.9	9
OSPU	0	0	0	0	0	0.2	0	0	3.4	2
OXMI	0	0	0	0	0	0	5.7	0	0	1
PEDSPP	0	0	3	0	0	0	0.1	0	0	2
PELT	18.4	6.2	2.6	15.1	6.1	0	12.5	0.1	0	7
PLAGI	0	0	0	0	0	0.2	0	0.1	3.1	3
PLSCH	49.9	39.9	4.6	14.7	10.2	0.1	3.6	0.6	0	8
POHLI	0	0	0	0.9	0.8	0.3	0.3	0.6	0.1	6
POLTR	1.6	3.6	1.8	2.5	0.8	0.1	6.1	0	0	7
PTILD	11.4	2.2	1.2	0.7	7	0	14.8	0.9	0	7
PTILM	0.1	0.2	0.1	0	0.1	0	0	0	0	4
PYSE	0	0.9	0.8	0	1.2	0.6	0	0	0	4
RITR	0	0	0	0	0	1.3	0	0	1.5	2
ROAC	0	0.2	0	0	0	3.8	0	0	0.1	3
RUCH	0	0	0	0	0	0	0.8	0	0	1
RUID	0	0	0	0	0	1.4	0	0	0.9	2
SPHAG	0	0	0	0	0	0	7.7	0	0	1
VAUL	7.2	0	3.3	0	0	0	14.3	0	0	3
VAVI	62.9	46.4	55.2	62.9	31.7	0	59.4	0	0	6
VIED	0	0	0.1	0	0	0.1	0	0.1	0	3
VISP	0	0	0	0	0	0	0	0	5.5	1

APPENDIX 12: 1995 DAUBENMIRE FREQUENCY

FREQUENCY OF OCCURENCE IN 25 - 20x50cm QUADRATS

PLOT	HAK 1	HAK 2	HAK 3	HAK 4	HAK 5	HAK 6	HAK 7	HAK 8	HAK 9	FREQ (9 MAX)
ACRU	0	0	0	0	0	2	0	0	1	2
ARU-U	0	0	0	2	1	0	0	0	0	2
AULAC	2	14	6	0	4	0	8	4	2	7
BRACH	0	10	25	20	19	12	0	19	13	7
CERAT	1	0	0	3	0	0	1	0	0	3
CLRA	17	12	9	19	22	3	24	7	0	8
COCA	21	20	21	15	9	0	1	6	4	8
DDWOOD	NA	NA	14	19	21	18	14	24	21	7
DEGL	0	0	0	0	0	0	0	0	2	1
DICRN	0	1	2	4	9	0	7	3	0	6
DRDI	0	0	0	0	0	1	0	0	0	1
DREPA	4	18	9	16	22	2	5	12	1	9
EMNI	0	0	2	0	0	0	1	0	0	2
EPAN	8	4	12	2	3	0	1	0	0	6
EQAR	0	0	0	0	0	5	1	0	0	2
EQFL	0	0	0	0	0	0	2	0	0	1
EQSC	0	0	0	0	0	8	0	0	15	2
EURHY	0	0	1	0	0	7	0	1	9	4
GASP	0	0	0	0	0	2	0	0	12	2
GELI	1	24	11	15	3	0	0	0	0	5
GRASS	22	12	15	7	1	12	3	0	16	8
GYMNO	0	0	0	0	1	0	0	0	0	1
HELA	0	0	0	0	0	2	0	0	2	2
HYLOC	0	0	7	1	3	0	0	5	1	5
LEPA	0	0	1	0	0	0	13	0	0	2
LFLTCO	NA	NA	25	25	24	25	11	25	25	7
LIBO	0	0	16	3	9	0	0	2	0	4
LUNO	2	0	7	0	0	0	0	0	0	2
LYANN	0	3	1	0	0	0	0	0	0	2
LYCOMP	0	0	4	0	0	0	0	0	0	1
MEPA	0	0	0	0	0	2	0	0	0	1
MOLA	0	0	0	0	0	8	0	0	7	2
MOSSCO	25	25	25	24	25	16	25	22	17	9
OSPU	0	0	0	0	0	2	0	0	7	2
OXMI	0	0	0	0	0	0	3	0	0	1
PEDSPP	0	0	3	0	0	0	1	0	0	2
PELT	22	13	*10*	17	11	*0*	*19*	1	*0*	7
PLAGI	0	0	0	0	0	2	0	1	12	3
PLSCH	23	22	11	15	18	1	9	6	0	8
POHLI	0	0	0	5	4	3	3	6	1	6
POLTR	16	13	14	13	8	1	19	0	0	7
PTILD	17	10	8	3	16	0	14	5	0	7
PTILM	1	2	1	0	1	0	0	0	0	4
PYSE	0	5	4	0	1	2	0	0	0	4
RITR	0	0	0	0	0	2	0	0	4	2
ROAC	0	2	0	0	0	3	0	0	1	3
RUCH	0	0	0	0	0	0	4	0	0	1
RUID	0	0	0	0	0	3	0	0	5	2
SPHAG	0	0	0	0	0	0	4	0	0	1
VAUL	2	0	2	0	0	0	9	0	0	3
VAVI	25	24	24	25	20	0	24	0	0	6
VIED	0	0	1	0	0	1	0	1	0	3
VISPP	0	0	0	0	0	0	0	0	12	1

Fig. 1: Permanent Plot Locations

Appendix 14: Roadmap of Permanent plot Locations

HAKALA PLOT #1

E. BERG KNWR 2-12-2001

J:\BERG\HAKALA\HAK1.JNB

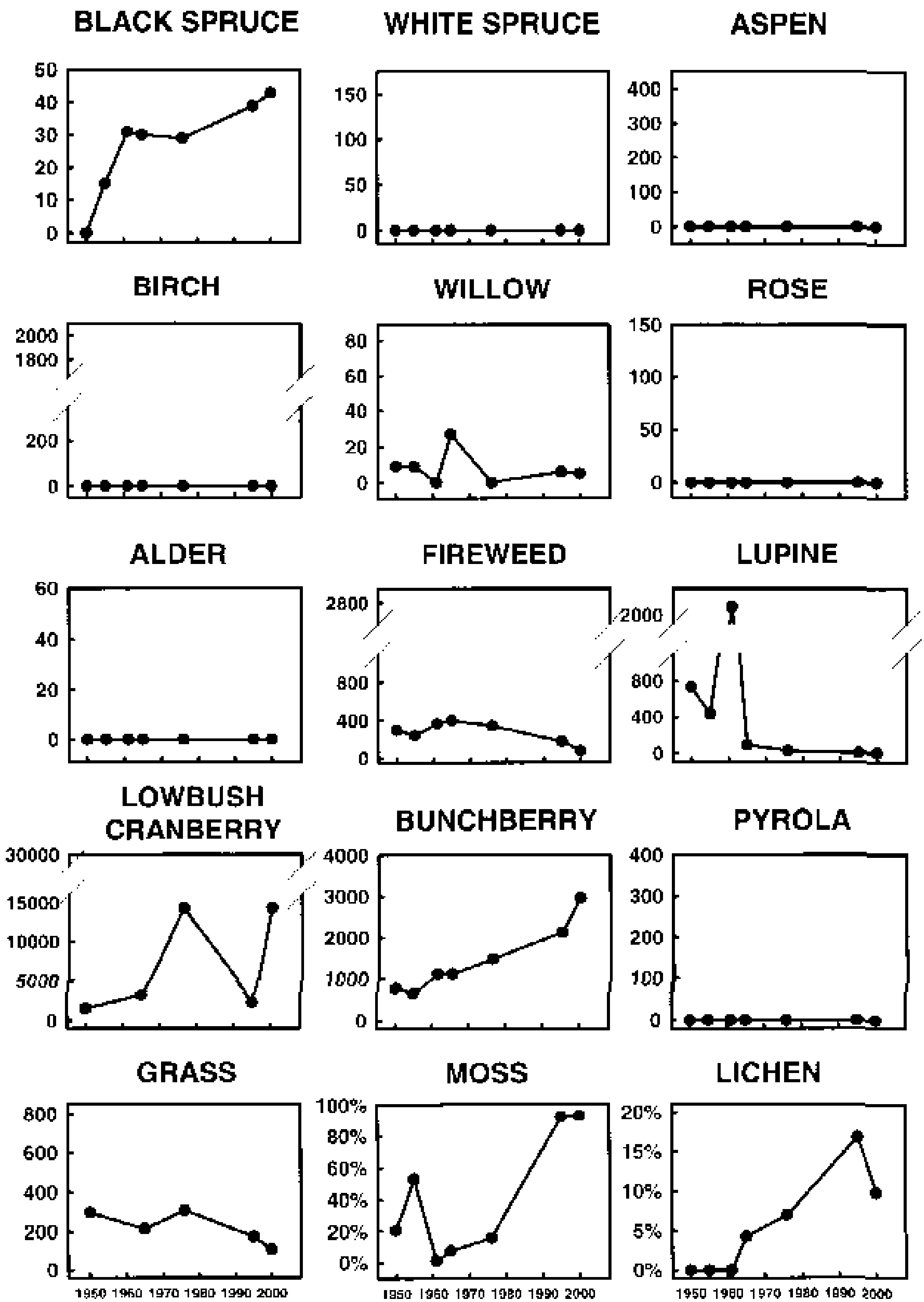

Fig. 6.1. HAK 1 was a lightly burned stand of young black spruce, which recolonized as pure black spruce, with a few willows as the shrub understory, and a typical Pleurozium - lowbush cranberry ground cover.

E. BERG KNWR 2-13-2001

J:\BERG\HAKALA\HAK2.JNB

HAKALA PLOT #2

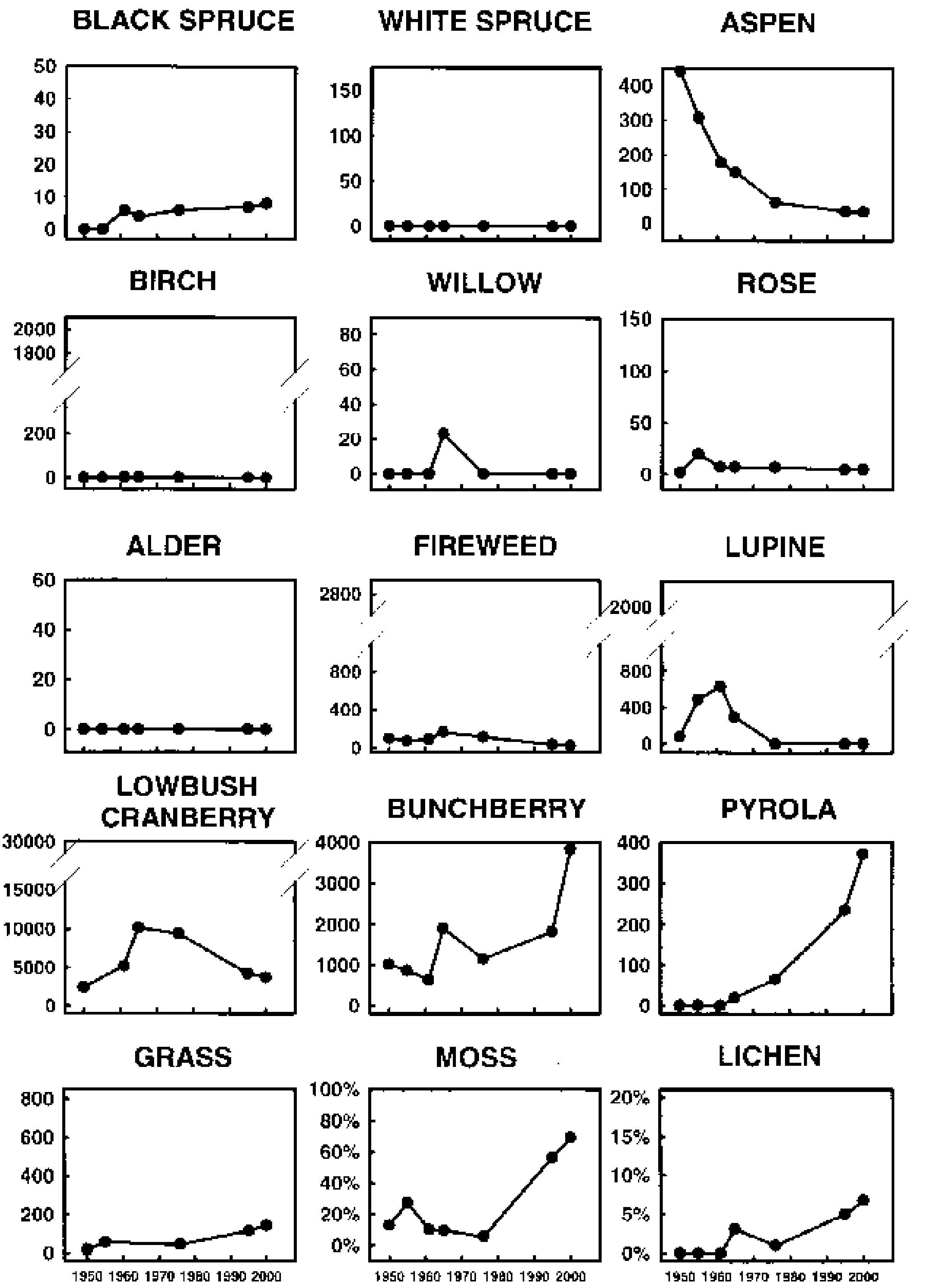

Fig. 6.2. HAK 2 was a lightly burned young aspen - black spruce stand. Three years postburn the ground was covered with aspen suckers, which grew into a dense scrub, as shown in the photographs of 1950 through 1965. In 1995 the stand was predominantly aspen with a sparse understory of smaller black spruce (canopy cover 13%). The 1995 stand possessed a much more open appearance than the stands of 1965 and earlier. The herbaceous layer is now dominated by Pyrola, bunchberry, lowbush cranberry and moss.

E. BERG KNWR 2-13-2000

J:\BERG\HAKALA\HAK3.JNB

HAKALA PLOT #3

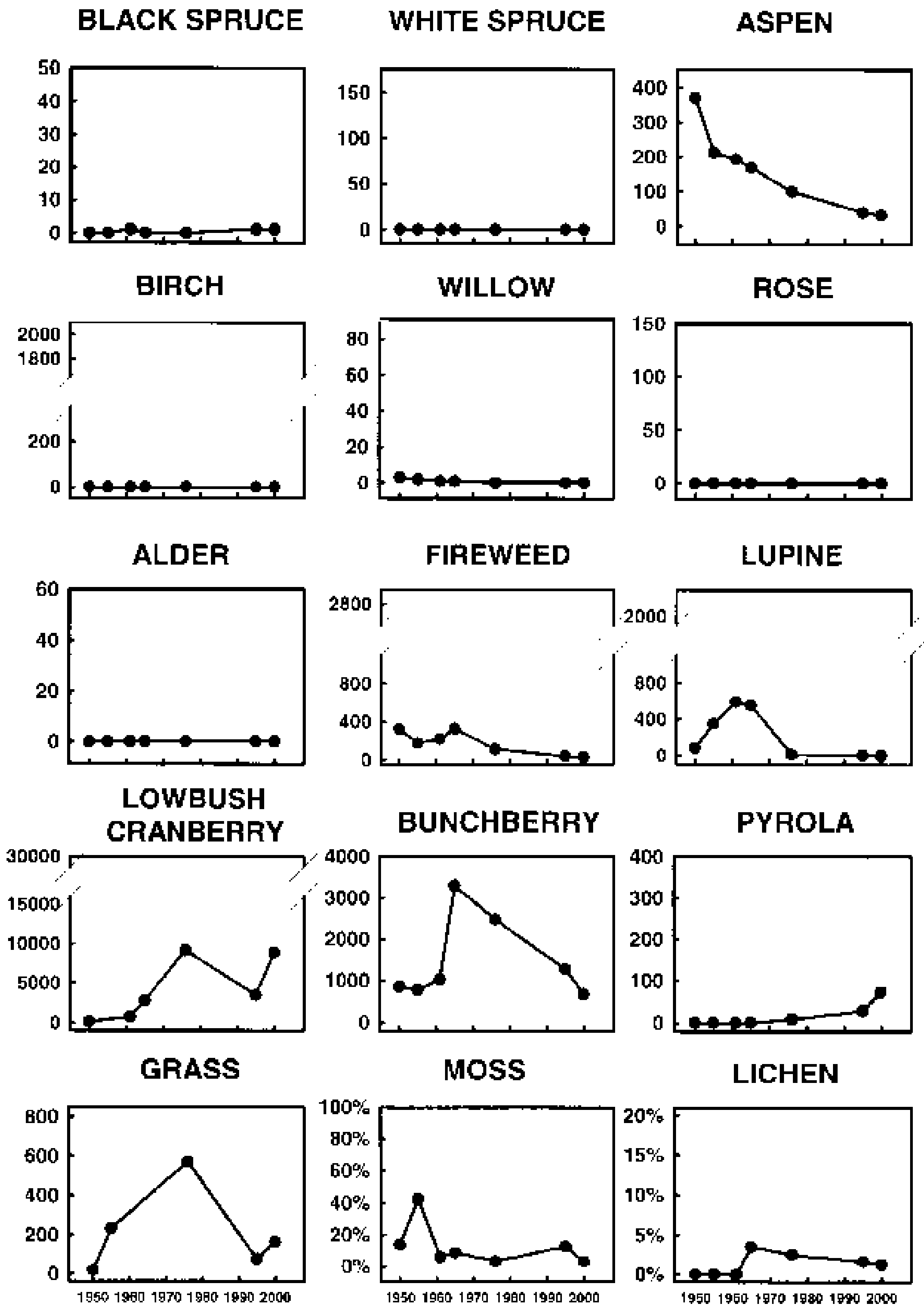

Fig. 6.3. Like HAK 2, HAK 3 was a lightly burned young aspen - black spruce stand. With abundant root suckering, HAK 3 regenerated as an almost pure aspen stand. There is less moss in HAK 3, because of a nearly complete litter cover of dead leaves, due to the closed aspen canopy. Bunchberry and lowbush cranberry dominate the herbaceous layer.

HAKALA PLOT #4

E. BERG KNWR 2-13-2001

J:\BERG\HAKALA\HAK4.JNB

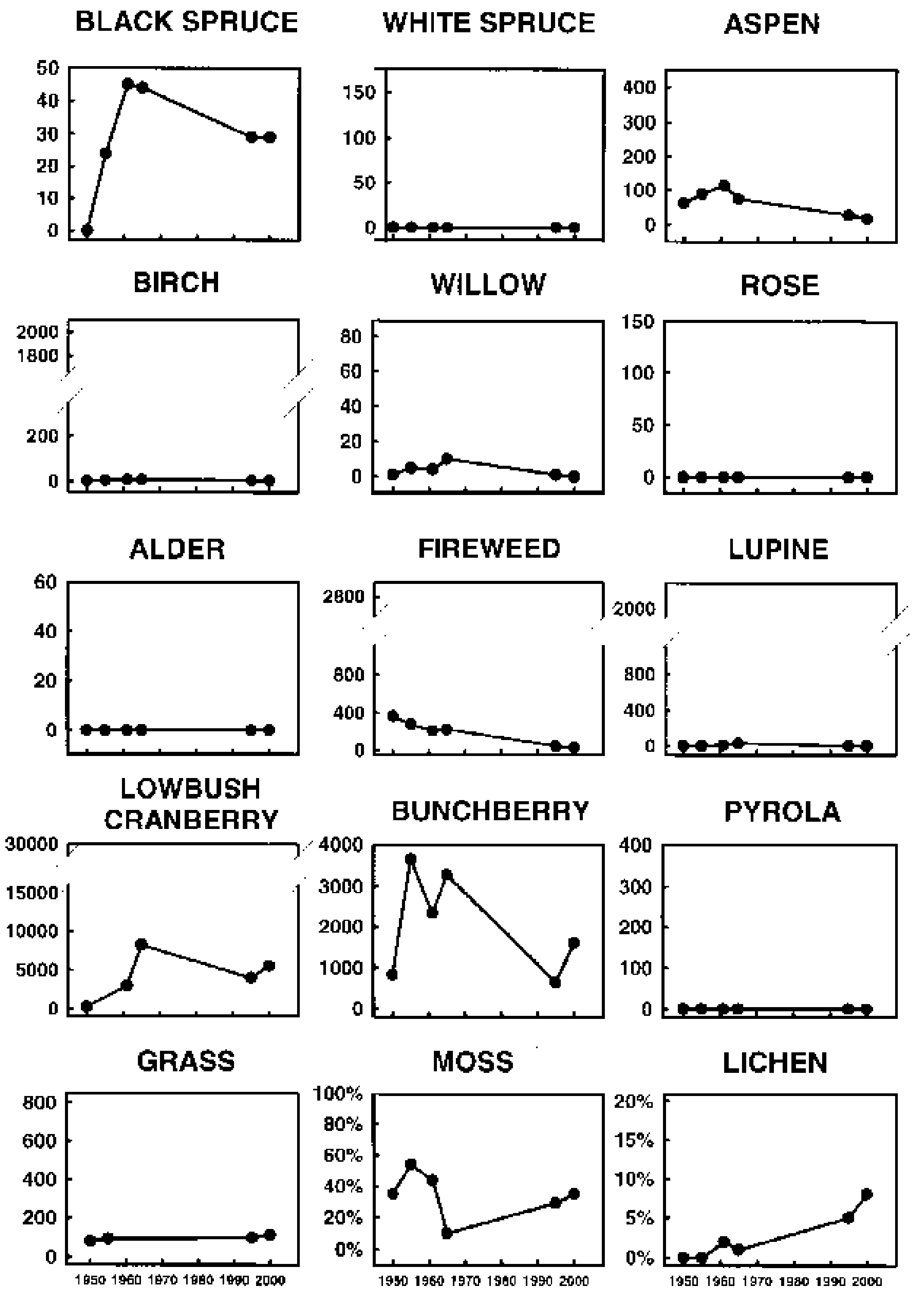

Fig. 6.4. HAK 4 was a severely burned 85 year old black spruce and aspen stand. Aspen recruitment was primarily through suckers, which continued to proliferate at least until the 1961 census. In 1995 aspen was the canopy dominant species with black spruce subdominant with cover of 32%. Lowbush cranberry, bunchberry, and <u>Drepanocladus</u> formed the primary ground cover, with thick aspen leaf litter.

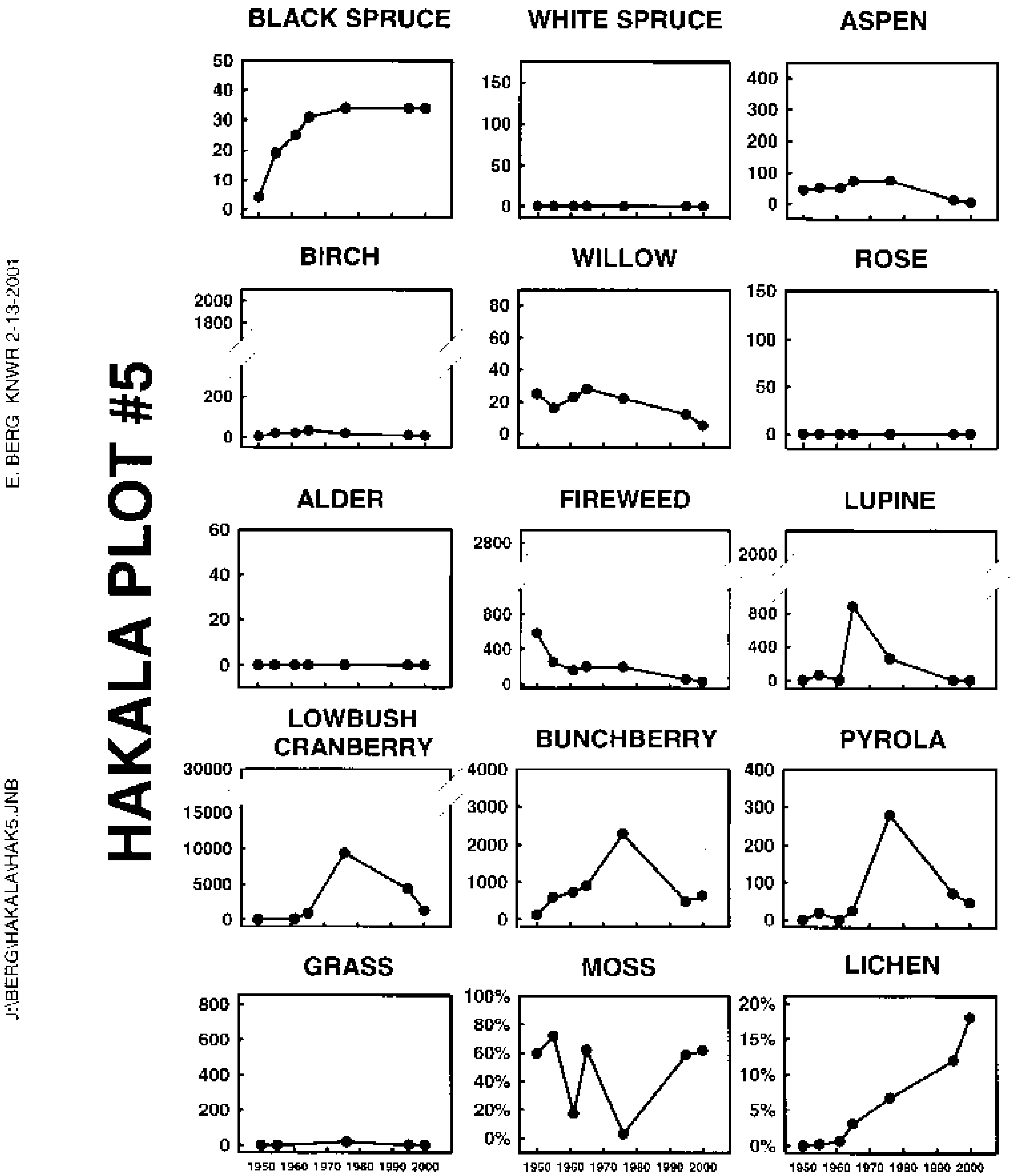

Fig. 6.5. HAK 5 was a very severely burned 100 year old pure black spruce stand. Aspen regeneration was less intense on this plot than the previous plots, because there was no aspen in the original stand and all recruitment was through seedlings. Black spruce regeneration was abundant, like that of HAK 4, with a cover of 43% in 1995. Lowbush cranberry and Pleurozium are now the dominant ground cover; grass was never significant on this plot.

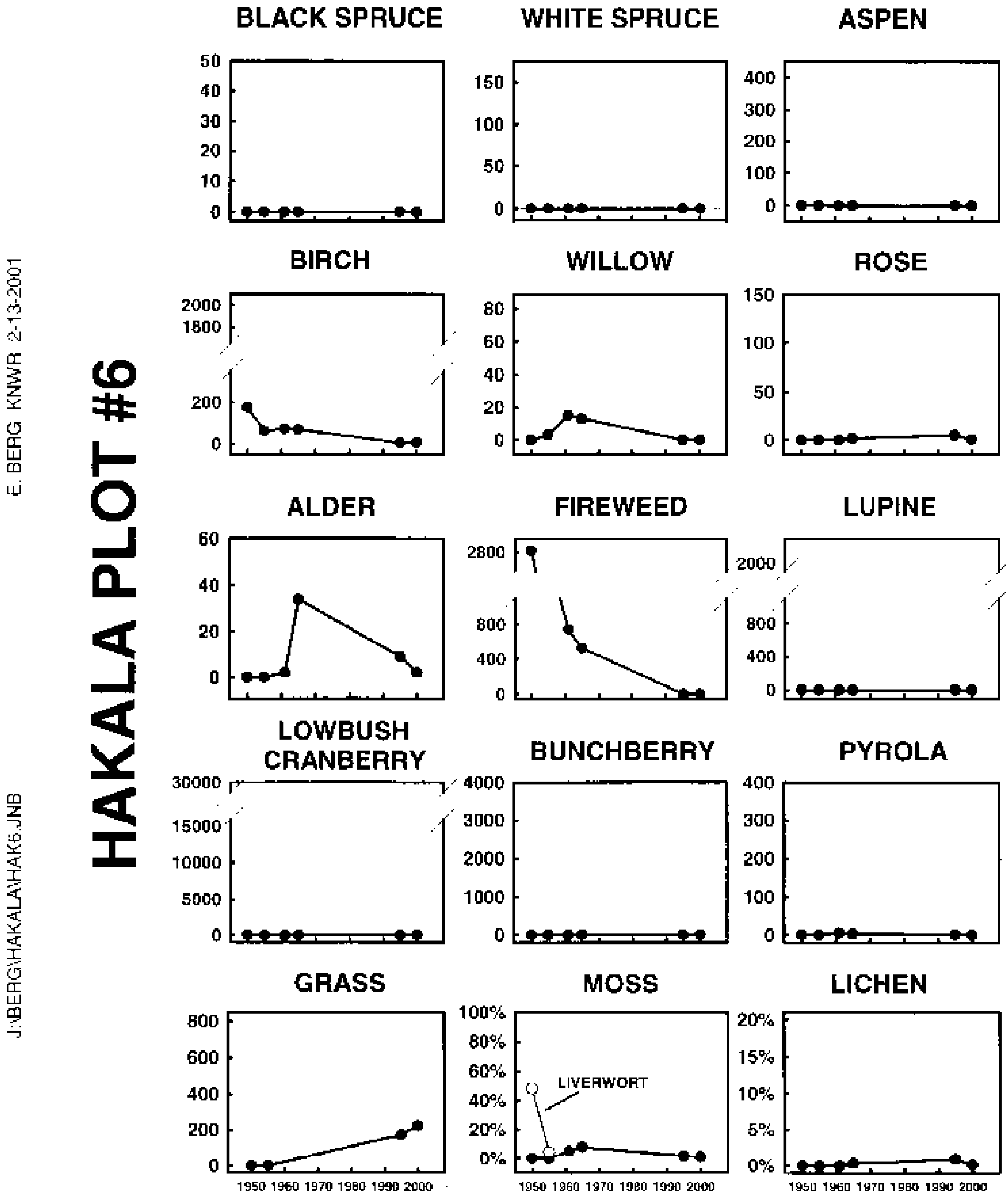

Fig. 6.6. HAK 6 was a very severely burned mature birch, cottonwood and white spruce stand, which regenerated as birch and alder, with a well-developed <u>Heracleum</u> layer, accompanied by <u>Actaea</u>, <u>Equisetum</u> <u>arvense</u>, and grass. HAK 6 and HAK 9 are floristically very similar.

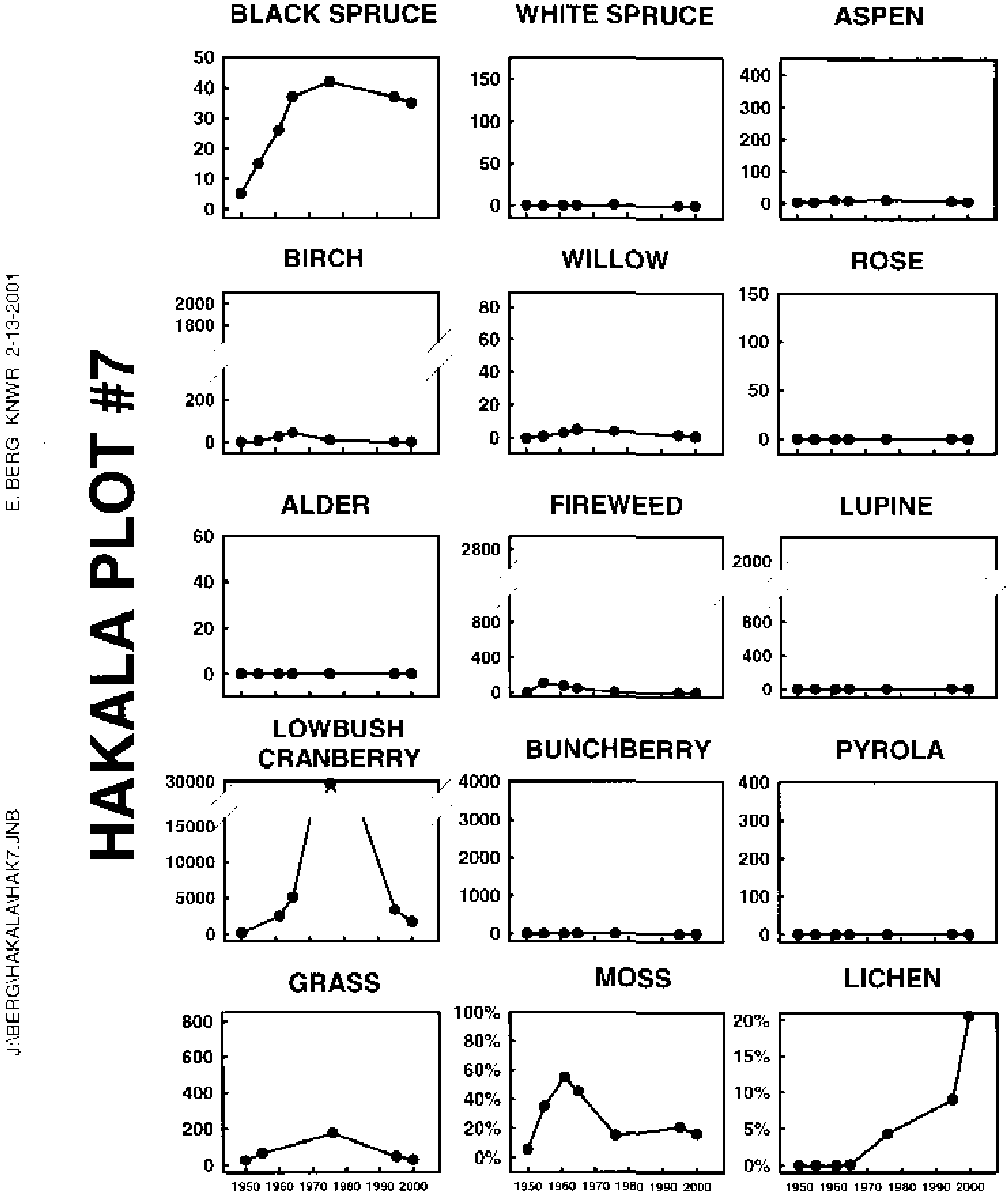

Fig. 6.7. HAK 7 was a moderately burned 110 year old dense lowland black spruce stand. The stand regenerated as an open black spruce woodland (17% cover), with a dense Ledum shrub layer (77% cover). The substantial Polytrichum ground cover (14%) suggests that the site is presently rather dry, at least on the surface. This plot had the lowest production of woody species of all nine plots, with a greater stand basal area of only 17 ft^2/acre of black spruce. The original burn charred the heavy sod layer, but apparently not to such an extent that mineral soil was effectively opened up for seedling recruitment.

E. BERG KNWR 2-13-2001

HAKALA PLOT #8

J:\BERG\HAKALA\HAK8.JNB

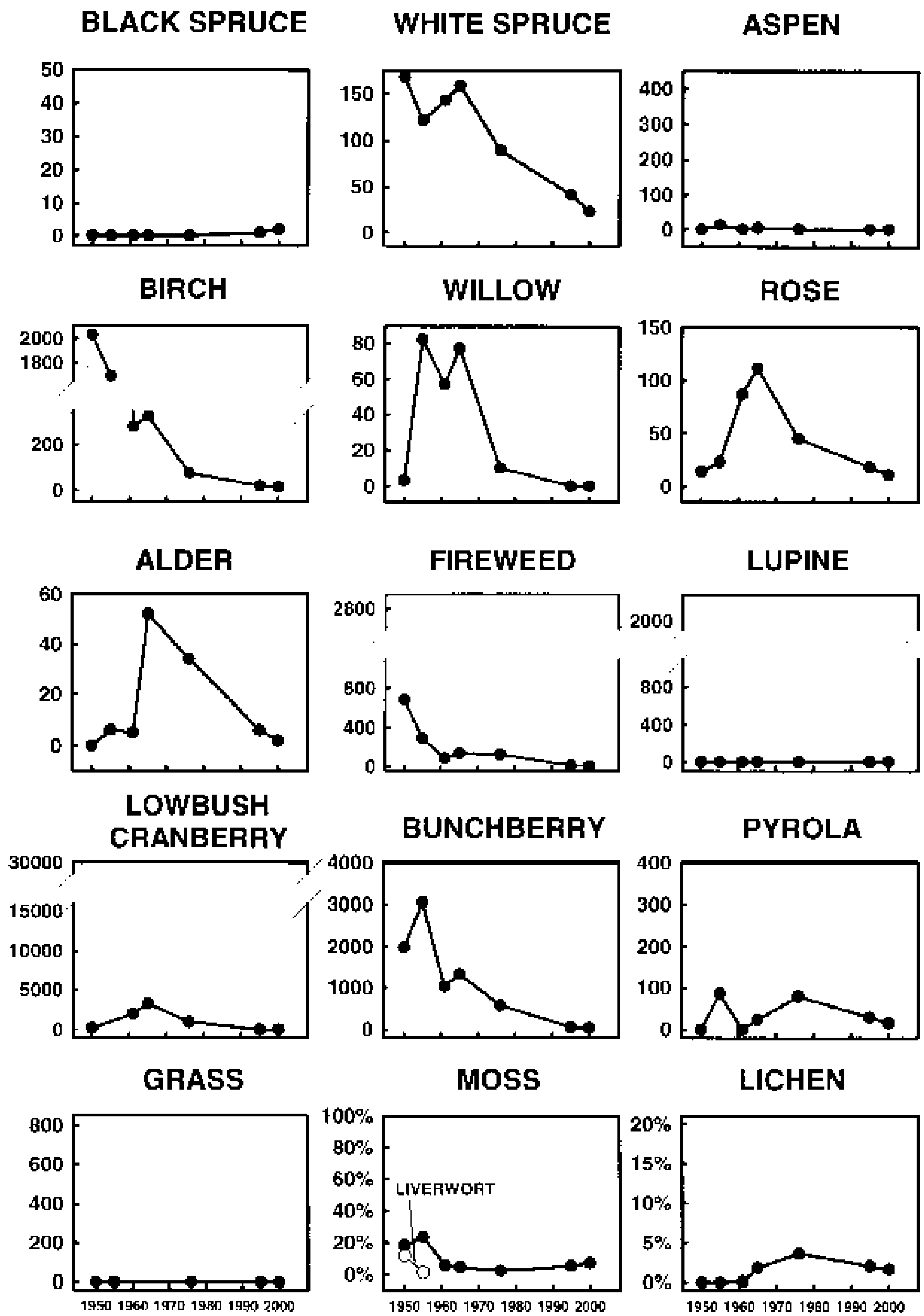

Fig. 6.8. HAK 8 was a moderately burned birch and white spruce stand, which regenerated birch, white spruce, and alder, with thick hardwood leaf litter which appears to suppress growth of grass and an herbaceous layer.

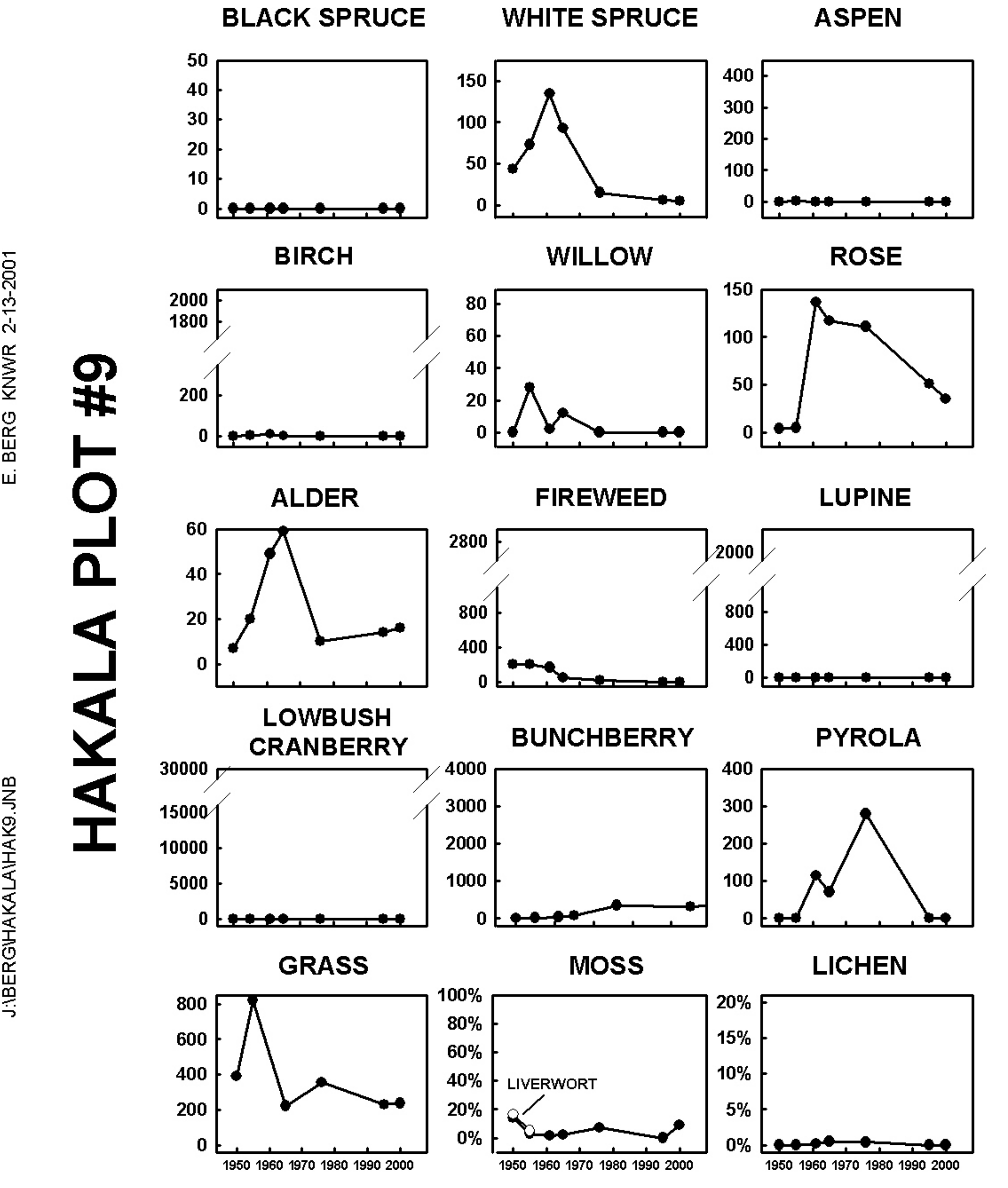

Fig. 6.9. HAK 9 was an alder thicket that replaced itself, probably by root or stump sprouting. As the alder canopy closed, fireweed and nettles disappeared, and bunchberry and Viola became abundant. Grass and Heracleum dominate the herbaceous layer today.