Mew Gull   Larus canus   Summer Resident

This species displaced the Herring Gull from the Warm Ponded Swamp during 1975. One Mew Gull was recorded May 5 and 7 with both members of the pair first noted May 8. They were noted in this area until I left in mid July. On the infrequent occasion when a Common Raven was rash enough to fly over this area, one or both birds would attack the larger bird and chase it from the area. Nesting-like behaviour (sitting on a small island in the Warm Ponded Swamp) was noted May 10 and 11 but no nest was discovered when this phenomenon was investigated. R.

Bonaparte's Gull   Larus philadelphia

Rand recorded a dried up wing found at the park August 4, 1943. R

Great Horned Owl   Bubo virginianus   Permanent Resident

April 2(1) Found dead April 22 at Alpha Hot Pool where it was apparently shot. Rand recorded evening hooting August 12, 13, 14, 20, 21 and 22, 1943 at the Liard Crossing camp. E-D,R.

Barred Owl   Strix varia   Permanent Resident

Rand collected one and heard another August 12, 1943. Godfrey (1966) states "scarce: Liard Crossing". E-D.

Common Nighthawk   Chordeiles minor   Summer Resident, breeding

Earliest tentative identification may 5(2) although this is considerably earlier than migration dates published by Munro and Cowan (1947). Erskine and Davidson (1975) record "Grant.. saw a barely flying young one with an adult at Liard Hot Springs, 1 August 1966". At other locations Rand noted last booming August 15, 1943 and last bird August 29, 1943. P.

Rufous Hummingbird   Selasphorus rufus   (Summer Resident)

Hypothetical. Mrs. Renfroew, a resident of Lower Liard River Lodge for over a decade has reported seeing "hummingbirds" on several years. They were not observed for 1974 (perhaps due to the unusually wet summer), nor (to my knowledge) in 1975. Godfrey (1951) received reports of "hummingbirds" at Carcross and Mile 1019 Alaska Highway which he believed to be of this species.

Belted Kingfisher _Megaceryle alcyon_ Summer Resident

May 4(1); 5(1); 9(1). This species was noted throughout the summer of 1974. Rand reported August birds from the park northward and in another location, a September 2, 1943 migrant. E-D, P.

Common (Yellow-shafted) Flicker _Colaptes Auratus_ Summer Resident probably breeding.

May 8(1); 10(2) drumming; 11(3) head bobbing; 13(1); 16(3) drumming and excavating a cavity 25' up an aspen in forestry area. Rand peported hearing a bird August 6, 1943 and considered this species scarce. Pavlick (1974) reported July 1972 or 1973 birds E-D, R.

Pileated Woodpecker _Dryocopus pileatus_ Permanent Resident?

May 16(1) in mature poplar at entrance to service area. Rand received one aural report (Williams) near Liard Crossing on August 8, 1943. He continues "Mould knows these birds as occurring on his trap line to the north of the lower Liard Crossing." The park is near the western limit of their breeding range (Godfrey, 1966). E-D

Yellow-bellied Sapsucker _Sphyrapicus varius_ Summer Resident breeding.

May 3(1) (reports from two people); 7(1M) excavating cavity in the campground; 8(1)1 9(4) two head-bobbing; 10(1 pr.) head bobbing; 11(several obs.) including drumming and head bobbing; 13(1M); 14(1); 15(1 pr., 1M) territorial defense; 16 (several obs.) drumming in four different areas; 21(1) alarm call; 22(1pr.); 29(1pr.) mating (R. Tierney, pers. comm.) and June 25(1). Rand stated "In view of the abundance of this species in the Peace River area, where Cowan....records up to five pair to the acre, it was surprising that I found few of them, even on the Liard where conditions seemed ideal." He collected two on August 10, 1943. Erskine located four nests with calling young on July 9, 1974. E-D, R,P.

Hairy Woodpecker <u>Dendrocopos villosus</u>

Hypothetical. The one bird observed May 4 was not differentiated from the Downy Woodpecker. E-D,R.

Downy Woodpecker <u>Dendrocopos pubescens</u>

Hypothetical. The one bird observed May 4 was not differentiated from the Hairy Woodpecker. E-D, R.

Black-backed Three-toed Woodpecker <u>Picoides arcticus</u> (Permanent Resident)

Hypothetical. February 21 report (Bev Reid, pers. comm.) appeared to be a female of this species. I was unable to find and verify this bird. E-D, R.

Northern Three-toed Woodpecker <u>Picoides tridactylus</u> Permanent Resident

February 6 (1M) adjacent to a snowshoe trail to the ostrich fern glade; March 14 (1F) in the campground. Rand collected one on August 5, 1943. E-D, R.

Eastern Phoebe <u>Sayornis phoebe</u> (Summer Resident)

Hypothetical - identification uncertain. May 9(1)? near the highway pond. Recorded for southern Yukon (Godfrey, 1951) and Fort Nelson (mile 308, 325, 335) area (Erskine and Davidson, 1975).

Say's Phoebe <u>Sayorna saya</u>

May 13(1); 15(2) acrobatic flight ritual; 16(1); 22(1). Erskine considered the bird a transient, as did Rand. The latter records a report (Williams) near or in the park August 7, 1943 and he observed the species August 10 within the park. E-D, R.

Alder Flycatcher <u>Empidonax traillii</u> Summer Resident

Rand collected one August 22, 1943. E-D, R.

Olive-sided Flycatcher <u>Nuttallornis borealis</u> Summer Resident

Possible observation May 22 (1)? in the Warm Ponded Swamp complex. Rand recorded one August 10, 1943. E-D, R.

Horned Lark <u>Eremophila alpestris</u> Transient

Hypothetical. Observation of flock of eight birds with the folded wing flight characteristic flying up the Liard Valley. Previous reports of these birds received prior to this observation on March 12. This is a month earlier than spring migration data published by Munns and Cowan (1947). Fall migration in another locality September 1, 1943. (R)

Violet-green Swallow Tachycineta thalassina Summer Resident

I encountered field identification problems between this and the following species. Distant or high flying birds were tentatively assigned (i.e. "probable" status) if they lacked the circle glide-short climb pattern (Peterson, 1961) typical of the Tree Swallow. The presence or absence of the white rump patches was the major criterion for lower birds. Two unidentified swallows were noted on April 30, and May 8 (1); 10(1); and 11(3). May 2, "probable"; 10(5); 11(8 to 12) at Lodge; 13(6); 21(21) at Lodge; 22 (21 to 26); 24(1) at Lodge. Locations not given are for the Warm Ponded Swamp complex. This location is to the east of the published range (Godfrey, 1966). E-D,R.

Tree Swallow Iridoprocne bicolor Summer resident

May 24 (2) at Lodge. Note above section for taxonomic uncertainties. Some of the unidentified swallows, or perhaps a few individuals from the large park flocks (e.g. May 22) that contained many Violet-green Swallows may have been Tree Swallows. The earliest unidentified swallows stand a good chance of being of this species as it is known from Alberta (Salt and Wilk, 1958) and several B.C. localities (Munro and Cowan, 1947) that this species is the first to arrive. Erskine has recorded this species was observed "Mostly in Fort Nelson, only scattered singles elsewhere." whereas he did not find the Violet-green Swallow near this town. E-D, R,P.

Bank swallow Riparia riparia Summer Resident

Recorded for the park by Pavlick (1974). Additional reports by Rand: August 4, 1943 (6 to 8) along the river bank, and by Erskine: July 10, 1974 (2) at the Liard River bridge. E-D,R,P.

Barn Swallow Hirundo rustica Summer Resident

May 21(1) at Lodge; 22 (1 or perhaps 2) at Warm Ponded Swamp; 24(2) at Lodge. E-D.

Gray Jay <u>Perisoreus canadensis</u> Permanent Resident, breeding
November 30, 1974 (2); December 30, 1974 (4); January 4 (3); 9(1); 21(2); February 9(2); 13(1); 14(2); 15(1 pr?); 16(1); 19(1 pr. singleton) territorial behaviour?; 21(3); March 25(3); 26(1); 31(1); April 2(1); 3(1); 4(1); 12(1); May 8(2); May 21(1) flying young; 22 (2 adults, 1 flying young). February, March, and April include feeding table observations. Egg incubation is believed to have started by March 26 since only singletons appeared at the feeder from this date until early April. One bird was often observed to fly directly away from the feeder and carry food to the suspected nest location in the Lantern Inn vicinity. These data would appear to agree well with the reported incubation of 16-18 days (Godfrey, 1966). Flying young were observed May 21 and 22. These two observations agree with Rand's data "Family parties were usually of three birds, rarely including more than one young. This suggests some controlling factor." He also commented on the comparative scarcity in the park area. "A common bird in all the coniferous and mixed wooded country investigated, except the old poplar-spruce forests along the Liard River where it was rare." Only two pair appeared to be utilizing the feeder (Plate 27). Erskine echoed this comment when he stated "seldom noted in poplar areas". E-D,R,G,P.

Common Raven <u>Corvus corax</u> Permanent Resident
Fifteen observations between November 30, 1974 and April 5, 1975, usually at or near park garbage pails or the refuse dump. On April 22, one bird from a flock of six to eight was observed to perform the "tumble" manoeuver. On May 3 a stick carrying bird was pursued by a second bird for a three minute tumbling, diving, swooping aerial display. One bird of a pair observed May 29 was carrying a short stick. This species was occasionally observed to be chased from the warm Ponded Swamp Area by the resident Mew Gulls (May 8,16, July 11). E-D, R,P.

Plate 27. The Gray Jay is a permanent resident with early nesting habits.

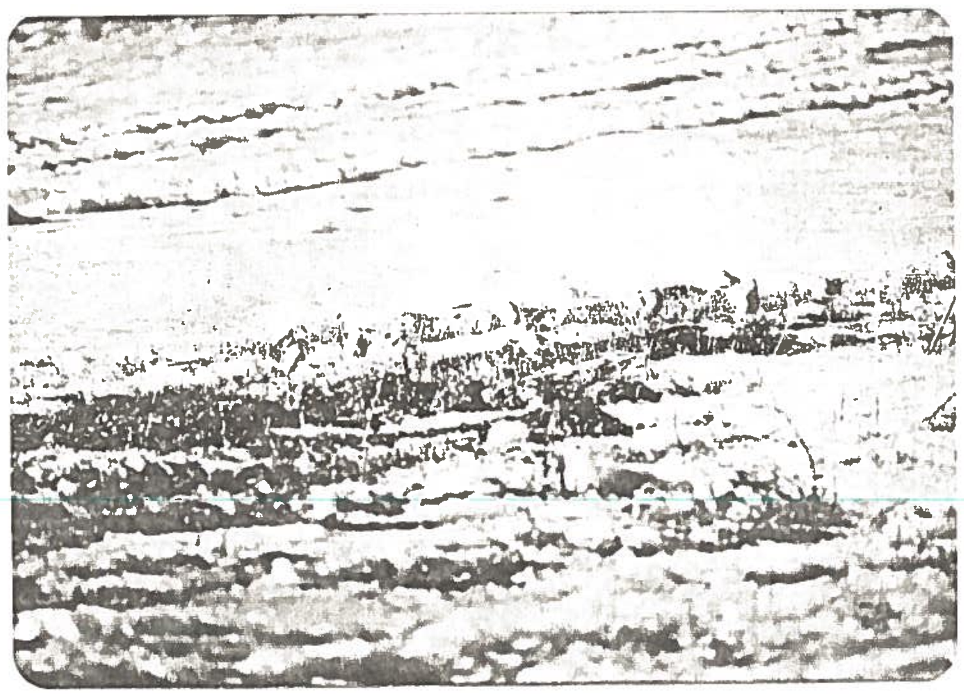

Plate 28. Snow Buntings were observed only as spring transients at the Lower Liard River Lodge.

Black-capped Chickadee *Parus atricapillus* Permanent Resident
November 30, 1974 (1); February 13(1); 15(1); April 22(2); May 15(1); 22(1). Rand collected one August 22, 1943. E-D,R,G,P.

Boreal Chickadee *Parus husonicus* Permanent Resident
February 14(2); March 25(1); April 1(2); 4(2); 5(2); 7(2); 9(3 or 4); May 13(2); 14(1) 15(1); Rand collected 2 August 6 and 22, 1943. E-D, R,G,P.

American Dipper *Cinclus mexicanus* Permanent Resident
One individual observed November 30, 1974; December 21, 1974; January 20 and 28; February 5 and 10. Although observations were made on this species at the drainage stream from the Warm Ponded Swamp during the summer of 1974 and as recorded above, the bird was not observed after February 10. R.

American Robin *Turdus migratorius* Summer Resident, breeding
April 29(5M); 30(2 flights of 15 plus several singletons); May 1 (10 M, 2F); 8(6); 9(3M,F,? - suggest territorial behaviour as chasing noted); 10(1M); 11(4M,2F); 14(1pr.);... 21 (building nest). In other localities, Davidson (in E-D) first recorded April 22, 1974. Rand recorded fall migration in other localities from August 26-September 16, 1943. This was within the same period that Griffith (1973) recorded it- September 11, 1971. E-D,R,G.P.

Varied Thrush *Ixoreus naevius* Summer Resident, breeding
May 14(1) believed to be a female suggesting that males had arrived earlier. Davidson (in E-D) first recorded the species "about 3 May", 1974. Songs were frequently heard in the spring but not recorded. Rand records breeding evidence. "Young, barely full fledged and still accompanied by their parents were found there August 5" 1943. He lists a migration date of September 9, 1943 for another locality. E-D,G,P.

Hermit Thrush *Hylocichla guttata* (Summer Resident)
Hypothetical. One possible observation May 14. E-D,R.

Red-breasted Nuthatch *Sitta canadensis* Summer Resident?
Reported by Rand, August, 1943. E-D,R.

Swainson's Thrush <u>Hylocichla ustulata</u> Summer Resident
May 22(1); 23(2). Rand records them for August 4-14 and 23, 1943. Grant (in E-D) reports a nest in another location on July 25, 1967. E-D,R,P.

Gray-cheeked Thrush <u>Hylocichla minima</u> Transient
May 27(1). The bird flew into the cabin window and was examined in hand.

Mountain Bluebird <u>Sialia currucoides</u> Transient
May 15(1) at the Warm Ponded Swamp complex. It is noteworthy that Davidson (in E-D) recorded Fort Nelson area migrants from "12 April until about 10 May" (MS) for 1974, but by May 10, 1975 he had not seen one (pers. comm.)

Townsend's Solitaire <u>Myadestes townsendi</u> Summer Resident
Pavlick (1974) records this species in the park. Rand records migration in other locations on August 12 (?) and September 11, 1943. A spring migration date in another locality is given by Davidson (in E-D) on April 28, 1974. The park record confirms the presence of this species near the eastern edge of its breeding range (Godfrey, 1966). E-D,R,G,P.

Ruby-crowned Kinglet <u>Regulus calendula</u> Summer Resident
May 4(1M); 8(1M,1F); 11(1 singing); 16(1M singing). Rand collected one August 10, 1943 and recorded fall migration in other localities from September 2-17, 1943. E-D,R.

Water Pipit <u>Anthus spinoletta</u> Transient
April 27(4) on highway; 28(at least 10); May 1(18) overhead; 2(10) overhead; 4(2); 5(15); 15(20); 16(6); 23(2). Davidson (in E-D) recorded the same time period: April 28-May 25, 1974 in another locality. Rand recorded fall migrants from August 31 - September 10, 1943.

Bohemian Waxwing <u>Bombycilla garrulus</u> Summer Resident
April 27 (about 40) at Proshniak Creek; 28 (at least 7); May 4(2); 8(5), July 9, 1974(2) (Erskine); August 10 and 13, 1943 (1) (Rand). Rand noted "Apparently of erratic distribution, and flocking even during the breeding season".

This species is reported to over-winter in southwestern Mackenzie at Fort Liard (Godfrey, 1966) but no evidence was noted that would suggest over-wintering in this area. E-D,R,G,P.

Northern Shrike <u>Lanius</u> <u>excubitor</u> Summer Resident

May 19(1). Davidson (in E-D) reported 1974 migrants as April 16(3); 20(1); all presumably near Fort Nelson. The park is near the limit of the breeding range and, on occasion, a bird may reside within the park during the summer. R.

Common Starling <u>Sturnus</u> <u>vulgaris</u> Summer Resident

April 9(1); 23(3); May 7(1); 8(1); 11(2); 13(4); 14(5); 22(3); June 28(2). Rand did not record this species in 1944. The 1964 breeding range was given as including the Peace River district (Godfrey, 1966). Grant (in E-D) recorded five in Fort Nelson on July 27, 1967. Erskine recorded an adult feeding young in that town during 1974. This species may now breed within the park. E-D.

Solitary Vireo <u>Vireo</u> <u>solitarius</u> (Summer Resident)

Hypothetical. One possible sighting May 23. This possible station is outside the known breeding range (Godfrey, 1966). E-D.

Red-eyed Vireo <u>Vireo</u> <u>olivaceus</u> Summer Resident

Recorded by Pavlick (1974). Rand also found it August 4-14 and 20-24, 1943. This station is at the western edge of its known breeding range (Godfrey, 1966).

Warbling Vireo <u>Vireo</u> <u>gilvus</u> Summer Resident, breeding

May 23(1) at Epsilon Ponded Swamp. Godfrey (1966) reports breeding at Lower Liard Crossing. Rand collected a specimen August 22, 1943. E-D,R,P.

Tennessee Warbler <u>Vermivora</u> <u>peregrina</u> Summer Resident

Recorded in Pavlick (1974). Rand reported one specimen August 21, 1943. E-D,R.

Orange-crowned Warbler <u>Vermivora</u> <u>celata</u>

One "probable" sighting: May 23(2M). Rand recorded a fall transient on August 21, 1943 and in another locality on September 2, 1943. E-D,R,G.

Yellow Warbler _Dendroica petechia_ Summer Resident
May 9(1M,1F); 13(1M); 19(1M). Rand reports for August, 1943: 10(1); 21(1); 22 (several). E-D,R.

Magnolia Warbler _Dendroica Magnolia_ Summer Resident, breeding
Reported in Pavlick (1974). Godfrey (1966) reports breeding at Liard Crossing. In another locality, Erskine did not record the species until June 6, 1974. Rand recorded one bird on August 8 and 9, 1943. E-D,R,G.

Yellow Rumped (Myrtle) Warbler _Dendroica coronata_ Summer Resident
April 30(40); May 1(2); 4(1); 7(1M); 8(1M); 9(1M,2F) 11 (singing); 15(1 pr.). Rand considered this species "The common warbler, and one of the few common widespread birds of the area". He reported "After the first of August, only immature birds were seen." and collected one August 22, 1943. Davidson (in E-D) recorded the first 1974 migrants on April 28. E-D,R,G,P.

Townsend's Warbler _Dendroica townsendi_
One "probable" sighting: May 13(1M). This probable station is well to the east of the known breeding range. Griffith (in E-D) recorded fall migrants: September 4 and 5, 1969(7).

Bay-breasted Warbler _Dendroica castanea_
Godfrey (1966) suggested possible breeding "perhaps Lower Liard Crossing". Rand suggested his August 10 and 22, 1943 specimens may have been migrants. E-D.

Blackpoll Warbler _Dendroica striata_
May 14(1M); 16(1M); 22(1M); 23(1). Erskine recorded spring migrants in other localities from May 23 to June 9, 1974. Rand noted "several in immature plumage were seen at the Lower Liard Crossing August 9, 10" 1943. E-D,R.

Palm Warbler _Dendroica palmarum_ (Summer Resident)
Hypothetical. Recorded "?" in Pavlick (1974). Erskine first records this in another locality on May 22, 1974. Rand recorded fall migrants in another locality September 16, 1943. This station is slightly to the west of the known breeding range. (Godfrey, 1966).

Ovenbird Seiurus aurocapillus Summer Resident, breeding
Erskine first noted this species May 23, 1974 in another locality. He cites a July 11, 1967 nest with young recorded in another locality. Rand observed an adult with well grown young July 18, 1943 in another locality. Godfrey (1966) reports breeding in Liard Hot Springs. E-D,R.

Northern Waterthrush Seiurus noveboracensis Summer Resident
May 8(1); 9(2); 23(1) in the Warm and Epsilon Ponded Swamps. This species was first recorded by Erskine May 15 in another locality. E-D.

Mourning Warbler Oporornis philadelphia Summer Resident
Recorded in Pavlick (1974). Erskine first recorded the species on June 5, 1974 in another locality and heard it in the park on July 9, 1974. He notes "No pervious records published for British Columbia, but there may have been some confusion with the following species." (i.e. MacGillivray's Warbler). However, this station is well outside the known breeding range. (Godfrey, 1966). Erskine considers the species "probably breeds" presumably based upon his recording the species for twenty-one dates. His early July park observation would suggest this may be true.

MacGillivray's Warbler Oporornis tolmiei
Rand observed in 1943: August 6(1); 21 and 22 (several). At least the latter records considered migrants. Godfrey apparently considered the first as a breeding record. This station is on the eastern edge of the known breeding range (Godfrey, 1966).

Common Yellowthroat Geothlypis trichas Summer Resident,breeding
May 13(1M) in the Warm Ponded Swamp area. Rand collected a specimen August 21, 1943. Rand considered the bird as breeding. This station is at the edge of the breeding range. Godfrey, 1966).

Wilson's Warbler Wilsonia pusilla Transient?
May 9(1M); 11(1M, L "probable" F); 15(1M); 16(1M); 22(1M); 23(1M). Erskine recorded spring migration in another locality from May 25-June 9, 1974. Rand recorded several fall migrants on August 21, 1943 and in another locality from

September 1-3, 1943. Griffith (in E-D) recorded migrants in the park in "early September" (presumably the 4th and 5th) of 1969.

American Redstart <u>Setophaga ruticilla</u> Summer Resident, breeding
Recorded in Pavlick (1974) Erskine first noted the species June 6, 1974 in another locality. Godfrey (1966) listed the species as breeding at Liard Crossing. E-D,R.

House Sparrow <u>Passer domesticus</u>
Hypothetical for park. May 15 (1 pr.) at Lodge. Permanent resident (E-D), and breeding (Godfrey, 1966) in Fort Nelson E-D,R.

Red-winged Blackbird <u>Agelaius phoeniceus</u>
May 4(1); 10(3M); 11(1M); 13(1M,3F); 21(1); 23(1). E-D

Rusty Blackbird <u>Euphagus carolinus</u>
May 1(2 pr.); 2(1) singing; 3(1) singing; 4(2M,1F); 8(1 pr.); 9(3); 10(1F); 16(1M); 22(1F). On June 28, three flying from an unidentified blackbird species was observed in the Warm Ponded Swamp area. Griffith (in e-D): September 4 and 5 - small flocks. Rand noted migrants in other localities on August 25(1); September 1-8(1-25/day); 17(3).

Brewer's Blackbird. <u>Euphagus cyanocephalus</u> Summer Resident
May 16 (1pr.) at highway stream; 22(3); 23(1 pr.). On June 28 in the Warm Ponded Swamp area three flying young of an unidentified blackbird were observed. This station is considerably north of the known breeding range (Godfrey, 1966). However, there is at least one breeding record now known for Fort Nelson (Grant, in E-D), E-D.

Brown-headed Cowbird <u>Molothrus ater</u> Summer Resident, breeding
May 7 (1M) at Lodge; 10(1pr.); 11 (about 20) over Lodge; 14(3M,9F) getting gravel in the service area; 15(6M,3F); 16(1M); 22(4M,2F). On June 30, 4 adults and one flying young of this parasitic nesting species was observed in the Warm Ponded Swamp area. This station is outside the known breeding range (Godfrey, 1966). Erskine has noted displaying and thought they probably breed in other localities. E-D,P.

Western Tanager *Piranga ludoviciana* Summer Resident

May 16(1M); 30(1M) singing; June 23 (1 'probable'). July 1972 or 1973 in Pavlick (1974). E-D.

Rose-breasted Grosbeak *Pheucticus ludovicianus* Summer Resident Breeding

May 31 (1M) report (Puttonen, pers. comm.); July 1 (1 pr. plus one flying young). In other localities, Erskine's first record was May 25, 1974, and received reports from Grant of newly hatched young June 23, 1953 and family groups on July 27, 1967 and August 2, 1968. Pavlick (1974) has 1972 or 1973 July park records. This station is slightly to the west of the published breeding range (Godfrey, 1966). E-D.

Evening Grosbeak *Hesperiphona vespertina*

May 10 (2M, 1F) singing; 11(3M, LF); 13(1); 15(more than 11); 23 (3 heard). Pavlick (1974) has July 1972 or 1973 records. Davidson reports January 1975 records for Fort Nelson. The park station is considerably north of the known breeding range (Godfrey, 1966).

Purple Finch *Carpodacus purpureus* Summer Resident

May 10 (1) singing; 13 (1pr.); 16 (1M,2F) singing; 23 (1) "probable". July 1972 or 1973 records in Pavlick (1974) E-D.

Pine Grosbeak *Pinicola enucleator* Permanent Resident

February 9 (2M, 3F); March 10 (1M, 1F); July 15 (30 to 40). Rand gives a report (Williams) for August 7, 1973. It is noteworth that they have not been reported from the Fort Nelson area in the summer (Erskine and Davidson, 1975).

Redpoll sp. *Acanthis* sp. Winter Resident

Field identification problems arose between the Common Redpoll (*Acanthis flammea*) and the Hoary Redpoll (A. *hornemanni*). Most birds were believed to be Common Redpoll, but the occasional Hoary Redpoll was observed: March 21(1); April 9(1). It is probable that this species is more common than suggested by these data. The following list is best interpreted as consisting largely (but probably not entirely) of the Common Redpoll. Feb. 13(1M,2F); March 9(about 15); 10(14); 14(15 to 20);

21(at least 10); 26(6); April 1 (10-15); 2(1M); 5(8-9); 7 (about 30) pre-migration restlessness; 13 to 15 (30-50) large flocks observed several times; May 9 (at least 6); 14 (several); 16(1M) "possible" identification. Alder seeds a favorite food. E-D.

Pine Siskin <u>Spinus pinus</u> Summer Resident
Davidson reports the first migrants March 19 (Fort Nelson News, March 26, 1975, p. 13). May 23 (1) "probable"; June 12 (1) "possible", gathering feathers; June 28(1). Erskine noted "mostly in Fort Nelson, only a few flying over woods elsewhere; birds in town displaying in June" as a summary of his study area in another locality. Pavlick (1974) lists July 1972 or 1973 records. Rand noted "common, in flocks numbering up to 30, about the Lower Liard Crossing, August 4-14 and 20-24", 1943. I occasionally heard songs, believed to be of this species, in the park in spring but the source of the sound was not confirmed for identification. R,G.

Savannah Sparrow <u>Passerculus sandwichensis</u> Summer Resident
May 13 (Wayne P. Neily, pers. comm.); 21(1) at the Lantern Inn adjacent to the park. In other localities, Rand reports migration August 30 - September 8, 1943. E-D,R,G.

Dark-eyed (Slate-colored) Junco <u>Junco hyemalis</u> Summer Resident
April 23 (at least 3); 28(12); 30(20); May 1(1); 8(1M); 14(1M); 15(1); 16(1M,2F); 21(1M); 23(1M). Davidson (in E-D) noted first migrants April 20, 1974 in another locality. Rand summarized the regional status as "A common, widespread species, recorded from all stations visited, in bush areas, and edges of forest. Adults were seen feeding young as late as July 22 on McDonald Creek." Pavlick recorded July 1972 or 1973 birds in his report (1974). E-D,R,G.

Tree Sparrow <u>Spizella arborea</u> Transient
April 30 (4); May 1(4); 7(1); 9(2). Rand noted fall migrants September 6 and 7 in another locality. R.

Chipping Sparrow *Spizella passerina* Summer Resident, breeding
May 11(1) at Lodge; 14(1); 16(6); 19(2); 21(2) at Lantern Inn adjacent to the park. On July 1, I observed an adult carrying an insect at the Epsilon Hot Pool area. The adult was alarmed by my presence suggesting a nest was close. Rand made a 1943 nesting observation in the park vicinity "young just out of the nest were seen near the Lower Liard Crossing on August 9." He collected a park adult the following day. E-D,R,G.

White-crowned Sparrow (Gambel's form) *Zonotrichia leucophrys* Summer Resident
April 28(1); May 1(2); 3(2); 4(1); 7(20); 9(1); 11(2 or 3); 16(2); 19(1); 23(1). Rand found this species only in migration. In other localities he reported August 25(6); September 1 to 8 (abundant to a few). E-D,R,G.

White-throated Sparrow *Zonotrichia albicollis* Summer Resident
May 11(1); 16(1). Calls often heard but not recorded. Rand collected an immature female July 22, 1943. E-D,R.

Fox Sparrow *Passerella iliaca* probably Summer Resident
April 29(1); 30(15); May 7(1). Rand noted migration in another locality on September 1, 1943. E-D

Lincoln's Sparrow *Melospiza lincolnii* Summer Resident
Rand reported 1943 observations "occasionally seen at the Lower Liard Crossing August 4-14, and more commonly evidently migrating, August 20-24". R.

Swamp Sparrow *Melospiza georgiana* Summer Resident
One "possible" observation May 9(1)? Pavlick (1974) reports July 1972 or 1973 observations. This is slightly to the east of the published breeding range (Godfrey, 1966). E-D

Song Sparrow *Melospiza melodia*
May 23 (1). This station is outside the published breeding range (Godfrey, 1966). It was not recorded by Rand or Erskine and Davidson, but Griffith made some early August, 1970 observations in the Summit Lake Pass area.

Lapland Longspur *Calcarius lapponicus* (Transient)

Hypothetical for park. May 7 (1M, 2F) at Lodge. Full breeding plumage was not yet attained by the male. (A flock of about 15 brown-bodied sparrow-sized birds with whitish outer tail feathers was observed but could not be positively identified.). In another location, Rand reported 1943 observations on August 30 to September 8 with peak numbers amounting to "several flocks of hundreds."

Snow Bunting *Plectrophenax nivalis* (Transient)

Hypothetical for park. March 21 (1); 22(6); 26(30) at Lodge. Although this species was searched for on several occasions, it was not observed except as a migrant (Plate 28). Davidson reports winter observations in Fort Nelson.

ADDENDUM

A number of species have been reported in other localities that have not been observed within the park. The following list represents species observed between Muskwa (near Fort Nelson) and Watson Lake that are not currently known within the Park. Many of these species have the potential for being future additions to the park airfauna. Literature citations are the same as for the main text. With the exception of the six species marked by an asterisk, all species are recorded in Erskine and Davidson.

Common Loon
Arctic Loon
Red-necked Grebe
Horned Grebe
Pintail
Ring-necked Duck
Canvasback
Lesser Scaup
Bufflehead
Oldsquaw
White-winged Scoter
Surf Scoter
*Common Merganser (R)
*Rough-legged Hawk (R)
Bald Eagle
Merlin (Pigeon Hawk)
American Coot
American Golden Plover
*Black Turnstone (R)
Whimbrel
Upland Sandpiper
*Baird's Sandpiper (R)
Bonaparte's Gull
Black Tern
Rock Dove
Mourning Dove
Great Gray Owl
*Boreal Owl
Eastern Kingbird
Yellow-bellied Flycatcher
Least Flycatcher
Dusky Flycatcher (?)
Western Wood Pewee
Cliff Swallow
Common Crow
Brown Creeper (?)
House Wren
Winter Wren
Golden-crowned Kinglet
Cedar Waxwing
Philadelphia Vireo
Black-and-white Warbler
Cape May Warbler (?)
Chestnut-sided Warbler
Connecticut Warbler
Canada Warbler
Common Grackle
*Gray-crowned Rosy Finch
White-winged Crossbill
Clay-coloured Sparrow
Lincoln's Sparrow

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J. Map and Photograph Orientation

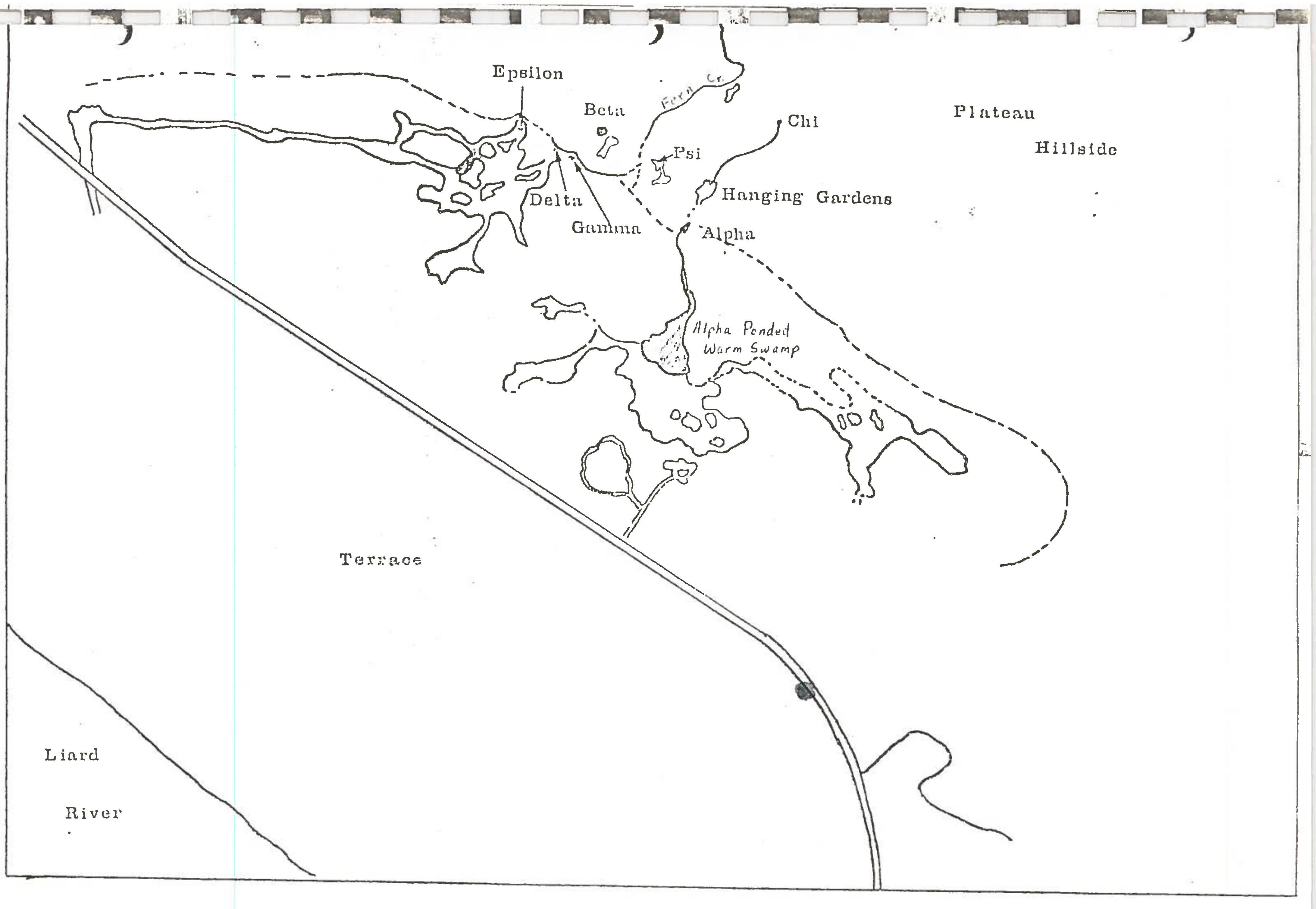

Fig. 3 Fig. 1. Reference names used for springs, waterways and geomorphological features in Liard River Hotsprings Park. (Pavlick, 1974)

A. Unrecorded Hotspring Area
B. Non-thermal Cold Pond
C. Alpha Ponded Warm Swamp
D. Hanging Gardens
E. Beta Hot Pool
F. Epsilon Hot Pool
G. Alpha Hot Pool
H. Ostrich Fern Glade

Fig. 4. Locations of the Areas Mentioned in the Report.

Plate 29. Hotspring area as viewed from Mt. Ole.

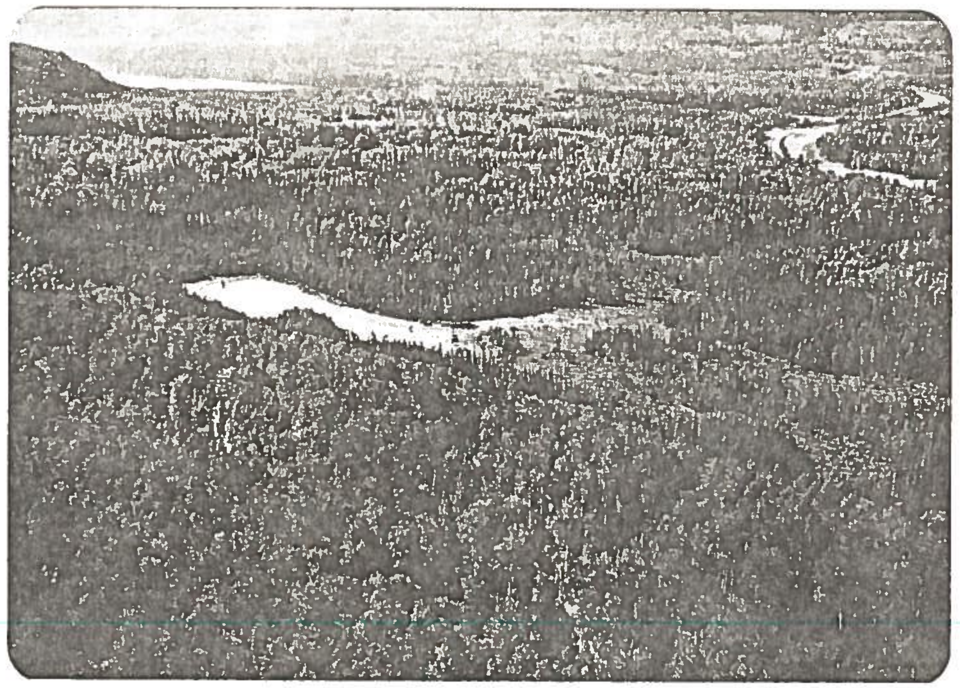

Plate 30. Non-thermal large cold pond area of the park. The base of Mt. Ole is in the background and the fenland towards the lower right is the source of the previously unreported hotsprings.

Plate 31. Aerial view of Alpha Hot Pool.

Plate 32. Aerial view of the Ostrich Fern glade.

Plate 33. Aerial view of the Warm Ponded Swamp.

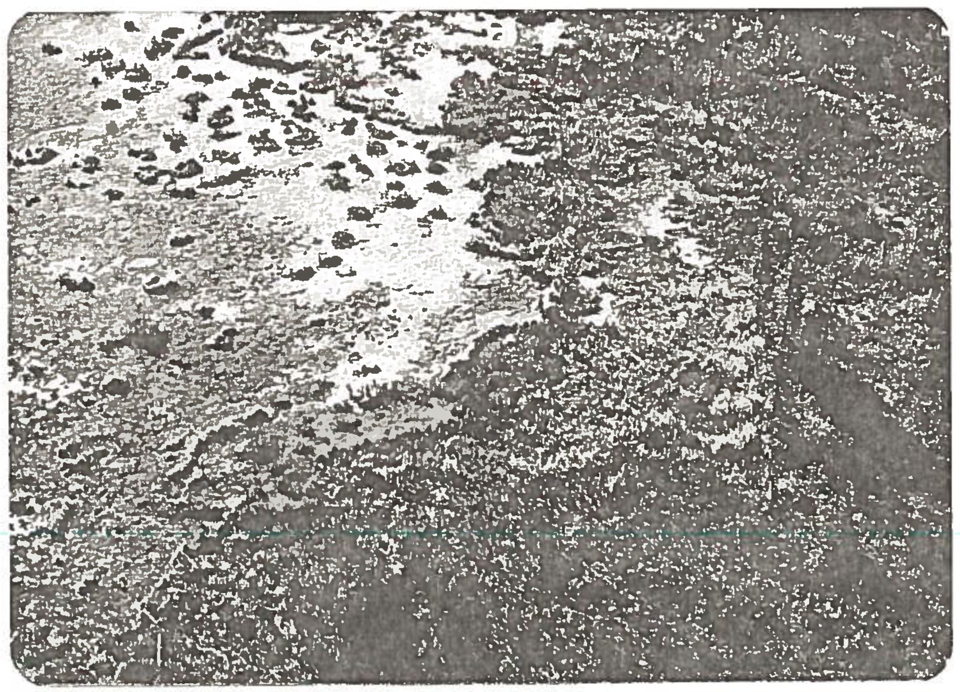

Plate 34. Aerial view of the Warm Ponded Swamp tufa rim.

Reference

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APPENDIX

Some Historical Considerations Relevant to the Flora of Liard River Hotsprings Provincial Park

T. C. Reid
BISC 804
75 - 3

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Introduction

My phytosociological research was done at Liard River Hotsprings Park (59°26'N 126°06'W). Boreal hotsprings such as this one are of considerable botanical interest, not only for the luxuriance of their vegetation but also for the occurrence of many species that are not found growing beyond the influence of the thermal springs. Approximately thirty percent of all vascular species growing within the park could be placed in this category and consequently could not be found in the surrounding area. This is also illustrated on Disko Island off the west coast of Greenland in which sixteen percent of the vascular flora is restricted to hot spring areas (Porsild and Crum, 1961).

One possible explanation for the presence of these species would be their arrival due to migration. Although this is a possibility "This could not likely have been the case with warm springs of arctic or subarctic regions, because they are commonly of very small area and geographically isolated so that the likelihood of plant diaspores of temperate species reaching them spontaneously is very small indeed" (Porsild and Crum, 1961, p. 131).

An alternate way of viewing these disjunct species is that they may be vegetational relics from a previously warmer period. During a prolonged warm period (such as the Hypsithermal Interval) such species may have been widespread. Subsequent cooler conditions may then result in the fragmentation of their former ranges into a number of disjunct locations in thermally favorable areas.

A consideration of this possibility has resulted in the following examination of some of the broader aspects of phytogeographic theory and potential phytologic history of the Liard River Hotsprings flora.

Summary of Some Recent Phytogeographic Theories

1. Darwin-Hooker Concept

The Persistence Theory or the concept that plants survived in suitable areas after glaciation disrupted their former continuous ranges has played an important role in phytogeographic thinking. One of the forms of this theory was the Darwin-Hooker concept. First formulated in "Outlines of the Distribution of Arctic Plants" by J. D. Hooker in the early 1860's, it proposed large-scale plant migrations: plants moved south before the advancing ice and moved north and to the top of mountains as the ice retreated. Other proponents of this view were J. W. Harshberger (1910's), H. G. Simmons (1910's), J. M. Macoun and M. O. Malte (1910's), and T. Holm (1920's).

This simplistic view is undoubtedly correct for many geographic areas and for many species in their flora. For example, Crum (1966) has suggested that bryophyte repopulation occurred "mainly from the central plains of the United States, although there must have been some invasion of the area from northern and western residual areas as well" (p. 39). The same idea of a northward migration from the area south of the former glaciation has been advanced for the Western Interior (foothills to western Ontario) vascular flora by Ritchie (1966).

However, this concept has been frequently criticized by students of northern floras. The phenomenon of forest colonization apparently appearing quite rapidly after glaciation has withdrawn from an area has prompted suggestions of relatively close refugia rather than migration from a position south of the ice (Hansen 1950, 1952, 1953, 1960; Heusser 1957, 1960).

2. Nunatak Concept

Another limitation of the Darwin-Hooker concept is that it did not appear helpful in explaining disjunct plant distributions. M. L. Fernald pondered the problem of some arctic plants being found both in the western Cordillera and the Gulf of St. Lawrence lowlands. No intermediate stations were known. Several isolated and disjunct stations were also known within each of these two regions. How did these plants arrive at their present locations and why do they not spread? His "Persistence of Plants in Unglaciated Areas of Boreal America" in the mid 1920's suggested that these species had wide distribution prior to the Pleistocene. Glaciation removed these species from their former intermediate stations, and their present occurrence in the cordillera and St. Lawrence regions is due to their persistence in nunataks (small unglaciated areas above the surface of the ice) during the glaciation. They have not spread from these localized areas because of their conservative or non-aggressive nature due to their pre-Late Wisconsin age. This basic proposal was also supported by Fr. Marie-Victorin in his late 1930's paper.

There is much evidence to suggest survival on nunataks. The sword moss (*Bryoxiphium norvegicum*), a species believed to be from the late Cretaceous or early Tertiary flora, has been collected only from localities known or suggested to have escaped at least the Wisconsin glaciation (Steere, 1937). It was Deevey's opinion (1949) that the nunatak theory was correct for Greenland. Heusser (1957) remarked on the increasing popularity of this theory and pointed out that Dahl's work in Scandinavia supported this view. Recent work (Packer and Vitt, 1974) suggests many potential nunatak sites in the Rocky Mountains.

3. Hulten's Concept

Hulten (1937) mapped the geographic ranges of boreal species and recognized numerous repetitions of several basic "equiformal" patterns. The recognition of these similarities was in marked contrast to the opinion of Deevey (1949) who stated "The distribution of every species is virtually a law unto itself; worse, it is a law that is incapable of precise formulation, and that nobody understands fully, for every change of range may have a separate explanation." (p. 1406).

Hulten suggested that the region within each equiformal area which showed a concentration of species (the "centra") served as the center of dispersal from which the plants migrate. Some of the centra include the Bering Sea region (Fig. 1), the Yukon River valley (Fig. 2), the Arctic Archipelago, and areas on the west coast to Washington (Fig. 3).

He then stated these centra lacked glaciation: "All plants of our area radiate (migrate) from districts that were not completely buried under the ice-sheet of the maximum glaciation. In other words: the plants have spread over the arctic and boreal belt from the refugia close to the ice, where they were left in possession of a small part of their earlier area, and where they were able to survive the severe conditions of the maximum glaciation" (p. 25 - all italicized). Areas that lacked centra - e.g. between the Yukon valley and the Great Lakes - were glaciated during the Wisconsin.

He suggested that consistent geographic gaps occurring for the ranges of many species within an equiformal area could be explained by "the plants in question already occupied at least the greater part of their present area earlier than the maximum glaciation and

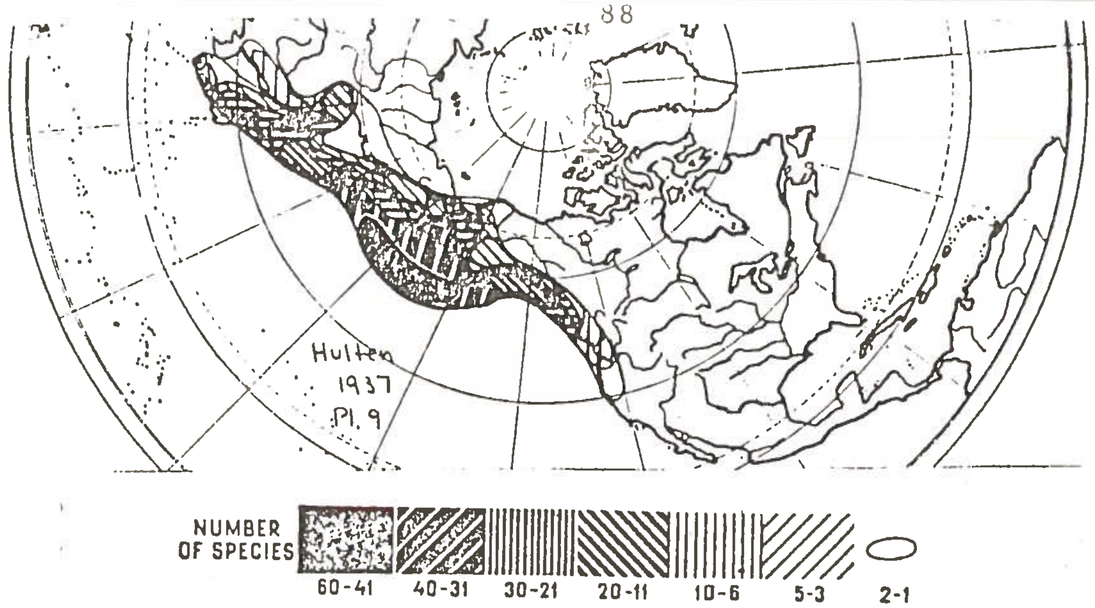


Fig. 1. Southern Beringia Radiants

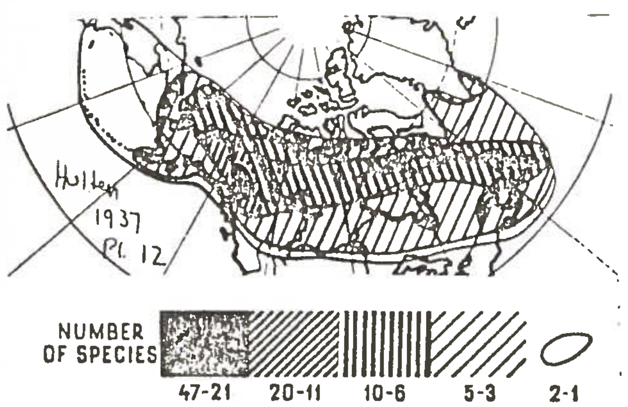


Fig. 2. Yukon Valley Radiants

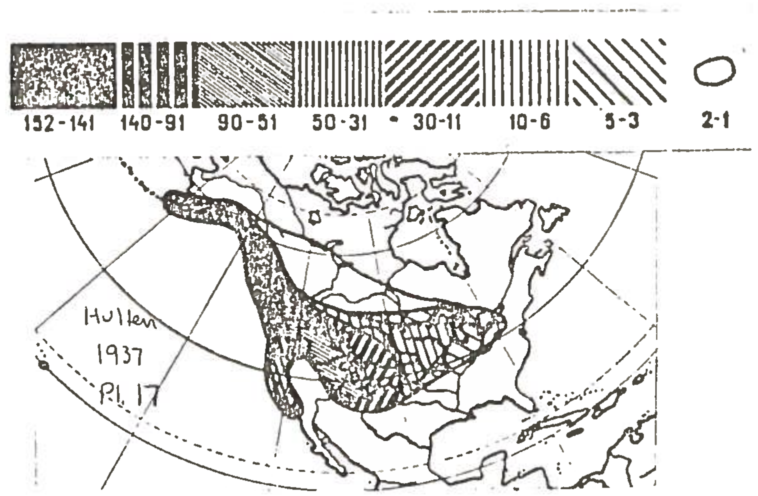


Fig. 3. Coastal Refugia Radints

<u>that this old area was split up into parts separated from one another by heavy glaciation or by districts with such severe climatic conditions during maximum glaciation that the species concerned were exterminated there</u>. After the maximum glaciation, when the amelioration of the climate set in, the isolated partial areas, which I propose to call elementary areas, started to send out progressive radiants in all available direction and in this way the old original areas of the plants were more or less completely restored" (p. 42) (Fig. 4 and 5).

He also suggested that biotype depauperation occurred: "Within a given species there is always a certain potential variation. Under the influence of a catastrophe such as the glacial period, when large parts of the area of the species in question are covered with ice and the rest is severely exposed to unfavorable conditions, a reduction of this variability is inevitable, as all biotypes, being more sensitive to the hardships, are exterminated" (p. 22). Great biotype depauperation may mean the loss of the ability to spread and this would account for the observed gaps in the range of many species.

In broad terms, the similarity of Hulten's proposal to that of Fernald may be noted. A rather large refugium (e.g. Yukon valley) is substituted for the smaller nunatak and the lack of migration observed in some species can be explained in genetic terms rather than in a rather vague concept of senescence.

In a detailed look at Hulten's theory, Raup (1947) examines his own floristic work at Brintnell (Glacier) Lake. With some minor modifications to small details of Hulten's work (e.g. the addition of species to Hulten's lists, some reclassification of a few species into different radiants, etc.), Raup found agreement with what was to be expected from the theory.

Fig. 4 Elementary Areas of Southern Ericineae Radiants
(compare with Fig. 1)

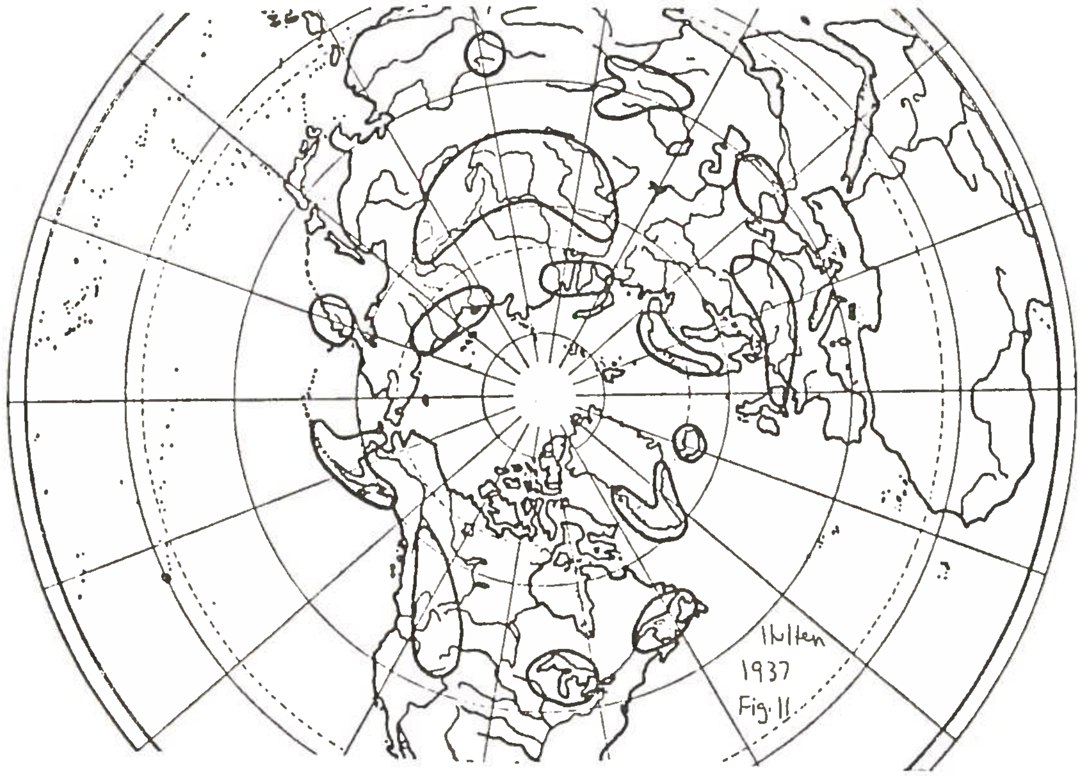


Fig. 5 Elementary Areas of Circumpolar Plants.

Heusser (1957) cites the Chaney and Mason study which identified macroscopic remnants of eight trees: Picea glauca, Populus tremuloides, Salix glauca, S. reticulata, Betula alaskana, and B. glandulosa. These were found in the Fairbanks muck and the date of more than 30,000 BP suggest they survived two or more intervals of glaciation. All of these species are found in the region today. Pewe (1957) has reported buried wood fragments (much of it in the form of fossil beaver dams in the Yukon-Tanana uplands) consisting of aspen, cottonwood, white spruce, black spruce, larch, birch, alder, and willow. All species are common today in the Fairbanks region but the position of the treeline is different, as well as the relative amount of trees in the area. Both of these studies support the existence of the Yukon valley refugium proposed by Hulten.

The work of Heusser (1960) also supports Hulten's theory and Heusser has stated "It is remarkable that Hulten, using plant-distribution patterns as his guide and without much glacial-geological data, was able to recognize coastal refugia that...are almost certain to have existed" (p. 200).

In summary it would appear that some elements of the present northern flora have survived south of the ice and other elements have survived in various refugia, either of a highland nunatak type or a lowland coastal type.

Survival Problems

Many writers have questioned the ability of species to survive in the vicinity of a glacier. The problem may not be acute for bryophytes and Crum (1966) has stated: "As small plants growing in the uniform conditions of micro-habitats, bryophytes are not subject to the same environmental pressures which may force larger plants to adapt, move out, or die. For this reason, bryophytes may have survived quite catastrophic climatic or geological alterations in isolated niches, on small nunataks, for example" (p. 32).

Heusser (1957) addressed himself briefly to the survival problem and he stated: "It is not difficult to conceive of plant survival during an interval of glaciation. Mature conifers thrive today in proximity to Alaskan glaciers. In fact, trees are growing virtually in contact with the ice of Taku glacier near Juneau and upon the moraines that are underlain by ice of the Bering and Malaspina glaciers on the southern coast. Nunataks of the Juneau Ice Field in southern Alaska, for example, support many species of plants, some reaching 6,900 feet elevation, including specimens of Sitka spruce at elevations up to 3,900 feet" (p. 146).

He elaborated on this theme in 1960. He cited a study that suggested the lowest North Pacific temperature for the last 100,000 years was reached about 15,000 BP and was about 6° C below the present level. When this lower temperature was compared to Gulf of Alaska areas that may have been refugia, Heusser concluded "it seems unlikely that a 6° C depression would be critical to many of the plants now growing in unglaciated tracts representing possible refugia" (p. 205).

It is possible for glaciation to occur at temperatures warmer than we have at present. Radiocarbon dates in Alaska show that "some of the glaciations overlap some of the warmest parts of hypsithermal time" (Deevey and Flint, 1957, p. 184). The phenomenon of glaciation occurring in a period warmer than present can be explained on the basis of warmer temperatures causing increased precipitation resulting in glaciation.

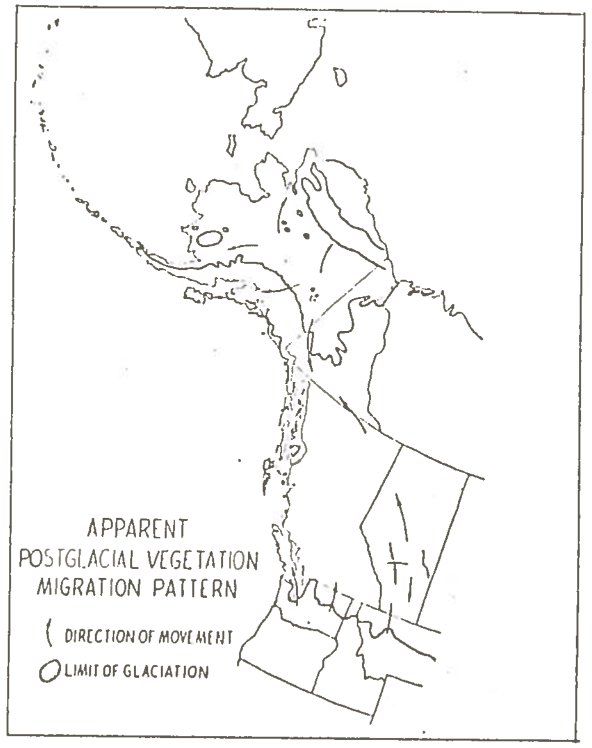
From a consideration of the foregoing, it may be concluded that it is possible for many species to survive in an area adjacent to glaciation.

Location of Proposed Refugia

A generalized description of bryophyte refugia has been suggested for "part of the Arctic Archipelago, in the Brooks Range of Alaska, in some of the mountainous areas of the Canadian Northwest, and here and there along the Rocky Mountains, especially south of the Canadian border" (Crum 1966, p. 34). Heusser (1960) cites geological and biological evidence to support his coastal ice-free areas, many of which he considers to be refugias. Hulten (1937, p. 52) suggested the possibility of refugia in the Rocky Mountains. Recent biological and geological evidence of a refugium near Jasper has been published (Packer and Vitt, 1974). These authors cite papers for other refugia proposed for Waterton Lakes, Willmore Wilderness Provincial Park, Whistler Mountain, Banff National Park locations, and Nordegg. The finding of a new species (*Draba kananaskis*) in the Kananaskis area led Mulligan (1970) to suggest this species may be an endemic from an area that was not glaciated during the Wisconsin. Porsild (1951), in opposition to geological evidence, suggested that for the southeastern Yukon mountains "the botanical evidence forcibly suggests that the alpine floras here are much older than those of the valleys and that they survived above the 4,000 foot level during the most recent Pleistocene advances of the ice" (p. 61). However, Denny (1952) suggested that large nunataks were probably lacking in southeastern Yukon and northern British Columbia. Hansen has struggled with the problem of an ice-free corridor and plant refugium between the Cordilleran and Laurentian ice sheets in northeastern British Columbia and western Alberta. Due to the proximity of this hypothetical refugium to my study area, his proposal shall be examined in some detail.

Although Hansen conceded a coalescence of the two ice sheets at some of their stages, he stated (1949, p. 57) "their fronts during the Late Wisconsin stage in southern and central Alberta were widely separated". This proposition was reiterated in 1950 with "an extensive ice-free area probably existed in western Alberta during the last glacial stage" (p. 412). However, for northeastern British Columbia he could only state: "It is not known whether the Cordilleran and Keewatin glaciers coalesced during any of the glacial stages. As this region is near the border of both ice sheets, the ice was probably much thinner than toward the centers of accumulation. The Cordilleran glacier was probably lesser in extent and thickness because of the low precipitation on the east slope of the Rockies, and it is possible that ice-free areas existed at times during the Late Wisconsin glaciation and at least early during its recession" and "the thinness of the ice in the region of this study suggests the possibility of its early postglacial junction with the unglaciated region in the upper Yukon River valley. The writer believes that forests persisted in ice-free areas in western Alberta during the Late Wisconsin glaciation and permitted early postglacial invasion of adjacent deglaciated terrain." He concluded this paper by stating: "The forests along the Alaska Highway in British Columbia obviously did not persist there during the last glaciation, but there apparently was opportunity for them to invade the area almost upon the heels of the retreating ice" (p. 412).

His opinion at that time of no refugium for northeastern British Columbia is reflected in Heusser's map (Fig. 6).



Heusser, 1957

FIGURE 3. Sketch map of northwestern North America showing the apparent postglacial vegetation migration pattern and the location of unglaciated areas.

Fig. 6 Refugium Lacking in Northern B. C.

However, Hansen appears to have reversed his position for in an apparent reference to northeastern British Columbia he has stated (1960, p. viii): "An abundance of forest tree pollen in the lower levels of peat sections, as much as seven meters deep along the Alaska Highway on the east slope of the Rocky Mountains, indicates that there were ice-free areas between the Cordilleran and Keewatin ice that supported forests during the Late Wisconsin glaciation." Heusser has now modified his map to show Hansen's proposed northeastern British Columbia refugium (Fig. 7).

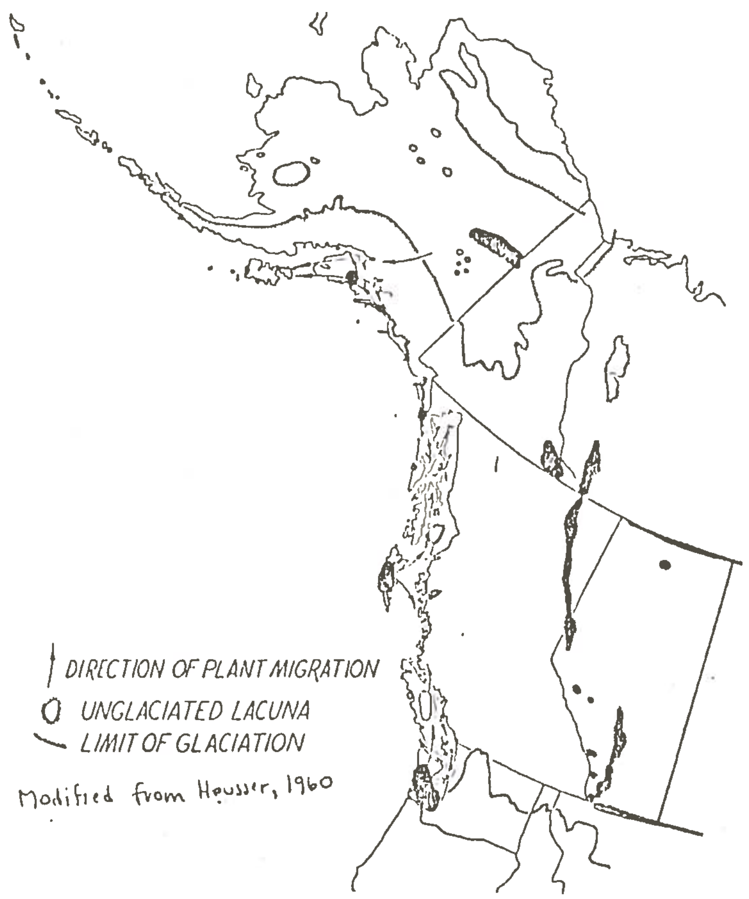


FIG. 48. Sketch map of northwestern North America and adjacent Siberia showing the extent of glaciation and the pattern of plant migration following the last ice age in the study region.

Fig. 7 Location of Proposed Refugia

There is some biological evidence for the presence of the refugium in western Alberta (Halliday and Brown, 1943). In addition, the geological evidence is now impressive: "the evidence for unglaciated enclaves, associated with the meeting of the Cordilleran and Laurentide ice sheets, now appears conclusive" (Packer and Vitt, 1974, p. 1395). Continuing their discussion of the Alberta Rocky Mountains they stated "based on our current knowledge of glacial events, there were large areas of land in Pre-Wisconsin times available for plants at both low and high elevations, while in

Wisconsin time, during the most intensive glaciation, both nunatak types of refugia on the higher mountain peaks (such as in Mountain Park) and unglaciated areas in the foothills regions were available. In addition, lowland areas in the vicinity of the merger of the Laurentide and Cordilleran glaciers were probably present, and at least in Mid-Wisconsin times, may have formed a corridor in north-west and west-central Alberta" (p. 1397-8).

If the corridor did not extend into northeastern British Columbia, the probable thinness of the ice in this area may have resulted in an early withdrawal and consequently an early plant migration into this area. These plants would then be in a position to expand into areas exposed by the retreating Cordilleran and Laurentian ice sheets.

It would appear that there is a wide range in the amount of documentation available for supporting claims for proposed refugias. Several refugia proposals appear to be well founded and must be viewed as potential sources for the distribution of species in northern floras.

Applicability of Hulten's Theory to Liard River Hotsprings Park

A detailed examination of the flora in relationship to Hulten's theory will not be attempted. For the present purpose, it is only necessary to suggest that the vascular flora may be explicable in terms of Hulten's theory. Table 1 illustrates some of the potential relationships.

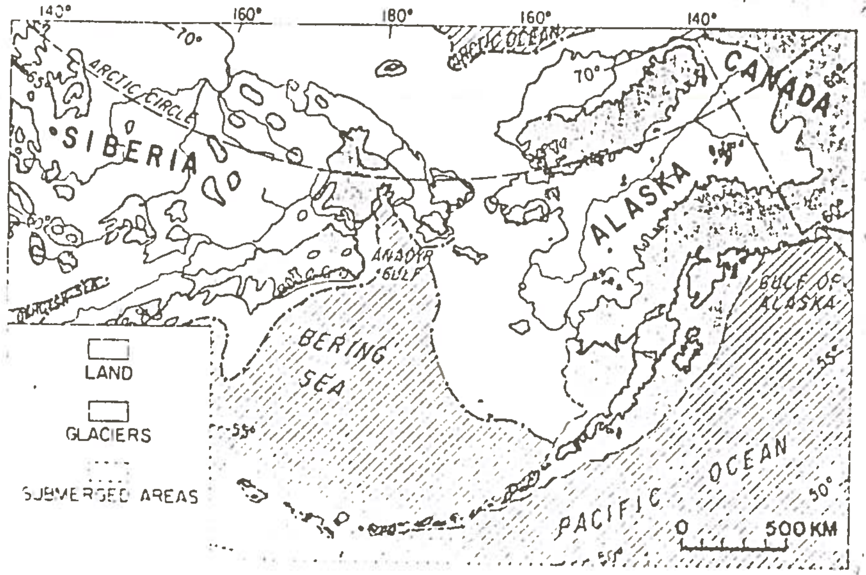
Hotsprings Flora	Refugia
Continental Boreal Forest	
Circumpolar(50)	cordilleran nunataks;south of ice
North American(115)	Yukon valley; south of ice; Atlantic continental shelf
Cordilleran	
Foothill(34)	cordilleran nunataks;south of ice
Coastal(7)	Washington, coastal refugia
Arctic-Alpine	
Circumpolar(13)	N. Beringia; Arctic Archipelago
North American(8)	cordilleran nunataks
Pacific Coast(8)	Washington
Raup's Alaskan Cordilleran(18)	Northern Beringia
North American Endemics(20)	cordilleran nunataks

Table 1. Proposed Refugia of Hotsprings Flora

Since the 165 wide ranging boreal forest species comprise sixty percent of this flora, this prominent element will be briefly examined.

Porsild (Porsild and Crum 1961) considers that the fifty circumboreal forest species "could easily have migrated back and forth across a tundra-covered Bering Strait land bridge, and undoubtedly did so in Pleistocene time" (p. 147) (Fig. 8). The absence of trees among these predominantly herbaceous perennials suggested to him that the climate may have been too cold or dry during the time that the land bridge was exposed (Table 2).

Porsild divided his remaining 115 boreal species into four sub-groups based on geographic distribution (Fig. 9).



ig. 5. Geography of Beringia dur- the height of the Illinoian or Riss ciation. Vegetation boundaries omitted because of lack of ade- te data. Reprinted from D. M. kins, ed., *The Bering Land ge* (Stanford: Stanford Univer- Press, 1967), p. 462.

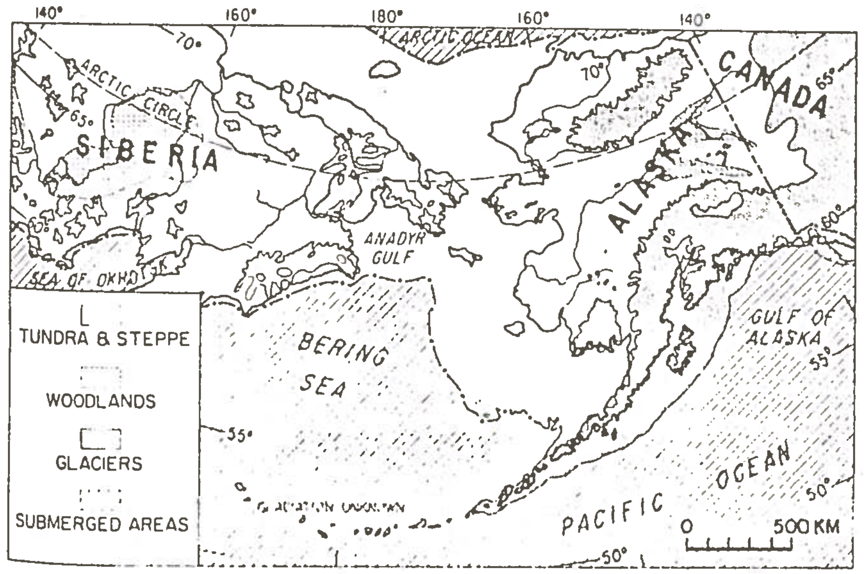
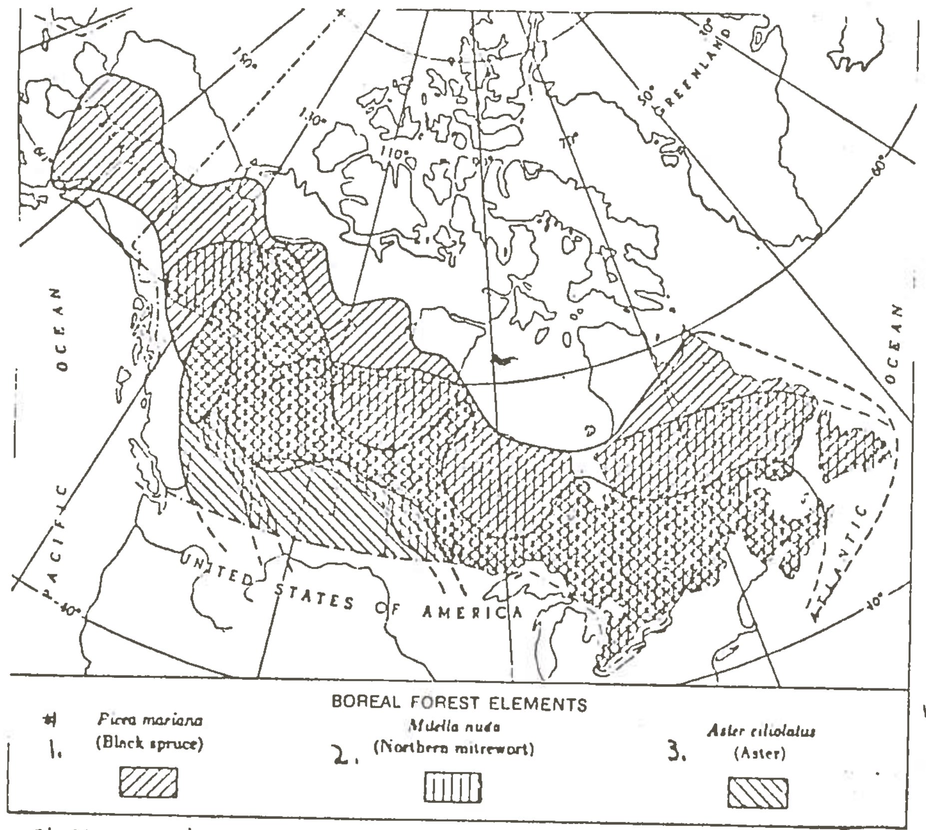


Fig. 6. Geography of Beringia during the height of the Wisconsin or Würm Glaciation. Reprinted from D. M. Hopkins, ed., *The Bering Land Bridge* (Stanford: Stanford University Press, 1967), p. 462.

Fig. 8. Pleistocene Land Bridge Permitted Plant Migration



4. Sphenopholis intermedia (not shown)

Hulten, 1961

FIGURE 2. Boreal Forest Elements.

Fig. 98. Boreal Forest Sub-groups.

These sub-groups may be summarized as follows:

Sub-group	No. of Species	Example	Remarks
1	50	Picea mariana	almost to Bering Sea
2	35	Mitella nuda	Yukon but not Alaska
3	30	Aster ciliolatus	southern boreal forest
4	≥9	Sphenopholis intermedia	disjunct ranges in Yukon and Alaska; restricted to thermally favorable areas

Table 2. Boreal Forest Sub-groups

Porsild notes that in "most cases" the climatic and biotic requirements for all sub-groups of the boreal forest element are similar. He then suggests that the geographic ranges "suggests that they are eastern species, that they came to Alaska and Yukon from somewhere east of the Rocky Mountains, and that they are later arrivals than the circumpolar species" (p. 147). He also suggested that the last three sub-groups are later arrivals than the first.

Hulten's work would suggest that the entirely eastern origin for sub-group 1 is in error. He considered Picea mariana to survive in the Yukon valley refugium as well as in the Atlantic continental shelf refugium. The close presence of the proposed Yukon valley refugium suggests that sub-group 1 should arrive in northern British Columbia earlier than the other three fractions. Mitella nuda (sub-group 2) has been considered by Hulten to have survived the last glaciation only in the eastern continental shelf refugium. This would suggest that greater distance between this refugium and northern British Columbia would result in this sub-group being a more recent element in the northern flora.

With the foregoing in mind we may now examine the applicability of Hulten's theory to the Liard River Hotsprings area. It was previously noted that Raup successfully tested Hulten's theory for the flora of Brintnell (Glacier) Lake. Porsild (1951) suggested that Raup's conclusions "apply equally well to a number of limited areas in southeastern Yukon" (p. 60). It would appear that at least some areas adjacent to my study area may conform to Hulten's theory. When comparing Raup's work to the Liard River Hotsprings area, Porsild noted: "A plotting of the ranges of the Liard Hotspring plants...would result in "equiformal" patterns that would differ from those obtained by Raup from the Mackenzie Mountains chiefly by the larger concentration of boreal forest species present in the lowland and more temperate flora of the Liard Valley" (Porsild and Crum 1961, p. 145). Since this would not affect the applicability of Hulten's theory, it would appear that Raup's conclusions could be applied to Liard Hotsprings; i.e. the flora is probably explicable on the basis of Hulten's work.

Palynological Research in Northeastern British Columbia

Pollen profile analysis is a useful research tool for determining past changes in vegetation. However, the technique suffers from severe limitations, and Heusser (1960) elaborates of the following problems:

1. pollen from insect-pollinated plants amount to only a few percent of that of wind-pollinated plants.

2. ferns and other sporulating species produce large amounts of spores.

3. wind may carry pollen for large distances.

4. owing to peculiarities of pollen sedimentation and preservation, a pollen analysis is not a direct representation of the wind-pollinated flora.

There are many other errors potentially present in method, vegetation representation, sedimentation, and interpretation. Ritchie (1966) provided an apt summary of the situation: "Thus while we assume reasonably, that at least in forested regions the dominant elements of the vegetation are represented in pollen spectra, we can hardly expect to find evidence in one site for much more than five percent of the total flora. Nonetheless, it is likely that the post-glacial history of our flora will be based almost entirely on the results of palynological analyses" (p. 67-8). He added "one should view the published interpretations of pollen diagrams with the utmost caution".

Hansen (1950) conducted palynological work in the north-eastern corner of British Columbia (Fig. 10).

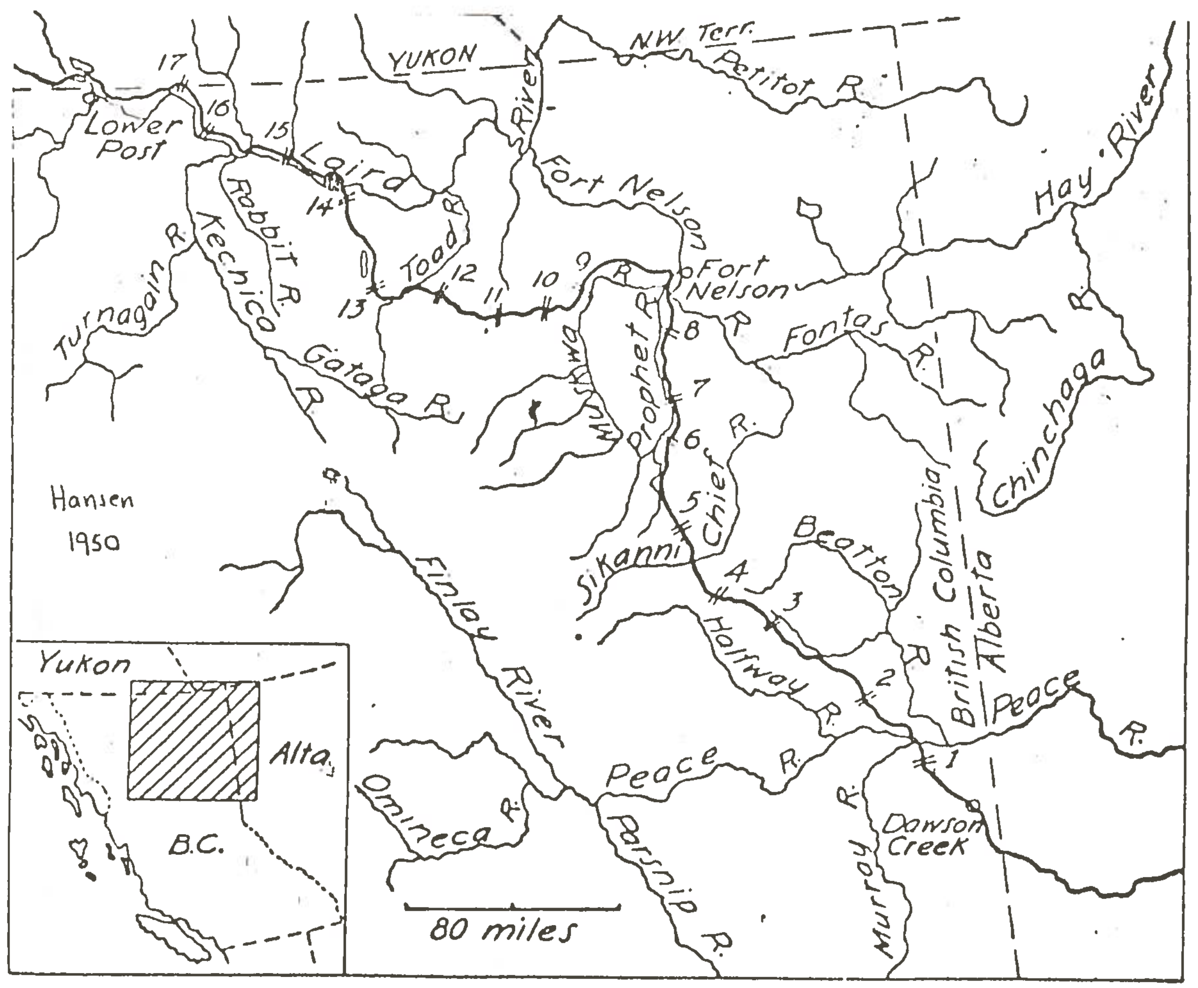


FIG. 1. Map of northeastern British Columbia showing Alaska Highway and the location of 17 sites from which peat sections were obtained for pollen analysis. Double lines crossing highway indicate location of muskegs.

Fig. 10. Palynological Work in Northeastern British Columbia

(The dot marks the location of the Hotsprings)

He enumerated several potential errors in his interpretation:

1. _Populus_ pollen is not preserved. Aspen (_P. tremuloides_) and poplar (_P. balsamifera_) records are lacking. This lack is especially serious in my study area where both species are common. The lack of this pollen may result in a general over-representation of spruce and pine.

2. _Betula_ pollen was not differentiated. The lowland bog birch (_B. glandulosa_) and the upland paper birch (_B. papyrifera_) are both in the area.

3. _Picea_ pollen was not differentiated. The lowland black spruce (_P. mariana_) and the upland white spruce (_P. glauca_) are both in the area.

4. _Pinus_ pollen is over-represented compared to other coniferous species. The lodgepole pine (_P. contorta_) produces a greater quantity of pollen and this production begins at an earlier age than other coniferous species.

5. _Larix_ is under-represented. Larch (_L. laricina_) is found in the area but does not appear in the pollen profiles.

6. The converse fluctuations of spruce and pine (due to the absence of significant proportions of other pollen) must be viewed as relative only and not absolute.

Hansen states "if one species was decimated in abundance by fire, the pollen record of the other immediately increased for that period without necessarily an actual increase in its abundance" (p. 416).

Results of his work are shown in Fig. 11. Although he interprets many common features or trends (Table 3) from his seventeen pollen diagrams, the numerous problems in palynological work suggest to me that a conservative approach is desirable. Therefore, only those characteristics that are significant at the five percent level (i.e. found to be present in at least thirteen of the seventeen samples) will be mentioned. These trends and his interpretations are:

1. Spruce predominant at bottom.

He concluded "The initial preponderance of spruce in the region may reflect the cooler and moister climate attendant in the wake of deglaciation, as well as the possible persistence of spruce nearer to the region in ice-free areas. However, the appreciable proportion of pine in the initial postglacial forests probably resulted from the unstable physiographic and edaphic conditions persisting from glaciation" (p. 419). Since the presumed cool-moist climate would be relatively uniform over the area of Hansen's study, his interpretation may suggest that physiographic-edaphic influences were more critical in some areas.

2. Spruce decline in upper few levels.

3. Pine increment in upper levels.

4. Pine showing higher proportions at top than bottom.

Hansen believes that a "systematic, widespread, regional influence" is responsible for the spruce decline and the pine increase. His conclusions on these observations are presented later. For the moment, a brief consideration of profile synchrony and the status of other arboreal species is desirable in the interests of completeness.

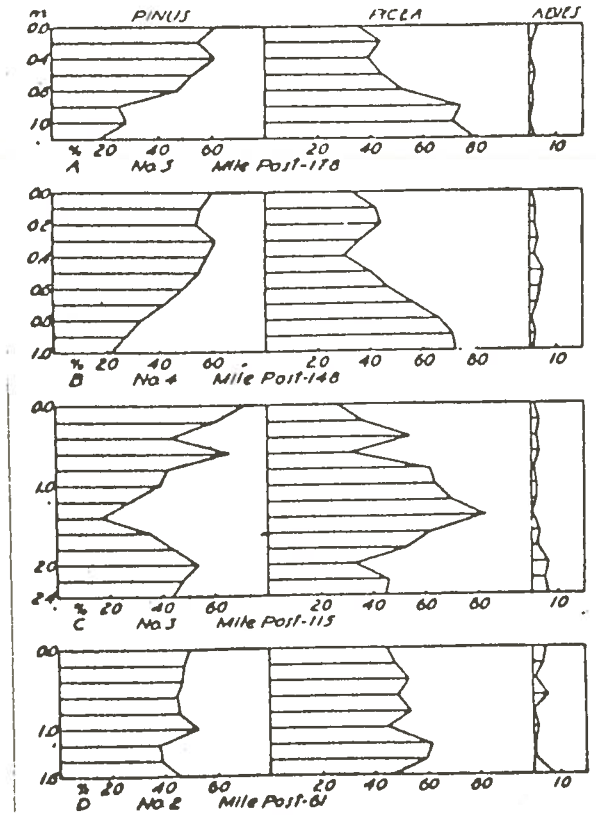


Fig. 4. Pollen diagrams of four muskegs along Alaska Highway.

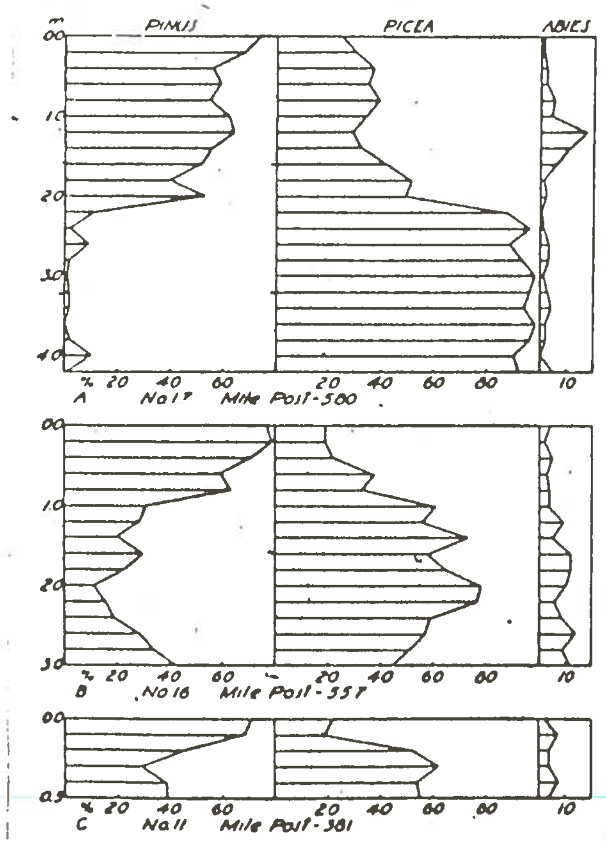


Fig. 5. Pollen diagrams of three muskegs along Alaska Highway. Spruce predominant at bottom, lodgepole predominant at top.

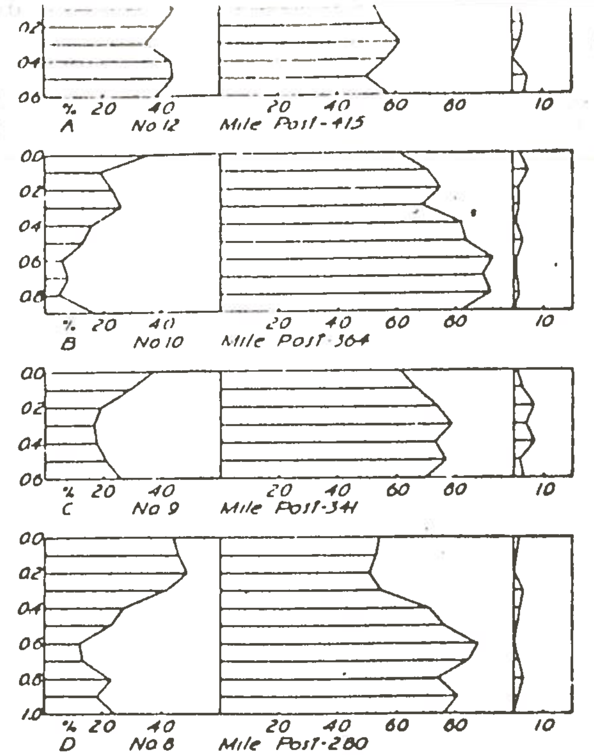


Fig. 6. Pollen diagram of four muskegs along Alaska Highway. Spruce predominant throughout.

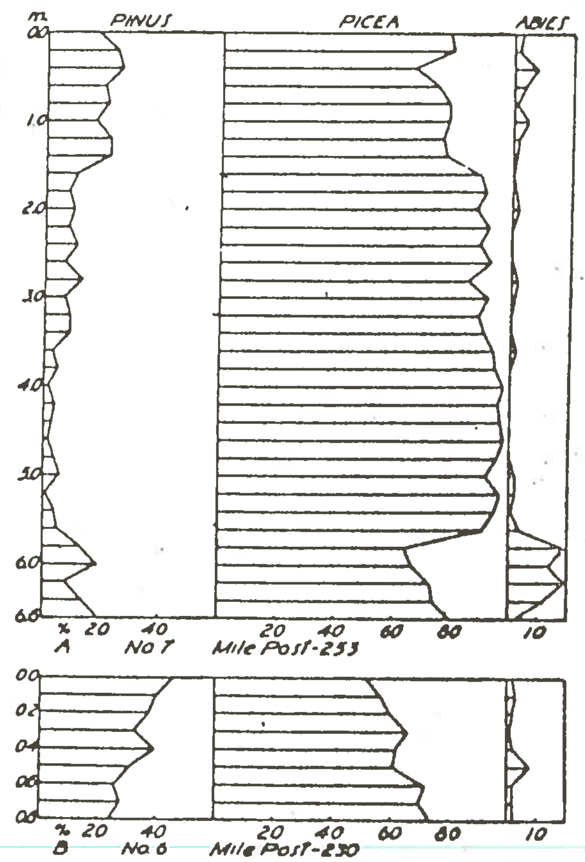


Fig. 7. Pollen diagrams of two muskegs along Alaska Highway. *A*, Deepest muskeg sectioned, showing predominance of spruce throughout, and maximum spruce proportions.

Fig 11.

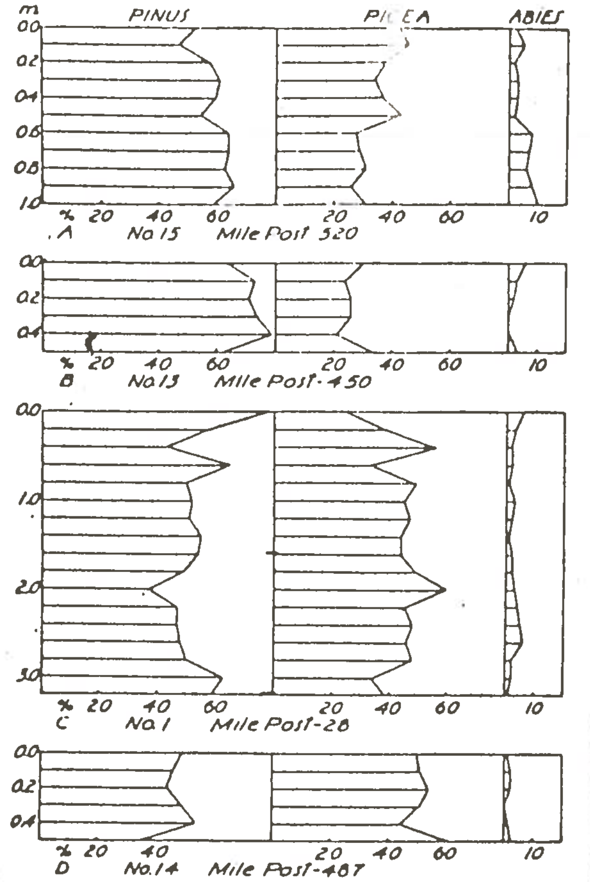


FIG. 8. Pollen diagrams of four muskegs along Alaska Highway. *A*, *B*, *C* show general predominance of pine throughout.

Fig. 11. Pollen Diagrams (from Hansen 1950)

TABLE 2 Hansen 1950

TRENDS AND FEATURES OF POLLEN PROFILES OF PEAT SECTIONS ALONG THE ALASKA HIGHWAY

Trend or feature	No. of 17	Sections in which it occurs
• Spruce predominant at bottom	(14)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 17
Spruce predominant throughout	(6)	6, 7, 8, 9, 10, 12
Spruce predominant at top	(7)	6, 7, 8, 9, 10, 12, 14
Spruce predominant in lower half with pine increasing in upper half to become predominant at top	(7)	2, 3, 4, 5, 11, 16, 17
Spruce increment in upper few levels	(4)	7, 8, 12, 15
• Spruce decline in upper few levels	(13)	1, 2, 3, 4, 5, 6, 7, 9, 10, 14, 15, 16, 17
Pine predominant throughout	(3)	1, 13, 15
Pine predominant at bottom	(3)	1, 13, 15
Pine predominant at top	(10)	1, 2, 3, 4, 5, 11, 13, 15, 16, 17
• Pine increment in upper levels	(13)	1, 2, 3, 4, 5, 6, 9, 10, 11, 14, 15, 16, 17
Pine minimum between bottom and top	(11)	1, 2, 3, 7, 8, 9, 10, 11, 12, 16, 17
Pine generally increasing throughout	(3)	4, 5, 6
• Pine showing higher proportions at top than bottom	(14)	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 13, 14, 16, 17

Table 3. Pollen Profile Trends
(significant trends marked with a dot)

Hansen remarked on the "apparently synchronous fluctuations" for many of the pine profiles. This would support his suggestion of a widespread influence. This apparent synchrony would also exist for the spruce profiles since the two species are so highly correlated.

The status of aspen is hypothetical. Hansen suggested it may have been present in abundance at the time of the pine minimum-spruce maximum. Alpine fir was not abundant nor did it show any significant trends. Although Hansen reported "Birch pollen is fairly consistently and abundantly present" (p. 416) no data were presented for this species.

Hansen makes a number of environmental inferences from his data:

1. "extreme boreal conditions did not exist" (p. 420) because of the presence of pine at the bottom of the profile.

2. deglaciation resulted in initial physiographic and edaphic instability because of the "appreciable proportion of pine in the initial postglacial forests" (p. 419). No explanation is given for the apparently contradictory, statistically significant fact of spruce being "the most abundant postglacial pioneer invader" (p. 417).

3. initially sufficient moisture (for spruce) and a prolonged fire-free period plus a stabilization of physiographic and edaphic conditions based on the expansion of spruce and the decline of pine for the initial third of the profile.

4. "dryer climate during the last few millennia which in turn increased the frequency and extent of fire" (p. 420) based on the expansion of pine in the upper half of most sections.

Hansen summarized the relative importance of these factors as "climate and physiographic-edaphic instability probably were more influential during the first two-thirds of the time represented while fire has played the more important role in more recent time" (p. 419). This is suggested by the expansion of the fire-successional pine in an area where the climatic climax is spruce.

Palynological Work in Adjacent Areas

The general predominance of spruce over pine in northeastern British Columbia does not extend into the Yukon. In a pollen profile from near Watson Lake, less than 150 miles away from my study area, lodgepole pine was more common than spruce throughout the profile (Hansen, 1953). This study showed lodgepole pine predominant over spruce until the vicinity of Whitehorse. Beyond Whitehorse (i.e. towards Fairbanks) the northeastern British Columbia pattern of spruce predominance prevails. Typical lodgepole pine profiles in this area are less than five percent of the total amount of pollen.

Results such as this suggested to Hansen that pine migrated to this area from western Alberta and/or northeastern British Columbia or from the unglaciated section of the Yukon. Although he found a few pine pollen grains in an exploratory study of the Fairbanks muck, he believed these pollen grains to have originated from distant sites. His belief that pine was not present in this area is consistent with the studies of the Fairbanks muck that were previously discussed.

In 1957, Heusser pointed out that Hansen's work at Mile Post 647 (near Watson Lake; pine initially present) and at Mile Post 872 (in which 1 meter of nonarboreal pollen was deposited before spruce was deposited) suggests that "pine had migrated from northeastern British Columbia - southeastern Yukon whereas spruce had spread from the unglaciated Alaskan interior or west-central Yukon" (p. 136).

Hypsithermal Interval

The Hypsithermal Interval may be defined as that postglacial time period when the mean annual temperature was warmer than it is at present. In the latitude of my study area (59°26'N) this period occurred on coastal British Columbia between 8,000-3,500 BP (Fig. 12). The length and intensity of this period is decreased by geographical increases in altitude and latitude (Heusser, 1960, p. 34, 180). His observation raises the problem of the presence or absence of the Hypsithermal Interval at my study area. (This question is of significance for as noted in the introductory remarks the present disjunct distributions of thermophilous plants may be explained on the basis of a previously warmer time period.) One method of examining this problem is to consider the probable history of adjacent areas.

There is a considerable amount of palynological evidence to indicate the presence of the Interval on the coast (Fig. 12).

The grass and chenopod influx in pollen profiles, plus the presence of a black grassland-type soil below present forest stands allowed Hansen (1949) to suggest the presence of the Hypsithermal for the region south of Edmonton (about 53°N). Although his 1952 paper on the Grande Prairie-Lesser Slave Lake region (about 55°N) found no evidence for the extension of grass, edaphic evidence

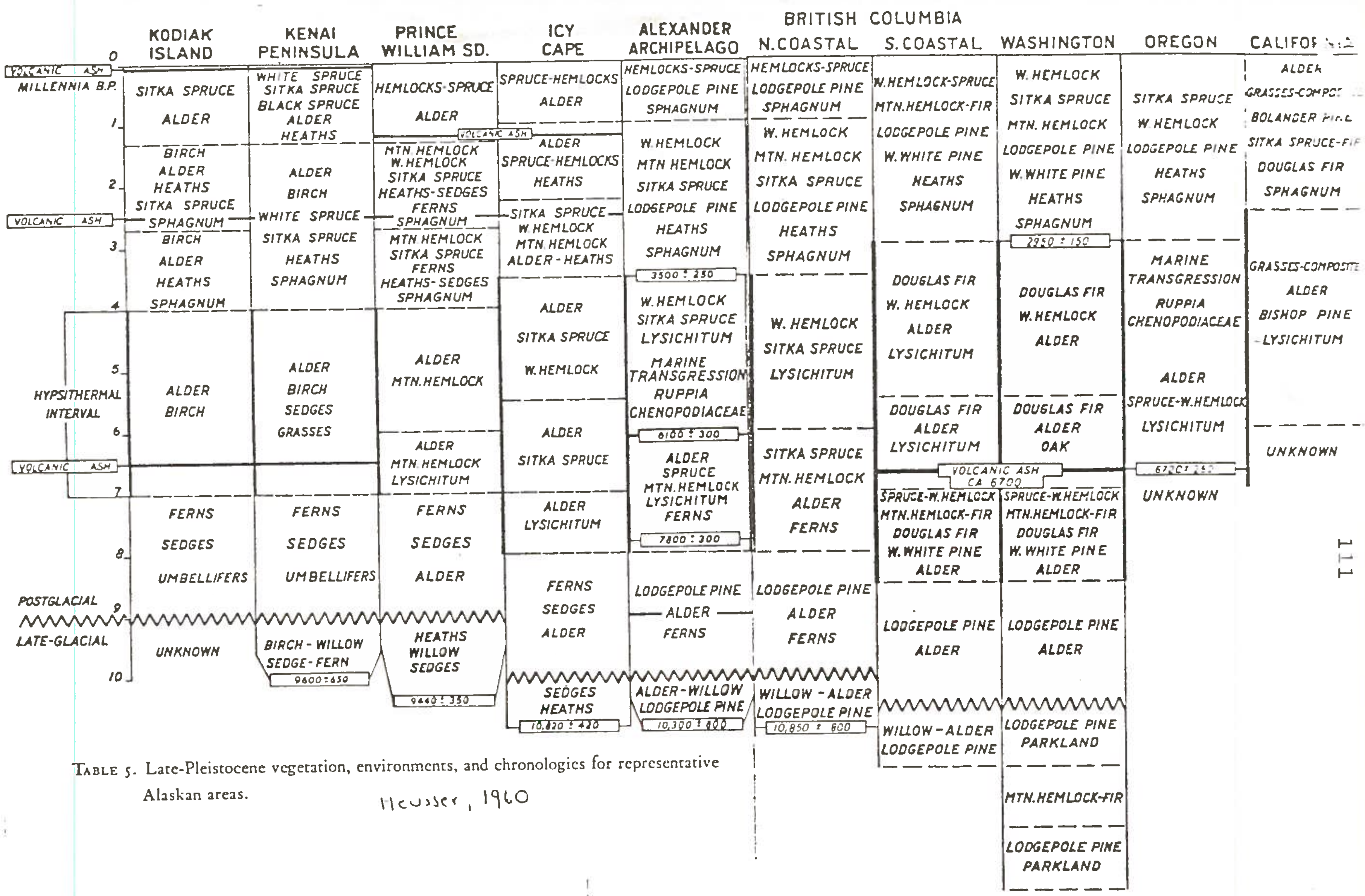


TABLE 5. Late-Pleistocene vegetation, environments, and chronologies for representative Alaskan areas.

Heusser, 1960

TABLE 6. Late-Pleistocene vegetation, environments, and chronologies for representative areas i Washington, Oregon, and California. British Columbia.

Fig. 12. Coastal Hypsithermal Interval Evidence.

suggested that the boreal forest may have once been further north than it is at present. This may suggest the presence of a previously warmer period.

Raup (1945) found some evidence that may suggest that the Beatton River valley (about 56-57°N) may have once been prairie.

The presence of Menyanthes trifoliata preserved in peat at Macmillan Pass (near 5,000 feet; above 63°N) when it is no longer growing in the area caused Porsild (1945) to suggest a deterioration of the climate. This may suggest the presence of the Hypsithermal Interval at this location.

However, in Hansen's 1953 Yukon Territory - Alaska study (between 60-65°N at a variety of altitudes) it was stated: "While the author believes that most of the deeper pollen-bearing sediments extend back to the postglacial thermal maximum so well shown elsewhere, there seems to be no evidence that the influence of this warm, dry interval extended this far north" (p. 540). Unfortunately, no radiocarbon dating is available for his sections and his dates are only based on an estimated pollen deposition rate.

Hustich (1953) suggested that the isolated forest stands found at the forest-tundra ecotone may be relics from the Hypsithermal. This suggestion may be supported by a study which is cited in Heusser (1957) which showed a gradual influx of spruce to the Brooks range until the close of the Hypsithermal (6,000 to 3,000 BP for this area based on radiocarbon dating). Additional evidence for the presence of this warm period in arctic Alaska was provided by the presence of an Isoetes which is now found only in the temperate south coast region of Alaska.

A more direct approach in considering the presence or absence of the Hypsithermal Interval at Liard Hotspring is to examine the northeastern British Columbia pollen profiles (Fig. 11). Hansen considered this pollen to be deposited at the rate of one meter in 2,500 years. On this basis, pollen profile No. 17, 16, 7, and 1 cover the time interval during which the Hypsithermal Interval was documented for other areas (Table 4).

If these pollen diagrams are examined for the 8,000-3,500 BP interval (coastal Hypsithermal) there is a decrease in spruce and an increase in pine for No. 17, an initial spruce increase-pine decrease for No. 16, and initial spruce increase-pine decrease for No. 1, and no apparent change for No. 7. Only profile No. 17 shows the anticipated trends for this interval but it may also be noted that the same trend continues after the termination of this time interval.

If the same diagrams are examined for the 6,000-3,000 BP period of the Hypsithermal at the Brooks Range, Nos. 17 and 7 exhibit the anticipated spruce decrease-pine increase, but Nos. 16 and 1 show a spruce maximum-pine minimum during the middle of this time span.

In conclusion, there is no clear palynological evidence either for or against the presence of the Hypsithermal Interval in northeastern British Columbia. If this interval did occur, the published pollen profiles suggest that physiographic, edaphic, and pyric factors may have masked the results. However, as noted in a previous section, this palynological study has many shortcomings including the failure to obtain a definitive time scale. Consequently, it may perhaps be best regarded as exploratory rather than definitive.

TABLE 1 Hansen 1950

Number of section	Mile post	Total depth of section in m.	Depth of pollen profiles in m.	Volcanic glass in upper levels	Estimated Age, 1000's BP
1	28	4.0	3.2		8.0
2	61	1.8	1.6		4.0
3	115	3.0	2.4		6.0
4	148	1.2	1.0	X	2.5
5	178	1.5	1.2	X	3.0
6	230	1.0	0.8	X	2.0
7	253	7.0	6.6		16.5
8	280	1.4	1.0	X	2.5
9	341	1.5	0.6		1.5
10	364	1.5	0.9	X	2.2
11	381	0.5	0.5		1.3
12	415	0.6	0.6		1.5
13	450	0.5	0.5	X	1.3
14	487	0.5	0.5		1.3
15	520	1.0	1.0	X	2.5
16	557	3.0	3.0	X	7.5
17	580	4.2	4.2	X	10.5

Table 4. Estimated Age of Pollen Profiles

However based on other evidence, the Hypsithermal Interval appears documented or suggested at several locations both north and south of my study area. This suggests the occurrence of this warm interval in northeastern British Columbia.

Summary

Boreal thermal springs are of considerable botanical interest and may harbor vegetational relics. Hulten has provided a detailed consideration of where plants have survived glaciation. This has phytogeographic, genetic, and ecological implications. His proposals appear to be applicable to the northern areas which have been examined from this viewpoint. There is evidence for the existence of several refugia which would then recolonize denuded areas in a complex spatial and temporal pattern. The composition of the colonizing spruce-pine forest in northeastern British Columbia has been

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NOTE: Although not cited specifically, much of my thinking has been influenced by H.M. Raup (1941) Botanical problems in boreal America, Bot. Rev. 7:147-248.