United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

General Technical
Report
PNW-GTR-270
May 1991

Provisional Tree Seed Zones and Transfer Guidelines for Alaska

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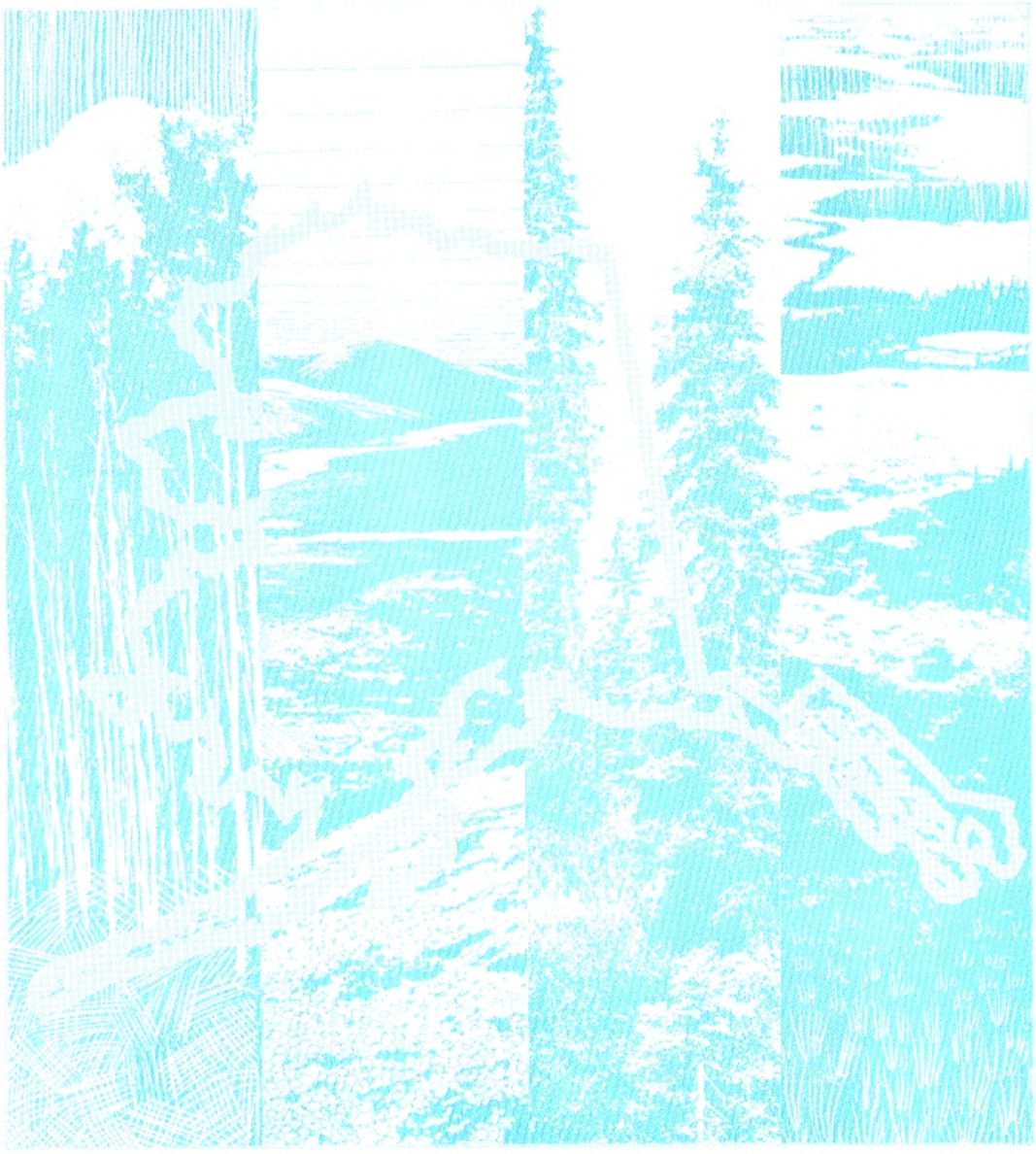

Abstract

Alden, John N. 1991. Provisional tree seed zones and transfer guidelines for Alaska Gen Tech Rep PNW-GTR-270 Portland, OR U S Department of Agriculture, Forest Service, Pacific Northwest Research Station 35 p

Four hundred and eighty-six provisional tree seed zones were delineated within 24 physiographic and climatic regions of Alaska and western Yukon Territory Estimated forest and potential forest land within altitudinal limits of tree species in Alaska was 51 853 000 hectares (128,130,000 acres) Seed transfer guidelines and standard labeling of seed collections are recommended to reduce losses from maladaptation and maintain the genetic identity and productivity of future forests in Alaska

Keywords Alaska, seed zone, seed transfer and labeling guidelines, tree distribution, tree limit, forest area, genetic diversity, climate, physiography

Contents

1 Introduction

1 Physiography and Tree Limits in Alaska

3 Climate and Soils

4 Genetic Variation and Effects of Seed Transfer

5 **Methods**

6 Results

26 Discussion

27 Recommendations

27 Transfer Guidelines

28 A Standard Labeling System

30 **Conclusions**

30 Acknowledgments

31 References

Introduction

Long-term growth and survival traits are genetically variable in widely distributed forest tree species These variations exist among wide-range provenances (the original geographic source of a population), local populations, stands, demes (local groups of interbreeding trees within stands), and individual trees Variation among provenances local populations, and stands is related to habitat, and depending on trait, may be continuous or discontinuous, or both Populations with continuous (or chnal) variation can be moved from their origin without risk of maladaptation only until the environment reduces growth and survival (Fowler and MacGillivray 1967) Populations with discontinuous variation can be moved freely in, but not among, habitats or geograph ic regions they adapt to For these reasons, seed zones and transfer guidelines are necessary to reduce the risk of maladaptation from transfer of seed to regions they do not adapt to

Populations from moderate environments usually have higher growth potentials than populations from harsh environments, and the transfer of seeds with clinal variation from their natural origin to less favorable habitats may increase growth and yield (Mangold and Libby 1978, Namkoong 1969) Preferred habitats of provenances with clinal variation can be identified and grouped into seed-use and breeding zones from regression models of long-term population performance at many test sites (Kung 1981, Raymond and Lindgren 1986, Shelbourne and Campbell 1976) Extremely heterogenous environments and discontinuous genetic variation underlying clinal variation may cause less growth and survival than predicted by regression models, however Environmental and genetic differences are often extreme and discontinuous in mountainous regions, populations from harsh sites may lack growth potential for mild sites, and populations from mild sites may lack survival potential for harsh sites (Campbell 1986) Although provisional seed zones and transfer guidelines can be derived from genetic variation mapped in short-term nursery trials, the effects of seed movement must be determined in long-term field trials if risks of maladaptation and reduced growth are to be minimized (Campbell and Sugano 1987)

Seed zones have been established for most commercial forests in the Northern Hemisphere to reduce the risk of long range seed transfer Alaska is the last major forest region of North America to prepare seed zones and seed transfer guidelines for forest renewal programs Seed zones and seed transfer guidelines maintain the genetic integrity of indigenous forest species, conserve genetic diversity, and reduce losses of wood yield from maladapted seed Used correctly, seed zones and seed transfer guidelines will ensure long survival and vigor of forests artificially regenerated with native tree and shrub species

Physiography and Tree Limits in Alaska

The Coast Range and the Rocky Mountains (Brooks Range) of Western North America extend westward into Alaska and create four major physiographic regions (Wahrhaftig 1965) (fig 1) The coastal mountains separate into a double arc in southeast Alaska and bend in a sharp west-southwest direction to curve around the Gulf of Alaska and create the coastal mountain physiographic region of south-central Alaska Mountains of the southern arc include the island range of southeast Alaska, the St Eilas Mountains, the Chugach-Kenai Mountains, and the offshore mountain tops known as Afognak and Kodiak Islands These mountains are in the maritime climatic zone of Alaska and form the interior boundary of the hemlock-Sitka spruce *{Tsuga* spp (Endl) Carr -*Picea sitchensis* (Bong) Carr) forests The Wrangell Mountains, the

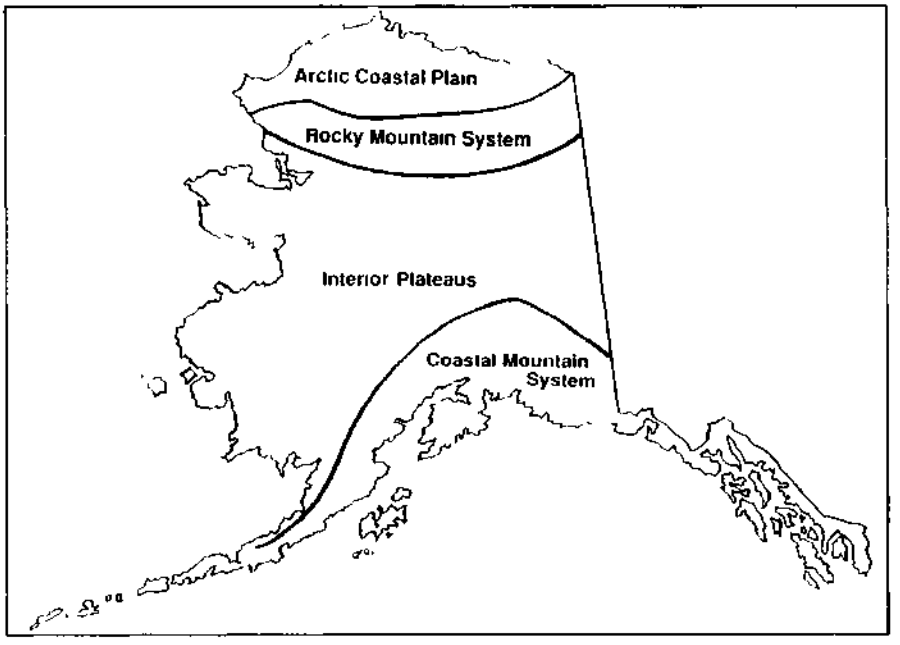

Figure 1—Major North American physiographic regions in Alaska, revised from Wahrhaftig 1965

Alaska Range, the Aleutian Range, and the Aleutian Islands form the northern arc. A trough between the northern and southern arcs contains the Copper River Plateau, the Talkeetna Mountains, the Cook Inlet Lowlands, and Shelikof Strait. This region has a maritime-continential transition climate and contains tree species of both coastal and interior forests.

Altitudinal limits of tree species in the coastal forests extend from nearly 400 meters (1,300 ft) on Kodiak Island to about 1200 meters (3,900 ft) above mean sea level (m s.l.) in southeast Alaska (Heusser 1954). White spruce *{Picea glauca* (Moench) Voss) usually attains altitudinal species limits at about 1000 meters (3,280 ft) in the Aleutian and Alaska Ranges (Cahalane 1959, Heebner 1982), and has been observed at 1329 meters (4,430 ft) in the White Mountains of the Alaska Range (Denton and Karlen 1977) and at 1500 meters (4,900 ft) in the Wrangell Mountains (Cooper 1986). Mountains of the northern arc range from about 1500 to 6200 meters (4,900 to 20,320 ft) in altitude and are the major land barrier to tree migration in Alaska. Only Mentasta Pass, 695 meters (2,280 ft), Isabel Pass, 915 meters (3,000 ft), Broad Pass, 700 meters (2,300 ft), Rainy Pass, 1035 meters (3,400 ft), Houston Pass, 825 meters (2,700 ft), and Merrill Pass, 1160 meters (3,810 ft) are potential tree migration routes between the interior plateau and the south-central coastal mountains.

The interior plateau between the Alaska Range in the south and the Brooks Range in the north contains the Yukon, Tanana, Koyukuk, Porcupine, and Kuskokwim River systems. The lowlands of this region support the most extensive forests in Alaska. Altitudinal limits for white spruce in the interior region decrease from about 1100 meters (3,600 ft) near the Yukon border in the east (Marchand 1976) to nearly sea level

at coastal limits on the Bering and Chukghi Seas in the west Balsam poplar *(Populus balsamifera* L) frequently grows above white spruce in the southwest interior and forms altitudmal tree limits at about 760 meters (2,500 ft) near Lake Clark on the northern slopes of the Aleutian Range (Marchand and Racine 1978)

The northern mountain region (Brooks Range) is an extension of the Rocky Mountains, the Continental Divide of North America Mountains in the Brooks Range are less than 1500 meters (3,280 ft) in the west and more than 2750 meters (9,000 ft) above m s I in the east, they form the northern limit of spruce in Alaska Altitudmal treeline for white spruce is about 760 meters (2,500 ft), but trees have been observed at 1465 meters (4,800 ft) between the headwaters of the Kobuk and Koyukuk Rivers in the central Brooks Range (Cooper 1986)

The Arctic coastal region north of the Brooks Range is a broad, level plain underlain with permafrost and pockmarked with many shallow lakes Balsam poplar is the only tree species indigenous to this region

Climate and Soils

The climate of Alaska is highly variable and ranges from maritime temperate in southeast Alaska to maritime arctic in the Aleutian Islands and on the Arctic coastal plain Low temperatures limit forest productivity in all regions Potential evapotranspiration decreases from 610 millimeters (24 in) per year in southeast Alaska to 305 millimeters (12 in) per year at the Arctic limits of white spruce and 200 millimeters (8 in) per year on the Arctic coastal plain (Patric and Black 1968) Potential evapotranspiration in interior Alaska often exceeds annual precipitation Low evapotranspiration and high precipitation in southeast Alaska produce excess groundwater and reduce soil temperatures (Andersen 1955) Average annual temperature in the southern coastal region decreases gradually with increasing latitude and longitude Climatic change is geographically distinct only in the wet islands of the east coast, the dry continental-maritime transition regions of upper Cook Inlet and upper Lynn Canal, and in the Aleutian Islands (Farr and Hard 1987)

A dry subarctic continental climate prevails throughout the eastern interior region Long days and low sun angles at high latitudes accentuate the effects of topography on local climate (Slaughter and Viereck 1986) Topography determines the amount of solar radiation reaching the ground and affects soil temperature and tree growth Temperatures and evapotranspiration decrease sharply with altitude, and in mountain ous regions, winter inversions are often extreme Southern aspects are warmer and drier than northern aspects in interior and arctic regions Northern aspects are wet and permanently frozen Forests are usually more productive on southern than on northern aspects, but trees on the former are frequently under moisture stress after snow-melt in late spring and early summer Flood plains are also warmer than northern aspects, but frosts occur earlier on flood plains than on southern aspects (Alden 1985) Alluvium deposits on well-drained flood plains occupy about 73 000 square kilometers (18×10^6 acres) and support the most productive forests (Neiland and Viereck 1977, Viereck and others 1983)

Interior Alaska was unglaciated during the Pleistocene epoch, and many upland soils are deep silt-loam loess deposits Mean annual temperatures are below freezing throughout the region Extended periods of cold temperatures inhibit mineralization of organic deposits and curtail nutrient cycling Many soils therefore are permanently frozen and nutrient deficient

Most soils of south-central and coastal Alaska are from recent glacial till or moraine deposits and are generally not as well developed as soils of interior Alaska Available nutrients are contained in thin surface organic layers (Farr and Harris 1979) Soils are warmer, precipitation is greater, and nutrient cycling is more rapid than in interior Alaska The most productive forests in south-central Alaska are on alluvial flood-plain and glacial outwash materials capped with finely textured loess deposits

Genetic Variation and Effects of Seed Transfer

Recent studies (Alden 1985, 1988, Alden and Loopstra 1987, 1988, Campbell and others 1989, Falkenhagen 1978) indicate that genetic variation of Sitka and white spruce in Alaska is large and closely related to the altitude and aspect of its habitat Growth and phenology of Sitka spruce is genetically variable in east-west and north-south directions, aspect, elevation, and slope in a small geographic area on Mitkof Island in southeast Alaska (Campbell and others 1989) The variation is continuous, and transfer of local seed to similar sites on distant islands in southeast Alaska may impart less risk of maladaptation than transfer of seed to different sites on Mitkof Island

Wide-range Sitka spruce and Lutz spruce *{Picea* x *lutzn* Little) populations from the Gulf of Alaska are also genetically variable in survival and growth traits (Alden and Loopstra 1988) Survival potential of wide-range provenances in the Aleutian Islands, 1,500 kilometers (930 mi) west of natural tree limits, increased with latitude and longitude but decreased with date of bud formation and nursery growth Long distance transfer of Sitka and Lutz spruce seed may impart greater risk of mortality and reduced growth than indiscriminate transfer of Sitka spruce seeds among islands of southeast Alaska Sitka spruce may vary in a stepped (discontinuous) ecochne for broad ecological regions in southeast Alaska and British Columbia (Falkenhagen 1978) Falkenhagen hypothesized from variation in cone and seed characteristics that the ecoregions contain regional Sitka spruce ecoclines and change according to "ecogeographic gradients' in the environment

White spruce is more widely distributed and may be more variable than Sitka spruce in Alaska Two geographic varieties of white spruce, *Picea glauca* (Moench) Voss var *albertiana* (S Brown) Sarg and var *porsildii* Raup, have been identified in Alaska, and isoenzyme variation among white spruce stands is larger than among Sitka spruce stands (Copes and Beckwith 1977) Allozyme analysis of white spruce within a small geographic area near Fairbanks, Alaska, showed that subarctic populations are genetically diverse even at altitudinal tree limits (Alden and Loopstra 1987) Seedlings from a flood-plain population at 120 meters (400 ft) above m s I in the same geographic area grew taller than seedlings from upper and mid-slope populations at 275 and 460 meters (900 and 1500 ft) above m s I in an unfavorable nursery environment, but more seedlings from the mid slope population died after outplanting (Alden 1985) Growth and winter injury varied among widely distributed white and

Lutz spruce provenances from Alaska in Iceland (Benedikz 1982) and at the Alaska Forest Tree Nursery, Palmer, Alaska (Alden 1988) Provenances from south-central and interior Alaska hardened at different rates in the nursery and seedling growth was negatively correlated with altitude

Natural hybridization and introgression among spruce species and races are also major sources of genetic variation in Alaska Although the region of hybridization and introgression is extensive for Sitka and white spruce (Copes and Beckwith 1977, Sigurgeirsson and others 1988) and balsam poplar and black cottonwood *{Populus tnchocarpa* Torr & Gray) (Viereck and Foote 1970), the extent of hybridization and introgression of the indigenous birch *{Betula* L) species and the long-term effects of seed transfer on productivity of the major tree species are unknown Genetic vana tion has not been associated with geography and local habitat or studied for tree species other than Sitka and white spruce For this reason, seed zones for tree popula tions must be delineated on physiographic features or sharp environmental gradients Seed zone boundaries should define areas of relatively uniform climate (growing conditions) and enclose populations with similar habitat requirements for long survival and optimum growth Physiographic features such as mountains, large lakes, and ocean channels or bays are genetic barriers to gene flow among populations and affect local climate Major physiographic features are excellent provisional seed zone boundaries for Alaska

Methods

The climate of major geographic areas and seed regions shown in table 1 was summarized from weather data provided by Farr and Hard (1987), Funsch (1964), Hartman and Johnson (1978), Patric and Black (1968), U S Weather Bureau (1960-80), and Watson and others (1971) Fourteen broad geographic areas identified from a preliminary multivanate analysis of 32 climate-related variables for 62 weather stations in interior and south-central Alaska (Alden 1981) were used to plot seed regions, subregions, and zones on 1 1,000,000 U S Geological Survey maps with 150-, 300-, and 500-meter (492- 984-, and 1,640 ft) contour intervals Seed region boundaries were established above altitudinal tree limits where possible and enclosed major watersheds Seed regions 14 to 20 in eastern Alaska (numbers 14 to 20) were extensions of Ecoregions for Yukon Territory' (Oswald and Senyk 1977) Yukon Territory ecoregions were delineated from vegetation patterns on landforms with similar climate Primary criteria for boundaries were topography, permafrost, and the presence or absence of trees

Subregion and seed zone boundaries were likewise located on physiographic fea tures between drainages within major watersheds Subregion boundaries for southeast Alaska (seed region 01) were drawn from physiographic boundaries on a USDA Forest Service, Alaska Region, seed zone map that limited north-south seed transfer to about one degree latitude (Harris and Johnson 1981)

Table 1—General climate of major geographic areas with potential for forest development in Alaska

Geographic area	Seed regions	Mean annual temperature	GGD[a]	Average growing season[b]	Mean annual precipitation	Potential evapo-transpiration	Permafrost
		-°C-		*Days*	*Mm*	*Mm/year*	
Southeast	01	2 to 7 5	800-1,450	150-200	1,000-6,000	500 600	Absent
Southcoastal	02-04	0 to 5	800-1,100	90-160	400-6,000	450-500	Absent
South-central and southwest	04 09	-2 to O	700-1,000	80-120	300-2,000	400-450	Isolated to discontinuous
West and interior	09-12	-5 to -1	400-1,000	60-120	400-1,000	350-400	Continuous
Interior	13-17, 20	-7 to -3	400-1,200	60-100	200 800	300-450	Discontinuous
Interior	18 20	-11 to -5	400 1,100	60 90	200 800	250-400	Continuous
Interior and northwest	21-22	-10 to-5	400-1,000	60-90	200-600	300-350	Continuous
Arctic	23	-12 to-5	400-800	60-90	100-500	200-300	Continuous
Southwest	24	-2 to 5	600-900	60-160	400-3,500	400-450	Continuous to absent

[a] GGD—Growing degree-days is the average daily temperature in Celsius scale (°C) less a threshold value of 5 °C and summed for all positive values during the year

[b] Yearly average number of days during the growing season with ambient temperatures above 0 °C Year-to-year variation in the Arctic zone is large, and many habitats have frosts every month regardless of the length of the average growing season

The total area of each seed zone was estimated with a Video Graphics-System 300 Computer designed for mapping the surface area of polygons and manufactured by Aeronca Electronics Inc , Charlotte, North Carolina [1] Forest and potential forest land for each seed zone were estimated from a dot grid of land area within altitudinal limits estimated for tree species. Total forested area in Alaska is 48 179 000 hectares (119,051,000 acres) (Hutchison 1967). Potential forest land is additional area within the outer limits of possible tree survival, regardless of growth form; the outer limit is defined as the potential species limit or "tree-species line" (Hustich 1979, Payette 1983). The potential tree-species limit may be achieved by cultivation and introduction of new species.

Results

Twenty-four seed regions, 72 subregions, and 486 zones were mapped for Alaska and western Yukon, Canada (fig. 2 and map insert [inside back cover]). The total area estimated within the seed zones was 146 960 000 hectares (363,140,000 acres) (table 2) of which 1 997 000 hectares (4,930,000 acres) were in Canada. Islands in the Bering Sea and glaciers comprised an additional 6 951 000 hectares (17,180,000 acres) in Alaska. Estimated forest and potential forest land capable of supporting trees were 51 853 000 hectares (128,130,000 acres) in Alaska and 1 347 000 hectares (3,330,000 acres) in Canada. Forest, potential forest land, and nonforest land excluding major glaciers are estimated for each seed region, subregion, and zone in table 3. Average area per seed zone was 302 000 hectares (750,000 acres). Forest and potential forest land ranged from 1000 hectares (2,500 acres) for zone 200315 (Tatonduk River) to 1 066 000 hectares (2,630,000 acres) for zone 200306 (Birch Creek) and averaged 109 000 hectares (270,000 acres) per seed zone or 36 percent of the total area.

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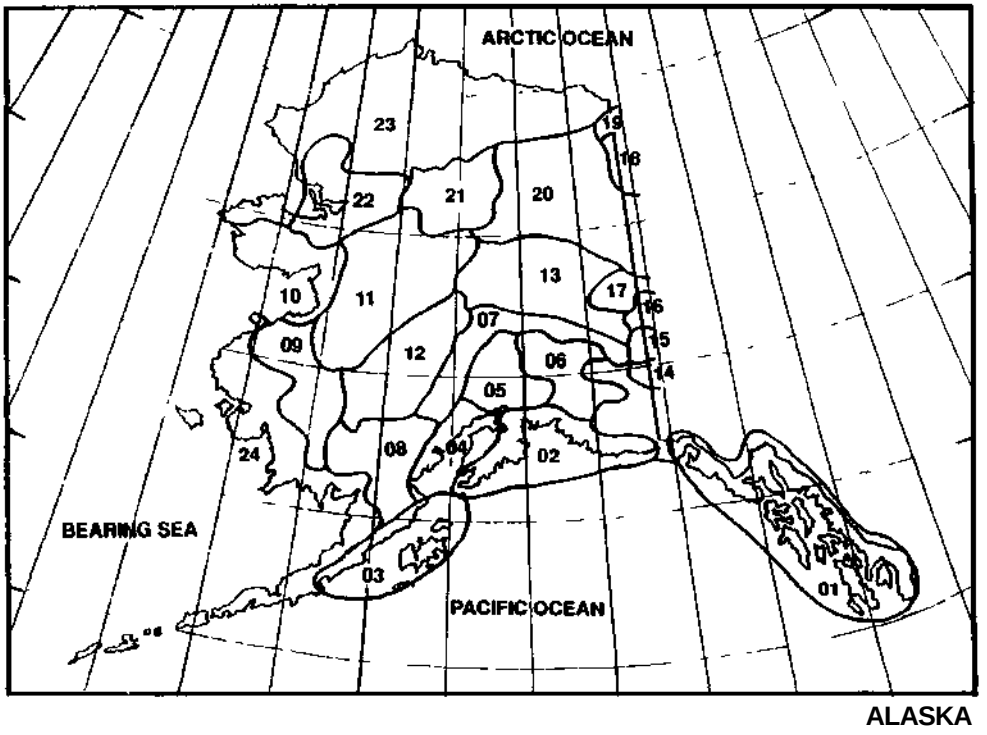

Figure 2—Seed regions of Alaska

Table 2—Forest or potential forest and nonforest land within seed regions, and nonforest land excluded from seed regions of Alaska

Seed regions	Estimated area				
	Forests or potential forests				
	Alaska	Canada	Total	Nonforest	Total
	Hectares x 10^3				
01 Southeast Alaska	4,853	116	4,969	3,204	8,173
02 Gulf of Alaska	1,119		1,119	1,514	2,633
03 Afognak-Kodiak-Alaska Peninsula	715		715	1,360	2,075
04 Cook Inlet	1,227		1,227	1,085	2,312
05 Matanuska-Susitna Rivers	1,859		1,859	1,764	3,623
06 Copper River Plateau	1,972		1,972	3,217	5,189
07 Alaska Range	952		952	2,814	3,766
08 Southwest coastal (Bristol Bay)	1,642		1,642	5,350	6,992
09 Lower Kuskokwim-Yukon Rivers	1,897		1,897	4,684	6,581
10 West coastal (Norton Sound)	1,166		1,166	3,478	4,644
11 Central Alaska basins	8,497		8,497	4,791	13,288
12 Kuskokwim Mountains	5,241		5,241	3,432	8,673
13 Tanana River	6,466		6,466	2,254	8,720
14RubyRange[a]	43	14	57	230	287

Footnote on next page

Table 2—continued

Seed regions	Estimated area				
	Forests or potential forests				
	Alaska	Canada	Total	Nonforest	Total
	Hectares x 10^3				
15 Wellesley Lake[a]	85	210	295	66	361
16 Dawson Range[a]	295	185	480	91	571
17 Klondike River[3]	1,118	101	1,219	437	1,656
18 Old Crow Basin[a]	422	100	522	110	632
19 Northern mountains[3]	64	75	139	317	456
20 Yukon River	7,083	546	7,629	6,249	13,878
21 Upper Kobuk and Koyukuk Rivers (Central Brooks Range)	2,812		2,812	3,366	6,178
22 Northwest Arctic (Kotzebue Sound)	1,580		1 580	5,012	6,592
23 Beyond Arctic limits of *Picea glauca*	335		335	28,523	28,858
24 Beyond southwest coastal limits of *Picea* spp	410		410	10,412	10,822
Total	51,853	1,347	53,200	93,760	146,960
Major areas in Alaska exclusive of seed regions					
Large glaciers and snowfields					6,087
St Lawrence and Nunivak Islands					864
Grand total					153,911

[a] An ecoregion of Yukon extended into Alaska (Oswald and Senyk 1977)

Estimated potential forest land beyond coastal and arctic spruce tree limits was 442 000 hectares (1,090,000 acres) in seed region 03, 110 000 hectares (270,000 acres) in seed region 10, and 745 000 hectares (1,840,000 acres) in seed regions 23 and 24 (table 3) Potential forest land devoid of trees within and beyond natural spruce limits in Alaska was 3 674 000 hectares (9,080,000 acres) This estimation may be conservative Sitka spruce has been successfully introduced to many sites in the Aleutian Islands (region 24) for more than 180 years (Alden and Bruce 1989, Bruce and Court 1945, Lutz 1963)

Text continues on page 26

Table 3—Alaska seed zones and potential forest and nonforest area

Geographic area	Seed zone code[a]	Estimated area				
		Forests or potential forests			Nonforest[b]	Total
		Alaska	Canada	Total		
		Hectares x 10^3				
Southeast Alaska						
Southeast Alaska	010000					
Portland Canal—	010100	101	88	189	85	274
Hyder	010101	101	88	189	85	274
Behm Canal Mainland—	010200	444	28	472	234	706
Smeaton Bay	010201	284	28	312	106	418
Leduc River	010202	94			50	144
Burroughs Bay	010203	66			78	144
Revilla and adjacent islands—	010300	641		641	70	711
Ketchikan	010301	188				188
Mount Reid	010302	152				152
Cleveland Peninsula	010303	159			3	162
Bradfield Canal	010304	142			67	209
Prince of Wales and adjacent islands—	010400	836		836	33	869
Hydaburg	010401	244			25	269
Kasaan	010402	200				200
Craig	010403	123				123
Thorne Bay	010404	158			8	166
Shaken Bay	010405	111				111
Wrangell and adjacent islands—	010500	166		166	11	177
Etolin Island	010501	74			8	82
Wrangell Island	010502	47			3	50
Zarembo Island	010503	45				45
Kupreanot and adjacent islands—	010600	508		508	52	560
Kuiu Island	010601	184			31	215
Kupreanof Island	010602	209			20	229
Mitkof Island	010603	115			1	116
Frederick Sound-Stephens Passage mainland—	010700	175		175	496	671
Stikine River	010701	61			134	195
Thomas Bay	010702	26			155	181
Port Houghton	010703	47			125	172
Endicott Arm	010704	41			82	123
Admiralty Island—	010800	263		263	162	425
Angoon	010801	147			82	229
Seymour Canal	010802	116			80	196
Baranof and adjacent islands—	010900	418		418	67	485
Whale Bay	010901	49			4	53
Port Alexander	010902	106			26	132
Sitka	010903	126			23	149
Baranof	010904	137			14	151

Footnote on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area: Forests or potential forests: Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Chichagof and adjacent islands—	011000	531		531	47	578
Chichagof	011001	156			15	171
Tenakee	011002	219			18	237
Hoonah	011003	156			14	170
Juneau mainland-	011100	179		179	490	669
Whiting River	011101	64			168	232
Taku	011102	56			122	178
Favorite Channel	011103	23			68	91
Bermers Bay	011104	36			132	168
West Lynn Canal mainland—	011200	68		68	118	186
Icy Strait	011201	37			52	89
Endicott River	011202	31			66	97
Upper Lynn Canal mainland—	011300	90		90	409	499
Haines	011301	30			98	128
Chilkat River	011302	40			243	283
Skagway	011303	20			68	88
Glacier Bay—	011400	210		210	517	727
Gustavus	011401	45			23	68
Fairweather Range	011402	60			70	130
Muir Inlet	011403	25			161	186
Reid Inlet	011404	27			145	172
Palma Bay	011405	28			34	62
Lituya Bay	011406	25			84	109
Yakutat—	011500	223		223	413	636
Dry Bay	011501	60			151	211
Situk	011502	133			97	230
Malaspina	011503	30			165	195
Region total		4,853	116	4,969	3,204	8,173
Southcoastal Alaska:						
Gulf of Alaska	020000					
Yakataga—	020100	94		94	274	368
Icy Bay	020101	13			124	137
Robinson Mountains	020102	25			86	111
Suckling Hills	020103	56			64	120
East Prince William Sound mainland—	020200	321		321	442	763
Bering River	020201	76			76	152
Copper River Delta	020202	101			163	264
Cordova	020203	92			88	180
Lowe River	020204	52			115	167

Footnotes on page 25.

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area				
		Forests or potential forests			Nonforest[b]	Total
		Alaska	Canada	Total		
		Hectares x 10^3				
West Prince William Sound mainland—	020300	242		242	320	562
Unakwik Inlet	020301	65			98	163
College Fiord	020302	39			64	103
Turnagain Arm	020303	59			91	150
Whittier	020304	47			40	87
Nellie Juan	020305	32			27	59
Prince William Sound islands-	020400	205		205	92	297
Kayak	020401	7			6	13
Hinchmbrook	020402	28			19	47
Naked	020403	6				6
Esther	020404	17			1	18
Chenega	020405	30			11	41
Knight	020406	25			1	26
Northern 1/2 of Montague	020407	31			18	49
Southern 1/2 of Montague	020408	28			18	46
Bainbndge	020409	33			18	51
Southern Kenai Peninsula—	020500	257		257	386	643
Blying Sound	020501	15			27	42
Seward	020502	57			64	121
Aialik Bay	020503	24			94	118
Nuka Bay	020504	42			57	99
Portlock	020505	37			26	63
Seldovia	020506	39			46	85
Kachemak Bay	020507	43			72	115
Region total		1,119		1,119	1,514	2,633
Shehkof Strait	030000					
Afognak and adjacent islands—	030100	183		183	59	242
Barren Islands	030101	6				6
Shugak Island	030102	44			14	58
Tonki Peninsula	030103	69			19	88
Raspberry Island	030104	64			26	90
Kodiak and adjacent islands—	030200	380		380	703	1,083
Kzhuyak Bay	030201	39			26	65
Mann Range	030202	57			96	153
Uganic	030203	45			104	149
Zacher Bay	030204	55			181	236
Sitkahdak Island	030205	46			68	114
Kaguyak	030206	34			63	97
Trinity Islands	030207	32			18	50
Ayakulik	030208	72			147	219

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area: Forests or potential forests: Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
West Shelikof Strait-	030300	72		72	295	367
Cape Douglas	030301	15			24	39
Hallo Bay	030302	20			61	81
Kukak Bay	030303	12			63	75
Katmai Bay	030304	12			108	120
Puale	030305	13			39	52
South coast, Alaska Peninsula—	030400	80		80	303	383
Kanatak	030401	7			18	25
Wide Bay	030402	18			72	90
Aniakchak Bay	030403	25			112	137
Chignik Bay	030404	30			101	131
Region total		715		715	1,360	2,075
South-central Alaska:						
Cook Inlet	040000					
Kenai Interior—	040100	783		783	514	1,297
Resurrection Creek	040101	66			24	90
Summit Lake	040102	37			19	56
Moose Pass	040103	58			77	135
Kenai Lake	040104	33			29	62
Russian River	040105	33			26	59
Mystery Creek	040106	77			24	101
Swanson River	040107	115			42	157
Skilkak Lake	040103	61			61	122
Tustumena Lake	040109	128			122	250
Ninilchik	040110	86			14	100
Anchor River	040111	68			33	101
Fox River	040112	21			43	64
West Cook Inlet—	040200	444		444	571	1,015
Kustatan River	040201	190			78	268
Kalgin Island	040202	5				5
Redoubt	040203	44			43	87
Tuxedni Bay	040204	30			106	136
Iniskin Peninsula	040205	35			94	129
Augustine Island	040206	7			3	10
Ursus Cove	040207	41			32	73
Kamishak Bay	040208	70			149	219
Douglas River	040209	22			66	88
Region total		1,227		1,227	1,085	2,312

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area: Forests or potential forests: Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Matanuska Susitna	050000					
Susitna River—	050100	1,359		1,359	746	2,105
Talkeetna	050101	277			172	449
Kashwitna River	050102	140			125	265
Yentna River	050103	230			17	247
Skwentna River	050104	137			147	284
Beluga Lake	050105	144			27	171
Mount Susitna	050106	115			53	168
Knik Arm	050107	172			126	298
Anchorage	050108	144			79	223
Talkeetna Mountains—	050200	500		500	1,018	1,518
Tsusena River	050201	97			156	253
Curry	050202	54			144	198
Chulitna River	050203	70			72	142
Talkeetna River	050204	114			215	329
Chickaloon	050205	69			136	205
Sheep Mountain	050206	52			188	240
Knik River	050207	44			107	151
Region total		1,859		1,859	1,764	3,623
Copper River Plateau	060000					
Copper River—	060100	1,458		1,458	1957	3,415
Tanada Lake	060101	38			118	156
Cobb Lakes	060102	66			119	185
Chistochina River	060103	20			92	112
Gakona River	060104	222			118	340
Paxson Lake	060105	13			113	126
Tangle Lakes	060106	22			118	140
Maclaren River	060107	47			136	183
Clarence Lake	060108	11			151	162
Tyone	060109	78			212	290
Lake Louise	060110	227			167	394
Gulkana River	060111	113			61	174
Glennallen	060112	232			23	255
Tazuna Lake	060113	111			242	353
Klutina Lake	060114	61			114	175
Tonsina River	060115	50			79	129
Edgerton Highway	060116	147			94	241

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area				
		Forests or potential forests				
		Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Chitna River—	060200	514		514	1,260	1,774
Chitna	060201	105			159	264
Wood Canyon	060202	27			58	85
Tiekel River	060203	40			73	113
Thompson Pass	060204	19			28	47
Tasnuna River	060205	18			27	45
Bremner River	060206	98			187	285
Hanagita River	060207	29			58	87
Tana River	060208	58			149	207
Granite Creek	060209	4			122	126
Logan Glacier	060210	26			152	178
McCarthy	060211	78			109	187
Nizina River	060212	12			138	150
Region total		1,972		1,972	3,217	5,189
Alaska Range	070000					
Telaquana Mountains—	070100	97		97	557	654
South Fork Kuskokwim headwaters	070101	26			154	180
Big River	070102	17			98	115
Snowcap Mountain	070103	16			61	77
Merrill Pass	070104	8			65	73
Chakachamna Lake	070105	30			179	209
Denali glaciers-	070200	414		414	423	837
Ruth	070201	29			80	109
Dutch Hills	070202	115			62	177
Yenta River headwaters	070203	202			109	311
Rainy Pass	070204	48			96	144
Tordrillo Mountains	070205	20			76	96
Summit—	070300	255		255	891	1,146
Little Delta River headwaters	070301	14			65	79
Wood River headwaters	070302	11			84	95
Yanert Fork	070303	51			114	165
McKinley Park	070304	17			162	179
Broad Pass	070305	44			128	172
Cantwell	070306	47			120	167
Susitna River headwaters	070307	71			218	289
Isabel Pass—	070400	13		13	214	227
Mount Hayes	070401	2			26	28
Black Rapids	070402	9			46	55
Amphitheater Mountains	070403	2			142	144

Footnotes on page 25.

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area: Forests or potential forests: Alaska	Forests or potential forests: Canada	Forests or potential forests: Total	Nonforest[b]	Total
		Hectares x 10³				
Mentasta Pass—	070500	116		116	420	536
Macomb Plateau	070501	23			76	99
Robertson River headwaters	070502	17			77	94
Tok River headwaters	070503	19			86	105
Salana River	070504	29			75	104
Mentasta Mountains	070505	28			106	134
Wrangell Mountains—	070600	57		57	309	366
Nabesna River	070601	33			159	192
Nutzotm Mountains	070602	24			150	174
Region total		952		952	2,814	3,766
Southwest Alaska						
Southwest coastal	080000					
Nushagak River—	080100	1,106		1,106	3,313	4,419
Tlikokila River	080101	10			143	153
Turquoise Lake	080102	5			127	132
Kijik	080103	9			216	225
Chilikadrotna River	080104	61			260	321
Tutna Lake	080105	53			250	303
Lake Clark	080106	41			78	119
Tazimma Lakes	080107	8			92	100
Kaktuli River	080108	61			113	174
Mulchama River	080109	116			345	461
Nushagak Hills	080110	102			213	315
King Salmon River	080111	111			305	416
Tikchik Lakes	080112	97			343	440
Wood River Lakes	080113	53			167	220
Dillingham	080114	127			197	324
Nunachuak	080115	252			464	716
Ihamna—	080200	536		536	2,037	2,573
Pile Bay	080201	28			200	228
Kakhonak Bay	080202	38			205	243
Ihamna Lake	080203	102			405	507
Kvichak River	080204	73			259	332
Kukaklek-Nonvianuk Lakes	080205	55			213	268
Savonoski River	080206	17			94	111
Lake Grosvenor	080207	41			117	158
Naknek Lake	080208	53			108	161
Lake Brooks	080209	49			138	187

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area: Forests or potential forests: Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Butteress Range	080210	4			78	82
King Salmon headwaters	080211	25			88	113
Becharof Lake	080212	51			132	183
Region total		1 642		1,642	5,350	6,992
Lower Kuskokwim-Yukon Rivers	090000					
Yukon River Delta—	090100	1,260		1,260	2,052	3,312
Atchuehnguk River	090101	20			122	142
East Fork	090102	71			218	289
Pastol River	090103	242			349	591
Andreafsky River	090104	48			165	213
Nageethluk River	090105	161			223	384
St Marys	090106	488			746	1,234
Ihvit Mountains	090107	230			229	459
Kuskokwim River Delta—	090200	637		637	2,632	3 269
Aniak	090201	131			229	360
Bethel	090202	161			645	806
Aniak River headwaters	090203	69			234	303
Kilbuck Mountains	090204	15			341	356
Kwethluk River	090205	16			167	183
High Lake	090206	99			212	311
Ahklun Mountains	090207	9			296	305
Togiak Lake	090208	37			158	195
Togiak	090209	61			160	221
Kulukak River	090210	39			190	229
Region total		1,897		1,897	4 684	6 581
Northwest Alaska						
West coastal (Norton Sound)	100000					
Bering Strait—	100100	110		110	1,302	1 412
Agiapuk River	100101	20			248	268
Noxapaga River	100102	35			417	452
Kuzitnn River	100103	30			430	460
Kigluaik Mountains	100104	25			207	232
Seward Peninsula—	100200	648		648	1 598	2,246
Eldorado River	100201	24			187	211
Niukluk River	100202	50			324	374
Darby Mountains	100203	89			174	263
Koyuk River	100204	105			245	350

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area				
		Forests or potential forests				
		Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x *1<P*				
Tubutulik River	100205	113			147	260
Norton Bay	100206	135			231	366
Shaktoolik River	100207	132			290	422
Stephens Pass—	100300	408		408	578	986
North River	100301	69			114	183
Unalakleet River	100302	214			189	403
Golsovia River	100303	56			119	175
Pikmiktalik River	100304	69			156	225
Region total		1,166		1,166	3,478	4,644
Interior Alaska						
Central Alaska basins	110000					
Yukon River—	110100	3,349		3,349	1,300	4,649
Melozitna River headwaters	110101	129			12	141
Tozina River	110102	287			75	362
Tanana to Rampart	110103	181			41	222
Bean Ridge	110104	128			59	187
Tanana	110105	232			107	339
Little Melozitna River	110106	229			71	300
Melozitna River	110107	197			34	231
Kokrine Hills	110108	403			176	579
Big Mud River	110109	207			91	298
Chitanana River	110110	200			160	360
Titna River	110111	247			60	307
Nowitna River	110112	126			153	279
Susulatna River	110113	189			129	318
Sulatna River	110114	227			60	287
Yuki River	110115	367			72	439
Koyukuk River—	110200	2,166		2,166	1,365	3,531
Hogatza River	110201	168			40	208
Purcell Mountains	110202	121			43	164
Huslia River	110203	133			63	196
Dubli Flats	110204	409			318	727
Dubli River	110205	196			68	264
Natlaratlen River	110206	291			289	580
Kateel River	110207	202			116	318
Nulato River	110208	238			82	320
Kaiyuh Lakes	110209	327			340	667
Whakatna (Bear) Creek	110210	81			6	87

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area				
		Forests or potential forests				
		Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Innoko River—	110300	2,982		2,982	2,126	5,108
Little Mud River	110301	82			80	162
Kaiyuh Mountains	110302	217			175	392
Mud River	110303	318			218	536
North Fork Innoko	110304	185			74	259
Dishkakat Flats	110305	194			126	320
Innoko River headwaters	110306	164			115	279
Dishna River	110307	126			71	197
Beaver Mountains	110308	122			55	177
Yetna River	110309	310			366	676
Shageluk Slough	110310	234			157	391
Anvik River headwaters	110311	149			143	292
Bonasila River Basin	110312	101			50	151
Stuyahok River	110313	147			79	226
Holy Cross	110314	125			197	322
Reindeer River	110315	173			42	215
Iditarod River	110316	198			62	260
Paimiut Hills	110317	137			116	253
Region total		8,497		8,497	4,791	13,288
Kuskokwim Mountains	120000					
Upper Kuskokwim River—	120100	2,288		2,288	2 128	4,416
Haystack Mountain	120101	190			90	280
Bearpaw River	120102	159			114	273
Lake Minchumina	120103	234			361	595
East Fork Kuskokwim	120104	348			370	718
North Fork Kuskokwim	120105	149			53	202
South Fork Kuskokwim	120106	534			546	1,080
Post River	120107	20			229	249
Big River headwaters	120108	33			120	153
McGrath	120109	300			94	394
Nixon Fork Kuskokwim	120110	148			124	272
Takotna River	120111	173			27	200
Central Kuskokwim Basin—	120200	2,953		2 953	1 304	4,257
Lyman Hills	120201	181			56	237
Swift River	120202	269			37	306
George River	120203	304			45	349
Sleetmute	120204	226			115	341
Stony River	120205	150			57	207
Gagaryah River	120206	95			33	128

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area				
		Forests or potential forests			Nonforest[b]	Total
		Alaska	Canada	Total		
		Hectares x 10^3				
North Fork Swift	120207	120			85	205
Lime Hills	120208	137			122	259
Telaquana Lake	120209	86			105	191
Whitefish Lake	120210	118			47	165
Hoholitna River	120211	153			33	186
South Fork Hoholitna	120212	164			148	312
Holitna River	120213	357			179	536
Chukowan-Kogrukluk Rivers	120214	302			81	383
Holokuk and Oskawalik Rivers	120215	291			161	452
Region total		5,241		5,241	3,432	8,673
Tanana Valley	130000					
Kantishna River—	130100	3,821		3 821	994	4,815
Rampart	130101	232			38	270
Hess Creek	130102	173			14	187
Tolovana River	130103	226			40	266
Chatanika River	130104	171			18	189
Minto Flats	130105	433			151	584
Hutlinana Creek	130106	111			27	138
Manley	130107	270			94	364
Chitsia Creek	130108	234			12	246
Toklat River	130109	163			17	180
Kantishna Hills	130110	76			170	246
Healy	130111	101			19	120
Totatlanika River	130112	73			70	143
Nenana	130113	353			30	383
Fairbanks	130114	438			66	504
Blair Lakes	130115	166			67	233
Delta Creek	130116	161			16	177
Shaw Creek	130117	131			16	147
Delta Junction	130118	222			54	276
Healy Lake	130119	87			75	162
White Mountains—	130200	1,770		1,770	767	2,537
Beaver Creek	130201	262			108	370
Preacher Creek	130202	139			60	199
Birch Creek headwaters	130203	181			126	307
Chatanika River headwaters	130204	131			2	133
Chena River	130205	408			40	448
Salcha River	130206	226			32	258
Salcha River headwaters	130207	116			74	190

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area: Forests or potential forests: Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x: 10^3				
Goodpaster River	130208	166			153	319
Charley River headwaters	130209	141			172	313
Tanana Valley—	130300	875		875	493	1,368
Lake George	130301	166			88	254
Dot Lake	130302	63			39	102
Tanacross	130303	164			72	236
Tetlin Lake	130304	187			96	283
Nabesna (Northway)	130305	149			85	234
Cheslina River	130306	75			49	124
Chisana River	130307	71			64	135
Region total		6,466		6,466	2,254	8,720
Ruby Range	140000					
White River—	140100	43	14	57	230	287
White River headwaters	140101	43	14	57	230	287
Region total		43	14	57	230	287
Wellesley Lake	150000					
Wellesley Mountain—	150100	85	210	295	66	361
Scottie Creek	150101	21	134	155	19	174
Snag River	150102	64	76	140	47	187
Region total		85	210	295	66	361
Dawson Range	160000					
Prindle Volcano—	160100	295	185	480	91	571
Sixty Mile River	160101	22	52	74	33	107
North Ladue River	160102	56	43	99	19	118
West Fork Ladue	160103	138		138	18	156
Ladue River	160104	79	90	169	21	190
Region total		295	185	480	91	571
Klondike River	170000					
Forty Mile River-	170100	1,118	101	1,219	437	1,656
North Fork	170101	157	101	258	79	337
Middle Fork	170102	364			113	477

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area				
		Forests or potential forests				
		Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Mosquito Fork	170103	128			100	228
South Fork	170104	214			68	282
West Fork	170105	123			43	166
East Fork	170106	132			34	166
Region total		1,118	101	1,219	437	1,656
Old Crow Basin	180000					
Old Crow River—	180100	422	100	522	110	632
Old Crow River headwaters	180101	121	10	131	8	139
Schaefer Creek	180102	31	67	98	6	104
Rapid River	180103	270	23	293	96	389
Region total		422	100	522	110	632
Northern Mountains	190000					
British Mountains—	190100	64	75	139	317	456
Joe Creek	190101	9	64	73	160	233
Firth River	190102	55	11	66	157	223
Region total		64	75	139	317	456
Yukon River	200000					
Brooks Range-	200100	1,226		1,226	2,753	3979
Davidson Mountains	200101	47			200	247
Sheenjek River headwaters	200102	25			177	202
Sheenjek River	200103	72			231	403
Junjik River	200104	50			432	482
Arctic Village	200105	86			253	339
Wind River	200106	43			242	285
Middle Fork Chandalar	200107	75			255	330
North Fork Chandalar	200108	27			158	185
Chandalar Lake	200109	33			126	159
Chandalar River	200110	97			215	312
East Fork Chandalar	200111	172			120	292
Smoke Creek	200112	91			36	127
Christian River headwaters	200113	158			127	285
Koness River	200114	150			181	331
Porcupine River—	200200	2,160	282	2,442	993	3,435
Coleen River	200201	228			102	330
Pass Creek	200202	210			115	325

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area: Forests or potential forests: Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Shoulder Mountains	200203	187			92	279
Black River	200204	409			203	612
Fish Creek	200205	302			26	328
Salmon Village	200206	403			185	588
Tetthajik Creek	200207	46	161	207	180	387
Salmon Fork Black River	200208	117	121	238	74	312
Wood River	200209	258			16	274
Yukon Flats—	200300	3,697	264	3,961	2,503	6,464
Christian River	200301	202			33	235
Venetie	200302	327			75	402
Hadweenzic River	200303	150			37	187
Hodzana River	200304	163			140	303
Ray River	200305	262			126	388
Birch Creek	200306	1,066			983	2,049
Little Black River	200307	439			253	692
Central	200308	154			67	221
Takoma Bluff	200309	73			50	123
Paddle Creek	200310	210			67	277
Woodchopper Creek	200311	256			199	455
Kandik River	200312	98	68	166	53	219
Nation River	200313	159	56	215	111	326
Eagle	200314	137	41	178	196	374
Tatonduk River	200315	1	99	100	113	213
Region total		7,083	546	7,629	6,249	13,878
Central Brooks Range	210000					
Endicott Mountains—	210100	567		567	1,890	2,457
Dietrich River	210101	14			288	302
Gates of the Arctic	210102	21			174	195
John River	210103	44			250	294
Alatana River headwaters	210104	34			326	360
Alatana River	210105	94			187	281
Allen River	210106	53			204	257
Middle Fork Koyukuk	210107	118			184	302
South Fork Koyukuk	210108	74			138	212
Jim River	210109	115			139	254
Upper Koyukuk River—	210200	1,825		1,825	631	2,456
Bettles	210201	102			43	145
Sozhekla River	210202	109			31	140
Struk Creek	210203	205			11	216

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area				
		Forests or potential forests				
		Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Hogatza River headwaters	210204	242			41	283
Hughes Creek	210205	147			34	181
Indian River	210206	258			57	315
Allakaket	210207	246			40	286
South Fork Koyukuk Flats	210208	133			69	202
Kanuti Flats	210209	270			146	416
Kanuti River headwaters	210210	98			56	154
Kilolitna River	210211	15			103	118
Upper Kobuk River—	210300	420		420	845	1,265
Walker Lake	210301	35			82	117
Reed River	210302	122			139	261
Mauenluk River	210303	57			386	443
Lockwood Hills	210304	131			139	270
Pah River Flats	210305	75			99	174
Region total		2,812		2,812	3,366	6,178
Northwest Arctic Noatak River—	220000	365		365	919	1,284
Trail Creek	220101	38			176	214
Kelly River	220102	19			131	150
Kaluktavik River	220103	100			233	333
Eh River	220104	190			257	447
Igichuk Hills	220105	18			122	140
Kobuk River—	220200	497		497	1,508	2,005
Ambler River	220201	75			221	296
Shungnak Flats	220202	63			181	244
Kiana to Ambler	220203	197			235	432
Hunt River	220204	19			110	129
Salmon River	220205	11			169	180
Squirrel River	220206	78			334	412
Kobuk River Delta	220207	54			258	312
Kotzebue Sound—	220300	718		718	2,585	3,303
Selawik River headwaters	220301	27			149	176
Kugarak River	220302	21			188	209
Waring Mountains	220303	60			214	274
Selawik River Flats	220304	179			325	504
Tagagawik River	220305	106			141	247
Buckland River headwaters	220306	59			186	245
Kouk River	220307	9			250	259
West Fork Buckland	220308	195			260	455
Kiwalik River	220309	27			209	236

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area				
		Forests or potential forests				
		Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Kugruk River	220310	35			663	698
Region total		1,580		1,580	5,012	6,592
Arctic Alaska-						
Beyond Arctic limits of *Picea glauca*	230000					
North Slope—	230100	105		105	3,496	3,601
Kongakut River	230101	20			326	346
Romanzof Mountains	230102	15			396	411
Hulahula River	230103	15			380	395
Canning River	230104	15			440	455
Marsh Fork Canning	230105	5			314	319
Phillip Smith Mountains	230106	5			695	700
Sagavanirktok River	230107	5			517	522
Toolik River	230108	25			428	453
Coville River—	230200	120		120	3,377	3,497
Anaktuvuk River	230201	22			724	746
Chandler River	230202	20			599	619
Anaktuvuk Pass	230203	5			505	510
Killik River headwaters	230204	8			421	429
KilliK River	230205	25			293	318
Kuparuk River	230206	35			489	524
Nigu River	230207	5			346	351
DeLong Mountains—	230300	110		110	21,650	21,760
Aniuk River	230301	15			332	347
Noatak River headwaters	230302	10			386	396
Cutler River	230303	15			322	337
Nanelik River	230304	10			105	115
Anisak River	230305	15			237	252
Nimiuktuk River	230306	25			199	224
Aklumayuak Creek	230307	20			264	284
Tundra--Salix species only	230308				19,805	19,805
Region total		335		335	28,523	28,858
Beyond southwest coastal limits of *Picea* species	240000					
Kuskokwim Bay—	240100				4,274	4,274
Beyond tree limits (no trees reported except *Alnus* and *Salix* spp.)	240101				4,274	4,274

Footnotes on page 25

Table 3—continued

Geographic area	Seed zone code[a]	Estimated area: Forests or potential forests: Alaska	Canada	Total	Nonforest[b]	Total
		Hectares x 10^3				
Bristol Bay—	240200	210		210	1,105	1,315
Arolik River	240201	25			183	208
Goodnews River	240202	35			214	249
Osviak River	240203	25			261	286
Kulukak Bay	240204	30			60	90
Nushagak Bay	240205	40			237	277
Kuichak Bay	240206	55			150	205
North coast, Alaska peninsula—						
Beyond tree limits (no native trees reported except *Alnus* and *Salix* spp)	240300	200		200	5,033	5,233
Aleutian Range	240301	200			5,033	5,233
Region total		410		410	10,412	10,822

a Region subregions and seed zones are coded with 2 digits each Seed zone codes follow subregion codes which in turn follow the region code

b Includes all rivers fjords and lakes and all glaciers or permanent snowfields less than about 20 000 ha (50 000 acres)

Discussion

The climate of major geographic areas and seed regions with potential for forest development in Alaska is summarized in table 1. Seed regions 01 to 03 are confined entirely to the coastal maritime climate of the Gulf of Alaska (fig. 2). Seed region 01 is in the northern maritime temperate zone of North America. The climate is colder and growing seasons are shorter in regions 02 and 03 than in region 01. The heights of forests in regions 02 and 03 are less than predicted from latitude, growing season temperature, and soil productivity (Farr and Harris 1979).

Between the coastal seed regions and the Alaska Range (regions 04 to 07), the climate changes from cold maritime to subarctic continental. Subarctic continental climates are characterized by warm dry summers and long cold winters. In interior Alaska, the subarctic continental climate extends from the Alaska Range in the south to the Brooks Range in the north and includes regions 11 to 21. At the western limit of trees in interior Alaska (regions 08 to 10), the climate changes to maritime subarctic. Seed regions 22 and 23 and subregion 2103 are north or west of the Continental Divide and include rivers flowing from the Brooks Range and Seward Peninsula into the Arctic Ocean. Subregions and seed zones were delineated for balsam poplar in region 23, which has an arctic climate and is north of spruce tree limits. Subregions and seed zones were not delineated in region 24 which is beyond the natural limits of all trees except *Salix* species, although seeds have been harvested from Sitka spruce introduced to the Shumagin and Aleutian Islands during the 19th and early 20th centuries.

The productivity of forest and potential forest land in Alaska can be enhanced with cultivation and introduction of adapted tree species and provenances. The geographic areas and seed regions in table 1 can serve as introduction zones or provenance test zones for indigenous and exotic species with well known environmental requirements. The procedure for introducing potential species is to test many provenances at as many sites as possible in a designated test region or introduction zone. Based on test results, similar sites can be grouped into plantation zones, and similar provenances within the natural range of the species can be grouped into provenance zones for intensive sampling. A provenance zone is the area within the natural range of a species where provenances have potential for adaptation to a plantation zone. Plantation zones may or may not be in the natural range of the species (Campbell 1974).

A breeding zone is the geographic area in which productivity of a population or strain of trees will be improved (Johnson 1984). Plantation zones are refined seed zones; they can serve as breeding zones for genetic improvement of adapted populations of either indigenous or exotic species. Provisional seed zones with relatively homogeneous environments within physiographic features (genetic barriers) can serve as breeding zones for genetic improvement of indigenous tree species.

Provisional seed zones and transfer guidelines for each species need revision after long term stability of many provenances is determined for a variety of habitats Habitats can be grouped into seed-use or plantation zones when provenances (and their genotypes) express provenance (genotype) x environment interaction for adaptative and growth traits and cause genetic correlations to depart from perfect relations (Burdon 1977, Wellendorf and others 1986) Genotype x environment interaction is the differential response of provenances, populations, families, and genotypes to environmental conditions Losses from seed transfer may be less if habitats are grouped into seed-use zones by genotype x environment interactions than if provenances are selected for fitness to a wide range of sites (Shelborne and Campbell 1976) Seed transfer effects and provisional seed-use or plantation zones can also be modeled from mortality rates in relation to severity of test sites (Campbell 1974 Eriksson and others 1980) Environmental and associated genetic variation are extreme in moun tainous regions of Alaska, and financial resources are inadequate for numerous long term field trials Provisional seed zones can be refined economically from relations of the genetic (clinal) variation in adaptative traits of genotypes grown in short-term common environment studies and location variables of their provenances following the methods of Campbell (1986), Campbell and Sugano (1987), and Campbell and others (1989)

Recommendations

Transfer Guidelines

Seed transfer guidelines are necessary to maintain the genetic integrity and diversity of forest tree species and reduce the risk of maladaptation in artifical reforestation programs The following procedures are recommended for harvest and use of tree seeds in Alaska

1. Record the geographic source (provenance) of each cone and seed collection The exact geographic origin (provenance) of the first-generation seed parents is needed to transfer seeds among similar habitats within seed zones and to meet source-identified certification standards for domestic and world trade Minimium seed certification standards are established by the Association of Official Seed Certifying Agencies of the United States and Canada for domestic use in all States and Provinces and by the Organization for Economic Cooperation and Development in world trade (Rudolf 1974) Minimum standards for source-identified seeds of each provenance in Alaska include the name of the collection area or nearest landmark, latitude and longitude to the nearest minute of arc (or township, range, and section), and altitude to the nearest 10 meters (about 30 ft) above m s l

Assign a six digit seed zone identification code to each collection

Physiographic and climatic region	=	xx
Physiographic subregion	=	yy
Seed zone number	=	zz
Complete seed zone code	=	xxyyzz

2. Collect seeds from at least 30 well-distributed trees (unrelated trees) for reforestation of each local population Record the number of seed trees in each collection to document the genetic base

3. Transfer seeds only from natural populations in environments that are similar to the environment of the planting sites

4 Avoid transfer of seeds from upland populations to flood-plain sites and from flood-plain populations to upland sites

5. Restrict transfer of seeds to 100 meters (330 ft) in altitude of its indigenous source in upland and montane zones

6. Transfer seeds among similar habitats within seed zones as first priority, among similar habitats and seed zones within subregions as second priority, and among similar sites and subregions within seed regions as last priority Always observe rules 1 through 5, above, when transferring seeds to new habitats Transfer of seeds between zones along seed region and subregion boundaries with continuous populations is preferable to long distance transfer of seeds within seed regions and subregions Transfer of seeds across major genetic barriers, for example mountains above treelines, should be avoided

These guidelines apply to the transfer of all forest reproductive materials, such as ortets of cuttings or other vegetative propagules from native populations, used in forestation and commercial trade in Alaska

An index (base map) for Alaska seed zones on 1 250,000-scale (1 inch = 4 miles) U S Geological Survey Alaska Boundary Series and Department of Energy, Mines and Resources, Ottawa, Canada, topographic maps is inserted in the back cover of this report Contour intervals are 200 feet (61 meters) Reprints from 1 250,000-scale Mylar overlays can be obtained from the USDA Forest Service, Alaska Region, P O 21628, Juneau Alaska 99802-1628 USDA Forest Service, State and Private Forestry, 201 E 9th Avenue, Suite 206, Anchorage, Alaska 99501-3687, and Alaska State Division of Forestry, 3601 C Street, Suite 1008, Anchorage, Alaska 99503 Orders for the maps should contain the seed zone names and numbers and latitude and longitude of each quadrat

A Standard Labeling System

A standard labeling system is needed for a common understanding of the genetic identity of seed sources used for forestation and to record the native geographic origin and other information for each collection at harvest, during propagation, and after forestation A labeling system adopted by the Alaska State Forest Nursery and similar to the 'standardized labeling system" of Buck and others (1970) is recommended for seed zones and transfer guidelines in Alaska This system provides for identification of species, collection whether from seed parent or ortet, seed orchard, a genetic cross seed zone, elevation and aspect of the native source, and the year of collection

Tree species is the first entry in the labeling system Codes for major tree species, varieties, and hybrids indigenous to Alaska are summarized for each seed region in table 4 Species are coded with the first two letters of the scientific names for the genus and species The first letter of a variety follows the species code as a lower case subscript and hybrids are coded with the first letter of each species after the two-letter genus code

Table 4—Major tree species of Alaska

Species[a]	Standard code	Common name	Seed region[b]
Abies amabilis Dougl ex Forbes	ABAM	Pacific silver fir	01
Abies lasiocarpa (Hook) Nutt	ABLA	Subalpine fir	01
Acer glabrum Torr var *douglasii* (Hook) Dipp	ACGLd	Douglas maple	01
Alnus crispa (Ait) Pursh	ALCR	American green alder	03-24
Alnus rubra Bong	ALRU	Red alder	01
Alnus sinuata (Regel) Rydb	ALSI	Sitka alder	01-09, 11, 13, 24
Alnus tenuifolia Nutt	ALTE	Mountain alder	01, 02, 04-09, 11-17, 20, 21, 24
Betula papyrifera Marsh •			
var *commutata* (Regel) Fern	BEPAc	Western paper birch	01
var *kenaica* (W H Evens) Henry	BEPAK	Kenai birch	02-05
var *neoalaskana* (Sarg) Raup	BEPAn	Alaska paper birch	06-18, 20-22
Chamaecyparis nootkatensis (D Don) Spach	CHNO	Alaska cedar	01, 02
Juniperus communis L[c]	JUCO	Common juniper	01, 02, 04-08, 10-23
Juniperus honzontalis Moench[c]	JUHO	Creeping juniper	06
Larix laricina (Du Roi) K Koch	LALA	Tamarack	07, 09, 11-13, 20, 21
Malus fusca (Raf) Schneid	MAFU	Oregon Crab apple	01, 02
Picea glauca (Moench) Voss	PIGI	White spruce	04-22
Picea x *lutzii* Little	PILU	Lutz spruce	01, 02, 04-06
Picea mariana (Mill) B S P	PIMA	Black spruce	04-07, 10-18, 20-22
Picea sitchensis (Bong) Carr	PISI	Sitka spruce	01-05
Picea sitchensis x *mariana* (new hybrid)	PISM		04
Pinus contorta Dougl ex Loud			
var *contorta*	PICOc	Shore pine	01
var *latifolia* Engelm	PICOi	Lodgepole pine	01
var *contorta* x var *latifolia*	PICOd		01
Populus balsamifera L	POBA	Balsam poplar	03-24
Populus balsamifera x trichocarpa	POBT		01, 03-06
Populus tremuloides Michx	POTE	Quaking aspen	01,04-18,20-22
Populus trichocarpa Torr & Gray	POTI	Black cottonwood	01-06
Salix alaxensis (Anderss) Cov	SAAL	Feltleaf willow	01-24
Salix arbusculoides Anderss	SAAR	Littletree willow	04-24
Salix bebbiana Sarg	SABE	Bebb willow	01-09, 11-13, 15, 17, 18, 20-22, 24
Salix hookerana Barratt	DAHD	Hooker willow	01, 02
Salix scoulerana Barratt ex Hook	SASC	Scouler willow	01-08, 11-18
Salix sitchensis Sanson ex Bong	SASI	Sitka willow	01-04, 06
Taxus brevifolia Nutt	TABR	Pacific yew	01
Thuja plicata Donn ex D Don	THPL	Western redcedar	01
Tsuga heterophylla (Raf) Sarg	TSHE	Western hemlock	01, 02
Tsuga mertensiana (Bong) Carr	TSME	Mountain hemlock	01, 02, 04, 05, 08

[a] Nomenclature follows Little (1979) and Viereck and Little (1972)
[b] Species distribution is from Viereck and Little (1975)
[c] Coniferous shrubs in Alaska *J communis* has circumpolar distributions and is the most widely distributed natural conifer in the world (Little 1979)

The seed collection, seed parent or ortet, orchard, or hybrid identification number is for certification purposes The identification number is separated with one space from the species code and a six-digit seed zone code Altitude above m s l x 10 meters (about 30 ft) is a three-digit code and is preceded by a decimal after the seed zone number Aspect is the azimuth or clockwise angle measured in degrees from true north to south to north, 0 to 360° It is a three-digit code following the slant line after altitude A level surface is coded as 000 and true north is coded as 360° Year of collection is two digits following a dash after aspect The example,

PiSi 17 010603 045/270-88 ,

represents a Sitka spruce seed collection from tree 17 in seed zone 010603 (Mitkof island) at 450 meters (1,476 ft) above m s l The aspect is 270° or due west, and the collection was made in 1988 Other provenance and transfer information may be added to the label as desired

Conclusions

Four hundred and eighty-six seed zones and 72 subregions were mapped in 24 physiographic and climatic seed regions for Alaska and western Yukon Altitudinal limits of spruce species ranged from sea level to about 1200 meters (3,900 ft) in the southeast and 1500 meters (4,900 ft) in the interior of Alaska Estimated forest and potential forest land in Alaska was 51 853 000 hectares (128,130,000 acres) including 1 297 000 hectares (3 200,000 acres) beyond coastal and Arctic spruce limits

Seed zone's transfer guidelines, and a standard labeling system that can record the genetic integrity and diversity of indigenous tree species were described Provisional seed zones will reduce the risk of maladaptation from seed transfer and can be used to identify populations for tree improvement, stratify geographic test regions for species and provenance introductions, and identify regions for resolution of genetic difference among populations and genotypes Provisional seed zones can be revised from improved environmental data for physiographic regions, from relations of genetic variation determined in short-term, common-environment trials and the geographic and environmental differences in seed origins and from the effects of seed transfer in long term field trials

Seed transfer guidelines are needed to maintain the genetic purity of seeds and propagules and to ensure that reproductive materials will perform as well as the parental populations before them Standard labels will provide a common reference for the geographic source of seed collections maintained in long-term reforestation records Long-term reforestation records are needed to certify the genetic origin, purity and performance of future seed crops

Acknowledgments

James Smith and Christian Teutsch measured the potential forest and total land areas of each seed zone The labeling standards for seed collections were recommended by Joseph Stehik, nursery manager Alaska State Forest Nursery Forestry staffs of the USDA Forest Service, Juneau and Fairbanks, Alaska, the Bureau of Indian Affairs, U S Department of the Interior, Juneau, Alaska, the State Division of Forestry and Bureau of Land Management, Anchorage, Alaska, and the University of Alaska Fairbanks, Alaska, reviewed the seed zone map and seed transfer guidelines

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Four hundred and eighty-six provisional tree seed zones were delineated within 24 physiographic and climatic regions of Alaska and western Yukon Territory Estimated forest and potential forest land within altitudinal limits of tree species in Alaska was 51 853 000 hectares (128,130,000 acres) Seed transfer guidelines and standard labeling of seed collections are recommended to reduce losses from maladaptation and maintain the genetic identity and productivity of future forests in Alaska

Keywords Alaska, seed zone, seed transfer and labeling guidelines, tree distribution, tree limit, forest area, genetic diversity, climate, physiography

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