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# Field Survey of Growth and Colonization of Nonnative Trees on Mainland Alaska

John Alden

## Author

**John Alden** was a forest geneticist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR, and is now Executive Director of the Alaska Reforestation Council, Inc., P.O. Box 82163, Fairbanks, AK 99708-2163.

## Abstract

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Six of nine nonnative boreal conifers in three genera (*Abies*, *Larix*, and *Pinus*) regenerated in 11 to 31 years after they were introduced to mainland Alaska. Lodgepole pine (*Pinus contorta* var. *latifolia* Engel.) and the Siberian larches (*Larix sibirica* Ledeb. and *L. sukaczewii* N. Dyl.) were the most widely introduced species and will likely be the first nonnative conifers to naturalize. Siberian larch grew up to six times more stem volume than white spruce in the first 40 years on upland sites, but was susceptible to the larch sawfly and a blue stain pathogen carried by bark beetles. On productive sites, lodgepole pine appeared to grow more stem wood than white spruce for about 35 years after planting. Snowshoe hares and moose were the most serious pests of the nonnative conifers. Balsam fir (*Abies balsamea* (L.) Mill.) was the only species to regenerate in an established moss understory. Growth and age relationships were negative for all adequately sampled nonnative conifers and positive for native white spruce (*Picea glauca* (Moench) Voss). Data were insufficient to assess niche availability for commercial use of productive nonnative conifers in mixed stands in Alaska. Survey results indicate that introduction and naturalization of noninvasive tree species may improve the diversity, stability, and productivity of managed forest ecosystems.

Keywords: Alaska, nonnative conifers, adaptation, regeneration, colonization, growth rates, wood yields, animal damage.

## Preface

To successfully invade new habitats, all nonnative species must complete three phases of introduction before they can be judged as either invasive or noninvasive:[1]

1. Introduction. Nonnative tree species depend on dispersal of their seeds or other propagules to new habitats. Introductions can be deliberate, but they are often accidental resulting from increased global trade and travel among countries.
2. Colonization. Successful colonization of nonnative trees depends on regeneration from production and local dispersal of propagules after they are introduced. Regeneration depends on favorable weather for meiosis, gamete formation, flowering, pollination, fertilization, and formation of viable embryos (seeds), or for vegetative reproduction. Favorable wind, water, and seed-gathering mammals and birds are usually necessary for dispersal of propagules such as seeds.
3. Naturalization. Naturalization is the permanent establishment and expansion of nonnative species without their reintroduction. Naturalization leads to expansion and the invasion of new habitats. If the nonnative species requires continual reinvasion for survival, it is not naturalized.

Naturalization of nonnative species is noninvasive if the environment is not significantly affected, if native flora and fauna are not displaced, and if there are no economic losses or effects on human health. Most naturalized tree species are noninvasive. Among about 250 invasive weed species on a global scale, only a few are nonnative *Pinus* that replace native forest flora and fauna locally and cause economic loss. In their native range and other forest habitats, these same *Pinus* are environmentally and economically beneficial.

This paper is a field survey of introduced conifers planned and funded by the Alaska Department of Natural Resources, Division of Forestry Central Office, Anchorage, AK 99501, and carried out by the Alaska Reforestation Council, Inc., P.O. Box 82163, Fairbanks, AK 99708 in 2002 and 2003.

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[1] Mulder, Christa. 2003. Characteristics of successful plant invaders and vulnerable habitats. 5 pages. In: Introduced and invasive species in resource management. Workshop sponsored by The Yukon River Chapter, Alaska Society of American Foresters, Fairbanks, Alaska. December 4–5, 2003.

## Summary

Six of nine nonnative boreal conifers in three genera (*Abies*, *Larix*, and *Pinus*) regenerated 11 to 31 years after their introduction to mainland Alaska. Lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) and the Siberian larches (*Larix sibirica* Ledeb. and *L.sukaczewii* N. Dyl.) were the most widely introduced species and will likely be the first nonnative conifers to naturalize in Alaska.

Siberian larch grew up to six times more stem volume than white spruce (*Picea glauca* (Moench) Voss) in the first 40 years on upland sites, but was susceptible to the larch sawfly (*Pristiphora erichsonii* Hartig) and a blue-stain-carrying bark beetle (*Dendroctonus simplex* LeConte). On productive sites, lodgepole pine appeared to grow more stem wood than white spruce for about 35 years after planting. Hares (*Lepus* sp.) and moose (*Alces alces* L.) were the most serious pests of the nonnative conifers. Most species regenerated on disturbed sites. Balsam fir (*Abies balsamea* (L.) Mill.) was the only species to regenerate in an established moss understory. The relationship of growth with age was negative for all adequately sampled nonnative conifers and positive for native white spruce.

Data are insufficient to assess niche availability for commercial utilization of productive nonnative conifers in mixed stands in Alaska. Survey results indicate that introduction and naturalization of noninvasive tree species may improve the diversity, stability, and productivity of managed forest ecosystems. Introduction of nonnative tree species may favorably alter the habitat for the indigenous wildlife as well. The plantings in this survey should be reexamined within 20 years to determine if more conifers are colonizing forest habitats in Alaska, and if some have naturalized.

## Contents

## Introduction[1]

Exotic or nonnative tree species have been managed in forestry, landscaping, windbreaks, and for aesthetics and other amenity purposes throughout the world for centuries. The transfer of a western Siberian larch (*Larix sukaczewii* N. Dyl.) provenance 500 km southwest of its natural range on Russia's White Sea to the Gulf of Finland in 1738 was one of the earliest and most successful examples of exotic forestry in the boreal region (Alden 2003, Lähde et al. 1984, Redko and Mälkönen 2005, Viherä-Aarnio and Nikkanen 1992). The introductions were made to grow decay-resistant timber for cargo shipbuilding in the 18$^{th}$ century. Long after wooden ships became obsolete in the 19$^{th}$ century, the introductions were found to be the most productive larch provenances north of 60° latitude in Scandinavia and Iceland. The exotic seed source is widely known as "Raivola larch," a cultivar or race named for a railroad station near the original introductions in the "Lintula Park" or "Lintula Larch Forest" near the Finnish border with Russia (Redko and Mälkönen 2005). The Raivola larch plantation is reported to be "the most magnificent stand in northern Europe  and one of the most remarkable forest cultures in the whole of Europe" (Viherä-Aarnio and Nikkanen 1992).

Historically, the primary reasons for introducing nonnative species were to increase wood yields for industrial forestry. Introduced nonnative tree species can enrich the biodiversity and improve the productivity of low-diversity forests (Andersson and Rosvall 1999). Examples of forest areas with few tree species are the harsh sites found in northern Scandinavia, northern Russia, northern Alaska, Iceland, and isolated islands or desert regions of the world. In absence of productive native tree species, exotics may double growth and yields compared to the 10 to 20 percent improvement per generation from conventional tree selection and breeding of the indigenous species.

But nonnative introductions may potentially spread uncontrollably, suppress indigenous species, and carry virulent pathogens or insect parasites of an indigenous species (Andersson and Rosvall 1999, Engelmark et al. 2001). The nonnative species may also be susceptible to indigenous pathogens or insect parasites, leading to a buildup of inoculums or insect populations that may cause epidemics. A foreign species may also cross with native species producing unstable hybrids,

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[1] This paper presents material revised from written reports presented to the Alaska State Board of Forestry, August 6, 2003, and to the Society of American Foresters—Continuing Forestry Education workshop "Introduced and Invasive Species in Resource Management." December 4–5, 2003, Fairbanks, Alaska.

contaminate species gene pools, change soil properties, and alter ecosystem processes. Results can be either negative or positive and are reasons for provenance research before species are introduced on a large scale.

This report presents the results of a 2002 survey of nonnative conifers introduced to 55 sites in northern Alaska. Most sites had small trial plantings without replication. Objectives of the survey were to determine if the introduced conifers (1) grew more rapidly than the native (indigenous) tree species, (2) if they were free of pests and winter injury, (3) if they had successfully reproduced, and (4) if they found satisfactory ecological niches in which to eventually naturalize, and either increase forest diversity and productivity or invade natural ecosystems by replacing native flora and fauna.

Lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) and the Siberian larches (*Larix sukaczewii* N. Dyl. and *Larix sibirica* Ledeb.), the most commonly planted nonnative conifers in northern Alaska, were the primary target species in this survey. Other less commonly planted nonnative species surveyed were Scotch pine (*Pinus sylvestris* L.), jack pine (*Pinus banksiana* Lamb.), Norway spruce (*Picea abies* (L.) Karst.), balsam fir (*Abies balsamea* (L.) Mill.), Siberian fir (*Abies sibirica* Ledeb.), Dahurian larch (*Larix dahurica* Trucz.), and Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* (Mirb.) var. *glauca* (Beissn.) Franco). Data for planted white spruce (*Picea glauca* (Moench) Voss) and natural paper birch (*Betula papyrifera* var. *neoalaskana* (Sarg.) Raup) and aspen (*Populus tremuloides* Michx.) are also mentioned. The sites and trees measured for the native and minor non-native species were limited.

To invade new habitats after introduction, each of the above species must first colonize (reproduce) successfully, and secondly naturalize by demonstrating long-term survival and ability to successfully spread to new sites (Mulder 2003, footnote 1). From Eric Hulten's (1968) *Flora of Alaska and Neighboring Territories*, Ager and Brubaker (1985) reported that more than 200 nonnative vascular species were added to Alaska's native flora during the past two centuries. European mountain ash (*Sorbus aucuparia* L.) was the only nonnative tree that naturalized in Alaska during this time (Little 1979).

## Procedures

### Establishment and Growth of Nonnative Parental Populations

One or more nonnative conifers were surveyed for tree survival, growth, and natural regeneration on each of 55 sites in interior Alaska (Tanana Valley), south-central Alaska (Matanuska-Susitna, or Mat-Su Valley), western Kenai Peninsula and Cook Inlet, and mid Copper River Valley on mainland Alaska (fig. 1, table 1, app. 1). Planting site and species characteristics considered for the survey were:

I. Site history:
   A. Quality
   B. Soils
   C. Vegetation
   D. Prior use
   E. Site preparation
   F. Present site conditions

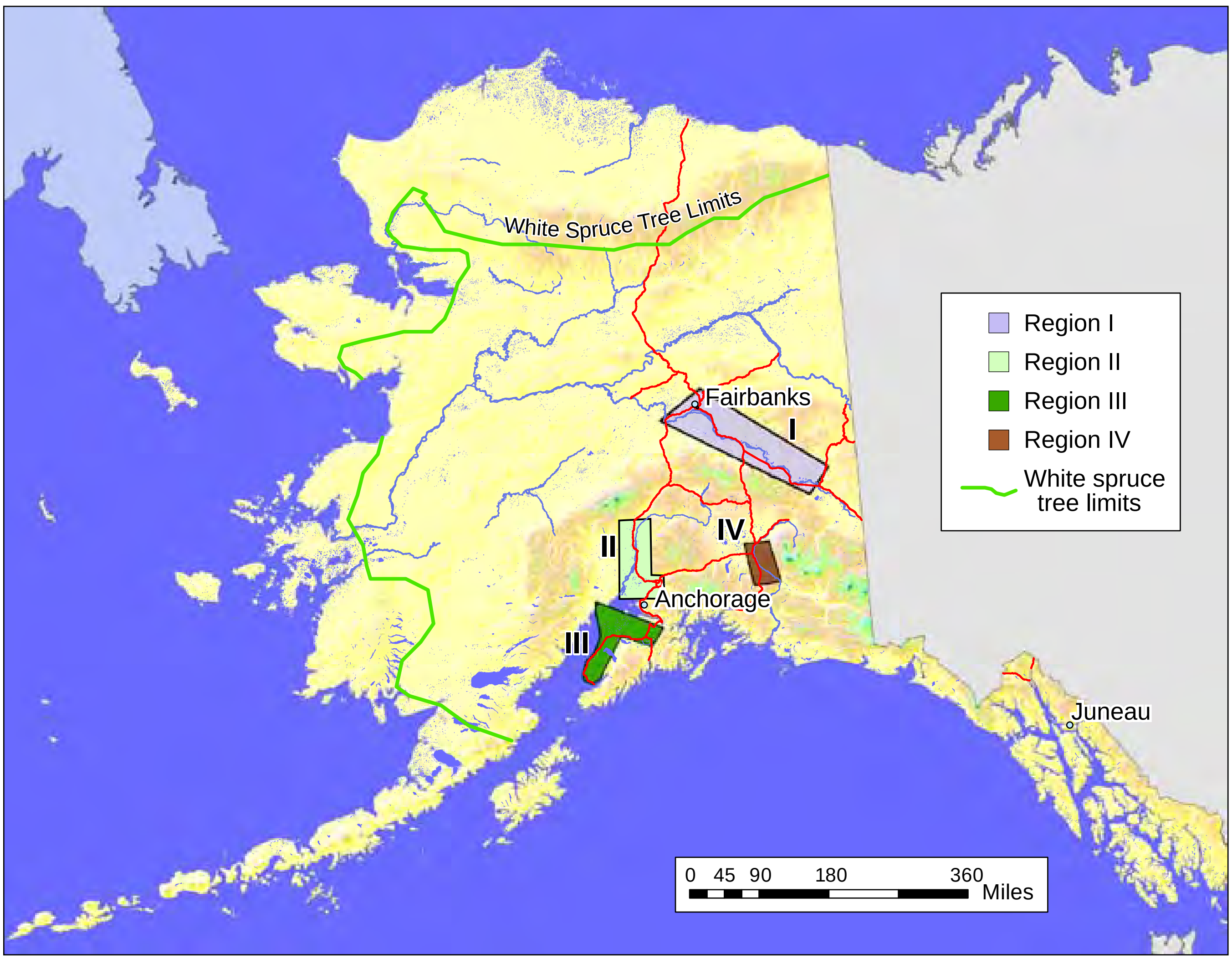


Figure 1a—Regions on mainland Alaska surveyed for nonnative conifers in 2002 and 2003, and locations of sites and plantings on 250-meter-resolution Modis 2003 satellite imagery for each region below.

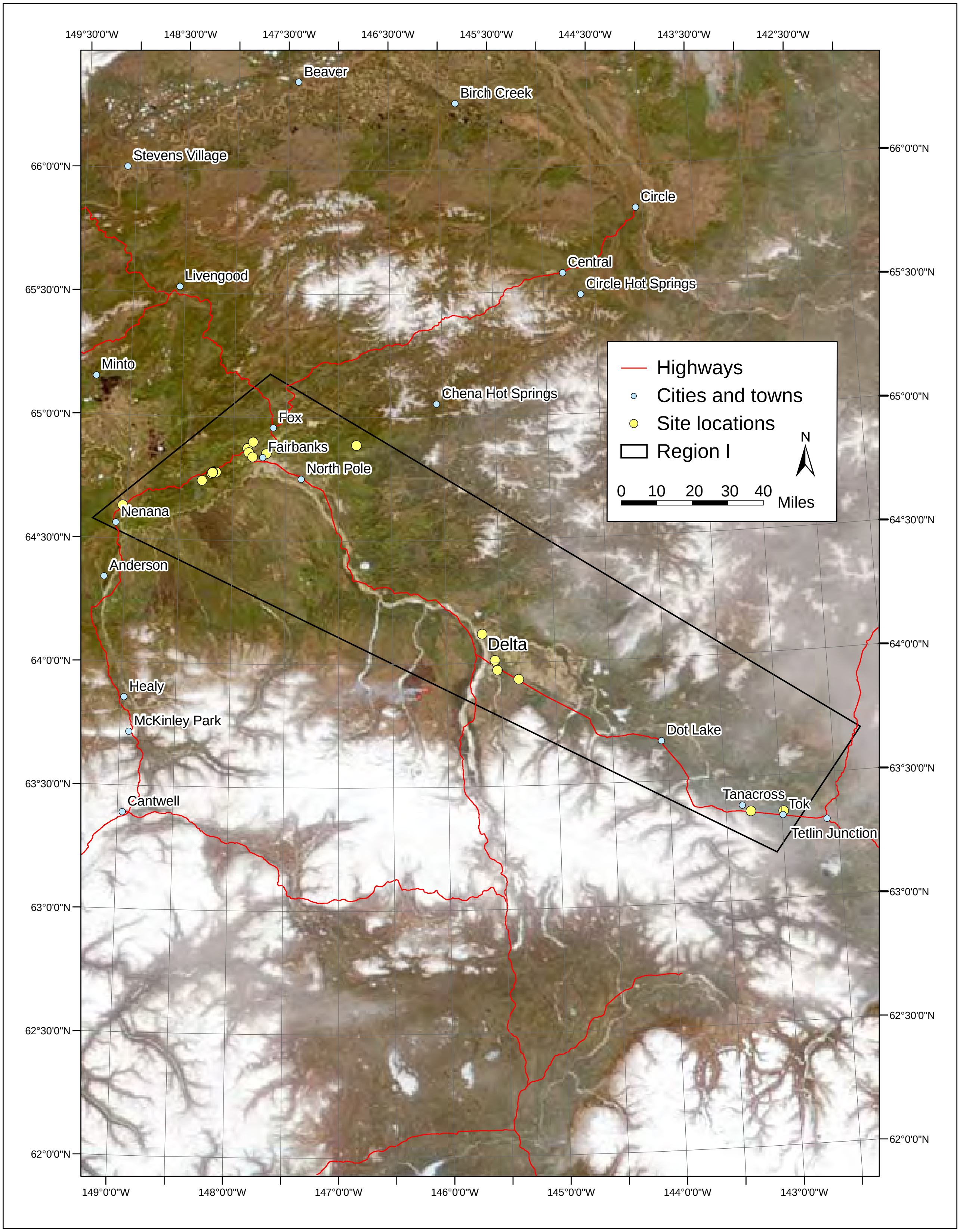


Figure 1b—Region I.

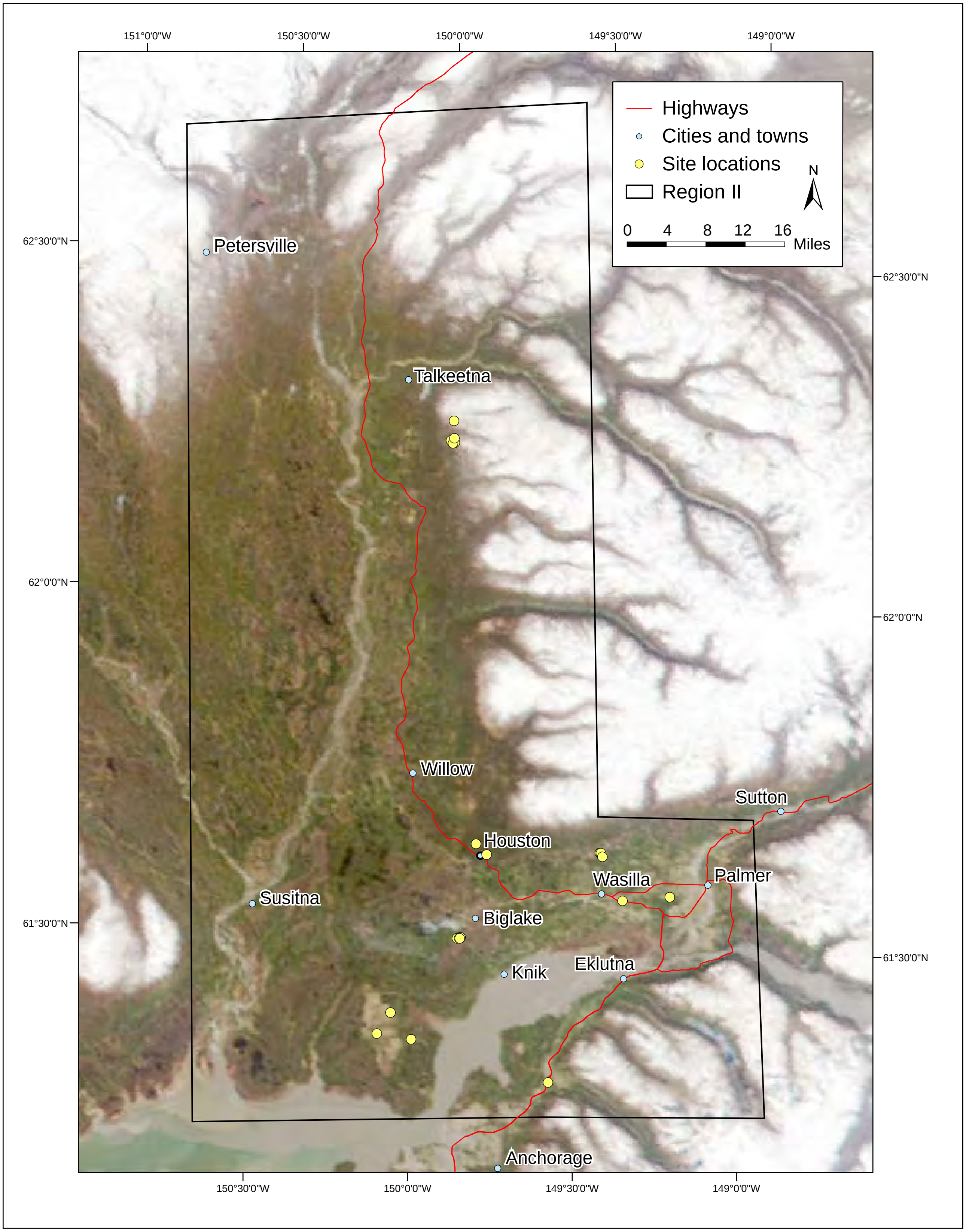


Figure 1c—Region II.

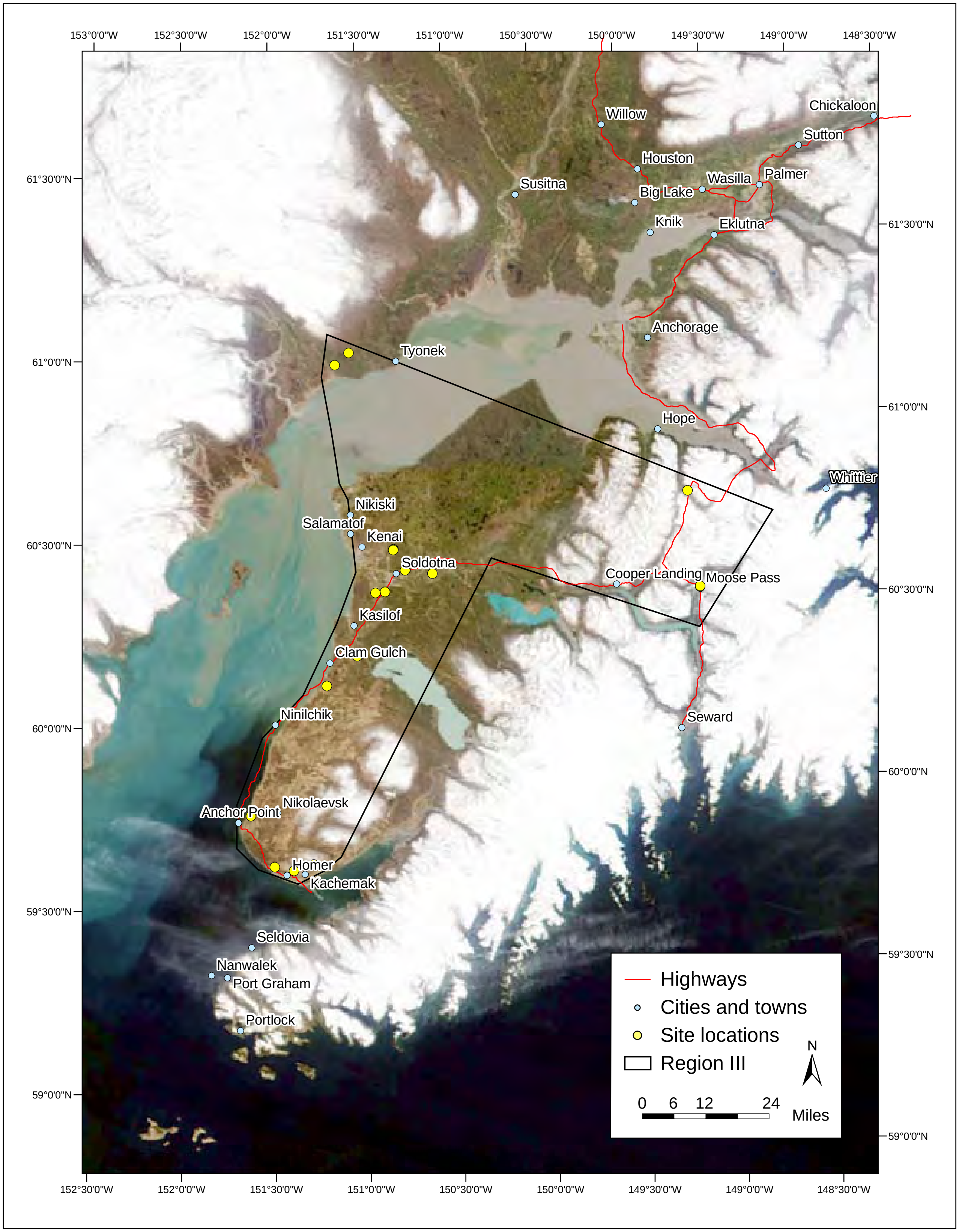


Figure 1d—Region III.

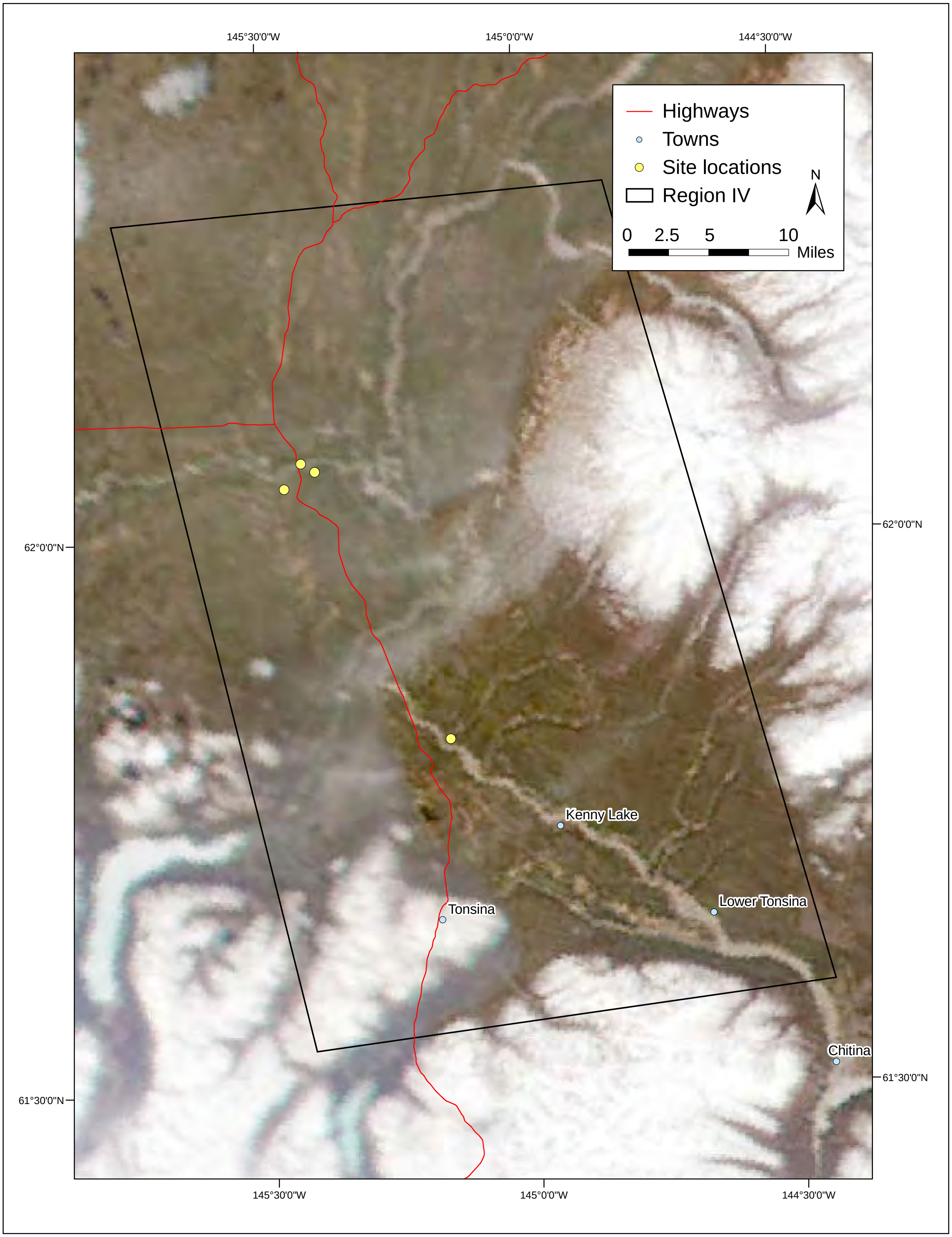


Figure 1e—Region IV.

**Table 1—Sites and plantings surveyed for colonization of nonnative conifers in interior and south-central Alaska**

| | | | | LP[b] plantings | | SL[b] plantings | | SP[b] plantings | | Other[c] plantings | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **No. sites** | **No. plantings[a]** | **Average age and range** | **No.** | **With regen.** | **No.** | **With regen.** | **No.** | **With regen.** | **No.** | **With regen.** |
| | | | *Years* | | *Percent* | | *Percent* | | *Percent* | | *Percent* |
| Interior (Tanana Valley) | 19 | 58 | 24 (10–48) | 21 | 33 | 11 | 55 | 3 | 0 | 23 | 13 |
| Mat-Su Valley | 14 | 31 | 22 (10–50) | 10 | 30 | 8 | 13 | 9 | 22 | 4 | 75 |
| Kenai Peninsula–Cook Inlet | 18 | 25 | 22 (13–36) | 17 | 47 | 5 | 20 | 2 | 0 | 1 S | 0 |
| Copper River Valley | 4 | 5 | 17 (15–18) | 4 | 0 | 0 | — | 0 | — | 1 | 0 |
| Total (N. Alaska) | 55 | 119 | 52 | 24 | 14 | 29 | | | | | |
| Average (Weighted) | | | 23 | | 34 | | 34 | | 14 | | 21 |

[a]Plantings include nonnative conifers ranging from 10 to 50 years of age after planting and native trees of the same age and site as the introduced conifers.
[b]LP = lodgepole pine; SL = Siberian larch (Sukachev's and Siberian larch); SP = Scotch pine.
[c]Other plantings include nonnative jack pine (5), Siberian fir (2), balsam fir (2), Norway spruce (2), Douglas-fir (1), Dahurian larch (1), and native white spruce (7). Native paper birch (5), aspen (2), Alaska larch (1) and white spruce (1) regenerated naturally and were not planted.

II. Species history:
   A. Survival, growth, age, and health of parent trees
   B. Cone production and seed dispersal distances from seed parents
   C. Seedbed conditions: forest floor and vegetation inside and outside the plot
   D. Height, diameter at breast height (d.b.h.), age, and condition of the offspring (natural regeneration)
   E. Height, d.b.h., age, and condition of indigenous trees of the same age, especially white spruce
   F. Stocking (density) and growth of the natural regeneration
   G. Stocking and growth of the indigenous trees, especially white spruce

All known nonnative conifers were sampled other than occasional landscape plantings. One to 10 (average about 4) trees in the dominant crown class of each planting were selected and measured for age, height, and d.b.h. (4.5 ft or 1.37 m from ground level). Heights were measured with a Suunto clinometer, Haga altimeter, or a hand-held Impulse 200 laser hypsometer manufactured by Laser Technologies, Engelwood, Colorado.[2] Stem diameters were measured with a diameter tape. Heights and diameters of trees less than 15 ft (4.5 m) tall and 3 in (7.5 cm) d.b.h. were usually estimated. Plantings less than 10 years old were not evaluated. Lodgepole pine and Siberian larch plantings were emphasized in the survey because they were more common than other nonnative conifers.

[2]The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

To estimate tree ages for unknown planting dates, internodes between yearly branch whorls were counted from tree top to ground level. The ages were used to derive annual stem elongation and diameter growth. Age at d.b.h. was extrapolated from mean annual height growth. For reliable comparisons of height and diameter growth among species, rates must be independent of age between 10 to 50 years. A simple regression of annual stem elongation and d.b.h. increment (dependent variables) on planting age (independent variable) was made for each species with more than 30 sample trees to determine if growth remained constant. A significant positive or negative change in the regression coefficient would indicate an increase or decrease in growth rate, respectively.

Annual volume growth per tree increases exponentially with increasing stem diameter and leader growth. Thus mean tree volumes were compared only for species of the same age and site that were planted or regenerated naturally (aspen and paper birch) for each of 13 plantings[3] on 11 sites. Species in this survey included the four major conifers, lodgepole and Scotch pine, the Siberian larches, and white spruce, and the minor species, jack pine, Norway spruce, Douglas-fir, the true firs, aspen, and paper birch. The true firs included subalpine (*Abies lasiocarpa* (Hook.) Nutt.) and balsam fir. The Siberian larches were identified as Raivola larch and Siberian larch. White spruce, paper birch, and aspen on the same sites and age as the nonnative conifers were sampled for comparing tree volumes among species. Stem volumes were estimated from the volume of a cone ($1/3\pi r^2 h$) where $h$ = tree height and $r$ = radius at the base of the tree. Radius at ground level was extrapolated from tree height and d.b.h.

## Regeneration Potential of the Nonnative Species

The regeneration potential of each nonnative species was evaluated from the frequency of sites exhibiting natural regeneration. Natural seedlings in areas under and adjacent to the seed parents were inventoried. Frequency of planting sites with natural regeneration among the four regions was tested for significance of association with a Chi-square distribution test of the G statistic (Sokal and Rohlf 1969: 599).

To estimate the age of natural regeneration from seed germination, internodes were counted from the apex of the oldest or tallest offsprings to ground level. Age of the oldest offspring was subtracted from the age of its seed parents and

[3] White spruce also regenerated naturally in T-Field Arboretum and was included in the analysis. Seven other sites in the comparisons were white spruce plantings.

averaged for all plantings to estimate the earliest reproductive age of each species. Natural regeneration was very recent and no attempt was made to estimate the number of seed crops.

Lodgepole and jack pine seed production and seed available for future dissemination were estimated from the numbers of closed cones retained in the crowns of the sample trees. The numbers of closed and open cones were estimated from cone counts on one side of each tree that was surveyed. The regeneration potential of lodgepole and jack pine was estimated from the number of offspring per site relative to the number and frequency of open cones per tree. Their future regeneration potential was estimated from the frequency of serotinous cones and the percentage of the total seed crop retained in the crowns of the parental populations.

## The Dispersal, Establishment, and Growth of Natural Regeneration

The distance of the outermost offspring from its parents was measured at each planting site. Estimated seedling densities were plotted on transects from the seed parents to their most distant offspring. This was done only for sites with more regeneration than 1 tree per 4 $m^2$. On sites with dense stocking, seedlings were counted in square meter plots at 5-m intervals on transects perpendicular to the seed parents. Stocking was calculated as seedlings per acre as well as seedlings per square meter. All seedlings were counted under and adjacent to the seed parents at stocking densities less than about 1 seedling per 2.5 $ft^2$ (4 per $m^2$).

Height of the tallest and age of the oldest offspring were measured and calculated, respectively, for each planting. Annual height growth was derived for the tallest offspring at each planting and averaged for each species and region.

The regeneration potential of the nonnative conifers was estimated from the frequency of sites with natural regeneration, numbers of natural offspring, offspring densities, and the earliest successful reproductive age. Success of the natural regeneration was assessed from seedling numbers and densities, distances of the outermost offspring from their seed parents, and the average age, height, and annual height growth of the tallest offspring for each species.

The average values of reproductive traits and seedling parameters were reported in a table of regeneration statistics. The SAS[4] General Linear Models analysis of variance (ANOVA) procedure was used to test for mean annual differences in height and d.b.h. growth between species and for significance of

[4]SAS is the registered trademark of SAS Institute Inc., SAS Campus Drive, Cary, NC 27513.

species x region interactions. Differences among species for all growth, reproduction, and regeneration variables were tested for significance at 0.05 probability of error with the Least Significant Difference (LSD) t-test.[5] Variables that failed to approximate a normal distribution including numbers and densities of offspring, height growth of the tallest offspring, and maximum dispersal distance were ranked in ascending order before the ANOVA procedure.

## Results

### Establishment and Growth

Lodgepole pine was the most commonly planted nonnative conifer in Alaska with 1.4 times as many plantings as the Siberian larches and Scotch pine combined (table 1). Both lodgepole pine and the Siberian larch plantings averaged 34 percent with natural regeneration, and 14 percent of the Scotch pine plantings had regeneration. Twenty-one percent of the other (minor) nonnative plantings also regenerated. Balsam fir at two plantings in Mat-Su Valley, and Siberian fir and jack pine at one site each in Tanana Valley were among the other nonnative species that regenerated, and they may have potential for colonizing site-specific habitats in Alaska.

The oldest nonnative plantings surveyed were 37-year-old (43 years from seed) lodgepole pine in T-Field Arboretum, Fairbanks, 50-year-old Siberian larches at Wasilla, and 48-year-old Scotch pine and Siberian larch at Fairbanks. The youngest plantings were 10-year-old lodgepole pine, Scotch pine, and Siberian larch. Average age was 22 years.

Average age and size statistics, and differences in both height and d.b.h. growth among the major species for all geographic regions are given in table 2. Differences in height and d.b.h. growth among the major species were highly significant ($P < 0.0001$). At average ages of 23, 20, and 26 years, the three major nonnative conifers grew more rapidly than did native white spruce that averaged 22 years of age. Average height growth of the Siberian larches exceeded the average height growth of lodgepole and Scotch pine, but d.b.h. growth of the Siberian larches was not significantly greater than the d.b.h. growth of lodgepole pine. Height growth of native paper birch and aspen (app. table 9) at five and three plantings, respectively, were comparable to the height growth of the major nonnative conifers.

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[5] The LSD test reduces the chance of not identifying differences among populations (species) when the differences are real. The chance of accepting the species as different when they are actually from the same population is high with the LSD test, however.

**Table 2—Mean age, size, and annual growth of the major nonnative species and native white spruce sampled in 2002 on mainland Alaska**

| Species | No. trees sampled | Mean age and range | Mean d.b.h. and range | Mean height and range | Growth* | |
|---|---|---|---|---|---|---|
| | | | | | Diameter at breast height outside bark | Height |
| | | *Years* | *Inches* | *Feet* | *Inches/year* | *Feet/year* |
| Nonnative: | | | | | | |
| Siberian larch | 88 | 23 (11–50) | 6.9 (3.0–18.8) | 39 (18–78) | 0.357 a | 1.77 a |
| Lodgepole pine | 192 | 20 (10–43) | 5.5 (0.6–14.4) | 26 (8–64) | 0.325 ab | 1.30 b |
| Scotch pine | 37 | 26 (12–48) | 6.5 (2.0–14.5) | 31 (10–46) | 0.306 b | 1.20 bc |
| Average nonnative: | 106 | 23 | 6.3 | 32 | 0.329 | 1.42 |
| White spruce | 32 | 22 (17–37) | 3.9 (1.5–8.9) | 24 (11–52) | .216 c | 1.08 c |

Note: Growth means with same letter were not significantly different.
*As determined by the Least Significant Difference t-test, species with less than 0.2-ft and 0.03-in differences in height and d.b.h., respectively, are not statistically different at P = 0.05.

Differences in growth statistics among regions could not be assessed because each region was represented by different species and sample sizes. Likewise, growth comparisions among the minor species were considered unreliable because they were inadequately sampled and not uniformly distributed among the regions. Mean age, size, and growth statistics of the minor species are summarized in app. table 9. Only lodgepole pine, Scotch pine, and white spruce were found in five plantings on four sites in the Copper River Valley (Region IV), and Alaska paper birch is not an indigenous species in this region.

For all nonnative species combined, average annual height and stem-diameter growth declined significantly (P = 0.0003 and <0.0001, respectively) from 10 to 50 years of age (figs. 2 and 3). The decrease was only 0.1 and 0.003 in (2.5 and 0.08 mm) per year, $R^2$ = 0.03 and 0.1, N = 354. Each of the major nonnative conifers displayed negative diameter and height growth relationships with age for trees from 10 to 50 years old (figs. 4 through 9), whereas native white spruce was positive for both diameter and height growth for trees from 10 to 36 years old (figs. 10 and 11, table 3).

The declines of height and stem-diameter growth rates with age for lodgepole pine were not significant (figs. 4 and 5, table 3), whereas the declines in both height (0.16 in or 4.0 mm, fig. 6) and stem diameter (0.0035 in or 0.09 mm, fig. 7) growth per year with age for the Siberian larches were significant (table 3). Only the decrease in stem-diameter growth with age for Scotch pine (0.003 in or 0.08 mm per year, figs. 8 and 9) was significant (P = 0.03). Both annual height and stem-diameter growth of white spruce increased from 10 to 36 years, but only the height growth increase (0.24 in or 6.1 mm per annum) was statistically significant (figs. 10 and 11).

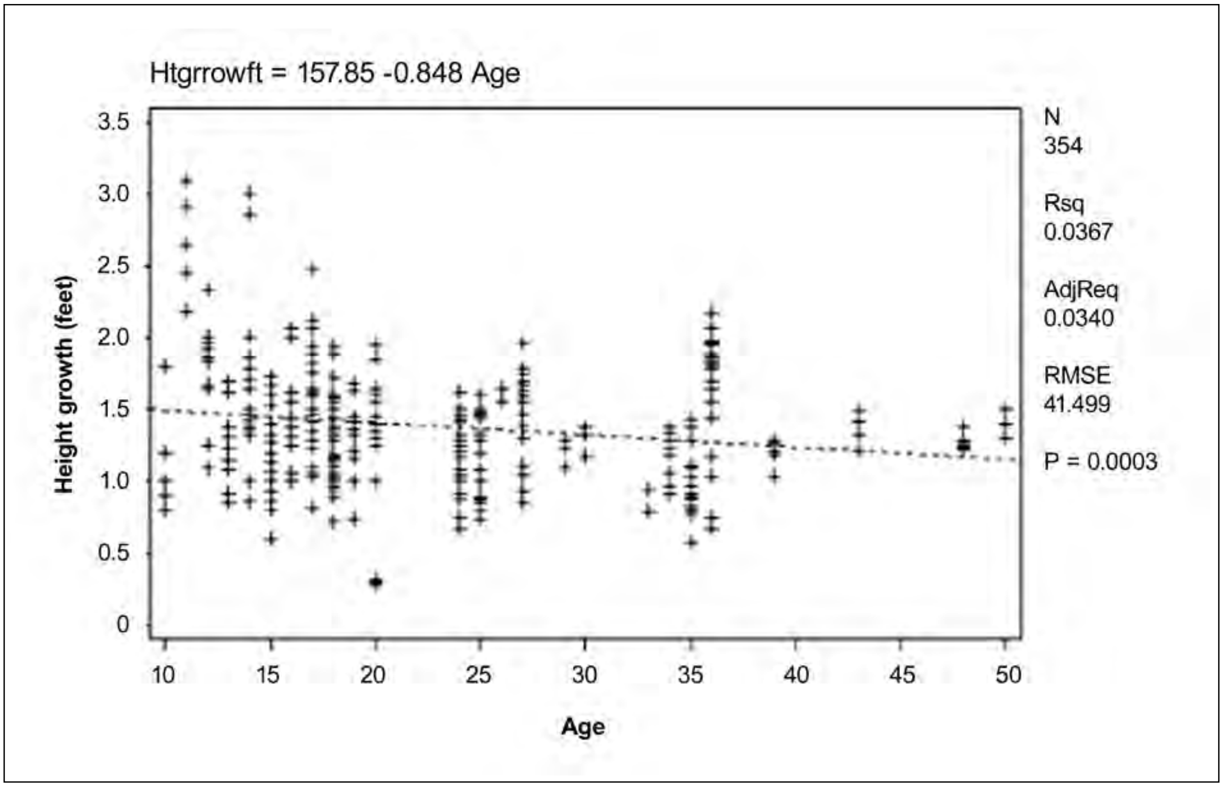


Figure 2—Mean annual height growth of nonnative conifers.

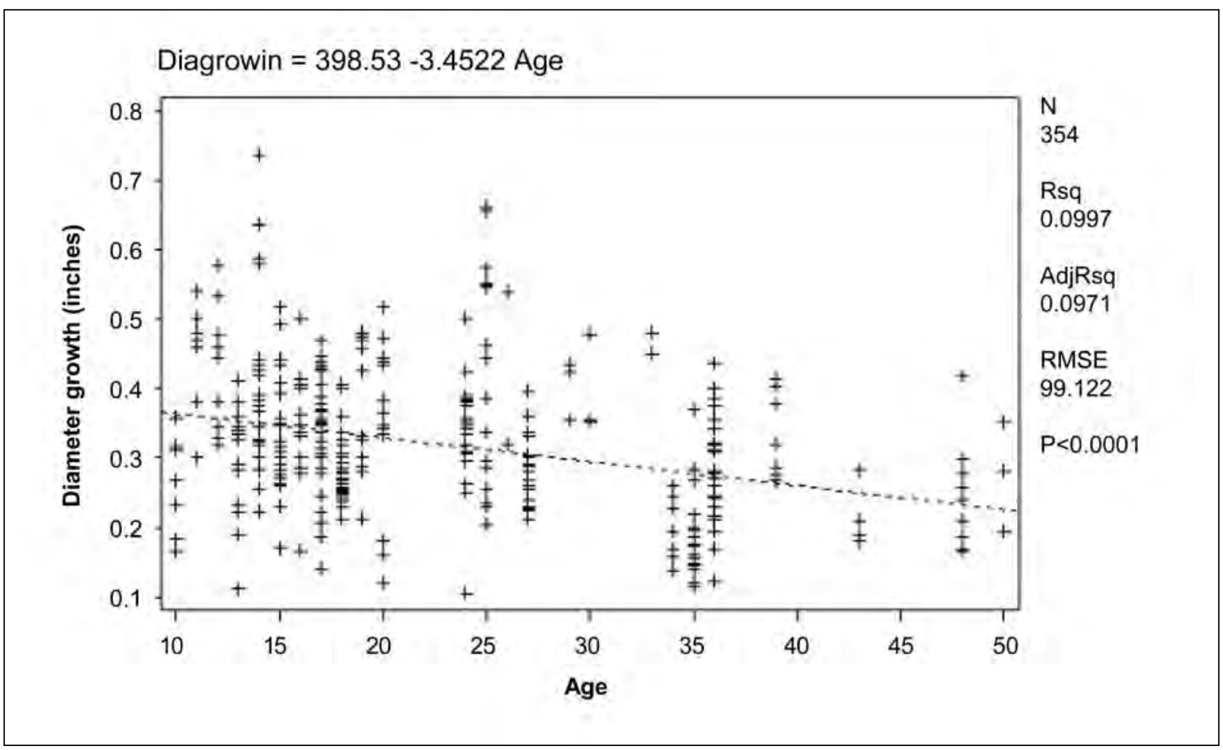


Figure 3—Mean annual diameter growth at breast height for nonnative conifers.

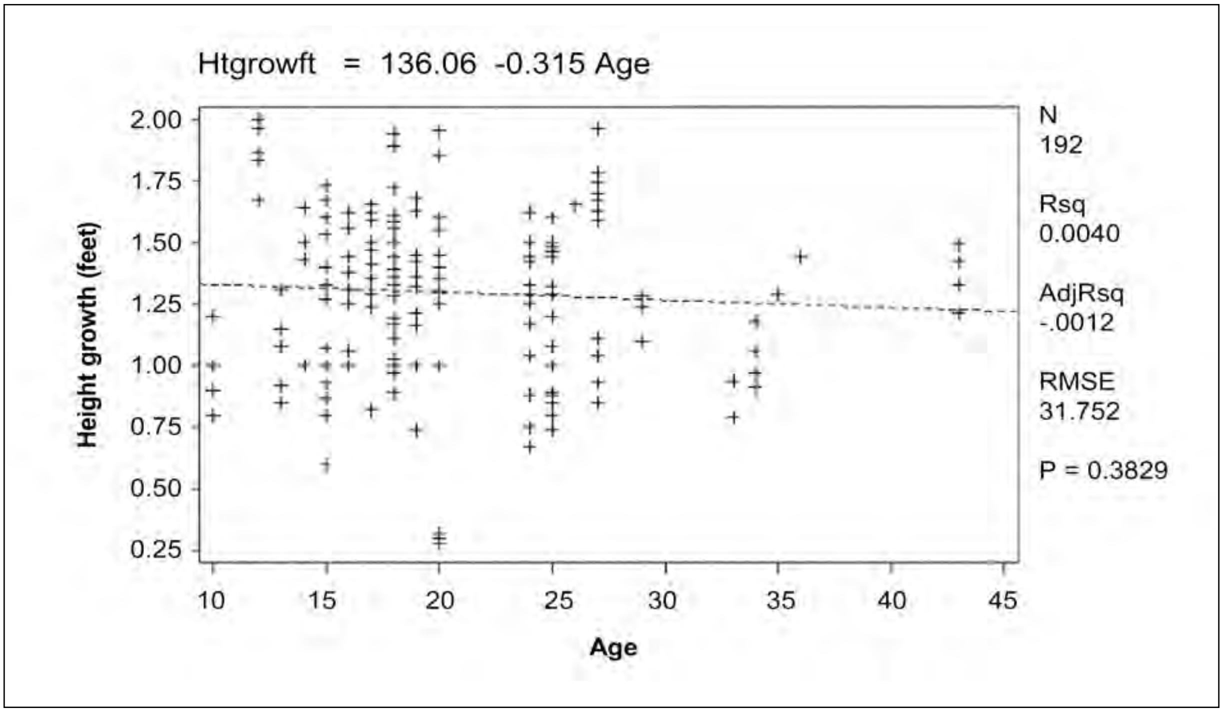


Figure 4—Mean annual height growth of lodgepole pine.

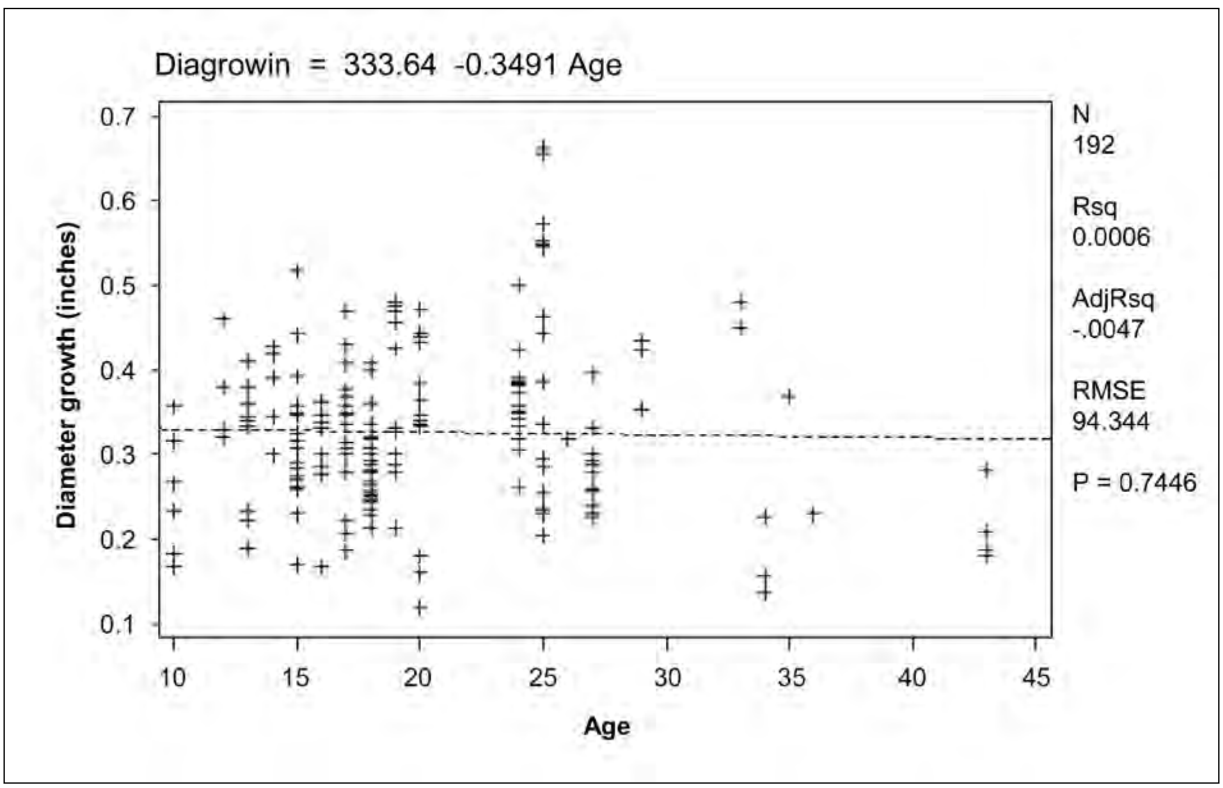


Figure 5—Mean annual diameter growth at breast height for lodgepole pine.

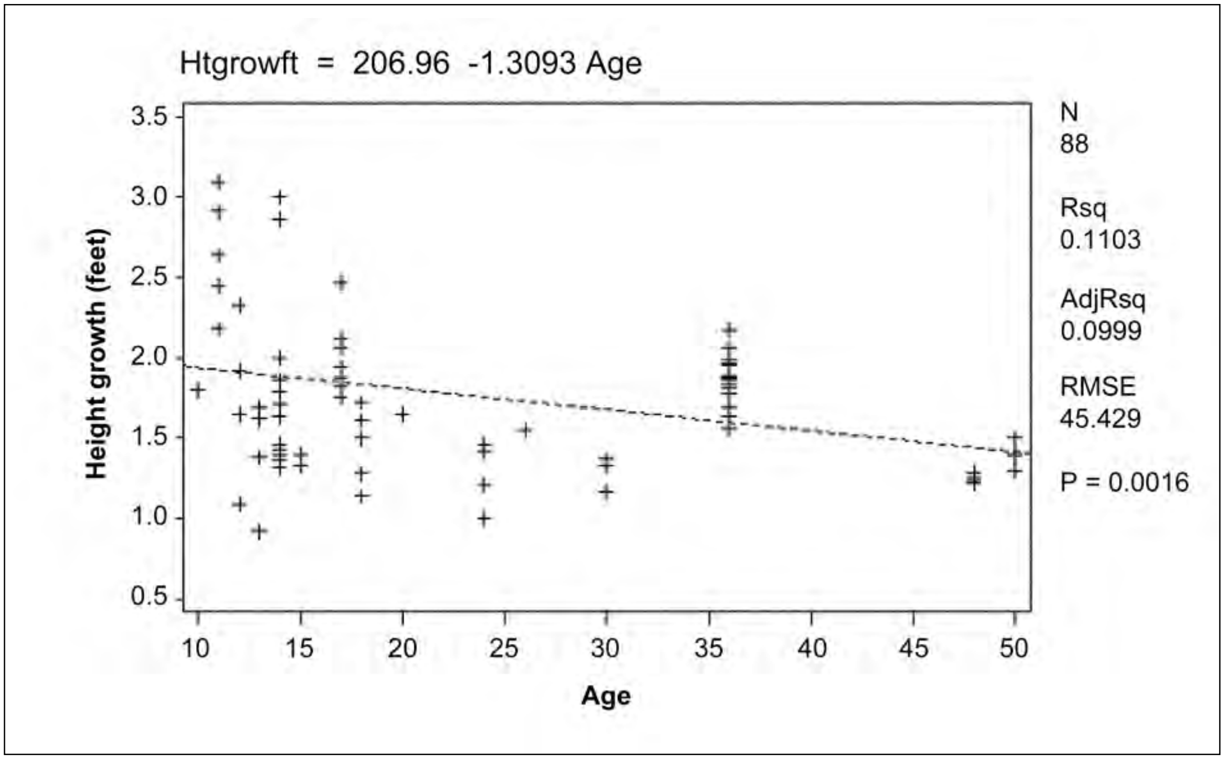


Figure 6—Mean annual height growth of Siberian larch.

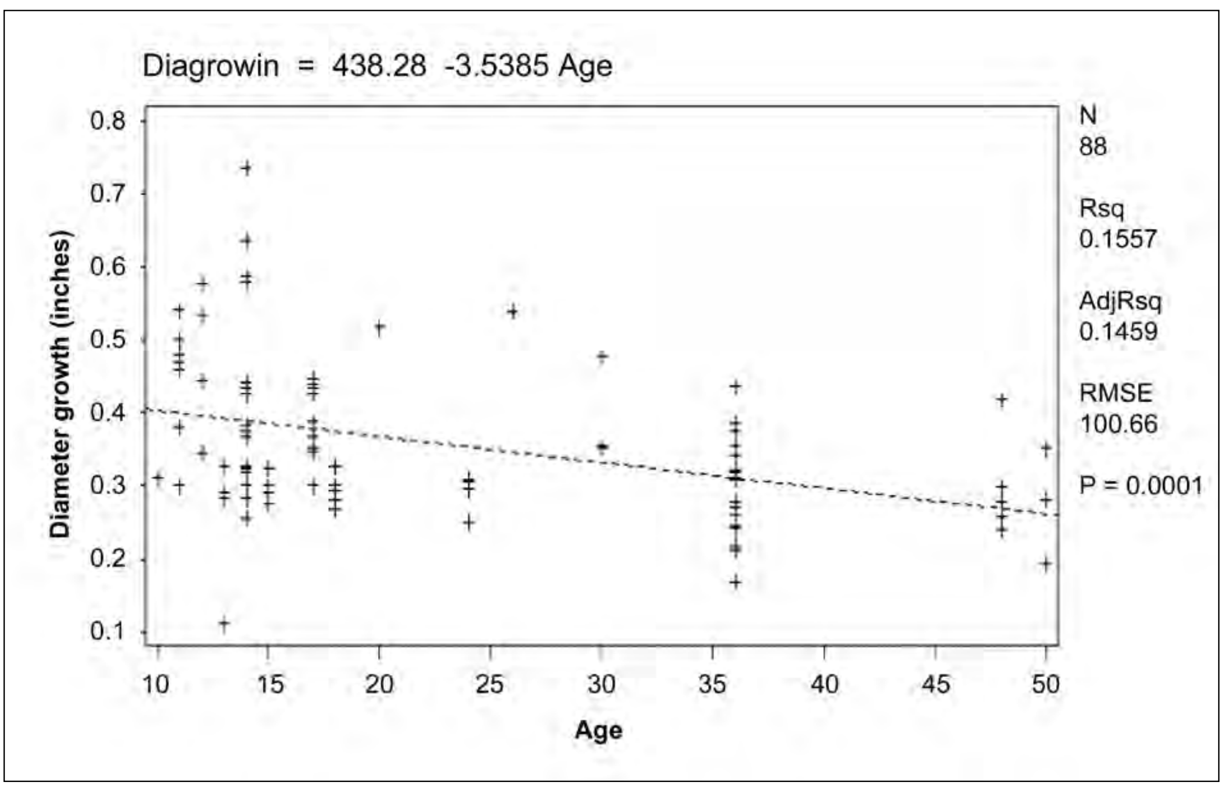


Figure 7—Mean annual diameter growth at breast height for Siberian larch.

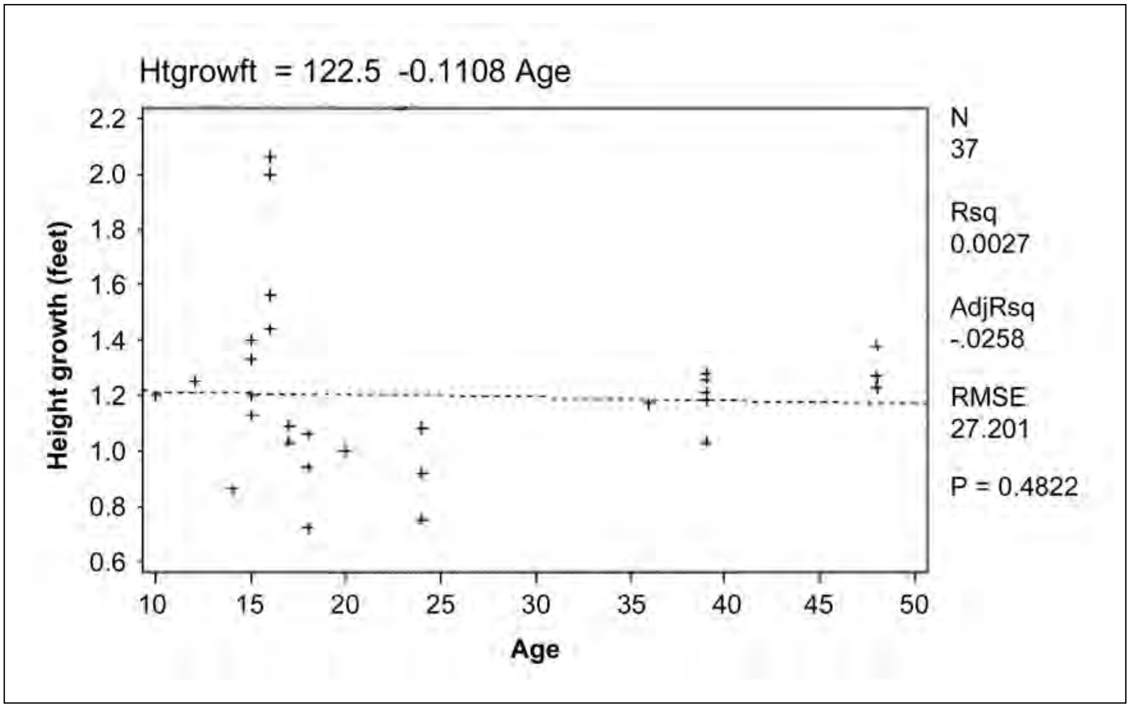


Figure 8—Mean annual height growth of Scotch pine.

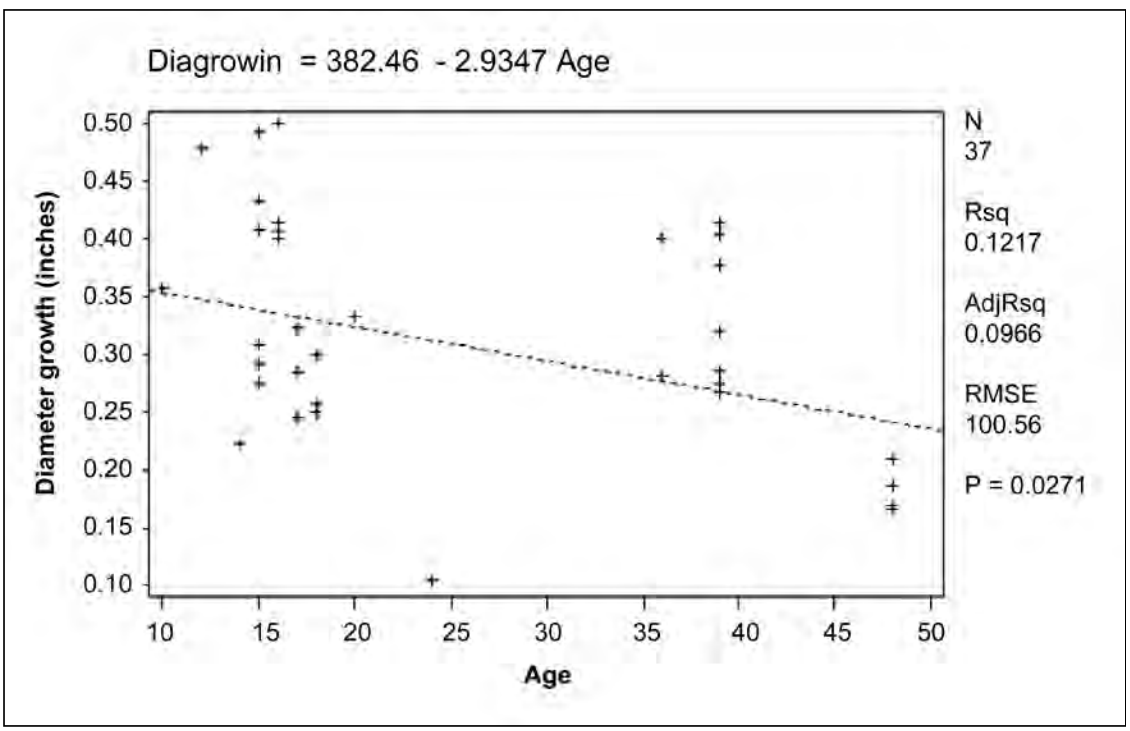


Figure 9—Mean annual diameter growth at breast height for Scotch pine.

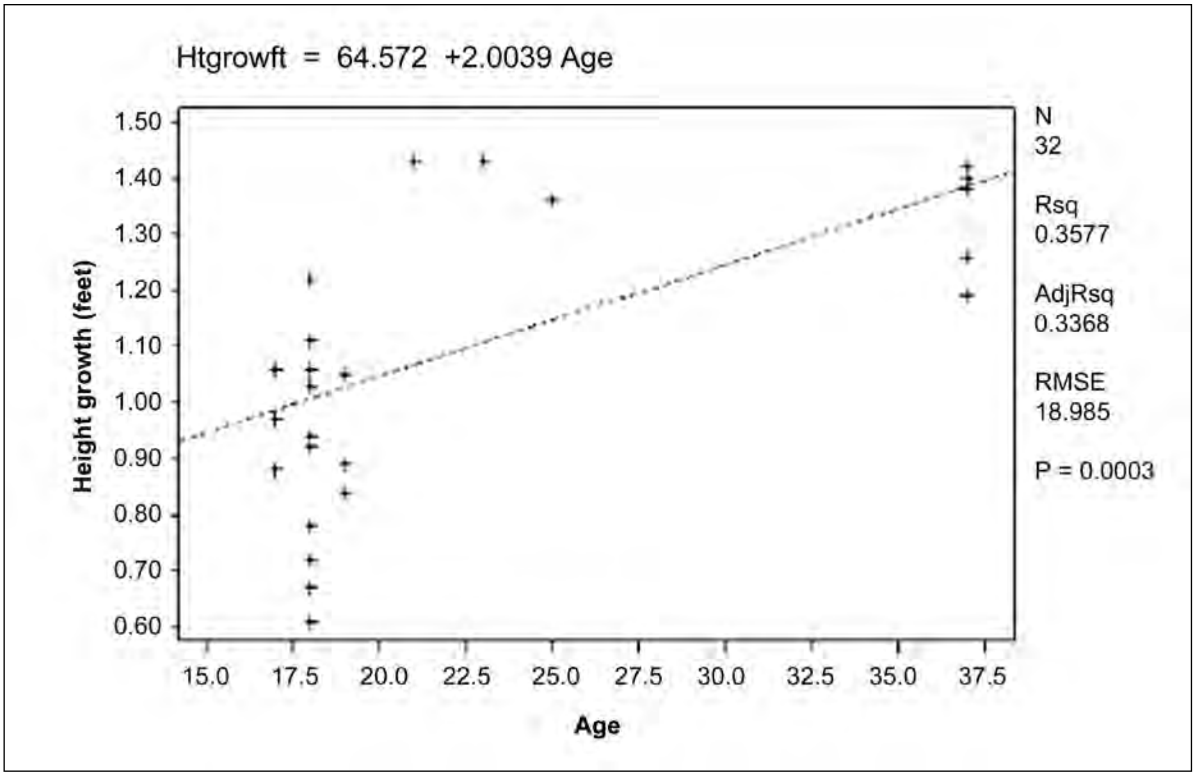


Figure 10—Mean annual height growth of white spruce.

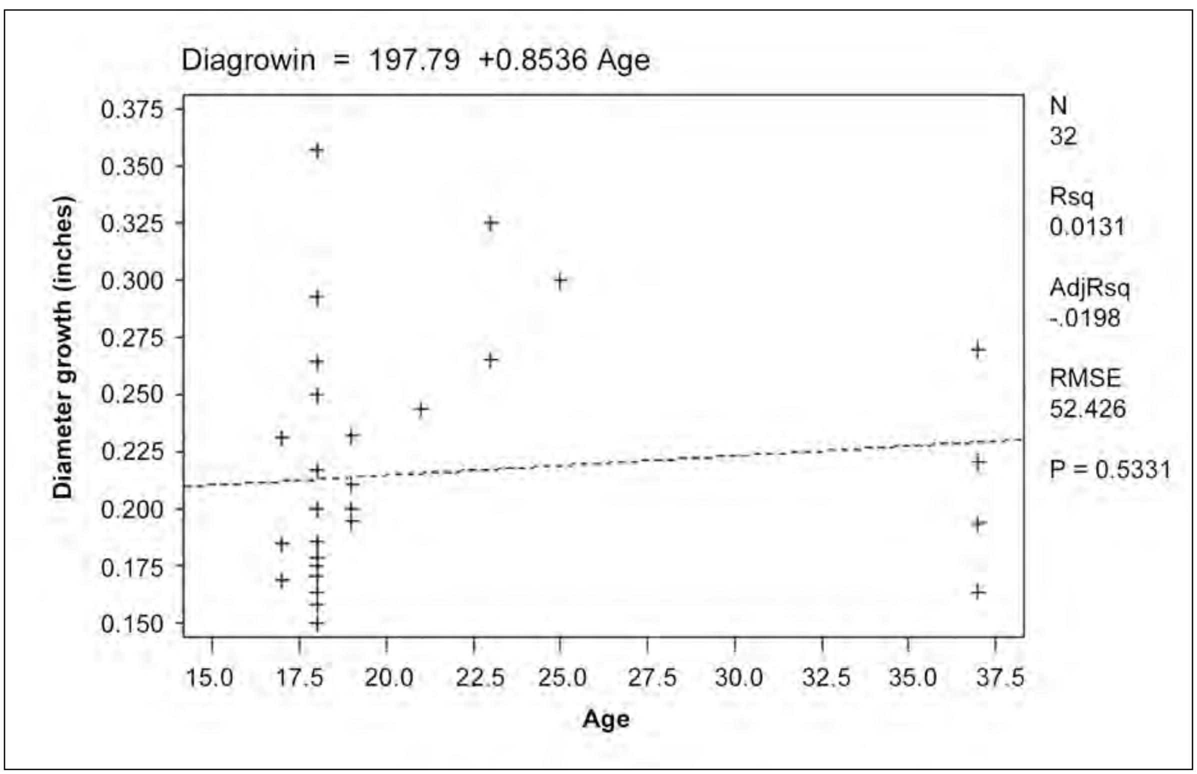


Figure 11—Mean annual diameter growth at breast height for white spruce.

**Table 3—Simple regression statistics for growth rates versus age of species between 10 and 50 years old, and N > 30**

| Species | Average age | No. Trees | Annual growth, height | | | Annual growth, d.b.h. | | |
|---|---|---|---|---|---|---|---|---|
| | *Year* | | *Feet* | *Probability* | $R^2$ | *Inches* | *Probability* | $R^2$ |
| Siberian larch | 23 | 88 | -0.013 | 0.0016 | 0.11 | -0.0035 | 0.0001 | 0.16 |
| Lodgepole pine | 20 | 192 | -0.003 | 0.3829 | 0.004 | -0.0003 | 0.7446 | 0.0006 |
| Scotch pine | 26 | 37 | -0.001 | 0.7605 | 0.003 | -0.003 | 0.0344 | 0.12 |
| White spruce | 22 | 32 | 0.020 | 0.0003 | 0.36 | 0.0008 | 0.5331 | 0.01 |
| All species | 23 | 411 | -0.008 | 0.0002 | 0.03 | -0.003 | <0.0001 | 0.09 |

Several species were established during the same year in 13 plantings at 12 sites (table 4). With the exception of the 36-year-old T-Field and Tazlina Experimental Plantings, white spruce grew the least volume per tree relative to the nonnative conifers and aspen on six of the eight sites where they were planted or regenerated naturally. Among the nonnative conifers, only Siberian fir and Norway spruce among the older T-Field Arboretum plantings grew significantly less volume per tree than white spruce.

The largest nonnative conifers in Alaska and the first- and third-largest Siberian larches were found on the Alaska Department of Natural Resources (DNR) Compound (46 $ft^3$ or 1.3 $m^3$) and on Les Viereck's Tree Farm (33 $ft^3$ or 0.93 $m^3$) in Fairbanks. The Siberian larches at both sites regenerated naturally. However, because taper was excessive in the upper crown of the DNR larch, a tree 16.5 inches (42 cm) in d.b.h., 75 ft (23 m) tall and 43 $ft^3$ (1.2 $m^3$) with excellent form in Mat-Su Valley was probably the largest nonnative conifer in Alaska. Even as young as 14 years, the Siberian larches at Swain's Tree Farm on Tanana Loop Road in Delta grew significantly more volume per tree than lodgepole pine at the same age (table 4). The fastest growing nonnative conifer was Raivola larch from a seed orchard in Norway and an experimental forest in Finland. Annual growth of four dominant trees averaged 2.9 ft (89 cm) in height and 0.63 in (16 mm) in d.b.h. during each of the 14 years at the Wasilla Veterinary Clinic.

## Regeneration and Potential for Naturalization

Interior, Mat-Su Valley, and Kenai Peninsula were not significantly different in frequencies of nonnative plantings with natural regeneration (P = 0.1745). Thirty-four percent of both lodgepole pine (n = 52) and Siberian larch (n = 24) plantings regenerated naturally before they reached an average age of only 22 years (table 1). Forty-seven percent of the Kenai Peninsula–Cook Inlet lodgepole pine plantings and 55 percent of the Siberian larch plantings in interior Alaska regenerated before average ages of 22 and 23 years, respectively. All four lodgepole pine

**Table 4—Approximate mean stem volume[1] per tree for native and nonnative species, by age and site**

| Site | Region | Age | Species[2] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LP | JP | SP | WS[3] | NS | PB[4] | AS | RL | SL | TF and DF[5] |
| | | *Years* | *Cubic feet per tree* | | | | | | | | | |
| Kratzer's Tree Farm | Interior | 19 | 3.1a | | | 0.9 | | | | | | |
| Viereck's Tree Farm | Interior | 36 | | | 11.4a | | 2.7b | | | 17.6a | | 3.0b |
| T-Field Arboretum | Interior | 36 | 7.7a | 5.0a | 4.8a | 5.3a | 2.0b | | | 11.8 | 6.0a | 1.4b |
| T-Field Arboretum | Interior | 27 | 5.7a | 6.6a | | 3.0 | | | | | | |
| Rosie Plantation | Interior | 17 | 1.4a | | | 0.4 | | | | | | |
| Rosie Creek—Malone #1 | Interior | 18 | 1.1a | | | 0.4 | | 1.4a | | | | |
| Rosie Creek—Malone #2 | Interior | 18 | 1.6a | | | 0.3 | | 1.6a | | | | |
| Samuel's Tree Farm | Interior | 18 | 1.6a | | | 0.2 | | 1.0b | | | 1.5ab | |
| Swain's Tree Farm | Interior | 14 | 1.2 | | | | | | | | 1.6a | |
| DNR Compound—Fairbanks | Interior | 48 | | | 8.8a | | | 6.6a | | | 23.0 | |
| Gonder's Tree Farm | South-central Alaska | 35 | | | 9.4 | | 2.9a | | | | | 3.6a and 2.6a |
| Tazlina Experimental Plantings | Copper River Valley | 18 | 1.2a | | | 1.0a | | | | | | |
| Old Edgerton Highway | Copper River Valley | 18 | 0.8a | | | | | | 0.5a | | | |

Note: Estimated volumes with the same letter for species at identical sites were not statistically different at P = 0.05.

[1] Stem volumes were derived from the formula of a cone ($1.074r^2h$) where the base radius (r) was extrapolated from diameter at breast height and total tree height (h) in feet. Volumes were estimated from samples of 2 to 10 trees (mean = 4) selected at random from the dominant crown class of each species at each site. Bole form was not factored into the equation and actual volumes are underestimated.

[2] Species abbreviations are: LP = lodgepole pine, JP = jack pine, SP = Scotch pine, WS = white spruce, NS = Norway spruce, PB = paper birch, AS = aspen, RL = Raivola larch (a selected variety of western Siberian or Sukachev's larch, *Larix sukaczewii* N. Dyl.), and SL = Siberian larch (*Larix sibirica* Ledeb.). TF and DF = true fir and Douglas-fir.

[3] The white spruce regeneration in T-Field Arboretum was natural seedlings that averaged 2.6 $ft^3$ (0.07 $m^3$) per tree at 23 years of age. The volume was adjusted to 3.0 $ft^3$ (0.08$m^3$) per tree at 27 years.

[4] All paper birch and aspen were natural regeneration. Paper birch included coppice regeneration in Malone sites 1 and 2.

[5] TF (true fir) includes Siberian fir in T-field Arboretum and balsam fir at Gonder's Tree Farm. Dominant and co-dominant Douglas-fir averaged 2.6 $ft^3$ (0.07 $m^3$) per tree after 35 years at the Gonder Tree Farm.

plantings that ranged from 15 to 18 years of age in the Copper River Valley (table 2) failed to regenerate by 2002.

The earliest successful reproductive ages of all lodgepole pine and Siberian larch plantings were 11 and 12 years, respectively (table 5). The average reproductive age of lodgepole and Siberian larch populations were 17 and 22 years, respectively. Differences among species in average reproductive age were significant ($P > 0.04$), but differences among regions ranked for average age were not significant ($P > 0.14$).

The offspring of all reproducing nonnative conifers ranged from 2 to 19 years of age, and the oldest averaged 4 to 12 years of age (table 6). Because only 32 percent of the plantings regenerated before 2002 and stocking levels were highly variable, differences in the regeneration statistics among the six reproducing nonnative conifers and regions were not significant. Six of nine nonnative conifers

**Table 5—Reproductive ages of the major nonnative conifers on mainland Alaska**

| | Species[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Reproductive age** | **LP** | **JP** | **SP** | **SL** | **DL** | **SF** | **BF** | **NS** | **DF** |
| Earliest reproductive age (years) | 11 | 28 | 27 | 12 | >24 | 31 | 20 | >36 | >35 |
| Average reproductive age and standard deviation (years) | 17 a ±6 | 28 ab | 27 ab ±0 | 22 ab ±10 | — | 31 b | 25 ab ±7 | — | — |
| Plantings with regeneration | 18 | 1 | 2 | 8 | 0 | 1 | 2 | 0 | 0 |
| Total plantings | 52 | 5 | 14 | 24 | 1 | 2 | 2 | 2 | 1 |

Note: Ages with the same letter are not statistically different at P = 0.05.
[1] LP = lodgepole pine; JP = jack pine; SP = Scotch pine; SL = Siberian larch; DL = Dahurian larch; SF = Siberian fir; BF = balsam fir; NS = Norway spruce; DF = Douglas-fir.

examined in this survey were in the colonization phase of introduction. None had entered the naturalization stage.

Average height and annual height growth of the tallest offspring for all plantings of each reproducing nonnative conifer are reported in table 6. Average height of the tallest lodgepole pine and Siberian larch offspring were 3.4 ± 6.4 and 9.8 ± 14.9 ft (104 ± 196 and 298 ± 454 cm), respectively. The tallest lodgepole offspring was 28 ft (853 cm) at 19 years, and was found in T-Field Arboretum. A probable Raivola offspring transplanted at Les Viereck's tree farm in Fairbanks was the tallest Siberian larch. As a first-generation offspring, it was 45 ft (13.7 m) tall, 6 in (15 cm) in d.b.h., and also 19 years old.

**Table 6—Regeneration statistics for the nonnative conifers sampled on mainland Alaska**

| | Average value and standard deviation | | | | | |
|---|---|---|---|---|---|---|
| **Seedling parameter** | **LP**[a] | **JP** | **SP** | **SL** | **SF** | **BF** |
| Maximum offspring distance from their parents (feet) | 72 ±82 | 66 | 89 ±62 | 102 ±98 | 36 | 49 ±13 |
| Oldest offspring (years) | 6 ±4 | 6 | 12 ±0 | 9 ±6 | 4 | 6 ±1 |
| Tallest offspring (feet) | 3.4 ±6.4 | 2.3 | 9.5 ±7.9 | 9.8 ±4.9 | 1.5 | 0.6 ±0.5 |
| Number of offspring per planting[b] | 69 ±240 | 0.2 ±.4 | 322 ±1,202 | 232 ±997 | 2 ±2 | 1,000 ±1,273 |
| Offspring density per planting[b] (number per acre) | 400 ±1,200 | 12 ±32 | 1,620 ±810 | 2,430 ±810 | 40 ±80 | 16,200 ±20,200 |
| Annual height growth of the tallest offspring (inches) | 5.1 ±3.9 | 4.7 | 9.4 ±7.9 | 9.1 ±8.7 | 3.9 | 1.2 ±0.8 |
| Number of plantings with regeneration | 18 | 1 | 2 | 8 | 1 | 2 |
| Number of plantings sampled | 52 | 5 | 14 | 24 | 2 | 2 |

[a] LP = Lodgepole pine; JP = jack pine; SP = Scotch pine; SL = Siberian larch; SF = Siberian fir; BF = balsam fir.
[b] The average is for all plantings with and without regeneration.

Densities of nonnative pine regeneration ranged from 1 lodgepole or jack pine seedling on each of four sites in Interior Alaska to 40,000 Scotch pine and 20,000 lodgepole pine seedlings per acre (10 and 5 seedlings per $m^2$) in south-central Alaska, respectively. The latter offspring were established on disturbed soils under the canopies of 39-year-old Scotch and 25-year-old lodgepole pine plantings at the Gonder tree farm in Big Lake (figs. 12 through 15). Twenty thousand 1- to 3-year-old seedlings per acre (5 per $m^2$) were also documented on exposed gravel at the edge of the crowns of lodgepole and jack pine trees in 15-year-old plantings in the Houston City Park, south-central Alaska (fig. 16). The estimated 1,000 seedlings per balsam fir planting at the Gonder tree farm correspond to about 1 seedling per 2.5 $ft^2$ (4 seedlings per $m^2$). Maximum average dispersal distance was only $50 \pm 13$ ft ($15 \pm 4$ m) from the seed parents. The most stocking (89,000 seedlings per acre or 22 seedlings per $m^2$) was found within 25 ft (8 m) of twelve 15-year-old Siberian larches on exposed gravel in Houston City Park (fig. 17). The seedlings were about 3 years old, and had been mowed frequently during City Park maintenance.

Maximum distance of natural Scotch pine seedlings from their seed parents was 150 ft (45 m) at Gonder's Tree Farm in Big Lake, Mat-Su Valley. Siberian (Raivola) larch offspring were found 250 ft (76 m) and 266 ft (81 m) from the nearest possible seed parents at Les Viereck's Tree Farm, and the Department

Figure 12—Two- to 10-year-old natural seedlings of a Finnish seed source on exposed gravel under the canopy of 39-year-old Scotch pine trees at the Carl Gonder Tree Farm in Big Lake, Alaska, September 14, 2001. The dominant parents averaged 42 ft (12.8 m) tall and 13 in (33.5 cm) in d.b.h. Regeneration averaged nearly one seedling per $ft^2$ (10 seedlings per $m^2$) (see fig. 14).

Figure 13—Mrs. Gonder and Mike Lyne of the Alaska Urban and Community Forestry Council, Inc., Anchorage, surveyed natural lodgepole pine regeneration at the Gonder's new garden site in Big Lake, south-central Alaska on May 12, 2001. The parents were transplanted as wild seedlings from Whitehorse, Yukon, in about 1977. Seedlings were distributed only 44 ft (13 m) from the nearest seed parents as shown in figure 15.

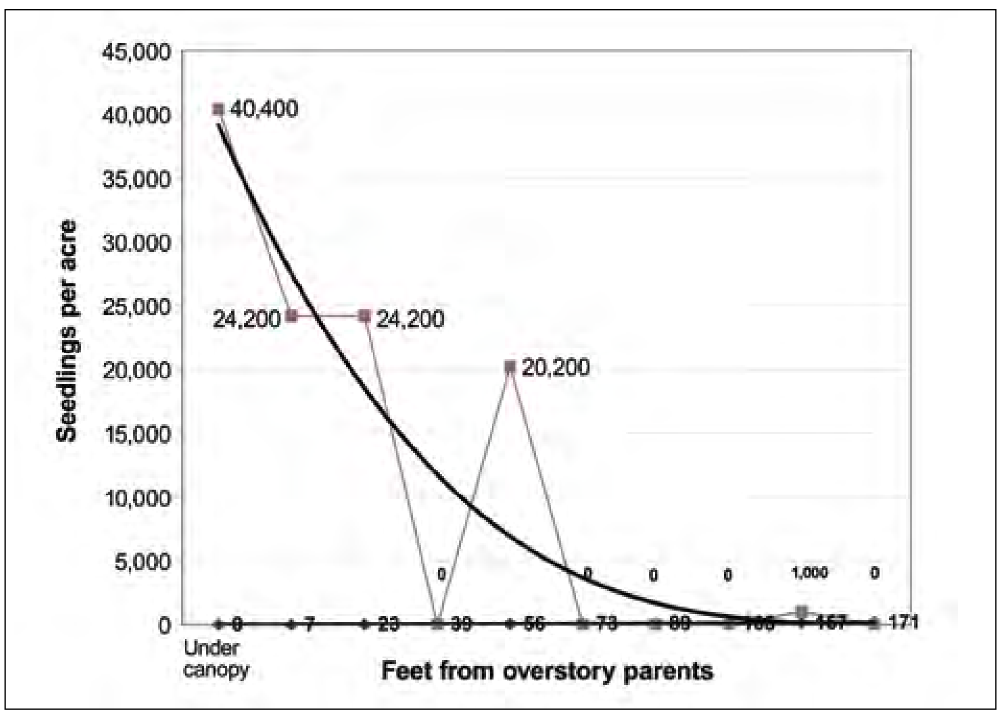


Figure 14—Scotch pine stocking in Gonder's meadow extending 171 ft from the understory of 39-year-old parents to an undisturbed forest edge on September 14, 2002. Stocking (y) was estimated from a polynomial distribution, $y = -0.0177x^3 + 6.77x^2 - 851.1x + 35906$, R2 = 0.79, and x was feet from the parents.

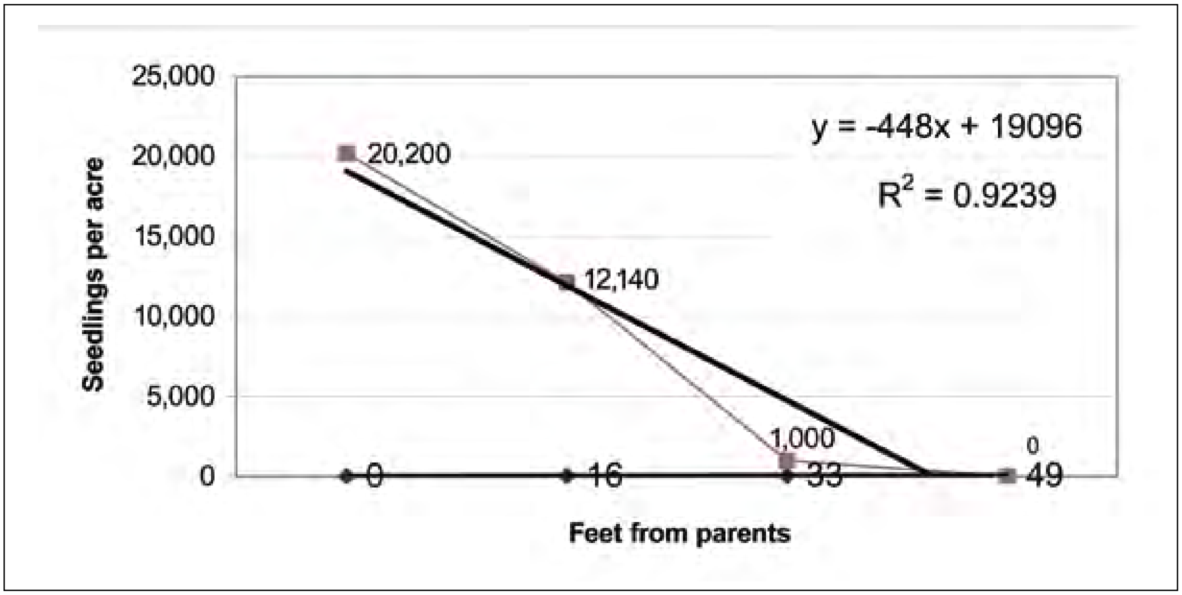


Figure 15—The distribution of natural lodgepole pine seedlings per acre from 25-year-old seed parents at the Gonder's new Garden Site.

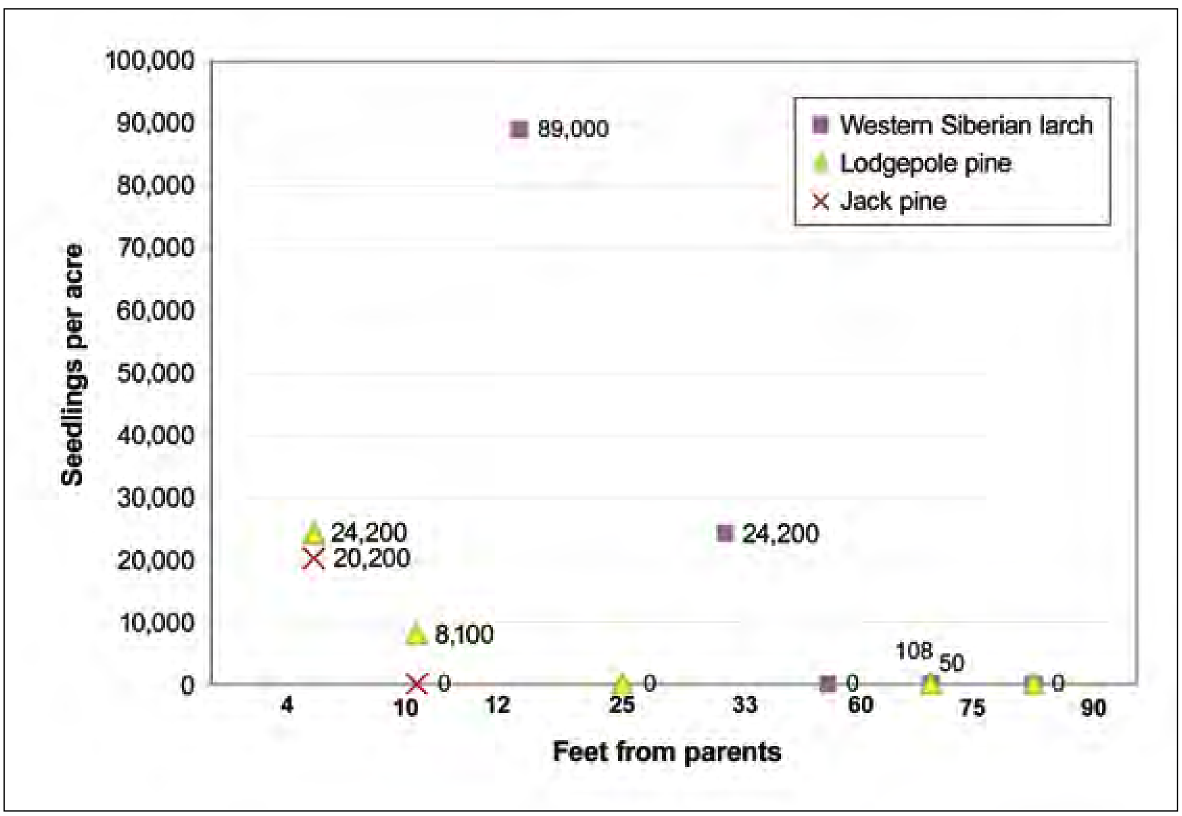


Figure 16—Distributions of lodgepole pine, jack pine, and Siberian larch seedlings on exposed gravel from 15-year-old seed parents in Houston City Educational Park.

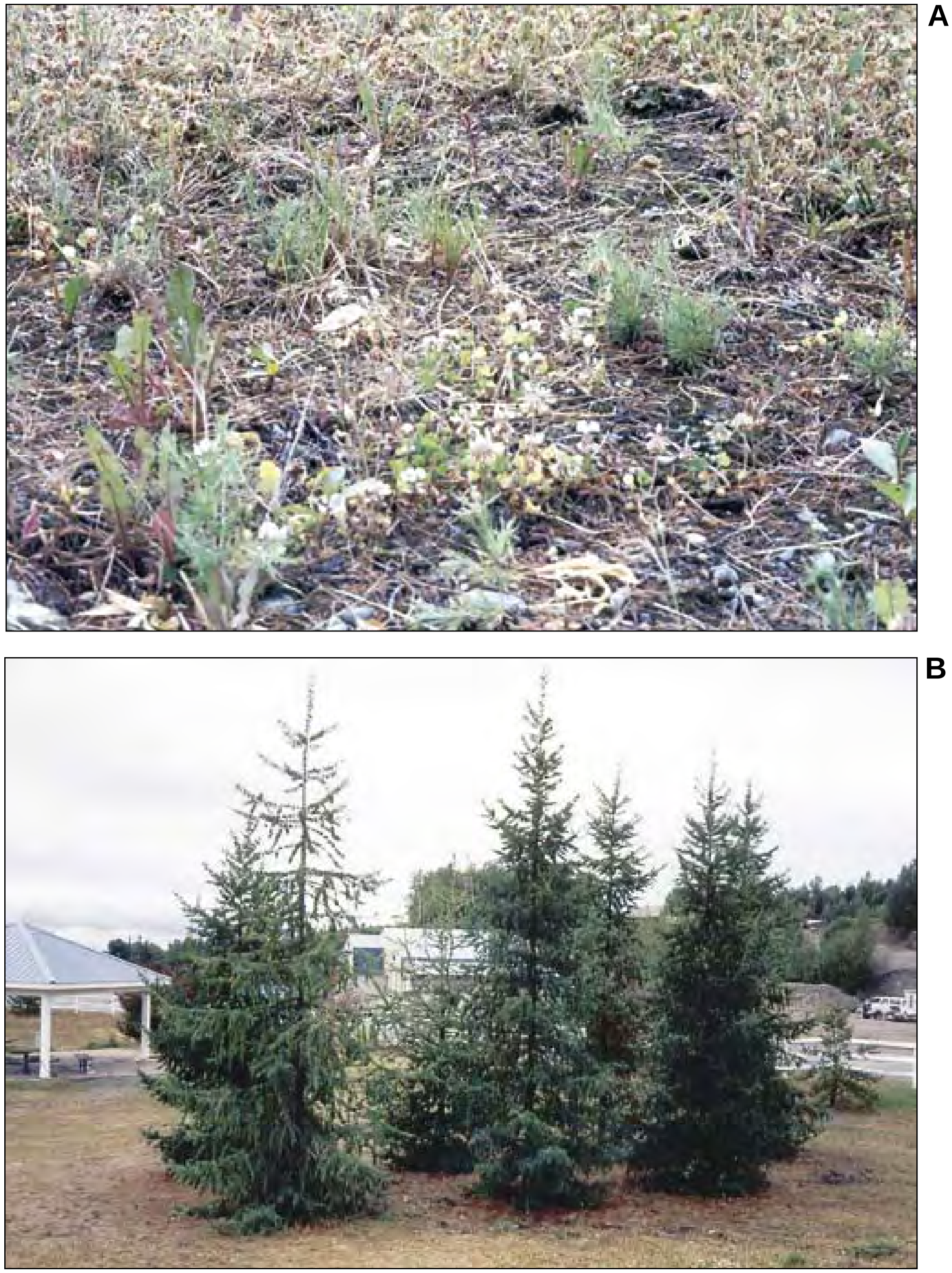

Figure 17—Numerous 1- to 3-year-old natural seedlings of Siberian larch (A) on exposed gravel within 35 ft (8 m) of their 15-year-old seed parents (B) in the Houston City Park. Seedling density within 35 ft of the seed parents was 2 offspring per $ft^2$ (22 seedlings per $m^2$, fig. 16).

of Natural Resources Compound in Fairbanks. The most distant nonnative offspring was a lodgepole pine seedling that was 341 ft (104 m) from its nearest possible seed parent at the Hermansen Homestead on Cohoe Loop Road, Kasilof River, Kenai Peninsula. Average maximum offspring distance from each of the six reproducing nonnative species and plantings ranged from 36 to 102 ft (11 to 31 m) (table 6).

Open and closed cones were retained as long as 15 to 20 years on older lodgepole and jack pine trees. Differences among the three major regions in number of cones per tree were not significant (table 7). Cone production of lodgepole pine plantings in the Copper River Valley was not compared with cone production of plantings in the interior and south-central regions where plantings averaged 2 to 5 years older and four times as frequent (table 1). In addition, closed cones were harvested from the dominant seed trees for seedling production in two of the four Copper River plantings. As a result, the percentage of open cones was higher in the Copper River region than in the interior and south-central regions.

**Table 7—Average number of cones per tree and percentage of open cones for lodgepole and jack pine plantings in four geographic regions on mainland Alaska**

| Region | Number of trees | Average number of cones and standard deviation | Number of trees with cones | Average percentage of open cones and standard deviation |
|---|---|---|---|---|
| Interior (Tanana Valley) | 93 | 128 ± 156 | 85 | 21a ± 25 |
| Mat-Su Valley | 22 | 140 ± 251 | 17 | 25ab ± 21 |
| Kenai Peninsula–Cook Inlet | 53 | 173 ± 172 | 39 | 34b ± 28 |
| Total | 168 | | 141 | |
| Weighted average | | 144 | | 25 |
| Copper River Valley | 14 | 26 ± 28 | 11 | 36 ± 36 |

Note: values with a common letter are not statistically different at P = 0.05.

All nonnative regeneration was found on sites that were disturbed by logging, thinning, agricultural clearing, or site preparation before the seed parents were planted. Nonnative conifers had not regenerated on sites with undisturbed natural vegetation. One exception was 3- to 5-year-old lodgepole pine seedlings that were found on two sites in the Kenai Peninsula and Cook Inlet Region (fig. 18). The seedlings were growing in native understory vegetation that was recovering from logging and thinning disturbances in about 1980. Several balsam fir seedlings were also found in about 6 in (15 cm) of understory moss at the Gonder Tree Farm (fig. 19), indicating that shade-tolerant *Abies* can regenerate somewhat in recovering indigenous vegetation without recent surface disturbance.

Figure 18—A 4-year old lodgepole pine seedling on a moist microsite in association with *Betula* (Kenai birch), *Vaccinium* (blueberry), *Viburnum* (highbush cranberry), *Empetrum* (crowberry), *Rosa* (prickly rose), *Sphagnum* moss, *Cornus* (bunchberry), *Epilobium* (fireweed), *Menziesia* (rusty menziesia), *Ledum* (Labrador tea), *Spiraea* (Beauverd spirea), *Alnus* (Sitka alder), *Picea* (Lutz spruce), *Salix* sp. (willow), *Calamagrostis* sp., and other indigenous flora at Congahuna Lake, Tyonek on September 13, 2002. The seed parents were planted in 1982, apparently without site preparation. Commercial-size virgin spruce was clearcut in 1980.

## Insects and Disease

Although the pines are susceptible to several bark beetles and rust pathogens in their natural range, insects and diseases were not observed in the pine plantings in northern Alaska. The larch sawfly, *Pristiphora erichsonii* (Hartig), was observed on the Siberian larches at several sites in interior Alaska, and on at least one site (Mat-Su College Arboretum in Palmer) in south-central Alaska. Minor defoliation and deformed branches and twigs from a budmoth of the *Zeiraphera* genus were observed on smaller Siberian larch in Brann and Samuel's Delta species trials (Trummer 2003).

Trees weakened from defoliation appeared susceptible to an unknown bark beetle, probably the eastern larch beetle, *Dendroctonus simplex* LeC. The infested trees died from the tops downward similar to *Ips*-caused mortality of *Pinus*. Siberian larch mortality, apparently from the insects and a blue stain fungus, *Leptographium abietinum* (Peck) Wingf., was observed at four sites in interior Alaska. The blue stain fungus was identified in the bark galleries of one second-generation tree that died after bark beetle attack (McBeath et al. 2004). Phloem and cambium necrosis from the blue stain pathogen appeared to prevent recovery of the tree from insect attacks.

Figure 19—A 6- to 7-year-old balsam fir seedling was growing in 6 in (15 cm) of sphagnum moss under the canopy of an estimated 27-year-old balsam fir planting at the Gonder Homestead, Big Lake, September 14, 2002. Six seedlings were observed in understory moss up to 12 in (30 cm) deep. High shade tolerance may enable balsam fir to colonize mesic sites in south-central Alaska regardless of the indigenous understory and overstory flora.

## Animal Damage

In the boreal forests, lodgepole pine was susceptible to injury and mortality from all vegetation-consuming animals, both herbivores and omnivores wherever their populations were high. Northern red-backed and Taiga voles (*Clethrionomys rutilus* Pallas and *Microtus xanthognathus* Leach, respectively) cut 1- to 2-year-old seedlings at the ground level in plantings in interior Alaska. Snowshoe hares were particularly destructive in the Copper River Valley, killing 90 percent of the trees planted at two sites and partially girdling most of the remainder (fig. 20). Trees as large as 3 in (8 cm) in d.b.h. were damaged or killed. The injured trees recovered only after their boles were enclosed in chicken wire. Red squirrels (*Tamiasciurus hudsonicus* Erxleben) cut branches of lodgepole pine causing extensive branch mortality and defoliation in gathering cones for winter middens in Bonanza Creek Experimental Forest, Fairbanks (fig. 21).

On Kenai Peninsula, moose were destructive, especially during rutting season, when more than half of the lodgepole pine plantings in Tustumena Lake area were damaged or destroyed (fig. 22). Moose also heavily damaged Siberian larch in Brann's 1984 species trial a few miles east of Delta Junction, and severely browsed Scotch pine plantings at Kingsberry and Porkorny Tree Farms in Talkeetna (fig. 23). Moose appeared to prefer Scotch pine to lodgepole pine as winter browse on both tree farms, causing extensive plantation loss. As a result of the damage, Scotch pine plantings were abandoned in preference for lodgepole pine plantings at the Porkorny Tree Farm (fig. 24).

Figure 20—Snowshoe hare injury to 12-year-old lodgepole pine in the Old Edgerton Highway, Copper River provenance trial in May 1997. The trees were planted as 2-year-old seedlings in 1985. Hares killed 90 percent of the trees from 1986 until 1998 when the surviving trees were enclosed in chicken wire to prevent further injury.

A

B

Figure 21—Branch and foliage mortality in lodgepole pine from squirrels cutting branches and cones (A) for lodgepole pine middens (B) in a 17-year-old provenance and family variation trial in Bonanza Creek Experimental Forest, Fairbanks. The injury was photographed in late May 2001 (A) and early June 2003 (B).

Brown bears (*Ursus arctos* L.) observed in the Tyonek area consumed or stripped the bark of lodgepole pine plantings, apparently after emerging from winter hibernation (fig. 25). The North American porcupine (*Erethizon dorsatum* L.) also consumed the bark of about 500 11-year-old Siberian larch trees at Wasilla, killing some of the trees outright, and killing the tops in the remainder (fig. 26). Animal injuries are summarized for each site and species in the appendix table 8.

Figure 22—Moose damage to 19-year-old lodgepole pine plantings in the Tustumena Lake area of Kenai Peninsula, August 7, 2002. Moose seem to prefer the resinous odor of lodgepole pine during the rutting season. Stems and branches of young trees are typically broken as bull moose rub velvet from their antlers. Injuries to lodgepole pine from browsing were less common than the physical breaking of stems and branches.

Figure 23—Alan Kingsberry standing by moose-browsed Scotch pine at his Birch Creek Ranch, Mastodon Road, Talkeetna, Alaska, September 15, 2002. The trees were planted in 1986 for Christmas tree production. Crowns of surviving dominant trees averaged 18 ft (5.5 m) tall and 3.7 in (9 cm) in d.b.h., and appeared to be above the reach of most moose. Injury included stripped bark and browsed foliage and twigs up to 2 cm in diameter.

Figure 24—Moose browse damage to 11-year-old Scotch pine raised for ornamental plantings at the Pokorny Tree Farm, Mastadon Road, Talkeetna, September 15, 2002. Nearly all Scotch pine were browsed or physically damaged, forcing the landowner to plant lodgepole pine. Lodgepole pine was not heavily browsed.

# Discussion

## Relative Growth Differences Among Species

The nonnative conifers, especially the Siberian larches and the hard pines (lodgepole, jack, and Scotch), not only grew significantly faster in height and stem diameter than native white spruce, but they produced two to six times more stem volume at the same age from planting and on the same sites in seven of eight plantings (table 4). From the regression analyses, white spruce was the only conifer with significant height growth acceleration from 10 to nearly 40 years of age. With the exception of lodgepole pine (N = 192) and the Siberian larches (N = 88), samples for native white spruce (N = 32) and the other less common nonnative conifers were inadequate for reliable assessments of annual height and diameter growth rates. Nevertheless, if white spruce height growth increases 0.24 in (6 mm) annually, it would overtake the height growth rate of lodgepole pine at about 35 years of age and the Siberian larches at about 45 years of age. The assumption is that the height growth of the Siberian larches will continue to decline at about 0.12 in (3 mm) per year after they exceed their 22-year average age in this survey. Annual growth of the Siberian larches is long lasting, however. In the Raivola larch forest, mean annual increment (MAI) began to decline from more than 6 $m^3 \cdot ha^{-1} \cdot yr^{-1}$ only after 150 years (Redko and Mälkönen 2005). Eis et al. (1982) reported that the growth rate of spruce exceeds the growth of lodgepole pine on the best sites in Central British Columbia after about 40 years, very close to the above-35-years estimated for spruce in Alaska. Bonnor (1989) also found that pure lodgepole pine regeneration on a cleared site of moderate productivity (2.5 $m^3 \cdot ha^{-1} \cdot yr^{-1}$) in southeast Yukon grew faster than mixed pine-spruce regeneration until the stands were about 40 years old. After 40 years, lodgepole grew slower than spruce. Mean annual increments appeared to culminate for pine and spruce at predicted rotation ages of about 80 and 110 years, respectively.

At what age white spruce overcomes the height advantage of lodgepole pine and Siberian larch in Alaska is unknown. Radial growth and probably height growth of interior white spruce are slowing in response to climate warming (Barber et al. 2000, Fitzgerald and Barber 2003, Juday et al. 2003). Managed-stand yield tables for British Columbia show that the mean annual increment of fully stocked white spruce stands begins to exceed the MAI of fully stocked lodgepole pine stands at about 70 years (Nigh 1995). Because lodgepole pine canopies closed before interior spruce canopies in central British Columbia, heights of spruce did not exceed those of lodgepole pine until trees were 88 years old on the most productive alluvium soils, 110 years on sites intermediate in moisture and nutrients, and 130 years on dry sites dominated by *Cornus* and moss species (Eis et al.

Figure 25—Bears stripped the bark from the boles of about 10 percent of 18- to 20-year-old Whitehorse, Yukon, lodgepole pine in a 1982 planting on the northwest shore of Congahuna Lake, Tyonek, Alaska. Bears are known to feed on the inner bark and cambium of conifers after emerging from winter hibernation, especially when traditional foods are in short supply. Dominant trees averaged 33 ft (10 m) tall and 7.8 in (20 cm) in d.b.h. Lodgepole pine was colonizing the site on September 13, 2002 (see fig. 18).

Figure 26—Porcupines debarked the stems of 11-year-old Siberian larch saplings near Wasilla in 2001 and 2002. Limbs were uninjured. Dominant trees averaged 26 ft (8 m) tall and 4.1 in (10 cm) d.b.h. July 18, 2002. An estimated 75 percent of the trees were damaged. Marc Lee, Area Forester, State of Alaska, reported similar injury in an unsurveyed 10-year-old lodgepole pine planting in Rosie Creek, Fairbanks, Alaska.

1982). Diameters of spruce and pine were equivalent at 75, 82, and 115 years of age, and volumes were equal at about 95, 110, and 135 years on the productive, intermediate, and impoverished sites, respectively. After 88 years, mean annual volume increment for spruce was larger than pine on the most productive sites, about the same on intermediate sites, and less than pine on impoverished sites. Under short rotations (e.g., 80 years) on intermediate sites, lodgepole pine grew up to 50 percent more volume than spruce of the same age. On impoverished sites, lodgepole pine always grew more volume than spruce of the same age.

Native white spruce may have difficulty in succeeding lodgepole pine after it naturalizes on fire-prone sites in interior Alaska (Johnstone and Chapin 2003). Wildfire cycles are as frequent as 40 to <120 years in the eastern Yukon River lowlands (Foote 1983, Kasischke et al. 2002, Yarie 1981), and should favor lodgepole pine. Long fire cycles should favor white spruce, which regenerated successfully under the closed canopy of a 28-year-old lodgepole pine provenance study in T-Field Arboretum, Fairbanks, after more than 10 years of competition control (fig. 27). Competition control was terminated in 1985.

## Lodgepole Pine

Lodgepole pine was the most common nonnative species introduced to mainland Alaska before 1992. Seed and wild seedlings were readily available from neighboring Yukon Territory. In central Yukon, lodgepole pine showed consistent increases in seedling recruitment following wildfires at the edge of its northern range (Johnstone and Chapin 2003). These authors concluded that northern lodgepole pine populations had not reached their climatic limits, and that the northern populations "have a capacity for rapid local population expansion" in spite of the limited seed dispersal distance as shown in table 6. Except for uncommon wind events and human transport of seeds, the limited dispersal distance of lodgepole pine regeneration appears to be typical for the major nonnative conifers in Alaska (figs. 14 through 16).

Lodgepole pine is widely planted in Alaska because its natural range extends to about 64°15' N. latitude in Hamilton Creek, east of Dawson City, Yukon, and the Alaska border. Readily available seed sources in the Yukon are advantageous compared to seed sources of nonnative species indigenous to Europe and Asia. In addition, lodgepole pine produces serotinous cones, and seed is easy to collect and propagate at a young age. With the exception of herbivore injury, our experiments with northern lodgepole pine provenances in interior Alaska show that they are well adapted to permafrost-free upland sites.

Common pathogens and insect pests of lodgepole and jack pines such as the rust fungi, *Cronartium* and *Peridermium* species, have not arrived in northern Alaska to date, but western gall rust, *Peridermium harknessii* J.P. Moore is a common disease of shore pine, *Pinus contorta* Dougl. ex Loud. var. *contorta* in southeast Alaska (Wittwer et.al. 2004). The bark beetles, *Ips* and *Dendroctonus* species, especially the mountain pine beetle, *D. ponderosae* Hopkins, are among the most destructive insect pests of lodgepole and jack pine forests of North America (Furniss and Carolin 1977), and will likely be future pests of the *Pinus* in Alaska.

Figure 27—After more than 10 years of competition control, natural white spruce invaded the understory of a closed lodgepole pine canopy in T-Field Arboretum. The lodgepole pines were planted as 2-1 seedlings at 6-ft intervals in June 1974 from provenance collections provided by the International Union of Forest Research Organizations. On June 4, 2002, dominant trees in four superior provenances averaged 46 ft (14 m) tall and 7.5 in (19 cm) in d.b.h. after 27 growing seasons. White spruce in the understory averaged 4.2 ft (1.3 m) tall after 16 years, whereas dominant white spruce natural regeneration outside the 1974 study averaged 32.5 ft (10 m) tall, 5.7 in (14.5 cm) in d.b.h. and 23 years old. On productive upland sites in Alaska, the annual growth and tree volume of native white spruce are expected to exceed the annual growth and tree volume of lodgepole pine in about 35 and 70 years, respectively. On xeric sites, however, lodgepole pine volume may exceed the volume of native white spruce even at maximum rotation age (Eis et al. 1982).

Absence of lodgepole pine natural regeneration in the Copper River Valley may be attributed to the young age of the plantings, high mortality from hares, and the commercial harvest of almost all cones in two of the four major plantings surveyed. The cones were harvested for seeds to grow nursery seedlings. In spite of the earlier reproductive age for lodgepole pine (table 5), the approximate numbers of offspring per planting, and numbers of offspring per unit area for the nonserotinous Siberian larches and Scotch pine were more than three times the number of offspring for lodgepole pine (table 6). In T-Field Arboretum, lodgepole pine produced cones that averaged 5 to 6 viable seeds each at 5 to 7 years of age (Alden and Zasada 1983). Viable seed recovery was normal (20 to 25 seeds per cone) after the trees were about 10 years old.

Absence or low stocking of lodgepole and jack pine regeneration at all sites may be attributed to the high percentage (74 percent) of closed cones in the crowns of seed-bearing dominant and codominant trees. In Alberta, lodgepole pine trees lose about 3 percent of their cones annually, retaining about 50 percent of each cone crop for 15 years (Hellum 1983). Cones of trees less than 20 years old are generally less serotinous than older trees. Serotinous cones retained in the crowns of older trees open to disseminate their seeds slowly over time, or when heated to high temperatures for short periods such as during wildfires. Oven-drying temperatures of only 40 to 60 °C overnight will open most lodgepole and jack pine cones. With nearly three-fourths of their seeds available in about 50 percent of all cones produced for 30 years, lodgepole and jack pine have potential for abundant regeneration in Alaska. In the Yukon, natural regeneration of lodgepole pine is usually associated with fire and rarely includes understory regeneration without site disturbance[6] (Stanek and Orloci 1987).

The relatively high percentage of open cones in the Cook Inlet Region may result from a high frequency of wet and dry weather cycles. The extensive harvest of closed cones in the Copper River region increased the percentage of open cones observed on the cone-bearing trees.

Jack pine is closely related to and hybridizes naturally with lodgepole pine. Recent natural hybrids are often unstable in new enviroments. For this reason, jack pine should not be introduced on a large scale in Alaska until the performances of jack pine and its lodgepole pine hybrid are fully investigated.

The slow establishment and height growth (1 to 9 inches or 3 to 24 cm per annum, table 6) of the nonnative regeneration relative to their parents may be caused by competition from the parent population and native vegetation that was recovering from preplanting disturbances. In addition, natural regeneration usually grows slower than planting stock, especially when the planted seedlings are young and establish a vigorous root system in 3 or 4 years.

More plantings in forest settings would help to fully test hypotheses concerning seed production, regeneration success, and growth of the nonnative species in Alaska. Operational forest plantations older than 10 years do not exist for nonnative species, thus it is difficult to determine the preferred sites and accurate growth and yields of the nonnative conifers. At this time, lodgepole pine and the other nonnative conifers do not appear to displace the indigenous flora.

From the early regeneration successes, growth rates, and relative shade tolerances of the nonnative conifers, I believe that lodgepole pine will eventually naturalize in Alaska. On productive sites in unmanaged forests, lodgepole pine

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[6] Johnstone, J.F. 2005. Personal communication. Dr. Jill Johnstone is a Research Fellow, Department of Geography, Carleton University, Ottawa, Canada, and is in residence at the Division of Arts and Science, Yukon College, Whitehorse, YT Y1A 6P8. E-mail: jjohnstone@yukoncollege.yk.ca.

will likely require fire cycles of 100 years or less to compete successfully with the indigenous *Picea*. On dry permafrost-free marginal sites, the indigenous *Picea* may have difficulty competing successfully with lodgepole pine. A mosaic of intermixed or nearly monospecific stands of white spruce and lodgepole pine frequently populate dry areas in Yukon Territory. Although lodgepole may dominate specific sites, there is little evidence for competitive exclusion of white spruce at the landscape scale (see footnote 6).

## Siberian Larches

On exceptional sites in Alaska, native white spruce is unlikely to overcome the faster early growth of the Siberian larches. Both western Siberian and Siberian larch grow rapidly to 150 ft (45 m) tall and more than 40 in (1 m) in d.b.h. at maturity (>100 years) on well-drained upland sites in Russia and Siberia (Bukshtynov 1959, Popov and Rozhkov 1966). Old-growth trees are reported to achieve 195 ft (60 m) in height and 78 in (2 m) in d.b.h., and occasionally survive more than 1,000 years. Similar rapid growth occurred in Alaska on 10 Raivola larches at Les Viereck's Tree Farm in Fairbanks. The trees averaged 68 $\pm$ 6 ft (20.7 $\pm$ 2 m) tall after only 36 growing seasons from planting (fig. 28).

Western Siberian larch appears likely to maintain superiority on productive upland sites in Alaska because in its natural range, trees grow rapidly for 100 years, achieve large size, and survive more than five centuries (Popov and Rozhkov 1966). But the indigenous Norway spruce and Scotch pine succeeded western Siberian larch on inferior lowland sites before 150 years in the Raivola plantation (Ilvessalo 1923), and on poor-quality sites in Sweden (Martinsson 1995). Thus, in spite of the early slower growth and smaller size, native spruce and deciduous species in Alaska may similarly replace the Siberian larches on poor to average sites where site indices of native species may exceed those of the Siberian larches. In the Raivola Forest, Siberian larches are more productive managed as pure species than managed in mixed pine, spruce, and birch stands (Redko and Mälkönen 2005). In addition, 110 foliage insects (32 percent of all Siberian larch pests) are known to attack the Siberian larches in their natural range (Verzhutskii and Raigoredskaya 1966). Two foliage insects, a bark beetle, and a blue stain pathogen were found in this survey, less than 50 years after the first introductions.

On productive sites in their natural range, the Siberian larches replaced the more tolerant conifers only after wildfires (Popov and Rozhkov 1966). Seed crops averaged about 1 million seeds per hectare annually, but during rare heavy seed years 18 million seeds were produced per hectare. Thick bark (10 in or 25 cm) on tree trunks near the ground protects old-growth trees from ground fires. In


Figure 28—A 36-year-old "Raivola strain" of western Siberian larch (A) at Les Viereck's Tree Farm on Red Fox Drive, Fairbanks, Alaska, June 13, 2002. On productive sites, western Siberian larch outgrew all boreal conifers surveyed on mainland Alaska. The largest tree was 75 ft (23 m) tall and 16.5 in (42 cm) d.b.h. in 50 years. (B) The tree, shown by Stanley Vlahovich of the Alaska Department of Forestry, was planted in a partial birch-spruce overstory on Schrock Road, Wassila in 1953.

absence of permafrost and on productive sites, the Siberian larches have deep root systems that are protected from cold and fire. On sites with shallow soils and active layers, root growth is restricted and trees are subject to windthrow.

The Siberian larches are excellent carbon sequestration species. In its natural range, Siberian larch absorbs 2.5 and 1.5 times as much $CO_2$ during the growing season as Siberian spruce and pine, respectively (Popov and Rozhkov 1966). At about 500 kg/m$^3$, wood density of Siberian larch is intermediate between the wood densities of spruce and birch (Gonzalez 1990), and contains about 50.5 percent carbon by weight (Matthews 1993). The heartwood is heavily lignified (lignin is 66.7 percent carbon) and highly decay resistant, especially in moist environments. Seasoned wood requires special moisture treatments to prevent checking, and the low cellulose/lignin ratio is undesirable for wood pulp and paper manufacturing.

In this survey, the Siberian larches appeared more shade tolerant than the *Pinus*. The Siberian larches were precocious, produced many seedlings, and survived tenaciously at close spacing. How well the Siberian larches compete with the indigenous *Picea* on productive upland sites is unknown, but I believe white spruce is not likely to overtop the Siberian larches once they are established on productive upland sites in interior Alaska. However, white and black spruce (*P. mariana* (Mill.) B.S.P.) may compete successfully in the understory of the Siberian larches. Larch loses its foliage in winter, and provides less shade and competition during spring and early summer than during late summer. In addition, unlike the toxic phenol contents of *Picea* and *Pinus* needles, Siberian larch foliage provides organic amendments and nutrients for soil microflora and shade-tolerant understory vegetation, especially on mesic habitats. More than 90 species of fungi were described in the understory of Raivola larch in the early 1920s (Ilvessalo 1923). On dry habitats where decay is inhibited, needle cast from the Siberian larches may accumulate and prevent the regeneration of understory flora.

## Other Nonnative Species

Balsam fir is another nonnative conifer that was capable of dense regeneration on disturbed sites, and limited regeneration in recovering understory mosses (fig. 19). Balsam fir is more shade tolerant than the indigenous *Picea* in Alaska, and is associated with white and black spruce in eastern Canada where it is the climax species (Frank 1990). It is a small to medium tree, and is not likely to overtop native white spruce on high-quality sites in Alaska. In addition, balsam fir has many insect and fungal enemies among which the spruce budworm (*Choristoneura fumiferana* Clemens and other species) is a common defoliator of white spruce in Interior Alaska. Balsam fir is highly valued for pulpwood and timber, and its wood may be stronger than white spruce.

Only two balsam fir plantings were found in Alaska, and both had regenerated naturally. At 1 seedling per 2.5 $ft^2$ or 4 seedlings per $m^2$ (table 5), balsam fir regeneration was dense, but distances of its seedlings from their seed parents were limited to less than 50 ft (15 m) (fig. 29). Limited offspring dispersal distance (table 6) is typical of most conifers with wind-dispersed seed. As a result, population spread will probably be very localized for balsam fir and most other conifers except for rare natural dispersal events or human transport of seeds.

Future naturalization surveys of nonnative species should consider the relative contributions of cone crop heights, seed weights, wind events, and site disturbances on the distances and densities of offspring distributions. For open cone species, the frequency of seed crops can be estimated from the age distributions of their offspring.

Because of its shade tolerance, balsam fir could be a major competitor of the indigenous *Picea* on mesic and wet sites in south-central Alaska where wildfires are less common than in interior Alaska. Balsam fir is intolerant of wildfire,

Figure 29—Four 1- to 5-year-old balsam fir seedlings per square meter on mineral soil within 50 ft (15 m) of their seed parents at the Gonder Tree Farm in Big Lake, September 14, 2002. Yellow flags mark each seedling. The parents were planted at 6 ft (2 m) spacing in about 1974. Dominant parents averaged 36.7 ft (11 m) tall and 5.5 in (14 cm) in d.b.h. Balsam fir is highly shade tolerant, and grows best on moist sites.

extreme cold, and short, dry growing seasons. Therefore, it is unlikely to naturalize in interior Alaska. If balsam fir and its close relatives adapt to cold dry habitats in interior Alaska, they could be major fire hazards.

Balsam fir is closely related to subalpine fir, and hybridizes with Siberian fir (Frank 1990). The three species have similar habitat and shade requirements, and the latter species also have potential for naturalizing in northern Alaska. Natural subalpine fir populations are found at 5,000 ft above sea level in central Yukon at 64° latitude (Keno Hill), and on the Stewart River only 125 mi (200 km) east of the Alaska border (Viereck and Little 1972). In southeast Alaska, subalpine fir is found naturally at the head of Lynn Canal and at other coastal sites extending to the mountains southeast of Ketchikan. Spruce-fir associations are common in eastern boreal forests, but their relation with the indigenous *Picea* should be investigated before they are widely introduced in Alaska.

Scotch pine is the most widely planted nonnative conifer in North America. More than 10 million trees have been harvested for Christmas trees in the United States annually (Skilling 1990). As a result, Scotch pine has naturalized in the Northeast and Lake States regions of the United States, and in Ontario, Canada, where regeneration is prolific and spreads on disturbed gravel and light sandy soils. In New York, the stem and branch canker caused by *Gremmeniella abietina* (Lagerb.) Merelet., an indigenous pathogen of native red (*Pinus resinosa* Ait.) and jack pines, keeps Scotch pine regeneration in check (Skilling 1981). Scotch pine is shade intolerant and has little chance of naturalizing extensively in Alaska except perhaps on disturbed sites, and on sand dunes that are unfavorable habitats for the indigenous species. Scotch pine is a highly variable species geographically and morphologically (Tseplyaev 1961). Latitudinal clines for growth and survival of the Scandinavia variety (*P. lapponica* Fries.) are steep and negative (data on file for a 1984 species trial in Delta, Alaska). In northern Sweden, native Scandinavian provenances grow 35 to 40 percent less volume than introduced lodgepole pine from the Yukon (von Segebaden 1993).

Norway spruce, Dahurian larch of Far East Asia, and Douglas-fir produced seed cones, but they failed to regenerate. A Norway spruce planting in Mat-Su Valley was vigorous and had high-quality trees, but three unsurveyed plantings of a Baltic Sea seed source in interior Alaska sustained frequent winter injury during the 1980s. Douglas-fir of a probable Rocky Mountain seed source developed poor form and appeared least likely among the conifers surveyed in south-central Alaska to compete successfully with the indigenous species.

Other boreal conifers were introduced to mainland Alaska in demonstration or species trials before 1990, but they were not investigated in this survey. They include subalpine fir, Siberian spruce (*Picea obovata* Ledeb.), Siberian pine (*Pinus sibirica* Du Tour), Japanese stone pine (*Pinus pumila* (Pall.) Regel), and limber pine (*Pinus flexilis* James). Each of these species has economic value in industrial or urban forestry. The Siberian and stone pines have additional value because their seeds are valued as a food crop for both human and wildlife consumption.

These conifers are among more than 300 exotic broadleaf and needle-leaf species that have industrial or urban forestry value and potential for introduction to mainland Alaska (list on file). Nearly one-third already survive as single trees or in small plantings in Alaska from introductions before 1990. Performances of the most promising should be studied in arboretums and replicated field experiments before they are introduced on a landscape level.

Growth and yields of the nonnative conifers in well-managed operational plantations for industrial forestry are unknown in Alaska. The potential for disruption of natural forest ecosystems from naturalization of nonnative conifers is a concern of some resource managers and scientists. Boreal forests are naturally lower in biodiversity and productivity than temperate and tropical forests. The performance of nonnative conifers mixed with boreal tree species, and of subsequent forest ecosystems are also unknown.

## Conclusions

Lodgepole pine and Siberian larch provenances reproduce after only 10 years on disturbed sites in Alaska. Lodgepole pine and the Siberian larches colonized at one-third of their introduction sites, and may soon be the first conifers to naturalize on mainland Alaska.

Lodgepole pine and the Siberian larches are shade intolerant relative to Alaska's *Picea* species, and are not likely to dominate or replace the native conifers in undisturbed forest ecosystems. The prolific regeneration and shade tolerance of balsam fir indicate that it could naturalize on moist sites in south-central Alaska.

On productive sites, annual stem-diameter, height, and volume growth of lodgepole pine and Siberian larch are likely to exceed the growth of native white spruce until they are at least 35 and 45 years of age, respectively. In absence of disturbance on productive upland sites, white spruce should succeed lodgepole pine in 100 years or less, but white spruce is not likely to replace adapted western Siberian larch until after the first generation when it recaptures a dominant crown position.

The western Siberian larches grow as fast as lodgepole pine in diameter, and faster in height. The larch sawfly, an unknown bark beetle and a blue stain fungus that is a pathogen could limit western Siberian larch as a forest crop species in Alaska.

Animal damage may limit lodgepole pine's potential as a crop tree in eastern Alaska. Lodgepole pine remains susceptible to hare damage at peak population cycles until it is at least 3 in d.b.h. Large moose populations cause extensive injury and mortality. Animal damage is especially severe where (1) plantings are small and animals concentrate, (2) habitats are favorable for large animal populations, (3) natural browse is inadequate, and (4) migration is limited, i.e., by deep snow. Large plantings would distribute the damage over wider areas and reduce losses.

Data is insufficient to determine the productivity of pure and mixed forests of spruce, fir, pine, and larch in Alaska. Well-planned species and provenance trials of sufficient size and design to yield satisfactory results are necessary to evaluate the productivity of pure and mixed-species forests on mainland Alaska.

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## Metric Equivalents

| When you know: | Multiply by: | To find: |
|---|---|---|
| Miles (mi) | 1.609 | Kilometers |
| Feet (ft) | .3048 | Meters |
| Inches (in) | 2.54 | Centimeters |
| Square feet ($ft^2$) | .0929 | Square meters |
| Cubic feet ($ft^3$) | .0283 | Cubic meters |
| Acres (ac) | .4047 | Hectares |
| Trees per acre | 2.471 | Trees per hectare |
| Trees per square feet | 10.7639 | Trees per square meter |

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## Appendix

**An inventory of sites examined from June to October 2002 (and 2003 as indicated) for colonization and potential naturalization of nonnative species on mainland Alaska**

| Location and date planted | Date checked |
|---|---|
| **Interior and Copper River:** | |
| 1. T-Field Arboretum 1964 to 1974 | 6/25, 9/24/03 |
| 2. Bonanza Creek Experimental Forest lodgepole pine provenance/family trial, 1985 | 7/03 |
| 3. Rosie Creek lodgepole pine prov./family trial, 1985 | 6/26 |
| 4. Rosie Creek lodgepole pine container seedling trial, 1986 | 8/15 |
| 5. Rosie Creek lodgepole pine operational seedling trial, 1985 and 1986 | 8/15 |
| 6. Malone Rosie Creek sites I and II | 10/3 |
| 7. Samuel's lodgepole pine provenance, provenance/family, and species trials, 1982–86 | 7/5 |
| 8. Brann's lodgepole pine provenance/family and species trials, 1984 | 8/1 |
| 9. Tanana Loop Road lodgepole pine and Siberian larch plantation, ~1988 | 8/1 |
| 10. Tok Rifle Range lodgepole pine provenance/family and species trials, 1989 | 8/22 |
| 11. Lodgepole pine stocking study, Red Fox Drive, Tok, AK, 1992 | 8/21 |
| 12. Glennallen Division of Forestry Tazlina Experimental Planting, 1984 | 8/22 |
| 13. James Luebke's lodgepole and Scotch pine 0.25 mi Copperville Rd., mi 112 Richardson Highway planting, Glennallen, 1985–87 | 8/23 |
| 14. Nick Zerbinos' Rose Av. ~1987 lodgepole pine planting on Tazlina Terrace, Glennallen | 8/22 |
| 15. Old Edgerton Highway lodgepole pine provenance/family trial, 1984 and 1985 | 8/23 |
| 16. Don Kratzer's Tree Farm, Nenana, 1982–87 | 6/20 |
| 17. Georgeson Botanical Garden and Irving Bulding Siberian larch, 1974 | 6/11 |
| 18. Les Viereck's lodgepole pine, Scotch pine, Siberian larch, Norway spruce, and Siberian fir plantings on Red Fox Drive, Fairbanks, 1966–82 | 6/12–13 |
| 19. Lodgepole pine and Siberian larch at Al and Robin Near home, and J. Zasada's former home, 1555 LaRue Drive (Farmers Loop), Fairbanks, 1975–~1985 | 6/13 |
| 20. Lodgepole pine at 24 mile Chena Hot Springs Road, 1967 | 6/25 |
| 21. Siberian larch seed orchard, Delta Agriculture Experimental Farm, 1984 and 1985 | 8/21 |
| 22. Siberian larch, former Bureau of Land Management Office, Airport Way, ~1955 | 9/25 |
| 55. Alaska Tree and Garden Center, ~1978 | 7/1/03 |
| **South-Central Alaska**: | |
| 23. Mat-Su College Arboretum (*Pinus, Larix, Picea, Abies, Pseudotsuga*), 1985 | 7/18 |
| 24. Gene Holmberg's northwest field of Siberian larch, Schrock Road, Wasilla, 1991 | 7/18 |
| 25. Gene Holmberg's understory Siberian larch, Schrock Road, Wasilla, 1953 | 9/16 |
| 26. Gene Holmberg's south field of Siberian larch, Schrock Road, Wasilla, 1991 | 9/16 |
| 27. Houston City Educational Park, Houston, 1986 and 1987 | 7/18 |
| 28. Mike Peacock Demonstration Forest (Willow Experimental Forest), Houston City Landfill, 1986 | 7/18 |
| 29. Siberian larch at Wasilla Veterinary Clinic, 40 mi Parks Highway, 1988 | 7/18–19 |
| 30. Point Mackenzie tree farms: Scotch pine, T15 N, R5W, E1/2 S26, ~1985 | 7/19 |
| 31. Point Mackenzie tree farms: lodgepole pine, Scotch pine, Siberian larch, Guernsey Road, ~1991 | 7/19 |

| Location and date planted | Date checked |
|---|---|
| 32. Point Mackenzie tree farms: lodgepole pine, Point Mackenzie and Airstrip Roads, ~1982 | 7/19 |
| 33. Gonder Homestead (*Pinus, Abies, Pseudotsuga, Picea*), Gonder Road, Big Lake, 1964–95 | 7/19, 9/14-16 |
| Lodgepole pine at 5 mi Goose Bay-Knik Road, ~1990 | Not found |
| *Pinus* and *Larix* at northeast end of Yarrow Rd., Wasilla, or Palmer, T18N, R2E, Sec, 6, 1988 | Not found |
| 34. Lodgepole pine at former Alaska Forest Tree Nursery, Eagle River, ~1983 | 7/19 |
| 35. Siberian larch, Scotch pine, and lodgepole pine at Pokorny Tree Farm, Talkeetna, ~1990 | 9/15 |
| 36. Lodgepole pine and Scotch pine at Kingsberry Tree Farm, Talkeetna, ~1985–90 | 9/15 |
| *Picea, Pinus, Abies*, and *Larix* on University of Alaska Anchorage Campus, ~1975–95 | Not examined |
| *Picea* and *Larix* in the University of Alaska Fairbanks Palmer (Babb) Arboretum, 1949–85 | Not examined |
| **Kenai Peninsula**: | |
| 37. Division of Forestry Area Office lodgepole pine and Arboretum, Soldotna, 1978–85 | 8/6–7 |
| 38. Division of Forestry Area Arboretum, Soldotna, 1978–2000 | 8/7 |
| 39. Lodgepole pine and Siberian larch plantings on power line road extending from Tustumena Lake Road, ~1980 | 8/7 |
| 40. Lodgepole pine on Richard Stingley Farm, 3 mi North Fork Road, Anchor Point, 1977 | 5/29 |
| Scotch pine at seismic line crossing, 2.4 miles southwest of 2 mi Falls Creek Road, T1N, R13W, Sec 25, Kenai Peninsula, ~1985 | Not examined |
| 41. Arc Loop Road, south of Soldotna, ~1973 | 8/6 |
| 42. Lodgepole pine and Siberian larch on a burned site in Moose Pass, 1988 | 8/8 |
| 43. Curly Wynkoop home, Strawberry Road, Soldotna-Kenai, 1975 | 8/6 |
| 44. Southeast of Curly's, Strawberry Road, Soldotna-Kenai, 1978 | 8/6 |
| 45. Funny River State Recreation Area, 1987 | 8/6 |
| 46. Dean Glick, Lake Street, Soldotna, 1989 | 8/6 |
| 47. Siberian larch and Scotch pine at 2.5 mi Falls Creek Road, 1988 | 8/7 |
| 48. Mossy Kilcher's Seaside Farm, East Homer Road, ~1977 | 9/10 |
| 49. East Hill Road lodgepole pine, Homer, ~1977 | 9/10 |
| 50. Lodgepole pine in the Homer Demonstration Forest, ~1982 | 9/10 |
| 51. Milepost 54.1 Seward Highway lodgepole pine, ~1968 | 9/11 |
| 52–3. Two lodgepole pine of six plantings on Division of Forestry salvage sites at Tyonek, ~1975 | 9/12–13 |
| 54. G. Hermansen lodgepole pine on Cohoe Loop Road, Kenai Peninsula, ~1969 | 7/17/03 |

**Table 8—Locations and foreign conifers examined for evidence of escape and colonization, and injuries from indigenous animals and snow or wind in interior and south-central Alaska**

| Site | GPS | Species | Acres | Date | Progeny | Injury | Animal | Percentage of trees injured | Percentage of trees killed | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| **Interior Alaska:** | | | | | | | | | | |
| 1. T-Field Arboretum | 64.8740229N; 147.8647104W; 219M | *Larix sukaczewii* N. Dyl. and *L. sibirica* Ledeb. | 0.1 | 1964 | Yes | | | | | Fenced site |
| | (64.8739012N; 147.5638589W; 193M—escape) | *Pinus contorta* Dougl. ex Loud. var. *latifolia* Engelm. | 0.1 | 1964 | Yes | | | | | Fenced site |
| | 64.8733984N; 147.8636730W; 188M | *Pinus contorta* Dougl. ex Loud. var. *latifolia* and *Pinus banksiana* Lamb. | 0.5 | 1974 | No | Broken tops and branches | | 37 | | Fenced site; snow 1984–85 |
| | | *Pinus sylvestris* L. | 0.05 | 1966 | No | Broken roots at ground | | 15 | 5 | Fenced site; snow 1984–85 |
| | | *Pinus banksiana* | 0.05 | 1966 | Yes | Browse | Hare | 10 | | Fenced site; hare browsed one natural seedling; snow 1984–85 |
| | | *P. sibirica* Du Tour, *P. pumila* (Pal.) Regel, *Picea abies* (L.) Krast., *Abies sibirica* Ledeb. | 0.1 | 1966–78 | No | None | | | | Fenced site |
| 2. Bonanza Creek Experimental Forest, Rep 6 | 64.7414780N; 148.2909996W; 236.6M | *Pinus contorta* var. *latifolia* and *P. banksiana* | 2 | 1985 | No | Bark, branches | Squirrel | 1 | 0.01 | Defoliation in cutting cones |
| 3. Rosie Creek Prov./ family Trial, Rep 8 | 64.7780558N; 148.1828052W; 235M | *Pinus contorta* var. *latifolia* and *P. banksiana* | 2 | 1985 | No | Bark stripping, top and branch kill | Moose | 30 | 10 | Low initial survival; dense aspen, birch; large moose population |
| 4. Rosie Creek Container Trial | 64.7753584N; 148.1592672W; 235M | *Pinus contorta* var. *latifolia* | 0.25 | 1986 | No | None observed | | | | Low initial survival; few trees; extreme competition |
| 6. Malone's Rosie Creek trial No. 2 | 64.7748192N; 148.1899687W; 212M | *Pinus contorta* var. *latifolia* | 0.5 | 1985–86 | No | Browsed tops | Moose | 5 | 20 | Low survival; kill in patches; difficult to judge injury and losses |
| Malone's Rosie Creek trial No. 1 | 64.7737949N; 148.1940113W; 217M | *Pinus contorta* var. *latifolia* | 0.5 | 1985–86 | No | Browsed tops | Moose | <5 | 50 (of recent losses) | Low survival. Difficult to judge losses from moose injury |

**Table 8—Locations and foreign conifers examined for evidence of escape and colonization, and injuries from indigenous animals and snow or wind in interior and south-central Alaska (continued)**

| Site | GPS | Species | Acres | Date | Progeny | Injury | Animal | Percentage of trees injured | Percentage of trees killed | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 7. Samuel's lodgepole pine prov./family test, Delta Junction | 64.0063942N; 145.5554455W; 381M | *Pinus contorta* var. *latifolia* | 1 | 1982 | Yes (in 2003) | Cut stems, branches | Hares | 1 | 40 | Caused initial mortality; injured trees recovering |
| Samuel's lodgepole pine prov./family and species trials | 64.0102363N; 145.5530110W; 387M | *Pinus contorta* var. *latifolia*, *Larix sukaczewii* and *L. sibirica*, *L. laricina* var. *alaskensis* (W.F. Wright) Raup, *Pinus sylvestris*, *P. banksiana*, *P. flexilis* James, *Picea abies*, *P. obovata* Ledeb. | 6 | 1984, 1987 | Yes (in 2004) | Cut stems, branches | Hares and voles | 0–50 | 5–75 depending on species | *P. obovata* especially susceptible to hares; impacted trees recovering; voles cut 1-0 and 2-0 *P. latifolia* seedlings; moose damage not reported |
| 8. Brann's lodgepole pine prov./family and species trials | 63.9705751N; 145.5325712W; 389M | *Pinus contorta* var. *latifolia* | 4 | 1984 | Yes | Cones stripped; cut stems and branches | Squirrels<br>Hares | 5<br>0 | 0<br>20 | Moose damage not reported; hares cut trees to 3 cm diameter |
| Brann's species trial | 63.9705751N; 145.5325712W; 389M | *Pinus contorta* var. *latifolia*, *Larix sukaczewii* and *L. sibirica*, *L. laricina* var. *alaskensis*, *Pinus sylvestris*, *P. banksiana*, *P. flexilis*, *Picea abies* | 4 | 1984 | No | Broken tops and branches | Hares and moose | As above | Up to 50 | Low initial survival; moose damage to *L. sibirica* and *L. sukaczewii*, severe in early 1990s |
| 9. Swain's Tanana Loop plantation | 64.1179010N; 145.6659476W; 338M | *Pinus contorta* var. *latifolia*; *Larix sukaczewii* | 2 | ~1988 | No | None | Squirrel cutting larch cones | 0 | 0 | Heavy moose browse on aspen and birch but no injury on pine and larch |
| 10. Tok Rifle Range lodgepole pine prov./family and species trials | 63.3590475N; 143.2740616W; 490M | *Pinus contorta* var. *latifolia*, *Larix sukaczewii* and *L. sibirica*, *L. laricina* var. *alaskensis*, *L. dahurica* Turcz., *Pinus sylvestris*, *P. banksiana*, *P. flexilis*, *Picea abies* | 3 | 1989 | No | Branch pruning on pines | Hares | 10 | <5 (recently) | Moose caused past damage and mortality |
| 11. Malone's Stocking Study, Red Fox Drive, Tok | 63.3519755N; 142.9792464W; 494M | *Pinus contorta* var. *latifolia* | 6.5 | 1992 | No | Branches clipped, browsed | Hares<br>Moose | 10<br>0 | 5<br>>5 | Trees recovering from early hare injury; moose damage documented for 1 in 5 trees measured |
| 12. Division of Forestry Tazlina Experimental Planting, Glennallen | 62.0484757N; 145.4575409W; 421M | *Pinus contorta* var. *latifolia* | 4 | 1984 | No | Stems to 4 in diameter girdled and branches cut | Hares voles | 5 | 90 | 50 in 500 survive; screened from further hare injury; dense cover |
| 13. J. Luebke's Copperville plantings, 112 Rich Highway, Glennallen | 62.0713223N; 145.4244732W; 364M | *Pinus contorta* var. *latifolia*, *P. sylvestris* | 0.1 | 1982–87 | No | None | Hare | | | Hares controlled by mowing ground cover and shooting |

**Table 8—Locations and foreign conifers examined for evidence of escape and colonization, and injuries from indigenous animals and snow or wind in interior and south-central Alaska (continued)**

| Site | GPS | Species | Acres | Date | Progeny | Injury | Animal | Percentage of trees injured | Percentage of trees killed | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 14. N. Zerbinos' Rose Ave., Tazlina Terrace planting, Glennallen | 62.0636783N; 145.3981067W; 348M | *Pinus contorta* var. *latifolia* | 1 | ~1987 | No | Forked | Hare | 5 | 90 | 5–10% survival; losses probably from hare injuries |
| 16. D. Kratzer's Tree Farm, Nenana | 64.6344257N; 149.0365430W; 115M | *Pinus contorta* var. *latifolia* | 1 | 1983 | Yes | Broad crowns | | | | Winter injury in early 1980s caused forking of lodgepole pine |
| | | *Pinus contorta* var. *latifolia* | 4 | 1984–85 | Yes | None observed | | | | |
| | | *Pinus contorta* var. *latifolia* | ~18 | 1986–87 | No | None observed | | | | |
| | | *P. sylvestris, Larix sukaczewii* | ~10 | 1985, 1992 | No | None observed | | | | |
| 17. Georgeson Botanical Garden and Irving Building | 64.8567760N; 147.8535984W; 166M | *Larix sukaczewii* | 0.1 | 1974 | Yes | None noted | | | | |
| 18. Les Viereck, Red Fox Dr., Fairbanks | 64.8998033N; 147.8109484W; 245M | *Larix sukaczewii* | 0.1 (10 trees) | 1966 | Yes | | None noted | | | |
| | | *Abies sibirica* | (2 trees) | 1986 | Yes | | None noted | | | |
| | | *Pinus contorta* var. *latifolia, P. sylvestris, Picea abies* | 0.75 | 1966, 1982 | No | | None noted | | | |
| 19. Al and Robin Near, and J. Zasada, 1566 LaRue Dr. (Farmers Drive), Fairbanks | 64.8929488N; 147.7967253W; 325M | *Pinus contorta* var. *latifolia* | (1 tree) | 1975 | Yes | None noted | | | | |
| | | *Pinus contorta* var. *latifolia* | (8 trees) | ~1985 | No | None noted | | | | |
| | | *Larix sukaczewii* | (5 trees) | 1980 | No | None noted | | | | |
| 33. At Gonder home | 61.5079739N; 149.8759461W; 45M | *P. sylvestris* | 0.25 | ~1965 | Yes | None | | | | |
| Naturals back 40 | 61.5069775N; 149.8808315W; 46M | *Abies balsamea* | 0.1 | 1997–99 | Yes | None | | | | |
| Gonder driveway | Douglas-fir on ridge south of Norway spruce below | *P. pungens* Engelm., *Pseudotsuga menziesii* var. *glauca*, *Pinus ponderosa* Dougl. ex Laws | 0.6 | 1964–70 | No | None | | | | |
| Gonder Ridge | 61.5072910N; 149.8739658W; 54M | *Picea abies* | 0.2 | ~1970 | No | None | | | | |
| Original Gonder access road | 61.5072038N; 149.8721514W; 46M | *Abies balsamea* | 0.2 | 1968 | Yes | None | | | | |

**Table 8—Locations and foreign conifers examined for evidence of escape and colonization, and injuries from indigenous animals and snow or wind in interior and south-central Alaska (continued)**

| Site | GPS | Species | Acres | Date | Progeny | Injury | Animal | Percentage of trees injured | Percentage of trees killed | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 34. Former Alaska Forest Tree Nursery, Eagle River | 61.3009417 N; 149.5835821W; 142M | *Pinus contorta* var. *latifolia*, *P. sylvestris* | 0.2 | 1982–83 | No | None recorded | | | | |
| 35. L. Pokorny Tree Farm, Mastadon Road, Talkeetna | 62.2371594N; 149.9692437W; 188M (Entrance to farm) | *Pinus contorta* var. *latifolia*, *Larix sukaczewii* or *L. sibirica* | 0.2 | 1990 | No | None recorded | | | | |
| | 62.2339857N; 149.9569300W; 196M | *P. sylvestris* | ~20 | 1990 | No | None | | | | |
| Start of major plantings; south end of lodgepole pine | 62.2329558N; 149.9620689W; 179M | *P. sylvestris, P. pungens, Larix sukaczewii or L. sibirica* | ~40 | 1990–2000 | No | Severe top damage and stem breakage | Moose | 80 | 15–20 | Many injured trees are permanently deformed or will die |
| North end of lodgepole pine | 62.2406993N; 149.9620689W; 184M | *Pinus contorta* var. *latifolia*, *Larix sukaczewii* or *L. sibirica* | ~15 | 1990–2000 | No | Tops of pines browsed; larch damaged | Moose<br>Hares? | 10 pine<br>40 larch | 90 pine<br>10 larch | Pine tops and branches browsed at about 4 ft; frost damage on larch |
| 36. Kingsberry's Birch Creek Ranch, 3-mi Mastadon Road, Talkeetna | 62.2658746N; 149.9588078W; 206M | *P. sylvestris, P. pungens, A. balsamea* | 1.5 | 1986, 1989 | No | Tops and branches browsed | Moose | 75 pine 50 spruce and fir | 10 pine 5 spruce and fir | Fir and spruce also frost damaged; poorly adapted seed sources |
| | | *Pinus contorta* var. *latifolia* | 0.1 | 1987–88 | Yes | Tops and stems | Moose | 15 | 5 | |
| **Kenai Peninsula:** | | | | | | | | | | |
| 37. Division of Forestry, Kenai-Kodiak area office, Soldotna | 60.4983793N; 151.0117140W; 46M | *Pinus contorta* var. *latifolia* | 0.2 | 1978–85 | Yes | None documented | | | | |
| 38. Division of Forestry, Kenai-Kodiak area arboretum and weather station, Soldotna | 60.4977675N; 151.0129182W; 49M | *Pinus contorta* var. *latifolia* | 0.1 | 1978–85 | Yes | Severe top damage | Moose | 50 | Unknown | Trees >15 ft not damaged; one tree uprooted by snow and wind |
| | 60.4977675N; 151.0129182W; 49M | *L. dahurica*, *Larix sukaczewii* or *L. sibirica*, *Abies lasiocarpa*, *Picea abies*, *Pinus sylvestris*, *P. aristata* Engelm., *Thuja plicata* Donn ex Don | 0.1 | 1978–85 | No | Some damage | Moose | 25 | Unknown | Some moose and severe weed whip damage, but extent not documented |
| 39. Power line road extending from Tustumena Lake Road | 60.2563713N; 151.2413619W; 77M (At group 3) | *Pinus contorta* var. *latifolia*—15 groups of 3 to 20 trees each | 5 (net) | ~1982 | No | Trees stripped of bark; stems and branches broken | Moose<br>Bear or porcupine | 30<br>1 | 10 (guess)<br><5 | Early damage caused stem forking |
| | 60.2543994N; 151.2479777W; 86M | *Larix sukaczewii* | .05 (2 trees) | ~1982 | No | | None | | | |

**Table 8—Locations and foreign conifers examined for evidence of escape and colonization, and injuries from indigenous animals and snow or wind in interior and south-central Alaska (continued)**

| Site | GPS | Species | Acres | Date | Progeny | Injury | Animal | Percentage of trees injured | Percentage of trees killed | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 40. R. Stingley Farm (David Newton Boyer Homestead), 3-mile North Fork Road, Anchor Point | 59.7972136N; 151.7689794W; 58M | *Pinus contorta* var. *latifolia* | 1.5 | 1977 | No | None recorded | | | | Domestic livestock pastured in planting and likely caused mortality |
| 41. Arc Loop Road, Soldotna | 60.4349124N; 151.1170936W; 56M | *Pinus contorta* var. *latifolia* | 0.05 (3 trees) | 1973 | Yes | None recorded | | | | Adjacent hardwoods heavily browsed by moose |
| 42. Moose Pass power line | 60.4926732N; 1493714115W; 180M | *Pinus contorta* var. *latifolia*, *P. sylvestris* | 0.5 | 1988 | No | None recorded | | | | |
| | 60.4940396N; 149.3715517W; 182M | *Larix sukaczewii* | 0.5 | 1988 | No | None recorded | | | | |
| 43. Dave (Curly) Wynkoop, Strawberry Road, Soldotna-Kenai | 60.5528488N; 151.0850293W; 31M | *Larix sukaczewii* | 0.05 (6 trees) | 1975 | Yes | Tops broken and bark stripped | Moose and porcupine | 50 | 0 | Curly observed more browsing on lodgepole than larch |
| | | *Pinus contorta* var. *latifolia*, *P. sylvestris, Picea, Abies, Tsuga* | 0.1 (1–5 trees each) | 1978–~1985 | No | Broken tops and branches | Moose | 30 | 20 | Overstory with 40–80 $ft^2$ basal area; *Abies* and *Pinus* injured |
| 44. Strawberry Road, SW of D. Wynkoop, Soldotna-Kenai | 60.5509673N; 151.0860314W; 36M | *Pinus contorta* var. *latifolia* | 0.1 | ~1974–78 | Yes | Trees forked and crooked | Moose | 40 | 0 | Trees recovering; Curly reported previous mortality |
| 45. Funny River State Recreation Area, Soldotna | 60.4929988N; 150.8603450W; 34M | *Pinus contorta* var. *latifolia* | 0.05 | ~1987 | Yes | None | | | | |
| 46. Dean Glick, Lake Street, Soldotna | 60.4305789N; 151.1698003W; 66M | *Pinus contorta* var. *latifolia*, *Tsuga mertensiana* (Bong.) Carr. | 0.05 | 1989 | No | None | | | | Back yard planting 5 of 6 trees survive |
| 47. 2.5 mi Falls Creek Road | 60.1670571N; 151.4036339W; 94M | *Larix sukaczewii, Pinus sylvestris* | 3 | 1988 | No | Broken tops and forking | Moose | 5-10 | <2 | |
| 48. Seaside Farm, East Homer Road | 59.6766577N; 151.4101712W; 28M | *Pinus contorta* var. *latifolia* and var. *contorta*, *P. sylvestris* | 0.1 | 1978 | No | None | | | | |
| 49. East Hill Road, Homer | 59.6557901N; 151.5143179W; 79M | *Pinus contorta* var. *latifolia* | 0.05 | ~1977 | No | None | | | | |
| 50. Homer Demonstration Forest | 59.6621930N; 151.6194564W; 219M | *Pinus contorta* var. *latifolia* | 0.5 | 1982 | No | Bark stripping | Moose | <5 | 5 | Poor survival and growth |

**Table 8—Locations and foreign conifers examined for evidence of escape and colonization, and injuries from indigenous animals and snow or wind in interior and south-central Alaska (continued)**

| Site | GPS | Species | Acres | Date | Progeny | Injury | Animal | Percentage of trees injured | Percentage of trees killed | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 51. Milepost 54.1, Seward Highway | 60.7546546N; 149.4608109W; 252M | *Pinus contorta* var. *latifolia*a | 0.05 | 1968 | No | None | | | | |
| 52. Tyonek, Site 82-3 | 61.0820566N; 151.4077338W; 121M | *Pinus contorta* var. *latifolia* | 3 | 1982 | Yes | Bark clawing and stripping | Bear | 5-10 | 5 | Bite chunks of wood and bark from 6 to 8 inch stems |
| 53. Tyonek, Site 76-3 | 61.0457344N; 151.4817521W; 93M | *Pinus contorta* var. *latifolia* | 0.2 | 1976 | No | Bark stripping | Bear | 20 | <10 | 8 of 35 trees damaged; snow-windthrow losses common from maladaptation |
| 54. Cohoe Loop Road, G. Hermansen | 60.3467272N; 151.3153560W; uncorrected | *Pinus contorta* var. *latifolia* | 0.05 (2 trees) | 1969 est. | Yes | Scarred and forked | Human | 100 | 0 | Vehicles injured and killed regeneration |

**Table 9—Mean age, size, and annual growth of native and nonnative species sampled with <30 trees on mainland Alaska**

| Species | Trees sampled | Mean age and range | Mean d.b.h. and range | Mean height and range | Growth | |
|---|---|---|---|---|---|---|
| | | | | | D.b.h. outside bark | Height |
| | | *Years* | *Inches* | *Feet* | *Inches/year* | *Feet/year* |
| Jack pine | 12 | 25 (13–34) | 6.0 (2.4– 9.0) | 36 (16–48) | .273 | 1.36 |
| Dahurian larch | 3 | 24 (0) | 5.4 (4.0–6.2) | 29 (26–31) | .255 | 1.21 |
| Paper birch | 18 | 26 (18–48) | 4.9 (2.9–8.4) | 40 (25–64) | .227 | 1.63 |
| Balsam fir | 8 | 31 (27–35) | 5.9 (4.8–8.3) | 38 (31–48) | .217 | 1.24 |
| Aspen | 10 | 23 (18–34) | 4.4 (2.0–6.4) | 33 (20–47) | .216 | 1.52 |
| Douglas-fir | 4 | 35 (0) | 5.8 (4.8–8.0) | 30 (27–34) | .195 | .86 |
| Norway spruce | 8 | 35 (35–36) | 5.5 (3.7–8.8) | 34 (24–50) | .180 | .97 |
| Siberian fir | 5 | 35 (0) | 4.9 (4.0–6.1) | 32 (20–46) | .149 | .91 |
| Alaska larch | 2 | 34 (0) | 5.0 (4.4–5.5) | 35 (29–41) | .146 | 1.03 |
| Average | 8 | 30 | 5.3 | 34 | .206 | 1.19 |

Note: D.b.h. = diameter at breast height.

## Table 10—Spreadsheet summaries of sites and species data

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| **Region I. Interior Alaska** | | | | | | | | | |
| 17. Georgeson Botanical Garden | *Larix sukaczewii* | P | 35 | 9.2 | 30 | | | | Open grown; former farmland |
| | | | 40 | 9.5 | 30 | | | | |
| | | | 9 | 1.5 | 20 | | | | |
| | | | 41 | 12.9 | 30 | | | | |
| | | | 33 | 9.3 | 20 | | | | |
| 1. T-Field Arboretum | *Larix sukaczewii* | P | 70.1 | 9.2 | 36 | | | | Former University of Fairbanks agricultural land—6/4/02; the selected “Raivola” strain; dust in bark crevasses from Ips borings |
| | | | 66 | 10.6 | 36 | | | | |
| | | | 66 | 8.8 | 36 | | | | |
| | | | 65 | 8.3 | 36 | | | Sawfly predator eggs on defoliated branches | |
| | *Abies sibirica* | P | 32 | 4.9 | 35 | | | | |
| | | | 20 | 4 | 35 | | | | |
| | | | 31 | 4.2 | 35 | | | | |
| | *Larix sukaczewii* | P | 56 | 7.4 | 36 | | | | A Ural Mountain provenance |
| | | | 59 | 5.7 | 36 | | | | |
| | | | 56 | 7.2 | 36 | | | | |
| | | | 64 | 7.4 | 36 | | | | |
| | *Pinus contorta* var. *latifolia* | P | 64 | 8.4 | 37 | 150 | 20 | Older cones (15 yrs.) on lower crown | 1958 Whitehorse provenance |
| | | | 61 | 7.5 | 37 | 100 | 20 | | |
| | | | 57 | 11.3 | 37 | 450 | 35 | Stem forked several times | |
| | | | 52 | 7.2 | 37 | 75 | 10 | Top forked | |
| | *Pinus contorta* var. *latifolia* | P | 40 | 7.6 | 35 | 300 | <5 | | Teslin, Yukon Provenance |
| | | | 49 | 11.8 | 35 | 600 | >5 | | |
| | | | 47.5 | 7.4 | 35 | 100 | <5 | | |
| | *Pinus banksiana* | P | 48 | 5.4 | 35 | 50 | 0 | Cones to 12 yrs.; older cones on low branches | Fort Simpson, NWT provenance |
| | | | 43 | 8.3 | 35 | 500 | 5 | | |
| | | | 47 | 6.2 | 35 | 350 | 5 | | |
| | | | 45 | 7.8 | 35 | 500 | 4 | Open only on low branches | |
| | *Pinus contorta* var. *latifolia* | P | 53 | 7.2 | 27 | 500 | 4 | Carmacks, Yukon-R1, tallest tree | 1974 lodgepole pine provenance study, reps 1 and 2 |
| | | | 48 | 8.3 | 27 | 500 | 15 | Ethel Lake, Yukon-R1 | |
| | | | 46 | 6.5 | 27 | 100 | 50 | Jackfish Creek, BC-R1 | |
| | | | 47 | 9.9 | 27 | 500 | 10 | Cassiar, BC-R1 | |
| | | | 45 | 7 | 27 | 100 | 0 | Jackfish Creek, BC-R2 | |
| | | | 44 | 7.3 | 27 | 500 | 0 | Ethel Lake, Yukon-R2 | |
| | | | 43 | 7.2 | 27 | 500 | 2 | Carmacks, Yukon-R2, codominant | |
| | | | 43 | 6.4 | 27 | 300 | 2 | Cassiar, BC-R2 | |

Table 10—Spreadsheet summaries of sites and species data (continued)

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| | *Pinus banksiana* | P | 46 | 9 | 27 | 500 | 0 | | 1974 provenance study, Petitot River, BC |
| | | | 42 | 8.4 | 27 | 100 | 0 | | |
| | | | 42 | 7.6 | 27 | 500 | 4 | | |
| | | | 47 | 7.5 | 27 | 500 | 4 | | |
| | *Picea glauca* | P | 52 | 6.4 | 37 | | | | 21-tree plot; trees germinated from seed in 1963 and planted in 1966 |
| | | | 52.5 | 8.9 | 37 | | | | |
| | | | 51 | 7.3 | 37 | | | | |
| | | | 46.5 | 7.3 | 37 | | | | |
| | | | 44 | 5.4 | 37 | | | | |
| | *Picea glauca* above | P | 50.5 | | 36 | | | | Adjusted for an extra (2003) year of height growth |
| | | | 51.5 | | 36 | | | | |
| | | | 50 | | 36 | | | | |
| | | | 44.5 | | 36 | | | | |
| | | | 43 | | 36 | | | | |
| | *Picea glauca* | N | 4.89 | | 16 | | | | Understory regeneration inside the 1974 lodgepole pine provenance trial and estimated age |
| | | | 4.95 | | 18 | | | | |
| | | | 4.07 | | 14 | | | | |
| | | | 6.04 | | 16 | | | | |
| | | | 3.64 | | 17 | | | | |
| | | | 3.61 | | 17 | | | | |
| | | | 2.49 | | 17 | | | | |
| | *Picea glauca* | N | 30 | 4.4 | 21 | | | | Regeneration outside the 1974 lodgepole pine provenance trial and estimated age |
| | | | 33 | 5.3 | 23 | | | | |
| | | | 34 | 6.6 | 25 | | | | |
| | | | 33 | 6.5 | 23 | | | | |
| | *Picea abies* | P | 38 | 3.8 | 36 | | | | Plots of 14 and 21 trees each planted in 1965 |
| | | | 33 | 4.3 | 36 | | | | |
| | | | 50.5 | 6.1 | 36 | | | | |
| | | | 44.5 | 4.6 | 36 | | | | |
| | | | 48 | 3.9 | 36 | | | | |
| | *Pinus sylvestris* | P | 58 | 7 | 36 | | | | Thirty-six trees planted in 1965, first growing season 1966 |
| | | | 54.5 | 6.7 | 36 | | | | |
| | | | 48 | 6.8 | 36 | | | | |
| | | | 44 | 6.4 | 36 | | | | |

## Table 10—Spreadsheet summaries of sites and species data (continued)

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| 16. D. Kratzer, Nenana, Alaska | *Pinus contorta* var. *latifolia* | P | 21 | 4.8 | 17 | 250 | 20 | | Planted in 1984 and 1985 |
| | | | 22 | 4.9 | 17 | 300 | 50 | | |
| | | | 14 | 4.5 | 17 | 100 | 30 | | |
| | | | 21 | 6.1 | 17 | 100 | 20 | | |
| | *Pinus contorta* var. *latifolia* | P | 27 | 7.6 | 19 | 200 | 15 | | Planted in 1983 |
| | | | 25 | 7.3 | 19 | 300 | 10 | | |
| | | | 22 | 4.6 | 19 | 100 | 10 | | |
| | | | 25 | 7.6 | 19 | 300 | 1 | | |
| | *Picea glauca* | P | 16 | 3.7 | 19 | | | | Planted in 1983 |
| | | | 17 | 4.0 | 19 | | | | |
| | | | 20 | 3.8 | 19 | | | | |
| | | | 17 | 4.4 | 19 | | | | |
| | *Larix sukaczewii* | P | 24 | 3.9 | 14 | | | | Planted in 1987 (est. 14 years) |
| | | | 26 | 4.4 | 14 | | | | |
| | | | 24 | 5.1 | 14 | | | | |
| 20. Chena Hot Springs Road | *Pinus contorta* var. *latifolia* | P | 40 | 6.8 | 34 | 10 | 0 | | Transplant bed—1968 (est. 34 years), 14 of 42 surviving trees |
| | | | 33 | 4.1 | 34 | 0 | | | |
| | | | 36 | 4.7 | 34 | 6 | 17 | | |
| | | | 31 | 4.7 | 34 | 6 | 0 | | |
| | *Larix laricina* var. *alaskensis* | N | 29 | 4.4 | 34 | | | | |
| | | | 41 | 5.5 | 34 | | | | Estimated age |
| | | | 35 | 5.0 | 34 | | | | |
| | *Populus tremuloides* | N | 47 | 6.4 | 34 | | | | |
| | | | 37 | 6.0 | 34 | | | | Estimated age |
| | | | 38 | 6.0 | 34 | | | | |
| 3. Rosie Creek | *Pinus contorta* var. *latifolia* | P | 23 | 2.9 | 17 | 20 | 95 | | 1985 prov./family trial (17 years) |
| | | | 22 | 4.3 | 17 | 200 | 80 | | |
| | | | 23 | 2.6 | 17 | 20 | 65 | | |
| | | | 24 | 3.9 | 17 | 100 | 0 | | |
| | | | 25 | 3.1 | 17 | 45 | 65 | | |
| | *Pinus banksiana* | P | | 2.4 | 17 | | | | 1985 prov./family trial (17 years); tree heights and cones were not measured |
| | | | | 4.2 | 17 | | | | |
| | *Betula papyrifera* | N | 30 | 4.3 | 18 | | | | Estimated age |
| | | | 25 | 2.9 | 18 | | | | |
| | *Populus tremuloides* | N | 34 | 4.2 | 18 | | | | Estimated age |
| | | | 43 | 5.2 | 18 | | | | |

**Table 10—Spreadsheet summaries of sites and species data (continued)**

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated no. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| 2. Bonanza Creek Experimental Forest | *Pinus contorta* var. *latifolia* | P | 19 | 3.9 | 15 | | | | 1985 prov./family trial (16 years); dominant (crop) trees in buffer row were measured on May 15, 2001; cone crops were not evaluated |
| | | | 20 | 4.2 | 15 | | | | |
| | | | 20 | 3.7 | 15 | | | | |
| | | | 24 | 4.7 | 15 | | | | |
| | | | 23 | 3.8 | 15 | | | | |
| | | | 25 | 3.8 | 15 | | | | |
| 4. Rosie Creek | *Pinus contorta* var. *latifolia* | P | 22 | 4.5 | 16 | 50 | 60 | | 1986 University of Alaska Fairbanks container study; few survivors; severe competition |
| | | | 17 | 3.6 | 16 | 3 | | | |
| | | | 21 | 4.3 | 16 | 50 | 30 | | |
| | | | 26 | 3.7 | 16 | 25 | 60 | | |
| 5. Rosie Creek | *Pinus contorta* var. *latifolia* | P | 24 | 4.4 | 17 | 60 | 20 | | 1985 Alaska Division of Forestry operational planting; alternate rows with *Picea glauca* |
| | | | 28 | 4.7 | 17 | 100 | 20 | | |
| | | | 27.5 | 4.2 | 17 | 100 | 30 | | |
| | | | 25.5 | 5.0 | 17 | 25 | 0 | | |
| | *Picea glauca* | P | 18 | 3.0 | 17 | | | | 1985 Alaska Division of Forestry operational planting; alternate rows with *Pinus contorta* var. *latifolia* |
| | | | 16.5 | 2.4 | 17 | | | | |
| | | | 15 | 2.2 | 17 | | | | |
| 21. Delta Agricultural Experiment Station | *Larix sukaczewii*/ *L. sibirica* | P | 32 | 5.2 | 17 | | | | Seed orchard planted in 1984 |
| | | | 31 | 5.5 | 17 | | | | |
| | | | 30 | 5.3 | 17 | | | | |
| | | | 30 | 4.5 | 17 | | | | |
| | | | 33 | 5.8 | 17 | | | | |
| 11. Red Fox Drive, Tok, Alaska | *Pinus contorta* var. *latifolia* | P | 9 | 1.6 | 10 | | | | University of Alaska Fairbanks 1992 stocking study |
| | | | 9 | 1.0 | 10 | | | | |
| | | | 8 | 1.1 | 10 | | | | |
| | | | 10 | 1.4 | 10 | | | | |
| | | | 12 | 1.9 | 10 | | | | |
| 10. Tok Rifle Range | *Pinus banksiana* | P | 16 | 3.4 | 13 | | | | 1989 species trial |
| | | | 18 | 3.8 | 13 | | | | |
| | *Larix sukaczewii*/ *L. sibirica* | P | 18 | 3.1 | 13 | | | | 1989 species trial |
| | | | 22 | 3.6 | 13 | | | | |
| | | | 21 | 3.2 | 13 | | | | |
| | *Pinus contorta* var. *latifolia* | P | 17 | 3.8 | 13 | | | | 1989 prov./family trial |
| | | | 17 | 3.4 | 13 | | | | |

**Table 10—Spreadsheet summaries of sites and species data (continued)**

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| 18. L. Viereck's Tree Farm | *Larix sukaczewii* | P | 70.5 | 10.6 | 36 | | | | |
| | | | 67.6 | 11.3 | 36 | | | | |
| | | | 70.4 | 10.2 | 36 | | | | |
| | | | 67 | 9.2 | 36 | | | | |
| | | | 60.8 | 12.4 | 36 | | | | |
| | | | 61 | 8.0 | 36 | | | | |
| | | | 68 | 10.5 | 36 | | | | |
| | | | 74 | 12.7 | 36 | | | | |
| | | | 78 | 14.4 | 36 | | | Tallest tree evaluated | |
| | | | 67 | 11.7 | 36 | | | | |
| | *Picea abies* | P | 37 | 5.8 | 36 | | | | |
| | | | 24 | 3.7 | 36 | | | | |
| | | | 27 | 5.8 | 36 | | | | |
| | *Abies sibirica* | P | 31.8 | 6.1 | 36 | | | | |
| | | | 46 | 5.4 | 36 | | | | |
| | *Pinus sylvestris* | P | 42 | 12.8 | 36 | | | | |
| | | | 42 | 9.0 | 36 | | | | |
| 55. Alaska Tree and Garden Center | *Pinus contorta* var. *latifolia* | P | 37.5 | 7.4 | 25 | 30 | 0 | | |
| | | | 37 | 8.5 | 25 | 100 | 5 | | |
| | | | 40 | 6.5 | 25 | 100 | 5 | | |
| | | | 36 | 6.5 | 25 | 50 | 20 | | |
| | | | 36.5 | 6.3 | 25 | 50 | 10 | | |
| 7. Samuels Tree Farm, Delta Junction | *Pinus contorta* var. *latifolia* | P | 26 | 6.2 | 20 | 300 | 10 | | 1982 provenance trial |
| | | | 25 | 6.2 | 20 | 200 | 10 | | |
| | | | 31 | 5.9 | 20 | 50 | 50 | | |
| | | | 29 | 5.7 | 20 | 50 | 5 | | |
| | | | 28 | 5.8 | 20 | 0 | | | |
| | *Pinus contorta* var. *latifolia* | P | 25 | 6.1 | 18 | 300 | 10 | | 1984 species trial |
| | | | 25 | 4.8 | 18 | 200 | 10 | | |
| | | | 21 | 4.0 | 18 | 50 | 50 | | |
| | *Pinus contorta* var. *latifolia* | P | 28 | 5.4 | 18 | 30 | 10 | | 1984 provenance/family trial |
| | | | 23 | 4.3 | 18 | 50 | 10 | | |
| | | | 26 | 4.3 | 18 | 10 | 0 | | |
| | | | 26 | 6.0 | 18 | 150 | 50 | | |
| | *Larix sukaczewii*/ *L. sibirica* | P | 27 | 4.5 | 18 | | | | 1984 species trial |
| | | | 27 | 4.8 | 18 | | | | |
| | | | 29 | 4.3 | 18 | | | | |
| | | | 31 | 4.7 | 18 | | | | |
| | *Picea glauca* | P | 14 | 1.9 | 18 | | | | 1984 species trial |
| | | | 13 | 2.1 | 18 | | | | |
| | | | 12 | 1.8 | 18 | | | | |
| | | | 11 | 2.6 | 18 | | | | |

**Table 10—Spreadsheet summaries of sites and species data (continued)**

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| | *Betula papyrifera* | N | 29 | 3.7 | 18 | | | | |
| | | | 29 | 3.9 | 18 | | | | |
| | | | 26 | 3.6 | 18 | | | | |
| 9.B. Swain's plantings | *Pinus contorta* var. *latifolia* | P | 23 | 4.3 | 14 | 100 | 2 | | 4.5 mi Tanana Loop Extension; planted in 1988 (estimated) |
| | | | 20 | 3.8 | 14 | 25 | 90 | | |
| | | | 20 | 4.7 | 14 | 100 | 75 | | |
| | | | 21 | 4.6 | 14 | 50 | 15 | | |
| | *Larix sukaczewii*/ *L. sibirica* | P | 25 | 4.4 | 14 | | | | Trees climbed and branches broken for cone collection |
| | | | 28 | 4.5 | 14 | | | | |
| | | | 28 | 5.2 | 14 | | | | |
| | | | 26 | 5.3 | 14 | | | | |
| | | | 23 | 4.6 | 14 | | | | |
| 8. Brann's Tree Farm | *Pinus contorta* var. *latifolia* | P | 21 | 3.9 | 18 | 0 | | | 1984 prov./family study; poor site (glacial outwash) |
| | | | 18 | 3.7 | 18 | 30 | 50 | | |
| | | | 20 | 4.2 | 18 | 50 | 10 | | |
| | | | 16 | 3.3 | 18 | 20 | 95 | | |
| | *Larix sukaczewii*/ *L. sibirica* | P | 23 | 4.9 | 18 | | | | 1984 species trial; shallow soils; glacial moraine |
| | | | 20.5 | 4.2 | 18 | | | | |
| | *Pinus banksiana* | P | 16 | 3.5 | 18 | 75 | 10 | | 1984 species trial; represents surviving dominant trees |
| 22. Alaska Division of Forestry Compound | *Pinus sylvestris* | P | 66 | 9.4 | 48 | | | | 3700 Airport Way, Fairbanks; planted in ~1955 |
| | | | 59 | 7.5 | 48 | | | | |
| | | | 59 | 8.4 | 48 | | | | |
| | | | 61 | 7.6 | 48 | | | | |
| | *Betula papyrifera* | N | 56 | 7.4 | 48 | | | | |
| | | | 58 | 6.7 | 48 | | | | |
| | | | 60 | 5.6 | 48 | | | | |
| | | | 64 | 7.8 | 48 | | | | |
| | | | 62.5 | 8.4 | 48 | | | | |
| | *Larix sukaczewii*/ *L. sibirica* | P | 62 | 10.8 | 48 | | | | |
| | | | 60 | 11.6 | 48 | | | | |
| | | | 61.5 | 18.8 | 48 | | | Largest d.b.h. measured | |
| | | | 59 | 13.4 | 48 | | | | |
| | | | 58.5 | 12.5 | 48 | | | | |
| 6. Rosie Creek, site 2 | *Pinus contorta* var. *latifolia* | P | 27 | 3.8 | 18 | 15 | 50 | | 1985 "G" Spur Road seedling age study for container lodgepole and spruce |
| | | | 24.5 | 3.2 | 18 | 12 | 20 | | |
| | | | 29 | 4.3 | 18 | 58 | 20 | | |
| | | | 24.5 | 3.7 | 18 | 100 | 30 | | |
| | | | 28 | 4.4 | 18 | 150 | 15 | | |

**Table 10—Spreadsheet summaries of sites and species data (continued)**

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| | *Betula papyrifera* | N | 30.5 | 3.1 | 18 | | | | Some coppice following a 1983 Rosie Creek fire |
| | | | 33.5 | 4 | 18 | | | | |
| | | | 32 | 4.1 | 18 | | | | |
| | | | 35 | 5.6 | 18 | | | | |
| | *Picea glauca* | P | 19 | 2.8 | 18 | | | | Spruce and lodgepole pine planted at 4 × 8 ft (8 ft between rows); survival was ~20% |
| | | | 18.5 | 2.5 | 18 | | | | |
| | | | 16.5 | 2.6 | 18 | | | | |
| | | | 20 | 2.5 | 18 | | | | |
| 6. Rosie Creek, site 1 | *Pinus contorta* var. *latifolia* | P | 31 | 4.8 | 18 | 180 | 20 | | 1985 "G" spur road seedling age study; 1985 trees superior to 1986 trees |
| | | | 28 | 4.5 | 18 | 9 | 0 | | |
| | | | 34 | 4 | 18 | 50 | 8 | | |
| | | | 34 | 4.1 | 18 | 80 | 20 | | |
| | *Picea glauca* | P | 18.5 | 2.4 | 18 | | | | |
| | | | 17 | 2.3 | 18 | | | | |
| | | | 22 | 2.6 | 18 | | | | |
| | | | 19 | 2.3 | 18 | | | | |
| | *Betula papyrifera* | N | 41 | 4.3 | 18 | | | | Some trees appeared to be coppice following the 1983 Rosie Creek Fire |
| | | | 34.5 | 4.4 | 18 | | | | |
| | | | 31.5 | 4.5 | 18 | | | | |
| | | | 37.5 | 4.3 | 18 | | | | |
| **Region II. Mat-Su Valley** | | | | | | | | | |
| 34. Alaska Division of Forestry Nursery | *Pinus contorta* var. *latifolia* | P | 20 | 5 | 20 | 20 | 50 | | Former Eagle River nursery site that closed in 1992 estimated average statistics for dominant survivors among 100 trees planted under an open birch and spruce overstory in 1982 |
| | *Pinus sylvestris* | P | | | | | | | An estimated 50 suppressed survivors under a birch and spruce overstory |
| 24. G. Holmberg Tree Farm | *Larix sukaczewii*/ *L. sibirica* | P | 24 | 5 | 11 | | | | A 1991 planting in North Field 1, Schrock Road, Wasilla |
| | | | 27 | 4.7 | 11 | | | | |
| | | | 24 | 3.8 | 11 | | | | |
| | | | 27 | 3 | 11 | | | | |
| | | | 27 | 3.8 | 11 | | | | |
| 25. G. Holmberg Tree Farm | *Larix sukaczewii*/ *L. sibirica* | P | 75 | 16.5 | 50 | | | | Surviving trees planted under a birch and spruce overstory in 1953 |
| | | | 70 | 13.2 | 50 | | | | |
| | | | 65 | 9.1 | 50 | | | | |
| 26. G. Holmberg Tree Farm | *Larix sukaczewii*/ *L. sibirica* | P | 34 | 5.4 | 11 | | | | A 1991 planting in South Field 2, Schrock Road, Wasilla |
| | | | 32 | 4.8 | 11 | | | | |
| | | | 29 | 4.8 | 11 | | | | |

## Table 10—Spreadsheet summaries of sites and species data (continued)

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| 27. Houston City Educational Park | *Pinus sylvestris* | P | 21 | 5.9 | 15 | | | | Site was graded and 7 trees were planted in ~1987; soils are gravel |
| | | | 20 | 5.2 | 15 | | | | |
| | | | 17 | 4.9 | 15 | | | | |
| | *Larix sukaczewii*/ *L. sibirica* | P | 20 | 3.3 | 15 | | | | An estimated 12 trees were planted in gravel subsoil in ~1987 |
| | | | 21 | 3.9 | 15 | | | | |
| | | | 20 | 3.5 | 15 | | | | |
| | | | 21 | 3.6 | 15 | | | | |
| | *Pinus contorta* var. *latifolia* | P | 14 | 3 | 14 | 100 | 40 | | A typical dominant tree on gravel soils in 2002; no other trees measured; 40 trees were planted in ~1988 |
| | *Pinus banksiana* | P | | | | | | | Fourteen trees were planted in ~1988; statistics are equivalent to *Pinus contorta* var. *latifolia* above |
| 28. Division of Forestry's Houston Demonstration Forest | *Pinus contorta* var. *latifolia* | P | 24 | 4.5 | 15 | 200 | 70 | | Recently released from competition |
| | | | 24 | 3.4 | 15 | 20 | 25 | | |
| | *Pinus sylvestris* | P | 18 | 3.3 | 15 | | | | Planting date was ~1987; alternate rows were planted with lodgepole pine; no cones; recently released from severe birch competition |
| | | | 18 | 3.7 | 15 | | | | |
| | | | 18 | 3.5 | 15 | | | | |
| 29. Wasilla Veterinary Clinic, Parks Highway | *Larix sukaczewii* | P | 42 | 10.3 | 14 | | | | Seed source: Jonsberg seed orchard, Norway; planted as 1-2 stock |
| | | | 40 | 8.1 | 14 | | | | |
| | | | 42 | 8.1 | 14 | | | | |
| | | | 40 | 8.9 | 14 | | | | |
| 23. Mat-Su College Arboretum | *Larix sukaczewii* | P | 42 | 6.7 | 17 | | | | Planted as 1-1 stock in 16-tree plots in 1985 |
| | | | 36 | 5.5 | 17 | | | | |
| | | | 35 | 6.6 | 17 | | | | |
| | | | 33 | 6.4 | 17 | | | | |
| | *Pinus contorta* var. *latifolia* | P | 25 | 4.9 | 17 | | | | Cone production was not assessed |
| | | | 25 | 5.7 | 17 | | | | |
| | | | 27 | 6.0 | 17 | | | | |
| 30. Thom's Point Mackenzie Farm | *Pinus sylvestris* | P | 23 | 5.6 | 16 | | | | Dense (6 × 6 ft) shelter belt |
| | | | 25 | 5.7 | 16 | | | | |
| | | | 33 | 5.8 | 16 | | | | |
| 31. Trytten's hedge row | *Pinus contorta* var. *latifolia* | P | 12 | 2.5 | 10 | | | | To buffer farm from Guernsey road, Mackenzie Point; trees only recently planted |
| | *Pinus sylvestris* | P | 12 | 2.5 | 10 | | | | |
| | *Larix sukaczewii* | P | 18 | 2.5 | 10 | | | | |

**Table 10—Spreadsheet summaries of sites and species data (continued)**

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| 32. Mackenzie Creek Airstrip Road | *Pinus contorta* var. *latifolia* | P | 23 | 4.9 | 20 | | | Few cones, not assessed | 1983 Bureau of Land Management spot planting in birch and aspen coppice after logging; a wet site |
| | | | 25 | 4.2 | 20 | | | | |
| | | | 19 | 3.2 | 20 | | | | |
| | | | 22 | 4.5 | 20 | <20 | 1 | | |
| 33. Gonder Homestead, Big Lake, Alaska | *Pinus sylvestris* | P | 46 | 9.9 | 39 | | | | 1963 garden plot of ~20 trees; Finnish seed source |
| | | | 49 | 9.9 | 39 | | | | |
| | | | 50 | 9.6 | 39 | | | | |
| | | | 47 | 10.3 | 39 | | | | |
| | *Pinus sylvestris* | P | 40 | 14.5 | 39 | | | | 1964 transplanting on drive to home |
| | | | 40 | 13.2 | 39 | | | | |
| | | | 40 | 11.2 | 39 | | | | |
| | | | 50 | 14.1 | 39 | | | | |
| | *Abies balsamea* | P | 39 | 5.8 | 35 | | | | 1968 planting of ~100 trees on a woods road east of home |
| | | | 31 | 4.8 | 35 | | | | |
| | | | 48 | 8.3 | 35 | | | | |
| | | | 38 | 6.2 | 35 | | | | |
| | *Abies balsamea* | P | 39.5 | 6.4 | 27 | | | | "Back-40" plot of ~100 trees planted in about 1975 |
| | | | 35 | 5.1 | 27 | | | | |
| | | | 37.5 | 5.4 | 27 | | | | |
| | | | 35 | 5.4 | 27 | | | | |
| | *Picea abies* | P | 39 | 6.8 | 35 | | | | Estimated 1968 planting of ~100 trees on east ridge; intra-specific and indigenous competition are severe |
| | | | 29 | 4.6 | 35 | | | | |
| | | | 36 | 4.3 | 35 | | | | |
| | | | 31 | 4.5 | 35 | | | | |
| | | | 50 | 8.8 | 35 | | | | |
| | *Pseudotsuga menziesii* | P | 28 | 5.3 | 35 | | | | Estimated 1968 planting of ~100 trees on east ridge; severe intra-specific and indigenous competition; cone bracts protruding |
| | | | 34 | 8.0 | 35 | | | | |
| | | | 27 | 5.3 | 35 | | | | |
| | | | 32 | 4.8 | 35 | | | | |
| | *Pinus contorta* var. *latifolia* | P | 20 | 4.7 | 16 | 400 | 0 | | Estimated 1987 planting of ~50 trees on the west slope of east ridge |
| | | | 25 | 4.4 | 16 | 150 | 20 | | |
| | | | 23 | 4.4 | 16 | 50 | 20 | | |
| | *Pinus contorta* var. *latifolia* | P | 30 | 11.5 | 25 | 600 | 10 | | Estimated 1977 planting of probable Whitehorse, Yukon seed at new garden site; open-grown trees with large bushy crowns |
| | | | 27 | 9.3 | 25 | 1000 | 60 | | |
| | | | 27 | 9.3 | 25 | 400 | 10 | | |

**Table 10—Spreadsheet summaries of sites and species data (continued)**

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| 36. Kingsberry Tree Farm, Talkeetna | *Pinus contorta* var. *latifolia* | P | 20 | 3.3 | 15 | 5 | 40 | | Estimated 500 trees planted in 1988 |
| | | | 21 | 3.4 | 15 | 40 | 25 | | |
| | | | 19 | 3.3 | 15 | 25 | 20 | | |
| | *Pinus sylvestris* | P | 17.5 | 4.2 | 17 | | | | Estimated 200 trees planted in 1986 |
| | | | 18.5 | 3.7 | 17 | | | | |
| | | | 18.5 | 3.2 | 17 | | | | |
| 35. Pokorny Tree Farm, Mastadon Road, Talkeetna | *Pinus contorta* var. *latifolia* | P | 22 | 3.8 | 12 | 10 | 0 | | A large tree farm with transplant beds was initiated in 1990 |
| | | | 24 | 4.6 | 12 | 5 | 20 | | |
| | | | 20 | 3.3 | 12 | 0 | | | |
| | | | 23.5 | 4.6 | 12 | 30 | 0 | | |
| | | | 22.5 | 3.2 | 12 | 0 | | | |
| | *Pinus sylvestris* | P | 15 | 4.3 | 12 | | | | Moose killed or damaged several thousand trees |
| | *Larix sukaczewii*/ *L. sibirica* | P | 23 | 5.2 | 12 | | | | Trees were measured in transplant beds |
| | | | 18.5 | 4.8 | 12 | | | | |
| | | | 28 | 4 | 12 | | | | |
| **Region III. Kenai Peninsula–Cook Inlet** | | | | | | | | | |
| 37. Division of Forestry Kenai-Kodiak Area Office | *Pinus contorta* var. *latifolia* | P | 36 | 10.5 | 24 | 450 | 50 | | Forty-two trees survive from 1978–85 plantings |
| | | | 34 | 8.2 | 24 | 450 | 10 | | |
| | | | 34.5 | 8.1 | 24 | 450 | 5 | | |
| 41. Arc Loop Road, Soldotna | *Pinus contorta* var. *latifolia* | P | 36 | 11.3 | 29 | 500 | 50 | | Sandy loam soils; 30 offspring lifted for transplanting locally |
| | | | 32 | 9.3 | 29 | 400 | 50 | | |
| | | | 37 | 11 | 29 | 500 | 25 | | |
| 44. Strawberry Road, Soldotna | *Pinus contorta* var. *latifolia* | P | 39 | 7.3 | 24 | 100 | 60 | | Planted in a meadow in 1978 |
| | | | 34 | 8.9 | 24 | 400 | 70 | | |
| | | | 31 | 6.7 | 24 | 200 | 40 | | |
| | | | 32 | 5.5 | 24 | 50 | 10 | | |
| | | | 21 | 7 | 24 | 200 | 20 | | |
| 43. Wynkoop | *Larix sukaczewii*/ *L. sibirica* | P | 45 | 12.4 | 26 | | | | Planted in a garden site in 1976 |
| 46. Lake Street, Soldotna | *Pinus contorta* var. *latifolia* | P | 15 | 3.7 | 13 | 0 | | | A back-yard planting |
| | | | 15 | 3.1 | 13 | 30 | 90 | | |
| | | | 12 | 2.1 | 13 | 5 | 100 | | |
| | | | 11 | 1.7 | 13 | 0 | | | |
| | | | 14 | 3 | 13 | 7 | 86 | | |

## Table 10—Spreadsheet summaries of sites and species data (continued)

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| 38. Division of Forestry Kenai-Kodiak Area Arboretum | *Larix sukaczewii*/ *L. sibirica* | P | 35 | 6.2 | 24 | | | | Small planting in 1978 |
| | | | 34 | 6.5 | 24 | | | | |
| | *Larix dahurica* | P | 30 | 6.2 | 24 | | | | |
| | | | 26 | 5.9 | 24 | | | | |
| | | | 31 | 4.0 | 24 | | | | |
| | *Pinus sylvestris* | P | 18 | 2 | 24 | | | | |
| | | | 26 | 2 | 24 | | | | |
| | | | 22 | 2 | 24 | | | | |
| 39. Tustumena power line | *Larix sukaczewii*/ *L. sibirica* | P | 29 | 6.1 | 24 | | | | Species planted in small groups of 6 to ~300 trees |
| | | | 24 | 5 | 24 | | | | |
| | *Pinus contorta* var. *latifolia* | P | 27.5 | 6.8 | 19 | 75 | 25 | | Groups 1 and 3 |
| | | | 19 | 5.3 | 19 | 20 | 10 | | |
| | | | 31 | 6.8 | 19 | 100 | 10 | | |
| | | | 27 | 7.7 | 19 | 200 | 20 | | |
| | | | 32 | 7.5 | 19 | | | | |
| | *Pinus contorta* var. *latifolia* | P | 28 | 7.2 | 24 | 300 | 70 | | Groups 9 and 11 |
| | | | 31 | 7 | 24 | 100 | 20 | | |
| | | | 30 | 8 | 24 | 400 | 30 | | |
| 42. Moose Pass | *Pinus contorta* var. *latifolia* | P | 12 | 2 | 13 | 1 | 0 | | Old burn; severe competition; 20 survivors of 200 seedlings planted |
| | *Larix sukaczewii*/ *L. sibirica* | P | 12 | 1 | 13 | | | Typical dominant tree | 10 survivors of 200 seedlings planted |
| 47. Falls Creek Road | *Larix sukaczewii*/ *L. sibirica* | P | 16 | 2.8 | 14 | | | | Estimated 500 trees planted in 2.5 mi 1988 spruce beetle salvage; indigenous white spruce seeded into the understory |
| | | | 19 | 3.3 | 14 | | | | |
| | | | 18.5 | 3.1 | 14 | | | | |
| | | | 20.5 | 3.6 | 14 | | | | |
| | | | 19.5 | 3.5 | 14 | | | | |
| | *Pinus sylvestris* | P | 12 | 2 | 14 | | | Average dominant Scots pine | ~200 survivors |
| 48. Kelcher Seaside Farm | *Pinus contorta* var. *latifolia* and var. *contorta* | P | 33 | 12.6 | 25 | 50 | 0 | | Stock from an Anchorage nursery planted at Kachemak Bay, Homer; var. *contorta*, cones not counted |
| | | | 32 | 10.2 | 25 | 20 | 0 | | |
| | | | 30 | 12 | 25 | | | | |
| | | | 27 | 14.4 | 25 | | 100 | | |
| 49. East Hill Road, Homer | *Pinus contorta* var. *latifolia* | P | 20 | 13.9 | 25 | 20 | | Roadside open grown | Wildlings transplanted from the Alaska Highway, Yukon |
| | | | 25 | 11.6 | 25 | 20 | | | |

## Table 10—Spreadsheet summaries of sites and species data (continued)

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| 50. Homer | *Pinus contorta* | P | 6 | 0.9 | 20 | 0 | | | Planted on an unprepared site in a spruce |
| Demonstration | var. *latifolia* | | 5.5 | 0.6 | 20 | 0 | | | understory |
| Forest | | | 6.5 | 0.8 | 20 | 0 | | | |
| 51. Milepost 54.1, | *Pinus contorta* | P | 52 | 7.6 | 36 | 0 | | | Rooted from a transplant box into an open |
| Seward Highway | var. *latifolia* | | — | 5.8 | 36 | 0 | | Severely malformed | birch-spruce understory |
| | | | — | 3.9 | 36 | 0 | | Severely malformed | |
| 52. Tyonek, 2000 | *Pinus contorta* | P | 32 | 6.9 | 20 | 400 | 30 | | Division of Forestry site 82-3; planted at ~20 ft |
| Road Northwest | var. *latifolia* | | 37 | 7.9 | 20 | 200 | | | spacing in 1982 to fill in a clearcut |
| | | | 27 | 8.5 | 20 | 200 | | | |
| | | | 32 | 7.8 | 20 | 200 | | | |
| | | | 39 | 8 | 20 | 100 | | | |
| 52. Tyonek, 1000 | *Pinus contorta* | P | 23 | 5.5 | 27 | 300 | 10 | | Division of Forestry site 76-3 planted in 1976; 17 |
| Road West | var. *latifolia* | | 25 | 6.9 | 27 | 100 | 5 | | of ~35 survivors uprooted from snow or wind in |
| | | | 30 | 5.2 | 27 | 100 | 40 | | the late 1980s and 1990s |
| | | | 28 | 5.3 | 27 | | | | |
| 40. Stingley North | *Pinus contorta* | P | 18.6 | 4.1 | 25 | 25 | 50 | | North Fork Anchor River Road; seedlings were |
| Fork Ranch | var. *latifolia* | | 22.2 | 4.7 | 25 | 25 | 50 | | planted under a spruce overstory in 1977 at 2 to |
| | | | 22 | 5.1 | 25 | 25 | 50 | | 6 ft spacing; the trees were felled for pasture in |
| | | | 22.1 | 4.5 | 25 | 25 | 50 | | 2002; only 2 of 291 seeds examined in a cut test |
| | | | | | | | | | were filled |
| 45. Funny River | *Pinus contorta* | P | 26 | 6.2 | 15 | 400 | 1 | | |
| Recreation Site, | var. *latifolia* | | 23 | 5.3 | 15 | 200 | 5 | | |
| Soldotna | | | 23 | 4.3 | 15 | 10 | 100 | | |
| 54. Hermansen, | *Pinus contorta* | P | 31 | 12.6 | 33 | | | | Transplanted as yard trees from the Alaska |
| Homestead, | var. *latifolia* | | 26 | 13 | 33 | | | | Highway; many cones and natural seedlings |
| Cohoe Loop Road | | | | | | | | | (not assessed) |
| **Region IV. Copper River Valley** | | | | | | | | | |
| 12. Tazlina | *Pinus contorta* | P | 24 | 4.5 | 18 | 20 | 25 | | Planted in 1984; few survivors from hare and vole |
| Experimental | var. *latifolia* | | 23 | 4 | 18 | 0 | | | injuries; cones harvested for commercial seed |
| Planting | | | 21.5 | 4.5 | 18 | 42 | 25 | | |
| | | | 24 | 4 | 18 | 50 | 80 | | |
| | *Picea glauca* | P | 20 | 4.1 | 18 | | | | Planted in 1984 |
| | | | 19 | 3.5 | 18 | | | | |
| | | | 20 | 3.7 | 18 | | | | |
| | | | 22 | 5 | 18 | | | | |

**Table 10—Spreadsheet summaries of sites and species data (continued)**

| Site | Species | Status[a] | Height | D.b.h. | Age | Estimated No. cones | Open cones | Tree notes | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Feet* | *Inches* | *Years* | | *Percent* | | |
| 13. Luebke Planting | *Pinus contorta* var. *latifolia* | P | 17 | 3.6 | 16 | 10 | 0 | Seedling source: Alaska State Nursery | Copperville, 112 Mi. Richardson Highway |
| | | | 16 | 2 | 16 | 30 | 20 | | |
| | | | 20.5 | 4.7 | 18 | 100 | 20 | Seedling source: Alaska State Nursery | |
| | | | 20.5 | 4.3 | 18 | 3 | 0 | Seed source: Alaska Highway before Whitehorse | |
| 14. Zerbinos Planting | *Pinus contorta* var. *latifolia* | P | 9 | 1.7 | 15 | 0 | | | Rose Avenue, Glennallen; site restoration project after gravel extraction; nutrient-impoverished subsoils; ~ 10 percent survival |
| | | | 14 | 2.3 | 15 | 20 | 90 | | |
| | | | 16 | 2.3 | 15 | 0 | | | |
| | | | 13 | 2.9 | 15 | 30 | 20 | | |
| | | | 12 | 2.7 | 15 | 50 | 20 | | |
| | | | 15 | 2.6 | 15 | 15 | 100 | | |
| 15. Old Edgerton Highway Provenance Experiment | *Pinus contorta* var. *latifolia* | P | 17.5 | 3.4 | 18 | | | | Planted in 1984; cones harvested for commercial seed |
| | | | 18.5 | 3.3 | 18 | | | | |
| | | | 17.5 | 3.2 | 18 | | | | |
| | | | 18.5 | 3.7 | 18 | | | | |
| | | | 21.5 | 4.1 | 18 | | | | |
| | *Populus tremuloides* | N | 24 | 3 | 18 | | | | From coppice and natural seeding |
| | | | 22 | 2.2 | 18 | | | | |
| | | | 20 | 2 | 18 | | | | |
| | | | 27 | 3.8 | 18 | | | | |

[a] P = Planted; N = Natural regeneration.

## Regeneration Data and Notes Summarized from Spreadsheets

**Region I. Interior Alaska—**

1. T-field Arboretum:
   (1) *Larix sukaczewii*, Raivola strain—06/04/02:
   No. of offspring: 175 (Additional holes where 3 trees were removed)
   Two trees were found on east side of plot. All others were observed on the north side
   Mean height: 64 cm; StDev: 82.6 cm; Range: 8 to 390 cm
   Mean age: 8 years; StDev: 3.4 years; Range: 3 to 17 years
   Offspring stocking (density): 850/acre (810 seedlings/acre within 25 ft of seed parents)

   (2) *Larix sukaczewii*, Ural Mountain provenance—06/05/02:
   No. of offspring: 3 (25 ft northwest of Ural Mountain plot. Offspring could be from either the Ural Mountain or Raivola plot)
   Mean height: 132 cm; StDev: 163.6 cm; Range: 22 to 320 cm
   Mean age: 9 years; StDev: 3 years; Range: 5 to 12 years

   (3) *Pinus contorta* var. *latifolia*, 1958 Whitehorse provenance:
   No. of offspring: 6 (On east side of plot. Two additional progeny removed from Arboretum)
   Mean height: 233 cm; StDev: 307 cm; Range: 51 to 853 cm
   Mean age: 11 years; StDev: 4.6 years; Range: 6 to 19 years
   (The 6-year-old and 70-cm-tall seedling is east of the jack pine (JP) plot and is probably a JP or JP X LP hybrid; the 19-year-old seedling is 175 ft east of the Whitehorse provenance, and may have been planted)

   (4) Teslin, Yukon *Pinus contorta* var. *latifolia* provenance—06/05/02:
   No regeneration with the possible exception of a 105-cm-tall, 12-year-old progeny that was observed under the crown and 4 ft west of the Teslin provenance.

   (5) *Pinus banksiana*, Fort Simpson, NWT provenance:
   No Regeneration with exception of the 6-year-old jack pine or jack pine hybrid offspring described under (3) above. The seedling is ~20 ft from its likely seed parents.

   (6) *Pinus contorta* var. *latifolia*, 1974 provenance study, rep 1 and 2: No regeneration.

   (7) *Pinus banksiana*, 1974 provenance study, Petitot River, BC: No regeneration.

   (8) For native *Picea glauca* regeneration outside and inside (understory) the 1974 *Pinus contorta* var. *latifolia* provenance trial and estimated age (years), see Table 10.

2. Offspring of a *Larix sukaczewii*/*L. sibirica* seed orchard at the Delta Agriculture Experimental Farm:
   Average stocking under 10 seed parents was 289 ± 193 offspring per acre.
   At the edge of an open meadow 33 ft (10 m) east of the seed orchard stocking was 40 offspring per acre (100/ha).

3. Georgeson Botanical Garden:
   More than 126 offspring of *Larix sukaczewii*/*L. sibirica* were counted on mineral soil and in the grass within 80 to 90 ft of four, 20- and 30-year-old seed parents. The offspring ranged from a few inches to 3.9 ft (120 cm) tall and 3 to 5 years old. Average *Larix sukaczewii*/*L. sibirica* stocking, age and height were 2,400 offspring per acre (5,928/ha), 4.2 ± 0.8 years, and 30 ± 11 in (75 ± 29 cm) tall, respectively. With few exceptions, the offspring were repeatedly mowed.

4. *Pinus contorta* var. *latifolia* regeneration at Kratzer's Tree Farm, Nenana:
   (1) 1984–85 *Pinus contorta* var. *latifolia* plantings produced five 3 year-old offspring on exposed mineral soil.
   Seedling height averaged 12 in (32.5 cm). Native *Picea glauca* seedlings on the same site averaged 17.5 in (44.5 cm) tall at 4 and 5 (ave. 4.25) years old.
   (2) Ninety-six trees per acre from 1983 *Pinus contorta* var. *latifolia* plantings produced 230 1- to 6-year-old offspring/acre on cultivated loess soils, including 130 offspring lifted for transplanting. *Picea glauca* also planted in 1983 produced 4,856 1- to 5-year-old offspring per acre. The offspring grew to a mean height of nearly 2 in (4.25 cm) at 1 to 5 (ave. 2.5) years of age.

5. Brann's 1984 *Pinus contorta* var. *latifolia* provenance/family trial, Delta:
   One 4-year-old, 8-inch (20 cm)-tall offspring was noted.

6. Viereck's Tree Farm, Red Fox Drive, Fairbanks:
   (1) Ten 36-year-old *Larix sukaczewii* produced 1,110 surviving offspring per acre. Tops were mowed and 20 were lifted for transplanting. Other noteworthy statistics:
   Including transplants, stocking was 1,450 offspring/acre (3,582/ha) within 40 ft of the seed parents.
   The most distant offspring was 250 ft from the nearest seed parent. It was 40 ft tall, 3.7 inches in d.b.h., and ~15 years old.
   The largest offspring was transplanted in 1984 from the 1981 seed crop. It was 45 ft tall and 6 inches in d.b.h.
   (2) Two 36-year-old *Abies sibirica* produced three, 4-year-old offspring that were 36 ft from their parents.

7. Near's 1975 *Pinus contorta* var. *latifolia* planting, 1566 LaRue Drive, Fairbanks: One 5-year-old offspring that was 30 in (77 cm) tall regenerated 30 ft from the nearest possible seed parent. No other offspring were found.

8. At the former BLM Office, 3700 Airport Way, Fairbanks: Ten *Larix sukaczewii* offspring were observed in 8 $m^2$ of garden area at the base of the largest tree. Offspring totaled 5,060 per acre (12,498/ha), 3 to 4 years from seed. The seedlings were distributed as far as 4 chains (260 ft) from their seed parents.

**Region II. Matanuska-Susitna Valley—**

1. Regeneration from the Gonder plantings, Big Lake:
   (1) The survivors of ~100 *Abies balsamea* trees planted in the "Back 40" (planting 1) in 1975 produced 4- to 7-year-old offspring <100 ft from their seed parents. The stocking estimated from six, 1-$m^2$ plots was 30,300 ± 10,462 offspring per acre.
   (2) Stocking of *Abies balsamea* offspring from a 1968 planting 2 on "Wood Road or Trail" was 2,428 ± 5,429 seedlings per acre. The offspring were found on mineral soil less than 50 ft from their seed parents.
   (3) *Pinus sylvestris* stocking from a 1964 roadside to Homestead transplanting: Offspring per acre (per ha) in the understory estimated from six 1-$m^2$ plots:

| | |
|---|---|
| *Pinus sylvestris* | 37,700 (93,119) |
| *Betula papyrifera* | 28,193 (69,637) |
| Both species | 65,893 (162,756) |

Estimated offspring per acre (per ha) from eight, 1-m$^2$ plots in a mowed field that extended 164 ft to undisturbed woodlands:

*Pinus sylvestris* 5,657 (14,017)

(4) *Pinus contorta* var. *latifolia* stocking within 33 and 16 ft of seed parents in a mowed field at the new (1977) garden site:

Offspring 11,113/acre (27,500/ha) within 33 feet (10 m), and 16,150/acre (39,890/ha) within 16 ft (5 m) of their seed parents.

(5) *Pinus sylvestris* regeneration at the old (1963) garden site:
Seedlings per acre (per ha) on about 800 ft$^2$:

| | |
|---|---|
| *Pinus sylvestris* | 500 (1,235) offspring were up to 8 ft tall and 12 years old. |
| *Picea glauca* | 2,500 (6,175) offspring were up 12 ft tall and 14 years old. |
| Both species | 3,000 (7,410) |

2. *Pinus contorta* var. *latifolia* stocking on mineral (cultivated) silt loam soil within 19 ft (6 m) of 15-year-old parents at Kingsberry's Tree Farm, Talkeetna: Seedlings/acre (per ha): 661 (1,500). No seedlings were observed beyond 19 ft (6 m) of the seed parents.

3. Regeneration in the Houston Educational Park:

(1) *Larix sukaczewii*/ *L. sibirica* stocking of 5-in seedlings on exposed gravel to within 75 ft (23 m) of their 15-year-old parents:

Seedlings/acre (per ha): 28,327 (69,968). No seedlings were observed beyond 75 ft (23 m) of the seed parents.

(2) *Pinus contorta* var. *latifolia* regeneration on gravel soils within 10 ft (3 m) of 14-year-old seed parents:

Seedlings/acre (per ha): 16,150 (39,890). Only one 5-in seedling was observed beyond 25 ft (7.5 m) of the seed parents.

(3) *Pinus banksiana* or possibly *Pinus contorta* var. *latifolia* seedlings were observed under one of fourteen 14-year-old *Pinus banksiana* trees. Five seedlings were counted under one tree.

(4) No cones or regeneration were observed for seven 15-year-old *Pinus sylvestris* trees.

**Region III. Kenai Peninsula–Cook Inlet—**

1. Division of Forestry, Kenai-Kodiak Area Office: Regeneration under *Pinus contorta* var. *latifolia*, and on a road bank 6.6 ft (2 m) from the crowns of the *Pinus contorta* var. *latifolia* plantings:

Trees per acre (ha) from 22, 1-m$^2$ plots each under *Pinus contorta* var. *latifolia* crowns and on a road bank:

| | Under crowns | Two meters from crowns | Average |
|---|---|---|---|
| *Pinus contorta* var. *latifolia* | 2,024 (5,000) | 4,626 (11,428) | 3,325 (8,213) |
| *Picea xlutzii* | 368 (909) | 2,506 (6,190) | 1,437 (3,549) |
| *Betula papyrifera* var. *kenaica* | 184 (454) | 578 (1,428) | 381 (941) |
| All species | 2,576 (6,363) | 7,711 (19,047) | 5,144 (12,706) |

2. Regeneration estimated from three, 1-$m^2$ plots on sandy loam soils within 100 ft south of the Arc Loop Road *Pinus contorta* var. *latifolia* planting in ~1972 (29 years):

| | Seedlings per acre (ha) |
|---|---|
| *Pinus contorta* var. *latifolia* | 1,348 (3,330) |
| *Picea xlutzii:* | 6,744 (16,658) |
| *Betula papyrifera* var. *kenaica* | 37,770 (93,292) |
| *Populus tremuloides* | 4,046 (9,994) |
| *Populus balsamifera* | 5,395 (13,326) |
| All species | 55,303 (136,600) |

Six pine seedlings to 22 inches (55 cm) tall on disturbed road bank, north side of plantings.

No regeneration on grass under the pine parents.

Thirty pine seedlings lifted for transplanting on south side of the plantings.

3. Wynkoop's *L. sukaczewii*/*L. sibirica* on Strawberry Road, Kenai Alaska:

   Eight seedlings/$m^2$ or 32,000 per acre (79,040/ha) were counted in a garden site under the seed parent. No seedlings were observed on exposed sandy (roadside) soils beyond 70 ft (21 m) of the seed parent.

4. *Pinus contorta* var. *latifolia* regeneration in an open meadow south of Wynkoop's *L. sukaczewii*/*L. sibirica* and west of Strawberry Road, Kenai Alaska:

| | Seedlings per acre (ha) 131 ft (41 m) from nearest *P. contorta* seed parent | Seedlings per acre (ha) 40 ft (12 m) from nearest *P. contorta* seed parent |
|---|---|---|
| *Pinus contorta* var. *latifolia* | 100 (247) | 800 (1,976) |
| *Picea xlutzii* | 3,000 (7,410) | 7,000 (17,290) |
| *Betula papyrifera* var. *kenaica* | 500 (1,235) | 0 |
| *Populus tremuloides* | 100(247) | 200 (494) |
| *Populus balsamifera* | 500 (1,235) | 800 (1,976) |
| All species | 4,200 (10,374) | 8,800 (21,736) |

Over the entire meadow, an estimated 120 *Pinus contorta* var. *latifolia* offspring per acre (296/ha) were observed within 131 ft (41 m) of the nearest seed parents.

5. Division of Forestry's Kenai-Kodiak Area Office Weather Station, Soldotna Alaska:

   One 37-in-tall (95-cm-tall) *Pinus contorta* var. *latifolia* seedling from the 1995 seed year was found one chain from the nearest seed parent. Seven *Pinus contorta* var. *latifolia* seedlings were observed overall. Two were found in a 4-in moss layer in an open (thinned) *Picea mariana* understory.

6. *Pinus contorta* var. *latifolia* seedlings in the 82-3 planting on three acres, Tyonek:

   Four 12- to 26-in (30- to 65-cm) tall seedlings, 4 to 6 years from seed were observed in moss and herbaceous vegetation.

7. *Pinus contorta* var. *latifolia* regeneration at the Funny River Campground, Soldotna:

   One 3-year-old, 4-in (10-cm) tall seedling was found at the base of a 15-year-old seed parent.

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| **Web site** | http://www.fs.fed.us/pnw/ |
| **Telephone** | (503) 808-2592 |
| **Publication requests** | (503) 808-2138 |
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| **Mailing address** | Publications Distribution<br>Pacific Northwest Research Station<br>P.O. Box 3890<br>Portland, OR 97208-3890 |

U.S. Department of Agriculture
Pacific Northwest Research Station
333 SW First Avenue
P.O. Box 3890
Portland, OR 97208-3890