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White Spruce Seedling (*Picea glauca*) Discovered North of the Brooks Range along Alaska's Dalton Highway

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ABSTRACT. A white spruce seedling, *Picea glauca* (Moench) Voss, was found at the northern edge of the Brooks Range in Alaska, more than 50 km north of the latitudinal tree line. The seedling, 19 cm tall and about nine years old, was growing at the side of the Dalton Highway to Prudhoe Bay. It most likely sprouted from a seed transported across the Brooks Range on a vehicle and has survived on the well-drained gravel road berm, where site conditions are more favorable for germination and survival than in the surrounding tundra. This spruce has survived for about a decade under current climatic conditions. Even with a warming climate, natural seed dispersal is severely hampered by the rugged topographic barrier of the Brooks Range. Considering the amount of vehicle traffic on the Dalton Highway, however, it is likely that more pioneering spruce seedlings will turn up along this corridor. Once over the Brooks Range, a spruce population can potentially develop and expand.

Key words: boreal forest, Brooks Range, forest-tundra, tree line, white spruce

RÉSUMÉ. Un plant d'épinette blanche, *Picea glauca* (Moench) Voss, a été trouvé du côté nord de la chaîne de Brooks en Alaska, plus de 50 kilomètres au nord de la limite forestière latitudinale. Le plant de 19 centimètres de hauteur a environ neuf ans et pousse au bord de l'autoroute de Dalton, vers la baie Prudhoe. Il est vraisemblablement le fruit d'une graine transportée par un véhicule à travers la chaîne de Brooks. Il a survécu sur la berme de la route de gravier bien irriguée, où les conditions sont plus favorables à la germination et à la survie des graines que dans la toundra environnante. Cette épinette vit depuis une dizaine d'années dans les conditions climatiques actuelles. Malgré le réchauffement climatique, la dispersion naturelle des graines est gravement entravée par la barrière topographique accidentée de la chaîne de Brooks. Cependant, compte tenu de l'intensité de la circulation routière sur l'autoroute de Dalton, il est fort possible que d'autres plants d'épinettes poussent le long de ce corridor. Une fois de l'autre côté de la chaîne de Brooks, une population d'épinettes pourrait se développer et prendre de l'expansion.

Mots clés : forêt boréale, chaîne de Brooks, toundra forestière, limite forestière, épinette blanche

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In the summer of 2008, a U.S. Fish and Wildlife Service field crew discovered a healthy 19 cm white spruce seedling, *Picea glauca* (Moench) Voss, growing at the northern edge of the Brooks Range, more than 50 km north of latitudinal tree line. The nearest known cone-bearing trees are in white spruce woodlands along the Dietrich River, on the south side of the continental divide. Densmore (1980) reported white spruce up to 500 years old at the tree line in that area, but the spruce had apparently not been able to migrate farther north during that 500-year period. The site where the seedling was found, north of 68˚25′ N latitude and at ~850 m elevation, is separated from the Dietrich River woodlands (at elevation above 950 m) by the 1415 m high Atigun Pass, a rocky pass with discontinuous tundra vegetation. Means of dispersal of spruce across the Brooks Range are of interest to Arctic researchers because the climate of the south-central North Slope, where this spruce was found, has very likely been warm enough to support spruce for the past two decades (G. Juday, pers. comm. 2008).

The seedling grew along the side of the Dalton Highway to Prudhoe Bay, on sparsely vegetated gravel road fill (Fig. 1). This human-made substrate is very different from the surrounding tundra, which is low shrub–sedge tussock tundra with a thick mat of poorly decomposed organic material. All the conditions for successful seedling establishment by white spruce, a mineral soil seedbed, well-drained soil, deep seasonal thaw, and little shading by surrounding plants (Zasada and Gregory, 1969), are present at this site. Because of its good drainage and coarse texture, gravel typically has a summer seasonal thaw depth of 1.5 m, much greater than in the natural tundra. Soil on the nearby pipeline right-of-way was 73% gravel, compared to 7% in the surrounding tundra; soil moisture was 8% on the right-of-way and 122% in the tundra (McKendrick, 2001). A band of willows 60 cm tall along the road edge may collect windblown snow, providing protection from winter winds. Desiccation and mechanical injury from winter winds are major causes of tree mortality at the forest-tundra ecotone (Savile,

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FIG. 1. White spruce seedling and habitat on lower part of road berm along the Dalton Highway, Alaska. Seedling is in lower center.

1972). At present, the seedling is small enough to be completely covered by the winter snowpack. Circumstances that may hinder survival as it grows taller include extreme winter winds, which can blow the ground nearly free of snow in this valley, and the possibility that the seedling could be obliterated the next time the road is graded.

We believe the seedling sprouted in 1999 for two reasons: the number of whorls of branches and the fact that white spruce in the southern Brooks Range produced prodigious amounts of seed in the unusually warm summer of 1998 and very little seed in the three years before and after that year (G. Juday, pers. comm. 2008). The seedling was growing vigorously. Some current-year twigs were over 2 cm long in mid-July, with needles still not fully grown. For comparison, spruce south of Atigun Pass were more advanced phenologically on the same date, and the length of current-year twigs ranged from 3 to 10 cm.

The Brooks Range is a topographic barrier to northern expansion of the boreal forest in Alaska. The tree line in the central Brooks Range appears to have been fairly stable in recent decades, compared to the lower-elevation western Brooks Range and other mountain ranges of Alaska (Barber et al., in press). Rupp et al. (2001), who modeled potential tree-line advance in northern Alaska, predicted that under plausible climate warming scenarios, it would take many centuries for spruce to cross the Brooks Range and invade the North Slope of Alaska. They did predict that, if brought by humans, spruce could survive the climate of much of the central and western North Slope with a warming of only 4˚C.

All known cases of isolated spruce growing naturally beyond the tree line in the Brooks Range are from the south side of the range. All previously known spruce seedlings found north of the range are the result of intentional experiments. In the southern Brooks Range, naturally occurring white spruce has been found in isolated stands up to 5 km beyond the tree line (Brubaker et al., 1983; Cooper, 1986). White spruce has also been planted experimentally in tundra. Two of 100 seedlings transplanted in 1968 to a site 5 km beyond the tree line in the south-central Brooks Range survived until found in 2001, while any sprouts resulting from seed sown in 1939 at the same site by the naturalist Bob Marshall apparently did not survive, since no sign of spruce was found in 1968 (Wilmking and Ibendorf, 2004). At the Toolik Research Station (25 km north of our site), white spruce seedlings were transplanted into tundra vegetation during experiments as far back as 1980 (Shaver et al., 1986) and 1990 (Hobbie and Chapin, 1998). Several have survived to the present but have not yet produced cones (G. Shaver, pers. comm. 2009; S. Hobbie, pers. comm. 2009).

We believe that the seedling beside the Dalton Highway germinated in situ from a seed carried accidentally by a vehicle. The road and adjacent oil pipeline, constructed in 1974–77, provide a corridor for exotic plant species to invade Arctic Alaska, and these species currently reach their farthest north extent on ground disturbed by humans, but do not occur in the surrounding landscape (McKendrick, 2001; Alaska Non-Native Plants Database, 2008). Since white spruce requires a mineral soil seedbed, it may prove to be as successful on the roadside as ruderal weed species. Small spruce trees are common on gravel road berms in interior Alaska.

This small white spruce is significant in that it has evidently grown from seed 50 km north of the latitudinal tree line and has survived for about a decade under current climatic conditions. Even with a warming climate, seed dispersal northward is severely hampered by the rugged topographic barrier of the Brooks Range. Considering the amount of vehicle traffic on the Dalton Highway, it would not be surprising if more pioneering spruce seedlings turn up along this corridor, inadvertent hitchhikers on their way north. Once over the Brooks Range, a spruce population can potentially develop and expand. Although eventual colonization of Arctic tundra by white spruce may seem inevitable if climate warming continues, it will be cause for regret if mechanized human activity alters the pattern and rate of dispersal so that we will never know how it would have occurred naturally. The authors welcome comments on whether to protect or pull this likely human-introduced seedling or leave its future to chance.

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