



United States
Department
of Agriculture

Forest Service

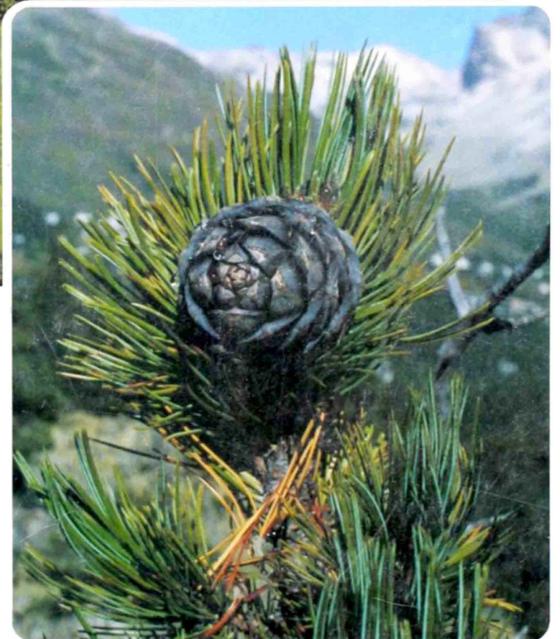
Intermountain
Research Station

General Technical
Report INT-GTR-309

July 1994



Proceedings—International Workshop on Subalpine Stone Pines and Their Environment: the Status of Our Knowledge



Proceedings—International Workshop on Subalpine Stone Pines and Their Environment: the Status of Our Knowledge

St. Moritz, Switzerland, September 5-11, 1992

Compilers:

Wyman C. Schmidt
Intermountain Research Station
Forest Service
U.S. Department of Agriculture

Friedrich-Karl Holtmeier
Department of Geography
University of Münster
Germany

Workshop Sponsors:

Intermountain Research Station
Westfälische Wilhelms-Universität,
Landscape Ecology Division, Germany
Swiss Federal Institute for Forest, Snow,
and Landscape Research
Karl and Sophie Binding Foundation,
Switzerland



DISTRIBUTION AND ECOLOGY OF SIBERIAN STONE PINE IN THE URALS

P. L. Gorchakovsky

Abstract—The northern and southern boundaries of the distribution area of Siberian stone pine (*Pinus sibirica*) in the Urals and in the adjacent plains are examined; the main sociological factors limiting boundary positions are described. There is a natural tendency of this species to spread northward and southward, from places recently invaded, but this process is usually stopped or turned back by human influence. Numerous occurrences of Siberian stone pine beyond its present continuous range indicate that the former distribution area of this species was larger in the past than at present.

Siberian stone pine (*Pinus sibirica*), or briefly Siberian pine, is considered to be one of the most valuable species of coniferous trees growing in Russia. Research on the limits of natural distribution of Siberian pine, on their causes and dynamics, is of indisputable theoretical and practical interest. Research is especially necessary for scientific substantiation of rational use of all forests, particularly those with Siberian pine, for the definition of measures to protect it from being exterminated, and for solving the problems concerning possible cultivation of this species in adjacent regions.

The general distribution area of Siberian pine includes: (1) northeastern regions of the European part of Russia (the farthest west locality is in the upper reaches of the Vycheгда River); (2) the Ural Mountain range; (3) western Siberia; (4) middle and eastern Siberia (up to the Aldan River); and (5) mountain ranges of Altai, the Transbaikalian area, and northern Mongolia.

The main limiting factors of the distribution of this species are: heat deficiency in the north; permafrost, peatland, and severe winter in the northeast; water deficiency and low air humidity in the south.

The western part of the area is located in the Ural Mountains and in the northeastern regions of the European part of Russia adjacent to them. Siberian pine occupies rather large areas within the territory of Sverdlovsk and Perm provinces, Komi Republic, and within Khatanga national district of Tyumen province.

THE NORTHERN LIMIT

The northern border of the distribution area (fig. 1) passes along the Izhma-Pechora watershed, advances

considerably northward (up to 65°30' N. latitude) along the valley of the Pechora River and even farther northward (67° N. latitude—the northern polar circle). Then it switches back south in the form of a tongue, to the foothills of the elevated eastern part of the Russian plain. From Telpos-Iz Mountain, 64° N. latitude, it leaps northward along the eastern slope of the Polar and Prepolar Urals reaching 66°10' N. latitude. It then recedes southward in the space between the rivers, but returns northward again in a tongue-shaped projection along the valley of the Ob River.

Besides that, a few isolated occurrences of Siberian pine are known outside its main distribution area.

The northern limit of Siberian pine does not reach the extreme boundaries of the distribution of larch (*Larix sibirica*) and spruce (*Picea obovata*). The well-known Russian botanist B. N. Gorodkov (1929) supposed that the advancement of Siberian pine to the north is restricted because its seeds do not get ripe under the severe conditions of the short growing season.

However, the latest observations demonstrate that even at the northern limit of the distribution area seeds of Siberian pine usually get ripe. The main reason likely is that Siberian pine is not able to develop its root system under low soil temperature (Tyrtikov 1954). In cold soils, the roots of Siberian pine ramificate comparatively weakly and grow more slowly than the roots of spruce and larch. Consequently, insufficient soil heating during the growing season impedes normal development of root systems, and this appears to be the main factor limiting the distribution of Siberian pine in the north. Under the severe climatic conditions of northern Siberia, pine does not grow on cold, peatland soils.

Close to the northern boundaries, in the upper reaches of the Pechora River, Siberian pine selects the warmest well-heated locations, inhabiting even the riverside limestone outcrops and cliffs. Contrary to that, in the regions farther south, for example in the middle and southern Urals, Siberian pine never grows in such habitats because the riverside limestone cliffs are too warm during daylight periods.

In the plains adjacent to the Urals (the Pechora and western Siberian lowlands), the far-north occurrences of Siberian pine are restricted to the valleys of the large rivers (the Pechora, the Ob, and some of their tributaries). The boundary deviates northward in the form of narrow strips along the river valleys. In marshy areas between the rivers, however, where superficial bedding of permafrost frequently occurs, the border line is farther south. Under plain conditions, the river valleys characteristically have more permeable ground, lower levels of permafrost bedding, and warmer soils that are more favorable to

Paper presented at the International Workshop on Subalpine Stone Pines and Their Environment: The Status of Our Knowledge, St. Moritz, Switzerland, September 5-11, 1992.

P. L. Gorchakovsky is Professor, Doctor of Biology, Chief Scientist at the Institute of Plant and Animal Ecology, Russian Academy of Sciences, Ural Branch, 620219, Ekaterinburg, Russia.

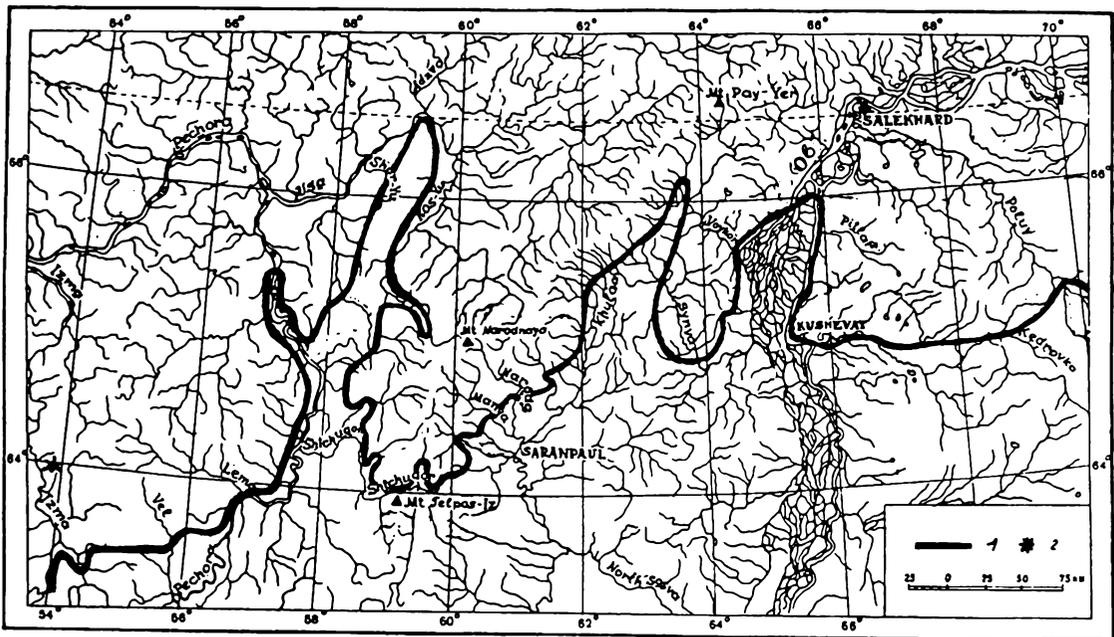


Figure 1—Northern distribution limit of Siberian stone pine in the Urals and in the adjacent plains. * = isolated occurrences.

Siberian pine. Moreover, one should bear in mind that the valleys of the large rivers that bring masses of comparatively warm water from the south are characterized by a warmer local climate favorable to the growth of Siberian pine.

At the Lyapin depression, in the region of Saranpaul, Siberian pine-dominated forests are to be found on buried palsa peatbogs covered by sandy loam deposits. On hillocks, better conditions for drainage and heating of the superficial layer of accumulated deposits favor the formation of rather tall Siberian pine forests. On the other hand, raised bogs with pools and ridges between the hillocks are treeless. The level of permafrost here is rather high; ice-lenses are found inside the peaty hillocks.

In the plains, at the extreme limit of its distribution area, Siberian pine is usually represented by solitary specimens dispersed within spruce-larch-birch forests; trees usually are healthy, without signs of atrophy; their trunks reach 10 to 14 m in height.

Within the western and eastern outskirts of the Ural Mountain range, the Siberian pine border displaces northward along meridionally oriented low foothills and mountain ridges. There, this species grows on slopes or near brooks and small rivulets under moderate or slightly increased (flowing) ground moisture conditions. The advance northward is promoted by a variety of sites suitable for forest growth as well as by favorable drainage, better soil heating, and consequently by lower depth of permafrost.

In the watershed of the Urals there are huge mountains topped by woodless tundra-like "goltsy" summits, located

within the mountain tundra and high-mountain cold desert belts (Gorchakovskiy 1975, 1989). They are characterized by a more severe climate, and consequently the northern limit of Siberian pine is considerably displaced southward.

Siberian pine almost absolutely escapes the mountain massif of the Prepolars from the west; its distribution is restricted to the Pechora lowland; in rare cases it occurs in the mountain part along deep erosion-tectonic valleys of the large rivers.

On the eastern slope of the Prepolars, however, Siberian pine ascends rather high in the mountains, almost to the upper forest limit. In the "subgoltsy" belt (analogous to the subalpine belt), in the region of Gorodkov Mountain (Sale-Ur-Oika), Siberian pine shows dwarfed growth (2.5 to 5 m in height), exhibiting trunks thickened at the basal portion of the tree and tapering upward, and with wide-branched crowns of low stability. Frequently, such dwarfed trees bear abundant cones. At lower elevations, within the mountain-taiga belt in the plain, Siberian pine reaches 10 m in height. From the eastern side, along the foothills, this plant extends to the Polar Urals reaching 66°10' N. latitude in the mountains of the so-called Small Urals.

More intensive advancement of Siberian pine northward, along the eastern slope of the Ural Mountain range, was favored partly by historical causes. This species invaded from Siberia to new places in the Urals. It arrived earlier on the eastern slope of the Ural Mountain range, favored mainly by the specific natural conditions of the eastern slope. The eastern slope of the Prepolars and

Polar Urals has a more continental climate than the western slope. Relative air humidity is lower here; annual precipitation including that in the winter is less heavy; and snow cover melts earlier in spring. Consequently, the growing season is longer, and the top soil layer is better heated.

On its northern boundaries, Siberian pine is distributed disjunctively and occurs as dispersed small clumps or solitary specimens in the taiga. All these extreme localities are rather disjunct from each other. This may be explained primarily by the fact that only in rare locations are the combinations of various environmental factors favorable for growth of Siberian pine at the limits of its range. On the other hand, the dispersion of this species has been reduced here and there due to forest fires, extension of bogs, trampling of seedlings and young growth by reindeer, and extermination by humans. In locations where human activity is reduced to a minimum, Siberian pine invades new places north of its present limit. This advance is observed especially clearly in the mountain regions of the Urals.

THE SOUTHERN LIMIT

The southern borderline of continuous distribution of Siberian pine (fig. 2) passes through the Russian plain near the city of Perm; then it turns southward along the western slope of the middle Urals, reaching the most southern position at 56°10' N. latitude; then it switches back north following the eastern slope of the middle Urals until retiring into western Siberia.

A few outliers occur beyond this limit. The most interesting of them are to be found in the mountain dark coniferous taiga of the southern Urals in the region of the town of Zlatoust and in the Ilmen Mountains.

At the southern limit of its range, Siberian pine usually grows in the form of single-standing, tall trees. Only on rocky outcrops does it exhibit prostrated growth forms (krummholz).

Natural regeneration of Siberian pine near the southern boundary of its distribution is generally satisfactory. However, there are many factors unfavorable to regeneration, such as seed collection difficulties, fires, and trampling of

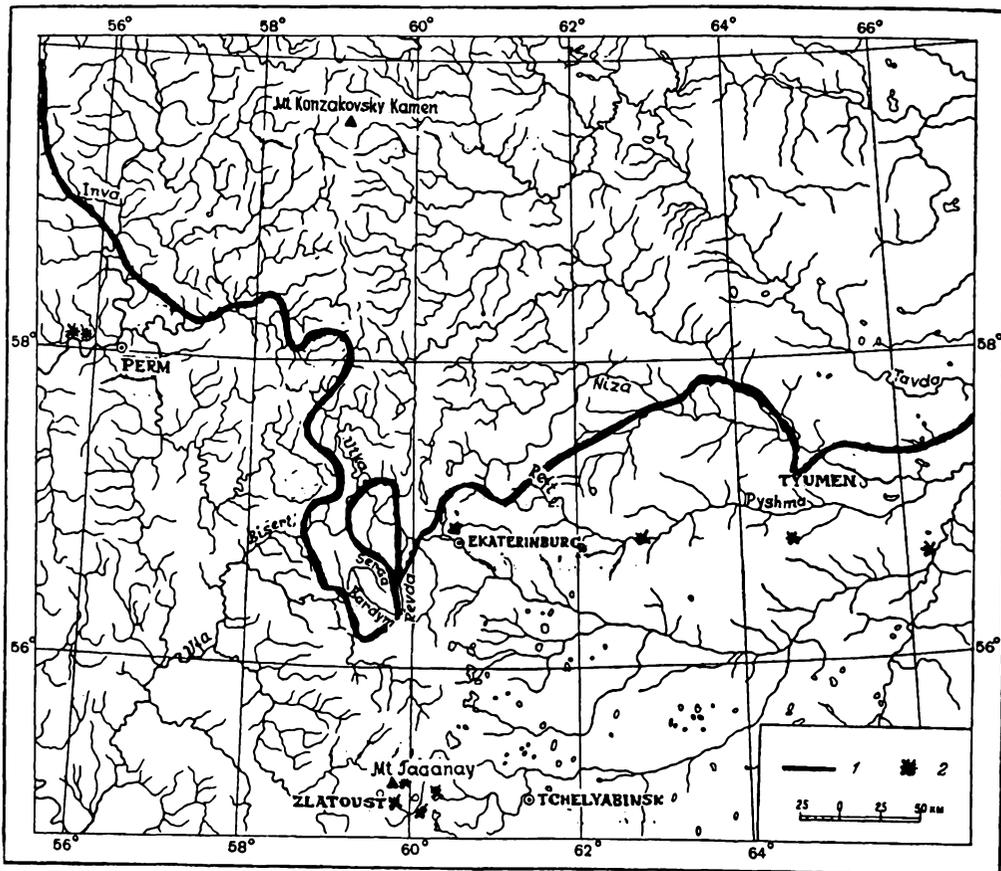


Figure 2—Southern distribution limit of Siberian stone pine in the Urals and in the adjacent plains. * = isolated occurrences.

seedlings by livestock. In locations where such unfavorable influences are absent, or they manifest themselves to a lesser degree, regeneration of Siberian pine is usually good. So, for example, Siberian pine reproduces very successfully on raised sites protected from fire within the Bakhmet Bog, which is surrounded by Scots pine forests in the basin of the Pyshma River.

Along the western slope of the Urals, as well as in certain sites within the watershed zone where the climate is more humid, Siberian pine has invaded new places significantly farther south than in the Preural and Transural regions. Its southern limit projects southward in the form of tongues that comprise the western slope and part of the watersheds of the mountain range. Climate of the eastern slope of the middle Urals is drier; the amount of precipitation is less compared to the western slope. Therefore, on the eastern slope of the mountain range and in the foothills zone adjacent to it (the region of predominance of Scots pine forests), Siberian pine occurs considerably farther north.

Within the peatland between the rivers of the western Siberian plain, the southern limit of Siberian pine turns south again. There Siberian pine grows mainly on raised sites within bogs, where it is well protected from fire.

Siberian pine invaded the southern Urals later than spruce and fir (*Abies sibirica*) and has not had enough time in the prehistoric period to reach the climatically influenced limit of its distribution. Human activities hampered the southward advance of Siberian pine into new places along the Ural Mountain range. Here and there, numbers of this species have declined. Several centuries ago Siberian pine had been distributed farther south in the Urals compared to its contemporary limit. Since then it has receded northward due to forest fires and human impact. There is clear evidence of recent decline in total distribution. In the southern part of the area, Siberian pine occurs sporadically in small groves, groups of trees, or as single trees. It grows in places least endangered by fire, most frequently on moist soils in the headwater regions and valleys of brooks and rivulets, on the margins of bogs and on raised sites within them, on lake shores (somewhere close to water), and on steep outcrops of acid rocks.

Formerly, the region of continuous distribution of Siberian pine extended south at least to the isolated localities mentioned earlier, but probably this tree species extended even farther south. Literature data as well as oral statements by local residents provide evidence of it. Siberian pine disappeared from these places not only due to cutting of timber and forest fires, but also because local inhabitants picked all the cones, often before cones were completely ripe. They also dug up seedlings for transplanting into personal gardens.

DISCUSSION AND CONCLUSIONS

The rather complicated picture of distribution of Siberian pine in the Urals depends to a large extent on climatic differences between the relatively humid western slope of the range and the more continental eastern slope.

Humidity of the western slope restricted the northward advance of Siberian pine, but favored its advance to the south. On the contrary, continentality of the eastern slope favored the advance of this species northward, but restricted its advance southward.

At both the northern and southern limits of its distribution, Siberian pine does not occur high up in the mountains. Its northernmost occurrences in high mountains are in the eastern part of the Preural Urals.

In the northern Urals, Siberian pine is widespread almost everywhere in the high-mountain belts. On certain mountains (Oika-Nyor, Pas-Nyor, Chistop, and others), however, it forms the upper forest limit. High-mountain Siberian pine-dominated forests grow on steep slopes with poorly developed soils. Near the upper forest limit, such forests may be found mainly in less high mountains far removed from large mountain massives. In such isolated mountains, the upper forest limit is caused chiefly by edaphic factors, while the climate of their treeless zone and of the subgoltsy belt is less severe. Dwarfed, prostrate, and, in most cases, noncone-producing specimens of Siberian pine of the northern Urals occur in high-mountain tundras significantly higher in elevation than the normal upper forest limit. For instance, dwarf specimens occur on the mountains Isherim, Oika-Chahl, Yalping-Nyor, Denezhkin Kamen, Konzhakovsky Kamen, Kosvinsky Kamen, and others. The occurrences of krummholz growth forms above the normal upper forest limit have to be explained by the dispersal of seeds into the mountain tundra zone by the nutcracker and rodents.

In the middle Urals near the summits of relatively high mountains, Siberian pine also forms singly standing, dwarfed trees (the mountains Kachkanar, Starick-Kamen, and others). South of Mount Starick-Kamen, this species is never found in high-mountain belts, but in the forest belt its area spreads considerably farther south.

Judging by its biological and ecological features, Siberian pine may not be considered as a species becoming extinct. It is perfectly well adapted to the taiga environment; it is a good cone producer, and, if human impact does not interfere, it regenerates quite satisfactorily. Almost everywhere, regeneration occurs close to old trees. However, one should bear in mind that Siberian pine grows more slowly than other shade-tolerant coniferous trees. Therefore, ground fires that annihilate second-growth trees adversely affect natural regeneration of this species.

The border lines of Siberian pine, especially on the southern border, have been reduced by careless and sometimes barbarian treatment of this valuable plant. It is necessary to secure proper protective measures for its southern localities in the Urals and to use seeds gathered from trees mainly for sowing under the forest canopy and in tree nurseries.

In the course of intensive harvest cuttings in the dark coniferous fir-spruce forests that have individual Siberian pine trees in the admixture, foresters usually retain Siberian pine as seed trees for natural regeneration. However, in many cases, this does not work well because in the heavy clay and loamy soils of the plains, and in the

mountains on poorly developed soils, such trees run the danger of windfall. To avoid windfall, it is necessary to retain clumps of Siberian pine with accompanying tree species instead of single specimens of Siberian pine.

Natural conditions of the middle Urals and of the mountain-range portion of the southern Urals (at least up to 54° N. latitude) are favorable for regeneration and growth of Siberian pine. This valuable tree species may be reintroduced to areas south of its present distribution. This can be concluded from the successful cultivation of Siberian pine south of its present border line in the mountain taiga regions of the middle and southern Urals.

REFERENCES

- Gorchakovsky, P. L. 1975. The plant world of the high-mountain Urals. Moscow: "Nauka" Publishing. 284 p. [In Russian].
- Gorchakovsky, P. L. 1989. Horizontal and altitudinal differentiation of the vegetational cover of the Ural Mountains. *Pirineos*, N 133: 33-54.
- Gorodkov, B. N. 1929. The Polar Urals in the upper reaches of the rivers Voykar, Synya and Lyapin. In: *Materials of the Committee for Expeditional Researches*, v. 7, Leningrad: 1-28. [In Russian].
- Tyrtikov, A. P. Growth of tree roots at the northern limit of forests. *Bull. of Moscow Soc. of Naturalists. Section of Biology*. 59(1): 72-82. [In Russian].