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HISTORY OF THE GIANT MTS.' DWARF PINE (*PINUS MUGO* TURRA SSP. *PUMILIO* FRANCO)

Historie kosodřeviny v Krkonoších (*Pinus mugo* Turra ssp. *pumilio* Franco)

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Dwarf pine stands form the dominant part of the area above tree limit in the Giant Mts. Historical resources confirm long-term human activity in this area. Colonisation led to gradual spreading of grass plots instead of dwarf pine stands for the expansion of pasture, grass making and wood utilisation for heating. Agrarian utilization of the area culminated in the second half of the 18th century and declined during World War II. Agrarian utilization was gradually substituted by tourism. At the end of the 19th century the first attempts to regenerate artificially dwarf pine stands in the region were done, the main artificial regeneration started after the World War II. The historical analysis should contribute to the correct assessment and must be taken into account by the creation of future management of the area.

Keywords: Dwarf pine, Giant Mts., history, colonization

INTRODUCTION

Each of the mountain regions in the Czech Republic has its peculiar character based on natural conditions, location and history. Each of them has exceptional qualities formulating and defining its position in relation to different criteria. For the Giant Mts. – Krkonoše National Park and Karkonoski park narodowy – typical and undoubtedly exceptional is the existence of an area above the alpine forest limit, subalpine and alpine area, dwarf pine altitudinal zone, dwarf pine zone, how their highest "nucleus" area is called.

True "Krkonoše" dwarf pine and its stands are among the most valuable components of the Giant Mts.' nature, not only from the science aspect. The climatic, soil conservation, aesthetic and hydrological importance of these stands is exceptionally high because the precipitation sums in the Giant Mts. are highest at the altitudes where its vast stands are located.

Even though it has been proved by air pollution, which assumed critical values in the eighties, that among the softwood tree species occurring in mountain regions dwarf pine is the most resistant to air pollutants, especially in comparison with Norway spruce, its vitality has evidently been disturbed and debilitated. It is reflected in a higher occurrence of pests, decrease in assimilation tissue production, and particularly in reduced fertility and seed quality. Therefore its natural regeneration, which has already been weakened to a large extent, is substantially lower; in the context of global warming it could lead to dwarf pine decline in the long run.

Taking into account the exceptional characteristics of the dwarf pine zone and its main component – true dwarf pine, largely disturbed and anthropogenic stressed in the last four hundred years as well as at present, it is necessary to find and define specific methods of the use, management and care of this region lying in the two national parks. The genesis of this region that will help reveal historical conditionality of

the present state of the nature and define procedures of not only its maintenance but also necessary improvement will provide indispensable and very valuable background information.

The unique wealth of archival documents from the Giant Mts. deposited not only in the Czech Republic's archives but also in many European archives makes it possible to investigate the past of the Giant Mts.' nature, to answer many questions objectively and to complete the knowledge of this country's mountains, but their informative value is also limited.

DWARF PINE IN THE GIANT MTS.

Before the humans came to the Giant Mts. in the 14th–15th century, that means at the time when the border forests lost their strategic importance because Silesia became a part of the Czech Crown Kingdom in 1335, a larger part of the region above the alpine forest limit was covered with dwarf pine with an admixture of spruce and other tree species. Dwarf pine stands have outlasted from the older Atlantic era (2500 years ago). Its range was extensive in Pleistocene, also situated at lower altitudes. In the post-glacial period two relict islands of dwarf pine subranges in the Czech Republic's territory were isolated: Krkonoše-Jizerské Mts. and Šumava Mts. ones. It disappeared from the remaining territory in the Boreal and Atlantic period. The dwarf pine altitudinal zone, dwarf pine zone, how this region is called, is situated above the forest limit, on either side of the historical Czech-Silesian, Czech-German border, today's Czech-Polish state border. Before the air-pollution disaster, which partly influenced its course in the eighties, the forest limit lied at an altitude of 1210 m a.s.l. It ascended maximally to 1350 m a.s.l. and descended to 960 m a.s.l. Its localization was considerably influenced in some localities – it was shifted to lower locations by anthropogenic activities (Jeník, Lokvenc 1962). The zone above the forest limit is 3342 ha in size on the Czech side of the mountains while its area on the northern, Polish side is smaller – about 1700 ha. The zone comprises smaller plots of the arctic-alpine tundra character that are considered as unique and most valuable in the space of Central Europe. The whole dwarf pine altitudinal zone was included in Zone I within the Krkonoše National Park, i.e. in a strictly natural one.

True dwarf pine (*Pinus mugo* (Turra) ssp. *pumilio* (Haenke) Franco et Holubičková) is the main vegetation component of ecosystems in the dwarf pine zone, its determinant. Jizerské Mts., Giant Mts. and smaller islets of mineral soil in the Šumava Mts. appear to be its original range in the CR territory. It was artificially introduced in the Jeseníky, Beskydy, Krušné hory Mts. and Orlické hory Mts. and in Šumava Mts. Its occurrence in the Jizerské Mts. and in Giant Mts. is the westernmost locality of its range. As a climatic type it was designated by Svoboda (1953) as Giant Mts.' dwarf pine – *Pinus mugo corcontica*. It is characterized and defined by the cone shape, and maybe its other exceptional characteristics and specific determinant traits will be demonstrated. Even though it is as a plant species in the shade of more attractive species, maybe for their abundance in the Giant Mts., it is not so in the European context and in the perspective of its existence endangered to some extent. It must be considered as one of the most valuable plant species in the Giant Mts.

Dwarf pine is accompanied by other tree species (lower proportions or scarce occurrence) outreaching from lower forest altitudinal zones, such as Norway spruce (*Picea excelsa*), European beech (*Fagus sylvatica*), European mountain ash (*Sorbus aucuparia*) and some willow species (*Salix* sp. *div.*), and by taxa typical of this region, e.g. *Betula carpatica*, *Sorbus aucuparia* var. *glabrata*, *Sorbus sudetica*, *Salix lapponum*, altogether it is about a third of 60 species growing in the area of the Krkonoše National Park (Lokvenc et al. 1992).

The oldest written reports on the occurrence of dwarf pine in the Giant Mts. date back to the second half of the 16th century and the first half of the 17th century. It is likely D. D. Pareus' first report from 1564–1566 (Pareus 1647) and a record of 1608 made by clerks of the Kutná Hora mines describing the occurrence of dwarf pine on the Obří hřbet (ridge) (Lokvenc 1978, Zuman 1948/9).

Dwarf pine was a known species to A. Matthioli, personal physician of Ferdinand I. He described it in the Czech edition of the herbarium from 1562 as a kind of pine that "*does not have any bole*". But

he did not mention either its Czech name or its occurrence in the Giant Mts. even though he made a trip to these mountains in the mid-16th century. K. Schwenckfeldt, who published the first information on the nature in the Silesian and Czech part of the Giant Mts. in 1600–1607, put dwarf pine on a list of plants as *Pinaster alpina repens* (Alpkiefer, Knickholz).

In the book Respublica Bohemiae (1643) by Pavel Stránský the name "Knieholz" is used in the Latin text as an oronym. The Labe headspring is localized between two mountains: one of them is called Schneekippe and the other according to a low shrub growing there, "Knieholz"; "...alterum ad arbusculis que in eo humiles sund Knieholz ...".

Very interesting information on the Giant Mts.' dwarf pine was given in a document summarizing findings from an expedition of the Royal Czech Society of Sciences undertaken from 27th July to 15th August 1786 (JIRASEK J., HAENKE T., GRUBER A. et GERSTNER F. 1791). Physical geographer Father Gruber paid attention to the biology of dwarf pine, especially to its vegetative propagation of shrubs, and refuted a contemporary opinion that dwarf pine was a form of Scotch pine. Tadeus Haenke published an article with Latin description of dwarf pine as one of the new mountain species *Pinus mugo* ssp. *pumilio* referred to by Gruber. In the first Czech forestry textbook of 1800 its author František de Paula Dušek described dwarf pine from the Giant Mts. as "*a pine that does not have any body*" and "*its patriotic Czech name is not known and our patriot doctor Třebický calls it a lying, lame pine*" (DUŠEK 1800). Wood-reeve V. HAVELKA (1823) published the name "kosodřevina" used by Slovaks, claiming that it occurred in the Giant Mts. only.

Haenke's classification of the Giant Mts.' dwarf pine as an autonomous subspecies of mountain dwarf pine – true dwarf pine (currently designated as *Pinus mugo* Turra subsp. *pumilio* /Haenke/ Franco et Holubičková) has been maintained until now.

HISTORY OF GIANT MTS.' DWARF PINE

1.1. Beginnings of colonization

Deep forest stands covering the Giant Mts. were a part of the boundary forest of the Czech Kingdom. They separated two areas of Slav settlement: the Bober tribes in the north, the Czech tribes in the south, who were connected by ancient paths leading round the mountain ranges. A lowland reaching from the north nearly as far as the main mountain ridge (Kotlina Jeleniogorska) allowed the humans to get to its proximity in Neolith (JAHN A. 1985). Due to the relatively unfavourable terrain configuration the Slav settlement from the southern side proceeded from Bohemia's interior to the foothills sporadically and later, in the 12th century. This first wave coincided with German colonization in the 13th century, supported by the ruler Přemysl Otakar II. It came from the north through Novosvětský a Žacléřský průsmyk (pass) from Silesia, which was already germanised, and from Eastern Franconia across the Ore Mts. Most Slav settlements were germanised, and new settlements were also established. Large Trutnov vassalage – Provincia Trutnoviensis (WOLF 1967) originated in the Giant Mts. foothills at that time, west of the Labe and Jizera divide adjoined by the territory of the later dominion Štěpanice. The noblemen were allotted land estate by the ruler's will; it required cultivation and amelioration of natural resources, which German settlers managed to do efficiently. The Silesians had enough experience in virgin forest liquidation and land cultivation carried out in their territory previously. The forests of that region lost their protective function as a natural barrier between Poland and Bohemia after Silesia had freed itself of its dependence on Poland and became a part of the Czech Crown lands after 1335. Colonization proceeded to the Giant Mts. foothills and to the boundary forest, approximately to the line Jizera – Jizerka in the west and to the connecting line Vrchlabí – Mladé Buky – Trutnov – Žacléř in the east. There originated tens of villages, towns as well as big and small castles, strongholds necessary for the protection of land borders, new territories and their population. The basic territorial division of the Giant Mts.' region into dominions was established during the 14th century. In order to use the allotted lands appropriately also in

mountain regions, and advised by Italian prospectors of ore deposits, the aristocratic families focused their activities on mining and resources of game and wood, supported by the ruler. Settlements proceeded to mountain valleys and ascended to mountain locations, above the forest limit.

Colonization and agricultural use of this region as mountain pastures required enough pastures, meadows and basic raw materials necessary to survive there, mainly sufficient amounts of firewood. Some interventions had to be carried out in dwarf pine stands occurring in these localities because their natural condition did not allow the agricultural use of these regions that was the main concern of owners of all three Giant Mts. dominions. Before a new wave of settlers from the Alps came in the second half of the 16th century, the landlords' interest shifted from the foothills above the forest limit. After devastation extraction of timber for the Kutná Hora mines had terminated in the eastern part of the Giant Mts. around 1609, the settlers, who were called for those logging operations, started to keep livestock even at the highest locations following the decline of mining. This supported the activity of the dominions and brought about work for many serfs. The settlers introduced the elements of life style and mainly of agriculture – Alpine farming into the Giant Mts. from their homeland in the Alps. They penetrated into the mountains along the axes – the two oldest Giant Mts. paths crossing the ridges from Bohemia to Silesia and originally connecting the Slav population on either side of the mountain range. In the eastern part it was Slezská (Vrchlabská) path leading via Vrchlabí and Výrovka (chalet) around Luční bouda (chalet), and Česká (Semilská) path ascending from the Jizera valley, via Dvoračky (chalets) and Labská louka to Silesia. Their origin is not exactly documented it dates back to the 13th century (Musil 1981). Important economic centers were established along these paths: Rokytenské Dvorské Boudy (Dvoračky), chalets in the localities Zadní Rennerovky, Bílá louka and somewhat aside lying Dvorské Boudy (chalets) at Sedmidolí, on the Silesian side Stará Slezská chalet, chalets near Malý stav and Schlingel's chalet.

Herdsmen attacked dwarf pine stands from the ridges and plateaus that were crossed by the paths and where in the gaps of dwarf pine stands there were natural primeval meadows suitable for grazing (Jeník 1961). Agricultural enclaves – grass ecosystems originated through extension of these primeval meadows by felling dwarf pine and spruce trees and building summer chalets and haylofts (Mosch 1858).

1.2. Livestock grazing and grass cutting

Livestock raising that developed in typical Giant Mts.' Alpine farming was the main activity influencing the Giant Mts. nature in the dwarf pine zone. It was necessary to build chalets including outbuildings (haylofts, stables), communications, driveways for livestock, to establish and extend pastures and meadows.

Forest stands, primeval meadows, and intentionally deforested areas in the dwarf pine zone were used for livestock grazing. Grazing was concentrated on these areas after it was banned in forests in the second half of the 19th century. The necessary size of areas was given by the quality of pastures. It was relatively low because lower-quality swards were selected for grazing while the communities with richer species composition – "grass gardens" were used for grass cutting. In 1609, a commission of Kutná Hora mines discovered a grass cutting inside dwarf pine stands on the exposed Obří hřbet (ridge) at an altitude around 1400 m a.s.l.

In the 16th–17th century the local population accepted cattle for a charge for summer grazing on deforested areas where they lived in abandoned loggers' huts and ascended to the dwarf pine zone. This mode of grazing was practiced on some chalets until the 18th century. E.g. up to 100 head of cattle were regularly driven from Kraus's chalets (today's Labská chalet) to a pasture in Vosecká bouda (chalet) locality at the end of June. Hay was made in the environs for the winter season (Rohkam 1937). Cattle were driven to remote forests and mountain ridges also for other reasons. Settlers had to pay a charge for each head of cattle or goats. Therefore the stocks were controlled by the owner, the Czech Chamber in the eastern Giant Mts. As reported from this region in 1609, chalet dwellers hid the livestock before the stock census by driving them to remote places and to the mountains.

Landlords were eminently interested in the more intensive agricultural use of lands, in development of Alpine farming that would cultivate barren lands and bring profits. Among the oldest feudal chalets in the Central Giant Mts. were those established in Vrchlabí dominion under Kryštof Gendorf (*1497 – †1563, the proprietor of Vrchlabí dominion since 1533) on the forest limit in the upper part of an extensive enclave of today's Zadní Rennerovky. In the western Giant Mts., there existed chalets on the southern slope of Kotel Mt. since when they were owned by the landlords Harant of Polžice and Bezdružice before 1688 (Sahlenbach chalets – Dvoračky). The steward Donth delivered agricultural products to the landlords' pantry. Sixty head of cattle and 80 goats could be kept there (DONTH, F., DONTH, H. H. 1974). An extensive enclave around the chalets was created by liquidation of dwarf pine stands on the southern slope of Lysá Mt. and Kotel Mt. and spruce and beech stands reaching as far as the Huťský potok (creek) (900 m a.s.l.). The chalet dwellers also used areas in Labská louka (meadow) locality.

Count Harrach started building other chalets for summer pasture in 1707–1708; for that purpose vast stands of dwarf pine and dwarf spruce in Míšečná stráň (slope) locality and a part of Lysá Mt. were felled (SCHMIDT 1879, NOŽIČKA 1959). Peaceful, more intensive use of some mountain regions for Alpine farming was largely limited because they had become a matter of contentions between the Czech and Silesian noblemen since the 16th century. It was mainly the Labská louka (meadow) locality, a part of the territory to which Count Schaffgotsch of the Kynast dominion pretended. The serfs caught at haymaking were punished by imprisonment in the 17th century. Interventions in forest stands, their use was dangerous and therefore inconsiderate. Only after the border contentions were terminated in 1710, when such a border-line was stabilized that roughly corresponds to today's border, purposeful and peaceful farming was possible; in 1744 Count Harrach ordered to extend grasslands gradually by felling dwarf pine shrubs and to build other chalets and shepherd's chalets in Labská louka (meadow) locality (Particular Wirtschaft Puncta 39, 1744). Count F. K. R. von Swečrts-Sporck developed an extensive and unique project of rational use of the whole region above the forest limit of Jilemnice dominion. The project and Harrach's instructions of the 21st Feb. 1748 were inspired by deforested areas already existed at that time in the localities Labská louka (meadow) and Dvoračky (southern slope of Lysá Mt. and Kotel Mt.) used for sporadic grass cutting.

The existing areas were envisaged to extend for pasture of 1000 cows. The project implementation started in 1748, but it failed to be accomplished (MENŠÍK 1899, LOKVENC 1978).

Nevertheless, Alpine farming expanded all over the Giant Mts. In the 18th century the expansion of deforested enclaves was greatest in localities Bílá louka and Čertova louka (meadows), on southern slope of Luční Mt., in Zadní Rennerovky locality and in the western part of these mountains, on southern and northern slopes of Kotel Mt. and Lysá Mt., on the southern slope of Krkonoš Mt. and in Labská louka (meadow) locality. Later on, some other smaller areas were used that were often situated on slopes of larger gradient where soil devastation by grazing livestock and erosion were imminent.

After villeinage was abolished and following other political and economic changes, in the second half of the 18th century most of the feudal chalets were sold to serfs at a low cost or with a duty to pay a rent (emphyteusis.) Previously in 1774–1775, the serfs received twenty feudal chalets in Rokytnice dominion (Dvoračky) and in 1784 Dvorské boudy in Sedmidolí locality. The chalets were restored and many new ones were built – Petrovka (1790), Martinovka (1795), Rennerovka in Bílá louka locality (1797), Pudlova (around 1800), Davidova (1835), etc. It was a culmination of Alpine farming. Each chalet was allotted an exactly fixed land or the chalets were leased lands for a definite period, mostly above the forest limit. It was the origin of easements granting to the chalets the right of pasture, grass cutting, timber extraction and other benefits on some feudal lands.

"Hay meadows", mostly with mat grass sward in the Labe region, created a stretch of land in Vítkovice and Bedřichov forest districts from the state border in the north to Kotel Mt., the width of this stretch reaching from Česká path to Labský důl (valley). There were two isolated stretches on the southern slope of Lysá Mt. in the environs of Dvoračky. Their total area was 350 ha. It was divided into 58 lots while 6 lots were near Dvoračky. A complex of hay meadows in Studenov forest district was adjacent to the above lands. It stretched from the state border, descending west of Sokolník Mt., along the

slope of Navorská louka (meadow) to the forest limit; it followed the forest limit to the stream Malá Mumlava, Velká Mumlava (rivers) and along its stream upwards to Česká path, to the boundaries of Vítkovice forest district. Its area exceeded 250 ha. (The layout of this part of "hay meadows" cannot be reconstructed exactly because only a plan drawn by forester Šmíd is available: "No other sketches are at disposal"). The area of hay meadows in this part of the western Giant Mts. was larger than 600 ha in the second half of the 19th century. It was leased by auction to villagers or to chalet dwellers who harvested on average 2–8 q hay per hectare from these mountain meadows once in two years. E.g. the Jilemnice dominion obtained 1596 gold coins in 1885. Contracts were concluded with tenants binding them not to cut grass low near the ground and not to graze livestock on hay meadows; they were prohibited to cut out and damage old shrubs and dwarf pine and spruce self-seedlings that grew on their lots. They were not allowed to carry axes under a penalty of 2 crowns (Lokvenc 1982). Aerial photos show haymaking carried out on some areas until 1945. On many lots, especially in Pančavská louka (meadow) locality, there were single dwarf pine shrubs and spruce trees as well as their stands with few gaps and peat bogs. Grass cutting was possible on small areas only, which decreased harvest and made work difficult. These lots were drawn only schematically and were beyond the tenants' interest similarly like lots on pit slopes.

The numbers of grazing livestock were high according to literary sources from the beginning of the 19th century. The estimates of e.g. Mattis (1829) are almost in agreement with data of Jirasek (Jirasek, Haenke, Gruber, Gerstner 1791) and Hoser (1804) amounting to 20 000 cows and 10 000 goats kept in 2600 Czech and Silesian chalets. But only a part of the livestock grazed in the dwarf pine zone. It is sure that grazing was frequent there and its influence on plant communities and soil was significant. Fifty head of cattle and 80 goats grazed in the locality of Rokytenské Dvorské chalets in 1688 (Donth F., Donth H. H. 1974), in the 18th century it was 110 dairy cows, 59 heifers and 46 goats with 32 kids; the chalet called Vosecká had 18 cows and 10 goats (Rohkam 1937), Labská 4 cows, Kotelská 80 cows and 30 goats, and Dvorské chalets in Sedmidolí locality 25 cows (Burket 1892, Mosch 1857). In the 19th century in Bílá louka locality there grazed 32 head of cattle and 12 goats from the chalet Luční and the same numbers from Rennerovky locality. At the beginning of the 19th century the remaining dwarf pine stands on mineral soil must have been of quite a large size. It is documented by a record that Jakub Renner, who used about 92 ha of pastures in the environs of Luční bouda (chalet), received a 25 % discount of the charge for pasture (1826) because his livestock grazed inside dwarf pine shrubs where the pasture was recognized to be poorer (Nožička 1961). These were not the dwarf pine stands on peat bogs preserved until now where grazing was not possible. There were 108 cows and 31 goats in Čertova louka (meadow) locality in 1824. The livestock was grazed regularly for almost four months a year, from June to the end of September. Such grazing load is assumed to have lasted for about 200 years (in the 18th and 19th century).

Charges for pasture were contributions to the budgets of dominions in the regions without any other resources.

Chalet dwellers were not likely to graze someone else's cattle from lowlands on a larger scale at that time like in the 16th and 17th centuries, even though Father Gruber encountered it at the end of the 18th century (Jirasek, Haenke, Gruber, Gerstner 1791). Enough hay was necessary for the above livestock numbers for the winter season. It was made in so called "grass gardens" as well as on mat grass upland meadows. Grass cutting dramatically influenced natural regeneration of dwarf pine and other tree species on these plots. Grazing and grass cutting prevented the natural course of progressive succession. All seedlings in a juvenile stage were cut. When mown grass was cocked, dwarf pine branches were put under hay heaps to prevent their rotting and to ensure their ventilation (Ludvík J. M. 1824).

Grazing promoted necessary eutrophication by increasing nitrogen and phosphorus contents, brought about gradual changes in the composition of vegetation cover and contributed to the origin of nitrophilous phytocenoses, especially in the chalet environs, caused mechanical injuries of plants and a significant change in the structure of the ground surface by trampling down (hills, contour footways on slopes) that initiated soil erosion. Soil disturbance was more intensive on moist ecotypes, particularly near water sources – watering places. The extent of grazing was considerably reduced after World War One. It was

an exceptional practice in the fifties of the 20th century when a small herd of cattle and horses grazed in the environs of Luční chalet (LOKVENC 1993).

Forests were mostly preserved on soils unsuitable for agriculture. It was on peat bogs where there were stands suitable for firewood production but after their felling they could not be used either for pasture or for grass cutting. Single interventions in dwarf pine stands on peat bogs (meadows Hraniční, Pančavská and Labská louka) were carried out in 1859, when drainage ditches were built to create conditions for spruce forest regeneration; but it was admitted very soon that it was unrealistic and erroneous efforts (LOKVENC 1979). Cirque phytocenoses were influenced by anthropogenic measures to the smallest extent (the hollows Kotelní jámy, Labská jáma, Úpská jáma – the zone of floriferous tundra). As part of the influence of anemo-orographic systems the main factors affecting the composition of forest stands, existence of forest-free areas, their distribution and size are mechanical forces of wind and snow – snowdrifts, snow-slide and avalanches. Steep cirque walls prevented the use of rich phytocenoses for pasture and firewood extraction. The evidence of grass cutting on rich alpine meadows of the hollows Labská jáma and Úpská jáma was scarce (JIRASEK, HAENKE, GRUBER, GERSTNER 1791, a picture by A. Balzer from 1793 and E.W. Knippel from the first half of the 19th century). A map of pasture allocation from the second half of the 19th century shows lots reaching as far as the hollows Labské jámy and the Labe river. It is not known whether they were leased or not, but grass cutting on steep slopes would be very difficult. No human dwellings were built in these localities even though there were sheltered locations and rich meadows (of the alliance *Adenostylon alliariae, Calamagrostion arundinaceae* – JENÍK 1961). Mountaineers were aware of the danger of periodic avalanches sliding to these locations that caused several tragic accidents (JENÍK 1961). Stands were disturbed by mining carried out in the kettles Kotelní jámy, Úpská jáma and in the Kotel Lomniczki in the first half of the 16th century (LOKVENC 1978). As reported by Wallenstein's office at Jičín the mine Hohenburg was established in 1630 on the Kotel ridge separating the hollows Velká and Malá Kotelní jáma at an altitude of about 1350 m a.s.l. High-quality ore was conveyed to Rokytnice. Buildings for miners were constructed near the mine and the way from Vítkovice was cut through (DONTH, F., DONTH, H. H. 1974). Mining in the valley head of Obří důl (valley) started at the beginning of the 16th century, when some of 12 exploratory excavations drawn on Hüttel's map were situated in the Úpská jáma (hollow) – SCHNEIDER 1938, LOKVENC 1978. The evidence of mining in cirques on the Silesian side of the mountains at Karpacz, namely at Dolina Lomniczki, comes from the 15th and 16th century, when the penetration of "Italian prospectors to the Giant Mts." was documented (SCHNEIDER, K. 1922, STECZ, T., WALCZAK, W. 1962). Mining activities caused not only damage to stands and their liquidation at the place of mining but also it was necessary to make distant and hardly accessible sites accessible to workers and transporters of provisions and ore, to provide for firewood, etc. The vestiges of mining in these localities are not discernible any longer because they have disappeared over 400–500 years.

The intervention in dwarf pine stands for agricultural purposes on the Silesian side was much less extensive than on the Czech side. Alpine farming did not develop there due to unfavourable terrain configuration. Therefore the number of chalets in the dwarf pine zone was considerably lower than on the Czech side. These chalets included Old and New Silesian chalets (Schronisko pod Labskim Szcytem 1632, Schronisko na Hali Szrenickej 1786), Hampl's chalet (Strzecha Academicka before 1642), Schlingel's chalet (Schronisko Bronislava Czecha 1642). An important chalet, Bouda prince Jindřicha (1889–1946), was supplied with agricultural products from Bohemia. Land borders were respected by chalet dwellers since 1710, when the long-time border contentions terminated. From the 16th century to those times the localities Labská louka and Bílá louka (meadows) were a matter of contentions between the Czech and Silesian dominions (NENTWIG 1900, ROHKAM 1939). Silesian serfs penetrated there, and they cut grass in Labská louka (meadow) locality as well as they cut out dwarf pine shrubs in order to maximally use the disputed territory.

In the second half of the 18th century the ideology promulgating a return to the nature aroused an interest in seeing the mountains, and very busy tourism developed from isolated trips undertaken since the 16th century. Mountaineers responded to this interest by transformation of the Alpine farming

system. Chalets were adapted to new economic resources and refurbished, new chalets were built (Renner's chalet 1797, a chalet near Sněžné jámy 1825, Labská chalet 1830, etc.). New communications were constructed making access to attractive sights and sceneries, providing for supplies to chalets and grounds for sports and recreation. All these activities caused great damage to forest stands, cutting out shrubs, disturbance of stand compactness and their ecological stability. By traffic and erosion enlarged cuts of roads, particularly on plateaus with deep soil, were like drainage ditches and substantially influenced the water regime in the environs. A total of 2 000 trenches of this sort were counted in Labská louka (meadow) locality (VÁLEK 1955).

Tourism – recreation activities and hiking have augmented so much that they have become the most important factors influencing the Giant Mts.' ecosystems, especially of the dwarf pine altitudinal zone. Currently, the area of the Czech and Polish National Park is frequented by 10 million tourists a year (JENÍK et al. 1996).

Dwarf pine shrubs were likely harvested by stumping out. Lower parts of stems were of highest quality for consumers (a high proportion of reaction wood), and roots were also used in a specific way. They had to be removed to facilitate further farming, mainly grass cutting, because their decomposition is very slow. Stumping out was not difficult because the dwarf pine shrub has a very shallow root system, without taproot.

Dwarf pine cutting down around the Labe headspring was a unique massive intervention in the stands in order to make enough space for its consecration in 1684 and for a ceremony organized there in 1686 in which 3000 pilgrims participated, and in 1884 in commemoration of the 200-year anniversary from its consecration (NENTWIG 1905, NOŽIČKA 1959, LOKVENC 1978).

Interventions in the pre-war politically tense period 1936–1938 were exceptional. Masaryk's mountain road, making the mountain ranges accessible, was constructed that ended on Krkonoš Mt. in the dwarf pine zone. Jestřábí chalets were built at its end. Fortifications were erected on the ridges from Studniční Mt. to Lysá Mt., 23 fortresses of the first line (model 37) were built and connected by cutout shooting passes and trenches. Large reconstruction of the chalet Luční bouda after fire in 1938 when it suffered great damage was a result of those circumstances. Building material was obtained from the surrounding localities. The building stone – granite was extracted on the left-bank slope of the Stříbrná torrent with remnants of dwarf pine and spruce stands that were preserved in a hardly accessible part of Čertova louka, and transported to the building site (LOKVENC 1999). These works must have largely disturbed forest stands.

Cutting out a border strip in Poland along the Czechoslovak-Polish border interrupted the continuity of dwarf pine stands. When a cableway to Sněžka Mt. was constructed between 1946 and 1949, the dwarf pine stand from Růžová Mt. upwards was also damaged. After 18 years a one-meter strip planned by the investor to be cut out became a 5–10 meter strip of dead dwarf pine stand of the area almost 10 000 m^2 (ŠTURSA 1967).

1.3. Wood exploitation

The knowledge of the size of pastures, hay meadows and livestock numbers kept in an Alpine farming system does not provide enough information on the conditionality of forest-free or grass ecosystems by human activities. More informative is the knowledge of wood consumption resulting from liquidation of forest stands in the dwarf pine zone. Firewood essential for the life in the mountains was obtained from spruce and dwarf pine stands above the forest limit by cutting out paths and driveways for livestock, and particularly by the extension of agricultural areas.

Its consumption for expanding Alpine farming increased at the beginning of the 19th century, when many of formerly summer chalets became residential chalets all the year round. But heating was necessary also in "summer" chalets that were lived in only in the summer season. It is documented by finds of a fireplace from excavations of a summer chalet near the Labe headspring (LOKVENC, BARTOŠ, ŠVEC 1973) and of Stará chalet in Čertova louka locality (BARTOŠ 1991). Especially chalets above the forest limit had to supply wood for their consumption from dwarf pine stands. In the course of the human expansion into

the dwarf pine zone, i.e. allegedly from the 16th century, there were 35 chalets in total on its area, 24 on the Czech side and 11 on the Silesian (Polish) side of the mountains and several temporary haylofts (e.g. 12 haylofts in Labská louka locality in the mid-18th century). About 6 chalets were not engaged in Alpine farming (chalets on Sněžka Mt., near Sněžné jámy, Bouda prince Jindřicha, Havlova bouda, Jestřábí Boudy). They depended on supplies of agricultural products from other chalets, and they needed wood supplies. Some of the chalets ceased to exist. The number of chalets was highest in the second half of the 19th century. Economic interests of many chalets exceeded the forest limit even though they were situated below it, in lower altitudinal zones (Dvorské Boudy in Sedmidolí locality, Brádlerovy Boudy, Horní Mísečky, Schlingelovy Boudy in Silesia, etc.). It applied to about 30 chalets; only five of them were in Silesia. Of course, from time to time settlers from more remote chalets and settlements in the valley made hay or grazed cattle there (e.g. dwellers from Krausovy Boudy - chalets).

It is to assume that in the beginning settlers harvested wood without limitation, and by cutting out dwarf pine shrubs they extended areas for agricultural use in a system of Alpine farming in dominions. The burn and clear system known from the Tatras Mts., Alps and Balkans was not used for dwarf pine stand liquidation very frequently.

After shrubs were removed mechanically, often with their roots, an area with thin discontinued vegetation originated; the ground surface was covered with litter only and a thicker layer of raw humus. Therefore the ground was trampled by livestock and enriched with their excrements, which influenced succession. The origination of a sward suitable for pasture or grass cutting – secondary succession – depended on the environmental conditions. Grasses (*Deschampsia flexuosa*, *Calamagrostis villosa*, *Festuca supina*, *Agrostis rupestris*) appeared to cover the areas in about 30–50 years. Continuous coverage with mat grass, consolidation of the areas after liquidation of dwarf pine stands with original mat grass blanks, and the onset of a very stable stage of secondary succession likely occurred only after 100 years. That means the extensive, continuous mat grass stands (Nardeta) reported in localities Bílá, Čertova and Labská louka (meadows) at the end of the 18th century were deprived of gapped dwarf pine stands in the 17th century at the latest.

Dwarf pine wood was valuable, sought-after and indispensable fuel for chalet dwellers. It has one of the highest heating values, and it burns perfectly in fresh state. Therefore it was appreciated more than spruce wood.

Wood supply in dwarf pine stands was so high at the end of the 18th century that the inhabitants did not have to use peat for heating as stated by Haenke (Jirasek, Haenke, Gruber, Gerstner 1791) even though it was also a possibility under consideration (Lokvenc 1979). In the beginning, wood was received free of charge during pasture extension, later as a part of easements or for a charge, but it was always cheaper than other firewood. The foresters' supervision of dwarf pine stands and activities carried out in them was not so tough as in forest stands (Hoser 1841) where wood harvest was restricted. The oldest instructions and rules from the beginning of the 17th century (Serfdom Rules of 1631 for Lánov dominion, penal regulations of 1688 for serfs from Jilemnice dominion) laid down high penalties for wood harvest from the forest. Chalets and lands were owned by lords, therefore their activities were not anyhow restricted because they bore the only fruits from "unfruitful" regions in the dwarf pine zone. Nevertheless, an extensive use of these regions was envisaged. This is documented e.g. by the above-mentioned project of Count F. K. R. Swečrts-Sporck from the second half of the 18th century aimed at an extensive agricultural use of the Elbe region (Menšík 1899).

The expansion of Alpine farming occurred in the second half of the 18th century in the context of political and economic changes. The chalets that did not belong in dominions any longer received some easements, among them the easement of wood harvest from feudal lands. These were e.g. the most extensive easements of Rokytenské (Sahlenbach) Boudy – Dvoračky drawn up in 1774–1775. Among other things, with the forester's consent they were permitted to extract 5 fathoms of dwarf pine wood a year for each of 17 chalets, in the stands below Sokolník Mt., Tvarožník Mt., in Navorská louka locality and on Kotel Mt., for a charge 5 kreutzers per fathom. The estate owner could substitute this quantity by logging waste and wood from thinning. The landowners required that chalet dwellers would

process dry dwarf pine shrubs e.g. on an area of 3.5 ha in Studenovský forest district after feeding of the European pine sawfly in 1882–1883. They did not obey and felled sound dwarf pine shrubs although they were prohibited to do so. Therefore an order was imposed in 1884 to process it at the dominion's own cost and to sell it to a tenant of Labská bouda (chalet). This tenant was strictly prohibited to cut out dwarf pine shrubs and was obliged to convey firewood from Labský valley (důl). After easement modifications in 1863 some chalet owners were left some plots for pasture and grass cutting on a continuous area stretching from the valley head of Velká Mumlava (Smetaní důl) across the ridge of Lysá Mt. as far as Zadní Plech Mt., and across Kotel Mt. as far as Čihadlo Mt., as a substitution for small dispersed plots. But dwarf pine stands on these plots were the property of the dominion that committed itself to cut it out at its own expense if the new owner did not take it over for firewood under the right concerned. The burden of easements was liquidated by regular buy-outs of particular Rokytenské Boudy (chalets). Only five out of the original 20 chalets were in the hands of private owners in 1895. Although the easements were largely modified that year, the right of wood harvest from dwarf pine stands was not abolished because it was considered less harmful than pasture and haymaking that were restricted. Seventeen chalets continued to possess the right of cutting 85 fathoms of dwarf pin (*"wo sie geschlossen sind"*) 100-years-old stand per morgen it is a cutover area of 2.5 ha. The timber volume of 110-years-old closed dwarf pine stand converted per 1 ha was estimated to amount to 31–39 fathoms (JAHNEL, TSCHAPEK 1826/7), i.e. 59–69 m³ of small timber (*Prügelholz*) of logs 10.5 cm in diameter. Fifty fathoms (95 m³) of firewood per year were cut from dwarf pine stands to meet the easements of Sahlenbach chalets in 1879 (SCHMIDT 1879). Such an amount could be produced on an area of 1.5–2 ha. In case the stands were gapped or younger, the area would be adequately larger. SCHMIDT (1879) stated that *"Alpine farming, lease of hay meadows on Lysá Mt. and on the north-west slope of Kotel Mt., as well as in the environs of the headsprings of Velká and Malá Mumlava streams, and easements of Sahlenbach chalet owners to harvest wood for their own need, were the causes of dwarf pine disappearance from these localities many years ago."*

In the first half of the 19th century, unlike Rokytenské chalets, the chalets in Čertova louka locality received firewood for a charge from gathered waste wood "Klaubholz", not from dwarf pine stands. These chalets also belonged in Jilemnice dominion. Three of them were situated above the forest limit and one just below it. In 1814 the Jilemnice landlords sold 110 fathoms of dwarf pine timber to the owners of adjacent forest chalets and recommended to try to burn charcoal from dwarf pine timber in inaccessible stands of Čertova louka near the borders to save logs (NOŽIČKA 1959). The liquidation of dwarf pine stands to obtain fuel on a particular area, i.e. in the upper part of Studniční hora (mountain) slope at Modrý důl (valley), on the mountain ridge, is documented by forester Pompe's report on a specialized excursion of a forestry association in 1855. Some excursionists descended from the saddle along the slope to a snowfield. They were told, *"...the dwarf pine stand was in better shape there 30 years ago. This evident impairment was caused by clear cuts in dwarf pine stands, preventing natural regeneration, and due to a failure of supervision encouraging the mountaineers, by the use of some plots, non-productive ones for this tree species, to open up the stand canopy to produce wood for their households and to obtain larger areas for grass cutting. It is today's task to protect the existing dwarf pine and to improve its stands or to try to expand them."* (POMPE 1855)

Limestone extraction and lime burning on dwarf pine timber for the construction of Labská chalet in 1878 was a unique use of dwarf pine wood and unique intervention in Kotelní jámy (hollows) considered as the most valuable locality in terms of natural science.

The consumption of dwarf pine firewood was undoubtedly high in the whole mountains because it was the only energetic source in a cold region with average temperature of 3°C. It resulted in liquidation of extensive stands. As direct data on wood consumption are missing, a hypothetical idea should be made at least. Let's begin with the need expressed by a quantity granted to Rokytenské chalets in form of easements. The annual claim of each chalet amounting to 5 fathoms, i.e. about 9 stacked cubic meters, can be considered as an indicator of consumption. If it is realistically supposed that about 25 chalets depended on dwarf pine wood in the whole Giant Mts. for 150 years, the total consumption of wood is

34 000 stacked cubic meters over this period. This quantity can be obtained by cutting 560 ha of closed dwarf pine stands older than 100 years. It is also necessary to add the wood consumption of herdsmen who spent whole days on pasture from June to the end of September.

It is to understand that mountaineers used all available natural resources for their own needs. Dwarf pine was not solely valuable firewood. It was suitable for the production of different objects for households (pine torches, snow-shoes, etc.). Tourists, whose numbers started to increase in the second half of the 18th century, were interested in small objects made of dwarf pine wood; chalet dwellers enlarged the assortment in accordance with demand. They carved and turned wooden products – decorative boxes for tobacco, baskets for fruits and objects made of dwarf pine roots, figurines of Krakonoš, toys, etc. called in German "*Knieholzwaren*" (dwarf pine ware) (Fiek 1882, Hoser 1804, Mattis 1829, Mosch 1857). These articles were sold in all Silesian and Czech villages and towns at the Giant Mts.' foothills. The domestic industry expanded so much that it considerably endangered dwarf pine stands. The strongest dwarf pine stands were felled (Mosch 1857). In the first half of the 19th century the landlords were adverted of this danger by Wroclaw university professor Christian Gottfried Nees von Esenbeck (1776–1858) and warned that the stands would not regenerate spontaneously (Hoser 1804, 1841).

The production of dwarf pine oil (*Oleum pini pumilionis*) by dry distillation of young branches, needles and buds, used at a large scale in the Alps and Tatras from the 17th century to the thirties of the 20th century (Bukovčan 1953), did not become popular in the Giant Mts.

Anthropogenic activities posed the threat of fires to the vegetation and dwarf pine. Fire damage to dwarf pine stands is great because its fresh wood burns well, it has relatively thin bark and the fire spreads quickly in the mountains due to permanently windy weather. No natural fire caused by lightning has been reported in the Giant Mts. even though the lightning is said to have struck and set on fire human dwellings several times, most frequently the buildings on Sněžka Mt. Fires were mostly caused by careless people. As mentioned above, unlike in other mountain regions, fires, burning for intentional liquidation of dwarf pine were not used in the Giant Mts., probably because its wood was considered a very valuable raw material. No vestiges of carbonised horizons were discovered, and toponyms recalling fires are missing. Perhaps except the older German name for a rocky slope of Luční Mt. above Obří důl – Brandkoppe (maybe Burnt Hill). It is a locality where scattered dwarf pine shrubs were destroyed by fire in ancient times (Jirásek 1915). One of the few evidences of burning dry, beforehand cut out dwarf pine is in the decree of Count Harrach from 1744 (Particular Wirtschaft Puncta, 39 1744 – Donth H. 1993). It is claimed that dwarf pine wood liquidated for further expansion of grasslands shall be heaped, burnt and ashes shall be dispersed on the grassland.

The threat of fires due to carelessness was posed especially by herdsmen who grazed livestock on hay meadows and among dwarf pine shrubs in summer and made fires. But the reports on fires caused by them are very scarce because the local inhabitants did not want to provoke conflicts with landlords on whom they depended to a large extent. But in 1901 a tourist caused a fire that damaged 8 ha of hay meadows above Martinovka and Labská chalets. The greatest fire occurred on the southern slope of Kotel Mt. on the 26th December 1924. It damaged an area of about 70 ha from the forest limit to the summit. A major part of gapped dwarf pine and spruce stands was burnt, and perhaps the flames penetrated as far as Kotelní jáma (hollow) where they destroyed the locality of the rare willow *Salix herbacea*. It is said that a tourist unintentionally not far from Dvoračky has caused the fire, and it spread eastward. Forty mountaineers extinguished it.

1.4. Evidence of written documents

Maps are usually very valuable documentary materials. The oldest maps of the Giant Mts. drawn by Šimon Hüttel in the mid-16th century, Samuel Globic of Bučín in 1668, Johann Christian of Wolffsburg in 1701 and some others do not represent the highest regions of the mountains adequately and do not provide an exact picture of dwarf pine stands at that time. But Hüttel's map contains very valuable data in its legend: local names, verbal additions and explanatory notes. It is however difficult to precisely

distinguish the composition of forest stands and to localize them from photocopies of the original and from map reconstruction (BARTOŠ, NOVÁKOVÁ 1997). Forests and forest-free areas are discernible from each other; forest-free areas are schematically represented on most mountain summits. Out of the total number of 430 notes on this map only about 16 notes describe the occurrence of a particular tree species, mainly at lower locations, in the areas of interest in logging that was the main reason to draw this map. The most frequent is beech in six cases, spruce, maple and oak twice and birch once. Dwarf pine is indicated twice at higher locations. Dwarf pine stand (im knieholtz auf dem mittel gepirk) is described near Slezská path somewhere above Modrý důl and in the western Giant Mts., perhaps above Rokytnice on Jizera (die knie streichle). The map shows a vast willow stand ("der grosse Veiden Strauch") near Slezská path before the meridian stones across the border in Silesia. In the sphere of anthropogenic activities, two mines can be located with some probability where the localization of Bílá louka is assumed: "dz Johanss grab" and "der goltt gruntt" in its western part. These may be works mentioned by Johannus Walle, who described his Giant Mts.' journey in the mid-15th century (SCHNEIDER 1922). Slezská path is clearly represented on this map ("der wegk ubers gebirge") with the activities of humans along this path at the highest locations, e.g. "herbalists" gathering snake-root (BARTOŠ, NOVÁKOVÁ 1997). Globic's map shows forest stands on the whole area of the eastern Giant Mts., without specification of particular tree species or clear cuts. The disputed territory between neighbouring dominions in Bílá louka locality is forest-free; a dwarf pine stand called "Knieholtz" is drawn along the western border on Liščí Mt. (FLÉGL, KUCHAŘ, ROUBÍK 1949).

Mann's map of the western Giant Mts. from 1743 gives a more detailed picture of this region. Dwarf pine stands are represented by symbols of shrubs in the whole region; Puchmajerová (1952) considered it inappropriately as an evidence of continuous forestation. The exception is forest-free areas drawn around the summit of Vysoké kolo Mt. below the Labe headspring and a vast forest-free area on the slopes of the Labský důl valley head, Giant Mts.' ridge as far as the Velká Mumlava headspring and Mísečná stráň locality where there are several haylofts. Of course, the density of dwarf pine shrubs represented on the map is not intentionally identical on the whole area. Striking are thin stands on the slope from Violík Mt. to the Labe and in the Mumlava headspring area. Dead dwarf pine stands ("... gefrohrenes dürres Knieholz ... ") are plotted in Labská louka locality, on the area of about 30 hectares below Violík Mt. as far as the Labe headspring, and on a smaller, about 3-hectare area from the Labe headspring as far as Pančava and Labská jáma (hollows). Even though frost was allegedly the cause of their decline, it is not probable.

Mann's map shows a detail of the meadow Čertova louka, which was an autonomous locality, an enclave more than 500 ha in size, belonging in Jilemnice dominion, situated in Maršov dominion. It was established after the border contentions terminated in 1710. The Alpine forest limit curving along the southern and/or southwestern slope from Bílé Labe to Čertova strouha is clearly marked. In the latter locality, there is a meadow with haylofts Boudy in Čertova louka. Relatively dense dwarf pine stands are plotted in the area above the forest limit as far as Luční bouda (chalet); their existence is specified by No. 4 designating an area with dwarf pine according to the map legend. Smaller forest-free areas described as "*acid and clear water swamps*" are drawn in a peat bog where the torrent Stříbrná bystřina springs. There is an extensive forest-free area on an undulated slope, cirque depression on the right bank of Stříbrná bystřina, where a primeval meadow is assumed to have existed that was extended for grass cutting. It is stretching below Čertovo návrší as far as the forest limit in the Bílé Labe valley. It is a locality where Scharf's chalet was built around 1750. The map shows dwarf pine stands in Čertova louka that were liquidated from the second half of the 18th century, particularly in its eastern part from Stříbrná bystřina to Bílá louka.

Newer Graupar's map from 1765 shows dwarf pine stands rather schematically. A larger forest-free area is located on the summit similarly like in Mann's map, and contrary to it, also on the southern slope of Vysoké kolo Mt. The region above the forest limit is regularly plotted just in accordance with the concept of working-plan officers on newer forest management maps that are parts of working plans. Different feudal and private lands (meadows) belonging to chalets are indicated, but dwarf pine stands

on the remaining lands are represented schematically, vaguely. The representation of new dwarf pine plantings in the Bílé Labe perimeter is quite accurate on a map drawn for a trip of the Czech Forest Association to Vrchlabí and Maršov estates in 1906. Therefore the most maps, except Mann's and Graupar's ones, provide little information on the condition of forest stands above the forest limit.

Balzer's engravings from the second half of the 18th century are an interesting evidence of changes in dwarf pine distribution (BALZER 1794). One of them shows dwarf pine stands on the western slope of the Kozí hřbety ridge. The forest limit is at a considerably lower location than at present, and gapped dwarf pine stands are on the slope above it. As confirmed by the residues of dead dwarf pine shrubs in a spruce stand (they occurred there still in 1953), the forest limit ascended on a relatively large area during 150 years to the detriment of dwarf pine stands (JENÍK, LOKVENC 1962). Another of his engravings depicts the vegetation above the valley head of Labský důl. There is a forest-free area above the Labská hollow – a pasture where a herd of about 20 cows is grazing.

1.5. Biotic damage

The occurrence of fungal diseases and animal pests in dwarf pine stands has been recorded in greater detail since the mid-19th century. The degree of damage caused by fungal pathogens was not economically important in the past, even though a number of parasitic and occasionally parasitic species was detected. The infection by the pine needle-cast fungus (*Lophodermium pinastri*) was rather severe in 1894–1895, in the Polish part of Stříbrný ridge, on Violík Mt. and Krkonoš Mt. On the other hand, the damage caused by pine needle-cast (*Lophodermium pinastri*) and dwarf pine needle-cast (*Hypodermella sulcigena*) in the High Tatras and Liptovské Tatras and on artificially established stands in the Jeseníky Mts. was of greater extent.

Insect pests cause greater damage, especially the European pine sawfly (*Neodiprion sertifer*). As a result of its feeding, accompanied by the mass outbreak of the pine-needle gall-midge (*Thecodiplosis brachyntera*), 115 hectares of dwarf pine stands declined in 1880–1884: 69 ha in the eastern part in Čertova louka locality and on Luční Mt., 46 ha on Sokolník Mt., in Malá Mumlava headspring area, and in the saddle between Harrachovy kameny and Krkonoš Mt. Dead dwarf pine wood was allotted to chalet dwellers from Dvorské chalets for processing to meet their easements. Since then, several gradations of this pest occurred: e.g. in 1893–1895, 1917, 1927 and in 1932–1935, when greater damage on an area of 4–5 km^2 was reported by Kolubajiv. Other outbreaks followed both in the eastern and western part of the Giant Mts. in 1963–1967 (KUDLER, VEBER 1965).

The strongest feeding was recorded in Pančavská louka, on Krkonoš Mt., Kotel Mt., near Jestřábí Boudy (chalets), in the saddle between Velký Šišák and Mužské kameny, on Stříbrný ridge, the feeding in the western Giant Mts. in Navorská louka and Labská louka (medows) was of lower intensity.

Another, very important animal pest, the pine-needle gall-midge (*Thecodiplosis brachyntera*), occurs almost every year similarly like the pine sawfly, especially on debilitated stands (peat bogs, new plantings). The extensive occurrence was recorded in 1870–1891, when this pest along with the fox-coloured sawfly gradation caused a decline on 115 ha of dwarf pine stands; in 1948–1949 they caused stand damage in the localities Úpská rašelina, Bílá louka, Rudník and Výrovka. A strong attack of 9 % of stands was recorded in the western part of the Giant Mts. in 1966–1970 (the highest occurrence in Pančavská and Navorská louka, Kotelské sedlo and under the summit of Velký Šišák); in the eastern part 2 % of stands were attacked (Úpská rašelina, the edge of Úpská jáma, Modrý důl valley head) (SKUHRAVÝ, HOCHMUT 1971, SKUHRAVÝ 1978). Since 1997 the infestation has been heavy in plantings established on Čertova louka in 1973–1980, near the chalet Na rozcestí built in 1977, where some shrubs decline after repeated feedings, and in older cultures in U čtyř pánů locality planted in the forties.

In 1981, a dangerous fungal pathogen *Ascocalyx lagerbergii* (Gremmen) causing shoot dieback was detected by Doc. A. Černý, CSc., from the University of Agriculture at Brno, in a 25-year planting in Navorská louka and below Kotel Mt. The fungus occurrence largely decreased by 1984 and it was not observed in the next years any more (LOKVENC 1996).

STAND REGENERATION

2.1. Natural regeneration

The replacement of liquidated stands by natural regeneration was not possible in the Giant Mts. because natural reproduction has always been very rare, and the cleared areas were immediately used for pasture or grass cutting. P. Svoboda in the Liptovské Tatras drew similar conclusions in 1939. The return of dwarf pine to areas that originated by dwarf pine cutting was found scarce even if the pasture was not possible. He wrote: "*once the stand has been destroyed, its regeneration is very difficult even under sufficiently favourable living conditions*". "*A number of factors, a complex of hardly analysable, differently powerful and differently combined, and hitherto little known causes, are responsible for an almost permanent decline of dwarf pine from the destroyed areas.*" It is to state objectively that the knowledge of this problem has not progressed very much.

Currently, dwarf pine natural regeneration – reproduction is also negatively influenced by air-pollution that critically increased in the late eighties. Fertility and quality were impaired, seed germination decreased from previous 70–80 % to average 40 % and to mere 14 % in 1981 (LOKVENC 1996).

The results of observations of dwarf pine natural regeneration show that natural regeneration is scarce although seed production is relatively high and grazing and grass cutting are not practiced. It originates most frequently on poor soils with limited competition of the herb layer. It was confirmed by Štursa's investigations (1966) that reported the highest occurrence of seedlings in gapped stands with the associations *Cetrario-Festucetum supinae*, mostly in the facies with heather (*Calluna vulgaris*). They have more favourable light and heat regimes. Self-seeding is scarce on rich soils where the enclaves inside the shrubs are covered with mat grass (*Nardus stricta*), reed (*Calamagrostis villosa*), moor grass (*Molinia coerulea*) and other species of the associations *Carici (fyllae)-Nardetum*, *Crepidi-Calamagrostidetum villosae* etc.

2.2. Stand reconstruction

At the end of the 19th century forest managers were already aware of the importance of dwarf pine stands, of their positive effect on forest stands (SCHMIDT 1879) and hydrological conditions (BAKESCH 1906). Therefore dwarf pine liquidation was restricted, and it was consistently protected during grass cutting that continued in the ridge areas to some extent. Dwarf pine planting started in Jilemnice dominion in the western Giant Mts. in 1870. Gradual reforestation* was carried out on areas of 439 ha in the whole Giant Mts. in 1870–1913 while 110 ha of dwarf pine, 13 ha of spruce and 30 ha of cembra pine were improved. The reason for reforestation was that the liquidation of dwarf pine stands and unfavourable condition of forest stands near the forest limit were considered as one of the main causes of disastrous floods in 1882, 1883, 1897 and 1900 that afflicted the Giant Mts. and their foothills. Especially extensive grasslands in the localities Bílá, Čertova and Labská louka (meadows) were reforested, exclusively using plants grown from seeds of foreign provenance (Austrian, German, Swiss Alps) bought from specialized trading companies (LOKVENC 1989).

Dwarf pine reforestation of smaller extent was carried out in the western Giant Mts. after 1922 and at the beginning of the forties of the twentieth century (after 1937), but no evidence has been found. An area of about 15 ha was reforested with dwarf pine in Studenov and Vítkovice forest districts (Jilemnice estate) along the road to the Labe headspring (compartments 303 a, 201 b, 233 a, b).

Reforestation in the Silesian (German) part of the dwarf pine zone was carried out only exceptionally due to the lack of suitable areas on which dwarf pine was liquidated. There is an evidence of plantings

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* *The term reforestation is used even though it is not forest regeneration and establishment because planting is carried out above the upper forest limit.*

e.g. on the slopes of Malý rybník (Hasenrand) and on its moraine, on the northern slope of Stříbrný ridge (Schneeloch – 1380 m a.s.l., HUECK 1939) in the territory of Count Schaffgotsch's estate from the thirties.

After World War II a decision was taken in the Giant Mts. territory, which was handed over to the State, to reforest the areas where dwarf pine stands had been liquidated, mainly for hydrological reasons. Opočno Research Station, a part of the Research Institute of Forest and Game Management, was charged by research into this area and by elaboration of the complex plan of alpine reforestation, including the choice of tree species and methods of plant production, planting technology, etc. More than 900 ha were delimited for reforestation.

The plant was taken over by the Forest Management Institute, adapted for practical operations and gradually implemented by specialized responsible bodies of State Forests.

2.3. Present condition of stands

Reforestation was terminated in 1991: an area of 619 ha was reforested, out of it 440 ha of dwarf pine. In 1992 the executives of the Giant Mts. National Park stopped reforestation in the dwarf pine zone and the plan has not been accomplished. On the contrary, they proposed to reduce some newly established plantings arguing that "*the expanding continuous plantings gradually decrease the area of grass tundra, they will cover the unique cryogenic soils and substantially change the snow and microclimatic conditions*" (KRNAP 1977). But this opinion has not been accepted unanimously and documented appropriately, and the dwarf pine zone, particularly its part designated as arctic-alpine tundra, are objects of present research.

The present condition and area of dwarf pine stands (reduced dwarf pine area) were determined in 1990–1992 on the basis of detailed field surveys conducted by Forest Management Institute, its branch at Hradec Králové, historical research, processing of aerial photographs carried out by Research Institute of Forest and Game Management and Opočno Research Station.

Of their total area 2055 ha above the Alpine forest limit, 1502 ha, i.e. 73 %, are taken by the original stands of Giant Mts.' dwarf pine that had originated naturally; a major part of these stands was declared as a genetic resource. An area of 261 ha, i.e. 13 %, is covered by stands artificially established between 1879 and 1913 (by 1945 to a smaller extent) using plants of foreign imported provenances. Their age is from 41 to 100 years. The third group consists of dwarf pine plantings established between 1952 and 1992, when reforestation terminated. Plants produced from the seed of local provenances (from the first group) were used. They take up the area of 292 ha, that means 14 % of the total dwarf pine area.

Besides these stands, there are 125 ha of dwarf pine stands below the forest limit. Forty percent (50 ha) are stands older than 100 years and the remaining 60 % (75 ha) are plantings established after 1980, when clear cuts caused by air pollution were reforested. The dwarf pine area in the Czech part of the Giant Mts. amounts to 2 180 ha in total (LOKVENC T., MINX A., NEHYBA J., STEJSKAL O. 1994). In Rýchory locality, there are several dwarf pine shrubs that were planted there.

CONCLUSION

Most authors who studied the Giant Mts. vegetation and their history agree with the historically proved fact that the stands above the Alpine forest limit in the Giant Mts. with dominant dwarf pine were significantly affected by anthropogenic activities (HUECK 1939, JENÍK 1961, JENÍK, LOKVENC 1962, ŠTURSA 1966, ŠOUREK 1969, SOUKUPOVÁ, KOCIÁNOVÁ, JENÍK, SEKYRA et al. 1995, and others). Their result was an extensive, permanent liquidation of forest stands – "deforestation" and significant changes in the environment and disturbance of environmental functions of the ecosystems.

It can be assumed on the basis of historical analysis and environmental knowledge that before the humans came to this region in the 14th–15th century there were vast shrubby stands with dominant dwarf

pine above the forest limit, which was mostly formed by spruce and to a lesser extent by beech. With increasing altitude and at some sites with exceptional, particularly soil conditions closed dwarf pine stands changed into gapped stands – "dwarf pine mosaics" with a decreasing proportion of spruce. The gaps in dwarf pine stands were likely to increase to become areas with scattered dwarf pine shrubs until dwarf pine totally disappeared. It was a situation on climatically and pedologically exposed deflation summits and on their slopes (Sněžka, Studniční Mt., Luční Mt., Malý Šišák, Vysoké kolo, Kotel, etc. – areas with cryogenic soils), with the intensive summit phenomenon, in troughs, cirque walls and stone fields, in the cuts of streams and in other localities with long-lasting snowfields and avalanche slopes. There are no convincing synecological circumstances in the pedo-climatically relatively favourable localities that would condition its original absence since the ecological amplitude of dwarf pine is relatively wide. It applies especially to the extensive areas of Labská and Bílá louka peneplain in the accelerating part of anemo-orographic systems, which were under intensive use for a long time.

About 1000 ha of dwarf pine areas were liquidated during 400 years of the human existence and farming in the Giant Mts., and a major part of the remaining stands was disturbed either by direct anthropogenic activities or by anthropgenically induced environmental changes.

Alpine farming was the main cause; it was introduced by settlers coming from the Alps at the end of the 16th century, culminated in the second half of the 18th century and declined during World War II. Its goal was to obtain the largest possible areas of pastures and hay meadows by expansion of original primeval meadows and liquidation of dwarf pine stands, and dwarf pine wood to meet a high consumption of firewood and to produce home equipment for chalet dwellers.

Alpine farming gradually adapted to the requirements of tourism, interest in the mountains that aroused from the beginning of the 19th century. Livestock raising declined and the life in chalets fully adapted to tourism by the end of the century; it brought about new threats to nature and damage to dwarf pine stands by spontaneous building of new communications, chalets, etc.

The relations between the area of forest stands and that of herb associations as well as their spatial distribution and species composition have changed during the long period of anthropogenic activities in the mountains. So the natural environment changed, and permanent farming on forest-free areas caused long-term changes in its herb associations, soil, succession, etc.

In consequence, particularly as a result of floods at the end of the 19th century that were considered to have been caused by the bad condition of forest stands above the forest limit, regeneration of dwarf pine stands was carried out in 1879–1913, and then between 1952 and 1962 for hydrological reasons. Taking into account the present knowledge and requirements it is evident that some mistakes were made during its implementation; currently, remedies are sought while there arise conflicts of specialists' interests. The presented historical analysis should contribute to their settlement and to the definition of optimum care of this region and of one of its most valuable plant species – true dwarf pine.

SOUHRN

Porosty kleče horské pravé (*Pinus mugo* ssp. *pumilio*) v Krkonoších jsou jednou z nejcennějších složek zdejších ekosystémů. Jsou omezeny na oblast nad alpínskou hranicí lesa, klečový vegetační stupeň z větší části do oblasti arkto-alpínské tundry. Před příchodem člověka, který je kladen do 14. až 15. století, převládaly zde při hranici lesa víceméně zapojené, se stoupající nadmořskou výškou a zhoršujícími se podmínkami prostředí se mozaikovitě rozestupující křovité porosty kleče a dalších vtroušených dřevin, přecházející až v jednotlivé keře. Zejména po kolonizaci Krkonoš alpskými kolonisty koncem 16. století rozšířil se zájem panství i obyvatel z podhůří o nejvyšší polohy hor pro pastvu dobytka a sklizeň trávy, tzv. budní hospodářství se všemi dopady. Zprvu se soustředilo na lokality poblíž stezek překračujících snad již od 10. století horské hřebeny z Čech do Slezska. Původní menší, roztroušené plochy praluk postupně rozšiřovali likvidací kleče, kterou byla kryta i vysoká spotřeba palivového

dřeva pro vznikající boudy. Vzhledem k tomu a i k využívání klečového dřeva k výrobě upomínkových předmětů se téměř nepoužívalo vypalování porostů. Rozšiřování ploch pro budní hospodářství bylo podporováno majiteli panství, kterým nájem z doposud bezcenných ploch přinášel určité zisky. Intenzívně využívanými se staly zejména rozsáhlé peneplény Labské, Bílé a Čertovy louky, kde se staly převládajícími rostlinnými společenstvy druhotné smilkové louky. Trvalá pastva a sklizeň trávy znemožnily přirozenou obnovu kleče. Podle historických analýz bylo v české části subalpínské a alpínské oblasti přesahující plochu 3 300 ha zasaženo antropogenní činností přes 30%, asi 1000 ha ploch bylo „odlesněno" a velká část zbývajících porostů byla narušena přímým zásahem člověka a další jím vyvolanými změnami prostředí. Probíhající pokles zemědělského využívání oblasti nahrazoval postupně od začátku 19. století rozvoj turistiky. Na tento posun reagovali budaři transformací původního budního hospodářství, avšak intenzita využívání se nesnížila a změnily se jen její formy a projevy. K jeho úplnému zániku došlo během druhé světové války a odsunem německého obyvatelstva.

V menším rozsahu byly porosty negativně ovlivňovány houbovými a zejména hmyzími škůdci, hřebenulí ryšavou a bejlomorkou borovou. Jejich žír při opakovaném výskytu kleč oslaboval a docházelo i k jejímu plošnému úhynu.

Pod tíhou důsledků likvidace kleče, zejména po povodních koncem 19. století, za jejichž příčinu byl i špatný stav porostů na hranici lesa v pásmu kleče považován, byla likvidace kleče zastavena. Panství, za podpory státu přistoupila v létech 1879 až 1913 k její obnově, pro kterou však používali výhradně sazenic vypěstovaných ze semen cizích, většinou alpských proveniencí. Další etapa rekonstrukce porostů nad hranicí lesa, iniciovaná zejména vodohospodářskými motivy, vycházející z exaktních poznatků výzkumu se uskutečnila v létech 1952 až 1992. Její realizaci však Správa KRNAP zastavila vzhledem k rozdílným názorům na její účelnost a obavy z negativního vlivu na stav krkonošské arkto-alpínské tundry, jejichž oprávněnost je objektem současných studií.

Imisní kalamitě, která po roce 1978 Krkonoše zasáhla kleč na rozdíl od smrku nepodlehla. I u ní však došlo k určitým projevům signalizujícím snížení vitality.

V současné době je z celkové výměry klečových porostů 2 055 ha v české části hor 73% původní krkonošské kleče, z nichž podstatná část je vyhlášena jako genová základna. Nepůvodní porosty uměle založené s použitím cizích proveniencí v první etapě výsadeb, staré od 50 do 100 let zaujímají 13% a porosty založené sazenicemi vypěstovanými ze semen autochtonních porostů po roce 1952 zbývajících 14%.

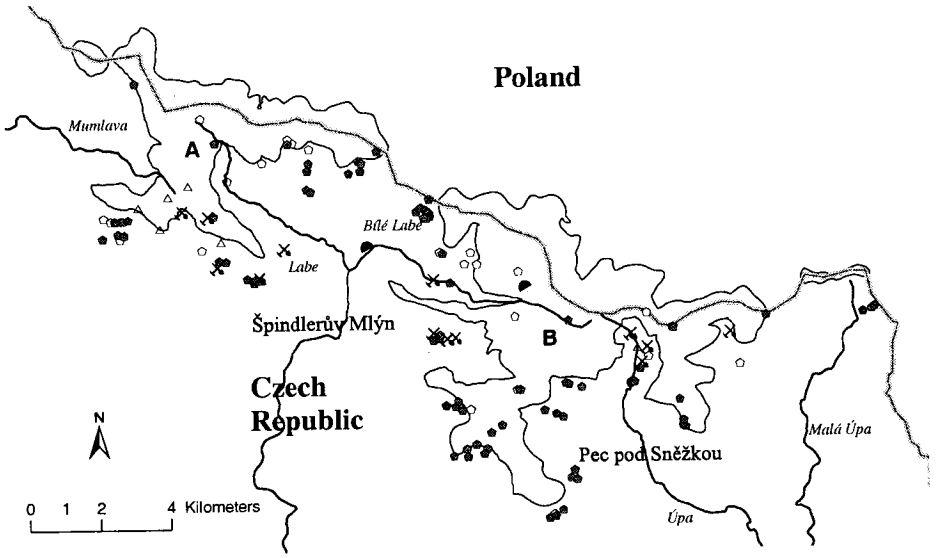

Fig.1. Colonization and human activities in the tundra zone and in its close surroundings
A - western, B - eastern part of tundra, stone-pit, mining, extinct chalet, existing chalet, hay-loft (in past), state boundary, tundra zone boundary

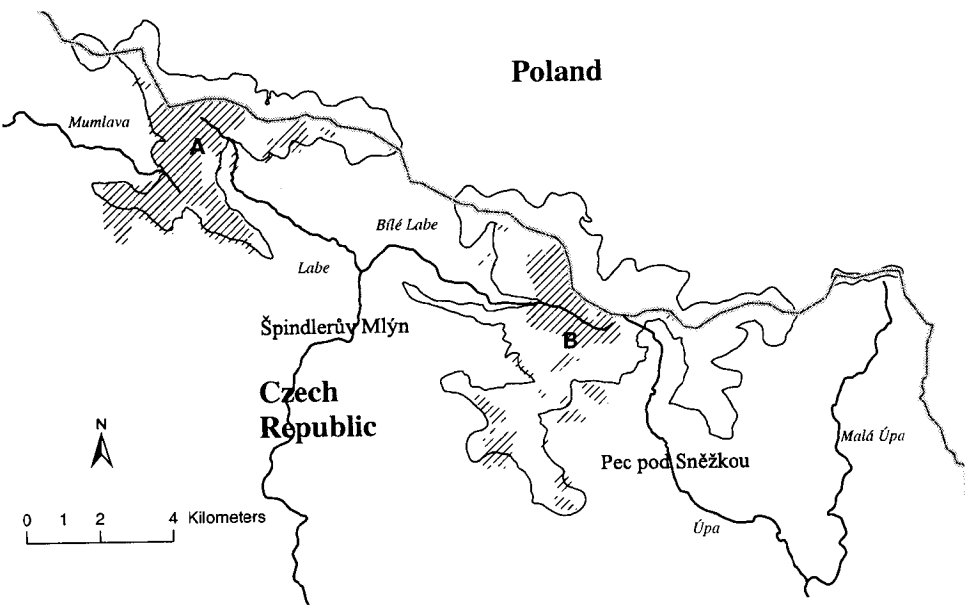

Fig.2. Supposed area of human activities (in relation to the arctic - alpine tundra zone).
A - western, B - eastern part of tundra, state boundary, tundra zone boundary, maximum area of human activities

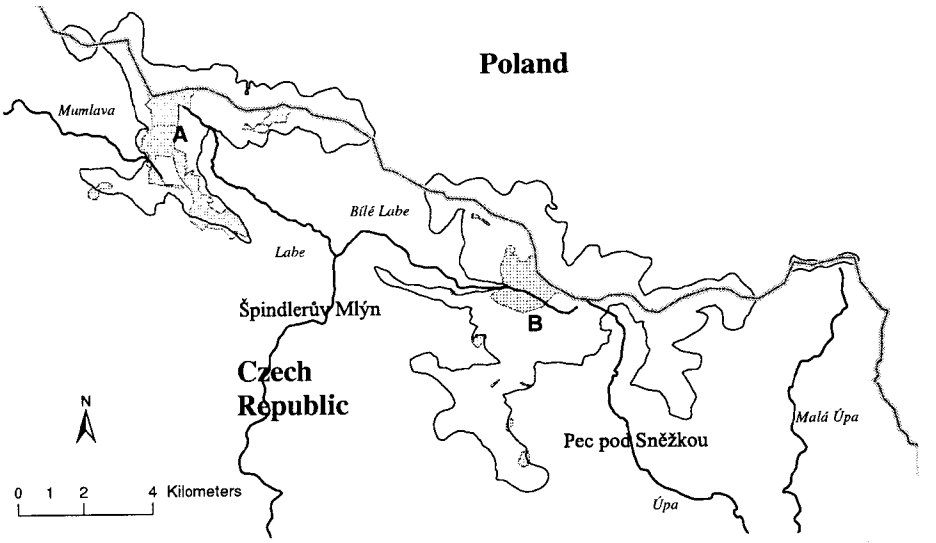

Fig.3. Area of reforestation of dwarf pine.
A - western, B - eastern part of tundra, state boundary, tundra zone boundary, dwarf pine plantations

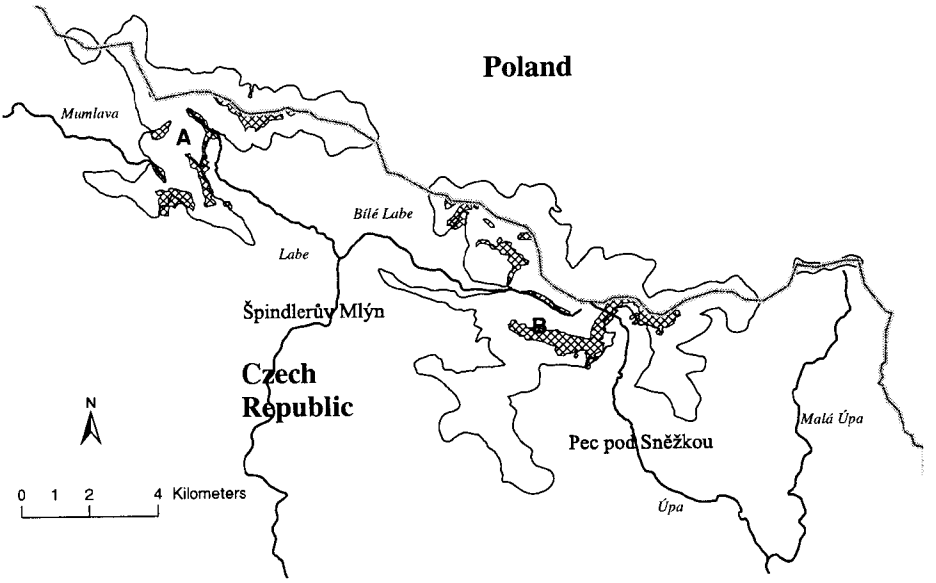

Fig.4. Supposed treeless area without dwarf pine.
A - western, B - eastern part of tundra, state boundary, tundra zone boundary, area without dwarf pine

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