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Altitudinal maxima of *Tilia platyphyllos* and their status in the Sudeten and Western Carpathians

Charakter výškových maxim lípy velkolisté (*Tilia platyphyllos*) v Sudetech a Západních Karpatech

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Outlying occurrences of broad-leaved lime near the timberline of Central European mountains are linked with comparatively warmer, nutrient-richer and avalanche-perturbed habitats impairing the competition of beech, spruce and dwarf pine. Parallel presence of companions, normally associated with mixed broad-leaved woodlands, provides evidence for the relic status of the small populations of lime, left behind after the retreat of this species from the northern edge of its range and upper-montane belt, achieved in the mid-Holocene period.

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Despite a dense coverage of the Central European territory by floristic reasearch, not a single locality of any *Tilia* species has been recorded from the upper-montane and subalpine belt of the mountains, until the middle of this century. This state of knowledge is explicitly noticed by Fekete and Blattny (1914: 269), Schustler (1918: 84), Domin (1931: 147), Vincent (1933: 49), Firbas (1949: 176) and Svoboda (1955: 322). In recent decades this opinion has abruptly changed after a series of unexpected findings of small outlying populations of broad-leaved lime, *Tilia platyphyllos* Scop., in the Sudeten and Western Carpathians (Vulterin 1954; Somora 1958; Jeník 1959; Jeník, Bureš and Burešová 1983; Bernátová, Hajdúk and Kliment 1983). New collections and pertinent ecological observations brought about a number of questions referring to (1) upper limits of the range of *Tilia* species in Central Europe, (2) growth-form and life strategies of trees in marginal habitats, (3) effective factors enabling the establishment of pioneer forerunners or survival of outlying relic populations, (4) native status versus man-induced establishment of outlying populations, (5) difference between forerunner species in a forepost, and relic species in a refuge, (6) conservation aspects of outlying populations in European mountains. In the following treatise I intend to deal with these problems in the above given sequence.

ALTITUDINAL LIMITS IN THE AREA OF DISTRIBUTION

With regard to latitudinal and longitudinal boundaries, the range of the both native Central European *Tilia* specis (*T. cordata* Miller, *T. platyphyllos* Scop.) are satisfactorily described Hegi 1925; Firbas 1949; Svoboda Huntley and Birks 1983). While the former species penetrates beyond the

Tab. 1. — Reiteration of the recent findings of *Tilia platyphyllos* in the upper montane and subalpine belt of the Sudeten and Western Carpathians (for comparison a locality from Šumava Mts.); for their situation see Fig. 1; relevant growth-forms illustrated in Fig. 2 and Plate V and VI.

Locality	Habitat	Growth-form	Reference
Krkonoše Mts., Pančava Cirque, 1130 m a.s.l.	Grassland/scrub, 30° slope to S.E.S., avalanche track, leeward, warm	Procumbent polycormone, 0.5 m high, chamaephyte	Jeník 1959, 1961
Hrubý Jeseník Mts., Velká Kotlina Cirque, 1260 m a.s.l.	Scrub on 35° slope, facing E.S.E., avalanche track, leeward, warm	Ascendant shrub, 1.5 m high, nanophanerophyte	Jeník, Bureš et Burešová 1983
Šumava Mts., Černý les, near Želnava, 900 m a.s.l.	Mixed forest, scree slope, facing S.W., moderately warm	Erect tree, 20 m high, phanerophyte	S. Kučera (manuscript)
Malá Fatra Mts., Stratenec, above Prostredná Valley, 1380 m a.s.l.	Scrub on a cliff, facing S.W., loaded by snow, warm limestone	Ascendant shrub, up to 2 m high, nanophanerophyte	Bernátová, Hajdúk et Kliment 1983
High Tatra Mts., Kobylí Vrch, between 800 and 1000 m a.s.l.	Mixed forest, slope facing east, lee area of a massif	Erect tree, phanerophyte	Somora 1959
High Tatra Mts., near Tatranská Lomnica, 885 a.s.l.	Precipitous slope of a glacial moraine	Coppice tree and scrub, phanerophyte	Somora 1959
Belanské Tatra Mts., Červená Hlina saddle, between 1250 and 1350 m a.s.l.	Scrubby woodland, on precipitous slope, facing S	Coppice tree, up to 6 m high, phanerophyte	Vulterin 1954 Somora 1959 Šmarda 1961

63° N. in Finnland (Kihlman 1896) and Sweden (Mascher 1977), the latter lime ceases growing spontaneously at about 54° N. on the continent (Firbas op. c.) and in Great Britain (Pigott 1969). With regard to altitudinal limits, earlier works express the view that *Tilia platyphyllos* "ascends mostly to lesser elevations than *T. cordata*" (Hegi op. c.: 447) but new evidence brings about the opposite conclusion (Firbas op. c.: 176; Svoboda op. c.: 323).

While pursuing the altitudinal maxima in the area lying to the north of the Danube, we should not forget to note the maxima reached by broad-leaved lime in the Alps and Jura: Wallis up to 1790 m, Tessin up to 1200 m, Jura au des Dôle 1678 m, and Schneeberg in Lower Austria 1550 m. The last mentioned locality, itself a classical area of Austrian botany, is evidently controled by limestone microclimate and vicinity of the warm Pannonian Region. Another locality outside our area of observations is that of *Tilia*

intermedia, an assumed hybrid between *T. cordata* and *T. platyphyllos*, found at 1150 m in the glacial cirque of Hohneck, the Vosgue, by Issler (1909). To the north of the Danube findings of spontaneous *Tilia platyphyllos* never surpassed the 1000 m contour line: 948 m in the Bavarian Forest, 612 m in the Ore Mountains, 600 m in Krkonoše range, 700 m in Bieszczady

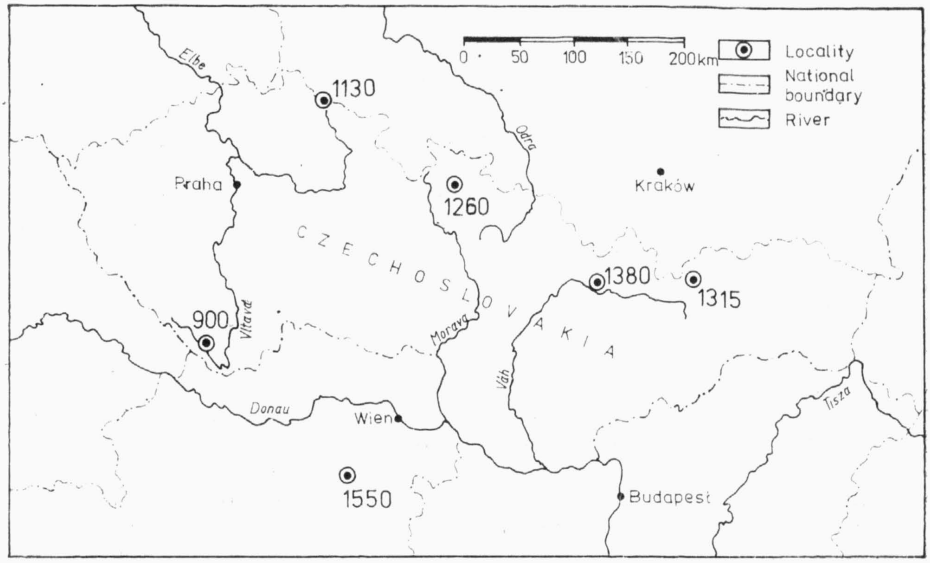

Fig. 1. — Distribution of altitudinal maxima (bold numbers indicate m a.s.l.) reached by *Tilia platyphyllos* in the Central European mountains; for further details see Tab. 1.

and 960 m in Pieniny (see Firbas 1949; Šourek 1969; Szafer 1959: 191; Zarzycki 1981 : 115).

As mentioned above, recent findings revealed a few outstanding localities of *Tilia platyphyllos* in the upper montane and subalpine belt of the Sudeten and Western Carpathians (Tab. 1). The series of new records was started by Vulterin (1954) reporting an outlying occurrence in Belanské Tatra, the limestone part of the High Tatra, at 1350 m a.s.l. (the altitude was corrected by Somora, 1959, giving 1315 m). In his account of distribution of woody species in the High Tatra Somora (1958: 103) reported on an isolated population of coppice trees of broad-leaved lime on the S.E. slopes of a glacial moraine near Tatranská Lomnica between 870 and 970 m a.s.l.; the same author described single-trunk trees of *Tilia platyphyllos* on Kobylí Vrch, between 800 and 1000 m (Somora 1959). In connection with geobotanical survey of the Krkonoše range, the Sudeten, Jeník (1959, 1961) described creeping scrub of broad-leaved lime at 1130 m in Schustler Garden, Labský Valley (see Plate V.). Later, Burešová noted another outstanding altitudinal maximum (Jeník, Bureš et Burešová 1983) at 1260 m in Velká Kotlina cirque, Hrubý Jeseník range, the Sudeten (Plate VI). Finally, Bernátová, Hajdúk and Kliment (1983) triumphed in reporting the absolute

altitudinal maximum of *Tilia platyphyllos* at 1380 m on Stratenec, Prostredná Valley, Malá Fatra Mts., the Western Carpathians. Still unpublished is the highest locality of *Tilia platyphyllos* in the Bohemian Forest (Šumava Mts.) at 900 m in Černý Les near Želnava. All of the above mentioned elevation maxima are illustrated in Fig. 1 (including the old record on Schneeberg in the Lower Austria).

GROWTH-FORM AND LIFE STRATEGY IN MARGINAL HABITATS

Reports on altitudinal maxima of broad-leaved lime always refer to particular growth-form adapted to local environmental factors. As it was in the case of northernmost latitudinal extremes, the populations in the remote mountain localities are represented mostly by coppice trees, low shrubs and even creeping scrub. It is a common experience that lime develops a broad range of growth forms — from tall broom-shaped trees in the closed-canopy woodland to stunted coppice shrubs in harsh or perturbed habitats on riverbanks and avalanche tracks. For the public, the widespread crown developed in solitary lime trees seems to represent an ideal model tree. Man-affected forests are known for the occurrence of clusters of coppice trees produced by forester's cutting.

The range of growth-forms encountered on the highly elevated locations is summarized in Tab. 1. The maximum in the Bohemian Forest occurs within a closed-canopy upper-montane forest where mature trees developed from successful germination of viable seed. Other reports on highly elevated locations point out the coppice trees and scrub produced by coppicing of disturbed trees. In the absence of human factor, the perturbation effects are caused by creeping snow, avalanches and water impact; the impact pressure of snow avalanches ranges between 5 to 50 t m^{-2}, thus causing the same effect as man-made exploitation. ŠMARDA (1961) managed to observe the perturbation effects of an avalanche on the outlying population of broad-leaved lime in the Belanské Tatry and reported a ready coppicing from the remaining stumps.

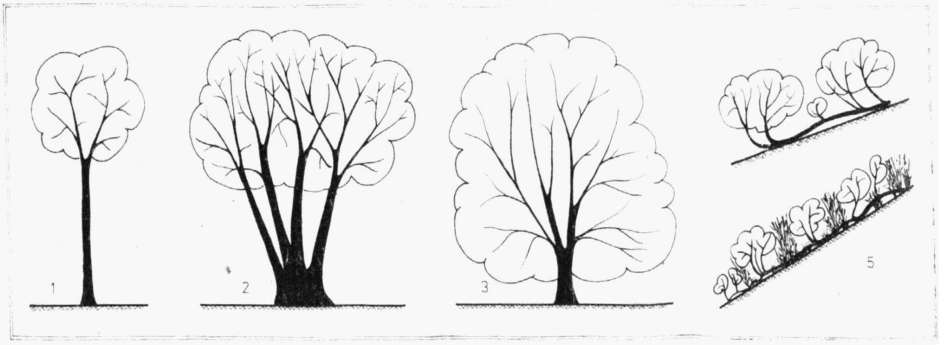

Fig. 2. — Range of growth-forms of *Tilia platyphyllos* developed in various habitats of Central Europe: 1 — single-trunk tree in a mature closed forest, 2 — polycormic coppice tree in perturbation-dependent or man-exploited woodland, 3 — solitary tree in the open air of a man-made landscape, 4 — polycormic shrubs affected by subalpine microclimate and snow pressure, 5 — procumbent polycormic scrub affected by frequent snow avalanches.

Young twigs and trunks are flexible and curve under the impact of snow drifts and creeping snow. The basal portion of the sabble-shaped twigs can root in the moist soil and thus secure — in the absence of viable seeds — vegetative reproduction of lime in the harsh conditions. In the Sudeten, this mode of reproduction seems to counteract the occassional losses of specimens torn out by slab avalanches. The sabble-shaped twigs of *Tilia platyphyllos* in Velká Kotlina were found frequently rooting in the substrate and successive translocation of the scrub down the slope could be estimated. The growth-form of lime in Labský Valley is still more extreme: slender and much contorted twigs (see Fig. 358 in JENÍK 1979: 267) interlace the tussocks of dominating *Calamagrostis arundinacea* and, occassionally, root in the gaps where tissues of the lime come into contact with wet mineral soil. In this way a true polycormone is created and it is hardly possible to distinguish individual specimens. In the wide range of growth-forms (Fig. 2) the prostrate scrub, obviously, represents the ultimate adaptation towards harsh subalpine conditions, particularly, towards the disturbance by avalanches. Indeed, it is fairly curious to find life twigs of lime associated with arctic-alpine species, such as *Anemone narcissiflora* (see Fig. 23 in JENÍK 1961: 51).

At its absolute altitudinal maximum in Velká Fatra Mts., *Tilia platyphyllos* survives as a polycormic shrub consisting of 4 larger limbs and 6 smaller branches curved under the pressure of snow (BERNÁTOVÁ, HAJDÚK and KLIMENT op. c.: 914). The same growth-form was described from the northernmost localities in Finnland (KIHLMAN 1896) where *Tilia cordata* occurred in peat bogs and on riverside.

Neither flowering nor fruiting specimens of broad-leaved lime were found at the altitudinal limits in the Sudeten and Western Carpathians. Also there are no seedlings which might indicate the generative life-cycle. This can be explained by difficulties in pollen-tube growth and fertilisation which requires higher temperatures, as shown by PIGOTT and HUNTLEY (1981) for *Tilia cordata*. The vegetative reproduction, however, can secure successful survival of small populations or polycormic shrubs for many decades, better for several centuries.

CONTROLLING HABITAT FACTORS

Precipitous slopes, avalanche tracks, screes, cliffs and riverbanks provide the shelter of broad-leaved lime at its altitudinal limits in the Sudeten and Western Carpathians. In the absence of direct measurements, the controlling habitat factors must be derived from general observations made by individual botanists with regard to bedrock, orientation and insolation of the slope, wind exposure, snow pressure and avalanche action.

VULTERIN (1954) described the highest locality in the Tatra as a precipitous scree cone facing south; ŠMARDA (1961) reported actual avalanche action; snow drift could be explained by leeward situation with regard to prevailing orographic winds blowing through the system of Přední and Zadní Měďodoly valleys (JENÍK 1958, 1961: 348). According to BERNÁTOVÁ, HAJDÚK and KLIMENT (op. c.) the locality in the Malá Fatra seems to be supported by the southern exposure of a precipitous slope and by a "thermo-orographic system," i.e., favourable arrangement of relief and insolation, enabling the ascent of warm air from the heated headwalls of the limestone valley;

snow pressure is also accounted for. The two altitudinal maxima in the Sudeten are distinct by their position in the "leeward turbulent space" of "anemo-orographic systems" (JENÍK 1961). The environmental regime in the Schustler Garden, Krkonoše range, has been explained after long-term observations and measurements summarized by ŠTURSA et al. (1973); the habitat peculiarities of Velká Kotlina cirque are clarified in a monograph by JENÍK, BUREŠ and BUREŠOVÁ (in prep.). Both Sudetic localities are favoured by morning and midday insolation and perfectly sheltered against

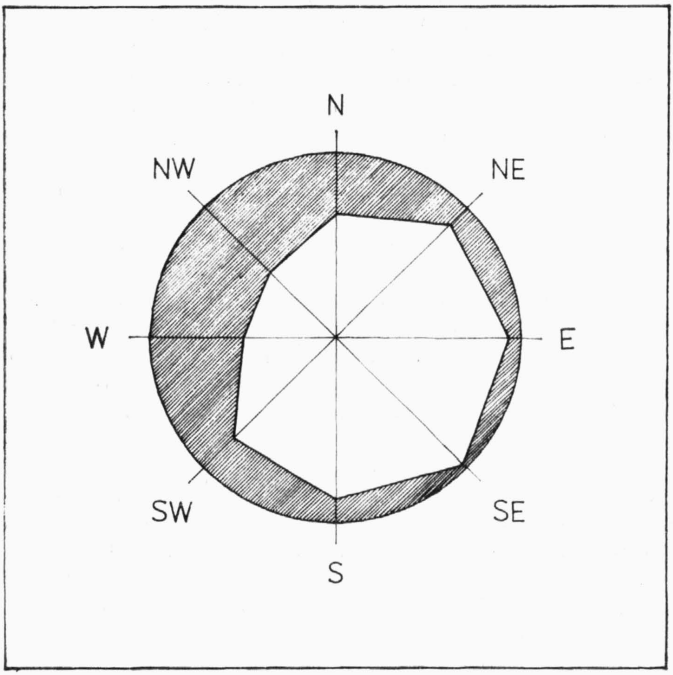

Fig. 3. — Illustration of the visible horizon at the highly situated refuge of *Tilia platyphyllos* at 1130 m a.s.l. in the Labský Valley, Krkonoše range; individual radii represent a scale of measured vertical angles from 0° (at the circumference of the diagram) to 90° (in the centre); white area marks the openess to morning and midday insolation from E and S, and sheltering effects against prevailing western winds.

prevailing western winds (Fig. 3); heavy snow drifts and avalanches disturb the competition of K-strategy species; enrichment of soil by calcium has been proved by both measurements and indirect evidence of calciphilous companions.

Warm, lime-rich and perturbation-dependent habitats seem to unify the localities of the altitudinal maxima of *Tilia platyphyllos*. No doubt, creeping snow and snow avalanches act as contraversial factor preserving, on the whole, the sites against invasion of competitive trees or graminoids, and, simultaneously, keeping the growth-form of lime in a shrubby stage. In the absence of snow pressure, the favourable microclimate may allow individual

limes to grow as a straight single-trunk tree, such as the 4 m high and 10 cm thick specimen growing at 1220 m a.s.l. in Velká Kotlina (see the "Podpěra Rock" in JENÍK, BUREŠ and BUREŠOVÁ 1983).

NATURAL OR MAN-INDUCED OCCURRENCE?

Discovery of the outlying localities of broad-leaved lime in the Sudeten caused some doubts about the origin of these individual woody plants or polycormones. Floristic exploration in the past and numerous lists of species published from the Labský Valley and Velká Kotlina in the past made it unbelievable that lime could grow as native species in the subalpine belt of the Sudeten. In the latest monograph of the Krkonoše flora, ŠOUREK (1969: 281) denies the indigenous status of the *Tilia platyphyllos* scrub in Labský Valley. An altitudinal gap of more than 500 m between the upper limits of the common occurrence of *Tilia platyphyllos* (about 600 m a.s.l.) and the outlying location (1130 m a.s.l.) seems to be a puzzle, particularly in view of the heavy nut-like fruit whose bracteole acts as a modest means in anemochorous distribution. Foresters planning avalanche control in the both above mentioned localities could have planted experimental trees whose relics are the crippled shrubs found here today. Also, the frequented tourist trails in the vicinity and occassional jokes of irresponsible botanists might have been the source of unexpected findings.

The strongest evidence for believing *Tilia platyphyllos* is native in the two above mentioned Sudetic localities is the general ecological similarity of habitat, and floristic aspects. Facing similar decision PIGOTT (1969: 502) put it clearly: "Probably the strongest evidence ... is its close association in every site with an assemblage of other species of which some have a rather restricted distribution in Britain as a whole". And this is the case of the outlying localities of broad-leaved lime in Labský Valley and Velká Kotlina, where *Corylus avellana*, another extremely rare woody species, grows side by side with lime (Tab. 2). Other species, such as *Acer pseudoplatanus*, *Betula carpatica* and *Daphne mezereum*, illustrate similar development of these indigenous communities described as the *Bupleuro-Calamagrostietum arundinaceae* and *Daphno-Aceretum*, respectively. In the broader surroundings of the both localities compared, there thrives a species-rich native flora described in detail by JENÍK and KOSINOVÁ-KUČEROVÁ (1964: 76–85) and JENÍK, BUREŠ and BUREŠOVÁ (1983); a number of herbaceous species represented by small populations was never suspected as "allochtonous" element introduced by man.

The remote and less accessible localities of *Tilia platyphyllos* in the subalpine belt of the Western Carpathians were never suspected to be planted by man. As described by the authors quoted above, natural establishment of these outlying populations can be taken for granted.

FORERUNNER OR RELIC PLANTS?

If the native status of the outlying occurrences of *Tilia platyphyllos* in the Sudeten and Western Carpathians is accepted, the question of the pertinent chronology must be examined. In an earlier work explaining the successional trends in the Sudetic glacial cirques, I have treated the isolated small populations of (sub)thermophilous woody plants as forerunners marking

the progress of pioneer species into the subalpine belt (JENÍK 1961: 286). A reference to anemochorous dispersal by ŠOUREK (1969: 58) also suggests recent establishment of *Tilia platyphyllos* on its subalpine locality in the Krkonoše range. BERNÁTOVÁ, HAJDÚK et KLIMENT (1983: 916) are also inclined to explain the absolute altitudinal maximum in mountains lying to the north of the Danube as a foreposte. The findings of *Tilia platyphyllos* in the High Tatra were explained by SOMORA (1959: 104) as relic specimens surviving from the warmer Postglacial period. The latter opinion conforms to the earlier assumptions of generally raised altitudinal limits of broad-leaved trees in European mountains (see, e.g., SCHARFETTER 1938: 338).

The forerunner/relic problem should be answered in agreement with the palynological evidence summarized by FIRBAS (1949) and HUNTLEY and BIRKS (1983). These works show an obvious difference between the current area of distribution of *Tilia* sp. and its maximum extent in the mid-Holocene time. FIRBAS (op. c.: 177) concludes that "the current northern limits must — at least locally — represent a retreat line from the Warm Period". The same author remarks (op. c.: 182) that the restriction of *Tilia*'s range is connected not only with general climatic deterioration, but also with successive expansion of spruce, beech and fir. Mapping of pollen data on an European scale by HUNTLEY and BIRKS (op. c.) showed obvious progress of lime in the past, beyond the present limits of distribution; expansion north-westwards and coalescence of isolated centres continued until 5000 B.P.

We can assume that expansion of *Tilia* species in the mid-Holocene period proceeded more or less simultaneously both in horizontal and vertical direction. LOŽEK (1973, Appendix B) estimated that in the second half of the Epiatlantic Era (about 5000 B.P.) the upper forest limits in Central European mountains reached a level about 200 to 300 m higher than that observed today. Progress of broad-leaved trees, including *Tilia platyphyllos*, across the montane belt towards the subalpine belt was enhanced by slightly warmer and drier climate, and by minor competition of beech and spruce, the two later dominants of the montane belt. The community of mixed broad-leaved woodland easily reached the sheltered and microclimaticaly favoured valleys, particularly the abandoned glacial corries loaded by lesser snow drifts and affected by fewer avalanches. In the Sudetic corries the past expansion of the mixed broad-leaved woodland is marked by the relic populations of *Asarum europaeum*, *Asperula odorata*, *Campanula persicifolia*, *Carex sylvatica*, *Hepatica nobilis*, *Melica nutans*, *Pulmonaria obscura*, *Rubus saxatilis*, and by many other forbs and grasses.

In the late-Holocene period the upper forest limit was lowered by the deteriorating climate and the mixed broad-leaved woodland eliminated by closed-canopy beech and spruce forests. Both in the Sudeten and in the Western Carpathians resumed avalanche action and pressure of snow drifts were the only protection of small relic populations against the

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Tab. 2. — Comparison of habitat factors and community in the two refuges of *Tilia platyphyllos* in the Sudeten; K — Schustler Garden in Pančava Cirque, Labský Valley, Krkonoše Mountains (recorded on 3rd November, 1984); HJ — Firbas Slant in Velká Kotlina cirque, Hrubý Jeseník Mountains (recorded on 8th August 1973); cover values of plant populations after Braun-Blanquet's scale.

Refuge	K	HJ
Altitude	1130 m	1260 m
Slope aspect	S.E.S.	E.S.E.
Slope inclination	30°	35°
Parent rock	Granite	Phyllite
Soil enrichment by lime	Likely	Obvious
Microclimate	Leeward, warm	Leeward, warm
Avalanche action	Frequent	Frequent
Shrub layer (cover)	20 %	60 %
Acer pseudoplatanus L.	+	2.2
Betula carpatica Waldst. et Kit.	3.3	+
Corylus avellana L.	+.2	+.2
Daphne mezereum L.	+.2	+.2
Picea abies (L.) Karsten	+	.
Rosa pendulina L.	.	+
Salix silesiaca Willd.	2.2	+
Tilia platyphyllos Scop.	+	3.3
Herb layer (cover)	100 %	70 %
Calamagrostis arundinacea (L.) Roth.	3.3	3.3
Digitalis grandiflora Miller	+	+
Dryopteris filix-mas (L.) Schott	r	+
*Senecio *nemorensis* L.	1.1	1.1
Silene vulgaris (Moench) Garde	+	+
Vaccinium myrtillus L.	+.2	1.1
Anemone narcissiflora L.	+	.
Calamagrostis villosa (Chaix) Gmelin	3.3	.
Cirsium heterophyllum (L.) Hill.	r	.
Gentiana asclepiadea L.	+	.
Vaccinium vitis-idaea L.	r	.
Aconitum callibotryon Rchb.	.	+
Actaea spicata L.	.	r
Angelica sylvestris L.	.	r
Asarum europaeum L.	.	2.2
Athyrium filix-femina (L.) Roth	.	+
*Bupleurum *vapincense* (Vill.) Todor	.	+
Convallaria majalis L.	.	+
Geranium sylvaticum L.	.	+
Laserpitium archangelica Wulf *in* Jacq.	.	+
Phyteuma spicatum L.	.	+
Pleurospermum austriacum Hoffm.	.	+
Potentilla erecta (L.) Raeuschel	.	r
Ranunculus platanifolius L.	.	+
Sedum maximum Hoffm.	.	+
Solidago virgaurea L.	.	+
*Veratrum *lobelianum* (Bernh.) Rchb.	.	r
Association	*Bupleuro-Calamagrostietum* Jeník 1961	*Daphno-Aceretum* Jeník, Bureš, Burešová 1980

shade and root competition of beech and spruce. Beside th enumerous herbs, shrubby wood species, including *Tilia platyphyllos*, survived in small refuges. It is this general trend of postglacial succession, and evidence of numerous outlying plant populations which bring us to a conclusion that the above described altitudinal maxima of broad-leaved lime represent genuine relics. In Fig. 4 the variant No. 3 represents a case of terminated life history of broad-leaved lime at its present-day altitudinal maximum; variants No. 4 and 5 are the two possible ways of its future development.

CONSERVATION CONCERN

The outlying refuges of *Tilia platyphyllos* in mountains to the north of the Danube are of great value for the biogeographical image of Central Europe, and for palaeoecological studies of zonation and vertical distribution of vegetation belts. These localities deserve further observation and, possibly, monitoring of growth, reproduction and decline of individual polycormic specimens. Taxonomic evaluation of all relic shrubs will be desirable. Observations of herbivorous insects may also contribute towards epiontology of plant distribution in Central Europe.

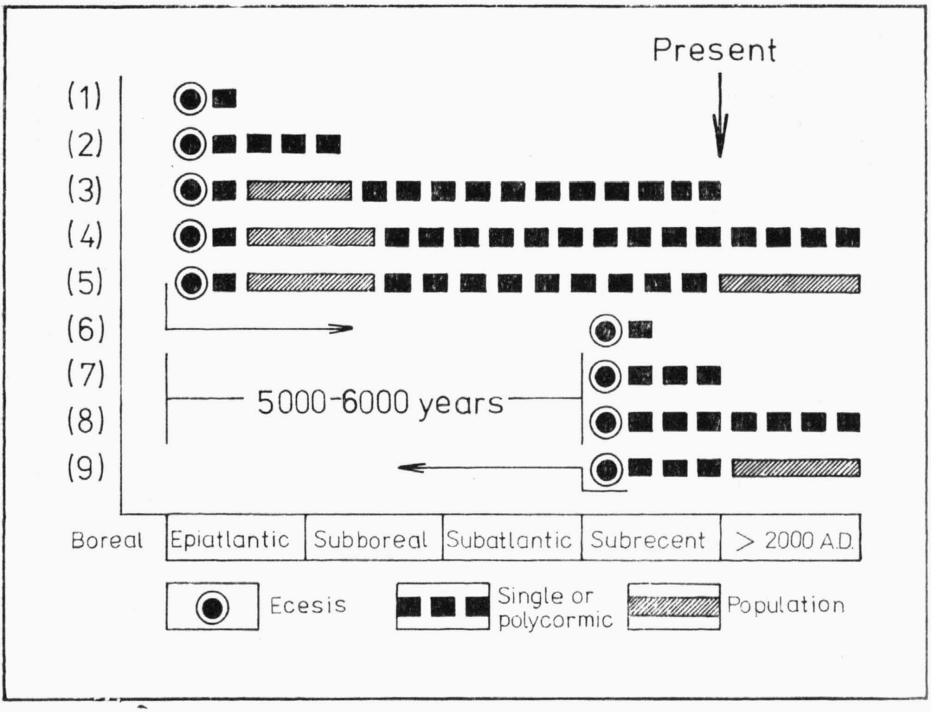

Fig. 4. — Hypothetical variants of the life history of a (sub)thermophilous plant species invading a forposte in the second part of the Holocene period: 1 — short-lived establishment of individual plants; 2 — transient survival of relic individuals; 3, 4 — development of self-sufficient population and its succesive decline; 5 — rejuvenation of the population after its decline; 6 — short-lived establishment under man-induced factors; 7, 8 — transient survival of relic individuals, 9 — development of self-sufficient population after a period of stagnation.

For the above given reasons it is desirable to preserve the outlying localities of broad-leaved lime in untouched, natural conditions. Upon the first view this goal seems to be already achieved by the appurtenance of Sudetic and West Carpathian localities to national parks (Krkonoše National Park, Tatra National Park) and protected landscape reserves (Jeseníky, Šumava, Malá Fatra). Even more, the two Sudetic localities belong to two strictly protected nature reserves. However general acidification of the rainfall and pollution of the air bring about large-scale alteration of soil and vegetation in all Central European mountains. The locality in Labský Valley is strongly endangered by deposition of ash particles and acidification of rain and snow, caused by large power stations using low-quality brown coal. Velká Kotlina is in the endangered zone, too. The air and soil pollution may prominently shift the balance between the woody plants, forbs and grasses, and, eventually, disturb the relic populations. Exaggerated avalanche control may also create unpredictable shifting of community structure, e.g., in favour of spruce or dwarf pine. Lack of proper understanding of the role of avalanches in the outlying refuges (Šourek 1969; Šmarda 1961) may result in "reforestation" of the respective avalanch paths — a step actually executed in Velká Kotlina Reserve only a few years ago.

SOUHRN

V průběhu posledních desetiletí byla ve středoevropských horách severně od Dunaje zjištěna nová výšková maxima lípy velkolisté. Tyto pozoruhodné lokality leží v subalpínském stupni Vysokých Sudet a Západních Karpat a mají některé společné stanovištní vlastnosti: jsou ve srovnání s okolím teplejší, jejich půda je bohatší na živiny a struktura rostlinného společenstva je rušena tlakem sněhových závějí i lavin. Díky své výtečné pařezové výmladnosti a schopnosti zakořeňovat poléhavé větve se lípa na lokalitách udržuje navzdory konkurenčnímu tlaku buku, smrku a kosodřeviny. Souběžná přítomnost řady dalších vzácných dřevin, bylin i živočichů, na nichž člověk nemá přímý zájem, svědčí pro přirozený výskyt lípy na těchto izolovaných místech. Když vezmeme v úvahu současné poznatky o vývoji areálu smíšených listnatých lesů a jmenovitě lípy ve střední Evropě v průběhu postglaciálu, dospějeme k závěru, že ojedinělé výskyty lípy velkolisté v subalpínských polohách jsou skutečnými relikty z epiatlantika, kdy se horní hranice lesa i hranice rozšíření náročnějších dřevin významně posunula do vyšších nadmořských výšek. Sudetské výskyty lípy ve vyšších polohách již trpí průmyslovými imisemi a kyselými srážkami a všechny lokality je žádoucí chránit před neuváženým zalesňováním, pramenícím z neporozumění ekologické roli sněhových lavin.

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Plate V. — Growth-form of *Tilia platyphyllos* in the subthermophilous *Bupleuro-Calamagrostietum arundinaceae* community at 1130 m a.s.l. in the Schustler Garden, Pančava Cirque, Labský Valley, Krkonoše Mts. (photographed in 1957).

Plate VI. — Growth-form of *Tilia platyphyllos* in the *Daphno-Aceretum* community at 1240 m a.s.l. on the Firbas Slant, Velká Kotlina cirque, Hrubý Jeseník Mts. (photographed in 1978).