Discussion – Keskustelua

Snow and soil frost in Finnish forests: ecological interdependencies between climate, flora, fauna and early culture in the province of Uusimaa

Reijo Solantie

Introduction

Abundant snowfalls and thick snow cover influence forest ecology mainly in two ways. First, snow loading increases the number of damaged stems, which in turn increases the amount of rotten stems, in which many animals can nest and live. Secondly, the ground can remain unfrozen under the thick snow cover, which is of crucial importance for many perennial species of the forest ground vegetation. These winter phenomena also reflect in the early Finnish culture as man in his everyday life in the wilderness was in a close contact with nature. In this article, these ecological interactions between snow conditions, forest flora, fauna and early culture are discussed mainly with reference to the province of Uusimaa in southern Finland.

Snow and soil frost conditions in relation to forest vegetation

Perennial vascular plant species

Abundant snowfalls in early winter prevent the forming of a deep soil frost. For this reason, deep soil frost is less common in eastern than in western Finland. The heat flux in the soil in springtime decreases northwards with decreasing heat storage in the ground. The delay of the disappearance of soil frost, in relation to the rise of air temperature, is mainly determined by these two factors, again increasing north-westwards. For some species, the combination of frozen soil and warm air after the beginning of the thermal vegetational period may be crucial disadvantage. For example, the distribution of *Dryopteris dilatata* (Kujala 1964, p. 30, maps 18, 194) covers the southern boreal vegetational zone but only those parts of the middle and northern boreal zones (Fig. 1a) where the soil frost, on the average, melts before the beginning of the thermal vegetational period (Solantie 1990, p. 64).

For many perennial species, the duration of the soil frost period also seems to be a critical factor. The duration of the soil frost period is mainly determined by the thickness of soil frost and the duration of the thermic winter. Thus, the mean duration of the soil frost period decreases towards southeast. Consequently, the limits of the sporadic and common occurrence of many species of perennial vascular forest plants (Kujala 1964) follow certain isopleths of the mean duration of soil frost (Solantie 1989). The common forest berries *Rubus idaeus* and *Fragaria vesca* (Kujala 1964, p. 65, 66, maps 97, 98) are such species (Fig. 1b) whose occurrence extends rather far northwards. Many species which demand a shorter soil frost period occur typically in a region of which the province of Uusimaa forms the south-western limit of their sporadic or general occurrence (Figs. 1c and 1d).

A sample of such perennial vascular plants are given in connection with the duration of soil frost in Table 1; the limits of their uniform (A) and sporadic (B) occurrence according to Kujala (1964) correspond to certain mean duration of soil frost (Solantie 1989) as given in Table 1 and for some of the species in Figs. 1b to 1d. Further, a vascular plant *Scrophularia nodosa* with wintering sprouts and early spring blossom, as well as a bush species *Myrica gale*, have similar distributions. The limit at which the soil frost penetrates deeper than 15 cm in 75 % of all winters, seems to be significant for some of these species (Solantie 1986, p. 106), i.e. those denoted by a. On the other hand, *Knautia arvensis* seems to avoid such south-western regions where ice

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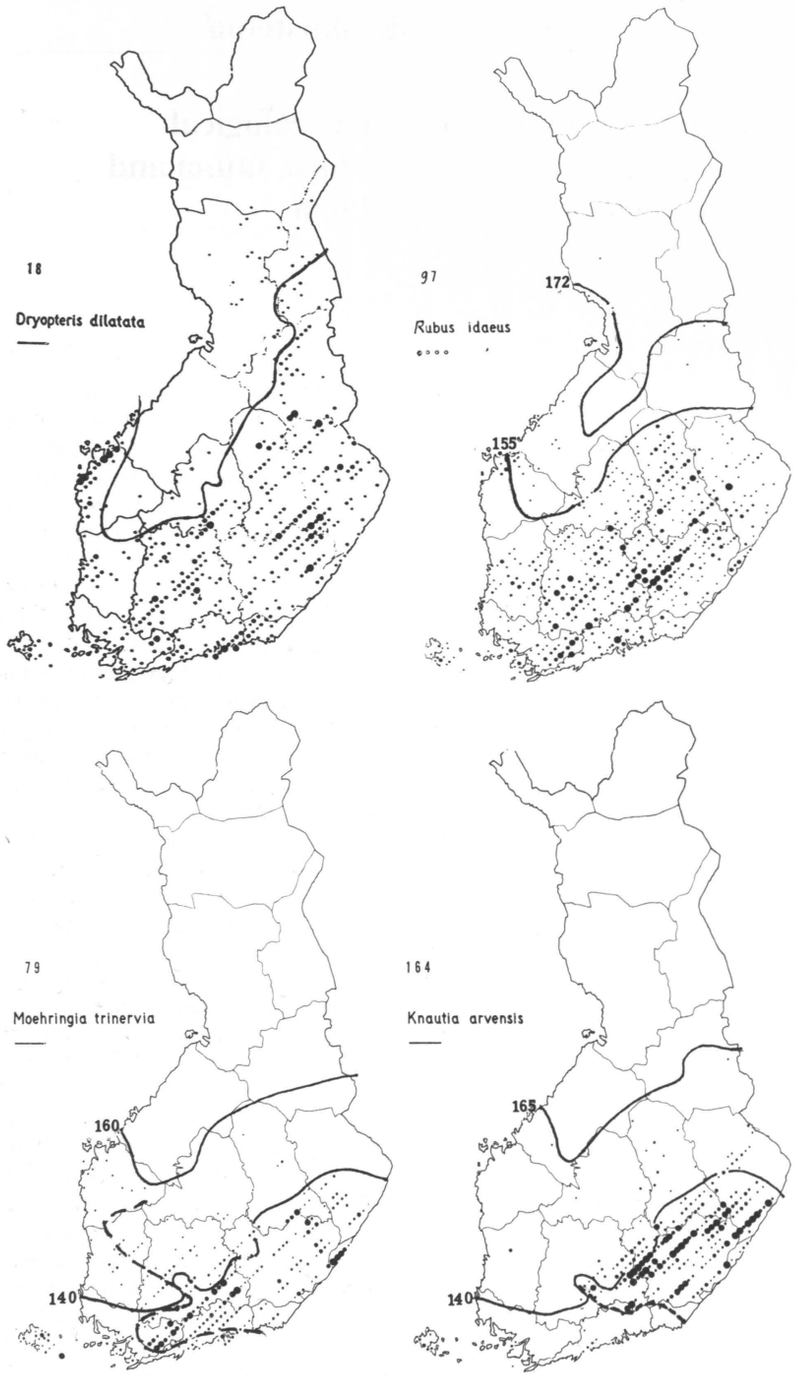

Fig. 1. Distributions of some vascular plant species (Kujala 1964) in relation to isopleths (solid lines) of the mean delay (Fig. 1a) or duration of the soil frost (Figs. 1b, c, d) corresponding to the limits of the uniform and sporadic occurrence of the species. West of the broken line (Fig. 1c) the frequency of the winters during which the maximum depth of soil frost is less than 15 cm, is less than 25 % (Solantie 1986), and west of the dotted line (Fig. 1d) ice scorching is common (Rantanen and Solantie 1987).

Table 1. Perennial forest vegetation species in relation to the duration of soil frost corresponding to the limit of their uniform (A) or sporadic (B) occurrence according to the distributions by Kujala (1964). Species denoted by a, have an additional western limit on a line, on which the frequency of winters, with a soil frost penetration of 15 cm or more, is 75 %.

Species		Limiting duration of soil frost		Referring to Kujala	
		A	B	map	text page
Fragaria vesca		150	172	98	66
Rubus idaeus[1]		155	172	97	65
Campanula glomerata	a	140	155	166, 193	93
Centaurea phrygia	a	130	147	171, 193	95
Hypochoeris maculata	a	147		172, 193	95
Knautia arvensis[2]		140	165	164, 193	92
Moehringia trinervia[3]	a	140	160	79	58
Stachys silvatica		135	147	150	86
Thymus serpyllum		145		151	86
Scrophularia nodosa		140	160	152	87
Myrica gale		140		66, 193	53

[1] See Fig. 1b
[2] See Fig. 1d
[3] See Fig. 1c

scorching is common (Rantanen and Solantie 1987, p. 24); thus, the region of its common occurrence extends only to the north-eastern corner of the province of Uusimaa. This conclusion agrees with the notation by Kujala (1964, p. 92) that this species avoids clay soils which are prone to promote ice scorching.

The distribution of soil frost in relation to the ecology of trees

The branches of conifers direct snow onto the outer parts of the root system, which lessens soil frost and is advantageous for fungi and the soil fauna, as well as the decomposition of litter and nutrient up-take. During the natural succession, such places slowly migrate across the forest floor as a whole.

Linden in relation to snow and soil frost conditions in the province of Uusimaa

The high frequency of the occurrence of unfrozen ground and snow damage also affects the ecology of the linden *(Tilia cordata* Miller) which is more common in the province Uusimaa than in western Finland (Kujala 1964, p. 72, map 113). According to historical evidence, this province was especially prominent producer of fibre. Up to the 16th century, linden was a tax item in Sweden and Finland (Hertz 1925, p. 81). According to the tax statistics from the 16th century, the amount of linden tax in Finland was larger than in Sweden. In 1533, 97 % of the linden tax in Finland paid in actual lumber was recorded in the province of Uusimaa. Moreover, Uusimaa was the only region in which lumber was actually used in payment. Elsewhere it was mostly replaced by money (Hertz 1925, p. 85). Within Uusimaa, the exploitation of linden was larger in the eastern than the western part, so that in the eastern part the stands declined but remained abundant in the western part (Hertz 1925, p. 86). This explains the occurrence of linden in the western part of Uusimaa as a significant merchandise in the 18th century (Heinricius 1766) and its frequent occurrence in the 1920's (Hertz 1925, p. 18–37), as well as at the present according to the subjective observations of the author.

In any case, natural conditions in Uusimaa are obviously particularly favourable for linden. Linden is a species which, in Finland, renews mainly vegetatively, making sprouts from twigs, stubs, broken stems and twigs touching the ground. Further, it grows more rapidly than Norway spruce, which is its most significant competitor (Hertz 1925, p. 63) and the most common tree species in Uusimaa.

According to Hertz (1925, p. 62), linden makes use of snow loads which bend twigs to touch the ground; twigs touching ground shoot new roots. Perhaps significantly, the author could not find any broken linden in forests in which other species had suffered severe snow damage. Linden was in fact utilized for ropes, because of the tensibility fibre (Hertz 1925, p. 61, 90). When spruces break in the vicinity of linden, the latter rapidly makes new sprouts which grow faster than spruce seedlings and can thus dominate the opening in the forest (Hertz 1925, p. 64). Further, damaged linden heals rapidly (Hertz 1925, p. 57, 58, 61). Further, due to the frequent occurrence of abundant snow falls in early winter in this province, the ground may remain unfrozen throughout the winter, which may be favourable for the sprouting and rooting of linden. Hertz (1925, p. 47) also emphasizes the role of soil frost as a factor which delays the end of the winter dormancy of linden in the spring. Linden also regenerates in Finland from seeds (Söyrinki

1985), which is however significantly restricted by a demand of a long vegetational period (Pigott 1981) in agreement with its distribution northwards (Kujala 1964, map 113). In comparison to other regions of Finland, in which in more than 25 % of winters the maximum depth of soil frost is less than 15 cm, the vegetational period is longest in Uusimaa. Thus, the climatic conditions for linden are in this province the best in Finland.

Rotten stems and animal species

After having almost died out, the marten *(Martes martes)* has, since World War 2, again spread over Finland. The frontiers of the occurrence of the marten during different phases of its re-expansion (Ermala 1980) are well in agreement with the hypothesis that it favours regions with large snow loads (Fig. 2). In southernmost Finland, the first signs of marten were observed about 10 years later than in places farther north with equal snow conditions. The reason may be that in the dense forests which dominate south of the latitude 61.5°N, the marten is able to traverse from tree to tree (Siivonen 1977, p. 117), and is therefore able to proceed long distances without descending to the ground and to leave detectable footprints on the snow. In any case, in late winter 1992 the tracks of marten in Uusimaa were fewer than farther north and east (Helle et al. 1992).

Considering that this province is full of broken standing stems of various ages and tree species, it is especially favourable not only for the marten, but also for other animal species which nest in hollows of dead and rotting trees. A similar advantage exists for the flying squirrel *(Pteromys volans)* which may explain its particular occurrence in the area of Nuuksio west of Helsinki, where the theoretical occurrence of snow damage is particularly large. According to Heliövaara et al. (1991), the population of bark beetles in Uusimaa is larger than elsewhere in Scandinavia, which is obviously consequent upon the high frequency of broken stems from various species and the varying degrees of decay (Fig. 3).

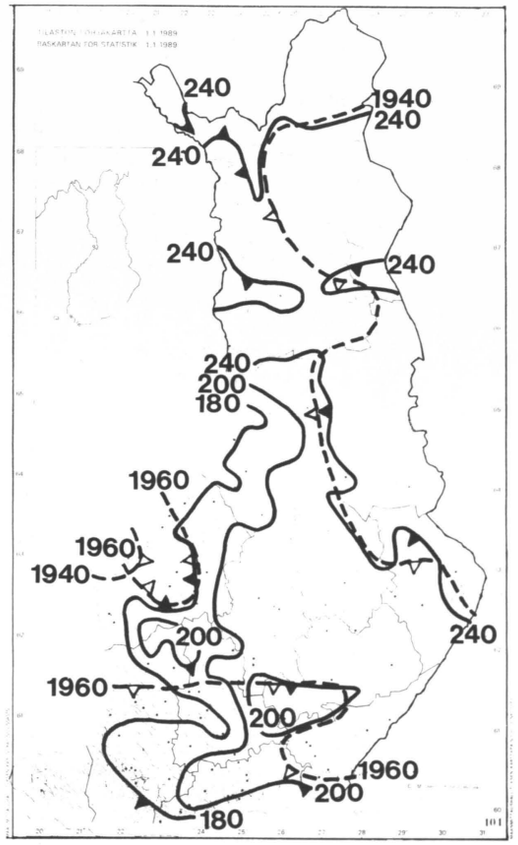

Fig. 2. The spread of the marten *(Martes martes)* in 1940 and 1960 (Ermala 1980) (with broken lines). in relation to isopleths of the water equivalent of snow cover (mm) exceeded at 20 year intervals (Solantie 1980) (solid lines). The unfilled triangles at broken lines denote the direction of spreading, whereas the filled triangles at solid lines denote towards decreasing values.

Snow conditions in relation to early culture in the province of Uusimaa

The boundaries of the province of Uusimaa follow exactly the outer boundary of the region with high risks of snow damage and unfrozen ground. This is indeed no mere chance, but is closely connected with early old Finnish culture. On unfrozen ground and under thick snow, wintering sprouts of rye are destroyed by snow mould fungi. Consequently, areas such as Uusimaa (= "New land" in English) remained as hunting regions and agricultural settlement developed later than in the surrounding areas. Consequently, an administrative unit was created of this "New Land", with its strictly climatic boundaries (Solantie 1992). Ancient villages of Lapps living on hunting and reindeer rearing were concentrated along the climatic coastal and inland ridges of Uusimaa (Fig. 4). These climatic ridges remained significant regions of Lapp culture approximately until the 14th century. Small villages and natural places in that region, which possess in their names evidence of the earlier presence of Lapps (e.g. Vahtola 1980, p. 61), were not all established for hunting, but some of them were excellent for fishing, particularly for sea trout *(Salmo trutta)*, or known as places of medieval trade. The places form a cluster that could be perambulated easily both by light sledges and boats along certain routes, consisting mostly of shallow and narrow water ways (Fig. 4).

Fig. 3. An example of rotten stems, remained from snow damage during previous winters, ideal nesting places for many animal species.

The village Nuuksio, as well as several other places at the axes of the climatic ridges of Uusimaa, can be derived from an old name ("nois") for the marten *(Martes martes)*, the most important medieval fur animal in Finland, which nests in broken and dead stems. In the Finnish medieval economic system, Lapps hunted marten and supplied the pelts to buyers and tax collectors who regularly visited the Lapp villages. The village name "Nuuksio", in its original form, also meant marten (Solantie 1992, p. 35, Nirvi 1986, p. 30–44). In the same district, there also occur place names referring to cottages for storing furs; similar to the usage in northern Finland. Such cottages were located safely one or two kilometres away from the main travelling routes used by fur collectors. For example, the place and lake name "Bodom", means "at the storage cottages". Bodom is not only located in a region in which an ancient travelling route crosses the coastal ridge and in which names referring to marten and Lapps occur; Bodom is also located at a mouth of a little river "Piruån" (Paikkala 1992, p. 74), which is a very ideal place for nesting of beaver *(Castor fibers)*, another important fur animal. "Piuru", indeed, meant beaver, particularly in this province (Nirvi 1986, p. 51). In Southern Finnish forests, the "timbering" by beavers was, in addition to snow damage, another significant process which maintained places where plenty of broken stems favoured animals such as the marten. The fact that place names including the word "nois" (marten) and its derivates were also associated with the occurrence of beaver (Nirvi 1988, p. 51–56) can thus be understood.

Thick snow with unfrozen ground below it, and stems of trees broken by snow, made transportation troublesome using small medieval horses, hauling sledges or bearing riders. The course of the main medieval coastal road (Gardberg and Dahl 1991) is in a good agreement with this

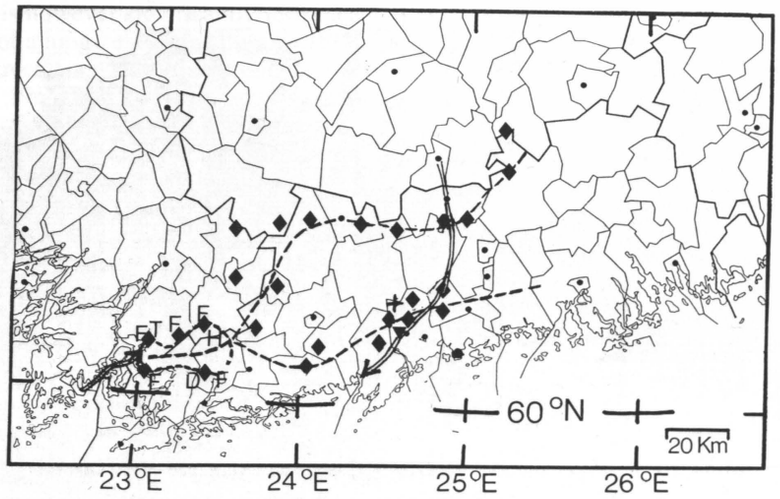

Fig. 4. Axes of the "coastal" and "inland" climatic "ridges" formed by the lines of largest risk of snow damage (broken lines). The ecological significance of these ridges for the ancient hunting culture is in agreement with evidence of place names:

◆ = Ancient villages of nomadic and hunting Lapps. The special functions of the westernmost of these places are denoted by D (dwelling), F (fishing), H (hunting) and T (Trade), and are linked by a suggested route of perambulation (a dotted line)

+ = The village of Nuuksio, the name referring to the hunting of marten

▼ = The place and lake name Bodom, meaning at fur storage cottages

The arrows indicate ancient trade routes.

hypothesis. This way was established during the 14th century to connect two medieval cities, Turku in west and Viipuri in east. The road circumnavigated the southwestern end of the inland ridge (Fig. 5). Eastwards, it passed along either the northern or southern sides of the coastal ridge, or doubled along both sides. It did not pass through it. The road crossed the ridge only through saddle points with "gap" settlements in the ridge. It also followed, for considerable distances, ancient wilderness tracks from the interior to the coast (Fig. 5). Only after World War II was the main road between Turku and Helsinki straightened to pass directly through both climatic ridges.

In any case, the disadvantage of abundant snow falls for rye cultivation, the advantage of snow damage for marten, the frequency of place names referring to the occurrence of marten and beaver (e.g. Nirvi 1986, p. 10, 11, 25, 52, 62, Paikkala 1992, p. 61), as well as the significance of these fur animals in the taxation of Lapps (e.g. Nirvi 1986, p. 54–58) and the occurrence of place names referring to Lapps all concentrate along the climatic ridges of the province of Uusimaa. There is, then, considerable evidence of the significance of snow falls, not only for nature, but also for the early Finnish culture which depended upon it.

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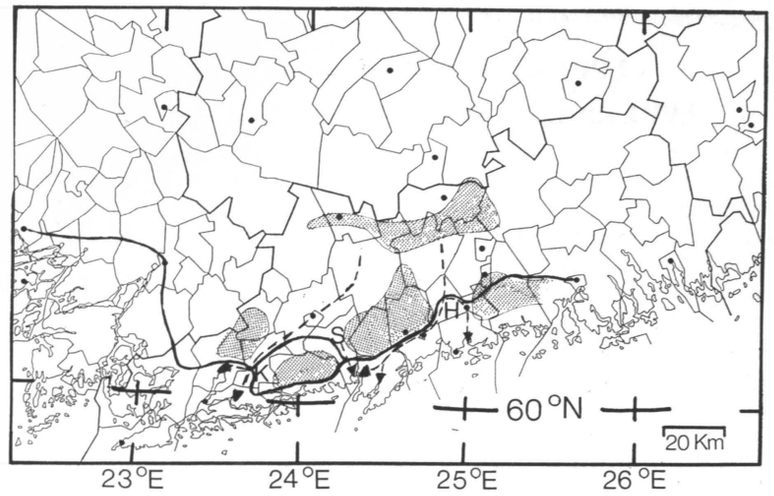

Fig. 5. The route of the main medieval "coastal road" (solid line) through the western and middle parts of the province Uusimaa (Gardberg and Dahl 1991) in relation to the ancient wilderness tracks linking the interior to the coast (broken lines) and the climatic ridges of the province of Uusimaa in which 14 % or more of winters experience maximum snow depths > 75 cm (hatched areas). Note the "gap" settlements of Karjaa (K), Siuntio (S), and Helsinki (H) between the cells.

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