

IO. On relics in the Swedish Flora.

By

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Introduction.

This paper is meant to be a summary of our present knowledge about the occurrence of relics in the Swedish flora, based upon the works of several scientists, chiefly those of RUTGER SERNANDER and GUNNAR ANDERSSON.

With a *relic plant* is meant such a one that, owing to special favourable conditions has been able to remain in one or several scattered localities in a tract, where the flora to which the named plant properly belongs has once lived, but where it no more, owing to climatic or other conditions, is able to thrive.

It is of course difficult to know whether a more or less isolated plant occurrence really is a relic one or if it is in spreading. According to

SERNANDER [46] the »relics occur in closed formations or old colonies of a constant nature, the new-comers in recently formed colonies and in young plant formations». In the special cases the opinions of the different scientists are however very disagreeing, and several of the »relics» which will be described in the following are really rather problematic as such.

However, when connected with the results got from other researches (the investigations of peat-bogs etc.), a great number of such plant occurrences seems to tell us much about the climate of former times and about the late- and post-glacial history of the flora. As is well known, the opinions about the climatic conditions during the post-glacial time are very disagreeing.

SERNANDER who, like BLYTT [9], considers that the occurrences of stool-layers in the peat-bogs and the present distribution of the flora show that there during the post-glacial time have been epochs with alternating insular and continental climate, has in a recently published scheme made a correlation between this climatic development, the post-glacial history of the Baltic, and the archeological and phyto-geographical development in South Sweden [49]. Referring to this paper I will use the same terminology for the epochs.

Several other investigators agree pretty well with SERNANDER, but others again, who like GUNNAR ANDERSSON, HOLMBOE, and WARMING [22, 50] do not think that the stools show anything about the climate conditions, have, in many cases, come to rather different conclusions.

GUNNAR ANDERSSON [2, 4, 5] considers that at the end of the late-glacial time the climate became better and better until the warmth reached its maximum during the later part of the Ancyclus age and the beginning of the Litorina age. Then the temperature sank again and this deterioration in climate is still going on. During the warmest epoch the time of vegetation was considerably longer than now and with about $2,5^{\circ}$ C. mean temperature higher, while the winters were presumably about the same as now. According to the same author, the climate during the later part of the Ancyclus age was, at least in E. Sweden, drier than the present, whereas the following part of the Litorina age was wetter than our time. (As to other opinions about the post-glacial climate see the works referred to at p. 169.)

The oldest fossil plants found in peat-bogs and other post-glacial deposits are in South and Central Sweden some species belonging to the *Dryas* flora, which flora in the present time is otherwise found chiefly in the arctic tracts and up in the high mountains. As representatives for these there might be named, except *Dryas octopetala* itself, some small mountain-willows; *Salix polaris*, *S. herbacea* and *S. reticulata*, the Black Bearberry (*Arctostaphylos alpina*), and the Dwarf Birch (*Betula nana*), and further some less pronounced mountain-plants, as *Polygonum viviparum* and *Salix phyllicifolia*.

In the earlier part of the Ancyclus age *Betula odorata* and *Populus tremula* arrive, and together with them also some other subarctic plants. Somewhat later the pine-flora immigrates, and at the end of this epoch also the oak-flora. This latter has its widest distribution during the first part of the Litorina time (compare p. 157), and during this time also the beech and the *Ilex* floras arrive, the former from S. and the latter from SW. Later on the spruce immigrates from the east.

It is only in the southern and the central parts of the country that our peat-bogs have a *Dryas* zone, in Norrland, on the other hand, the lowest zone is always composed of species belonging to the pine flora, as the melting of the ice there took such a long time that the *Dryas* flora in S. Sweden had given way to the pine flora, and this latter thus formed the first vegetation which covered the country after the ice had melted. It is possible that the arctic flora which during the Ice age lived in Central Europe and that afterwards followed the border of the melting ice, never reached our mountains, and that most of our alpine plants have come from N. Russia or N. Siberia, the Polar-tracts, and the northern and northwestern coasts of Norway, where an arctic flora is supposed to have lived also during the last glacial time, these coast region not being reached by the landice. For this speaks the fact that our most diversified alpine flora is found in the northern parts of the country and not in our southern mountains in Jämtland and Herjedalen, where the same ought to have been found, if the plants had wandered from the south.

History.

Already ELIAS FRIES [14] mentioned the fact that the oak and some other deciduous trees once were more common in our flora than what they now are. This was the case also with some of the herbs which generally accompany the named trees and with several other plants. He says (l. c. p. 104) »Several of our most common plants, such as *Vicia pisiformis*, *V. dumetorum*, *Stipa*, *Betonica*, *Elymus europeus* a. o., which still live in few individuals on scattered localities or at one special place, are remains of this former vegetation, and, probably, they are on the road to be ruined as *Trapa*, *Xanthium*, *Ilex* a. o. during the last 50 years». He regards these changes in the vegetation as being chiefly due to the influence of man, the grazing of cattle etc. and continues: »Whether the changes in climate have any part in this, we have no sure facts to be able to decide. It is said, indeed, that great tree-trunks occur on the Norwegian mountains high above the present tree-limit; but this is ascribed to the successive arising of the land.» And further on (p. 114): »If the nature restores to its original liberty, we hardly hesitate that the past vegetation will appear again as *Pyrolæ* in Denmark, e. g. *Trapa* in those lakes where one has destroyed her by the sweeping with a seine.»

The first Swedish author who really has described these isolated plant-occurrences as climatic relics is F. W. C. ARESCHOUG [6], although he has not used the term relic. He mentions several of these plants (partly arctic or alpine, partly more southern species), which are found on isolated localities and which »form rears, so to speak, of a vegetation, which formerly has prevailed in that tract, where they now appear quite isolated on such spots, where local conditions in some degree balance the otherwise unfavourable changes in climate» etc. [6, p. 5].

He gives several examples of such arctic and alpine plants both from the south of Sweden, from Denmark, Finland, and from Germany. About the epoch when these southern plants immigrated he says that »coming researches may decide whether the climate during this time, was not milder than now and if not several of the plants and animals that immigrated during this epoch have died out or become restricted to especially favourable spots through this change in the climate, e. g. *Emys*, *Trapa natans* L., *Acer campestre* L., *Ilex aquifolium* L., *Erucastrum Pollichii* SCH. and Sp. a. o.»

At about the same time OSWALD HEER [20] has expressed the same opinion as ARESCHOUG about the occurrence of alpine plants in the lowland of Switzerland. He says (p. 168) »Chose singulière, des marais tourbeux de la plaine comptent quelques plantes des Alpes et leur ont offert une station dans laquelle elles ont pu se maintenir. Nous y remontons entre autre l'Ail civette, l'Airelle des tourbières (*Vaccinium uliginosum*) et la Linaigrette des Alpes (*Eriophorum alpinum*)».

He considers that during the Ice age the flora of the lowland was like the present one in the high mountains, and although there have not been found fossil plants in the moraine, »un autre document important affirme l'existence de la flore des Alpes dans la plaine et ce document, ce sont précisément ces colonies déjà signalées de plantes alpines dans notre canton».

HEER considers that, during the Ice age the flora of the arctic North and the flora of the Alps became mingled with each other on the European lowland and, as a prove of this assumption, he regards the fact that »La Suisse possède aujourd'hui environ 360 espèces de plantes alpines, parmi lesquelles 158 espèces, à peu près la moitié, appartiennent à la flore arctique, et parmi nos colons alpins 42 peuvent être assimilés à ces habitants du nord».

Still earlier SVEN LOVÉN had pointed out that some arctic animals lived in some of the Swedish lakes as relics from the late-glacial sea [29].

Since then the question about the occurrence and the origin of relics (in this case the plant-relics) has been studied by several scientists (NATHORST, GUNNAR ANDERSSON, SERNANDER a. o.) and is still one of the leading subjects in the modern phyto-geography.

Glacial relics.

Some of the plants which immigrated with the *Dryas* and the birch floras are still living over nearly the whole of Scandinavia; some occur only in the mountains or in the northernmost parts of the country; a third part again has its proper habitat in the mountains or in the arctic tracts, but some species are also found on isolated spots in other parts of the country, as relics.

Some localities are more than others suited to maintain a relic flora. Such are e. g. the limestone-fields, which after their chief localities on Öland, generally are called the »Alfvars». The limestones which form the substratum of the »Alfvars» are uncovered or only covered with a thin layer of soil, and the plants living there have been especially adapted to the prevailing natural conditions and are thus not so easily displaced by other new-comers and, further, these natural conditions of the »Alfvar steppes» can be said to be somewhat corresponding to those of the alpine heath (compare p. 164). Besides on Öland, Alfvar formations are found on Gotland and also, in a minor scale, in Wästergötland [53].

The real alpine plants occurring in the »Alfvar vegetation» seem, for the most part, to be veritable glacial relics from the first flora that after the Ice age immigrated in the country, as it in consequence of the special circumstances, just mentioned, is rather likely that they have been able to remain there since that time, and, further, their occurrence together in localities which are very isolated from their proper arctic-alpine habitats speaks for an immigration under conditions favourable for a continuous glacial flora.

Among the typical glacial relics occurring in the »Alfvar» formations there are some lichens such as *Cetraria cucullata* and *C. nivalis*, *Thamnolia vermicularis*, and *Lecidea decipiens*, and mosses e. g. *Amblystegium turgescens*, *Clevea hyalina*, and *Hylocomium rugosum*, and of phanerogams: *Poa alpina*, *Allium schænoprasum*, and *Viscaria alpina*. The last named plant occurs on Öland in the dwarf-form *petræa*, and *Poa alpina* both on Öland and Gotland in the small »Alfvar» form *nodosa* [53, 42].

Both *Poa* and *Allium* are, however, found at several other places in the south of Sweden. *Allium* is e. g. rather common on rocks near to the sea and is perhaps not to be considered as a relic.

Other localities where several northern plants occur which are probably also to be regarded as true glacial relics are peat-bogs and marshes. On Gotland occur on such places e. g. *Bartsia alpina*, *Pinguicula alpina*, and *Equisetum tenellum*. *Bartsia* also occurs on scattered spots in Wäster- and Östergötland and also, of course, as all the plants under consideration, in Norrland [42, 45].

JOHANSSON [26] enumerates 11 such northern relics from Gotland, viz., besides the three just mentioned, *Euphrasia salsiburgensis*, *Cornus*

suecica, *Batrachium confervoides*, *Cochlearia danica*, *Draba incana*, *Oxytropis campestris*, *Rumex domesticus*, and *Poa alpina*. With the exception of *Cornus suecica*, *Batrachium confervoides*, and *Cochlearia danica*, these plants are also found in the mountains of Central Europe. »It is however obvious that on Gotland these plants form relics from a glacial flora, which after the Ice age wandered from the plain in a chiefly northerly direction» [26].

Also in crevices in the rocks several glacial relics are found e. g. *Cerastium alpinum* on Hunneberg in Wästergötland. Another glacial relic occurring in the same province is *Saussurea alpina* [45]. Of other plants considered to belong to this category *Asplenium viride* and *Echinosperrum deflexum* at Taberg in Småland might be mentioned.

At the sea-shore where the waves and the wind prevent the forming of a closed vegetation several northern plants are found, as, besides the just mentioned, *Equisetum tenellum* and *Cochlearia danica*, and further *Stenhammaria maritima*, *Fucus balticus*, and *Ammodenia peplodes*.

These plants might have arrived already during the time of the Glacial Sea or early during the Ancylus age and afterwards they have followed the shore-line by the successive wandering of the same. Thus, they are at all events not relics exactly on those places where they are now found. It is however quite possible that they can have immigrated occasionally to these localities and that they, thus, in no way can be regarded as relics.

The glacial flora became afterwards scattered by the birch and pine floras, but elements of the same, no doubt, formed an essential part of the vegetation during the following time. *Bartsia* and *Pinguicula*, as well as *Equisetum*, are found living on marshes situated considerably lower than the highest level of the Litorina sea (42). This seems to indicate that these plants were able not only to stay at their original localities but also to spread under climatic conditions quite unlike those prevailing during their first immigration. However, these plants, as well as some of the arctic plants immigrated from N. Russia, the Polartracts or NW. Norway, which plants are now found on isolated spots in Norrland, might perhaps not be relics but be recently spread in later time [7].¹

The contribution which the glacial flora has given to the present vegetation of our lowland does not, as is well known, consist only of these scattered relics, but a good deal of our most common plants, occurring both on the lowland and in the mountain tracts, might descend from this flora, although only a few of them are found in the fossiliferous deposits from the late-glacial or the first part of the post-glacial time. *Arctostaphylos uva ursi*, *Hippuris vulgaris*, *Myrtillus uliginosa*, *Menyanthes trifoliata*, *Polygonum viviparum*, a. o. have been found as fossils. Among those

¹ Likewise, it can be suggested that several alpine plants living in the lowlands of Switzerland are not relics from the late glacial time, but have migrated downwards later on.

which are not found as fossils might be mentioned *Achillea millefolium*, *Deschampsia cæspitosa*, *Caltha palustris*, and *Galium boreale*.

Sub-glacial relics.

The birch-aspens- and the pine floras were in their turn, at least in the south parts of the country, scattered by the still later immigrated oak flora, and of the first named floras relics seem to have been left. As such e. g. *Astragalus penduliflorus* (*Phaca alpina*), *Phyteuma nigrum*, and *Galium triflorum* have been considered (12, 13). *Astragalus* and *Phyteuma* occur also in central Europe, but there generally higher up in the mountains.

WILLE [51] has treated the distribution of *Astragalus penduliflorus*, *Campanula barbata*, and some other plants with isolated occurrences in Norway and Sweden, and he does not believe that they are relics, but that they are recently and generally quite accidentally spread.

It is well known that in our days the pine does not live in the S. and SW. parts of our country. That it formerly lived there, as well as in Denmark is, however, shown by several finds in the peat-bogs, and S. and SW. of its normal boundary the named tree lives on some isolated spots, and here and there »degenerated» pine forests occur as »clear and typical» relics [4, 5].

Pseudo-glacial relics.

Except the real glacial relics, there are found some alpine (or sub-alpine) plants isolated in localities, where they for some reason or other cannot be interpreted as relics from the arctic time. These plants, which have been called pseudo-glacial relics or glacial pseudo-relics (2, 5, 32, 43) must have come to these places during some later time.

Atlantic pseudo-glacial relics [43, 44]. In the N. of Scandinavia at several places, e. g. at the shores of brooks and rivers as far down as 400—500 m. above the sea, there occur colonies of typical mountain plants such as *Alchemilla alpina*, *Andromeda hypnoides*, *Bartsia alpina*, *Phyllo-doce cærulea*, *Salix herbacea*, *Cerastium alpinum*, *Oxyria digyna*, *Rhodiola rosea*, *Saxifraga aizoides*, *S. oppositifolia*, and *Solorina crocea*.

On fens and swamps situated 300—400 m above the sea are found, near Östersund, *Salix reticulata*, *Primula stricta*, *Thalictrum alpinum*, *Tofieldia palustris*, and *Bartsia alpina* together with some other northern, if not really arctic plants [34].

In the heaths, on the mountain-steeps, and in their fissures arctic plants are also found far below their normal occurrences. In the first named localities occur e. g. *Azalea procumbens* and *Arctostaphylos alpina*,

and at dry places near Östersund: *Sibbaldia procumbens*, *Phyllodoce caerulea*, *Azalea procumbens*, *Draba hirta*, *Viscaria alpina*, and many others.

Even the *Dryas*-formation has sent some outposts down in the region of the fir-forest. SERNANDER mentions the following plants living together on a small area of about 1 m²: *Arctostaphylos alpina*, *Azalea procumbens*, *Betula nana*, *Carex capillaris*, *Dicranum* sp., *Dryas octopetala*, *Empetrum nigrum*, *Grimmia* sp., *Hylocomium proliferum*, *Myrtilus nigra*, *Pedicularis lapponica*, *Pinguicula vulgaris*, *Polygonum viviparum*, *Salix reticulata*, *Saxifraga oppositifolia*, *Silene acaulis*, *Thalictrum alpinum*, *Tofieldia palustris*, *Vaccinium Vitis idæa* [44].

That these outposts should be relics from the first flora, which after the Ice age covered the country, does not seem very likely, although this presumption perhaps is the one nearest at hand, and such an opinion has also earlier been expressed [30].

SERNANDER turns against this hypothesis and points out that the plants under consideration ought to be considerably more scattered, than what they are, if they had been subject to the competition with the later immigrated floras for such a long time. In several of these colonies it is just the »glacial» relics, which play the principal part both as to the richness in individuals and in species [43 p. 196].

Nor does SERNANDER think that these plants have spread recently, for instance by the rivers directly from the alpine or subalpine regions. Sometimes, when they live near the corresponding formations in the mountains, this might have been the case, but when these outposts are found at great distances from the nearest high mountains, it does not seem very probable that several different species would have been able to meet in these colonies. There is another fact, that seems to speak against such a presumption and that is the circumstance that these outposts do not belong to those species, which in the corresponding formations in the mountains are the most common, some of them, on the contrary, occurring there relatively sparsely.

About the occurrences of plants belonging to the *Dryas*-formation SERNANDER says [44, p. 14]: »This formation with its richness in characteristic constituents can hardly have been accidentally formed anew only at a couple of limited places down in the region of the fir-forest. Besides, in such case almost the half of the phanerogamous constituents would have wandered down from the alpine and subalpine regions and met each other on these small spots, in as much as they do not occur in the neighbourhood. One must suppose that the formation once formerly was more common and has now been driven aside to a few isolated places. The outposts — *Arabis alpina*, *Arctostaphylos alpina*, *Astragalus alpinus*, *Azalea procumbens*, *Dryas octopetala*, *Pedicularis lapponica*, *Phyllodoce caerulea*, *Salix reticulata*, *Silene acaulis* — would thus be relics as the whole formation.»

SERNANDER considers these plants as relics from the »atlantic» time (44, p. 162).

Except in the mountain regions these plants are found also on lower levels, namely at the W. coast of Norway. As far to the south as in the neighbourhood of Bergen *Salix herbacea*, *Bartsia alpina*, *Rhodiola rosea* and other alpine plants commonly occur right down to the sea.

The elm lives at the Norwegian coast as far as to 67° N, and its northern boundary in Sweden goes much further to the south. But the elm is found as fossil or as relic rather far N. in our country and, what is here of greatest interest, together with the elm there occur sometimes also mountain plants, e. g. *Viola biflora*, *Cerastium alpinum*, *Dryas*, a. o. that are common at the Norwegian coast. Also together with some other species which in Sweden live at lower latitudes these alpine plants are found [16, 24, 44].

It seems possible that during a maritime climate, like the climate at the W coast of Norway, these alpine plants could have spread far beyond their present boundaries towards the E. and that the elm might have crossed the mountain passes from the W. There is reason to believe that at the same time several plants from central Sweden migrated towards the N. a good way beyond their present N. boundary (see below).

During the latest part of the Ancyclus time the climate became more and more dry, the »boreal» period of BLYTT and SERNANDER [9, 49, a. o.], but during the following »atlantic» time, the climate is supposed to have been mild and damp as now at the W. coast of Norway, and it is during this time that the southern plants would have spread far to the N. and the western alpine ones down into the region of the fir-forest. Also some paleontological reasons speak for that. At several places in the lowlands of Norrland calcareous tufas occur, which by SERNANDER are regarded as being of atlantic age, and these tufas contain remnants of a mountain flora e. g. *Dryas octopetala*, *Salix reticulata*, and *S. herbacea* together with remnants of pine and other plants belonging to the flora of the lowland.

Also on other places than in Norrland atlantic pseudo-glacial relics occur, according to SERNANDER [43]. On scattered spots e. g. in Bohuslän *Alchemilla alpina* and *Rhodiola rosea* are found. Both these plants are rather common at the Norwegian coast and might have spread from there during a time when the climates at these places were more like each other than now. That these plants cannot be real glacial relics, at least at some of their present localities, is shown by the fact that these localities are situated below the highest level of the Litorina sea. Very likely also the *Ilex* flora arrived to these tracts during the atlantic time, and during a later change in the climate the plants of both these categories became scattered.

Another peculiarity which probably might be put in connection with this epoch is the circumstance that the mountains and the coast tracts in Norrland have several common species, which are wanting in other parts

of the country [10, 24]. It is very likely that these plants were spread over the whole of Norrland during the atlantic time, but later on became displaced by others, which immigrated during different geographical and climatic conditions. In some cases the plants occurring in the mountains are not quite the same, although very nearly related to those found at the coast. It is possible that they have varied differently because of different conditions of life, since the time when they occurred more mixed with each other. As examples of such plants might be mentioned: *Stellaria crassifolia* with the variety *subalpina* in the mountains, and among water-plants *Potamogetan filiformis* by the sea and *v. alpinus* in the mountains. Really common for both places are e. g. *Woodsia hyperborea* and *Fucus balticus*. *Hippophaë rhamnoides* might also belong to this category, although now in Norrland only living at the coast, but as fossil the plant is found in the interior of the country in calcareous tufas, the other fossil remains of which are supposed to be of atlantic age [44]. This plant occurs rather commonly at the Norwegian coast and is also found in the interior of the country 450 m above the sea. It, thus, seems very likely that there formerly has been a communication between the now separated areas [10, 22, 44]. With regard to the eastern occurrences at the Botnian Gulf, there is, however, to be noted that they cannot be regarded as relics in a proper sense, in as much as the plants must have wandered outwards during the land rising, successively occupying the outermost border of the coast, just as has in the foregoing been remarked about some other coast plants (p. 151). Really, the coast-border below the high water level offers retreats for these plants, not only because of the maritime climate, but also because the competition with the dominating vegetation there is less keen [24].

About the relic character of the atlantic plants now treated, some authors, however, have expressed opinions which differ from the views of SERNANDER. According to BIRGER [7] these plants might have begun to spread, when, after the post-glacial temperature-maximum, the warmth decreased again. This deterioration in temperature and the spreading of mountain plants seem still to continue (according to him).

HAMBERG does not either agree with SERNANDER, but thinks that »the occurrence of pseudo-glacial relics is to be explained in some other way, for instance as depending on the capability of the mountain plants to thrive in warmer tracts on damper ground» [18].

N. WILLE and JENS HOLMBOE [52], who have studied the occurrence of *Dryas octopetala* at Langesand, have come to the conclusion that *Dryas* there probably has spread during the latest 100 years. On some places *Dryas* was found together with *Corylus avellana*, *Anemone nemorosa*, and *Angelica silvestris* and »Die Fundorte sind überall sonnig und offen gegen Osten und Südosten; nur wenige Exemplare wachsen an Orten mit nördlicher Exposition». Relics ought to have been able to stay on the S. sides, not on the W. and NW. ones. WILLE and HOLMBOE seem to be

inclined to think that the distribution of mountain plants on the lowland generally might depend upon »die klimatischen Verhältnisse und die Verbreitungsmittel der Gegenwart» [52].

HEINTZE turns also against the theory on »atlantic relics». As mountain plants are found at the coast, coast-plants are found in the mountains (he mentions *Armeria elongata* v. *sibirica* and *Elymus arenarius*) and »everything indicates that we here have to do with local causes, no climatic ones of general application» [21].

Sub-atlantic pseudo-glacial relics. There is another group of s. c. pseudo-glacial relics that we will now consider.

On a peat-bog in Nerike in a *sphagnetum myrtillosum* with much *Ledum palustre* there live, according to SERNANDER [43], *Betula nana* and *B. intermedia* (*B. nana* × *B. odorata*). The bog is situated only 40 m above the sea. *Salix lapponum* has also an isolated occurrence on swamps about 32 m above the sea [43].

In Upland, the greatest part of which landscape was covered by the Litorina sea, there are found on fens, bogs and the like, situated beneath the highest level of this sea several arctic or subarctic plants: *Salix lapponum*, *S. hastata*, *S. phyllicifolia*, *Sceptrum Carolinum*, *Carex microstachya*, *C. heleonastes*, a. o. [39, 43, 47].

On the Tunåsen near Upsala there live some northerly lichens: *Cetraria cucullata* and *C. nivalis*, and further *Pulsatilla vernalis* which perhaps might be named in this connection [47].

On similar localities on Gotland one has found e. g. *Andromeda polifolia*, *Empetrum nigrum*, *Oxycoccus palustris*, *Eriophorum alpinum*, *E. vaginatum* and several other northerly plants [42].

That these plants cannot be real glacial relics from the time of the Glacial Sea or the beginning of the Ancylus time is shown already by the fact that all these localities are situated beneath the highest level of the Litorina sea and far from the coast of the named epochs. Nor does it seem likely that these plants would have spread as far as to Gotland during the warm and damp atlantic time. Besides, the Pardume träsk (their chief locality on this island) is situated on such a low level, that the warm and dry sub-boreal climate probably prevailed, when this lake became isolated from the Litorina sea. SERNANDER [42] thus considers that these plants have spread during the cold and damp sub-atlantic time (see p. 163). During this time the southern flora which prevailed in Norrland since the warmer climate was also (according to him) driven towards the south. This retreat certainly was much accelerated by the contemporaneous spreading of the spruce.

The alpine and subalpine flora which during this time migrated to central Sweden should have been forced northwards again when the climate towards our time became milder and the plants under consideration should then have been left as relics [43, 44, 48]. GUNNAR ANDERSSON and most of the other scientists who have dealt with these subjects

do not consider these plants to be relics. Contrary to SERNANDER, ANDERSSON thinks that the deterioration of the climate began already during the earliest time of the Litorina land-rising, and that the same is still going on [2, 4, 5]. WARMING [50] is also of another opinion than SERNANDER. He has described some similar occurrences of northern plants in Denmark and considers that these plants for the most part have immigrated lately across the Skagerack to Denmark, and continues (p. 79) »They deserve, no doubt, the name »Pseudorelikter» which NATHORST has introduced (B. N. 1895) for plants that at some places seem to be relics, but which must have come there in later times.»

Relics from the advance of southern plants towards the north.

At the end of the Ancyclus time and in the beginning of the Litorina time several plants advanced towards the north far beyond their present N. boundary.

This flora became scattered during the severe climate of the following time, but at several places far up in Norrland relics are left. According to SERNANDERS [48] opinions of late years this advance towards the north should chiefly have taken place during the subboreal time and the flora would have become scattered during the subatlantic time (compare 5 and p. 165).

This kind of relics is generally found at places which are more sheltered and more sunny than the surroundings in general. When one has removed these plants from their relic-locality to some other place, e. g. to a garden in the neighbourhood, they do not thrive and generally they die out very soon.

GUNNAR ANDERSSON has studied the spread of the hazel as fossil and as relic [3] and thereby mapped not less than 89 such relic-localities N. of the present climatic N. boundary of this shrub. These are comparatively few in the interior of the country, and do not there reach as far N. as nearer the coast. The hazel thus proves to be a decided coast plant also as a relic. According to the just mentioned author »*the period of vegetation at the time of the widest distribution of the hazel was 2,4° C. warmer than now*». This would be proved by the comparison of the occurrences of this shrub as relic and as fossil to its present normal distribution.

ANDERSSON divided these relic-localities into two chief groups: Mountain bases and Southerly slopes [3, p. 133].

1. *Mountain bases.* The upland parts of N. Sweden are very rich in steep hills and mountains and below the steep walls consisting of a hard rock there is generally a »talus» formation, between the blocks of which mould has gathered which because of the surrounding stones does not get dry. Especially at the boundary between the mountain wall and

this block-ground there is very much mould. This kind of ground does not generally become covered by a closed tree-vegetation, but among sparsely occurring fir-trees there live deciduous trees of different kinds and also a great many herbs. Localities of this kind turned towards the S. or the SE. play a great part for the retaining of southern relics. The reason why these plants can live here and not in the surroundings is that these localities serve almost as a kind of hot-beds, as the temperature here is considerably higher, these places being so well sheltered from all cold winds, and further the sun-rays falling nearly horizontally because of the inclination of the ground. Also the cold during the night is here less severe than in the valleys further down. And even during the winters the conditions here are very favourable as the snow which drifts together beneath the steeps hinders the refrigeration from becoming too strong or too rapid, and besides, when melting, waters the ground thoroughly.

It is only on such localities that the northernmost hazel relics are found. Except the hazel several other southern plants are found as relics at such mountain bases.

Already LINNÉ has described such a locality from Dalecarlia [27]. The same is later on described also by SAMUELSSON [38]. Of southern plants the following are here found: *Tilia ulmifolia*, *Acer platanoides*, *Hepatica triloba*, *Geranium robertianum*, *Arenaria trinervia*, *Astragalus glycyphyllos*, *Pyrola media*, *Polygonum officinale*, *Pteris aquilina*, *Ribes alpinum*, and *Verbascum thapsus*.

2. The *Southerly slopes* are not as the mountain bases limited from the surroundings, but consist of the most favourable localities in a hilly neighbourhood. They are generally rather sheltered from the wind, especially from the N. and richer in warmth and sun than the surroundings, and if there is also subsoil water enough these slopes can hold southern plants of different kinds, but it is comparably difficult for these latter to remain here, and the northernmost localities of this kind, where hazel relics are found, are situated 110 to 120 km S. of the northernmost occurrences of this shrub at mountain bases. One thing that makes it difficult for the plants to remain on these slopes is the interference of man, as these places are very suitable for cultivating. Also other relics are however found there, viz. *Tilia ulmifolia*, *Anemone nemorosa*, *Arenaria trinervia*, *Viola riviniana*, a. o., but generally the relic flora here is very poor, and sometimes only one solitary hazel shrub occurs [3].

Recently also the relic localities of *Ulmus montana* in Norrland has been studied and mapped by HOLMGREN [23]. *Ulmus* occurs as a relic chiefly on the same kind of localities as the hazel, but the former lives also here and there at the shores of brooks or on meadow-grounds and its relic boundary is not, according to the named author, a climatic boundary, but is to a great extent due to the competition with other species, chiefly the spruce. At several localities there live together with *Ulmus* some species which otherwise are very rare in these tracts, but in south

and central Sweden generally occur together with the named tree. Such are e. g. *Viola mirabilis*, *Arabis hirsuta*, *Stachys silvatica*, *Epilobium montanum*, *Rosa cinnamomea*, *Triticum caninum*, *Asperula odorata*, *Pteris aquilina*, a. o. [16, 23]. These plants probably belonged to the original *Ulmus* flora and are also to be considered as relics from a once wider distribution of the same. On some localities they occur without *Ulmus*, but possibly this tree once lived there, but has now died out.

Some of the western relic occurrences of *Ulmus* probably belonged to the Norwegian, not to the Swedish distribution area [23, 54].

About southern relics in the flora of Medelpad COLLINDER writes [11]. »As relics from the Litorina time or from the later part of the time of the pine, except the ones just mentioned, (*Corylus avellana*, *Ulmus montana* and *Alnus glutinosa*) the following might be considered. The ones marked with f are found as fossils within the landscape»:

<i>Gentiana baltica</i>	<i>Erythræa vulgaris</i>
<i>Solanum dulcamara</i> f.	<i>Tilia ulmifolia</i>
<i>Acer platanoides</i>	<i>Peplis portula</i>
<i>Epipactis latifolia</i>	<i>Neottia nidus avis</i>
<i>Iris pseudacorus</i> f.	<i>Stratiotes aloides</i>
<i>Butomus umbellatus</i>	<i>Fucus Leersii</i>
<i>Ceratophyllum demersum</i>	<i>Potamogeton acutifolius</i>
<i>Carex pseudocyperus</i> f.	<i>C. paradoxa</i>
<i>Polystichum thelypteris</i>	<i>Ophioglossum vulgatum</i> .

»Most of them occur sparsely and only on one locality each, *Gentiana baltica* and *Tilia ulmifolia* mostly occur in dwarfed specimens. *Butomus* does not bloom every year. *Corylus*, *Ceratophyllum*, and *Potamogeton acutifolius* propagate only in a vegetative way. The same is the case with *Tilia*, except perhaps on one locality where this species seems to be able to set reape fruits. The maple, on the other hand, is one of the most vigorous relics».

Also from most of the other Norrlandian provinces one could mention about as great a number of southern relics [8]; and they are found even in the northernmost parts of Sweden. SELIM BIRGER [7] mentions e. g. *Sagittaria sagittifolia* and *Butomus umbellatus* in Karesuando, more than 68° N. As these two species only seem to live on some solitary localities and, besides, only occur in sterile specimens, it seems very probable that they are true relics.

The scattered occurrences of pine-trees in the birch region and of birch-woods considerably above the present tree-limit in our high mountains have also been regarded as relics from this warmer time [15, 19]. The same is probably the case with other mountain plants generally living in the subalpine tracts, but also found higher up.

Also the great forests of deciduous trees, that during the boreal and, above all, during the atlantic time covered great parts of central Sweden, became more and more scattered as the spruce (and in the southern part of the country, the beech) gained ground. The deterioration in the climate made this invasion easier as the oak and the oak plants became less and less suited to resist the spruce in this struggle. The wood-meadows which still occur in central Sweden must be considered as relics from this greater distribution [39, 40]. Such a locality is described by SERNANDER as follows: »Der sydliche Abhang des Thales zeichnet sich durch einige Pflanzen aus: *Lactuca muralis* (L.), FRESEN, *Lonicera xylosteum* L., *Actæa spicata* L., welche für die Hainthälchen typisch sind und ausserdem in der durch die Invasion der Fichte entstandenen Pflanzengesellschaft oft übrig blieben. Diese Formen deute ich deshalb als *Relicten* desjenigen Hainthälchens, das vor der Ankunft der Fichte den Platz beherrschte. Eine andere ganz deutliche Relictpflanze ist die hier spärlich auftretende *Carex remota* L., die übrigens in ganz Nerike sehr selten ist» [40, p. 76]. Also another locality of this kind, described by the same author [39] from Nerike, might here be mentioned. This is a narrow valley, part of which is characterized by a rather peculiar vegetation. Here and there on the moistened mountain walls there grows a multitude of plants such as *Lactuca muralis*, *Viburnum opulus*, *Lonicera xylosteum*, *Lathrea squamaria*,¹ *Actæa spicata*, *Tilia ulmifolia*,¹ *Circæa alpina*, *Sorbus aucuparia*, *Orobus vernus*, *Corylus avellana*,¹ *Salix caprea*, *Polygonatum officinale*, *Festuca silvatica*,¹ *Calamagrostis arundinacea*, and *Milium effusum*. The species marked with ¹ might, according to the same author, belong to the oak flora, the others to the subglacial flora, which became displaced by the former. The spruce occurs very richly in the surroundings and »the oak flora which formerly dominated over the whole of the valley has found a refuge in this part of the cleft». Also of cryptogams there occur several rare southern species: *Hypnum molluscum*, *Thelotrema lepodium*, a. o.

The ivy (*Hedera Helix*), the yew (*Taxus baccata*), and the mistletoe (*Viscum album*) were probably more common in central Sweden during the time of the greatest distribution of the oak flora than what they are now. It is true that their occurrences in peat-bogs do not tell us much about their former frequency (*Hedera* is only found at two and *Viscum* at one place), but their present distribution seems to speak for their being relics.

The ivy rather commonly lives on the Baltic islands, where the same even sets fruit and reaches considerable dimensions. Further, there have been found sterile specimens of a low and creeping form at some few places in the coast-tracts of Södermanland [45].

The yew occurs here and there in the valleys of the Mälaren and the Hjälmarén. The present rareness of this plant is partly due to the influence of man. It is well known that in former times, when this tree was more common than now, the same was used for the making of several things, especially bows [45].

The mistletoe lives at several places near the Mälaren on oaks, maples, lime- and apple-trees. These occurrences are now very isolated, but it is possible that the same once have communicated with the ones at the Kristiania fiord and in Bohuslän, Wästergötland, and Småland. In Skåne, where the plant once occurred (which is shown by a fossil find), the same does not now live [2, 45].

Even in the South of Sweden there are some occurrences of plants which otherwise are found more commonly on the European continent. The common maple (*Acer campestre*) e. g. lives at one place in Skåne and is also found here and there in Denmark. As fossil the plant is found at one place in the South of Sweden, in a layer formed before the maximum level of the post-glacial Litorina Sea [2].

Tilia platyphylla now occurring on some islands in Bohuslän, is probably a relic from the same time as the common maple [2].

These plants have probably come to Sweden in Atlantic time and somewhat later during the same epoch the beech flora has immigrated. This flora seems to be still spreading towards the north.

Also the vegetation of peat-bogs, marshes and lakes became considerably enriched during this warmer climate.

Among plants of these categories which have been found as fossils far N. of their present N. boundary *Carex pseudocyperus* deserves to be mentioned. It seems as if this plant had immigrated rather early. On Gotland the same is found in layers from the late subglacial time together with the likewise rather southern plants *Cladium mariscus* and *Iris pseud-acorus* [42], and when the Litorina sea had its greatest extent, *Carex pseudocyperus* was a common plant in Norrland as far as at least 250 km N. of its present normal occurrence. As a relic the same is found e. g. at Sundsvall [37].

Of a still greater interest is the distribution of some water plants during this warmer time. One example hereupon is *Najas flexilis*, in our country now occurring in one locality in Skåne, and formerly in the lake Hederviken in Upland, which lake is now drained. Also in one locality in each of the lakes Vesijärvi and Onega and on two localities in Norway the plant is found. Even in other parts of Europa *Najas flexilis* is very rare and it has its greatest distribution in N. America. It has been suggested that it once belonged to the tertiary circumpolar flora. The fossil finds show that it lived already at the shores of the Ancylus lake and it is possible that the fresh water of this lake has contributed to the spreading, but fossil finds show that it was once spread also to Norway [2, 22].

A little later than the plant just mentioned, *Ceratophyllum demersum*, *Najas marina*, *Trapa natans*, and *Stratiotes aloides* immigrated [2, 4, 45].

The seeds of *Ceratophyllum demersum* are rather common in the peat-bogs of central and South Sweden, and they are also found in Norr-

land. At those places where the plant now lives in Sweden the same very seldom sets fruit.

In the centre of its area (in central Europe), *Najas marina* is always a fresh-water plant, but in Scandinavia it is found in fresh water only at two places on Gotland and at one in Norway. In brackish water, on the other hand, this species occurs round the whole of the Baltic basin. The localities are, however, rather isolated from each other and might be considered as relic occurrences from a formerly greater distribution. The plant was also once very common in the lakes of S. Sweden. When the temperature sank, *Najas marina* was probably not able to endure the struggle with other plants better suited to a cold climate, but as enduring better in brackish water it has taken refuge there, where the competition was not so keen [1, 42].

Trapa natans is a plant which belongs to the flora of S. Europe; already in N. Germany the same is rather rare. The very easily recognized nuts are found at several places in Sweden, in the peat-bogs, in atlantic and in older beds, as far N. as to the Mälaren. *Trapa* nuts are also found as fossils in W. Prussia, Denmark, and Finland. In our flora this plant has nowadays only one relic occurrence viz. the lake Immeln in NE. Skåne. But at LINNÉ'S time *Trapa* lived also in some lakes in Småland, and in one of them it still remained in the beginning of the 19th century, but now one can only find the nuts on the bottom of the lake [45].

Relics from the advance of southwestern plants towards the east.

During the mild and wet atlantic time the *Ilex* and the beech flora probably immigrated, the former from SW. the latter from the S. (p. 148). Among the different plant-regions into which Scandinavia has been divided the *Ilex* region, which now is represented on Jutland and at the W. coast of Norway, is the one with the most maritime climate.

There have not been found any *Ilex* plants as fossils in the peat-bogs, but the rather isolated occurrences, especially in Halland and Bohuslän, of species otherwise living at the W. coast of the British Islands, France, and Spain, have been interpreted as relics from a once wider distribution, and it seems as if the climate during the atlantic time was best suited for a greater spreading of the plants under consideration.

Ilex aquifolium does not now live in our country, but still about 1840 it had one locality in Bohuslän, but then the last *Ilex* died out there. As the plant occurred only in one specimen it is difficult to say if it really was a relic or if it had spread quite accidentally, e. g. from one of its localities in Denmark, then in that country *Ilex* occurs, although rarely, both on Jutland and on some of the islands.

Among other *Ilex* plants living in S. or W. Sweden on isolated spots,

mostly on heaths, the following generally are regarded as relics: *Genista anglica*, *G. germanica*, *Hypericum pulchrum*, *Sedum anglicum* (at some few localities on rocks by the coast of Bohuslän), *Bunium flexuosum* and *Digitalis purpurea* (at some few places in Bohuslän and in one locality in Halland). At other places in Sweden where *Digitalis* is found, it seems to have spread accidentally from gardens [31]. *Teucrium scorodonia* lives in one locality in Bohuslän and in three in Wästergötland, but it might possibly originate from some cultivated specimens [2, 4, 5, 45].

During the atlantic time *Ilex* plants seem to have spread even as far E. as to Gotland, and at least two relics of this kind are still found there. These are *Scolopendrium officinale* which lives on »Lilla Karlsön» and is recently found also in Halland (5, 35, 42), and *Ranunculus ophio-glossifolius*, which latter properly belongs to the flora of the Mediterranean countries and S. France [42], but also occurs in the north of Gotland by a well and in an adjacent *Carex panicea* formation. GUNNAR ANDERSSON considers that also *Lactuca quercina* on the islet »Lilla» Karlsön is a relic from the same time [4].

Quercus sessiliflora which is found only on one locality on Gotland ought perhaps to be included in the same category as *Ranunculus* and *Scolopendrium*, and also *Fucus obtusiflorus*, which plant occurs sparsely in calcareous marshes on Gotland and in Skåne [26].

In this connection another peculiar relic occurrence of plants otherwise belonging to the W. coast flora, which SERNANDER has described from the Tived of Nerike, deserves to be mentioned. Near the lakes Laxsjöarna in a small *sphagnetum cariciferum* enclosed by *pineta hylocomiosa* there grow e. g. *Erica tetralix*, *Potamogeton polygonifolius*, and *Narthecium ossifragum*. Of other plants occurring here *Alnus glutinosa*, *Molinia coerulea*, and *Myrica gale* have also a prevailing westerly distribution in our country, *Fucus stygius* and *Carex chordorhiza* are northerly, *Orchis angustifolia*, and *Rhynchospora fusca* northerly as well as westerly.

SERNANDER has earlier [41] interpreted these plants as atlantic relics, but as there is a stool-layer, which he considers to be of subboreal age, in the peat-bog, he has later [48] come to the conclusion that they are of subatlantic age, as they of course must have arrived later than the forest. Thus the whole formation should, according to the named author, be a relic from that time (compare p. 156).

Relics from the advance of southeastern plants towards the W.

It has long been known that especially in the calcareous districts of S. Sweden there occur some plants which have »their chief centre in the steppe and karstenite regions of SE. Europe. This supports the assumption

of a former dry climate in such tracts where the species named are now to be met with only on very dry and warm habitats» [GUNNAR ANDERSSON, 5].

Already when speaking of the glacial relics, it has been mentioned that the »Alfvar»-formations have a certain capability of retaining relics of a steppe- or heath-flora. WITTE says about the »Alfvar» vegetation [53, p. 17] that it is a steppe vegetation occurring in a more or less insular climate and occasioned by edafoid factors and that it has several qualities in common with the SE. European steppe vegetation and also shows some likeness with the vegetation of the alpine heath (mountain-steppe?) in the far north (compare also p. 150).

Already LINNÉ has mentioned several of these »steppe» plants [28] and ARESCHOUG [6] considers them as »rears» from a formerly more prevailing vegetation. SERNANDER [42] mentions the following species, which in the Gotlandian flora are rather isolated from their centre in SE. Europe and »which by their manner of appearing indicate that they are relics from a time when suitable climatic conditions caused a more continuous distribution» [42, p. 82]: *Anemone silvestris*, *Pulsatilla patens* (might possibly not belong to this category), *Lactuca quercina* on Lilla Karlsön (compare p. 163), and *Rosa Fundzilli* on Stora Karlsön. Other plants of this kind which within the Swedish flora only occur on Gotland or Öland are e. g. *Adonis vernalis*, *Artemisia rupestris*, *Galium rotundifolium*, *Linum catharticum*, *Globularia vulgaris*, *Helianthemum procumbens*, *Helianthemum oelandicum*, and *Ranunculus illyricus*.

From Wästergötland SERNANDER [48] mentions the following plants of which all, with the exception of *Stipa pennata*, also occur at several other places in Sweden, Norway, or Denmark: *Potentilla rupestris*, *Dracocephalum ruyschiana*, *Prunella grandiflora*, *Polygala comosum*, *Asperula tinctoria*, *Pulmonaria angustifolia*, and *Stipa pennata*.

All these are more or less distinct xerothermes with a prevailing SE. distribution in Europe. Several are characteristic for the S. Russian steppes and also on other kindred localities such as dry fields or hills one has found them living together at many places in South and Central Europe. In Wästergötland they are found on very unique edafoidic localities where for one reason or other a closed tree-vegetation has not been able to constitute itself. All the three »Stipa» localities,¹ described by SERNANDER, are situated on hillsides sloping towards the SE., S. or SSW. that is to say at the most sun-exposed places. The one locality is on a small fluvioglacial »ås», the gravel of which is very rich in Silurian shales and limestones, another on a hill of calcareous moraine, and the third locality is a hill composed of Orthoceras limestone situated quite near a small »Alfvar» area covered by a typical »Alfvar» vegetation. As is the case on Got-

¹ *Stipa pennata* is now only found on two of these, but lived not so long ago also on the third one, where the same has now become rooted out.

land and Öland, the calcareous substratum seems to play a great part also in Wästergötland for the distribution of these steppe-plants.

»Most of these xerothermes, especially the SE. European ones, live on the Stipa-hills on Falbygden» (in Wästergötland) rather widely separated from their other localities within Scandinavia; and some of them far away from their continental area of distribution (SERANDER 48, p. 84). According to SERANDER [48, p. 83] the transition-zone between the Russian forest and steppe regions is the district where the vegetation of the same type as the Stipa formation is best developed and stands in the best accordance with the now prevailing climatic conditions. Also in the flora of Upland there occur some SE European xerothermes which seem to be relics. Such are *Asperula tinctoria*, *Draba nemorosa*, *Hieracium mollisetum* and *Polygala comosum*. Some other southeastern plants, viz. *Salvia pratensis*, *Lavatera thuringiaca* and *Melampyrum arvense*, which are known from the neighbourhood of Upsala from the middle or the last part of the 18:th century, have perhaps been spread by the direct or indirect influence of man. According to GUNNAR ANDERSSON and SERANDER the plants under consideration have immigrated in several groups and at different times. The former says (4, p. 72) »Nach ihrer Verbreitung ausserhalb und innerhalb unserer Halbinsel kann man sie in verschiedene Gruppen teilen: eine rein östliche, die im allgemeinen ein höheres Alter in unserer Flora hat und wahrscheinlich während der Kiefernzeit eingezogen ist, und eine südöstliche, deren Arten (meist nur auf Gotland und Öland lebend) ihre weiteste Verbreitung gegen Norden in der ersten Eichenzeit erlangt haben. Von diesen letzteren sind einige, wie gesagt, typische Karstpflanzen». He considers thus that the immigration of these plants took place during the later part of the Ancyclus time when, according to him, the east, but not the west coast of Sweden was dry and continental [2, 4, 5].

But, if only eastern Scandinavia was influenced by this continental climate, these plants could have spread to Öland and Gotland; the relic occurrences in Wästergötland, on the other hand, are more difficult to understand. It is of course possible that when these steppe plants were more common in E. Sweden they could quite accidentally have spread also to the west parts of the country; their present occurrence in Wästergötland, thus, might be due to local conditions. If this is the case, they are not there to be regarded as real relics from a formerly wider and more continuous distribution.

SERANDER considers, as is already mentioned, that the continental climate during the last part of the Ancyclus age, the boreal time, prevailed also in W. Sweden and formerly he has also regarded the plants under consideration as relics from that time [42, 45], but in later years he has come to other conclusions [48]. He does not deny that they could have immigrated for the first time to S. Sweden as early as during this epoch and he even thinks it probable that they then commonly associated to formations of about the same kind as the *Stipa* hills. But as the dry cli-

mate during the boreal time was followed by the decidedly insular during the atlantic, it is, according to the named author, quite evident »that the greatest part of the xerothermes in the flora of Wästergötland must then have disappeared or become reduced to relics. The question is then: is it those relics which have as such survived until the present time? Or have not during the subboreal period which succeeded the atlantic one new immigrations and associations of the same xerothermes taken place, and are there not more chances that it is just some of these which have been maintained until our days?» [48, p. 208].

Another reason to assume that these plants are relics from the subboreal time seems to be that some of them now occur at places that were once covered by the Litorina sea. *Anemone silvestris* e. g. is found on N. Gotland, in about 20 localities most of which are situated less than 15 m above the sea. Similar is the case with the above mentioned xerothermes found in Upland. As is known, this landscape was to the greatest part covered by the Litorina sea.

According to the opinion of SERNANDER it is also during the subboreal time that the hazel reaches its greatest distribution towards the N. And during the same time the tree-limit in our mountains, according to the recently modified views of the same author, reached its highest level in postglacial time.

Relics in the interior of the country from a once greater extension of the sea.

A particular position those plants occupy which have become relics at the places where they now occur, not because of any changes in the climate, but because of the variation in the distribution of land and water.

Here and there in the interior of the country sea-shore plants are found, which have probably lived here since that time when the sea reached these places. As is well known the Mälaren was once a bay of the Baltic sea. and at the shores of the same, there live still several plants which otherwise do not occur at our lakes, but are common at the coast and archipelago of the sea [47]. Such plants are *Trifolium fragiferum* (also found at the shores of the Dalälven), *Carex arenaria*, *Triglochin maritimum*, *Scutellaria hastæfolia*, and *Funcus Gerardi*. To this group also *Armeria elongata* and *Asparagus officinalis* belong. The occurrence in the Mälaren of *Zannichellia polycarpa* also seems to be a relic from the time when this lake was a bay of the sea. On the Kungsängen S. of Upsala *Glaux maritima* has been found. On some hills N. of Upsala, where on account of the unfavourable substratum a tree-vegetation has not been able to constitute itself, one can find a few coast lichens, f. i. *Lecanora cartilaginea*, which may have lived here since that time when these hills rose out of the Litorina sea [47].

Besides the plants already mentioned, SERNANDER gives still another example of this kind of relics in the flora of Upland. In the middle of a flat meadow-ground a salt-spring is situated, the salinity of which derives from the marine clay of the surroundings. Because of the drainage conditions the original richness of sea-water salts of the clay has not been able to become quite removed, thus several elements of the old salt-loving vegetation have also been able to remain around the spring. We find there not only the Mälär-relics *Fucus Gerardi* and *Triglochin maritimum*, but also *Glaux maritima* and *Alopecurus ventricosus*.

Elymus arenarius is quoted as another example. It belongs generally to the flora of the sea-coast, but is also found at the shores of the Vettern and the Vänern and at some rivers in Norrland [24, 33]. However, these occurrences might be due to quite accidentally spreading, as this grass also lives in the interior of Skåne on a place which never in post-glacial time has been reached by the sea.

JOHANSSON mentions that *Silene petræa* lives on Gotland as well in the interior of the island as by the coast. On the former localities it is perhaps a relic from the time when a great part of Gotland was lying underneath the sea [26, p. 51].

Other examples from Gotland might be mentioned: of waterplants e. g. *Potamogeton pectinatus* and *P. filiformis*, both living at the bottom of the Fardume »träsk», which lake is 1—2 m deep and the surface of which is 7,9 m above the sea, and further the shore-plants *Plantago maritima* and *Carex arenaria*, of which the latter, however, is found also in the interior of Skåne like *Elymus*.

A particular position is occupied by the already (p. 162) mentioned *Najas marina* which also occurs in the Fardume träsk and in another Gotlandian lake the Paviken. This plant lives now (as already mentioned) in Scandinavia chiefly in brackish water, but did formerly occur more commonly in fresh water (1). According to SERNANDER [42] the occurrences on Gotland might be best explained as relics from the Litorina sea, although *Najas* now is not found at the coasts of Gotland.

Concluding remarks.

It is already in the introduction pointed out how difficult it generally is to know whether a plant is to be considered as a relic or not, and how different the opinions often are on this subject. It is possible that the result of coming researches will be such that the theory about relics must in many cases be abandoned, or that the occurrence of »relics» can be explained as due to other causes; accidental spreading, the influence of man, morphological changes of the species etc. Conclusions about the climate of former times founded only on the occurrences of these isolated species are thus rather ambiguous. The expulsion of a plant from a lo-

cality is, perhaps, in many cases only seemingly due to the changes in the climate, the utmost causes might be other.

The sea plants found in the interior of the country seem, however, to be best explained as relics. The same is the case with those southern plants living on especially favourable localities in Norrland. Also the fossil finds in the peat-bogs speak for this assumption. The pseudo-glacial relics, on the other hand, are more dubious and are most probably to be explained in some other way. In several cases they have very likely spread quite accidentally. It is of course possible that some of the s. c. sub-atlantic pseudo-glacial relics originally were real glacial ones which quite by chance have spread to new localities, that until rather late have been covered by the sea: but in reality it seems rather unlikely that glacial relics in general were able to survive the warmest epoch of the post-glacial time, if the climate then was of the character, that now is generally supposed. It seems as if northern plants that were then able to live as relics in South Sweden ought now to thrive comparatively well and to spread, if their distribution was only due to climatic conditions. The flora on the »Alfvars» might of course be an exception, just because of the special conditions prevailing in those localities. Thus also the southeastern plants found there and in the *Stipa* formations seem to be relics.

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Addenda.

To the above quoted literature may be added three important memoirs published since this paper was already in the press, viz.

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- MUNTHE, HENR., Studier öfver Gotlands senkvartära historia. Sveriges Geol. Unders. Ser. C a, N:o 4 (1910).
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