A change in attitudes regarding the importance of climatic fluctuations

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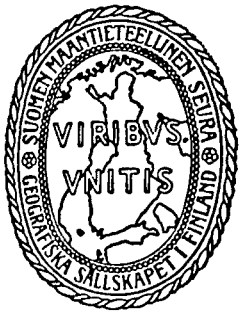

Hustich, I. (1978). A change in attitudes regarding the importance of climatic fluctuations. *Fennia* 150, pp. 59—65. Helsinki. ISSN 0015-0010.

Having taken part in two symposia sponsored by the Geographical Society of Finland (1951 and 1976) on the influence of climatic variations and fluctuations on nature and the activities of man, the author is aware that a certain change in attitudes regarding the significance of the climate has taken place among biogeographers in the intervening period. Nowadays there seems to be a tendency to play down the influence of climatic variations on crops and growth phenomena, for instance. One reason for this may lie in the acceleration of technological advances, accompanied by rapid industrialization and urbanization. The whole land use pattern has changed over large areas in Finland, and new methods for primary organic production (in agriculture, fishing and forestry) have been introduced. No economist today would try to correlate fluctuations in the economy with variations in climate, as was the case only a few decades ago. We also talk more frequently about 'man-made climate', although opinions regarding the increased carbon dioxide content of the atmosphere, for instance, are as divergent today as they were 25 years ago. The author stresses the importance of the *climatic hazard coefficient* and evaluates the complexity of the *ecoclimatic triangle*. Man's influence on nature seems to have increased so much that it tends to obscure the continuing primary importance of the climate itself.

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The interactions between the climate and nature and between the climate and man are complicated ones. During a symposium arranged by the Geographical Society of Finland in 1951 the various effects of the climatic 'improvement' in the 1930's on organic life were discussed. This climate fluctuation, which included the warmest summers for a century (see i.a. diagrams in Heino 1978), could be clearly detected in higher yields per hectare, good forest regeneration in the north and a northward extension of the distribution of a number of animal and plant species. The papers from this symposium (published as volume 75 of *Fennia* in 1952) were well received by the scientific community as a timely report on a problem which greatly interested both geophysicists and biologists at that time.

Partly as a follow-up to this, the Society discussed the same problems again at a meeting in 1976, at which the optimistic approach of the previous occasion was in some sense absent. The climatic 'improvement' of the late 1930's had, as was expected, given way to a colder trend in the 1950's and 1960's, but more important in this connection, industrialization in Finland had accelerated markedly between the early 1950's and the early 1970's. The result was a more cautious approach to the problems of climatic fluctuations and their effects on plant and animal life. The alteration in the structure of the whole economy, the heavy impact of industrialization on the environment and the new methods used in agriculture, fishing and forestry all tended more or less to neutralize or eliminate the effects of climatic variations of fluctuations on primary organic production.

The influence of man on the climate itself has, in fact, developed into a much more important subject of research than we could appreciate in 1951. The use of fossil fuels has increased rapidly: whereas the world consumption of oil was about 500 mill. tons in 1950, it had risen to about 2500 mill.tons by 1975; the consumption of coal has increased by about 100 % over the last 20 years. This has lead to an increased content of dust and sulphur in the air, which has had a profound effect on man's environment.

Nowadays we talk about a 'man-made climate' and tend to play down the importance of the climate itself for organic production. Nevertheless, the use of fertilizers, for instance, cannot eliminate the effects of climatic variations. It must be admitted, however, that there are other factors which are increasingly

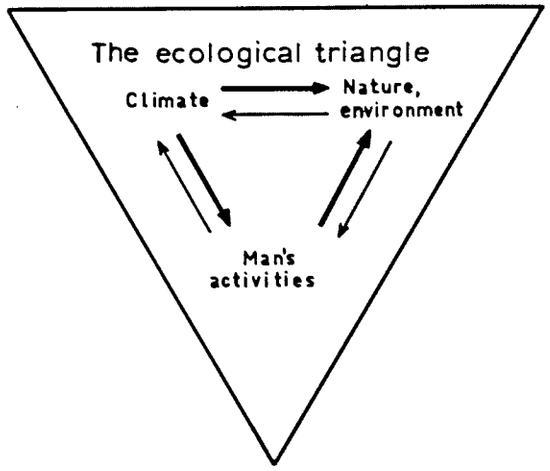

Fig. 1. The 'ecoclimatic triangle' illustrates the interaction between climate, nature and the activities of man. The width of each arrow indicates approximately the importance of the connection between the components concerned.

changing economic base for agricultural production in general in the developed countries, the problem of 'over-production', etc. (see below).

In this respect the problems of agriculture in Finland are quite different from those encountered 25 years ago, when we still followed the practice of previous centuries in striving to increase production and push the limits of cultivation northwards, trends which were stimulated by the 'improved' climate in the 1930's and the resulting good harvests. In common with most developed countries, Finland now has an over-production problem.

Not many decades ago economists correlated fluctuations in the general economy of the country with the relative success or failure of the harvests. Today it is almost impossible to find such a simple correlation between economic fluctuations, yields of cereals and climatic variations. The period between the previous symposium and the present one happens to coincide with that phase in the history of man which has seen the most rapid, and for our environment of land, water and air the most far-reaching, industrial and technical development, both in a beneficial and a detrimental direction. (This trend has slackened off slightly during the present decade.)

In short, the interaction between climate, man and nature is now very much more complex than it was only 25 years ago. This pattern of interactions, the 'ecoclimatic triangle' is illustrated in Figure 1.

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One aspect of the problem of climatic fluctuation which was mentioned at the symposium in 1951, but not touched on at all in 1976 is the *variability* of the climatic series (or crop and growth series, for instance) over a certain period.

In northern latitudes the growth processes depend on the annual variations in the summer temperature, i.e. the variation coefficient, or as I have called it in this connection the *'climatic hazard coefficient'* (see Hustich 1950) for growth series of different kinds tend to be higher towards the northern latitudes, a factor which has to be considered in all ecological studies. The climatic hazard coefficient (v), as understood by the author, is simple:

$$\sigma = \frac{\Sigma(x\text{-}M)^2}{n}\ ;\ v = \%\ \sigma|M$$

where M = mean, n = number of years, x = the annual values of a series, σ = standard deviation, v = variation coefficient.

The variation coefficient of the temperature series in Finland increases towards the north, as, of course, also do those for yields of cereals and tree growth. Climatic fluctuations also sometimes seem to exercise an *over-accentuated effect* on growth, as reflected in the higher variability of the crop and growth series than of the climatic series. This climatic hazard coefficient is a concept which should be of some importance in evaluating the problems of the relationship between climate, nature and the activities of man (see Fig. 1).

Figure 2 illustrates how the growth and crop series which in the northern latitudes are mainly influenced by the temperature, increase in variability towards the

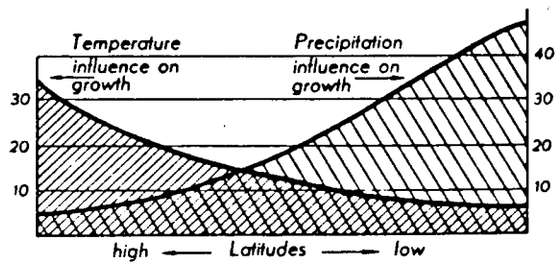

Fig. 2. Towards the north the main factor affecting growth is temperature. The temperature series (mean July or summer temperatures, etc.) show increasingly higher, as indicated by the numbers, variation coefficients (i.e. the climatic hazard coefficient; see the text) towards the north, as also do the growth series. At lower and drier latitudes precipitation influences growth more than temperature; it seems that the growth series mainly influenced by precipitation show comparatively higher variation coefficients.

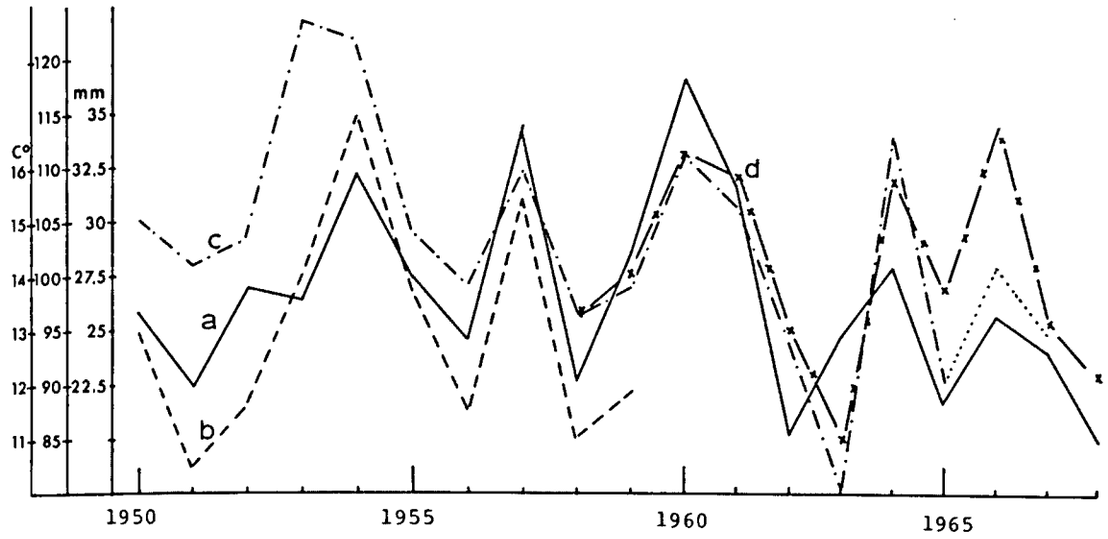

Fig. 3. Strong correlations may be observed between the temperature series (here the mean July temperature at Sodankylä, Northern Finland: a) and some growth series for pine: (b) radial growth in pine in northern Finland, after Mikola (1978) (c) length increment of secondary-order pine shoots (cf. Hustich 1969, p. 162) in northernmost Finland and Norway, (d) length of pine needles at the same localities as in (c). Note that the series (c) has been backdated one year in the diagram, since the growth in height and length of pine shoots in northern Finland depends very markedly upon the temperatures in the previous summer, i.e. a simple form of the 'lag effect' as described above. In spite of the long distances between the sites used for the growth series, the correlation with temperature is very clear, compare Fig. 2.

north. Towards the southern latitudes where the growth and crop series are influenced mainly by precipitation, the variation coefficient increases from the middle latitudes towards the lower and drier latitudes. Although drawn entirely from intuition (Hustich 1950), Figure 2 happens to indicate almost the correct variation coefficient for the precipitation series at the drier latitudes (see Hare 1976, p. 44). It is somewhat surprising, in fact, that so little interest until recently seems to have been shown in the concept of 'climatic hazard coefficient'.

The high variation coefficients of both the climatic and the organic production series implies that *we cannot rely upon data from one year alone or only from a few years* when describing climates or growth and production phenomena, particularly in the north or in areas bordering on deserts. Note, for example, the degree to which the July isotherm may shift northwards in good summers and retreat southwards again in bad ones. The biological consequences of this fact for Finnish conditions were probably first pointed out by Kujala (1927), when discussing seed formation in the pine at northern latitudes (see also Thomas 1960 with regard to northern Canada).

In addition to the over-accentuated effect of sudden climatic variations or fluctuations on growth and organic production (see below), we may also observe a 'lag effect'. This is depicted in its simplest form in Figure 3, which shows the one-year lag in length increment in the secondary shoots of pine in northern Finland and Norway (see Hustich 1945, 1969).

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Two kinds of short-term climatic change may be distinguished:

(1) *variations* in temperature, precipitation, hydrology, etc., occurring from year to year and measurable i.a. by the 'climatic hazard coefficient', as illustrated above, and

(2) longer, more or less periodic climatic *fluctuations* of the kind which occurred in the 1930's, for instance.

The periodicity (or quasi-periodicity, see Hare 1976, p. 39) of climatic fluctuations has long been a topic of great interest, such fluctuations having at times been related to sun spots, etc. Interest seems to have diminished more recently (note, however, Sirén 1961, Bray 1971, and others).

Recent discussion has been focussed extensively upon the effect of *human activity* on the climate and on climatic fluctuations, although as Hare (1976, pp. 92—93) points out, "at the macroclimatic level, i.e. the general circulation and its regional anomalies, the influence of man is not yet proven, though a variety of hypotheses have been put forward and defended".

He goes on to claim that "the role of man at this global level is still controversial, and existing models of the general circulation are not capable of testing the effects in a conclusive way".

In this connection it may be useful to recall the discussion entered into at the previous symposium, particularly the highly relevant remarks made by Erik Palmén (1952, pp. 52—53) and the late Kurt Buch (1952, pp. 53—55) concerning the increase in the amount of carbon dioxide in the atmosphere and its impact on the general circulation and possible relevance for any 'warming' or 'cooling' of the climate (see also Buch 1949, Heino 1978). Dunbar (1976, p. 190) writes that he finds "if difficult to believe that either Carbon dioxide in the atmosphere, water vapour, freon, or any other substance produced by man's efforts is going to compete seriously with Nature in changing our climate".

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The papers in this volume speak for themselves. They are written by prominent Finnish specialists in their various fields of science. There is, however, a marked difference between the approach adopted by some of these authors to the problem of climatic fluctuations and their effects on various aspects of nature and human activity, and the attitudes of the participants in the symposium held 25 years ago. The role of the climatic variations and fluctuations are now more in the background than in the papers published in 1952.

Heino's diagrams illustrate the exceptional nature of the climatic improvement experienced in the 1930's, but they also show clearly the slow deterioration which set in in the 1950's. The 1960's constituted climatically a rather unfavourable decade from man's point of view, while the summers of the early 1970's have again been more favourable, though not yet as markedly so as in the 1930's.

Heino also makes a comparison between the period 1961—75 and the 'normal period' 1931—60. But what is this 'normal period'? As the young climatologist Juhani Rinne asked in a pertinent newspaper article (Helsingin Sanomat, Sept. 15th, 1976), 'is the climate normal at any time?' Meteorologists use 30-year periods as norms (the periods 1901—30 and 1931—60) because they believe that over such a length of time the effects of annual variations and short-term fluctuations will be more or less eliminated, so that we obtain a type of average or 'normal climate'.

In Figure 4 I have placed the July isotherms for the period 1901—30 and those for the period 1931—60 together on the same map. The result is striking. The isotherms have 'shifted' markedly further north by 1931—60. The reason lies, of course, in the exceptional warm summers experienced in the late 1930's, even though this period (i.e. 1931—60) was mostly a rather unfavourable one, as Heino's data illustrate. The result would certainly have been quite different if we had compared, for instance, the periods 1911—40 and 1941—70.

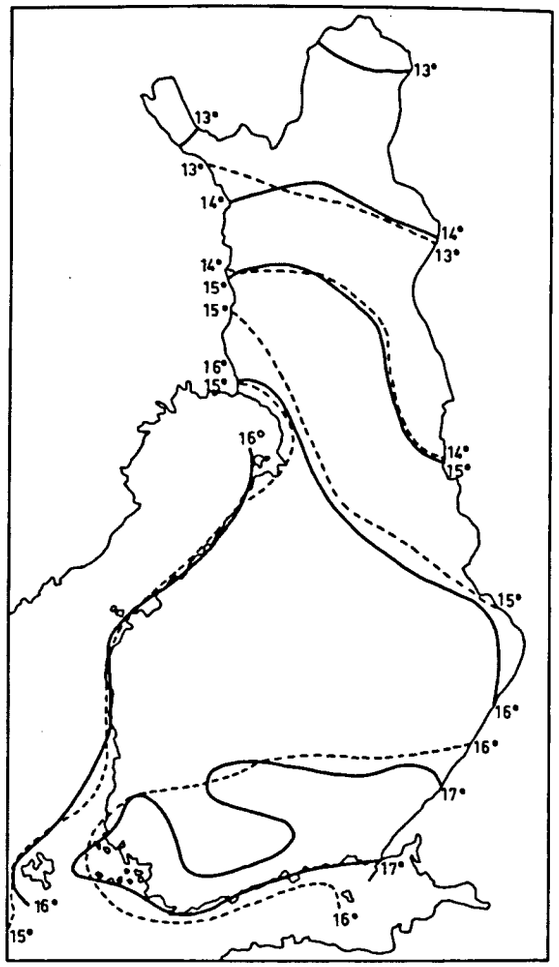

Fig. 4. Comparison between the mean July isotherms for the 'normal periods' 1901—30 and 1931—60. Note how the isotherm has 'moved' northwards (in 1931—60) by one degree (for discussion, see text).

The problem of how climatic factors influence ecological chains is one which is rendered more and more difficult by the increasing role played by human activities and the changing economic structure of modern society.

The influence of climate and the changing environment on breeding in certain bird species in Finland is discussed by v. Haartman. Against a background of many years of ecological observations, he streses particularly such factors as the destruction of the natural environment with increasing industrialization, the eutrophication of the lakes and new land use patterns. Nevertheless, there are many bird species which seem to be more numerous now than in earlier times, one reason being simply the greater amount of information available due to the larger numbers of observations. A similar experienced view of the complicated nature of the interactions which govern the 'ecological triangle' (see Fig. 1 above) was expressed during the previous symposium by Nordman (1952, pp. 60—68) regarding variations in the distribution of insects.

In 1956 Erkamo published an important paper dealing with the influence of the climatic fluctuation of the 1930's on the vegetation and flora of Finland, in which he described the northward shift in the distribution of many species and the northward extension of seed formation in some tree species. As he points out here, however, he has not been able to follow up his earlier observations. It would have been interesting to know, for instance, the extent of the backlash effect of the unfavourable temperatures of the 1950's and 1960's on the growth phenomena and distribution data which he discussed then. In his present paper he chooses to illustrate mainly the close correlation between phenological data and spring temperatures. In this connection the unpublished thesis by Johnson (1965) on the relation between climate and vegetation in Sweden is of interest.

Varjo's paper particularly stresses the fact that nowadays the general economic situation influences agricultural production both quantitatively and qualitatively to a greater extent than does the climate itself. The correlations between summer temperatures and yields per hectare are thus not as good as they were in former times (compare also Sandvik 1968). Varjo justifies this assumption by claiming that agricultural production in Lapland has decreased relatively more than the cooling of the climate in the 1950's and 1960's would in itself have warranted. Here it depends, of course, on which period we use for such a comparison, for as I mentioned above, the 'normal period' 1931—60 appears to be rather a favourable one *only* because it includes the exceptional warm phase of the late 1930's. A more important factor in Varjo's opinion is the combined effect of increased production costs and comparatively low market prices in recent years, which has forced producers in the north to use less fertilizers, thus further accentuating the effects of a number of poor summers. Conditions for agricultural production in northern Finland are thus less favourable nowadays than they were in former times mainly as a consequence of these economic factors. Varjo notes, however, that there is still a positive correlation between yields and climatic variations in the north of Finland. See Johansson 1954.

To the general problem of the relation between climate and agricultural production we must also add the complicated question of the over-production of cereals in Finland, a feature which did not exist 15—20 years ago, when the aim was to increase agricultural production. (In common with most developed countries nowadays, Finland has been suffering from severe over-production of agricultural produce for many years, the reduction in the consumption of bread in the daily diet being a factor of some importance in this.)

Man tries, of course, to neutralize or eliminate the effects of climatic fluctuations as a way of stabilizing cereal production. But it is i.a. easier to improve the quality of the soil than to neutralize climatic variations. In areas close to the northern limits of agricultural production or on the margins of steppes or deserts (see also Hare 1976) the effects of climate cannot be eliminated. And by the introduction of improved varieties we can only hope to soften the impact of a less favourable climate during the growing season.

An almost dramatic southward retreat has occurred recently in the case of the limits of cultivation of certain cereals which previously extended well towards to north of the country. This is illustrated in a map in Varjo's paper (p. 46). For comparison, see Valle (1952, p. 465).

Climatic fluctuations are indirectly related to the various practices advocated at different times for agriculture and forestry. Mikola gives (1978) a clear account of the correlation between such changes in forestry practices and the recent climatic fluctuations. Of particular interest are his comments regarding the failure of the reforestation projects in northern Finland in the 1960's, especially in 1962 and 1968, which he believed weakened the "physiological condition of the seedlings, making them susceptible to pests and diseases". In a previous paper Mikola wrote that the "bright optimism which had previously prevailed in regard to the prospects of forestry in Lapland was gradually replaced by serious concern" (Mikola 1971, p. 120).

Referring to the natural regeneration at the timberline on mountains in Finland which was a consequence of the climatic improvement in the 1920's and 1930's, Kallio has stated recently (1975, p. 24) that "thousands of seedlings from the latest warm

period in the low alpine belt in N. Inari and Utsjoki ... have been killed by freezedrying, a common ecological eliminator of pine". Thus the rather optimistic view of pine reproduction at the timberline given, albeit cautiously, for instance in my paper of 1958, has not entirely been fulfilled. This picture may again be changed, however, by the warmer summers of the early 1970's.

The opinions of the forest scientists regarding the question if the forest is retreating or advancing in the north (or how far northwards cutting of timber can by extended) are, of course, mainly based on the climate and growth in the period concerned. Thus, the opinions vary from time to time due to the climatic fluctuations. After some years with cold summers and poor tree growth, the opinions are rather negative, but after a period like the climatic 'improvement' in the 1930's the opinions were accordingly more positive, as I have illustrated in some of my earlier papers. As the paragraphs above show the opinions regarding, for instance, reforestation possibilities in the north tend to be negative today.

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When compared with the symposium held 25 years ago, that of 1976 demonstrated that

(1) The climate of the last 25 years has in general been less favourable. Whereas a melting of glaciers was noted in the 1930's and 1940's, subsequent decades have partly seen an increase in ice and snow cover.

(2) Interest in the study of the effects of climatic changes upon growth phenomena in nature and the primary production features of man's endeavours has waned over the intervening period.

(3) The earlier optimistic approach to the cultivation of cereals and the reforestation further north has given way to a more negative view, note i.e. recent changes in forestry practices and the retreat southward of the limit of cereal cultivation in Finland.

(4) The chain reaction between climate, nature and man (see Fig. 1) is becoming more complicated due to increasing industrialization and urbanization and the marked effects, locally at least, of the activities of man upon the climate. The discussion concerning the importance of the increased content of carbon dioxide in the atmosphere is still practically as vague as it was 25 years ago.

(5) There seems to be a feeling amongst scientists working in the field of primary production and in biogeography that climatic variations or fluctuations are of less importance than was thought some 20—30 years ago, i.e. a belief that man is able to neutralize the effects of climate to a greater degree than was previously thought possible.

(6) Over-production, an important controlling factor in agriculture in many developed countries today, was almost an unknown concept in 1951. At one time it was thought possible to base theories regarding economic fluctuations on variations in yields of cereals, and thus on climatic fluctuations. This does not seem possible today.

(7) Future research must nevertheless continue to take account of annual variations in climate, and also of short-term climatic fluctuations of the type discussed during the 1951 symposium, and to a lesser extent in 1976. The details of how climatic changes affect biological processes and the ecological chain systems still remain largely an unsolved problem.

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I finished my concluding remarks at the symposium 25 years ago with the words, "The recent climatic fluctuation has probably passed its culmen, as some of the above statements point out. But irrespective of whether the culmen of this climatic fluctuation has been reached or not, it can be assumed that the correlation between climate and its consequential phenomena will remain much the same century after century" (Hustich 1952, p. 117). The first part of this quotation seems to have proved correct, but the validity of the latter part remains a rather more complicated question, as the interaction between climate and the activities of man has become a so much more complex matter over recent years.

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