Great Historical Events That Were Significantly Affected by the Weather: 4, The Great Famines in Finland and Estonia, 1695–97

Abstract
In the years 1694 to early 1697, cold winters and cool and wet springs and autumns led to extreme famine in northern Europe, particularly in Finland, Estonia, and Livonia. It is estimated that in Finland about 25–33% of the population perished (Jutikkala, 1955; Muroma, 1972), and in Estonia–Livonia about 20% (Liv, 1938). As far as is known the population disasters associated with the famines of the 1690s in France, Italy, and Scotland; 1816–17 in western Europe; 1845–46 in Ireland; and 1867–68, again in Finland; were all notably smaller than those of Finland, Estonia, and Livonia in 1695–97. A reconstruction is attempted of the coarse features of weather conditions in northern Europe in the years preceding the famine. This is based on previous work by other investigators (especially Jutikkala), and on contemporary documents and literature examined by the present authors.

Records indicate that in the absence of an appropriate diet, the population consumed unwholesome and partly or fully indigestible foods which led to widespread diseases and epidemics (diarrhea of sorts, including lientery, dysentery, etc.). There were even some cases of cannibalism. The greatest rise in mortality took place in spring and early summer of 1697, when weather conditions were already in the process of improving. Somewhat paradoxically, city residents suffered less than the utterly poor landless peasants and small peasants. Many of the farms were abandoned during the crisis, either through the death of either all or some members of the family concerned, or through migration (and a lower birthrate). The number of people who turned to begging was massive. The abandoned farms were reoccupied, shortly after the crisis, by landless peasants and by others.

1. Introduction
In Part 2 of this series of articles, Neumann (1977) examined the effects of the drought of 1788 in France on the course of events leading to the revolution of 1789. The famine that arose in consequence of the drought may be described, in view of the ‘character’ of the weather conditions causing the drought, as a warm-dry famine. In the present paper we study a case where a famine was caused by weather conditions of an opposite character, viz. the cold-wet famine of the years 1695–97 in Finland and Estonia, including what was then called Livonia. And while in France’s case, the hunger conditions had but an effect, albeit an important one, on the events culminating in the great Revolution, the cold-wet famine of 1695–97 in Finland and Estonia made the event studied in this paper; namely the decimation of the population of these two countries either through prolonged starvation or through epidemics and other diseases promoted by undernourishment, unwholesome and/or indigestible food, contamination of water resources, etc.

Finland apparently was the country most severely hit by the cold-wet famine, losing between 25 and, perhaps, 33% of its population (Jutikkala, 1955, pp. 48 and 52–53). A more recent study (Muroma, 1972) puts the loss between 25 and 30%. At about the same time, Estonia lost about 20% of its population (Liv, 1938, p. 124).

The magnitude of the disaster suffered by Finland and Estonia in the 1690s will be better appreciated by comparing its consequences with those of other major famines in European history.

In the cold-wet hunger years of 1695–99, Scotland lost between 5 and 15% of its people. These figures result from the latest investigations by the Edinburgh economic historian Smout (1978, p. 181) who estimated that, to a rough approximation, half the loss was due to the increased death rate and the remaining half due to emigration (and a lower birthrate). The period was popularly called “King William’s Ill Years,” “King William’s Dear Years,” and the “Black Years of King William” (Smout, 1978, p. 164). In the Irish Potato Famine of 1845–46 about one million people, that is ca. 12% of Ireland’s population at the time, perished of starvation (Salaman, 1949, pp. 303–304). In the famine year 1867–68 in Finland about 8% of the population consumed unwholesome and partly or fully indigestible ‘foods’ which led to widespread diseases and epidemics (diarrhea of sorts, including lientery, dysentery, etc.). There were even some cases of cannibalism. The greatest rise in mortality took place in spring and early summer of 1697, when weather conditions were already in the process of improving. Somewhat paradoxically, city residents suffered less than the utterly poor landless peasants and small peasants. Many of the farms were abandoned during the crisis, either through the death of either all or some members of the family concerned, or through migration (and a lower birthrate). The number of people who turned to begging was massive. The abandoned farms were reoccupied, shortly after the crisis, by landless peasants and by others.


2 Historically, Livonia was a Swedish province for nearly a century, beginning in 1629. (See Fig. 3.)

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Bulletin American Meteorological Society

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population died of hunger and epidemics (Lefgren, 1973, p. 23). Thus, all the aforementioned dearth cases entailed a smaller population loss, percentagewise, than the disaster that visited upon Finland and Estonia in 1695–97. As far as European history is known, only the Black Death of the 14th century caused as high and higher losses (Abel, 1966, pp. 48–49) to any one nation as the 1695–96 hunger did to the northern countries. The famine of 1695–97 in Estonia is referred to by the Estonian historian Liiv (1938) as “The Great Famine in Estonia 1695–97.” In a rather similar vein the parallel famine in Finland is referred to by Jutikkala (1955) as “The Great Finnish Famine in 1696–97.” In some cases Finnish historians relate to these years as “The Years of Many Deaths.” It must be added, however, that so far as northern Europe goes, not only Finland and Estonia were afflicted. To a lesser extent Sweden (especially its northern region), Norway, and northwest Russia suffered as well (Liiv, 1938, p. 105). In 1697 the famine in Sweden was quite grave, though the demographic consequences of the famine seem to have been much smaller than in Finland (Heckscher, 1954, p. 81; Utterström, 1965, p. 538).

2. The general climatic setting

In climatic history the 1690s form part of a period known under the name the “Little Ice Age” (LIA). The limits of that “age” are often set at 1550 and 1850. As is known, never since the peak of the last major glaciation about 18 000 years ago, have the glaciers of Europe, Asia Minor, and North America extended so far; snow lay for months on Ethiopia’s high mountains (Lamb, 1966, p. 66).

In Europe, the 1690s were characterized by very cold springs and summers (von Rudloff, 1967, Fig. 22b), the somewhat uncertain estimate being that the average temperature for the decade was 1.5°C lower than that for 1580–1790. In France the years 1690–92 had springs and summers so cold and rainy that “with the harvest of 1693 began one of the worst famines western Europe had known since the early Middle Ages. It turned France into a ‘big, desolate hospital without provisions’ (the writer Fénelon’s words), a concentration camp of the size of a kingdom, with Louis XIV the commandant” (Le Roy Ladurie, 1972, p. 70). In 1695 the Po River overflowed meadows, fields, and destroyed crops, leading to a severe famine in the area. Lakes Zuerich, Constance, and Neuchatel froze completely and “one could travel over them as over a bridge.” There were ice floes in the Thames. These foregoing reports are from Weikin’s (1961, p. 510) invaluable collection of hydrometeorological excerpts from contemporary literature. A further reference to that volume shows that rivers over a great part of Europe were in heavy flood in 1695–97. Many of the rivers and lakes were frozen for comparatively long periods to late dates in spring.

Another aspect to the LIA worth emphasizing (in connection with what will be said in regard to the weather of the years preceding the years 1695–96 in Finland and Estonia) is the extreme variability of weather conditions in space as well as time. Thus while in the 1690s the glaciers of Iceland (and Norway) expanded (Thorarinsson, 1943, pp. 28–29, 38–47), those of the Alpine region were in temporary retreat. This retreat did not prevent the weather that produced other extremes such as the great famine in France, the famine in (northern) Italy or the “solid” freezing in winter and early spring of Swiss lakes. A series of good years was abruptly followed by years of inclement weather—one example for this being the case of Finland (see Section 4).

3. Sources of information on Finland

What we know about the Ice Ages, and especially about the climatic fluctuations in recent centuries, indicates that the “amplitude” of the fluctuations tends to increase poleward. On this basis, therefore, we would anticipate that in the 1690s the climatic conditions in northern Europe should have been even more inclement than they were in the middle latitudes. There are no contemporary meteorological observations for northern Europe such as those began toward the close of the 17th century in England and France. Tree-ring analyses are, however, available for Finland, due to the early work of Boman (1927) and the more recent investigations of Sirén (1963), and these will be referred to later. Sporadic remarks on some of the weather events of 1695–97 are available in a number of different types of documents such as:

a) Reports of the Swedish Governors or Vice-Governors to the King of Sweden (Finland and Estonia were then parts of the Swedish Empire);

b) Sheriffs’ and Bailiffs’ reports;

c) Petitions of peasants to landowners (most of the great landowners resided in Sweden), and of the clergy and of peasants to the King;

d) Minutes of court proceedings. In 1696–99 many of these court cases arose out of farmers’ pleas for tax relief on the grounds of crop and property losses due to severe weather conditions. The Swedish Administration was rather firm in exacting the taxes (the same applies to the Crown as “owner” of state lands as well as to the great landowners, usually titled people, in their relation to the payment of rents by tenants) and unless a court sanctioned a tax relief, no quarter was given. The courts were “mobile”; that is, the proceedings usually took place in locations close to the ap-
applicants’ residence. Also, there was a jury composed of peasants, and in some cases witnesses, in court. In view of all these circumstances and checks we believe that the statements made concerning extreme weather conditions deserve credence.

e) Another source of information is the register of deaths, many of which have survived. In the fateful year of 1697 some parishes, e.g., Nastola and Loppi in the province of Tavastia (Finnish name: Häme) central Finland (see Fig. 1), registered eight times more deaths than in 1696; in 1693 in the Jääskö parish, Karelia (near Lake Ladoga, see Fig. 1), there was a total of 40 burials; in 1697 the figure rose to 1029 (Koskinen, 1866, p. 74). It is true that quite a few of the death cases were those of beggars coming from other areas of the country. And while the latter fact is not material from a national point of view, the great rise in the number of beggars is in itself an indication of difficult times.

f) Rolls of poll tax and tithe payers. An abrupt drop in the number of tax and tithe payers can be associated with catastrophic events, such as a major famine and associated epidemics. Jutikkala (1955) and other historians have drawn suitable information from such rolls.

g) Reports of peasant disorders in times of hunger, manifesting in looting of manors and storehouses. Some official reports on such disorders have been preserved (Forsström, 1891, pp. 259–260).

We have drawn on most of the above records. In many cases our work was aided by the fact that some of the records were studied previously and published by Finnish scholars.

Other “records” are reports published many years after the hunger years. Cases in point are the reports published in the magazines Åbo Tidningar 7 (1793, issues Nos. 38–40, 42), and Borgå Tidning (1842, issue No. 12).

4 Registers of births and marriages, too, can be useful as a source of information. See, e.g., the work of Smout (1978, p. 180–181) in regard to Scotland’s years of hunger in the 1690s.

5 Many of the original registers of deaths for the Tavastia province are to be found in the Provincial Archives, Hämeenlinna. In some cases, as e.g., in Loppi’s case, these registers are called ‘Account Books’ since they record, among other data, the fees paid for the funerals (where a fee was paid).

6 The names of the dead beggars were not entered in the registers. The records only say that on day so and so, so many beggars were buried.

7 It is generally assumed by Finnish historians that the articles in the Åbo Tidningar are based on material from the Turku Chapter Archives. These Archives were destroyed in the great fire of Turku in 1827. (Turku’s Swedish name is Åbo.)

FIG 1. Finland and her provinces at the end of the 17th century.

4. General characteristics of the weather in the 1690s, and agricultural operations

Sirén’s (1963, p. 19) curve of fluctuations in tree-growth rates at the northern forest limits of Scandinavia indicates that the decade 1685–94 was favorable to tree growth. A reference to Sirén’s paper shows that the years 1689–94 form one of the best pentades for the entire series that begins with 1181. The information available in regard to crops tallies, in a qualitative sense, with the inference drawn from the rings up to 1692, but not quite with the information on hand for 1693–94.

Thus the Åbo Tidningar’s issue No. 38 for 1793 says that in the years before 1694 the harvests in Finland were good, that there was a surplus of grain and that as a

8 We have mentioned in Sections 1 and 2 Scotland’s “Ill Years” 1695–99 (according to others, from 1692–99). Before these years Scotland, too, experienced good years. Smout (1970, p. 154) says that between 1600 and 1660 there were 17 dearth years, most of them between 1630 and 1650. “Then apparently quite suddenly, there was an improvement. Between 1660 and 1695 only four were marked by high prices, and the rest were distinguished by remarkably low grain prices.” These sudden shifts further emphasize the point made in Section 3 about the LIA, viz. the extreme variability and the abrupt changes in the weather characteristics.
result the peasants had to stand for days in the market to sell the grain at a low price. As a further illustration of the abrupt change that Finland was to face in 1695–97, we shall quote some lines from Topelius, the Finnish historian and storyteller (1818–98) who is especially famous for his volumes "The Surgeon’s Stories," many passages of which are based on fact. Topelius (1883, pp. 339–340) writes that in the years 1689–93 "... all lived for the day only; nobody thought of the future. No general storehouses were established, no supplies were kept; the birds of the air devoured the wasted grain, and mankind enjoyed the days ... and then the calamity fell, heavy, quick and unexpected over the Northern Lands."

The above accounts of cornucopia before 1694 do not accord with inferences drawn by more recent and critical investigations. The historian Jutikkala (1957, p. 343) states that the crop of 1693 was meager and that drought and frost afflicted the barley. Also, the historian Luukko (1967, p. 664) says that the summer of 1693 was dry and then a frost destroyed the inadequate harvest; Kallamauto (1976, p. 95) states that the harvest in 1693 was below normal. It may well be that the story of a good harvest in 1693, published 100 years later in the Åbo Tidningar, which may have been the source (or one of Topelius’ sources) was due to the fact that after the disastrous years 1695–97, even the not-too-abundant harvest of 1693 took on the appearance of plenty. Further, it would appear that tree-ring data cannot always be taken as safe indicators of crop conditions. It is known that in high latitudes such as those of Finland, temperature is the prime factor for tree growth and, if the spring and most of the summer are favorable temperaturewise, a frost in August will not affect the total annual tree growth, while the same may critically damage crops.

The marked change in weather conditions that set in about 1695 adds color to the point made in the foregoing section about the extremes of weather during the LIA. The beginning of 1695 is said (Topelius, 1883, p. 340) to have been colder than any winter since 1658. Parish registers mention, according to Topelius, that the wolves attacked people in their houses. Spring came late and it was a cold spring, so much so that sowing could not be finished before midsummer, leaving too short a time for maturation. The summer too was cold; the cereals could not ripen before a killing frost came. According to the earlier quoted issues of the Åbo Tidningar, in Uusimaa (Nyland, in Swedish), the province adjacent to the Gulf of Finland, the rye did not "blossom" before July’s end, and a frost in September11 destroyed the half mature grain. In the good agricultural area of the province of Tavastia, the harvest did not amount to more than about one-third of "normal" (Jutikkala, 1957, p. 344). The autumn was rainy and in many areas it was impossible to carry out the winter sowing. And where this was possible, the lack of seed in sufficient quantities spelled still less grain for 1696. Referring back to Sirén’s (1963) work, his data show for 1695 a notable drop in tree-growth rate. Tree-ring and crop yield agree now in indicating unfavorable conditions.

Strangely enough the first months of 1696 were mild. On 2 February grass of finger length was seen at Stockholm (Topelius, 1883, p. 341). It appears that there are at least three sources indicating that this pernicious winter mildness occurred in Finland and in Estonia too. Ahvenainen (1970, p. 114) quotes statements to the effect that at Rovaniemni, northern Ostrobothnia, an area of Finland almost on the arctic circle, in 1696 "the seasons were in the wrong order." Laurinnäki (1957, p. 147) says that in Uusimaa province, north of Borgå, the 1696 spring came very early, the snow and ice melted, trees and bushes turned green, but in March a new winter set in. Also the Estonian historian Liiv (1938, p. 105) says, without quoting his sources, that the extraordinarily snowy early winter of 1695–96, which halted forest work and traffic, was interrupted in January 1696 in Estonia as well as in Sweden and Finland, by a thaw, the fields turning green. Then on 7 March, there was a renewed cold outbreak (Topelius, 1883, p. 341). Lakes and bays froze again, the ice cover being so thick that people drove across them. Spring arrived late, and the summer was rainy so that the crops were slow in ripening. On the night of 17–18 August (Gregorian dates are used by us throughout) a frost occurred, followed two weeks later by four night frosts in a row. The first frost, 17–18 August, was so severe that in the morning the ears of

11 Issue No. 12 of the Borgå Tidning for 1842 says that the damaging frost occurred in August. It is possible that this apparent difference is due to the fact that in those days the "old style" (Julian) calendar was in use, which at the end of the 17th century was 10 days behind the sun.

12 A mild winter period could have been produced by a blocking anticyclone over eastern Europe and much of Asia, being associated with a southerly flow over western and central Europe. Such a flow would carry relatively warm air to northwestern Europe. Prof. E. Holopainen (Dept. of Meteorology, University of Helsinki) drew our attention to the fact that such a situation occurred, e.g., in February 1974 (see the sea level pressure and temperature anomaly charts in the "Die Grosswetterlagen Europas" (1974)). The temperature anomaly chart, p. 9, indicates that the average of the month for Finland was 6–8°C above "normal."
cereals were found coated with a layer of thick ice.\textsuperscript{13} According to Abo Tidningar (1793, No. 38), the second frost affected the whole of Finland, finishing off crops. There was almost nothing to gather in at the harvest. Referring once again to Sirén’s (1963, p. 19) paper, we note that in 1696 tree-growth rate exhibits a drop, continuing the decline that started in 1695.

The year 1697 began cold and the spring was dreary (Topelius, 1883, p. 344). The rest of the year was more favorable weatherwise, as is suggested also by Sirén’s data, which now show an improvement in growth rate. But there was virtually no seed for sowing. Besides, 1697 was “The Year of Many Deaths,” especially the spring and early summer; see Section 7, which follows.

The minutes of court proceedings, in many cases going back to the 17th century, have been preserved from several districts of Finland. They are stored either in provincial archives or in the Finnish National Archives (FNA). As was pointed out in Section 3, many of the court cases deal with pleas for tax relief, based on damages due to severe weather, and thus these cases provide information on individual weather events of a severe nature, such as heavy rains, floods, hail, frost, etc. Another unusual feature of the period was the occurrence of severe hail. The interest in hail cases is all the greater as in recent times in Finland hailstorms are not frequent and, moreover, cases of unusually large hailstones are not known.\textsuperscript{14} Since the growth of hail-

\textsuperscript{13} Franssila (1949, pp. 228–229) states that night frost occurs (presumably, Franssila means ‘radiation frost’) mainly in an arctic air mass and that during spring and autumn it is observed also in polar air masses. Specifically, Franssila (p. 228) says the following: “Jurva (42) has studied in more detail those weather situations, in which night frost occurs. According to him night frost is observed in Finland mainly in the rear side of depressions of the arctic front. If the low is followed quickly by a high pressure area, in which the sky clears up and the wind calms, the conditions for the occurrence of night frost are favorable. On the other hand, if the high pressure has time to become relatively strong, night frost is usually avoided. In spring and autumn, however, night frost is observed even in cases of strong highs.” It is likely that the severe August frost, and possibly also the September frost in Finland in 1696, occurred either in arctic or in polar air masses where the temperatures and humidities were very low across a thick air layer, from the surface up to some nonconsiderable altitude in the troposphere, promoting the development of severe radiation frost conditions near the surface. In this connection we wish to acknowledge the discussions with Professors (Erik) Palme and Holopainen. A publication of the Finnish Meteorological Institute (Harjama and Laitinen, 1970) indicates that frost conditions occur as early as August in Finland, even in the more southerly areas of the country. That study (p. 47) shows that at Tampere Airport, the site of which was in Satakunta province in the 17th century, in the second half of August 1951–60 screen minimum temperatures of 0.9—1.1°C (the class interval of the lowest observed minima) occurred on a total of 3 days (0.6% of the days). The “ground” minimum temperatures would, of course, be lower, perhaps by 1–3°C, depending on the surface, i.e., the corresponding ground minimum could be, say, 0—4°C. However, the heavy ice cover said to have developed overnight in August 1696 on cereal ears is likely to indicate a much lower minimum temperature.

\textsuperscript{14} We owe this information to Dr. U. I. Helmikä, Director Finnish Meteorological Institute.

5. Population and livelihood in Finland

Finland is lacking in reliable population statistics for the years prior to the institution in 1749 of “Tabellverket” (“The Tabulation Work”), i.e., the collection of demographic data, and there are several outstanding problems relating to estimates of size, age, structure, and fluctuations in population. However, some attempts have been made, mainly by Jutikkala and some of his pupils. They have chiefly used church registers and fiscal sources of various kinds. It is estimated that in 1690 Finland’s population amounted to about 440 000 (Muroma, 1972, p. 244).

Finland was during those days a society based on agriculture, with low urban development, poor communications and transport. Agricultural techniques were primitive and the simplest way of increasing pro-

\textsuperscript{15} Although this case does not seem unusual in light of present-day experience, we have included it because of the term “unusual” appearing in the court records.
duction was by extending the area under cultivation (Muroma, 1972, p. 244). In years of "normal" harvest the supply of food matched the demand and in conditions of peace, such as occurred before the 1690s, the population was growing.

There are no estimates for the country as a whole of the magnitude of agricultural production either before or during the famine years of the 1690s. It is known, however, that in 1695-97 the harvest amounted to 40-50% of "normal" in Ostrobothnia (Luukko, 1967, pp. 664-665) and, as was already mentioned towards the middle of Section 4, to no more than one-third in the good agricultural area of Tavastia (Jutikkala, 1957, p. 344).

The agricultural productivity of Finland is, like probably all countries in high geographic latitudes, very sensitive even to small changes of climate. Long and severe winters, cool and wet springs and/or summers profoundly affect the growing of crops. For a detailed description of the effects of harsh winters in high latitudes on agriculture and cattle breeding, see a paper by Utterström (1961, pp. 184-188). During severe winters the cattle had to be kept indoors for a long period, often with fatal results. In 1693 some cattle disease was raging in southern Ostrobothnia and in the eastern parts of the country, causing a reduction in the number of heads of cattle. We are told (Luukko, 1967, pp. 664-665) that the people of Tavastia already in 1695 and 1696 slaughtered their cattle and horses. A reduction in the number of cattle entailed a loss of manure (the production of milk and meat from the cattle was marginal in Finland of the 17th century) for the fields on which the all-important staples of rye and barley were raised.

One may ask: How is it possible that in a country like Finland that abounds in forests, lakes (some 62,000) and sea area, the people could not find enough wild animals, birds, and fish on which they could subsist? The answer to this appears to be in that even short-term disturbances upset the ecologic balance of the fauna. During snowy and hard winters, the elk and hare, the two most important species of game, have difficulties in finding forage. A cold early summer reduces the black game—the hatching of eggs is disturbed, and there are not enough insects to feed the nestlings. Thick ice covers over lakes and sea areas, making fishing difficult. A cold summer with a poor crop of plankton has pointed out to us (September 1977) that soil having a high content of organic matter (such as is likely to be the case with old well-established farms) has a higher water-holding capacity than soils poor in organic matter with the consequence that the soils of such farms are likely to suffer less from excessive rains.

Dr. G. Stanhill (Div. of Agricultural Meteorology, Volcani Center, Agricultural Research Organization, Ministry of Agriculture, Bet-Dagan, Israel) has drawn our attention to the fact (letter of 11 October 1977) that a number of agricultural practices, in particular those which increase the depth of the root zone and its store of available water or plant nutrients, have the effect of "weatherproofing" agriculture and points to the Broadbalk experiment at Rothamstead, England, where, on a plot receiving a heavy dressing of manure each year, wheat crops are grown continuously for some 150 years, with a relatively high average yield and a low coefficient of variation of yield (we may add: despite the climatic fluctuations of the past century and a half); see Stanhill (1976, pp. 6-8). It stands to reason that in Finland of the 1690s, old, well-established farms, run by experienced farmers, had a higher degree of "weatherproofing" than did new farms.

6. Food supply in Finland

In consequence of the repeated crop failures, the overwhelming majority of the population had to live on unwholesome diet, such as bark bread, straw, nettles, hay, ground mast, husks, moss root of marsh-calla (calla pallustris), etc. (Abo Tidningar, 1793, No. 39; Topelius, 1883, p. 343). Cattle as well as horses had to be slaughtered, dog and cat meat was consumed (Lappalainen, 1967, p. 347; FNA, Grievances of the Peasants of the Upper Hololla District, dated 4 November 1697). Additionally, the shortage of salt made it impossible to preserve any meat or fish available. The shortage of salt, too, was a consequence of the inclement weather conditions in Europe at the time. As a rule, the Baltic countries obtained their salt supply from southwestern Europe and, in particular, from Setúbal, Portugal. A contemporary review of historical events, the Theatrum Europaeum (1702, vol. 14), states that because of persistent rains salt production was reduced at Setúbal and at Bordeaux, France. (Setúbal is quoted in the Theatrum under its French name, viz. St. Yves.)

Thefts of food were on the increase. For instance, records for Virolahti (near Viipuri, Viborg, in Swedish) state that four cases of such theft were brought to court (Kaukiainen, 1970, p. 314). In Helsinki, the burgurers had to protect the Crown granaries from looting peasants. Cases of storming and plundering of manor houses took place as, for instance, in northern Karelia (Suolahti, 1950, p. 402; Saloheim, 1976, p. 335). Even during a normal harvest the landless population sometimes had to eat bark bread. It is, therefore, natural to suppose that this population class had the worst starting point. But soon the food shortage spread to the peasants. Distress prevailed among the clergy as well. We have a document, e.g., from northern Ostrobothnia,
The severe hunger seems to have led to some cases of cannibalism. In 1697, the clergy of the province of Ostrobotnia submitted a petition to the King and the Diet (in Stockholm) describing their difficult situation in those days of starvation and large number of funerals. The clergy say, among other things: "Parents ate the corpses of their children, and children of their parents, brothers and sisters." This petition is reproduced in full in Simolin (1916). Other cases of cannibalism are on record, e.g., a court-documented case in northern Karelia (Saloheimo, 1976, p. 333).

7. Famine, mortality, and diseases (epidemics and other)

By 1696, a rise in mortality rates began in some parts of Finland. The really sharp rise took place in 1697, and it was then countrywide. Earlier, in Section 1, we cited Jutikkala's (1955, pp. 48–53) estimate that in the 1696–97 famine, between about 25 and 33% of Finland's population perished. We have also stated that a reexamination of various records by Jutikkala's pupil Muroma (1972) confirms the earlier assessment, and puts the loss between 25 and 30%. The various provinces of the country were not affected at the same rate; there are clear regional differences. Figure 2 is a reproduction of Muroma's results. The picture put forward by him seems to be justifiable, with the possible exception of the eastern parts of Finland, for which the documentary evidence is inadequate. It is possible that the estimates for these areas are somewhat high.

In 1696 the mortality rate was increasing strikingly in the northern parts of Ostrobotnia and Savo, to reach its peak in June–August (Muroma, 1972, pp. 240–244). The food shortage forced the population of that area to leave. Crowds of beggars were on the move towards southern Finland, Russia and, to a certain degree, Sweden and Norway (Ahvenainen, 1970, p. 115; Luukko, 1945, p. 128). Similar increases in the number of beggars were experienced in other countries in years of famine, as, e.g., Scotland during "King William's Ill Years" (Smout, 1978, pp. 169–171); France in the famine of 1788–89 (Sée, 1927); several countries of western Europe in the famine that followed the summer of 1816, "the year without a summer" (Post 1977, pp. 86–97); and, to return to northern Europe, Estonia in 1695–97 (Liv, 1938, p. 106).

During the following winter and spring the death toll of the country reached close to 30%. The toll was lower in the southern and southwestern sections of Finland. The lowest mortality rate appears in the Aaland Islands (Muroma, 1972, pp. 244–246 and Fig. 2 in this paper). Altogether there is a tendency for the rates to increase from the southwest toward northeast. This may be a consequence of the mitigating effect of the sea areas in the southwest and south; but it may be connected in part with the "climatic-change gradient" already referred to.

In many areas the peak of the death rate was reached in April–May 1697. Some examples follow. We have mentioned in Section 3 the cases of Loppi and Jääski. In 1695 Loppi had about 800 inhabitants (Kallenauto's 1976, p. 97, estimate: 850; Muroma's 1972 figure: 700); Jääski about 4,000 (Muroma, 1972, p. 215). According to the Account Book, which includes the death register of Loppi parish in the province Tavastia (see Fig. 1 for the location of that province), on 8 May 1697 17 persons were buried, among them three unknown beggars. For 12 May there is an entry telling us that five children of the farmer Jöran from the farm Heickila in the village of Sadeniemi died of hunger. The wife of Jöran's brother also died (HPA, Account Book for Loppi for 1669–1707). According to the register of Jääski parish, on 12 April 1697 in Karelia, 150 mostly unknown persons were buried into a deep and wide grave in Jääski's churchyard (FNA, Copy of Jääski's Death Register for 1697). As a result of the many funerals, in at least in one township the churchbell cracked (Suvanto, 1954, p. 147).

Was the direct cause of the many, or most of the many, deaths starvation or epidemics? This problem is just one particular case of the general problem discussed in the literature on demography and famines. Eversley (1965, pp. 52–53) presents arguments in favor of the famine-epidemics-death chain of events; most recently, Post (1977, ch. IV) marshals arguments based on medical investigations in support of the existence of a noninfectious "starvation disease" or "famine disease," which is thought to be the direct cause of at least many of the deaths that occurred in cases of major famines of past history.

In preindustrial societies epidemic crises did, of course, occur without being associated with famine. Such a case on record is Finland in the year 1737. On the other hand, there were some famine years which did not lead to epidemics (Meuvret, 1965, p. 512). Utterström (1965, p. 545) believes that in high latitudes the highest death rates are attributable to a conjuncture of crop failures, severe winters, and epidemics.

Some light is shed on the relationship between epidemics and starvation by investigations of conditions in the German concentration camps of World War II. In these camps diarrhea was the most common cause of "natural" death among the prisoners, according to
Helweg-Larsen et al. (1952, pp. 124–133). The same authors say that the diarrhea concerned was not of a contagious character; they believe that it was a direct result of starvation, being one case of the different types of "famine disease."

In the fragmentary descriptions of the diseases raging in Finland during the famine years, there are references to swollen legs, arms, etc., which, we believe, are possibly manifestations of edema (Ilmoni, 1849, p. 266); i.e., an abnormal accumulation of serous fluid in some
tissues, etc., causing swelling and distention. It usually occurs after a more-or-less prolonged starvation and, in particular, it is due to protein deficiency. Individual variations of the disease are great; it can develop also at a time when the nutrition situation is in the process of improving (Helweg-Larsen et al., 1952, p. 95).

The death register of Naantali, a small town north of Turku, provides information on the ages of the persons buried and, in some cases, on the causes, or rather the presumed causes, of death (FNA. Copy of Naantali’s Death Register for 1696–97). The vicar was not likely to have been an expert in determining the cause of death; moreover, the ages given by him for the grown-ups must be taken with reserve. There are 68 cases listed for the period 22 April 1696–30 June 1697. The most common cause reported is lientery, a diarrhea produced by indigestible, or partly indigestible food. The number of lientery cases registered is 16, the next “largest” group being dysentery. The age distribution indicates that these diseases chiefly hit those physically weak. All the eight cases of dysentery were those of children under the age of seven; nine children under the age of six died of lientery. The rest of the lientery cases were those of persons between 50 and 65 years of age. Characteristically, the first lientery death took place in October 1696, the last one in June 1697.

Interestingly enough, it seems that percentagewise the cities lost less of their residents than did the countryside. It is estimated that Turku lost about 10% of its population, while the surrounding parishes lost considerably more. Muroma (1972, p. 160 and p. 247) estimates that in Helsinki the total number of deaths amounted to 640, of whom 453 were from parishes outside the city ‘proper,’ where the term ‘proper’ or the city ‘proper’ means Helsinki parish. Viipuri (Viborg, in Swedish) shows a similar situation. The Estonian historian Liiv (1938) indicates that the established residents of the capital Reval (Tallinn, in Estonian; see Fig. 3) were much better off than the country people. All the above comes as a surprise, for it is known that in old times starvation was the scourge of the countryside. However, during the era of mercantilism, i.e., the economic trend common in Europe during the 17th century (and beyond), cities enjoyed a monopoly trade network while the frequently recurring epidemics were the curse of the cities. However, he has not paid attention to the important question of immunity and differences in immunity between city and rural residents.

In the precrisis years the small parish of Loppi in Tavastia province had about 800 inhabitants, the authorities for this figure having been quoted earlier in this section. Loppi’s Register of Deaths shows 26 entries in 1694, 24 in 1696, over 300 in 1697 (Kallenautio, 1976, p. 95, gives the figure of 322 dead in 1697), and 7 each in 1698 and 1699. Thus, during 1696–97 a total of some 350 were buried in the parish. If the necessary allowance is made for the not inconsiderable number of nameless beggars who died while in ‘transit’ in Loppi, the number of Loppi-parish residents who perished in the years of famine comes to over 200, which is about the number of people who died in the same year in Helsinki parish (see the figures cited a few lines above based on Muroma’s work), which in 1695 had, according to Muroma’s (1972, p. 160) estimate, 2100 residents. Considering that a number of people would have died a ‘natural’ death (about 25 in Loppi, judging by the above-mentioned figures for 1694 and 1695), and that this figure must have been much larger in Helsinki’s case, the discrepancy between Loppi and Helsinki becomes even more pronounced.

The remark “starved to death” is found in many of the death lists. Descriptions of edema have been preserved, and those of a smaller number of lientery and other diarrhea cases. These entries might be indicators

Fig. 3. The Baltic provinces Estonia and Livonia of the Swedish Realm at the end of the 17th century. Ingria, another province (of a relatively small size) of the Realm lay to the east of Narva. The Estonian name of Reval is Tallinn, that of Dorpat is Tartu.
of a 'famine disease', since its most important symptoms are emaciation, edema, and diarrhea (Helweg-Larsen et al., 1952, p. 74). But besides the "famine disease," endemic diseases and epidemics were raging, although the data do not enable us to distinguish between the different causes of death. Jutikkala (1958, p. 193) has suggested some type of typhus, a suggestion based on the fact that in some cases grown-ups and children were affected alike. In view of the defective sanitary conditions, the outbreak of typhus is likely (Salaman, 1949, p. 304). In addition to typhus, types of endemic diseases seem likely as a consequence of the increased geographic 'mobility'. The inappropriate diets previously mentioned must have enhanced the death rate.

A common feature of the diets mentioned is their low nutritive value combined with a richness in indigestible fibers. This leads to a swelling of the stomach and intestinal hemorrhage. If such a diet is not changed, death will often follow. Reindeer lichen, which also was 'consumed', contains an acid that causes symptoms of a similar kind. Neither the marsh-calla nor its relations are suitable as food for human beings. (Information received from MMK Ala-Fossi, Dept. of Food Chemistry and Technology, University of Helsinki.)

8. Some social consequences of the famine in Finland

The most serious consequence of the famine was, of course, the large reduction in population. But the famine had other consequences as well. Among other things, it resulted in an increasing number of abandoned farms. In some cases either the whole family perished, or the surviving members of the family moved away; in other cases, the owners could not subsist any longer and took to migration.

The essential problem for the Crown was to find new inhabitants for the abandoned farms as soon as possible in order to get tax income. The Crown was, as usual, badly in need of funds, this time because of the Great Northern War (1700–21). Already before the famine some farms had been unable to pay the taxes, and their situations became worse during the famine years. If the Crown had little hope of receiving the unpaid taxes, the alternative was to take over the farms and to find a new inhabitant. Some farmers survived the famine but were unable to pay the taxes. They left the farm and joined the army or went to work for an estate. The rapid resettlement of the farms is a striking feature in the process. Already in the early 18th century the number of abandoned farms was quite low. The new inhabitants were recruited from among the farmer population (younger sons got a chance to have a farm of their own). The landless population was a creation of the 17th century when a greater differentiation took place in the agrarian society. We have to calculate a substantial loss within this lowest class during the famine and now it more or less disappeared, being one of the major social consequences of the famine.

9. Estonia

Our main sources of information on Estonia (including Livonia, see Fig. 3), are:

a) The excellent book of the Estonian historian Otto Liiv (1938). Most of the introductory text of this book is in Estonian, but there is an extended 'Referat' in German (pp. 103–130, about one-third of the length of the Estonian text), and what is of particular importance, Liiv reproduces a large number of contemporary documents and records, or parts thereof, many of them in German and Swedish (pp. 133–189).

b) The posthumously published chronicles of the pastor Christian Kelch (1875, pp. 42–48) who went through the events himself. Kelch was born in 1657 and died in 1710; Liiv was born in 1905 and died in 1942.

The information on weather events in Estonia is less than what is available for Finland, but it indicates a good deal of parallelism in the outline features of the main events, which is not surprising. Abel (1974, p. 164) quotes reports by the (Swedish) Governors General of Estonia to the King in Stockholm that the harvests of 1692 and 1693 were poor, the winters too long, the summers too short, the peasants had to borrow grain, and many of the fields were left unattended to, partly because of the long winters and partly because of the lack of seed in adequate quantities. Also Liiv (1938, p. 103) remarks that the harvest was already poor in 1694. The foregoing statements tally with the report cited in Section 4 that in Finland in the years 1693–94, just preceding the Great Hunger, the harvests were below "normal." Both Kelch and Liiv say that the summer 1695 was overly rainy; rain fell most of the time from Johann's Day (June 24) to Michael's Day (September 29), flooding the low-lying lands and destroying the hay and crops. Thus Estonia faced hunger, and what was no less grave, there was hardly any seed for the autumn and spring sowings.

The first part of the winter 1695–96 was very cold and the snow high, halting work in forests and the traffic. But early in 1696, there came a thaw (Liiv, 1938, p. 105), "as did in Finland and Sweden," (see Section 4). The winter returned in March (again, see Section 4) so that it was not possible to sow with the seed available before May's end. Then the heavy rains of the summer ruined the harvest. The total harvest did not amount to more than about one-fifth to one-fourth of the seed. It is probably a good indication of the magnitude of the crop failure that the Reveals (name in Estonian: Tallinn) merchant B. Rodde was forced to report to London that Livonia and some other areas could supply only about 3% of the "normal" flax harvest (Liiv, 1938, p. 106). Shortly after summer there was no hay to be had for any money. Many of the destitute, hungry peasants, and dismissed farmhands and servants (landlords could feed them no longer) took to begging. Even a few
members of nobility were reduced to begging (Liiv, 1938, p. 111).

Already in autumn 1696 the famine became terrible, and in October there was a pronounced rise in the death rate. Several documents use the expression “the peasants died like flies” (Liiv, 1938, p. 108). Bodies of the dead were lying everywhere. Winter 1696–97 was so harsh and the snow so high that the corpses were left unburied until spring when they were put into mass graves.

As in Finland’s case, some instances of cannibalism took place (Liiv, 1938, p. 107). Also as in Finland, some cases of plundering of storehouses and manor houses occurred. In desperation, some people revived pagan rites imploring the deities to alleviate their plight (Liiv, 1938, p. 118). It can be seen from the above sketchy account that the major weather events and famine visiting upon Estonia were largely parallel to those of Finland. However, the great rise in deaths had already occurred in Estonia in autumn 1696, whereas the rise in Finland took place mainly in 1697 (see Section 7). This is all the more astounding, at first sight, as Estonia and Livonia counted as granaries of the Swedish Empire and, in fact, large quantities of grain were shipped from the Crown warehouses to Sweden and Finland. But Estonia and Livonia occupied a low position in the King’s priorities. Liiv (1938, p. 115) cites repeated royal instruction saying that the local residents should be supplied with grain only if any is left after the shipment of amounts earmarked for export (to Sweden and Finland). Despite the urgings of the Governors of Estonia and Livonia, the King and his Government in Stockholm did not relax their policies before 1697. But what was then given out came too late and, in any case, was not enough. The great shortage of food supplies is further illustrated by the fact that when in 1697 the young Peter the Great went on his first visit of the West and passed through Livonia with his retinue of 250 (+ horses), the Swedish Governor General of the province had to apologize for the inadequate provisions that he could offer to the Tsar and his entourage and for the fodder for their horses. In 1700, when Peter the Great declared war on Sweden (The Great Northern War, 1700–21) the Tsar made these incidents one of the main pretexts for the war (Grey, 1962, p. 100).

Liiv (1938, pp. 123–124) estimates that in Estonia and Livonia the total number of deaths due directly or indirectly to starvation amounted to 70,000–75,000 out of a population of 325,000–350,000; that is, the mortality rate reached about 20%. Some other estimates, e.g., by the statistician P. Jordan, put the total number of deaths at 100,000 (Liiv, 1938, p. 124).

Reading through the copies of church death registers published by Liiv (1938, pp. 304–322) one gains the impression from the remarks entered by the pastors that the fraction of the total number of deaths directly due to starvation, i.e., where the reported cause of death was not an epidemic but hunger, was higher in Estonia than in Finland. Although the excerpts from the death registers, including the remarks, are enough to shock the reader, this shock is nothing like the one received on reading the copy of an accounts book for 1697 of the Office for the Poor ("Armenbuechse") of Narva, an important city in Estonia’s northeastern corner. This book came to light about the mid-19th century, and a copy of the entries was published by a writer who signed himself “H” (Anonymous, 1860). Frequently in April through 20 June poor were buried nameless in a mass grave: 40 on May 17. The total for 1697 was 849 and Narva was not a big city.

Acknowledgments. The authors are pleased to record their indebtedness for the stimulating conversations and for the considerable assistance received from the following scientists: In Finland: F1 H. Halen, Research Assistant, Dept. of Asian and African Studies, University of Helsinki; FT U. I. Helimäki, Director, Finnish Meteorological Institute; Prof. E. Holopainen, Head, Dept. of Meteorology, University of Helsinki; FT O. Jussila, Lecturer, Institute for Historical Research and Documentation, University of Helsinki; Prof. E. Jutikkala, Dept. of History, University of Helsinki; FK J. Kuusamäki, Archivist, Finnish National Archives; FL S. Muroma, Tampere (Special thanks are due to FL Muroma for permission to reproduce in a diagram (Fig. 2 above) the results of his researches on the mortality rates in different parts of Finland in 1696–97); FTS. Myllyniemi, Director, Provincial Archives, Hämeenlinna; Prof. T. J. Paloposki, Director, Finnish National Archives; Prof. Erik Palmén, Dept. of Meteorology, University of Helsinki; Prof. Ernst Palmén, Rector, University of Helsinki; Prof. H. Simojoki, Dept. of Geophysics, University of Helsinki; Prof. G. Siirén, Finnish Forestry Research Institute; FL O. Turpeinen, Research Assistant, Dept. of History, University of Helsinki; Prof. L. A. Vuorela, Director-in-Chief, Finnish Meteorological Institute; Dr. S. Zetterberg, Institute of History, University of Helsinki. In Israel: Prof. N. Kaufmann, A/Dirctor, Dept. of Nutrition, The Hebrew University—Hadassah Medical School; Dr. C. Stanhill, Div. of Agricultural Meteorology, Volcani Center, Agricultural Research Organization, Ministry of Agriculture. In Sweden: Dr. J. Cavallie, Archivist, Swedish State Archives. In U.K.: Dr. J. V. Lake, Director, Agricultural Research Organization, Ministry of Agriculture; Dr. C. Stanhill, Div. of Agricultural Meteorology, Volcani Center, Agricultural Research Organization, Ministry of Agriculture.

Finally, thanks are due to Mrs. Ruth Aharonov and Mrs. Fanny Mazur for typing the paper.

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17 Dr. S. Zetterberg, a scholar of Estonian history, has suggested that the author "H" of the article is likely to be Heinrich Johann Hansen, 'local historian'; in 1858–61 he reorganized Narva’s city archives. In 1860 he was elected member of the Learned Estonian Society, Dorpat (Estonian name: Tartu).
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Siting handbook for wind energy conversion systems

Information on determining the best locations for small windmills is available in a handbook written by researchers at the Department of Energy's Pacific Northwest Laboratory, operated by Battelle. The publication is a step-by-step guide to finding the best site for a small Wind Energy Conversion System (WECS); i.e., a site that takes advantage of the best winds.

The handbook defines a small WECS as one or more machines with a total output of <100 kW of electricity. They are an attractive energy option in remote areas, where uses include powering irrigation pumps and providing electricity for farms, dwellings, and isolated installations. Finding the best possible location for a WECS and estimating available power are the major purposes of any siting study. The handbook explains the relationship between wind speed and wind power, and describes techniques for gathering wind data and making estimates of machine output. When estimating available wind power, topographical features or barriers, which could affect airflow near the proposed site, must be considered. The handbook provides guidelines for evaluating all types of sites, from flat, open spaces where airflow is unhindered to mountainous areas where wind behavior makes siting problems more complex. The specific problems of siting on ridges, isolated hills, and mountains, as well as in valleys and passes, are also discussed.

It is suggested that A Siting Handbook for Small Wind Energy Conversion Systems (PNL 2521) be used in conjunction with information from manufacturers and distributors on the characteristics of their machines. The 66-page handbook is available for $5.50 from: National Technical Information Service, United States Department of Commerce, 5285 Port Royal Road, Springfield, Va. 22151.