THE SPREAD OF POTATO BLIGHT IN EUROPE IN 1845-6 AND THE ACCOMPANYING WIND AND WEATHER PATTERNS

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Cover: Famine Funeral at Skibbereen (from Illustrated London News, January 30, 1847) (archives of the National Library) and picture of blighted potato foliage on background synoptic map of July 31, 1846 (see Fig. 10).

Famine letter on page 12: Original letter from 1847 reproduced in an article by R. McKay, late Professor of Plant Pathology, UCD, as published in Department of Agriculture Journal 1953-54

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PREFACE

The first R & D programme in the field of climatology, which was adopted by the Council of the European Communities in 1979, led to the promotion of 51 international research projects in different aspects of understanding climate and of man-climate interactions. Under the terms of Contract CLI 065 UK(H), Professor H.H. Lamb (Norwich) and Dr Austin Bourke (Dublin) undertook a study of the biometeorological background to the historic epidemic of potato blight which raged in Western Europe in the years 1845-6 and which culminated in the great Irish famine. Apart from its historical interest, the study has implications for the present day epidemiology of plant diseases of food crops, particularly in the Third World.

The report is published in its present form by kind permission of the Commission of the European Communities, and the Director of the Irish Meteorological Service.

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Mention must also be made of the valuable facilities provided by the Climatic Research Unit at the University of East Anglia, Norwich, by the kind agreement of the present Director, Dr T M L Wigley. Without the use of the valuable unpublished gazeteer of early meteorological observing stations compiled, and graciously made available, by Mr J A Kington, and reference material in the Unit's library, this project would have needed more than twice as long for its completion. Professor J C Zadoks (Wageningen) kindly provided information on the modern impact of potato blight in the Netherlands.

The authors are also indebted to the Irish Meteorological Service, Dublin, for various facilities generously made available, including observational data of the time and copies of the potato blight warnings currently being issued.

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CHAPTER 1

INTRODUCTION

1.1 Subject

This report is concerned with a quantitative biometeorological study of the interaction of weather and plant disease in the historic potato blight epidemic of 1845-6 in western Europe. Dr Austin Bourke (Dublin), author of a number of previous studies of potato blight and the Irish disaster in the eighteen-forties, extended his studies in this report with the aid of a much more comprehensive collection of meteorological data from all over Europe than was previously available. Professor Hubert Lamb (Norwich) reports in Chapter 4 on the data collected and on the reconstruction of the meteorological situations in the 1840s which were part of the background to the disaster.

1.2 Background

Concern has been growing in recent years as to how future climatic change might affect agricultural production. A realistic assessment of this question needs to take account not merely of how the changed environment would affect the growth and wellbeing of plants and animals, but also of the repercussions of an altered climate on the distribution and virulence of a wide variety of diseases and pests which can damage farm crops and livestock. Nearly thirty years ago Dr R O Whyte of FAO drew attention to this problem as an aspect of great economic significance to land use and agricultural production which merits a full review by a competent authority (Whyte, 1963). No such review has yet been undertaken. Meanwhile certain trends in agricultural practice have tended, if anything, to increase the risk of sudden sharp crop losses due to disease or pest, despite the development of resistant plant varieties and of chemical and other counter-measures.

Paradoxically the risk of serious attacks by plant parasites has tended to increase by reason of the very practices designed to promote food production: rapid and widespread adoption of new cultivars, more intensive cropping, the growing of more than one crop per year, the wide use of irrigation and increased fertilizer use. The phytosanitary dangers of devoting ever greater areas of land to a single crop and often to a single variety (monoculture) in place of the diversified patterns of traditional farming have already begun to show themselves in different parts of the world.

1.3 Objective

An example of a most devastating sudden disease attack on a food crop is the historic epidemic of potato blight which ravaged much of western Europe in 1845-6. The objective of this report is to carry out a detailed case study of the 1845-6 epidemic, covering its first impact in the Low Countries and its subsequent spread, and relating these to the accompanying weather and wind patterns. The research sought to throw light on the factors that favoured the rapid spread of the potato disease through western Europe in the first year of its appearance (1845), on the contribution which the wind-borne spread of fungal spores made to the propagation of the disease over fairly lengthy distances, and on the contribution that weather conditions made to its life-cycle in the years1845 and 1846. It is hoped that the detailed analysis of the 1845-6 analogue, with its profound economic and social consequences, may help towards the interpretation and countering of similar plant disease epidemics in the future in whatever part of the world they strike.

The impact of unfavourable weather conditions on a community, whether by direct action or by limiting food supplies, depends to a major degree on the socio-economic conditions which prevail. In this respect the situation in Ireland on the eve of the potato blight disaster, with a swollen population very largely dependant for survival on a single vulnerable food crop, was precarious in the extreme.

An example of how even a modern European economy may prove vulnerable to risks somewhat analogous to the Irish experience of the potato disease in the 1840s, particularly where rationalization in agriculture has eliminated diversity (i.e. has tended to restore monoculture as in the famine situations of the past), occurred in the Netherlands in the 1950s with a newly developed strain of wheat. This wheat, known as Heines VII, had been hailed as a much prized product of scientific plant breeding, developed for its resistance to the then known forms of yellow rust disease. Three years after its introduction in 1952, 80 per cent of the wheat sown in Holland was Heines VII. Then a new variety of yellow rust appeared and destroyed over two-thirds of the winter wheat sown in that country for the 1956 harvest. Happily, in this case there was enough diversity in the Dutch agricultural economy to withstand the blow. Such events could be much more devastating in the Third World.

1.4 Structure of the Report

Chapters 2 and 3 of the report are devoted to a broad survey of the emergence of potato blight in the 1840s, of the way the disease operates to damage the potato crop, and of how its seasonal course is affected by weather conditions. Chapter 4 describes materials and methods available for revealing the meteorological characteristics of those years and the development of the weather in the seasons concerned, while Chapters 5 and 6 deal with the European potato blight epidemics of 1845 and 1846 respectively. The findings of the study are summarised in Chapter 7.

CHAPTER 2

THE POTATO CROP IN EUROPE

2.1 The Potato Crop in Europe and the Emergence of a New Disease

The first manifestation of blight in the European potato crop in 1845 was greeted with unprecedented panic and consternation. No previously known crop disease had carried out its destructive work with such terrifying speed and completeness. The superstitious dread of the common people, faced by a disease so inexplicably different in its course from the slowacting and localised ailments which had previously taken partial toll of their food crops, was intensified by the confusion and discord among the learned who were hopelessly divided about the cause of the new disease, how it might be combatted, whence it had come, and the reason for its sudden emergence from previous obscurity, unless perhaps it had arisen by 'spontaneous generation' (Bourke, 1991).

It was not initially realised in Europe that potato blight had made its appearance two years earlier in North America, close to the great seaports of the east coast of the United States, and had spread with impressive speed to almost the entire area in which the disease is a serious problem for today's American potato growers. Fig. 1 is based mainly on the work of Stevens (1933), supplemented by a limited amount of extra information on the arrival of the disease in Canada (Bourke, 1969).

2.2 The Potato Crop and its Earlier Problems

After the potato was first brought by the Spaniards from South America to Europe about the middle of the sixteenth century, it remained for many years free of serious diseases. It showed itself to be a crop of remarkable sturdiness and vigour of growth, more typical perhaps of a weed than of a cultivated plant; in those early years it grew outstandingly well in wet seasons when the failure of the wheat and other grain crops led to a shortage of food. This advantage loomed particularly large in the damp climate of Ireland where the potato soon came into widespread cultivation; and, from Ireland, its reputation "as a bulwark against starvation" in bad seasons led to its introduction, often under the name of the 'Irish potato', into other countries.

With the rapidly growing popularity of the potato, things began slowly but surely to change for the worse. The more widely a particular crop is grown, the more vulnerable it becomes to disease. Gradually the potato began to suffer from specific maladies, apart from frost damage and simple water-logging in poorly drained soils. The more important developments were virus disease ('the curl') and dry rot ('the taint'), ailments which tended to be a bigger problem in dry seasons and on the continental mainland.

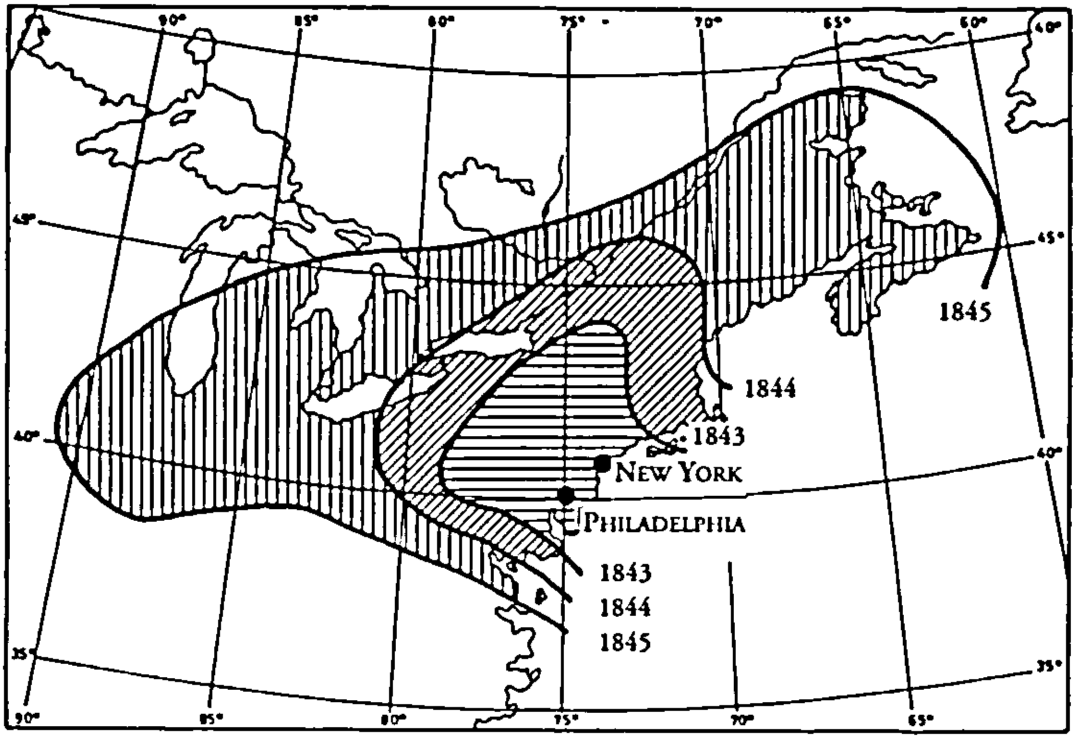


Fig. 1 Approximate extent of potato blight attacks in the USA and Canada in the years 1843-45 (after Stevens)

Despite these rather worrying developments, the reputation of the potato as the most reliable of European food crops, and the solid bottom line of defence against famine, lasted right down to 1845 when the bubble burst with a vengeance.

2.3.1 Whence came the Blight Fungus

Nearly one hundred and fifty years after potato blight made its first appearance, there is still no agreement amongst the scholarly as to where the cradle of the causal fungus was located, with the main body of opinion divided between Mexico and the Andean homeland of the potato (apart from the stubborn few who cling to the theory that the fungus had long been present wherever the potato was grown, but had somehow managed previously to keep a low profile no matter how favourable the weather had been or how susceptible the potato varieties grown).

In favour of a South American birthplace is the fact that a number of other major plant diseases have been shown to have originated in the same areas as their host plants. Furthermore, a ready means of transport of diseased potatoes direct from Peru to the USA and Europe in the early 1840s was provided by a large fleet of cargo boats which was engaged in catering for the guano boom of those years.

2.3.2 A Potato Importation from the Americas

It seems most probable that blight came from America to Europe in a cargo of potatoes officially imported into Belgium in an effort to bring new vigour into an ailing crop (Bourson, 1845). At the opening of the provincial council of West Flanders on 4 July 1843 the Governor referred to the food problems facing the poor because of the 'degeneration' of the potato, due mainly to virus disease and dry rot, and proposed that recourse be had to America, land of origin of the potato, in order to renew and improve the species. The original idea of importing wild potatoes was soon dropped when expert advice pointed out that these could not be developed into a useful crop for some years after introduction. Instead, trials of commercial potato varieties from different countries were undertaken at the experimental farm at Cureghem, and when two particularly promising cultivars had been selected, it was announced that large quantities of these varieties had been ordered from abroad and would, it was hoped, arrive shortly - presumably in time for the 1844 growing season. According to Bourson (1845), the 1844 potato crop at Cureghem grew very well, but a number of the harvested tubers developed black spots and rotted in storage.

We know that potatoes from Peru, and, in particular, varieties named 'Peruvienne', 'Lima' and 'Cordilieres' were among the first crops which were badly attacked by blight in 1845. No doubt, however, the Cureghem imports also included potatoes from the United States, so that it is not possible to point the finger of guilt with conviction to imports from any particular region. In any case, once blight had established itself in North America, which had constant sea traffic across the Atlantic and a free exchange of potato varieties with Europe, it could not be very long before the disease found its way to the Old World.

2.4. How Blight Damages the Potato Crop

The modus operandi of potato blight is no longer the mystery it was on its first appearance. The long-distance spread of the disease into districts where it had formerly been unknown is normally brought about by the unwitting introduction of infected tubers. Thus, early in World War II the urgent need to grow potatoes in Kenya to feed allied troops led to the importation and planting in 1941 of a large consignment of seed potatoes from the UK. The season of introduction was exceptionally favourable for the onset and development of potato blight, and the disease spread with devastating energy throughout Kenya and later invaded Tanzania, Uganda and Zaire (Cox and Large, 1960).

Diseased tubers are also the means by which blight is carried over through the winter from one planting season to the next, either as infected seed which goes undetected at planting time, or as tubers discarded at harvest time and surviving over the winter, or as groundkeepers.

It is convenient to consider the damage caused by potato blight under three separate headings:

2.4.1 Foliage Blight

The disease can reduce the growing season of the crop by killing the foliage before the normal harvest date is reached. The earlier the tops are effectively dead, the lower will be the yield. The broad growth pattern of maincrop potatoes, which require a six-month season from planting to full harvest, may be summarised as follows. The plants emerge above the ground, on average, about one month after planting. During this period, and for a further period of one-and-a-half months, the entire energy of the plants is devoted to the production of roots and haulms. Tuber formation begins slowly in the second fortnight of the third month when approximately 15 per cent of the potential final crop weight is produced. In the following six fortnights, up to full harvest time, the successive additions of tuber weight are, in round figures, 15 per cent, 20 per cent, 20 per cent, 15 per cent, 10 per cent and 5 per cent. Thus, if the planting date of maincrop potatoes is taken as 1 April, with an expected harvest date of the end of September, destruction of the tops by mid-July would lead to a crop loss of 70 per cent, by

1 August of 50 per cent, by mid-August of 30 per cent. This is, of course, a generalised picture of potato crop growth which, in a particular season, needs adjustment to take account of changes in the date of planting, and of any checks to growth caused by drought or other factors. This being allowed for, the figures reflect surprisingly well the extent of yield losses in different seasons corresponding with the dates of haulm destruction.

2.4.2 Tuber Blight Prior to Harvesting

Spores of the disease formed on the foliage may be washed down by rains into the earth where they can infect the tubers in the ground. The extent to which this occurs depends on a number of factors, the main one being the frequency of heavy rains when the spores of the disease are in active production. Often a long, slow attack of foliage blight in which sporulation continues until late in the season will give rise to more tuber blight than a rapid and spectacular early-season destruction of the haulms, which indeed leads to a major drop in yield, but one which is often made up of mainly healthy potatoes.

2.4.3 Tuber Blight at Harvest Time

Direct infection of the tubers when they are dug out at harvest time can be a serious source of loss in some years. It does not take place if the foliage has died, due to disease or natural causes, sufficiently in advance of harvest date to avoid survival of the blight fungus in the surface soil. It is most likely to occur in the case of late-season foliage blight attacks, when the plants are still green and producing spores at the time of digging. Destruction or removal of the haulms well in advance of harvesting destroys this source of infection.

2.5 Rotting of Tubers in Storage due to Blight

The post-harvest rotting of tubers in storage due to blight came as a complete shock to the growers in 1845 who thought that the full extent of their losses had been made plain at digging time. It was feared that the entire harvest would melt away. They were unaware that the disease did not normally spread in storage from infected to sound tubers; thus the ultimate losses in many cases were substantially less than had been feared when rotting in storage was first noted.

2.6 The Extent of Carry-Over of Infection from One Season to the Next

A factor of some importance affecting the seasonal onset and development of potato blight is the amount of inoculum present early in the season, which in turn depends on the degree of carry-over of infection from the previous year.

Over a hundred years ago, Jensen (1887) remarked on the tendency for the disease to make its appearance relatively late and relatively early in successive years. This could reflect the trend, discussed in the previous section, for late season blight to contribute to a higher level of tuber infection in the seed used in the following season.

Another factor which can contribute to a high carry-over of infection is the lack of awareness of the importance of hygiene, particularly in areas where the disease is new, leading to widespread abandoning of diseased potatoes in the fields (as happened, for example, in Chile in 1950-51). A mild winter can contribute to the survival of discarded tubers and of groundkeepers, and to early sprouting of infected tubers in cullpiles.

CHAPTER 3

THE METEOROLOGY OF POTATO BLIGHT

3.1 Weather and Blight

The fact that the seasonal weather plays a dominant role in the development of an epidemic of potato blight was recognised soon after its first appearance in Europe. At that time the fungal cause of the disease was recognised only by a handful of scientists: hence the weather's function in controlling the life cycle of the fungus was equally unrecognised. The consensus of opinion in 1845 considered that blight was a direct consequence of weather conditions alone (Graham, 1847).

It was not until the 1860's that the fact that blight is caused by a fungus (*Phytophthora infestans)* won general acceptance, and not until the turn of the century that the use of fungicides against the disease was introduced. The first empirical attempt to develop a practical model of the meteorological conditions which favour the blight fungus, which might be used to advise growers on what dates to apply fungicides, was carried out in the Netherlands at the end of the First World War (Bourke, 1955). Building on the Dutch foundation, a simple criterion, the so-called 'Beaumont period', was later evolved in England and was used as the basis for the British blight forecasting system until quite recent times. Alternative models were developed in the USA, Germany and elsewhere.

None of these models proved effective in Ireland, so it was decided to revert to first principles, and to try to incorporate into a new system the essential features of a comprehensive series of laboratory determinations (Crosier, 1934) of the relationship between weather conditions and successive stages in the development of blight on the foliage of potato plants. The 'Irish Rules', as developed in 1949, were designed for use with hourly observations made at standard meteorological stations, and required as an absolute minimum:

a) a period of at least 12 hours during which the relative humidity of the air does not fall below 90 per cent nor the air temperature below 10.0°C. (Conditions which permit the formation of disease spores outside the leaves of already infected plants, to be carried by air currents to new sites)

b) free water on the potato leaves for a subsequent period of at least four hours. (A condition which permits any newly arrived spores to germinate and cause further infection).

As a device to take account of the relative importance of blight weather spells of different lengths, a minimum period of 12 hours in which condition (a) is met is considered to constitute an 'effective period' of one hour; more generally, a blight period of x hours constitutes an 'effective period' of x-11 hours. Two consecutive blight periods separated by a gap of less than six hours are combined to calculate the effective duration, i.e. only one deduction of 11 hours is made from the total length of the consecutive periods.

Different blight periods and different seasons are compared in terms of the total numbers of Effective Blight Hours (EBH) calculated in this way.

In practice, whenever condition (a) has been met, it is rarely that condition (b) will not be found to follow automatically: rain or drizzle frequently accompanies periods of high humidity. Nature so organises itself that spores will rarely be discharged into a hostile environment.

The Irish Rules, having been tried experimentally during the 1950 and 1951 crop seasons, were adopted as the basis for an Irish blight forecasting system in 1952. No modification has been found necessary during their successful operation over a period of forty years. They have given satisfactory results also in Chile and Tasmania. The relative humidity criterion of 90 per cent has been adopted in the UK for use in the blight warning procedures which replaced the Beaumont system in 1975. Accordingly, the Irish Rules have been selected with some confidence for use in the present study to analyse the blight potential of different weather seasons.

A spell of blight weather permits the fungus to undergo the three consecutive stages of sporulation, germination and infection—a sequence which is followed by a period of incubation, i.e. the interval which elapses between infection and the first appearance of damage. The length of the period depends mainly on temperature, but is normally between between three and five days.

The four basic processes - sporulation, germination, infection and incubation - complete one cycle or generation in the spread of the disease. If the necessary meteorological conditions are repeated, a second and naturally more general infection will take place. The effect of each generation on the spread of the disease will depend on the amount of the inoculum initially present, and on the duration of the favourable conditions. Experience in Europe suggests that, where a crop is not subject to direct infection from a neighbouring early crop in which the disease is already raging, between three and five generations may be needed to develop the disease to the level at which it can be noticed readily in the crop.

3.2 Weather Patterns, Airmass Analysis and Plant Disease

An essential adjunct to plant disease forecasting in Ireland from its early stages has been the synoptic weather chart (Bourke, 1957). It was soon confirmed that the conditions favourable to potato blight do not come together by blind chance, but are associated with particular types of recurrent synoptic weather situations. Those which normally give the most significant periods of blight weather in western Europe fall into two broad categories:

3.2.1 Open warm sectors of maritime tropical air, particularly where two or more waves follow in sequence

Maritime tropical air, as it reaches northwest Europe in summer, normally gives ideal conditions for the development of blight, especially close to the wave centres: high humidity, overcast skies with drizzle, wet fog or rain, and temperatures normally of the order of 12°C - 16°C. By its very nature, this situation is essentially maritime, and often the associated pressure systems sweep northeastwards, affecting mainly the coastal regions. In some seasons, however, the invasion of maritime tropical air plunges eastwards to take large parts of continental Europe into its sphere of influence.

3.2.2 Stagnant or slow-moving, shallow depressions giving long periods of wet overcast weather

The shallow, stagnant "puddle low" is primarily a continental rather than a maritime phenomenon, although its effects can spill over westwards from the European mainland to East and South-east England, and very occasionally to Ireland. The temperature level in this situation in summer in north-west Europe is almost always favourable to the disease, and the persistent rainfall associated with convergence maintains a high level of air humidity. Ill-defined quasi-stationary fronts are frequently associated with the stagnant area of low pressure which may show more than one shallow centre. The air is often unstable and, particularly in the later stages of the puddle low, widespread outbreaks of thunderstorms are not uncommon.

3.3 The Importance of Temperature

In the various models for blight weather which have been developed over the years for use in western Europe, the specified minimum temperature level has remained unaltered at 10.0°C. The importance of the minimum temperature has been strikingly illustrated in Iceland where potatoes form an important food crop despite low summer temperatures and a comparatively short growing season. In their pioneer study of potato blight epidemics throughout the world, Cox and Large (1960) remarked that "the occurrence of potato blight in Iceland is of special interest as the temperature conditions are here at the lower limit for any epidemic development of the disease".

The Icelandic blight records showed that, in favourable conditions of air humidity, the disease damaged the crop in those years when the mean daily temperature in July and August reached the 12° - 13°C level, but appeared to be inhibited when these temperatures ranged about 10-11°C. In the period 1936 - 1959, during which blight built up to become a serious and recurrent problem in Iceland, there were six years of severe blight; in those six years mean air temperatures were consistently higher in July (average 12.3°C, as against 11.2°C), and in August (average 11.7°C, as against 10.7°C) than they were in the years of little or no disease.

Nor was this the whole story. Table 1 shows the mean monthly air temperature in Reykjavik for the months of July and August for each decade of the present century up to 1980.

TABLE 1: Mean Monthly Air Temperature (°C) during July and August in Reykjavik in successive decades, 1901 - 80

	July	August
	°C	
1901 - 10	11.4	10.3
1911 - 20	11.6	11.0
1921 - 30	11.1	10.4
1931 - 40	12.0	11.3
1941 - 50	11.5	11.1
1951 - 60	11.2	10.7
1961 - 70	10.6	10.5
1971 - 80	10.6	10.2

Concurrent with the rise of temperature and blight impact in Iceland, there occurred a gradual rise of air temperature early in the century to a clear plateau of warmth in the 1930's, followed by the onset of cooling, gradual at first but sharper since 1960, to a level in the 1970's represented by lower values than any recorded for the earlier decades of this century. Simultaneously with the temperature fall, the impact of blight in Iceland has gradually died down, so that in the late 70's the disease has been hard to detect. It would be premature to hail this phenomenon as the success of a climatic fluctuation in killing off a troublesome plant disease. Only time will tell whether the return of a series of mild summers to Iceland may not reawaken a fungus which had managed to slumber on at a sub-clinical level.

3.4 The Role of the Wind in the Spread of Disease

Nowadays, when blight is a familiar and recurrent phenomenon wherever the potato crop is grown, the inoculum of the disease is present within or close to every potato patch, and the mean distance from source to a new site of infection is so short that it might be more precise to picture the spores as being transported by local air movements than as being carried on the wind. In such cases, the spores which are windborne over long distances are of negligible importance in comparison with the myriads which are locally produced.

However, the case is very different where the inoculum does not survive locally from one growing season to the next, or where a disease is attempting to establish a foothold in an area where it has not previously been known.

The best-known of the disease spores which regularly commute over great distances are those of the black rust of wheat, *Puccinia graminis*.

Hogg (1970) describes the wind trajectories which have been found to bring black rust spores from continental Europe to England, a country which is not subject to the disease except in growing seasons when inoculum is imported on the wind from abroad. Each case of uredospore (rust spore) introduction was shown to involve a precise synchronisation of spore liberation and deposition with the movement of weather systems and the speed of the winds within them. A similar atmospheric mechanism supports the familiar south-to-north transfer of rust spores in North America.

Where, as in these cases, the itinerary of the inoculum is mainly over land, crops may be progressively infected along the track of the spores, each successive outbreak along the route acting in turn as a fresh source. More controversial is the suggestion that disease may be carried by wind across the oceans in one giant step. Recently, the entry into South America of the dreaded coffee rust disease has been plausibly attributed to carriage from coastal West Africa by the northeast trade winds (Bourden *et al.* 1971).

It was suggested very soon after blight first appeared in England that spores of the disease might have been carried across the North Atlantic from America on the gale force winds which blew in August 1845 (Gardener's Chronicle, 1845, p.785). However, nothing in the subsequent history of the spread of potato blight supports the theory that viable spores of the disease might be transported by wind over thousands of miles of ocean. In the case of shorter sea passages, of the order of a hundred kilometers or so, such as would be involved in the travel of disease from the continental mainland to England or from Britain to Ireland, recent findings suggest that the windborne spread of even highly perishable inoculum, whether in the form of fungal spores, bacteria or viruses, can successfully take place in suitable conditions.

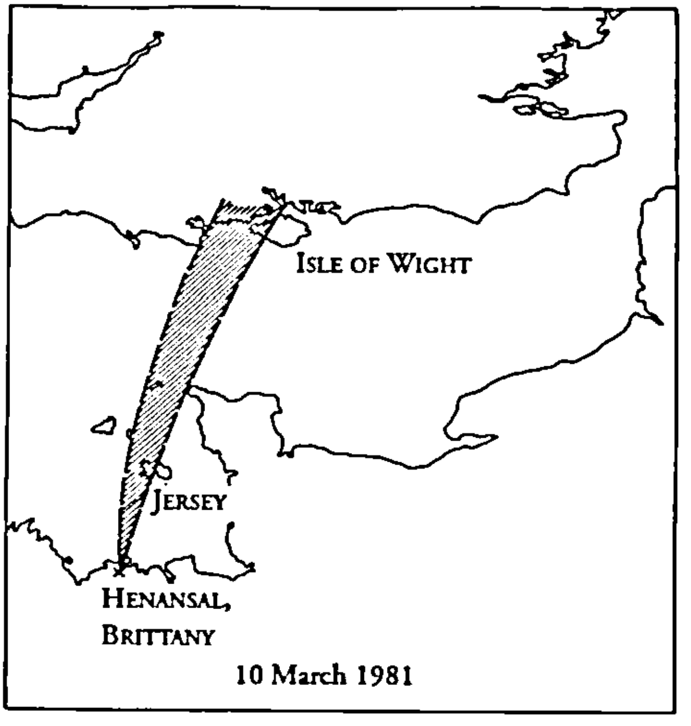
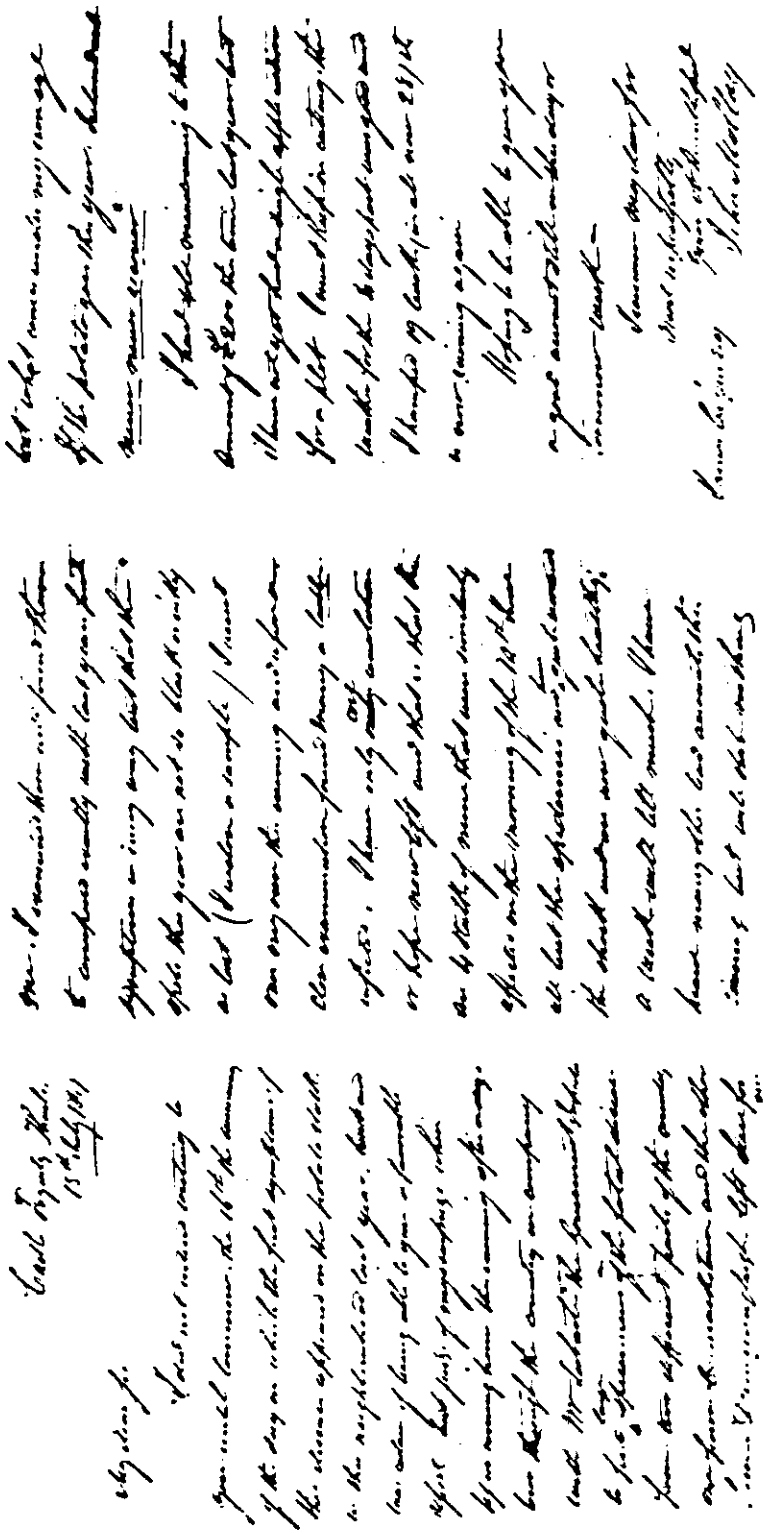


Fig 2. Air trajectory for the transport of foot-and-mouth disease from Brittany to the UK on 10th March 1981 (after Donaldson *et al*, 1982)

A particularly relevant example (Fig. 2) concerns the successful forecasting of the spread of an outbreak of foot-and-mouth disease in March 1981 from Brittany to Jersey and the Isle of Wight, in association with a warm sector of maritime tropical air (Donaldson *et al*, 1982).

Coincidentally, one of the earliest reported outbreaks of potato blight in England in 1845 occurred in the Isle of Wight, and followed the appearance of the disease along the northern French coast and in Jersey (see paragraph 5.6).



Reproduction of original letter relating to potato blight and famine year 1847.
(see last page for typed version)

CHAPTER 4

THE WEATHER IN THE YEARS CONCERNED

4.1 The Types of Weather Information and Meteorological Instrument Data Available

For the reconstruction of wind and weather patterns prevailing in the eighteen-forties, at the times of the first appearance of potato disease in Europe, its spread and of the famine which followed in Ireland, the types of data available may be classified as follows:

(i) Registers of daily meteorological observations including instrumental measurements. The intervals between successive observations ranged from once daily to hourly throughout the 24 hours at major observatories, such as Greenwich and St Petersburg, and every 20 minutes throughout the day and night at Helsingfors (now known by its Finnish name—Helsinki).

The observations usually included pressure, temperature and measurements of rainfall, wind direction and cloud cover; at a smaller number of places humidity measurements. often readings of the wet and dry bulb thermometers, were included. The sources of observation data used in this study are listed in the Appendix to this report.

(ii) Weather diaries, mostly without instrument measurements, but occasionally including once daily measurements of barometric pressure, rainfall or temperature made from instruments of unknown quality, type and exposure. Wind directions were again usually, but not always, included. Frequency and times of observation varied, but were mostly either once daily or given as a single summary, or survey, of the 24 hours.

(iii) Summary reports of the seasons, sometimes with a few details of certain days, and sometimes including references to the crops and natural vegetation etc.

No official national weather services having been formed as early as that time, the official weather observations were mostly made at observatories which were primarily concerned with astronomy or earth magnetism. Other observation registers and diaries were kept by interested individuals—such as clergymen, doctors, farmers, landowners and scientists—whose standards of performance, nonetheless, often matched those of the personnel of official observatories. Their importance can be seen from the following extracts.

4.2 Notes on the Occurrences of Potato Disease included with the Weather Data

The farm weather diary notes written at Klepp in Jaeren in southwest Norway include the following :

> "The summer of 1845 was a good normal year, with enough rain to give a tolerably good harvest of corn and hay, though the dry rot increased strongly on the potatoes so that there were few of them on sale in the village and they became dear...."

> "The summer of 1847 was extraordinary good and fruitful. With the variations between rain and warmth there were a massive hay harvest, the most that anyone can remember. The growth in the cornfields was also prolific, so that many had to stack their corn in the open.... The potatoes also yielded heavily and were not so much damaged by the dry rot as in 1846. This dry rot of the potatoes continued for several years. In 1846 it damaged the potatoes so much that they rotted not only in the earth but also after they had been taken up and put into the cellars. Many lost all their potato crop, so that when spring came, it was hard to get seed potatoes.... (They became very dear). This potato disease was not only in Norway, but over almost the whole of Europe. In consequence there was hunger over all Europe in 1847. Oats became very dear.... The suffering was not as great in Norway as in other lands where people died of starvation by the thousand, particularly in Ireland. In 1847 here on the farm a great many salmon were fished...."

The disease of the potatoes affecting the districts concerned, but known to have been widespread in Europe, is also discussed in the 1845 account of The Meteorology of Whitehaven (Cumberland) and in a long article by J Couch, F.S. in the Annual Report, for that same year, of the Royal Cornwall Polytechnic Society (p.9 ff.). "Cultivation of the potatoe" and the export of large quantities to London and other cities had lately become important to the economy of the county of Cornwall and the loss of the crop in 1845 was "regarded ... as a public misfortune". In the eastern part of the county the first signs of injury to the crop were noticed as early as the first week of July among the early potatoes, which had become watery. The later maturing varieties showed it about a fortnight later. In the previous seasons on average each square yard of ground yielded "a bushel of sixteen gallons", but in 1845 in some fields the crop was not worth digging.

Similarly, in France, a note in the Chronique de Neuvillers (Neuwiller, Alsace, 48.8°N, 7.4°E) records the first symptoms of potato disease in that area at Ban-de-la-Roche on 18 August 1845 and, by that time, "in a great number of countries of Europe". By 6 October of that year the potatoes in the area mentioned were everywhere rotten and, in the winter that followed, charitable collections in response to appeals "in Alsace and in France" resulted in the distribution of aid in the form of money, food (including potatoes), and clothing to the population thereabouts. In the autumn of 1846 the potato crop was again rotten, more widely than in 1845, and no appeal was possible: "everywhere there was suffering, death in all the countries of Europe, in Ireland a frightful famine". Again, in the autumn of 1847, the potato crop was rotted although less than in the two previous years, some varieties were unaffected and several communes even in Ban-de-la-Roche escaped.

There were many speculations and proposals for investigation of how the weather conditions prevailing at the time could have affected, or might have been largely responsible for, the epidemics of potato disease.

4.3 Homogenization of the Meteorological Data

The meteorological observations and instrument readings were made at various times of the day, and a variety of scales and units were used.

Where observations were made only once a day, 2 p.m. local time seems to have been by far the commonest choice. Nearly everywhere it was possible to base the mapping on observations made at some time between midday and 3 p.m. Although synoptic weather maps were drawn up for only one time each day, notes were made of the weather reported at other times, and these were taken account of in identifying the progress of fronts.

Some difficulty, requiring caution on the part of the meteorologist, is presented by the way in which time was reckoned at the astronomical observatories where some of the finest series of meteorological instrument observations were made in those days. According to either "Greenwich Mean Astronomical Time" or the "Göttingen Astronomical Reckoning" (an analogous system determining the time for the longitude of Göttingen), the day began at midday: this means that, for example, what we now call the 14h. observations were printed as "2h.", and the 2 a.m. observations of the following day were printed as "14h." on the day that began at midday. Thus, both the times and the dates need adjustment: the 8 or 10 a.m. observations were printed as "20h." or "22h." of the previous day. (We are indebted to the Royal Greenwich Observatory at Herstmonceux for this information, which confirmed the solution to a difficult puzzle: personal communication, 18 July 1983).

The tabulated meteorological observations for the Russian stations, as printed in the sources here used (see Appendix to this report), and also for Finland which was then under Russian rule, are already adjusted to the Gregorian calendar used internationally elsewhere in Europe. (This is unlike the situation that obtained in the previous century, when the Russian observations in the yearly volumes of the Ephemerides of the Societas Meteorological Palatina were published under the dates of the old Julian calendar used in Imperial Russia).

The most commonly used temperature scale in Europe generally was Reaumur (80°R = 100°C), although some places used Centigrade and others, including Palermo in Sicily, used Fahrenheit.

Pressure readings were mostly in Paris inches and lines, and the pressure values usually corrected for the temperature of the instrument, usually to 0°R (= 0°C), but at the Russian stations to 13½°R or 16.9°C. Adjustment of these Russian barometer readings to the equivalent height of the mercury column at 0°C means adding 2.8 to 3.0 hectoPascals (millibars) to the pressure. One Paris inch was 27.07mm; 28 Paris inches of mercury, or 336 lines, at 0°C, represented a pressure of 1010.5 hectoPascals. However, Austrian inches (1 A.inch = 26.34 mm), English inches (1 inch = 25.40 mm), Rhineland inches (1R.inch = 26.15 mm), Spanish inches (1 Sp.inch = 23.2 mm) and Swedish decimal inches (1 Sw.D.inch = 29.7 mm) were also encountered (*see* Lamb and Johnson, 1966, for further similar details). Such experiences are quite persuasive as regards the advantages of the universal units of the metric system!

Some uncertainty arises about the equivalence in modern units of some of the forms of measurement of humidity and wind (e.g. by pressure-plate anemometer). But some wet and dry bulb thermometers were in use, and relative humidity, dew point etc., can be calculated in the usual way: some observation registers indeed already give the calculated relative humidity and dew point. Dew point values were plotted on the maps wherever possible.

The Beaufort scale of wind force was already in use at some places, and in some tabulations of the observations conversion to wind speeds in km/hr had already been done. Other observing stations were still using the five-point scale of wind force enjoined by the old Societas Meteorological Palatina in the previous century. On this scale:

0 = quite light wind
1 = moderate air motion bringing the leaves of the trees into movement
2 = stronger air motion, causing the twigs and small branches of the trees to move
3 = very strong wind, big branches moving, dust swirls up from the ground
4 = storm.

However, by the 1840s, Norwegian stations, and perhaps most others also, seem to have used the same scale with the numbering changed to 1 to 5. The instruction in Norway about force 5 read "only used when the wind is of storm force such as here sometimes occurs with S or SW storms accompanied by frequent hurricane-like gusts". A conversion to Beaufort force was used for plotting the maps here presented, on which each full fleck on the tail of a wind arrow represents two points of the Beaufort scale.

In this project, regular use was made of the gazeteer of old observing stations, with notes on the sites, the observers, the instruments, times of observation, scales used etc., compiled over recent years in the Climatic Research Unit at the University of East Anglia, Norwich, in the course of production of eighteenth and early nineteenth century daily synoptic weather maps for other projects. And, of course, the information supplied with (or otherwise discovered about) the 1840s data here used has been added to the gazeteer. For the present study, observation reports were collected from 71 places scattered over Europe from Iceland and north Norway to the Mediterranean and from Ireland to the Caucasus, also the logs of twelve ships at sea. (For further details, please refer to the Appendix of this report).

4.4 The Synoptic Weather Maps

Once daily weather maps were plotted and analyzed. Sample days—23 July and 17 September 1845, as well as 31 July 1846—are illustrated in this report (Figs. 8, 9 and 10). The analysis represents as nearly as possible the meteorological situation at about 14h. GMT on the days in question.

Plotting Conventions used

The data shown on the maps here illustrated are limited to—Cloud Cover:(shown by blacking in the circles the number of quarters of the sky covered); Present Weather:(using the modern international symbols:
rain • drizzle , sleet •* snow *
rain shower •▽ snow shower *▽ hail shower △▽
thunder Ꞩ lightning seen ↯
fog ≡ fog with sky visible ⁼⁼ mist = haze ∞
continuous rain; light •• moderate ∴
heavy ⁘ and so on); Air temperature: (°C); Barometric Pressure: hectoPascals (hPa), omitting the hundreds and thousands digits); Wind Direction and Beaufort Force (by the direction of the arrow tails and the number of flecks on the tail: one for each two points of the Beaufort scale).

The present weather symbols are shown to the left of the circle which marks the station's position, except in a few cases where a position at the lower right-hand side of the circle means rain, snow, shower (or whatever) observed within the past hour but not at the time of reporting. The figures to the upper left of the station circles are the temperature and those to the upper right are the barometric pressure after correction to sea level and standard gravity. On the original weather maps, not here reproduced in full, additional items entered included: types of cloud (where reported), past weather (in many cases from the beginning of the day - i.e. previous midnight) and later weather (in many cases up to midnight), dew point temperature (wherever humidity measurements were reported) and (in some cases) extreme values of temperature or pressure observed earlier or later during the day (with time of observation).

Types of Meteorological Map Produced

The full range of meteorological maps used in this study included:

(i) Barometric pressure at mean sea level (in hectoPascals (hPa)) averaged for each month June, July, August and September in 1845 and 1846.

(ii) The anomaly, or departure, of the monthly mean barometric pressure in each of the eight months named from the 1851 to 1950 average.

(iii) The variability of the barometric pressure from day to day, measured by the standard deviation of the once-daily pressure values within each of the months named.

(iv) The anomaly, or departure, of the monthly mean temperature in each of the eight months named from the 1851 to 1950 average temperature for the same month.

(v) The anomaly, or departure, of the seasonal mean temperature for the 3-month seasons June to August or December to February from the 1851 to 1950 average temperature for the same season in each summer and each winter between 1844 and 1847.

(vi) The difference of monthly mean barometric pressure between 1845 and 1846 (1846 values minus 1845 values) for each of the eight months named.

(vii) The difference of monthly mean temperature between 1845 and 1846 (1846 values minus 1845 values) for each of the eight months named.

Arrangements can be made to see the original maps, or copies of them, at the Climatic Research Unit, University of East Anglia, Norwich. Samples of most of these categories of map are reproduced in this report.

On the barometric pressure maps the isobars are drawn at intervals of 5 hPa (full lines) with intermediate values indicated by dotted lines at intervals of 2.5 hPa. On the originals of these maps wind roses, indicating the percentage frequency of surface winds from different directions within the month named, were also entered but are not reproduced in this report.

On the anomaly maps the departures of barometric pressure and temperature from the long-period average are shown by isopleths at 1hPa and 1°C intervals.

4.5 The Meteorological Analysis: Problems and Procedures Used

One has to start from the assumption that the observations and measurements reported in the manifestly carefully kept weather registers, particularly at the most highly respected observatories of that time, were reliable. This assumption can, however, be (and was) subjected to a certain amount of testing at later stages in the analysis.

A problem that also had to be resolved is the fact that few details were known about the local sites, and particularly the height above sea level of the barometers, at a good many places, including a few of the high quality observation stations.

The first step, therefore, was to draw monthly mean maps of barometric pressure reduced to sea level, based just on the best observation records and places about which our knowledge of the specific details mentioned above was sufficient. This provided eight separate monthly mean maps, for June to September in the two years 1845 and 1846. And from these, the corrections needed to make the monthly mean pressures at all the other stations reporting barometric pressure were studied. In nearly all cases, this yielded indications of a sufficiently consistent adjustment that could be applied to the reported barometer heights at each station to make the readings useful for the first attempts at daily synoptic meteorological map analysis.

Many of the observing stations used in this study were places where weather observation and instrument measurements had already been made many years earlier, in the previous century, and used in the daily synoptic weather maps (mainly covering the years 1781 to 1786 and some months in the 1790's) reconstructed in the Climatic Research Unit. This meant that some details of the sites etc. could be learned from the Gazeteer of early Meteorological Observing Stations, compiled in the Unit. In a few cases, however, as was natural, it became obvious that the instruments had deteriorated with age by the 1840's.

Maps of the day-to-day variability, in terms of standard deviation, of pressure over the entire area studied from Iceland across Europe were drawn for the basic purposes of discovering:

(i) the belts, or zones, of most activity of cyclonic disturbances, which in general cause the greatest variability of pressure level within each month;

(ii) any individual stations where a high variability figure untypical of the surrounding area on the map indicated that the barometer, or the observer, must be regarded as unreliable. An untypically low variability figure should also attract interest, since it could for example indicate extreme trouble with sticking of the barometer (sticking needle or mercury column).

At this stage, the first analysis of the synoptic meteorological maps for the individual days selected for study in 1845 and 1846 could be carried out. An airmass and frontal analysis was drawn, and isobars sketched in, on once daily maps for altogether 24 days in those two years.

The dates for which maps were completed

1845	1846
14 - 16 June	
3 - 9 July	28 - 31 July
20 - 24 July	7 - 8 August
16 - 18 September	

The dates were chosen in connection with the history of the developing outbreaks of the potato disease. This analysis revealed that there were some places where the pressure values derived from the instrument readings gave more trouble than others. The average, and the extreme range, of the discrepancies at each place between the pressure value entered on the map and the best-fit isobar analysis of the whole map were logged. On this basis, a modified value of the standard pressure adjustment[1] to be adopted for each place was decided: and a note of this and the magnitude of the error range was added to the details for each station in the Gazeteer.

The standard errors of the pressure values so adjusted were one hPa or less at the best stations (e.g. 0.5 to 0.7 hPa at Brussels, Copenhagen, Den Helder (Holland), Geneva, Helsinki) and only 1.7 to 2.3 hPa in the case of the Danish naval ships in port or at sea in the southern North Sea, Baltic and English Channel. The higher figure of 3.0 hPa for ships operating in the Faeroe Islands - Iceland region may be partly attributed to the difficulties of precise analysis with strong pressure gradients and more rapid changes of pressure in that region. Notably, higher values of the standard error at two points indicated that the barometer

[1]Meteorological readers will be aware that the correction of barometric pressure to sea level etc should vary a little from day to day, depending on the air temperature and pressure level. However this refinement had to be largely disregarded because of time restriction in the present study.

readings on certain particular days, at Ballimore in the western Highlands of Scotland could be treated as quite untrustworthy and that the old barometer at Montdidier in northern France (which had performed well in the 1790's), had to be disregarded in the years 1845 and 1846 here studied.

The corrected pressure values at stations where there was least specific knowledge about site and instruments have been entered in brackets on the daily maps, even in those cases where the results from the corrections derived give apparently consistent and reliable pressure values that fully support the analysis. Pressure values derived from the barometric measurements in ships have also been entered in brackets on the maps in this study.

The derivation of maps of monthly mean temperature for the eight months studied was not a simple matter, because many of the observers only read their instruments at one, two or three times of the day, and these times differed from place to place. This, however, meant only that detailed large-scale mapping of the temperature variations within an area such as the British Isles, where there were twenty-three stations reporting, could not be done without the expenditure of a great deal of time in study of the diurnal temperature curves. There were enough places distributed over Europe, however, for which daily maximum and minimum temperatures were recorded (i.e. the highest and lowest temperatures in the 24 hours recorded by automatic instruments) to make it possible to map the general pattern of temperature deviations over the region as a whole for each month and each season.

The possibilities of a really extensive survey of the occurrence of potato blight weather conditions in the eighteen-forties were limited by shortage of reliable humidity measurements. Although wet and dry bulb thermometers were already in use at a good many places, and other types of hygrometer were also employed, not very many places produced humidity records that were obviously self-consistent and fully credible. It may be that the requirements for proper exposure and maintenance of the wet bulb thermometer were not widely understood at that time. Luckily, the humidity measurements at both Dublin and Brussels, with which this study is necessarily concerned, do appear reliable, as do those at a number of other high-grade stations.

4.6 Results of the Meteorological Analysis: The Nature and Development of the Seasons

4.6.1 General

The eighteen-forties were a decade of special interest climatically being one of the final stages of the long period of colder climate in recent centuries that has become widely known as the Little Ice Age. In the 325-years-long thermometer record of temperatures in central England (Manley, 1974; Lamb, 1977) it displays one of the three longest runs of cold summers; eleven out of twelve summers between 1838 and 1849 have a mean temperature (June, July and August) of 15.0°C or less as against an average of 15.6°C in the present century. Only the 1690's, with a ten-year mean of 14.5°C and 1809-18 with 14.6°C appeared colder. On the other hand, one summer (1846) in the 1840's was out of line with this in England, with a mean temperature of 17.1°C, one of the warmest on record, compared with 17.6°C in 1826 and 1976.

The glaciers in the Alps were still near their most advanced positions down in the valleys, the extremes being generally reached in different cases around either 1850 or 1820 (as well as earlier around 1600 and 1720), in evident response to periods of cold summers. But the great recession, which continued with little interruption until 1965 or after, was about to begin. And symptoms of a warmer climate beginning were already apparent in another part of the European environment, with the disappearance for fifteen years of the Arctic sea ice from Iceland waters: it was not seen at the coasts of Iceland from 1840 until 1855.

Features which doubtless correspond to these changes affected the prevailing wind climate. The long record (Lamb and Weiss, 1979) of the frequency of days with general westerly winds blowing over the British Isles runs from 1781 to 1786 and from 1861 to now. It is the commonest single type of situation and is regarded as a basic feature of the European climate.

Although it does not cover the eighteen-forties, the correlation with the frequency of southwesterly surface winds in London, which is known—it is a record of observations unbroken from 1669 to the present—indicates an average for 1840-49 of about 70 general westerly days a year. This is a higher figure than those indicated for the severer phases of the cold Little Ice Age climate before 1830, and is, in fact, quite similar to recent years (since 1968), although in the 1860's, and between 1900 and 1954, the average was between 90 and 110 days a year. So, in this sense the eighteen-forties appear more particularly similar to the present day. The figures register how wide the long-term variations are in the frequency of so-called "blocking of westerlies", when wind and weather patterns differ more or less substantially from the supposedly normal prevailing westerly winds situation.

4.6.2 The Winds and Temperatures in 1845 and 1846 .

The years with which we are concerned here had rather more days with southwesterly wind in London than the average of the eighteen-forties decade. Nevertheless, the temperature and pressure maps over Europe and the eastern Atlantic for June to September 1845 and 1846 all show features characteristic either of blocking of the westerlies in some part of the map or of a lower than normal latitude of the main westerly wind flow over the whole region.

The maps of temperature departure in each month from the long-term (1851-1950) average reproduced here in Figs. 3 and 4 all show some region of temperature anomaly over western or central Europe with decidedly different experiences indicated in other longitudes, east and west of it. This is an indication of regions unusually affected by northerly or southerly winds or, in some cases, of repeated influence of either cyclonic disturbances with cloudy skies and rainfall or of anticyclones with fine weather. In the seasonal temperature departures (Fig. 5) this is less obvious because of shifts of the persistent warm or cold, wet or dry influences from one month to the next. Samples of the barometric pressure maps, for July 1845 and July 1846, are reproduced as Figs. 6 and 7.

Table 4.1 shows the percentage frequencies of winds from directions of interest to this study at Dublin in the months from June to September 1845 and 1846 (Ordnance Survey of Ireland, 1856). When converted to percentages of the average for the years 1831 to 1852, the most remarkable features in 1845 were the high

Table 4.1: Wind Dirrection Frequencies in Phoenix Park, Dublin for months June to September (Percentages of the observations)

	1845				1846			
	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep
SW + W	42	32	34	42	32	56	28	32
NW	20	15	29	6	1	8	11	8
NE + E + SE	12	27	6	27	45	12	36	45
Calm	17	16	16	17	3	1	8	6

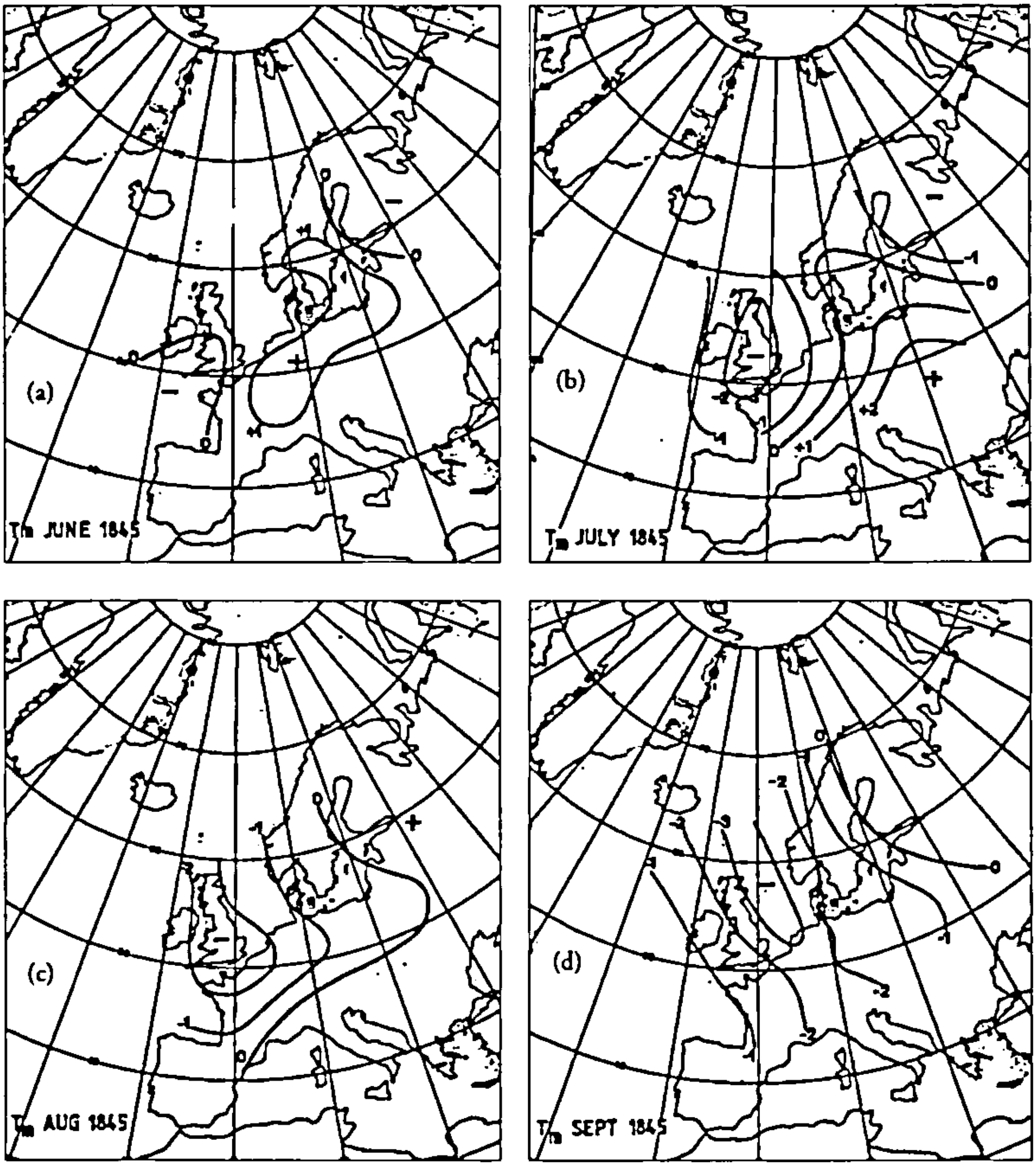


Fig. 3 Anomalies of the air temperatures prevailing in (a) June, (b) July, (c) August, and (d) September,1845 —i.e. departures in °C of the monthly mean temperature from the 1851-1950 average.

frequency of calms in each month, the frequency of winds from easterly points in July, and the frequency of NW winds in June and August. All were about twice as prominent as usual. In 1846 the winds were not so light; and, except in July, the prominence of winds from easterly points, particularly from the SE, was quite unusual. In July, however, winds from between S and W accounted for nearly three-quarters of all the observations, a frequency nearly twice as high as their usual.

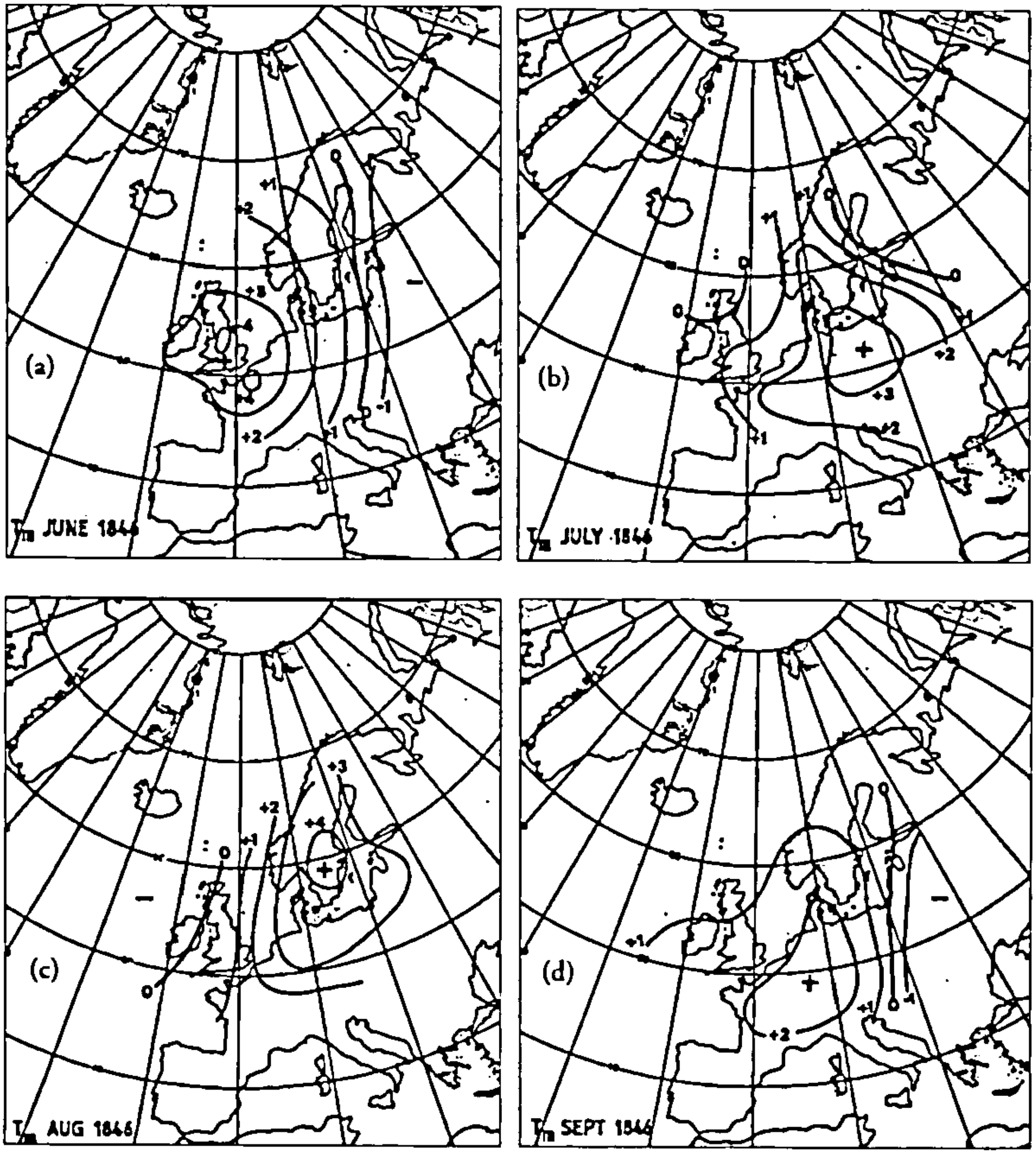


Fig. 4 Anomalies of the air temperatures prevailing in (a) June, (b) July, (c) August, and (d) September, 1846 —i.e. departures in °C of the monthly mean temperature from the 1851-1950 average.

4.6.3 The Winter

Four of the winters of the decade (1839-40, 1842-3, 1845-6 and 1848-9) were marked by very strong wind circulation sweeping mild Atlantic air in towards Europe and at times right across the continent. Additionally, in 1841-2, and 1847-8, a similar windstream, passing over or near western parts of the British Isles, drove mild air from the SW and S far in to the Arctic. The other winters of the

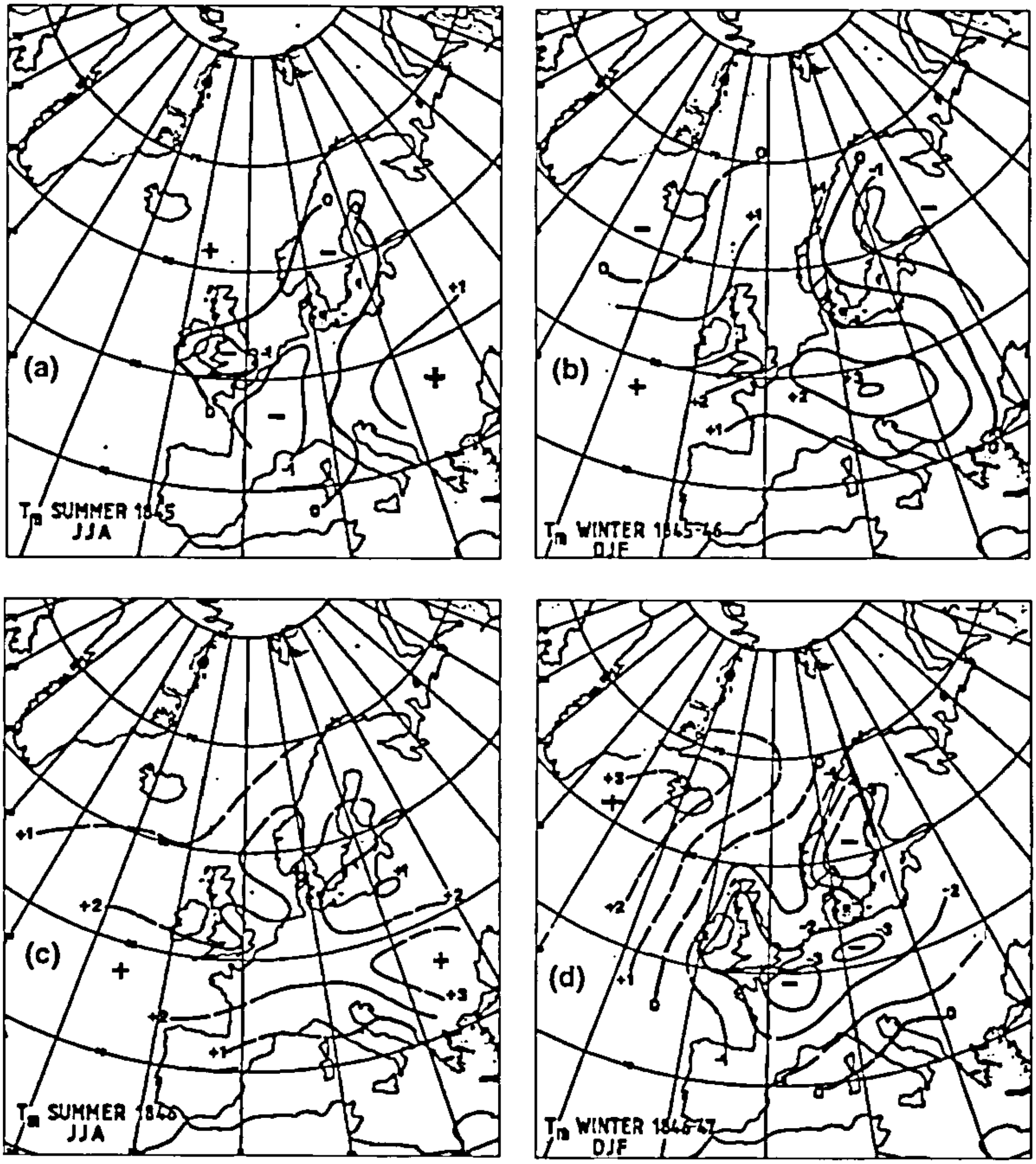


Fig. 5 Anomalies of the Mean Air Temperatures for the (a) summer of 1845, (b)winter of 1845-46, (c) summer of 1846 and (d) winter of 1846-47, i.e. summer departures in °C of the Mean Temperature of the period June, July and August and winter departures of the period December January and February from the 1851-1950 average.

decade showed more distorted patterns. The winters of 1844-5 and 1846-7 (Fig. 5(d)) were cold, with the mean temperature of the three months December, January and February between 1.0 and 2.5°C below the 1851-1950 average over most of the British Isles and about 4°C below average in parts of continental Europe and Scandinavia. By contrast, the winter

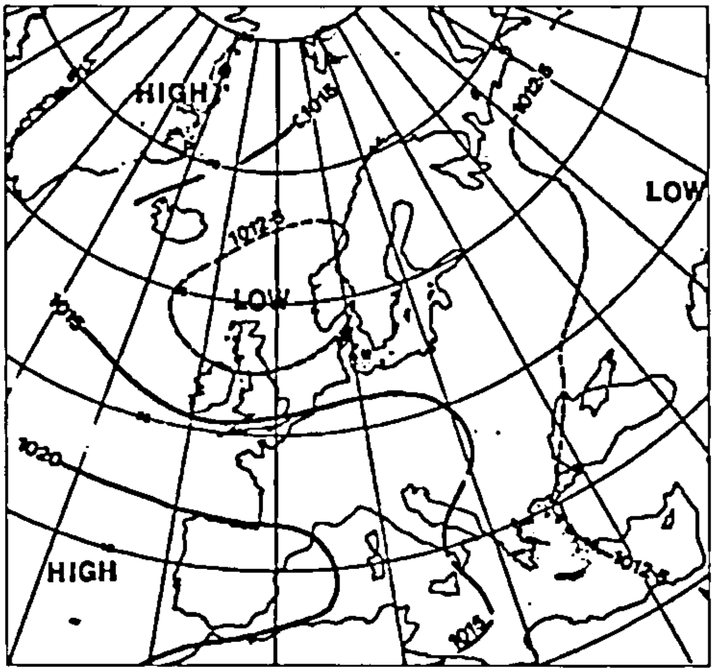


Fig. 6 Mean barometric pressure at sea level in hectoPascals in July 1845

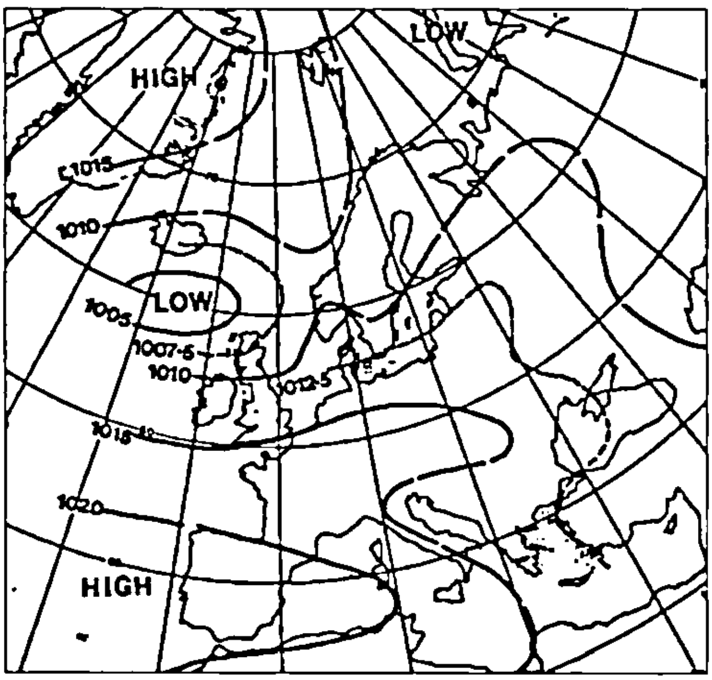


Fig. 7 Mean barometric pressure at sea level in hectoPascals in July 1846

1845-6 (Fig. 5(b)) was very mild, with mean temperature up to 3°C above normal in central Europe.

At De Bilt in the Netherlands the mean temperature of the winter three months (December to February) in 1845-6 was as high as +5.2°C, one of the highest in a 300-year record, whereas the figure for 1846-7 was -0.6°C. Sabine (1846) writing about it at the time, along with two earlier winters noted for their exceptional mildness (1776-7 and 1821-2), was able to report that the warm water of Gulf Stream origin advanced far beyond its usual bounds in the eastern Atlantic.

4.6.4 Sea Surface Temperatures and Atmospheric Humidity

We do not have the sea surface temperature observations made in individual years in the eighteen-forties at hand. It is likely, however, that the warmer than usual water remained a feature of the ocean surface near the British Isles into the summer of 1846. This conjecture could not be justified on the basis of persistence alone; but the winds observed in Ireland, showing excesses of southwesterly and southerly directions in nearly every month to July 1846 inclusive, make it probable that the drag on the ocean surface continued to drive the warm water towards these islands. And so, higher than usual atmospheric humidity could be maintained. Monthly averages of the dew point temperature at Dublin show the effect (Table 4.2). Dew points were higher in 1846 than in 1845 in all the months studied. The average difference was more than 2°C. And this was not in the main due to the greater frequency of northwesterly and northerly winds in 1845. The difference between the two years was almost as great when the comparison was confined to days with similar winds, from the southwest quarter and from the Irish Sea coast nearby.

4.6.5 The Summer of 1845

The weather in all three of the main summer months of 1845 was dominated by cyclonic disturbances over the Atlantic passing from southwest to northeast, or from west to east, near the British Isles. The axis of lowest pressure, in each case, passed between Scotland and Iceland, where northerly winds prevailed. At times, the high pressure whose prevalence is implied over the Greenland region extended or was temporarily displaced far south towards Scotland and England, the southern North Sea, or south Norway. At such times, weaker cyclonic depressions with thundery activity moved eastwards over Europe, mainly between France, southern Germany and Poland, or Austria, while others approached Ireland from the southwest. During late July, August and particularly in September 1845, northwesterly and northerly winds were established over the Norwegian Sea, reaching at times as far south as Orkney and Shetland and on over eastern England and the North Sea, bringing high frequencies of N winds to Holland and NW winds to Denmark. This supply of cold air is a prominent feature of the temperature maps (Figs. 3(b),3(c) and 3(d)), particularly in September 1845 (Fig. 3(d)). And, as will be

TABLE 4.2: Dew Point Temperature (monthly averages) from measurement at Phoenix Park, Dublin

	1845				1846			
	June	July	Aug	Sept	June	July	Aug	Sept
Dew Point (°C) at 15h	12.3	11.7	11.8	9.6	14.3	13.4	14.3	13.2
Difference 1846 minus 1845					2.0	1.7	2.5	3.6
Dew Point (°C) on days with winds from between WSW through S to NE	13.1	12.3	13.5	10.8	14.6	14.5	14.6	14.1
Difference 1846 minus 1845					1.5	2.2	1.1	3.3

noted in Chapter 5, it doubtless explains the failure of the potato disease to reach the northernmost parts of the British Isles in 1845.

4.6.6 The Summer of 1846

In 1846 the season was warmer all through. In Orkney, where the warmer sea should be important, every month except April and December was warmer than in 1845 (Clouston 1861). September, in spite of a rather similar preponderance of northerly wind in both years, was 2.7°C warmer in 1846. In London (Greenwich Observatory) the difference was over 3°C in each month June, July, August and September. In Dublin those months were from 2.0 to 3.2°C warmer in 1846 than in 1845. Except in July westerly winds were less frequent, easterly winds more frequent, the eastward progression of depressions from the Atlantic more blocked, than in 1845 (cf. Table 4.1 and Figs. 6 and 7 for the different situation in July). Barometric pressure was higher over northern Europe than in 1845, by more than 5 hectoPascals in a belt from northern Scotland to Scandinavia, in June, August and September. And, even in July 1846 the high pressure over central Europe extended a ridge over the North Sea to southern Norway. Thus, continental Europe and eastern England were protected from Atlantic depressions, which again affected Ireland, northern Scotland and, from July onwards, western Norway.

The difference between the summer weather of the two years in London, and their similarity in Dublin, is seen in the number of days with rain (Table 4.3). The higher level humidity present on many days in 1846, and the occasional thunderstorms which interrupted the fine weather even on the continent, meant that the total rainfall was actually a little greater in the summer of that year than in 1845, by a margin of 7 per cent in London and 13 per cent in Dublin. But in the months from June to September London had only 45 days with rain in 1846 compared with 64 in 1845; in Dublin, both years had 74 days with rain.

TABLE 4.3: Number of Days with measureable Rain and the Total Rainfall each Month

	1845				1846			
	June	July	Aug	Sept	June	July	Aug	Sept
London (Chiswick Royal Horticultural Society)								
Days with rain	12	21	17	14	6	14	16	9
Rainfall (mm)	34.5	58.7	70.9	45.0	20.3	45.3	114.3	44.7
Dublin (Phoenix Park)								
Days with rain	16	19	21	18	10	20	24	20
Rainfall (mm)	83.8	70.6	62.2	26.4	24.6	74.4	121.7	54.9

4.6.7 Day-by-Day Weather and the Potato Disease

There is no doubt that there were enough occurrences of easterly wind in the summer and early autumn of 1845 to carry the potato blight infection in Belgium to Ireland. And there were plenty of occasions with winds from other directions, able to account for the spread of the disease to the other parts of Europe, from south Norway to southern France and east as far a Germany at least. The three daily weather maps in this report have been chosen to illustrate sequences which clarify the spread and distribution of the disease (Figs. 8-10).

Fig. 8 shows the weather situation on the afternoon of 23 July 1845. The days from 20 to 24 July were analysed. Pressure was high over the Norwegian Sea throughout that time, and an anticyclone centre moved south to become established between Scotland and the Faeroe Islands. There were weak low pressure systems stagnating, or moving slowly eastwards over the continent from Biscay, over Britanny and south Germany, to Austria. And there was a good deal of thundery activity, showers and occasionally heavy rain, followed by fogs at night, along and near the fronts dividing the warmer air over central and southern Europe from the colder air that came south over Scandinavia and the North Sea.

At first, on the 20th, there were easterly winds all the way from north Russia to Ireland. But on the 22nd-23rd the warm weather that had extended as far north as Stockholm and Christiania (Oslo), with temperatures 26 to 29°C on 20th-22nd July, was replaced by much colder air from the north. On the 23rd-24th the main channel of the cold air supply was transferred west to the North Sea, and afternoon temperatures were as low as 15 to 16°C in southern England. At this point the winds were more northeasterly in England and the belt of easterly winds was transferred a little south, to northern France. But for nearly a week, from 19th to 25th July, there was a belt of easterly winds passing over, or near, Belgium to the Atlantic shores of Europe.

Fig. 9 illustrates a much more cyclonic sequence, with active fronts across most of Europe, in the early autumn of the same year. The depression centres were mainly between latitude 50 and 60°N, and one of them deepened to about 970 hPa as it approached the Faeroe Islands on the 18 September 1845. The map for September 17th, illustrated in the figure, shows strong S and SW winds developing near the British and Dutch coasts and a very wide area of rainfall. Temperatures and dew points in all the warmer air masses over Ireland, Britain and the continent after the leading warm front were high enough to sustain potato blight development. In Germany, air temperatures exceeded 25°C in this air on the 18th, but in most places the continuing cloudy to overcast skies, associated with all the frontal activity, kept the temperatures a few degrees lower and relative humidity high enough to foster the blight.

The weather map for 31 July 1846 (Fig. 10) has been chosen to show one of the many weather situations of that year which, although partly similar to the maps of 1845, gave much finer, warmer weather over much of Europe, especially northern Europe. Cyclonic activity again maintained frequently overcast skies and humid conditions over Ireland and, sometimes, other parts of the Atlantic fringe; but elsewhere there was much less cloud and some very high temperatures. The map shows 30°C in Stockholm and Copenhagen, 31°C in London and 32°C or over at several points in northern France and western Germany.

A week later, on 7-8 August 1846, weak cyclonic centres had penetrated east as far as Denmark, bringing thunderstorms into southern Scandinavia and widely over central Europe, where temperatures still ranged from 26 to 33°C. With the overcast skies in the next few days after that activity, there must have been an interval when the threat of blight conditions arose in those areas, but soon the mainly fine weather was restored. In Ireland, by contrast, as we have seen (Table 4.3), the disturbed conditions continued, and there was rain in Dublin on 24 days in August.

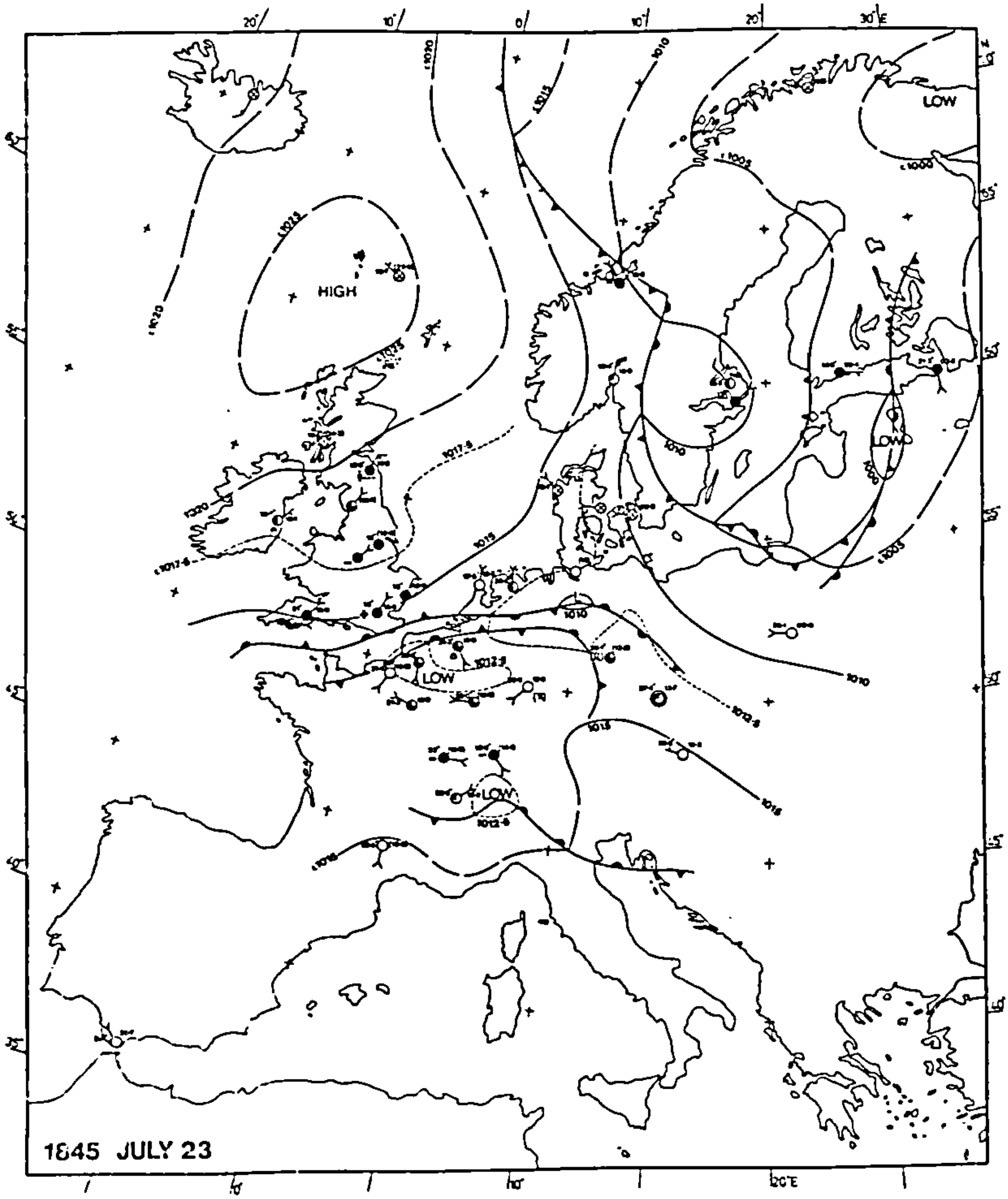


Fig. 8 Synoptic Weather Map : situation at 14h on 23 July 1845

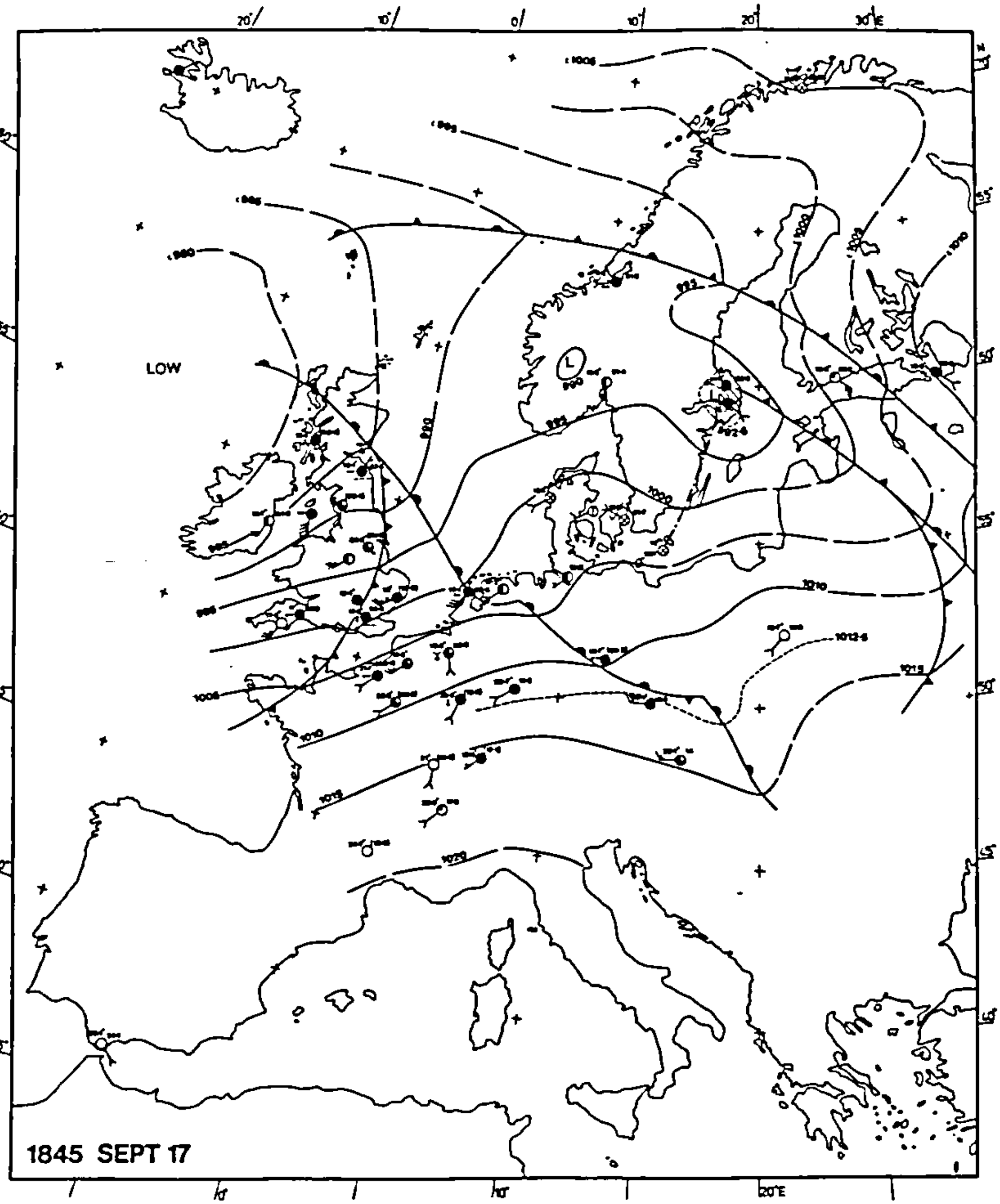


Fig. 9 Synoptic Weather Map : situation at 14h on 17 September 1845

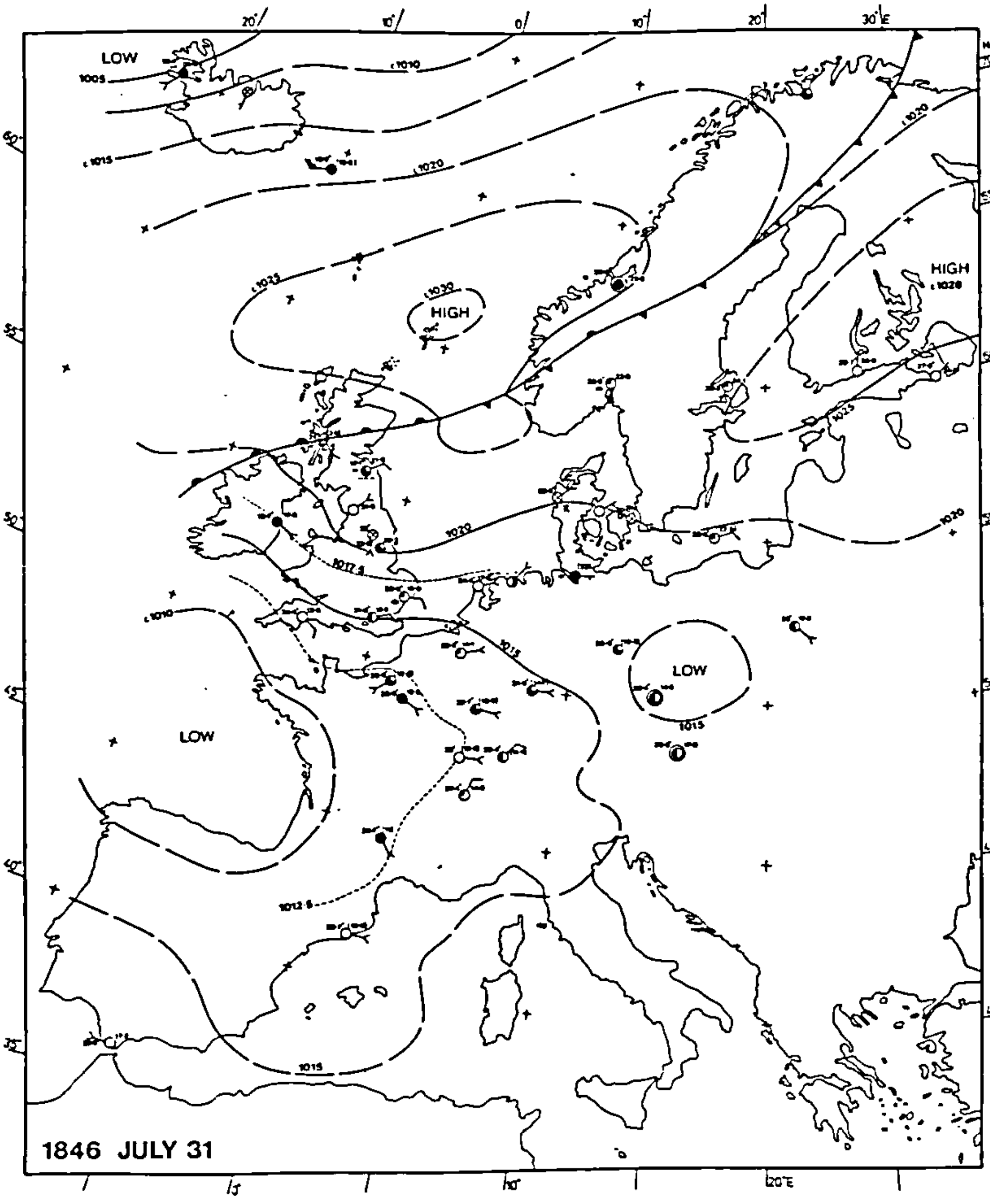


Fig. 10 Synoptic Weather Map : situation at 14h on 31 July 1846

CHAPTER 5

POTATO BLIGHT IN EUROPE IN 1845

5.1 Data on the Blight Epidemic

It is possible to chart the onset and development of the 1845 outbreak of potato blight in Europe in far greater detail than that of any subsequent attack down to the present day. This is because the spectacular first impact of the disease and the level of public concern led to the appointment in most of the affected countries of governmental commissions which compiled comprehensive reports on the epidemic. Similar accounts were prepared by the special committees set up by many scientific and agricultural bodies. Detailed weekly reports on the impact of the disease in Ireland in 1845 and 1846, drawn up by the constabulary at more than 250 police stations throughout the country, are preserved in the Public Record Office, Dublin. A flood of books, pamphlets and newspaper articles was devoted to the subject. The accounts published in the Gardeners' Chronicle (hereafter referred to as GC), covering most of Europe, are particularly voluminous and helpful. Useful data are to be found in publications as diverse as the Moniteur Belge (MB) and the Irish Farmers' Journal (IFJ).

5.2 Synthesis of the Disease Data

Fig. 11 is a pioneer reconstruction of the spread of the epidemic based on the approximate dates when blight came to attention in 1845, commencing with the earliest report from near Courtrai (Kortrijk) in West Flanders towards the end of June (Bourke, 1964). The dates of the first recorded appearance of disease in each district were plotted on a large scale map, and isolines for fortnightly intervals were drawn to envelop all attacks which were described as serious by the date in question.

In areas of particularly abundant reports such as Ireland, where the numerous police returns were supplemented by much extra material, some outliers of lesser impact were found to be located beyond the lines of main advance, as was no doubt to be expected because of the windborne spread of the disease.

It is important to note that the dates shown in Fig. 11 are those on which the disease attracted general attention and published comment, not those on which the fungus first began its attack. In the early inner zones, they are thus the dates on which foliar decay was sufficiently advanced to attract the concerned attention of persons hitherto unfamiliar with the disease; in the outer zones, where natural ripening at so late a date in the growing season tended to mask the progress of the disease on the foliage, the first alarm often dated from the discovery of tuber rot. For example, when the constabulary in Ireland were first asked to report on the disease in mid-September 1845, it was for tuber rot that they primarily looked; many of their reports made only incidental mention of premature decay of the foliage.

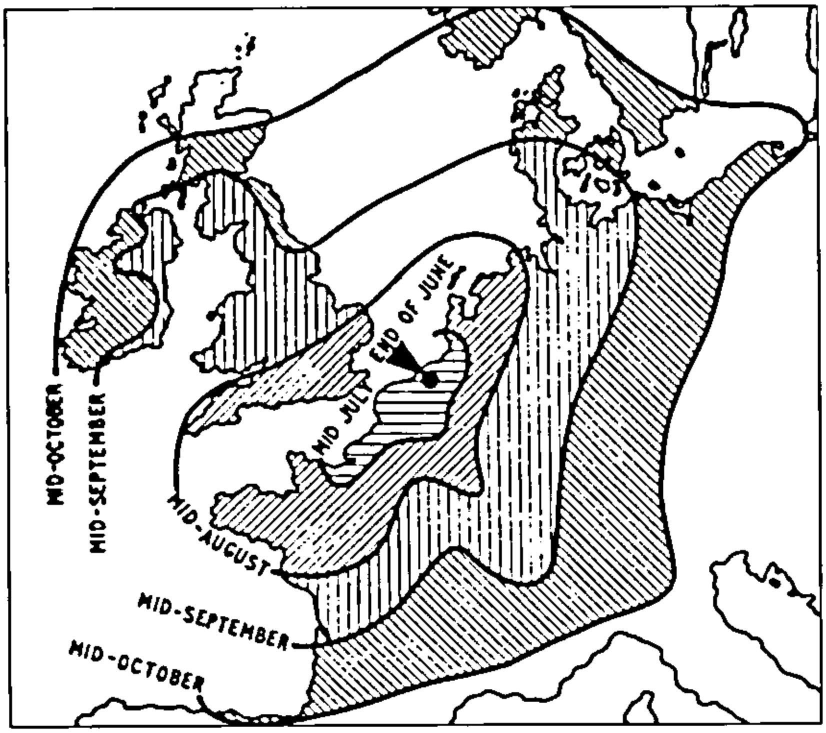


Fig. 11 Dates in 1845 when progress of blight was so generally noticeable as to cause comment and alarm

5.3 Checking the Disease Picture

The essential accuracy of the broad lines of Fig. 11 has been confirmed by different types of supplementary information. Thus, for example, at a meeting of the Société Royale et Centrale d'Agriculture held in Paris on 20 August 1845, (Bulletin de Séances, 1845-6, p.284), M. Elisée Lefebvre put on exhibition samples of diseased potato foliage and tubers which he had collected in the Brunoy suburb of Paris. On 30 August, Dr M J Berkeley in England received from his friend and fellow mycologist, Dr J F Montagne of Paris, 'some leaves affected with the mildew'. Dr Berkeley made enquiries in every direction but failed to locate the disease in the neighbourhood of his parsonage at King's Cliffe, near Peterborough. His own potato crop was 'never more abundant or finer' (GC 1845, p.593). No more than a week later the position had changed dramatically for the worse: "Since I last wrote to you I am sorry to say that the potato-murrain has made its appearance in Northamptonshire and is spreading very rapidly" (GC 1845, p.608).

An unexpected by-product from some of the weather diaries kept by farmers in the year 1845 proved to be comments on the blight epidemic which tended to confirm Fig. 11. From Montdidier, near Amiens in northern France, the 'maladie de moisissure' was reported as attacking the potato crop in August, affecting first the foliage and then the tubers. In Uckfield, south of London, the diarist felt that 1845 would be particularly remembered for the appearance of potato blight as a new disease. He first noticed it on 28 July; within ten days it had become rife throughout Sussex, but it was absent from the north of England until early September. The observer at Ipswich recorded damage to the potato foliage as beginning in early August; by the end of that month "the whole crop appears as if completely seared". From Tutbury in the English north Midlands notes on the month of September say that the disease was in large measure confined to the more southerly counties; locally it had been only partially felt. The diarist casts doubt on the theory that the damage to the crop was the direct result of unseasonable weather: "we have had similarly wet seasons without any similar result".

Some accounts of cross-country journeys provide cross-sections to verify Fig. 11. Mr J Dillon Croker set out early in September from his home near Mallow, Co. Cork, for a journey to London. He wrote lengthy letters on the condition of the potato crops en route to the Cork Constitution which were widely copied in other newspapers. When Mr Croker left home on 8 September his potato fields were generally luxuriant, except for two partially withered which at the time he attributed, more significantly than he knew, to the east wind. Travelling on 10 September between Bristol and London, he did not see a single exception to a total failure of the potato crop, the stalks all decayed and dying. Many of the fields looked like an undug garden in January. His son, a student at Cambridge University, told him that the epidemic had swept to the north of that town. He understood that blight also raged in Holland, Belgium, Germany and France.

In the following week, Croker travelled northwest from London to Liverpool, where he noted that one-quarter of the potato crop being brought to the market there was found to be unfit for sale at the first picking, while a further proportion rotted later. On the journey from London to Birmingham he saw only few surviving potato fields; in many cases a replacement crop had been sown to follow the destroyed potatoes.

From Birmingham to Wolverhampton all the fields were in poor shape, but between Wolverhampton and Crewe some had escaped lightly. Between Hartford and Warrington, and close to Liverpool, things were much better. He hoped that the progressive improvement which he found in travelling from the SE towards the NW of England might prove a hopeful sign for the Irish potato crop.

He was, of course, unaware that three considerable periods of blight weather, with a combined effective duration of 67 hours, had occurred during his absence from home (see Fig. 13). Returning to Mallow on 20 September he was shocked to find that every one of his potato fields had changed from rich green to the dark brown and black colour which indicates the ravages of blight. Only in a small part of one field had tuber rot as yet set in, but there were many complaints of this among his neighbours.

Most of the newspapers in Ireland which reprinted Croker's letters, especially those in the midlands and west, felt that he was unduly pessimistic about the crop. There was no general panic in Ireland for another month or so, until the extent of tuber rot was revealed at digging time.

5.4 Windborne Spread from an Infected Central Area?

The pattern of successive discovery of blight in 1845 as depicted in Fig. 11 is consistent with a gradual outward windborne spread from an initial infection area centred on Belgium. At first sight such an interpretation may seem improbable in view of the high vulnerability of blight spores to all but humid weather, which means that they are normally short lived. However, the geographical analysis of the spread of blight in North America in 1843-5 (Fig. 1) shows annual extensions of the disease over comparable distances. A more recent experience confirms the 'alarming rapidity' with which a rather similar disease, the blue mould of tobacco, could move from local points of introduction to a very wide area (Todd, 1961; Rayner and Hopkins, 1962); "in two years it spread right across Europe", and this despite modern phytosanitary vigilance and the fact that the European tobacco crop is grown in widely scattered patches and is not at all as extensively cultivated as was the potato in 1845. Populer (1964) has drawn up an informative series of charts to depict the successive spread of the tobacco disease from primary foci both in Europe and in America which are basically similar to Figs. 1 and 11. Recent proof that the wind can carry perishable disease inoculum across the English Channel and initiate attacks in southern England is referred to in paragraph 3.4 above.

Some further questions remain to be discussed about the spread of blight in Europe in 1845, as depicted in Fig. 11: the extent of the initially infected area; the carriage of blight spores, not merely to the west and north, but eastwards against the trend of the prevailing winds; the failure of the disease to penetrate to the very north of Scotland; the vulnerability to blight of the potato cultivars of the time; and the extent to which the seasonal weather in 1845 favoured the development of the epidemic. These topics are dealt with in turn in the following paragraphs.

5.5 The Extent of the Central Infected Area in the Spring of 1845

Most competent observers recognised that the blight of 1845 was a new disease in Europe which had not, for example, been described in a recent comprehensive survey of potato diseases assembled by von Martius (1842). However, quite a few commentators interpreted the ailments of the potato as successive stages in a progressive 'degeneration' of the crop, and some specifically considered it to be no more than a further development of the dry rot which had been particularly troublesome in recent years.

For this reason, it is not easy to segregate from the mistaken claims of earlier appearances of blight the small number of possibly accurate reports of some spread of the disease already in 1844 from the planting in West Flanders. One of the most plausible of the latter is provided by Mr Robert Parker, an extensive potato grower in East Kent, who wrote to the British Home Secretary on 12 August 1845 to warn him of the severe outbreak of the disease which had begun to attack in his district at the end of July 1845. He added that the same disease had appeared for the first time late in September in the previous year, when it was confined to East Kent and was partial in effect (Farmers' Magazine, 1845, p.545).

There is also fairly convincing evidence (Harting, 1846) that blight occurred late in 1844 in Lille in northeast France, close to the Belgian border, so that it seems that some limited preliminary spread from Flanders had already taken place in 1844.

5.6 The Westward Spread of the Epidemic

There is plentiful statistical evidence of the relative frequency of easterly winds during several periods of the 1845 growing season (for example, Cooper 1846; Jones 1849). The overall absolute frequency of different wind directions is, however, not the critical factor in the spread of the disease; what is important is the wind direction at the times when the fungus is actively sporulating. Other relevant factors for the successful transplant of a disease to a new area include its closeness to the sea (where relative humidity tends to be higher), the susceptibility to blight of the varieties grown in the area, and the density of potato growing. All these factors would, in due course, promote the rapid spread of the disease as soon as it reached Ireland. Meanwhile, they tended to favour the extension of the disease on either shore of the English Channel. In England damage by blight was noted in the first days of August near Sandwich, Kent and was quickly found in other coastal areas towards the west. South of the Channel the potato crops were soon ravaged all along the Cotes-du-Nord, the damage being dated back by some observers to the first days of August. The blackened belt of destruction along the coast was ascribed by some to the passage of a ball of fire (MB, 31 August 1845). From Normandy or Brittany the disease soon appeared in Jersey, where the observer "at once attributed it to the easterly winds" (GC 1845, p.576), words which would later be echoed by Croker in Ireland. Almost simultaneously with its appearance in Jersey, blight was found in the Isle of Wight (cf. paragraph 3.4 and Fig. 2).

A pressure pattern which recurred during many of the continental blight periods in June and July of 1845 featured high pressure to the north of Scotland with a weak ridge extending southwards and a complex set of shallow, thundery depressions over the Low Countries and France. A characteristic example is provided by the synoptic chart of 23 July 1845 (Fig. 8). This situation gave rise to a light, but persistent, easterly wind-drift down the English Channel while simultaneously creating blight weather (see paragraph 3.2.2). This is reflected in Fig. 13 where a succession of blight weather spells are recorded at Brussels in the second half of July 1845, with no corresponding spells in Dublin.

The other main blight-fomenting pressure pattern, as described in paragraph 3.2.1, is illustrated in Fig. 9, in which broad, warm sectors of maritime tropical air are shown driving eastwards into Europe, giving widespread and repetitive periods of blight weather in Dublin in the week ending 20 September, and a little later in Brussels. It will be recalled that it was at this time that Croker returned to Mallow to find his potato fields riddled with blight. It might have been thought that the Belgian potato crops, already destroyed by the disease in earlier months, could suffer no further damage from this later spell of blight weather. However, a number of Belgian growers had re-seeded their potato fields after the July failure, only to see their replacement potato crops go down after the mid-September attack (Dumortier, 1845, p.285).

5.7 The Northern Boundary to the Spread of Blight

In the unusually cold growing season of 1845 (Fig. 3) it was inevitable that the disease, at some stage of its march towards the north, should encounter the kind of discouraging temperature conditions which have inhibited its impact in Iceland in recent years (see paragraph 3.3). The temperature anomalies for September 1845 (Fig. 3(d)) are particularly significant; at this stage when the epidemic was pressing northwards in Britain, the comparatively delayed appearance in Yorkshire (Fig. 11) reflects the colder conditions in northeast England. Temperatures were still lower in the north of Scotland. Milne (1847) lists the average temperature in September 1845 for a large number of Scottish locations: in northern Scotland the level was sufficiently low (10°-11°C) to explain the failure of the disease to secure a foothold there in 1845. The temperature check to the spread of the disease was fated to be short-lived; in the warmer summer of 1846 (Fig. 4) blight would extend to the whole of Scotland and to the islands beyond.

The impact of blight on crops grown on high ground in the cool summer of 1845 was similarly affected. In Ireland the growing population and the ever rising demand for more ground to grow the essential potato had driven the crop higher and higher into the hills where signs of its cultivation, high above the current level of tillage, persist to the present day.

In 1845 it was found that the potato crops grown in the cooler uplands suffered appreciably less from blight (IFJ 1846 (I), p.1185; 1846 (II), p.177). In the warmer summer of 1846 they would no longer escape: "the mountain lands which were unaffected or but partially affected last year (1845) are reported to be very much affected by the disease this year" (Thirteenth Annual Report of the Poor Law Commissioners, 1846, p.123).

5.8 The Susceptibility of Different Potato Varieties to Blight

A great number of different potato cultivars were grown in Europe in 1845, many to a limited extent (Bourke, 1971). As few commentators failed to note, they presented a wide range of resistance to the new disease. Trials to quantify these differences were carried out in several countries. For example, a replicated study of tuber resistance in two kinds of soil took place in the Netherlands on 148 different potato cultivars and gave results ranging from complete rotting to perfect soundness (Harting, 1846, pp.288-9). It was the increased use of the less susceptible sorts, hitherto in limited cultivation, which enabled the potato to recover from the initial disaster and to survive as a major food crop over the lengthy interval until breeding for resistance to blight and the use of fungicides had been introduced.

The tragedy lay in the fact that the potato varieties most widely grown by the poor because of their higher yields - such as the ill-famed 'Lumper' which was almost universally grown in Ireland - were precisely the sorts which succumbed most rapidly and most completely to the new disease (British Cultivator and Agricultural Review, 1845, p.334; IFJ 1846 II, p.222). There was a tragic time lag before the more resistant varieties could be multiplied and brought into general use.

5.9 Blight Weather in 1845

There was much controversy in 1845 as to whether the weather in that growing season was, in itself, an adequate cause of the failure of the potato crop. Those who took the trouble to compare the meteorological data of that year with the figures for earlier years agreed that the summer of 1845 had indeed been drab, cool and cloudy, but were equally unanimous that there was no feature of that season which had not been equalled or surpassed in earlier years through which the potato crop had come unscathed. Only Harting (1846), who examined the weather records for Utrecht and Breda for the years 1838-45, noted that the relative humidity of the air had been unusually high in 1845, and related this to a finding by Unger in 1833 that high humidity was significant for the development of many plant diseases.

The correctness of Harting's observation is confirmed by the entries for Brussels in Figs 12 and 13, which portray the occurrence and effective duration of blight weather spells, as defined in paragraph 3.1. The first of these figures relates the early season development of blight in Belgium in 1845 to a similar first appearance of the disease in Chile in 1950-51 (Bourke, 1956) and to a recent case of a severe early attack in the Low Countries in 1981.

The year 1981 was selected with the kind assistance of Professor J C Zadoks (Wageningen) as one in which potato blight in the Netherlands and Belgium attracted wide attention in the popular media by reason of its early and severe onset. It commenced as early as the first week in June, and progressed with such rapidity that it much alarmed the growers, and revived memories of, and professional interest in, the 1845 precedent (Semal *et al.*, 1983). The analysis of blight weather in

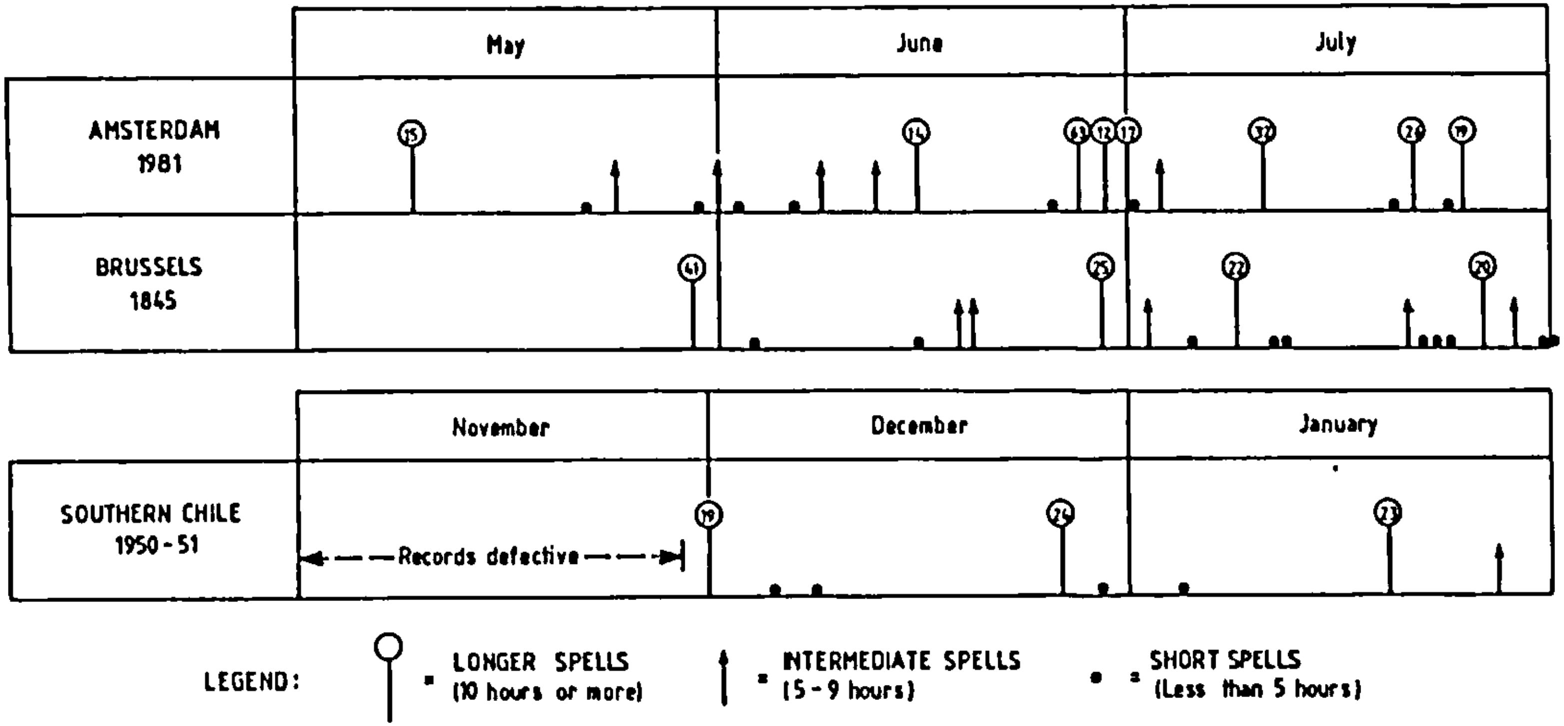


Fig. 12 Blight weather spells and their effective duration (in hours) in seasons of early development of potato blight in the Netherlands, Belgium and Chile

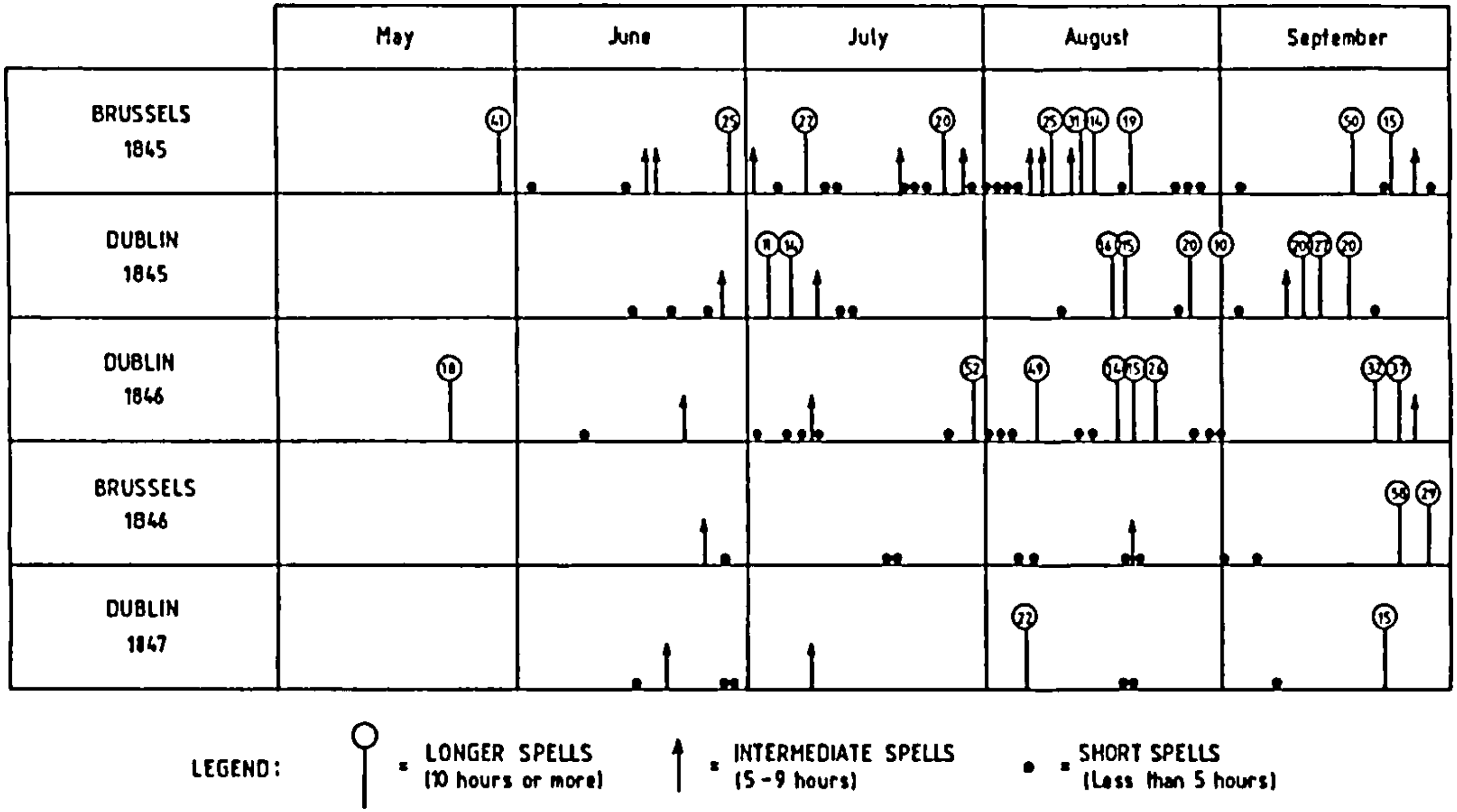


Fig. 13 Blight weather spells and their effective duration (in hours) in Belgium and in Ireland during the potato growing seasons 1845-7

Amsterdam in the first three months of the 1981 growing season (Fig. 12) confirms that three infection cycles had already occurred by 1 June, and shows that the weather in June and July 1981 was substantially more favourable to blight than that in Brussels in the corresponding months of 1845; nevertheless the greater resistance to disease of modern potato cultivars combined with the use of fungicides sustained the 1981 crop until better weather conditions prevailed in August and September.

Thus, although the air humidity in Brussels in 1845 was above average, it was not so much abnormally favourable weather conditions in Belgium which favoured the violent impact of the disease in 1845 as the high vulnerability of the crop. The same was true of the first Chilean epidemic of 1950-51 (Fig. 12) in which the partial deficiencies of weather records do not conceal the comparative infrequency of blight weather.

Fig. 13 shows the dates and effective duration of blight weather spells (EBH) (see para. 3.1) during the whole growing season for Brussels and Dublin in 1845 and 1846, as well as for Dublin in 1847, a dry sunny year of little blight. The totals of EBH over the potato growing season are a fairly crude index of disease impact, especially in seasons where the foliage was dead well before the normal harvest date; nevertheless, it is of interest to compare the Dublin figures of total EBH for the years 1845 (191), 1846 (303) and 1847 (67) with the corresponding figures for a recent period of 25 years - 1957-81: minimum 28, mean 110, maximum 391 (Keane, 1982).

In the earlier months of the 1845 season, when continental-type shallow depressions (as in Fig. 8) were setting up frequent spells of blight weather in their locality, there was less blight weather in Dublin. Nevertheless, sufficient favourable weather occurred before mid-July that, had the inoculum of blight been present in Ireland, the disease could not have escaped widespread attention by that time. Later in the year a meteorological mechanism affected wider areas (as in Fig. 9) which gave rise to corresponding spells of blight weather both in Ireland and Belgium.

Before considering the 1846 season in detail in the next chapter, we may draw some broad conclusions from Fig. 13. The 1846 growing season in Ireland would prove climatically very favourable for the disease, although by no means uniquely so; the EBH total in one modern year (1958) was nearly one-third higher than in 1846. The figure correctly reflects the contrast of severe disease in Belgium in 1845 and its slight impact in 1846. In the latter year, the contrast between the Dublin and Brussels totals of blight weather foreshadows the irregular distribution of blight in 1846, with, as we shall see, the disease remaining relatively dormant in continental Europe while it raged in Ireland.

5.10 Losses Caused by Blight in 1845

Without question, the greatest damage to the potato crop in 1845 occurred in Belgium, Holland and neighbouring areas, i.e. the inner core of earliest attack in Fig. 11. Where the haulms had been destroyed by the middle of July only about 30 per cent of the normal yield would have been formed at the time of death of the plants (see paragraph 2.4.1). This figure must be further reduced to allow for losses due to tuber blight; in Ireland these averaged 40 per cent in 1845 and in places reached as much as 75 per cent. The quoted figures for the 1845 Dutch harvest of 24 per cent and the Belgian of 12.7 per cent are therefore not unreasonable (Bergman,1967; Mokyr, 1980).

In the outer zones of Fig. 11, where the potato crop was moving towards ripeness by the time the disease struck, losses were mainly due to tuber blight. They were heavy enough to cause severe distress even in Switzerland where the effect on the lives of the very poor is vividly described in the famous novel, Käthi, die Grossmutter, by Jeremias Gotthelf (Albert Bitzius) published in 1847. In Ireland, the average tuber rot of 40 per cent operated on a crop which had yielded remarkably well, so that the production of sound tubers was only a quarter or a third below normal.

At first sight, it may seem odd that the resultant distress in Ireland between the harvests of 1845 and 1846 should be greater than in the Low Countries. However, the dependance upon the potato was far greater in Ireland where the per capita annual human consumption stood at 0.8 tons as against 0.3 tons in the Netherlands, while the normal diet of a Dutch working man was not confined to potatoes as in the case of the majority of the Irish, but included rye and other foods (Vissering, 1845, pp.9-12; Bourke, 1968).

CHAPTER 6

POTATO BLIGHT IN EUROPE IN 1846

6.1 The Vulnerability of the Irish Potato Crop

For Ireland, as for all countries on the outer fringe of Fig. 11, blight arrived late in 1845 and struck only a glancing blow at the potato crop of that year. But the foundations were laid in these peripheral areas for a much greater disaster in 1846, should the weather prove favourable to the disease. The late autumn attack of 1845 and the widespread abandoning of diseased tubers in the fields at the end of the season guaranteed a high carry-over of inoculum into the following season (paragraph 2.6). Ireland, in particular, was in a highly vulnerable position. Its whole economy was built around the potato, upon which a large part of the population depended exclusively for food. Consequently, the extent of land devoted to the crop was enormous; it stretched high up into the mountains and deep into the bogs. Further, the increasing food needs of a large and economically oppressed population had led in Ireland to the replacement of superior varieties of the potato by the high-yielding but watery 'Lumper', which had many resemblances to a turnip, and which was grown, outside of Ireland, only as cattle food.

The potato fields of Ireland constituted an overcrowded slum of uniformly vulnerable inhabitants, wide open to epidemic disease. Now that potato blight had found its way into the country—a disease far more destructive, more contagious and faster acting than any previously encountered—disaster was inevitable. Only the timing and extent of that disaster remained to be decided, depending on the weather.

6.2 1846, A Year of Remarkable Weather

Despite the best efforts of those who argued that the European potato failure of 1845 was the direct result of a climatic aberration, it proved impossible to pin the blame on the seasonal weather. The weather of 1845 had, in truth, been drab, cloudy and cold, but also quite undistinguished. Earlier years which had been wetter and colder had seen the potato crop standing up stoutly to the conditions. In 1846, on the contrary, the weather was to prove exceptional in a number of respects. After a winter of rare mildness and a very wet spring, temperatures from the second half of May onwards soared to record or near-record heights in many parts of Europe. Violent gales in the autumn were followed by a severe winter with much snow.

These successive weather stages contributed, each in its own way, to the food problems which were to culminate in a major crisis in Ireland in 1846-7, and we shall discuss them in turn in the following paragraphs.

6.2.1 A mild winter and a wet spring

The very mild winter of 1845-6 over much of western Europe (Fig. 5(b)), which was particularly marked in the months of January and February, was the subject of much contemporary comment, especially in farmers' diaries and agricultural periodicals. In an exceptionally long series of temperature records in the Netherlands (van den Dool *et al*., 1978), the mean temperature of 5.2°C reached in the winter of 1845-6 was exceeded in only three out of 344 years.

In addition to being mild, the first month of 1846 was very wet; extensive tracts of Ireland were "saturated in water" at the end of the month. The mildness of the winter persisted in February which, however, was a generally dry month and one which held out hopes that farming land would be workable early in spring. These hopes were dashed, especially in Ireland, by the heavy rains of March and April which persisted into May. There had been only fourteen days without rainfall in Dublin in the three month period from 24 February to 23 May 1846.

6.2.2 A summer heat-wave

The summer of 1846 was superbly hot and dry over most of Europe (Fig. 5(c); Fournet, 1846). In France, where the months of June and July were particularly torrid (Lortet , 1846), the grapes were gathered three weeks in advance of the usual time; in Hamburg the grain was harvested fully a month early. The permanent snows melted on Alpine peaks, and crags were revealed on the summit of Mont Blanc which the oldest inhabitants had never seen before. The heat in Russia was tropical throughout June, July and August, so that it was claimed that one could fry eggs on the sand in Archangel. One may well suspend judgement on this traditional evidence of extreme heat, but the long-period meteorological records, for example for Vienna (Steinhauser *et al*., 1955) confirm the general accuracy of the record-making temperature levels of 1846.

Along the northwest maritime border of Europe things were rather different (Fournet, 1846, p.601). The sequence in Fig. 4 shows very clearly the drift of the nucleus of highest temperature anomalies away from this area after the month of June 1846. Both Ireland and Scotland had participated to the full in the hot dry weather for much of June (Fig. 4(a)), but for both of these countries the heat-wave broke before the last week in June, and while rainfall amounts were still small in gloomy, overcast conditions to mid-July, for the remainder of the summer there were few hot dry days to break the monotony of rain, often accompanied by thunder. London and the southeast of England also experienced a number of violent thunderstorms as short-lived interruptions to mainly warm dry continental weather. Townley (1847) could, however, classify the summer as a whole in London as 'hot and droughty'. In London too June was the outstanding month with a mean temperature at Greenwich 3.2°C above normal, which was only once exceeded in the next hundred years (Marshall, 1952), while even higher values were recorded close to the city centre. A fascinating survey of literary life in London in June 1846 owes its title and setting to this 'sultry month', and gives some data in passing on the high temperatures reached (Hayter, 1965).

The heat-wave lasted longer, reached higher temperature levels and was less interrupted in southeast England than elsewhere in the United Kingdom. The end of the hot spell in Ireland and Scotland towards the end of June was marked in London only by a very temporary lull, and although there were periods of thundery rain early in July, and again, in violent form, in the first few days in August, the weather was quick to recover its former brilliance in both cases (The Times, 4 July 1846; Graham, 1847). The contrast of the July weather across Great Britain was the subject of much comment: "In the south of England harvest began in July, and the result was solely owing to the dry weather experienced in that part of the country, when Scotland and the northern part of England were visited by daily showers and even rainy days in that month, for the crops of this country (Scotland) were as far advanced in June as they were in the south of England" (Journal of Agriculture 1846, p. 490).

6.2.3 Autumnal gales

There were several exceptionally violent Atlantic gales in the autumn of 1846, of which at least two almost certainly originated as hurricanes.

A tropical storm, first noted on 12 September in the Barbados - Martinique area, moved northwards and skirted Bermuda on 14-15 September (Ludlum 1963, p.132). In the following weeks a number of ships close to its track were battered, with much loss of life. When the storm hit Ireland on 22 September, fishermen were drowned and their boats destroyed, a girl was swept out to sea, and the famous ship, the "Great Britain", was driven ashore in Dundrum Bay on its maiden voyage.

The next major storm appears to have originated in 'the great hurricane of 1846' which in Florida was reckoned to be "the most destructive of any that has ever visited these latitudes in the memory of man" (Ludlum 1963, pp.94-5, 151-3). It lashed Cuba on 10 October and New York on the 13th. The Irish brig, 'Rose of Newry', bound from St Johns to Sligo, was overtaken on 14 October by 'a fearful hurricane'; it ran on for some time 'on bare poles' before capsizing in the heavy seas. The storm struck Ireland on 20 October and did great damage; many ships were lost or stranded on the Irish coast.

The gale of 19-20 November was, in some respects, the most destructive of all; when it had passed about 150 ships were floating around off the Irish west coast, deserted and dismantled.

The stormy weather on the North Atlantic continued right into the early months of 1847.

6.2.4 The severe weather of December 1846 and early 1847

The severity of the cold winter of 1846-7 is illustrated in Fig. 5(d). The month of December 1846 was bitterly cold, with ice and snow over much of Europe. Charles Dickens reported from Paris: "The water in the bedroom jugs freezes into solid masses from top to bottom, bursts the jugs with reports like small cannon, and rolls out on to the table and washstands hard as granite" (Pearson 1949, p.156).

In England, the Thames had ice to mid-channel, roads were blocked by snow, and trains were brought to a standstill (Dodds, 1953, p.285).

In Dublin there was air frost on no fewer than 21 nights in December 1846, and on five days the temperature never rose above freezing point.

January 1847 was considerably less harsh, but in the last days of the month and in early February it again became very cold, culminating with a quite exceptional minimum temperature for Dublin of -12.2°C on the 13th. This was the crisis of the winter weather of 1846-7, but it left a legacy of recurrent cold spells at intervals until the end of April, at which time the Dublin mountains were still snow-capped.

6.2.5 Some consequences of the curious weather of 1846

The weather before and after, as well as during, the potato growing season of 1846 had major consequences on the distress caused by blight, particularly in Ireland in that year.

In the mild winter of 1845-6, diseased tubers, left undug in the ground or discarded as worthless in the furrows, survived to provide numerous infection centres for the coming season's potato crop (IFJ 1847, p.2).

The heavy rains of spring seriously retarded agricultural work in Ireland so that even in the beginning of June it could be said that "in many parts of the country, the potato planting is not completed; in other parts, not begun" (Nenagh Guardian, 6 June). When the rains ceased, the weather swung to the opposite extreme; it introduced one of the longest and most intense heat-waves known in Ireland. A soil which had been saturated towards the end of May reached a soil moisture deficit of over 90 mm four weeks later and continued at about the same level of drought until late in July. Everywhere the growth of the potato crop, in particular, suffered a severe check so that by the end of July the tubers were, at best, no bigger than walnuts. In England the eventual verdict was that potato yields in 1846 were reduced as much by the aridity of the summer as by the ravages of blight which, in that area, showed a much reduced activity (Journal of Agriculture, 1848, pp.355-6).

The high winds of autumn increased distress in several ways. They made fishing difficult and often impossible, and reduced catches (Society of Friends, 1852, p.409); in a number of cases, boats were lost and fishermen drowned. Over the North Atlantic the recurrent gales harassed and delayed the food ships bound for Ireland (Distress correspondence 1846, p.218; IFJ 1846, p.411); along the Irish coast they hampered relief operations (Distress correspondence 1846, pp.92, 101, 110, 111, 189, 198, 201, 205).

The severity of the winter of 1846-7 hindered the relief efforts of the Quakers and others (Society of Friends 1852, pp.148-9); at the same time the bitter weather struck one final blow at the starving millions in Ireland, whose condition at the end of the year may be illustrated by a quotation from a letter written by a relief inspector to his superiors on Christmas Eve, 1846. He wrote from a parish in the west of Ireland where relief work had been suspended because of an act of violence: "I must again call your attention to the appalling state in which Clare Abbey is at present. I ventured through that parish this day to ascertain the condition of the inhabitants, and although a man not easily moved, I confess myself unmanned by the extent and intensity of suffering I witnessed, more especially among the women and little children, crowds of whom were to be seen scattered over the turnip fields, like a flock of famishing crows, devouring the raw turnips, and mostly half-naked, shivering in the snow and sleet, uttering exclamations of despair, whilst their children were screaming with hunger. I am a match for anything else I may meet with here, but this I cannot stand" (Salaman 1949, p.308). The reason for the grave distress was the almost complete annihilation of the Irish potato crop in 1846.

6.3 The Second Season of Blight In Europe

The early potato crops of 1846 were scarcely above ground than they were carefully and continuously scanned by anxious eyes for the slightest signs of disease. So many blighted tubers had been discarded during the previous harvest and so many of the deliberately planted seed potatoes had in them the germ of disease, that early signs of blight were inevitable as soon as the weather became in the slightest degree favourable to its development. In fact a lengthy spell of blight weather was registered at Dublin on May 22-3, to be followed by a shorter spell on June 8-9 (Fig. 13). The disease showed its teeth sharply in early potato crops on the coasts of southern Ireland and southwest England (Milne, 1847, p.259; GC 1846, p.390).

By reason of the hot dry weather which prevailed for much of June, the disease made limited progress at first and was reported from only a few places, often in the form of stem lesions as is characteristic of blight in a dry year.

A series of blight weather spells, none of long duration but of appreciable cumulative effect, occurred in Ireland in the period 22 June - 10 July (Fig. 13), at a time when the weather in Brussels was almost continuously unfavourable to the disease. The reason is reflected in the maps of mean atmospheric pressure for July in 1845 and 1846 (Figs. 6 and 7). The area of low pressure centred over the North Sea in the earlier year was the origin of the poor weather which was shared by all the countries of northwest Europe in July 1845. In 1846, however, the North Sea area was dominated by a ridge of high pressure, and the region of disturbed weather was largely confined to Ireland and Scotland.

By mid-July the potato disease was sufficiently obvious in Ireland to persuade the Dublin correspondent of the London Times to abandon his sceptical attitude about the reappearance of the disease: "I regret to say that the apprehension of a failure to a considerable extent in the crop of this year appears to be only too well founded" (The Times, 11 July). About the same time the disease manifested itself in Scotland, fully two months earlier than in the previous year (Milne, 1847), and later was reported from the Highlands and Islands, including the Orkneys which had escaped in the previous year (GC 1846, pp.595, 647).

6.4 Meanwhile, on the Continent...

It was already clear by mid-July 1846 that the geographical distribution of blight damage in Europe was going to be radically different from that of the previous season. While alarm was mounting steadily in Ireland and Scotland, it fell away on the neighbouring continent where as the dry hot summer continued unabated, the disease made little progress except in isolated areas and gradually disappeared as a subject of discussion in newspapers or even in learned journals.

The broad features of the final distribution of damage done by potato blight in 1846 are shown in Fig. 14. The potato crops in areas of the earliest and heaviest attack in 1845, i.e. those of Belgium and Holland were now virtually free of damaging disease in a season which afforded only the scantiest of blight weather (Fig. 13), although here too the final yield was reduced because of drought.

A curious incident illustrates that, while the majority of people on the continent rejoiced in the health of their potato crops, the occasional food speculator, poised to profit from public alarm, was chagrined at the failure of the disease to cause a second panic. Two prisoners were brought to trial at Breda in the Netherlands on 24 July 1846, having been caught in the act of sprinkling acid on the leaves of potato crops, in an effort to deceive the country people that the resultant black spots were caused by the onset of blight (Limerick Chronicle, 1 August 1846).

The relative distribution of blight damage in 1846 (Fig. 13) is what we should recognise nowadays as characteristic of a season in which the main periods of blight weather were associated with Atlantic depressions moving generally towards the northeast on the fringe of a continental area of high pressure. In contrast to the abnormal pattern of the previous year (Fig. 11), the chart of blight progress had fallen into what was to become a familiar mode.

6.5 The Destruction of the Irish Potato Crop in 1846

An abstract of the country reports received in the week ending 25 July 1846 and preserved with the papers of the Relief Commission in Dublin, graphically illustrates the rising tempo of the blight attack in that month. From all over Ireland the alarmed reports poured in - "disease making daily progress", "early crop completely destroyed", "early crop and Lumpers withered", "great panic". The Grand Jury of the city of Cork respectfully directed attention, on 25 July, to the "impending calamity".

The crowning blow was not long delayed. On July 26 - 27 there was a short spell of blight weather, and then, in the last four days of the month, the most sustained period which occurred in the years 1845-7 (Fig. 13). The synoptic situation on 31 July 1846 (Fig. 10) has been chosen as representative of this period and

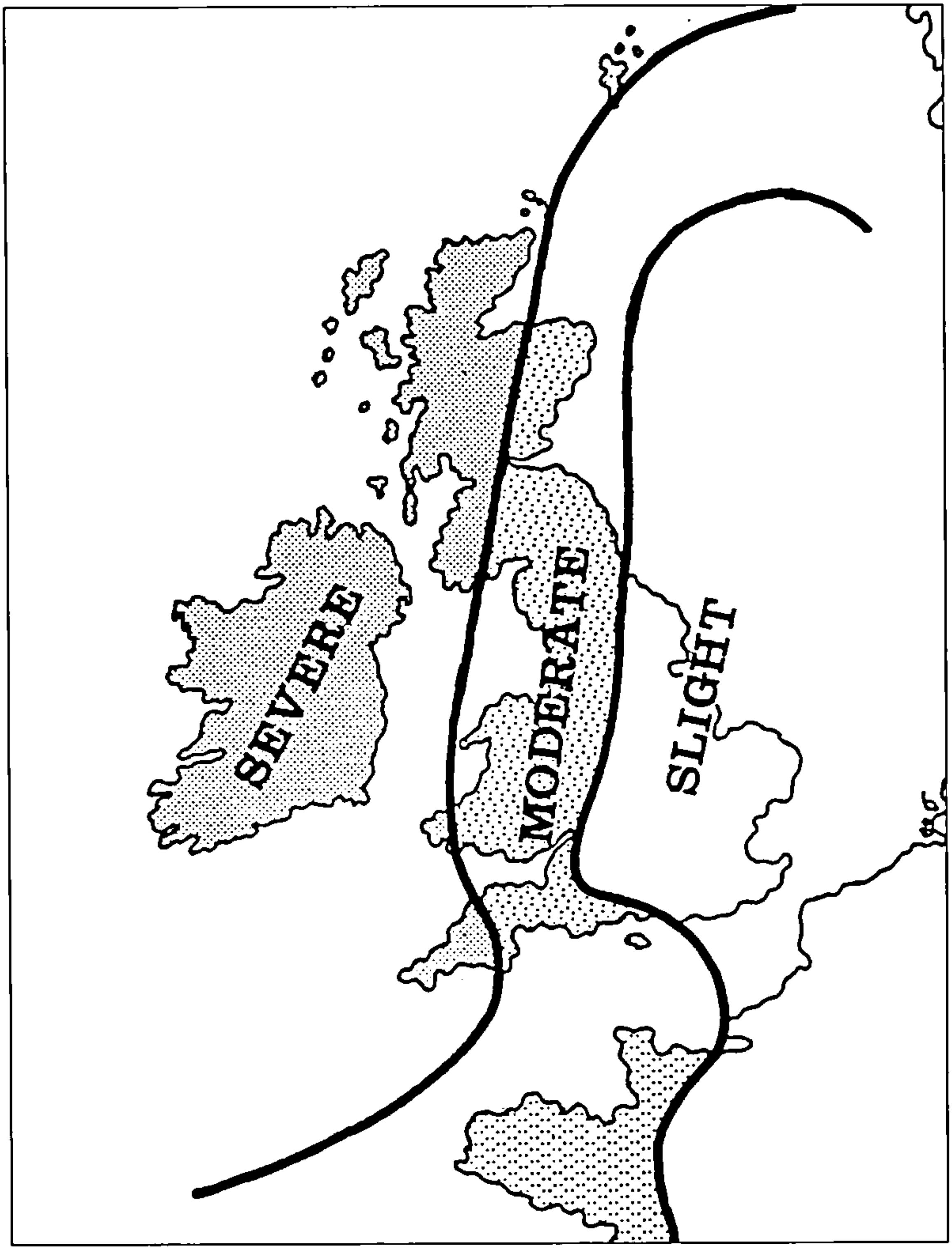


Fig. 14 Approximate distribution of potato blight damage in western Europe, 1846

shows a broad belt of maritime tropical air sweeping northeastwards over Ireland and Scotland, where it gave ideal conditions for the final onslaught of blight, but with hot dry weather elsewhere, broken only by an occasional thunderstorm. Note the contrast in Fig. 13 between the conditions which continued right through August in Dublin and the scanty impact of blight weather in July and August in Brussels.

Virtually the entire potato crop of Ireland went down in ruins in the last week in July and the first two weeks of August 1846. In a well-known letter dated 7 August 1846, Father Theobald Mathew described the change which took place in a single week: "On the 27th of last month I passed from Cork to Dublin and this doomed plant bloomed in all the luxuriance of an abundant harvest. Returning on the 3rd instant, I beheld with sorrow one wide waste of putrifying vegetation. In many places the wretched people were seated on the fences of their decaying gardens, wringing their hands and wailing bitterly the destruction which had left them foodless".

In 1845, upland potato fields had stood up reasonably well to the disease, but it was not so in the warmer summer of 1846. Steuart Trench, a land agent in the Irish midlands, had planted potatoes on some 50 hectares of reclaimed bogland high up in the Slievebloom mountains. On 1 August, he confirmed for himself rumours that the disease was striking fatally at lowland crops, but when he rode up to inspect his mountain crop, he was relieved to find it "as luxuriant as ever, in full blossom, the stalks matted across each other with richness, and promising a splendid produce". A week later the picture had radically changed. "On August 6, 1846—I shall not readily forget the day—I rode up as usual to my mountain property, and my feelings may be imagined when, before I saw the crop, I smelt the fearful stench, now so well known and recognised as the death-sign of each field of potatoes.... I saw the crop fast disappearing and melting away under this fatal disease.... My plans, my labour, my £3,000, and all hopes of future profit by these means were gone. But my own losses and disappointments, deeply as I felt them, were soon merged in the general desolation, misery and starvation which now rapidly affected the poorer classes around me and throughout Ireland" (Trench, 1868).

6.6 Losses Caused by Blight in Ireland in 1846

Under normal circumstances, destruction of potato haulms by 1 August would cause a loss of about 50 per cent of the expected yield (paragraph 2.4.1). But 1846 was far from being a normal year: the planting of the crop had been much delayed because of heavy and continuous rainfall, and drought had later radically slowed down the development of tubers so that they were abnormally small when blight destroyed the plants.

Detailed surveys carried out at the time showed that the average loss was as high as 90 per cent, so that of a year's supply of food, the residue would last only between four and six weeks. In Scotland and in parts of Ulster where oats still made up part of the popular diet, there was some hope for survival until relief cargoes of maize arrived from North America, but for the majority of the poor Irish there was no hope whatever. Even the lull in the severity of blight in the dry weather of 1847 (Fig. 13) brought little relief, for the acreage sown in potatoes in that season was only one-tenth of normal, and by then the ravages of famine fever had been added to those of starvation. Within a couple of years there was an abrupt fall in the Irish population due to death or flight of nearly two million souls, and this was followed by a century of continuous haemorrhage due to emigration (Fig. 15).

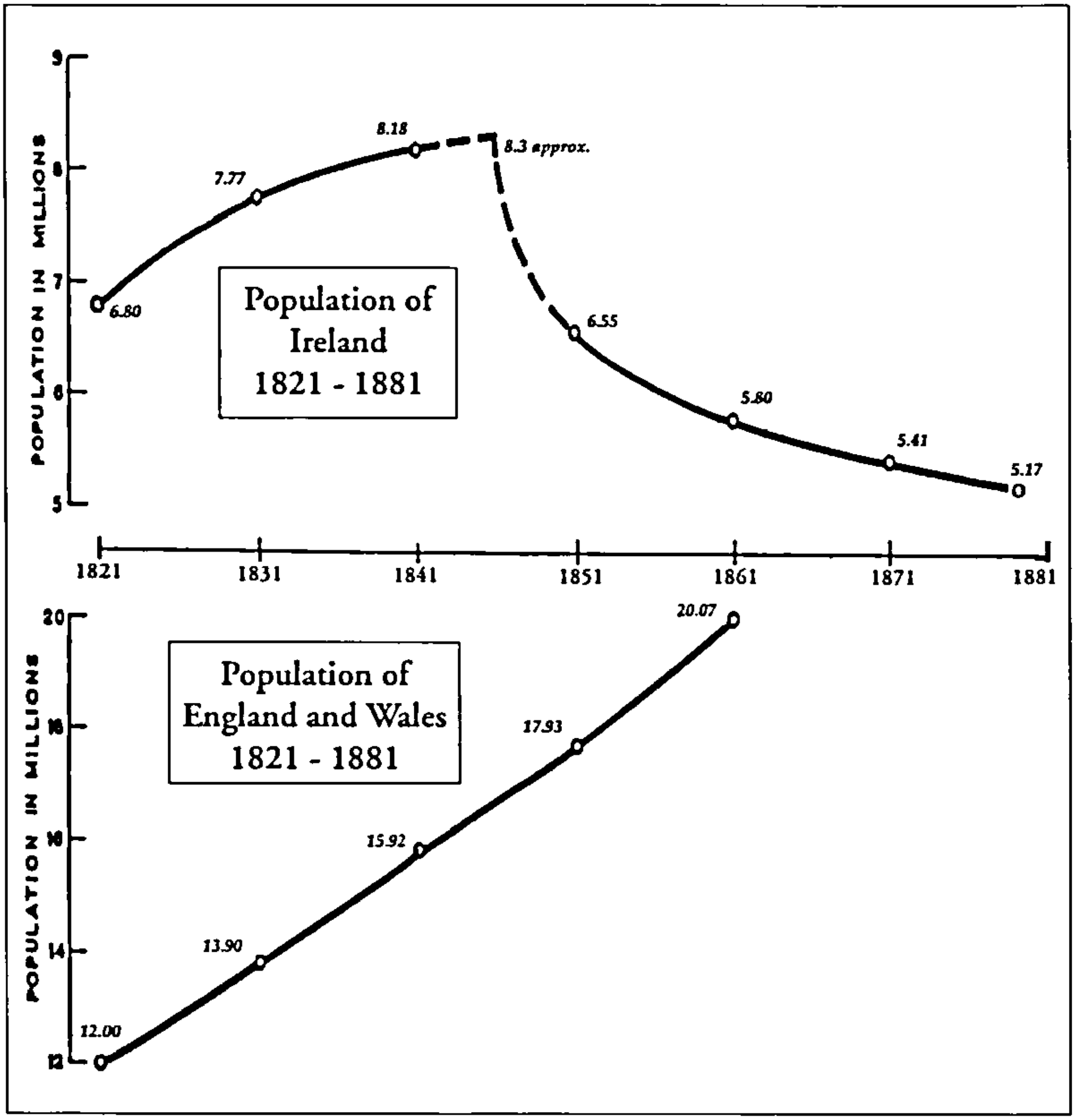


Fig. 15 Population changes after 1821 in Ireland and England - Wales

CHAPTER 7

SUMMARY OF CONCLUSIONS

7.1 Blight in 1845

All the evidence suggests that it was the search — which must now, in retrospect, be seen as an incautious effort—for a remedy for a lesser ailment of the potato which opened the floodgates for the entry into Europe of what was to prove itself a far greater evil, potato blight. In an effort to reduce losses in the potato crop caused by dry rot, and to counter the consequent food problems among the poor, the Belgian government decided to import fresh potato varieties from the Americas, and these were tried out as field crops in West Flanders in 1844 and 1845. It is highly probable that the germ of potato blight was introduced in these imported stocks, either directly from the Andes region of Peru-Bolivia, or indirectly via North America where the disease had already appeared in 1843.

The approximate dates on which potato blight was first reported in different parts of Europe in 1845 appear in Fig. 11. This shows the earliest impact of the disease in West Flanders in late June, and its gradual extension to reach Ireland, Scotland and Scandinavia close to harvest time.

An analysis of the weather data for the growing season of 1845 shows that conditions were indeed favourable for the development of the disease to epidemic level in that year. However, they were not uniquely so; even more favourable weather conditions have occurred in some modern years. The main reason why the impact of the disease on the crop was abnormally great was that many of the most popular potato varieties grown at the time proved to have no resistance whatever to the new disease and were soon to drop out of cultivation. The losses of crop in Belgium and Holland in 1845 were very heavy, of the order of three-quarters or seven-eighths.

The spread of the disease, not only in the direction of the prevailing winds but also towards the west, has been shown to be consistent with the weather patterns of the season, and the mechanism for the windborne transport of blight spores across the English Channel to be closely analogous to that of foot-and-mouth disease in recent years. The failure of blight to reach northern Scotland in 1845 reflects the low temperatures of that summer.

7.2 Blight in 1846

The second season of the blight invasion in 1846 showed a very different distribution of disease. The summer of 1846 was mainly dry and hot on the continent and the potato crop there—as well, indeed, as in the south and east of England—suffered much more from drought than from blight (Fig. 14). Meanwhile, depressions skirting the northwest border of the continental anticyclone brought very different conditions to Ireland and Scotland, where the weather favoured a renewed epidemic of blight. The severity of the attack was once again not due to anything unique in the frequency of blight weather; more favourable seasons for disease have occurred later. Part of the damage was caused by the complete susceptibility of the poor man's "Lumper", but even more was due to a remarkable sequence of weather abnormalities, both within and outside the 1846 growing season, which intensified the consequences of the plant disease.

If a malevolent fate had set its mind to the destruction of the Irish people, it could scarcely have devised a more disastrous sequence of weather phenomena than that which marked the year 1846.

The nearly unique mildness of the winter of 1845-6 permitted infected tubers from the 1845 crop, which had been abandoned in the fields or discarded as worthless in the furrows, to live on to become infection centres for the new season's potato crop.

A spring of continuous heavy rain seriously delayed the planting of the new crop, and was followed by an unprecedented heat-wave in the months May-June which so slowed the bulbing of the tubers that they were no bigger than marbles when blight wiped out the plants in the early days of August. Violent autumnal gales restricted fishing, retarded food ships bound from America and hampered relief operations around the coasts. A winter of great severity and much snow in 1846-7 was the final bitter blow to the starving millions.

The potato yield in Ireland in 1846 was no more than 10 per cent of normal, and hence little worse than in parts of Belgium in 1845. However, the population which had to bear the loss was immensely more vulnerable in the conditions of the Irish potato economy, where grain foods were no longer part of the normal diet of the mass of the working population.

The situation in Ireland in the 1840s, with its rural population heavily dependent on a single crop, can be clearly seen in retrospect as precarious to the point of being ripe for disaster. The arrival of the potato disease and the weather, which in several successive years favoured its development, was the spark that produced the tragedy, cruelly exposing the inherent weaknesses of the socio-economic structure of Ireland at the time. Nevertheless, in the light of modern climatic and agricultural knowledge, and studies such as the present one, we can say that foresight and precautionary planning—on an international scale where necessary—should be able to mitigate, and sometimes largely avert, the effects of such visitations by weather and disease.

For this reason the story of the Irish potato famine of 1845-7 may have useful lessons to teach in connection with modern food crises, especially in Third World countries, and in particular to point the need, before anything else, to recognise the inherent vulnerability of the population as the prime cause of disaster and to take steps to remedy it.

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Bibliographical details of sources of meteorological observation data used are given in the Appendix to this report.

APPENDIX

LIST OF METEOROLOGICAL OBSERVATION SITES AND DATA SOURCES

The records used in this study included:

ICELAND

Eyjafjördur, on the north coast, near 65.5°N 18.1°W. Weather diary without instrument measurements, from the last months of the daily record maintained (with some changes of site) by the parsons Jón Jónsson, father and son, from 1746 to 1846, ending a few days before the latter's death in August 1846. Copied, the difficult handwriting deciphered, and kindly translated, by Sjöfn Kristjánsdóttir, from the manuscript in the Icelandic archives in Reykjavik.

Stykkisholmur, on the west coast, near 65.1°N 22.8°W. Meteorological observation register, kindly supplied by the Iceland Weather Bureau (Vedurstofa Íslands). The observations begin in September 1845. Instrument measurements are included from November 1845 onwards.

FAEROE ISLANDS

Observations, including some instrument measurements, occasionally available when Danish naval ships were in harbour or patrolling waters near the islands. Ships' logs kindly supplied by the Danish Meteorological Institute, Copenhagen.

NORWAY

Alten Observations made at a British expeditionary station, at 70°N near 23°20'E, operating from 1839 onwards. Instrument measurements are included, barometric pressure in mm, temperatures in °C. Register in the Meteorological Office Archives at Bracknell, England.

Trondheim (63.5°N 10.4°E). Once daily observations, including barometric pressure in Paris inches and lines, temperatures in °R, as printed in the newspaper "Adresseavisen". Kindly supplied by the University Library, Trondheim.

Klepp, or Grude, near Varhaug (58.8°N 5.6°E), in Jaeren, S.W. Norway. This place is in a broad agricultural lowland province near the coast between Egersund and Stavanger.

Notes from a farm weather diary at Grude covering the years 1808 to 1850, printed in a Norwegian-language text on Jaeren, its economy and communal development from 1814 to 1914 by the lensmann (sheriff) M.K. Grude, published as "Jaeren 1814-1914" at Sandnes (Ingvald Dahles Forlag) 1914.

Besides summaries of the seasonal weather each year, reports of the crops, including a "dry rot" of the potatoes increasing strongly in the autumn of 1845 and continuing for several years, though less in 1847 than in 1846.

Christiania (now Oslo). (59.9°N 10.8°E approx.). Five times daily observations, including barometric pressure in Paris inches and lines, temperatures in °R, wind direction and force, and cloud details (type and amount), published with a German language text about the observers, the instruments and their exposure, in a collection covering the years 1837 to 1863, kindly supplied by the Norwegian Meteorological Institute, Blindern, Oslo.

SWEDEN

Uppsala, near 59.9°N 17.6°E. Three times daily observations, including barometric pressure in Paris inches and lines (and, as an alternative, in another column in Swedish decimal inches and thousandths), temperatures in °C (also the maximum and minimum each day), humidity measurements in terms of wet bulb temperature, wind directions and force. The necessary excerpts from the register with precise details of the site were kindly supplied by the librarian of the Meteorology Department of Uppsala University.

Stockholm, near 59.3°N, 18.1°E. Three times daily observations of barometric pressure in Swedish decimal inches and hundredths, temperatures, wind direction and state of the sky and weather, supplied by Stockholm University Library.

Lund, near 55.7°N 13.2°E . Three times daily observations of pressure in millimetres, temperature in °R, wind direction and force (thought to be speeds in kilometres per hour), state of the sky and weather, supplied by the University Library, Lund.

FINLAND

Helsingfors (now known internationally outside Finland by its Finnish name, Helsinki) 60°10'N, 24°57'E. Observations three times every hour made at the Magnetic and Meteorological Observatory, under the direction of the professor (Nervander) of physics at the University. The observations include barometric pressure in millimetres, temperatures in °R, wind direction and force (thought to be wind speeds in km/hr), state of the sky (cloud cover in fourths) and weather, with twice daily measurements of rainfall. A brief text in German, taken from "**Die Temperatur-Verhältnisse des russischen Reiches**" (Finland was after 1809 a province of Russia) by Count P.A. von Waluew, critically examined by H. Wild; a Supplementband, published in 1881 to the **Repertorium für** Meteorologie series of the Kaiserliche Akademie der Wissenschaften, St Petersburg, explains the exposure etc. of the thermometers, in use from 1829.

An extract from another Supplementband, published in 1887, gives monthly averages of rainfall over various periods of years for many places in Finland, mostly after 1870, but including Åbo (Turku) 1749-94, 1797-1800 and Helsinki 1844-82. This material was supplied by the Library of the Finnish Meteorological Institute, Helsinki.

DENMARK

Copenhagen, 55°41'N, 12°35'E. Three times daily observations, including barometric pressure measured in Paris inches and lines and given in hundredths of lines, temperatures in °R (measured in the shade, 2 1/2 feet above the soil), also temperatures at 2 feet depth in the earth, duration(in hours) and depth of rainfall measured once a day, and wind direction observed four times a day, together with a short printed text in Danish language describing the instruments, their history and corrections applied, and their exposure, kindly supplied by the Danish Meteorological Institute, Copenhagen.

Ringkøbing (actually at Stadil, near Ringkøbing), near the west coast of Jutland. A manuscript register (kept near 56.2°N 8.2°E) in Danish, with three times daily temperature measurements in °R, once or twice daily reports of wind direction, notes on the occurrences of rain, thunder and occasional notes of extremes or a barometer reading, kindly supplied by the Danish Meteorological Institute, Copenhagen.

Traneberg, on the island of Samsø. Relevant portion of a manuscript register (in Danish) of meteorological observations, kept at a point 55°50'N 10°37'E, including twice daily temperature measurements in °R, three times daily barometric pressures in various units (sometimes in millimetres), rainfall measured once daily in Paris lines.(The register started in 1838, when all measurements were in Paris lines and °R .) Wind direction and strength (on a scale from 0 to 4 or 5) reported three times daily. Kindly supplied by the Danish Meteorological Institute, Copenhagen.

Danish Naval Ships at Sea. Observations transcribed from twelve ships' logs, usually every 4 hours, and including the ship's position, direction and strength (converted to Beaufort force) of the wind, weather (in letter code), cloud cover (converted to eighths of the sky covered), temperatures in °R, and barometric pressure measurements in Paris inches, lines and tenths, kindly supplied by the Danish Meteorological Institute from their archives.

The ships' positions were often notably useful for analysis of the synoptic meteorological situation over Europe. Apart from many reports in Danish home waters, about the Great Belt and Øresund (the Sound, between Denmark and Sweden) and the Baltic island of Bornholm, positions in port or patrolling near the south and east coasts of Iceland and near the Faeroe Islands were included, also on voyages between either Denmark or Iceland and the mouth of the (English) Channel on voyages to or from the East or West Indies. On most days, observations made on board Danish vessels in port at Altona (then a Danish naval base, but now part of Hamburg) in the Elbe were available.

IRELAND

Dublin, 53°22'N, 6°21'W. Meteorological observations made three to five times a day (in different years) at the Ordnance Survey Office in Phoenix Park, Dublin, collected in a volume covering the years 1829 to 1852 (edited by Captain Cameron, R.E., under Lt.Col. H. James, F.R.S., Superintendent of the Ordnance Survey of Ireland), published by Alexander Thorn and Sons, Dublin 1856 for Her Majesty's Stationery Office (603pp). The observations include barometric pressures in inches and thousandths (with temperature correction applied, as usual in the sources here used), temperatures in °F, also daily maximum and minimum temperatures, dew point temperatures (from June 1841 onwards), wet bulb temperature (from 1842), raingauge measurements, wind direction and its strength measured by various (usually pressure-plate) anemometers.

Remarks also give descriptions of the weather, cloud types and indications of the total amount of cloud. An introductory text also gives details of the instruments and their exposure.

(The volume also includes reports of observations at a number of other places concerned with the triangulation of Ireland, in the years 1825 to 1831.)

Markree Castle, Co. Sligo, near 54.2°N, 8.6°W. Monthly values of temperature each year from 1842 to 1863 and of rainfall from 1833 to 1863, printed in the *Quarterly Journal of the Royal Meteorological Society, 10,* pp.158-161, 1884. Further details of the weather at Markree Castle are given in a paper by E. J. Cooper (see references).

Portarlington, 53.2°N, 7.2°W. Daily rainfall measurements throughout 1845 and 1846, from the "*Dublin Medical Press*", vols. XIII-XVI, 1845-1846.

Athlone, 53.4°N, 7.9°W. Monthly rainfall measurements throughout the years 1845-1848, also notes of big rises in the level of the River Shannon in July, October and December 1845, and in May, November and December 1846, and of big falls in the level of the river in February, March, April and August 1845 and February, May, June and September, 1846. Easterly winds were noted as prominent in July and September 1845 and NW winds in June to August of that year. Source: *Proceedings of the Royal Irish Academy*, vol.IV (1850), Appendix VI, pp. lxix to lxxiv.

Limerick, near 52.7°N, 8.6°W. Yearly rainfall totals for the years 1841 to 1850 inclusive.

SCOTLAND

Ballimore, beside Loch Fyne, near Lochgilphead, near 56.0°N, 5.4°W. Once daily measurements of barometric pressure in inches of mercury, and of temperature °F, usually also the wind direction, in a manuscript register, with remarks on the weather twice or more times a day and occasional rainfall measurements spanning several days catch, from the archives of the Meteorological Office, Bracknell, Berkshire (England).

Makerstoun, near Kelso, 55°34'N, 2°31'W. Hourly observations (on Sundays not every hour), including barometric pressure reduced to 0°C, temperatures (dry and wet bulb), wind direction (32 points of the compass) and its force given as the maximum pressure measured on a pressure plate in 10 minutes and in the hour, cloudiness given in tenths of the sky covered, and details of the types of cloud present and the direction from which they were moving in each of the main levels (low, middle and high) represented, as well as remarks on the weather. The observations; for 1845 and 1846, made at the Makerstoun Magnetical and Meteorological Observatory belonging to General Sir Thomas Makdougall Brisbane, Bart. F.R.S., F.R.A.S., President of the Royal Society of Edinburgh, and edited by John Allan Brown, Director of the Observatory, were published in full in Part 1 of the *Transactions of the Royal Society of Edinburgh*, vol.XIX, in 1849 by Robert Grant and Son, Edinburgh.

Tables of statistical results, including daily and weekly means of temperature and water vapour pressure, extremes, ranges, measurements of evaporation and so on, were published in Part II of the *Trans.Roy.Soc. Edin.*, vol XIX, in 1850.

Sandwick, Orkney, near 59°7'N, 3°21'W. Monthly mean values of the air temperature (°F from 1833 to 1859 (and from 1827 to 1832 at the manse at Stromness) and of barometric pressure in inches from 1839 to 1859, and monthly rainfall totals from 1841 to 1859, together with the number of days each year from 1827 to 1859 that the wind blew from each direction (8 points of the compass) or was calm, and more details including temperature of the sea and soil temperature at 12 inches depth for the year 1827, printed in "*Meteorological Observations taken at Orkney with Remarks on the Climate*", by Rev. Charles Clouston, published in London by Eyre and Spottiswoode, 1861.

ENGLAND

Whitehaven, on the coast of Cumberland (near 54.6°N, 3.6°W). A printed sheet giving monthly mean, and highest and lowest values, of barometric pressure (in inches) and temperatures (°F), as well as rainfall totals (inches and thousandths), amounts of snow and monthly readings of an evaporation gauge (in inches), as well as monthly summaries of the weather, all for 1845, and annual values of all these items for the previous three years, 1842-44, printed under the title "*The Meteorology of Whitehaven*" by George Irwin, Herald Office, Whitehaven: obtained from the Meteorological Office Archives, Bracknell, as were all of the following items.

Newcastle-upon-Tyne (approx 55°N, 1.6°W). Three times daily observations of barometric pressure (reduced to 0°C), temperatures (dry and wet bulb), and wind direction, together with the daily maximum and minimum temperatures, rainfall amounts, and a summary of the weather, reprinted by the Literary and Philosophical Society from the *Newcastle Journal*.

Kendal (54.3°N, 2.75°W). A rather untidy manuscript, but meticulously kept record in good handwriting of three times daily observations of the barometer, once daily readings of an unidentified form of hygrometer and of the wind direction at noon, together with summary descriptions of each day's weather.

Pontefract, Yorkshire (53.7°N, 1.3°W approx.). Daily readings of maximum day and minimum night temperatures, rainfall measurements and once daily wind directions, as well as monthly summaries of the weather, listing many daily events, in 1845 and 1846,in a well written manuscript.

Walkeringham, Nottinghamshire (near 53°27'N. 0°50'W. Three times daily readings of the barometer and thermometer, with summaries of the weather each day - a very neat and well written record.

Tutbury, Staffordshire (near 52°52'N, 1°42'W). A well written diary of the weather, with once daily reports of wind direction, written as notes on the blank pages of The Farmer's Almanack, covering the months June to September 1845.

Cornwall Monthly values of the barometric pressure, dry and wet bulb temperatures at 9a.m., 3p.m. and 9p.m., of wind direction and force, of rainfall, of mean cloudiness (in tenths of the sky covered), numbers of wet and dry days etc., at Helston, Cornwall (50°7'N, 5°18'W), and of some of these items at Falmouth, in 1845 and 1846, printed in the *Annual Reports of the Royal Cornwall Polytechnic Society*. Falmouth (J.Trathan).

Modbury, near Plymouth (near 50.5°N, 3.9°W). A meteorological journal, begun in 1788 and continued to 1866, giving once daily temperatures, wind direction observations, and a summary of the weather.

Sidmouth (near 50.7°N, 3.2°W). A meteorological register with daily morning and afternoon readings of barometer and thermometers, usually also wind direction and a descriptive indication of its strength, notes of when rain was falling, and a description of the weather in a neatly written manuscript.

Isle of Wight (near 50.5°N, 1.25°W).- Monthly mean values of temperature (°F), barometric pressure (inches and thousandths), and rainfall (inches and hundredths), printed for each of the years 1841 to 1856, from observations by J.C. Bloxham, printed in a publication "*On the Meteorology of the Isle of Wight*", published in London by Simpkin, Marshall and Co., in 1860 (2nd edition).

Ipswich, near 52.1°N, 1.2°E. Three times daily readings of barometric pressure and temperature, and wind direction and force, with a careful description of the daily weather and state of the sky, and monthly totals of rainfall and evaporation, in a beautifully written manuscript.

Greenwich, 51°29'N, 0°. Observations, every 2 hours, of barometric pressure (corrected to 0°C), dry and wet bulb temperatures, wind direction, occasional measurements of wind strength by pressure-plate anemometers, and descriptions of the weather, cloud amount, and frequently dew point values, as well as daily measurements of rainfall by three rainguages, printed in the "*Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich*". Published in London (Palmer and Clayton) in 1848, by order of the Board of Admiralty (George Biddell Airy, M.A., Astronomer Royal).

Observation registers for 1845 and 1846 were also received for Uffington (Lincolnshire), Welbeck Abbey (Nottinghamshire), Benefield (near Oundle, Northamptonshire), Swaffham Bulbeck (Cambridgeshire), Wycombe and Burnham (Buckinghamshire), Cobham (Surrey), Uckfield (Sussex), and two additional points in London (one of them being the Royal Horticultural Gardens, Chiswick).

BELGIUM

Brussels, 50°50'N, 4°20'E. Observations published in the *Annales de l'Observatoire Royal* and presumably made at the observatory; though the barometer height above sea level (56.56 metres) differs from that at the modern station there (104m), and it is possible, therefore, that the site in 1845-6 was at the headquarters of the Royal Academy of Science (as had been the case in the previous century). Readings of the instruments at fourteen different hours of the day and night, including barometric pressure in millimetres (reduced to 0°C), temperature (°C), wet and dry bulb readings, also a hygrometer (de Saussure type, giving relative humidity), and wind direction and force, as well as once daily measurements in millimetres of the rain and snow fallen, and descriptions of the state of the sky and weather. Supplied by the Institut Royal Météorologique, Brussels.

THE NETHERLANDS

Den Helder, 52°58'N, 4°45'E. Copy of the extremely neat manuscript register of observations at this point on the coast in the northwest of Holland, with observations three times daily of barometric pressure in millimetres (corrected to 0°C), temperature (°C), relative humidity, vapour pressure (mm), wind direction and speed (in ells per second), and state of the sky and weather, as well as maximum and minimum temperature and measured rainfall once a day. Also tide level measurements. Supplied by the Royal Netherlands Meteorological Institute, as were all the other Dutch observations.

Groningen (in the north easternmost part of the country) near 53.25°N 6.5°E. Tabulated observations of temperature (°C), wind direction and weather, and once daily rainfall measurements.

Leeuwarden, north Friesland, 53.2°N, 5.8°E approx. Monthly summaries of the weather, with notes of the monthly mean and extreme barometric pressure and temperature readings with dates of the occurrences, prevailing winds, and monthly rainfall totals, printed in Dutch language.

Zwanenburg, in central Holland, 52°23'N, 4°44'E. Copy of the observations of barometric pressure in Rhineland inches and lines (1 Rhineland inch = 26.2mm), temperatures (°F), wind direction and weather, observed three times daily and monthly rainfall totals (in ells), in the original manuscript register, supplied by the Royal Netherlands Meteorological Institute.

GERMANY

Altona, on the River Elbe, now part of Hamburg, near 53.5°N, 9.8°E. Observations supplied by Danish ships in what was at that time a Danish naval station (see under Denmark).

Frankfurt am Main, near 50.1°N, 8.7°E. Three times daily observations of barometric pressure in Paris inches and lines, temperature in °R, wind direction and weather, as well as daily maximum and minimum temperatures from a thermograph and the height of the River Main in Rhineland in feet and inches, as well as some further notes on the weather day by day. Supplied by the Deutscher Wetterdienst.

Dessau, in the Dukedom of Anhalt, central Germany, near 57.8°N, 12.25°E. Three times daily reports of barometer readings in Paris inches and lines, temperatures in °R, and brief reports of the weather daily, copied from the newspaper Dessauisches Wochenblatt; supplied by the Deutscher Wetterdienst.

Berlin, near 52.5°N, 13.4°E. Daily mean temperatures, tabulated, covering the years 1781 to 1919, for the months of June to September, supplied by the Deutscher Wetterdienst.

Three times daily observations of barometric pressure in Paris inches and lines (reduced to 10°R or 12.5°C), temperature (°R), vapour pressure (in lines), wind direction and force (on the 5-point scale defined by the Societas Meteorologica Palatina in the previous century), cloudiness (in fourth parts of the sky covered) and brief coded descriptions of the weather at the high-level observatory Hohenpeissenberg, near Munich, c, 1052 metres above sea level were also supplied by the Deutscher Wetterdienst. These data were published under the authorship of J. Lamont in "*Beobachtungen des Meteorologischen Observatoriums auf dem Hohenpeissenberg von 1792-1850. I. Supplementband zu den Annalen der Münchener Sternwarte*", München 1851.

CZECHOSLOVAKIA

Prague (Klementinum), 50°05'N, 14°25'E. Once daily values of barometric pressure in millimetres, observed at 14h., daily mean temperature, also the daily maximum and minimum, wind directions and Beaufort force, and cloud cover (in tenths of the sky covered) also at 14h., and the daily rainfall totals, as tabulated in the two volumes of "*Meteorologická Pozorování v Praze-Klementinu: I 1775-1900*" and "*II 1901-1975*", published in Prague 1976 by the Hydrometeorological Institute, which kindly supplied the volumes.

Relative humidity observations (presumably at 14h.) are included in the tabulation from 1845 onwards. Certain details of the instruments and their exposure are given in a short introductory text in vol.I in Czech, Russian and English.

POLAND

Warsaw, 52°13'N, 21°2'E. Four times daily observations made at the Astronomical Observatory of barometric pressure in millimetres, temperature (°C), wind direction, and state of the sky and weather, and once daily values of relative humidity and measured rainfall, also monthly summary values, photocopied from printed tables, together with a translation of the key words from Polish into English, were kindly supplied by the Institute of Meteorology and Water Management, Warsaw.

RUSSIA

St Petersburg, 59°57'N, 30°17'E. Hourly observations throughout the 24 hours, of barometric pressure, reduced to 13.5°R (16.9°C) (the printed figures being in "half lines", i.e. twenty-fourth parts of an English inch), temperatures in °R, state of the sky (by symbols) and weather (in French language), and wind direction, the force also being indicated by abbreviations (C = calme, fb = faible, t.fb probably = très faible, m = moderate, f = fort, t .f probably = très fort), also measurements of rain and snow fallen twice daily at 8 and 20h, and notes in the Remarks column of the times of occurrence and other details of the weather, printed in the '*Annuaire Météorologique et Magnétique du Corps des Ingénieurs des Mines (ou Recueil d'Observations Météorologiques et Magnétiques) faites dans l'étendue de l'Empire de Russie*' published by order of his Majesty the Emperor Nicolas I (A.-T. Kupffer, Director of the Observatories), St. Petersburg (Imperial Academy of Sciences), the 1845 and 1846 observations published, each in a separate volume, in 1848 and 1849 respectively. Obtained from the UK Meteorological Office Library, Bracknell.

Ekaterinburg (now Sverdlovsk), 56°48'N, 60°38'E. Details as for St.Petersburg, in the same volumes.

Tiflis (Tblisi), 41°41'N, 44°57'E. Details as for St. Petersburg, in the same volumes.

Nicolaefsk sur la Mer Noire (Nikolaev), c. 47°N, 31.8°E. Three times daily observations of barometric pressure (printed in Paris lines) and temperatures (apparently in °C), printed in *Supplements* to the series of volumes in which the St. Petersburg, Ekaterinburg, and Tiflis observations appear. No details of wind or weather are given.

AUSTRIA

Vienna, near 48.2°N, 16.2°E. Three times daily observations of barometric pressure (reduced to 0°C), temperature and wet bulb temperature (in a column headed "Hygr.") in °R, and wind direction and force (on the usual 0-5 scale, standardized by the old Societas Meteorologica Palatina in the previous century) and, in extremely abbreviated form, a note of the weather or sky cover (Rg. = Regen/rain, W = wolkig/cloudy, tr = trüb/ overcast, h = heiter/clear) and additional notes in a Remarks column (e.g. Gew. = Gewitter/thunder, Wtte. probably meaning Wetterleuchten/lightning), printed in an official volume "*Meteorologische Beobachtungen an der k.k. Sternwarte in Wien von 1775 bis 1855*", by Carl von Littrow & Edmund Weiss, vol.5 (1839-1855), Vienna 1866. An explanatory Foreword gives some details of the instruments and their exposure, height of the station, the original units employed, corrections applied, and a few special observations on particular dates. Copy obtained from the UK Meteorological Office Library, Bracknell.

SWITZERLAND

Basle (Merian), near 47.6°N, 7.6°E. Five times daily observations of barometric pressure (in Paris inches and lines), temperature (in °R), wind direction and force (0-5 scale), and abbreviated notes of sky cover and weather (h = heiter/clear, bw or bew = bewolkt/cloudy or overcast, bed = bedeckt/overcast, R = Regen/ rain, Neb = Nebel/fog). Kindly supplied by the Swiss Meteorological Institute (Schweizerische Meteorologische Anstalt), Zürich.

Geneva, near 46.2°N, 6.1°E. Four times daily observations of barometric pressure (reduced to 0°C) in millimetres, temperature (°C), relative humidity (by hair hygrometer), and daily values of maximum and minimum temperature and measured rainfall (in m), also wind direction twice daily and state of the sky and weather (using extreme abbreviations, e.g. "cou.pl" = couvert, pluie/ overcast, rain), in a printed tabulation, kindly supplied by the Observatory, Geneva, under an arrangement made by the Schweizerische Meteorologische Anstalt, Zürich.

FRANCE

Montdidier, near 49.7°N, 2.5°E. A record of daily observations of barometric pressure (in Paris inches and lines), temperature (°C), wind direction, and state of the sky and weather, extending from about 1780 to 1860; copy available on microfilm in the Climatic Research Unit, University of East Anglia.

Rouen, near 49.4°N, 1.1°E. Three times daily observations of barometric pressure in millimetres, and temperature in °C, as well as the daily maximum and minimum temperatures, and once daily observations at noon of wind direction and the state of the sky and weather. Rainfall totals for each month are also given. An introductory text gives some details of the instruments and their exposure. The relevant pages from the printed observation collection, from the "*Comptes Rendus de l'Académie des Sciences*", Paris, kindly supplied for this study by the Météorologie Nationale (Service Météorologique Métropolitaine, Division de Climatologie), Ministère des Transports, 2 Avenue Rapp, Paris.

Metz, near 49.1°N, 6.2°E. Details similar to Rouen. The record for 1845 and 1846 kindly supplied by M. Claude Pichard of Geispolsheim, Lorraine, from an archive in Strasbourg.

Paris, 48°52'N, 2°30'E. Four times daily observations of barometric pressure in millimetres, and temperature °C, at the Observatory, together with the day's highest and lowest temperatures and daily observations of the wind direction, weather and sky cover at midday, kindly supplied by the Météorologie Nationale (as for Rouen) from the "Comptes Rendus" of the Academy of Sciences. Monthly rainfall totals are also given.

Dijon, near 47.3°N 5.1°E. Details as for Paris, except that daily rainfall measurements (in millimetres) are also given.

Rodez, 44°21'N, 2°41'E. A high-level station (630m above sea level) in the south of France. Four times daily observations of barometric pressure (in mm), and temperature (°C), together with the day's highest and lowest values, and once daily wind direction and state of the sky and weather at noon. Monthly rainfall totals also given. The relevant pages from the "Comptes Rendus" of the Academy of Sciences kindly supplied by the Météorologie Nationale, as for Rouen.

SPAIN

Barcelona, near 41.3°N, 2.2°E. Three times daily observations of barometric pressure in Spanish inches and lines, and temperatures in °R, together with wind direction and a brief note of the state of weather and sky (in Spanish). Kindly supplied by Professor Manuel Puigcerver, Secretary of the Academy of Sciences and Arts, Barcelona, from the newspaper Diario de Barcelona. (Reports of weather in this newspaper begin in 1792, but the year 1845 seems to be missing).

GIBRALTAR Near 36.1°N, 5.3 W. Once daily reports of barometric pressure (in English inches), temperature (in°F), measured rainfall (in inches), wind direction, and state of the weather and sky, photocopy supplied by the kind arrangements made for this study by W.D.Hyde, Principal Meteorological Officer, Royal Air Force, Gibraltar in 1982 from the files of the newspaper Gibraltar Chronicle in the Garrison Library.

SICILY

Palermo, near 38.1°N, 13.3°E. Monthly values of mean barometric pressure (in English inches), together with the highest and lowest values measured during the month and dates of occurrence, similar details of temperature (in°F), rainfall and notes of the days with rain (and snow) falling, days of thunderstorms, and days with wind, copied from printed summaries of the observations at Palermo in "*Ristretto generale delle Osservazioni meteorologiche fatte nel Reale Osservatorio di Palermo*", in the British (Museum) Library under Pressmark AC4122. (The observations are believed to have been made in the Alameda Gardens, 33.5 metres (102 feet) above sea level: they are known to have started in 1792 and the early years are believed to have been published by C.L. von Littrow and F. Schaub in "Storia celeste del Real Osservatorio di Palermo dal 1792 al 1813" (observations by Piazzi) in the *Annalen der Kaiser-Königliche Sternwarte,(Neue Folge) Band 4-12*, 1821, under Pressmark 8564 b and c in the British Library. Some later years' data appeared in the Giornale astronomico e meteorologico del Osservatorio di Palermo, Palermo, 1855-1857; in the library of the Royal Astronomical Society, London.

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Castle Fogarty, Thurles.
15th July, 1847

My dear Sir

I did not intend writing to you until to-morrow, the 16th, the anniversary of the day on which the first symptoms of the disease appeared on the potato stalks in this neighbourhood last year, and was certain of being able to give you a favourable report, but judge of my surprise when on coming home this evening after a day's tour through the country in company with Mr. Labach the Government Inspector to find large specimens of the fatal disease from two different parts of the country, one from Cormackstown and the other from Drumeenaghlugh, left here for me. I examined them and found them to compare exactly with last year's first symptoms in every way but that the spots this year are not so black or inky as last (I enclose a sample). I went over my own this evening and upon close examination found many a bulb (?) infected. I have only one consolation or hope now left and that is there are 4 stalks of mine that were similarly affected on the morning of the 10th June, all but the epidermis, and have quite recovered the shock and are now quite healthy. A week will tell much. I have heard many other bad accounts this evening but will state nothing but what comes under my own eye. If the potato goes this year, Ireland will ***never never recover.***

I had sold meadowing to the amount of £200 this time last year but I have not yet had a single application for a plot. I must keep on cutting. The weather for the 4 days past was good and I tramped 19 cocks (in all now 28). It is now raining again.

Hoping to be able to give you a good account still on this day or to-morrow week.

I remain, my dear Sir,
Most respectfully,
Your ob. humble sert.,
JOHN MOLLOY

James Lenigan, Esq.,

(see page 12 for original letter)