Climatological Memorandum No. 108

The climate of the agricultural areas of Scotland

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by

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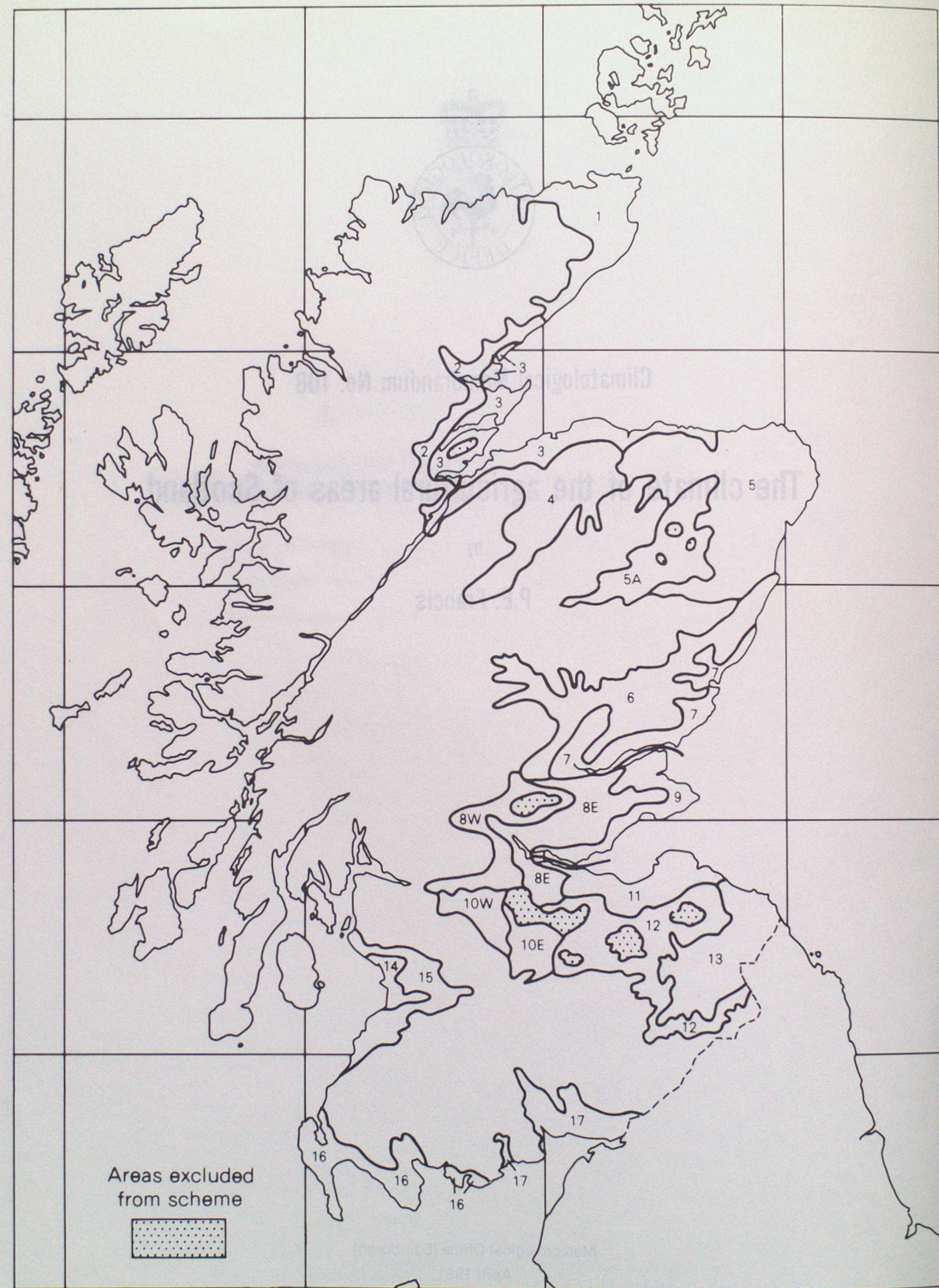

The agroclimatic areas for which data are presented in this publication

Introduction

Over many generations agriculture and horticulture in Scotland have developed under the constraints of climate, soil and economic conditions to give broadly defined areas of particular farming types. These areas can be approximately delineated by using climatic factors only, specifically those conditions known to be of importance to crop growth, development and harvesting. This publication attempts to define the climate of most of these 'agro-climatic' areas of Scotland, setting out the average values of basic meteorological variables, and giving some additional information on other agriculturally significant climatic factors which can be derived from the basic data.

Weather conditions in Scotland have been recorded in a scientific manner for nearly three centuries, although the earliest records are for only a small number of sites. More recently the network of weather observing stations in Scotland has become more widespread, but there is still a marked tendency for a higher density to be concentrated in the lowland areas and in the south as a whole. The weather variables most often recorded are air temperature, rainfall, sunshine and wind speed, although not all of these have been recorded at every observing station.

The weather conditions of each day, when assembled into periods of months and years, form a body of data which can be interpreted to describe the climate of an individual site, or of a region if that site is representative of the surrounding area. An optimum period of time over which to assemble data for a climate description is 30 (or more) years, and most of the basic meteorological variables presented here are averaged over the period 1941–70. In addition to the data from this standard period, it has been necessary to make use of data over shorter periods, of not less than ten years, contained within the period 1941–70. These data are from observing stations in areas not well represented by stations with the full length of data. Various techniques have been used in order to ensure that the mean values for the shorter-period stations have been made compatible with those using the full 30-year period. The more agriculturally biased information, such as excess winter rain amounts, is drawn from the period 1957–75. The reason for the choice of this period is one of expediency, since most of these derived parameters (i.e. those not directly recorded but calculated from basic data) are obtainable only after much careful processing of the basic information, a situation ideally suited to modern computing techniques. The Meteorological Office computer data archives contain information for many stations from 1957 onwards, hence the derived variables were obtained for a period of 19 years from that date.

The problem of defining the boundaries of agro-climatic areas in Scotland could be approached in many ways. The solution adopted here is to accept that topography and rainfall are two of the most dominant physical factors affecting Scottish agriculture, and that these factors are themselves highly correlated. The choice of annual average rainfall amount as the main classifying variable then implies that areas delineated by isohyets (lines of equal rainfall amount) will also have a fairly homogeneous range of altitude. The few exceptions to this rule are specifically dealt with. The annual average rainfall totals taken as being significant for agricultural purposes are 800 mm and 1000 mm in the east, and 1000 mm and 1200 mm in the west. Areas with more than 1200 mm (circa 47 inches) of annual rainfall have been omitted from the descriptions that follow, which means that the Highlands and Islands are not considered in this publication, and that the predominantly sheep-rearing areas of the Southern Uplands are also excluded. Although the distribution of rainfall stations in Scotland is sufficient to enable a good approximation to annual and monthly rainfall distributions in areas of high rainfall totals, the number of full climatological stations in such areas is very small, and insufficient information exists in most regions to enable an areal average to be defined. The topographic complexity of such areas, in general, also makes the definition of areal mean values very difficult.

A map of each agro-climatic area is accompanied by a description of the boundaries defining that area. In addition to the annual average rainfall totals already mentioned, it has in some cases been necessary to use extra geographical features such as rivers or watersheds in order to define areas of a reasonable extent. As mentioned above there are a few areas which contain a not insignificant height range although being bounded by annual isohyets that differ by at most 200 mm. The 600 ft (about 180 m) contour is used an an extra geographical feature in those areas where an additional subdivision is thought to be necessary. A few areas contain zones of higher rainfall amount (i.e. greater than 1000 or 1200 mm) as isolated features. These areas are identified on the maps but have been ignored in the preparation of averages and other statistics.

The areas delineated by the means described previously remain as purely climatological entities until some attempt is made to interpret them in the light of current agricultural practice. The Scottish Colleges of Agriculture were very co-operative and supplied 'broad-brush' maps which illustrated the main farming types in their own advisory regions. The correspondence between the climatic areas and the agricultural regions was quite acceptable, to the degree that a brief agricultural description has been given for each agro-climatic area.

The derivation of mean areal values of the basic meteorological variables was accomplished by plotting all the relevant information, month by month, on to a series of charts. Isopleths were then drawn, taking careful note of topographic features, and areal averages estimated. The derived variables, obtained by computer analysis, were available only from a subset of the total number of stations used in the chart plotting exercise, mainly because a combination of several observable variables was needed and not all stations record all such variables. In order to be able to assign areal values for the derived variables an empirical set of relationships was derived between these variables and the basic variables, from the same subset of observing stations. The resulting relationships were then evaluated using areal values of the basic variables as input parameters. Back-reference to the original values was sufficient to check that the resulting areal averages were acceptable, at least in those few areas where sufficient stations existed to enable a comparison to be carried out.

Before presenting the maps and statistics for each area, there is a short discussion of each of the tabulated variables, basic and derived. Supplementary data, e.g. illustrating year-to-year variations of the variables presented here, or giving information on variables or locations omitted from these pages, can be obtained from the following address.

Principal Meteorological Officer,
Agricultural Unit
Meteorological Office
231 Corstorphine Road
Edinburgh
EH12 7BB Telephone 031-334 9721 Ext. 502 or 545

A charge may be made for information supplied, depending on the staff time needed to handle the enquiry.

Mean air temperature

Mean daily air temperature is evaluated as half the sum of daily maximum and minimum temperatures. These maximum and minimum values are not presented separately here since they are very dependent on site characteristics, whereas the daily mean value shows less spatial variation. Air temperatures are measured in a ventilated screen at a height of 125 cm above a level grass surface. The mean values presented are for the period 1941–70. Details of extreme values, and of monthly average maxima and minima for various locations, can be found in Meteorological Office 1976a, 1976b. *

Because of the ameliorating effect of the sea, coastal mean temperature values are warmer in winter and cooler in summer than those at inland sites. The differences in mean temperature between coastal and inland sites not much above sea level rarely amount to more than 1.0 °C. The effect of increasing height on mean temperature is more marked. It is very important, and especially in Scotland, to calculate temperature lapse rates from local data, since the differences between humidity levels in ascending west coast and and descending east coast air masses can be very marked, leading to different mean lapse rates. All temperatures are given in degrees Centigrade.

Rainfall

Monthly totals of rainfall averaged over the period 1941–70 are given in the text accompanying each map. Rainfall data for this period are available for a relatively large number of locations throughout Scotland, and a computer program was available to print monthly totals on to charts for subsequent analysis. A map of annual average rainfall for the period 1941–70 is available (Meteorological Office 1977) to the general public. Since the largest variation in annual rainfall within an area is 200 mm following the definition of the agro-climatic regions, the variation on a month to month basis is necessarily smaller and rarely exceeds 30 mm. There is therefore no need to attempt to give an assessment of the variation of rainfall with height. All totals are estimated to the nearest 5 mm.

Potential evapotranspiration

Potential evapotranspiration (PE) is a measure of the atmospheric potential to take up moisture either from a green vegetative cover (transpiration) or by evaporation from open water surfaces or wet soil and vegetation. The values of PE were calculated using the Penman combination method, employing an empirical sunshine term in place of the more correct radiation values. The data presented are for the period 1956–75, and only for a small number of stations. The spatial variation of PE is such that areal averages can be deduced with some degree of certainty, however, and values are tabulated in the text to the nearest 5 mm.

Hours of bright sunshine

Daily hours of bright sunshine are measured by employing a glass sphere to concentrate the rays of the sun on to a prepared card in order to burn a trace. When correctly set up and exposed the instrument gives good results, but in hilly or mountainous areas it is often

* References are on page 7

difficult to find a site where the rays of the sun are not cut off by topography during the morning or evening, thus giving a total of sunshine hours that is lower than for a perfectly exposed site. Totals of bright sunshine hours vary geographically, often over small distances, especially near the east coast of Scotland, where sea-fog or *haar* is usually localized and sometimes quite persistent. The values given in the tables are to the nearest 5 hours per month, a degree of accurary that is commensurate with the requirement to give an areal average value.

The soil moisture balance

The tables of data for each area include information on soil moisture parameters such as maximum soil moisture deficit and excess winter rain. In order to obtain these values it is necessary to construct a model of soil moisture extraction and replacement that uses the available information on rainfall and evapotranspiration. The model used here is one developed by L.P. Smith of the Meteorological Office, and described in MAFF 1967, 1971. The model may be briefly summarized as follows:

(a) A daily balance of rainfall and PE is calculated.

(b) A total of 125 mm of water is defined as available for extraction.

(c) The rate of extraction falls below the potential rate when a total of 50 mm has been removed without replacement. The extraction rate then becomes half the potential rate.

(d) When 100 mm has been removed without replacement, the extraction rate further drops to a quarter of the potential rate.

(e) Rainfall is evaporated at the potential rate.

(f) Excess rainfall is assumed to drain in 3 days.

The above model gives reasonably accurate results for a permanent short green crop such as grass, but has obvious shortcomings for crops such as cereals where the soil is bare for a proportion of the year and the height of the crop is appreciably more than that of grass. The variation of extractable water in different soil types is another source of error, the value assumed in the model is a rough median. The main argument in favour of such a simple model is that when applied consistently it affords adequate comparisons between areas of different rainfall and PE. As mentioned earlier in this preamble the derived agricultural parameters were obtained by using regression analysis applied to a limited number of stations. The quartiles and median values give a useful indication of year to year variability.

Date of ending field capacity

The date of ending field capacity in the spring, a useful indicator of early or late access to the land for animals or machinery, is very rarely well defined. The pattern of spring rainfall is irregular in amount and duration while the daily values of evaporation potential are still far below the summer maximum. Several drying periods may occur in the spring of most years and hence it is difficult to present information on a date from which access to the land is guaranteed. Data on a daily basis were available for 17 stations over the period 1957–75 and the patterns of drying and wetting sequences could be identified. The practice adopted was to accept as date of ending field capacity, the starting day of the first drying sequence that reached a soil moisture deficit of 5 mm or more. In this manner some of the minor drying/wetting fluctuations were ignored. The quartile points were extracted from the 19 years of dates and an attempt was made to relate these points with annual totals of rainfall and potential evapotranspiration for each of the stations. The scatter of values was too great to allow a regression analysis, hence values of ending field capacity date were estimated, in 10-day periods, by direct examination of the data. This information on date of ending field capacity is thus by far the most subjective of the data based on the soil moisture balance, and should be treated with caution. The differences in date between areas is itself a useful piece of information, as is the range of the inter-quartile points for each area. The relative suitability of different areas for early spring field work is easily assessed.

Maximum actual summer moisture deficit

The model described above was used for a 19-year period on a total of 17 stations in Scotland for which reliable values of PE could be obtained. The resulting maximum soil moisture deficit (SMD) for each year was noted for each station. The quartile points were extracted and a separate regression analysis performed for each of the points. It became apparent that better results would be obtained if different analyses were performed for areas with greater or less than 800 mm annual average rainfall. The results of the analyses are as below.

(a) Areas with less than 800 mm annual average rainfall (8 stations)

1st quartile: Maximum actual soil moisture deficit (SMD) $= (0.330 \times \text{PE}) - (0.042 \times \text{Annual Average Rainfall } (R)) - 58$

where PE = annual average total potential evapotranspiration.

Median: Max SMD $= (0.249 \times \text{PE}) - (0.055 \times R) + 11$

3rd quartile: Max SMD $= (0.170 \times \text{PE}) - (0.085 \times R) + 82$

The percentages of variance expressed were 93.1, 84.5 and 81.0 respectively, with standard errors of 4.5, 6.0 and 6.4 mm.

(b) Areas with more than 800 mm annual average rainfall (9 stations)

1st quartile: Max SMD = $(0.179 \times PE) - (0.029 \times R) + 2$

Median: Max SMD = $(0.177 \times PE) - (0.036 \times R) + 26$

3rd quartile: Max SMD = $(0.208 \times PE) - (0.032 \times R) + 24$

The percentages of variance expressed were 94.8, 93.2 and 94.8 respectively, with standard errors of 4, 5 and 4 mm. It is important to note that the values of annual average rainfall employed when deriving the regression equations were those for the period 1956–75, in order to be consistent with the period for the PE values. However, when evaluating areal average values the rainfall averages for 1941–70 were used. The differences between the rainfall averages for the different periods are small, of the order of tens of millimetres, hence the relative smallness of the rainfall coefficients and the rounding to the nearest 5 mm (or 10-day period) of the results, lessens the effect of this inconsistency.

Date of return to field capacity

The date of return to field capacity is a good indicator of possible flexibility in an agricultural system since an early return makes autumn harvesting and cultivation difficult. The soil moisture model results were examined for return to capacity events in the autumn. Where a further drying period was observed it was the second or even subsequent date of return which was recorded. The quartile points were extracted from the 19 years of records and separate regression analyses carried out for stations with greater or less than 800 mm annual average rainfall. It was found that in the areas of lower rainfall only the annual total of PE contributed meaningfully towards the regression, while in the areas of higher rainfall it was rainfall alone that appeared to be a significant indicator. The results were

(a) Areas with less than 800 mm annual average rainfall (8 stations)

1st quartile: date of return = $116 + (0.358 \times PE)$ days after January 1st

Median: date of return = $117 + (0.395 \times PE)$

3rd quartile: date of return = $156 + (0.365 \times PE)$

The percentages of variance expressed were 90.1, 90.2 and 93.3 respectively, with standard errors of 5, 5 and 4 days.

(b) Areas with more than 800 mm annual average rainfall (9 stations)

1st quartile: date of return = $310 - (0.047 \times R)$

Median: date of return = $335 - (0.055 \times R)$

3rd quartile: date of return = $352 - (0.057 \times R)$

The percentages of variance expressed were 95.3, 85.0 and 95.6 respectively, the standard errors were 3, 6 and 3 days.

The actual day number of the year that results from these equations is not in itself a reliable piece of information since return to capacity events can be associated with heavy rainfall events, giving a sudden return, or with a more gradual replacement of soil moisture. The practice adopted has been to divide months into 3 x 10-day periods, i.e. 'early', 'mid', or 'late'.

Excess winter rainfall

The definition of excess winter rainfall used here differs slightly from that in general use. The excess rainfall is defined to be the total rainfall between return to capacity dates in the autumn and the first date the following spring when capacity was lost, less of course the total PE in the same period. A soil moisture deficit of 5 mm in the spring was taken as being indicative of a meaningfull drying period, thus avoiding most of the minor drying and wetting cycles associated with leaving capacity. Totals of excess winter rain under this definition were extracted for the 19 years of available data, and the quartile and median points identified. Separate regression analyses for high and low rainfall areas indicated that for the high rainfall zones annual rainfall totals alone were sufficient indicators in the regression equations. The equations for the low rainfall areas include annual PE totals as being another significant factor. The equations are as follows:

(a) Areas with less than 800 mm annual average rainfall (8 stations)

1st quartile: excess winter rainfall (XWR) $= 74 - (0.566 \times PE) + (0.496 \times R)$

Median: XWR $= -153 - (0.384 \times PE) + (0.800 \times R)$

3rd quartile: XWR $= 23 - (0.780 \times PE) + (0.899 \times R)$

The percentages of variance expressed were 97.6 98.0 and 94.3 respectively, with standard errors of 10, 12 and 25 mm.

(b) Areas with more than 800 mm annual average rainfall (9 stations)

1st quartile: XWR = (0.763 × R) − 376

Median: XWR = (0.826 × R) − 365

3rd quartile: XWR = (0.967 × R) − 434

The percentages of variance expressed were 99.7, 98.7 and 99.3 respectively, the standard errors were 12, 25 and 21 mm.

The results have been tabulated to the nearest 5 mm owing to the uncertainty of accuracy of areal rainfall and PE figures.

Length of accessibility period

The amount of time during the year that the land can be grazed by animals or worked by machinery will obviously control to a large extent the pattern of farming practice that is possible in any area. The number of days between loss of capacity in the spring and return to capacity in the autumn gives a good approximation to the 'accessibility' period. In wetter areas it is necessary to subtract intermittent periods of soil wetness in the summer when return to capacity takes place. For the purposes of this exercise the date of leaving capacity in the spring is taken as the first date when a drying period begins during which a deficit of 5 mm or more is reached, thus avoiding several short-lived minor drying phases. Quartile and median values were extracted from the 19 years of available data, and separate regression analyses performed for high and low rainfall areas. The results are as follows:

(a) Areas with less than 800 mm annual average rainfall (8 stations)

1st quartile: length of accessibility period (LAP) = 64 + (0.437 × PE) − (0.118 × R)

Median: LAP = 14 + (0.579 × PE) − (0.091 × R)

3rd quartile: LAP = 198 + (0.424 × PE) − (0.198 × R)

Percentages of variances expressed were 95.5, 93.5 and 91.6 respectively, with standard errors of 6, 8 and 10 days.

(b) Areas with more than 800 mm annual average rainfall (9 stations)

1st quartile: LAP = 82 + (0.326 × PE) − (0.080 × R)

Median: LAP = 114 + (0.321 × PE) − (0.085 × R)

3rd quartile: LAP = 170 + (0.257 × PE) − (0.087 × R)

Percentages of variance expressed were 97.7, 97.3 and 96.5 respectively, and standard errors were 6, 6 and 7 days.

As with other results using regression equations and areal average values of rainfall and PE, it was thought best to round-up the resulting accessibility period lengths to the nearest 5 days.

Date of last air frost in spring

The incidence of air frost in spring is critically dependent on the physical attributes of the surrounding area, i.e. on slope, aspect and soil type. A further complication is that sites with wet soils tend to be less prone to air frost than those with dry soils, because of the greater thermal capacity of wet soils. The presence of a crop cover that effectively insulates the air from any warming by the soil will also tend to increase the rist of late frost occurrence. Coastal effects are very marked, i.e. proximity to the sea prevents late frosts, except that sandy soils tend to become dry and hence encourage frosts. The dates of occurrence of the last air frost in spring for a large number of stations were extracted for the years 1957–75 mainly by use of computer methods. A careful choice of stations, i.e. excluding those with a marked coastal bias, known frost hollows and unrepresentative urban locations, enabled a broad classification of frost risk to be carried out. The quartile points are presented in the tables as 10-day period, the best estimate that can meaningfully be given as an areal value for such a localized variable. The tabulated figures enable a comparison of one area with another, and also present a basis from which roughly to evaluate the frost risk for a site with known advantages (freely draining air, heavy wet soil, near the coast) or disadvantages (valley bottom, light dry soil, vegetative cover, sheltered from wind).

Accumulated temperatures above 0 °C

The suitability of an area for crop growth may be gauged by the potential for rate of vegetative cover increase in spring. The yield of many crops is greatly affected by whether or not enough leaf area exists in mid-summer in order to make most use of the maximum radiation that is available at that time. There is experimental evidence that leaf growth is related to temperature and that, at least for grass and cereal crops, such growth is present although slow at temperatures down to 0 °C. The accumulated temperature total in the first six months of the year thus presents an indication of the potential for leaf growth and development.

Using the data available in the Meteorological Office computer archives, the accumulated temperature totals above 0 °C for January to June were calculated for a total of 31 stations. The algorithms used in the calculation are described in Meteorological Office 1969. The period for which data were extracted was 1957–75 for the reasons given in the introductory paragraphs. The quartile points were extracted and it was evident that separate regression lines would need to be fitted to north and north-east stations as opposed to those in the south and south-west. The chosen predictor was average temperature, January to June ($\overline{T}$).

(a) Stations in the north and north-east of Scotland (10 stations)

1st quartile: Accumulated temperature total (A) $= 176.7\,\overline{T} - 16.9$

Median: $A = 181.0\,\overline{T} + 52.0$

3rd quartile: $A = 167.6\,\overline{T} + 209.1$

The expressed percentages of variance were 98.0, 91.9 and 97.5 while the standard errors were 13.4, 28.0 and 14.7 degrees Centigrade.

(b) Stations in the south and south-west of Scotland (21 stations)

1st quartile: $A = 133.2\,\overline{T} + 303.4$

Median: $A = 150.6\,\overline{T} + 264.2$

3rd quartile: $A = 168.0\,\overline{T} + 226.5$

The percentage of variance expressed in each case was 90.4, 92.4 and 95.9 respectively, with corresponding standard errors of 26.8, 26.3 and 20.8 degrees Centigrade. The values of $\overline{T}$ in use were those for the period 1941–70; hence the corresponding area mean values of $\overline{T}$ were consistent when used to evaluate accumulated temperature totals for individual areas. Areal values have been recorded to the nearest 10 degrees Centigrade in all cases for presentation.

Growing season

There is no very precise way in which to define a growing season for crops in terms of meteorological variables. Even at low temperatures, near freezing, there is evidence that grass and cereals grow at a slow rate, hence an air-temperature 'trigger' point is a misleading concept. As far as grassland is concerned the critical factor is a rate of growth sufficient to meet grazing demands, and a time of year sufficiently far advanced as to minimize the risk of a return to very cold and wet conditions. The above specification is reasonably approximated by choosing the duration of time for which soil temperatures at 30 cm depth are above 6 °C. Such temperatures are measured at 0900 GMT, and the value at that time is not far from the minimum, although diurnal variation is much less than in the atmosphere. Although there are not sufficient observations of this variable to enable a tabulation of values on a monthly basis for each agro-climatic area (see later), the mean length of time for which the temperature is above 6 °C is correlated with mean annual air temperature, thus enabling an approximation of length of growing season to be made. Temperatures at 30 cm depth for 18 stations were available, and averages normalized to the period 1941–70 were evaluated. The major difference between growing seasons in east and west Scotland was immediately evident and, as stated above, so was the relationship between growing-season length and mean annual air temperature. Estimates of length and beginning and end of season dates were made for each agro-climatic area on the basis of mean annual air temperature and the available 30 cm temperature data. The values presented have little absolute value, but do underline the variation from area to area. Variation from year to year is appreciable hence these 'growing seasons' should be treated only as guidelines, not as infallible rules.

Variables not presented

The major omissions in the data presented here are statistics on soil temperature (10 cm, 20 cm and 30 cm depth) and radiation amounts. The networks of stations in Scotland that measure these variables, especially radiation, are very sparse indeed, certainly too sparse to allow meaningful areal values to be presented. Data on earth and soil temperature statistics for the stations that do measure these variables are to be found in Meteorological Office 1975, 1974 or from the address quoted earlier. Similarly the limited radiation data that are available may be obtained on application.

Acknowledgements

I wish to record my appreciation of the help and advice of my colleagues at the Meteorological Office, Edinburgh, during the preparation of this work, especially that of Miss Jane Love of the Agricultural Unit. The computing aspects of the data extraction and manipulation work were ably carried out by Mr Iain Barrie at the Meteorological Office HQ, Bracknell.

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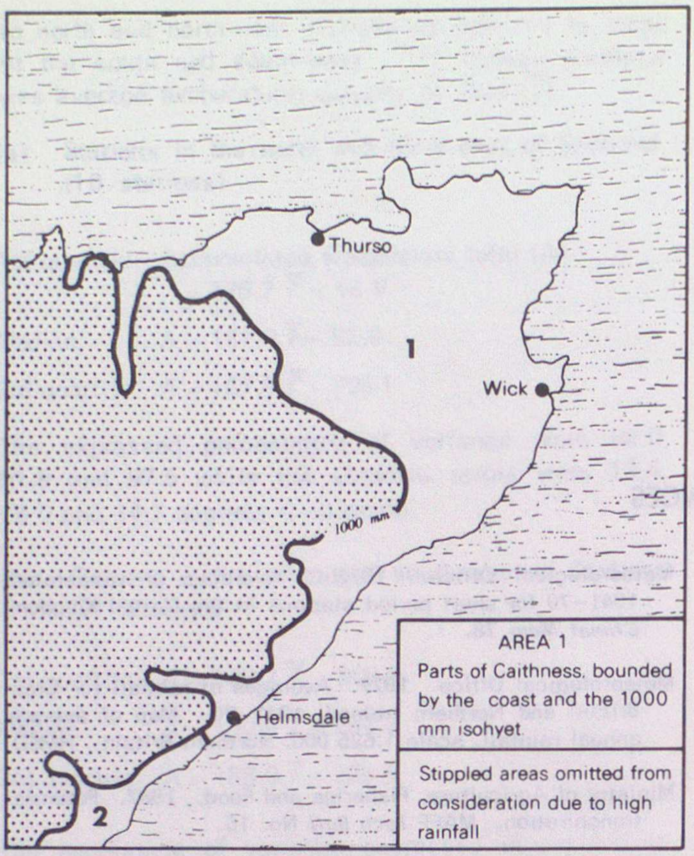


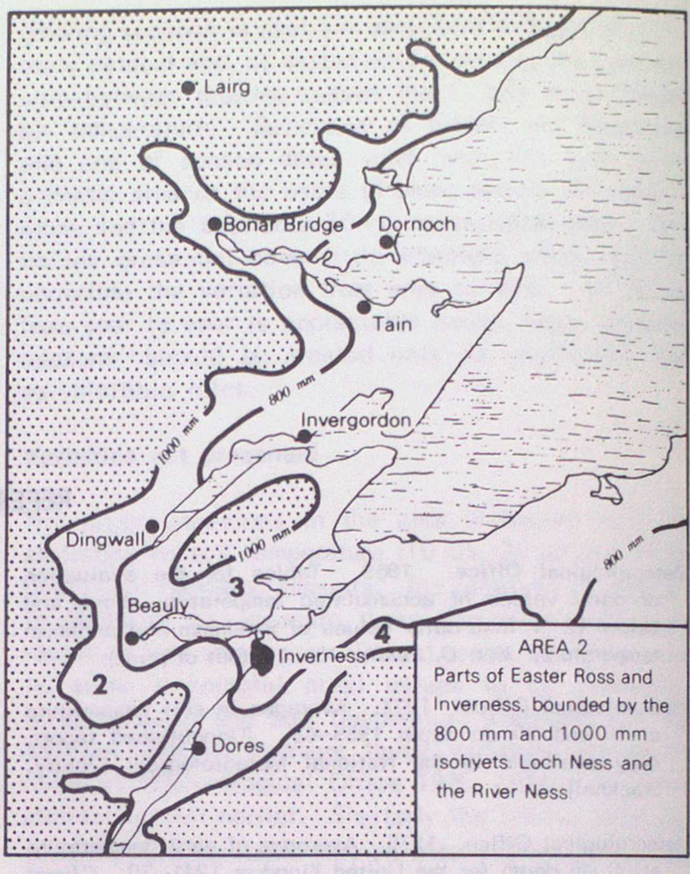
Area 1

Predominant agricultural land-use: Livestock rearing

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.7	90	10	40
Feb.	3.0	70	10	65
Mar.	4.5	60	30	100
Apr.	6.3	50	45	150
May	8.5	50	65	160
June	11.5	55	75	160
July	12.7	70	70	135
Aug.	13.0	80	55	130
Sept.	11.5	80	35	110
Oct.	9.2	90	20	80
Nov.	5.7	95	10	45
Dec.	4.0	95	10	30
Total		885	435	1205
Mean	7.7			

Growing season 215 days 10 Apr.–10 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	180	155–205
Ending field capacity	Early Mar.	Early Mar.–Early Apr.
Return to field capacity	Mid Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	70	55–85
Excess winter rainfall (mm)	365	300–420
Degree – days above 0 °C Jan.–June	1150	1060–1230
Date of last spring air frost	Early May	Late Apr.–Mid May



Area 2

Predominant agricultural land-use: Arable/Livestock (fattening)

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.4	80	5	40
Feb.	2.4	70	10	65
Mar.	4.1	60	25	100
Apr.	6.7	60	45	145
May	9.2	65	65	155
June	12.3	55	70	160
July	13.5	70	70	135
Aug.	13.3	85	50	125
Sept.	12.0	75	35	105
Oct.	9.0	85	15	80
Nov.	5.0	85	10	45
Dec.	3.2	95	5	30
Total		885	405	1185
Mean	7.8			

Growing Season 215 days 10 Apr.–10 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	170	145–195
Ending field capacity	Early Mar.	Early Mar.–Early Apr.
Return to field capacity	Mid Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	65	50–80
Excess winter rainfall (mm)	365	300–420
Degree – days above 0 °C Jan.–June	1170	1080–1250
Date of last spring air frost	Late Apr.	Mid Apr.–Early May

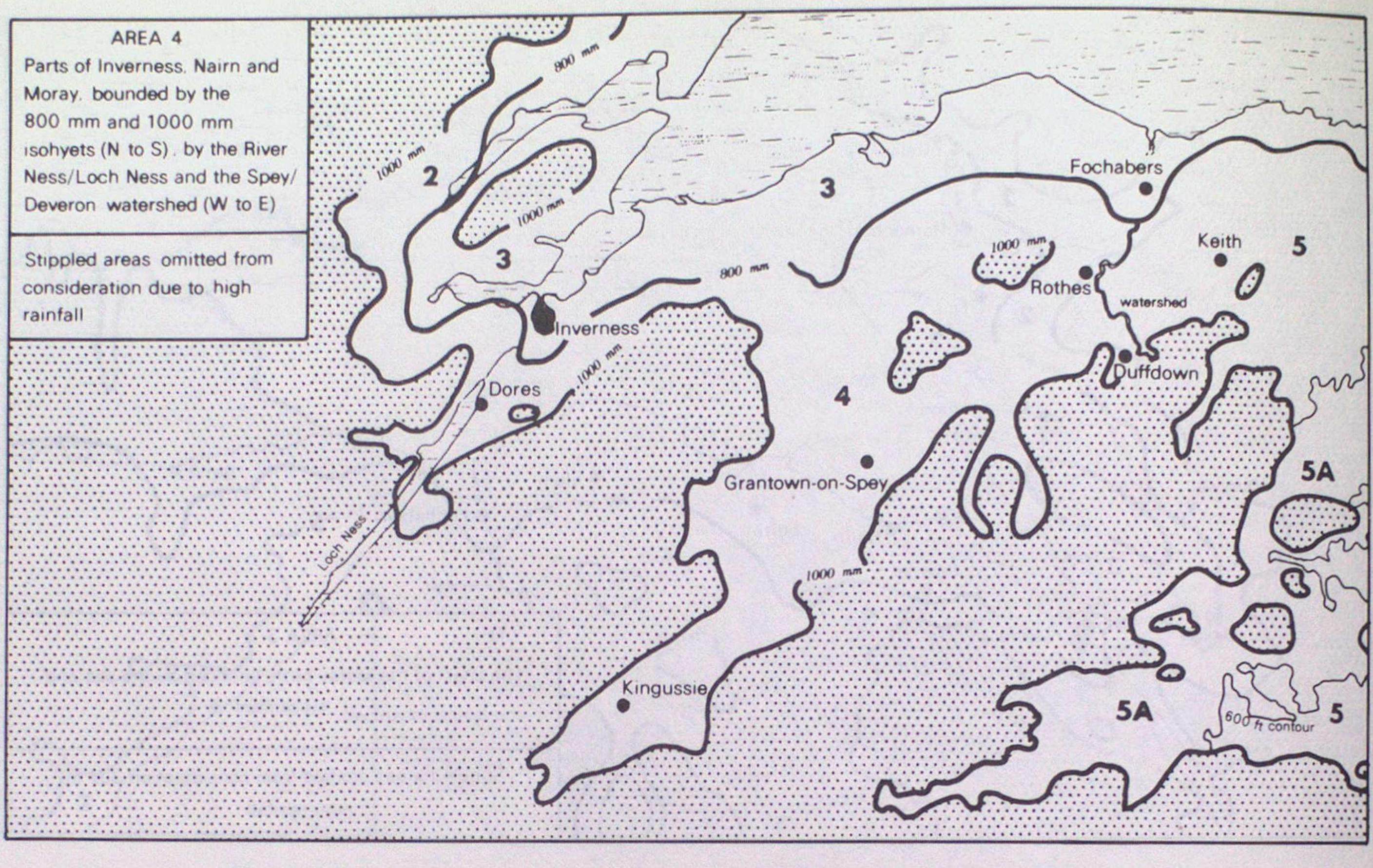
Area 3

Predominant agricultural land-use: Arable/Livestock (fattening/dairying) and some horticulture

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.8	55	10	45
Feb.	3.3	45	10	75
Mar.	5.2	40	30	110
Apr.	7.3	45	50	155
May	9.7	55	75	170
June	12.7	55	85	170
July	14.2	70	80	145
Aug.	13.8	95	60	140
Sept.	12.3	65	40	115
Oct.	9.5	65	20	90
Nov.	5.7	65	10	55
Dec.	4.0	65	10	40
Total		720	480	1310
Mean	8.4			

Growing season 220 days 5 Apr.–10 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	225	190–260
Ending field capacity	Early Mar.	Late Feb.–Mid Mar.
Return to field capacity	Early Nov.	Mid Oct.–Late Nov.
Maximum summer SMD (mm)	90	70–100
Excess winter rainfall (mm)	240	160–295
Degree – days above 0 °C Jan.–June	1290	1190–1350
Date of last spring air frost	Mid Apr.	Early Apr.–Early May



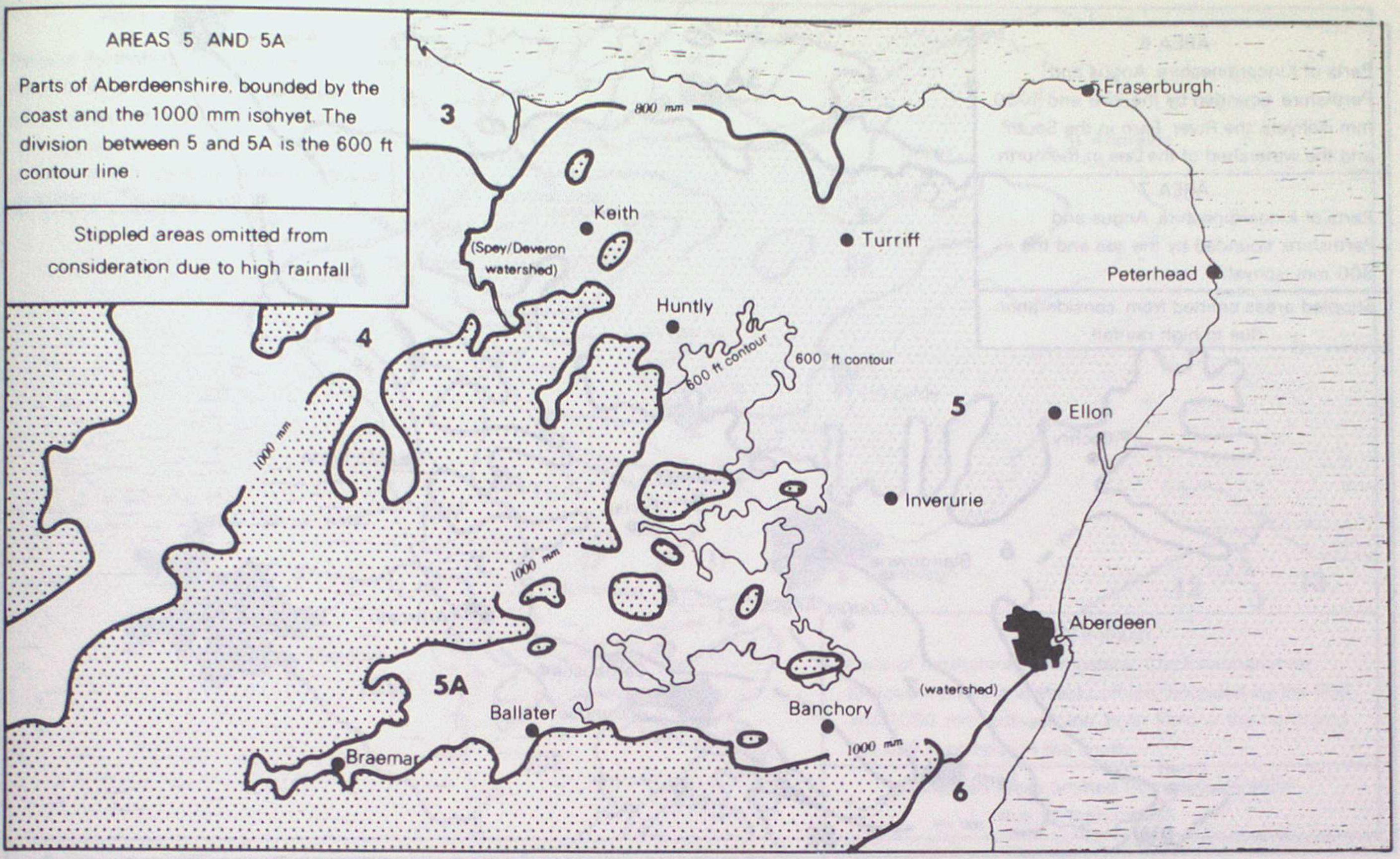
Area 4

Predominant agricultural land-use: Livestock (rearing) and upland.

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	1.5	70	5	40
Feb.	1.7	60	5	65
Mar.	4.0	50	25	105
Apr.	6.3	55	45	140
May	9.0	65	70	165
June	12.0	70	75	160
July	13.0	85	70	140
Aug.	13.0	100	55	125
Sept.	11.3	80	35	105
Oct.	8.3	85	15	85
Nov.	4.5	80	5	45
Dec.	2.5	85	5	30
Total		885	410	1205
Mean	7.3			

Growing season 210 days 15 Apr.–10 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	170	145–200
Ending field capacity	Early Mar.	Early Mar.–Early Apr.
Return to field capacity	Mid Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	65	50–80
Excess winter rainfall (mm)	365	300–420
Degree – days above 0 °C Jan.–June	1090	1000–1170
Date of last spring air frost	Early May	Late Apr.–Mid May



Area 5
Predominant agricultural land-use: Arable/Livestock (general)

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.1	80	5	50
Feb.	2.3	60	10	75
Mar.	4.3	50	25	105
Apr.	6.6	50	45	155
May	8.9	65	70	170
June	12.2	55	80	170
July	13.6	80	75	150
Aug.	13.3	90	60	140
Sept.	11.8	70	35	120
Oct.	8.9	80	20	90
Nov.	4.9	90	5	55
Dec.	3.1	80	5	40
Total		850	435	1320
Mean	7.7			

Growing season 215 days 10 Apr.–10 Nov.

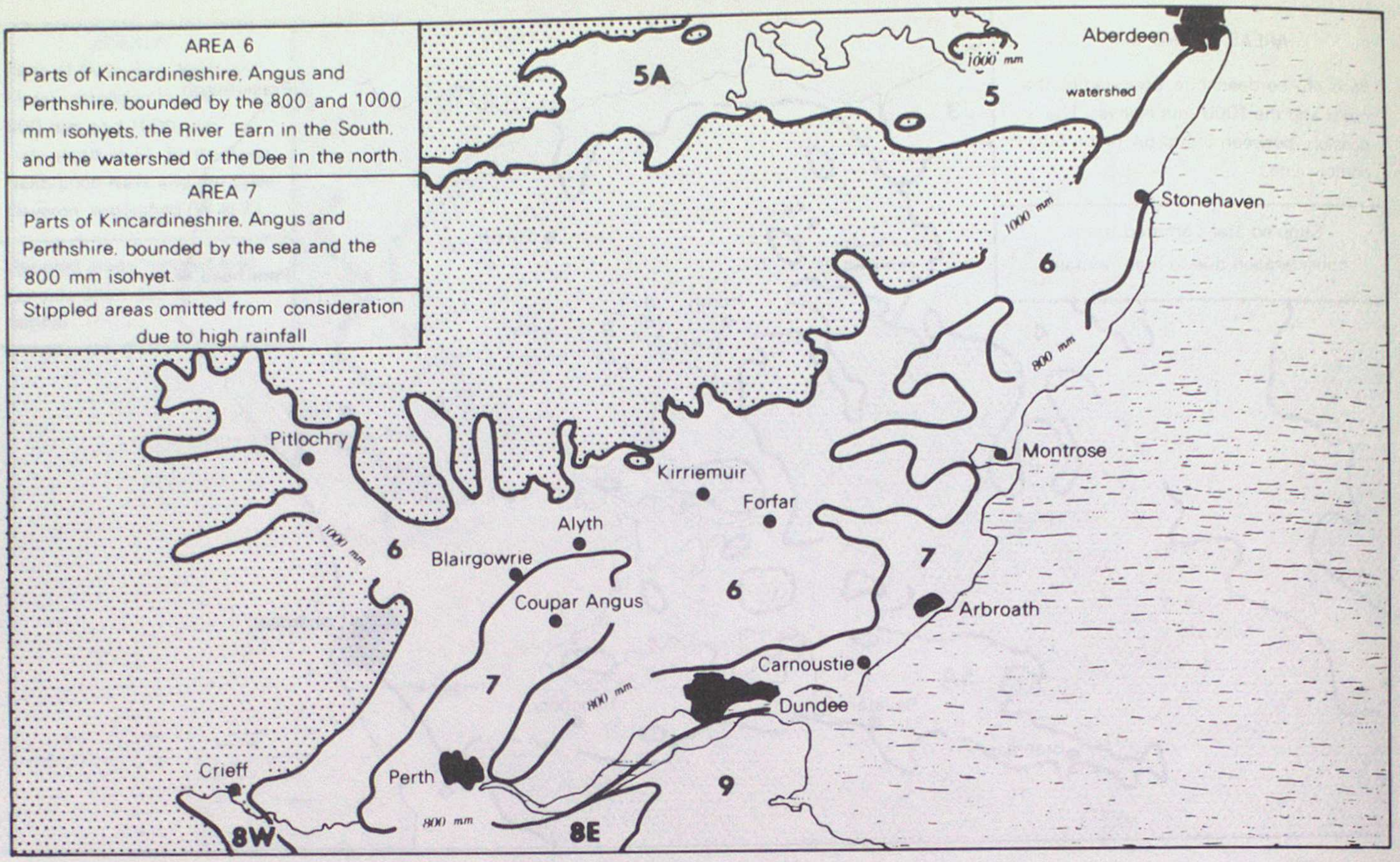
	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	180	155–210
Ending field capacity	Early Mar.	Early Mar.–Early Apr.
Return to field capacity	Mid Oct.	Late Sept.–Early Nov.
Maximum summer SMD (mm)	70	55–85
Excess winter rainfall (mm)	335	275–390
Degree – days above 0 °C Jan.–June	1150	1060–1230
Date of last spring air frost	Early May	Late Apr.–Mid May

Area 5A
Predominant agricultural land-use: Livestock (rearing) and upland.

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	0.9	85	5	35
Feb.	1.0	65	10	60
Mar.	3.3	55	20	100
Apr.	5.6	55	40	145
May	8.5	70	65	165
June	11.7	60	75	165
July	12.9	80	70	145
Aug.	12.5	95	55	125
Sept.	10.7	80	30	105
Oct.	7.8	90	15	80
Nov.	3.7	95	5	45
Dec.	2.0	95	5	30
Total		925	395	1200
Mean	6.7			

Growing season 210 days 15 Apr.–10 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	160	135–190
Ending field capacity	Mid Mar.	Early Mar.–Mid Apr.
Return to field capacity	Mid Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	65	45–75
Excess winter rainfall (mm)	400	330–460
Degree – days above 0 °C Jan.–June	990	900–1080
Date of last spring air frost	Mid May	Early May–Late May



Area 6
Predominant agricultural land-use: Arable/Livestock (mainly fattening)

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	1.8	85	5	45
Feb.	2.1	60	5	80
Mar.	4.3	55	25	105
Apr.	6.7	55	45	155
May	9.3	70	70	170
June	12.4	60	80	170
July	13.9	80	75	155
Aug.	13.3	90	55	130
Sept.	11.5	85	30	110
Oct.	8.6	85	15	85
Nov.	4.7	85	5	55
Dec.	2.7	90	5	40
Total		900	415	1300
Mean	7.6			

Growing season 215 days 10 Apr.–10 Nov.

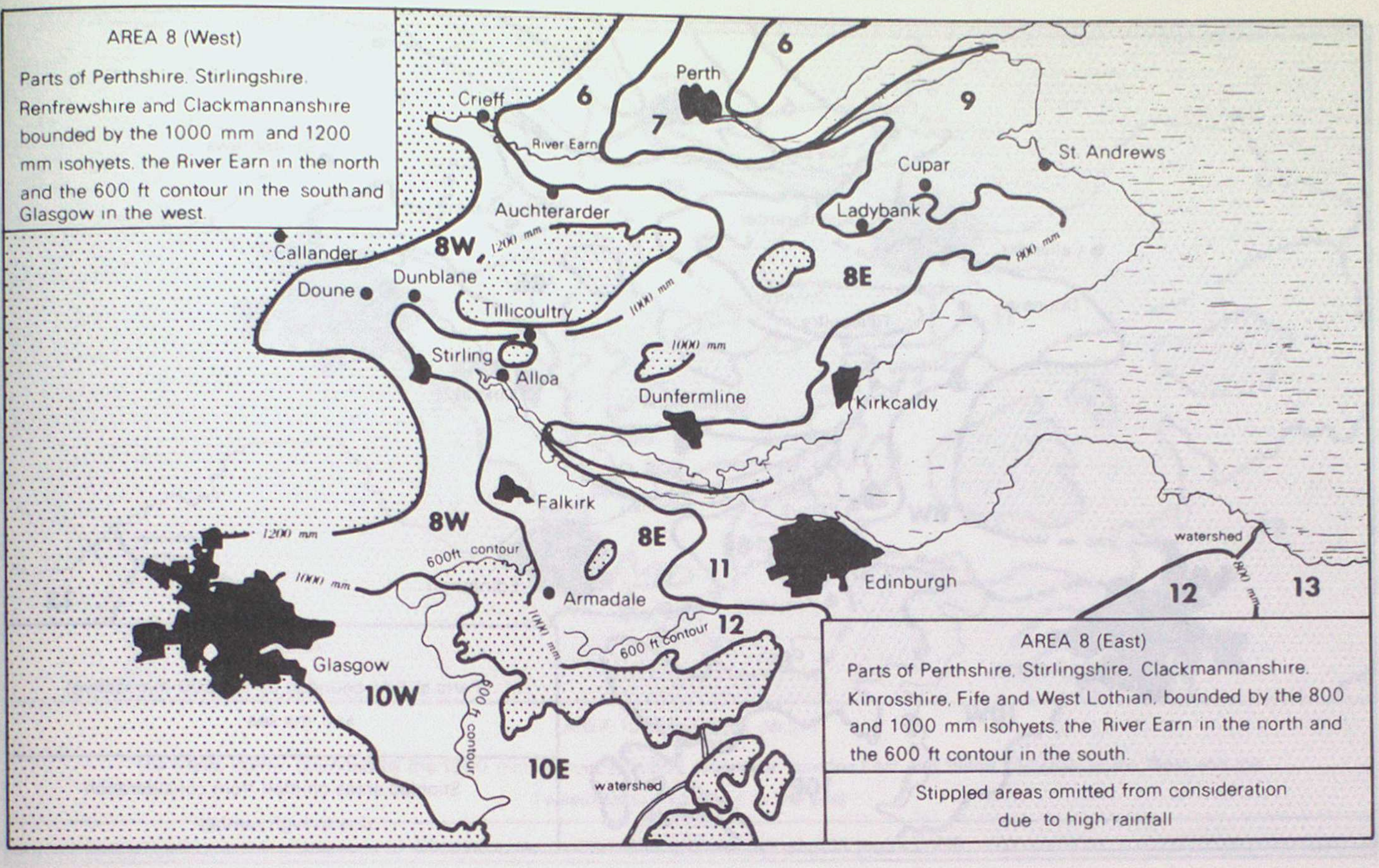
	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	170	145–200
Ending field capacity	Early Mar.	Early Mar.–Early Apr.
Return to field capacity	Mid Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	65	50–80
Excess winter rainfall (mm)	380	310–435
Degree – days above 0 °C Jan.–June	1180	1120–1250
Date of last spring air frost	Late Apr.	Mid Apr.–Early May

Area 7
Predominant agricultural land-use: Arable/Horticulture

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.4	65	5	50
Feb.	2.8	45	10	80
Mar.	4.8	45	30	110
Apr.	7.3	45	50	160
May	9.7	65	75	180
June	13.0	50	85	180
July	14.3	70	80	170
Aug.	13.8	80	60	145
Sept.	12.1	65	35	120
Oct.	9.2	65	15	95
Nov.	5.4	70	5	65
Dec.	3.5	70	5	45
Total		735	455	1400
Mean	8.2			

Growing season 220 days 5 Apr.–10 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	210	175–245
Ending field capacity	Early Mar.	Late Feb.–Mid Mar.
Return to field capacity	Late Oct.	Early Oct.–Mid Nov.
Maximum summer SMD (mm)	85	60–95
Excess winter rainfall (mm)	260	180–330
Degree – days above 0 °C Jan.–June	1270	1190–1350
Date of last spring air frost	Mid Apr.	Early Apr.–Late Apr.



Area 8E

Predominant agricultural land-use: Livestock (fattening/dairying)/Arable

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.5	80	5	45
Feb.	3.1	60	10	75
Mar.	5.2	55	30	105
Apr.	7.7	55	50	150
May	10.4	70	75	175
June	13.4	65	85	180
July	14.8	85	85	165
Aug.	14.4	95	65	135
Sept.	12.6	85	35	115
Oct.	9.5	80	15	85
Nov.	5.5	90	5	55
Dec.	3.8	90	5	35
Total		910	465	1320
Mean	8.6			

Growing season 225 days 5 Apr.–15 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	185	160–210
Ending field capacity	Early Mar.	Early Mar.–Late Mar.
Return to field capacity	Mid Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	75	60–90
Excess winter rainfall (mm)	385	320–445
Degree – days above 0 °C Jan.–June	1330	1240–1410
Date of last spring air frost	Mid Apr.	Early Apr.–Late Apr.

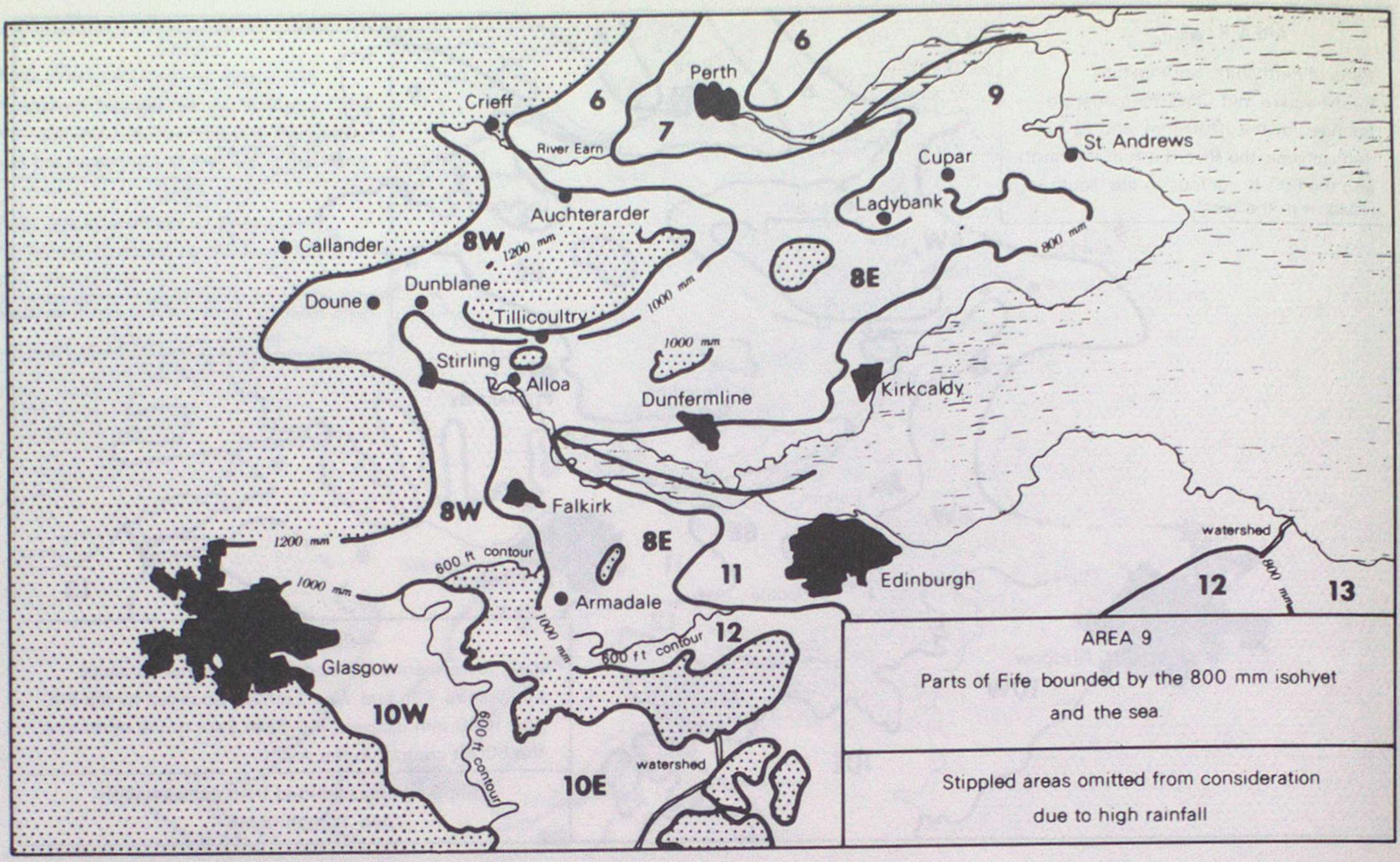
Area 8W

Predominant agricultural land-use: Arable/Livestock

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.5	100	5	40
Feb.	3.0	75	10	70
Mar.	5.2	70	30	95
Apr.	7.8	70	50	140
May	10.6	75	70	175
June	13.6	75	85	175
July	14.8	85	80	160
Aug.	14.5	110	60	130
Sept.	12.5	115	35	105
Oct.	9.5	110	15	80
Nov.	5.5	100	5	50
Dec.	3.8	115	5	35
Total		1100	450	1255
Mean	8.6			

Growing season 225 days 5 Apr.–15 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	165	140–190
Ending field capacity	Early Mar.	Early Mar.–Early Apr.
Return to field capacity	Early Oct.	Mid Sept.–Mid Oct.
Maximum summer SMD (mm)	65	50–80
Excess winter rainfall (mm)	545	465–630
Degree – days above 0 °C Jan.–June	1340	1250–1420
Date of last spring air frost	Mid Apr.	Early Apr.–Late Apr.

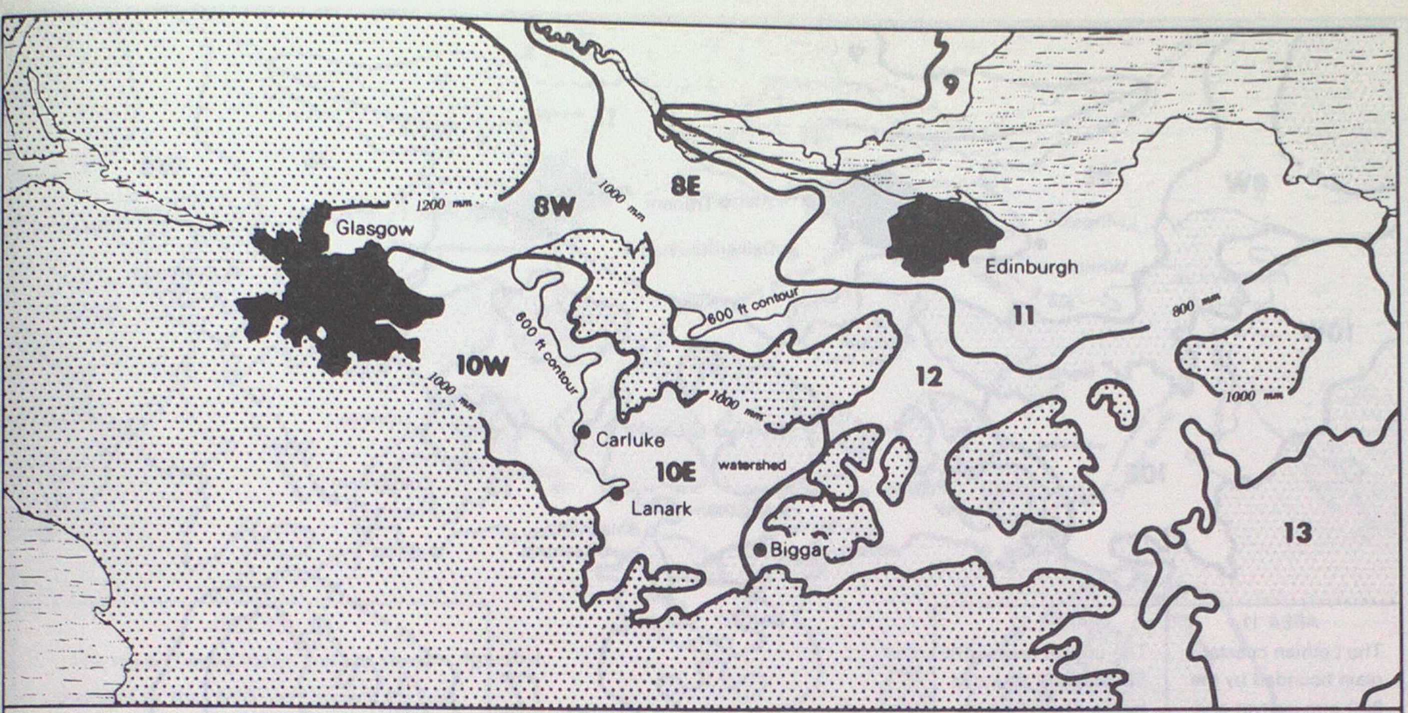


Area 9
Predominant agricultural land-use: Arable/Horticulture

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.7	60	5	50
Feb.	3.1	50	10	80
Mar.	5.1	45	30	105
Apr.	7.5	45	50	160
May	9.8	60	75	175
June	12.8	55	90	180
July	14.5	75	85	175
Aug.	14.1	85	65	145
Sept.	12.5	65	40	125
Oct.	9.6	65	20	95
Nov.	5.7	70	5	60
Dec.	3.8	65	5	45
Total		740	480	1395
Mean	8.4			

Growing season 225 days 5 Apr.–15 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	225	185–255
Ending field capacity	Early Mar.	Late Feb.–Mid Mar.
Return to field capacity	Early Nov.	Mid Oct.–Late Nov.
Maximum summer SMD (mm)	90	70–100
Excess winter rainfall (mm)	255	170–315
Degree – days above 0 °C Jan.–June	1290	1210–1370
Date of last spring air frost	Mid Apr.	Early Apr.–Early May



AREA 10 (EAST AND WEST)

The Clyde Valley, bounded by the 1000 mm isohyet, (the 600 ft contour devides East and West). Glasgow to the West and the Tweed/Clyde watershed to the east.

Stippled areas omitted from consideration due to high rainfall

Area 10E
Predominant agricultural land use: Upland livestock

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	1.6	75	5	45
Feb.	1.8	60	5	70
Mar.	4.1	50	25	95
Apr.	6.4	55	45	130
May	9.3	65	70	170
June	12.2	65	85	160
July	13.4	85	80	135
Aug.	13.1	90	60	130
Sept.	11.4	95	30	100
Oct.	8.6	85	15	85
Nov.	4.7	85	5	50
Dec.	2.8	85	5	35
Total		895	430	1205
Mean	7.5			

Growing season 215 days 10 Apr.–10 Nov.

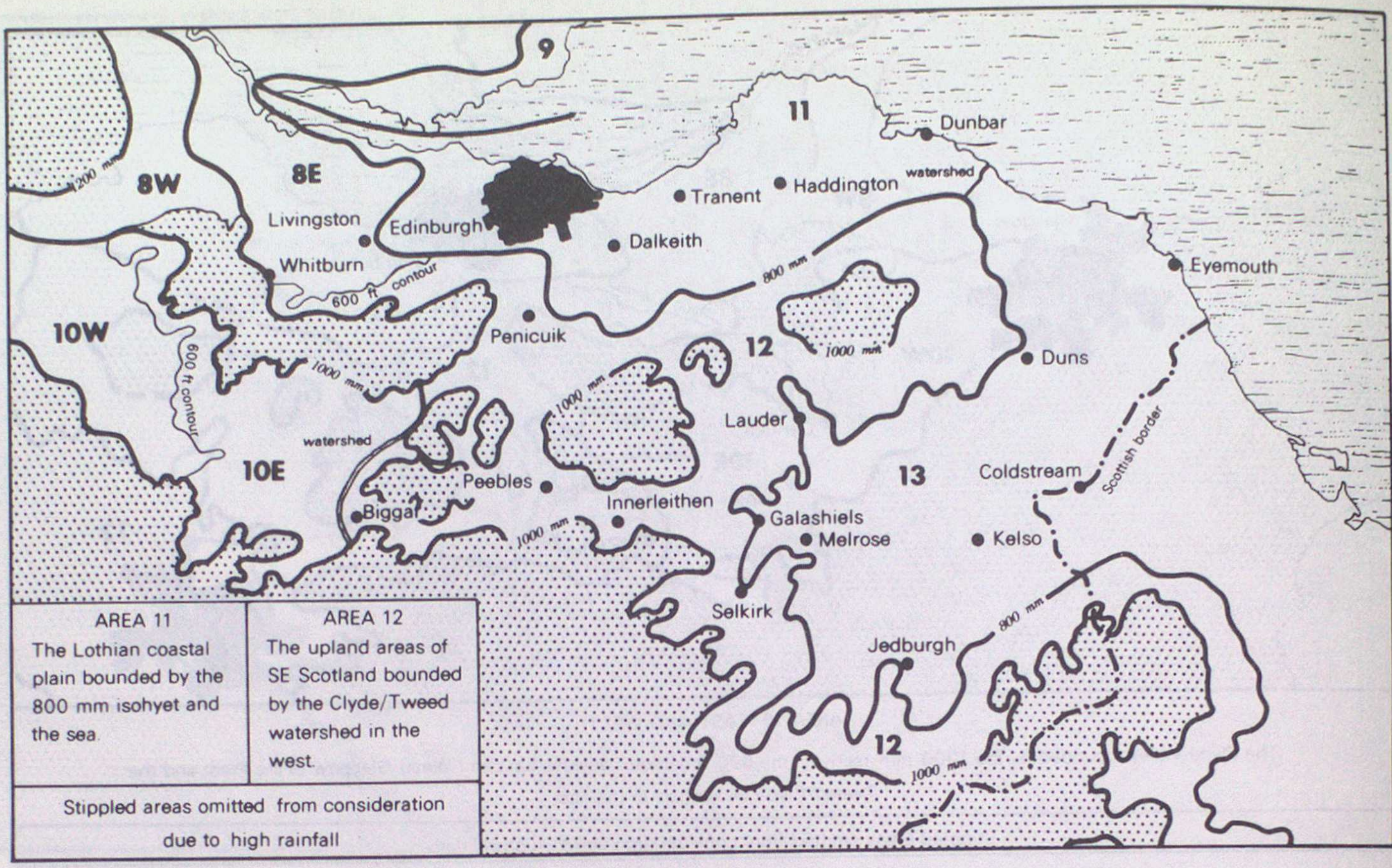
	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	175	150–205
Ending field capacity	Early Mar.	Early Mar.–Early Apr.
Return to field capacity	Mid Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	70	55–85
Excess winter rainfall (mm)	375	305–430
Degree – days above 0 °C Jan.–June	1150	1090–1220
Date of last spring air frost	Late Apr.	Mid Apr.–Early May

Area 10W
Predominant agricultural land-use: Dairying/Horticulture

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.3	80	5	45
Feb.	2.7	60	10	65
Mar.	4.9	55	30	95
Apr.	7.4	55	50	135
May	10.3	65	75	175
June	13.2	65	90	170
July	14.3	80	80	145
Aug.	14.1	90	65	130
Sept.	12.3	95	35	100
Oct.	9.4	90	15	80
Nov.	5.5	85	5	50
Dec.	3.6	90	5	35
Total		910	465	1225
Mean	8.3			

Growing season 225 days 5 Apr.–15 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	185	160–210
Ending field capacity	Early Mar.	Early Mar.–Late Mar.
Return to field capacity	Mid Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	75	60–90
Excess winter rainfall (mm)	385	320–445
Degree – days above 0 °C Jan.–June	1290	1210–1370
Date of last spring air frost	Mid Apr.	Early Apr.–Late Apr.



Area 11
Predominant agricultural land-use: Arable/Horticulture

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.9	55	5	50
Feb.	3.2	40	10	75
Mar.	5.1	40	35	105
Apr.	7.5	40	50	150
May	9.9	55	75	180
June	13.0	45	90	185
July	14.5	65	85	165
Aug	14.2	85	70	150
Sept.	12.6	60	40	120
Oct.	9.8	60	25	95
Nov.	5.7	70	10	55
Dec.	4.0	60	5	45
Total		675	500	1375
Mean	8.5			

Growing season 225 days 5 Apr.–15 Nov.

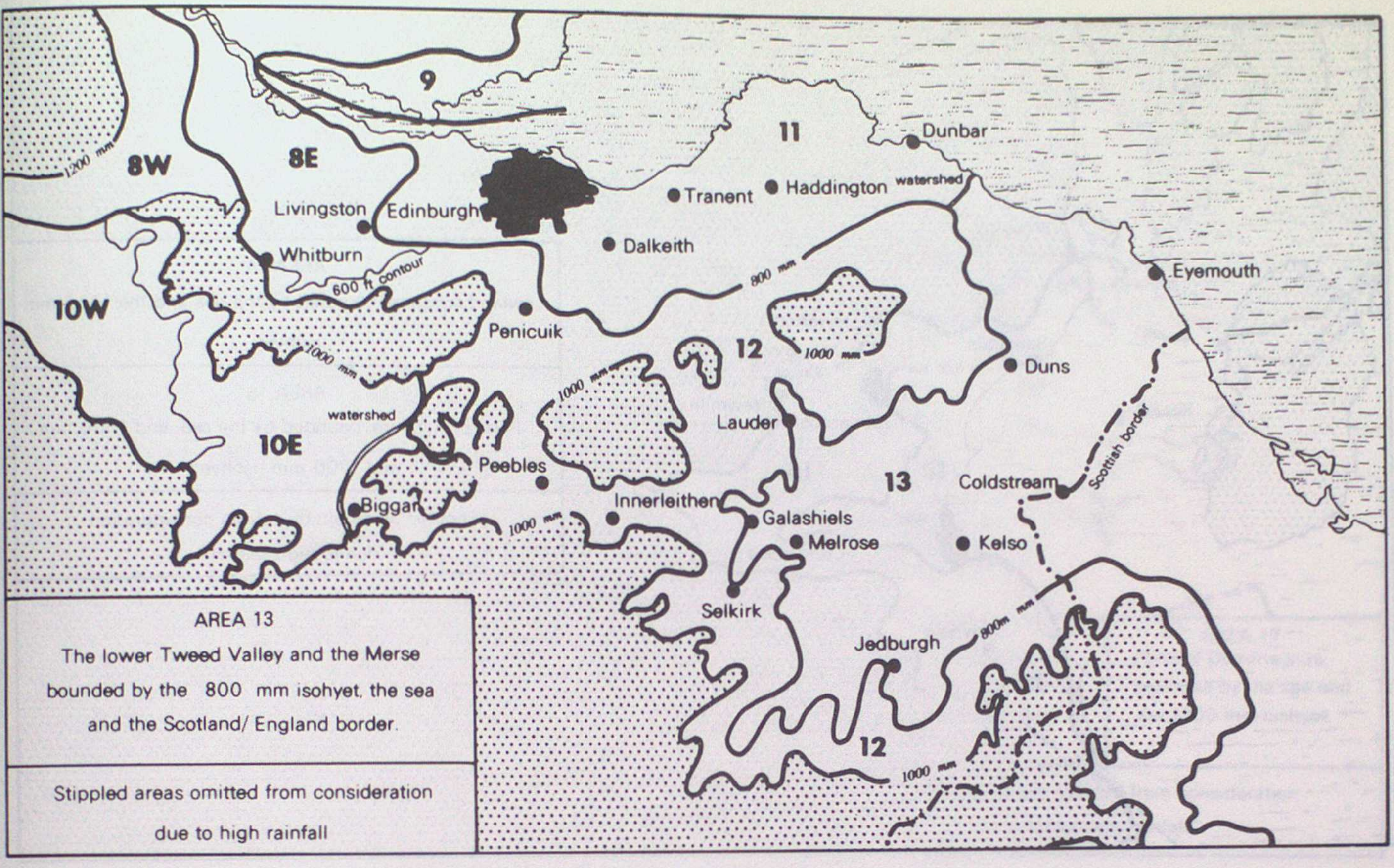
	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	240	205–275
Ending field capacity	Early Mar.	Mid Feb.–Early Mar.
Return to field capacity	Mid Nov.	Late Oct.–Early Dec.
Maximum summer SMD (mm)	100	80–110
Excess winter rainfall (mm)	195	125–240
Degree – days above 0 °C Jan.–June	1310	1230–1390
Date of last spring air frost	Mid Apr.	Early Apr.–Early May

Area 12
Predominant agricultural land-use: Livestock/Arable and upland

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	1.6	80	5	45
Feb.	1.7	65	10	70
Mar.	4.0	50	25	100
Apr.	6.4	55	45	140
May	9.1	70	70	170
June	12.2	60	85	170
July	13.5	80	80	150
Aug.	13.2	95	60	135
Sept.	11.4	85	40	105
Oct.	8.6	80	20	85
Nov.	4.6	90	5	50
Dec.	2.7	85	5	35
Total		895	450	1255
Mean	7.4			

Growing season 215 days 10 Apr.–10 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	180	155–210
Ending field capacity	Early Mar.	Early Mar.–Late Mar.
Return to field capacity	Mid Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	75	55–90
Excess winter rainfall (mm)	375	305–430
Degree – days above 0 °C Jan.–June	1140	1080–1210
Date of last spring air frost	Early May	Late Apr.–Mid May

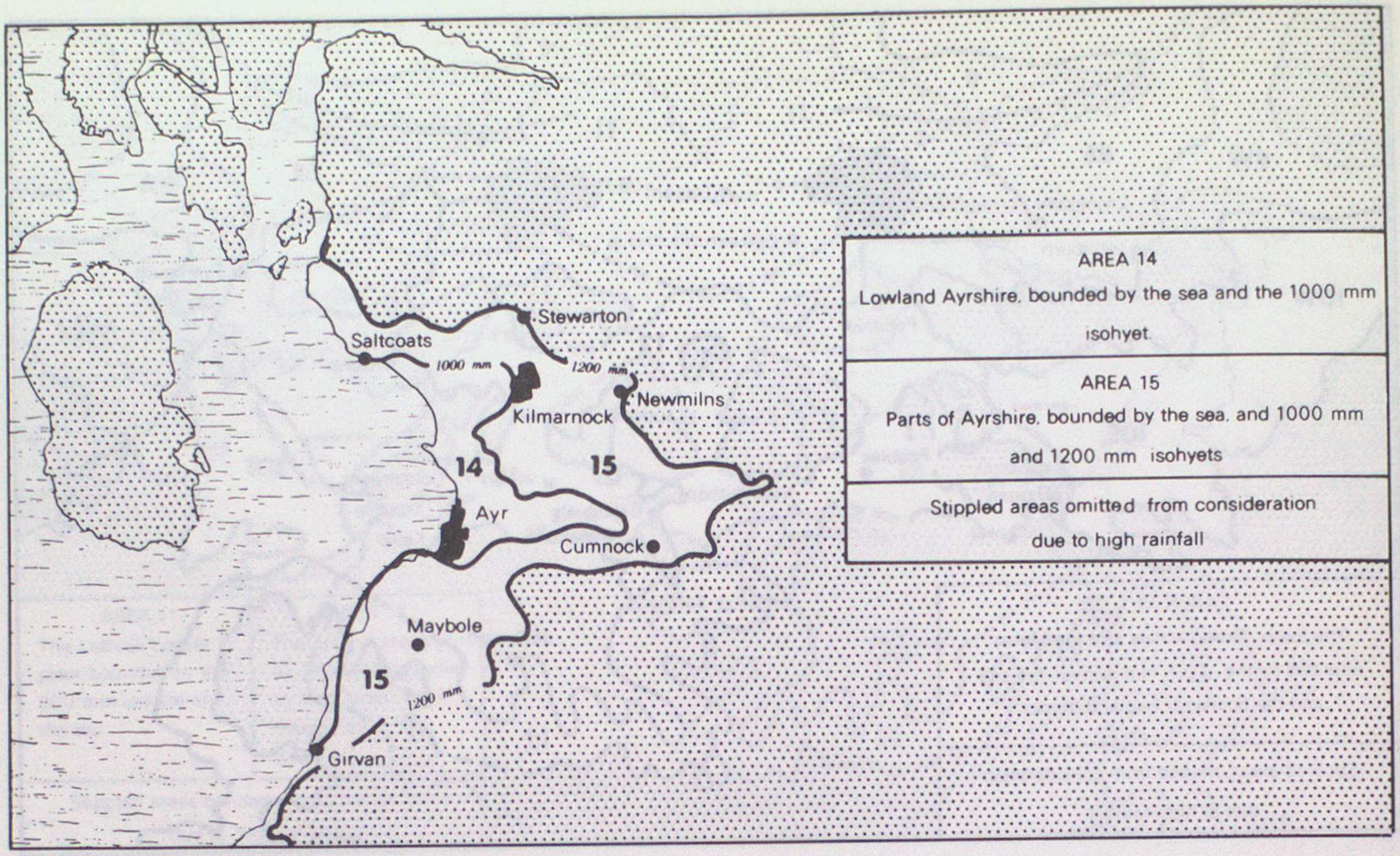


Area 13
Predominant agricultural land-use: Arable/Livestock and some horticulture

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.7	65	5	50
Feb.	3.0	50	10	75
Mar.	4.5	40	30	105
Apr.	7.0	45	50	150
May	9.7	55	75	180
June	12.7	55	85	180
July	14.0	65	85	160
Aug.	13.7	85	65	145
Sept.	11.9	65	40	120
Oct.	9.0	65	25	95
Nov.	5.2	75	5	55
Dec.	3.5	65	5	45
Total		730	480	1360
Mean	8.1			

Growing season 220 days 5 Apr.–10 Nov.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	225	190–255
Ending field capacity	Early Mar.	Late Feb.–Mid Mar.
Return to field capacity	Early Nov.	Mid Oct.–Late Nov.
Maximum summer SMD (mm)	90	70–100
Excess winter rainfall (mm)	245	165–305
Degree – days above 0 °C Jan.–June	1260	1180–1340
Date of last spring air frost	Mid Apr.	Early Apr.–Early May



Area 14
Predominant agricultural land-use: Dairying/Arable

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	3.5	85	5	50
Feb.	3.7	55	10	75
Mar.	5.6	55	35	110
Apr.	7.8	55	50	155
May	10.5	60	80	195
June	13.2	65	90	185
July	14.4	80	80	155
Aug.	14.4	95	65	150
Sept.	12.8	105	40	115
Oct.	10.1	100	20	85
Nov.	6.3	90	10	55
Dec.	4.7	95	5	35
Total		940	490	1365
Mean	8.9			

Growing season 255 days 31 Mar.–10 Dec.

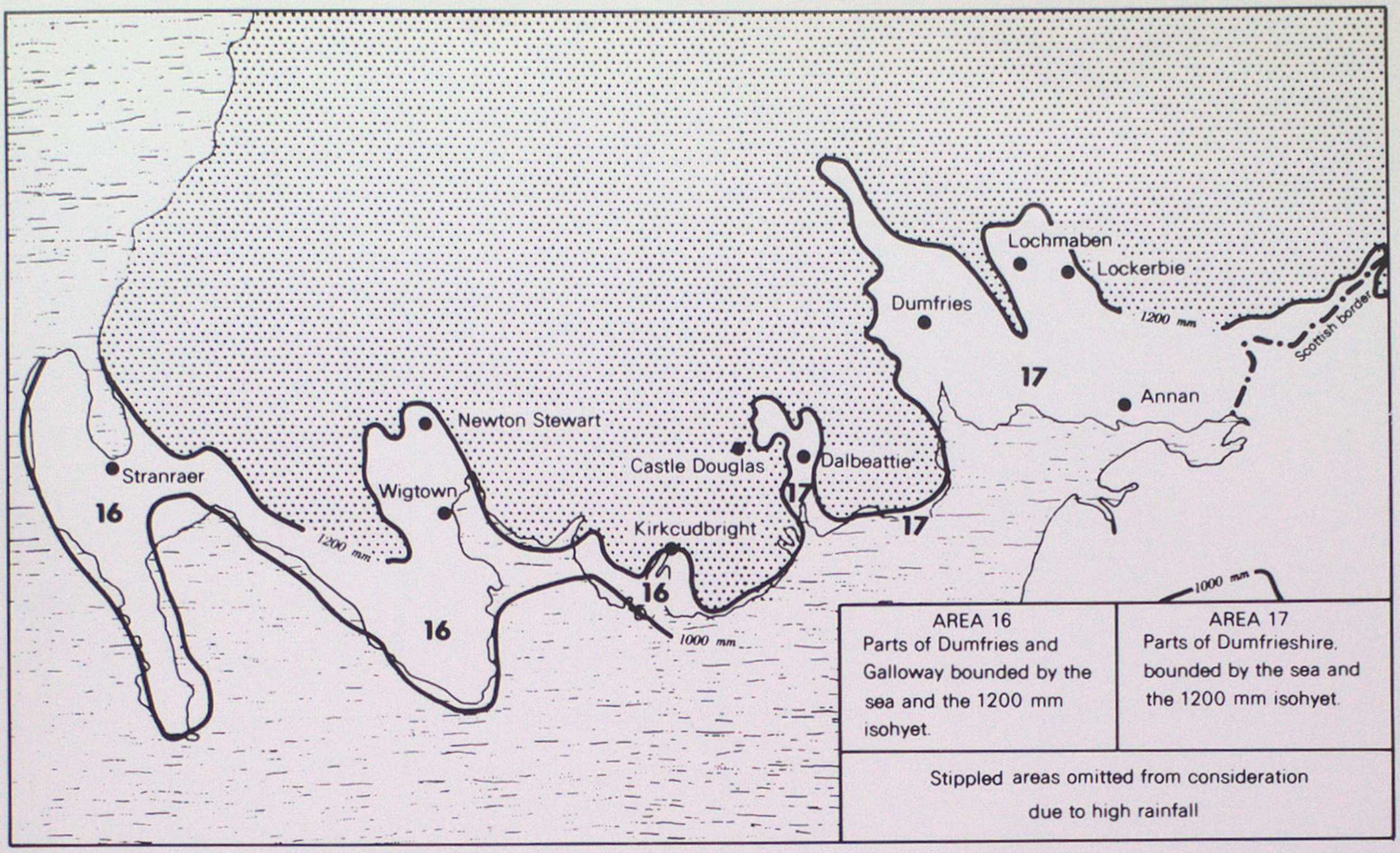
	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	190	165–215
Ending field capacity	Early Mar.	Late Feb.–Mid Mar.
Return to field capacity	Early Oct.	Late Sept.–Late Oct.
Maximum summer SMD (mm)	80	60–95
Excess winter rainfall (mm)	410	340–475
Degree – days above 0 °C Jan.–June	1380	1290–1470
Date of last spring air frost	Mid Apr.	Early Apr.–Late Apr.

Area 15
Predominant agricultural land-use: Dairying

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	3.3	95	5	50
Feb.	3.5	70	10	75
Mar.	5.5	65	30	105
Apr.	7.7	65	50	155
May	10.5	65	75	195
June	13.3	70	90	185
July	14.4	95	80	155
Aug.	14.3	105	65	150
Sept.	12.7	120	35	110
Oct.	9.9	120	20	80
Nov.	6.0	110	10	50
Dec.	4.4	115	5	35
Total		1095	475	1345
Mean	8.8			

Growing season 255 days 31 Mar.–10 Dec.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	175	150–195
Ending field capacity	Early Mar.	Early Mar.–Late Mar.
Return to field capacity	Early Oct.	Mid Sept.–Mid Oct.
Maximum summer SMD (mm)	70	55–90
Excess winter rainfall (mm)	540	460–625
Degree – days above 0 °C Jan.–June	1360	1280–1450
Date of last spring air frost	Mid Apr.	Early Apr.–Late Apr.



Area 16
Predominant agricultural land-use: Dairying

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	3.4	105	10	45
Feb.	3.5	65	10	75
Mar.	5.4	70	30	115
Apr.	7.5	65	50	165
May.	10.1	70	70	200
June	13.0	65	85	190
July	14.3	80	75	170
Aug.	14.1	100	60	160
Sept.	12.6	115	35	120
Oct.	10.0	115	20	85
Nov.	6.3	115	10	55
Dec.	4.8	115	10	40
Total		1080	465	1420
Mean	8.7			

Growing season 250 days 31 Mar.–5 Dec.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	170	145–195
Ending field capacity	Early Mar.	Early Mar.–Late Mar.
Return to field capacity	Early Oct.	Mid Sept.–Mid Oct.
Maximum summer SMD (mm)	70	55–85
Excess winter rainfall (mm)	525	450–610
Degree – days above 0 °C Jan.–June	1340	1260–1430
Date of last spring air frost	Mid Apr.	Early Apr.–Late Apr.

Area 17
Predominant agricultural land-use: Dairying/some arable

Month	Air temp. °C	Rainfall mm	PE mm	Sunshine hours
Jan.	2.6	105	5	45
Feb.	3.0	70	10	70
Mar.	5.0	65	25	110
Apr.	7.5	65	45	150
May	10.4	75	70	185
June	13.3	70	80	185
July	14.5	85	75	155
Aug.	14.3	105	60	150
Sept.	12.4	115	35	110
Oct.	9.6	105	15	85
Nov.	5.6	105	5	55
Dec.	3.6	105	5	35
Total		1070	430	1335
Mean	8.5			

Growing season 250 days 31 Mar.–5 Dec.

	MEDIAN	INTER-QUARTILE RANGE
Access period (days)	160	135–185
Ending field capacity	Early Mar.	Early Mar.–Early Apr.
Return to field capacity	Early Oct.	Mid Sept.–Mid Oct.
Maximum summer SMD (mm)	65	50–80
Excess winter rainfall (mm)	520	440–600
Degree – days above 0 °C Jan.–June	1310	1230–1400
Date of last Spring air frost	Mid Apr.	Early Apr.–Late Apr.