FIRST REPORT

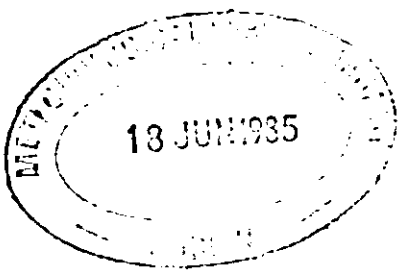
AGMET

JOINT WORKING GROUP ON
APPLIED AGRICULTURAL METEOROLOGY

MARCH 1985

Research is the spark plug which is essential to progress. But, of itself, it can make no contribution to economic and social progress; it is only when the spark plug is attached to an engine that you get power. So simultaneously with redoubling our research effort we must give serious thought to improving the machinery which will convey our expertise to the food grower and put it into his hands in usable form.

P M Austin Bourke



From a lecture on Meteorology and Hydrology in aid of Food Production presented at the 7th World Meteorological Congress, 1976 (WMO No 435, 1976). Dr Bourke, was President of the Commission for Agricultural Meteorology of W.M.O. 1958-1962 and Director of the Meteorological Service 1964-1978.

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Abbreviations and Irish Form of names used in the Text.

ACOT	An Comhairle Oiliúna Talmhaiochta Council for Development in Agriculture
AFF	An Foras Forbartha National Institute for Physical Planning and Research
AFT	An Foras Taluntais The Agricultural Institute
CSE	Comhlucht Siucra Eireann Irish Sugar Company
IFA	Irish Farmers' Association
IHP	International Hydrological Programme
RTE	Radio Telefis Eireann

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Foreword

On February 29 1984 an informal group of agricultural and meteorological scientists with the formal approval of their organisations, met at the Meteorological Service, Glasnevin, to form a working group on agricultural meteorology. The group adopted the title of JOINT WORKING GROUP ON APPLIED AGRICULTURAL METEOROLOGY, abbreviated to the Joint AGMET Group. Representatives of organisations forming the Group were drawn from ACOT, An Foras Taluntais, Department of Agriculture, Meteorological Service and a number of Departments at Trinity College Dublin, and the University Colleges of Dublin and Galway. (Contributors to the AGMET Group are listed in page 2).

In his welcoming address the Director of the Meteorological Service, Mr D L Linehan, commended the initiative taken in forming the Group. Mr Linehan told the Group that while limited resources were available to the Meteorological Service, the Service has an extensive meteorological data bank, provides forecasts up to seven days, and would as far as possible facilitate the Group's activities. He hoped the efforts of the Group would be of as practical a nature as possible.

The aims and objectives which the Joint AGMET Group set out for itself were :

[1] To support agriculture at the national level in the application of agricultural meteorology.

(i) by serving as an advisory group to identify needs and problems in agrometeorology and make recommendations to the relevant authorities.

(ii) by fostering increased collaboration between the Meteorological Service and the Agricultural Authorities, Advisory Services, Institutes and University Departments in research and applied agrometeorology.

[2] To act as a stimulus to the organised transfer of agrometeorological knowledge to the farm level.

The AGMET Group undertook initially to study and report back to the appropriate organisations on the co-ordinated requirement of agricultural meteorology to better serve the needs of agriculture, to review the level and type of agrometeorological services that could be provided with existing technology and to follow through by promoting activities towards achieving these ends.

At its first meeting the Joint AGMET Group appointed a Co-ordinator and organised itself into Task Groups each with its own convenor to study and report on a particular topic set for it by the Joint Group. In line with the aims and objectives adopted by the Joint AGMET Group the main areas which were identified for study were questions on soil water balances in Ireland, animal and crop diseases and their control, phenology, services to agriculture, temperature and radiation measurement, training and education and methods of improved general awareness.

The Task Groups co-opted additional expert members to their deliberations. The evolving submissions of the Task Groups were discussed at the regular meetings of the Joint AGMET Group (steered by the chairman for the day) who made additional contributions. Based on these collaborative structures the recommendations of this First Report are drawn.

T Keane
Co-ordinator

Section One

DIRECTORY OF IRISH AGROMETEOROLOGY

Towards a new awareness of agrometeorology in Ireland

Scientific endeavour is facilitated by sustained dialogue and interaction between researchers in their professional work. Knowledge and experiences already acquired by agricultural scientists in the course of their work should prove particularly profitable to others working in related professions. Such a utilization of professional expertise becomes all the more relevant in the context of the complex interactions that obtain between meteorological factors in relation to agricultural production.

One of the aims of the AGMET Group is to foster an increased awareness of the importance of meteorology among agricultural scientists in Ireland and to promote closer contact between all who have a common interest in agrometeorology. To this end the AGMET Group proposes to compile a National Index of Scientists who are actively engaged in, or concerned with, the promotion of some aspect of agricultural meteorology. It is envisaged that the production of the Index will provide a ready guide and invaluable condensation of the special responsibilities and meteorological interests of agricultural scientists and practitioners throughout Ireland.

Rec 1.1 That an Index of Scientists/Advisors and other workers actively interested in Irish Agrometeorology (including Northern Ireland) be compiled and periodically updated by the AGMET Group enlisting the support of the Meteorological Service for publication.

Over the years many studies and technical papers on subjects related to agriculture with an agrometeorological content have been published. While a number of these have had some circulation, mostly within

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Footnote: Rec 1.1 The compilation stage of this project is currently in hand.

their institutions of origin, nevertheless they often can remain entirely unknown outside a limited readership. A wider awareness of these publications, highlighting their meteorological content, could be a source of considerable benefit to agricultural development in this country.

In order to bring these studies to all who are involved with the application of research, the AGMET Group considers that a Bibliography of published material in relation to agrometeorology in Ireland would be a very valuable asset. The Bibliography should include information on subject matter, publication and location (if limited circulation) of any article, paper or other published work which encompasses the function of weather and climate in the broadest sense in relation to agriculture and which treats this information as part of the discussion.

Rec 1.2 That a Bibliography of published material in relation to Agrometeorology in Ireland (including Northern Ireland) be compiled and periodically updated by the AGMET Group enlisting the support of the Meteorological Service for publication.

A considerable amount of the research, and the application of the research to agriculture, undertaken both in this State and in Northern Ireland is of mutual benefit. The AGMET Group considers that increased co-operation with fellow agriculturists/ meteorologists in Northern Ireland would be very valuable to both. As a first step agriculturists/meteorologists in Northern Ireland would have to be made aware of the Group's existence and aims. Ultimately increased involvement in the Group's activities might ensue. The Meteorological Office, Belfast, has agreed to participate in an observing capacity and other Departments and Research Centres in Northern Ireland expressed interest in the Group's work.

Rec 1.3 That the AGMET Group should foster increased interaction and co-operation with fellow practitioners in Northern Ireland in relation to agrometeorological research and services.

Footnote: Rec 1.2 This project is to begin in 1985

Section Two

SERVICES TO AGRICULTURE

The Joint AGMET Group examined the existing structures which convey weather-data or weather-based advice to farmers. A recent survey (see Appendix 1 to this report) has shown that all sections of the farming industry see the weather forecast as playing a significant role in the production system. Several systems are in use currently for transmitting weather forecasts to the community. Forecasts generally are not specifically tailored to the needs of agriculture. In the particular cases where the system is aimed at agriculture the timing is not ideal. Radio and Television have a particularly important part to play in the context of up-to-date dissemination of farm management support information. The Group makes the following recommendations concerning services on radio and television.

Rec 2.1 A daily farm weather bulletin with a 2-3 day outlook should be provided in the early morning on RTE radio. Apart from basic weather data the transmission should include any topical warnings or advice arising out of the current weather situation.

Rec 2.2 A weekly Farm Weather Bulletin of approximately 5 minutes duration should be provided on RTE television. The survey referred to above indicated that the preferred time for such a broadcast would be on Sunday evening. The broadcast should provide an agriculturally relevant weather forecast and outlook followed by the presentation of a topical issue - possibly in the form of an interview.

The Group also considered weather forecast services provided by the Central and regional forecast offices. The automatic telephone weather (ATWS) service, which is used extensively by farmers, is primarily suited to the needs of the community at large. The weather information on the telephone recording would have greater impact to farming if it were given an agricultural slant reflecting the current activities on the farm. The ATWS should be extended to the remaining west and north west regions, keeping costs to the user to a minimum (see Appendix 1).

Rec 2.3 Weather forecasts on the ATWS system should be related to a greater extent to current activities on the farm.

The development of an agricultural slant in weather forecasts generally is possibly hampered by a lack of awareness among forecasters of the values of the weather elements which have critical biological significance.

Rec 2.4 Data of critical biological significance should be compiled (by the AGMET Group) and placed at the disposal of the forecaster. It is also recommended that appropriate in-service training in matters concerning the interaction of agriculture and weather be provided to forecasters, (courses, seminars) by the organisations concerned.

Videotex Services

It is noted that the Joint ACOT/AFT videotex system which will begin to operate in 1985 provides a new channel for transmission of information to the farmer. The Joint Group welcomes this development. Its success will to a large degree depend on the quality of the service provided by the participating organisations. In similar systems operated in other countries, it has been shown that weather information, particularly local short term (1-day) and medium term (5-day) forecasts are of primary importance to the system.

Rec 2.5 Because of the importance of weather to farming the Group recommends that there should be a strong input of weather information by the Meteorological Service into the videotex system operated by ACOT/AFT.

Farm Management - Farm Situation Bulletin

Throughout the year weather is a primary factor affecting agricultural efficiency - either directly by its effects on crop or animal growth or indirectly by its effects on the time lines of management operations. At present there is no co-ordinated system for interpreting current weather conditions in terms of their effects on management or yield at farm level.

Potato blight warnings are issued by the Meteorological Service on the basis of a potato blight model. The warnings are taken up by the media in an informal way. Apart from being broadcast on RTE Radio 1 with the 1.30 pm news and on Farm Diary on the day of issue, in general there is no structured procedure for relay of warnings to

the producers. In the special report in Appendix 1 one ACOT adviser is quoted as stating that blight warnings have "a profound effect" in increasing the national production of potatoes. However a farmer from the west of Ireland noted that blight warnings "**are too easily missed**" and there is a need for them "**to be reinforced or followed up**". Equally there has been no proper structures developed within ACOT or AFT for dissemination of these warnings to the grower. Similarly, the Agricultural Institute uses a grass/weather model as a basis for weekly data on grass growth published in the agricultural press. The published data provide a basis for better farm management leading to a quantitive approach to farming. ACOT operates a cereal disease monitoring and warning system throughout the cereal-growing season. Comhlucht Siucra Eireann operates a comprehensive crop monitoring and advice service for beet growers, though the service could probably be usefully applied to some extent in other tillage crops.

The general impact of the agricultural research, advice, and administrative super-structure on farm efficiency would be greater if the various activities described above were co-ordinated. With the present fractured approach the system is slow to take up other available systems such as the liver fluke forecasting model and the foot and mouth disease spread model. A co-ordinated approach would also lead to the identification of areas which have been neglected in research, such as cereal yield forecasting.

The cereal disease monitoring and warning system which operates within ACOT should be expanded to include general monitoring and advice for all the major agricultural enterprises. The Group envisages a Central Unit being established within ACOT where weekly reports for several crops from selected regional centres would be compiled and an assessment of the current situation would be prepared. The summary of the current situation and expected developments shouldbe issued weekly as a Farm Situation Bulletin. The Bulletin would provide production forecasts, animal disease and crop disease forecasts and farm operations advice.

Forecasts of developments in the following week would be based on regional weather forecasts supplied by the Meteorological Service and on the use of models relating crop or animal performance to weather. The models may be complex mathematical packages supplied by outside agencies or they may be simple statements (for example, a crop process will occur only when one of the weather elements exceeds a critical value). The Unit within ACOT responsible for the Bulletin should have access to a panel of experts in ACOT, AFT, the Meteorological Service, Department of Agriculture, Universities and Comhlucht Siucra Eireann.

Rec 2.6 Expansion of the current cereal disease monitoring and warning system operated by ACOT is strongly recommended and a Unit within ACOT should be set up to provide general monitoring and advice for all major agricultural enterprises. The expanded service should include the production of a weekly advisory bulletin which interprets the current situation and provides production forecasts, animal disease and crop disease forecasts and farm operations advice.

Towards improved agrometeorological expertise

Agriculture at farm level is becoming an increasingly quantitative exercise. Weather is a major input in the system and there is an increasing demand for precise information on its effects on the system. Research and teaching in the field of agricultural meteorology have been neglected in Ireland. The subject is not formally recognized in the universities nor does An Foras Taluntais employ an agricultural meteorologist, - the climatologist attached to the Institute in the nineteen seventies resigned in 1980, and since then this position has not been filled.

The Meteorological Service first set up its Agricultural Meteorology Unit in 1966. From this Unit a range of meteorological studies have been published related to agriculture. The Unit has also provided meteorological advice to agricultural researchers, advisers and the farming community in general as well as to the Central Forecast Office in relation to agricultural needs. In the Meteorological Service however, there is currently only limited scope for research in the area. While there is a very adequate provision of forecasts and historical weather data, the Service is not sufficiently perceived as a source of expert advice on weather

interpretation for agricultural applications. The Group makes the following recommendations :

Rec 2.7 In the faculties related to agriculture, the Universities should establish teaching and research programmes in the field of agricultural meteorology to ensure that expert personnel be available to supply the information requirements of agriculture in the future.

Rec 2.8 An Foras Taluntais should review its activities in the field of agricultural meteorology and co-ordinate its efforts in this field.

Rec 2.9 The meteorological service should provide a consultancy service to assist researchers, advisers and farmers in the interpretation of weather data (for example, local climates can affect the interpretation of regional weather forecasts. Similarly, the siting of horticultural units on the basis of regional weather records without regard to smaller scale local anomalies can lead to expensive mistakes). This development would imply the assembly of an information bank comprising animal, plant disease models and critical values of the weather elements. In the same way that new instruments in use for weather recording are critically evaluated for accuracy and precision so also should the contents of the information bank be continuously monitored.

Section Three

EDUCATION AND TRAINING

The Joint AGMET Group considered the subject of Education and Training under the headings:

The purpose of training and education
The recipients of such education and training
The desirable target level at this stage

Purpose of Education and Training:

It was felt that the purpose of **education** in the present context was to create a better awareness and knowledge of climate as a resource and its role in crop and animal production, both among professional people working in these areas and farmers.

A separate need for training may arise in relation to climatological stations in the country that are not under the direct control of the Meteorological Service. Those stations provide invaluable data but, because weather observations are only a secondary function at such centres, there is a tendency for performance to fall off from time to time.

Recipients of Education and Training:

There is a need for all professional people working in Agriculture, Horticulture and Forestry as well as farmers to have a greater awareness of the role of meteorology in the production process. More specifically, the group considered that the immediate thrust should be directed at ACOT advisers in the field and at University students.

Desirable target level for education:

Education in the area of Agricultural Meteorology is likely to be a gradual and continuing process. The Group is not in a position to define target level for ACOT Advisers or University students in

Agriculture, Forestry or Horticulture but it would encourage that a thorough education should be available in this fundamental subject to everyone concerned professionally with these areas of work. The minimum initial target at farming level should be to create a thorough understanding and appreciation of climate as a resource. This would imply a full understanding of the climatic potential and limitations for specific crops, seasonality of growth, weather hazards, disease, moisture problems, etc.

Handbook on Agricultural Meteorology

The Group concluded that the absence of an appropriate publication in agricultural meteorology in relation to Ireland was of great concern to all in agricultural education in this country. A handbook of Agricultural Meteorology for Ireland needed to be produced. This would be a very major undertaking. A handbook is generally considered more desirable than a text book. There are several good quality text books available and the production of yet another one might prove to be too ambitious a project, considering the resources and time available. On the other hand, there is need for a handbook that describes Agricultural Meteorology in Ireland in detail. It would be a very useful teaching and reference aid at all levels. A strong point of such a book would be the comprehensive lists of relevant references that it would contain.

A good balance should be achieved both in subject matter and length of book. With this objective in view, the Group proposes a list of chapters and an outline of their contents. The outline is given in Appendix 2. The chapters would be written by various authors drawn from the Joint Working Group on Applied Agricultural Meteorology. It is considered that there are people on the Joint Working Group who are fully competent to write the various chapters as set out. Others from outside the Group would be asked to assist if this is considered desirable.

The following target dates have been set by the Group;Completion of chapters - December 1985; Publication - September/October 1986. Sponsors for the publication are to be sought from agricultural concerns in this country.

In relation to the background set out above, the following recommendations are made by the Group.

Rec 3.1 The Joint AGMET Group should undertake as a matter of priority the production of a handbook of Agricultural Meteorology for Ireland, enlisting sponsorship from various agricultural concerns in the country.

The possibility of introducing climatological topics into various seminars and courses arranged by ACOT for its advisory personnel is seen by the Group as a most necessary step to effect a proper understanding among the agricultural community of the interaction between climate and agricultural production. It is envisaged that a period of possibly two hours per seminar might be devoted to aspects of climatology with lectures being given, as appropriate, by the Meteorological Service, An Foras Taluntais, the Universities etc. In relation to all sectors of the community, there is scope for much progress through informed articles in the press and in radio and TV presentations.

Rec 3.2 Climatological topics should be introduced into various seminars and courses arranged by ACOT for its personnel.

Rec 3.3 It is recommended that ACOT advisers should include agricultural meteorology in their courses for farmers.

Meteorology in the Agricultural Curriculum in Universities

The support of the Universities is essential to the development of the science of meteorology applied to agriculture. Co-operation has existed in this field for many years between various Departments, especially in the agricultural faculties, An Foras Taluntais and the Meteorological Service. While this co-operation is evident at the individual level, for example, students pursuing studies or projects involving meteorological data are facilitated by AFT and the

Meteorological Service, the importance attached to meteorology, however, is not always evident in the general curriculum. In relation to Agricultural Education in the Universities the following recommendations are made.

Rec 3.4 Consideration should be given to establishing Agricultural Meteorology as part of core material in the University degree programmes for students of Agriculture, Forestry and Horticulture. The course should cover theoretical, practical and interpretational aspects of meteorology.

Rec 3.5 Consideration should be given to the possibility of increased involvement of students in undergraduate projects with a strong agrometeorological content and, if possible, providing encouragement and facilities for students to pursue agro-meteorological themes for post graduate studies.

Training in Observation

Because of the difficulties in maintaining standards, continued attention needs to be paid to quality of observation at those stations that are not operated by the Meteorological Service. Special attention to these stations is required so that a high standard of maintenance of site and equipment is encouraged and a continuous effort is made to maintain high standards of observations. In this context also the Group thinks automatic recording should be seriously examined (see Section eight of this report).

It could be of considerable help towards achieving those objectives if the Meteorological Service Station Inspectors could step up rate of visits to those sites and discuss the state of the sites and of the records with the local observers.

Rec 3.6 Both the Agricultural Institute and the Meteorological Service should increase their efforts to maintain a high standard of observation at all climatological stations.

Section Four

Water Balance Studies

The two main areas examined by the Group were evaporation and soil moisture in Ireland. Problems relating to the measurement, evaluation and archiving of data were identified. Experts from outside the Group were also called upon to contribute to the discussions.

Evaporation/Evapotranspiration

Loss of water by evaporation was discussed under two main headings:

(a) evaporation from an open water surface and
(b) evaporation loss from vegetation.

There are up to 30 Class-A Pans located throughout the country and around 20 years of evaporation data is available for many of the locations. The Group were particularly concerned about the susceptibility of Class-A Pans to errors such as wind splash. A questionnaire was sent to all participating bodies. There was a magnificant response to the questionnaire from which it was learned that most of the instruments are in good condition but some may need additional protection because of interference by animals or birds. The Class-A Pan is internationally recognised, and is independent of crop and soil type.

The Irish National Committee of the International Hydrological Programme published a comprehensive report on Irish hydrology activity in 1982 (see Footnote). With the publication it was hoped that a fuller use of the resources be achieved as well as helping towards correction of observed deficiencies and overall organisational structures.

Footnote : Hydrology in Ireland, (1982), (Chairman M A Lynn). A contribution to the UNESCO International Hydrological Programme by the Irish National Committee for the I.H.P.

Rec 4.1 The former working group on Class-A Pan evaporation (see footnote) should be reactivated. The Irish National Committee of the IHP would be in the best position to undertake this proposal.

Rec 4.2 An examination, quality control, and archiving on computer store of existing data should be immediately undertaken.

A network of six Thornthwaite lysimeters have provided valuable data on potential evapotranspiration and actual soil moisture deficit estimates at ten-day intervals since the nineteen sixties. There are many difficulties associated with the upkeep and maintenance of the lysimeters. It is important that these instruments are operated as effectively as possible. There is also a need to correlate lysimeter evapotranspiration readings with solar radiation and other meteorological elements.

Rec 4.3 Regular inspection procedures should be adopted by the Services concerned in order to assess each instrument's performance and to decide on replacement or repair.

Rec 4.4 The lysimeter network should be expanded to include a station where solar radiation and soil moisture are measured.

Soil Moisture

Soil moisture measurements are of particular importance to the agriculturist. It is emphasised that a knowledge of soil moisture throughout the year is critical to farm management decisions and that, with the increase in popularity of autumn farm operations, dates of first (and repeated) return to field capacity (and/or plastic limit) are important. In addition, the increasing role of irrigation in the water balance equation of farms is important, not just for crops needing irrigation water per se, but as an aid to planning the disposal of farm wastes (slurry, wash-water).

Footnote : This group held regular meetings in the 1960s and were responsible for the setting up and maintenance of the Class-A Pan network.

Both the content of soil water and the tension (suction, negative pressure) at which it is held are important parameters. These vary with soil texture, structure and organic matter content as well as with soil depth. Hence each soil type has a unique soil water state and the content varies seasonally/weekly/ daily according to the balance between inputs from precipitation and losses from drainage, evaporation, crop use, etc. The type of crop is also important. Penman introduced the concept of a "root constant" which defines the amount of soil moisture that can be extracted from the soil by a given kind of vegetation.

A practical approach would be to consider the installation of soil moisture measuring equipment (cf. Appendix 3) at a synoptic station where personnel are readily available. These measurements are enhanced if they are made alongside measurements of solar radiation, lysimeter and Class-A Pan evaporation.

Rec 4.5 Measurements of soil moisture status should be undertaken at a synoptic station which also measures solar radiation and evaporation/evapotranspiration.

There are variations involved with instrument type, soil type, crop cover and other relevant characteristics in a given rainfall environment.

Rec 4.6 The performance of the instruments in different soil types and at various depths should be assessed at selected Agricultural Research Centres.

As there are gaps in the Class-A Pan and lysimeter networks and also these instruments can be prone to error - the Penman forumula can give valuable alternative estimates of evaporation. The Penman method gives a reasonable monthly estimate but this model is not suitable for estimating values for periods of less than a month. The MORECS model (Meteorological Office Rainfall and Evaporation Calculation System) shows greater promise.(see Footnote 1,page 21). However, experiments would have to be run in conjunction with the MORECS model to validate particular constants used in the model

for this country. The validation method could be similar to the one undertaken for this model in Great Britain (see Footnote 2). The outputs of the MORECS model assist hydrologists and agriculturists in Britain in the assessment of catchment water balance, river flow, leaching of nutrients, and short term irrigation requirements. More consideration needs to be given to the question of validation bearing in mind the problems associated with soil moisture measurements, soil characteristics and the depths at which measurements are to be made. Where rough general estimates are only required, in practice an average value obtained using Class A Pan, Lysimeter or Penman can be as useful as the output from an elaborate model. Based on the experience of other countries, the simulation modelling approach coupled with ground truth data is the best way forward.

Rec 4.7 The simulation modelling approach needs a special study with reference to soil classification and other parameters relevant to the Irish situation. Close co-operation in this context is essential for the validation of the model.

There remains the problem of correlating values obtained by various methods, for example Class-A Pan Lysimeter or calculated Penman values of evaporation. There is the question of water loss from different types of crop and the "root constant" involved, and the further question of the type of soil and its capacity for water storage.

Rec 4.8 A greater emphasis should be placed on the study and research into operational methods of applied climatology in support of Agriculture.

Footnote 1: 'The Meteorological Office Rainfall and Evaporation Calculation System MORECS (July 1981)', N Thompson, IA Barrie and M Ayles, Hydrological Memorandum No 45, Meteorological Office.

Footnote 2: 'An Evaluation of the Success of MORECS, a Meteorological Model, in Estimating Soil Moisture Deficits' Catriona M K Gardiner and M Field, Agricultural Meteorology, 29 (1983), pp 269-284.

Section Five

CROP DISEASE CONTROL

Apart from the direct effects of weather on crop production, such as the cumulative effects of variations in radiation, temperature and rainfall, the more serious consequences each year arise from the indirect effects on crop production caused by weather induced diseases. The AGMET Group considered the broad question of meteorology and disease control. A number of forecasting models which are either in use or under development here and elsewhere were considered. It was stressed that one of the greatest problems concerns the validation of the forecasting systems and various methods of overcoming this problem. Whatever weather-based models or systems are available would benefit the Farm Situation Bulletin and Cereal Disease Advisory Unit of ACOT (Section Two).

Eyespot

Eyespot is of major importance in this country. Being relatively predictable it should be suitable for development of a reliable forecasting model. Regression and simulation studies have been made with disease levels and weather parameters at the Agricultural Research Centre, Oak Park (Cunningham et al). Data were processed for two continuous barley sites 1965 to 1977. The occurrence of 'rogue' years was established. It is imperative that studies have to be completed in this particular area, especially because of the recent discovery of widespread resistance to Benzimidazole fungicide in this country. Such resistance is a consequence of indiscriminate use of benzimidazole in chemicals.

Rec 5.1 The studies on eyespot simulation should be pursued with vigour, and with a view to developing a reliable forecasting model.

Cunningham, P.C. Harrington, H Murphy, P — Relationships between Weather Parameters and Eyespot Development in Spring Barley. Proc. 3rd International Congress of Plant Pathology, Munchen, 1978. p 311

Powdery Mildew and Septoria Nodorum

Attempts at warning services for other cereal diseases are realistic, despite the sporadic nature of their occurrence. Some have been put into practice with varying degrees of success. Powdery Mildew and Septoria Nodorum are widespread and serious. They are considered by the Group as priorities for attention. In Britain emphasis has been placed on treatment for Powdery Mildew based on risk days, determined by a number of factors ; temperature, sunshine, absence of rain and wind. Spraying advice for Septoria Nodorum is based on the degree of rain fall during consecutive days. In fact, most spraying is based primarily on the stage of disease with some consideration to general weather parameters.

Barley Yellow Dwarf Virus

Affecting the three major cereal crops, Barley Yellow Dwarf Virus (BYDV) has become increasingly significant with the swing to winter cereals.
Meteorological data could be of help in studies on multiplication of the specific aphid vectors over winter and spring periods. Build-up of BYDV in the plant in early autumn depends on weather conditions. Autumn 1983 was particularly favourable, resulting in appearance severe virus symptoms in November rather than late Spring as is normal.

Oilseed Rape

The crop has two serious diseases that would be amenable to prediction based on climatic factors. The first is Light Leaf Spot, which manifests itself throughout the season. The second is Dark Leaf Spot (Alternaria) which occurs at the ripening phase. In the latter, infection periods occur with 36 hours above 14^{o}C, with continuous wetness.

Other Cereal Diseases

At University College Dublin, Steadman and Cooke are working on a model to predict spore generative capacity within Net Blotch using relative humidity, temperature and rainfall. Attempts are also being planned for a model to predict Rhynchosporium.

Going on these examples the Group makes the following recommendations:

Rec 5.2 Empirical cereal disease models currently available should be run on an operational basis during season on meteorological data from synoptic stations, the outputs to be transmitted to the ACOT Advisory Unit.

Other Plant Parasites

A number of diseases of horticultural crops were reviewed and further attention will be given by the Group during 1985 (see Appendix 4). Aphids are of considerable importance in spreading various virus diseases. Attempts to develop predictive models, however, is thought not to have been successful.

EPIPRE SYSTEM

The EPIPRE (Epidemic Prevention) system was also given some consideration by the Group. It is a system of supervised control of diseases and pests in winter wheat. In this system the participating farmers do their own disease and pest monitoring, according to well defined simple and reliable observations and sampling techniques. This information is forwarded to a central computer, which runs disease models and produces specific recommendations - to spray, not to spray or to make new observations, so optimizing the financial returns.

The system was developed in Holland and has been adopted to some extent in Britain. The Group is of the opinion that this type of system is most likely to emerge from private enterprise,

if at all, and will be an 'all-embracing package' style service. It would be of benefit to farmers with less than 100 acres who can act on a warning more readily than large growers.

Potato Blight

Late blight, caused by Phytophthora infestans (Mont.) de Bary, is the most serious form of disease to affect potatoes, causing significant yield losses almost every year. The increase in potato crop yield which results from a successful extension of the life of the green foliage can be seen from the following table (after Large 1958) to be very great.

MEAN LOSS (%) OF POTENTIAL CROP
IN RELATION TO 75% BLIGHT ON HAULM

End of July	Mid-August	End of August	Mid-September	End of September
50	28	13	4	0

Considerable control of blight can be effected by proper management, especially in relation to spray programmes. Most spray programmes tend to be based on a routine. However substantial economic gain could be achieved from a reduced number of applications in some years by spraying according to a reliable warning system.

Bourke's model, developed in the nineteen-fifties, is proving dependable for Irish conditions. Its use generally affords the opportunity for preventative spraying on a regional basis. With the advent of medium range weather forecasts, the potential of this model is extended and some further refinement is possible. Correlational studies with the forecast weather parameters from the ECMWF (European Centre for Medium Range Weather Forecasting) models with the potato blight model should indicate upcoming periods when the necessary conditions will be favourable to the spread of potato blight.

Large, E C 'Losses caused by potato blight in England and Wales', Plant Pathology, 7, No 2, 1958, pp 39-48.

Rec 5.3 Model output statistics (MOS) should be developed in the Meteorological Service linking parameters from the ECMWF model with surface conditions favourable to the spread of potato blight according to Bourke's Irish rules.

Computer simulation modelling

A model simulating the development of potato blight is currently undergoing some refinement in Britain. Its relevance for Ireland will need to be tested.

Section Six

ANIMAL DISEASE CONTROL

Weather and its association with animal disease is an important biological fact. This relationship may be direct in that it affects, for example, development and survival rates of vectors and parasites. It may be indirect in that it influences physiological stress with consequent disease onset such as occurs in pregnancy: toxaemia, swayback and milk fever. Where possible, precise quantification of the relationship is desirable but if, in the early stages of study, only a general empiric relationship is possible, this is at least a start on which further study can be based. If we are to understand disease dynamics and disease processes where they are influenced by weather, then the mechanisms through which the effects are produced must be studied and understood.

Models on Parasitic Diseases

Studies of the direct effects of weather are common for many parasitic diseases, as the relationship is obvious. WMO produced a Technical Note (NO 159; Weather and Parasitic Animal Disease - Geneva 1978) which collected together the results of such work on a variety of parasitic diseases. Both empiric and quantitative models are included. Since then models for other parasitic diseases have been published to the point where a number of practical models, which can or have been suitably modified for forecasting purposes are available. However, these first generation systems generally require further validation and probably some further modifications. It must be remembered that forecasting prevalence of a parasitic disease is really a spin-off from the basic study and mathematical formalization of the various processes of birth, death and development which are absolutely essential to the study of a disease and its control.

To take an example, the work on fascioliasis over the last two decades in Ireland has provided a number of publications and at least 3 Ph.D thesis. Two of these were biological and the

third has provided a mathematical analysis of development times and of the consequences following from biological events, including work on control theory and cost-benefit analysis. This work has been extended to predation, diagnosis, low temperature survival and economic therapy.

In terms of forecasting, a first generation program using weather data has been devised and early validation suggested some promise but it was not developed further nor modified to include a cost benefit analysis because of computing difficulties. Forecasting in itself may not be vital, but recent developments in therapy of fascioliasis require an effective early warning system of pasture infestation to maximize the potential control effect. In this instance, an accurate forecast based on weather data, if it can be developed, offers a probably cheaper system of early warning than is likely using conventional diagnostic techniques. It must be pointed out that a precise and accurate forecast system reflects the basic understanding of the underlying epidemiological factors of disease prevalence,particulary if it is firmly based on scientifically measured biological parameters such as temperature dependent development rates. Consequently, it must be emphasised that forecasting is not an end in itself but a consequence of a logical, detailed and biomathematically oriented study.

In terms of fascioliasis, the various aspects from biology and forecasting to cost-benefit analysis of therapeutic regimes need to be completed. The major cost of this work is labour; both scientific and technical. The capital resources required are relatively small and fit in with other research projects (ie a microcomputer). The same situation exists for a number of nematodes and for Ixodes Ricinus (vector of bovine redwater) which again needs development study and validation and which will inevitably improve the ecological/epidemiological understanding. This can do nothing but improve the development of control of programmes.

In conclusion, while the study of weather in relation to disease and particularly parasitic disease in animals may not be of top priority in practical terms (eg new drugs), it most certainly offers a better understanding of the overall disease dynamic processes, and the substantial hope of better and more rational control programmes maximise benefit from costly outgoings such as therapy.

Liver Fluke Disease Model

Weather will continue to be an important input to liver fluke forecasting. At the present time forecasts are issued based on the Ollerenshaw Index.

Rec 6.1 Further development of liver fluke forecasting should be undertaken based on further development of the Hope-Cawder et al model. The main aim of this would be to optimise therapy. It is proposed that the latter model be rewritten to run on a microcomputer and appropriate steps to validate the model should be worked out and undertaken.

Other Animal Parasites

The possibility of developing and using predictive models for other animal parasites is still being considered. Aphids are of considerable importance in spreading various virus diseases. Attempts to develop predictive models however have not been successful.

Foot and Mouth Disease

It has been long established that the spread of Foot and Mouth (F and M) disease from primary sources is airborne and is closely related to low-level winds and precipitation during the period when infected animals have been emitting virus. Since 1970 the Meteorological Service has agreed with the Veterinary Section of the Department of Agriculture to provide Meteorological information to the Veterinary Authorities in the event of an outbreak of the disease. The Meteorological Service would plot in a sector diagram hourly reports of wind and precipitation and from this diagram deduce the various compass point sectors which appear to be at risk over the period. The sector diagram method is a rather general graphical approach and does not use such factors as threshold emissions, local topography and virus survival rates; it also incorporates a wide safety margin. If emission has been taking place over a number of days before confirmation of the disease, then, in relatively light winds, which can be very variable, it is probable that all sectors will prove to be at risk,and the method will be largely eneffective for the purpose of concentrating resources. In addition only winds recorded at the nearest synoptic station are used.

Notwithstanding the latter limitation of the method it was noted in a recent Department F & M disease Exercise that liaison between the Meteorological Service and the Veterinary Authorities would be necessary from the earliest moment.

Meteorological Considerations attending F & M dispersal

The conditions found to be necessary to satisfy the maximum potential transport of disease over a long distance are high virus output, low virus dispersion, high virus survival and large number of susceptible livestock exposed to virus for many hours. Apart from a powerful emitting source, such as can be found in a piggery, the strongly meteorological aspects of the survival, such as travel and diffusion of virus aerosols, must be considered both in the horizontal and vertical, as well as considering the vertical temperature structure. Other factors are survival rates of the virus, which have been shown to be related to the relative humidity, deposition, and wash out of the air, which depend on the capture efficiency of the raindrops.

Gaussian Dispersion Plume

The model is used almost universally for calculating the disperion of aerosols or pollutant from a continuous point source. This model is the basis for the Foot & Mouth disease dispersion programme. Two methods have been developed: The first is not more than an exemplification of the Gaussian equation for the dispersion. In this method a set of overlays showing concentration isopleths are drawn to fit standard topographic maps. The set of overlays have been designed to cover a usefully realistic combination of wind speeds and stability classes. An overlay appropriate to a given wind and stability class is chosen, placed on an appropriately scaled map and the relative concentrations displayed over the area of interest to assist the veterinarians with criteria to aid their operational decision-making.

The second method is concerned with a computer model, which has been developed in Britain to provide an objective estimate of the area most at risk from airborne spread of the virus overland within a 10 km radius, centred upon a known source. The model solves the Gaussian dispersion equation, takes in the effect of relative humidity on the virus survival and the topography on plume dispersion as well as the previously mentioned parameters. The dispersal of the virus is simulated and outputs are generally valid for radial distance up to 10 km. At greater distances the ever changing meteorological conditions will have an increasing effect on the trajectory of the virus plume.

The latter method, despite residual problems with spurious secondary outbreaks, is a considerable advance on the sector diagram approach. The computer model method in particular would enable the authorities here to optimise their efforts to prevent spread by wind. The Joint AGMET Group agreed that this was urgent and a letter was sent to the Minister for Agriculture who agreed to consider the proposal.

Rec 6.2 The Group urges that the wind dispersion model be made available in this country for use in the event of an outbreak. Operational procedures with the organisations concerned,involving meteorological services in the event of an outbreak,should be formulated and clearly set out.

Section Seven

Phenology

The early and accurate prediction of yield in crops such as wheat has important economical consequences for the agricultural sector in Ireland. This can only be achieved by a proper understanding of the interactions between weather and crop growth/development within the individual phase of the crop.

Phenology deals with the relationship between weather and climate and the development phases of plants. Changes of phase in crops are recorded as obvious external changes during a plant's development, say from germination to flowering and maturity to the production of new seeds. These changes are related, among other factors, to meteorological parameters such as temperature, sunshine, rainfall, humidity, wind etc as well as day length. Meteorological studies of themselves can only say something of the climate of an area in terms of means, extremes, return periods and probability of occurrences. The effects of weather on crops cannot be fully determined by observation of the weather alone . The timing of phases may be used both for within season statements on crop development and in predicting the subsequent performance and yield, the disease susceptibility as well as the development of crop yield/disease models.

Crop modelling with respect to a range of crops must precede accurate and informed prediction methods. The unexplained effects of the weather of 1984 on crops serve only to emphasise its importance. The costs involved however in mounting dedicated experiments can be very great and such experiments are unlikely to be repeated in several regions. Phenological observations in conjunction with meteorological observations at a representative number of locations in different growing areas would enable the resulting simulation model for a particular crop to be generalised to other regions. Some phenological observations have been made from time to time in association with sugar beet experiments but their use was limited to particular trials. A programme of routine and on-

going phenological observations on certain crops over ten years at a network of stations should now be formalized. The successful outcome of such a programme should enable in subsequent years rate of development and production estimates to be predicted based on weather observations alone. Sugar beet and winter wheat offer greatest potential for such undertaking.

Representative locations for phenological observations in regard to sugar beet should encompass the areas Carlow, Mallow, Thurles, Tuam and Wexford. Centres in Co's Carlow, Dublin, Wexford and Cork offer suitable locations in the case of winter wheat. Phenological observations on horticultural crops may not yet be justified on economic grounds.

As An Foras Taluntais has an existing wide distribution of experimental stations throughout the country, they would be in the best position to undertake these programmes supported by other relevant enterprises and organisations. (eg Comhluch Siucra Eireann, Millers, Agricultural Colleges).

Rec 7.1 Phenological observations in addition to meteorological observations should be undertaken at a representative number of locations for a period of say ten years for sugar beet and winter wheat crops. A collecting centre to which the observations are dispatched should be designated to quality control and archive the data routinely on a computer.

Phenological observations have been made over the past twenty years on a number of specially imported trees eg Picea Abies, Prunus Avium Bov, Populus Canescens, Salix Smithiana at Valentia Observatory, Co Kerry, Johnstown Castle and JFK Park Co Wexford and at the National Botanic Gardens Dublin. The Reports are forwarded to the German Weather Service for inclusion in the annual publication of observations, **ARBORETA PHAENOLOGICA.** An analysis of the data in relation to Ireland has not been undertaken. Despite the failure to survive of a number of the trees over the years at each of the gardens, sufficient data are available for a detailed analysis. This analysis should be made as soon as possible.

Rec 7.2 An analysis of the phenological data from the existing phenological gardens in Ireland should be undertaken with a view to its early publication. (It is the opinion of the AGMET Group that this analysis could form part of a Higher Degree Thesis of a University student.)

Section Eight

TEMPERATURE AND RADIATION

Due to various recent trends (increased education and reducing profit margins for example) decision making at farm level is becoming more quantitive. There is an increased awareness of the impact of weather on agricultural production and it may be anticipated that the demand for weather related information will increase in the future. The Joint AGMET Group discussed the situation regarding the temperature and radiation record in this context and attempted to identify the principal areas where improvements are needed.

Soil Temperature Data

Soil temperature has a significant impact on the production, particularly in spring, of grassland and on tillage crops. Outside the limited number of synoptic stations soil temperature is only recorded once daily at 0900 GMT and the Group was concerned that this record might not be adequate. The 0900 GMT record is generally close to the diurnal minimum. Connaughton (Agromet Memo No 3, 1970 Meteorological Service) found that the difference between the 0900 GMT reading and the daily mean calculated from 4 records at 6 hourly intervals was constant. The comparison was made for the synoptic stations where these data were available. The difference did not vary through the year or between stations. However, Connaughton worked with monthly averages and a more detailed study is required to determine what relationship exists over shorter periods than a month. Connaughton pointed out that the simple relationship he obtained could only be used with confidence in situations where the thermal characteristics of the soil were similar to those of the soils at the synoptic stations. He found that the relationship did not apply on peat soils. Presently, soil temperature is measured at 10 cm depth, in addition to other depths, at synoptic and climatological stations. These values, however, are applicable only to the soil series on which the station is sited. Because of the large variability which exists in soil types within relatively small areas, soil temperature values may not be relevant to different soil types situated close to the meteorological station.

For example, the Oak Park station is situated on a soil series called Athy complex which represents a mixture of free draining soil types. These data would not be applicable to the soils of the heavy Castlecomer plateau which are heavy and slow draining. Similarly soil temperature data from Rosslare would not be relevant to the gley soils of the Macamore series in Co Wexford. Differences in soil temperatures between soil types are due to soil moisture content which is largely influenced by soil texture and structure. Heavy clay soils are usually more poorly drained than lighter sandy soil. Clay soils hold more water due to their greater proportion of small pores. This increases their heat capacity leaving them slower to warm up and slower to dry out in spring.

Rec 8.1 The Agricultural Institute and the Meteorological Service should be requested to install max/min thermometers along with the existing soil thermometers at 10 cm depth at a limited number of locations to provide a data record and the daily mean value.

Rec 8.2 The Meteorological Service should expand the existing study at Mullingar of the effects of peat versus mineral soil on temperature to allow valid statistical comparisons to be made. In collaboration with the Agricultural Institute the study should be repeated with a comparison between mineral soils of different textures. This could be done at the Oakpark Research Centre as part of the existing soil temperature studies in sugar beet crops.

Automatic Recording

The group discussed the absence of temperature records at higher altitudes (below the upper limit of agricultural activity). There appeared to be no practical means of setting up manually operated recording stations at these altitudes and it seemed likely that little progress could be made until automatic recording stations become generally available. As the result of rapid technological developments in recent times automatic weather recording systems have become available at reasonable cost. Automated systems have the advantage of being free from operator recording errors. They make possible recording outside normal working hours. They also make it possible to extend the weather recording system to upland areas where the current recording network is very poor. With the addition of radio-link facilities the automated systems become extremely flexible. To study the current status and options presented by the new technology in automatic weather recording:-

Rec 8.3 The Group recommends that a panel of experts be set up to examine the prospects for automated weather recording - to assess the accuracy of the equipment currently available and of the equipment under development and to examine the implications for staff relations in the current system. The panel should also investigate computer compatability problems involved. After reviewing the situation the panel should draw up a recommended policy for this area.

Water Temperature Monitoring

Aquatic monitoring is important with respect to weed growth, the presence of nutrients in water and the growth and development of fish. Some farm activities can generate water pollution, e.g. slurry spreading. Also water temperature conditions have considerable potential for developing a forecast of the output of juvenile trout from fresh water. Brown trout, for example, is an important and widely distributed game species, The number produced in a river system can be related to the temperature conditions prevailing there. In fresh water the weight gain by juvenile salmonoids responds to temperature but much of the data collected at present is unsuitable where predicting the salmonoids is concerned.

Although water temperature data are collected on a wide scale in Ireland, by a wide range of state and semi-state bodies and by institutions and individuals, eg An Foras Forbartha, OPW, ESB, local authorities, the value of the data is greatly diminished by the current fragmented approach. A nationwide collection of data could not be justified on wild fisheries management alone but the value of the effort made by all groups would be greatly enhanced by the adoption of a co-ordinated approach to water temperature data collection. It may be necessary to establish a water temperature/ water quality liaison committee.

Rec 8.4 The Group noted that the recording of water temperature (in the various water systems) is incomplete and the accumulation of the records is disorganised. The group recommends that An Foras Forbartha should investigate the situation and develop a policy in this area.

Solar Radiation

The duration of bright sunshine is recorded at many Meteorological stations and provides a good national picture. While this may be used as a guide to the radiation environment it is necessary that this record be supplemented by measurement of global solar

radiation. There are extensive and agriculturally important areas west of the Shannon and across Munster and south Leinster without any radiation record.

Rec 8.5 The Group recommends that a uniform cover of global solar radiation measurements be provided by installing radiometers in these areas located at Claremorris (Meteorological Service), Moorepark and Johnstown Castle (An Foras Taluntais).

Temperature Stress in livestock

Recent field grazing studies in The Agricultural Institute have provided circumstantial evidence that temperature stress in livestock in spring affects performance significantly. As far as the group is aware there are no studies underway at present to show the energy expended by the grazing animal in the physical activities involved in grazing. The objective is to determine the extent to which differences in animal performance in different grazing systems can be explained by differences in physical activity.

Rec 8.6 The Group recommends that the research scholarship scheme of the Agricultural Institute be used by one of the Universities to set up a post-graduate research project to examine temperature stress in livestock.

Appendix 1

Some perceptions of Weather Forecasts among the Agricultural Community

T Keane
Meteorological Service

There has been a greatly increased awareness in recent years among the general public, and the farming community in particular, of the value of weather information especially weather forecasts. This in no small way reflects improvement in communication as well as improved weather forecasting. Twenty-four hour weather forecasts, for example, show that current skill in precipitation forecasting is almost 35% more than that achieved some twenty-seven years ago. Of the direct telephone calls to the forecast offices, now numbering almost 86,000 annually, 40% are agricultural based. Since the regional automatic telephone weather service (ATWS) system was first introduced in 1979, and gradually extended since then, the number of calls to the system now exceeds 560,000 (1984). Since Dublin is catered for separately by the 1199 system, an even larger proportion of calls to the regional services must be from the agricultural sector.

Survey Details

At the end of 1984 the AGMET Group undertook to ascertain the perceptions and needs of the Irish agricultural community in relation to weather forecast services by means of a questionnaire. Five different source groups were targeted, namely ACOT advisory officers, AFT researchers, co-operative milk suppliers, IFA County Committee and a number of other farmers. Two hundred replies were received, which was satisfactory, ie 53 ACOT, 49 AFT, 42 IFA, 27 Co-operative and 29 general farmers. All types of farming enterprises were represented, large and small, in crop (root, horticulture and cereals) and animal (cattle, dairy and sheep) production. Replies were received from all 26 counties (see Footnote).

Footnote: The complete study may be had from the writer

Analysis of the Responses

Almost all (96%) replied that they were very interested in weather forecasts or used them in the course of their work, such as in planning their daily farm activities or in their advisory duties. The importance farmers attach to weather forecasts is reflected in Table 1 where it can been seen that all groups rated them positively or very improtant. Many perceive a greater need of them at certain times for particular farm operations while others have a year round requirement.

Table 1

Importance of Weather Forecasts

	ACOT	AFT	CO-OPS	IFA	GEN[1]	TOTAL
Extremely	6	7	8	9	17	47
Mostly Very	20	13	16	16	7	72
Sometimes Very	22	22	3	15	5	67
Not Very	3	6	0	2	0	11
Never	0	0	0	0	0	0
Response *	51	48	27	42	29	197

* A few respondents did not complete all the questions

1 Includes some farmers who are voluntary rainfall observers

One farmer (IFA) wrote **"good farming means a good knowledge of all the inputs and that includes the elements rain, sun and wind, so weather forecasting is important to me".**

TV was the preferred means of reception by about 50% of respondents, while 30% favoured radio (including local radio) because it was stated that "forecasts are more available on radio with transistors in cars and tractors". 9% opted for the ATWS as first choice (18% as second choice), 5% for other means such as direct contact with the forecaster with only 2% putting newspapers

as first choice. **"The cost of phoning the ATWS is off-putting"** one Co Galway farmer wrote, **"a call costing 10p to 30p would be more acceptable".** Similar points were made by other farmers, especially in Co's Leitrim and Donegal.

Most respondents (66%) rated the greatest shortcoming of current presentations of weather forecasts as not being sufficiently related to agriculture or being too general. While one suggested that **"the speed at which fronts are moving sometimes catches you out"** another stated **"the service is very good and valuable".** 42% of respondents rated the 24-hour forecasts as their first choice and a further 20% required a two-day forecast. Despite the obvious need for to-day's or tomorrow's forecast it is interesting that some 40% of respondents placed an extended forecast of 3-7 days as their first choice, the period from 3-5 days being considered **"extremely important to farming"** (ACOT Adviser). About 39% of respondents indicated that they made a periodic or regular effort to obtain the current weekly forecasts on radio on 'Farm Diary', 28% on 'Agriview' and 50% in the Farmers' Journal. Farmers rated the latter service the more consistently used. However,many felt they missed the radio service too often **"because TV watching is the main activity in most households at night".**

Importance of a Weekly Weather Forecast on TV

Question 11 of the questionnaire sought to elicit the demands for a weekly weather forecast on TV. Respondents were reminded of existing services and comments were invited. Table 2 summarises the results.

Table 2

Importance of Weekly Forecasts on TV

	ACOT	AFT	CO-OPS	IFA	GEN	TOTALS
Extremely	12	10	16	11	17	66
Very	18	9	4	14	5	50
Fairly	10	20	4	9	4	47
Not Very	7	8	0	3	3	21
Not at all	1	2	3	0	0	6
Response	48	49	27	37	29	190

There is a high loading on the positive first and second categories (61% of replies to the question) and a minor loading only (13%) in the negative categories. Some of the 24% of respondents who rated the fairly important category said that they would have given an improved rating "if they thought (weekly) forecasts could be relied upon".Week-end days were most (60%) favoured, especially Sunday,transmission to be after 9 pm. Other preferences included association with Landmark or Mart and Market.

To be economically useful, the predictions should be reliable and accurate, but also designed and geared to provide sufficient advance warning to permit counter measures to be put into effect (Mukammal, Canada,1978). One ACOT adviser "would find it very important in advising growers on when to prepare seed beds,when to sow/plant,spray or harvest because many operations have a time scale of from four to six days such as hay saving, silage making or booking contractors".
Another adviser remarked that he is "always interested in the (weather) forecast and particularly liked the diagnostic presentation with the professional comment". While some farmers expressed doubt that the forecasts could be accurate so far ahead as "it appears to be difficult to achieve here for such a period",others felt the service was valuable between May and September in relation to "silage,hay,spraying and grain harvesting".

Many farmers thought weekly forecasts were important all the year round, for putting out cows to pasture after winter housing, for fertilizer application etc. Almost all who currently have the option of the BBC weekly weather forecast on Sunday afternoon emphasised that the particular transmission was "a date not to be missed for many years". The prospect of such a service here was most enthusiastically endorsed by them. One ACOT adviser noted that blight warnings have "a profound effect" in increasing production of potatoes but a farmer from the west of Ireland also stated that blight warnings "are too easily missed" and there is a need for them "to be reinforced or followed up".

Conclusion

Despite a lack of certainty in the forecasts, the results of the survey clearly demonstrate that considerable and sustained interest in weather forecasts has been generated among the agri-

cultural community. Farmers clearly showed that while for many their their first need was for a daily weather forecast, they also had equal need for an extended forecast of from 3 to 7 days. The Sunday BBC weather forecast is an 'automatic date' for those in the midlands and east who can receive it. "Timeliness is critical for many operations, being able to plan some days ahead is vital to getting the work done on time" a farmer concluded.

Appendix 2

PROPOSALS FOR FORMAT AND CONTENTS OF AGMET HANDBOOK

The purpose of the proposed handbook would be for use as a teaching aid for general use in agriculture but more specifically for ACOT advisers. It is envisaged that the book would be valuable to all people engaging in the teaching of Agricultural Meteorology. A strong point of the book would be the lists of relevant references that it would contain.

The scope of the book is set out in the following summary of chapter contents.

Title: Handbook of Agricultural Meteorology for Ireland.

Chapter 1: Introduction.

Chapter 2: Individual components of climate and weather, short explanatory descriptions of the individual components of meteorology and methods of measurement e.g. precipitation, temperature, radiation, evaporation and evapotranspiration, wind. The chapter should contain a short account of different types of weather stations e.g. synoptic, climatological, etc. It should deal briefly with automatic recording. In general it should be confined to "standard" meteorological instruments and practices. Measurements for specific purposes e.g. soil moisture by neutron meter will be described in Chapter 4.

Chapter 3: Meteorological parameters in Ireland. Ranges of meteorological parameters in Ireland showing local and regional variations. Include effects of location, slope, aspect, elevation, etc. Weather hazards - storm, hail, frost, snow, etc. (general treatment of weather hazards in Ireland). The object of this chapter is to set out the ranges of the various meteorological parameters in the country and factors that influence them. For example, they should be discussed from the points of view of both regional and seasonal variations, and absolute values. There should also be some reference to comparable parameters in other countries.

Chapter 4: The Moisture Balance. Information on and analysis and significance of moisture balance in Ireland with background information on role of slope, elevation, soil type, etc.

The chapter should include some discussion on instruments and methods of measurements. Reference should be made to both excess moisture (drainage) and deficits (droughts) and their roles in Irish agriculture.

Comparisons with other countries should be made (as in Chapter 3).

Chapter 5: The Energy Balance. Details in general as for Chapter 4. This chapter should deal with energy in its various forms eg temperature and radiation. Regional and seasonal variation to be discussed. Effects of slope, aspect,elevation,etc to be included. The temperature profile at and near the ground surface, and factors affecting it should be discussed, as should also be the partitioning of radiation into its various components. The relative and complementary roles of temperature and radiation in photosynthesis should be included. International comparisons should be made as for Chapters 3 and 4.

Chapter 6: Weather and soil management. Tillage soils: Role of soil moisture and temperature. Soil workability and timeliness of operations - ploughing, subsoiling etc. Grassland soils: Concepts of trafficability and poachability, critical autumn and spring periods, length of growing season etc. Soil fertility and fertilization: leaching losses of lime and fertilizers, volatilization losses of N; Run-off; Nutrient gains from rain and wind. Recommendations on regional basis. Irrigation: Soil type, crop requirements adn water sources. Experience with farm and horticulture crops in Ireland. Drainage: Arterial and land drainage; Meteorological parameters in drainage design. Erosion and Conservation: Wind and water erosion; conservation of soil and water resources.

Chapter 7: Weather and crop production. Coverage to be given to the full range of crops including grass, cereals,roots, potatoes, vegetables and fruit. Regional differences Some discussion of borderline or difficult crops (both agricultural and horticultural) should be included with reference also to crops at special risk from weather,eg hail,wind,frost. Climate modification and the role of shelter and protective cropping including glasshouses. Irrigation should be dealt with briefly.

Chapter 8: Weather and animal production. Coverage to be given to the full range of farm animals including dairying, beef, sheep and pigs. In general, the concepts are as for Chapter 7 but should deal with grass utilization rather than production. Environmental aspects to be considered including shelter, housing and animal well being.

Chapter 9: Weather and pests and diseases of crops. A general discussion of the relationships between weather and the various weeds, insects and pathogens etc and crops. It is considered that detailed discussion of individual items should be avoided in the interests of brevity. References to detailed sources of information should be supplied.

Chapter 10: Weather and pests and diseases of animals (as for Chapter 9).

Chapter 11: Weather and Forestry:
Climatic requirements and limitations for tree growth Hydrological and energy cycles in forests. Forest fires, wind. Other hazards - frost, snow, hail, erosion, etc. Pests.

Chapter 12: Potential and limitations of the Irish climate for agriculture. This chapter should summarise in general terms the subject matter of the other chapters in the context of Irish agriculture. Land evaluation - Reference would be made to the interaction between climate and soils in relation to land use, and some mention might be made of borderline crops.

While a suggested brief for this chapter is set out above, is is expected that the authors would be guided by the contents of the other chapters in the book. The authors should be provided with drafts of the other chapters at as early a date as possible.

General Comment

The book should contain not more than approx 200 printed pages (approx 500 words per page), or an average of 18 pages per chapter. It is expected that some chapters will be considerably shorter than the average. This will allow scope in some chapters for more than 18 printed pages if necessary but authors are requested to exercise economy in words as far as possible. All authors should provide a list of relevant references.

Appendix 3

Some Methods for Soil Moisture Determination

Gravimetric method; a sample of known volume is removed, weighed and dried. Laboratory facilities are needed and this direct method is time consuming.

Neutron Scattering; a fast neutron emitting source is lowered into the soil. The instrument must be calibrated for different soil types; the cost of the instrument is almost prohibitive, and its operation requires the use of trained technical staff.

Tensiometer; measures the negative pressure in the soil. In practice, tensiometers are only useful up to suction of about 0.85 bar, which is a comparatively low tension for soils with a high clay content. (Ref: Hydrology in Practice, Elizabeth M Shaw).

Electrical Resistance Blocks; a porous block of gypsum with a pair of electrodes embedded is buried in the soil. Measurements are being made at Mullingar using these gypsum blocks on an experimental basis. Gypsum blocks are not very accurate at the wet end of the scale. They are much more useful in summer during dry periods. On the other hand tensiometers are more accurate on moisture distributions under saturated and near saturated conditions.

Appendix 4

Horticultural Crop Diseases

The following diseases are put forward as being of economic significance as well as being 'weather linked'.

- Alternaria of horticultural crucifers.
- Mycosporella Ring Spot of horticultural crucifers
- Celery Leaf Spot.
- Cladasporium Leaf Spot of onions.
- Blackcurrant Leaf Spot.
- Botyritis of Strawberries.
- Apple Scab
- Apple Mildew

Alternaria is becoming increasingly important on horticultural crucifers. Predictive data for Oilseed Rape would be of benefit in vegetable production.

Mycosporella Ring Spot is considered the disease for which a predictive system would be most beneficial, because of the long period when cabbages, cauliflowers and sprouts are amenable to infection. On the other hand, Celery Leaf Spot has to be sprayed almost routinely.

Gladasporium Leaf Spot was particularly severe on onions in 1978, 1979 and 1980. It has not been serious since.

In the area of fruit, whereas Mills Periods were effective guidelines for Apple Scab by contrast with routine sprayings, their use was not adequate for Blackcurrant Leaf Spot.

For soft fruits, Blackcurrant Leaft Spot and Botyritis of Strawberries are the two most serious diseases for which prediction systems may have some relevance. It seems to be accepted that certain individual sprays at specific times will be done routinely e.g. at bud burst in blackcurrants.