1932.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(REPORT OF THE).

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The Right Hon. G. W. FORBES, Minister of Scientific and Industrial Research,—

I have the honour to submit herewith the annual report of the Department for the year 1931-32.

E. MARSDEN.

SECRETARY'S REPORT.

The Research Council has held four regular meetings during the year, at which there have been full attendances, and, in addition, there have been numerous committee meetings.

The personnel of the Council is as follows:—

Mr. George Shirtcliffe, O.B.E. (Chairman).

Professor Henry George Denham, D.Sc., M.A., Ph.D., Professor of Chemistry, Canterbury College, Christchurch.

Mr. Quentin Donald, Featherston.

Professor John Malcolm, M.B., Ch.B., Professor of Physiology, University of Otago, Dunedin.

Mr. Theodore Rigg, M.Sc., Assistant Director, Cawthron Institute, Nelson.

Mr. Charles Rhodes, Manager of the New Zealand Mines Trust, Auckland.

Mr. Hugh Vickerman, D.S.O., O.B.E., M.Sc., M.Inst.C.E., Wellington.

Dr. Ernest Marsden, M.C., D.Sc., F.N.Z.Inst. (Secretary).

On the 11th November, 1931, an amendment to the Scientific and Industrial Research Act, 1926, was enacted, which made provision for an alteration in the personnel of the Research Council and the establishment of two special divisions to deal with Industrial and Agricultural problems respectively.

The Industrial Division of the Research Council, now titled "The Development of Industries Committee," was constituted early this year, and held two meetings, at which the main lines of development for certain New Zealand secondary industries were given consideration.

The expenditure of the Department during the year was as follows:—

Permanent services—	£
Dominion Laboratory (with branches)	12,553
Geological Survey	5,573
Meteorological Office	7,639
Petrological Laboratory (four months only)	157
Apia Observatory	2,611
Dominion Observatory	1,808
Magnetic Observatory, Christchurch (8 months only)	1,187
Lincoln College	3,616
Research investigations (including contributions)	35,246
Head Office, Publications, Research Scholarships, and miscellaneous	6,744

The grants made by the Empire Marketing Board and industries in support of research investigations amounted to a total of £20,845 for the year.

Owing to uncertainties of finance, the Department has shared the general difficulty of working steadily towards definite goals, but, fortunately, interference with programmes has been confined to a minimum, and these difficulties have been kept as far as possible from the actual workers. Moreover, the general realization of the economic position has had the effect of stimulating one and all, and of bringing prominently to the realization of each worker the need for putting forth his best efforts for the common good. This realization has shown itself in the intensity of his efforts, and has evoked the genuine spirit of true team work. It can truly be said that research workers at all centres, and under various authorities, are working to an increasing degree in active co-operation and helpfulness towards the solution of the many national problems coming within their purview.

The Department was established to undertake scientific work and investigations proper to Government activities. Its purpose was also to stimulate in the country generally, by example and otherwise, the idea of the value of the research method and the importance of steady and long-range research in connection with our main industries. It was particularly necessary to show that these questions of research must be regarded as being part of and vital to the organization of industry. Moreover, it was imperative that these researches be fostered and directed by industrialists themselves, with such assistance as the Government, with its special facilities, and with its broader outlook of the welfare of the whole community, might be able to give. To be successful, this task involves patient, steady, slowly penetrating effort—industry cannot be driven—the best that can be done is to endeavour to encourage leadership through the industry's most enlightened members. A broad view of the situation, compared with six years ago, shows definitely that the scientific outlook of industry, and of the community, has grown, and with it the realization that industries are more stable on such a basis, more resilient, and that progress must be built up on intelligent forward moves and initiative, based on the fact-finding methods of research.

Apart from the encouragement of the research idea, there remains the problem of inculcating the principles of the proper amount of co-operation between units of an industry in pursuit of research, fundamental to all. This is only part of the whole principle and spirit of that co-operation, which does not sacrifice individual initiative, but rather provides for it a surer basis and removes competition to the efficiency of the methods by which the results of fundamental research are applied in industry.

The spirit of co-operation in research in industry grows slowly, and there are special features militating against its development in New Zealand. In the derived primary industries there are the differentiating interests of the local co-operative concern and the proprietary concerns; in secondary industries we have the purely local manufacturing concern, the combined importer and manufacturer, and the units of industry devolved from overseas. Many cases have arisen in our experiences where these interests have been antagonistic to co-operation in research, but gradually a broader outlook is being built up as each recognizes the amount of fundamental information of interest to each and all, and the sphere of co-operative research efforts becomes more definitely defined.

In general, during the year the value of organized experimental shipments of our products to England has been realized. These shipments of products of fully known and scientifically determined processing and history are examined in Great Britain by combined technical and trade experts, so that reliable information is obtainable as to their characteristics, good or bad, and the factors from which they arise. Thus lines of butters prepared in different ways have given a valuable lead as to the preparation of products which will be accepted by the Glasgow market. Shipments of cheese have thrown considerable light on maturation and the effect thereon of various practices in New Zealand factories. Shipments of pelts have indicated the effect of small traces of iron on keeping-quality, and have also indicated the suitability of various methods of processing for different manufacturing uses. Similar results have arisen from consignments of wool, meat by-products, apples, passion-fruit, kauri-gum, &c.; but in all cases it has been proved that the only way to obtain benefit from such shipments is to have a full technical knowledge of preshipment history and of the conditions during transport, followed by an examination in Great Britain which combines a knowledge of trade requirements and their interpretation in scientific language.

This is the only safe method of obtaining information on which to base extension of existing markets or marketing of new products, and in this work we are fortunate to have the co-operation of the Empire Marketing Board, the various research associations in Great Britain, and of our corresponding Department.

Dealing with certain of the special activities—

DOMINION LABORATORY.

The Dominion Laboratory is engaged chiefly in carrying out chemical work required by all Government Departments, except that of Agriculture, and this work still continues to occupy the greater part of the time of the staff. During the year a considerable variety of stores was examined for purchasing Departments. The renewed interest in gold-mining evinced throughout the Dominion entailed reports on an increased number of samples for prospectors and advice as to treatment when required. Work for the Police Department has increased considerably.

At the request of the Under-Secretary for Mines, research on the blending of New Zealand coals for gasworks use was advanced another stage. The proportions of Reefton slack coal required to correct the swelling tendencies of several high-grade bituminous coals were ascertained, and the information circulated by the Mines Department to all gas companies. The investigation on the relation of iodine to the incidence of goitre, undertaken in conjunction with the Health Department, was continued, and that on the ripening of bananas completed. A report on the latter will be issued shortly.

Industrial investigations still in progress deal with extraction and refining of kauri-gum and the improvement of meat offal for export. Work on a test of the keeping-quality of butter, in association with the Dairy Research Institute, has been proceeding during the past year. Another feature of the Laboratory work has been the examination and analyses of sprays for fruit-trees. The Director of the Laboratory again supervised the work of the Fuel Research Association, and maintained close relations with the chemist to the Leather Research Association. It is unfortunate that the work on coal must be curtailed owing to lack of finance and loss of contributions from the industry. Unless we keep up to date in the fundamental characteristics of our coals, the application of newly developed methods of treatment will be attended by considerable uncertainty. The work of the Laboratory during the year has resulted in information on which commercial briquetting can be undertaken in certain areas.

GEOLOGICAL SURVEY.

During the season, owing to shortage of funds, field-work had to be restricted to those districts in which it was possible for the geologist to obtain board, and where the country was open enough for him single-handed to fill in the topography of unsurveyed patches in the map. Since large parts of the Amuri Subdivision is sparsely inhabited, no work was carried out in that district.

Last April field-work in the Te Kuiti Subdivision, which was begun in 1928, was finished. A small scale black-and-white map of the district and a summary of its geology appears in the report of the Geological Branch of this Department.

The exploration of the Eketahuna Subdivision, part of the petroliferous region that extends along the east coast of the North Island, was continued; the examination of this area will probably be completed next year. At present little money is being spent in New Zealand in the search for oil, but the indications of its presence are so widespread along the east coast that further drilling is likely to be undertaken in the not-distant future, and the early mapping of the whole region is advisable.

Since it has been demonstrated that a cheap limonite-salt lick largely obviates many of the troubles of raising stock on bush-sick lands, considerable areas in the Rotorua–Taupo district will probably be occupied. Last season two geologists were engaged in the reconnaissance mapping of the soils in different parts of this region for the Native and Lands Departments. Considerable areas of Native lands have still to be examined, but it is hoped next year that some soil-mapping will be undertaken in the Waikato lowlands.

Where the results should have considerable economic significance owing to the amount of fertilizer used, and the possible economies and efficiency of utilization, the important results arising from the soil survey justify the formation of a soil branch of the Geological Survey, as the geological origin and changes in the soil are proving of fundamental importance.

The rise in the value of gold has greatly stimulated work in the goldfields, and has, indeed, altered their whole economic position. Since the beginning of the year an officer of the Geological Survey has been detailed to examine the old alluvial goldfields in Nelson and Otago, and to report on the possibility of large numbers of unemployed being able to win enough gold to reduce substantially the present charge of their maintenance by the State. Next season he will visit the West Coast and Otago. In the latter province he will examine more closely the extensive deposits of quartz-drifts that have in the past yielded such large amounts of gold.

Dr. H. T. Ferrar's untimely death must be recorded with great regret. He had specialized in the study of soils for many years, and at this time, when the importance of soil-classification is becoming widely recognized, the death of one of its leading exponents in New Zealand is particularly unfortunate.

METEOROLOGICAL OFFICE.

The Meteorological Branch has continued throughout the year to exercise its two main functions of forecasting the weather and of collecting and making available information regarding the climate of the Dominion in its various aspects. It has not been possible to provide for any extension of the work of the Branch, some of its activities, indeed, having had to be reduced.

The year was the first spent in the new quarters at Kelburn, and considerable advantage has been derived from the location of the Office near its Observatory and from the conveniences of a building designed for the specific purpose for which it is used. In particular, it has been of assistance to the forecaster to be able to watch the weather-changes and to record the direction and speed of cloud-motion.

In response to urgent representations from those concerned with maritime pursuits, the evening broadcast of weather reports for shipping from the Wellington Radio Station was restored. A special report was again broadcasted, in co-operation with the Radio Broadcasting Co. of New Zealand, from 2YA Wellington at 3 p.m. during the greater part of the year. This issue gives a general description of the existing meteorological situation in simple language, and indicates the developments to be expected therefrom for as long a period in advance as the situation warrants. It is intended especially for the agricultural community. The city-dweller has little comprehension of the value attached to the weather forecast by those in the country, or the extent to which farmers and others plan the next day's operations in accordance therewith. The increasing evidence of this is, however, very gratifying. It is not possible at present to make an earlier issue of the "farmers' forecast," since its accuracy depends largely on information from Australia, which does not arrive until the afternoon.

The Director while in Europe recently made a brief study of the methods of weather-forecasting developed in recent years by the Norwegians, which are generally acknowledged to be an advance on pre-existing methods. Since his return he has applied the method to the region covering Australia and New Zealand and the islands to the northward, using for the purpose reports received through the post, in addition to those telegraphed daily. Conditions in Australia are found to be very favourable for the successful application of the method. But, since it depends on the existence of a close network of reporting stations, the situation is much less satisfactory so far as the New Zealand area is concerned. Nevertheless, there is no doubt that were detailed reports available by cable or wireless from Australia the adoption of the method would lead to considerable advances. In this connection it is to be regretted that it has been found necessary, owing to the economic depression, to reduce the number of reporting stations.

A continually increasing number of people take advantage of the facilities for securing by telegraph or telephone special forecasts of the weather as it is likely to affect their activities. Much assistance can be given in such cases. Usually they involve some specific point which cannot receive full attention in a general forecast, which is necessarily limited to a few words.

Climate is an important factor in many enterprises, and therefore one which must be taken account of in the scientific planning which the competition of modern civilization requires in any business. This is reflected in increased demands both for data from existing climatological stations and for the establishment of new ones, the Meteorological Office staff being taxed to its utmost capacity in this respect. The country owes a debt of gratitude to the many voluntary observers who, on all days and in all weathers, make the observations on which our knowledge of the climate is based. As soon as conditions permit, the observing stations should receive regular visits, so that the equipment may be inspected and observers given instruction. The classification and summarization of the climatic data collected hitherto has been proceeded with. The results have been incorporated in a series of monographs dealing with specific aspects or in more general accounts of the climate. These publications will undoubtedly prove of much value, especially to agriculturists, forestry experts, and engineers. Details will be found in the Director's report.

OBSERVATORIES.

Apart from the routine observations of the Dominion, Apia, and Christchurch Observatories, a special advance has been made in earthquake-location, so that now the epicentres of all earthquakes of any magnitude in New Zealand are located within a circle of some twenty-five miles. This will assist materially in indicating the movements which are taking place, and the nature of the stresses causing them. During the year the land-movements and seismic occurrences connected with the Hawke's Bay earthquake have been worked out, and a bulletin is in course of publication. The observatories have made preparations for as active co-operation as possible in the international magnetic, meteorological, and radio observations during the Polar Year.

MINERAL CONTENT OF PASTURES.

The year has been characterized by marked progress in the knowledge gained regarding the variations in the mineral content of pastures, and the effect of these variations upon stock health in a number of districts in the Dominion. A striking advance has been made, particularly in regard to knowledge of the methods of controlling bush sickness on those areas of the North Island which have been afflicted with this stock ailment. Experimental proof is now available, indicating that insoluble compounds of iron, and particularly limonite, used in the form of licks, provide an adequate means of maintaining both sheep and cattle in sound health. The amount of iron which the animal requires to ingest in order to ward off attacks of bush sickness is apparently very small, and where ordinary methods of sound farm-management are adopted the making available of licks, comprised for the most part of limonite and salt, is all that is necessary. Consequently, it is now possible to farm the large area afflicted by bush sickness without any fear of considerable losses through stock mortality; and, further, it is possible to use to a great extent the top-dressing fertilizers whose use previously tended to accentuate the onset of bush sickness.

The investigations conducted by Mr. B. C. Aston, director of the mineral content of pastures investigations, have established the fact that bush sickness can now be readily and cheaply controlled, and that only in exceptional cases, where the disease has assumed an acute form before remedial measures have been commenced, is it necessary to resort to dosing with the iron-ammonium-citrate compound previously in general use.

The investigations at the Cawthron Institute have substantiated the fact that small quantities of insoluble iron compounds are effective in controlling stock anæmia, and have indicated that it may be possible to hold this class of stock complaints in check by providing stock with access to soil containing iron, a fair proportion of which is soluble in oxalic acid, or else by making available to stock the iron compound of these soils in the form of licks.

Of great importance in connection with the mineral content of pastures investigation has been the realization among the farming community of the need for giving due attention to mineral deficiencies which occur seasonally, even in the best pastures, throughout the year. With the variations in the mineral content of these pastures generally known, steps are now being taken to maintain stock thriftiness during those seasons of the year when there occurs a low level of available mineral matter in the pastures.

PHORMIUM TENAX.

There has been definite progress made in the knowledge regarding *Phormium*, along a number of directions. As will be seen from the report of Dr. J. S. Yeates, a good start has been made along the road towards good high-yielding varieties. It would appear that the special needs of various avenues of utilization will now have to be considered, and production linked up with manufacture. Thus the requirements for cordage and for weaving differ, while, if cellulose only is required, strength of fibre is of little significance compared with total yield and cellulose content. If *Phormium* of good quality were available at a price less than 10s. per ton of green leaf, delivered at a neighbouring factory, then the prospects for big-scale industry are good, whether for cellulose, weaving, or cordage. An estimate of cost of production, based on Dr. Yeates's figures for yield, &c., shows that production should be economically possible at these prices.

The experimental stripping-machine erected by the Garret Engineering Co. at the flaxmill of Messrs. Rough, Ross, and Co., at Foxton, developed satisfactorily, particularly the tail-stripping device. It is unfortunate that the liquidation of the Garret Company has delayed final development of the machine. However, there are other promising developments taking place with regard to decorticating-machines.

Some commercial tests of bleaching were undertaken in conjunction with Mr. Nightingall, and it was shown that chemical bleaching can yield a fibre of 15 per cent. higher average strength than paddock bleaching. Important results were also obtained with regard to the loss of strength in scutching.

Investigations have also been commenced regarding the production of cellulose from flax. A developing company has erected a digester, and made trials using green leaf as a basis, and has produced a good pulp. It is claimed that the yield from green leaf is over 20 per cent. of cellulose, involving only a relatively short cook. With green leaf of high quality at 10s. per ton, these figures indicate that the raw material in cellulose pulp from flax should cost less than £2 10s. per ton, a price which compares well with such cellulose from wood or other sources.

WHEAT RESEARCH INSTITUTE.

The programme of research under the ægis of the Wheat Research Institute showed steady and continued progress during the year. In all departments the amount of work covered was greater than in previous years, and has reached a stage when the maximum efforts of staff and facilities are being put forth.

In connection with the wheat breeding and selection work, over nine thousand individual plots were sown and subjected to detailed investigation during the year. These plots cover a wide range of crossbred wheats, bred by the Institute, which are undergoing the process of selection and elimination with a view to securing types of wheat better suited to New Zealand conditions than those at present in use. A large number of introduced varieties was grown for trial, almost every wheat-growing country in the world contributing samples of its wheats. The field-work has revealed important practical information, which is being immediately made available to farmers, regarding the optimum amount of seed and manures to be used, the winter hardiness of the main varieties of wheat, the tillering-capacity and ripening-capacity of different strains, and other matters which have a very considerable effect upon yield and quality.

In the laboratory, baking, milling, and chemical tests, totalling well over ten thousand in number, were completed. The laboratory worked in the closest association with bakers and millers, and the results of the work undertaken have been conveyed speedily to representatives of these two industries, with the result that improved practices are gradually being adopted.

The services of the laboratory have also been available to farmers, especially at harvest-time. These were particularly acceptable this year, when the difficulties at harvest-time were very pronounced. The wheat in the North Canterbury area for the most part shrivelled considerably as the result of drought, while in South Canterbury, under very wet weather conditions, considerable spoilage occurred through sprouting. As the result of tests carried out by the laboratory it was possible to save for milling purposes some 150,000 bushels of wheat which had suffered from the damp weather.

The Wheat Research Institute was also instrumental in providing information enabling the proper blending of wheats harvested in what was probably one of the most difficult years of wheat-growing in Canterbury to be gristed in such a manner as to maintain as far as was possible the good quality of the flour.

KAURI-GUM.

Striking advance has been made in regard to methods of refining kauri gum and resin. Methods were worked out in the Laboratory by Dr. J. R. Hosking for (1) solvent extraction of low-grade kauri-gum, and refining to a product preserving, unaltered, the valuable properties of the gum; (2) solvent extraction of resin from fossil kauri timber, and hill timber, to produce a kauri-resin of good colour and low acid value. These methods were tried out on a pilot plant, towards the cost of which the Unemployment Board contributed, and hopeful reports on the products have been received from overseas.

Following the experience with the pilot plant, arrangements were made to modify a solvent extraction plant for kauri-gum refining at Henderson, and it is hoped that this plant will soon be in operation. In addition, plans and specifications have been drawn up with a view to inviting tenders for alterations of a resin-extraction plant near Dargaville.

PLANT RESEARCH STATION.

The work at the Plant Research Station is of the utmost importance to the primary industries of the Dominion, because, as it deals with grasses and pastures, with insect and fungous diseases of farm crops, with plant breeding, selection, and certification, with fundamental botanical studies of all farm crops, and with all forms of field trials, it ensures that the basic problems of this industry are receiving due attention. The full utilization of our resources of soils and pastures is dependent upon the progress of knowledge in all divisions of agricultural science, and it is imperative that continued study be devoted to the class of problems outlined above. Marked progress has been made, particularly in regard to the value of strain influences in grasses and clovers, and in the control of several serious diseases of farm crops, all of which may speedily result in marked improvements in the financial returns from farming.

DAIRY RESEARCH.

Ranking of first importance in our primary industries, dairying and its problems have claimed closest attention from research workers during the past year. It has been found necessary to undertake a considerable amount of fundamental work in order that it may be possible to make more progress on the more practical difficulties affecting butter and cheese production. As a result of continued attention to the original wide problems of cheese openness, it is now apparent that this defect could not be attributed to any one specific factor. Both laboratory experiments and factory-scale tests have indicated that there are at least some seven influences which are conducive towards this trouble. The search for the causes of the trouble of openness have led investigators to explore completely the whole range of processes involved in cheese-manufacture, from farm to the market. The result has been the tracing of defective processes, so that the Dairy Research Institute is now in a position to refer specifically to features in cheese manufacture and transport which when given due attention will be a means of improving in a large measure the quality of our produce.

In connection with studies relating to butter, the aim has been directed towards providing the British customer with an article fuller in flavour than that which has previously been despatched. The trials made in regard to the incorporation of a fuller flavour to butter, and the successful transport of this class of butter to the British markets, have promised well, and would appear to indicate that persistence in this type of work is amply warranted. The trials that have been made with butter so far have also been concerned with the question of the spreadability, and a stage has now been reached when the physical texture of New Zealand butter, as delivered in Great Britain, has been shown to be possible of considerable improvement.

In connection with both cheese and butter investigations the greatest emphasis during the year has been laid upon endeavours to improve the quality of raw milk as delivered by suppliers. The great importance of pure milk-supplies has been amply shown, and measures have been taken with a view to advising methods whereby the average quality of milk and cream received may be raised to higher standards.

GEOPHYSICAL PROSPECTING.

It is becoming increasingly evident that geophysical methods of prospecting could usefully be employed in connection with further developments of the mineral and oil resources of the Dominion. The position is being closely watched, and as much information as possible is being collected from abroad with a view to facilitating the prosecution of a geophysical survey of promising localities.

STANDARDIZATION.

Mr. C. B. Le Maistre, of the British Standards Institute, visited New Zealand in February of this year, and at the various centres discussed the question of standardization with the local interests.

Before Mr. Le Maistre's departure a meeting was called in Wellington representative of the various bodies concerned in standardization, and at this meeting it was decided that a New Zealand Standards Institute should be set up, with an independent status. It was further decided that the Development of Industries Committee of this Department should undertake the preliminary organization of the local Standards Institute.

FRUIT RESEARCH.

The programme of fruit research affords a good example of co-ordinated effort on the part of several organizations—viz., the Plant Research Station, Cawthron Institute, Horticulture Division, and the Cambridge Low Temperature Research Station. This co-ordination of effort has enabled a wide sphere of activity to be covered and fruit research to proceed on regular lines. The research orchard at Nelson is now being fully utilized for a comprehensive series of manurial and spraying trials, while detailed information regarding the yields of each tree is being accumulated in order that the basis of all future experimental work may be sound. Marked advances have been made in the knowledge of fruit-tree sprays during the year, and this is of such a nature that it can be used in the direction of improved orchard practices almost immediately. Rootstock investigations and manurial trials have been inaugurated which will provide ultimately long-range results which will yield important fundamental knowledge to the fruit industry. Steady progress has been made in the study of the more serious insect and fungous pests affecting orchardists. An extensive series of transport and cold-storage trials have been maintained, so that it has been possible to trace the effect of the many influences which play a part in the causation of fruit-wastage. The attention devoted in the past to problems of fruit cold storage and transport has been in large measure responsible for the high standard of quality in which it is now placed on overseas markets.

MISCELLANEOUS.

The amount of miscellaneous investigations conducted by the Department has shown an appreciable increase, and would indicate that trade and industry are paying greater attention to the need for scientific guidance in all their activities. The range of requests received during the year has widened considerably, and has claimed the closest attention from officers of the Department. The qualifications of officers of the Department cover such a wide range that it is possible to render, by means of the measure of co-ordination which can be developed readily, services of a most diversified kind in connection with scientific problems affecting trade and industry.

REPORTS OF THE RESEARCH COMMITTEES OF THE COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

DAIRY RESEARCH.

Advisory Committee: Hon. Sir George Fowlds (Chairman), Mr. A. Morton, Mr. T. A. Winks, Mr. W. Iorns, Mr. Dynes Fulton, Mr. Quentin Donald, Professor H. G. Denham, Dr. C. J. Reakes, Mr. W. Singleton. Director of Research: Professor Wm. Riddet.

The following is an outline of the progress results of investigations carried out by the Dairy Research Institute on problems affecting the manufacture of butter and cheese.

Butter problems have had special reference to flavour, whilst cheese problems relate to quality in general. Three years ago it was planned to investigate the causes of openness of texture in cheese, but it was soon found that this problem could not be adequately studied without considering other factors affecting cheese quality.

Cheese Studies.

Openness of Texture.

Many factors operating individually and collectively influence this defect. It is further complicated by the fact that there are three distinct types of openness, two of which generally are associated with other defects in quality, whilst the third, to a limited extent, is often present in cheese which otherwise is of finest quality.

In the present state of knowledge, it is not possible entirely to prevent openness, but it has been shown that the trouble may be attributable to or aggravated by any or all of the following conditions:—

(*a*) Low-grade milk:
(*b*) Inactive starters:
(*c*) Faults in manufacture:
(*d*) The aim for excessively high yields:
(*e*) Unduly hastening the manufacturing process:
(*f*) Excessively high curing-room temperatures:
(*g*) Sale of cheese before it is properly matured.

(*a*) Low-grade milk influences the defect in two ways: it may unduly hasten the making process or make it too slow. In neither case can the cheesemaker by any variation in the process of manufacture adequately prevent the condition from arising. Moreover, when milk varies in grade from day to day and from vat to vat, the factory-manager cannot standardize his manufacture to suit his factory supply. That type of milk known as non-acid milk frequently gives rise to cheese which is open in texture. The reason for the spasmodic occurrence of non-acid condition is not clearly understood.

(*b*) Inactive starters cause considerable trouble. The factory-manager's difficulty is to know in advance when a starter is good, because a starter may appear to be normal when added to the vat and yet prove quite inactive in the making process. Furthermore, it has been shown at the Institute that one of the several cans of starter, all made up in exactly the same way, may prove inactive, while the others are normal. The reason for this is not definitely known; but the problem has been narrowed down to a few possibilities, which are being closely investigated. A most important advance in the control of starters has been made by the development of a test for accurately determining the vitality of a starter without actually making cheese with it. This same test may be used for detecting non-acid milk; details of it have been published in the *New Zealand Journal of Science and Technology*, April, 1932.

(*c*) Errors in manufacture of cheese may contribute to the openness defect, but, since this involves technical considerations, it may be omitted from the present report.

(*d*) Any endeavour to reach an excessively high yield of cheese per pound of butterfat plays a prominent part in the defect. Any attempt to increase yield by incorporation of excessive moisture in cheese will result in increased openness of texture, besides deteriorating quality in other respects. The most important aspect of the evil effects of aiming at excessive yields is that these become most evident after the cheese leave the factory, and even after the cheese is graded, with the result that the factory never has the opportunity of adequately realizing the disastrous effects of this policy.

(*e*) Unduly hastening the manufacturing process: A close examination of hundreds of records of cheeses made at the Institute and correlated with quality reports of the mature product shows that cheese which work normally in the vat in from seven to eight hours from the time of adding the starter till the curd is hooped give the best results. To this time must be added that required for receiving and pasteurizing the milk, cleaning up the factory, and dressing the cheese at the end of the day's work. Therefore it is essential that the prompt delivery of milk at the factory in the morning should be enforced, and that hours of labour should be so arranged as to give a reasonable time of manufacture for even the last vat filled with milk in the morning. It may be observed that hurried manufacture may not make noticeable its adverse influence till some time after the cheese has been graded.

(*f*) The control of temperature of cheese-curing rooms is very important. A temperature of from 55° to 60° F. is needed to promote ripening; but when temperatures rise above 65° F. openness is accentuated, especially if the cheese is slightly sweet or somewhat high in moisture content. High temperatures also give rise to excessive shrinkage. Many curing-rooms are not sufficiently insulated to prevent an excessive rise of temperature in summer. Attention also should be devoted to the control of humidity of curing-rooms. It must be realized that the curing of cheese is just as important as the making of it.

(*g*) Lack of maturity has been proven to be one of the causes of slit openness. This defect may be present in a green cheese, and, as the cheese ripens, it may either entirely disappear or become markedly less. Thus the ripening of cheese to a mild degree of maturity before it is offered for sale is one immediate and simple measure for mitigating openness. This measure is not applicable to excessively moist cheese. The maturing of cheese also has the decided advantage that it prevents cut surfaces exposed to the atmosphere for a few days from cracking and developing the yellow horny appearance characteristic of immature cheese.

Attention to the foregoing considerations will assist factories in controlling openness of texture to a considerable extent. It has been shown that neither the pasteurization nor the test of milk affect openness of texture, although they have other influences. It has also been shown that types of presses and hoops have no distinct influence. However, the keeping of cheeses in the press for three days, if accompanied by the daily easing of the cheeses in their hoops, is a decided advantage, and can be recommended when this is practicable—for example, when a factory is not working to full capacity.

Methods of improving the State of Maturity of Export Cheese.

A series of experiments were undertaken to provide straightforward practical methods of improving the state of ripeness of export cheese on its arrival in the United Kingdom. When these experiments were carried out there were no regulations in force in regard to the heating of curing-rooms. Taking as standard a cheese held on the factory shelves for fourteen days at from 45° to 50° F. and sold at nine weeks old after having been treated in the usual export manner, there were compared with it eight other cheeses from the same vat exposed to other conditions likely to improve ripeness when mature, such as holding on the factory shelves at higher temperatures for the same time, and for a longer time and prolonging the period of storage in the grading-stores before export. The influences of the use of greater amounts of rennet than are commonly employed in practice and different types of cheeses were studied. In all, some 360 cheeses from forty vats were individually examined at various stages of maturity. The cheeses were mostly judged by Mr. Ross, of the Dairy Division, who used as his standard the degree of maturity and type of cheese wanted by the Home market. It was found that—

(*a*) Good cheese materially improved in quality as it matured. Maturing brought out real Cheddar character and reduction in slit openness. There was a difference of as much as 2·9 points in average grade of the same line, varying from 89·2 to 92·1. The best line of cheeses were those held on the factory shelves for a month at 60° F. and in the grading-stores for two months before they normally would have been exported. Cheeses held on the factory shelves at 60° F. for fourteen days and a month respectively, and examined when they would have arrived Home at from nine weeks to fourteen weeks old, did not grade so well as did those held at 45°–50° F. during the first fourteen days and graded at the same age—they had metallic flavours where the others had green yet clean flavours. Those held on the shelves for fourteen days at 60° F. and in the stores for up to four months improved in quality with age, but they were still inferior to those held on the shelves for a month and in the stores for two months prior to the normal time of export. The shrinkage of the best line was approximately 5 per cent. of their green weight, which is in keeping with accepted expectations. It was higher by 1·75 per cent. than the immature produce which had not been exposed to high temperatures, but actually less by 0·6 per cent. than cheese subjected to normal factory export procedure and held till they were six months old, such as may be practised by Home buyers to provide what is wanted by the trade.

(*b*) Cheese of the type made for yield fell off markedly in quality with keeping. They graded best when held in the factory at *low* temperatures and when finally sold at three-and-a half months old; but even under these conditions they were not of high enough quality for trade needs. They badly deteriorated when held on the factory shelves for a month or six weeks. In addition to the falling-off in flavour, several other noteworthy features emerged from their examination: (1) The shrinkage between green weight and factory packed weight was high; (2) the shrinkage in store was very high; (3) they developed excessive openness, which in no case was overcome by maturing; (4) they cracked badly, particularly at the ends, and developed discoloration. This experience emphasizes the fact that the worst features of this type of cheese are brought out after the cheese is normally graded.

(*c*) Cheese made from curd to which an excessive quantity of salt has been added does not ripen normally. Even when held at 60° F. on the factory shelves for a month or six weeks and in the stores for two months it is still harsh in texture and metallic in flavour, both of which qualities are objectionable to cheese-consumers. While the quantity of salt added to curd can with advantage be increased in the autumn, it should be carefully controlled at all times. It is equally important to avoid over- and under-salting.

(*d*) The use of rennet at the rate of 4 oz. per 1,000 lb. milk, instead of lower rates, tends to improve the rate of ripening of cheese. It hastens flavour-development and makes the cheese break down more quickly than is normal; but the advantage of using increased amounts of rennet is not equal to that of improving maturity by reasonable curing temperatures and age. The use of additional rennet intensifies flavour defects of any kind.

These experiments uphold the regulations affecting the heating of curing-rooms and the holding of spring-made cheese on factory shelves for three weeks; but they go further by emphasizing the need for longer time on the shelves and two months' storage prior to export. It is realized that such storage would involve difficulties, especially in the flush periods. Accordingly, the industry is urged to consider either the more uniform distribution of its production over the year or the provision of the necessary storage accommodation.

Harsh and Gritty Body in Cheese.

Experiments reported at the annual conferences in 1930 and 1931 showed that the addition to curd of excessive quantities of salt was responsible for harsh, gritty bodies of cheese which mature very slowly. Produce made from such curd resembles skim-milk cheese. It is gratifying to learn that cheesemakers are now alive to this fault, and that during the past season there has been a very material improvement in the bodies and flavours of cheeses as a result of paying attention to this matter. It must be recognized, however, that other factors—notably excessive acidity or inadequate acidity—play a part in producing harshness. The addition to curd of excessive salt also is a very common cause of cracked rinds. In experiments on this question curd salted at the proper rate produced cheese showing a perfect rind, while cheese from the highly salted curd showed very unsightly cracking of the rinds. Mould entering the cracks of such cheese causes loss by spoilage, which extends ½ in. to 1 in. in depth all round the outside of the cheese. Discoloration of coloured cheese frequently arises from cracked rinds.

In the light of the Institute's investigations, the importance of the control of the rate of salting curd cannot be overestimated.

Butter Studies.

These have been concerned mainly with the development of a fairly full flavour to suit particular parts of the British market. Meanwhile these areas are supplied by countries near to the British market, which to some extent develop acidity in their cream by the use of starter. Such butter does not keep well; but this does not constitute a drawback to those countries within a short distance of the British market. The practice of developing high acidity in cream with a view to obtaining this full flavour is not applicable in New Zealand because of the time it takes for butter to reach the British market, and of the risk of "fishiness" developing in transit. Thus the problem that we are attempting to solve is the manufacture of a fairly full-flavoured butter which will stand up to keeping for a reasonable period of time.

The extensive trials carried out in the 1929–30 dairy season indicated that by the addition of starter in limited amounts to fresh cream there could be developed a mildly full flavour which did not deteriorate on storage, and which, on the average, was superior to the flavour of butter made from fresh cream to which no starter was added. Corresponding trials with neutralized cream, on the average, showed no advantage in the adding of starter. In the following season butter was made from fresh sweet cream, the same cream ripened to a mild acidity, and the same cream ripened to an acidity comparable with that used in certain other countries. The Home reports on these butters invariably favour those made from a perfectly sweet cream. The cream used in this experiment was of very high quality, and had no neutralizer whatsoever added to it. What were considered to be dangerously high acidities were developed so that definite information might be obtained on the effect of these upon perfectly good cream. During last season trials were carried out with butter made from fresh cream, the same cream ripened to a very mild degree of acidity, and from neutralized cream to which starter had been added, and to which no starter had been added. Part of this butter was exported to an area characteristic of that desiring fairly full-flavoured butter, and, with the collaboration of the Home representatives of the Dairy-produce Board and Dairy Division, trade opinions were obtained on this butter. This market is well satisfied with a rich creamy butter made from fresh cream which still possesses a clean aroma, and which is easily spreadable. It prefers a butter rather paler in colour than many New Zealand makes. Fresh cream butter apparently is preferred to that made from a neutralized cream; and distinct objection is raised to a butter which is neutral or very insipid in flavour. The following extract is taken from a report by the Home manager of the Dairy-produce Board on inquiries made in Glasgow:—

> "Conversations with importers, wholesalers, retailers, and consumers reveal the interesting fact that our very best butter can be sold in this area on its own flavour, if salesmanship is exercised and the consumers are kept on the butter for a few weeks so that they become used to it. One of the largest retail establishments in one shop alone have increased their weekly sales of New Zealand butter from 30 cwt. in April, 1930, to 84 cwt. in April, 1932; whilst their sales of another brand of butter have decreased in the same period from 32 cwt. to 25 cwt. This result has been achieved by careful selection of New Zealand butter sold, by an attractive display of our goods, backed by efficient sales effort.
>
> "I found dozens of shops in the city itself and in the suburbs displaying New Zealand butter prominently on their counters, and in many cases New Zealand butter posters appeared in the windows. This is a very different state of affairs from that obtaining two years ago, and indicates clearly that there is a growing demand for good New Zealand butter. I am of the opinion that if all our output had the aroma and flavour of our very best butters as they are to-day the Danish bogy would be overcome in time. It is the flat neutral flavour, whether due to over-neutralizing or to age, that puts us so definitely in the second class compared with Danish."

Included in the consignment was butter made from cream neutralized to a low point; the reports on such butter indicated that it was not acceptable. The general results of these experiments is that care has to be taken, on the one hand, not to over-neutralize cream, and, on the other hand, to develop only a very low degree of acidity when starter is employed. In passing, it may be remarked that neutralizer-flavour reports are not always quite accurate. Whilst there are some cases in which the flavour is due to excessive neutralization of cream, we have had reported cases of neutralizer flavour in butter in which no neutralizer was used.

Another interesting observation made in these experiments was that butter made from borderline finest-grade cream did not stand up to storage so well as did that made from absolutely finest-grade cream. The spreadability of butter is being given close attention.

Dissemination of Results of Research Work.

A course for dairy-factory managers, lasting for a week, was held at the Institute during the first week of May, when the technical results of experiments were explained to the managers. This contact with managers was invaluable, as it enabled research workers to explain in greater detail the nature and results of our work than was possible by means of published articles.

A Monthly Bulletin which sets out matters of interest to dairy-factory managers is published by the Dairy Research Institute.

It can be claimed that a very considerable amount of work has been accomplished, and that not only have some definite results been obtained, but also that many problems have been narrowed down most materially. Much remains yet to be done, and this can be carried out only by persistent effort and careful observation.

The Institute has closely collaborated with the Dairy Division of the Department of Agriculture, the Massey Agricultural College, and the New Zealand Dairy-produce Board; to all of these bodies thanks are expressed for their hearty co-operation and assistance.

The Institute has had the invaluable services of Mr. N. L. Wright, Scientific Liaison Officer of the Department of Scientific and Industrial Research, attached to the Office of the High Commissioner, London, who has made first-hand scientific inquiries and experiments in the United Kingdom on behalf of the Institute.

PLANT RESEARCH.

PLANT RESEARCH STATION.

The Plant Research Station is conducted in co-operation with the Department of Agriculture, the work of the whole Station being directed by Mr. A. H. Cockayne. The reports set out below indicate those spheres of activity in which the Department of Scientific and Industrial Research is more particularly concerned.

Mycological Section.

I. *Brassica Diseases.*

(*a*) *Club-root* (Plasmodiophora brassicae).—A considerable number of resistant strains of swedes, turnips, and rape, procured from Canada, Scotland, Denmark, and by selection at the Plant Research Station area, have been grown on heavily infected soil. From these, plants apparently immune to the disease were selected and seeded under controlled conditions. This seed has again been sown in infected soil for further immunity trials.

Further work with field control of club-root by liming has been undertaken, attention being paid in this work to the effects of time of application upon control secured, even on heavily infected land, if 30 cwt. per acre of burnt lime is applied three months in advance of sowing the seed, and if seed is sown with 2 cwt. of basic slag or a 3 cwt. mixture of superphosphate plus hydrated lime.

(*b*) *Dry-rot* (Phoma lingam).—Many experiments conducted during the year have led to the production of a modified seed-disinfection method which it is hoped will give complete disinfection of lines infected with this disease. The process is a hot-water treatment, now modified so that seeds are immersed for fifty minutes in water held at 124° F. It would appear to be effective, since in the many hundreds of thousands of seeds tested (from a line averaging about 15 per cent. infection) no dry-rot fungus has appeared. Furthermore, those field areas sown with seed treated in this manner have remained free from infection. Seed of six varieties of swedes and turnips have been grown to maturity from seed treated by this method. The plants, which have remained disease-free throughout, have been seeded, and the seed, when tested, was likewise found to be clean. A portion of this seed is being utilized for bulking purposes, the remainder has been forwarded to certain British seedsmen who intend utilizing these clean nucleus lines for production of seed for this market.

An improved method of testing seeds for the presence of dry-rot has been evolved, and has proved most useful against lines carrying out minute percentages of the disease. By this method, which is a modification of the cloche seed-germinator, from eight thousand to ten thousand seeds may be tested at one time.

Certain British seedsmen have forwarded, from time to time, lines of swede and turnip seed which they claimed to have grown under conditions precluding dry-rot infection. Unfortunately, when tested under field conditions in New Zealand most of these lines have developed the disease.

II. *Potato Diseases.*

(*a*) *Corticium Disease* (Corticium solani).—It has been found that this fungus spreads in the soil from one plant to another, that it remains in the soil for at least twelve months, and that crop rotation does not appear to affect this period of persistence.

A series of investigations, extending over a period of four years, has demonstrated that it is economically unsound to treat potato-tubers for the control of this disease, since the fungus does not appear materially to reduce yields under New Zealand conditions.

(*b*) *Virus Diseases.*—During the year it was demonstrated that a condition known locally as "curly-top of Dakotas" was a graft-transmitted virus disease. Trials demonstrated that net necrosis decreased yields by upwards of 50 per cent. A masked virus, isolated from apparently healthy potatoes, has produced mosaic when inoculations were conducted with seedlings of tobacco and *Datura*.

A quantity of apparently virus-free tubers has been raised from eight varieties in several localities. Part is being used in the glasshouse for further studies of virus diseases, the remainder being reserved for bulking up preparatory to making them available for commercial purposes.

(*c*) *Wilt Diseases.*—Approximately 2,500 cultures have been secured from potato stems and tubers. From these numerous fungi have been secured, and tests are being made of their pathogenicity as the limited glasshouse accommodation permits. It would appear that many of the fungi isolated are unrecorded as pathogens of potatoes, and several would appear to be unnamed, and internal brown fleck and dry-rot are also being studied.

III. *Legume Diseases.*

(*a*) *Collar-rot of Peas* (Ascochyta *App.*).—Experiments conducted during the past three years have demonstrated convincingly that it is not possible by known methods of treatment to free commercial lines of pea seed from this disease. Consequently, work has been concentrated upon the production of disease-free nucleus lines of several varieties. From certain of these a fair quantity of clean seed has been raised at Tangimoana, portion of which is being tested under glass preparatory to using the major portion for bulking prior to commercial distribution.

(*b*) *Bean Wilt* (Bacterium medicaginis *forma* phaseolicola).—Since this disease was introduced with seed imported from Australia last year, it has become widespread throughout the Dominion. As it is seed-carried, and as it is not possible to sterilize seed by known artificial means, the production of clean nucleus lines has been attempted. A quantity of seed has been grown in this manner, which is apparently free from wilt, and this will be bulked under isolated conditions in the spring.

(*c*) *Virus Diseases.*—Needle inoculations have shown that a mottling and dwarfing of garden peas is due to a virus. A second disease, known locally as "streak," and suspected of being due to a virus, is under investigation. Attempts are being made to raise nucleus lines of garden peas free from both troubles. Cross-inoculations from clovers have resulted in the appearance in garden peas of symptoms of both diseases, showing that the former hosts are carriers, and illustrating the difficulties facing the attempts at production of clean lines of seed.

(*d*) *Sore-shin* (*Cause unknown*).—From this troublesome disease of lupins two fungi have been isolated. Experiments are now in hand to determine which is responsible for this disease, and field trials have been laid down in which various soil-treatments are being tested with a view to working out practical control.

(*e*) *Legume Nodule Organism* (Bacillus radiciperda).—During the past twelve months 653 farmers have been supplied with cultures of the lucerne nodule organism, quantities being sent out sufficient to inoculate 46,185 lb. of seed.

IV. *Cereal Diseases.*

Barley Smuts (Ustilago Jensenii *and* U. tritici).—Several proprietary seed-disinfectants were tested against the hot-water treatment. Results convincingly demonstrated that hot water alone gave satisfactory control of either smut, showing that these proprietary compounds are of little value under New Zealand conditions.

V. *Tobacco Diseases.*

(*a*) *Leaf-spot* (*Cause unknown*).—Experiments with treated *versus* untreated seed failed to combat this disease. It is highly probable the trouble is of a physiological origin.

(*b*) *Tobacco Virus Diseases.*—Needle inoculations have shown that a diseased condition of plants prevalent in Nelson and Auckland is due to tobacco mosaic.

A crinkle-leaf condition, which developed in a line of tobacco raised at the experimental area at Auckland from seed imported from Turkestan, is now under investigation, infected plants being seeded with a view to ascertaining whether the disease is carried with the seed.

VI. *Strawberry Diseases.*

Detailed surveys were made during the year of the strawberry areas at Auckland with a view to investigating those factors responsible for losses suffered by growers in that region. Seedling plants have been raised in quantity, and these are being used in attempts being made to determine the nature of these diseases. Attempts are being made to produce virus-free plants on a small scale, preparatory to bulking for commercial distribution.

VII. *Fruit and Fruit-tree Investigations.*

(*a*) Sprays.—A comprehensive series of field experiments is being conducted with a view to improving the spray control of our major orchard diseases. For the purpose 676 experiments, concerning thirty-three district investigations, were handled during the year.

Analyses are being made of commercial sprays with a view to making operative the Fungicides and Insecticides Act of 1927. In this connection the sulphurs and lime-sulphurs have been dealt with, and completed accounts published in the *New Zealand Journal of Agriculture.*

(*b*) *Fruit-rots in Store.*—A second season's survey of all rots found in cool stores has been completed. The fungi responsible have been isolated, identified, and are now being inoculated into fruits to determine their pathogenicity. A study has been made of the factors which enhance or inhibit fungous attack, with a view to working out methods of reducing losses.

The serious losses experienced in lemons in the curing-sheds at Tauranga led to an investigation being made into methods of handling and storing fruits. Recommendations made were adopted and losses materially reduced.

VIII. *Cheese Moulds.*

An investigation into the possible role played by fungi in producing discoloration of cheese has been in hand for the past twelve months. This has necessitated a critical investigation of species and strains of those fungi found in association with discoloured areas. So far it has been ascertained that one strain of *Penicillium* is more or less directly involved in one type of discoloration.

IX. *Silage Investigation.*

Experiments have been initiated to ascertain the effects of various organisms on the preparation of grass silage. Preliminary work has shown that is is possible to alter the quality of silage by means of artificial inoculation. Attempts are being made to work out a technique whereby this may be made use of in farm practice.

X. *Forest-tree Diseases.*

(*a*) *Die-back of Pines.*—During the year investigations were made of a serious outbreak of disease in many of the afforested areas in the Dominion. It was found that the disease was due to two species of fungi (at present but tentatively named) attacking trees weakened by snow, frost, or as a result of growing in unsuitable soils or localities. It would appear that both are species of exotic fungi, probably introduced to nurseries with the seed, and from these to the field during the process of blanking.

(*b*) *Mycorrhiza.*—The economic significance of mycorrhizal fungi has been experimentally demonstrated. In experiments it was found that very material results were secured when *Pinus radiata* was grown in soil infected with certain fungi, as species of *Rhizopogon* and *Boletus*. Further experiments are in progress to determine the effects of four species of fungi on several different species of forest-trees, and methods of propagating and introducing these beneficial fungi into nursery soils.

AGROSTOLOGY SECTION.

Strain in pasture-plants dominated the work of this section during the year, and the improvements of strain have already been widely recognized both by the seed trade and by farmers.

In view of the fact that seed of pedigree strains is at first comparatively scarce, it would seem necessary to conserve lines of mother seed, in order to increase as rapidly as possible the supplies of high-grade seed.

Comparison of New Zealand rye-grasses with those derived from overseas indicates that the quality range in the Dominion is exceptionally wide, and that there occurs local types much superior to anything under test at Aberystywyth, and also other much inferior to the worst grown at this Welsh Seed Station.

Observations during the year showed that it is a comparatively safe practice to retain the seed for certification from lines once removed from permanent strains. No deterioration has been evidenced as a result of this practice, and, indeed, this fact should be utilized to exploit as far as possible all the available seed-growing areas of the Dominion.

The continuation of strain-selection work is being designed with a view to securing elite pedigree strains, and it is at present regarded as of utmost importance to continue the segregation of separate strains with a view to effecting general improvement of existing certified lines by both culling and selection.

The introduction of the ultra-violet-light method of differentiating true perennial rye-grass has rapidly speeded up the detection of true lines and the consequent work of seed-certification. Field trials have proved beyond question that a very complete correlation exists between ultra-violet tests and those conducted in the field.

Certified rye-grass grown in all parts of the Dominion has invariably given results markedly superior to those in general use, no matter what type of soil or climatic conditions prevail in the locality.

Investigations of cocksfoot indicate that there is a good deal of uniformity of type occurring with the New Zealand lines, and comparisons between New Zealand strains and those of Denmark show that the former are markedly superior from the pasture-yielding point of view.

Two hundred and fifty lines of *Agrostis* are under test in connection with certification, and have demonstrated the purity of New Zealand brown-top and the absence of contamination with red-top.

Work in connection with the dry-land type of brown-top promises well towards establishing an improved export trade in this seed, which has proved eminently suitable for the formation of fine close turfs for playing-areas.

Strains and selection work with Yorkshire fog, timothy, and red fescue are also proceeding.

White Clover.—The progress of the strain-selection work has indicated that there are two types which under New Zealand conditions appear to give superior results to the noted Kentish Wild type. The superiority exists in the lesser mortality rate of the New Zealand selections, and the fact that they give persistently high leaf-production throughout the whole year.

At present there are indications that the amount of flowering in the seedling year shows fairly accurately the type of the ultimate plant, those which seed freely being of the less persistent and less desirable types of white clover.

The selection designated "Type I" in all trials has made excellent growth of a dense leafy texture, and the strain showed its marked superiority, particularly during the late winter and early spring, when, despite adverse weather conditions, it commenced to make growth while all the other types still remained dormant.

Red Clover.—Special attention has been given to selections of Montgomery type red clover, which have been grown under a number of different soil and climatic conditions throughout the Dominion with a view to selecting strains which show distinctly persistent characteristics.

Similar trial-work is being carried out with subterranean clover and *Lotus major*.

Investigations on the regrassing of secondary-growth country in the Taranaki District have been continued, special attention being devoted to seed-mixtures and to methods of pasture-control.

Botanical Section.

Systematic botanical identifications of species of farm economic plants has been continued, and the volume of work has increased. Careful identifications are fundamental in connection with all experiments of an applied nature.

The Herbarium now contains over 7,500 specimens of indigenous and introduced species, while the section of foreign plants, made with special reference to the importance for research on the introduced flora, contains over 4,000 specimens. The Herbarium is a necessary adjunct to the identification work of the Station.

In order to make the identification work of greater value, specimens of grasses, weeds, and other farm plants are now grown, so that minute observations carried out on individual plants serve to eliminate the possibility of errors likely to arise through the examination of dried specimens.

During the year it has been possible to devote close attention to the strains and species of large groups of economic farm-grasses as represented by *Agrostis*, *Poa*, *Danthonia*, *Festuca*, and *Deyeuxia*.

During the year twenty new species have been added to the list of identified and naturalized plants. Among these specimens, some are of plants occupying considerable areas, evidently established years ago, though unnoticed up to the present. Some of these have decidedly undesirable characteristics, such as saffron thistle, squirrel-tail, *Oxylobium*, *Eupatorium*, and *Calycotoma*. The prompt identification of these undesirable species will give opportunity to place them under control before they have reached a stage when they occupy large areas and eradication made either very costly or almost impossible.

Examination of introduced species has indicated that grave danger arises through faulty identification, and two cases of real interest in New Zealand might be mentioned in this connection. A plant known as Canadian wild rice has on several occasions been introduced, and a considerable amount of what is alleged to be this grass is at present established on the Northern Wairoa River. Close botanical investigation has shown that the Northern Wairoa material is the Manchurian species, and one which has not the desirable characteristics of the Canadian. A species of *Heleenium* recently imported was found not to be true to name, but really a dangerous plant, on account of its poisonous nature to stock.

Systematic botanical investigations are also being made of rushes, piripiri (this in order to co-operate with the control of piripiri by the insect species *Antholcus* recently imported from South America), and brassicas, while co-operation is being maintained with the Royal Botanic Gardens, Kew, in the general systematics of the New Zealand flora.

Chemical Section.

Analyses of herbage samples from the Marton mowing trials, where different manurial applications were applied, have revealed the following facts :—

(1) Both the yield and the chemical composition of the herbage are superior in the pasture selected from those plots which have received frequent light dressings of fertilizers as compared with others receiving infrequent and heavier applications.

(2) The chemical composition of the herbage from plots treated with super has been shown to be superior to that from the slag-treated plots in respect to its content of lime, phosphoric acid, and protein.

(3) The belief that slag acted similarly to super and was equally effective, only at a slower rate, has not been borne out by these investigations.

In connection with the soil-investigation work, critical examination of the results has shown,—

(1) That the technique of sampling now adopted allows very accurate samples to be taken by the methods now in use.

(2) That there are indications that rapid leaching of added phosphates takes place in soils of the Marton type.

(3) That losses of phosphate appear to be reduced if the applications are small and applied at frequent intervals, as opposed to large infrequent applications.

(4) That, while it is generally believed that phosphates leach out of the soil very slowly, results obtained on the Marton soil indicate that in a case where 8 cwt. of super was applied, about three-fourths of this amount have been removed from the surface 6 in. of the soil in a period of two years. In this instance, the major portion of this loss of phosphate would appear to have been attributable to leaching.

(5) Trials of successive applications of sulphate of ammonia to pasture having had a depressing effect on yields, experiments were inaugurated with a view to ascertaining whether the depression could be attributed to the increasing soil-acidity, and the work carried out indicated that soil-acidity was not a factor which produced this result.

WHEAT RESEARCH INSTITUTE.

DIRECTOR'S REPORT.

Advisory Committee: Professor H. G. Denham (Chairman), Mr. C. H. Hewlett, Mr. James Carr, Mr. W. W. Mulholland, Mr. P. R. Talbot, Mr. R. K. Ireland, Mr. W. S. Pratt, Mr. R. J. Lyon, Mr. C. E. Boon, Mr. F. H. Hawker, Mr. G. A. Laurenson, Mr. A. G. Cannons, Mr. A. Jones, Mr. J. W. Hadfield. Director of Research: Dr. F. W. Hilgendorf.

The Institute has continued work with its former organization.

Wheat-breeding.

The object of this work is to produce a wheat that yields as well, and is as adaptable as Tuscan, but which is of higher milling-quality. The permanent experimental field of 26 acres was half under fallow and half under plots. These consisted of: (1) Yield trials of standard varieties; (2) yield trials of the cross-bred Tuscan by White Fife; (3) yield trials of pure line reselections of the same cross; (4) observation plots of the F_4, F_3, F_2, from sundry crosses; (5) F_1 plots; (6) parents for current year's crossing; (7) three chessboards of five or six varieties each for analyses of yield factors; (8) a collection of wheats from all over the world—over 2,000 varieties. The whole number of plots totalled 9,400.

The direction in which most progress has been made is with a cross of Tuscan by White Fife. Last year this yielded almost as well as Tuscan, and was markedly superior in milling extraction and baking-quality. In the harvest just completed it has again compared favourably with Tuscan in yield in two out of the three localities in which it was tried, but was distinctly lower in the other (Wakanui). The baking-quality has, however, proved very disappointing when compared with the Tuscan grown in the same field. This was of quite exceptional quality, and it is still possible that the crossbred may be superior to Tuscan in normal years.

Variety trials and certification of seed wheat are proceeding in co-operation with the Department of Agriculture, and the Institute acknowledges its great indebtedness to the Department for its work in these directions.

Milling, Baking, and Chemical Tests.

The scope of the work done at the laboratory in Christchurch may be seen from the summary of the work for the calendar year 1931.

Milling.

White flour—	
Variety trials	119
Manurial and smut treatments	35
Cut green and cut ripe	21
Harvester header	20
Ashburton Experimental Farm trials	27
Miscellaneous—	
Farmers, millers, stock and station agents	404
Wholemeals—	
Millers only	64
Total	690

Baking.

Variety trials	119
Manurial and smut treatments	35
Cut green and cut ripe	21
Harvester header	20
Ashburton Experimental Farm trials	27
Miscellaneous (from milling-samples)	404
Wholemeals (from milling-samples)	64
For testing of milks, malts, fats, and other flour improvers (about)	500
Distributors' flours	508
Millers' flour-samples other than Distributors	1,367
Bakers' direct	62
Bakers' indirect for articles	200
For heat-treatment laboratory trials	173
Total	3,500
All these are baked in duplicate	7,000

Chemical Work.

Protein survey	618
Protein milling-samples	626
Total	1,244
Moistures	860
Malt-testing—developing a suitable analytical method for rapid testing of wheat-malt plus malt-testing samples	70
Diastatic activity of flours	97
Complete analysis of animal-feeding stuffs ranging from cereals, cereal by-products, to fish-meals for blending purposes	69
Miscellaneous ash tests	36
Confidential chemical analysis of cereals, cereal by-products, and products used by bakers, &c. This work varied extremely, ranging from determination of crude fibre in baby-foods for the Plunket Society to various dairy by-products used by bakers	19

During the harvest of 1932 a great deal of wheat in South Canterbury and North Otago was spoiled by rain, and there was often grave doubt whether the wheat as threshed would be fit for milling. Samples of four hundred or five hundred lines were therefore sent to the Institute by merchants and millers to be milled and baked, and as a result many thousands of bushels which on inspection only would have been rejected and classed as fowl-wheat were accepted as milling-wheat. These tests necessitated the experimental mill being worked a double shift; the extra miller required was paid as to half his wages by Distributors Ltd., and the Institute expresses its gratitude to that body for its assistance.

In the table of operations for the year will be noted two items—Distributors' flours, 508, and millers' flours other than Distributors, 1,367.

That the millers sent in for baking 1,875 samples of their flour for testing, shows that they are doing all that lies in their power to keep up or improve the quality of their product. This must react favourably on farmers, in that it indicates an effort to produce the best flour from the wheat available, instead of looking overseas for foreign wheats of supposedly superior quality; and it must react favourably on the bakers and the public, as giving them the best flour that can be obtained from our home-grown product.

Work which is then done directly for millers is of advantage to all the industries who are contributing to the Institute.

NOXIOUS WEEDS RESEARCH.

Advisory Committee: Professor H. B. Kirk (Chairman), Mr. Q. Donald, Dr. F. W. Hilgendorf, Mr. A. H. Cockayne. Director of Research: Dr. David Miller.

Blackberry.—The researches on *Coraebus rubi* were continued throughout the year. Further observations show that the adult beetle has a strong liking for the foliage of important fruit-trees. Further, it is doubtful if the larvæ would be an effective check upon blackberry, since infested canes have not been killed, but continue growing. In view of all the evidence, it has been decided to discontinue the researches on *Coraebus* after the present observations have been finalized.

Gorse.—*Apion ulicis* was liberated in the field early in 1931, and during the present year further extensive liberations have been made in Otago and at Nelson. Examination of the area in Otago, where the weevil was first liberated, showed that infestation of the gorse-pods had taken place.

Ragwort.—During the past season a total of 957,300 *Tyria* eggs were distributed throughout the Dominion. No further consignments of this insect will be imported, since there are now sufficient supplies available in the Dominion. The insect is well established at several points, where it is having a decided influence upon the ragwort. By itself, however, it is unable to cope with the weed, and to overcome this difficulty a seed-infesting fly has been imported, and is now being studied and reared.

Piripiri.—The pre-pupae of *Antholcus varinervis* imported from Chile during 1930 developed to pupæ, and gave an excellent supply of adults. The latter readily oviposited in the foliage of New Zealand *Acaena* (piripiri), and from these eggs a good supply of larvæ was secured and reared to the prepupal stage. Early in 1932 a large consignment of pre-pupæ was received from Chile and arrived in excellent condition. With the adults from this consignment and from the material reared last season, the researches will be continued this winter. There is every indication that *Antholcus* will prove an important check upon piripiri.

FLAX RESEARCH.

Progress during the period under review has consisted mainly of the normal development of the selection and hybridization scheme originally undertaken.

The "fans" planted for rootstock selection are in many cases now old enough for their fibre qualities to be judged, and it is evident that several strains of very high quality have been secured. The selection of strains resistant to yellow-leaf disease requires a longer period, since it is unsafe to base conclusions on the immunity of only three or four plants. Several otherwise good strains have already been shown as most susceptible to the disease. The number of varieties collected as "fans" has not increased greatly during the year, on account of the reduction in travelling.

Hybrids.—The first hybrid plants are now four years old. They are mostly the result of crosses between S.S. (resistant) and 13 K (less resistant). Most of these are now large bushes about 9 ft. or 10 ft. high, and some already have been culled out on account of susceptibility to disease. The more promising of these bushes have been broken into "fans" and set out in order to increase stocks and to test them further for disease resistance. Other hybrids, mainly between S.S. and Ngaro, to the number of about twenty thousand are being grown for selection of the best types.

Pedigree Seedlings.—The seedlings grown pod by pod for a study of inheritance and to develop pure lines have grown excellently. It is already apparent that while the seedlings, in general, breed true to the parent in habit of growth, yet there is great variation in leaf and fibre characters. Genetical study of pedigree seedlings and of hybrid seedlings has provided a great deal of interesting material concerning the inheritance of certain characters. It is not proposed to publish the results until they have been tested by further hybridization during next summer.

Several thousand two-year-old and three-year-old pedigree seedlings are being destroyed, since lack of money prevents their being set out in a plantation.

Yellow-leaf.—Since Mr. Meadows's appointment terminated, at the beginning of the year, no laboratory work on the cause of the disease has been possible. A considerable amount of observation has been carried out concerning the onset and progress of the disease. This has been facilitated by the considerable and not-unexpected spread of the disease in our main area. Selection and hybridization to secure resistant strains is still the main line of attack on this disease.

Manurial Trials.—These trials were set out largely in order to test the effect of fertilizers on yellow-leaf disease. In the main trial area careful examination shows that so far none of the dressings has any effect on the disease. The plots treated with blood-and-bone are showing the best growth on the College farm. On account of the curtailment of travelling, it has not been possible to keep under observation the manurial trials in other districts.

Growth of Leaves.—In August, 1931, there was taken in hand the careful measurement and recording of growth in leaves. This was carried out on some fifty plants of vegetatively propagated Ngaro, and provided some interesting results. The work required about two days in each week, and when economy made it necessary to dispense with our laboratory assistant in December the work could not be carried on. Growth in length of approximately 2 in. a day was recorded at times. Comparisons of leaf-growth between healthy and yellow-leaf-affected bushes gave especially significant results.

Fibre-testing.—Preliminary work has been carried out in an attempt to find the most accurate and rapid method for testing fibres without previously passing them through a stripper. It has been found that fibre hand-dressed from leaves in the Maori fashion does not give a true criterion of the strength of the total fibre of the leaf. The search for an accurate testing method is being continued.

J. S. Yeates.

MINERAL CONTENT OF PASTURES RESEARCH.

I. FOURTH ANNUAL REPORT, DEPARTMENT OF AGRICULTURE.

Mr. B. C. Aston, Director of Research.

The mineral content of pastures investigation is a research carried out conjointly by the Chemistry Division of the Department of Agriculture and the Cawthron Institute. As the result of the accumulation of information regarding the mineral composition of improved and unimproved pastures of all types and at all seasons in many parts of New Zealand, it is now possible to devote attention, for the most part, to the remedying of the deficiencies revealed.

Bush Sickness.

The most important feature of the year's work has been the conclusive demonstration of the efficacy of finely ground limonite (hydrated oxide of iron) in preventing and curing bush sickness in sheep. With the knowledge that breeding-ewes can be maintained in perfect health, and can produce a normal percentage of high-class lambs, which in turn can be fattened or reared for flock purposes at a trifling increased cost and trouble, the problem of bush sickness can at last be deemed to have been satisfactorily solved. The evidence for this claim is based upon a large-scale experiment using limonite mixed in equal proportions with salt as a lick for breeding-ewes and lambs. Limonite is procurable from the Whangarei district, where the supplies occur naturally, and, after grinding, are incorporated with salt to form a lick.

Originally, spathic iron-ore (iron carbonate) was tried, but was abandoned because of its costliness, irregular quality, and the difficulty to secure regularly samples of even grade.

The field experiment was conducted at Atiamuri, a locality in the Rotorua district well within the area affected by bush sickness. From a flock of two thousand ewes, four groups of fifty were selected between two and three years of age. All had been on the property for at least two years. The groups were subjected to the following treatment:—

Group 1: Control, no lick.
Group 2: Lick containing iron and ammonium citrate, and salt.
Group 3: Lick containing Whangarei hydrated iron oxide (limonite) and salt.
Group 4: Lick containing spathic iron-ore and salt.

All groups grazed the same paddocks in rotation. Possibly owing to taste, the iron-citrate lick was only sparingly consumed, but the iron-oxide lick was taken freely. The quality of the spathic iron-ore was poor, and consequently was likely to have yielded only a small supply of iron.

In each of the groups twelve ewes were selected for weighing at monthly periods. By mid-February all the lambs in the control and citrate groups were dead. In the iron-oxide group forty-four lambs from forty-five ewes were well developed, robust, and with a healthy bloom in their wool, while the ewes were bright and healthy. Only sixteen of the control ewes survived, and were in poor condition, while twenty-four of the citrate group survived, and were in slightly better condition than those of the control group. Post-mortem examinations of lambs from the limonite and from the main flock showed that, while the latter was badly infested with worms, the former was entirely free, thus giving some indication that the iron-oxide treatment enabled the lambs to resist parasitic infection. The results may be tabulated as follows:—

——	Ewe's Weight.		Lambing Percentage.		Surviving at February, 1932.	Weight of Ewe's Fleece, 20th February, 1932.
	5th May, 1931.	8th February, 1932.	At Birth.	When marked.		
	lb.	lb.				lb.
Limonite group	120	128	100	90	98	8·1
Iron ammonium-citrate group	112	92	62	16	Nil	7
Control group	114	72	76	50	Nil	6½

Experiments with the incorporation of iron in ensilage have been continued, and it was found that cows which refused to take an iron lick and had sickened were readily cured when fed with treated ensilage. Good results have been secured from feeding limonite to dairy cows and calves, and it has also proved useful when used as a drench for animals already sick.

Evidence is available from dairy-farmers located in the bush-sick areas of the efficacy of the limonite licks made available for their herds, and it would appear that already a large number of farmers in this area have no longer any fear of being unable to cope with bush sickness.

Experiments in this district, where the practice of green-manuring has been adopted, indicated that stock showed decided preference for the grass growing on areas so treated.

On the Mamaku Demonstration Farm, which has for long been seriously affected by bush sickness, and where the original iron-ammoniun-citrate treatment had been in vogue for a number of years, a change was made to the use of the limonite salt lick in January, 1932. With the change, no sickness has been reported, the whole herd has done splendidly, and the lick is freely consumed. Before the change was made, sheep which sickened on the property had to be sent out of the district to recuperate, but it is anticipated that the adoption of this treatment will now render such action unnecessary.

Waitomo County: Stock Deficiencies.

In consequence of a spring season exceptionally favourable to mortality in sheep in the Mairoa district, even a good top-dressing with lime and super was not adequate to prevent a somewhat disastrous experience with the sheep experiments in this locality, the mortality being high, although checked to some extent by the fertilizer top-dressing. It is probable that lack of an adequate supply of cattle to control surplus feed contributed to the result, and consequently, as some of the paddocks top-dressed with 5 : 2 and 3 : 2 superphosphate mixtures had only been stocked for a short time, it was thought advisable to commence a new series of experiments, using sheep from an outside district, and at the same time providing adequate control of growth by means of cattle. In the meantime, numbers of pasture analyses, both from the Mairoa and the Kopaki experimental areas, have been made. The most striking features of the Kopaki soil are high content of phosphoric acid and lime, low content of iron, small seasonal variation in mineral composition, and the lack of marked response to top-dressing.

Estimation of sulphur in the pasture-analyses from the experimental paddocks at Mairoa revealed no significant increase in sulphur content, as the result of manurial applications of gypsum.

Te Popo District, Taranaki.

In this district sandstone hills have a thin covering of volcanic ash, upon which grows a pasture composition for the most part of danthonia. Lamb mortality, especially in very young lambs, has been high in this district, where it is also most difficult to rear fat lambs. The fact that the pasture is composed largely of danthonia makes it unresponsive to phosphatic top-dressings, but the health of the stock was greatly benefited by making available to them a lick comprised of iodized salt, bone-meal, oxide of iron, and molasses.

Morton Mains District, Southland.

In this district increasing difficulty is being experienced in rearing lambs. The nature of the soil is alluvial, of a leached silty loam texture overlying gravel of rounded quartz. In general contour the land is undulating with many boggy depressions. Until recently the country was stocked generally with cattle, which before phosphatic top-dressing was adopted was often affected by Waihi disease. The pastures on this area were frequently broken up for cropping, and were treated with heavy applications of either burnt or ground lime, but when sufficient phosphate was applied to the soil Waihi disease disappeared. Sheep, however, could not be successfully reared in the absence of cattle. Sickness usually appears in December, when lambs which have thrived up till then become low-conditioned, anæmic, dull, and lustreless in their wool. The mortality is large, death occurring rapidly, while ewes, and even wethers, sicken in some seasons.

Various licks have been tried, but so far without result. However, as the disease may be a modified form of bush sickness, the limonite and salt lick is at present being given a careful trial.

Pasture analyses made so far have indicated no deficiency of any of the usual mineral constituents, both phosphorus and lime being present in adequate amounts, though there are some indications that the iron content is lower than the average.

Analyses of ewes' milk and of bones from sick lambs have been made, but, although the bones were apparently somewhat abnormal, the work is not sufficiently far advanced to allow any opinion to be expressed.

A somewhat similar trouble in calves on new bush-burn peaty soil, near Riverton, undoubtedly due to iron deficiency, has been cured by the administration of iron-ammonium-citrate.

Bovine Eclampsia in the Waikato District.

This disease occurs on a number of farms in the Waikato district, and, as it was thought that excessive amounts of nitrates or nitrites in young pasture might be a predisposing factor, estimates of these were made in a number of pasture-samples collected. Analyses indicate that very little difference occurs in the nitrate content of affected and unaffected pastures, while the figures for phosphoric acid and calcium did not afford any means of distinguishing affected farms from those more fortunate.

Miscellaneous.

(*a*) An outbreak of bone-chewing and falling-off in milk-yield in North Taranaki was shown to be due to overstocking during a seasonal drought. The addition of superphosphate to the drinking-water is indicated as an appropriate remedy for such occurrences.

(*b*) Severe illness occurring in a dairy herd near a superphosphate-works was traced to the condensation of fumes containing fluorine on the pasture, through the use at the works of North African rock phosphate.

(*c*) Flax-strippings analysed to determine their value as supplementary stock-feed showed a content of only 5·95 per cent. protein in the dry matter, an amount too low to render this a satisfactory stock-feed.

(*d*) Thyroid glands of sheep and lambs have been obtained from animals of known history, and analysed for iodine content, in order to determine the occurrence of iodine-deficient areas in New Zealand. In association with this, experiments have been continued with rabbits to ascertain which minerals affected iodine metabolism in such a way as to produce goitre. Results indicate that if the animal is not receiving sufficient iodine owing to its being on an iodine-deficiency diet, or owing to the presence of minerals exercising a depressing effect, the total amount of iodine in the thyroid glands tends to be depleted.

An experiment on cows indicated that the amount of iodine in the blood was dependent upon the amount fed by way of licks, and upon the time which elapsed between dosing and sampling. The blood content of the iodine showed a very sudden rise to the maximum, with a more gradual fall subsequently to normal.

II. FOURTH ANNUAL REPORT, CAWTHRON INSTITUTE.

Mr. T. Rigg, Director of Research.

During the period under review the work has embraced the following principal investigations: (1) Bush sickness; (2) influence of fertilizers on the yield and chemical composition of typical Nelson dairying-pastures; (3) the relationships between soil-fertility and the chemical composition of pastures. The more important features arising out of these investigations are summarized below.

I. Bush Sickness.

Investigations at Glenhope, Waimea County, Nelson, have shown that a stock ailment, particularly associated with sheep-farming on certain granite soils in the Sherry and Hope Valleys, has all the symptoms of typical bush sickness described by Aston in connection with certain volcanic soils of the North Island. The investigations have shown that the chemical characteristics of three soil-types in the Glenhope locality—two of which are healthy and one unhealthy for stock—present no outstanding differences other than a low iron content in the unhealthy soil. The iron soluble in dilute oxalic acid is much lower in the unhealthy soil than in the others.

Analyses of pasture-samples collected from three types in the Glenhope locality did not show lower iron figures for the unhealthy pasture than was the case with the Moutere Hills pasture, which is not associated with bush sickness.

The chemical examination of a wide range of soil-samples collected from the volcanic districts of the North Island revealed a somewhat similar result. Two soil-types, named Kaharoa and Taupo, which are associated with bush sickness were found to contain a lower content of total iron than was the case with healthy volcanic soils. When extraction of the soils was made with 5 per cent. oxalic acid the amounts of iron found in the unhealthy soils were very much lower than proved to be the case with soils known to be healthy. The low "available" iron content of all the soils known to be affected with bush sickness supports an hypothesis that this ailment is caused by a deficiency of iron. The occurrence or non-occurrence of bush sickness on pastures which, like those of the Glenhope pastures, contain similar amounts of iron in plant-tissue appears to be dependent on the amount of and of the quality of the soil eaten by stock when grazing pasture.

The greater the facilities presented for soil-contamination of pasture and the higher the content of available iron in the soil, the greater should be the freedom of stock from bush sickness or similar ailments. Data have been presented showing that in the case of pastures located on (*a*) the unhealthy granite soil of Glenhope and on (*b*) the healthy Moutere Hills soils an amount of soil-contamination of pasture as low as 0·4 per cent. of the green material eaten by stock would make a great difference in the iron intake of stock.

Experiments conducted by Gilruth and Aston in New Zealand and by Orr in East Africa give considerable support to the hypothesis that soil iron is a very important factor in determining the incidence of bush sickness.

II. Influence of Season and Fertilizers on the Yield and Chemical Composition of Typical Nelson Dairying-pastures.

Careful studies have been made of the effect of both season and fertilizers on the yield and chemical composition of two typical Nelson pastures.

One important aspect of these investigations is the influence of season and fertilizers on the percentage of dry matter contained in mixed pasture. Determinations made over a large number of samples taken throughout the year showed that the dry-matter content of pasture was very high during periods of drought, and also in the winter, when growth was very slow. Low figures for dry-matter content were found in the spring and early summer periods when optimum growth was being made. The seasonal average for dry-matter content taken over a series of sixteen plots representing eight different manurial treatments was 21·35 per cent. The lowest average percentage of dry matter was 16·7, and the highest was 33·6.

The percentage of dry matter in the mown pasture was but little affected by the manurial treatment of the plots. A small depression in the percentage of dry matter occurred on those plots which were treated with ammonium sulphate.

The type of flora and the nature of the sward did not materially affect the percentage of dry matter when pastures at the same growth stage were compared.

Another important aspect of the pasture studies has dealt with the effect of season and fertilizers on the chemical composition of pasture. Droughty soil conditions not only greatly reduced pasture-yield, but very adversely affected the content of soluble ash, nitrogen, potash, and phosphoric acid. The lime content, however, did not follow the curves for the other constituents. The highest percentage of lime occurred during the drought period, when the lowest percentages of the other constituents were found.

The effect of fertilizers in increasing the content of phosphoric acid or potash was clearly marked in the case of the plots receiving superphosphate and sulphate of potash respectively. One of the most striking fertilizer effects on chemical composition was the great reduction in lime content which accompanied the frequent use of ammonium sulphate. The widest difference in the lime percentages occurred during the drought period of March, when the following percentages were obtained on the different plots :—

Plot No.	Treatment.	Lime (CaO).
		Per Cent.
6B and D	Untreated	1·97
6	Five applications of ammonium sulphate at rate of 1 cwt. per acre ..	1·62
4 and 5	Complete manure plus five applications of ammonium sulphate at rate of 1 cwt. per acre	1·37
4 and 5	Complete manure with 2 cwt. of ammonium sulphate per acre ..	1·26

Another aspect of the detailed studies on the chemical composition of pastures is that connected with the effect of season and nitrogenous manures on the inorganic and organic sulphur contents of perennial rye, white clover, and mixed-pasture samples. The results of this investigation showed that the highest percentages of inorganic and organic sulphur were obtained in the spring and early summer when optimum moisture conditions prevailed. During periods of drought the sulphur figures fell to a much lower level.

The influence of ammonium sulphate was particularly marked on the inorganic-sulphur content of both rye and mixed pasture.

A relatively great increase in the inorganic-sulphur content occurred in these cases as a result of the treatment. The effect of ammonium sulphate on the organic-sulphur content of rye and mixed pasture was much less marked, the average figures for the season being approximately the same as those obtained on the control samples.

In the case of white clover, ammonium sulphate exerted only a small effect on either the inorganic or organic sulphur content. The average figures for organic sulphur were, however, consistently higher with ammonium sulphate than was the case with the control samples.

No close correlation was found in this investigation between protein content and that of organic sulphur.

III. Soil-fertility and Pasture Composition.

The investigations have shown that in a number of cases where marked deficiencies of lime and phosphate occurred in the pasture soil-analyses using the conventional methods adopted by agricultural chemists have brought out striking differences in the lime and phosphate status of soils, provided soil-sampling was done to a depth of 3 in., and not 9 in., which has been used hitherto in soil studies. Even in cases of less-marked deficiencies of lime and phosphate, provided sampling was done to a depth of 3 in., the soil-analyses generally revealed a much smaller content of these constituents than was the case with soil-samples from adjoining treated pastures.

General.

During the year under review the following papers have been published or have been prepared for publication.

Published—

No. 10 : "Influence of Fertilizer and Crop on the Plant-food Status of the Soil," by T. Rigg, H. O. Askew, and L. Bishop.

No. 11 : "Note on Effect of feeding Titanium Oxide to Sheep," by H. O. Askew.

No. 12 : "Occurrence of Bush Sickness at Glenhope," by H. O. Askew and T. Rigg.

No. 13 : "Occurrence of Bush Sickness on the Volcanic Soils of the North Island : Part II — The Mechanical and Chemical Characteristics of Bush-sick Soils," by T. Rigg, assisted by L. Hodgson.

No. 14 : "Soil Iron in Relation to the Incidence of Bush Sickness," by T. Rigg and H. O. Askew.

No. 15 : "The Importance of the Depth of Soil-sampling in Studies relating to the Mineral Content of Pastures," by H. O. Askew and T. Rigg, assisted by L. Bishop and O. Barton.

No. 16 : "The Effect of Season and Fertilizers on the Dry-matter Content of a Nelson Dairying-pasture," by T. Rigg and H. O. Askew, assisted by L. Bishop and L. Hodgson.

Prepared for publication—

No. 17 : "Influence of Season and Nitrogenous Fertilizers on the Inorganic and Organic Sulphur Contents of Perennial Rye, White Clover, and Mixed Pasture," by H. O. Askew and L. Bishop.

PAKIHI SOILS RESEARCH.

FOURTH ANNUAL REPORT OF INVESTIGATIONS CONDUCTED BY THE CAWTHRON INSTITUTE.

During the period under review the experimental plots of pasture and of *Phormium tenax* laid down in previous years have been continued.

Several new series of pasture plots have been established at Sergeant's Hill in order to test further points connected with the reclamation of pakihi land. In addition, a commencement has been made at Sergeant's Hill with the establishment of a small dairying-farm. Ten acres of an initial area of 25 acres leased from Mr. C. Lemon have been sown in grass according to the methods and treatment recommended by the Institute.

As a result of the success which has been obtained in the Westport experiments, several farmers have sown in grass areas of their own pakihi land. One block of 33 acres, adjoining 6 acres of pasture established by the Cawthron Institute on what was locally known as Wood's Farm, has been sown by Mr. E. Skilton, who recently purchased this property. At Onekaka, between Takaka and Collingwood, Mr. F. G. Gibbs has sown an area of 75 acres of pakihi land. Officers of the Cawthron Institute have acted in an advisory capacity to Mr. Gibbs in the preparation and treatment of the land prior to pasture-seeding. The area at Onekaka was sown towards the end of March, and a good strike of grasses and clovers has been obtained. On the drier portions of the property, where discing was carried out in order to secure a suitable seed-bed, perennial-rye has made excellent growth.

Pasture Experiments.

The plots which have been established during the last four years are still making satisfactory growth, and heavy cuts of hay have been taken from many plots during the summer. All established pasture plots receive a top-dressing of 2 cwt. superphosphate per acre in July. Where hay has been repeatedly cut and removed from the land, sulphate of potash at the rate of 1 cwt. per acre has been given in addition to superphosphate, in order to maintain the potash supply of the soil.

The grazing of established pasture on pakihi land has effected a wonderful improvement in the textural qualities of the soil. The spongy peaty layer has consolidated in a remarkable way, and the soil has improved greatly in aeration and drainage qualities.

The following data for soil-samples taken to a depth of 6 in. from untreated pakihi land and from grazed three-year-old pasture illustrate the great difference in textural properties which has resulted from the establishment of pasture and its grazing by stock :—

—	Untreated Pakihi Soil (in Native Vegetation).	Pakihi Soil in Pasture (grazed for Two Years).
	Per Cent.	Per Cent.
Water content*	58·2	40·7
Loss on ignition	21·8	11·7
Relative weight of dried soil (equal volumes)	100	151

* Samples taken, 10th June, 1932.

Preparation of Seed-bed.

The experiments have continued to show the success of surface treatment without resort to ploughing in the preparation of the seed-bed. Where the soil is deep and moist, simple burning of the pakihi vegetation, followed by the distribution of lime and fertilizer and double harrowing with an improvised set of harrows, has enabled an excellent stand of grasses and clovers to be obtained.

Where the soil is somewhat thin and the surface is hard and dry, discing in order to obtain a shallow mulch has given better results in pasture establishment. The experiments have shown the desirability of delaying seeding until the surface is sufficiently moist to secure rapid germination of the seed and a quick strike of the young plants.

Use of Lime.

The experiments continue to show the importance of applying at least 1 ton of ground limestone per acre in the treatment of the land. In so far as the initial establishment of pasture is concerned, no great advantage over the 1-ton application of ground limestone has been observed by the use of 2 tons of ground limestone per acre. On the other hand, plots treated with $\frac{1}{2}$ ton only of ground limestone per acre are inferior to those treated with the 1-ton application, using 5 cwt. superphosphate in each case in the manurial treatment of the land. Plots treated with only 5 cwt. of ground limestone per acre plus the standard amount of superphosphate are poor compared with plots treated with the larger amounts of lime. The response, however, even with this small amount of lime is surprisingly good.

Use of Phosphatic Manures.

The experiments have shown the supreme importance of liberal phosphatic manuring in the treatment of pakihi land. The best results have been obtained by the use of 5 cwt. of basic slag or of superphosphate per acre in conjunction with liming at the rate of 1 ton of ground limestone per acre. Plots sown with only $2\frac{1}{2}$ cwt. of phosphatic manure instead of the standard 5 cwt. dressing have resulted in a comparatively poor growth of grasses and clovers.

Retention of Lime and Phosphate by the Soil.

Under the high rainfall of the West Coast—80 in. to 100 in. per annum—it was thought possible that the downward movement of lime and phosphate would be rapid. Two series of soil-samples taken from treated and untreated pakihi land have shown on analysis that the phosphate added in manures is held tenaciously by the top 3 in. of soil. In the case of lime the analyses indicate that the downward percolation of lime is more rapid, but after two years the enrichment of lime compounds in the soil below a depth of 6 in. is not great.

Use of Inoculating Soil.

In the early experiments conducted by the Cawthron Institute on pakihi land, it was thought possible that in view of the small bacterial population of the untreated land the inoculation of the land at time of sowing mixture would help materially in the rapid establishment of clovers. Plots sown with and without soil inoculation have shown little difference, probably indicating that the seed carries sufficient bacteria to enable normal development of clovers and lotus. Sowings on the field scale have confirmed the plot results, and inoculation of the land prior to pasture seeding has been abandoned.

Grass-seed Mixtures.

In so far as the initial establishment of pasture on pakihi land, where little is done in the preparation of the seed-bed, is concerned, the inclusion in the seed mixture of suitable amounts of white and red clovers, lotus, alsyke, crested dogstail, and fog are important. All these make good growth in the early stages of establishment. Perennial rye, cocksfoot, and paspalum are not prominent during the first two years after sowing, but show more vigorously as consolidation of the land is effected under grazing. Where the land is drier, and where discing is employed to secure a seed-bed, growth of both rye and cocksfoot is much better. For the wet conditions on the West Coast the following mixture of grasses and clovers has given the best results: Perennial rye, 8 lb.; Italian rye, 6 lb.; cocksfoot, 4 lb.; brown-top, 2 lb.; crested dogstail, 2 lb.; Yorkshire fog, 2 lb.; white clover, 4 lb.; red clover, 2 lb.; alsyke, 1 lb.; *Lotus major*, 1½ lb.; *Lotus augustissimus*, ½ lb.: total, 35 lb. per acre.

Grazing Established Pastures.

Records have been kept during the past season of the amount of grazing afforded by pastures which at the commencement of the season had been down for three years. Dairy cows were grazed on one block, yearling heifers on another, and hoggets on a third. In every case stock has kept in good condition. The dairy cows have milked well, and both the heifers and hoggets gained rapidly in weight.

Particulars of the grazing on the three blocks are recorded below:—

Block I (Area, 6 acres, located on Wood's Farm, off the Main Gorge Road).—Monthly grazing record in cow days: October, 14; November, 158; December, 180; January, 84; February, 60; March, 45; April, 35; May, 35: total, 611.

In addition, a horse had intermittent grazing on the 6-acre block. This grazing could be safely estimated at not less than the equivalent of 14 cow days, making a grand total of 625 cow days for the season, or 104 cow days per acre. During those periods when the block was spelled the cows had but poor grazing on the open pakihi. On this account the cows came back to the 6-acre block in a hungry state, and consequently the actual grazing was heavier than would appear from a consideration of the actual number of cow days recorded. For the whole year there can be little doubt that the pasture under good management would have carried not less than one-third cow per acre.

Block II (Area, 1$\frac{1}{16}$th acres, located at Sergeant's Hill, Westport).—This block was grazed by yearling heifers. The following is the monthly grazing record, in heifer days: November, 28; December, 112; January, 98; February, 47; March, 31; April, 30; May, 31; June, 10: A total of 387 heifer days on 1$\frac{1}{16}$th acres = 365 heifer days per acre.

On the basis of two heifers being equivalent to one dairy cow in consumption of pasture, the block has given grazing equal to 182 cow days per acre during the season. For the full year the figures indicate that this pasture would carry half a cow per acre.

Block III (Area, $\frac{7}{15}$th acre, located at Sergeant's Hill, Westport).—This block was grazed by four hoggets. When feed was scarce the sheep were transferred to an adjacent block where somewhat similar grazing was available. A record was kept of the actual grazing on Block III, which provided 796 lamb days for the whole season, or the equivalent of 1,705 lamb days per acre. The figures indicate that the pasture would carry over four and a half hoggets per acre throughout the year. This is equivalent to nearly half a cow per acre in carrying-capacity. During grazing the hoggets increased in weight from an average figure of 87½ lb. per head early in November to 111½ lb. per head on the 7th March.

Phormium tenax.

Good growth of flax has been made on a number of the experimental plots. The best result has been secured with the complete treatment consisting of lime, phosphate, potash, and nitrogen. The omission of nitrogen from the treatment has been noticeable at once in poor colour and reduced growth. The omission of phosphate from the treatment has resulted in very little growth of the flax-plants. Plots without phosphate, even although supplied with the other plant-foods, were as poor as the untreated plots.

The omission of potash from the manurial treatment has had, so far, no marked detrimental effect on growth of the flax-plants.

Tree-culture.

Very marked differences in the suitability of different trees for pakihi land have been noticed during the past season. The best results have been obtained with *Pinus densiflora*, followed by *Pinus ponderosa* and *Pinus radiata*. *Thuja plicata* has not done very well, while *Cupressus Lawsoniana*, *Cupressus Benthami*, and *Cupressus macrocarpa* have proved failures.

General.

Owing to the wide interest displayed in the pakihi experiments, it has been found desirable to publish a guide to the experimental plots, so that visitors may have all the information before them when making their inspection. A popular pamphlet, entitled "The Conversion of Pakihi into Dairy Pasture," has also been published for the benefit of farmers wishing to break in areas of this land on their own properties.

Thomas H. Easterfield.
T. Rigg.

PIG RECORDING.

A grant made by the New Zealand Meat-producers' Board has enabled the pig-recording work to be continued in the Auckland District under the immediate control of the Waikato Pig Recording Club. Through this means there is at present being accumulated a mass of valuable data regarding growth-rates, response to feeding, influence of strain, and general efficacy of pig-management. These records have been made available to this Department. The Department has facilitated the investigations conducted on selected lines of pig-carcasses forwarded to Great Britain for special inspection and report.

The Department's Liaison Officer, Mr. Nevill Wright, has generally arranged for the whole of the inspections, chemical and cooking tests, and the compilation both of statistical and photographic records of the experimental consignments in England. These results have been transmitted to New Zealand, and the information gained therefrom made available to the Pig Recording Club.

In the aggregate, the amount of information concerning the suitability of New Zealand pigs for the overseas trade is now fairly considerable, and would indicate that the quality of the carcasses at present being forwarded meets fairly satisfactorily the requirements of the overseas buyers.

PORK AND BACON.

In order to supplement the trials arranged through the Waikato Pig Recording Club, and also the examination of those carcasses forwarded to Great Britain, a number of chemical investigations into the nature of pig meat have been carried out in the Dominion Laboratory.

Special attention has been devoted to the quality of the fats occurring in pig flesh, and their behaviour in regard to the onset of rancidity, the development of taints, and the absorption of flavours. These investigations are throwing important light into the influence of feed, storage, and treatment upon the quality of New Zealand pork and bacon, and in some cases they are fundamental as adequate guides to pig-management practices.

WOOL.

Massey College.—As a result of investigations continued during the year, a stage has now been reached when it is possible to assess rapidly and readily any development of medulated fibre which may have occurred in the fleece. This will enable work to be done in co-operation with breeders on investigations relating to the influence of quality of feed and climate on the production of hair. In this work the use of the Benzol test has been of great practical assistance. On the evidence collected to date, it would appear that heredity is the factor primarily responsible for hairiness, and that such factors as feed are able to produce their results only through their influence on hereditary tendencies to produce medulated fibre. This, however, requires further study over a wider range of flocks than has been possible up to the present.

Investigations have been commenced upon mycotic dermatitis, a disease of wool which has only recently been detected as occurring in New Zealand. Research has also been devoted to the diseases termed pink rot, cakey yolk, and green coloration of wool.

Fleece-testing and Wool-testing.—A good deal of attention has been devoted to ascertaining methods whereby a simpler method of fleece-testing may be evolved, and its consequent use as a guide towards flock-testing.

Other investigations are those dealing with the problems of the chemical nature of wool-yolk, and on the parasitic nematodes of the sheep. In addition, there is being accumulated a large amount of data connected with sheep-management.

Lincoln College.—Observations dealing with variation in the fibre type of the Romney fleece, with a view to ascertaining whether the birth-coat provides any indication of the character of the ultimate fleece, have been continued, but no conclusive results have yet been secured. The occurrence of coloured fibres in the fleece has been under investigation from the breed point of view.

Researches are in progress on mycotic dermatitis. Investigations have also continued on the influence of breeding upon fleece weight, and information is being accumulated which should ultimately throw considerable light upon this matter.

Washing and scouring tests of samples of wool to determine yields of clean wool have been commenced, and the results secured to date show that there is a considerable range of variation between the weight of greasy and of scoured fleeces. The variations are of such a nature as indicate that it is necessary to follow up this work by a closer relation of the fleece weights to the individual animals under observation.

The occurrence of medulated fibres has shown that the result of hereditary influences on the occurrence of this defect are exceedingly variable, but the breeding trials have not been continued for a sufficiently long period to enable the full import of this matter to be accurately assessed.

FUEL RESEARCH.

Advisory Committee: Colonel W. D. Holgate (Chairman), Professor H. G. Denham, Mr. C. C. Davis, Mr. W. Donovan, Mr. W. A. Flavell, Mr. A. H. Kimbell, Mr. H. Vickerman, Mr. T. O. Bishop (Secretary, Coal-mine Owners' Federation), Dr. E. Marsden (Secretary, Fuel Research Committee).

Laboratory Staff: W. A. Joiner, M.Sc., A.I.C.; W. G. Hughson, M.Sc., A.I.C.; A. K. R. McDowell, M.Sc., A.I.C.

At the commencement of the year a bulletin was published containing the results of low temperature carbonization experiments on Millerton (Westport) and Blackball coals. These experiments were briefly described in the report for the preceding year. During the year work has been carried out on the utilization of both bituminous and "brown" coals, and the work is summarized under appropriate headings below.

Examination of Tar-oils.

Early in the year an examination of low-temperature tar-oils was commenced upon tar-oil produced in the laboratory from Waikato coal. Shortly after this the Waikato Carbonization Co.'s plant at Rotowaro commenced operations and work was continued on tar-oils produced by this plant. It is considered that a fairly complete examination of the tar-oils is of considerable importance to the industry. Although certain fractions could undoubtedly be disposed of as fuel oil, the return in this way would be small, and other more profitable means of utilization should be investigated. As a fair proportion of the binder used in briquetting the char at Rotowaro is derived from the low-temperature tar-oil methods of increasing the yields of pitch were studied. Blowing the heavy fraction of the tar-oil with air at various temperatures, and with or without catalysts, in many cases gave increased yields of pitch, which, however, were not always suitable as briquette-binders. From the results obtained it would seem to be worth while to carry out further experiments on a larger scale.

Efforts have been made to produce an effective sheep-dip or disinfectant from the lighter fractions of the tar-oils, and, although satisfactory products have been produced, from a chemical standpoint their biological efficiency has not yet been thoroughly tested out. Arrangements have been made for this work to be done elsewhere, as this laboratory is not equipped for such investigations. In the meantime a chemical investigation of the tar-oils is proceeding.

Briquetting.

A large number of briquetting tests have been made with a small laboratory hydraulic press on the efficiency of treated pitches, as mentioned above. This work was extended to the briquetting of Lurgi char, as some difficulty was being experienced in making briquettes which would stand up satisfactorily in the fire under forced-draught conditions. By mixing a proportion of coking coal with the char this could be largely obviated. Alternatively, it was shown in the laboratory that a rapid evolution of volatile matter from the char took place between 700° and 800° C., which would have a tendency to cause the briquettes to open up when heated. A carbonizing temperature of over 700° C. was suggested, and this effected a considerable improvement in the briquettes. At the beginning of December, 1931, the semi-large-scale Yeadon ovoid press was put into operation, and briquetting trials have been made with Westport, Liverpool, Paparoa, Reefton, and blends of bituminous and "brown" coals. The press is capable of treating several tons of coal per day, and it is thus possible to obtain sufficient briquettes for large-scale firing trials. Briquettes made from bituminous slack, such as Westport, proved superior to the screened coal when burned in a domestic grate. This can be attributed to the shape of the briquettes and their regular size preserving a more open fire, in spite of the fact that swelling takes place in a similar manner to that of the raw coal. Swelling can be entirely reduced by blending with a non-coking coal, and blends of bituminous and "brown" coals produced a very satisfactory domestic fuel. Paparoa briquettes are very suitable for domestic purposes, and they have proved especially good under forced-draught conditions. The results so far obtained show that in some cases briquetting on a commercial scale could be recommended. Commercial developments will of necessity, however, be governed by the state of the coal-market, and the difference in costs of screened and small coal.

Railway Trials.

One of the staff (Mr. W. G. Hughson) has assisted in extensive railway trials throughout the year. Tests were conducted on the Auckland–Frankton and on the Thorndon–Paekakariki sections in a full investigation of the possibility of eliminating sparking from Waikato coals with the aid of the Langer combustion-control apparatus. Later in the year tests were conducted on the Christchurch–Springfield section both with and without the Langer combustion-control apparatus, and burning a wide variety in screen sizes of the following coals: Dobson, Wallsend, Goldlight, Liverpool, Paparoa, Tyneside, Blackball, Westport Main, Millerton, Briandale, Brunner, and Flower Creek (Reefton). The trials resulted in the accumulation of much valuable information, and have shown to what extent the use of run-of-mine coals can be increased. All data is incorporated in confidential reports to the Railways Department. The trials have also entailed an amount of laboratory work in analysing samples of the various coals used.

FRUIT COLD STORAGE RESEARCH:

Advisory Committee: Messrs. J. A. Campbell (Chairman), R. Sutherland, W. Benzies, F. W. Grainger, L. W. Tiller, A. M. Robertson, Captain W. Olphert, Dr. M. A. F. Barnett, and F. R. Callaghan.

Fruit cold-storage investigations are carried out as a joint activity of the Horticultural Division and the Cawthron Institute.

At the Cawthron Institute the investigations involve trials of manurial treatments on the storage quality of Jonathans and Sturmer apples; on the effect of light and heavy dressings of nitrogenous manures on Cox's Orange and Sturmers; on the influence of locality on the storage quality of Jonathan and Sturmer apples; and the effect of rootstocks on the storage of Cox's Orange Pippin, Jonathan, and Sturmer apples. These experiments, which have been conducted in land stores at Nelson, have proved the previous findings that a complete manurial treatment greatly assists in reducing wastage losses, while the response to nitrogenous manures has been shown to depend to some extent, at least, on varieties. While Statesman and Cox's apples show increased wastage as the result of both light and heavy dressing of nitrogenous fertilizers, Delicious show no adverse effect whatsoever.

During the year, in collaboration with the Cambridge Low Temperature Research Association, an extensive set of fruit cold-storage investigations was devised and carried out with the assistance of officers of the Horticultural Division. The experiments involved trials as to the effect of soil-types, maturity, handling, wrapping, and packing upon wastage in fruit sent overseas. Some two hundred experimental cases of fruit were sent forward for detailed examination in London, and a similar number representative of each trial were retained for inspection in New Zealand. In addition, one small trial shipment of passion-fruit was despatched, and the report received on this indicated that it was quite possible to transport this fruit successfully under ordinary ship's cool-storage conditions, while further attention to a few details was necessary in order to land passion-fruit in a form attractive to the British consumer. It is proposed to continue this work for a further season.

FRUIT RESEARCH.

Advisory Committee: Messrs. H. Vickerman (Chairman), F. Firth, A. M. Robertson, F. S. Pope, Thos. Waugh, H. E. Napier, Wm. Benzies, T. C. Brash, W. J. Rodger, A. H. Cockayne, J. A. Campbell, T. H. Easterfield, T. Rigg, and G. Shirtcliffe.

The fruit-research programme is being carried out through the co-ordinated activities of the Plant Research Station, Cawthron Institute, and the Horticultural Division of the Department of Agriculture.

Periodical meetings of investigators are held, when progress reports are reviewed and the whole programme of work discussed.

The field research work is conducted at the experimental orchard at Appleby, Nelson, an area of some 72 acres acquired specially for the purpose, and in a number of private orchards selected throughout the main fruitgrowing districts of New Zealand. At present the nursery-work is being conducted at the Plant Research Station, Palmerston North.

Research Orchard.

In order to acquire detailed knowledge of the trees proposed to be used for manurial trials individual tree yields have been recorded for two seasons, and on this information a series of trials has been planned in detail. Portions of the orchard have been used for spraying trials, insect and fungus investigations. The yield from the orchard during the past season was particularly good, some eight thousand cases being made available for export purposes. An outbreak of eye-rot disease, following heavy rain in December, was responsible for the loss of some three thousand cases. The fruit from the orchard was also called upon for the cold-storage research work conducted at the Cawthron Institute and by the Horticultural Division.

During the year increased office, storage, and living accommodation has been erected at the orchard, while improvements have been made to the spraying outfit and to the water-supply. A further area has been cleared and ploughed in preparation for the planting of experimental trees from the Nursery.

Insect Pests.

Attention has been devoted specially to codlin-moth, leaf-roller caterpillar, and red mite. The life-histories of all these insects under New Zealand conditions is being worked out carefully as an assistance to any control measures to be devised. It has been ascertained that only one brood of codlin-moth occurs in New Zealand each year in most fruit districts and that red-mite eggs appear to be of two distinct types, one of which has proved highly resistant to spray treatment.

Fungous Pests.

Black spot of pip-fruits has been studied during the year and the times of ascopore discharges in different districts ascertained with a view to suggesting a more effective method of control.

Investigations into fungous diseases causing wastage during cold storage has been continued, it being found particularly necessary to secure accurate identification of these rots before proceeding with detailed tests designed to devise methods of control.

Spray Materials.

Work has proceeded on the chemical composition of orchard sprays with a view to determining wherein their efficiency lay. Two very important practical results have emerged from the investigations. Firstly, the efficiency of a sulphur spray has been shown to depend entirely upon the fineness of the sulphur-grains themselves, and consequently colloidal sulphur excelled other forms in its effectiveness. Secondly, the virtue of lime-sulphur was shown to be estimated by its polysulphide content, and not by its relative density, as previously was the rule. Attention to polysulphide content will in future enable both russeting to be avoided and applications of this spray to be really effective.

Field-work in connection with sprays has involved tests of modifications of the Bordeaux formula and the use of this and other mixtures in the control of peach leaf-curl and bud-drop of peaches.

Tests have also been carried out with different summer and winter oil sprays for the purpose mainly of securing more adequate control of red mite.

Manurial Experiments.

Following on the records kept of individual tree yields at the Research Orchard for the past two seasons, and which have been subjected to close statistical analyses, blocks of experimental trees have now been selected for both permanent and temporary manurial trials designed to show the effect of both a full range of individual manures and combinations of manures upon tree-growth, fruit-yield, and fruit quality.

Observational manurial trials have been continued in some fifty-seven orchards throughout the different districts of New Zealand, using a full range of manures. In all instances, except in trees growing on rich soils, the additions of nitrogenous manures in promoting growth have been apparent. In the Canterbury and Hawke's Bay trials it would appear that applications of lime exert a beneficial effect upon fruit-colour.

Rootstock Investigations.

As the result of collection of rootstocks from most of the New Zealand nurseries, it would now appear that some nine types of Northern Spy may be isolated. This work is now being followed up by propagating varieties of each of these stocks with a view to ascertaining their influence on tree-growth, fruit-yield, &c. Contemporaneously further rootstocks will be secured from established orchards where the conditions of growth, yield, &c., which they have already produced can now be measured.

Trials are still proceeding with the East Maling stocks in order to ascertain such strains as may be suitable for New Zealand conditions.

LEATHER RESEARCH.

Advisory Committee: Messrs. J. E. Astley, A. E. Lawry, D. Phillips, and W. Donovan. Research Chemist: Mr. P. White.

There are two things necessary before an article can be sold satisfactorily. The first of these is that the quality of the material must be good, and the second is that the price must be right. The aims of the Research Association have been to keep these two essentials to the forefront. In past reports references have been made to practical and laboratory wear tests, water-absorption tests, and analyses of New Zealand sole-leather. The results of these tests have been applied to factory processes, with the elimination or modification of those tending to reduce the wearing-values of the sole-leather produced.

The methods of manufacture have been carefully considered with a view to the elimination of waste in materials, time, labour, and power as far as possible. In this way the cost of production has been lowered without reducing in any way the quality of the finished article.

The New Zealand tanners have been able to supply the requirements of the Dominion with leather of the desired quality and at a reasonable price. If this had not been possible the cost of leather would have advanced appreciably, following the rate of exchange, which makes imported leathers dearer.

The price of leather has advanced, it is true, but only to counteract the increased cost of tanning-materials, due to Britain going off the gold standard.

The opinions of a leading boot-manufacturer in England, and also one in Australia, were that New Zealand sole-leather was "good honest leather, price all right." It would appear as if the New Zealand tanners were now reaping the reward of their foresight in establishing the Leather Research Association, and also their own individual efforts in the improvement of their products.

It is realized that efforts must be maintained not only to retain the present high quality, but also to improve it. At the present, output is probably the main consideration; but now is the time to look for improved methods, lowering cost of production, and new outlets for leather. The low prices of hides and skins should enable leather to recapture some of the markets which the various substitutes have taken.

During the year the work in the laboratory has been maintained, in the absence of the Research Chemist in England, by Mr. F. G. Caughley, M.Sc. The action of lime and sodium sulphide on hides was investigated, with special reference to the problem of greasy leather. This was in continuation of the work previously carried out as to the cause and possible means of eliminating this defect. Reports as to how this trouble may be reduced, if not entirely eliminated, have been circulated to the members.

Investigations were commenced on the effect of time and temperature on the processes of soaking and liming, with a view to determining the modifications necessary to suit local conditions. This is necessary where it is not economical to maintain the temperature at a uniform point all the year round. Interesting results have been obtained which have a direct bearing on the methods of manufacture of both vegetable sole and chrome upper leathers. Special attention has been given to microscopical investigations in carrying out this work. It is realized that the microscope is one of the most valuable pieces of apparatus in solving some of the problems of the leather-manufacturer, and it is proposed to develop still further this aspect of the association's activities.

During the year the Research Chemist visited England, and valuable contact was made with the various Research Associations there. The interchange of ideas, new viewpoints with which to approach definite problems, and the broadening effect of the contact with other workers were some of the valuable results accruing from the visit. At the same time visits were paid to large and small tanneries, and boot-factories. The broad-minded attitude taken by these manufacturers was greatly appreciated, and it is hoped that the benefits derived were to some extent mutual. The slump in the markets for skins had led to the position that deer-skins could not be sold in New Zealand. Stocks were accumulating, with little possibility of disposal. One of the direct results of the visit to England was to open up a market for these skins, and at the same time to demonstrate the quality of the local product as compared with those of other sources. Direct contact has enabled a comprehensive idea of the requirements of this trade to be obtained, and it is expected that eventually this trade will be definitely established, and will in time help to reduce economically the number of deer in New Zealand.

Pelt Research.

During the past years research work on New Zealand pickled pelts has been carried out. The results of this work have already been experienced. Manufacturers in England obtained information of the work being carried out in New Zealand and by the British Leather Research Association. Purchases were made by these tanners to determine if any improvement had been made. Confidence was established, with the result that New Zealand pickled pelts are being used in large quantities there. The fact that America is now purchasing only small quantities of the Dominion's pelts has had the effect of considerably reducing the demand.

Consequently, prices are extremely low, and, low as they are, there is little doubt that but for the increase of the English trade they would have been considerably worse. There are many problems awaiting solution. These are being investigated both in England and in New Zealand. This is possible by the grant given by the Empire Marketing Board for this purpose, and also by the support of the English tanners. This collaboration between the producers and the consumers should have a good effect on the trade, which will lead to a product not only satisfactory to the purchasers in England, but in other parts of the world.

The interests of pelt and leather research are so bound up in one another that the results obtained are of great benefit to each other. This has already been demonstrated, as investigations of pelt problems have suggested another line of approach to a difficult problem in leather-manufacture.

STANDARDIZATION.

Consequent on the visit of Mr. C. B. Le Maistre, Director of the British Standards Institution, to New Zealand, a representative meeting was called of those interested in the standardization movement, when it was decided that the Development of Industries Committee should undertake the launching of the local Standards Institute.

It was decided that the institution should consist initially of a Council and four Technical Committees, as follows: (1) Chemical; (2) Engineering; (3) Electrical Engineering; (4) Building.

The Council was to consist of two representatives from each of the sections, together with one representative from each of the following: Chamber of Commerce; New Zealand Manufacturers' Federation; Society of Civil Engineers; Development of Industries Committee; University of New Zealand.

Meetings of the various committees were called, and it is felt that once the Institution is fully organized, much good work of real assistance to industry will be accomplished.

SECOND ANNUAL REPORT OF THE CENTRAL NORTH ISLAND RECONNAISSANCE SOIL SURVEY.

In continuation of the work undertaken last year, in which the more important soil-forming volcanic showers were identified and their approximate boundaries mapped in the north and north-west sectors of the central territory, attention has been directed in the field to the detailed survey of a number of important blocks which have been proposed for settlement purposes by the Government.

Field-work.

Detailed soil surveys have been made by the field workers, Messrs. L. I. Grange and N. H. Taylor, assisted by Mr. Jones, of the Geological Survey, of a considerable area in the Rotorua, Bay of Plenty, and Urewera districts. In all, thirteen blocks have been mapped in detail for the Department of Native Affairs. In addition, soil maps have been made of the Galatea Estate for the Department of Lands and Survey, and a considerable amount of work has been done on the Waihaha–Tihoi–Poukani–Tirohanga Block, lying west of Lake Taupo.

In connection with the work of the Department of Native Affairs, the surveys made by the field workers include the following blocks: Horohoro, Parekarangi, Te Peka, Tiohonga, Wharenui, Puketawhero, Tikitere, Mourea, and Taheke, in the Rotorua district; Maketu and Rangiuru, in the Bay of Plenty; Rangitahi, in the Rangitaiki Valley; and Ruatahuna, in the Urewera country. The total area covered by the detailed soil surveys is 60,000 acres.

The soil surveys show that three very distinct soil types occur on the different blocks. These types have resulted from the weathering of volcanic ash of different origin. They are associated with (1) Taupo volcanic-ash shower, (2) Kaharoa volcanic-ash shower, (3) Rotomahana volcanic-ash shower. Each of these volcanic-ash showers is responsible for distinctive properties in the soil, but several sub-types occur in each case, due to slumping, river resortment, and textural differences in traversing country from the vicinity of the eruptive vent to the outskirts of deposition.

A report by Messrs. L. I. Grange and N. H. Taylor has been prepared of these detailed soil surveys, and is published in the report of the Geological Survey Office (see page 40).

Chemical Work.

At the Cawthron Institute a large number of chemical and mechanical analyses of soil samples has been carried out by Miss E. B. Kidson and Mr. L. Hodgson, in order to assist the field workers in the classification of soils and in the characterization of their properties.

The mechanical analyses have shown that soils derived from the Taupo volcanic ash are usually of the sandy-silt texture, but that on certain blocks, particularly the Waihaha–Tihoi Block, to the north-west of Lake Taupo, the sand texture is predominant. In the case of soils derived from the Kaharoa volcanic ash the texture varies from coarse and medium sands to gravelly sand. In the vicinity of Te Puke soils of the sand texture predominate. Near Rotorua, however, the texture of soils derived from the Kaharoa volcanic ash is usually of the gravelly sand type. In the case of soils derived from Rotomahana ash the texture varies from sandy loam to coarse sand. The sandy loam type, however, is more prominent than the coarse-sand type. Soils derived from the Tarawera lapilli are frequently of the gravelly sand texture. This type is met with on a part of the Galatea Estate.

Estimations of available plant-food, the determination of pH values and of lime requirement have been made on a number of samples secured by the field workers from the blocks which have been mapped. The analytical data in connection with available plant-food show that soils belonging to the Kaharoa series are frequently low in available phosphoric acid. Deficiency of phosphate is also very marked in soils derived from the old Egmont volcanic showers, and even in the case of the Taupo series the percentage of phosphoric acid is below normal. The percentages of phosphoric acid in the Rotomahana ash and in many alluvial soils derived from the resortment of volcanic material are much higher.

In the case of available potash the figures are much better, and in a number of instances are outstandingly high. Certain samples from Maketu contained percentages in the vicinity of 0·08 per cent. available potash, and many samples ranged from 0·02 per cent. up to 0·03 per cent. Where, however, the Kaharoa gravel sand texture was encountered, the percentage of available potash was somewhat low.

All the samples which have been examined have shown an acid soil reaction, the pH values ranging mainly between 5·0 and 6·0. The lime-requirement figures have shown a much greater range than pH values, and in certain cases figures as high as 0·75 per cent. have been obtained where high loss-on-ignition figures occur. Generally speaking, high lime-requirement figures are associated with old weathered deposits of the Egmont and Mairoa series. The lowest lime-requirement figures have been associated with the Rotomahana series, soils belonging to the Taupo and Kaharoa series falling into an intermediate group.

Soil Iron in Relation to the Incidence of Bush Sickness.—In pursuance of the suggestions made by workers at the Cawthron Institute concerning the role of soil iron in connection with the incidence of bush sickness, further work has been undertaken by Miss E. B. Kidson in order to ascertain (*a*) the

solubility in dilute acids of certain iron compounds which have been used as stock-licks with apparently good results on land where bush-sickness or allied stock-ailments have caused serious trouble; (*b*) the effect of fine grinding on the solubility of iron compounds in dilute acids; (*c*) the amounts of soil iron which can be extracted by dilute acids from typical samples of all the soil-forming volcanic showers in the Central North Island Territory. In earlier reports it has been shown that 5 per cent. oxalic-acid solution extracts very different amounts of iron from typical bush-sick soils on the one hand, and from other volcanic soils which have been considered healthy by stock men. This strength of oxalic acid has been employed to determine the solubility of limonite, spathic iron-ore, and magnetite, the former two of which have been shown to be helpful in combating bush sickness. The results of the analyses, using this reagent, have shown that in the case of limonite relatively large amounts of iron were extracted, but in the case of ferrous carbonate the quantity of iron extracted by this reagent was relatively small. The analyses have also shown that even 1 per cent. oxalic acid extracted a large amount of iron from limonite and that the fineness of grinding of the limonite ore materially affected the analytical results. The results indicated that in order to secure maximum solubility the limonite ore should be ground to pass a sieve with not less than sixty meshes to the inch. In view of the fact that hydroxide of iron must form a considerable percentage on well-aerated soils of the more easily soluble iron compounds, the use of dilute oxalic acid would appear to be valuable in determining the relative amounts of more easily available soil-iron compounds in different volcanic soils.

A number of determinations on different volcanic soils using both N/10 oxalic acid and N/10 hydrochloric acid indicated that the results obtained with oxalic acid were more consistent with the known iron deficiencies of the soils.

The Available Iron Content of Typical Bush-sick Soils.—Determinations of available iron, using N/10 oxalic acid, have been made on nine typical bush-sick soils. The soils comprise a sample from the granite formation at Glenhope, Nelson; a sample from the Kaharoa series at Waerenga, Rotorua; and seven samples from different locations on the Taupo series of soils. In every case bush sickness has caused serious trouble, and in several instances has greatly hindered the use of the land for animal husbandry. In the case of the nine samples, the percentages of available iron range from 0·43 to 0·69, giving an average figure of 0·57 per cent. iron oxide (Fe_2O_3). The lowest percentages were found in the case of the Glenhope granite soil and the Kaharoa sample. The Taupo samples, with one exception, were considerably higher in available iron.

Determinations of available iron made on three other samples taken from properties on which bush sickness, although present, did not give serious trouble showed a somewhat higher percentage of iron. The percentages in the three samples range from 0·71 to 0·82 iron oxide (Fe_2O_3), the average being 0·77.

Estimation of Available Iron in Typical Healthy Volcanic Soils.—A large number of soil-samples taken from other volcanic-soil types on which bush sickness is not known has been examined and the amount of available iron soluble in N/10 oxalic acid has been determined.

Four samples taken from the Rotomahana series showed a variation in iron of 1·51 to 1·82 per cent., the average percentage being 1·61 iron oxide. Three samples from known healthy locations on the Mairoa series gave figures varying from 1·97 to 2·24 per cent., the average being 2·15 per cent. iron oxide. In the case of the Tongariro series two samples of soil gave 1·68 and 2·35 per cent. iron oxide respectively. Five samples of soil taken from different locations in connection with the Egmont volcanic soils gave figures ranging from 1·38 to 2·5 per cent. iron oxide, the average being 1·94 per cent. In the case of the Hamilton series, four samples of soil taken in the vicinity of Hamilton and Te Awamutu gave figures varying from 2·9 to 3·80 per cent. iron oxide, the average being 3·34 per cent. Two samples taken from the Tirau series near Putaruru gave 1·29 and 1·32 per cent. respectively of iron oxide. A sample taken from Eskdale, on the Taupo series, and which is stated to be healthy for stock, contained 1·12 per cent. of iron oxide. Several samples taken from the healthy soils of the Waikato Plains gave figures ranging from 1·74 to 2·50 per cent.

The results of the iron estimation made on bush-sick soils and healthy volcanic soils definitely show much lower percentages of iron soluble in N/10 oxalic acid where bush sickness occurs, and the use of this reagent appears to have considerable value in predicting the probable incidence of bush-sickness or healthiness of soil in the case of land which is in process of development. Further confirmation of the association of comparatively high iron figures on healthy volcanic soils is provided from our examinations of soils taken from what are known as "change" fields. These fields are used as change pastures for ailing stock in districts where bush sickness is experienced. They have been found by experience to enable recovery of the affected animals to take place in a comparatively short time.

Five samples taken from Hamurana, from lakeside flats, Rotorua district, and from Tirau, all gave comparatively high figures for available iron. The percentages range from 1·29 iron oxide to 4·26, the average being 2·81.

Field observations in conjunction with estimations of available iron have shown that variations in the amount of available iron may be experienced on any property located on those showers which are known to be associated with bush sickness. The presence of a coating of Rotomahana ash even of a depth of 3 in. confers distinct benefit to the soil in so far as stock is concerned. The outcropping of underlying volcanic showers higher in available iron is thought to be responsible for the freedom from bush sickness of certain areas on different farm properties. The action of streams and rivers in resorting volcanic-ash material and in depositing fragments of rock brought sometimes from a considerable distance has in a number of cases resulted in the formation of soils healthy to stock. These soils contain much larger amounts of available iron than typical volcanic-ash samples which have not undergone resortment.

Available Iron in Sedimentary Soils.—A considerable number of samples taken from soil types derived from sedimentary formations have been analysed for available iron. The results have shown that the majority of these sedimentary soils contain relatively large percentages of iron soluble in N/10 oxalic acid. Two exceptions, however, have been noted in which the percentage of available iron is as low or lower than that found in soils subject to bush sickness. At the present time no explanation is available concerning the reasons for the apparent non-occurrence of bush sickness on these soil types. It is possible that plants grown on these soil types are able to acquire more iron than is the case on typical bush-sick soils. The whole question requires further investigation.

T. Rigg,
Director of the North Island Soil Survey.

PUBLICATIONS.

During the year six new bulletins were published as follows:—

No. 30: "Wool Research," by D. J. Sidey.
No. 31: "Pasture Investigations," Parts I, II, and III, by A. W. Hudson.
No. 32: "Bush Sickness," by T. Rigg.
No. 33: "Butterfat Losses in Buttermilk," by W. H. Udy.
No. 34: "The Nutritive Value and Vitamin Efficiency of New Zealand Dairy-produce," by Misses M. Herrick and M. G. Frengley.
No. 35: Wheat Research Institute—Second Annual Report.

RESEARCH SCHOLARSHIPS.

Two National Research Scholarships, with an annual value of £100, have been awarded during the year. The holders of these scholarships, and the researches upon which they are respectively engaged, are as follows:—

I. R. Sherwood, Auckland University: Synthesis of Diterpenes. (Extension for one year.)
E. R. Cooper, Canterbury College: X-ray Crystal Analysis.

"NEW ZEALAND JOURNAL OF SCIENCE AND TECHNOLOGY."

The *New Zealand Journal of Science and Technology* has been used for the publication of the results of various research activities which have been completed during the year. Reprints of articles from the *Journal* have been extensively used in the dissemination of results of researches to the industries concerned.

IMPERIAL AGRICULTURAL RESEARCH BUREAUX.

The Department acts as the co-ordinating link between the Directors of the eight Imperial Agricultural Research Bureaux, whose headquarters are all centred in Great Britain, and local correspondents in New Zealand. The various Bureaux have regularly issued valuable publications giving details of researches in progress in all parts of the world, and thereby facilitating contact between New Zealand workers and overseas activities. Numerous inquiries, seeking the assistance of the different Bureaux, have been transmitted through the Department.

It is evident that the inauguration of this research organization has been the means of facilitating and co-ordinating research activities in an essentially practical manner throughout the Empire.

RESEARCH WORK AT CANTERBURY AGRICULTURAL COLLEGE, LINCOLN.

I. Plant Breeding.

(*a*) *Cereals.*

(1) *Wheat.*—This work has continued in co-operation with the Wheat Research Institute, and has given the following results:—

(i) Tuscan has proved the best wheat on all light and medium soils.
(ii) Hunters is best suited to all heavy land.
(iii) Garnet is payable only when sown late on heavy soil, or as a spring wheat on light soil in a wet season.
(iv) Yeoman has possibilities on the heavy dairy-land type of soils in Canterbury, while Garnet and Solid-straw Velvet show promise in Otago wheat areas.

A useful test, the Pelshenke test, has been utilized for demarcating Canadian types of wheats.

(2) *Oats.*—Variety trials have been conducted with some sixteen separate varieties of oats, and yields determined for future reference. Two crossbred oats developed at the College—Algerians × Dunns, and Algerians × Gartons are still under trial.

(*b*) *Herbage Plants.*

(1) *Cocksfoot.*—A variety of selection is still being continued in order to determine suitable strains of cocksfoot for New Zealand conditions, and one—Strain C 23—has been multiplied sufficient to establish in a 10-acre field, which will be used for the production of mother seed. This type has shown distinctly promising characteristics regarding growth character, feed-production, and permanency.

(2) *Red Clover.*—Selection of perennial types of red clover and hybrids from these selections are still being tested with a view to securing types of a desirable kind. The work shows distinct promise, but as yet has not reached a stage when any considerable amount of improved strain seed is available.

(3) *Rye-grass, &c.*—Strain-selection work is also proceeding with rye-grass, danthonia, and other pasture grasses.

II. Sheep Investigations.

(1) *Winter and Spring Feeding of Sheep.*—Careful experimental work upon different systems of winter and early spring feeding of breeding-ewes has been continued, and have indicated that lambing percentages, average weight of wool per ewe, and weights of lambs and ewes are in large measure affected by defective winter feeding, when too much reliance is placed on grass, and too little use made of oat-sheaf chaff and meat-meal. This is well borne out in investigations which have indicated that ewes thin and poorly fed yield a gross profit of 7s. 6d. compared with one of 11s. 2d. from those that have been fed well consistently during the winter and spring months.

(2) *Relationship between Birth-weight and Daily Live-weight Increase.*—Investigations have shown, and have confirmed previous findings, that the rate of thrift of lambs was in proportion to their weight at birth, a fact which points to the importance of adequate winter feeding.

(3) *Feeding of Grain to Ewes and Lambs on Intensively Grazed Pasture.*—In order to test out the contention that under intensive grazing grass is too rich in protein to form a suitable diet for ewes and lambs, this system of feeding was tested out against another diet, which included an admixture of grain. The results indicated that, while the grain fed was of slight benefit to the ewes, it had no effect on the lambs.

III. Bran for Pigs.

Experiments have been inaugurated to test out the value of bran as a supplementary feed for pigs.

IV. Feed Value of Skim-milk.

On trials with calves it was ascertained that when veal sold at 2d. a pound skim-milk was capable of yielding a return of 0·45d. per gallon, ranging up to 1·8d. per gallon when veal reached a price of 5d. This gives a slightly higher return per gallon for skim-milk than when fed to pigs. With pigs the trial indicated that when pork was 4d. a pound skim-milk was worth 0·63d. per gallon, and 1·29d. per gallon with pork at 7d. a pound.

V. Veterinary Problems.

Investigations of treatment for rickets in hoggets indicated that a dose of $\frac{1}{4}$ oz. per day of bone-flour was effective in curing lighter cases of rickets, but did not compare with a treatment involving a daily dosage of $\frac{1}{4}$ oz. of bone-flour, plus 2 drachms of Radiostoleum, a standardized concentrate of vitamins A and D. This latter treatment produced marked improvements in the straightening of bones, disappearance of stiffness and lameness, and increase in weight. The percentage gained on the initial weight with this treatment was 32·5, in comparison with one of 11·8 with bone-flour only, and with 5·2 with the control sheep. The sheep weights in this experiment throw interesting light on the extent to which growth can be retarded when sheep are on a diet containing an insufficient amount either of lime or phosphorus. Age for age, animals affected with rickets are at least 50 per cent. lighter than the average Canterbury hoggets.

The fact that this mineral-deficiency disease occurs during the winter, when natural herbage reaches its lowest nutritive value and worm parasites are most aggressive, indicates how treatment for these latter may be followed by disastrous results. The results secured from the use of bone-flour and Radiostoleum cannot be attributed to their having special feeding-values, but merely as therapeutics designed to restore body functions to physiological normality.

VI. Lamb-mortality Investigation, Ashburton County.

During the year a number of farms in the Ashburton district were surveyed from the point of view of stock losses from disease. The highest incidence of disease from all causes on any farm inspected was 3 per cent., while the average was less than 1 per cent. As outbreaks of serious disease did not occur, these figures would indicate that stock-losses are inclined to be overestimated.

From fifty-two post-mortem examinations of lambs, wool-ball was shown to be by far the greatest cause of death. Investigations of this complaint seem to indicate that, owing to the presence of earthy material, grass-roots, and indigestible fibrous material in the stomachs of the lambs, lack of nourishment was the chief cause of the trouble.

Pulpy kidney, gastro-enteritis, inanition and phæmic nephritis were also causes of lamb mortality. The investigations generally indicated that too large a percentage of mortality has been attributed to pulpy kidney, and that the principal cause of mortality can be attributed to faulty diets.

VII. Farm Economics.

Farm-produce Prices.—Records of prices paid to farmers for wool, fat lambs, beef, butterfat, pork, oats, potatoes, wheat, perennial rye-grass, cocksfoot, and red and white clover seeds during the past thirty to sixty years have been compiled for the purpose of analysing future trends in annual and monthly prices. Investigations of actual farming-conditions at the present time in Canterbury indicate that farmers working largely on borrowed capital, after having reduced all other costs to a minimum, are faced with interest charges totalling some 75 per cent. of all costs. It is difficult at the present time to see any alleviation, except through reduction of capitalization and interest rates, or through a rise in the general price-level. In the meantime, in order to relieve the strain caused by the sharp fall in price-level, the effect of various temporary expedients has been examined.

Surveys of the beef cattle production, and of arable farming in New Zealand, embracing the results of statistical and farm-costing analysis, have been completed, while the compilation of data relative to farm-management, land-valuation, methods of land-settlement, income and expenditure for various types of farms is being continued.

A convenient small-farm account-book has been issued to enable farmers to record their business transactions during the year.

VIII. Chemical Work.

This has been mostly concerned with the analysis of samples of pure strains of grasses and clovers collected at monthly intervals during 1930 and 1931 with a view to ascertaining the changes occurring in the chemical composition of the grasses and clovers comprising normal Canterbury pastures.

A modification of the ultra-violet-ray apparatus for detecting perennial rye-grass strains has been elaborated. Records of yields of pasture from manurial applications of lime, super and sulphate of ammonia, super, nitrophoska, and leunaphos are being kept.

IX. Farm Implements.

During the year work has been concentrated on the measurement of grain-drill efficiency. Grass-drilling trials have been inaugurated, but no results are yet available owing to the fact that further attention will require to be devoted to the technique of drill operation before reliable trials can be inaugurated.

X. Farm-management.

During the past three years research has been proceeding into the methods of applying the latest scientific advances in agriculture to actual farm practice, both the methods and the results being assessed on an economic basis. Several Canterbury farms have been directed entirely by Mr. A. H. Flay, and, following an initial report and valuation, detailed records have been kept of all operations, both of cultivation and of marketing, carried out each year. At the end of the year the economic returns are reviewed in the balance-sheet, and profit and loss statements prepared. The result gives a good idea of the economic value of scientific methods of farming. On the farm which has been dealt with for the longest period under this system the budget has been balanced during the past two years despite the fall in prices, interest charges have been met in full, the earning-capacity of the farm increased, while the sheep-carrying capacity has been advanced from 160 ewes to some 540 ewes contemporaneously with an increase in the area on the farm devoted to crops. Were similar practices adopted generally—and there is no reason why they should not—the depression among the farming community would be by no means as acute as it is to-day.

In addition to the farms under detailed and complete control, there are some sixty to seventy others in receipt of periodical guidance, and who are following the guidance resulting from farm-management investigations. Consequently there are throughout Canterbury a number of farms where latest scientific developments are being put into practice along economic lines, and by this means the results of research are being disseminated widely.

XI. Iodine Investigations.

The research into the effect of iodine fed to sheep was continued with the experimental flock, the iodine being given in the form of potassium iodide. Records of the live weights of the ewes, hoggets, and lambs, lambing returns, and wool returns from dosed and control sheep have been kept. Examination of these records to date have shown that no significant results can be attached to the benefits or otherwise received by sheep grazing on a reputed iodine-deficient land when they are dosed regularly with iodine compounds.

DOMINION LABORATORY.

The work during the year has consisted principally of chemical analyses and investigations carried out on behalf of Government Departments. The numbers of samples received in Wellington from various Departments and Branches are as follows: Customs, 378; Police, 42; Geological Survey, 89; Main Highways Board, 334; Marine, 26; Mines, 464; Health, 3,591; Post and Telegraph, 30; Public Works, 283; Railways, 69; Stores Control, 36; Agriculture, 57; other Departments, 171. In addition, 29 were received from municipal and other public bodies, and 232 from miscellaneous sources. The total for the year was 5,832. The totals for the branch laboratories are: Auckland, 2,280; Christchurch, 2,278; Dunedin, 1,714. Of these, the greater proportion consists of milks and other foodstuffs examined for the Health Department. Quite a number in each centre were submitted by the Police Department.

Comment on the Work.

Defence Department.—As rifle-cartridges of New Zealand manufacture were developing slight cracks in the brass when kept for a long period, regular analyses of all brass used and of the nickel caps have been undertaken. The specifications for these materials is necessarily rigid.

Mines Department.—There has been renewed interest in gold-mining during the year, and the number of prospectors' samples for assay has increased considerably. Some attention has also been given to ores of antimony, chromium, and manganese.

Police Department.—Examinations of liquor and analyses in cases of suspected poisoning constitute the greater part of the work for the Police Department. In Wellington the following poisons were found in various cases: Aconite, cyanide, morphine, phenol (carbolic acid). There were two cases involving counterfeit coining. Two investigations were associated with murder charges. In Christchurch poisonous substances detected in connection with police investigations were prussic acid, arsenic, ergot, strychnine, tetrachlorethane, and methylated spirits. In Dunedin the samples examined consisted of beer, wine, medicine, partially burned articles from a fire, safe-linings in breaking and entering cases, and exhibits in poisoning cases. Methyl alcohol was detected in a case of supposed poisoning by methylated spirit. Strychnine was detected in another case of death from poisoning.

Public Works Department.—Numerous samples were submitted in connection with hydro-electric works. Mastic and bitumen for use at Arapuni were carefully examined. Galvanized hardware of numerous types was tested for efficiency of galvanizing. Used and reconditioned oils from several stations were examined for suitability for further use. Absorption tests were made of switchboard material and various types of porcelain fittings used in domestic installations of electric current. Sand for concreting was examined for salt content. A special investigation was made regarding the cause and extent of corrosion of a large coil of aluminium cable.

Post and Telegraph Department.—This Department required tests of sulphuric acid used in storage-batteries, of floor-polishing oils, of used lubricating-oils, fire-extinguishing liquids, and other miscellaneous supplies.

Gas Inspection.

Gas-supplies in the four main centres and in most of the other principal towns of the Dominion were regularly examined for heating-value, purity, and pressure.

Research.

Incidence of Goitre.—This research, undertaken in conjunction with the Health Department, was continued during the year. Special determinations were made of the iodine content of milk, eggs, vegetables, and urine from the Thames district, a somewhat anomalous area, where, although the iodine content of the soil is low, the incidence of goitre is also low.

Coal.—In addition to the work carried out under the Coal Research Association, the use of Reefton slack coal for blending with other coals for gasmaking was investigated. The results were circulated to gas companies by the Under-Secretary for Mines.

Bananas from Cook Islands.—The conditions under which bananas could be attractively ripened for the market were ascertained by numerous experiments in a small cabinet. A small room was fitted up later in which humidity, temperature, and ventilation were under control, and in this room two lots, each of twenty-eight cases, were successfully ripened. A full report will be issued shortly.

Kauri-gum.—A special investigation on the purification of kauri-gum chips by means of solvents has given very promising results, which have been confirmed in a small-scale intermediate plant. The process will be tried out on a commercial scale, and, if successful, should materially assist in reviving the kauri-gum industry.

Spray Research.—Careful analyses of various lime-sulphur sprays have proved of great assistance to the staff of the Plant Research Station engaged in the study of orchard diseases and their control. Similar work on other types of sprays is in progress.

Meat Offal.—Some work is being done on varying methods of treatment and packing of meat offal, such as livers, kidneys, &c., for export to Great Britain. There seems little doubt that the prices obtained for these goods would be enhanced if improved methods of packing were adopted.

The Director of the Laboratory has supervised the work of the Coal Research Association, and kept in touch with the Chemist of the Association for Leather Research. He was also associated with the late Mr. J. A. C. Bayne, Inspecting Engineer, Mines Department, and Mr. F. W. J. Belton, Engineer to the Christchurch Gas Co., in the preparation of a special report on the utilization of New Zealand coals.

W. Donovan,
Dominion Analyst and Director, Dominion Laboratory.

GEOLOGICAL REPORT.

REPORT OF DIRECTOR (DR. J. HENDERSON).

The Director, during the year ended 31st May, 1932, visited Kaikohe in North Auckland, Mahakipawa in Marlborough, the Howard Goldfield in Nelson, and several goldfields in Otago, including Nokomai, Alexandra, Ophir, Roxburgh, and Lawrence, as well as a few of the blacksand beaches along the south coast east from Waikawa. A report on the artesian water in the Hutt Valley was prepared for the Wellington City Council, but the publication of this and other reports is held over owing to lack of space.

Dr. H. T. Ferrar and Mr. J. H. Williamson finished field-work in the Te Kuiti Subdivision, where they examined 466 square miles, and returned to Wellington early in April. Mr. M. Ongley and Mr. H. E. Fyfe, for a time assisted by Dr. J. Marwick, examined about 600 square miles of the Eketahuna Subdivision. Mr. Fyfe spent a month in the Napier district, where he mapped the area surrounding the Heretaunga Plain. He was in the Gisborne district for a few days collecting samples of bentonite from outcrops near Whatatutu.

Mr. L. I. Grange and Mr. N. H. Taylor carried out soil investigations in the Rotorua district. They were so much engaged in mapping the soils of special areas for the Native and Lands Departments that they were able to devote but little time to the problems, the solution of which must precede any considerable advance in our knowledge of the formation of soils from volcanic ash under the conditions obtaining in New Zealand.

Mr. E. O. Macpherson, who had been lent to the Taranaki Oil Fields for several years, reported for duty at the beginning of 1932, and has since been employed in examining old alluvial goldfields and organizing the placing of unemployed on them. In the course of this work he visited the Collingwood, Takaka, and Howard goldfields in Nelson, and most of the diggings accessible from Queenstown, Newcastle, Cromwell, Clyde, Alexandra, Ophir, St. Bathan's, and Naseby, in Otago. He is to continue this work next season, when it is hoped he will visit the West Coast. He will also spend some time in Otago Central, there examining the quartz drifts that have contributed so much of the gold won in that province.

Dr. J. Marwick completed his investigation of the fossils from the Dargaville-Rodney, Motueka, and Kaitangata subdivisions, made preliminary examinations of fossils from the Te Kuiti and Eketahuna subdivisions, and prepared a card index of New Zealand Tertiary molluscs.

Over a thousand square miles were mapped in detail during the season, an area that, in the circumstances, must be considered satisfactory. Since no funds were available for employing field hands or maintaining camps, the geologists boarded where convenient or where they could. Only well-settled districts can be examined in this way, and, as much of the Amuri Subdivision is very sparsely inhabited, work there was suspended.

The only publications issued by the Geological Survey last year were the Twenty-fifth Annual Report and Palæontological Bulletin No. 13. L. I. Grange and N. H. Taylor wrote the section on "The Distribution and Field Characteristics of Bush-sick Soils" in "Bush Sickness," Bulletin No. 32 of the Department of Scientific and Industrial Research. Some members of the staff also contributed papers to the *New Zealand Journal of Science and Technology*. These are "The Ancient Glaciers of Nelson" (J. Henderson), "A Comparison of American and New Zealand Earthquakes" (H. T. Ferrar), "Conical Hills on Egmont and Ruapehu Volcanoes" (L. I. Grange), and part of "A Successful Experiment on Sheep-sick Country at Mairoa" (N. H. Taylor). This year, if funds permit, Bulletin No. 34 will be issued. The manuscript of Dr. R. S. Allan's report on the fossils of the Reefton beds also awaits publication. Other bulletins in different stages of preparation are those describing the Motueka, Kaitangata, Rotorua-Taupo, Murchison, Tongariro, and Wairoa subdivisions. A report on the Hawke's Bay earthquake is also ready for publication.

A great deal of correspondence has been attended to, many requests more or less connected with the work of the Geological Survey answered, and samples of rocks, minerals, and ores examined. The increased interest taken in gold-mining and in prospecting in general has greatly added to this part of the office-work.

During the year Mr. G. E. Harris drew for photographic reproduction nine large maps, eight block-drawings, and a number of graphs, sections, &c. He also prepared thirty-two field sheets for different officers and a number of tracings, as well as doing other miscellaneous work.

The only new text-books added to the library this year were a few received for review in the *New Zealand Journal of Science and Technology*. The periodicals were regularly received, as well as many valuable exchanges.

The death of Hartley Travers Ferrar at the age of fifty-two is recorded with the deepest regret. His wide knowledge of many branches of geology, especially of glaciology and pedology, was of great service. Early this year the New Zealand University had, for his work on the soils of Otago Central, granted him the coveted doctorship in science. His cheerfulness in all the trials and discomforts of camp life and his eagerness to help in any difficulty make those with whom he came in closest contact mourn his passing as a personal loss.

EKETAHUNA SUBDIVISION.

(By M. Ongley and H. E. Fyfe.)

The Eketahuna Subdivision, which extends forty-five miles along the east coast of the North Island from Cape Turnagain to Castle Point and reaches inland fifty miles to include part of the Tararua Range, like other parts of the east coast, has in it rocks smelling of oil and springs yielding hydrocarbon gas. Several wells have been sunk in attempts to get oil and have failed, and it is accordingly desirable that any further drilling should be preceded by geological examination to see if any more evidence can be obtained. If holes are drilled haphazard and fail, nothing is proved; but if the favourable parts can be located and tested, then the field will have had a fair trial.

As was shown in last year's report, the grain of the country runs north-east, parallel with the coast on the east and the mountains on the west, and it was stated that the northern part of the subdivision, forty miles wide from east to west across the strike, contains nine anticlinal ridges, mostly of pre-Tertiary rocks, alternating with nine synclinal valleys floored with Tertiary. This year some corrections must be made and some new data added.

The Puketoi Range, last year described as an anticline, is found to be a cuesta formed by the strong limestone on a westward-dipping homocline. Again last year it was reported that the beds between the Puketoi and Waewaepa ranges were synclinal or faulted; it is now evident that they are faulted and the west block is upthrown 2,000 ft., bringing up the greywacke in the Waewaepa Range.

About 600 square miles of country south of the area covered last season was mapped, and the structure and rock-formations were found to be similar—that is, the district consists of anticlinal ridges of Cretaceous rocks and synclinical basins filled with Tertiary rocks, trending east of north. The most easterly syncline, with its axis at Cape Turnagain, runs out to the coast near Herbertville, and south of that the ridge of Cretaceous rocks occupies the coast for at least twenty miles. This ridge is simple in the north, but south of the Waimata Stream, across the Akitio and Aohanga, and as far south as was examined—that is, for fifteen miles—it has a core of greywacke two to three miles wide, flanked on both sides by the Cretaceous hard shaly mudstone. The ridge is eight miles wide. Inland of it is the southern extension of the Te Awa Putahi syncline, also eight miles wide and filled with Tertiary beds. This is simple in the north, composite near Weber, containing anticlinal corrugations, and farther south simple again. The next Cretaceous range to the west plunges to the south. At Pongaroa it is four miles wide, and south of that the Tertiary beds close in and completely cover it. West of that is the westward-dipping homocline of which the crest forms the Puketoi Range. At the western foot of these is the big fault with 2,000 ft. throw that brings up the greywacke in the Waewaepa Range. From there to the Tararua Range, twenty-one miles away, is a broad synclinorium with a small anticlinal fold on each limb, and in the south-west two small greywacke ridges cropping out. East of the Tararua Range runs another big fault, along which the greywacke of the mountains is upthrown.

The structure can be summarized as four main structural "highs" forming ridges of old rock trending east of north, and four corresponding synclines of Tertiary beds, in places composite or corrugated with minor folds.

Geology.

The area mapped last season contains the same geological formations as that before examined, and a little more evidence about them has been gathered. In the previous report the greywacke rocks of the Tararua and Waewaepa ranges were classed as pre-Cretaceous (non-fossiliferous). This season in the Waewaepa Range we found *Aucella*, indicating an Upper Jurassic age. In the same range we found blocks of feldspar-porphyry and amygdaloidal basalt. The presence of the basalt suggests that the greywacke, though mapped as one formation, may consist of two. South of Eketahuna, also, the greywacke has in it tuff and vesicular basalt, together with interbedded marble containing the same *Aucella* as that found in the Waewaepa Range; no fossil has been found in the greywacke of the Tararua Range or that at Akitio and Aohanga.

The Cretaceous beds have yielded a few specimens of *Inoceramus*, *Belemnites*, a *Pecten*, and a *Limatula*, and probably contain Turonian and Senonian beds.

In several places the Tutamoe (Miocene) beds rest directly on the Cretaceous and contain conglomerate of pebbles of Cretaceous chocolate-coloured mudstone. Along the west of the Waewaepa Range, Te Aute (Pliocene) beds rest directly on the greywacke. Evidently there are major unconformities before the Tutamoe and before the Te Aute beds were deposited.

The Te Aute formation contains 2,000 ft. of beds, including three pebbly shallow-water limestones.

Economic Geology.

The most important economic work has, of course, been the geologic studying and mapping of the subdivision. Incidentally we have mapped areas of limestone (suitable for various uses), greywacke (suitable for roads, concrete, &c.), a small area of marble, and several small areas of pumice sand.

We inspected several reported coal-seams and found them valueless. We sampled several springs of natural gas, most of which contain 8 per cent. or less of ethane, but one has the following composition:—

Carbon dioxide	0·4
Oxygen	0·8
Unsaturated hydrocarbons	3·2
Methane	63·0
Ethane	31·5
Nitrogen	1·1
	100·0

TE KUITI SUBDIVISION.

(By J. H. Williamson.)

Field-work in the Te Kuiti Subdivision was completed this season. Since the final report is not likely to appear for several years, a summary of the geology of the whole district, together with a small-scale black-and-white map, has been prepared.

The Te Kuiti Subdivision is an area of 1,190 square miles lying south of Kawhia Harbour on the west of the North Island. It adjoins the Huntly-Kawhia Subdivision on the north, the Mokau and Tongaporutu-Ohura Subdivisions on the south (described respectively in Bulletins Nos. 28, 24, and 31), and extends some forty miles eastward from the Tasman Sea. Important limestones and clay deposits occur in the district, but this investigation has shown the improbability of the existence of any considerable amount of coal. The chief industries are agricultural, but here, as in some other parts of the central portion of the North Island, deficiency diseases in stock have developed on several farms. One of the reasons for this survey was to see if the rocks underlying the affected farms could in any way be connected with the occurrence of the trouble. Accounts of some of the results obtained have already appeared.

Physiography and Structure.

A depression extends north and south through the district. To the east rise the uplands forming the western part of the great central plateau of the North Island, and to the west broad uplands extend to the Tasman Sea. A well-marked zone of faulting, striking a little east of north and passing about seven miles west of Te Kuiti, forms the west boundary of the depression, but to the east the boundary is indefinite; the depression is rather a warped and broken fault-angle depression than a graben, although parts of it could be so regarded. North of Te Kuiti a north-east-striking fault diverges from the main fault-zone and forms the edge of a block extending from Waitomo to the north boundary of the subdivision and intermediate in height between the lowlands and the western uplands. In this part also the depression merges into the lowlands of the middle basin of the Waikato, where post-deformational infilling largely obscures the structure.

From Te Kuiti the land rises eastward for eight or nine miles to the crest of an anticlinal warp, and then slopes downward to the fault along the west base of the Rangitoto Range, highlands rising 3,000 ft. along part of the east boundary of the district. The warp dies out southward, and the sloping surface rises gently to the Maraeroa Plains (1,400 ft.), overlooking the downfaulted area drained by the Waimiha and upper Ongarue. A series of subparallel streams flow north-west down the slope of this large block, which forms most of the eastern portion of the subdivision; the Mokau and its tributaries to the south flow to the fault-angle and thence southward; the Mangaokewa and other streams to the north join the Mangapu, which flows north in the lowest part of the depression to the Waipa. The last-mentioned river rises on the sloping block, is diverted down the depression at the west base of the Rangitoto Range, and cuts across the anticlinal warp at Otewa.

The broad western uplands form a distorted and in parts deeply dissected plateau. A strong east–west fault, with upthrow to the north of several hundred feet, separates the northern third of the uplands from the main part of the plateau. This northern third consists of a large earth-block tilted gently north and west, and drained by streams flowing down its surface to Kawhia Harbour. The little-dissected central portion of the uplands, which slopes gently north-westward to the east–west fault, is drained by the Marakopa, a stream that flows west to the Tasman Sea along or near the fault; the upwarped western part of the plateau forms the Herangi Range; the southern part slopes southward, in which direction its deeply entrenched streams discharge to the Mokau.

North of the mouth of the Marakopa the uplands extend to the coast. South of that river a strip of relatively depressed country lies between the sea and the faults that bound the uplands. The Kiritehere and Waikawau are short deeply entrenched streams that cross the depressed strip from the steep west-facing scarp of the Herangi Range, which in Maungamangero rises to 2,656 ft.

The western uplands consist of an undermass of folded Mesozoic strata, on the planed surface of which rest horizontal or gently inclined beds of middle Tertiary age. Crustal movements during the late Pliocene caused the above-described faulting and deformation, which are quite independent of the folding and structure of the basal Mesozoic rocks of the district. These seem to be flexed into broad north–south folds. Thus the undermass of the western uplands consists essentially of a syncline a dozen or more miles across that plunges gently northward. Near the eastern edge of the uplands the strata seem to turn over to form an anticline, but east of this so much of the Mesozoic rock is concealed and so weathered and shattered are the outcrops that the structure could not be made out.

General Geology.

Correlation of the Mesozoic rocks is rendered difficult by the varying definitions of the series into which these strata have been divided in other districts, more particularly in the case of beds of Triassic age, and to avoid confusion local series names are used. The subdivision here adopted is based on an examination of two sections—one at Kawhia from Arawi Point to Waiharekeke Inlet, and the other on the coast south from Marakopa River to Ngukuhakare Bay.

The classification of the Tertiary and Mesozoic rocks is as follows :—

Series and Approximate Thickness.	Beds.	Age.
	Beaches, dunes, terraces, river-gravels, volcanic ash, pumice silts	Recent and Pleistocene.
Patetere (300 ft.)	Rhyolitic tuffs, subaerial, in places subacqueous	Pliocene.
Tongaporutu (100 ft.)	Yellow sandstone	Taranakian (Upper Miocene).
Mohakatino (400 ft.)	Tuffaceous sandstone, mudstone, and limestone ; Whareorino andesite	? Awamoan (Miocene).
Mokau (600 ft.)	Sandstone and shelly conglomerate ; coal ..	Awamoan (Miocene).
Mahoenui (400 ft.)	Mudstone and sandy limestone	Hutchinsonian (? Oligocene).
Te Kuiti and Whaingaroa (500 ft.)	Limestone and calcareous sandstone and mudstone ; argillaceous and glauconitic sandstone ; coal	Ototaran (Oligocene).
	Serpentine	Unknown.
Puaroa (2,000 ft.)	Conglomerate, grit, sandstone, and mudstone	Upper Jurassic (? Cretaceous).
Kawhia (10,000 ft.)	Mudstone, sandstone, grit, and conglomerate	Bathonian-Oxfordian.
Herangi (5,000 ft.)	Greywacke, argillite, grit, conglomerate, sandstone, and plant-beds	Lower Jurassic.
Otapiri (3,000 ft.)	Sandstone, grit, and argillite	Rhætic.
Marakopa (1,000 ft.)	Greywacke and argillite	Noric.
Whakahau (700 ft.)	Coarse sandstone, greywacke, and argillite ..	Carnic.
Oreti (2,500 ft.)	Conglomerate, greywacke, argillite, banded sandstone	Lower Carnic.
Moeatoa (4,000 ft.)	Igneous conglomerate and minor sandstone ..	Ladinic ? or older.

Moeatoa Series.—North of Ngukuhakare Bay there outcrops for 180 chains along the coast a coarse, indurated conglomerate composed chiefly of pebbles and boulders of granites and porphyries ranging in size from less than ¼ in. to 8 ft., and smaller pebbles of sedimentary rocks up to 8 in. in diameter. The boulders are angular, subangular, and rounded, the cementing medium is hard and compact, and the conglomerate is badly sorted and rudely stratified. Near Ngukuhakare Bay it contains pebbles of hard, dark, fine-grained greywacke. Occasional beds of sandstone, striking north-north-west and dipping east at 25° to 30°, occur near the top of the series, but in the lower part, where sandstone bands are absent, it is difficult to make out any bedding. The total thickness of the beds is estimated at 4,000 ft.

On the accompanying map the series has been shown as Triassic, but it may be older ; for throughout the Mesozoic rocks of New Zealand no similar beds have been found, the one most resembling it being a conglomerate near Clinton, described by Ongley, to which a Permian age is assigned on fossil content. No contact with underlying beds was seen, the conglomerate at its southern end being cut off by a fault with a downthrow to the south of more than 1,000 ft. Its relation to the overlying beds is not clear, but the break which is taken as the top of the series may well be erosional.

Oreti Series.—Overlying the Moeatoa Series are conglomerate and sandstone beds, followed by greywacke, argillite, and banded sandstones, striking generally north-west on the coastal section, and having a general north-east dip of 30°. Red, pink, or grey bands of coarse material, from 2 in. to 15 in. thick, occur at intervals. They may be tuffaceous, as Hector suggests for similar beds in the Oreti Series in the Hokonui district. No fossils were found in this section, but on stratigraphic and lithologic grounds the beds are placed in the Oreti Series.

Whakahau Series.—Beds containing *Maoria problematica* (*Mytilus problematicus*), which is the type fossil of the series, occur at several localities on the western limb of the syncline, and a good collection was obtained in an argillaceous bed in Whakahau Creek, a small tributary entering the Kiritehere Stream from the south near the mouth. On the eastern limb of the syncline it occurs in Oamaru Creek, Orahiri Survey District, in beds faulted against *Pseudomonotis* beds. It is now also recorded for the first time on the coastal section at Kawhia, between Arawi Point and the *Pseudomonotis* beds to the east. The series, which consists of argillite, greywacke, and coarse sandstone, is of Carnic age.

Marakopa Series.—Conformably following the Whakahau Series is a succession of sandstones and argillites, which is well developed in the south-west corner of Marakopa Survey District. This series is characterized by *Pseudomonotis richmondiana*, which occurs in crowded masses in a fine-grained grey sandstone outcropping on the coast. This fossil has also been found in abundance in Whakahau Creek, in a quarry in Kiritehere valley, and on the saddle between the Waikawau and Kiritehere streams with intruded andesite. It also occurs on the eastern limb of the syncline in the Triassic rocks extending north from Wairere Falls, and in the gorge of the Mokau down-stream from this point. Beds containing obscure carbonaceous remains outcropping on the coast just south of Kiritehere Stream are taken as the closing member of the series, which according to Trechmann's classification is of Noric age. Similar carbonaceous beds occur in some of the upper branches of the Waikawau River.

Otapiri Series.—Conformably overlying the *Pseudomonotis* beds at Kawhia is a series of beds 3,000 ft. thick characterized by the Rhætic brachiopod *Clavigerina* and correlated with the Otapiri Series. The beds extend south into the Te Kuiti district, and, though no Rhætic fossils have been found, the series must be well represented here. Accordingly the beds between the Marakopa Series and the overlying beds containing *Pseudaucella marshalli* are placed in the Otapiri Series.

Undifferentiated Triassic.—Hard greywackes and argillites classified as Triassic on lithologic grounds form the Rangitoto Range. Similar rocks outcrop over considerable areas in the eastern uplands and probably underlie all the younger rocks of that part of the subdivision.

Herangi Series.—Rocks of Jurassic age, characterized by *Pseudaucella marshalli*, are well exposed on the coast section extending south from Te Maika, at the entrance to Kawhia Harbour. The series, for which the name Herangi is proposed, begins at the conglomerate band indicated in Bulletin No. 28 as the base of the Jurassic and is closed by the plant beds at Te Maika and Totara Point. It forms the great part of the Herangi Range, where *Pseudaucella* boulders are commonly found in the beds of the creeks on both the east and the west. *Pseudaucella* is found also in the east of Orahiri Survey District on the eastern limb of the syncline.

The rocks of the series are fine-grained greywacke, argillite, and indurated claystone, overlain by 2,500 ft. of coarse-grained greenish sandstone, which weathers spheroidally. At Kawhia the beds have a total thickness of 5,000 ft.

The *Pseudaucella* beds of the Herangi Series are correlative with the Bastion Series of the Hokonui Range, and the plant-beds at Te Maika probably correspond in part to the Flag Hill Series. Sufficient work has not yet been done in the Te Kuiti district to enable a subdivision of the Herangi Series and a closer correlation with the Hokonui beds.

Kawhia Series.—Following the plant-beds which close the Herangi Series are softer argillites and sandstones with bands of igneous conglomerate and characterized by *Inoceramus* cf. *galoi*, *I. haasti*, *Aucella boehmi*, and *Astarte*. The section on which the series is based is exposed along the south side of Kawhia Harbour between Totara Point and Waiharakeke Inlet, where the overlying conglomerate is taken as the base of the next-succeeding series. The beds, where they outcrop on the harbour, dip regularly to the east, and show an apparent thickness of 10,000 ft. for the series. Examination of the beds of this formation exposed along the road between Kinohaku and Taharoa Lake reveals folding and faulting, and the actual thickness of the series may be less. The beds continue southward, and in Kawhia South and Maungamangero survey districts outcrop widely in the trough of the syncline and largely form the basement rock on which the overlying Tertiary beds rest. The series has a partial correspondence to the Putataka Series as defined by Hector in his classification of 1886.

Puaroa Series.—Near Waiharakeke Inlet, on Kawhia Harbour, a conglomerate forms the ridge east of Kinohaku and continues southward to Te Anga, where it occurs at the falls in the Marakopa River, and thence disappears under Tertiary limestone. It passes up into coarse brown and grey sandstones and soft shale containing ammonites and carbonaceous fragments. The beds from the base of the conglomerate to the top of the Mesozoic sequence in this locality are the Puaroa Series of this report. They are flat-lying in the trough of the syncline, and southward were eroded prior to the deposition of the Tertiary beds, so that they are not now found south of Te Anga. The series is in the main the Mataura Series of McKay, who, however, included beds as far west as Te Waitere, now definitely shown by Trechmann to be of Bathonian–Oxfordian age. Pending an examination of the ammonites it is tentatively placed in the uppermost Jurassic.

Te Kuiti Series.—Overlying the Mesozoic rocks with great unconformity are flat-lying Tertiary beds, containing thin coal-seams at the base. The lowest beds contain fossils which may be referable to the Whaingaroa Series; but sufficient evidence to separate these beds from the overlying Te Kuiti series was not found. Therefore they have been shown on the accompanying map as part of the latter series.

The Te Kuiti Series is in the main calcareous. In its lower portion the limestone is massive and decidedly arenaceous, but towards the top the rock consists of tabular layers of nearly pure calcareous material. The limestone is overlain by blue arenaceous mudstone containing shell-fragments and Foraminifera. In several localities the basal rock is separated from the limestone by thin deposits of fine conglomerate; in others beds of blue mudstone intervene; and in others grit, shale, and carbonaceous mudstone with seams of brown coal are to be found.

Te Kuiti limestone forms the surface rock over a large area of the western uplands, and only in the southern part of Maungamangero Survey District is it overlain by younger rocks. In the Te Kuiti depression the limestone outcrops along the western edge, and also east of Te Kuiti; but elsewhere it is overlain by younger beds.

The dip of the beds is generally low, and over a large portion of the district the limestone is horizontal.

Mahoenui Series.—The Mahoenui beds occur chiefly in the central depression, where they conformably overlie the Te Kuiti Series. For the most part they are calcareous argillaceous rocks, with thin sandstone bands. At Oparure, two miles and a half north-west of Te Kuiti, a limestone band 25 ft. thick occurs 200 ft. above the Te Kuiti limestone, and probably corresponds to the band of limestone occurring in the lower Awakino valley, which is there unconformable with a limestone of the Te Kuiti Series. West of Mahoenui are limestone and calcareous beds of Mahoenui age, but limestone definitely referable to this series has not been observed elsewhere in the district. Index fossils are absent, and the subdivision has been made on lithologic comparison with the Mahoenui beds of the Tongaporutu district, where the series is well developed.

Mokau Series.—In the southern part of the Te Kuiti depression a thick massive sandstone overlies the Mahoenui beds, and in part overlaps on to Te Kuiti limestone, and, in the east of the subdivision, on to Mesozoic rocks. In the latter locality there is a conglomerate bed at the base, consisting mostly of greywacke pebbles up to 1½ in. across; above this are carbonaceous shales, containing some coal. In the Mangapehi valley five miles east of Mangapehi Railway-station a seam of coal 10 ft. thick is reported to occur at this horizon.

At a point some two miles north-east of Te Kuiti, on the Mangarino Road, there is unconformity between Mokau beds and a calcareous mudstone referred to the Te Kuiti Series. Overlap occurs about a mile south of Tahaia, a small village in the south-east of Mangaorongo Survey District, some thirteen miles east-north-east from Te Kuiti.

Where the Mahoenui is the underlying series, the basal Mokau bed in places is a fossiliferous conglomerate about 5 ft. thick, containing greywacke pebbles up to 1½ in. in diameter, and waterworn sandstone fragments, though in some localities this bed gives place to a gritty or sandy limestone or shell-bed. The overlying fine-grained massive sandstone is correlated with the lower Mokau beds of the adjoining Tongaporutu Subdivision. Except in the south-west corner of Totoro Survey District, where thin seams of coal occur, the overlying coal-measures and upper sandstone beds have been denuded.

Mohakatino Series.—Beds of this age form a few outliers to the south of the Mokau River, but the main development of the series occurs on the coastal section south from Ngukuhakare Bay, where calcareous mudstone and sandstone, containing a great deal of disseminated volcanic ash and numerous tuff bands, form the surface of a downfaulted block. Only to the south-east is there an overlapping contact with the basement Mesozoic rocks, against which the Mohakatino beds are elsewhere faulted. Southward the series extends into the Mokau Subdivision, where it overlies Mokau beds with angular unconformity. The tuff appears to increase in coarseness and amount towards Whareorino, which is most probably the source of this material in the Mohakatino beds. Current-bedding is frequent in the sandstones.

Igneous Rocks.

Serpentine.—On the Rangikotuna Road, a mile south-south-east of the Wairere bridge across the Mokau River, serpentine of a greenish mottled colour, much shattered, is exposed for a couple of chains.

Basalt.—Basaltic rocks occur in the extreme north of Orahiri Survey District, being the southern edge of the material ejected from Mount Pirongia, a peak in the adjoining Huntly–Kawhia Subdivision. Twelve miles farther east is a small patch of fine grained dark-greyish basaltic lava.

Andesite.—In Whareorino Survey District two andesite peaks, Pehimatea and Whareorino, break through the Mesozoic beds. Neither has any sign of a crater, and the appearance of Whareorino suggests that it is a plug laid bare by denudation. The andesite, which strongly resembles that from Orangiwhao, near Kawhia, is light-coloured and contains feldspar phenocrysts up to ¼ in. and hornblende aggregates an inch or more across. It occurs as dykes near Moeatoa Trig. and on the south side of the saddle between Waikawau and Kiritehere, where it is intruded in *Pseudomonotis* beds standing vertically.

Rhyolite.—Much of the eastern portion of the subdivision is covered with rhyolitic tuffs and breccias, in places several hundred feet thick, ranging from fine and unconsolidated sands to hard, coarse, and compact rock. Generally the tuffs have been laid down subaerially, but some are undoubtedly subaequeous. No evidence indicating a local origin for the tuff was found.

Ash Showers.—The district has at one time been covered by pumiceous or andesitic ash showers, which have been removed by denudation in some parts, but in others have weathered down to form the soil. These showers and their effect on the productivity of the district form the subject-matter of a special investigation by the Soils Branch of the Department.

Economic Geology.

Coal.—Coal occurs in the Mokau beds in the Aria district, south of Piopio, and in the upper Mangapehi valley, where a 10 ft. seam has lately been found. Seams of workable thickness below the Te Kuiti Limestone are known in the Otewa district north-east of Te Kuiti, in the Awaroa valley south-east from Kawhia Harbour, and at several points on the western uplands.

Limestone and Clay.—High-grade limestone, and clay suitable for brick and tile manufacture, are to be found in the district. The limestone is largely pulverized for agricultural lime, but so far no use is made of the clays.

Iron-ore.—Iron-ore occurs as grains of magnetite and ilmenite in the beach and dune sands of the western coast, and also as a compact deposit capping a hill of Mesozoic rock at Harihari, some seven miles north of Marakopa.

SOIL SURVEYS OF NORTH ISLAND VOLCANIC AREAS.

(By L. I. Grange and N. H. Taylor.)

Introduction.

In the 1931–32 field season the writers made soil surveys for the Department of Native Affairs of a considerable area of Native lands in the Rotorua, Bay of Plenty, and Urewera districts. In all, thirteen blocks which are to be roaded and subdivided for settlement were mapped in detail. For the Department of Lands and Survey, reports were prepared on Galatea Estate and on the Waihaha–Tihoi–Poukani–Tirohanga Block, lying west of Lake Taupo. Laboratory work in connection with these surveys was done at Cawthron Institute under the direction of Mr. T. Rigg, director of Central North Island Reconnaissance Soil Survey, and at the Dominion Laboratory by Mr. F. T. Seelye.

TASMAN SEA

Iron ore

MAROKOPA

Marakopa River

Kiritehere Stm.

Pehimatea

Moeatoa

Ngukuhakare Bay

Tirua Pt.

Waikawau Stm.

Mokau River (S.D. bdy)

Warren Rd

Tongaporutu Series (Bull 31)

Ohura Road

Ongarue River

Otorohanga

Te Kuiti

Pukemako

— LEGEND —

— SEDIMENTARY ROCKS —

- RECENT AND PLEISTOCENE
- TERTIARY
  - Mohakatino Series
  - Mokau Series
  - Mahoenui Series
  - Te Kuiti and Whaingaroa Series
- MESOZOIC
  - JURASSIC
    - Puaroa Series — P
    - Kawhia Series — K
    - Herangi Series — H
  - TRIASSIC
    - Otapiri Series — Ot
    - Marakopa Series — Ma
    - Whakahau Series — W
    - Oreti Series — Or
    - Moeatoa Series — Mo
    - Undiffentiated

— IGNEOUS ROCKS —

- Rhyolite tuff and ash
- Andesite — A
- Basalt — B
- Serpentine — S

Generalised strike and dip

Faults

Geology by H. T. Ferrar, J. H. Williamson and N. H. Taylor.

J. HENDERSON
DIRECTOR.

KEY TO SURVEY DISTRICTS

MARAKOPA | KAWHIA SOUTH | ORAHIRI | MANGAORONGO | WHAREPAPA

WHAREORINO | MAUNGAMANGERO | OTANAKE | PAKAUMANU | RANGINUI

TOTORO | MAPARA | PAHI | HURAKIA | ONGARUE

SCALE
10 5 0 10 20 10 5 0 10 20 30

GEOLOGICAL MAP OF TE KUITI SUBDIVISION

SCALE
Mile 1 ½ 0 1 2 3 4 5 6 7 Miles
Km 1 0 1 2 3 4 5 6 7 8 9 10 11 12 Km.

G.E.H. del. 1932.

NATIVE BLOCKS FOR DEVELOPMENT.

The blocks surveyed are Horohoro, Parekarangi, Te Peka, Tihiotonga, Wharenui, Puketawhero, Tikitere, Mourea, and Taheke in the Rotorua district; Maketu and Rangiuru in the Bay of Plenty; Rangitahi in the Rangitaiki valley; and Ruatahuna in the Urewera country. Soil types were mapped over a total area of about 60,000 acres.

In general it has been found that the soils on each block are closely dependent on the topography—soils on steep slopes form one type, those on rolling and flat country another, and valley-bottom flats still another. Thus the soil-maps show the class of topographic relief, and this should aid in the cutting-up of the blocks into sections and mark out areas not well suited for dairying.

The blocks to be developed may be divided into the three following groups, according to the origin of the volcanic ash deposit from which the soil is mainly derived:—

(1) Horohoro, Parekarangi, Te Peka, and Tihiotonga, on which the soil is derived from the Taupo shower.
(2) Rangiuru, Maketu, Ruatahuna, Rangitahi, and Waerenga, on which the soil is derived from the Kaharoa shower.
(3) Wharenui, Puketawhero, Tikitere, and Taheke, on which the soil is derived from Rotomahana ash.

Group (1).—Horohoro and Tihiotonga consist chiefly of rolling and flat country; on Parekarangi a quarter is classed as steep, and on Te Peka half is steep.

Rotorua district, in which these areas are located, has a generous rainfall, which is fairly well distributed throughout the year. Summer temperatures are high, winter temperatures low, and ground frosts are fairly common between April and November. Owing to low temperatures, pasture-growth is small till after October.

Much the greater area of the soils on group (1) are formed from subaerially deposited Taupo pumice (rhyolitic in composition). The deposit is in general about 22 in. thick on Horohoro, 13 in. on Parekarangi, and 9 in. on Te Peka and Tihiotonga. Underlying the Taupo pumice on all these areas is the Mamaku shower. Two soil types are mapped on the subaerial deposits—(*a*) Taupo sandy silt on rolling and flat country, and (*b*) Taupo free sandy silt on steep slopes. In many places on the steep slopes the Mamaku medium sands are mixed with the Taupo pumice. On well-defined terraces bordering the main streams on Horohoro the parent material of the soil is water-sorted Taupo pumice. The textures are those of sands, sandy silt, and silt. These water-sorted sands cover a relatively small area. Small patches of loam, usually swampy, occur in many of the valley-bottoms.

Taupo sandy silt after a period of dry weather contains more than four times as much moisture as the Rotomahana sand and the Kaharoa gravelly sands at Tikitere—as much as, indeed, the loams of the Waikato. This high moisture content is no doubt largely due to the silt fraction, which packs closely together. Taupo pumice soils will not dry out badly during a prolonged dry spell.

In several districts stock depastured entirely on Taupo pumice soils are liable to develop an anæmia which is usually called "bush sickness." On those farms on which the sickness is definitely reported the soil is low in "available" iron. Soils belonging to group (1) are quite as low in "available" iron as those on which sickness has been reported, so that farmers have to be prepared for a certain amount of trouble. It must be said, however, that farmers to the south of Horohoro state that none of their dairy cows have become anæmic. The safest way to prevent any occurrence of bush sickness on the blocks examined is by means of a mineral lick, composed of equal parts of limonite and salt, which the Department of Agriculture have found so efficacious at Messrs. Hill and Son's farm at Atiamuri. Other means of preventing or curing bush sickness in the early stages are (1) use of subsoil licks, (2) grazing on drained-swamp areas, and (3) grazing on native vegetation. A trial of a lick made from a mixture of salt and Rotorua sandy loam which underlies the Mamaku medium sands is suggested. Mr. Rigg has found that at Glenhope (Nelson) a soil lick high in "available" iron is helpful. Swampy areas are too small to be important in this connection. Native vegetation will be grazed to a very limited extent when the blocks are well developed. Aston* records that at Atiamuri on water-sorted Taupo pumice bush sickness is worse than on the subaerial deposits. A striking difference between these two types is the very low nitrogen content of the former. It seems desirable, then, to aim at building up the nitrogen content of the pumice soils.

Group (2).—Blocks belonging to group (2) show so many differences that it is advisable to describe each separately. On Rangiuru (near Te Puke), which is classed as flat, Kaharoa ash (rhyolitic in composition) is a soil-forming shower over an area of 70 acres out of a total of 200 acres. The profile is—

7 in. dark, fairly loose, coarse sands (Kaharoa).
9 in. dull brown, moderately compacted, coarse sands.
18 in. light brown, compacted, coarse sands.

The remainder of the area, which borders the Kaituna River, is covered with loam, peaty loam, and sands, derived from alluvium deposited by the river. Loam and peaty loam predominate.

Kaharoa coarse sands, similar to those on Rangiuru, form the soil on 1,240 acres of the Maketu Block (total area, 1,662 acres). On the steep slopes (258 acres) the Kaharoa sands are thin. Water sorted beds, which lie in the valley-bottoms and along the coast, are chiefly loams and peaty loams. At high tide, or when a strong wind is blowing from the sea, salt water covers the swampy land along the Maketu–Te Puke Road.

Rangitahi Block at Murupara on the Rotorua–Ruatahuna Road, is classed as flat land. Two-fifths of the total area (670 acres) is mapped as Kaharoa medium sands. The profile is—

5–6 in. medium sands, fairly compact at base (Kaharoa).
16 in. light-brown, loose, gravelly sand (Kaharoa).

The soils of the alluvium deposited by the Whirinaki River, which forms the eastern boundary, are gravels, stony sands, sands, and loams. Of these, loams make up much the smallest proportion.

* B. C. Aston: N.Z. Jour. Agri., Vol. 44, p. 11; 1932.

Ruatahuna Block, about thirty-four miles east of Rangitahi Block, contains 12,181 acres. Of this area somewhat less than 5,000 acres is in pasture, the remainder being in heavy bush. About 2,500 acres of the area in pasture, mainly in the valley-bottoms, is classed as flat and rolling. The remainder of Ruatahuna, including that covered with bush, is practically all steep country. The soil profile on Ruatahuna is—

7–9 in. grey to white coarse sands (Kaharoa).
6 in. brown, fairly compact sands (Taupo).
15 in. cream, loose pumice gravel.

This profile is found on all classes of country, so that only one soil type is needed for the subaerial deposits. Water-sorted beds, which consist chiefly of pumice with a small amount of greywacke, are not important, as they are less than 100 acres in area.

On Waerenga Block (north shore of Lake Rotorua) 1,097 acres are classed as rolling and flat country and 595 acres as steep. The soils are derived almost entirely from Kaharoa subaerial deposits, the texture of which is that of a gravelly sand. On the eastern corner Rotomahana coarse sands, 3 in. thick, overlie the Kaharoa ash, at one mile to the west they thin to 2 in., and on the western boundary are ¼–½ in. thick. On steep slopes the Kaharoa gravelly sands have slumped and are mixed with the underlying Rotokawau sandy loam. Water-sorted beds, mainly resorted Rotomahana ash, cover about 100 acres.

Rangiuru and Maketu Blocks have a much better climate than Rotorua. Winter temperatures are higher, and consequently there is a much earlier growth of pasture. There are no data on climate for Rangitahi, but its climate is probably between that of Rotorua and Maketu. Ruatahuna has a high rainfall, more than 80 in., and snowfalls are common in winter.

As is to be expected, the moisture content of the sandy soils of this group is in general low during dry weather. The pasture on Kaharoa medium sands at Rangitahi suffers badly owing to the presence of the loose gravelly sands 5 in. below the surface. The coarse sands, stony sands, and gravels on Rangitahi dry out even more than the Kaharoa medium sands. At Ruatahuna the high rainfall keeps the soil moist during summer.

The "available" iron in the soils of Rangitahi and Waerenga is considerably lower and on Rangiuru and Maketu a little higher than in the Taupo pumice. Bush sickness is to be expected on all these blocks if the stock are confined to the Kaharoa soils, though on the Maketu and Rangiuru Blocks the trouble may be confined to sheep. But there are large areas of healthy water-sorted beds on Maketu, Rangiuru, and Rangitahi, and if each farmer gets a portion of them in his section or, if this is not possible, as is the case on Maketu, has the use of a section of healthy land reserved for common grazing, he can keep his stock healthy. The thin coating of Rotomahana ash on Waerenga will have a beneficial effect as far as bush sickness is concerned, for on areas where this ash is thick anæmia in stock does not develop. Judged by the experience of a settler in the district there will be a slight amount of sickness in sheep where the ash is less than 3 in. thick. Maori farmers state that sheep grazing on Ruatahuna do not go sick; this year the Department of Native Affairs took off fat lambs in April.

Group (3).—The areas to be developed on which grey Rotomahana ash forms the soil contain in general a high proportion of steep land. On Taheke nearly two-thirds of the land not covered with bush is classed as steep, on Tikitere one-sixth, on Puketawhero slightly more than half, and on Wharenui almost three-fifths.

The climate on these blocks is similar to that of Rotorua.

Rotomohana ash, deposited during the Tarawera eruption of 1886, is a mixture of fragments of rhyolite and of basalt. It is thickest on Wharenui and Puketawhero, where it ranges from 6 in. to 9 in.; on Tikitere it is between 3 in. and 5½ in.; on Taheke the 4 in. on the southern boundary thins to 2 in. on the northern boundary. The texture of the soil is that of a sandy loam on Puketawhero and Wharenui, and a coarse sand on Tikitere and Taheke. On most of the steep slopes the grey ash is thin or absent, having been washed into the valley-bottoms, where it forms water-sorted beds of relatively small area. Underlying the grey ash are the gravelly sands and sands of the Kaharoa shower. The Kaharoa ash is the most important soil-forming bed on the steep-slopes at the northern end of Taheke.

The Rotomahana sands contain a low percentage of moisture during dry weather. The sandy loam holds the moisture fairly well.

The grey ash contains more "available" iron than the Taupo pumice, and bush sickness is unknown on soils derived entirely from it. Over much of Taheke the Rotomahana ash is between 2 in. and 3 in. thick, and since the Kaharoa ash underlies, a slight amount of sickness in sheep is to be expected.

GALATEA ESTATE.

Galatea Estate, which lies 30 miles south-east of Rotorua, is eight miles long by four miles and a half wide, and has an area of 21,694 acres, of which 21,000 acres is easy to flat country. It occupies the greater part of a flattish basin, 600 ft. to 700 ft. above sea-level, lying between the Kaingaroa Plains to the west (1,800 ft.) and the Tawhinau Range to the east, which rises abruptly to 3,300 ft.

Streams draining the Tawhinau Range have built up a series of gravelly fans, which give the estate a gentle west-north-west slope. Much of the water of these streams soaks into the gravels of the fans and appears farther west as springs. Swamps occupy slight depressions between the individual fans, the largest, which is known as "No Man's Land," being 400 acres in extent.

The Rangitaiki River, which bounds the estate on the east and the Whirinaki on the south, are entrenched about 50 ft. and are bordered by a belt of low terraces. The northern two-thirds of the estate is well watered; the remainder is poorly watered, but large supplies of good water are close at hand.

At two points the Whirinaki and Rangitaiki rivers show signs of changing their courses, and if this is not prevented 240 acres of river-flat may be lost to the estate.

The whole estate has been covered with about 15 ft. of volcanic-ash deposits. The latest of these deposits is the Tarawera basaltic ash, which, however, is appreciably thick in the north-west corner only. The chief soil-forming deposit, the Kaharoa rhyolitic ash, a bed of hard white pumice 18 in. to 22 in. thick, rests on Taupo rhyolitic pumice, which in turn rests on older rhyolitic-ash beds. Since the Kaharoa eruption the streams and rivers have deposited along their banks beds of pumice mixed with fragments of greywacke, and some of the smaller drainage-channels at the foot of the Tawhinau Range have changed their courses on the fans and spread out similar material.

Climate.

According to Kidson's maps, the rainfall at Galatea is between 50 in. and 60 in. per annum. It is greatest in October, least in February, and moderate in December and January; but great variations occur in mean monthly rainfalls. The statement of residents that the grass commences to grow in October and that growth is sustained until well on in May gives some idea of the temperatures. Although the rainfall is moderate, the leaching of plant-foods is fairly rapid, for the soils are very porous and the run-off is low.

Soil Series and Types.

Three soil series are recognized—(1) the Kaharoa Series, derived from the Kaharoa rhyolitic pumice; (2) the Tarawera Series, from the Tarawera basaltic lapilli; and (3) the Water-sorted Series, derived from the resorted ash and greywacke detritus deposited by the rivers and streams. As far as possible, these are further subdivided into types on the basis of texture.

The *Kaharoa medium sands* occupy 10,544 acres, and thus cover a much greater area than any other type. The profile on the southern part of the estate is:—

Kaharoa ..	4–5 in. dark medium sand. 7 in. dry, loose, white, gravelly sand. 4 in. fine grained, white, gravelly sand. $\frac{1}{4}$–$\frac{1}{2}$ in. white sand. 4 in. fine, white, gravelly sand.
Taupo ..	9 in. dark brown, sandy silt, *on* gravelly sand.

In the northern part of the estate the top medium sand layer thickens to about 8 in., the bottom few inches being mottled cream and brown, and in some places compacted. In all profiles the top 9 in. of the Taupo pumice is dark brown in colour and seems to contain more clay than it does in other districts where it forms the soil. The 400-acre swamp—"No Man's Land"—is mainly on Kaharoa medium sand, the profile being—

Kaharoa ..	3 in. black medium sand, much humus. 1 in. mottled dark-brown and buff medium sand. 3 in. buff medium sand. 15 in. gravelly sand *on* Taupo pumice.

In deeper parts of the swamps muck and peat are accumulating on the top of the sands.

The pasture on the Kaharoa medium sand is poor, being chiefly sweet vernal, *Danthonia pilosa*, and tussock. The native vegetation is manuka, tussock, and *Leucopogon Fraseri*, together with a short rush which grows in the northern area where the medium sands are compacted.

The *Kaharoa gravelly sands* occupy only about 600 acres, being confined to the steeper parts along the eastern margin. The largest area is in the south-east corner, where greywacke and tuff hills rise to 1,400 ft. The dark humus layer is usually 7 in. or 8 in. thick. On the steep greywacke slopes the soil contains fragments of greywacke.

The *Tarawera gravelly sand* covers the northern end of the estate and thins gradually southward. It covers 93 acres to a depth of 3 in., 1,350 acres to depths between 2 in. and 3 in., and 4,324 acres to depths between 1 in. and 2 in. This type can be divided into two sub-types—one, the Tarawera ash on Kaharoa medium sand; the other, the Tarawera ash on water-sorted deposits. The vegetation on the Tarawera gravelly sand is largely influenced by the type of soil that underlies it.

Water-sorted loams, silts, sands, and gravels, light brown in colour occupy 8,546 acres, 2,704 acres of which are covered with Tarawera gravelly sand. They occur principally in the north and east of the estate on the flood-plains of the streams from the Tawhinau Range and on terraces bordering the Whirinaki and Rangitaiki Rivers. In general, the existing river-channels and old watercourses are bordered with greywacke gravels, and back from these the soils become progressively finer, grading from sands to silts and loams. Sands are the predominant type in all the main areas of water-sorted beds.

White clover is much more abundant on these soils, and on the silts and loams rye is often the most common grass.

Soil Moisture.

With the exception of the loams and silts, all the soils and subsoils of the estate are coarse in texture and very porous, and consequently are expected to dry out badly during periods of low rainfall. On areas covered with Kaharoa medium sand and Tarawera gravelly sand the main source of moisture to deep-rooting plants is the top 9 in. of the Taupo pumice, 20 in. to 24 in. below the surface. The loams and silts are usually well supplied with moisture, as they occur in low-lying places.

Bush Sickness.

Bush sickness is reported from many localities north of Rotorua where cattle and sheep are grazed on soils derived from Kaharoa ash, so that its appearance is to be expected among stock grazed entirely on the Kaharoa soils of Galatea. The trouble, however, will probably be less acute at Galatea, where the soil is finer in texture, than nearer Rotorua. However, the only way to get definite information on this point is to conduct actual stock experiments. Bush sickness is now being successfully combated with licks and drenches and is not the great obstacle to settlement it was once thought to be.

It is not known whether the 400-acre swamp, "No Man's Land," should be considered free from bush sickness or not. North of Rotorua, where the thin layer of Tarawera gravelly sand rests on Kaharoa ash, sheep become sick, and occasionally cattle; similar soils on Galatea must therefore be regarded as liable to bush sickness.

The water-sorted group of soils, with the possible exception of some that appear to consist entirely of pumice, should be healthy for stock. Water-sorted soils with a surface layer of Tarawera gravelly sand should also be healthy.

WAIHAHA, TIHOI, POUKANI, AND TIROHANGA BLOCKS.

While Mr. W. Traill, of the Lands and Survey Department, was making a topographical survey of the Waihaha, Tihoi, Poukani, and Tirohanga Blocks the writers visited his camp on two occasions, remaining each time for a week in order to make a reconnaissance soil survey of those parts of the blocks lying east of the Mangakino and Huruhuru streams.

*Topography**.—The area examined, some 114,000 acres, is situated close north-north-west of Lake Taupo on a plateau most of which slopes gently northward to the Waikato River. Near the southern end of the blocks the plateau is 2,000 ft. and in the north 1,000 ft. above sea-level. Much of the country is steep and broken, but there are five areas of easy to rolling country totalling approximately 49,000 acres. One of these areas (about 13,000 acres), lying north of the Waihora Stream, is well watered, but the others are poorly watered.

Climate.—There is no meteorological station near the blocks, but Kidson's maps show the rainfall between 60 in. and 70 in., heaviest in October, lightest in February, and moderate in December and January. As it is so far inland, summer temperatures will be high and winter temperatures low, compared with other parts of New Zealand. Heavy frosts are common, these being more severe in the wide valley-bottoms.

Vegetation.—The steep and broken areas are covered with heavy fern and tutu, with manuka in the easier basins and tussock on the dry valley-floors. On the rolling country, fern, tutu, and to some extent manuka occupy the knolls and slopes; while on the easier country the dominant growth is tussock, with manuka, monoao, and celmisia.

Soils.—The blocks are covered with about 3 ft. of Taupo rhyolitic pumice. Underlying the Taupo pumice is a brown sandy loam derived from the weathering of an earlier andesitic ash which has been named Tongariro. Along the stream-valleys are terraces which are formed mainly of Taupo pumice washed from neighbouring slopes.

The main soil types are (1) Taupo sand; (2) Tongariro sandy loam; (3) water-sorted sands and gravelly sands.

The Taupo sand covers almost the whole of the rolling and easy country and the greater part of the moderate to steep areas. Where the pumice is undisturbed the section is—

Taupo ..	3 in. dark grey sand. 15 in. brown to buff sand, slightly compacted. 18 in. cream gravelly sand, free.
Tongariro	*on* brown sandy loam.

The brown *Tongariro sandy loam* forms the surface soil over only a small proportion of the blocks. It appears at the surface on the crests of knolls and ridges and on some of the steeper slopes, where, in some places, it is mixed with Taupo pumice.

The *water-sorted sands and gravelly sands* probably form much less than 5 per cent. of the total soils. The most extensive terrace formation is the upper one, generally 50 ft. above the larger streams, and composed entirely of resorted pumice. In streams draining from the greywacke hills in the west the lower terraces are formed in part from greywacke detritus, and a better soil results.

Strips of rich loamy soil occupy the floors of many stream-valleys but are rarely more than half a chain wide.

The *moisture content* of soils derived from the Taupo pumice is much greater than that of the average soil of the same texture. The sandy top layer can be expected to be fairly retentive of moisture, although it allows free drainage. The soils of the lower terraces are generally overdrained. The Tongariro sandy loam and the loamy soils bordering the streams are well supplied with moisture.

Bush Sickness.—As the soil is derived mainly from Taupo pumice, stock grazed on these blocks will probably be subject to bush sickness; in fact, bush sickness has appeared among stock on some of the farms lying farther north. It must be pointed out, however, that the "available" iron and the total iron and lime content of the Taupo sands on the blocks are unusually high for a normal Taupo soil. Stock grazed on Tongariro sandy loam are free from bush sickness, but there appear to be insufficient areas of this soil on the rolling country to make farms healthy.

Possibilities of Development.—The soils on the whole area are so similar that topography and drainage determine the value of the land. The five easy rolling areas could be used for dairying. The fact that four of the areas are badly watered is not a serious drawback, for water could be raised from one or more strong streams that cross them or form their boundaries. The area north of the Waihora River could be developed first, and later the rolling country that is badly watered.

In considering the development of these areas the following disadvantages, some of which are serious, have to be taken into account: (1) Although the soil resembles that of Ngakuru, it is coarser in texture, and the subsoil is less compact and more gravelly. This means that the soil will probably be less fertile than at Ngakuru. (2) As a result of the severe winters and the lower fertility of the soil the carrying-capacity will be less than at Ngakuru. (3) The blocks are farther from the Government railway than Ngakuru, though this is somewhat offset at present by cheap fares on the light railway to Mokai. (4) The area is probably subject to bush sickness; but this form of anæmia can now be successfully combated by using a lick made of equal parts of limonite and salt.

With such a large tract of easy country, it is advisable that experiments be conducted to obtain exact data, for as yet no successful farms have been established on Taupo soils of this texture.

* A detailed report on the topography of these blocks has been prepared for the Lands and Survey Department by Mr. Traill.

METEOROLOGICAL BRANCH.

REPORT BY THE DIRECTOR, 1931–32.

General.

The advantages anticipated from the removal of the Meteorological Office to Kelburn have been fully realized during the past year. Much time is saved through being near the Observatory site, and we are able not only to exercise a better supervision over the equipment, but to undertake work which would be impossible, or very difficult, from an office situated in the city. In connection with weather forecasting, it has proved to be a great advantage to have the whole sky continuously in view, and to make frequent and accurate observations of cloud-movement. The more convenient storage of records and publications has greatly facilitated reference and has led to greater efficiency.

Forecasting.

During the year, owing to representations from bodies concerned with the various aspects of maritime activity, the evening broadcast of weather reports for shipping from the Wellington Radio Station was resumed. Except during a few of the winter months, a special afternoon forecast for farmers has again been issued at 3.30 p.m. from 2YA. In this forecast the endeavour is made to give an outlook for as long a period in advance as possible. From correspondence received, reports, and personal interviews, it is clear that this forecast is much appreciated and that an increasing number of farmers arrange their work in accordance with it.

The number of requests for special forecasts in connection with aviation, shipping (especially small shipping), journeys by launch, invalids requiring to travel, open-air meetings of all kinds, and many other activities continues to increase rapidly.

Enforced economies have led to the further reduction of the number of country towns to which the noon forecasts are sent. There has been some reduction also in the number of regular reporting stations, while most rainfall-stations have had to be instructed to discontinue the telegraphing of reports of heavy precipitation. Except that with increasing development it has been possible to secure a better distribution, the situation with regard to the number of reporting stations, although a contrary view appears to prevail with the public, is now less satisfactory than it has been for very many years. As an illustration of the way in which the forecast may be affected, it may be mentioned that in two cases recently when heavy rain had been predicted for certain districts the reports seemed to indicate that little had fallen. Since the meteorological conditions remained much the same, the forecast was naturally affected. On receipt of the monthly returns from rainfall-stations, however, it was found that flood rains had been experienced in parts of the districts concerned.

A preliminary attempt has been made to apply the Norwegian methods of forecasting to Australian and New Zealand conditions. Very little can be done with the daily telegraphic reports, owing to sparseness of data from Australia, but by plotting on our charts the complete reports, received by post from Sydney through the kindness of the Commonwealth Meteorologist and his staff, it was found that Australia was a very favourable region in which to apply the methods. The situation so far as New Zealand is concerned is not so satisfactory, since there must inevitably be large blank spaces on our charts in the Tasman Sea area and the ocean waters to the eastward. But with the complete Australian data available there is no doubt that a much better insight into the weather processes could be obtained by adopting the Norwegian methods, and there will be occasions, also, when they will be of direct advantage in preparing the local forecast. It is quite likely that in the near future many additional Australian reports will be available by wireless without involving much extra expense.

The cordial co-operation of the Post and Telegraph Department throughout the year is gratefully acknowledged.

Observing-stations.

Five new climatological stations have been established, the equipment in several cases having been paid for by those requiring the resulting information. The demand for the new stations generally arose in connection with some industry—*e.g.*, the production of tung-oil—or some special research, such as that at the Fruit Research Board's orchard at Appleby, near Nelson. Several requests for additional stations have had to be refused, the Branch now having as many as it can cope with.

A number of new rainfall-stations have been set up in districts where they were previously lacking, while seven old ones have lapsed. At some of the new stations the gauges are privately owned.

Very little inspection has been possible, owing to shortage of funds, and supervision has had to be exercised mainly by correspondence. The great majority of observers have shown every desire to maintain a good standard and to follow any suggestions. The quality of the observations is undoubtedly improving. This is especially the case as regards private and voluntary observers. Few people realize the tie that observations made at the same time on every day of the year constitute for these observers, and the thanks of the country as well as of the Meteorological Office are due to them.

Upper-air Observations.

Observations of winds in the upper air by means of pilot balloons have been continued at Wellington throughout the year on all working-days. The results of similar observations at the Christchurch Magnetic Observatory have been telegraphed daily also, and have proved of value in connection with the forecast. Thanks are due to Mr. H. F. Skey for his continued co-operation in this direction. Monthly frequency tables of the upper winds at various heights, classified according to direction and speed, in conformity with an international scheme, have been prepared regularly. Three years' results are now being summarized for publication. Data regarding horizontal visibility and the height and frequency of low cloud will be included. This information will be of value to aviation, especially when any regular flying services are established.

Reports of the visibility have been included in the daily weather reports from Timaru and Kaikoura, and, until the report had to be dropped on grounds of economy, also from Blenheim. Under the existing financial conditions it has not been possible to attempt the establishment of a proper meteorological service for aviators, but this is undoubtedly one of the needs for the near future. The number of requests for weather information and forecasts from aviators grows every year.

Director's Visit to Europe.

In August, 1931, I was invited to become one of the delegates of the Australian and New Zealand Association for the Advancement of Science to the centenary meeting of the British Association in London in September, a grant of £150 being made by the British Association towards the expenses of each of the chosen delegates. The Government did not see its way to providing any additional assistance, but I was given leave to attend the meeting at my own expense. The occasion was unique in that the Faraday centenary was to be celebrated also in London at about the same time. Both the British Association and the Faraday centenary meetings were extremely interesting and successful functions. But, as usual in such cases, the greater part of the benefit of the gathering arose from the meetings and discussions with fellow-workers.

At the close of the British Association meeting Dr. G. C. Simpson, Director of the London Meteorological Office, invited me to accompany him to a meeting of the International Meteorological Committee at Locarno, in Switzerland. This committee is appointed from the Directors of the Meteorological Institutions of the world. Its duties are to arrange the international co-operation necessary for the collection of uniform and accurate knowledge of the climate of the world, for the interchange of information by telegraph, cable, and wireless, on which forecasting, and especially the meteorological services for aviation, are based; and generally to maintain and improve the standard of meteorological work. There were three vacancies on the committee through death or retirement of members, and the writer was done the honour of being elected to one of them, the others not being filled. There is no other member in the Southern Hemisphere. The committee has been responsible for the organization of the Polar Year scheme. Some members felt that the scheme should be postponed owing to the financial depression. It became clear, however, that a considerable success was already assured and that some nations were already deeply committed. Under the circumstances, therefore, it was decided to go ahead.

From Locarno the writer proceeded to Bergen in order to study the most recent methods of forecasting at their place of origin. At the instance of Dr. J. Bjerknes, the leader in the recent developments and a meteorologist of world-wide repute, accommodation was provided at the Geophysical Institute at Bergen, and the fullest possible facilities given for studying the Norwegian methods. Furthermore, Dr. Bjerknes made a point of studying the writer's work in the Southern Hemisphere and discussing it with him. Dr. S. Petterssen, Director of the Meteorological Institute, also gave every possible assistance. The visit proved most helpful and stimulating.

One was impressed by two outstanding features of conditions in Norway. The first of these was that with very little suitable land available, and climatic conditions vastly inferior to those in New Zealand, the same classes of commodities are being produced for sale in England. The second was the importance attached by Norwegians to scientific research. The amount of work carried out with the aid of Government grants and by means of endowments provided by wealthy business men in a country with approximately the same population as New Zealand is astounding.

After a week at Bergen a return was made to England, and the remainder of the available time spent in gaining an insight into the work of the different branches of the London Meteorological Office and in visiting various research institutions. Amongst the latter was the Radio Research Station at Slough. One of the branches of the work carried out at that station, under the direction of Mr. R. A. Watson Watt, is the study of atmospherics, one of the most troublesome features of reception by wireless. Atmospherics are connected with weather phenomena, and their study will be to the mutual advantage of meteorology and wireless.

At Oxford Dr. G. M. B. Dobson has developed a spectroscope for the measurement of the amount of ozone in the atmosphere by a simple and rapid process. Since the ozone is contained principally in layers at very high altitudes, Dr. Dobson's researches seem likely to give a means of gaining information regarding the state and movements of those layers. It is probable that conditions at these high altitudes have an important influence on the weather, and interesting results should accrue from the world-wide studies which Dr. Dobson is organizing and in which it is to be hoped that New Zealand will, at a later date, be able to take part. Promising results were obtained at Christchurch by Dr. C. Coleridge Farr, F.R.S., with an earlier instrument devised by Dr. Dobson. Dr. Dobson kindly demonstrated his new instrument to me, and the whole problem was discussed with him.

Visits were paid, also, to the Agricultural Experiment Station at Rothamstead and the Fruit Research Station at East Malling. At each of these stations important investigations of the relation between climatic factors and agricultural problems are being carried on. At both it was emphasized that these factors were more important than those which could be controlled, but that at present they are insufficiently understood.

The members of all branches of the London Meteorological Office staff all showed the utmost cordiality, explaining their equipment and methods used and giving any other possible assistance. But it is to the Director, Dr. G. C. Simpson, C.M.G., F.R.S., that the writer is chiefly indebted for the most stimulating and informative experience which the voyage proved. Dr. Simpson was principally responsible for my nomination as a delegate to the British Association meeting, secured the invitation of myself and my wife to the Faraday centenary meeting, arranged for me the visits to Locarno and Bergen, and did all in his power to make our stay pleasant both socially and scientifically.

During my absence the work of the Office was carried on satisfactorily without untoward incident or interruption by the staff under the direction of Mr. B. V. Pemberton. To be responsible every day, including Saturdays, Sundays, and holidays, for months on end for several weather forecasts imposes a considerable mental strain, and my thanks are especially due to Mr. Pemberton. He was assisted in the work during the week-ends by Mr. R. G. Simmers.

MISCELLANEOUS.

The article on the climate of New Zealand for the "Handbook of the Climatology of the World," which is being issued in sections by Drs. W. Köppen and R. Geiger, was completed and is now advertised. It is included in a separate volume with the climate of Australia, by Professor T. Griffith Taylor. The joint editors of the Handbook expressed themselves as pleased with the work. The figures for the article were drawn by Mr. G. Harris, of the Geological Survey, and I am indebted to Dr. Henderson for the loan of Mr. Harris's services and to Mr. Harris for his excellent drawings.

The Institute of Pacific Relations has in view the publication of a volume on "Land Utilization in New Zealand." In connection with this we have been asked to write an article on climate and its relation to agriculture. With this aim in view, the study of various aspects of the climate has been intensified and a number of articles have been published in the *New Zealand Journal of Science and Technology*. These include,—

"Mean Temperatures in New Zealand," by Dr. E. Kidson.
"Annual Variation of Pressure in New Zealand," by Dr. E. Kidson.
"Dry Years in New Zealand," by Dr. E. Kidson.
"The Diurnal Variation of Temperature at Wellington," by Dr. E. Kidson and A. G. C. Crust.
"The Occurrence of Frost, Hail, and Snow in New Zealand," by Dr. E. Kidson.

In the first of these, the first part, after discussing the data available, gives for each month and the year maps indicating by means of isothermal lines the variation in temperature over the Dominion. This is the first occasion on which anything of the kind has been attempted in any detail. The next section discusses the annual variation of temperature and its relation to topography and other factors. The final section deals with the rate at which the temperature falls as one proceeds from north to south. This is an important question, because it determines to a large extent the character of our winds, and consequently of our storms. The rate of change is not simple, but to the south of New Zealand, at any rate, the variation of temperature with latitude is least in winter and greatest in summer, which is somewhat surprising.

The study of the annual variation of pressure showed that there are two maxima and two minima. The principal maximum is in April, all parts of the Dominion having, on the average, their highest pressure in this month. At Auckland the second maximum is in September and is quite pronounced, but as one goes southwards it becomes earlier and decreases in importance. At Dunedin it is represented by a slight rise of pressure from July to August, but the September pressure is lower than that of July. The rate at which the pressure normally falls with increasing latitude was also discussed in the paper. This rate is greatest in spring and least in winter. This corresponds with the fact that westerly winds are strongest in spring and lightest in winter. Actually, the wind velocity and pressure gradient go very closely together, and the latter gives the best measure of the air-flow from the west at a moderate height that is at present available.

The diurnal variation of temperature at Wellington was investigated primarily in order to discover how close an approximation to the mean temperature of the day was given, on the average, by the mean of the maximum and minimum. It was important to discover this, because for most places the only means of determining the mean temperature is from the mean of the maximum and minimum. But, in addition, information regarding the diurnal variation is of practical value in connection with the heating of buildings, &c. Indeed, it was an interesting coincidence that just after the hourly temperatures at Wellington were tabulated we were asked by a large business concern, engaged in the provision of heating-appliances, for the number of hours during each month of the year in which the temperature fell below a certain value. Similar data will be tabulated for other places where continuous records of temperature are being made.

The paper on frost, hail, and snow is intended to indicate how frequently, on the average, a person in any part of the Dominion may expect these phenomena to occur in the different seasons of the year. The information is of value to those engaged in or connected with the organization of agricultural pursuits. Many orchards, for instance, have been established without due regard to the incidence of frost, and have proved failures in consequence.

The paper on dry years showed by means of charts by how much the rainfall in the driest years for which we have records fell below the appropriate average in different districts.

The object of this series of studies is to put on a definite basis our knowledge of the various aspects of the climate of New Zealand, so that works of all kinds in which climate and weather are important factors may be scientifically planned. At the same time, the information is essential to the meteorologist and of general interest to the public. It is the intention to continue the series.

One of the most difficult of the present problems of soil research is to find a means of accurately recording soil moisture. Since vegetation has to live by means of the mineral salts extracted from the soil in solution in water, the importance of soil moisture is obvious. The source of the moisture is normally the natural rainfall, but what happens to the rain after its fall varies greatly with the class of soil, its mechanical condition, and various topographical features. While on a visit to the Fruit Research Station at East Malling, Kent, England, I was shown apparatus devised by Mr. W. Stephen Rogers, for measuring soil moisture by means of the capillary pull exerted by the soil on a supply of moisture with which it was brought in contact but which it was unable to abstract. Since then Mr. Rogers, who had removed to Canada, has given complete details of his equipment and results. The method seems quite promising, and I have asked Mr. R. G. Simmers to commence a series of experiments with a view to its development here.

Monthly rainfall maps have been drawn for the six odd months of the year, and the completion of the remainder would be a simple matter. Sufficient funds for their publication are, however, unfortunately not available.

Mr. D. C. Meldrum has continued the tabulation of hourly amounts of sunshine and rainfall.

Miss M. E. Ewart has completed a tabulation of hourly wind velocities and directions for a year at the aerodromes at Hobsonville, near Auckland; Rongotai, near Wellington; and the Wigram Aerodrome, near Christchurch. The discussion of these data is nearly complete, and when available will give much information regarding the character of the winds in these localities and enable a comparison to be made with conditions elsewhere.

In conclusion, I have pleasure in acknowledging the cordial co-operation of my staff.

DOMINION OBSERVATORY.

REPORT OF THE DOMINION ASTRONOMER AND SEISMOLOGIST FOR THE YEAR ENDED 31ST DECEMBER, 1931.

BUILDINGS AND EQUIPMENT.

The buildings and equipment have been kept in good order and condition. The Observatory ground has been kept in good order by the Wellington City Corporation.

ASTRONOMY.

Astronomical Observations.

Owing to the increase in the seismological work of the Observatory, it has not been possible to carry out as many meridian transit observations as in previous years. The Observatory standard clock is controlled mainly by means of radio time signals.

Reception of Radio Time Signals.

The following long-wave radio time signals have been received for the purpose of checking the observatory standard clock:—

Station.	Call Sign.	Hour (G.M.T.).	Number of Times received.	Greatest Error of Observatory Clock.
Nauen	DFY	00	312	1·28 seconds fast, April 24.
Malabar	PKX	01	68	1·92 seconds fast, April 24.
Annapolis	NSS	08	20	0·38 seconds slow, February 3.
Bordeaux	FYL	08	64	0·87 seconds fast, May 19.
Rugby	GBR	10	42	0·3 seconds fast, July 6.
Nauen	DFY	12	3	..
Bordeaux	FYL	20	161	0·58 seconds fast, August 16.
Annapolis	NSS	21	48	0·36 seconds fast, December 6.

The total number of signals received was therefore 718. Annapolis commenced sending signals at 21 hours G.M.T. on October 1st, 1931. The above numbers include both mean-time and rhythmic signals in the case of Nauen, Bordeaux, and Rugby. Malabar and Annapolis transmit mean-time signals only.

By means of a special telephone circuit connected to the Observatory clock it is possible for an officer who has a wireless receiving-set at his residence to check the Observatory clock by W/T time signals at times out of official hours. Since June 23rd the Bordeaux time signals at 20 hours G.M.T. (7.30 a.m. N.Z.M.T.), has been used to check the Observatory clock every day in this manner. The reception of this signal, together with the signal from Annapolis at 21 hours G.M.T., has resulted in a marked improvement in the accuracy of the radio time signals sent out from the Observatory at 23 hours G.M.T.

It is not possible to make much use of the British time signals from Greenwich, transmitted by Rugby Radio, owing to the very unsuitable times of transmission, at 9.30 p.m. and 5.30 a.m. N.Z.M.T.

Time Signals sent out from the Observatory.

The time service has been maintained, and the regular signals have been transmitted daily. The present routine at the Observatory provides for the following time signals, most of which are sent automatically by the Observatory standard clock. The error of the standard clock seldom exceeds one quarter of a second of time:—

Automatic Time Signals—

(1) To the General Post Office and to the Railways Department, Wellington, by telegraph, daily, except on Government holidays, and on Sundays.
(2) To ships and to the general public at Wellington, by electric lights at the Observatory daily.
(3) To the Auckland Harbour Board, by electric lights at Auckland, on Tuesdays and Fridays, except Government holidays.
(4) To the South Island telegraph-offices, by telegraph, on Tuesdays and Fridays, except Government holidays.
(5) To the Lyttelton Harbour Board, by dropping the time-ball at Lyttelton, on Tuesdays and Fridays, except on Government holidays.
(6) Radio time signals through the Wellington Radio Station ZLW, every day at 10.30 a.m. (23 hours G.M.T.).
(7) Radio time signals through the Wellington Radio Station ZLW, on Tuesday and Friday evenings at 8.30 p.m. (9 hours G.M.T.), except on Government holidays.
(8) Radio time signals through the Radio Broadcasting Station 2YA, at Wellington, daily at 4 hours G.M.T.

In transmitting radio signals, the call sign of the Observatory is ZLY.

Non-automatic Time Signals—

(1) To ships and watchmakers in Wellington, and to Government Departments by telephone, on application to the Observatory.
(2) The Observatory automatic time signals sent to the General Post Office at 9 a.m. daily are distributed by telegraphic hand signals to some 2,300 telegraph and telephone offices distributed all over New Zealand.
(3) Similar hand signals are also sent to all railway offices in New Zealand at 9 a.m. daily—by telegraph to 221 offices and by telephone to 257 stations.

The following time signals were sent out from the Observatory during the year 1931 :—

	Signals.
Radio time signals through Station ZLW	463
Time signals by telegraph	508
,, lights at Wellington	364
,, lights at Auckland	102
,, time-bail at Lyttelton	109
,, telephone	19
Total number of signals sent out in 1931	1,565

The signals sent to Auckland and Lyttelton include nine repeat signals, owing to first signals failing to reach their destination. Time signals are supplied twice daily to Station 2YA, but these are not always broadcast.

The following table indicates the degree of accuracy of the radio time signals transmitted from the Observatory by Station ZLW during the year 1931 :—

Number of times correction did not exceed 0·25 sec.	378
,, between 0·26 and 0·50 sec.	64
,, between 0·51 and 1·00 sec.	19
,, exceeded 1·00 sec.	2
Total number of time signals sent out	463

Government Buildings Clock.

The Government Buildings clock has been kept under fairly close control. A record is obtained at the Observatory by direct circuit from the clock, and the adjusting weights on the pendulum are altered from time to time. The greatest errors of this clock during the year 1931 were 72 seconds fast on October 12th and 57 seconds slow on March 16th.

General Post Office Clock, Wellington.

The Post Office clock is checked by W/T at 3 p.m. daily, except on Saturdays, Sundays, and Government holidays. The greatest errors recorded during 1931 were 7·5 seconds fast on January 20th and 14 seconds slow on March 11th. This clock is not under the control of the Observatory.

Sun-spots.

Numerous observations of the sun are made by members of the Solar Section of the New Zealand Astronomical Society, and the records obtained are available for use at the Observatory. These observations are sent to Zurich, where they are used for international work in determining the Wolf-Wolfer relative sunspot numbers.

Occultations.

In response to a request from Professor E. W. Brown, F.R.S., for more observations of occultations, the following New Zealand observatories have expressed their willingness to make the necessary observations: Christchurch, Dunedin, Hawera, Nelson, New Plymouth, Wanganui, Wellington.

The time signals sent through ZLW and 2YA are useful to these observatories.

The occultations of stars were observed at Wellington on March 3rd; April 28th; May 5th and 28th; June 23rd; September 17th; November 19th. At New Plymouth occultations were observed on March 2nd, 27th, and 30th; June 23rd; August 21st; September 17th, 18th, 19th, and 20th; and one at Stratford on August 21st. These observations have been reported to Dr. L. J. Comrie, Superintendent, H.M. Nautical Almanac Office, London. In a compilation and discussion of 663 occultations observed in 1930 Professors E. W. Brown and Dirk Brouwer used the New Zealand Observations. (*Astronomical Journal*, Vol. 41, No. 22.)

Photographs of Moon and Surrounding Stars.

In addition to the ordinary occultation observations, a photographic method is in use at the Wellington Observatory by means of which the moon and surrounding stars are photographed on the same plate, and the time of exposure on the moon is recorded on the chronograph. Plates taken in this manner in former years with the 9 in. telescope have not yet been measured, as there is no staff available for this duty. This research was begun at the Lick Observatory, and the method is available for—

(1) Fundamental determination of the position of the moon, and was undertaken originally in response to an invitation from Professor E. W. Brown to provide material for testing his tables of the motion of the moon.
(2) This method may also be used as an independent one in the determination of longitude.
(3) In the determination of latitude.

In (2) and (3) the errors are different from those in the determination of longitude by wireless telegraphy and in the determination of latitude by zenith telescope observations.

Solar Parallax Programme.

In response to a request from Dr. H. Spencer Jones, Chairman of the Solar Parallax Committee, H.M. Astronomer at the Cape of Good Hope, the 9 in. telescope was used during January and February for taking photographs of the minor planet Eros. This was part of a programme for the determination of the solar parallax, in which sixty-four observatories took part. Owing to extremely poor weather conditions at the time, only eighteen plates could be attempted on the regions in which Eros was situated. The planet was definitely located on six of the plates. This work was undertaken by members of the New Zealand Astronomical Society, in conjunction with the staff of the Dominion Observatory. The plates have been forwarded to Dr. Spencer Jones, who will have them measured up, and the material will be used in his work on the solar parallax.

International Astronomical Union.

By the courtesy of the Central Astronomical Bureau, arrangements have been made for this Observatory to receive advice of all important astronomical discoveries. The information is forwarded by the Bureau at Copenhagen to this Observatory through the Melbourne Observatory. The following information was received in this way during the calendar year 1931 :—

(1) Discovery of an object by Nakamura, Mag. 11·8, 1931, June 8th.
(2) Rediscovery of Encke's Comet by Bobone, Mag. 9, 1931, June 21st.
(3) Confirmation of discovery of comet by Nagata, 1931, July 27th.
(4) Ephemeris of Comet Nagata, 1931, July 27th.
(5) Discovery of a comet by Ryves, Mag. 4, 1931, August 14th.
(6) Ephemeris of Comet Ryves, 1931, August 21st.

Comets.

Of the objects reported by the International Astronomical Union, only Encke's Comet was observed in New Zealand. The other objects were either too faint for most instruments or were in an unsuitable position for southern observers. Encke's Comet was observed visually at Wellington with the 9 in. telescope on July 5th, 16th, and 17th, six observations being taken of its positions by means of the equatorial circles. The observations were forwarded to Dr. A. C. D. Crommelin, England.

Meteors.

SUMMARY OF METEORS FOR 1931.

Place.	New Zealand Date.	Notes.
Auckland ..	Feb. 18d. 20h. 15·5m.	Left train.
Wanganui ..	Nov. 17d.	Very brilliant, left train, disappeared in direction of sea.

Besides these appearances, which were brilliant enough to excite public notice, a large number of observations were obtained by the Meteor Section of the New Zealand Astronomical Society for the determination of southern radiants.

"New Zealand Nautical Almanac."

An article on the Dominion time-service arrangements, giving full particulars of all the time signals supplied by the Observatory, was prepared and published in the "New Zealand Nautical Almanac."

Summer Time.

The Summer Time Act, 1929, provided for the time in New Zealand being half an hour in advance of New Zealand standard time for the period beginning at 2 a.m., New Zealand standard time, on Sunday 11th October, 1931, and ending at 2 a.m., New Zealand standard time, on Sunday, 20th March, 1932.

SEISMOLOGY.

Seismological Stations.

During the year 1931 the two Milne-Shaw seismographs, the Galitzin-Wilip vertical seismograph, and the Ishimoto clinograph (E.–W. component) have been in continuous operation at the Observatory. On January 28th a Wood-Anderson short-period seismograph was established at the Observatory for the purpose of recording local earthquakes.

The Milne twin-boom seismograph at Suva has continued in operation during the year. The seismograph is operated by Miss Mune, of the Telephone Exchange, Suva. The records are developed and forwarded to this Observatory for measurement.

The Milne seismograph at Arapuni has been maintained and operated under the charge of the District Engineer of the Public Works Department, Arapuni. The records of this station were particularly useful in locating the epicentres of many of the Hawke's Bay earthquakes.

The following new seismological stations were established in New Zealand during the year 1931 :—

The Imamura strong-motion seismograph was transferred from Wellington to Takaka in January. This seismograph has been recording continuously in the charge of Mr. W. J. Smith, Postmaster, Takaka.

Immediately after the Hawke's Bay earthquake on February 3rd a Milne-Jaggar shock-recorder was placed at Hastings for recording after-shocks. This recorder has been operated by Mr. Henry de Denne, of Hastings, and it has given a valuable record of earthquakes in Hawke's Bay during the year.

On February 6th a Wood-Anderson seismograph was established at New Plymouth under charge of Mr. McCabe, Chief Draughtsman, Lands and Survey Department, New Plymouth. On May 1st this station was discontinued until August, when it was re-established at the New Plymouth Prison under the charge of Mr. W. H. Todd, an officer of the prison.

In July a Wood-Anderson seismograph was sent to the Magnetic Observatory, Christchurch. The records are sent to this Observatory for measurement, and are finally returned to the Magnetic Observatory.

From November onwards Mr. C. J. Westland undertook to supply the Observatory with seismological data from his private station at Glenmuick, North Canterbury. Mr. Westland also has a seismograph located at Seatoun, Wellington. The records and reports supplied by Mr. Westland are very useful in the determination of epicentres.

The following is a list of the seismological stations operating in New Zealand and surrounding islands on December 31st, 1931 :—

Station.	Position.		Instruments.	Person or Institution in charge.
	Latitude.	Longitude.		
	° ′	° ′		
Apia, Samoa ..	13 48 S.	171 47 W.	Wiechert, three components ..	Apia Observatory.
Suva, Fiji ..	18 9 S.	178 26 E.	Milne, twin-boom	Miss Mune.
Arapuni ..	38 5 S.	175 39 E.	Milne, E.–W. component ..	District Engineer, Public Works Department.
New Plymouth ..	39 5 S.	174 4 E.	Wood-Anderson	Mr. W. H. Todd.
Hastings ..	39 38 S.	176 53 E.	Milne-Jaggar	Mr. Henry de Denne.
Takaka ..	40 51 S.	172 48 E.	Imamura, three components ..	Mr. W. J. Smith.
Wellington ..	41 17 S.	174 46 E.	(*a*) Wood-Anderson (*b*) Galitzin-Wilip (*c*) Milne-Shaw, two components (*d*) Ishimoto clinograph (*e*) Milne-Jaggar	Dominion Observatory.
Seatoun* ..	41 19 S.	174 48 E.	Inverted pendulum	Mr. C. J. Westland, F.R.A.
Glenmuick* ..	42 54 S.	173 9 E.	Inverted pendulum	Mr. A. S. Westland.
Christchurch ..	43 32 S.	172 37 E.	(*a*) Galitzin-Wilip, three components (*b*) Wood-Anderson	Magnetic Observatory.

* Privately owned stations.

Thanks are due to those who are assisting the observatories in their seismological work by operating instruments and forwarding records and reports.

As the result of the increased number of seismological stations in New Zealand, earthquake epicentres can now be determined with greater precision, and an indication of the focal depth of the more important earthquakes can usually be obtained. Present results indicate that the average focal depth for most of the earthquakes in New Zealand is of the order of ten to twenty miles, while those in the Gisborne – East Cape region appear to have a somewhat greater depth.

The following table gives the number of earthquakes recorded at those stations which were operating during the greater part of the year :—

Month.	Wellington.			Arapuni.	Takaka.	Hastings.	New Plymouth.	Christchurch.
	Near.	Distant.	Total.					
1931								
January	4	24	28	4	..	..	..	..
February	625	12	637	21	23	141	179	..
March	81	12	93	8	7	71	70	..
April	58	14	72	7	4	50	78	..
May	56	7	63	4	10	44	..	..
June	40	4	44	5	3	42	..	..
July	53	4	57	1	6	29	..	1
August	30	9	39	6	3	23	17	1
September	74	7	81	4	4	24	10	4
October	30	14	44	2	1	21	6	8
November	57	19	76	9	1	22	8	8
December	36	25	61	6	1	12	..	9
Total ..	1,144	151	1,295	77	63	479	368	31

NOTE.—The stations at Takaka, Hastings, and New Plymouth were not established in January.

The New Plymouth seismograph was not recording during the months of May, June, and July.

The numbers given for Christchurch are those from the Wood-Anderson seismograph only, which was established in July.

Non-instrumental Reports.

Much valuable information has been obtained during the year from the non-instrumental reports of earthquakes as felt in different part of New Zealand. These reports are sent in to the Observatory by officers of the Marine Department, officers of the Post and Telegraph Department, and also by a number of private observers. The information from the non-instrumental reports is used to assist in the determination of epicentres, and in the preparation of maps showing the distribution of seismic intensity.

The following is a summary of all earthquakes reported as felt in New Zealand in 1931 :—

Month.	Number of Earthquakes reported.				Maximum Intensity (R.-F. Scale).	Locality of Maximum.
	North Island.	South Island.	Both Islands.	Total.		
1931.						
January ..	4	41	..	45	5	Kahurangi Point.
February ..	33	21	6	48	10	Hawke's Bay.
March ..	24	37	3	57	7	Hawke's Bay
April	15	24	3	36	7	Hawke's Bay.
May	31	27	1	57	8–9	North Hawke's Bay.
June	26	9	..	35	7	Opotiki, Wairoa.
July	29	9	3	35	7	Hinakura, Porangahau, Farewell Spit.
August ..	12	14	1	25	5	Hawke's Bay.
September ..	20	12	1	31	8	Opotiki.
October ..	15	6	..	21	5	Hawke's Bay.
November ..	9	12	3	18	6	Buller District.
December ..	10	13	..	23	5	Taumarunui.
Totals ..	228	225	21	431	10	

It will be seen from the above summary that the total number of earthquakes felt in New Zealand for 1931 was 431, the number experienced in each island being approximately equal.

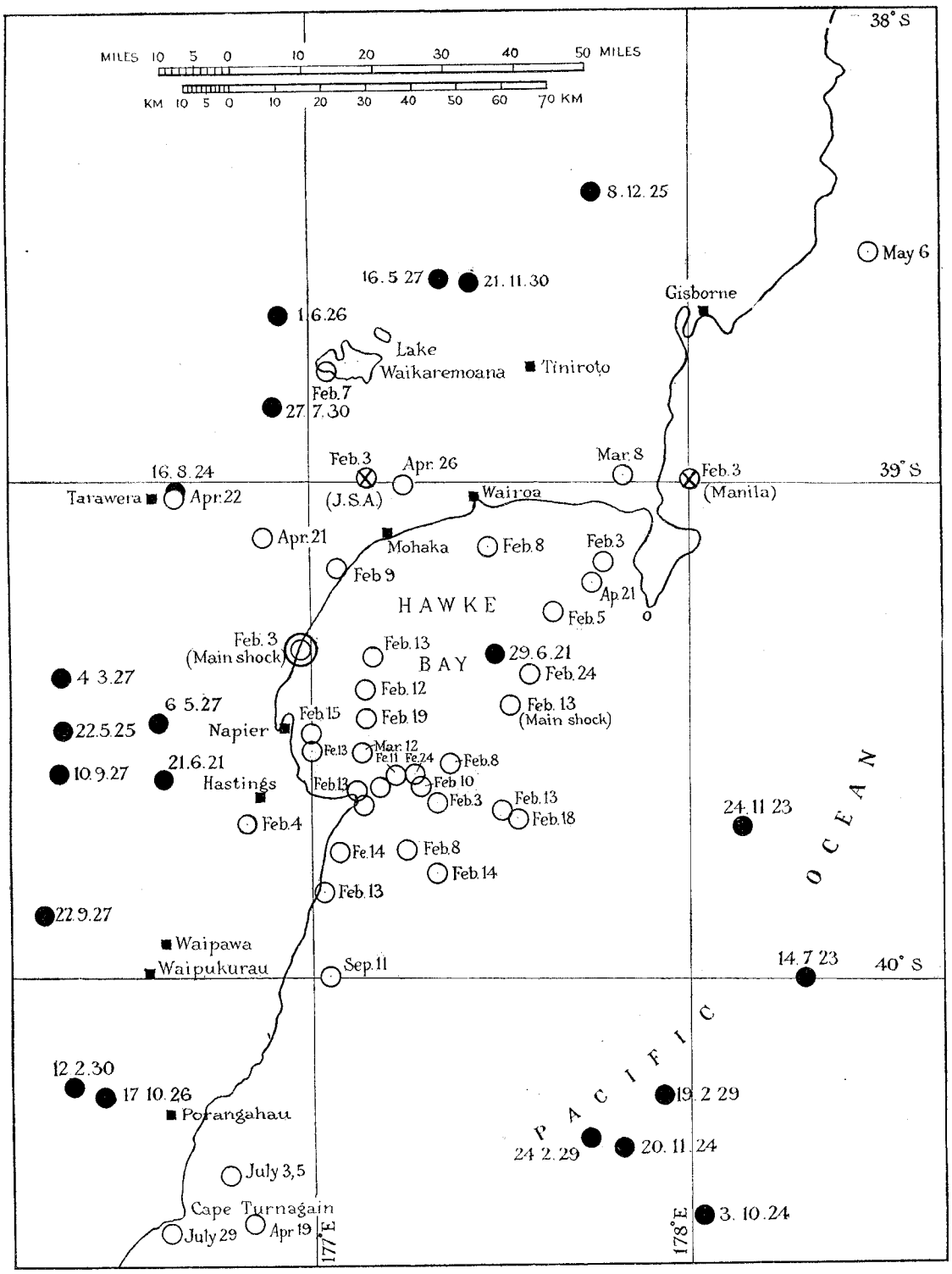
The following table gives the number of earthquakes in 1931 in which the maximum intensity reached various numbers on the Rossi-Forel scale of intensity :—

Month.	Rossi-Forel Intensity.										Totals.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
1931.											
January	..	4	21	17	3	..	..	..	..	..	45
February	..	2	17	11	9	6	1	1	..	1	48
March	..	6	15	20	9	6	1	..	..	..	57
April	..	..	8	15	9	2	2	..	..	..	36
May	1	6	12	25	9	3	..	..	1	..	57
June	1	7	10	8	6	2	1	..	..	..	35
July	..	4	13	9	4	2	3	..	..	..	35
August	..	3	6	12	4	..	..	..	..	..	25
September	1	5	10	10	3	..	1	1	..	..	31
October	1	7	5	6	2	..	..	..	..	..	21
November	..	1	8	5	1	3	..	..	..	..	18
December	..	2	12	8	1	..	..	..	..	..	23
Totals	4	47	137	146	60	24	9	2	1	1	431
Per cent. totals	0·9	10·8	31·7	33·7	13·8	5·5	2·7	0·5	0·2	0·2	100·0

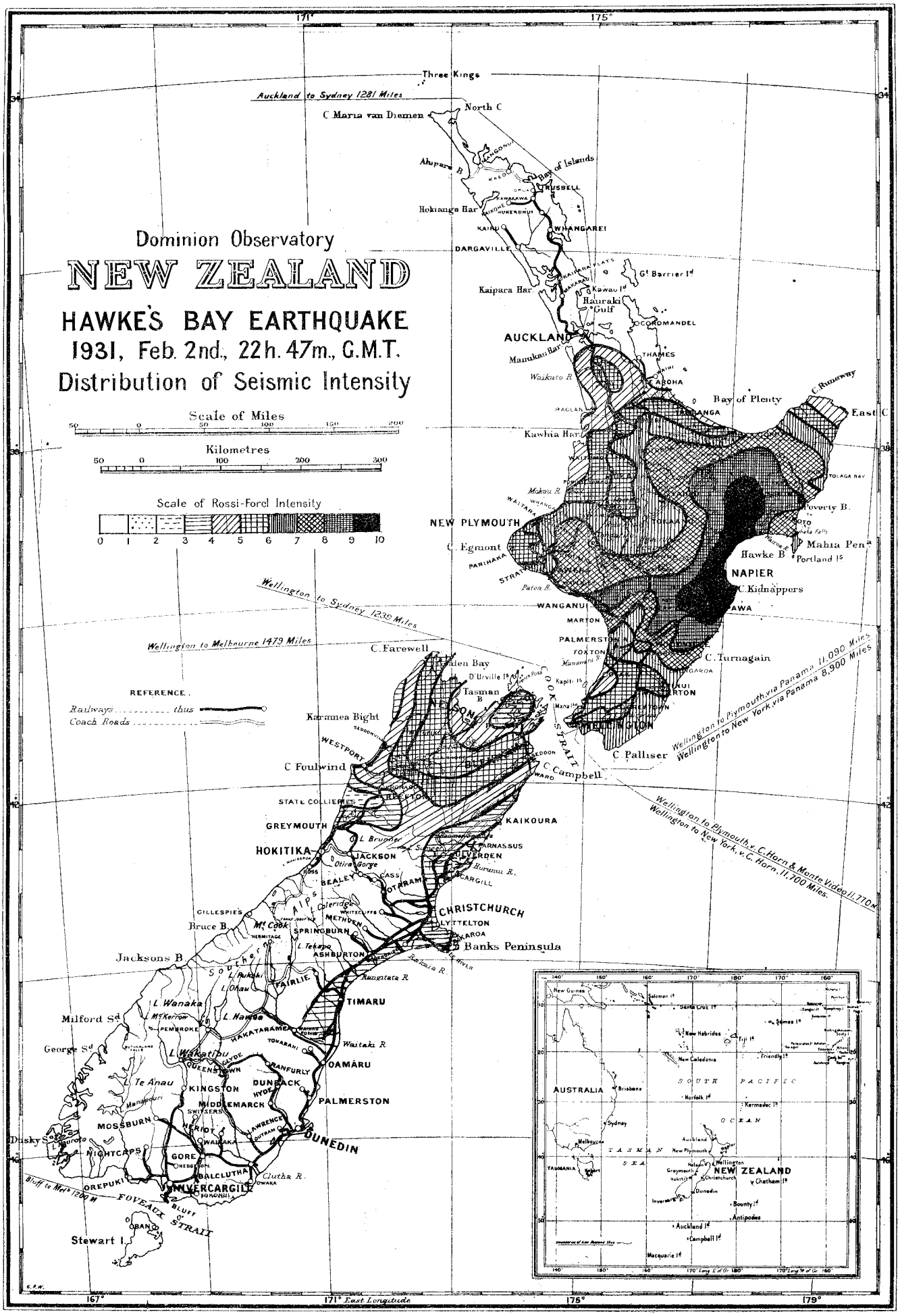
The maximum intensities reported in each of the past ten years were : 1922, 8 ; 1923, 6 ; 1924, 7 ; 1925, 8 ; 1926, 8 ; 1927, 8 ; 1928, 8 ; 1929, 10 ; 1930, 8 ; 1931, 10.

The Hawke's Bay Earthquake.

The outstanding seismic feature of the year was the disastrous Hawke's Bay earthquake on February 3rd. The epicentre of this earthquake was located on the coast-line of Hawke's Bay, from five to fifteen miles north of Napier. A detailed study of the seismograph records indicated that the seat of disturbance was probably from ten to fifteen miles beneath the earth's surface. The main shock was felt over practically the whole Dominion, and exceeded R.-F. 8 at many places in the Gisborne and Hawke's Bay districts.



EPICENTRES OF PRINCIPAL EARTHQUAKES IN HAWKE'S BAY AREA 1921-30... ● 1931 ..... ○


Dominion Observatory
NEW ZEALAND
HAWKE'S BAY EARTHQUAKE
1931, Feb. 2nd., 22h. 47m., G.M.T.
Distribution of Seismic Intensity
Scale of Miles
Kilometres
Scale of Rossi-Forel Intensity
REFERENCE.
Railways ..... thus
Coach Roads .....
Three Kings
Auckland to Sydney 1281 Miles
C Maria van Diemen
North C
Bay of Islands
Hokianga Har
Kaipara Har
Gt Barrier Id
Hauraki Gulf
AUCKLAND
Manukau Har
Waikato R
Kawhia Har
Bay of Plenty
East C
NEW PLYMOUTH
C Egmont
Hawke B
Portland Is
NAPIER
C Kidnappers
WANGANUI
Wellington to Sydney 1239 Miles
Wellington to Melbourne 1479 Miles
C Farewell
Tasman B
Karamea Bight
C Foulwind
C Campbell
C Palliser
C Turnagain
Wellington to Plymouth via Panama 11,090 Miles
Wellington to New York via Panama 8,900 Miles
Wellington to Plymouth, v. C. Horn & Monte Video 11,770 M.
Wellington to New York, v. C. Horn, 11,700 Miles.
COOK STRAIT
GREYMOUTH
HOKITIKA
KAIKOURA
CHRISTCHURCH
Banks Peninsula
Bruce B
Jacksons B
Southern Alps
Mt Cook
TIMARU
OAMARU
PALMERSTON
DUNEDIN
Milford Sd
George Sd
Dusky Sd
NIGHTCAPS
MOSSBURN
KINGSTON
Te Anau
L Wakatipu
QUEENSTOWN
INVERCARGILL
OREPUKI
Bluff to Melb 1200 M
FOVEAUX STRAIT
Stewart I.
OBAN
Clutha R.
Waitaki R
AUSTRALIA
TASMAN SEA
SOUTH PACIFIC OCEAN
NEW ZEALAND
Auckland Is
Campbell Is
Antipodes
Bounty Is
Chatham Is
Macquarie Is
167°
171° East Longitude
175°
179°

The following is a list of places (arranged in order of latitude) where the shock was reported as R.-F. 8 or greater :—

Station.	Intensity (R.-F. Scale).	Station.	Intensity (R.-F. Scale).
Opotiki	7–8	Te Aute	9
Gisborne	8	Taihape	7–8
Wairakei	7–8	Hunterville	8–9
Wairoa	8	Waipawa	9
Mohaka	10	Waipukurau	9
Ohakune	7–8	Dannevirke	7–8
Patoka	8–9	Porangahau	8
Napier	10	Woodville	8
Hastings	10		

The distribution of seismic intensity for the Hawke's Bay earthquake of February 3rd is shown on the map (fig. 1).

After-shocks were frequent for some weeks after the main earthquake, but fortunately the activity subsided fairly rapidly. During the remaining days of February 595 after-shocks were recorded at this Observatory, but in March the number fell to seventy-nine. The number of after-shocks as recorded at Hastings during the year showed a steady decline, only twelve being recorded in December.

Epicentres were determined for about forty of the principal after-shocks, most of which occurred in February.

The positions of the epicentres in the Hawke's Bay region for 1931 are shown on the map (fig. 2). The epicentre of the main shock on February 3rd, as determined by the Jesuit Seismological Association (J.S.A.), and the Manila Observatory, are also indicated on this map.

A second severe shock occurred on February 13th, reaching R.-F. 8 at a number of places in Hawke's Bay. The epicentre of this shock was located about thirty miles east of Napier.

A more detailed report of the Hawke's Bay earthquake, embodying also the geological and other aspects, is in course of preparation and will be published by the Department as a special bulletin.

Publications.

The Observatory has continued to publish preliminary seismological reports promptly at the end of each month, giving sufficient information for a preliminary determination of the epicentres of the principal earthquakes.

From August onwards a preliminary seismological report from the Magnetic Observatory, Christchurch, has been published, together with that from this Observatory.

The following full seismological reports of this Observatory have also been published :—

E.–23.—Earthquake Reports for 1929, October to December.
E.–24.—Earthquake Reports for 1930, January to June.
E.–25.—Earthquake Reports for 1930, July to December.
E.–26.—Earthquake Reports for 1931, January.

In addition, the following bulletins have been issued :—

Bulletin No. 78.—History of the Date or Calendar Line.
Bulletin No. 79.—Report of the Dominion Astronomer for 1929.
Bulletin No. 80.—Seismology in New Zealand.
Bulletin No. 81.—Earthquakes in New Zealand.

Staff.

The staff for 1931 was as follows . Mr. R. C. Hayes, Professional Assistant ; Mr. I. L. Thomsen, clerk. Mr. C. J. Westland was on the staff from February 3rd to March 31st as Assistant in Seismology. Besides his official connection with the Observatory, Mr. Westland gave voluntary assistance in the seismological work from April 1st to November 9th.

C. E. Adams,
Dominion Astronomer and Seismologist.

Dominion Observatory, Kelburn, Wellington, N.Z.,
June 9th, 1932.

APIA OBSERVATORY, SAMOA.

Director: J. Wadsworth, M.A.

The programme of work in terrestrial magnetism, atmospheric electricity, seismology, and meteorology has been generally maintained during the year 1931–32 as in former years.

Terrestrial Magnetism.

Absolute observations of the earth's magnetic field were obtained regularly with the Tesdorpf magnetometer and the Schulze earth inductor, and continuous records of declination and horizontal intensity were given by the Eschenhagen variometers. The variometer for vertical force remained out of action throughout the year, and the autographic records were interrupted in March, 1932, by a break-down of the driving clocks. A few experiments were made with stereograms as a means of representing terrestrial magnetic changes. With the exception of March, 1932, the year as a whole was free from magnetic disturbance.

The mean values of the magnetic elements—the so-called "all-days" value—for the past three years are given below:—

Annual Mean Values of Magnetic Elements.

——	1929.	1930 (Six Months).	1931.
Declination	E., 10° 33′·5	E., 10° 34′·2	E., 10° 35′·2
Horizontal intensity	35209 gamma	35195 gamma	35171 gamma
Vertical intensity	20418 gamma (six months)	20428 gamma	..

Seismology.

The seismographs are of Wiechert design. Both the horizontal and the vertical instruments have been out of action for a time during the year pending the arrival of new spare parts from Germany. The spare parts were eventually received, but the larger instrument still showed a certain amount of stiffness and defect of balance.

The following analysis shows the character of the records of earthquakes obtained during the year:—

Earthquakes registered 1st April, 1931, to 31st March, 1932.—Total number of shocks registered, 122. Of these, 10 were felt by residents in and around Apia.

The epicentres of the most prominent earthquakes have been determined, and are located as follows: Solomon Group, 7; near New Hebrides Group, 2; between Samoa and Fiji Groups, 1. None of these latter were felt by persons resident in Samoa.

Of the total number of shocks registered (122), 80 originated within 9 degrees of Apia, 17 from greater distances than 9 degrees, and 25 from indeterminate distances.

Meteorology.

The work in meteorology included surface observations twice a day, as in previous years, and some measurements of upper winds from time to time, using pilot balloons. The hygrograph did not function very well, in spite of its being fitted with new hairs. The anemometer at Niue Island was received for repairs, and Lieutenant Warrand of H.M.S. "Veronica" kindly undertook the inspection of the stations in the Union Islands on behalf of the Observatory during the visit of His Excellency the Administrator. A weather diary was commenced to supplement the observations at fixed hours at the Observatory, and a trial was made of Bergeron's method of measuring visibility. In the autographic records of pressure millimetres were discarded in favour of millibars.

Preliminary mean values of meteorological elements for the year 1931 are as follows:—

Meteorological Summary—Apia Observatory, Samoa, 1931.

Month.	Pressure.	Temperature.	Rainfall.	Humidity.	Sunshine.	Wind.
	In.	°F.	In.	Per Cent. (9 a.m.).	Hours.	Miles per Hour.
January	29·709	80·2	17·20	84	159·8	5·4
February	29·689	80·1	19·97	83	126·9	3·2
March	29·823	80·4	10·47	81	164·5	3·6
April	29·823	79·7	15·94	78	205·4	4·6
May	29·858	79·3	13·90	81	161·3	4·4
June	29·882	78·1	10·87	79	195·7	4·9
July	29·898	78·4	3·90	74	259·2	5·6
August	29·862	78·8	2·00	77	219·1	5·3
September	29·882	79·0	5·48	77	216·2	4·5
October	29·851	78·6	8·34	74	227·7	3·4
November	29·795	79·0	5·82	74	234·6	3·5
December	29·793	78·6	8·98	76	177·0	2·9
Total ..	..	..	122·87	..	2,347·4	..
Mean ..	29·822	79·2	..	78	..	4·3

There were three tropical cyclones in the vicinity of the islands during the wet season. The dates of these were as follows:—

18th January, 1932: A cyclone passed over the Tonga Islands.
6th February, 1932: A cyclone occurred near the Tonga Islands which ultimately developed into a storm covering a wide area to the south of the islands.
12th March, 1932: A cyclone passed over the Tonga Islands having previously developed northward of Samoa.

Storm Warnings.

Daily reports of weather were prepared, as in former years, for inclusion in the broadcast from Apia Radio Station. During the hurricane season, November to April, these reports go out twice a day, and they include reports of weather from the various groups of Southern Pacific islands.

Time Service.

The standard clock (by Strasser and Rohde) continued to give satisfactory service. It was checked at intervals by means of wireless time signals from Annapolis, U.S.A., and by transit observations of the sun.

Atmospheric Electricity.

The potential of the air has been registered by Benndorf self-recording electrometers at two stations, as in previous years—one in the lagoon, and the other in the grounds of the Observatory. The necessary financial support for this work was given by the Carnegie Institution, of Washington. A new insulator for the lead-in wire at the land station, designed by Mr. Sanderson, proved to be very satisfactory. The Public Works Department erected a platform in the lagoon for the purposes of making absolute observations, using a raft carrying a stretched wire. This arrangement was also suggested by Mr. Sanderson, and supersedes the older and more tedious method of observing on Watson's Island.

Personnel, Buildings, and Equipment.

Mr. H. B. Sapsford arrived at the end of November, 1931, to take the place of Mr. K. C. Sanderson. Mr. Sanderson left the Observatory at the end of December, 1931. Mr. Wadsworth visited the observatories and headquarters of the Department of Scientific Research in New Zealand in August, and also the meteorological stations in Fiji and Tonga.

The building used as a library was enlarged by taking in the space occupied by the veranda. The books and papers were then arranged in an orderly manner on the shelves. Rats have proved to be a great nuisance in the library, and they have damaged a good many of the books, especially the bindings. The grounds of the Observatory have been thoroughly cleared of shrubbery and some paths have been made by the Chinese labourers between the various buildings and huts. The doors and windows of the office and residences were thoroughly overhauled, and fitted with locks and fasteners. A new roof of malthoid cloth was put on the hut occupied by the two Chinese coolies. The Department of Public Works put up a new hut to house the spectrohelioscope which the Observatory has received on loan from Mount Wilson Observatory.

The Observatory purchased a duplicating-machine and a typewriter in the course of the year, and is using these machines to issue its monthly and quarterly reports.

Some preliminary experiments on the ripening of bananas were carried out in February and March at the Observatory, using the spare room in the magnetograph-house.

His Excellency the Administrator of Western Samoa visited the Observatory in May, 1931.

The Observatory makes grateful acknowledgment to the British Admiralty, the Department of Terrestrial Magnetism of the Carnegie Institution, and to the Rockefeller Foundation of New York for very generous and substantial grants made during the past year.

MAGNETIC OBSERVATORY, CHRISTCHURCH.

REPORT BY THE DIRECTOR.

In August, 1931, the control of the Magnetic Observatory was transferred from the Lands and Survey Department to the Department of Scientific and Industrial Research.

Magnetic Observations.

During the year 1931 the work of recording and tabulating the mean hourly values of the magnetic declination, horizontal force, and vertical force has been continued as usual. The Eschenhagen magnetographs at Amberley and the Adie magnetographs at Christchurch have been kept in operation.

The correction and tabulation of the hourly values for 1931 is not yet quite complete. The preparation in a revised form for a new method of printing of the reports for 1928, 1929, 1930, undertaken last year, involved great extra work upon the staff. The installation of new instruments has occupied considerable time. However, the true mean annual values will be available shortly, when the activities of the Polar Year programme permit.

Meteorological.

The programme of meteorological observations (thrice daily on most days) was continued for climatological purposes and the information was published in the local papers. There has been much demand for this information from other Departments and many sections of the community. Nine a.m. observations were telegraphed daily to the Director, Meteorological Services, Wellington, to assist him in preparing weather forecasts. On 239 days pilot-balloon observations were made to investigate upper-air currents; an abstract of each flight was also telegraphed, in code, for forecast purposes.

Atmospheric Electricity.

In atmospheric electricity the Benndorf recording electrometer has been kept operating, and the records obtained are being measured. The recent installation of a small electric heater of tube type has enabled the insulation of this instrument to be maintained much more effectively.

Seismological.

Some 150 earthquakes were recorded in 1931. Monthly bulletins of preliminary measurements of earthquakes were published from August onwards. The earlier records have been measured.

During the year instrumental equipment has been much improved. A three-component set of Galitzin seismographs was obtained from England, while a Wood-Anderson torsion seismometer, suitable for recording near shocks, was sent from Wellington.

The Milne seismograph, No. 16, was removed to another cellar, and just after the completion of the year was sent to the Chatham Islands.

The three Galitzin seismographs and the Wood-Anderson were set up in the Milne cellar, which is consequently cramped for space. Active steps are being taken to have all four recording-drums arranged on one shaft. Records will then last twenty-four hours, or twice as long as previously, without prejudicing seriously the wider Galitzin trace. The cellar will still be cramped, but later it may be possible to use the Adie cellar, which appears ideal.

In February the assistant, Mr. Baird, visited the Hawke's Bay earthquake area. Besides using customary methods in such preliminary investigations, he carried out a reconnaissance by aeroplane over the disturbed area. The course from Hastings was along the coast from Cape Kidnappers to Wairoa and back on a more inland route. A separate report on this work was forwarded to the Surveyor-General early in the year.

Staff.

In conclusion, I wish to express appreciation of the manner in which the members of my staff have carried out their duties during the year. It is pleasing to record that Mr. Beagley, computer, graduated M.Sc. with second-class honours in mathematics during the year, while Mr. Larsen, cadet, passed a further section of B.Sc.

Henry F. Skey, Director.

Christchurch, 21st September, 1932.

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