1937.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(ELEVENTH ANNUAL REPORT OF THE).

Presented to both Houses of the General Assembly by Leave.

CONTENTS.

The Hon. D. G. SULLIVAN, Minister of Scientific and Industrial Research.

I have the honour to submit herewith the annual report of the Department for the year 1936–37.

E. MARSDEN.

MINISTER'S STATEMENT.

PURSUANT to the policy enunciated in my report for 1935–36, the keynote of the Department's work during the past year has been related to my general plan of encouraging co-ordination, research, and standardization in relation to the whole of our industrial developments. Apart from the special functions of the Bureau of Industry in promoting industrial co-ordination in relation to what may be termed the organization or structure of industry, there has been a material advance during the year in the co-ordination of research activities relating to particular industries, and also in the co-ordination of various specialized research activities amongst themselves, so as to enable teamwork between various branches of science to be directed on industrial problems. In this latter connection special mention may be made of the Plant Research Bureau, which was created to co-ordinate and reorganize plant research in the Dominion. This is now effectively functioning, and significant practical results have already emerged from its activities. The Advisory Committee of the Bureau comprises representatives of the Departments of Agriculture and Scientific and Industrial Research, Massey and Canterbury Agricultural Colleges, and the Cawthron Institute, and the organization that has been evolved to deal with the main plant problems as conceived by the Committee and specific problems which have been referred to it, is designed to give the most effective service from every point of view. Similar progress has also been made in the field of research in soils and in animal diseases, and in regard to co-ordination with the investigational activities of various other Departments.

In pursuance of the Government's policy of co-operation with industrial groups in research and technical investigation, negotiations were completed during the year for the formation of three additional Research Associations—*i.e.*, by the woollen-manufacturing, tobacco, and footwear-manufacturing industries. The headquarters of the first-named will be at the University of Otago, and the hearty co-operation of the Otago University Council is gratefully acknowledged.

The advances in knowledge arising from the various branches of the Department's activities are enumerated in the individual reports of the sections concerned. It will be appreciated that the success of the work is measured not so much by spectacular discoveries, but rather by the steady co-ordinated advances made over a wide front, and, particularly, by the wide but basic conceptions which emerge from the researches and which assist in diagnosing and viewing more clearly the real and significant problems involved in the management of industry.

In this connection it may be noted in passing that a factor of almost equal importance to the provision of further research facilities is that of an improvement in the standard of technical education of managers, foremen, workmen, &c., in our various industries. It has been found that one of the results of co-operative work with industry, exemplified in the operations of the research associations, has been the raising of such standards throughout the whole of the industrial field. Those concerned in industry need a basic knowledge of science as applied to industrial processing so that they may avoid trouble in manufacturing operations by anticipating the cause of such trouble. The obtaining of this knowledge has been facilitated by the investigations undertaken mutually and with the staff of the Research Association concerned.

As I have said, it is the advance made over a broad front that counts, and while it may be invidious to enumerate the advances made during the year in any particular activity, nevertheless a few examples may be quoted by way of illustration.

The culmination of the researches on the significance of cobalt in relation to anæmia of sheep has led during the year to a substantial increase in the use of cobalt treatment. A stock and station agent in one district states that it will mean increased returns to his province of over £100,000 per annum, and there are

other larger districts in which the results seem likely to prove of even greater benefit. The soil and land utilization researches have pointed the way to greatly increased carrying capacity in one province in which they are at present concentrated, but, which is perhaps more important in the long run, the soil studies generally have led to more exact diagnosis of the processes involved in land deterioration and erosion. With such diagnosis the remedy is made easier and more economic.

In meteorology the foundations have been completed during the year for a service which will function adequately for the rigorous requirements of the rapid development of commercial aviation.

In plant research fundamental experiments and tests have been made for the building-up of a linen flax industry, while studies have been made in many general directions in relation to plant breeding and disease control. In dairy research great headway has been made on the problems of openness of cheese and cheese ripening and flavour.

Geological survey work during the year has led to some valuable generalizations regarding the occurrence of gold-bearing lodes in the Reefton district, while geophysical work has simplified our knowledge of structures possibly associated with oil in three districts.

In regard to seismology, important results have accrued from work during the year in the tracing of earthquake epicentres, and the data which are being assembled in regard to seismic activity in the Dominion are proving of considerable assistance in framing building by-laws and in connection with standards for building-materials.

In the Dominion Laboratory varied experiments are in progress—for example, those dealing with the gas-storage of apples, the curing of lemons, and the pulping of flax.

At the Wheat Research Institute an important advance has been made in the study of natural bread improvers.

Many other cases could be cited, but I quote these examples to show the nature of the progress made.

In my statement accompanying last year's report I emphasized the importance which I attached to the vigorous development and adoption of industrial and commodity standards in order to help in attaining maximum efficiency and productive output in our industries. It is clear that the sane application of the principles of standardization to our industrial and economic life is eminently desirable in that they should assist in securing a maximum return of goods and services from a minimum expenditure of effort, and should thus raise the standard of life of the people of New Zealand by conserving the buying powers of the consumer. The recognition of the fundamental importance of standards in relation to industrial development, particularly throughout this century, in almost every country of the world confirms this claim.

The progress made by the Standards Institute in the adoption and promulgation of standards has been most gratifying, especially in view of the short period in which it has been in effective operation. A large number of committees and sub-committees have been set up, and a very wide range of projects has been dealt with. The good will and active co-operation of the various interests to whom draft specifications have been sent for comment have greatly facilitated the work of the Institute.

To turn now to the social use and implications of scientific progress, it has come to be recognized that all changes in the material equipment of a country, in systems of production and distribution, have social implications of great importance. In a purely individualistic world the people affected by these changes would be left to take care of themselves; but twentieth-century opinion shrinks from such a view, and it is the task of the legislator to endeavour to anticipate and make provision for the consequences of the inevitable social changes which spring from scientific and economic progress. The demand for fundamental inquiries into the conditions of social life has come only with the progress of civilization. This demand has been stimulated in no small measure by the contributions which have already been made by researches in the fields of economics, political science, sociology, psychology, and education. That the future will

intensify this demand seems certain. The reasons for employment or unemployment of people, nutritional problems and questions of proper housing and of leisure, and provision for old age are all matters on which facts are now being eagerly sought as a basis for enlightened national and community action. It is in an endeavour to explore and meet this need for research in the social sciences that a Bureau of Social Science Research has recently been established as a new activity. The work of the new Bureau will include the co-ordinating of the activities of research bodies or individuals working in the fields of social sciences so that the utmost benefit will be realized from their efforts, the stimulation of interest in the social sciences, the development in the community of an appreciation of their significance, and the undertaking of investigations by the Bureau itself to assist Government by providing the necessary factual bases for policy measures of a social nature.

The drift of New Zealand University graduates overseas to take up appointments has often been the subject of adverse comment. It is therefore encouraging to observe that the effort to stem the drift is meeting with some success, in that the services of a number of New Zealand graduates who had migrated overseas have been secured for the Department, and that, too, there are two ex-Rhodes Scholars on the staff. Another pleasing feature is the increasing opportunity which is being given to women graduates to obtain scientific appointments.

D. G. Sullivan,
Minister in Charge of Scientific and Industrial Research Department.

SECRETARY'S REPORT.

The Council of Scientific and Industrial Research held five meetings during the year.

The personnel of the Council, prior to 1st January, 1937, was as follows:—

Professor Henry George Denham, M.A., D.Sc., Ph.D., Professor of Chemistry at Canterbury University College, Christchurch (Chairman).
Mr. Alfred H. Cockayne, Director-General of Agriculture, Wellington.
Mr. George A. Duncan, Executive Commission of Agriculture.
Professor John Malcolm, M.D., Ch.B., Professor of Physiology, University of Otago, Dunedin.
Mr. George A. Pascoe, Industrial Adviser, Department of Industries and Commerce, Wellington.
Professor William Riddet, B.Sc. (Agric.), N.D.A., N.D.D., Massey Agricultural College.
Mr. Theodore Rigg, M.A., M.Sc., F.I.C., F.R.S.N.Z., Director, Cawthron Institute, Nelson.
Mr. Archibald M. Seaman, F.P.A.N.Z., Public Accountant, Auckland.
Mr. Hugh Vickerman, D.S.O., O.B.E., M.Sc., M.Inst.C.E., Wellington.
Dr. Ernest Marsden, M.C., C.B.E., D.Sc., F.R.S.N.Z. (Secretary).

During the absence abroad of Professors Denham and Riddet, who represented New Zealand at the British Commonwealth Scientific Conference held in London during September–October, 1936, Mr. T. Rigg was Acting-chairman, and the temporary vacancies in the Council were filled by Messrs. L. J. Schmitt and J. M. Ranstead.

The term of office of the Research Council having expired on the 31st December, 1936, it was reappointed, with certain changes in personnel, for a period of three years from 1st January, 1937. The changes in personnel were the replacement of Messrs. A. M. Seaman and H. Vickerman by Dr. J. C. Andrews and Dr. R. O. Page, and the appointment of Mr. J. M. Ranstead in place of Mr. G. A. Duncan.

Mr. T. H. McCombs, M.P., attended meetings of the Research Council as the special representative of the Hon. the Minister.

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

Permanent Services—

	£
Head Office, Publications (including *New Zealand Journal of Science and Technology*), Research Scholarships, and grants to the Imperial Agricultural Bureaux, the Royal Society of New Zealand, and the Australian and New Zealand Association for the Advancement of Science)	9,212
Dominion Laboratory (with branches)	17,261
Geological Survey	7,409
Meteorological Office	12,069
Apia Observatory	2,241
Dominion Observatory	2,130
Magnetic Observatory	2,295
Canterbury Agricultural College	5,107
Research Investigations	74,233
	£131,957

The funds devoted to research work were derived from the following sources:—

	£
Imperial Economic Committee	411
Industries	13,268
Sales and miscellaneous recoveries	13,243
Consolidated Fund	47,311
	£74,233

As in previous years, grants were made to the Cambridge Low Temperature Research Station (£3,000), the Imperial Agricultural Bureaux scheme (£1,394), Farnham House (£750), the Imperial Institute of Entomology (£400), the Imperial Mycological Institute (£300), and the British Wool Industries Research Association, Torridon (£300). A grant of £200 was made towards the cost of a British expedition to Peru to collect new varieties of potatoes for the purpose of crossing with cultivated varieties in order to improve their disease-resistant qualities. A grant was also made to Massey College for assistance in work on some of the causes of sterility in sheep.

The biennial meeting of the Australian and New Zealand Association for the Advancement of Science was held in Auckland in January, 1937, and a grant was made by the Government, through the Department of Scientific and Industrial Research, to meet the cost of travelling concessions to overseas delegates and the printing of the official Handbook, programme, and other material. The meeting was attended by the majority of the professional officers of the Department, many of whom delivered scientific papers and took advantage of the opportunity of public and private discussions with Australian research workers on common problems.

As indicated by the increase in expenditure over that of last year, there has been a marked expansion in the work of the Department during the past year. The improvement in economic conditions generally has brought about a corresponding increase in industrial activity, which is reflected in the increased demands made on the Department for research investigations and scientific services.

The most outstanding developments during the year were the successful reorganization of plant research under the Plant Research Bureau, and the steps taken to establish an animal Research Bureau; the establishment of the Standards Institute and the Social Science Research Bureau; and the development of Research Associations in connection with the tobacco, wool-manufacturing, and footwear-manufacturing industries.

The Industrial Efficiency Act which was passed during the year provided that the Bureau of Industry established to administer the Act should, through the medium of the Department of Scientific and Industrial Research, collaborate with any research or other organization established in New Zealand or elsewhere and arrange for the publication and distribution of appropriate information among persons or organizations concerned, with the object of increasing the general standard of industrial efficiency in New Zealand. The Department's services have already been largely utilized in this connection, and it is anticipated that as the Act is more widely applied the demand for scientific services will be correspondingly greater.

A feature of the staff appointments made recently has been the obtaining of the services of a number of New Zealand science graduates who had migrated overseas. Some six have recently been appointed in this way, and incidentally it is interesting to note that there are two New Zealand ex-Rhodes scholars on the staff. Another feature has been the appointment of women graduates, there being six now employed in the Department.

The work of Head Office has been made more difficult during the year owing to the absence through unfortunate illness of the Dominion Analyst, also the necessity of sending one of the professional officers to England on account of the ill health of the Scientific Liaison Officer and his increased duties as Chairman of the Executive Council of the Imperial Agricultural Bureaux.

The loyal co-operation of the staff in successfully carrying out the year's programme of work and in adapting themselves to increased demands on their energies is gratefully acknowledged.

DOMINION LABORATORY.

Mainly owing to a number of special investigations being undertaken, there has again been a considerable increase in the amount of work carried out by the Dominion Laboratory, making a further increase in staff necessary.

During the year a laboratory has been fitted up for the chemical and related work required in connection with a comprehensive survey of the coal resources of the Dominion.

Experimental work on the gas storage of apples and the curing of lemons has entailed the setting-up and operating of complicated large-scale apparatus.

Probably the most noteworthy advance during the year was the installation of a Hilger automatic large quartz spectrograph. This has enabled the laboratory to avail itself of one of the greatest recent advances in connection with methods for detecting and estimating trace elements in various materials such as soils, mineral waters, alloys, &c.

The general work of the Laboratory consists of examination of many and diverse types of material for various Government Departments.

Increasing use is being made of the Laboratory by purchasing Departments to ascertain if supplies comply with specifications. A considerable amount of testing has already been carried out for the newly established Housing Department.

Large numbers of exhibits were examined for the Police Department at the Main Laboratory and the three branches, and this phase of the Laboratories' activities is also increasing.

For the Department of Health numerous samples of milk and other foods were examined to ascertain if they complied with the requirements of the Sale of Food and Drugs Act, and samples from existing and projected water-supplies were analysed.

It is satisfactory to record that on the whole the milk supplies of the Dominion are very satisfactory both as regards food value and cleanliness. With other foods also the results of analyses show that there is little wilful adulteration practised in New Zealand.

During the year investigations on deposits of bentonite, pozzolanic materials, clays, and diatomite were continued, and various other materials were analysed for the Geological Survey Branch, while clay fractions from large numbers of soils were examined for the Soil Survey Division. Analyses of waters and gases from the thermal regions were also made.

Two officers have been detailed for work dealing exclusively with general technological problems of industry. Numerous industrial questions have been dealt with, including flax pulping, process control methods at the Foxton woolpack factory, and testing of producer gas.

The library has as far as possible been kept up to date in all phases of general chemistry and chemical technology, and the staff therefore is able to keep abreast of latest advances.

Mr. Grigg, Government Analyst, Christchurch, recently visited Great Britain, France, and Germany, particularly with a view to investigating the latest practice in connection with toxicology, food and drug analysis and the examination of water supplies and sewage and gained much useful information.

METEOROLOGICAL BRANCH.

The development of commercial air transport, and particularly the prospect of the early development of trans-ocean lines, has required a rapid expansion of the meteorological services. The Director's report calls attention to the difficulties associated with the securing of personnel with the necessary qualifications. The shortage of meteorologists is being felt in almost all countries, and the additional staff has had to be recruited from students with a general training only in mathematics and physics. It will be some years before the new staff can reach full efficiency. In the meantime much of the work must be of a somewhat superficial character, and attention has been concentrated on the more immediate needs of the moment. A meteorologist now requires a long and highly specialized training, and it would be of great advantage if this could be provided at one of the University colleges.

Failing that, the difficulty might be overcome by appointing some one to the Meteorological Office staff who was specially qualified to give advanced instruction in the subject and who would be free to devote most of his time to duties of that nature and in the directing of meteorological research.

Gradually a satisfactory network of observing stations is being built up, both the close net of rainfall stations and the more sparse one where temperature and other elements are also recorded. Soil surveys and intense investigation of agricultural problems have, indeed, brought forward prominently the need for climatological data and the demand for new stations has been rather difficult to cope with.

Weather charts are now prepared four times a day, and special reports for aviation are broadcasted thrice daily, apart from special forecasts. These improved services have been much appreciated.

The production of the weather charts required for forecasting involves the co-operation of various countries over a wide area. Thus for New Zealand forecasters reports from Australia are of vital importance, and a complete understanding of the meteorological situation is often impossible without reports from the south-western Pacific. When trans-ocean flights are in operation frequent reports from both regions will become still more essential. The exploratory flight of the Pan-American Airways clipper from San Francisco to Auckland provided valuable experience regarding the efficiency of the weather service from the Pacific Islands. With the co-operation of other Governments and other Departments in New Zealand it is anticipated that a much improved service will be available shortly. It is clear, also, that a conference will have to be called before long between representatives of countries concerned with meteorology in this quarter of the globe in order that an adequate reporting system may be organized. One of the principal problems in connection with such an organization is that of communications. Meteorological institutions must be in very close touch with their reporting stations, with all main aerodromes and air bases, with aircraft in flight and with each other. Particularly in the case of trans-ocean flights must free intercommunication by radio be available. The provision and co-ordination of communication services is therefore receiving earnest attention.

Observations in the upper air, especially of wind and temperature, are of importance not only because of the increased knowledge they provide the weather forecaster, but also because of the practical value to aircraft in flight. In so far as is possible with the resources at our command, it will therefore be necessary to develop a network of upper air observing stations.

Attention is again called to the publications of the Meteorological Office, to which reference will be found in the Director's Report.

GEOLOGICAL SURVEY.

The field surveys this year were in the Dannevirke, Reefton, Wakaia, and Blackburn districts. Excluding the Reefton and Blackburn areas which were examined years ago, about 400 square miles of country was mapped in detail. Two bulletins have been published, and others are in the press and in the course of preparation for publication.

The Dannevirke Subdivision is part of the petroliferous province which extends along the whole of the east coast of the North Island. The rock sequence and structure is similar to those of the adjacent Eketahuna Subdivision. West of the Ruahine Ranges lies a wide gravel-covered lowland between which and the sea are a series of folds and elongated fault-blocks subparallel with the mountains and the coast. The stronger folds in the possibly oil-bearing eastern part are too broken and eroded to be likely to contain commercial accumulations of oil, but there are a few minor structures that may warrant further attention.

Studies have been made of the water-supply problems of parts of Hawke's Bay.

In the Reefton district intensive work has shown that the lodes occupy shears close to the axes of folds in the ancient rocks. The largest group of lodes follows the trough of a syncline which extends south through Boatmans, Ajax Hill, and Crushington. The Blackwater Lode is near the crest on an anticline which continues north under gravels and is perhaps the same fold as that in which the veins at Merrijigs appear. The Big River is in a much faulted syncline farther east, but the relations of the Globe-Progress Lode are doubtful. Owing to unfavourable weather and the diversion of an officer to other work no examination of the remaining area at Kirwans and Alexander was possible. This will be finished next spring.

Mapping in Wakaia Subdivision was completed this season. Two systems of faults cross the district at right angles. The older, parallel with the north fronts of the Kaihiku and Hokanui hills, is represented by the zone of dislocation followed by Winding Creek and part of Dome Creek. Crust movements along the north-north-east faults of the other system largely determine the present topography, which consists essentially of subparallel tilted blocks forming ranges separated by valleys occupying fault-angles. Parts of a former Tertiary cover involved in the faults have escaped erosion and contain richly auriferous gravels.

For many years the Blackburn coalfield has been regarded by some as a vast untapped reserve of fuel. Unfortunately, more detailed investigations in this area have but confirmed the unfavourable features the survey of twenty-five years ago disclosed. The total probable coal amounts to only 5,000,000 tons.

Aerial photographs of a considerable area of Dannevirke Subdivision facilitated field-work. In the future it is hoped to make more use of this modern method of topographic survey, and to this end photographs of part of the Glenorchy Subdivision have already been made, and the remainder of this extremely rugged district will be covered next season.

The geophysical work has been mainly confined to a thorough investigation of the Reefton field and to studies of the structure associated with oil seepages in three areas. The whole of the results of the work to date have been prepared for publication in bulletin form with a view to indicating the applicability and usefulness of these methods of survey. Publication was delayed pending the receipt of the results of boring and prospecting of some of the areas dealt with.

OBSERVATORIES.

The Dominion Observatory at Wellington, the Magnetic Observatory at Christchurch, and the Apia Observatory, Western Samoa, have carried out their usual programme of astronomical, seismological, meteorological, and magnetic observations.

The study of seismic activity in New Zealand and fundamental research in seismology is an important part of the work of the Dominion Observatory, in co-operation with the other observatories, the Post and Telegraph Department, and a number of voluntary research workers and observers. In our present state of knowledge reliable prediction of earthquakes in regard to exact, or even approximate, time, place, and magnitude cannot be given, but generalized forecasting is approaching practicability and, moreover, is the duty of the scientist to the public in countries liable to seismic activity.

Distinct progress has been made during the year in the more exact location of earthquake epicentres. This is due partly to advances in technique made by the staff and partly to a gradual improvement in equipment and in the more exact timing on records. Much interesting information is emerging regarding the nature and origin of our local earthquakes.

A considerable number of scientific papers were published during the year by the Observatory staff.

During the year proposals have been framed, in co-operation with the Royal Society of New Zealand and the Wellington City Council, for the establishment of an astronomical observatory with contributions from the Carter Bequest to the Royal Society of New Zealand, the Wellington City Council, and the Government. The proposed observatory will take over the astronomical research formerly carried out at the Dominion Observatory.

The data on the seismicity of cities, towns, and districts in New Zealand which have been assembled by the Dominion Observatory are proving of considerable value in the framing of building regulations and in connection with the development of standards for building-materials.

PLANT RESEARCH BUREAU.

The co-ordination and reorganization of plant-research activities in the Dominion under a newly-created unit of the Department—the Plant Research Bureau—has made very rapid progress during the year, and the new Bureau is now in effective operation.

The main plant problems have been reviewed by the Advisory Committee of the Bureau, comprising representatives of the Departments of Agriculture and Scientific and Industrial Research, Massey and Canterbury Agricultural Colleges, and the Cawthron Institute, with a view to deciding upon the best methods of attack and the most efficient use of resources available.

The four main divisions of the Bureau, dealing with plant diseases, grasslands, agronomy, and entomology, have been organized with due regard to personnel, location, and co-operation with existing research institutions so as to give the most effective service in their respective spheres.

The Plant Diseases Division has been located at Mount Albert, Auckland, on an area which from the point of view of diversity of soil type and accessibility is admirably suited for its work. In order to make immediate provision for the requirements of the fruit industry in the Auckland Province an established orchard area at Huapai has been leased, and the trees will be available for the testing of spray materials and other investigations connected with orchard management. Good progress has been made with the study of virus diseases of farm crops, particularly of tobacco. In regard to tobacco a stage has been reached when the efficacy of control measures devised in plot trials could be tested out on a field scale.

The Grasslands Division is located at Palmerston North adjacent to Massey College, and has the advantage of working in close association with that Institution. In connection with the pasture survey of Hawke's Bay, which is proceeding as a unit of the land utilization survey of that district, a novel and useful technique of pasture mapping has been devised. In addition to the work of selection and breeding of pasture plants, which is carried out in the closest association with the Fields Division of the Department of Agriculture, the Division is associated with the Dairy Research Institute and the Fields Division in studies on the cause of feed taints in dairy produce.

The Agronomy Division is located at Lincoln, thus enabling close association with Canterbury Agricultural College and the Wheat Research Institute. The work of the Division in connection with the selection and breeding of field crops is producing valuable results. The advance made towards the production of a smooth-coated pea for canning purposes may be mentioned by way of example. Trials of fibre-producing linseed of the Liral Crown variety have indicated that distinctly promising yields of good-quality flax can be grown in New Zealand, and this opens the way for the establishment of a new fibre industry.

The Entomology Division is working in close co-operation with the Cawthron Institute and with Canterbury Agricultural College. The parasite imported to control the white butterfly has continued to function very satisfactorily. A new line of attack has had to be adopted in regard to the control of the diamond-back moth, owing to the original parasite having been itself attacked by another insect.

The Botany Section is to be permanently located in Wellington. Its main activities have been in the study of ragwort, which is proving a serious economic problem to farmers in the North Island. A considerable amount of information in regard to the regenerative capacity of the plant has been accumulated which will have an important bearing on the selection of methods of control.

Remarkably good progress has therefore been made with actual research work, despite the interruptions incidental to bringing such a large organization into operation.

DAIRY RESEARCH INSTITUTE.

Further progress has been made during the year in the study of the control, by means of active single-strain starters, of gas-producing organisms which give use to openness in cheese. A difficulty arose, in that the starters were found to be subject to attack by bacteriophage, which caused their sudden failure, but the past season's work has provided a solution to this problem under conditions prevailing

in the Institute's dairy factory. Equally good results have been obtained in some commercial factories, but others still experience difficulty in preserving the vigour of their starters, and it remains to be determined whether certain milks make these starters more susceptible to bacteriophage.

The systematic study of the problem of eliminating feed taint that occurs in butter and cream in certain districts has been continued. The results obtained up to the present show that feed taint can definitely be attributed to certain types of clover in the pasture, especially when they are in the actively growing stage, and that the trouble can be minimized or entirely eliminated by appropriate pasture and stock management methods. Work is now in progress at the Institute to determine the percentage of clover that can be present in a pasture without causing taint, and also to define the growth conditions of the plants which induce it.

The whole problem of the relationship of New Zealand pasture species to the composition of butterfat is one to which little attention has yet been given, and some fundamental work is in progress at the Institute with a view to correlating not only pasture type, but also soil type with the quality of butterfat.

Other investigations in progress at the Institute include a study of the factors affecting the keeping-quality of unsalted butter, studies in the neutralization of cream for butter-making, and a study of the factors affecting the loss of butterfat in the manufacture of butter.

The annual special course for dairy-factory managers was held for the purpose of discussing the results of research with representatives of the industry, and a large number of scientific papers were published.

WHEAT RESEARCH INSTITUTE.

The harvest period was the wettest ever recorded in New Zealand, and this resulted in severe sprouting of all wheat that was not harvested very early. Reports indicated that approximately 50 per cent. of the wheat handled by the mills was more or less severely damaged. The problem of assessing the degree of damage to the baking quality of the flour, and the proportion of sprouted lines that could safely be used in blends, fell to the Wheat Research Institute. The ready co-operation of millers with the Institute enabled the problem to be very successfully coped with, as was indicated by the relatively small amount of trouble experienced by bakers in the circumstances.

The appointment of a travelling baker expert by arrangement with the Wheat Committee to advise bakers at first hand in their bakehouse problems has proved to be a very successful innovation, the services of the expert having been largely availed of.

The long-range work of wheat breeding continues to expand. Approximately 350,000 bushels of Cross 7—the wheat produced by the Institute—were harvested in 1937, and the ease of handling, good-milling qualities, and high baking-quality have firmly established it in favour. Several other equally promising crosses are in the process of multiplication.

A large amount of laboratory work was carried out, including, in addition to the regular testing of wheats and flours, research on specific problems in cereal chemistry. Among the latter should be mentioned the experiments having as their object the discovery of a safe and effective bread improver, and in which remarkably successful results have been obtained with lemon juice.

LEATHER AND PELT RESEARCH.

During the past year special attention has been given to the difficult problem of assessing the quality of leather by scientific methods as a guide to improvement. The properties demanded of leather vary, of course, according to the use to which the leather is to be put and according to the varied requirements of the tanner, boot-manufacturer, and the ultimate user. There have been many attempts to correlate certain chemical properties of leather with quality, but the standards of quality set up were arbitrarily fixed without a direct relation to the properties of leather as determined under actual wearing conditions. In the work carried out by the Leather Research Laboratory a particular group of chemical constituents known as " water solubles " has been studied in relation to the wearing-value of the leather as determined by actual tests under wet and dry conditions, and some valuable correlations have been obtained.

The interesting and important work on the effect of seasonal variations on the structure and quality of lamb-skins, which was begun last year, has been continued this year, and the results confirmed. Casks of skins of known history which had been examined microscopically at the Leather Research Institute were sent to England for reports on the quality for various purposes of the skins made from them. The report received confirmed the conclusions arrived at by microscopic examination, and if further experiments to be carried out are in agreement with these findings there will be no doubt that not only seasonal variation, but also the climatic conditions under which the animal has lived prior to slaughter, are very important in relation to the quality of lamb-skins. An understanding of these facts should help considerably in more economic marketing.

Steps have been taken to set up a co-ordinated organization for research, representative of freezing-works, tanners, and footwear-manufacturers. Such an organization is unique and should enable each section of the industry to operate at optimum advantage in relation to the others.

SOIL AND LAND UTILIZATION SURVEY.

The soil and land utilization survey in Hawke's Bay has now proceeded sufficiently far to give a fairly complete picture of the agricultural resources of that province and the possibilities of developing and utilizing them more fully and efficiently. The Hawke's Bay soils, which have now been mapped over an area of 3,000 square miles, are in general of high natural fertility, except for phosphate, and the amelioration of the poorer soils presents no serious problems.

The survey of the pastures of Hawke's Bay has produced much valuable information as to the relation between pasture type and soil, climate, top-dressing, and other factors. A novel technique of mapping the different pasture associations in detail was developed, and is illustrated by a map accompanying this report. It is apparent that there is considerable scope for the profitable improvement of Hawke's Bay pastures.

The farm management survey in Hawke's Bay carried out by officers seconded from the Department of Agriculture, although incomplete, has produced some important facts relative to the possibilities of expansion of fat stock production and carrying capacity.

In North Auckland some 2,000 square miles have been mapped and may be classified as follows:—

	Square Miles.	Per Cent.
Group 1: Flat to rolling land suited to permanent farming (dairying, fat-lamb raising, &c.)	650	33
Group 2: Rolling to steep land suited to sheep and cattle grazing	550	28
Group 3: Land covered with problem soils	150	7½
Group 4: Land too steep for permanent farming	400	20
Group 5: Land with soils unsuited to permanent farming ..	250	12
	2,000 square miles.	

The economic utilization of some of the soils of North Auckland presents difficult problems. In some cases the difficulty lies in the physical and chemical status of the soil itself, and this applies particularly to the mature soils; in others the steepness of the country and the liability to erosion resulting from the removal of the original forest cover are complicating factors. Interesting and valuable results have emerged, indicating the incipient stages leading to erosion, particularly to what is known as sheet erosion.

The soil survey maps have in some areas been made use of for assistance in land-valuation.

Reconnaissance soil surveys have also been carried out in Banks Peninsula and at Blenheim, while special soil surveys in relation to the conditions requisite for the development of tung and citrus growing have been carried out. Similar surveys in relation to the growing of tobacco and flax are contemplated.

FRUIT RESEARCH.

A comprehensive programme of fruit research has been carried out during the year by the various participating bodies under the general direction of the Fruit Research Committee.

The Plant Research Bureau and the Cawthron Institute have co-operated in an attack on the problem of mouldy core of apples in the Auckland District. A field survey of affected orchards has been made with a view to determining the incidence of the disease and the factors associated with it. The survey has indicated that the trouble occurs in all varieties possessing an open calycine sinus and is not restricted to any particular soil type or system of tree management, does not respond to spray or fertilizer treatments, and has not indicated a clue by which the disease may be remedied.

Experiments on the control of internal cork of apples by spraying or top-dressing with borax have fully confirmed the excellent results obtained last season. So far borax treatment has not been successful in the control of bitter-pit or tree-pit, indicating that these diseases are not of the same nature as internal cork.

Botanical investigations included the continuation of trials of East Malling and Northern Spy stocks. There is evidence that there are among the East Malling stocks under test at least two types which will, over a wide range of soils, produce trees of far greater vigour than those on Northern Spy stock.

At the Dominion Laboratory the study of the chemical characteristics of New Zealand grapefruit with a view to devising a satisfactory test for maturity has been continued. The effects of temperature, humidity, and ethylene concentrations on the curing of lemons are being studied under carefully controlled conditions in order to provide a scientific basis for recommendations in regard to commercial practice. For the purpose of investigating the possibilities of gas storage for fruit for the local market, a small cool store was installed adjacent to the Dominion Laboratory, and experiments on the keeping-qualities of apples in varying concentrations of carbon dioxide and oxygen were instituted.

Dunnage investigations were continued in a series of trial shipments to Great Britain, where the fruit was examined by officers of the Low Temperature Research Station. Local investigations were undertaken in connection with the influence of manurial treatments on the keeping-quality of fruit and the use of different types of wraps.

MINERAL CONTENT OF PASTURES.

The success which has attended the use of cobalt salts in the treatment of stock ailment at Glenhope, Nelson, Morton Mains, Southland, and certain areas in the North Island has been followed up during the past season by detailed studies of soils, pastures, and animal organs, with a view to determining whether the ailments were caused by an actual deficiency of cobalt in the food of animals.

An extensive survey of the cobalt content of the main soil types of New Zealand made by officers stationed at the Cawthron Institute showed a fairly good correlation between low soil cobalt and incidence of stock ailment. Certain anomalous results, however, indicated that attention must be given to methods for estimating the availability of cobalt from the soil and pasture under different seasonal conditions.

Analyses of animal organs from affected areas showed that the cobalt content of organs, particularly the liver, from sick animals was much lower than that of healthy sheep or sheep which had been drenched with cobalt chloride. The results indicated that the cobalt content of the liver was likely to be a useful index to the occurrence of ailment. Analyses of pasture samples also supported the theory of cobalt deficiency as a direct cause of stock ailment in the districts investigated.

Blood studies carried out by Dr. Muriel Bell at the Otago Medical School indicated that the anæmia so commonly associated with lamb sickness at Morton Mains does not run parallel with the severity of sickness, which suggests that anæmia results from weakness of the animals and is secondary to faulty or poor nutrition.

Field experiments were undertaken to determine the relative value of cobalt licks and cobalt top-dressing of pasture as alternative methods of supplying cobalt to stock. The top-dressing experiments were remarkably successful and demonstrated that the application of very small quantities of cobalt incorporated in fertilizers affords a highly efficaceous and practical method of raising to the optimum level the cobalt status of pasture which is deficient in this element. The success of these experiments marks a big step forward in the treatment and prevention of diseases of the bush-sickness type. An outstanding feature arising from the work has been the rapidity with which the results have been applied by farmers in many areas and the beneficial results obtained in practice. A prominent stock and station agent estimated that the use of cobalt will result in increased output to the value of £100,000 in one province alone.

It is interesting to note that four interesting cases of the beneficial effects of "trace" elements are under investigation in the Dominion at present—namely, cobalt and iodine in relation to stock and possibly human health; boron in relation to internal cork of apples and brown-heart of swedes and turnips; and zinc in relation to mottled leaf of citrus.

PHORMIUM TENAX.

An important development during the year in regard to New Zealand flax was the discussions leading to the formulation by the Bureau of Industry of a scheme for the rehabilitation of the flax industry, in the course of which the services of the Department have been largely drawn upon in connection with the research and technical problems involved. The visit in October of the Chairman of the Chairman of the Imperial Institute Advisory Committee on Vegetable Fibres was of great assistance in assessing the value of the work being done in New Zealand and the lines along which it should proceed.

A solid foundation for the production of flax fibre of proved and uniform quality and utility has already been laid as a result of the research work on flax-breeding sponsored by the Department. During the past year the area planted in special strains of flax has been increased from twenty-five to forty-seven acres, and all selected varieties are growing well. Yield trials of certain hybrids showed a 50-per-cent. increase in yield over best-selected plants, while the milling trials yielded fibre grading up to 98 points. Arrangements are now well in hand for large-scale multiplication on commercial areas. It is perhaps unfortunate that we do not yet know sufficiently well the relation between soil type or profile to suitability for permanent high yield of phormium with a minimum of yellow-leaf, but steps are being taken to collect information to this end.

With reference to the question of decortication, a thorough study has been made of the so-called explosion decortication method, while a stripper of new design has been constructed and will, it is hoped, be proceeded with after the inauguration of the organization under the Bureau of Industry. Other promising methods of decortication are under investigation by the Labour Department and by private interests. Considerable work has been carried out on the properties of pulp for fine papers produced from phormium. A chemist was also seconded to the woolpack factory at Foxton, and a valuable report on process control has been prepared and forwarded to the management.

MISCELLANEOUS.

Among the miscellaneous research investigations conducted with a view to promoting the development of new industries the following may be mentioned:—

Further experimental consignments of New Zealand asparagus were shipped to London in cold storage in order to test the practicability of developing an export trade to Great Britain. In conjunction with the main purpose of the experiments, which was to test the keeping-quality of the asparagus under cold-storage conditions during the requisite period and its after-storage life, the effects of different methods of wrapping and packing were examined. Arrangements were made, through the Department's Scientific Liaison Officer in London, to have the asparagus examined on arrival by officers of the Cambridge Low Temperature Research Station, assisted by Mr. L. W. Tiller. The bulk of the asparagus was also submitted for examination by Covent Garden merchants. The results of the experiments were, on the whole, most encouraging. The asparagus arrived in good condition and was considered to be suitable for the United Kingdom market. The only criticism of importance had reference to the overmature character of a considerable proportion of the heads and the necessity for stricter attention to grading for size. A number of points in connection with the effect of maturity on the storage life of asparagus and the optimum conditions for transport also await investigation, and it is proposed to give attention to these during the coming year, utilizing for this purpose the experimental cool store attached to the Dominion Laboratory.

A considerable amount of preliminary work has been carried out on materials likely to be useful in conjunction with cement to confer special properties on the various forms of concrete products. A pamphlet was published on the New Zealand resources of pozzolanic material, and the available supplies of diatomaceous earth have also been investigated. A fairly complete survey of our bentonite resources has been made, and experiments are now being undertaken in regard to its various avenues of utilization.

An increasing number of inquiries in relation to technical problems of industry have been dealt with during the year.

Overseas Contacts.—The Department's Scientific Liaison Officer, Mr. Nevill Wright, who is attached to the High Commissioner's Office in London, continues to perform valuable services in maintaining contact with research organizations in the United Kingdom; in representing the New Zealand Government on various scientific bodies; in making the necessary arrangements for the examination of experimental shipments of meat, fruit, and dairy produce; and in procuring information in connection with scientific matters in general.

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

DAIRY RESEARCH INSTITUTE.

Dairy Research Management Committee: Mr. A. Morton (Chairman), Messrs. G. A. Marchant, A. J. Murdoch, A. Linton, A. H. Cockayne, W. Singleton, J. Murray, Quentin Donald, T. C. Brash, and Professor H. G. Denham. Director of Research: Professor Wm. Riddet. Secretary: Dr. E. Marsden.

Material progress has been made during the year with the investigation of problems affecting the manufacture of cheese and butter. These can be briefly divided into three categories—namely, the control of defects, the raising of average standards of quality, and the assessment of yield of products and control of losses.

The elimination of open texture in cheese and feed flavour in butter have received most attention. The former is a serious and widespread occurrence which is exceedingly difficult to control in dairy practice and which has received close examination for a period of years. It has now been shown that the "slit" and "sweet" types of open texture of cheese are fundamentally due to certain strains of lactobacilli that play a part in the normal ripening of cheese. Although not present in large numbers in freshly-made cheese, lactobacilli rapidly increase during the curing process, and those which produce gas cause fractures to occur in the body of the cheese. These then develop into slits if the cheese is of normal acidity, or round (sweet) holes if the cheese is sweet and the curd is accordingly plastic. It has been shown that gas-producing strains of lactobacilli can be controlled at least in the early stages of the ripening of the cheese by the use of active starters. It is not yet clear whether this is due directly to the starter organisms or indirectly to chemical conditions induced in the cheese by the organisms; nevertheless, there is abundant evidence that active starters which produce acid vigorously during the cheesemaking process play an important part in making cheese close when graded at fourteen to twenty days old. The development by the Institute of starters prepared from single strains of lactic streptococci selected to grow at the temperatures normally employed in the cooking of cheese curd was shown in the previous year's experimental work to be a notable advance in encouraging acid development and in the control of openness. At that time difficulty was experienced in maintaining the vigour of these starters due to their frequent and sudden failure as the result of bacteriophage action, which similarly affects mixed starters. In the present year this difficulty has been overcome under the conditions prevailing in the Institute dairy factory. Equally good results have been obtained in some commercial factories, but others still experience difficulty in preserving the vigour of these starters. It still remains to be determined whether or not certain milks make these starters more susceptible to phage. The selected starters have received wide favour from cheese-factory managers, and in the dairy season 1936-37 some 2,639 starters were supplied to 140 separate cheesemaking companies.

Much work yet remains to be carried out on the best cheese-manufacturing technique when cheese-starters are employed, and on their influence on the final quality of cheese. The results of experiments to date indicate the desirability of using selected single strains as a partial source of the starter supply, but they do not justify their exclusive use as starter.

Work on "openness" is proceeding along other lines to identify the particular strains of lactobacilli that produce gas in ripening cheese and to trace their source with a view to controlling their occurrence in milk.

Fairly widespread feed flavour that occurs in cream and in butter in certain localities in the Dominion has been definitely attributed to types of clover present in pastures. Suckling, subterranean, and white clovers have all been shown to cause trouble, especially when they are in the actively growing stage. Field evidence collected by the Grasslands Division of the Plant Research Bureau, who are collaborating with the Institute in this investigation, shows that the "feedy" condition is not accentuated by top-dressing. Indeed, it emphasizes the fact that as fertility is increased by top-dressing and by carrying greater numbers of stock, the proportion of grasses present in pastures increases and the "feediness" in cream produced thereon falls off markedly. While the problem can possibly be overcome ultimately on farms by pasture and stock management methods which preserve a definite balance of clover and grasses, there is already definite evidence that the intensity of "feediness" in cream can be materially mitigated, if not eliminated, by preventing animals from grazing "feedy" pastures for a period of at least four hours prior to milking. This practice does not apparently reduce the production of dairy cows. Work at the Institute is in progress to define the percentage of clover that can be present in a pasture without causing taint and also to define the growth conditions of the plants which induce the taint.

On the manufacturing side it has been shown that taint can be largely removed from cream by special processing methods. This is a most useful recourse in case of emergency, but it should not be accepted as a final solution of the problem, because of the possible influences of this treatment on the finer flavour properties of butterfat.

Studies on the neutralization of cream have explained the fundamental reasons for occasional yet unintentional overneutralization and consequent ill effects on butter flavour. These same studies have emphasized not only the need for careful neutralization, but also the necessity for avoiding high acidity in butter that is to be stored for any period of time.

Attempts are constantly made by research to raise the existing standards of quality of food. This is just as necessary with dairy products as with others. In this connection good progress has been made at the Institute with the improvement of flavour in cheese by the addition to milk for

cheesemaking of selected strains of lactobacilli. This work is supplementary to that referred to above on starters. The work is yet only at a laboratory stage, but the results are very promising and are expected ultimately to be of considerable commercial value.

Recently some attention has been directed to factors affecting the keeping quality of unsalted butter. In particular, experiments have been started to study the relationship which acidity of unsalted butter bears to keeping quality, because, although it has been definitely shown that acidity prejudices the keeping quality of salted butter, it is commonly believed by scientific workers that acidity preserves the keeping quality of unsalted butter.

Some fundamental work is also in progress to get definite information on the relationship of New Zealand pasture species to the composition of butterfat. No corresponding work of any material extent has been carried out in other countries, where dairy cattle are less dependent on pasture, but it is most essential in New Zealand, since it is well known that the quality of butter is primarily dependent on the quality of the cream from which it is made and since it is evident that butter of better flavour is produced in some districts than in others. It is hoped at a later stage to correlate not only pasture type, but also soil type with the quality of butterfat.

An investigation started two years ago to determine a satisfactory method of paying for cheese milk on its cheese yielding capacity without entailing great expense in analytical work has now been completed. It has been shown that the cheese yeilding capacity of milk can be readily estimated from the ten-day samples of milk that are already collected at cheese factories for determination of fat content. As an extension of this work there has been studied the influence of the suggested method of payment on the redistribution of proceeds amongst cheese factory suppliers, and the relationship of the fat content of milk yielded by cows (of different breeds) to their cheese yield. It has been shown that while the suggested method of payment would not entail considerable redistribution of factory proceeds, a few suppliers in most factories would receive a material increase in their returns, to which they are justly entitled.

A detailed study has been made of factors affecting the loss of butterfat in the manufacture of butter. It has been shown that great care needs to be taken with the handling of cream when this is highly processed.

The following statement summarizes in more detail the projects undertaken by the several workers at the Institute :—

Cheesemaking Investigations.

(*a*) *Starter* (Dr. H. R. Whitehead and G. J. Hunter)—During the past year a significant advance has been made towards the solution of the problem of the variation in activity of starter cultures. It had previously been shown that certain single strains of lactic streptococci isolated at the Institute served exceedingly well as cheese starters by reason of their capability of withstanding the high temperatures used during the "cooking" period. The main difficulty attending the use of the single-strain cultures has been their liability to sudden failure. The failure was known to be due to the development of bacteriophage in the cultures, but at the beginning of the past dairying season no method of obviating the failures had been found. Experience during the last nine months, however, has shown that the use of a particular technique in the maintenance of the cultures will eliminate almost entirely the occurrence of phage and that the cultures can be kept for long periods in such a state that their activity in the cheese vat is almost constant from day to day.

The basis of the new technique is the use of a relatively heavy inoculum in the transference of the culture to a fresh batch of milk. In the past, cheesemakers have tended to use as low an inoculum as possible because they believe that "over-ripening" tended to damage the culture. With the Institute single-strain cultures, at any rate, the rapid growth and early clotting of the cultures which result from a heavy inoculation do not appear to cause any harm: on the contrary, it seems possible that the great reduction in the lag period of growth brought about by a massive inoculation carried the organisms rapidly through a phase which, if prolonged, is likely to cause development of bacteriophage. Whatever the underlying cause, it is a fact that in all cases so far investigated by the Institute staff the adoption of a heavy inoculation together with the usual aseptic technique in propagating starters has enabled the single-strain cultures to be maintained successfully in any milk supply of reasonably normal composition.

Practical cheesemakers still experience considerable difficulty in reproducing these results. It is possible that there exist in certain milk supplies factors which cause failure of the cultures, but the indications are that in the great majority of cases the trouble now encountered is due to difficulty in practising daily a true aseptic technique and exerting sufficiently accurate control over conditions of cultures. If this is so, the bulk of starter trouble can now be overcome by instruction and demonstration in the factories.

As was mentioned in the last report, the use of active single-strain cultures has been found to exercise a marked controlling influence on the development of slit openness. If, therefore, it proves possible in the factories to maintain single-strain cultures in an active state over a long period, as has been achieved in the Institute and in a number of individual factories, it follows that a great reduction in the incidence of openness will automatically result.

The question which remains to be settled is whether cheeses made with the use of single-strain starters ripen normally and develop desirable flavours. The fact that the use of single-strain cultures in many cases results in the award of somewhat higher grading points for the cheese at fourteen days and the absence of any unusually adverse reports on mature cheese examined in England indicate that, in general, cheese made with the use of single-strain cultures are acceptable to buyers. It is, however, desirable to attempt to ensure the production not only of acceptable cheeses, but of cheeses showing the true Cheddar bouquet at maturity. As is indicated in a later section of this report, it

is now definitely established that lactobacilli are the main agents responsible for the development of cheese flavours. The streptococci of the starter, however, prepare the ground for the lactobacilli, either by the particular degree of acidity which they produce, or by some other specific property. There are indications that the single-strain cultures sometimes yield cheese either lacking in flavour or even undesirable in flavour at maturity, possibly because they tend to suppress the growth of lactobacilli. There are three possible ways in which this difficulty may be overcome :—

(*a*) By a modification in cheese-manufacturing technique when single-strain cultures are used.
(*b*) By the use of a small proportion of a mixed culture in conjunction with the single strain.
(*c*) By the addition of desirable types of lactobacilli to the cheese vat.

As is indicated in the section on cheese flavour, these possibilities are being investigated.

The main significance in the discovery of methods by which starters can be prevented from failing suddenly lies in the degree of control given to the cheesemaker over his manufacturing methods. Variability in starter activity has probably caused more spoilage of cheese than any other single factor. The active single strains form a basis on which cheese-manufacture can be built up from the stage of an art to something resembling a science.

(*b*) *Cheese-Ripening* (I. R. Sherwood).—In previous reports a description was given of investigations which showed that the active acid-forming strains of streptococci normally present in cheese starters do not play any direct role in the formation of cheese flavour, although they exert an indirect influence by reason of their effects on the composition of the cheese curd. It was concluded from these investigations that lactobacilli are the chief agents responsible for the development of flavour in Cheddar cheese. Different strains of lactobacilli added to cheese milk in relatively large numbers caused the development of a wide variety of good and bad flavours, characteristic of the individual strains.

An attempt was therefore made in the year under review to isolate strains of lactobacilli capable of producing desirable flavours in cheese, with the object of making a selection of suitable types that could be added to cheese milk to produce cheese of consistently attractive flavour. This problem is complicated by the facts that there is no satisfactory laboratory technique for recognizing desirable strains and that results need to be based on cheesemaking experiments which introduce unavoidable variables due to the composition and source of the milk. It is clear that changes brought about in cheese made from cleanly-produced milk inoculated with lactobacilli are governed to a large extent by the physical and chemical constitution of the green cheese, which, in turn, depends on the composition of the cheese milk and the manufacturing procedure. Unfortunately, the present state of knowledge of these is still too meagre to define their effects with precision. There is the added difficulty that inocula of certain strains of lactobacilli may not "swamp out" some types, already present in the milk, which readily multiply in cheese and mask the effects of the organisms under observation.

The addition of gross inocula of lactobacilli has been found to lead to premature proliferation of these organisms in cheese, resulting in the development of a peculiar acid flavour in the early stages of ripening and an undesirable flavour in the mature products. Good results, however, have been achieved by inoculating the milk with a much lighter dose of organisms, especially in the vicinity of the order of the bacterial count of the milk used. In particular, notable advances have been made by the isolation of organisms from prize-winning cheeses possessed of choice flavour, when mature. The light inoculation of cheese milk with many strains which are slow gas-formers and accordingly do not produce slit openness has yielded excellent results in numerous cheeses manufactured in the Dairy Research Institute factory. Similar results have recently been obtained by several factory managers in various localities who have added these organisms with starter to vats of milk. The cheeses made from inoculated milk have developed very satisfactory flavours which, in most instances, were definitely better than the flavours of those made from milk which had not been inoculated.

Unfortunately, the propagation of cultures of lactobacilli is too difficult to be practicable in commercial factories. Attempts are accordingly in progress to make these cultures available to factories by incorporating desirable types in the single-strain cultures developed by the Institute during the past few years.

The possible role of betacocci in imparting "bouquet" to cheese is also being studied.

(*c*) *Acidity in Cheesemaking* (Dr. R. M. Dolby).—The importance of acidity changes in the process of cheesemaking is realized by all cheesemakers. The use of the active single-strain starters developed at this Institute involves, in many factories, a change to lower acidities in the whey at the various stages in the process of cheesemaking, if cheese of the best quality is to be obtained. During the past year a study has been made of the factors affecting the pH and acidity of cheese. Comparisons have been made of different types of starter cultures and of various modifications of the manufacturing process, to determine their effect on the acidity of the cheese. With most of the starters examined it was found that in normal cheesemaking procedure the type of starter did not affect the acidity developed in the cheese when fourteen days old, although acidity at this age of the cheese was developed more slowly when less active starters were employed. It was observed, however, that the cheese produced by the use of one starter culture had a definitely low acidity, although the rate and degree of acid development in the cheesemaking process was normal.

The chief factor controlling acidity in the cheese appears to be the rate of acid development between "drying" and "milling." With a given starter the rate is best controlled by adjustment of the "running acidity." The time of setting appears to have little effect on the acidity developed in the cheese, but does have a considerable effect on the body of the cheese. If, as is well recognized by cheesemakers, the salting is delayed until too high an acidity has been reached, the cheese is likely to have a harsh acid type of body.

(*d*) *Payment for Milk for Cheesemaking* (Dr. F. H. McDowall).—The full report of the investigations on the cheese yielding capacity of milk and its relation to the method of payment for milk for cheesemaking has now been published. The report contains a review of all the various systems of payment for milk; a study of the factors affecting yield of cheese, including butterfat and casein losses in the whey; a comparison of the cheese-yield data published by other workers with the data presented in the report; and a general discussion of the suitability of a system of payment for milk for cheesemaking based on its cheese yielding capacity, with and without the application of a deduction of ½d. per gallon of milk to correct for variations in the cost of manufacture of cheese from milks of different compositions. The "costed cheese" system of payment was used in three factories during the 1935–36 season, and by one factory during the 1936–37 season. The method was found to work satisfactorily. In addition, during the 1935–36 season, in co-operation with the directorates and managers of some seventeen cheese factories, an extensive trial was undertaken to study the application and implications of the system over a wide range of conditions. This trial yielded valuable information on the extent of underpayment and overpayment on the present butterfat system of payment. The proportion of the payout requiring redistribution among suppliers was surprisingly small, but in a number of factories the underpayment for the most part fell on a few individuals of the panel suppliers, and in these cases the degree of underpayment was very appreciable. In one factory on the present butterfat basis a supplier was underpaid to the extent of £136, or 13·8 per cent. of his gross receipts. From the point of view of this supplier the butterfat system cannot be regarded as satisfactory, although for the factory as a whole the total amount of redistribution of payout amounted to only £273, or 0·83 per cent. of the total payout.

(*e*) *Milk Supplies to Cheese Factories* (Dr. F. H. McDowall).—The steady decrease in average annual yields of cheese per pound of fat at many factories, due to the rise in average fat content of the milk-supplies, presents a problem of considerable importance. Hitherto, on the butterfat system of payment for milk for cheesemaking, emphasis has been laid on the production of butterfat instead of the production of cheese, and breeding has been directed wholly towards high butterfat production. Cows at present in dairy herds may be regarded as the result of the adoption of this system of breeding. During the past year a study has been made of the average annual cheese yielding capacity of cows. From certificate-of-record summaries of milk yields and composition, both in New Zealand and in America, and from figures compiled by Mr. A. H. Ward, of the Herd Recording Department of the Dairy Produce Board, the average annual cheese production of cows of different breeds has been related to the percentage of fat in their milk. The results indicate that with the cows at present available, the high-testing cow within a breed produces, on the average, as much or possibly somewhat more, cheese per cow than does the low-testing cow within that breed. The basis of breeding of cows for cheese production requires an extensive investigation from the standpoint of genetics. An inquiry into the possibility of breeding for high casein production as well as for high fat production is particularly desirable.

(*f*) *Effect of added Water in Milk on the Yield of Cheese* (Dr. F. H. McDowall).—An investigation of the effect of added water in milk, in proportions as high as 20 per cent., has confirmed previous conclusions that the addition of water to normal milk does not affect the yield of cheese obtained. The quality of cheese, however, made from watered milk is lowered. Moreover, adulteration of milk for cheesemaking with added water causes increased costs of manufacture and danger of contamination through use of water of inferior quality. Thus factory managers and directorates are justified in exercising a stringent control over their milk supplies.

Buttermaking Investigations.

(*a*) *Feed-taint Investigations* (I. L. Campbell and others).—The investigation of feed flavour in cream was continued during the 1936–37 season with six stall-fed and twelve grazing cows. As in the previous seasons, the work was carried out in collaboration with the staff of the Grasslands Division of the Plant Research Bureau. White clover, subterranean clover, perennial rye-grass, and Italian rye-grass were individually fed to the indoor cows from September till November in order to determine the extent, if any, to which these pasture species exert an influence on the flavour of milk and cream. Subsequently an attempt was made to define the percentage of white clover that may be safely included in a daily ration of perennial rye-grass and white clover without causing a clover taint in cream produced by cows so fed. The indoor group of cows was turned out to pasture at intervals to determine whether confinement of the animals to stalls exerted any effect on the experimental results.

The "outdoor" group of cows was first grazed in lots of three on swards of pure perennial rye-grass, perennial rye-grass and white clover, Italian rye-grass, and Italian rye-grass and red clover, in order to determine the influence of these grasses and mixtures of grasses and clovers on the flavour and composition of milk of animals grazing on them. Arrangements were thereafter made to study the influence on the flavour and production of milk of moving animals, at least four hours prior to milking, from tainting to non-tainting feeds and from abundant feed to bare pasture.

Results: The species trials confirmed the conclusions drawn from previous work—namely, that white clover, subterranean clover, and broad red clover all produce taint in cream, while pure perennial and Italian rye-grass do not exert any influence on flavour.

The relative degree of feediness produced by white and subterranean clovers was determined by feeding the same percentage of them to different stall-fed cows. Subterranean clover caused more feediness in the first two weeks of the trial, while white clover produced the greater effect in the following two weeks. The change in degree of intensity was probably due to the fact that the subterranean clover rapidly increased in maturity during the feeding period, while the white clover remained luscious.

An examination of the recorded taint figures shows a marked seasonal variation in intensity of taint. In the grazing groups, flavour from white-clover swards was relatively pronounced in September and October; it fell off markedly early in November, became more pronounced at the end of the same month, and continued at a moderately high level to the end of February. A similar trend was recorded for the broad red-clover swards to the end of November, but little flavour was produced on these from December onwards, when this feed had reached a mature stage of growth.

When the percentage of clover in a ration of perennial rye-grass and white clover was varied it was found that the intensity of the taint produced in the cream was directly proportional to the percentage of white clover in the feed at any one time. It was found that at this time, under the conditions of the experiment, approximately 50 per cent. of white clover in the ration was the "critical" percentage—below this percentage cream quality was not seriously affected; above this percentage cream quality was impaired. The critical percentage above which taint was produced varied, as indicated above, with the time of the year and the stage of growth of the feed; early in the season it was as low as 30 per cent., while later it rose to 50 per cent. and then to 80 to 90 per cent.

Seasonal variation in intensity of taint is illustrated by the following examples. During one week in January one of the stall-fed cows yielded cream free from taint although fed continuously on 80 per cent. to 90 per cent. white clover. Cows fed 60 per cent. of the same clover in October under identical stall-feeding conditions produced cream with higher degrees of feed taint than cows getting 90 per cent. to 100 per cent. clover in January and February. Cream produced by cows grazing on 40 per cent. white clover in October was as highly tainted as that from the same cows grazing on 80 per cent. white clover in February and March. Two cows grazing on 80 per cent. white clover in June yielded cream with a moderately strong flavour. It is accordingly suggested from evidence available at the present time that rate of growth and stage of maturity are important factors in connection with this variation.

No significant difference was shown in taint production when cows were changed from stall feeding to outdoor grazing of the same feed.

Evidence accumulated during the investigation indicates that intensity of taint in cream produced by cows varies with different cows fed on identical feeds and suggests that cows vary considerably in their ability to reduce or eliminate from their system the undesirable taint-producing elements in the feed.

The importance of the time elapsing between the consumption of tainting foodstuffs and milking is well recognized. In this connection data relating to the quantity of fodder eaten at various times throughout the day by stall cows was collected. The consumption of feed between midnight and morning milking-time was very low, and the cream produced in the morning was free from taint. On the other hand, relatively heavy consumption of tainting foods at midday intensified taint in the evening cream, while lower consumption at this period and again prior to milking reduced it. These observations agree with Levy's conclusions.

When the grazing animals were moved from non-tainting (rye-grass) to tainting (rye-grass and clover) pasture within four hours of milking-time a pronounced taint was observed in their cream: conversely, taint was nearly eliminated when the animals were moved at this time from tainting to non-tainting or very bare pastures. The information available from these trials indicates that production is unaffected by this management. The removal of animals from tainting to non-tainting or bare pasture at a time greater than four hours before milking is thus a practical measure for mitigating if not eliminating feed taint on badly affected farms.

Relation of Feed to Milk Composition and Properties of the Butterfat (Dr. F. H. McDowall, G. A. Cox, and J. D. Sargent).—The milks from the cows fed under the above controlled conditions have been analysed regularly and samples of the butterfat have been collected at intervals. Changes in the composition of the milk have not yet been sufficiently studied to merit report. The results of the butterfat analyses do not indicate any correlation between the type of feed consumed by the cows and the iodine value, saponification equivalent, Reichert-Meissl number, and the softening point of the butterfat. There is indication, however, of some correlation between the average weekly minimum air temperatures and these values for butterfat, but, because of a lag between changes in temperature and values, the observation needs further study before it can be accepted as definite.

(*b*) *Neutralization of Cream for Buttermaking* (Dr. F. H. McDowall).—This subject has been under investigation, as opportunity offered, for a number of years. The study has now been completed, and the reports on the work are either published or in the press. The experiments have shown that some of the anomalous results encountered in practice have been due to variations in the carbon dioxide content of the cream when delivered at the factory. Other anomalies have been due to the peculiar quality of the cream causing precipitation of calcium phosphate during the pasteurization process, and resulting in a reduction of the degree of neutralization achieved by the sodium bicarbonate added. The influence of the carbon dioxide retained in the cream on the acidity of the neutralized cream has also been demonstrated. For neutralization to very low acidities it is necessary to depend on the calculation of amount of neutralizer to be added, since the retention of carbon dioxide in the cream renders unreliable any estimation of acidity in the pasteurized cream. The relation of acidity in cream to pH of butter and to the keeping quality of butter has also been studied. It has been shown that soda flavour tends to appear in butter made from cream neutralized to a pH above 7·2 to 7·4. There does not appear to be any necessity for the production of butter with a pH figure above 7·0, and, on the other hand, it appears undesirable that butter for export under New Zealand conditions should have a pH below 6·5.

(*c*) *Butterfat Losses in Buttermilk* (Dr. F. H. McDowall).—A report on this subject has been prepared, in collaboration with Mr. W. H. Udy, of the New Zealand Co-operative Dairy Co., Hamilton.

The use of the vacreator for the pasteurization of cream appears to increase the fat that passes into buttermilk by about 0·3 per cent. to 0·4 per cent. of the total fat in the cream received at the factory. The increase is probably due to a measure of disruption of the fat globules in the passage of cream through the vacreator.

(*d*) *Unsalted Butter* (Dr. W. J. Wiley).—The deleterious effect of high acidity on the keeping quality of salted butter is well known. In cold store an acid salted butter gradually acquires a stale flavour which progresses through fishiness to tallowiness. Unsalted butter, however, does not develop a fishy taint, and the effect of acidity on such butter is not well established. Some authorities claim that a high acidity actually improves the keeping quality of unsalted butter, but it is not apparent why there should be such a radical difference between salted and unsalted butters. Accordingly, a series of experiments has been commenced to investigate the deterioration of unsalted butters during storage.

(*e*) *Wrapping and Packing of Butter* (C. R. Barnicoat).—The study of the results of investigations on the wrapping and packing of butter has now been completed. Some publications on the subject are now in the press. It has been shown that a good grade of parchment is a more satisfactory wrapper than most of the alternative materials such as waxed paper, greaseproof paper, metal-coated paper, and cellophane (both white and coloured) which have been submitted to the Institute for examination. Parchment backed with aluminium or tin foil gave better results than parchment alone, but it was found that tin foil needed protection from the frictional action of the wood of the box. The price of tin-foil wrapper is prohibitive, but as a result of the Institute's investigations a wrapper made of aluminium foil sandwiched between two layers of parchment has been developed. Under experimental conditions this wrapper gave excellent results in minimizing the development of "primrose" colour and of "toppiness" on the surface of the butter. During the past season this wrapper has been used to some considerable extent by commercial factories.

The Institute's investigations on the packing of butter in tins have shown that butter stored in tins, either at atmospheric air pressure or at reduced air pressure within the tin, does not develop "primrose" colour on the surface, and that there is in general a slight preference by graders for tinned butter on the basis of its flavour, when the butter is examined immediately after removal from the containers. The advantage, however, was not sufficient to be reflected in higher grading scores allotted by the graders to the butters. When the butters had been held out of the containers for seven to twelve days the advantages of packing in tins were for the most part no longer apparent. In the storage of patted butter there appeared to be some slight benefit from the use of reduced air-pressure within the tin. The benefit is probably derived from the effect of the atmospheric pressure outside the tin in causing a very close contact of the parchment wrapper with the surface of the block of butter. The use of a tin container appears to give definite advantages when butter is to be stored at "chill" temperatures, but the holding of butter for any length of time under these conditions should only be practised where freezing temperatures are not available, and should not be adopted in the transportation of export butter.

The Director (Professor Wm. Riddet) was awarded a travelling grant by the Carnegie Corporation of New York for the purpose of visiting the United States of America and European countries. This grant was supplemented by others from the New Zealand Dairy Board, the Meat Board, and the Government. After leaving New Zealand in February, 1936, he visited leading dairy colleges and research institutes in the United States of America, Canada, the United Kingdom, the Netherlands, Denmark, and Sweden. He also made a careful survey of the quality of New Zealand products in overseas markets and made useful contacts with both scientific and commercial institutions. While in England he attended the Commonwealth Scientific Conference as representative of the Council of Scientific and Industrial Research. On the return journey to New Zealand he made exhaustive inquiries regarding the manufacture of ghee in Bombay district and the prospects for the sale of New Zealand dairy produce there. During his absence Dr. H. R. Whitehead deputized as Acting-Director.

Staff Changes.

Mr. D. F. Sawers, who had been principal cheesemaker on the staff of the Institute since its inception, left to join the staff of the Dairy Division, and his place was taken by Mr. E. Sawyer. Mr. J. A. Singleton, who had been buttermaker for some time, left the staff to take up a post as manager of a commercial butter-factory, and his place was taken by Mr. J. O'Dea. Mr. J. N. Hodgson, dairy husbandman, joined the staff of the State Advances Corporation, and Mr. I. L. Campbell was appointed to this position in October, 1936.

Mr. C. R. Barnicoat was awarded a Commonwealth Fund Scholarship and was granted leave of absence for two years as from September, 1936, to take up special studies at the University of Minnesota. Mr. A. J. Wood, a post-graduate student at the University of British Columbia at Vancouver, arrived in November, 1936, to take up special studies on lactic organisms. This is an extension of work which has been in progress at Vancouver by Dr. Eagles and co-workers for a considerable period of time. In accordance with a reciprocal arrangement made between the Australian Council for Scientific and Industrial Research and the New Zealand Council of Scientific and Industrial Research, Dr. W. J. Wiley was seconded by the Australian Council to undertake research work at the Institute. Dr. Wiley entered upon this work in February, 1937, and is engaged upon a study of the keeping quality of unsalted butter.

Dissemination of Research Results.

As in past years, the Factory-managers' week was held at the Institute in the last week of April. This was patronized by a large number of factory-managers from all parts of the Dominion, and there was much useful discussion on the results of work carried out. A number of public addresses

were given to various dairying organizations during the year. In addition, a considerable number of inquiries from local and overseas sources were dealt with.

PUBLICATIONS.

Institute Publication No.	Title.	Author.	Journal.
83	The Coagulation of Milk with Rennet: Some Experiments with Slow Renneting and Soft Curd Milks	F. H. McDowall, R. M. Dolby, and A. K. R. McDowell	J. Dairy Research.
84	Investigation of Feed Flavours in Cream and Butter (D.S.I.R. Bulletin No. 52)	Wm. Riddet, J. N. Hodgson, E. Bruce Levy, and P. D. Sears	..
86	The Effect of certain Metallic Contaminants on the Cheddar Cheesemaking Process	C. R. Barnicoat ..	J. Dairy Research.
87	The Reactions and Properties of Annatto as a Cheese Colour (with Particular Reference to the Chemistry of Cheese Discoloration)	C. R. Barnicoat ..	J. Dairy Research.
88	Diacetyl in Cold Stored Butters: II	C. R. Barnicoat ..	J. Dairy Research.
90	The Determination of Casein by Formol Titration after Precipitation with Acid: An Improved Technique	F. H. McDowall and A. K. R. McDowell	Analyst.
91	Studies on the Chemistry of Cheddar Cheesemaking—V: Factors influencing the Acidity and Mineral Content of Cheese	R. M. Dolby, F. H. McDowall, and A. K. R. McDowell	J. Dairy Research.
92	Studies on the Chemistry of Cheesemaking—VI: Factors affecting the Relation between Lactic Acid and Titratable Acidity of Wheys	R. M. Dolby, F. H. McDowall, and A. K. R. McDowell	J. Dairy Research.
93	Studies on the Neutralization of Cream for Buttermaking—Part I: The Determination of the pH of Cream, Butter, and Buttermilk	F. H. McDowall and A. K. R. McDowell	N.Z. Jour. Sci. & Tech.
94	Studies on the Neutralization of Cream for Buttermaking—Part II: The Estimation of the Titratable Acidity of Cream	F. H. McDowall and A. K. R. McDowell	N.Z. Jour. Sci. & Tech.
95	Studies on the Neutralization of Cream for Buttermaking—Part III: The Carbon Dioxide Content of Cream and the Effect of Carbon Dioxide on the Acidity of Milk and Cream	F. H. McDowall and A. K. R. McDowell	N.Z. Jour. Sci. & Tech.
96	The Keeping Quality of Butter	C. R. Barnicoat ..	N.Z. Jour. Sci. & Tech.
97	Observations on the Activity of Bacteriophage in the Group of Lactic Streptococci	H. R. Whitehead and G. J. E. Hunter	Jour. of Pathology and Bacteriology.
98	Annual Report 1935–36	..	..
99	Lactic Bacteria in relation to Cheese Flavour ..	I. R. Sherwood ..	J. Dairy Research.
100	Studies on the Neutralization of Cream for Buttermaking—IV: The Effect of Dilution with Water on the Titratable Acidity of Milk	F. H. McDowall, R. M. Dolby, and A. K. R. McDowell	N.Z. Jour. Sci. & Tech.

The following are in the press:—

Institute Publication No.	Title.	Author.
85	Experiments in the Packing and Storage of Butter	C. R. Barnicoat.
89	Studies on the Chemistry of Cheddar Cheesemaking. Part VII—Acidity in Cheese: The Relation between Hydrogen Ion Concentration, Titratable Acidity, and Quality in Cheese	R. M. Dolby, F. H. McDowall, and Wm. Riddet.
101	Studies on the Neutralization of Cream for Buttermaking—Part V: The Reaction of Sodium Bicarbonate on Milk and Cream and the Effect of Pasteurization on the Reaction	F. H. McDowall and A. K. R. McDowell.
102	Studies on the Neutralization of Cream for Buttermaking. Part VI—Factors affecting the pH of Salted Butter: The Relation of pH to Quality of Salted Butter	F. H. McDowall, J. W. Smith, and A. K. R. McDowell.
103	Milk-supplies to Cheese-factories	F. H. McDowall.

Articles have also been contributed monthly by members of the Institute staff for publication in the *Exporter*.

As in past years, the Institute had the hearty co-operation of the Massey Agricultural College and staff, and enjoyed the privilege of use of the College herds, buildings, and plant for experimental purposes. The Institute also had the full co-operation of the Director and staff of the Dairy Division and members of the Investigational and Statistical Branch of the Department of Agriculture, of the Grasslands Division of the Plant Research Bureau, and of various commercial organizations. To all of these the thanks of the Institute are expressed.

PLANT RESEARCH BUREAU.

Plant Research Bureau Committee: Mr. A. H. Cockayne, Chairman; Dr. F. W. Hilgendorf, Vice-Chairman; Professor G. S. Peren, Massey Agricultural College; Professor E. R. Hudson, Canterbury Agricultural College; Mr. T. Rigg, Cawthron Institute; Dr. E. Marsden, Department of Scientific and Industrial Research; Mr. R. B. Tennent, Fields Division, Department of Agriculture; Secretary and Chief Executive Officer: Mr. F. R. Callaghan.

During the year the Plant Research Station was reorganized and has now become the Plant Research Bureau. In this form of organization it is possible to arrange for co-ordination of all work relating to investigations of plants at present being conducted in various Institutions throughout the Dominion. Participating in the Bureau are: (1) The Department of Agriculture and its various Divisions; (2) the Department of Scientific and Industrial Research and its several research sections; (3) Massey Agricultural College; (4) Canterbury Agricultural College; and (5) Cawthron Institute.

The Plant Research Bureau comprises four Divisions—Plant Diseases, Grasslands, Agronomy, and Entomology, while provision is made for a special section to deal with Botany.

With a view to facilitating co-ordination with existing Institutions and for the purpose of conducting researches in districts most appropriate thereto the Divisions have been located as follows:—

Plant Diseases Division	.. Mount Albert, Auckland.
Grasslands Division	.. Massey College, Palmerston North.
Entomology Division ..	.. Cawthron Institute, Nelson.
Agronomy Division	.. Canterbury Agricultural College, Lincoln.
Botany Section	.. Wellington.

In order to bring this about it became necessary during the year to arrange for the acquisition of land and the erection of buildings for the various Divisions. At Mount Albert an area of 16 acres of gently sloping land was purchased, and plans are now in course of preparation for laboratories, offices, and glasshouses for the Plant Diseases Division. Plans of new laboratories and offices for the Grasslands Division, to be erected in the vicinity of Massey College, have been prepared. Alterations have been effected to the Entomological Station at Cawthron Institute. New laboratories and offices for the Agronomy Division have been completed on an area adjoining Canterbury Agricultural College, Lincoln.

The Botany Section and the administrative offices of the Bureau have been established in Wellington.

Owing to the arrangements necessarily involved in this policy not being completed it was not possible to transfer the Plant Diseases Division to Auckland or to centralize the Entomology Division at Nelson during the year, and these have continued to function at Palmerston North.

The Plant Research Bureau Committee has met regularly during the year, a policy of co-operation in all aspects of plant research is being gradually evolved, and a much closer measure of co-ordinated effort between research workers, instructors, and teachers is already in evidence.

PLANT DISEASES DIVISION.

(Director: Dr. G. H. Cunningham.)

Introduction.

During the year the principal activities of the Division were conducted at Palmerston North, but with the acquisition of the land for the future site of the Divisional Headquarters at Auckland the fruit and spraying investigations have been carried on in that district. The investigations undertaken by this Division relating to fruit are reported in the section "Fruit Research," p. 53.

Plant Diseases.

Cereal Diseases.—(*a*) Organic Mercury Dusts: Comparative trials were completed of new experimental organic mercury dusts for the control of smut and other diseases of wheat, oats, and barley. The results have been communicated to the firms concerned to assist them in improving the materials at present on the market.

(*b*) Ergot and Allied Diseases of Grasses: Work has been commenced on an investigation of the ergot fungi in order to find the species concerned; their life history in New Zealand; their effects on seed production, particularly in regard to rye-grass, paspalum, and other grasses; and, in conjunction with Wallaceville Laboratory, their effects on the health of animals.

Legume Diseases.—(*a*) Bean-wilt: The trials of New Zealand and imported lines of so-called resistant varieties have shown that a number are highly resistant. Unfortunately, a number of these, particularly those of European origin, are not in demand for New Zealand commercial purposes. One line of Canadian Wonder beans has proved resistant, and with other varieties will be further tested and increased next season.

The principle of rogueing to eliminate bean-wilt has been applied under commercial conditions.

(*b*) Collar-rot of Peas: The selection of disease-resistant varieties was prevented owing to the persistent unfavourable weather conditions during the growing season.

(*c*) Pea-mosaic: Field and glasshouse trials have shown that of thirty-two varieties of garden and field peas, eight varieties—viz., Little Marvel, Lord Chancellor, Hundredfold, Wm. Massey, Daisy, Royal Salute, and Autocrat, and the field pea Black-eyed Susan—are immune to pea-mosaic. Evidence suggests that two other varieties—Onward and English Wonder—now under trial are also immune.

(*d*) Pea-streak: The host range of this disease has been shown to include sweet-peas, dwarf beans, soya beans, *Lupinus luteus*, *Lotus hispidus*, *Trifolium arvense*, tares, &c. Of thirty-five garden and field peas tested none proved to be immune, but several were definitely resistant and were not killed by the disease.

(*e*) Lucerne Deterioration: Investigations are in progress to determine the possible influence of a bacteriophage in relation to the usual deterioration after a period of time of established stands of lucerne. Up to the present no bacteriophage has been found.

Brassica Diseases.—(*a*) Soft Rot of Swedes: The field trials at Palmerston North dealing with the pathogenicity of the causal organism and its relation to other diseases and to stocking are still in progress.

(*b*) Turnip-mosaic: The list of susceptible hosts has been extended to include white mustard, wild turnip, hedge-mustard, narrow-leaved cress, shepherd's purse, and *Sysimbrium altissimum*. Several other cruciferous weeds are at present under test.

(*c*) Club-root and Dry-rot: Work on these diseases has been confined to field tests, partly on a local experimental area and partly in Southland, in co-operation with the Fields Division of the Department of Agriculture, to ascertain the relative powers of resistance of some seventy varieties and strains of swedes. The results confirm previous work in showing the outstanding qualities of the variety Wilhelmsburger in resistance to club-root disease as measured by weight of crop on infected land. No evidence was obtained pointing to varietal resistance to dry-rot disease.

(*d*) Brown-heart: Numerous field trials of the boron treatment for this disease showed the efficacy of the method in controlling the condition but that severe germination injury may take place if wrongly applied. The information gained has been very useful in planning the coming year's experiments on methods of application in practice.

Potato-diseases.—Masked Virus: The potato variety Iron Duke has been shown to be susceptible to this disease. It causes the typical severe streak symptoms on leaves and stem and also causes internal discoloration of the tubers.

The disease may be transmitted to tobacco, where it causes very severe symptoms—stunting of plant, mottling, and necrosis of leaves. It may also be transferred to tomatoes, on which it causes a mild mosaic mottling with very slight stunting.

Tomato-diseases.—(*a*) Spotted-wilt: Dahlias, chrysanthemums, zinnias, asters, Cape gooseberry, *Nicotiana rustica*, delphiniums, anemones, and cinerarias have been added to the list of hosts susceptible to this disease in New Zealand.

(*b*) Leaf-mould: Three years' experiments on the control of tomato leaf-moulds in the glasshouse (Hutt Valley) carried out in conjunction with Messrs. Dallas and Taylor, of the Horticulture Division of the Department of Agriculture, and Mr. Brien, of this Division, have been completed. The trials have shown that of the materials tested Shirlan AG gave the best results.

(*c*) Late Blight: Spray trials for the control of late blight have been carried out, but results are not yet to hand.

(*d*) Stem-disease: A tomato stem-disease widespread this season is being investigated.

Tobacco-diseases.—Mosaic: Experiments have shown that the disease may carry over from one season to the next in the seedling bed. In boxes exposed to the weather the virus remained viable for three months and a half. It has been shown that when mosaic-infected plants are replaced by healthy plants a high percentage of replants become infected—80 per cent. in trials carried out in the field.

Passion-fruit Diseases.—(*a*) Bacterial Diseases: The causal organism has been isolated and pathogenicity proved.

(*b*) Brown-spot: Investigations have been carried out, including isolations from Keri Keri specimens, and inoculation tests with the various fungi obtained. A species of *Alternaria* consistently isolated from brown-spot lesions has been found to be pathogenic, producing typical lesions on fruit and leaves.

Cucumber-diseases.—Mosaic: The host range of this disease has been extended to include tobacco, tomatoes (so-called "narrow-leaf"), blue lupins, *Lupinus mutabilis*, *L. Leuteus*, and violas, as well as pumpkins, spinach, marrows, and melons. Field experiments are being carried out to determine the effect of this disease on the yield of tomatoes and also of cucumbers, marrows, &c.

It has been shown that the disease may be transmitted by *Aphis gossypii* and *Myzus persicae*, and also through the seed of vegetable marrows.

Damping-off Diseases of Seedlings.—(*a*) Tomatoes: Further experiments have been carried out on the control of tomato seedling damping-off, by the use of seed-dust therapeutants. Ceresan, copper carbonate, and Agrosan dusts gave satisfactory results. Results in publication form are at present in the hands of the printer.

(*b*) Vegetables: Field trials have been carried out on the control of damping-off of cucumbers, spinach, and lettuce by the use of seed dusts.

Certification of Therapeutants.

Papers have now been prepared for this purpose, and the scheme will be made operative early in December. Owing to the lateness of the season it will be possible to certify this year only those orchard sprays which previous tests of the past three seasons have proved satisfactory.

Soil Biology.

Continuous work has been in progress on the biological analysis of soils, more particularly in regard to the fungi. In one series of experiments a distinct apparent correlation was obtained between the relative abundance of certain mould fungi and vigour of grass and clover as affected by different fertilizers. The probable error of the replication in those experiments was too high for reliability and further work has been necessary, directed towards improvement in technique.

Industrial Mycology.

Discoloration of house paint has been traced to two fungi—*Dematium nigrum* and *Cladosporium herbarum*. Laboratory experiments have shown the possibility of preventing the growth of these fungi by the addition of Shirlan paste to the paint. One large firm of paint manufacturers is now testing the method on a practical basis.

Investigations on behalf of the Public Works Department on the prevention of mould on tent calico have shown that the salicylanilide dip method is cheap, practicable, and efficacious. Failure of cork composition insulating washers in electrical transformers has been traced to a new species of *Paeciliomyces* which attacks and destroys the cementing material. Treatment with salicylanilide has been found to prevent growth of the fungus without other effect on the material. Advice has been given to ten industrial firms on the cause and control of mould infections.

Continuous work is under way on the systematics of the mould fungi of New Zealand, and a paper on the genus *Penicillium*, the " blue-moulds " of foodstuffs, &c., has been completed for publication.

Legume Cultures.

This season cultures for 94,000 lb. of lucerne-seed have been distributed to farmers, a decrease on last year of approximately 30,000 lb., probably due to weather conditions. The co-operation of merchants in this respect has been most satisfactory. A few cultures have been forwarded to farmers in Australia and one to the Argentine. The supply of cultures for other legumes is in the early stages of development, being limited to clovers (2,000 lb. seed), lupins (4,200 lb.), and peas (18,800 lb.).

Investigations of the value of " strains " in cultures, particularly those of clovers, peas, and lucerne, are being continued. In addition, field trials, in conjunction with the Fields Division, Department of Agriculture, of strains for red and white clover and for subterranean clover have been laid down in various parts of New Zealand.

Pyrethrum.

Flowers have been harvested from twenty-seven pure clone strains of pyrethrum, and samples of flowers from these were forwarded to the Dominion Laboratory for analysis. The results of these analyses have shown that the pyrethrin content varied very considerably with the strain, ranging from 1·0 per cent. to 2·35 per cent. In one set of buds sent down the pyrethrin content was only slightly less than the flowers of the same strain.

Routine.

During the period, 325 specimens were received for identification of disease and report.

Publications.

The following papers were published during the year :—

Pea-mosaic. *N.Z. Journal of Science & Technology* (1936), *17*, 544.
Turnip-mosaic. *N.Z. Journal of Agriculture* (1936), *53*, 321.
Nicotine Content of Tobacco. *N.Z. Journal of Science & Technology* (1937), *18*, 628.
Pea-mosaic. *N.Z. Journal of Agriculture* (1937), *54*, 129.

The following are awaiting publication :—

Spotted Wilt of Tobacco. *N.Z. Journal of Agriculture.*
Tomato Seedling Damping-off : Control by Seed-dusting. *N.Z. Journal of Agriculture.*

GRASSLANDS DIVISION.

(Acting Director : E. A. Madden.)

Introduction.

During the year Mr. E. Bruce Levy, Director of the Division, was appointed New Zealand official representative at the International Grassland Conference to be held at Aberystwyth in July, 1937. Advantage of this occasion has been taken to grant Mr. Levy extended leave in order that he may study grassland research problems in Great Britain and Europe.

The Division has been subjected to a number of staff changes, which have caused a certain amount of interruption in the progress of the work, but no serious interference has resulted, and an important new sphere of activity—viz., pasture survey—has been inaugurated in Hawke's Bay. This work forms part of the land-utilization survey now in progress, and is being done in association with the Soil Survey Division and the Fields Division (Department of Agriculture).

Plant breeding work and strain testing have been continued with quite a marked improvement in both the technique and quality of the material produced. Field plot trials to test strains of grasses and clovers have been laid down with the co-operation of the Fields Division of the Department of Agriculture, and the work there has been of great value not only to the Instructors and members of the staff, but also to the farmers in the districts where these trials have been commenced.

Work in connection with feed flavour investigation has been continued during the past year at Palmerston North in conjunction with the Dairy Research Institute, and at Morrinsville in conjunction with officers of the Fields Division of the Department of Agriculture and the dairy companies.

The general ecological work of the Division has been advanced, and detailed herbage analyses of mown herbage from plot trials have revealed many points of interest. Botanical analyses of pastures *in situ*, in conjunction with herbage dissection analyses, are enlightening regarding pasture transitions due to seasonal influences and stock concentrations.

The work of the Chemistry Section has been modified in a small way, and careful attention is now being given to analyses in connection with the field work of this Division. Staff increase in the Chemistry Section has enabled a wider scope of work to be undertaken, and the benefits of this will be more fully appreciated when working conditions are improved and when a bigger laboratory is available.

Pasture Survey.

Strain Testing and Certification.

The following numbers of lines have been sown and studied for certification and type test :—

Perennial rye-grass	616	Cocksfoot	220	Brown-top	345
White clover	427	Subterranean clover	67	Italian rye-grass	92
Phalaris tuberosa	27	Prairie-grass	21	Red clover	132

1. *Perennial Rye-grass.*—Plant Breeding, Selection, and Improvement: Approximately 10,180 single plants from control pollinations are now under study. Of this number, 3,480 plants have been raised from crosses made in the 1935–36 season. Crossing-work for the 1936–37 season has consisted of inter-family and back-crosses of F_1 plants selected from the progeny of the 1934–35 crossings. Some L_1 plants have been out-crossed. Each plant used in breeding and crossing-work has also been selfed. A total of 81 crosses has been made, and the seed from these has been harvested, threshed, and is now ready for sowing.

Pedigree Strain Selection: The increase area planted in 1934 has been harvested for the third year in succession. Seed from this area has sown down 32 acres, which have been harvested on a contract basis, and the pedigree seed from these areas is now widely distributed throughout New Zealand. Good reports of this line are coming to hand. A new glasshouse selection has been made and another increase area of $\frac{3}{4}$ acre has been planted out from the seed harvested in the glasshouse.

Single Plant Study: A selection of desirable plants has been made and 10,000 single plants which were raised for the purpose of providing suitable material for further work have been planted out.

Tiller-row studies of selected single plants are being continued. The plants selected from South Island uncertified low U.V.-light-testing lines are far below the standard of the plants found in the certified lines and so this material does not offer very satisfactory scope for the building up of a good strain from the South Island.

Low Germination of Perennial Rye-grass: The seed from the experimental areas at Winton and at Palmerston North has been harvested, and the seed is now ready for germination tests. Fungus infection has been heavy this year and it will be interesting to record the degree of infection which has occurred in each of the 300 lines of various origins which have been tested.

2. *Italian Rye-grass.*—Plant Breeding and Selection: From 8,600 single plants derived from inter-family groupings of 4 F_1 or L_1 plants 260 plants have been selected, and the crossings carried out from these have been as follows :—

Intra and inter-family crosses	110
Crossings of selfed plants	22

In addition, 46 original plants provided material for 30 crosses thus making a total of 162 for the season. Plants have been crossed in pairs only, and the selfing of these plants has also been a feature of the work.

Pedigree Strain Production: Fifteen selected plants were put out in the glasshouse, and the seed from these was harvested to provide sufficient material to plant out a $\frac{3}{4}$ acre block. This has been done and the increased area will be harvested in the 1937–38 season and will provide the first lot of pedigree Italian rye-stock seed.

3. *Cocksfoot and Brown-top.*—No work other than certification testing has been done with these species.

4. *Prairie-grass.*—Twenty different lines have been studied as plot rows and single plants. The New Zealand lines appear to be fairly uniform, and tests are now being made in connection with overseas material.

5. *Phalaris tuberosa and Phalaris Species.*—Twenty-seven lines have been under trial as plot rows and single plants. There are distinct strain differences to be noted in this trial. Seven lines were sown in the spring with a view to testing for certification *Phalaris tuberosa* free from *P. minor*.

6. *Timothy.*—Seventeen overseas strains have been compared with locally obtained samples.

7. *White Clover.*—(*a*) Plant Breeding and Selection: The 1934 block of plants has been retained, and the best 125 plants in the block have been put to further breeding tests. When their progeny have been studied final selections will be made from the 1934 block.

The 1935 block of 4,500 single plants is still under regular observation.

The 1936–37 season's crosses have consisted of—

Ten crosses to complete diallel crossings of the seven plants used in the 1936–37 glasshouse selection; and

Five crosses in which the experimental crossings of Type 1 × Type 5 (Kentish) have been carried to a second generation.

The 189 plants in tiller rows have been under constant study.

(*b*) Pedigree Strain Production: No nucleus stock seed has been distributed this year, but from the 58 acres sown down from previous distributions several thousand pounds of dressed seed have been harvested this year and will be distributed by the Department of Agriculture.

Some excellent reports have come to hand regarding the behaviour of the pedigree white clover under farming conditions.

A 1936–37 glasshouse selection has been made by the selection of seven plants, which are themselves exceptionally good plants and as the result of breeding tests are known to give good progeny when inter-crossed. The seed from this selection is being raised in boxes prior to planting out a $\frac{3}{4}$ acre increase block.

(*c*) Single Plant Studies: In order to build up a permanent strain of clover, less aggressive than our Type 1, plants are being selected from a block of 1,600 single plants raised from lines classified as being dominantly Type 2.

In connection with feed-flavour investigations, type analyses have been made of a block of 1,000 plants grown from seeds hand-harvested from the white clovers present in Waikato pastures.

Some six hundred plants representing first harvest progeny from areas sown with pedigree seed are under study also.

8. *Montgomery Red Clover.*—(*a*) Plant Breeding and Selection: The 1936 block of 2,400 single plants from controlled crossings has been under constant observation. Some seventy-four plants were selected from this block for further crossing in pairs, but as the result of unseasonable weather these plants failed to flower sufficiently. These crosses will be attempted again in the 1937–38 crossing-season. During the last twelve months virus infection has been most severe on all red clover single plants. This is making the selection work more difficult and is tending to retard progress towards improved strains.

(*b*) Pedigree Strain Production: As yet there is only one contract area of 3 acres sown with nucleus stock from the increase area. This year only 9 lb. of dressed seed have been obtained from the ½ acre increase block, which has been harvested for the third time in succession.

(*c*) Single Plants: A further 1,500 plants have been raised from best commercial seed and station-grown lines. These are required in order to increase the supply of superior original plants.

9. *Subterranean Clover.*—(*a*) Strain Testing: The strain-testing work has been continued and the testing of three New-Zealand-grown samples with a view to certification is in progress.

Two field strain trials have been put down this autumn—one being at the Pure Seed Farm, Lincoln, and the other on light plains land near Burnham. More field strain trials would be desirable but seed supplies of selected strains are limited.

(*b*) Seed Production: Owing to the extremely wet weather experienced in the summer months seed production from selected strains was not a success. Only small amounts of seed, each low in germination, were harvested.

Seed production will be attempted again this coming summer.

10. *Lotus Major.*—The original fifty-four tiller rows have been reduced to fifteen. Plants from them will be used for selection purposes.

Ecology and Field Trials.

During the year under review this Division has provided the seed for twenty-three sets of strain trial field plots, which have been laid down by the officers of the Department of Agriculture. The reports coming in regarding these trials indicate in most cases the superiority of the selected and pedigree strains of grasses and clovers. In all, 108 such trials have been laid down in various parts of New Zealand. Seed for special trials has been provided in addition to the above, and good reports on pedigree seeds have been received.

Pasture Analysis.

Point analysis of pastures has been continued at Marton Experimental Farm and on several of the strain trials sown down in this district, and also in connection with the pasture side of the feed-flavour investigations. Analysis by weight, of the plucked and mown herbage from the plots both at Palmerston North and Marton, has been continued, and some very valuable figures relative to pasture changes have been secured. An attempt has been made to correlate "point analysis" and "herbage dissection analysis" with a possibility of evolving a technique suitable to measure herbage production and seasonal production of various species.

The lack of trained assistants precludes the extension of exact pasture analysis over a wide area, but such work is highly desirable and will be persevered with as opportunity offers.

Pasture Survey.

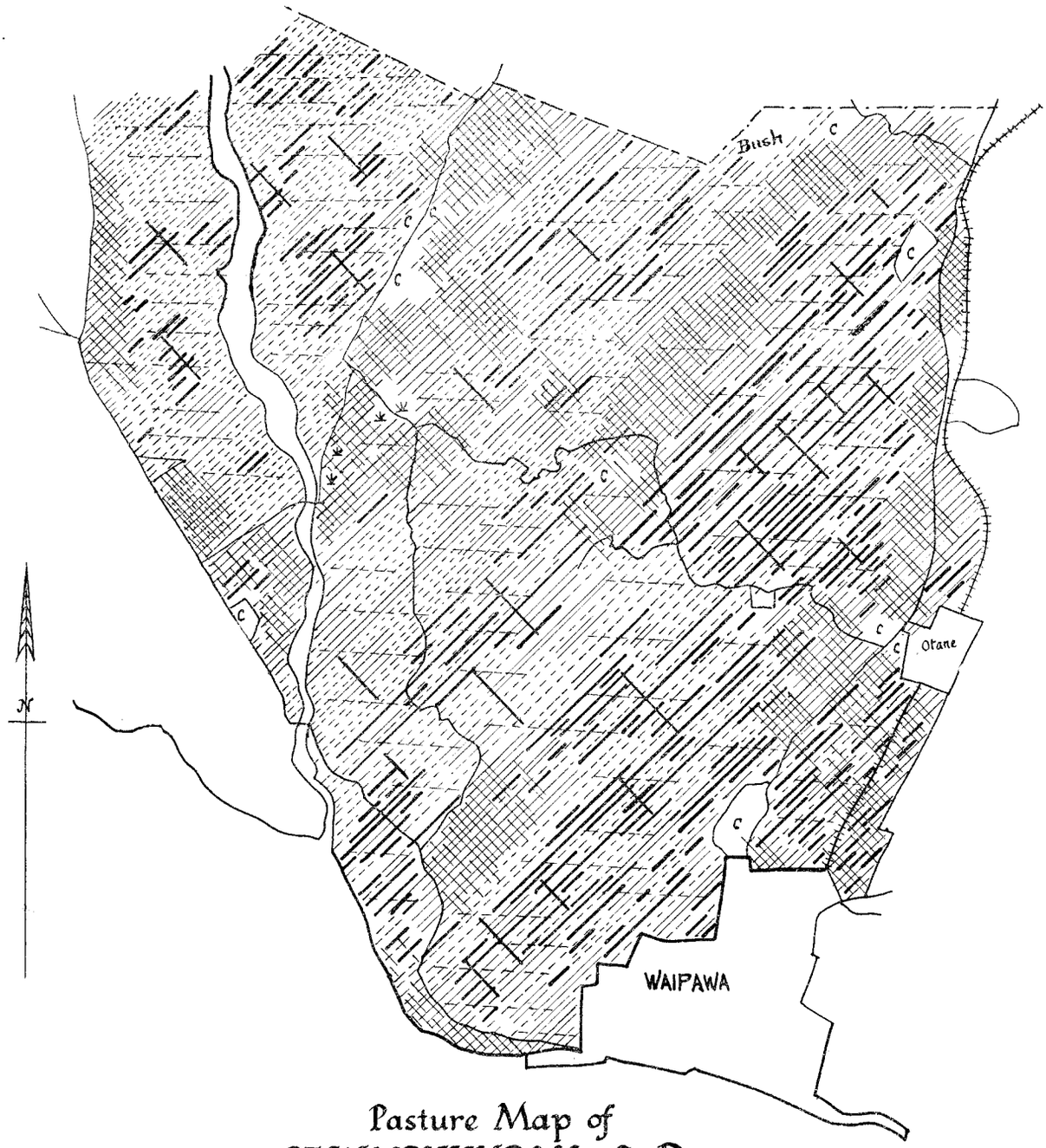
During the year a system was evolved of mapping the country fairly rapidly so that even small details, paddock to paddock differences, could be recorded. The area in Hawke's Bay completed up to 31st March comprises some six hundred square miles, and during the progress of this work much valuable information concerning the pasture types has been obtained. Great value attaches to this work, and it is probable that a much better general understanding of the pasture problems of the country would result from a complete pasture survey of the Dominion. The potentialities of all grasslands can be gauged fairly accurately by the use of the pasture map in conjunction with the soil survey map. A very heterogeneous mixture of pastures and pasture species has been recorded, and it is quite apparent there is much room for pasture improvement on a sound economic basis.

The factors influencing pasture type may be summarized as follows: Soil type; farm management and practice; climate; topography of country; proximity to rail; top-dressing; use of correct pasture species for the particular area; and whether the country was originally bush-clad or not.

The map accompanying this report shows approximately the type of pasture existing and the method adopted of recording such pasture types. The final map will be reproduced in colour and will show more detail. The pasture survey is a "stocktaking" of our grasslands and should be the basis for all future research and extension into pasture work of the Dominion.

Feed Flavour in Cream.

The work in the Waikato has been continued during the past season, but the results secured, while satisfactory in some respects, were disappointing in a few instances owing to the lack of adequate co-operation on the part of a few of the farmers. The work at Frankton, Te Awamutu, and Morrinsville was affected by staff changes and shortages in personnel. The findings during this season corroborated those of the previous season, but little fresh information has been gained.



Pasture Map of PT WAIPUKURAU S. D.

SHOWING ONLY MAIN PASTURE TYPES AND SPECIES.

SCALE.

Chs. 80 60 40 20 0 1 2 Mls.

LEGEND

Danthonia pilosa	Subterranean clover / Harefoot trefoil
Suckling clover	
Perennial rye-grass	Sweet vernal
White clover	Swampy areas
Brown-top	C Cultivated areas

Pasture survey by E. A. Madden and G. S. Harris, of the Grasslands Division, Plant Research Bureau, Department of Scientific and Industrial Research.

Compiled from data obtained from the Lands and Survey Department.

Drawn by G. S. Harris.

During the latter part of the year fresh arrangements were made with the Fields Division of the Department of Agriculture with a view to initiating some more exact detailed work at the Ruakura Farm of Instruction during the coming season.

At Palmerston North, in conjunction with the Dairy Research Institute, work progressed along lines similar to those of the previous season, and cows were fed with herbage consisting of rye-grass pure, rye-grass and white clover, Italian rye-grass, and Italian rye-grass and red clover. The small areas sown down to provide special feeds (subterranean clover, annual white clover, and sweet vernal) were utilized as occasion demanded, but little information of significant value was obtained from these. The results of the year's work have brought about a change in policy, and in future endeavours will be made to feed the various mixtures of herbage at different stages of growth to determine the influence of this on feed-flavour incidence, instead of as in the past, when various proportions of clover to grass were fed for the same periods. The clovery pastures were definitely more prone to produce an undesirable flavour in cream in both the Waikato and Palmerston North districts. A considerable amount of valuable information regarding pasture management has been secured in connection with the feed-flavour investigation, and great care in the management has been necessary.

Careful attention has been given to the production of the pure feeds required for both the grazing and stall-fed cows. The botanical composition of the pastures and pure swards has been recorded and an endeavour was made to measure the amount and rate of growth of different pastures, but with limited labour and inadequate facilities this was not carried out as fully as was anticipated.

Chemical analyses and dry-matter determinations of the diets of the cows under test have been regularly undertaken.

Green-keeping Research.

Very little new investigational work has been undertaken, the activities of research having been concentrated more on weed eradication and the testing of chemicals in connection with turf production and maintenance. The advisory officer engaged by the Golf Council reports having had a very satisfactory year and has covered most of the North and South Islands, learning the problems of the various golf and bowling clubs. He has given advice on most occasions where he has visited a club, and has brought back with him several problems requiring attention on the experimental area.

Chemistry Section.

The work of the section has continued along the lines of last year's report, but special attention has been given to some biochemical problems concerning grasses and clovers. The work on herbage and soil samples from the Marton Area has been continued. Special attention has been given to the movement of lime in plots treated with limestone at different rates of application, and much interesting data has been obtained.

A considerable amount of time has been devoted to the analysis of material fed to cows in connection with the feed-flavour investigations in conjunction with the Dairy Research Institute. Endeavours were made to produce artificially feed flavours in cream, from rye-grass and various clovers in the fresh state, and in various stages of digestion *in vitro* with digestive enzymes. Typical "feediness" was not produced in any instance, although flavours were readily produced from various clovers when vacuum distilled. The flavours obtained after digestion with ptyalin were markedly different from those produced from fresh material. Virtually no flavours were produced from rye-grass. Investigation of the nitrogen partition in clovers and grasses and the variation found from day to day was commenced. The results obtained were most interesting and are considered worthy of being followed up next season. Marked differences in the nitrogen partition between grasses and clovers were observed and daily variations were noticed, depending, apparently, on weather conditions.

The usual miscellaneous analyses have been made during the year.

Publications.

Investigation of Feed Flavour in Cream and Butter. Bulletin No. 52, Dept. S. & I. R.

Behaviour of New Zealand Certified Clovers in New Zealand and Abroad (*N.Z. Journal of Agriculture* (1936), *53*, 76.

Strain in Subterranean Clover. *N.Z. Journal of Agriculture* (1937), *54*, 82.

Effect of some Phosphatic Fertilizers and Superphosphate-lime Mixtures on Turnip-seed Germination. *N.Z. Journal of Science & Technology* (1937), *18*, 739.

Note on an Exudation of Glutamine from Chewing's Fescue. *N.Z. Journal of Science & Technology* (1937), *18*, 844.

Lectures and Demonstrations.

Lectures have been given to various Young Farmers' Clubs and at conferences held both in Palmerston North and at other centres. Visitors to the research plots have been numerous, and a considerable amount of time has been devoted to showing people over the areas. The number of overseas visitors has been considerable, and the number of farmers from different parts of New Zealand who have been shown over the plots indicates that there is an increasing demand for more intimate knowledge of the pasture research work.

Equipment, Implements, and Apparatus.

Further evidence of the value of good implements has been demonstrated during the year. By the use of tractors and cultivators the labour costs have been kept at a minimum and the working efficiency of the staff has been improved.

ENTOMOLOGY DIVISION.

(Director: Dr. D. Miller.)

Introduction.

The Entomology Division has been established under the direction of Dr. D. Miller, of Cawthron Institute, Mr. J. Muggeridge being Associate Director and Government Entomologist. The Plant Diseases Division will have an Entomological Section to deal specially with therapeutant problems, in charge of Mr. W. Cottier. Co-operation has also been effected with Canterbury Agricultural College, Lincoln, where a section of the Division will function in charge of Mr. L. Morrison.

It is proposed to locate the headquarters of the Division at Cawthron Institute, Nelson, in order to facilitate full co-ordination with the Entomological Station of that Institute and to utilize the excellent facilities already provided there. One field station will be established at Canterbury Agricultural College, Lincoln, and the facilities and staff at present at Palmerston North will be transferred to Nelson during the winter months of 1937.

During the year reorganization has been proceeding on the above lines and the main investigations reported on are those undertaken at Palmerston North and Canterbury Agricultural College, Lincoln.

Palmerston North.

(J. Muggeridge, Associate Director.)

Entomological activities for the past year are conveniently referred to under the two headings—Routine and Research:—

Routine.—The routine work of this section occupies a considerable amount of time and consists in identifying insects for the general public and advising them on suitable methods of control. In addition, it provides an advisory and working service on entomological problems met with by the Department of Agriculture. Records of some of the more important insect pests are kept and new information in regard to them is published as occasion demands. During the past year the following insects hitherto unrecorded in New Zealand made their appearance:—

(1) *Parlatoria pergandei.*—From plum at Tauranga.
(2) *Eucalymnatus tessellatus.*—On Kentia palm imported to Napier from Australia. The identity of this insect has yet to be confirmed by the Imperial Institute of Entomology.
(3) Black currant bud eelworm *(Aphelenchoides ribes).*—Hitherto this pest was recorded only from England. In New Zealand it has been discovered in material from the Wairarapa and Hawke's Bay, and from appearances must have been present in the Dominion for some years prior to its discovery. In the Wairarapa it is stated to be causing trouble, but, unfortunately, there is no known control for it. Inquiries are being made concerning the economic importance of this pest with a view to arranging investigations into control should they be warranted. An account of the eelworm is in the course of preparation for publication.
(4) *Chortophila florilega.*—From onions near Christchurch. A detailed account of this pest is being prepared for publication.

Research.—The problems dealt with under this heading are as follows:—

(1) Biological control work on Diamond-black Moth (*Plutella maculipennis*).
(2) Biological control work on White Butterfly (*Pieris rapae*).
(3) Use of oils against red mite.
(4) Use of insecticides against white butterfly.
(5) Control of mealy-bug on hot-house grapes.
(6) Citrus insect pests.
(7) Other investigations.

Biological Control of Diamond-back Moth: A special study of the diamond-back moth (*Plutella maculipennis*) problem was undertaken with the object of gaining a better control of this pest, if practicable, by the use of natural enemies. A detailed report which dealt with field surveys, anatomy of the larvæ, life-history studies, and natural enemies of the moth was presented in June, 1936. This investigation showed that the only known natural enemies in New Zealand were—(1) an undescribed species *Angitia*; (2) an undescribed species of *Diadromus*; (3) the fungus *Entomophthora sphaerospherma*; and (4) two Sryphid predators. Of the insect parasites none appears to be of any value in checking the pest, while the fungus, dependent as it is on climatic factors, is not prevalent normally at that period at which the most severe damage occurs in cruciferous crops.

The Imperial Institute of Entomology was requested to search for suitable parasites in England. Their investigations showed that the larval parasites (*Angitia cerophaga* and *A. fenestralis*) were important controlling factors which frequently parasitized between 70 per cent. and 80 per cent. of the moth in England, and consequently it was considered advisable to introduce them into New Zealand. A detailed report dealing with parasite importations has already been presented, but a brief outline of the work to date is as follows:—

The first three control shipments of *Angitia fenestralis* were received from the Farnham Laboratory during August, 1936. An attempt was made to breed from those parasites received alive, and mass breeding from the adults was begun on 12th September, 1936.

Owing to the fact that there is no hibernation period in the life cycle of the introduced parasites, and that the diamond-back moth is not present in the field in any great numbers in December, it was necessary to continue rearing the parasites in the laboratory until that time.

From August to March inclusive the consignments received and utilized for the laboratory breeding and field work were as follows :—

Number of consignments received	15
Total number of cocoons received	65,713
Total number of adult parasites alive on arrival	21,233 (9,926 females, 11,307 males).

Owing to restriction of space, &c., it was not possible to utilize all this material in the laboratory, and approximately three thousand parasites were liberated in the field in Hawke's Bay in September in the hope that some of them might find hosts.

Breeding in field cages in Hawke's Bay was begun on 18th November, and after the beginning of December the greater part of the material received was sent there, only a small part being retained in the laboratory.

The results of the laboratory experiments are as follows :—

Total number of females utilized for breeding	5,104
Total number of parasite pupæ reared in the laboratory	14,672
Total number of adult parasites reared in the laboratory	6,412

The parasites thus reared in the laboratory and, in addition, supplies of parasites received from England after December were placed in field cages in Hawke's Bay, and the first parasite pupæ were collected from these cages on the 10th December.

From the parasite-breeding work conducted in field cages in the field, 14,634 pupæ were reared, and the total number of adult parasites reared was only 1,167.

The total percentage mortality of the parasite pupæ was 92. The majority of the pupæ was extraordinarily large, but is explained largely by the presence of an important native hyperparasite. The final analyses of the hyperparasite position are not available at present, but preliminary analyses indicate that 65 per cent. or more of the primary parasites have been destroyed by these secondaries. The hyperparasite causing the mortality has been identified at the Imperial Institute as a *Eupteromalus* sp.

In addition to the above work, liberations of 6,104 of the above parasites were made in the field in Hawke's Bay, and at the time of writing it is interesting to record that field recoveries of the introduced species have been secured. A considerable amount of time must now elapse before the results of the experiment will be known, but meanwhile field surveys will be carried out as often as circumstances will permit.

Biological Control of White Butterfly : It is again pleasing to report that the introduced parasite of the white butterfly is proving an outstanding success in holding this pest within reasonable limits. It is difficult to see the importance of this control measure in its true perspective, but the writer is of the opinion that were it not for the presence of the parasite the successful growing of some six hundred thousand acres of cruciferous crops in New Zealand to-day would be so uncertain as to render it impracticable. In the last annual report it was mentioned that under wet conditions a differential rate of parasitism was found to occur, depending on whether the butterfly chrysalids were found in wet or dry places. The influence of these wet conditions was such as to lead to the belief that in wet seasons such as those of the last two summers the butterfly would increase and again prove a menace to the crops. Fortunately this has not occurred, although in many places where field surveys have been carried out there are signs of the pest increasing ; but, apparently, the parasite, although less efficient under wet conditions, is still able to keep its host from developing into a serious pest.

In the case of market gardening of cabbage, &c., a better degree of control of the pest is required than that which obtains for field crops, and consequently spray work on the control of the butterfly has been carried out ; this will be dealt with later in the report under the heading " Insecticides for White Butterfly."

During the past year a considerable amount of field work was carried out which had both scientific and economic value. It was of scientific value in that the proportion of parasitized to unparasitized pupæ collected proved to be a definite measure of the importance of the parasite, and also proved of significance when compared with results obtained in previous years. It was of economic value in providing approximately twelve thousand parasitized and unparasitized chrysalids. The material thus collected was all transferred to cold storage, and during the winter months the unparasitized chrysalids were parasitized under heated glasshouse conditions and again transferred to cold storage, where all parasitized material was held. Subsequently, during the summer and autumn months the parasites were reared and distributed wherever required. In response to the numerous inquiries from all over New Zealand 100,000 parasites were sent out—4,000 to the Wellington Province, 16,000 to Auckland, 20,000 to Otago, and 60,000 to Canterbury.

Use of Oils against Red Mite : Experiments were again conducted in both field and laboratory on the effect of winter oils on the overwintering eggs of *Paratetranychus pilosus*, C and F., the common red mite on orchard trees in New Zealand. The purpose of this was to corroborate previous findings and also to investigate certain matters in regard to technique. The past seasons's work has demonstrated that previous findings are correct, viz. :—

That with a 5 per cent. oil concentration—

(1) Increasing the viscosity of the winter oil through a range from 95 sec. Redwood 1 at 100° F. to 399 sec. at 100° F. has no appreciable effect in increasing the kill of eggs secured. The average winter oil used in New Zealand to-day is in the vicinity of 85° to 120° Redwood at 100° F.

(2) Emulsification has no appreciable effect on egg-killing properties of the oil. In the current work three types of emulsifier were used to secure varying types of stability—viz., a miscible oil, an ammonium oleo-resinate emulsifier, and a lime-casein emulsifier, all in order of decreasing stability. No worthwhile difference in kill could be detected.

It is thought that all likely methods for improving the type of winter oil spray have now been investigated, and nothing can be suggested that will offer any real advantage over the good commercial oils used to-day for winter applications against *P. pilosus*. It may be possible to improve the kill secured in winter applications by increasing the concentration of oil to water in the spray—*e.g.*, from 5 per cent. to 10 per cent. strength. This, of course, will be governed by what concentration the trees will stand in the late winter, and will be tested in the coming season. The difficulty of killing *P. pilosus* winter eggs with petroleum oils is apparently a characteristic of this species.

Since it seems that there is little possibility of any substantial improvement at present in winter application of oil sprays it is proposed to discontinue this phase of the work except for some experiments on the effects of concentration as explained above. Without some fundamental work on the method of killing red mite winter eggs there is little prospect of an advance being made in the improvement of petroleum oils for winter treatment of *P. pilosus* eggs. It is preferable to investigate the possible methods of summer treatments before any such fundamental work should be considered. From work performed to date it is known that summer oil will give an excellent kill of mites, and investigations made last summer showed that summer eggs of the mite were also readily killed by this treatment; this, of course, requires corroboration. The present recommendations for summer applications state that two summer oil sprays should be applied, with an interval of ten days between them—usually in January. Work last season showed that on heavily-infested trees that received no winter oil *P. pilosus* was browning the trees in November. Where, however, winter oil at 5 per cent. concentration was applied browning was retarded until towards the end of December, but even then summer treatment became necessary. Trees that received no winter oil but which were sprayed in November with two summer oils at an interval of ten days were beginning to bronze at the time of treatment, but an excellent kill of mite was secured, and by Christmas the trees were green again and in better condition than those in the plots sprayed with winter oil only.

Although summer oil is very effective against the mite the difficulty is to work it into the sulphur programme necessary for the control of fungous diseases. The possibilities of summer treatment will be further explored in the coming season.

Before long it is hoped to be able to present a detailed report on all winter oil experiments for publication, mainly with the object of providing a statement of the case.

Use of Insecticides against White Butterfly: This work was carried on further in the summer of 1936–37 and is now completed. The object in prolonging the investigation over three seasons was to test out the keeping qualities of derris and pyrethrum insecticides. Pyrethrum sprays and derris dusts were again effective, and the materials used were known definitely to be at least three years old. It was considered that the period over which derris and pyrethrum insecticides remain effective is very important if these materials are to have any place in the insecticide programme. The experiments at the experimental area were greatly curtailed this season on account of the almost total absence of white butterfly from the cabbage plots put down for the work. It was possible, however, to collect several thousand caterpillars and thus infest certain of the plots artificially, all 1936–37 work being carried on blocks so infested.

Arsenates are the cheapest insecticides that can be used at the present time to combat effectively the white butterfly. There is a prejudice against their use, however, on account of their poisonous nature, and a chemical investigation was carried out on the question of this spraying residue on market cabbages and cauliflowers. The results of this work have shown that with reasonable care and the provision of a suitable interval between spraying and harvesting there is very little danger of poisoning from the consumption of cabbages treated with lead arsenate.

It is proposed to prepare and publish a detailed account of the whole of this work.

Control of Mealy-bug on Hot-house Grapes: A certain amount of work on the control of grape mealy-bug (*Pseudococcus maritimus*) was carried out in glasshouses at Palmerston North, but owing to lack of sufficient time to devote to this work the results were not very satisfactory. It was demonstrated, however, that by stripping the bark from the vines and then painting them with a paste of tar, clay, and water excellent control of the pest was secured. Fumigation by spreading calcium cyanide on the floors of the houses gave very unsatisfactory results. The houses were by no means gastight, however, and the fumigation was carried out by the owner. It does appear, however, that this material is not very efficient for fumigation against mealy-bug in the average glasshouse.

Citrus Insect Pests: Investigations of the insect pests of citrus and their control are at present being undertaken with the co-operation of the Department of Agriculture. Most of the work has been written up, but the final statement is awaiting the results of experimental work at Auckland on the white-wax scale (*Ceroplastes sinensis*).

Other Investigations: Work on the bronze beetle and codling moth was carried out in conjunction with the Plant Diseases Division and will be reported on by that Section.

Canterbury Agricultural College, Lincoln.

L. Morrison.

1. *Diamond-back Moth Control.*—(*a*) An attempt is being made to breed, in large numbers, parasites of the diamond-back moth. A glasshouse 100 ft. by 30 ft. was planted with about six hundred cabbage-plants. As soon as the plants were fairly well grown diamond-back moth pupæ were collected in the field, allowed to emerge, and after they had mated were liberated in the glasshouse.

A consignment of 354 *Angitia cerophaga* parasites was received from Palmerston North and liberated in the glasshouse on 22nd January, 1937. The parasites appear to be established and to be breeding freely. The immediate aim of the work is to find out the behaviour of the moths and their parasites under glasshouse conditions during the winter months. There are no data available to show if *Angitia cerophaga*, which has been introduced from Britain, can survive the winter in New Zealand in an unheated house.

(*b*) *The Degree of Parasitism which takes Place in the Field by the Native* Angitia—*viz.*, A. lateralis—*in the South Island.*—A native species, *Angitia lateralis*, attacks the diamond-back moth in New Zealand. Work carried out by Miss Robertson showed that parasitism by the native species seldom rose above 1 per cent. in the North Island. In order to obtain similar data for the South Island collections of diamond-back moth larvæ and pupæ from field crops have been made, and these are forwarded on to Palmerston North periodically to be dealt with there. Up to the present time these collections have been made only in the vicinity of the College. It is intended to make such collections from various districts throughout Canterbury. Already it is clear that parasitism by the native species of *Angitia* reaches a very much higher degree in the South Island than in the North Island, at least in so far as the College area is concerned. Data of this nature have a direct bearing on any future work in connection with the biological control of the diamond-back moth by an introduced parasite closely related to the native form.

2. *Wheat Bug.*—In November, 1936, the Director of the Wheat Research Institute drew attention to the fact that certain lines of wheat from Otago produced sticky dough during fermentation, and that a similar defect occurred in Europe, due to the attack of certain insects on the grain in the field. It was decided that a thorough investigation of the problem should be undertaken in order to find out if the insects responsible for the damage to wheat in Europe had been accidentally introduced into New Zealand or if some other insects were responsible here.

North Otago was visited during the latter part of December, and a number of farms in the wheat area around Oamaru, Five Forks, Ngapara, Duntroon, Bortons, and Papakaio were thoroughly inspected. The wheat crops were examined and collections of insects made. The nature of the damage to the wheat grains pointed to the fact that sucking-mouthed insects were responsible. Hence special attention was paid to these. Aphids were present in most of the crops examined, but not in sufficient numbers to be responsible for the defects occurring in wheat. It soon became evident that Hemiptera-Heteroptera (bugs) were present in large numbers in all the crops examined. Numbers of bugs were collected from wheat fields, from clover, from shepherd's purse, and other vegetation. The bugs were brought back alive to Lincoln College and sorted out. It was then decided to experiment with the bugs on growing wheat at the College. Insect-proof cages were erected on Jumbuck, Cross 7, and Tuscan wheat on the plots belonging to the Wheat Research Institute, and the insects were introduced into the cages on 22nd December, 1936. Dr. Miller, of the Cawthron Institute, identified the various bugs, and there were four different species represented—viz., *Stenotus binotatus*, *Hudsona anceps*, *Nysius* sp. (probably *Huttoni*) and *Dictyotus caenosus*. The species *Dictyotus caenosus* was relatively scarce in individuals and there was not sufficient live material to include this one in the experiment. With the exception of *Stenotus binotatus*, which is cosmopolitan, all the others are native to New Zealand.

An examination of the cages a month after the experiment was laid down showed that the bugs were still alive and active. The caged wheats were harvested and threshed early in February. When the wheat grains were examined it was found that they were affected in the same manner as the slimy-gluten wheats from Otago of the previous season. The three species of bugs—*Stenotus binotus*, *Hudsona anceps*, and *Nysius* sp. (*Huttoni*)—were each responsible for damage to wheat. From the preliminary nature of the experiment it would be unwise to draw definite conclusions as to the relative importance of the various bugs or to the degree of attack shown by the different types of wheat. It is proposed to go further with this work next wheat season, and in the meantime arrangements are being made to carry out experiments on a larger scale, and also to work out the life histories of the bugs responsible.

3. *Hessian Fly.*—It was intended to carry out a survey of wheat crops this season in order to gain some accurate data in regard to hessian fly damage. This survey had to be confined to a few crops in Canterbury in the immediate vicinity of the College. Every crop examined showed the presence of hessian fly. In most cases the infestation varied from about 0·5 per cent. up to 3 per cent. or 4 per cent. In one instance—viz., on the farm of Mr. Dulieu, Deep Dene, Lake Ellesmere—a crop of College Hunters was damaged to an extent of approximately 25 per cent. The damage varied considerably in different parts of the field. Owing to the fact that the crop was thin, the broken straws were lying flat on the ground and could not be gathered by the binder. For this reason hessian fly damage to a thin crop is much more serious than a similar infestation where the crop is thick.

Cawthron Institute.

At the Cawthron Institute attention has been given to readjustment of the laboratories and the insectaries for the housing of the Division's staff. This involved the reconstruction of the large insectary so as to have two, one of which will be heated and partitioned. Attached to the other is the new quarantine room and workshop. In the quarantine room the cool-store chambers open so that shipments of insects can be kept in strict quarantine once they have been placed in the cool-store.

AGRONOMY DIVISION.

Director: J. W. Hadfield.

Introduction.

Headquarters have now been established at Lincoln on land leased from the Canterbury Agricultural College, and offices and laboratories are being erected thereon.

For convenience of organization the work of the Division is divided into three sections, as follows:—

(1) *Crop Ecology and Plant Introduction.*—Initial trials of all material, whether introduced or raised by the Division, are carried out either at Lincoln in the South Island or Palmerston North

in the North Island. Such preliminary trials permit the immediate elimination of much unpromising material. Anything of promise is further evaluated over a wider range of conditions by the helpful co-operation of the Fields Division of the Department of Agriculture.

(2) *Plant Breeding.*—Plant breeding in any crop is undertaken only after an exhaustive study of the material available in New Zealand, and as far as possible, in overseas countries. Such preliminary work leads not only to the selection of suitable breeding material, but also to the recommendation and distribution of superior varieties and strains already in existence.

In the main, the breeding technique follows that adopted by other plant-breeding stations, but has necessarily to be moulded to local requirements and to the facilities available.

(3) *Pure Seed Production.*—The purification and distribution of existing varieties and of material introduced or raised by the Division is a very necessary and important phase of crop improvement. Such material serves as foundation stock for increase and distribution under the Government scheme of seed certification. Whereas in the past activities have been more specifically confined to the purification and distribution of standard commercial varieties, attention is now being diverted to a more useful phase—namely, the distribution of varieties of proved merit not previously grown in New Zealand. This is due directly to the plant breeding and plant introduction activities of this and other Divisions.

Although the demand for seed is always far in excess of what can be produced it is nevertheless intended to adhere strictly to the production only of nucleus stocks of the highest standard of purity. The co-operation of the Canterbury Agricultural College in once growing these nucleus lots, and subsequently of the Department of Agriculture in its certification scheme, permit of an ideal organization of controlled distribution.

Field Crops.

Wheat.—This Division is concerned only in the multiplication and distribution of pure seed wheat. This is raised from single plant selections, which are multiplied individually for two seasons to ensure non-segregation, and then bulked. The control of loose and stinking smuts by means of hot-water treatment is an important factor.

Activities have now been almost entirely diverted from the distribution of standard varieties to that of new introductions. New wheats now being increased include Tainui and Taiaroa—two early spring varieties selected from Portuguese wheats by the Wheat Research Institute—and Ben Cubbin, a variety introduced from West Australia by a New Zealand farmer, which has gained popularity in the Oamaru district. Also included is Lin Calel, an Argentine variety propagated by this Division, which, owing to its outstanding performance, is to be increased as rapidly as possible. In field trials it has either equalled or exceeded in yield the standard variety Solid-straw Tuscan, and its baking quality is exceptionally good. A farinograph report on seed raised by this Division at Lincoln last season indicated its quality as being superior to any New-Zealand-grown wheat previously tested and equal to the best wheat grown in Canada.

Resclections of Hunters I and Hunters II have been made with a view to distribution under certification. Hunters II has been released this season, and Hunters I will follow next season.

In view of the interest in vernalization, trials were undertaken this past season with two spring and two autumn wheats, each of which was vernalized for eleven, eighteen, and twenty-five days and sown in late spring. In all cases maturity has hastened in proportion to the length of vernalization, but the extent to which this was induced by twenty-five days' treatment was insufficient to be regarded as having any economic significance.

Oats.—Pure seed of Gartons Abundance, Resistance, Algerians, and Duns has been raised and distributed.

Observational trials of twenty-eight varieties, mostly recent introductions, were carried out at three centres, and the same series was grown in a hand-sown replicated yield trial at Lincoln. Field trials of six promising varieties were undertaken at Lincoln and in five other centres by the Fields Division. In addition, the variety Resistance was grown on ten farms in Southland for comparison with the farmer's own variety. Resistance is a winter variety raised by the National Institute of Agricultural Botany, Cambridge, and introduced in 1925. In all trials it has outyielded every other variety, and owing to its winter hardiness and strength of straw it promises to become a very important variety for the South Island. It is yet too early to suggest that it might entirely replace Gartons Abundance as the standard white oat, owing to the somewhat higher proportion of husk to kernel and a correspondingly lower bushel weight. Anthony is a new variety of promise resembling Resistance, but less susceptible to rust.

Black Supreme has given consistently good results and is likely to become a popular black oat. There is no demand for Ruakura, although it is proving an excellent rust-resistant parent for breeding purposes. Lampton is highly resistant to rust and smut and is being used as a breeding parent, but in other respects fails as a commercial oat. Certain Algerian selections recently introduced from New South Wales are showing promise.

Breeding work has been confined to Ruakura × Lampton, Ruakura × Gartons, and Ruakura × Algerians. F_4 seed is now being threshed from segregates of these crosses, some of which are showing distinct promise. Selections within these segregates are being carried out at Palmerston North and Lincoln independently for North and South Island conditions respectively. The selection of an oat suitable for the North Island is restricted to one that can be grown profitably in the seed-producing districts.

Barley.—Pure seed of standard varieties has been produced in the past and may again become desirable. In the meantime arrangements are in hand for the testing of a number of New Zealand and foreign varieties next season.

Maize.—Owing to the prohibition of imports from tick-infested areas in Australia, extensive variety trials which had been arranged for in the North Island had to be abandoned. Maize is perhaps the easiest crop that the dairy-farmer can grow for pig feed, and investigations are urgently required to determine which, if any, of the existing varieties can be grown with reasonable hope of success in those districts where this crop is at present regarded as too unreliable for general cultivation. Material for further trials next season is on order from abroad.

Garden Peas.—Seed of garden peas is grown extensively in New Zealand for export. Seed stocks which become impure have in the past had to be replaced by the importation of fresh stocks from overseas. These at times are little if any better than those discarded by the merchants, and it is desirable that they should be able to see the growing crop from which their stocks are to be drawn.

Following the practice adopted for some years, an area of about 8 acres has been devoted to the raising of nucleus stock seed of garden peas on contract with merchants. This activity has been much appreciated, but is likely to be curtailed in the near future and attention devoted to the multiplication of new crosses which are now showing great promise in F_6.

Green-feast is undoubtedly the most popular variety in this country and Yorkshire Hero perhaps the heaviest yielding. It is from the crossing of these two varieties that some very promising segregates have been raised in which are combined desirable features of both parents.

Field Peas.—Field peas afford a crop that can be handled conveniently on dairy-farms and should be more extensively grown as a supplementary feed for pigs during winter. Attempts to decide on the most suitable variety for North Island conditions have not so far met with success. The trials laid down this past season failed on account of unusual seasonal conditions.

Supplies of seed of the Austrian Winter Field pea have now been raised, and the variety is being tested out as a cover crop by the Horticulture Division of the Department of Agriculture on a large number of orchards. Its chief virtue lies in winter hardiness, and it proved far superior in this respect to Partridge when autumn sown at Lincoln.

The major work in this crop has been an attempt to improve the yield and quality of peas grown and dried for local consumption and export. Of all varieties the heaviest yielding and most extensively grown is Partridge. A valuable export trade has developed, and the variety is used locally in the manufacture of split peas. Any improvement, therefore, in either yield or quality would be of considerable economic value. A new selection of Partridge introduced from England via Tasmania has this past season outyielded New Zealand Partridge by 39 per cent. Being later than the New Zealand strain it was favoured by the wet season, and this figure is probably an overestimate of its performance in a normal season.

In export quality it probably falls short of the New Zealand Partridge, being paler in colour and more dimpled, and the latter characteristic is likely to render it unpopular for splitting. Nevertheless, the increased yield should outweigh any discrepancy in price, and the variety will have a very definite place as a crop for pigs and sheep. Further trials are being arranged, and the seed stocks are being multiplied by Canterbury Agricultural College in anticipation of a demand.

An extensive breeding programme in field peas, now in F_4 and F_5 is progressing, and results are promising.

White Ivory is regarded as the ideal pea for splitting, but owing to erratic yields it is difficult to obtain and merchants have had to resort to the use of Partridge. Blue Prussian is the standard blue pea for boiling and canning, but here again the yield is unreliable and the quality such that it compares very unfavourably on the British market with British- and Continental-grown peas. It is in an endeavour to rectify these defects that the present breeding programme has been instituted. High-yielding segregates of correct type have been produced but their quality is a matter yet to be investigated.

Potatoes.—In view of the efficacy of seed certification, the production of pure and healthy seed potatoes is now regarded as unnecessary, and the Division's work in this connection has been discontinued except in the case of a few new introductions.

Attention is now almost entirely devoted to the breeding of new varieties by crossing commercial varieties with certain of the species recently discovered in South America and introduced by Russian and German explorers. Initial crosses were made in 1935–36, and the F_1 plants raised this past season. It is too early yet to comment on these progenies, many of which have not yet been harvested. Relatively few of them appear, however, to be of a type that might be of commercial value, and it is evident that back-crossing on to commercial varieties will have to be resorted to. This project is surrounded with difficulties, perhaps the greatest being that of devising effective isolation to prevent the spread of virus disease.

Rape.—The original selection work has led to the commercial production of rape seed in New Zealand under certification. This Division now produces annually mother seed of Giant and Broad Leaf Essex varieties which is distributed to merchants who grow the certified seed on contract. There has been a ready sale for certified seed, and much appreciation has been expressed by farmers in respect to its standard. It is important to record that the prejudice against New-Zealand-grown brassica is thus being removed, and the way is open for further development in this direction.

Present indications are that segregates from crosses between Broad Leaf Essex and Giant, back-crossed on to both parents, are likely to prove more productive and of better type than either parents. An annual swedelike rape is also being used for crossing purposes in an endeavour to introduce early maturity. Other crosses between rape and various kinds of kale are also being studied.

Swedes and Turnips.—Most of the varieties resistant to club-root are regarded as too high in fibre content and not of a type to appeal to farmers. Crosses between popular but non-resistant varieties

have been made with varieties of proved resistance. F_2 seed of thirty-three different crosses was raised last season, and arrangements have been made to study the F_2 segregates when grown on club-root infected land in Southland.

Brassica Crosses.—A series of interspecific crosses are affording interesting material, even though their economic possibilities are far from evident.

Lucerne.—The initial study of a large number of plants by means of inbreeding was concluded in 1933–34. The parent plants which consistently gave the best inbred progenies were crossed with one another in 1934–35, the object being to determine the most promising combinations. The F_1 progenies thus secured were studied during 1935–36, and from these the best plants from the best combinations were selected as basic material for strain building. They were grouped and transplanted into isolation blocks last season at Palmerston North, but, unfortunately, owing to the abnormal seasonal conditions virtually no seed was produced, therefore the seeding of these plants will have to be repeated next season.

As already mentioned, the initial study of the parental material necessitated inbreeding, which, owing to loss in vigour and extreme reduction in seed production, was possible in most plants for only two generations. Nevertheless, a high degree of uniformity was attained, and in certain instances was accompanied by little reduction in vigour, indicating the presence of relatively few undesirable factors. The most promising of the L_2 plants were then crossed with other desirable but unrelated L_1 plants, and these progenies have been grown during the last season. As might be expected, the majority have regained normal vigour and in many instances far surpassed in yield the open-pollinated Marlborough used as a control. It is hoped then, by further inbreeding and outcrossing conducted over a series of years, to eliminate most of the undesirable and generally recessive factors and synthesize into one strain the maximum of desirable and the minimum of undesirable factors. In such a strain self-fertilization would result in little, if any, deterioration, and the significance of this is appreciated when it is realized that self-fertilization occurs in the field to an appreciable extent.

Linen.—Owing to an Empire shortage of raw material for the manufacture of linen fabrics and cordage it has become desirable to investigate the possibility of growing linen flax and the manufacture of linen fibre and tow in New Zealand. Four trials were therefore laid down at Palmerston North, Lincoln, Leeston, and Timaru with Liral Crown, a variety bred for fibre production by the Linen Industry Research Association. Yields of straw and seed proved to be well up to English standards, and the trials indicate that production in New Zealand should be profitable, provided that the tests of quality and quantity of fibre in samples sent to England prove satisfactory.

Even if the establishment of manufacturing plants is not immediately undertaken the production of flax-seed for export offers prospects of a promising industry. In view of the dual possibilities ahead—namely, the production of fibre and seed—four tons of seed are now on order. It is anticipated that this quantity will produce enough seed in 1937–38 for the sowing of an area in 1938–39 sufficient to supply the requirements of a factory. Alternatively, the seed produced can be exported.

Vetches and Tares.—Owing to the damage caused by the black aphis, black tares are now rarely grown for seed, the price of which is therefore very high. An increase in the area in legumes is desirable in the grain-growing districts and in orchards, and therefore a new vetch now being multiplied and tested extensively throughout New Zealand is a welcome addition, because it has proved over a number of years to be immune to black aphis. In addition, it is more productive, retains its leaves longer than the black tare, and gives a satisfactory yield of seed.

Soya Beans.—Observational trials of fourteen varieties were laid down in six centres, and at Palmerston North a wider range of varieties were included in a yield trial. Yields of 30 bushels to 35 bushels per acre have been obtained in parts of the North Island and there are no serious difficulties in the cultivation of this crop. It is difficult, however, to visualize its economic possibilities in view of the cheaper production of linseed oil and the ample supplies of protein foods in New Zealand. The quantity likely to be used for baking and domestic purposes would be insufficient to warrant the erection of the necessary plant for processing the beans.

Onions.—Mother seed of several long-keeping varieties of onions is being raised for distribution, and it is anticipated that the general adoption of these varieties will help very materially in reducing the serious wastage that now occurs during storage.

BOTANY SECTION.

(Botanist: Dr. H. H. Allan.)

1. *Co-operation Routine.*—As in previous years, assistance has been given to all Departments requiring botanical information and also to the various Divisions of the Plant Research Bureau. The past year has shown the same interest in determination of both indigenous and exotic species, from all the sources previously enumerated, especially from Inspectors of Stock, Instructors in Agriculture, business firms, and educational institutions. Over four thousand specimens have been received and reported on. Considerable additions have been made to the herbarium, partly from the above-mentioned material, partly from collections made by the staff, and partly by exchange. We are indebted to various European and American institutions for material in exchange, and to the Auckland Museum. Of special interest have been a set of specimens of ragwort and allied species from the Royal Botanic Gardens, Kew, and a set of specimens from the Auckland Museum, illustrating some of the taxonomic work of the late Dr. L. Cockayne. Exchange of publications with individual workers has again provided much useful material for the working library. It is pleasant to state that, though many unrecorded weeds have been found by us or brought to our notice, no new weed of very serious importance has come before us this year. Work has been carried out at the herbaria of the Auckland, Wellington, and Dunedin museums in connection with special problems.

2. *Field-work.*—This has been mainly in connection with ragwort, but on each field excursion opportunity has been taken to deal with general botanical problems. The ragwort areas visited have been in the neighbourhoods of Te Awamutu, Otorohanga, Tirau-a-moa, Ruakura, Putaruru, Mamaku, Arohena, Owaka, and Dunedin. Incidentally, much important material was obtained for the herbarium. The progress of *Spartina* plantations was examined at Thames and at Westfield. It is of interest to record that Mr. Parr has located at Westfield the first seedling *Spartina* known with certainty in New Zealand. In connection with the work on facial dermatitis in sheep and photo-sensitivity in general, further botancial studies were made at Lake Tekapo, especially in the experimental area, and at Lake Wanaka. Special attention was given to the distribution of the various species of *Hypericum* and *Polygonum*, both genera being suspected as causes of photo-sensitivity. Various matters investigated during the field work are being dealt with in papers under preparation. A visit was paid to the regrassing experiments on the Dunstan Mountains, under the guidance of officers of the Department of Agriculture, and a short report made to that Department.

3. *Research Work.*—This has been continued on the lines indicated in previous reports. Mr. Zotov has advanced his studies of the taxonomy and ecology of indigenous grasses and grasslands in a basis especially for an investigation of problems arising in the South Island tussock-grasslands. He has also completed his studies on the vegetation of the Tararua ranges, and with his co-workers has prepared a full report for publication. I have continued work on special genera of grasses and on the taxonomy and ecology of both indigenous and introduced plants in general, with special reference to a full survey of the weed position.

Much time has been given up to various aspects of the ragwort problem, and a considerable advance made in our knowledge of the life history of the plant and the effect of sprays. Since his appointment to the staff, Mr. Poole has been located at Hamilton and has devoted his time to the experimental and observational work planned by the Fields Superintendent of Auckland at the Farm of Instruction at Ruakura and on the experimental farm at Mamaku. He is also assisting in the general campaign instituted against ragwort. A very comprehensive programme of work is in hand, and reports will be made as data accumulate. It is premature to give any general conclusion in this report. This will be done in due course as reports from the officers in charge of various sections come to hand.

Attention has been paid to reputedly poisonous plants, and arrangements are being made to co-operate in feeding tests on certain of these. Work on poisonous plants has been made a definite feature of the general weed survey in progress.

4. *Publications.*—In addition to several shorter articles the following papers were published during the year :—

(1) St. John's Wort and Allied Species. *N.Z. Journal of Agriculture.*
(2) Indigene versus Alien in the New Zealand Plant World. *Ecology* (America).
(3) An Introduction to the Grasses of New Zealand. Bulletin No. 49 of the Department of Scientific and Industrial Research.
(4) Ecological Features of the Main Islands. In Handbook for the Auckland (1937) meeting of the Aust. & N.Z. Ass. Adv. Science.
(5) Indigenous Grasslands of New Zealand. *Ibid.*
(6) Life-form Statistics of the New Zealand Flora. *Journal of Ecology* (England).
(7) An Artificial Cross between *Phormium colensoi* and *P. tenax*. *N.Z. Journal of Science and Technology.*

In course of publication are papers on the origin and distribution of the alien flora of New Zealand ; the Cladoniæ of New Zealand (both read at the Auckland (1937) meeting of the Australian and New Zealand Association for the Advancement of Science) ; and a survey of the work done on wild hybrids throughout the world (*Botanical Review*, America).

A paper by Mr. Zotov on the relations of the climate to timber-line was read at the Auckland meeting of the Australian and New Zealand Association for the Advancement of Science. This and his paper on leaf-anatomy in New Zealand grasses are being amplified for publication.

A number of papers are in preparation, including a Handbook of the Weeds of New Zealand.

NEW ZEALAND STANDARDS INSTITUTE.

ANNUAL REPORT, 1936–37.

The New Zealand Standards Institution was reconstituted within this Department during the past year and its designation changed to New Zealand Standards Institute. An Advisory Council consisting of the following persons was appointed :—

Mr. A. R. Galbraith, F.R.S. (Edin.), M.Inst.C.E. (Chairman), Municipal Associations.
Dr. E. Marsden, M.C., C.B.E., D.Sc., F.R.S.N.Z., Secretary, Department of Scientific and Industrial Research.
Mr. G. W. Wyles, A.M.I.E.E., M.I.R.S.E., Electrical Regulations Advisory Committee.
Mr. W. A. Joiner, M.Sc., A.I.C., representing Research Council of Department of Scientific and Industrial Research.
Mr. S. S. Millington, Stores Control Board.
Mr. H. C. Morton, A.R.I.B.A., A.N.Z.I.A., Institute of Architects.
Mr. F. W. Furkert, C.M.G., M.Inst.C.E., M.I.Mech.E., New Zealand Society of Civil Engineers.
Mr. G. A. Lawrence, B.Sc., F.I.C., New Zealand Institute of Chemistry.
Mr. W. Donovan, M.Sc., F.I.C., Dominion Laboratory.
Mr. J. Read, Trades and Labour Council.
Mr. L. J. Schmitt, Department of Industries and Commerce.
Mr. F. B. Stephens, M.A., B.Com., Department of Internal Affairs.
Mr. W. L. Newnham, A.M.I.C.E., M.N.Z.Inst.Eng., Public Works Department.
Mr. E. T. Spidy, A.M.S.C.E., Railways Department.
Mr. W. W. Mulholland, primary producers' interests.
Mr. A. Fletcher, Building Divisional Committee.
Dr. W. B. Sutch, Ph.D., M.A., B.Com., consumer interests.
Mr. G. A. Pascoe, consumer interests.
Mr. F. T. M. Kissell, B.Sc., Eng., M.I.E.E., A.M.Inst.C.E., Chief Electrical Engineer, Hydro-electric Branch, Public Works Department.
Mr. E. H. Langford, M.A., Private Secretary to Hon. Minister of Scientific and Industrial Research.
Mr. L. J. McDonald, Secretary and Executive Officer.

This body, in its advisory capacity, became responsible for the organization and administration of standards activity on the 19th August, 1936, and since then there has been highly satisfactory development of this work.

Consequent upon this development the Dominion is now contributing its quota to the reciprocal collaboration of all units of the British Empire and other important countries. This collaboration is a necessary prerequisite to the development of standards from which the Dominion has derived benefit throughout past years, disproportionate to the negligible contribution it has made. The progress that has been made during the past year establishes a basis for greater development of standardization in the future on a scale that will yield correspondingly increased benefits to the Dominion.

The Advisory Council has met six times and has appointed twenty-one committees. Close contact has been established and maintained with the British Standards Institution, Standards Association of Australia, Canadian Engineering Standards Association, South African Standards Institution, American Standards Association, American Society of Testing Materials, and the United States of America Bureau of Standards.

DRAFT STANDARD SPECIFICATIONS.

Under a standing arrangement, which is necessary to render the work of each standards organization within the Empire most effective, duplicate copies of all draft standard specifications prepared by these bodies have been submitted for the comments of the New Zealand Standards Institute. The vast majority of these proposed specifications have related to equipment, processes, or commodities used in the Dominion, either manufactured here or purchased overseas.

Under the direction of the various committees this matter has been circulated to competent and affected interests for comment, which subsequently has been co-ordinated and considered by the appropriate committees, and the respective overseas bodies have been advised whether the proposed provisions were suitable for the requirements of this Dominion. When they have not been suitable overseas manufacturers have been so advised, and when it has been possible to do so, amendments have been suggested which would make these provisions suitable to New Zealand requirements.

This aspect of the activity is very important in that the proposed specifications that have been so examined contain provisions which finally determine the quality and suitability of equipment and processes used by our local industries upon which their efficiency and the quality and utility of their goods and services depend.

Some classes of equipment used in the Dominion are supplied in part by local manufacturers and in part by overseas manufacturers. The need for uniformity of type, design, or quality in some instances requires that any change in the imported supply may compel adjustments in the corresponding equipment manufactured locally, necessitating changes in plant, process, or organization and thus imposing substantial disabilities upon our manufacturers without affording any corresponding advantage to other sections of the community. The circulation of the specifications covering such material to local manufacturers safeguards their interests in this respect proportionate to the range of equipment covered by specifications so circulated. The consideration of public safety is also advanced by this procedure, for it is substantially dependent upon the use of materials of adequate strength most suitable and efficient in design and construction. The proposed standard specifications

provide the most accessible, authoritative, and precise definition of these factors. The circulation of these drafts, which relate to considerations of public safety, to responsible administrative authorities, technological and other affected interests, therefore acquaints those responsible with the exact nature of material or equipment manufactured overseas for export to this country and whether or not it meets requirements of public safety and other considerations.

The foregoing briefly explains the purpose of the work which has been carried out in circulating draft specifications, though the full purpose can be considered only in conjunction with the general purpose of standard specifications of which draft specifications form the genesis.

Draft specifications received from the following bodies have been circulated as outlined in the foregoing :—

British Standards Institution	193
Standards Association of Australia	33
South African Standards Institution	3
Total	229

Approximately 2,500 copies of these have been circulated to affected interests and their comments have been co-ordinated and the bodies originating the specifications have been advised that—

(*a*) One hundred and four are suitable for New Zealand requirements ;
(*b*) Three require amendment and the nature of such amendment ;
(*c*) Nine have no application in New Zealand ;
(*d*) Eleven are unsuitable for New Zealand requirements ;
(*e*) Seventy-nine are held in abeyance pending further information ; and in
(*f*) Twenty-three instances decisions are being withheld until the standards are issued.

This work has been carried out under the direction of appropriate committees representative of interests affected by the respective specifications. The work of the committees in this regard is particularized in the section of this report under the heading " Activities of Committees."

STANDARD SPECIFICATIONS.

Nine hundred and forty three (943) specifications were taken over from the past Standards Institution and comprised—

British Standards Institution	672	
Standards Association of Australia	220	
South African Standards Institution	8	
Canadian Engineering Standards Association	43	
	—	943

plus approximately 1,000 additional copies and 1,000 copies of the New Zealand Standard No. 95, Model Building By-law.

In addition, further standard specifications which have been issued by these bodies have been made available to this branch since its inception :—

British Standards Institution	113	
Standards Association of Australia	33	
South African Standards Institution	2	
Canadian Engineering Standards Association	22	
	—	170
		1,113

This number represents the complete issue of the standard specifications of these bodies which have been made available, gratis, as part of a reciprocal service between the standards organizations of the British Empire countries. In addition to this, standard specifications have been received from the American Standards Association, American Society of Testing Materials, and United States Bureau of Standards as follows :—

American Standards Association	74	
American Society of Testing Materials	516	
United States Bureau of Standards	14	
	—	604
Total		1,717

The standard specifications issued by the standards organizations of British Empire countries have been circulated under the direction of the respective committees to interests affected by their provisions, and their comments have been invited concerning the suitability of the specification for New Zealand conditions and requirements ; and also recommendations as to whether or not they should be adopted as New Zealand standards. Following consideration of the comments received by the respective committees, forty-six British standard specifications were recommended for adoption as New Zealand standards and twenty-six held in abeyance.

The publications received from the American Standards Association and the American Society for Testing Materials and Bureau of Standards have not been circulated as a part of regular procedure. These have been retained within the library as they are extremely valuable for reference purposes and have been freely consulted by committees giving consideration to related projects.

In addition to the circulation of draft and standard specifications received from Empire Standards Organizations, the work of circulating British standard specifications has been commenced, and to date this activity has resulted in the adoption of thirty-three British standard specifications. If this number be added to those adopted prior to the institution of the present organization (ninety-five) the position is that one hundred and twenty-eight New Zealand specifications have been adopted to date. With one exception these are British standard specifications adopted as New Zealand standards, the one exception being New Zealand Standard No. 95, Model Building By-law Sections 1–10, which has been developed within the Dominion. This publication is now under revision. Several other original specifications are at present in the course of development, but reference will be made to these in the section reporting on the activities of committees.

The work represented in this aspect of the activity outlined in the foregoing, which has led to the adoption of New Zealand standards, is of value because the use of these—

(*a*) Defines the materials and processes which render production most efficient and economic, including the elimination of the waste that results from the production of inferior goods.

(*b*) Effects savings by concentrating purchases on the most suitable and efficient material.

(*c*) Eliminates superfluous types, sizes, and designs, with consequent economies in production and distribution costs.

(*d*) Eliminates danger hazards through the intelligent selection of material on a basis of competently defined strength and quality of equipment or conditions.

(*e*) Affords convenience through the more efficient facilities provided by specially selected materials and equipment on a basis of the most competent selection.

(*f*) Aids general acquaintance with the use of equipment and processes in certain specialized spheres because of greater uniformity, the advantage of this being particularly expressed in the transfer from unit to unit.

(*g*) Facilitates the ordering of purchases on a basis of national specifications in place of a multitude of individual specifications, the preparation of which is costly, while their use leads to misunderstanding and conflict. It also places trade on a basis that is equitable and intelligible as between suppliers and between the suppliers and purchasers.

REPORTS AND PUBLICATIONS OTHER THAN STANDARD OR DRAFT STANDARD SPECIFICATIONS.

The standard and draft standard specifications have been supplemented by approximately three hundred reports and publications other than specifications from various sources, mostly from overseas standards organizations. This matter has been recorded and indexed in a manner that makes it readily available as a source of reference to aid the committees in their deliberations and also to facilitate a service to Government Departments, local bodies, business, industrial, and other interests. The preparations for expanding this service are well in hand.

The specifications and reports which constitute the basis of this service embody the balanced conclusions of the most competent, experienced, and authoritative people in the different spheres who have been engaged on the problems to which the provisions of these publications relate. In other countries of the world investigations that have been carried out incidental to the development of the specifications or the preparation of the reports made available have frequently involved the most extensive investigations—experimentation and research—single instances of which have sometimes cost many thousands of pounds. The advantage of reports and specifications of this nature, which embody the conclusions resulting from such extensive and costly investigation, were available, for instance, to assist the development of the standard specification for galvanized (zinc-coated) fencing-wire, so that New Zealand is now enjoying, and will continue to enjoy, the advantages of the findings of overseas committees that have been reached at very substantial expenditure and effort and are thus made available to this Dominion at a negligible cost.

The service is augmented by the fact that the Standards Institute has been appointed the New Zealand agency for the distribution, within the Dominion, of British standard specifications from consignment stock amounting to approximately 4,300 publications supplied by the British Standards Institution. The publications sold since this service was initiated in February of this year number 373.

ACTIVITIES OF COMMITTEES.

Technical Advisory Committee.

This committee was recently appointed and has not commenced to function actively. It will in future, however, be responsible for directing and reviewing the work of all technical committees in order to ensure that their attention will be concentrated upon projects that satisfy the most important and urgent demands. It will also co-ordinate the work of the respective technical committees and be responsible to the Advisory Council for the fulfilment of its functions.

Building Code Committee.

This committee has held two meetings and has appointed a sub-committee, which has held fifteen meetings. It is engaged in revising New Zealand Standard No. 95, Model Building By-law, Sections 1–10, governing earthquake-resisting construction for steel-frame reinforced-concrete buildings and for buildings of bearing-wall construction. The revision of sections 1–3 of this by-law has been completed.

The importance and value of this work is that it is designed to ensure that all buildings erected in New Zealand in the future shall be so constructed as to protect persons using or frequenting the buildings or their vicinity against injury, while at the same time establishing the maximum practicable precautions against the economic loss that would result from the destruction of the buildings themselves through lack of resistance to earthquake stresses.

Building Divisional Committee.

This committee has held two meetings and has appointed several sub-committees, which are giving attention to paints and coatings, and plumbing supplies, while the Government Timber Committee that has been working for many years on standard grading rules for timber has agreed to complete its work within the Standards organization as a sub-committee of the Building Divisional Committee. A further sub-committee is giving consideration to the preparation of standard provisions covering timber insecticides. The Building Divisional Committee has also appointed a sub-committee which is developing a standard code covering light timber construction, and the many inquiries that have been made by local bodies for this code indicate that it will be readily adopted by local authorities when it is completed.

Very sound progress has been made in developing the projects enumerated and their completion should secure great advantages to building and related industries.

Thirty draft standard specifications have been considered by this committee, eighteen having been endorsed for adoption as New Zealand standards when they are finally issued as standard specifications, subject to consideration of any amendments that may be incorporated in the meantime, and eight standard specifications have been recommended for adoption as follows:—

B.S.S. No. 242/1936	Linseed oil for paints, including— No. 242: Refined linseed oil. No. 243: Raw linseed oil. No. 259: Boiled linseed oil.
B.S.S. No. 244/1936	Turpentine (types 1 and 2) and white spirit—Add. Nov., 1936, including— No. 244: Turpentine, type 1. No. 245: White spirit. No. 290: Turpentine, type 2.
B.S.S. No. 217/1936	Read lead for paints.
B.S.S. No. 254/1935	Zinc oxide (types 1 and 2).

Chemical Divisional Committee.

Five meetings of this committee have taken place and its work has been consistent and effective, it having examined twenty-nine draft specifications, twenty-five of which have been endorsed as suitable for New Zealand conditions. It has also examined four standard specifications, which have been recommended for adoption as New Zealand standards, as follows:—

B.S.S. No. 701/1936	Brewers' flasks.
B.S.S. No. 691/1936	Clinical maximum thermometers.
B.S.S. No. 443/1932	Testing of the zinc coating on galvanized wires.
B.S.S. No. 718/1936	Density hydrometers.

A specification covering meat meal for stock food is also well advanced.

The effect of the work, with which this committee has made such a good beginning, is to establish provisions guiding the use of equipment and processes for testing types of materials that must render this work more uniform and no doubt more economical.

Civil Engineering Divisional Committee.

Thirty-four draft specifications have been examined by this committee in collaboration with the Mechanical Engineering Divisional Committee, and three meetings have been held.

Through the activities of a sub-committee a specification for galvanized (zinc-coated) fencing-wire has been developed, covering strength and quality of zinc coating, and is at present in circulation. After consideration of the comments received, any desirable amendments will be made. This specification will become tentative New Zealand Standard for galvanized fencing-wire as from the 1st October next.

A further sub-committee has in course of preparation a New Zealand Standard for loads and stresses for bridges, on similar lines to British Standard Specification No. 153, Girder Bridges, which is not wholly applicable to New Zealand conditions.

The Civil Engineering Divisional Committee has also under consideration standard conditions of contract for civil engineering works, finalization of which will do much to eliminate the duplication of cost and effort in the preparation of different individual contracts relating to civil engineering works.

Electrical Divisional Committee.

A valuable contribution has been made to the work of the Standards Institute by this committee, which has met six times and has examined thirty-five draft standard specifications, twenty-six of which it has endorsed as suitable to New Zealand conditions. It has also examined seventeen standard specifications, which have been recommended for adoption as New Zealand standards, as follows :—

B.S.S. 710/1936	.. Electric study and reading table lamp.
B.S.S. 124/1934	.. Totally-enclosed air-break switches for voltages not exceeding 660 volts.
B.S.S. 140/1935	.. Liquid starters and controllers for the rotor circuits of induction electric motors.
B.S.S. 271/1926	.. Fixed condensers for radio-reception purposes.
B.S.S. 397/1933	.. Leclanche-type primary cells.
B.S.S. 714/1936	.. Cartridge-fuses for use in railway-signalling circuits.
B.S.S. 719/1936	.. Terms used in railway signalling, glossary of.
B.S.S. 162/1934	.. Electric-power switchgear for indoor and outdoor installations up to and including 220,000 volts (including addendum slip dated May, 1936).
B.S.S. 74/1937	.. Charging plugs and sockets for electric battery vehicles.
B.S.S. 156/1936	.. Enamelled high-conductivity annealed copper wire.
B.S.S. 160/1936	.. Slate and marble insulating slabs for electric-power switchgear up to and including 660 volts A.C. and D.C.
B.S.S. 560/1934	.. Engineering symbols and abbreviations, British standard.
B.S.S. 555/1935	.. Tungsten filament electric lamps (other than general-service lamps).
B.S.S. 488/1933	.. Moulded insulating materials suitable for accessories for general electric installations.
B.S.S. 446/1932	.. Braided cables with copper conductors for overhead transmission lines (addendum June, 1932).
B.S.S. 205/1936	.. Terms used in electrical engineering, glossary of.
B.S.S. 31/1933	.. Steel conduits and fittings for electrical wiring.

A sub-committee has been appointed which has almost completed a draft New Zealand standard specification for two and three flat-pin electric plugs and sockets, which will be circulated to affected interests within a few weeks. The convenience that will be afforded through the adoption of this uniform equipment is no less desirable than the uniform lamp socket and base adopted in the past.

Illumination Committee.

The Illumination Committee has held two meetings and is taking full recognition of the stress that has been placed upon the value of adequate lighting during recent years, which is necessary to prevent eye-strain and the general physical disabilities that this defect often causes. Consequently it is preparing tables of recommended values of illumination for domestic, office, and factory use, having due regard for the special demands upon eyesight entailed by the work carried out under differing conditions. A sub-committee has been carrying out interesting tests in offices, factories, and homes to assist these investigations.

Five standard specifications have been examined and recommended for adoption as New Zealand standards as follows :—

B.S.S. 230/1935	.. Portable photometer (visual type).
B.S.S. 667/1936	.. Photo-electric type portable photometers.
B.S.S. 354/1929	.. Photo-metric integrators.
B.S.S. 233/1932	.. Terms used in illumination and photometry, glossary of.
B.S.S. 566/1934	.. Internally illuminated yellow diffusing globes for traffic-control signals.

Mechanical Engineering Divisional Committee.

This committee has also performed most useful work in examining thirty-four draft specifications, of which twenty-three have been endorsed as being suitable for New Zealand conditions. Twelve standard specifications have been recommended for adoption as New Zealand standards, as follows :—

B.S.S. 725/1937	.. Hot-rolled mild steel strip (or hoop) not exceeding 10 in. wide for general engineering purposes.
B.S.S. 723/1937	.. Sewage pump tests.
B.S.S. 722/1937	.. Borehole and well pump tests.
B.S.S. 724/1937	.. Vapourizing liquid pump tests.
B.S.S. 674/1936	.. Rubber joint rings for water-mains and sewers.
B.S.S. 719/1936	.. Terms used for railway signalling, glossary of.
B.S.S. 265/1936	.. Cold rolled brass sheets, strip and foil, copper content 61·5 per cent. minimum and under 64 per cent. maximum.
B.S.S. 266/1936	.. Cold rolled brass sheets, strip and foil, copper content 64 per cent. minimum, 67 per cent. maximum.
B.S.S. 267/1936	.. Cold rolled brass sheets, strip and foil, copper content within range 68 per cent. minimum and 72 per cent. maximum.
B.S.S. 711–713/1936	.. Cold rolled brass sheets, strip and foil, copper content respectively : 711, 80 per cent. ; 712, 85 per cent. ; 713, 90 per cent.

A sub-committee which was working on standard specifications for portable chemical fire-extinguishers has agreed to work as a sub-committee of the mechanical engineering committee and is proceeding with the work of laying down specifications for this equipment that will ensure the effective fulfilment of its functions and safety in operation.

Public Authorities and Local Body By-laws Committee.

In undertaking the responsibility for directing the work of standardization of local body by-laws relating to building construction and materials, this committee is attacking a long-standing problem, the solution of which will almost certainly lead to a very considerable economy in administration and is almost equally certain to render it proportionately more effective and simplified. The committee will also be responsible for reviewing the work of other committees which specifically relates to local-body or public authority interests. Every endeavour is being made to complete this work expeditiously.

Dairy Machinery and Requisites Committee.

This committee has held two meetings and is conducting a useful investigation into the equipment used in the dairying industry, including refrigeration plant, efficiency of milk-coolers, and base metals from which milk and cream cans are manufactured. It is also giving attention to the chemical analysis of materials that enter into the production of butter and cheese.

Arrangements are being made for the closest collaboration with the dairy sub-committees working within the organization of the British Standards Institution, in particular those relating to bacteriological and chemical analysis.

Owing to the direction the work of this committee is taking it will probably prove to produce long-range, rather than immediate, tangible results.

Testing Facilities Committee.

The Testing Facilities Committee has held four meetings, during which a complete survey of the testing facilities within the Dominion has been made, which are in process of being catalogued, and has also submitted a report covering the needs of the position in this respect.

Town-planning Committee.

This committee has held two meetings, and through its executive sub-committee, which has held five meetings, has carried out comprehensive investigations covering past work in connection with town-planning, both within the Dominion and overseas, and these deliberations have paved the way towards the development of model clauses for town-planning which will assist local bodies to secure reasonable uniformity of provisions relating to town-planning. This work should also prove of considerable advantage to those responsible for local government.

Woolpacks Committee.

Although the Woolpacks Committee has met only three times, consideration has been given to the adoption of a standard woolpack, incorporating suitable provisions concerning size, weave, and weight.

Consultation with the representatives of interests affected have also taken place in regard to the adoption of a produce sack of standard size and quality.

Paper and Stationery Committee.

A Paper and Stationery Committee has also been appointed, which, however, has met but twice. Nevertheless, it has made considerable progress with the important consideration of adopting British Standard Specification No. 730, British Standard Paper Sizes, which may well lead to very considerable economy in the manufacturing and distribution costs of paper.

Consumer Standards Committee.

The Consumer Standards Advisory Committee has held three meetings and has appointed sub-committees dealing with fruit, footwear, and textiles. Draft provisions for standard grades for apples and pears have been completed and circulated, while draft standard grades for citrus fruits are almost completed. The Footwear Sub-committee is at present commencing its work in earnest, the work in this connection having received the full endorsement and approval of the conference of the Boot and Shoe Manufacturers' Association. Attention is being given by this committee to the question of the type and size of boot lasts and patterns that are used for the manufacture of footwear, particularly children's footwear, and this is of far-reaching importance in relation to the effect on children's feet of wearing badly fitted shoes, which in turn reacts on the posture and general physical well-being of the child.

CONCLUSION.

It will be noted that the work that has been undertaken by the foregoing committees is distinctly significant in its economic and social importance. This may be illustrated by the work of the Civil Engineering Committee in developing a standard specification for galvanized (zinc-coated) fencing-wire that may have as much as 50 per cent. longer life, involving a proportionate saving, than a competitive wire which is indistinguishable from a higher grade that is on the market. If this position be observed in its national proportions the value of the work of the committee responsible will be readily appreciated.

A further illustration is in the case of paint, for which specifications have been adopted by the Building Divisional Committee through the work of one of its sub-committees. The use of these specifications will ensure that the paint used will afford an effective coating over a period much longer than is possible with some inferior paints that may otherwise be used. The economic loss involved in painting at unnecessarily frequent intervals is aggravated by the deterioration of buildings that results from the use of inferior paint when the repainting is not carried out with the necessary frequency to compensate for the inferiority of the paint used. What applies in these two instances applies with equal emphasis, even though in different incidence, in relation to the work of the committees that has been outlined in this report. Serious injury, for instance, has occurred through the use of chemical fire-extinguishers manufactured from a metal that was so subject to corrosion as to render it distinctly dangerous. This illustrates in a minor way the importance of the work of the committees in relation to accident hazards through lack of provisions that ensure the use of suitable materials, designs, and construction. The work of these committees, therefore, when regard is taken of the hazards associated with equipment used in the spheres in which the electrical engineering, mechanical engineering, civil engineering, building divisional, and many other committees are working, is of utmost economic and social importance, especially if it is considered in relation to the greater economy and efficiency that is effected from the use of the best materials, designs, and processes.

The activity of the Standards Institute during the past year contains possibilities of benefits to the people of New Zealand that are not easy to calculate at this stage. It has also initiated a work that will facilitate internal and external trade in terms of equity to all parties concerned. In this respect it meets the requirements of the repeated recommendations of past Imperial Conferences, an extract from which, taken from the report of the Conference on Standardization to the Imperial Conference of 1930, copy No. 225, pages 2 and 3, reads as follows :—

> " The conference takes note of the growing recognition of the value of standardization as a means both to economy and to efficiency in the interests of producers and consumers, and draws attention to the importance of the contribution that may be made by its judicious development, to the economic welfare of the British Commonwealth of Nations as a whole, and of its various parts.
>
> " It welcomes the advance which has been made in various parts of the Commonwealth in the co-ordination of standardizing activities under one central body representative of all parties concerned ; and recommends to the consideration of those parts of the Commonwealth in which such co-ordination has not been achieved the adoption of steps to that end."

BUREAU OF SOCIAL SCIENCE RESEARCH.

Social Science Research Committee.—Mr. Evan Parry (Chairman), Dr. C. E. Beeby, Dr. Elizabeth Gunn, Mr. E. H. Langford, Mr. Geo. Lawn, Dr. E. Marsden, Mr. T. H. McCombs, M.P., Dr. D. G. McMillan, M.P., Professor R. W. Souter, Mr. F. B. Stephens, Mr. D. Wilson, Mr. Ormond Wilson, M.P. Secretary : Mr. W. T. Doig.

The Bureau of Social Science Research, which has just been established by the Government, has made a good beginning in its first important investigation—an inquiry into the standards of living of dairy-farmers—and although the actual field-work has not yet begun the preliminary plans have been drawn up and the technique and scope of the investigation decided upon. The inquiry is to be not merely a statistical analysis of the cost of living of a representative group of families, but a comprehensive economic and sociological survey of rural communities where dairying is predominant, including a detailed analysis of the living conditions of a representative group. Such important questions as nutrition, child and female labour, rural housing, educational and recreational facilities will also be closely studied. It is hoped that such a survey will help the Government in policy matters relating to the dairy industry.

This standard of living survey will be extended to cover city workers, and it is felt that the results will be useful to the Government in arriving at decisions on policy measures relating, *inter alia*, to wages, cost of living, and price control.

Although the Bureau is as yet in embryonic form, a good deal of preliminary work was done by the secretary during the period in which a report was being prepared for the Hon. the Minister on the desirability of setting up such a Bureau, and he is now completing a survey of economic research which has been conducted in New Zealand during the past ten years.

Further problems on which specialist members of the Committee are at present working are : (*a*) Nutrition (Drs. Gregory and Gunn) and (*b*) Industrial psychology (Dr. C. E. Beeby and Professor R. W. Souter) ; and the Bureau, when these reports are handed in, will decide what avenues of research are most urgent and practicable, and will act accordingly.

Apart from its own special investigations, the Bureau will grant assistance to independent workers in universities and other institutions if their research comes within the scope of the Bureau's activities and if the type of investigation receives the Committee's approval. It is hoped, further, that by providing facilities for publication of work of merit in the social sciences, and by providing conditions under which investigations may be undertaken, that a stimulus will be given to this type of research, and that some incentive will be given to future investigators by enabling them to obtain recognition for work done.

WHEAT RESEARCH INSTITUTE.

ANNUAL REPORT FOR THE YEAR ENDING 31ST MARCH, 1937.

Advisory Committee: Dr. H. G. Denham (Chairman), Messrs. J. O. Boniface, C. E. Boon, R. T. H. Norton, J. Carr, W. W. Mulholland, P. R. Talbot, R. K. Ireland, R. J. Lyon, J. P. O'Connor, A. H. Cockayne, R. B. Tennent, J. W. Hadfield, C. S. Sapsford, W. O. Rennie, G. Fleetwood.

Director: Dr. F. W. Hilgendorf.

STAFF.

Dr. O. H. Frankel expects soon to have the permanent assistance of Mr. J. B. Hair, M.Sc., who has long worked as a temporary assistant on the wheat-breeding plots. Mr. Hullett, Chief Chemist, leaves on the 20th April for an eight months' tour in America and Europe to visit the cereal laboratories there, and especially to inquire into the technical side of marketing wheat on the basis of quality. Part of his expenses is being paid by the Wheat Committee.

Dr. J. Melville arrived from Harvard last June, and is now temporarily in charge of the laboratory, with Mr. R. V. Peryman as Assistant Chemist.

By arrangement with the Wheat Committee, Mr. H. E. Hansen was appointed travelling baker expert, and he has been kept very busy in visiting bakehouses all over New Zealand giving advice on the best way to use New Zealand flour.

WHEAT BREEDING.

The work in this section continues to expand, as is inevitable with a crop that multiplies itself.

Cross 7.—The first wheat produced by the Institute is now established in the fields of the country, and approximately 10,000 acres were sown in 1936 and 350,000 bushels harvested in 1937. Preliminary trials in commercial mills and bakehouses of the wheat harvested in 1936 were rather discouraging because neither millers nor bakers were used to a wheat of the high quality of Cross 7, but these difficulties were soon overcome, and the wheat is now regarded with enthusiastic favour by nearly every one who handles it. Farmers favour it for its yield and its convenience in harvesting; millers find that it has a good extraction and when blended suits average milling conditions; and bakers like the loaf it produces. Some extracts from the reports of bakers who tested Cross 7 flour, pure, are as follows:—

Baker "A": "I think that if flour like this were obtainable on the market the demand for Canadian would be considerably reduced."

Baker "B": "I would say that flour of Cross 7 would be very useful in a mixture."

Baker "C": "I would say that Cross 7 was equal in baking quality to ordinary commercial flour plus 7½ per cent. Canadian."

Baker "D": "The loaves from Cross 7 were equal to commercial flour plus 10 per cent. Canadian."

The general approval is expressed by the fact that several millers were paying 2d. per bushel bonus for Cross 7 from the harvest of 1937 before any indication of its official price was made by the Wheat Committee.

Tainui.—This spring wheat evolved by the Institute has passed another season's trials with favourable results in both yield and quality. It is now being multiplied as rapidly as possible to supply the market.

More Recent Crosses.—Among more recent crosses, No. 31 shows several lines which are as good as Tuscan in growth characters and baking quality, but considerably superior in yield; and Nos. 36 and 60 show very high quality, with yield equal to Tuscan.

General Work.—Additional crosses are continuously being made, and the number of plots in the field this year totalled about 17,000. The sowing and harvesting and recording of this great number with the accuracy demanded of this type of work requires the most efficient organization and a superior type of casual labour.

LABORATORY WORK.

The number of samples of wheat milled and baked into bread for the year ending 30th November, 1936, was as follows:—

Wheats milled and baked—	
For flour millers and merchants	1,563
From the Institute's wheat-breeding plots	245
From variety trials	60
For A. and P. Association competition	53
	1,921
Flour samples baked—	
For millers and bakers (3,621 in duplicate)	7,342
For millers and bakers (46 second set of duplicates)	92
Blending trials for wheat-breeding (656 in duplicate)	1,312
For A. and P. Association (53 second set of duplicates)	106
Lemon-juice trials (250 in duplicate)	500
Arkady trials	307
Sprouted wheat blend trials	248
Various experimental bakes	803
	12,631

This is about 400 fewer millings and 1,000 more bakings than in the previous year.

Other laboratory work included—

Moistures of wheats and flours	1,278
Soil moistures from wheat plots	92
Complete bran and pollard analyses (18 in duplicate)	36
Complete bread analyses (12 in duplicate)	24
Partial bread analyses—moisture and protein	4
Proteins in flours (90 in triplicate)	270
Ash of flours (96 in duplicate)	192
Gassing tests of flours—routine	1,242
Gassing tests—special wheats	300
Gassing tests—on baking problems	464
Farinograph records	185
Diastatic activity tests	189
Refractometric starch damage tests (60 in duplicate with 60 checks)	240
Starch damage tests (iodine)	446

In addition to these actual tests recorded, a large amount of time has been spent in devising and adapting apparatus for future work, and many more trials than recorded have been made while testing these appliances.

Sprouted Wheat.—The harvest was the wettest ever recorded in New Zealand. At Lincoln nearly 10 in. of rain fell from the 15th January to the 28th February—the normal harvest period. Every district in New Zealand except Central Otago had a similar experience. The result was that practically all the wheat that was not harvested very early was severely sprouted, and reports indicate that 51 per cent. of the wheat handled by mills was more or less seriously damaged. The necessity of using these millions of bushels of sprouted wheat to the best advantage threw a great deal of work on the Institute.

The problem was almost new to us, and most of the year was spent in devising tests to measure the degree of damage, from a baking point of view, that the wheat had suffered, and in advising millers of the proportion of particular lines which could safely be used. That the baking trade passed through the season with a relatively small amount of trouble was gratifying evidence of the co-operation of the millers and the Wheat Research Institute.

Farinograph.—The rush of work on sprouted wheat restricted the testing of the Farinograph as a measurer of flour quality, but what work was done makes it certain that the instrument is an accurate measurer of quality on a broad basis.

Wheatgrowing Practice.

Investigations into the practice of wheatgrowing have been continued without extension into any new lines.

For the fourth year the extracts from the threshing returns supplied by the Government Statistician have been analysed on the basis of varieties and districts. The results are published in *The Wheatgrower*, which reaches the hands of every grower of wheat. In the latest returns there is distinct evidence that the trend of wheatgrowing is following the recommendations made by the Institute in earlier years.

Soil moisture determinations at weekly intervals have been continued for the fifth season. An experiment on feeding-off wheat by sheep was continued for the fourth season.

Co-operation with the Department of Agriculture.

The Department of Agriculture has continued to be of the greatest assistance to the Institute by making variety trials in all parts of the country and certifying wheat seed, and also by allowing its officers to act on the Specialists' Committee, which discusses the kind of experiments with wheat which should be conducted.

PHORMIUM RESEARCH.

REPORT ON WORK AT MASSEY AGRICULTURAL COLLEGE.

By Dr. J. S. Yeates.

The past year has again been marked by notable advances in the development of this work, particularly towards its application in industry. The considerable extension of planting at the Easton area, and the discovery of large supplies of good varieties, indicate that commercial production of fibre from such varieties is nearer to realization than was previously considered feasible.

Even more significant has been the broadened outlook and the prospect of considerable acceleration of the work as a result of the rehabilitation scheme at present being considered by the industry. The visit in October of Mr. Alfred Wigglesworth, Chairman of the Imperial Institute Advisory Committee on Vegetable Fibres, was particularly valuable at this juncture. Not only were the views of such an experienced man valuable to the work now being carried on, but also the contacts that were established should be of considerable value in research and in furthering good will in European markets.

A most encouraging feature this year has been the development among consumers in Britain of a conviction that New Zealand hemp has qualities which entitle it to a place among or near to the more expensive "soft" fibres rather than with "hard" fibres. Appearances indicate that here is available for exploitation a market which New Zealand hemp should be able to fill at prices above those which it realizes as a "hard" fibre.

A large proportion of the time has been spent on matters concerning the rehabilitation scheme for the industry—a scheme which it is hoped will result in the setting-up of a full-scale experimental area and mill.

Progress in different branches of the investigations is indicated below :—

Easton Area.

As a result of extra grants made available during the year, the area planted in special strains has been increased approximately from 25 acres to 47 acres. The main varieties now represented and the areas planted with them are roughly as follows :—

	Acres.		Acres.
Ngaro	20	No. 56	1
S.S.	7	No. 313	1
Paretaniwha	7	No. 314	1
No. 273	3	Ngaro × S.S. hybrids	1

The other varieties, which are in smaller quantity, include Nos. 301, 302, 310, 311, 312, 315, &c. All the varieties with numbers above 300 were new to this work during the year, and include some particularly promising ones, such as Nos. 301, 311, and 313. These were found in the course of searching conducted to find plants for the 22 acres planted during the season. The varieties S.S. and Paretaniwha, of which we now have 7 acres each, yield fibre of particularly high quality. Further supplies of suitable plants were found which should be sufficient to plant from 60 to 100 acres, if these plants can be procured. If the industry is to cater for a market demanding higher quality, these, and if possible other plants, should be secured and propagated as rapidly as possible.

Growth of the plants in the Easton area has been good, particularly in the newly planted area. This is probably due to the very wet summer, which has also promoted abnormal weed-growth and rendered cultivation very difficult. As a result of experience in this area, it is felt that tall fescue (*Festuca arundinacea*) is by far the worst weed of cultivated as well as of natural *Phormium* areas in the district. Experiments on controlling it by grazing with sheep should be initiated.

Flood damage was suffered in June, in the highest flood which the Manawatu has experienced for several years. The bank is now in much better order that at any time since we took possession. Considerable willow-planting has been carried out to protect the more exposed parts from severe wave action.

College Area.

The Ngaro fibre, mentioned in last year's report, won high praise from overseas spinners, and a quantity has now been sent to the Imperial Institute, London, for complete rope tests. A bale of S.S. fibre is also being sent, and smaller quantities from varieties 56 and 313, all of which are expected to give better results than Ngaro in strength tests.

Milling tests, as anticipated last year, were carried out in May and June by Messrs. Ross, Rough, and Co., Ltd., Foxton, to whom the greatest thanks are due. The milling of a hundred or so samples of leaf, which must be kept separate through all processes, is an exacting task, and causes much loss of time in a commercial mill.

The leaf tested came from plants of three types, namely :—

(*a*) Pedigree plants resulting from the inbreeding of good varieties, such as Ngaro, S.S., No. 212, No. 37, No. 22, Paretaniwha.

(*b*) Varieties collected and grown on the College area but previously not tested.

(*c*) Hybrids between some of the good varieties, such as Ngaro × S.S., and Paretaniwha × S.S.

Particularly pleasing results were obtained from plants in groups (*c*) and (*a*). Over thirty plants tested were Ngaro × S.S. hybrids, and almost without exception these gave heavy, strong fibre of very good colour, possessing a better combination of desirable qualities than the fibre of either parent. In addition to appearing thus to combine the better fibre characters of each parent, these plants are also vigorous and tall in their growth, thus overcoming the objection to the better fibre plant (S.S.) of the parents that it is somewhat short of growth.

It must be emphasized that the hybrid plants which were milled had previously been selected from a larger number by hand-stripping tests. Nevertheless, it can confidently be said that, with reasonable culling at the nursery stage, hybrids between Ngaro and S.S. will crop heavily and produce fibre which, in quality, is much above that obtainable from natural stands of *Phormium*.

These hybrids can readily be produced in large numbers, and seem particularly suitable for such commercial planting as must be done before large supplies of vegetatively propagated plants are available. About 100,000 have already been grown for commercial planting. Unfortunately, the past summer was remarkable for the fact that *Phormium* flowering was extremely sparse, and it was impossible to cross these varieties. In the coming summer, given temporary assistance, it should be possible to produce hybrid seed sufficient for 500,000 to 1,000,000 plants. This estimate is based on the expectation that 1 per cent. of the Ngaro plants at the Easton area will produce flowers.

The hybrids mentioned above (Ngaro × S.S.) produce fibre of the general type which has been sought in past years—easily cleaned, of good colour and strength. As mentioned above, present-day trends are towards the employment of *Phormium* as a "semi-soft" fibre, and it is therefore desirable to investigate the production of finer-fibred varieties and hybrids. In the last annual report it was recorded that hybrids between Paretaniwha and S.S. had given especially good results in fineness, combined with other good features of fibre and growth. Unfortunately, these two varieties are not so easily crossed as Ngaro and S.S. The proportion of plants with poor fibre in the hybrids is also high. For these reasons it appears improbable that these hybrids can be supplied *as seedlings* for commercial planting. Selected seedlings can be and are now being multiplied vegetatively for ultimate commercial use.

In the present state of our knowledge it appears that varieties with inherently fine fibre are likely to produce a smaller crop of leaf and fibre per acre than coarser-fibred varieties. This is because the fineness of the fibre in the blade of the leaf is related to leaf thickness, each undamaged fibre strand running from the upper surface to the lower surface of the leaf. Fine-fibred varieties therefore tend to be thin-leaved varieties, and, unless more leaves are produced, there must be a lower yield per acre. It is on such points as this that fundamental research is needed concerning the structure and growth of *Phormium* leaves.

In the milling tests of plants of group (*a*) mentioned above, very interesting results were also obtained, although it must be realized that the purpose of this section of the work (inbreeding) is not to provide immediate supplies of plants for commercial work. The aim is to choose good plants in each generation and to self-pollinate them generation after generation until we find plants which produce seedlings only of the desired type. By suitable crosses between such selected seedlings we should obtain hybrid seedlings which will be vigorous in growth and uniform in type. The improved varieties of the distant future are likely to be bred in this way, just as they have already been in older-established crops.

On the whole the inbred varieties noted above produced seedlings with a general resemblance to their parent plants. A large proportion of the seedlings were inferior to the parents, and a very small proportion equal or superior. These few good seedlings are retained for inbreeding in their turn. Seedlings of variety No. 212 yielded the best coloured fibre which we have seen from *Phormium:* but the plants themselves showed in some cases 100 per cent. mortality when broken up for propagation. This is obviously a case in which it will later be necessary to combine the good colour of these plants with the greater vigour of others.

After the milling tests of the above three types of plants were complete, those bushes which had given good results were broken up for propagation. Three acres were planted at the Easton area from this source, and others were set out in the College area. The bushes rejected after milling tests were given to a flaxmilling firm for removal to a commercial area.

Growth of plants newly set out at the College this year has been just as phenomenal as of those at the Easton area. Many single "fans" set out in September have already produced four, five, or six younger fans.

This year again there are a considerable number of bushes (hybrids and pedigree plants) which need to be tested and propagated.

Pedigree-plant Work.

A student was engaged as temporary assistant in the summer with a view to carrying out an intensive programme of self-pollination and cross-pollination. Unfortunately, no flowers were produced by any of the bushes involved. Only three varieties, including No. 56 and No. 273, produced flowers. All except those on No. 56 were destroyed, and slightly over 3 lb. of seed was obtained by natural self-pollination of eight inflorescences on this variety. As all the bushes of No. 56 in the College area have been propagated vegetatively since 1928 from one plant, we have here very complete evidence that this variety of *Phormium tenax* is definitely self-fertile.

The 3 lb. of seed from No. 56 and 12 oz. from bushes of No. 273 in another district have been sown to produce plants for immediate commercial requirements. About 100,000 seedlings should be produced.

It would be of great practical value for breeding work if one could forecast years of scanty flowering in *Phormium*. The Maori was accustomed to associate abundant flowering of this species with drier summers, and the Maori had every reason to take careful note, as he used the nectar from the flowers. From statements made by flax-millers in 1928, the summer of 1925–26 resembled that of 1936–37 in the scarcity of *Phormium* flowers. The suggestion of some relation to a supposed eleven-year weather cycle is obvious.

Interesting results have been noted in the growth of *Phormium* after cutting. Some bushes hook-cut in the usual manner in September, 1935, had grown again by March, 1937, to a height of 9 ft., and were apparently ready for cutting again. Thus in eighteen months from cutting a new crop was ready, instead of at the usual cutting interval of three or four years. The possibility of cutting more frequently and securing greatly increased yields is a very attractive one. There were, however, four conditions in the above case which are not always met with in combination, namely:—

(*a*) The plants were hybrids and were likely therefore to grow rather more vigorously than many others.

(*b*) The land was fairly clean—*i.e.*, there was no growth of tall fescue, &c., to compete with the *Phormium*.

(*c*) Cutting in spring and summer months promotes better regrowth than cutting in autumn or winter months.

(*d*) The original cutting was probably not so severe as is often the case in commercial areas, where the cutter is paid for the weight he cuts, and therefore includes as much fleshy leaf-base as possible.

Similar rapid regrowth has, of course, been recorded in commercial areas, but the above case is given as a specific example to indicate the possibilities of increased yield, and the need for systematic and prolonged yield trials under various conditions of growing and cutting.

Collection of Varieties.

The collection of plants of new varieties for propagation has already been mentioned in connection with the Easton area. Only some ten new varieties (Nos. 301, 302, 303, 310, 311, 312, 313, 314, 315, and 316) were collected, but in several cases hundreds of roots of each were secured. In addition to securing new varieties, large numbers of plants of other varieties (S.S., No. 273, No. 56, No. 22, Paretaniwha, &c.) were procured. It is a pleasure to record the fine spirit which prompted so many property-owners to denote their plants for removal in the course of this work.

MINERAL CONTENT OF PASTURES.

NINTH ANNUAL REPORT ON THE MINERAL CONTENT OF PASTURES INVESTIGATION AT THE CAWTHRON INSTITUTE, NELSON, PERIOD 1936–37.

(T. Rigg, Officer in Charge.)

During the past year the investigation of stock ailment at Glenhope, Nelson, and of lamb ailment in Southland has been continued. Dr. H. O. Askew has been in charge of work in the Nelson district, and Dr. J. K. Dixon has been responsible for the field experiments at Morton Mains, Southland. Dr. Muriel E. Bell, of the Otago Medical School, has given valuable assistance in connection with certain physiological studies of the sheep in the Morton Mains experiments, while Miss E. B. Kidson, M.Sc., has made an extensive survey of the cobalt content of the main soil types of New Zealand.

In last year's report mention was made of the outstanding results obtained both at Glenhope and at Morton Mains with cobalt chloride at the rate of 1 mg. cobalt (Co) per day. In both places cobalt chloride used in drench form proved completely successful in preventing the appearance of ailment and in curing affected sheep. Furthermore, analyses of drench materials showed definitely that a high content of cobalt was associated with all the beneficial drenches of past experiments, and a low cobalt content with unsuccessful drenches. During the past season the great value of cobalt in overcoming ailment at both Morton Mains and Glenhope has been confirmed, and much additional information is now available concerning the best method of supplying cobalt supplements to stock. Very considerable evidence has been accumulated which points definitely to an actual cobalt deficiency in connection with incidence of ailment, both at Glenhope and at Morton Mains.

The investigations during the period under review have comprised—

(1) Detailed studies of soils, pastures, and animal organs with a view to determining whether ailment of stock is actually caused by a deficiency of cobalt in the food of the animals.
(2) Field experiments designed to secure information concerning the value of cobalt licks, and of cobalt pasture top-dressing as alternative methods for the supply of cobalt supplements to stock.
(3) Animal studies with a view to securing information concerning the role of cobalt in animal nutrition.

Cobalt Deficiency.

The cobalt survey of the more important New Zealand soils has shown, for the most part, a fairly good correlation between low cobalt content of the soil and incidence of stock ailment. Several exceptions to this rule, however, were brought to light during the course of the survey. The Morton Mains soil was shown to have a considerably higher cobalt content than that of other soils associated with stock ailment either at Nelson or in the North Island. Furthermore, certain soils, such as the pakihi soil of Westport, which so far have been considered healthy for stock, have given unexpectedly low cobalt figures. The results which have been obtained suggest that further attention must be paid to methods for estimating availability of soil cobalt.

Analyses of animal organs from the Morton Mains and Glenhope experiments have given definite information concerning the very low cobalt status of sheep suffering from ailment. In certain cases the cobalt content of the liver of affected sheep was only one-eighth that of livers from healthy sheep killed at the freezing-works or of livers from healthy sheep which had been drenched with cobalt chloride. The analytical data suggest that the chemical examination of certain organs, particularly the liver, will prove very helpful in determining whether it is necessary to use cobalt supplements in districts where cobalt deficiency is suspected.

Analyses of pasture samples tend likewise to support a theory of cobalt deficiency as the direct cause of stock ailment at both Morton Mains and Glenhope. The figures for Glenhope show a very definite cobalt deficiency of the pasture in comparison with the data from healthy pastures in other parts of the Nelson district.

Supply of Cobalt Supplements.

Excellent results have been obtained at Morton Mains by the use of a cobalt-salt lick made by mixing 4 oz. of cobalt chloride per 1 ton of dairy salt. Ewes and lambs supplied with this lick have done extremely well, and results compare more than favourably with those obtained in the previous season using a drench of cobalt chloride. The success of the cobalt-salt lick suggests that this method of supplying cobalt will have a very extensive use in districts where ailments of the bush-sickness type are encountered.

Equal success has been obtained by the use of cobalt chloride top-dressings on affected pastures. At Morton Mains the use of 10 lb. of cobalt chloride per acre has been accompanied by very satisfactory weight increases and an entire absence of ailment. Excellent results are being obtained at Glenhope, using 2 lb. of cobalt chloride per acre.

Role of Cobalt in Animal Nutrition.

The blood studies made by Dr. Muriel Bell indicate that the anæmia so commonly associated with lamb ailment at Morton Mains does not run parallel with the severity of sickness. The data suggest that anæmia results from weakness of the animals and that the development of anæmia is secondary to poor nutrition. The blood studies show that obvious symptoms of sickness may develop prior to any considerable reduction in hæmoglobin content and red cell count.

Detailed reports covering the work in the Nelson district by Dr. H. O. Askew, in the Morton Mains field experiments by Dr. J. K. Dixon, and animal studies by Dr. Muriel E. Bell follow.

REPORT ON STOCK AND PASTURE INVESTIGATIONS IN THE NELSON DISTRICT, 1936–37.

(H. O. Askew.)

Introduction.

The spectacular results obtained with cobalt salts in the treatment of Glenhope bush-sickness has opened up a wide field of work. Animal experiments using cobalt salts in drench form have been continued at Glenhope and extended to the Moutere Hill country, where somewhat low figures for cobalt have been obtained in soil estimations.

Other methods of supplying cobalt to animals have likewise been investigated. A cobalt - common salt lick experiment has been established on Moutere Hills country, and the use of cobalt salts for pasture top-dressing has been put under test at Glenhope.

The very definite results obtained by the use of cobalt salts at Glenhope has raised the question whether cobalt supplies an actual deficiency or whether it acts in an indirect manner in improving the health of the animals. For the purpose of securing definite information on this point studies have been made of the cobalt status of animal organs from the Glenhope experiments and from healthy sheep grazed in other localities of the Nelson district.

In addition, attention has been directed to the cobalt status of healthy and sick pastures, and a start has been made in the determination of the cobalt status of different species of grasses and clovers and the influence of cobalt top-dressing on the intake of cobalt.

Animal Experiments at Glenhope.

(*a*) *Drench Experiments.*—A group of five animals has now been receiving 8 mg. of cobalt weekly (as cobalt chloride) since 1st November, 1935. All the animals have remained perfectly healthy and show no signs of any detrimental effects as a result of this long-continued ingestion of cobalt. On 9th November, 1936, the control group in this experiment averaged only 66·2 lb. live-weight, while the corresponding cobalt group averaged 86·8 lb. Since that date to 14th April, 1937, the cobalt sheep have increased to an average weight of 100·4 lb. Several deaths have occurred in the control group, and the remaining animals showed symptoms of bush-sickness.

An older sheep has been receiving the cobalt drench since 4th September, 1935, and this season successfully reared a lamb. The ewe is in good condition.

These results indicate that at Glenhope, cobalt, without addition of other elements, is able to maintain sheep in health over an extended period.

(*b*) *Cobalt Top-dressing Experiment.*—Early in December, 1936, an area at Glenhope, known to be unhealthy in previous seasons, was top-dressed with cobalt chloride at 2 lb. per acre and with superphosphate at 2 cwt. per acre to obtain a pasture on which sick animals could be placed to examine the effect of a light top-dressing of cobalt on their health. On 22nd December, 1936, three sheep, definitely affected with sickness, were placed on this pasture. Symptoms of the ailment soon disappeared and considerable increases in weight were shown. Over the period 22nd December to 14th April these sheep have increased in weight by 27 lb. (average). The results are therefore quite promising.

(*c*) *Other Drench Experiments.*—The groups receiving a drench of an acid extract of Nelson soil and of an iron-free extract of Nelson soil since November, 1935, continue in good health. No deaths have occurred, and increases in weight comparable with those of the cobalt group have been shown.

The control group and that receiving a drench of hydrochloric acid have deteriorated badly this season. Two deaths occurred in each group. All the remaining sheep have been transferred to the cobalt-top-dressed area as they became sick.

Animal Experiments on Moutere Hills Country.

Four trials with hoggets or ewes and one with lambs, using the cobalt chloride drench, have been established on four farms on the Moutere Hills soil type. A lick experiment with cobaltized common salt has also been started. No definite results have yet been obtained as the trials only commenced in October, 1936.

Cobalt Content of Pastures.

Preliminary experiments conducted at the Institute have shown the ability of several pasture species to absorb relatively large amounts of cobalt when soluble salts of this element were incorporated into the soil. It was decided to investigate under field conditions (*a*) the cobalt status of different pastures on healthy and unhealthy country, and (*b*) the influence of cobalt salts on the intake of this element by pasture plants under different conditions of manurial treatment and on different soil types.

Experiments have been established on pakihi soil at Westport; on the Moutere Hills, and at Glenhope; at Appleby; and at the Marsden Research Farm, Stoke, to secure information on these points.

(*a*) *Healthy and Unhealthy Pastures.*—Samples have been available from several healthy pastures and from several unhealthy pastures. Glenhope (unhealthy) samples have shown only 0·03 p.p.m. to 0·07 p.p.m. of cobalt on the dry basis. Other unhealthy pastures have given figures within this range, whereas healthy pastures, especially from the neighbourhood of Nelson, have given a minimum figure of about 0·2 p.p.m. and a maximum of approximately 1 p.p.m. of cobalt on the dry basis. The cobalt content of unhealthy pastures does appear to be definitely low.

(*b*) *Influence of Cobalt Salts on Intake of Cobalt by Pasture Plants.*—A number of trials on several areas have been started, using applications of cobalt chloride ranging from 1 cwt. per acre down to

2 lb. per acre. In all cases very appreciable increases in cobalt content have been obtained. Some figures obtained at the Marsden Research Farm with 1 cwt. per acre and 10 lb. per acre are given below.

Date of Sampling.	Cobalt as p.p.m. of Co. on Dry Basis.			
	Control.	1 cwt. Cobalt Chloride per Acre.	Control.	10 lb. Cobalt Chloride per Acre.
15th September, 1936	1·26	37·7	..	..
29th September, 1936	0·70	25·2	..	..
13th October, 1936	0·44	14·0	0·46	21·5
28th October, 1936	0·36	14·0	0·27	8·8
12th November, 1936	0·39	14·6	0·27	8·2
2nd December, 1936	0·29	14·9	0·27	4·6

NOTE.—1 cwt. application on 21st August, 1936; 10 lb. application on 23rd September, 1936.

These data show the changes in cobalt content which have occurred since top-dressing. A rapid fall in cobalt content occurs at first, but later a more or less stable value is approached. The 2 lb. application of cobalt chloride is of interest because of its use in the animal trials at Glenhope, and also because it provides an economic method of increasing the cobalt content of a pasture.

It has already been shown that sick sheep improved wonderfully in health after grazing the top-dressed pasture at Glenhope. A sample taken eight weeks after top-dressing showed a cobalt content of 0·20 p.p.m., whereas the control sample showed only 0·05 p.p.m. This increase in cobalt content could easily explain the good results with the sheep by reason of the cobalt supplement supplied in this treated grass.

COBALT STATUS OF ANIMAL ORGANS.

In April, 1936, typical sheep from the groups at Glenhope were slaughtered and the organs and blood removed for chemical examination. In the control (no drench) group low values for cobalt were found in certain organs and blood as compared with samples from the sheep receiving the cobalt drench. For example, in the liver of the control sheep only 0·02 p.p.m. of cobalt on the dry basis was found, as compared with 0·22 p.p.m. in the liver of cobalt-treated sheep. That this last figure is not abnormally high was shown by the examination of livers from healthy sheep in the Nelson district. Here the range of cobalt content was from 0·07 p.p.m. to 0·25 p.p.m. on the dry basis, with an average of 0·12 p.p.m. It would appear that the liver may be a useful organ for judging the cobalt status of animals.

The very low figures obtained at Glenhope suggest that the ailment there is due to cobalt deficiency and that the good results from the use of cobalt salts are due to this deficiency being removed.

Further to the drenching technique, experiments on the rate of excretion of cobalt have been made in collaboration with Mr. S. W. Josland, of Wallaceville. Sheep were given a dose of 4 mg. of cobalt (as chloride), and analyses made of the urine and fæces excreted. Rapid absorption and elimination through both urine and fæces were found, so that after five days the cobalt content of the excreta had returned to normal. This result indicates, and the analysis of the organs confirms, that large amounts of cobalt are not stored in the animal and that toxic effects are unlikely to follow the continued use of suitably prepared cobalt drenches and licks.

REPORT ON MORTON MAINS INVESTIGATIONS.

(J. K. DIXON.)

In a previous report it was recorded that cobalt drenches were completely successful in the control of a lamb ailment occurring at Morton Mains and other parts of Southland. In the present season's experiments an easier and equally effective method was sought for supplying cobalt to the animals. Drench guns have been used this year in Southland with success. Over two hundred lambs per hour can be drenched by a competent man. However reliable this method is, there is still the trouble of yarding and handling the lambs. Consequently two other methods—top-dressing of pastures and the use of licks—suggested themselves as worthy of trial.

LICK EXPERIMENTS.

A lick was made up containing 2 oz. to 4 oz. of cobalt chloride to the ton of dairy salt. For the experiment a flock of pregnant ewes was made available by the Southland Frozen Meat Co., and the sheep were divided so as to test the following points:—

(1) Whether the prepared lick was as effective as a cobalt drench.

(2) Whether a cobalt lick when supplied to pregnant ewes would enable sufficient cobalt to be transmitted to the offspring to make unnecessary the use of further cobalt supplements after lambing.

(3) Whether it was sufficient to feed a cobalt lick to the ewes and lambs only after lambing.

Tables I and II show in condensed form the weight-increases in the various groups and the grading results at the conclusion of the experiment.

TABLE I.

Group	A.		B.		C.		D.	
Before Lambing	No Cobalt to Ewes.		Control (no Cobalt at any stage).		Cobalt to Ewes.		Cobalt to Ewes,	
After Lambing	Colbalt to Ewes and Lambs.				No Cobalt to Ewes and Lambs.		Cobalt to Ewes and Lambs.	
Dates.	Average Weight.	Gain.	Average Weight.	Gain.	Average Weight.	Gain.	Average Weight.	Gain.
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
9th November, 1936 (commenced)	41·89	..	40·68	..	38·70	..	38·45	..
22nd February, 1937 (ended) ..	81·73	44·02	62·77	15·0	60·21	23·68	80·66	48·63

NOTE.—A certain number of fat lambs and cull lambs were removed before the experiment ended and this explains the discrepancy between total average gain and the average weight of those lambs in the experiment at the beginning and the end.

TABLE II.—GRADING OF LAMBS IN EXPERIMENTS.

Group	A.	B.	C.	D.
Before lambing	No Cobalt to Ewes.	Control (no Cobalt at any Time).	Cobalt to Ewes.	Cobalt to Ewes.
After lambing	Cobalt to Ewes and Lambs.		No Cobalt to Ewes and Lambs.	Cobalt to Ewes and Lambs.
Fat lambs to 22nd March, 1937 ..	51	11	25	56
Good stores	14	13	25	14
Stores	0	26	19	0
Died	0	14	5	0
Total	65	64	74	70

Tables I and II show very definitely the benefits to be derived from the use of a cobaltized salt lick. Cobalt lick supplied to the ewes only before lambing gave much better results than the control group not only in the number of fat lambs obtained by 22nd February, 1937, but also in the weight increases. Nevertheless, these results fell far behind those obtained by the use of cobaltized lick after lambing, when the lambs as well as the ewes, had direct access to the lick. In these two latter groups there were 80 per cent. fat lambs, compared with 17 per cent. in the controls, and the remainder of those having access to cobalt were expected to be fat by the end of the season. In these groups the weight increases were about three times that found in the control group. Comparison with cobalt drenching experiments of the previous season showed that the lick method was equally effective as a means of supplying cobalt supplements.

TOP-DRESSING EXPERIMENT.

Pot experiments with Morton Mains soil reported in the *N.Z. Journal of Science and Technology* have shown very definitely that grass can quickly take up relatively large amounts of cobalt from soil treated with cobalt chloride, and this suggested that the top-dressing of pasture with cobalt salts would be an effective way of combating sickness. Accordingly an acre was top-dressed with 10 lb. of cobalt chloride, and on it were run ten lambs, while another acre plot acted as a control with a further ten lambs. A mixture of superphosphate and African phosphate at the rate of 3 cwt. per acre was used as a medium for the distribution of the cobalt, and a similar quantity without cobalt was broadcast on the control plot. The lambs were put on the plot on 2nd February, 1937, and by 16th April, 1937, the controls had lost on an average 10·9 lb. per lamb, while the lambs on the cobalt top-dressed plot had gained an average of 15·55 lb. in the same period. Furthermore, the ten lambs on the cobalt plot are all in good condition, while on the control acre seven have died and two more appear likely to die.

The beneficial results obtained by the use of cobalt chloride for pasture top-dressing are associated with very definite increases in the cobalt content of the top-dressed areas. Analyses of the top-dressed and control pastures show an increase in cobalt content of over thirty-fold a month after the completion of top-dressing treatment. Even after the elapse of three months the cobalt content of the top-dressed pasture was over twelve times as great as that of the control area.

VALUE OF NICKEL SALTS IN DRENCH MATERIALS.

In their investigations relating to Denmark disease of stock in Western Australia, Filmer and Underwood found that small quantities of nickel were beneficial under certain conditions of sub-optimal cobalt intake.

An attempt has been made during the past season to ascertain whether nickel salts have a special value in the treatment of lamb ailment at Morton Mains. A drenching experiment was arranged using two groups of lambs—one group received cobalt alone, while the second group received cobalt plus nickel. On the 25th May, 1937, the cobalt lambs had gained an average of

14·25 lb. per head, while the increase for the nickel-cobalt group was 20·35 lb. per head. It appears from these figures that nickel may be of definite benefit to the lamb when given in addition to cobalt. This experiment is being continued to obtain confirmation of the beneficial properties of nickel when used in conjunction with cobalt.

Value of Cobalt Supplements for Dairy Cows.

Filmer and Underwood, in West Australian experiments on Denmark disease, have reported that cows, in addition to sheep, are affected, and that cobalt supplements are beneficial in increasing milk production even where no obvious symptoms of sickness occur. In the Southland district cows do not appear to be affected by the ailment, but it was considered desirable to test the value of a cobalt supplement on milk production.

Accordingly tests of cobalt supplements were made on two farms where lamb ailment in previous years had been pronounced. The results so far obtained are not significant, although the milk yield appears to have been maintained rather better in the case of the cows receiving cobalt drench treatment.

Cobalt Status of Animal Organs.

In addition to the field experiments given above, laboratory examinations have been made of different organs from the experimental lambs in the 1934–35 and 1935–36 experiments.

Analyses showed that cobalt was stored in the liver and to a less extent in the pancreas in lambs drenched regularly with cobalt. The extent of storage in the liver correspond with that attained in normal fat lambs from healthy areas in which no cobalt was given as a supplement. Other experiments with soil drenches which contain cobalt suggest that some degree of health may be attained without any marked storage taking place in the liver, and in these cases the dosage must be regarded only as a maintenance ration. Both from the field and laboratory examinations there are indications that cobalt fed to a pregnant ewe can be transmitted to the offspring, but further work is required.

PHYSIOLOGICAL INVESTIGATIONS AT MORTON MAINS.

(Muriel E. Bell, Otago Medical School.)

By arrangement with the Cawthron Institute certain physiological investigations have been conducted on the sheep in the Morton Mains field experiments by the Department of Physiology, Otago Medical School. During the past year four visits have been made to Morton Mains with the object of studying the animals from a physiological point of view. The studies comprised examinations of blood, urine, and animal organs.

Blood.

A very detailed examination of blood samples of both affected and healthy sheep was made. The results of the examinations have shown that an anæmia does accompany Southland lamb ailment, but this anæmia is only manifest as the season advances and the blood-counts do not necessarily accord with the degree of sickness. The administration of cobalt salts, moreover, does not appear to stimulate the production of red cells in abnormal numbers.

The blood studies show that obvious symptoms of sickness may develop prior to any considerable reduction in hæmoglobin content and red-cell count; and the severity of the sickness does not necessarily run parallel with the degree of anæmia. The data suggest that anæmia results from the weakness of the animals and that the development of anæmia is secondary to poor nutrition. It is more likely to supervene as the season advances and the nutritional impairment becomes more chronic.

It is interesting to note that sheep drenched with cobalt salts maintained very satisfactory hæmoglobin and red cell counts, in keeping with the absence of sickness in this group.

An attempt is now being made to determine the cobalt partition in sheep's blood.

Liver.

The presence of cobalt in livers has been confirmed, and studies are now in progress to ascertain whether cobalt is present in the ionized form. These studies should give information concerning the role of cobalt in animal nutrition and indicate whether cobalt is simply stored in the liver or whether it is in organic combination.

Urine.

Examinations of urine have been limited to samples from two moribund lambs. None of the more obvious types of pathological constituents was present. Urobilinogen was not increased. The lambs had the power of utilizing organic acids to neutralize bases. The organic acids, which included lactic acid, were determined by Van Slyke and Palmer's method (*Journ. Biol. Chem.*, *41*, p. 567; 1920). The sick lambs also were able to use glycuronic acid for neutralizing toxins, for the ether extract after hydrolysis reduced Fehling's solution.

The absence of sugar and acetone bodies from the urine shows that there is no lack of insulin. Creatinine appears to be in normal amounts. Indican is abundantly present as is expected in herbivorous urines.

LEATHER RESEARCH.

Advisory Committee: Messrs. A. E. Lawry (Chairman), J. E. Astley, C. Arlington, S. L. Wright, W. Donovan, F. Johnson.

Director of Research: Mr. P. White. Assistant Director: Mr. F. G. Caughley.

Not the least of the many difficult problems facing the leather research worker is that of assessing quality of leather on a purely scientific basis, especially when sole leather is being considered.

Quality may be defined as the summation of certain properties which are appropriate to the special purpose in view. There are many different types of shoes for use under different conditions of wear, and it would seem to follow that there should be many different standards of quality of sole leather. An added difficulty is that each shoe-manufacturer desires certain properties in the leather to suit his methods of building the shoe, which may not necessarily be those required by another firm, nor may they be related to the demands of the ultimate consumer.

What is quality in sole leather from the wearer's point of view? The average person requires that sole leather shall keep his feet dry in wet weather and have a reasonable wearing-life. Some people, however, may demand lightness and flexibility without giving any consideration to water-proofness and wear. The question now arises, Is it possible with present methods of leather-manufacture to combine the properties of resistance to water and wear with those of lightness and flexibility? Putting the question in another form, Is a person who has bought shoes with light flexible soles justified in complaining if the soles do not give reasonable wear and resistance to water in ordinary wet wear?

The demand for thin, light sole leather has compelled the tanner to use thin hides. These may be from immature animals or from those of a type recognized as not giving leather of high wearing value. In other words, the tanner is being compelled to turn out a product in which, in order to obtain certain desirable features, one of its essential properties is to some extent sacrificed.

Sole leather may be considered as consisting of leather fibres and a class of materials known as "water-solubles." During the year under review an effort has been made to determine some of the functions of water-solubles in sole leather in relation to resistance to water-absorption and wear. The results obtained, and summarized below, show that resistance to wear and water-absorption do not go hand in hand with flexibility. The average person knowingly buying shoes with light, flexible soles is therefore not justified in complaining if the soles do not wear well and do not resist the penetration of water.

Many people believe that shoes wear better after they have been resoled. This is probably the case, and will continue to be so as long as the sale of shoes with very light, flexible soles continues. On the other hand, many people complain of the thicker soles placed on the shoes by the shoe-repairer. It is evident that the wearer must choose which property he desires and be prepared to accept the result of that choice.

In past years there have been many attempts to correlate certain chemical properties of leather with quality. The standards of quality, however, were arbitrarily fixed without a direct relation to the properties of leather as determined under actual wearing-conditions. Although the method is somewhat tedious, actual wear tests were used to obtain the results which are given below.

Functions of Water-solubles in Sole Leather.

Generally speaking, it may be said that increasing the amount of water-solubles tends to make the leather less flexible. Specific effects are as follows:—

Insole Leather.

Increasing the amount of water-solubles in insole leather—

(1) Decreases the porosity and thus tends to reduce the rate of removal of the products of perspiration from the foot:
(2) Increases the amount of perspiration produced by the foot—*i.e.*, decreases the shoe comfort:
(3) Increases the tendency for the hose to become discoloured:
(4) Causes the leather to retain the products of perspiration longer, thus causing more rapid deterioration of the leather, as shown by the formation of cracks.

Insole leather should therefore contain as little water-solubles as possible, provided that due consideration is given to the fact that it is the foundation of the shoe, and as such requires a certain amount of rigidity.

Sole Leather.

(*a*) *Wearing-value.*—Increasing the amount of water solubles in sole leather increases the wearing-value when worn under alternate wet and dry conditions. For perfectly dry wear increasing the water-solubles decreases the wearing-value.

(*b*) *Resistance to Water-absorption.*—Increasing the amount of water-solubles increases the resistance to water-absorption. Water-solubles are washed out during wet wear, and it is important that they should be retained as long as possible. It was found that this was the case when the leather was less flexible, especially when wet.

The results obtained by research become of value to an industry when by their application they help to improve the quality of the finished product, increase the efficiency of manufacture, and help to solve the many problems which arise in the factory. During the year this sphere of the activities of the Research Association has been fully maintained. As in previous years, investigations of immediate factory problems have always taken precedence over the programme of research being carried out. This has involved the examination and testing of hides, tanning materials, tanning liquors, finished material, and processes of manufacture.

Circular Letters.

During the year the hundredth issue of the usual monthly circular letter was sent out. These letters deal with the results of investigations carried out, research work overseas, and other matters of current interest in connection with leather and allied trades.

PELT RESEARCH.

As our knowledge of hides and skins is increasing, the more evident it becomes that for a tanner to make the skins into the most suitable types of leather the more must he know about his raw material. This is well illustrated by a result described in a previous annual report. Pinhole pelts were considered as being of low-grade quality, and as such were used for the manufacture of cheaper kinds of leather. Actually if made into the type of leather for which they are most suitable they are a high-grade pelt.

There are generally accepted ideas regarding the effect of feeding, breed, climatic conditions, or season in which the animal is killed on the various qualities of hides and skins, but little connected research on these problems has been carried out. Much remains to be done along these lines before the tanner can with a fair degree of certainty make his raw material into the type of leather for which it is most suitable. This probably applies more to sheep-skins than to hides.

Seasonal Variation in Lamb-skins.

During the season 1935–36 about six dozen pelts were collected at monthly intervals. When complete a cask of skins was sent to England for a report on the quality aspect of the leather made from them. A microscopical examination of the untreated skins disclosed marked variations in the structure of the skin, especially in regard to the sudoriferous glands.

In the fœtal lamb the sudoriferous glands are only very slightly developed. After birth there is still little necessity for them to function, since the weather is generally cool. As the lamb and its wool grow and the weather becomes warmer the sudoriferous glands begin to carry out their function of keeping the body cool when necessary. During the summer the glands have to produce a large amount of perspiration, and so they form a very prominent portion of the skin structure. When the colder weather of winter arrives the necessity for perspiration decreases and the glands decrease in size.

During the process of manufacture of leather these glands are destroyed. Consequently, when they occupy a large portion of the skin, it would be expected that the resulting leather would be of a spongy type. Where the glands are more or less in a quiescent stage, it would be expected that the leather would be tighter in texture.

Late-season pelts are generally thinner than those produced earlier in the season. As such they have been regarded as of inferior quality, and have commanded a lower price. From the microscopical examination of the monthly samples of skin it would seem that late season's pelts should be more suitable for certain types of leather than those produced earlier in the season.

The report from London on the trial cask of skins mentioned above has confirmed the above conclusion. For one type of leather late season's pelts obtained in May were worth 3s. per dozen less than the others. For another type of leather May pelts were valued at 1s. 10d. per dozen more than the others. Should this result be confirmed in a more extended trial being carried out this season, then the late season's pelts should command a higher relative price than previously, provided that they are made into the most suitable type of leather.

In carrying out this season's collection of monthly samples of skins in two freezing-works, pieces have again been examined microscopically. The colder summer has had the expected effect on the development of the sudoriferous glands—viz., there being less necessity for them to function, the glands are generally not so highly developed. Should the report on the finished leather confirm the conclusions made from this condition, then not only is seasonal variation in the quality of lamb-skin important, but the climatic conditions under which the animal has lived prior to slaughter also are very important.

Breed Trial.

In conjunction with Lincoln College, a shipment of skins which have been taken from lambs of definite known crosses has been sent to England. This has been arranged to determine how far breed affects the quality of the skin from the leather point of view. The microscopical examination of the skins has shown two distinct types, which should be reflected in the quality of leather produced.

Effect of Shearing.

In past years efforts have been made to determine what effect shearing has on the structure of the skin. As a rule, sheep are not slaughtered until a period of four to six weeks has elapsed after shearing. During this time the wool has grown somewhat, and in normal seasons the weather has become much warmer. It would be expected that if the effects of shearing were of a temporary nature, then under the conditions described above very little difference would be noticed. Such was found to be the case.

The comparatively cold climatic conditions after shearing in 1936, however, enabled a distinct difference to be noticed. Shearing was found to reduce considerably the size of the sudoriferous glands, and in this way would affect the quality of the leather produced. Since shearing has a similar temporary effect on the animal as a change from summer to winter, the observed effect is in agreement with the previous results on the effect of seasonal variations.

PUBLICATIONS.

The following papers were published during the year:—

(1) "Effect of Perspiration on Leather." *N.Z. Jour. Sci. & Tech.* (1935), *17*, 412. (Also printed in *J.A.L.C.A.* (1936), *31*, 357, and *Jour. Fed. Curriers* (1937).)

(2) "Colour in Sole-leather." *N.Z. Jour. Sci. & Tech.* (1936), *18*, 1. (Also printed in *J.I.S.L.T.C.* (1936), *20*, 307.)

(3) "Estimation of Water-solubles in Sole Leather." *J.I.S.L.T.C.* (1936), *20*, 409.

(4) "The Storage of Pickled Pelts." *N.Z. Jour. Sci. & Tech.* (1936), *18*, 488. (Also printed in *J.A.L.C.A.* (1936), *31*, 314.)

(5) "Research on Processing N.Z. Pelts." *Jour. Fed. Curriers* (1935), *16*, 234.

(6) "Water-absorption of Sole Leather." *N.Z. Jour. Sci. & Tech.* (1937), *18*, 824. (Also printed in *J.I.S.L.T.C.* (1937), *21*, 12.)

(7) "Seasonal Variations in Lamb-skins, with Special Reference to the Sudoriferous Glands." *N.Z. Jour. Sci. & Tech.* (1936), *18*, 466. (Also printed in *J.I.S.L.T.C.* (1937), *21*, 64.)

FRUIT RESEARCH.

Advisory Committee.—Mr. A. H. Cockayne (Chairman), Messrs. T. Rigg, J. Corder, H. E. Stephens, A. M. Robertson, W. Benzies, T. C. Brash, R. Paynter, A. Osborne, J. A. Campbell, F. S. Pope, F. R. Callaghan, Dr. G. H. Cunningham, W. M. Hamilton (Secretary).

INTRODUCTION.

Owing to its extensive nature, fruit research is carried out by a group of institutions working in co-ordination. These comprise the Plant Research Bureau, Cawthron Institute, the Horticulture Division of the Department of Agriculture, and the Department of Scientific and Industrial Research.

In certain phases of the investigations the Dominion Laboratory, the Soil Survey Division, and the Meteorological Office also participate.

Full use is made of the Imperial Bureau of Fruit Production, East Malling Fruit Research Station, and the Low Temperature Research Station, Cambridge, particularly in connection with cold storage and transport problems, but also in relation to other problems relating to fruit varieties, propagation, nutrition, and general management.

In view of the importance of storage and transport problems, these have continued to be dealt with by the Fruit Cold Storage Research Committee, on which also a combination of interests are represented.

The field work involved in the fruit research programme is carried out at—(1) the Research Orchard of 72 acres at Appleby, Nelson, 20 acres of which are planted in full-bearing trees; (2) the Cawthron Institute Orchards, Nelson; (3) the Tiritea area, Palmerston North; (4) the Hawke's Bay Fruitgrowers' Association Orchard, Havelock North; (5) in a series of selected orchards distributed through the various fruitgrowing districts of the Dominion where investigations are conducted in co-operation with orchardists.

With the establishment of the Plant Diseases Division in Auckland a new trial area will be formed at Mount Albert, and for a number of years use will be made of an orchard which has recently been leased at Huapai.

The whole of the investigations have been greatly facilitated by the helpful co-operation received from the New Zealand Fruit-export Control Board, the New Zealand Fruitgrowers' Federation, and the shipping companies operating in New Zealand waters.

During the year the presence of Mr. L. W. Tiller, Assistant Manager of the Appleby Research Orchard, on extended leave in England has enabled a close contact to be effected between research work proceeding in Great Britain and that in New Zealand.

RESEARCH ORCHARD, APPLEBY.

The whole of the planted area of the orchard is in full utilization for the conduct of manurial, spray, and cultural trials, and is available for the field studies arranged by any of the workers engaged on various researches. Very detailed records of tree growth, yield, leafage, blossoms, &c., are regularly made so that the closest watch may be maintained upon any changes which appear. All the trial areas have been arranged in accordance with the best methods of experimental layout, and are designed to reduce experimental error to a minimum.

Following the heavy crop of the 1935–36 season, when 10,205 cases were harvested, 6,826 of which were packed for export, a light crop was expected for 1936–37, but it is satisfactory to report that the crop will be better than anticipated, and it is expected that exports will total 5,000 cases for the season. Up to the 31st March, 1937, 3,125 cases were packed for export.

Weather conditions have been very variable during the growing season, though the rainfall (40·40 in.) for the year ending December, 1936, was not nearly as high as in the previous year, when 54·13 in. were recorded.

In so far as insect pests are concerned, the season was not a difficult one. The most remarkable feature was the comparatively small amount of leaf-roller infection, in contrast to the previous season when the prevalence of this pest caused very considerable losses. Conditions on the local markets were much improved. Fruit was disposed of to much better advantage and rejects were inconsiderable. This is accounted for to some extent by the lighter crop in the district generally and the losses sustained by growers in the Hastings district through a heavy frost.

Experimental Work.

Testing of Highly-coloured Varieties.—Scions of varieties, principally Delicious and Jonathan of outstanding colour, were collected from various districts and grafted on to bearing trees at the orchard for testing purposes and have made satisfactory progress.

Cider-apple Varieties.—The New Zealand Fruitgrowers' Federation imported twenty-four trees of cider-apple varieties, and these were planted at the Research Orchard for testing purposes.

Manurial Experiments.—The work on the manurial trial plots has been kept up to date.

Cold-storage Trials of Fruit from Manurial Plots.—Fruit for cold-storage trials has been selected from the various manurial plots and stored at Stoke Cool Store. This fruit will be examined and recorded in due course. Special packs of Cox's Orange have been forwarded overseas to investigate the incidence of bitter-pit, and the testing of oiled wraps has been carried out on eleven varieties of apples, several of which have been prepared from the Research Orchard.

Spraying Experiments.—A variety of spraying experiments have been worked in with the general spray programme during the spraying season and provided much valuable information relative to black-spot control and russeting of fruit.

Improvements.—During the winter the spraying system was improved by the replacement of $\frac{1}{2}$ in. piping with $\frac{3}{4}$ in. piping, which greatly facilitated the work of spraying. This change was no doubt responsible for the cleaner fruit crop this season, as although the weather conditions during spraying-time in the early summer were very unfavourable, black-spot was kept well controlled.

ORCHARD SURVEY.

In conjunction with the Land Utilization Survey that is being undertaken in the Hawke's Bay district, an orchard survey has been carried out in an attempt to correlate tree performance and soil type. Much of the field work of the survey has been completed, but the data obtained have not yet been analysed. It is evident, however, that faulty drainage and indifferent management override unsuitability of soil as the chief cause of orchard failures on the Heretaunga plains. After making allowance for these disturbing factors it is hoped that there will be sufficient evidence to indicate the most suitable soils for the various types of fruit. The relationship of soils to individual varieties of each fruit appears to be rather obscure, the position being complicated by the fact that a common stock has been used for most plantations, and also by the management factor which produces wide variations within any variety on a given soil type. In addition to observations of the aerial parts of the trees, root excavations have been carried out on the major soil types. Marked differences in rooting system have been found, the limiting factor in root growth being the level of the water-table.

SPRAYING INVESTIGATIONS.

A full programme of experimental spraying was commenced on the Havelock North orchard, but the severe frost in October, 1936, destroyed practically the whole crop. The absence of fruit made it impossible to obtain complete records, but most of the schedules were continued to keep the orchard reasonably clean, and to determine their effect on foliage.

Black-spot.—Experiments on black-spot control showed that the "weak Bordeaux and summer-oil" treatment, at present being advocated by a proprietary firm in New Zealand, is quite useless where black-spot infection is high.

Summer Bordeaux 1½–3–50, which at present is extensively used in Auckland, was compared with the standard lime-sulphur plus colloidal-sulphur programme. Although slightly better control of black-spot was obtained with the former during this abnormally wet season, spray damage to fruit and foliage was considerably higher.

Codling-moth.—Standard spray treatments for codling-moth control yielded indefinite results owing to low incidence of infection.

Bronze Beetle.—Several different spray treatments for control of bronze beetle were tried on an area where infestation was particularly severe, check trees showing 100 per cent. of the apples damaged. None of the treatments gave commercial control under such conditions of high infestation, the most successful results being obtained with sprays applied at weekly intervals from petal-fall up to early December. Consequently, such additional measures as cultivation of the soil, &c., are necessary to reduce the severity of infestation.

Arsenical Substitute.—Preliminary experiments with a proprietary substitute for lead arsenate (Thiox) indicated that at equivalent weights it is not as effective as lead arsenate and under certain circumstances more likely to cause plant damage.

Brown-rot of Peaches.—Low infection of the check trees again prevented definite results being obtained. Preliminary experiments on dips indicated hat it may be practicable to effect considerable reduction in the loss of fruit from brown-rot during transit and in storage.

Spray Coverage.—Experts have demonstrated that inefficient methods of application limit disease control in many of the orchard areas in Auckland.

The final series of articles dealing with spray coverage are in course of publication.

Tomato-mite.—In conjunction with Mr. Cottier, the distribution and life-history of the tomato-mite, an outbreak of which recently occurred in Auckland, is being investigated. Experiments have shown that the mite can be controlled by fumigation with nicotine.

White Wax Scale.—In conjunction with Mr. Cottier, work on the life-history and control of white wax scale is being carried out preliminary to attack by sprays.

Mottle-leaf of Citrus.—Applications of zinc sulphate have been made to a few lemon and orange trees showing leaf-mottling of a type similar to that found in the United States of America and which has been controlled by applications of this chemical.

MOULDY-CORE INVESTIGATIONS.

Plant Diseases Division.

A survey was made of 118 orchards in the Auckland district to determine the incidence of mouldy core in Delicious apples and to discover any factors affecting the disease. As a result of the survey the following facts became evident :—

(1) The disease is widespread throughout the district, no part being free or even nearly so.
(2) Affected apples ripen prematurely and drop off as the crop approaches maturity. In the case of two orchards, one earlier than the other and both picking on the same date, the earlier one will have had a greater fall of affected fruit and therefore a smaller percentage of mouldy core.
(3) In any orchard the highest percentage of mouldy core is found on the parts having the poorest drainage.
(4) Mouldy core was found in a number of varieties other than Delicious. In every case it was associated with an open calycine sinus.
(5) It is uncertain how far small amounts of mould in the core will develop under storage conditions. To ascertain this a number of cases of Delicious have been placed in the cool store and will be examined at intervals during the year.

Samples were sent regularly to the laboratory at Palmerston North for isolation of the fungi present at various stages of maturity of the fruit. At intervals during the season windfall apples from the trees subjected to injections of chemicals were examined for mouldy core.

Reports concerning the incidence of mouldy core in Delicious in the Auckland orchards indicated that nutrition might play a part as a predisposing cause. Accordingly a series of injections was made on orchards affected with mouldy core. The crop was picked early in March and cut for examination. Relatively high percentages of mouldy core were found in all the samples, there being no significant differences between treatments.

Pruning.—A small block of Delicious trees were subjected to four different pruning treatments—viz., (1) spur-pruning ; (2) severe cutting back of leaders ; (3) light pruning of leaders ; (4) unpruned. No correlation was found between degree of mouldy-core infection and pruning treatment.

Pollination.—An experiment was carried out on Delicious to determine the influence, if any, of the pollinating variety on the morphological characters of the resulting fruit, with particular reference to the calycine sinus. Delicious, Cox's Orange, Dougherty, Granny Smith, Statesman, and Sturmer were used as pollinators. Owing to weather conditions delaying the application of pollen a very poor set was secured and only a few mature fruits were obtained. An examination of these yielded the results tabulated below—

Pollinating Variety.	Structure of Sinus.	Mouldy-core Infection.
Cox's Orange	Fairly narrow	Slight.
Dougherty	Wide	Severe.
Granny Smith	Fairly wide	,,
Statesman	Wide	,,
Sturmer	No fruit available.	
Delicious	,,	

It will be seen that Cox's Orange was the only pollinating variety which showed any significant effect on the structure of the sinus and the degree of mouldy-core infection. These results cannot, however, be regarded as conclusive owing to the small quantity of fruit available for examination. It is proposed to repeat this experiment next spring.

Cawthron Institute.

The investigations on mouldy core of the Delicious variety of apple during the year 1936–37 have largely been concerned with an inquiry into the correlation between the range of variation in the botanical structure of the apple fruit that occurs in typical orchards of the Nelson district and the method of invasion of the fruit by the fungi responsible for mouldy core, together with the mode of their subsequent spread within the fruit. The work has included the following phases :—

(i) An examination has been made of large numbers of infected fruit with reference to the range in structure of the calyx and of the channel that leads from calyx to pip-chambers. This has proved that within the limits of the types occurring in this district, though the open-type calyx and the wide channel naturally afford a less obstructed path for the entry of the fungi, yet the closed calyx, whether associated with a wide or a narrow channel, does not confer on the fruit immunity from infection. Further, a wide type channel was found to be more frequently associated with the open-type calyx. Nevertheless, the narrow channel preponderated in the total number of infected fruit in the experiment.
(ii) A detailed investigation has been made to determine the part of the fruit that is first liable to become infected. Contrary to what might be expected, the deeper-seated tissues in a large majority of instances proved to be the original point of infection.

The information secured in this phase of the research throws light on the question of the stage of development at which the fruit becomes infected.

(iii) The predominating method of spread of the fungi from the original point of infection out into the flesh proper has been traced.
(iv) Identification of the fungi involved in the recent phases of the work has been carried out. Among those of frequent occurrence are included species of *Alternaria*, *Phoma*, *Coniothyrium*, *Pestalozzia*, *Fusarium*, *Pleospora*, *Penicillium*, and *Periconia;* while in the group of rarer fungi occur *Sphaeropsis*, *Diplodia*, *Botrytis*, *Trichoderma*, *Hormodendron*, &c.
(v) The mode of occurrence in the fruit of all the fungi involved has been traced—*i.e.*, whether they occur as solo fungi or as a dominant or a subsidiary associate when a group of fungi is present.

The work being undertaken at present is mainly statistical and includes as its major lines:—
(i) Determination of the percentage of the fungi occurring both in the district as a whole and in individual orchards, the fungi being reckoned—
  (*a*) Together;
  (*b*) As solo fungi; and
  (*c*) As associated fungi in a group.
(ii) The determination of the parts first infected by individual solo fungi.
(iii) The correlation of variation in the structure of the fruit with the occurrence of the various solo fungi.

PHYSIOLOGICAL DISEASES.

Plant Diseases Division.

Bitter-pit.—To test the possibility of bitter-pit being similar in origin to corky-pit a series of injections was carried out at Greenmeadows. Twenty-two chemical salts were injected into Cox's Orange apple-trees. Samples harvested from these trees were held in storage until pronounced pitting developed in the untreated lots, when all the samples were cut and examined. The figures showed wide variations from tree to tree, but no significant differences that could be ascribed to treatment. Borax again failed to give any control of bitter-pit.

Corky-pit Control.—Although the experiments of the 1935–36 season demonstrated clearly that boron salts would correct the corky-pit condition in apples, data were still required as to optimum quantities and frequency of application. Plots treated in the autumn of 1935 were allowed to remain without further dressing in the 1936–37 season. Unfortunately, several were rendered valueless through misunderstandings, as growers top-dressed them with additional borax. Two, however, remained on which the check trees showed fairly high percentages of pitting. In both cases the dressings applied in 1935 had apparently prevented pitting for a second year, as no more than 2 per cent. could be found on any of the treated trees. In commercial practice the borax treatment of corky-pit has proved most successful; wherever it was applied good control has been obtained.

Cawthron Institute.

Boron Investigations.—Studies in connection with the use of borax in the control of internal cork have involved a number of separate experiments dealing with—
(*a*) The penetration of borax into the soil.
(*b*) The intake of boron by the tree and the transmission of boron to the roots, leaders, foliage, and fruit.
(*c*) The value of both top-dressing and spray methods of using borax in the control of internal cork.
(*d*) The value of borax in the control of bitter-pit and tree-pit in Wolseley and Cleopatra varieties respectively.
(*e*) The influence of borax applications on the amount of internal breakdown in the Jonathan variety of apples.

In brief, the experiments of the past season have confirmed those of the previous season in showing that two borax sprays of 0·25 per cent. give a complete control of internal cork. In three separate experiments no pit was found on trees receiving the borax sprays, while on control trees as high as 75 per cent. internal cork was found. The experiments have shown that borax used at the strength of 0·25 per cent. in conjunction with either Ialine, lead arsenate-lime spray, or with lime-sulphur-lead arsenate-lime spray is completely effective in the control of internal cork. Furthermore, large-scale tests at Annesbrook and the Research Orchard conducted on six different varieties of apples showed no detrimental effects either on the foliage or the fruit as a result of spraying the trees under commercial conditions with the combined borax sprays. The experiments have also shown that there may be a carry-over of the beneficial effect of borax injection or borax sprays into the following season, for trees which in the 1935–36 season received 2½ gm. and 5 gm. borax by injection, or alternatively received a 1 per cent. spray of borax, remained free of "cork" ailment despite the incidence of ailment in control trees to the extent of 46 per cent. The soil examinations have shown that borax top-dressings to the soil may penetrate to a depth of 30 in. in a period of twelve months. The examinations of the boron status of fruit soils from the main fruit-growing districts of New Zealand show that Auckland, Hawke's Bay, and Canterbury (Rangiora) are relatively well supplied with boron. Certain fruit soils from Central Otago, however, showed low amounts of boron. Here alkalinity in certain cases appears to accentuate the effect of boron deficiency on the trees.

Examinations of fruit from certain Otago orchards show a low boron status and the presence of typical "cork" trouble in the fruit.

In order to secure further data concerning the boron status of the fruit in the principal apple districts of New Zealand, typical samples of several varieties have been obtained for boron determinations. Chemical analyses of these samples will proceed during the winter months.

So far, borax sprays or top-dressings have not given any significant results either in the control of bitter-pit or tree-pit. Further examination of fruit samples will, however, be made during the winter.

On boron-deficient soils "pitting" or "cork ailment" is not confined to apples; a sample of cherries from an Otago orchard showed on analysis only 4 p.p.m. of boron, and this low amount of boron was associated with a well-marked pitting trouble of the cherries.

Silver-leaf.—A further attempt was made to find some method of treating fruit-trees attacked by the silver-leaf fungus (*Stereum purpureum*). The experiments were rendered abortive, as the trees inoculated for test purposes failed to develop the disease.

FERTILIZER TRIALS.

Cawthron Institute.

Fertilizer studies of apples have been maintained at Mildura (Upper Moutere), Waimea West, and at the Annesbrook orchard.

At Mildura leaf-scorch followed by defoliation is now a serious problem on the highest-yielding block of the experiments. This block has received heavy potash treatment for a number of years, but it is not known whether leaf-scorch is caused directly by the potash treatment or whether it is associated with unidentified deficiencies of minor elements—*e.g.*, magnesium. The block receiving nitrogen only is now the poorest block on the experimental area and the fruit is lower in quality than that from the untreated block. There is increasing evidence to show that both phosphates and potash, in addition to nitrogen, are of paramount importance in maintaining crop production and high quality of fruit on the Moutere Hills type of soil.

The cool-storage trials of fruit from the Mildura blocks show that internal breakdown is more pronounced on the block receiving nitrogen treatment only. No outstanding differences in the amount of internal breakdown have been found in the case of the other fertilizer treatments on this block. The same observation applies to the incidence of Jonathan spot.

In the case of the Waimea West experiments on Cox's Orange on a poor phase of the Moutere Hills soil the experiments continue to show a pronounced advantage in yield where 3 lb. ammonium sulphate are used in conjunction with super and potash as against 1 lb. application of ammonium sulphate. Over a period of six years the amounts of significant internal breakdown have been 40 per cent. in the case of the 3 lb. application and 16 per cent. in the case of the 1 lb. application.

At the Annesbrook orchard the Dougherty fertilizer trials show that a complete manure maintains the highest yield of fruit; treatment with potash and super alone, however, on this soil has given wonderful results over a long period of years. Cool-storage trials so far have not shown any pronounced differences in keeping-quality as a result of differential fertilizer treatment.

BOTANICAL INVESTIGATIONS.

Stocks.

(*a*) *Apple.*—East Malling: The trials of five East Malling stocks and Northern Spy in Auckland, Hawke's Bay, Manawatu, Nelson, Canterbury, and Otago are being continued. The varieties under test on these stocks include Cox's Orange, Delicious, Granny Smith, Jonathan, Statesman, and Sturmer.

The trees are now four years old and stock influence on the growth and general vigour of the scion varieties is becoming more evident. With the exception of Cox's Orange, all the above-mentioned varieties on Northern Spy compare unfavourably with the same varieties on the East Malling stocks. It is quite evident even at this early stage of the trials that there are among the East Malling stocks under test at least two types which will, over a wide range of soils, produce trees of far greater vigour than those on Northern Spy stock. The stock of M X II has shown a very consistent performance in this respect and should prove valuable not only for future planting where the Northern Spy is unsatisfactory, but also for the inarching of unproductive orchard trees.

Fruit from trees on the several stocks should be available in a season or two, when it will be possible to study the influence of stock on size, quality and colour.

Northern Spy: Jonathan trees budded on Northern Spy layers and root-cuttings show little difference in amount of growth at the end of two years. The deeper-rooting habit of the stocks propagated from root-cuttings does not appear, therefore, to have encouraged greater growth in the scions worked thereon than is shown in scions worked on layered stocks. This experiment is being continued.

Own-rooted Trees: Trees of the varieties Cox's Orange, Delicious, Gravenstein, Jonathan, and Sturmer, propagated on their own roots by layering, are now two years old and have become well established. The growth of these "own-rooted" trees during the two-year period is less than that shown by the same varieties on Northern Spy stock. These trees may prove of value in the study of certain physiological diseases as, being on their own roots, stock influence as a contributing factor is eliminated.

(*b*) *Stone-fruit.*—Two varieties of plum budded on five East Malling stocks and one cherry variety on six East Malling selections of Mazzard stock are being grown in the nursery; field trials will be established when the trees are of a suitable size.

(*c*) *Citrus.*—A survey of the citrus rootstock position in the Auckland District was made this summer. The leading nurseries and a large number of citrus groves were inspected and data secured

on nursery technique applies to citrus stocks and on their general performance on typical soils in the vicinity of Auckland. This investigation was carried out as a necessary preliminary to the proposed citrus research at Mount Albert.

VARIETIES.

(*a*) *Apples.*—Strains of Delicious, Cox's Orange, Jonathan, Sturmer, and Granny Smith are being tested. These include red types of the first three varieties. Special attention is being directed to strains of Delicious, with a view to discovering a type with a closed calycine sinus. Unfortunately for this work the hurricane experienced in Palmerston North last year destroyed the crop then carried and also the prospects of a following crop, owing to complete defoliation of the trees. The little fruit that has been obtained of a few Delicious strains indicates, however, that these show considerable variation in the formation of the calycine sinus, ranging from a wide passage to one almost closed. Fruit of all the strains should be available very soon under the more favourable climatic conditions obtaining in Auckland.

(*b*) *Citrus.*—A study of citrus varieties and strains in the vicinity of Auckland was commenced this summer, and will be continued as opportunity offers. Many lemon groves showed a large percentage of "off-type" trees. Special attention was paid to sweet orange varieties and trees that were found to be doing well have been marked as a future source of budwood.

ENTOMOLOGY.

CAWTHRON INSTITUTE.

Aphelinus mali.—Owing to the fact that *Aphelinus mali* does not in some seasons and districts maintain an efficient control over woolly aphis, a study has been undertaken to ascertain the factors that influence the late emergence of the parasite in the spring.

From August to October inclusive a series of experiments was undertaken upon the influence of temperature on overwintering *Aphelinus*. It was found, when kept at a constant temperature of between 60° and 79° F., that the adults will emerge as much as five weeks ahead of those subjected to normal conditions; also the higher the temperature between 60° and 79° the earlier the emergence. Under glass out-of-doors and subjected to natural temperatures, which varied 50° between day and night, the emergence was very low indeed. It was shown also that there is a considerable mortality, especially amongst pupæ under abnormally high temperatures.

In regard to the influence of sprays the evidence so far secured is not conclusive and demands a larger-scale programme. It would appear that the pupæ are much more sensitive to sprays than the larvæ. But it is true that the greatest mortality occurs amongst the pupæ even under untreated conditions.

Apple Leaf-hopper.—The work of establishing a dryinid parasite against the insect has been continued, though a detailed search involving the dissection of a large number of leaf-hoppers failed to reveal the presence of parasites where they had been liberated in the field last season. A further consignment of these dryinids was received from North America and the attempt at establishment proceeded with.

Citrus Red Scale.—A consignment of the *Lindorus* ladybird beetle was successfully imported from California and liberated near Auckland.

Raspberry Bud-moth.—A considerable amount of valuable data is being secured on the biology of this insect.

For Entomological Investigations conducted by the Entomology Division, see page 26.

FRUIT COLD-STORAGE RESEARCH.

Advisory Committee.—Messrs. J. A. Campbell (Chairman), H. G. Apsey, W. Benzies, F. R. Callaghan, J. T. Cross, W. K. Dallas, F. W. Grainger, J. L. Mandeno, T. Rigg, A. M. Robertson, H. E. Stephens, R. Sutherland, L. W. Tiller (absent in England), W. M. Hamilton (Secretary; now in England), and H. C. Heays (Acting-Secretary).

As in previous years, research on fruit during the storage and oversea-transport periods has been conducted by the Fruit Cold Storage Committee in co-operation with, and materially assisted locally by, the New Zealand Fruitgrowers' Federation, the New Zealand Fruit-export Control Board, the New Zealand Dairy-produce Board, the Horticulture Division of the Department of Agriculture, the Wellington Harbour Board, and the managing directors of certain local commercial cool stores. Equally valuable help from abroad has come from the Cambridge Low Temperature Research Station, the Scientific Liaison Officer in London, and the oversea shipping companies, while the keen interest and practical co-operation of the officers and engineers aboard the respective vessels have been invaluable.

Mr. L. W. Tiller, of the Research Orchard, Appleby, travelled to England on the s.s. "Port Nicholson" in charge of experimental consignments of fruit, and remained in England to study the production, handling, and marketing of fruit, in order to supplement his already extensive knowledge of these matters under New Zealand conditions.

VISIT OF DR. A. J. M. SMITH.

At the invitation of the New Zealand Government, Dr. A. J. M. Smith, of the Cambridge Low Temperature Research Station, who was undertaking an important official trip to Australia, spent about a month in New Zealand. During this time Dr. Smith visited selected dairy and cheese factories, meat-works, cool stores, orchards, and research institutions, and, in discussions with research workers and others interested in the Dominion's meat, dairy, and fruit industries, freely made available his wide experience and specialized knowledge of the transport and storage of foodstuffs.

Experimental Refrigerated Gas-store.

A relatively small but completely equipped, electrically-operated, and automatically-controlled refrigerated gas-store of three chambers has been installed at the Dominion Laboratory, and preliminary experiments on the gas storage of New Zealand apples are being undertaken. Two varieties of apples are being used, the trials being conducted at three different concentrations of CO_2 and at three different temperatures. The experiments have not been in progress long enough to give any reliable indication of the ultimate result.

Transport Trials.

(1) *Tower Dunnage on s.s. "Turakina".*—A demonstration shipment of apples stowed on the "tower" system devised by Dr. A. J. Smith, of the Cambridge Low Temperature Research Station, was loaded on the "Turakina" at Nelson for London in March, 1936, and twenty-four thermographs were placed at selected stations throughout the hold to record automatically the temperatures. The fruit was in good condition when discharged, and the numerous flesh temperatures which were taken supported evidence obtained from previous trials of this method of stowage, and it is now officially considered that the "tower" system as demonstrated on this vessel—also on the "Port Nicholson" mentioned in item (3) hereunder—is likely to give consistently satisfactory results for vessels using overhead grids and suitable brine temperatures. As the records of temperature made by the thermographs were, in general, and for the extended scientific research work of to-day, below the requirements, it has been recommended that in future experiments on overseas vessels the modern multi-point electric thermometer be used exclusively.

(2) *No-dunnage Trial on m.v. "Australia Star".*—To obtain a reasonably fair comparison on a modern overseas vessel of the "no-dunnage" system with an ordinary dunnage method of stowage and transport of fruit, approximately 19,200 bushel cases of apples in No. 4 lower hold and 19,500 in No. 4 'tween deck were carried by the m.v. "Australia Star" to London in April, 1936, and temperature readings by a 24-point electric distant-reading thermometer unit were taken throughout the voyage at twelve stations in each of the two holds.

After a careful investigation and extensive examination of the apples in the respective holds upon arrival in London it was found that the temperature distribution and the condition of the fruit were both satisfactory and there was no indication that the omission of dunnage in this lower hold, which has an efficient vertical forced air circulation, had had any adverse effect. In this connection special mention should be made of the excellent stowage throughout the lower hold.

(3) *Dearden No. 1 Method of Dunnage on s.s. "Port Nicholson".*—This trial, which was undertaken in No. 1 lower hold of the s.s. "Port Nicholson," was of very little practical value, first owing to the general unsuitability of a No. 1 lower hold for a systematic stow of cases of fruit, and secondly because numerous open spaces foreign to the system existed throughout the stow as a resultant effect of the then existing difficulty and difference of viewpoint regarding the conditions to be met in the loading of overseas vessels at Wellington.

Use of Oiled Wraps in the Control of Superficial Scald on Granny Smith Apples.—Wastage of Granny Smith apples during cold storage has been a matter of concern for some years. Local experiments were first undertaken in 1934 season and are still incomplete. It would appear that locality of the orchard is a significant factor, also that less mature apples develop scald earlier than the more mature, while oiled wraps, irrespective of locality and maturity influences, have a definite controlling effect.

Influence of Fertilizer Treatment in relation to Bitter-pit in Cox's Orange Pippins.—This storage experiment, the details of which are given in Covent Garden Paper, New Zealand, No. 5, was with thirty-six cases of Cox's Orange pippin from the Research Orchard, Nelson, and indicated that the development of bitter-pit is probably significantly affected by extra manurial treatment in the form of sulphate of potash and sulphate of ammonia, and gave a measure of agreement with some previous results published by Dr. T. Wallace, of the Long Ashton Research Station.

Effect of Fertilizer Treatment on the General Keeping-quality of Apples.—In the 1935 season Cox's and Sturmer apples from manurial plots at Mapua were specially stored and examined, and this experiment was extended to Delicious from the plots at Auckland and Sturmers and Delicious from Hastings, which had received the same fertilizer treatments over the same period of years as those at Mapua.

Regarding the Cox's, the results indicated that while fungal rotting was more or less general in all the samples, bitter-pit was more pronounced for potash treatment and there was no internal breakdown from any plot. There was sight internal browning in one lot of Sturmers from Mapua, but all the Sturmers from Hastings were affected and this disease was also very prevalent in the Hastings grown Sturmers held in local commercial cool-stores; the abnormal rainfall in the district of 21·91 in. for the first three months of 1936 may have rendered this variety less resistant to internal breakdown.

The Delicious apples from Auckland were badly affected by mouldy core, but those from Hastings were sound and in excellent condition. In neither case was there any indication during the storage period that the various manurial treatments influenced the condition of the fruit.

Use of Copper-sulphate-treated Wraps in Control of Spread of Grey Mould (Botrytis Rots) on Winter Cole Pears.—For this experiment thirty-six cases of Winter Cole pears were obtained, twelve each from Nelson, Canterbury, and Hastings. Half the fruit was wrapped in copper-sulphate wraps and the other half in plain wraps, and was held for seven months at a temperature of 30° to 32° F.

Three examinations were made, and on all occasions *Botrytis* was non-existent and these experimental pears finished 100 per cent. sound. In so far as the relative influence of the two kinds of wraps was concerned, the result was negative, but the experiment showed that clean, sound pears properly handled are not so liable under the same storage conditions to develop rots as inferior fruit improperly handled.

Further tests of a similar nature are being undertaken this season (1937).

Delayed Marketing of Cox's Orange Pippins.—This experiment, being five lots each of thirty cases of Cox's Orange Pippin apples, was undertaken at the request of the growers and with a view to determining, if possible and if the scheme were practicable, the best conditions as a guide to the Fruit-export Control Board.

The conclusion arrived at was that there should be no delay between picking and shipment of the fruit from New Zealand and that storage, if any, to prolong the marketing period should be undertaken at the store which supplied the final market.

The Influence of Position on the Tree with regard to the Incidence of Bitter-pit in Cox's Orange Pippins.—Apples for this trial were supplied from the Research Orchard, Nelson, and were picked from the sunny and the shady positions on the trees and shipped to England, as was the case in a similar but inconclusive experiment during the 1935 season. Details regarding the former trial (1936) are given in Covent Garden Paper, New Zealand Apples, No. 4, and the conclusion is that the fruit exposed to direct sunlight develops more bitter-pit in storage than fruit picked at a similar stage of maturity but from shaded positions on the tree. It was suggested, however, that further experiments with this variety of apple should be undertaken, and consequently a further small consignment has been sent forward this season (1937) for storage.

Apples transported to England under Ordinary Air-cooled Conditions and subsequently placed in Refrigerated Gas-storage.—Four cases, each of five varieties of apples—viz., Delicious, Dougherty, Statesman, Granny Smith, and Jonathan—were shipped to the Department of Scientific and Industrial Research, London, to obtain information with regard to the effect of storage in a controlled atmosphere of carbon dioxide after transport in air from New Zealand in comparison with a "full time in air" storage.

At present no report has been received concerning this experiment.

Transport of Cox's Orange Pippins under Refrigerated Gas-storage Conditions.—Two relatively small cool chambers on the m.v. "Empire Star" were reserved for this trial and carried three specially constructed gas-tight cabinets each with control cocks and equipped with an electric thermometer. Two of the cabinets were sealed up immediately after the apples were stowed therein, while the third cabinet was used for normal control purposes and was left open; thirty-six cases were placed in each cabinet, and a further thirty-six cases were carried in the ordinary way on the floor of one of the two cool chambers.

The fruit arrived in good condition, was very favourably reported upon after a very thorough examination, and portion of the shipment was placed into a refrigerated gas-store for a further period.

Overseas Investigations on Cox's grown in New Zealand.—An experiment was carried out with Cox's Orange Pippins to determine the effect of precooling before shipment, and of cold storage in England prior to marketing, also the influence of different types of wrappers was investigated. Details regarding this fruit are given in Covent Garden Papers, New Zealand Apples, No. 6, and the conclusions given therein are briefly as under:—

(*a*) Precooled and examined upon discharge in England: A fair amount of bitter-pit on arrival, but other forms of wastage only slight; fruit remained in good condition during the four weeks' storage except for slight increase in bitter-pit.

(*b*) Precooled and stored for five weeks following arrival and then examined: Showed increased wastage of all types, and storage for such period is inadvisable.

(*c*) Precooling for three days prior to shipment led to greater development of bitter-pit, but further tests with fruit of different maturities and of different types are needed, as fruit not subject to bitter-pit may be benefited by precooling.

(*d*) The Cox's in oiled wraps developed more bitter-pit than the fruit in plain wraps, but as very few of the samples were comparable in size and grade this result may not be significant, and further experiment with wraps is recommended.

In this connection see "Research and Experimental Work in 1937 Season," items (*b*) and (*c*) below.

Research and Experimental Work in 1937 Season.—Two special consignments only of fruit have been forwarded overseas during the 1937 season and, in the ordinary commercial transport, one demonstration shipment of apples per m.v. "Sydney Star" on the no-dunnage system of stowage.

The former comprised small experimental lots to determine—

(*a*) The influence of position on the tree and incidence of bitter-pit in Cox's Orange Pippins.

(*b*) The effect of precooling on the incidence of bitter-pit in Cox's Orange Pippins.

(*c*) The effect of different types of wrappers on wastage in Cox's Orange Pippins,—

the three lots being an extension of earlier trials for similar purposes.

Special work in ordinary cool storage and some research in refrigerated gas storage is also being done locally, including—

(1) The influence of copper-sulphate wrappers in controlling the spread of grey-mould (*Botrytis* rots) in Winter Cole pears; and extension of the experiments of 1934, 1935, and 1936 seasons.

(2) The control of superficial scald on Granny Smith apples, involving the maturity at time of picking, delayed storage and oiled versus plain wrappers.

(3) The effect of oiled wrappers on the keeping-quality and general appearance of apples for export—eleven varieties of apples are being tried.

(4) The experimental gas storage of apples of the Washington and the Ballarat varieties at various CO_2 gas concentrations and temperatures; also the determination of the rate of respiration of individual apples.

SOIL SURVEY.—SEVENTH ANNUAL REPORT.

Land Utilization Committee.—Messrs. T. Rigg (Chairman), A. H. Cockayne, E. J. Fawcett, R. B. Tennent, R. P. Connell, W. Robertson, Professor W. Riddet, Dr. L. I. Grange, Messrs. F. R. Callaghan, and F. J. A. Brogan (Secretary).

The land utilization survey programme under the general direction of the Land Utilization Committee comprises soil, pasture, and farm management surveys by the Soil Survey Division, the Grasslands Division of the Plant Research Bureau, and the Fields Division of the Department of Agriculture respectively. The Cawthron Institute and the Dominion Laboratory co-operate in carrying out the chemical analyses required in connection with the soil surveys.

In Hawke's Bay, which was selected as the starting-point for a comprehensive land utilization survey, substantial progress has been made. In North Auckland an extensive soil survey is in progress which will provide a sound basis for subsequent land utilization investigations.

In addition to the major activities in Hawke's Bay and North Auckland, special soil surveys have been conducted in connection with tung and citrus growing, and irrigation projects. The Director of the Soil Survey Division also visited Samoa to study the soils and their relation to agricultural practice.

REPORT BY DIRECTOR (Dr. L. I. Grange).

The soil surveys of Hawke's Bay Province (under the charge of Messrs. I. J. Pohlen and C. S. Harris) and North Auckland (under Messrs. N. H. Taylor and C. F. Sutherland) continued during the year. In North Auckland area a total of 1,900 square miles and in Hawke's Bay about 3,000 square miles have been mapped. Other activities included :—

(1) Mapping by Mr. Sutherland of 200 square miles of the district surrounding Kaitaia.
(2) A complete survey by Dr. M. M. Burns and Mr. N. H. Taylor of tung groves of North Auckland, including soils and all operations connected with the growing of the tung-tree.
(3) A detailed soil survey by Mr. H. A. Hughes of Heretaunga Plains.
(4) A soil and agricultural survey of Western Samoa by Mr. W. M. Hamilton and the Director.
(5) A survey of the Tauranga and Gisborne districts for possible areas to extend citrus planting by Mr. N. H. Taylor in co-operation with Mr. L. Paynter (Department of Agriculture) and Mr. W. M. Hamilton.
(6) Completion of the survey of Redcliff irrigation area by Dr. J. K. Dixon and Mr. K. S. Birrell.
(7) Chemical work by Dr. J. K. Dixon and Mr. A. C. Harris on some of the saline soils of New Zealand.
(8) Moisture and chemical analyses of soils in irrigation districts by Mr. K. S. Birrell (seconded to Mr. T. G. Beck, Public Works Department).

The Hawke's Bay and North Auckland areas are strongly contrasted as regards their present land utilization. In the former area practically all the soils are growing pasture, but in the latter pasture accounts for a relatively small area. Hawke's Bay soils in general have a high natural fertility, except for phosphate. The brown loams are among the poorer soils, but their amelioration involves no problems. A detailed knowledge of the Hawke's Bay soils is being sought to provide a basis for improved land utilization.

Most North Auckland soils are well leached, and pans impeding drainage are not uncommon; some of the brown loams are problem soils, and a percentage of the country is too steep for agriculture. From data obtained in land utilization surveys, advice can be given in regard to selection of land for future settlement and methods to be followed in utilizing such land to the greatest advantage.

The experience to date shows that aerial photography is a necessary part of land utilization surveys. Soil types and land utilization depend to a large extent on topography, and from air maps flat, rolling, and steep country may readily be delimited. Further, each kind of parent rock seems to have its individual topography. To obtain such data air photomosaics may be used. If the pedologist has also the topographic maps compiled from air photos he can map his soil boundaries much more accurately and rapidly than by other methods. Aerial mosaics of a part of the Hawke's Bay area are now being made from photos taken by the Defence Department.

As in the previous year full advantage has been taken of chemical analyses made at the Dominion Laboratory and Cawthron Institute. Fusion analyses of the soil, when compared with the composition of the rock from which it is formed, show to what extent percolating waters have washed out chemical constituents. Analyses of the clay portion are useful, for the colloids play an important part in soil fertility. Analyses which give the amount of exchangeable lime, &c., are of value in indicating order of fertility. Finally, the acidity of the soil (pH) is a useful guide in all soils, except the brown loams, as to whether lime is required.

HAWKE'S BAY SOIL SURVEY: PROGRESS REPORT.

By I. J. Pohlen and C. S. Harris

Introduction.

During the 1936-37 season the mapping of genetic soil types in Hawke's Bay was continued in slightly more detail than previously. Approximately 2,000 square miles were mapped this season, bringing the total area completed to about 3,000 square miles, or just over half the land district. The area includes the country south of the Napier-Taihape Road, except for small areas west of Tikokino, at Woodville, and a larger block between Weber and the coast.

Topography, Geology, Climate and Vegetation.

Only 5 per cent. of the area described has been mapped geologically in detail, a factor that has made the work of the pedologists considerably slower and more difficult. Topographically, three distinct units are recognized—(1) Western ranges and rolling country, (2) central plains, and (3) coastal belt of steep and rolling country.

(1) The *western ranges* are formed of the indurated sandstones and mudstones called greywacke and argillite, probably Trias-Jura in age. These rocks contain a good deal of volcanic ash. Ancient gravels, sands, and silts derived from these old rocks form the rolling country on the eastern flank of the ranges and narrow belts north and east of the central plains. Volcanic ash showers of pumice and andesite ash, derived from Lake Taupo and Tongariro volcano respectively, cover the northern portion of these ranges from a line drawn west of Hastings, and also the Tertiary limestone, mudstone, and sandstone beds which outcrop in the high country north-west of Napier. The rainfall over the southern portion of the ranges rises from 60 in. to over 80 in., but over the rest of the belt the rainfall is 50 in. to 60 in.

(2) The *central plains* stretch from the southern boundary of the province to the north of Tikokino. They include the Takapau Plains, the sediments of which are derived from greywacke sands, silts, and gravels; but a few miles south of Dannevirke mudstone and sandstone alluvium is incorporated with the greywacke and the soils are more fertile. The rainfall is mainly between 40 in. and 50 in. On the extreme west of the plains the rainfall is 50 in. to 60 in.

(3) The *coastal belt* contains the fairly steep to rolling country between the plain and the sea, formed of tertiary mudstones, sandstones, and limestones. In general the rainfall is below 40 in., except over the high limestone country west of Waimarama, where it rises to 70 in.

The vegetation in the area mapped was mainly fern, &c., except on the Kaweka and Ruahine Ranges and on a portion of the foothills and plains south of the Ngaruroro River on the extreme west, and in the "40 mile bush" belt stretching south of Norsewood, where fern gave place to forest. Isolated patches of forest grew in a few scattered valleys and on the limestone country south of Te Aute.

Genetic Soil Processes in Hawke's Bay.

Sufficient work has now been done to indicate the main soil types likely to be encountered in the province and the soil processes under which these types were developed. Parent rock, topography, vegetation, and climate usually govern the characteristics of the soil profile, and in Hawke's Bay, where the soils are very young, parent rock is chief among these factors. In fact, different classes of parent material give rise to distinctive groups of soils.

Where the topography is gentle, soils are subject to the fullest influence of rainfall and climate, and leaching has its greatest effect, and, although such soils give the greatest response in their particular groups to top-dressing, the rainfall is generally too low for extreme leaching such as that found in North Auckland. Where the slopes are steep a well-developed profile is rare in the area described. On steep topography it is general for constant slumping under high rainfall to distribute fragments of the parent rock throughout the profile, keeping it fertile.

The effect of vegetation on the soils is fairly striking. The forest humus raises the fertility above that of soils formed under light scrub vegetation, but the advantage of a former forest cover does not last more than fifteen or twenty years.

Classification of Soils.

With the recognition of the major soil types in the area surveyed it becomes possible to make a preliminary genetic classification based on the processes under which the various soils were developed. Over one hundred distinct soil types have been recognized, and these are classified into three broad groups according to the physical and chemical characters of their soil profiles. These are:—

(1) Rendzina group, derived from limestones.
(2) Podsol group, derived from mudstones and sandstones.
(3) Brown loam group, derived partly or exclusively from volcanic ash.

Each group is further subdivided into sub-groups according to the stage of development reached in the soil profile by its particular set of soil processes. The sub-groups are provisionally subdivided into series according to parent rock, and the series are further subdivided into soil types according to changes in the textural characteristics of the soil profile.

Description of Soil Types.

(1) *Rendzina Group.*

The rendzina soils are derived from calcareous rocks, mainly limestone, and are regarded as among the best sheep country in Hawke's Bay.

(*a*) *Immature Rendzina Soils* are usually developed on very steep slopes in soft limestone country where slumping is considerable, and this type is well shown on the steep scarp west of the Hastings–Otane main south road. The profile is: 6 in. black sandy loam on cream sandy loam consisting mainly of limestone fragments. As the limestone becomes more sandy it gradually gets harder until steep slopes tend to develop into massive bluffs which resist slumping and do not allow a soil to form. This type has a high base status and near Greenmeadows is high in phosphate, but under the rainfall conditions generally prevailing (below 35 in.) it dries out badly during the summer.

A second type, derived from calcareous mudstone ten miles west of Waimarama, has remained immature because of its heavy texture and steep slopes, despite a rainfall of 60 in. to 70 in. Where the mudstone grades into sandstone excessive leaching has left poor strips of almost pure sands of practically no carrying capacity.

(*b*) *Moderately developed Rendzina Soils* are derived from sandstones and mudstones containing thick bands of limestone which, because of its greater resistance to erosion, caps the crests of the hills and sheds down over the slopes, keeping them fertile and highly saturated with bases. A profile nine miles west of Hastings on sandy parent material is—

6 in. sandy loam, free, brownish-black ;
3 in. sandy loam, free, mottled black and dark brown ;
6 in. heavy sandy loam, dark dull-brown ;
On heavy silt loam mottled dull-brown and creamy-grey.

A certain amount of clay has moved down, and chemical figures also show a certain degree of development of a profile. The topsoil is slightly acid, but becomes neutral or alkaline below 12 in. The potash status of the soil is good, but the available phosphate only fair because it was low in the parent material. The subsoil has the high base saturation and free lime characteristic of rendzinas. When the parent material contains mudstone instead of sandstone, as at Raukawa, the profile contains more clay and is not so well drained, but it has a better phosphate status and is considered to be amongst the best sheep country in the province.

(*c*) *Strongly developed Rendzina Soils* are produced on rolling country from soft chalky limestone and hard sandy limestone. The common profile is—

6 in. sandy loam or clay loam, black ;
On clay or clay loam, chocolate-brown or dark brown.

Chemically this profile shows more development than the moderately developed rendzinas, being less alkaline and less highly saturated and having a lower phosphate status.

Climate is a most important factor in the fertility of the soils in this class. The Te Mata limestone at Havelock North under a rainfall of 30 in. to 35 in. dries out badly, and as the parent rock becomes more sandy a pan develops and the soil grades into the mildly podsolized sandstone series. At Pakipaki a greyish layer is developed between the black topsoil and brown subsoil. This soil dries out badly, but to a distinctly less degree than the Te Mata limestone. West of Te Aute the rainfall is 35 in. and forest was the original cover. The limestone is probably purer and softer than the Pakipaki or Te Mata types, and the following profile has developed—

6 in. sandy loam, blackish-brown ;
8 in. sandy loam to fine sandy loam, greyish or dull brown.
On clay loam to fine sandy clay loam, compact, greyish brown.

The greyish colours are partly due to poor drainage in wet seasons, but this soil does not dry out so rapidly as those at Pakipaki. Although the available phosphate is slightly less than that of the Te Mata type, the forest humus in the soil, together with steep slopes of immature soils, combine to rank this type with the Raukawa immature rendzina in fertility. A slight falling-off in natural fertility has been experienced, and this may be the result of depleting the fertility of the forest humus in the soil under continued grazing.

West of Waimarama there is a belt of limestone under a rainfall of 40 in. to 70 in. Although leaching has been excessive on much of this type, the rainfall is sufficient to prevent the soil from drying out despite its well-drained nature, and this, together with many slopes of immature soils, makes the Waimarama limestone more fertile than the Te Mata or Pakipaki types.

(2) *Podsol Group.*

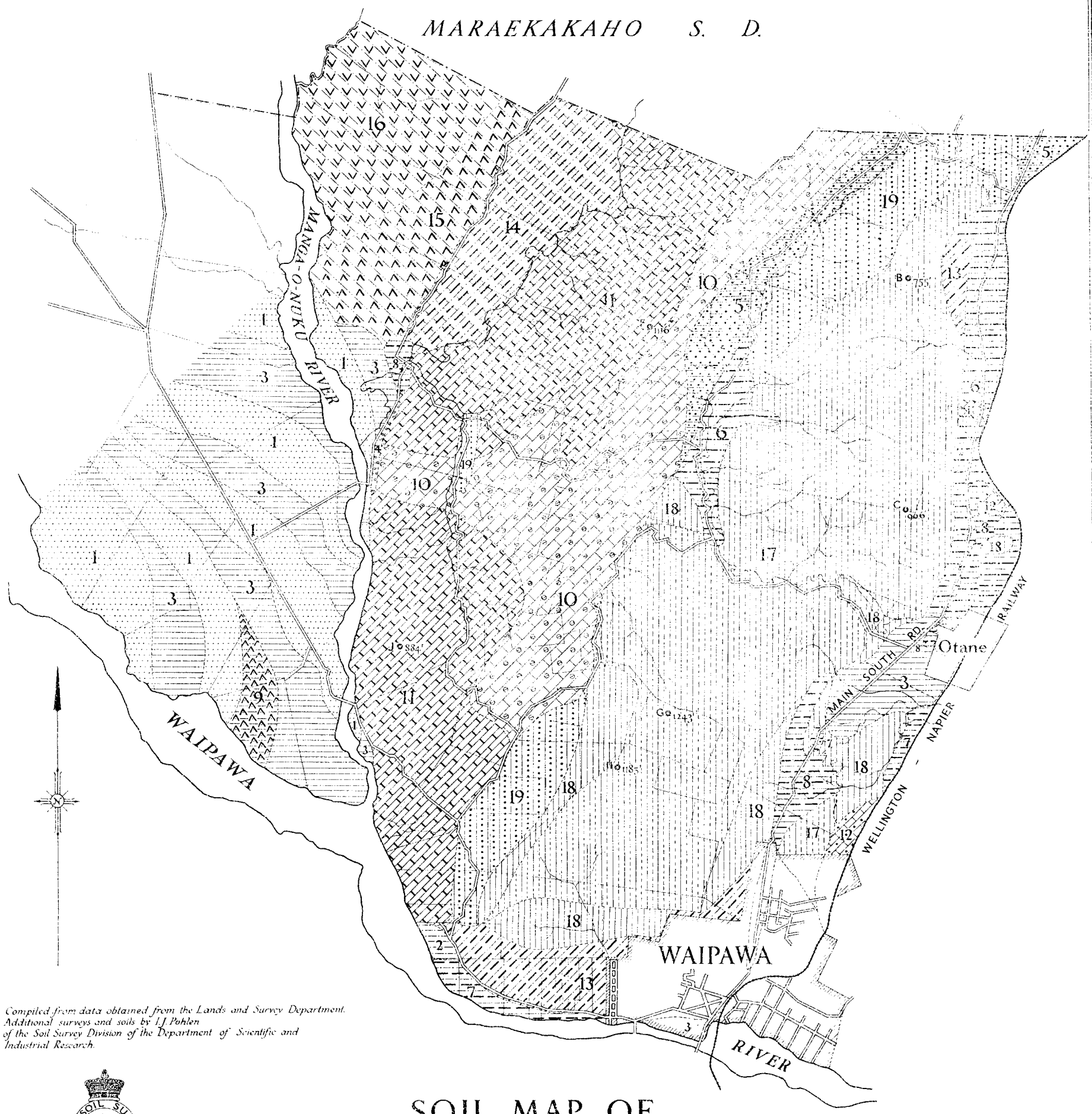
The podsol soils are derived from Tertiary mudstones, argillites, sandstones, and greywacke, and they depend for their fertility on the base status of the parent rock, together with the degree of development of the soil profile.

(*a*) *Skeletal Podsol Soils* are developed on recent alluvium or on steep hill country where the rainfall is sufficient to allow constant slipping and thereby constant rejuvenation of the soil profile. Among the hill soils those derived from mudstone are the most fertile in the class, because the parent material contains an appreciable quantity of the plant nutrients—lime, phosphate, and potash. It occurs in small areas in different parts of the coastal belt. The white argillite series has been described in the last annual report and forms a poor belt four or five miles wide on the west of the main south road between Pukehou and Waipawa and on the east of the road south-west from Waipawa to Wanstead. It is subdivided according to the shallowness of the soils.

Soils derived from sandstone occur on the steep Silver Range belt near Elsthorpe under a rainfall of 35 in. In the Dannevirke district west of the Waewaepa Range the same parent rock occurs under a rainfall of 50 in., but whereas on Silver Range the profile consists of a few inches of sands on the parent sandstone and formerly carried fern, &c., in southern Hawke's Bay the sandstone has broken down to form about 3 ft. of silty clay loam under the high rainfall conditions and it carried forest instead of fern.

On flat country, soils derived mainly from fluviatile silts and sands of mudstone, sandstone, and limestone are included in this group when they are flood deposits of recent times. They occur throughout the coastal belt and particularly on the Heretaunga and Porangahau plains. They are described in the last annual report as being highly fertile, insufficient time having elapsed to allow appreciable leaching.

MARAEKAKAHO S. D.



LEGEND

Flat Country

Skeletal or Meadow Soils

1 — Gravelly sands
2 — Sandy loam on sands
3 — Sandy loam, silt loam or clay loam
4 — Peat or peaty loam

Immature Soil

5 — Silt loam on cream clay loam & clay

Mildly Podsolized Soil

6 — Silt loam on whitish argillite gravels

Weakly Podsolized Soils

7 — Sandy loam on clay loam or pan
8 — Heavy loam on clay or pan

Brown Loam

9 — Brown sandy loam on greywacke gravels

Rolling Country

Rendzina Soils

10 — Sandy loam on clay loam
11 — Sandy loam on clay

Immature Calcareous Soil

12 — Clay loam on cream sticky clays

Weakly Podsolized Soils

13 — Complex of sandy loam or clay loam on pan or clay
14 — Sandy loam on clay or pan (limestone subjacent)

Brown Loams

15 — Very sandy loam on sandy loam, sand or pan
16 — Sandy loam on gravels or pan

Steep Country

Skeletal Soils

17 — Shallow clay loam on whitish argillite fragments
18 — Deep clay loam on whitish argillite fragments

Mildly Podsolized Soil

19 — Sandy loam on clay loam

Compiled from data obtained from the Lands and Survey Department. Additional surveys and soils by I.J. Pohlen of the Soil Survey Division of the Department of Scientific and Industrial Research.

N.Z. SOIL SURVEY

L. I. GRANGE
DIRECTOR.

SOIL MAP OF
Pt WAIPUKURAU S. D.
WAIPAWA COUNTY

SCALE

CHS. 80 60 40 20 0 1 2 MLS.
Kms. ½ 0 1 2 3 4 Kms.

Drawn by K.A.Bell. 1937

Conventional Signs

Roads	shown thus.
Tracks	
Trigonometrical Stations	C ⊙ 1841
Edges of Bush	
Swamps	
Drains	
Railways	

(*b*) *Immature Podsol Soils* are formed where profile development has been hindered by topography or texture. On flat country fairly young soils are also included. Among the hill soils those derived from mudstone are again the most fertile, and the common profile on steep slopes is—

6 in. silt loam, free, black ;
24 in. silty clay loam, yellow-brown, compact ;
On silty clay loam, yellowish-brown and creamy-grey, with mudstone fragments.

The slight degree of development in this type is reflected in the phosphate status, which is only fair. The rainfall is between 35 in and 50 in.

On rolling country two types come into this series. On one the profile is—

6 in. heavy loam to clay loam, black ;
9 in. clay, yellowish-brown ;
On clay, sticky, mottled yellowish-brown and grey.

This soil is a little more fertile than that on the steeper country, although this fertility is offset by poorer drainage conditions.

On flat country removed from the zone of deposition of river floods for an appreciable time leaching has started, and at Pukehou a small area derived mainly from mudstone silts belongs to this class. Between Pukehou and Waipawa argillite silts and gravels have built flats, the soils of which dry out badly and, like other argillite soils, are low in fertility, but are capable of being improved with top-dressing. The rainfall on this type is about 30 in.

(*c*) *Mildly Podsolized Soils* have developed sufficiently to enable the true podsol soil processes to be detected in the soil profile by field and chemical evidence. Not only have iron oxide and alumina moved downwards, but a leaching of silica from the topsoil can be recognized. Plant nutrients are also materially leached and removed so that the soils may be expected to respond to superphosphate.

Four types are recognized with mudstone as the parent rock. On one the profile is—

6 in. silt loam, fairly heavy, brownish-black ;
6 in. silty clay loam, creamy greyish-brown ;
On silty clay, creamy grey, mottled rusty-brown.

Leaching has been accentuated on this type by forest, and a thin grey layer is often recognizable. The rainfall is between 35 in. to 40 in., and the type has a fair phosphate and a high potash status.

Analyses indicate a good humus content, so that the forest probably accounts for the fertility of this mildly podsolized soil. When the rainfall rises above 40 in. a second type almost identical in the field with the first comes in, although it shows slightly more development and has a freer texture and a black topsoil. It is one of the poorest of the mudstone soils and is more leached than the forest type with a much lower base status.

On the Long Range Road east of Waipawa podsolization has proceeded still further on easier country not subject to slumping, and the natural fertility is very low, this type quickly reverting to scrub and such poor-fertility plants as *Leucopogon*, *&c.* However, a good response is obtained from top-dressing.

Mildly podsolized soils in the argillite series are formed where the rainfall is over 35 in. to 40 in. Apparently a higher rainfall is sufficient to convert the skeletal argillite soils into this class, possibly because this condition allows the slumping of large blocks of country. A typical profile in the Porangahau district is—

6 in. silt loam, black, free, powdery ;
6 in. clay loam, yellowish, brown ;
6 in. clay loam, mottled creamy-yellow and yellowish-brown ;
12 in. clay loam, creamy grey, or grey mottled with orange-brown ;
On heavy silt loam or sands, creamy grey.

This argillite soil is also low in phosphate.

A second type in the same district contains more lime in its parent rock and has a heavier texture resting on a sticky clay, so that the drainage is not very good. Probably because of the heavier texture and constant slumping the profile is not so leached, so that although the available phosphate is low, the base status is otherwise high and the soil type is the only one of the argillite series regarded as fair sheep country.

Soils derived from sandstone in this class have developed under a rainfall of, in general, over 40 in. and extend south of Ormondville to the boundary of the province. They also occur in the Maraetotara district west of Waimarama. Constant slumping under this rainfall has prevented the formation of well-developed profiles. A profile is—

6 in. sandy loam, free, black or brownish-black ;
6 in. heavy sandy loam, brown ;
6 in. heavy sandy loam, light brown ;
On heavy sandy loam to clay loam, mottled dull-grey and rusty-brown.

Infertile flat country in the Wilder Settlement district, eight miles west of Porangahau, is formed of argillite sands and silts, which are described in the last annual report. Under a rainfall of 35 in. to 40 in. these soils are mildly podsolized, compared with the immature podsol soils on similar parent rock under a rainfall of 30 in. In the Patangata district flats derived from mudstone alluvium come within this class. A profile is—

6 in. sandy loam, free, black ;
6 in. sandy loam, dull creamy-brown and cream ;
6 in. sandy clay loam, creamy-brown and creamy-grey ;
12 in. clay, pinky-grey and orange brown, sometimes bluish-grey and very sticky ;
On silty clay loam, dull grey to pale yellowish-brown.

(*d*) *Weakly Podsolized Soils* are among the most leached of the podsolized soils in Hawke's Bay, but the processes have not nearly reached the stage that has been produced in North Auckland. This means that the natural fertility of the podsol and rendzina groups which cover half of Hawke's Bay is much greater than that of many other areas in New Zealand.

With rainfall below 45 in. soils derived from muddy sandstone on the rolling country remain sufficiently stable for profiles of this class to develop, and a hard pan is formed. The largest area occurs in the Matapiro–Sherenden–Crownthorpe district and is described in the last report. A distinct change takes place in the profile when the rainfall rises above approximately 40 in. Though a pan is still formed, the profile is not quite so mature because the soils are slightly less stable and there is a tendency to slipping. Above 45 in. slipping is so important that a weakly podsolized soil cannot develop, and this series grades into the immature class. Where limestone bands traverse the parent rock the fertility of the country is improved and the soil is then classed as another type.

On flat country conditions are more favourable for leaching processes, and weakly podsolized soils derived from mudstone or sandstone alluvium are not uncommon. They are particularly well shown near Waipukurau, where the profile is—

6 in. sandy loam, black ;
10 in. sandy loam, mottled creamy-brown and grey ;
On clay, creamy-brown, cemented to form a hard pan.

Such soils are low in phosphate and often acid, but they respond well to superphosphate and lime and can be made to carry very good pastures.

(*e*) *Moderately Podsolized Soil.*—In this class is included a well-leached soil derived from a marine conglomerate of greywacke boulders. Its coarse texture allows ready leaching, but as it often caps ridges in the weakly podsolized country it is appreciated by the sheep-farmer because it rapidly warms up in the spring to provide feed at lambing-time. However, it dries out rapidly and is of small extent.

(3) *Brown Loam Group.*

The brown loams include soils high in iron oxide and alumina and derived exclusively or in part from volcanic ash. The free iron oxides present generally colour the profile shades of chocolate brown or golden, and the base status of the soils is extremely low, being highest in soils derived from greywacke, less in soils derived from andestitic ash, and lowest in the Taupo pumice soils.

(*a*) *Skeletal Soils* are developed on greywacke alone in the hill country, and where the rainfall exceeds 60 in. mixed forest formerly grew and still covers a large area on the crest of the ranges. A deep profile west of Dannevirke on forest country is—

6 in. fine sandy silt loam to heavy silt loam, dark brown and greyish-brown ;
6 in. heavy silt loam, light chocolate-brown to golden, with pink mottling and fragments of greywacke ;
6 in. to 24 in. heavy silt loam to silty clay loam, paler in colour, creamy yellowish-brown, with fragments of greywacke ;
On greywacke.

Other types are recognized according to the depth of soil and the degree of erosion, both of which are correlated with the angle of slope to a large extent. The golden colours in the profile are probably due to the highly hydrated iron oxide—limonite—which is formed under high rainfall from the free iron oxides in the soil. At Kumeroa, twenty miles south-east of Dannevirke, a hill of the shallow soil type under a rainfall of 50 in. to 60 in. is above the average fertility of this type. Being well drained, though not drying out under the prevailing rainfall, and having a high surface area per map-acre on account of the steep slopes, it is considered to be ideal sheep country in that district. Although this soil has a much lower base status than the argillite skeletal podsol soil, the higher rainfall gives a longer growing-period to the pasture, which gives a corresponding increase in the carrying capacity throughout the year. West of Hastings, on Big Hill station, a good pasture is growing on this type and the carrying capacity is above the average for this district.

South-west of Dannevirke some very fertile flats have been formed from silt loams and shingle of greywacke and mudstone origin ; these show certain affinities with the brown loams, but border on the podsol group. At Kuripapanga and on the Hastings plains flats of low fertility are derived from alluvium of pumice sands and gravels.

(*b*) *Immature Brown Loams* are developed almost entirely on the young Taupo pumice or the two older Tongariro andesite ash showers which cover the high country on the north-west of the province from a line due west of Hastings. They are described in the last annual report. The Taupo ash soil has a distinctly lower base status and fertility than the Tongariro ash soils. Soil types are recognized according to the rocks underlying the volcanic ash, because on these depend the topography and the degree of erosion. Although the texture of these soils approximates to a heavy silt loam in the field, mechanical analyses give the texture as a medium sand and this appears to be due to the high humus content of the soil, represented by a loss on ignition of up to 20 per cent. and apparently sufficient to effect this change in field texture. The significance of this result is seen in the higher nitrogen content which has long been recognized in such soils. Where harsh burning has been carried out it is distinctly more difficult to get the pasture to take than after a normal burn, and not only this, but erosion by wind and water quickly gets a footing. The loss-on-ignition figure in two sets of analyses is about 3 per cent. lower in the harshly burned areas, and although the exact significance of this is not yet definite, the presumption in conjunction with field evidence is that the soil humus has been partly destroyed both in structure and chemical composition, with the result that the soil approaches more closely to the medium sand texture and is therefore more liable to

erosion by wind and water. This, in conjunction with the removal of the vegetative cover and the exposure of bare soil for the longer time required by the pasture to establish, probably accounts for a considerable amount of the erosion of these soils in the area described.

(*c*) *Weakly developed Brown Loams.*—These are all derived from alluvium, consisting mainly of greywacke, gravels, silts, and sands, although they fall within the brown loam group with a very low content of exchangeable bases. The coarser texture and heterogeneous parent material has allowed mechanical and chemical differentiation within the profiles by processes comparable with, if not closely resembling, the podsol processes, so that there is a definite increase in exchangeable bases and base saturation in the lower horizons of the profile. This contrasts strongly with the decrease in base saturation and exchangeable bases in the lower portions of the soil profiles derived from young volcanic showers.

The greater part of the central plains from Tikokino south to beyond Dannevirke contains soils of this class which have been subdivided according to (1) age, (2) depth of soil, and (3) vegetation, and have been described in the last annual report. They were covered by forest in the Norsewood–Dannevirke district and temporarily have a good natural ferility.

In Southern Hawke's Bay, on either side of the plains between the Manawatu River and the Ranges, there are dissected rolling hills carved out of ancient alluvial deposits consisting mainly of greywacke silts and gravels on the west, and containing mudstone alluvium in addition on the east. Where the rainfall exceeded 50 in. forest formerly covered this soil class. Each of these soils had its own forest association, which can be recognized in the soil profile by the colour of the topsoil. Where this is dark chocolate-brown, totara–matai were the domimant trees, and where the topsoil is dark brown, matai–totara were dominant in that order. A greyish-brown colour indicates rimu, and other trees correspond with different shades of this colour. No doubt the colour of the particular kind of forest humus and the drainage of the soils preferred by each association affect these topsoil colours, and it is very noticeable that totara-dominant associations grow on light, free, sandy loam, or silt loam. Matai prefers somewhat heavier but otherwise similar well-drained soils, and Hinau heavy, well-drained, fairly fertile soils. Rimu tends to grow on heavy, poorly drained types, while rata follows very fertile country as a rule.

(*d*) *Moderately developed Brown Loams* include several soils derived from ancient greywacke fluviatile deposits of coarse texture, on rolling country, and under a rainfall of 35 in. to 60 in. These soils occupy a relatively large area on the foothills of the western ranges and in the narrow strip north of the central plains.

Soil Erosion.

Although slumping is particularly prominent in skeletal and immature soils, erosion is of greatest importance in the brown loam group. Greywacke soils are particularly liable to gullying and shingle slides. In the immature brown loams, which are mainly derived from volcanic ash, blowing is important, and in the past has been regarded as the main cause of erosion. However, it has been explained that the present investigations indicate that harsh burning is of great, if not major, importance as a factor in erosion in these and perhaps in the skeletal greywacke soil, because it affects the chemical composition of the humus and the crumb-structure which it imparts to the soil. The disintegrating influence of frost, snow, and percolating waters, and of temporary streams and wind, is then able to start erosion, which once begun is difficult to stop. The soil map shows clearly the extent of erosion in this country, and, if required, would provide a basis for attacking the problem. The weakly developed brown loams are particularly liable to blowing, and caution must be exercised in their treatment.

HAWKE'S BAY: FARM MANAGEMENT SURVEY.

Progress Report by Mr. R. B. Tennent, Director, Fields Division, Department of Agriculture.

The farm management survey which is being carried out under the direction of the Fields Division of the Department of Agriculture is making steady progress. Although this agricultural survey is far from complete certain important facts have already emerged relative to the farming of Central Hawke's Bay under normal price-level circumstances. Among these are :—

(1) The production of many of the present dominantly fat-stock-production farms can profitably be increased substantially.
(2) In many instances farms which at present produce both fat-stock and store stock could profitably be devoted to fat-stock production.
(3) Mixed breeding and fattening of stock could more frequently be carried out profitably in the area in which the majority of the farms are now devoted to breeding exclusively.
(4) The carrying capacity of a substantial portion of the area devoted exclusively to breeding could profitably be increased considerably.

HAWKE'S BAY: PASTURE SURVEY.

A progress report on the pasture survey in Hawke's Bay is contained in the report of the Plant Research Bureau (p. 23).

NORTH AUCKLAND SOIL SURVEY: PROGRESS REPORT.

By N. H. Taylor and C. F. Sutherland.

During the 1936–37 season soils were mapped over 800 square miles lying between Russell and Waipu and 200 square miles surrounding Kaitaia. In addition, a detailed soil survey was made of the property acquired by the Plant Research Bureau at Mount Albert and, in conjunction with Dr. M. M. Burns, a survey was made of the tung groves in North Auckland.

Throughout the year the survey has had the constant help of Mr. E. B. Glanville, local Instructor in Agriculture, and of Miss L. M. Cranwell, botanist to the Auckland Museum. The visit of the Australian pedologists—Professor Prescott, Dr. Teakle, and Mr. Leeper—to North Auckland was an occasion for much useful discussion.

Most of the area examined has been previously reported on by the late Dr. H. T. Ferrar, of the New Zealand Geological Survey, and his maps have greatly expedited the work.

Soils.

The genetic soil types mapped are mainly those set out in last year's annual report. Immature podsols cover the greatest area, but mature and submature podsols are well developed on the Cretaceous claystones and on small areas of Tertiary sandstones, greywacke, and alluvium. The red-brown soils derived from basalt cover about 70 square miles.

Podsols.—In the south-west corner of Purua Survey District mature and submature podsols are well developed on rolling country carved from upper Cretaceous claystones. The claystones were probably formed from detritus washed from the podsolized soils of a Mesozoic peneplain. They are siliceous and low in bases, and hence mature podsols are formed on them relatively quickly.

The low hill-tops and upper parts of the slopes are covered with manuka scrub, and a typical profile is—

A 6 in. to 12 in. light-grey structureless silt loam ;
B + C *On* compact grey and yellow-flecked clay with strong prismatic structure.

On the lower parts of the slopes and in the valleys the vegetation is largely stunted manuka, wiwi (rush), and umbrella fern, and giant podsol profiles such as the following are to be found :—

A_1 12 in. light-grey silt loam ;
A_2 40 in. white cemented silt loam ;
B + C *On* grey and brown mottled sticky clay.

In many places bands of charcoal and fragments of what appear to be charred resin are to be found both in the A_1 horizon and in the now cemented A_2 horizon.

The presence of kauri resin and of peg roots of the kauri tree, some of which pass through the cemented A_2 horizon, show that both types of profile were developed under kauri forest, but the original deep surface layer of organic matter (A_0) is missing and is replaced in part by an inch or so of grey powdery litter from the manuka scrub. Under large kauri trees the A_0 layer is 2 ft. to 5 ft. thick. Although inconclusive, the evidence suggests for this area the following cycle of events :—

(1) Area covered with kauri forest. The natural poverty of the claystones would tend to exclude trees demanding higher fertility.
(2) As soils became strongly podsolized, older trees lost vigour and younger trees reached maturity early, resulting in many unhealthy trees exuding gum, and a thickening A_0 layer.
(3) The dying forest was destroyed by fire. Sheet erosion truncated the soils of the upper slopes, the lower slopes being covered with a layer of detritus washed from the leached layers of the soils higher up the slopes. The area was covered by scrub.
(4) Kauri forest again invaded the area. It was during this stage that the giant podsols were formed on the detritus covering the lower slopes.

Stages 2 and 3 were then repeated, resulting in the scrub land of to-day.

The soils of the upper slopes would probably again be carrying kauri forest were the seed-dispersal of the kauri tree more efficient.

Red-brown Soils.—It is proposed to classify the red-brown soils in two groups—the red loams and the brown loams—following the suggestion of Professor Prescott, who recognized the soils at Waimate North as being closely related to the red loams of eastern Australia.

The red loams are compact and appear to have developed from scoriaceous basalt under a dicotylous forest (taraire dominant). The brown loams have developed on basalt flows under scrub and forest and show the stages outlined in last year's annual report. On Puhipuhi plateau brown loams in an immature stage are developed under taraire, whereas under kauri trees the soil is mature and has a similar profile to that of the ironstone land west of Kerikeri.

Otao Fine Sandy Loam.—An unusual soil type, the Otao fine sandy loam, covers about two square miles on easy greywacke country west of Pakaraka, and occurs in isolated patches at Waipu, Kaiwaka, Te Arai, Warkworth, and Silverdale. A typical profile is—

18 in. brown free, fine, sandy loam ;
6 in. cemented white sand ;
On compact brown or grey-brown flecked clay.

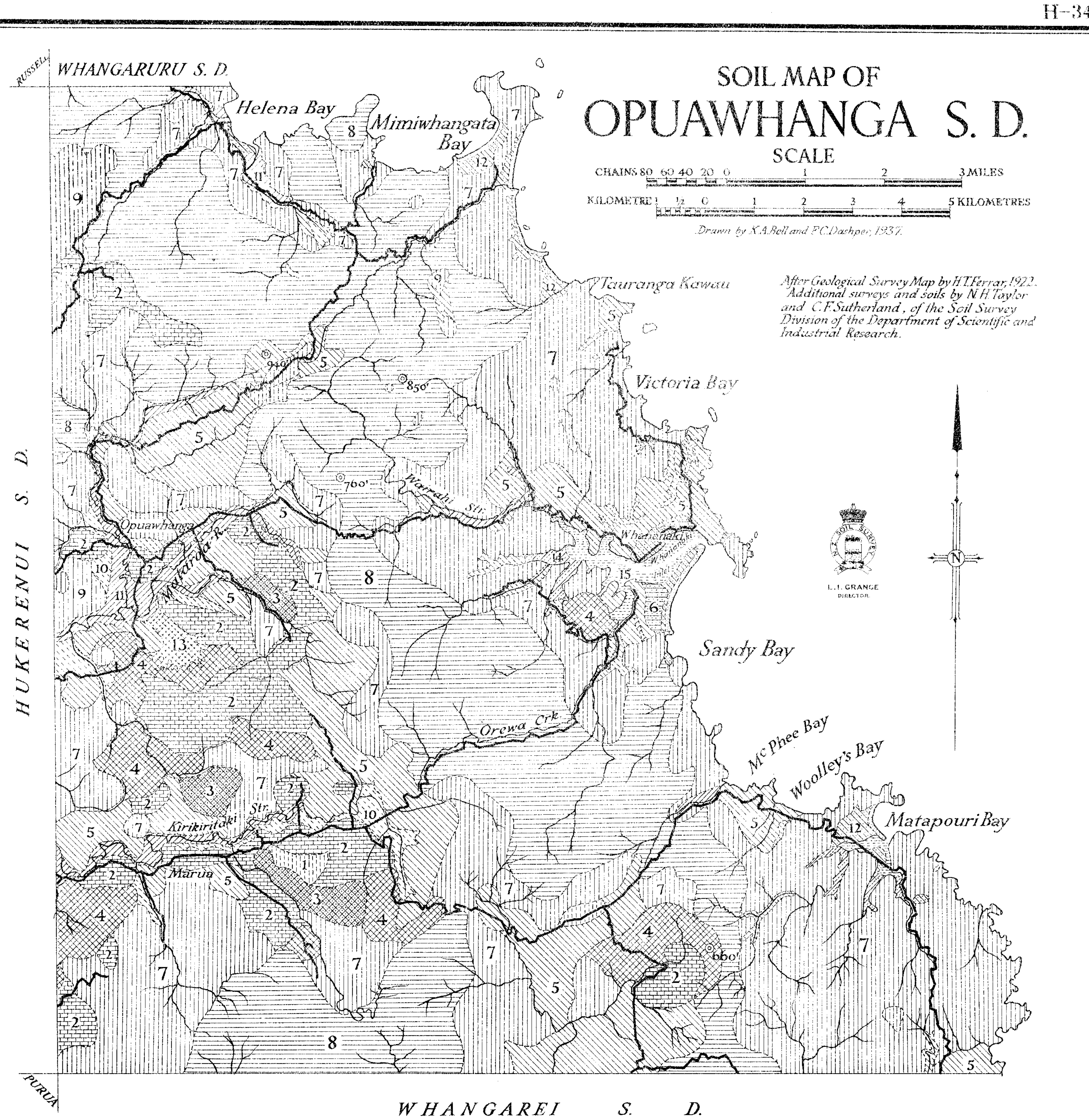
The cemented white sand layer appears to be the buried A_2 layer of a former podsol, but if so no satisfactory explanation can at present be given of the overlying brown loam.

Near Warkworth citrus and peach trees grow well in this soil, but apple trees are stunted.

Opuawhanga Survey District.

The Opuawhanga Survey District has been chosen as being fairly typical of about 400 square miles bordering the east coast between Whangarei and Russell, and the map and comprehensive legend have been prepared in an attempt to find a suitable form for presenting soil survey data.

The district, which lies athwart the north-north-westerly-trending range that forms the watershed between the east and west coast, is composed almost entirely of hill land. Within the district the general height of the main watershed is 700 ft. to 1,000 ft., but the roads to Whananaki Inlet cross it in low saddles at about 400 ft.



LEGEND

CLASSIFICATION	SOIL TYPE		PARENT MATERIAL	TOPOGRAPHY	ADAPTED TO:-	★ PASTURE EXPECTED TO RESPOND TO:-
Mature podsol	Parua silt loam	1	Greywacke	Easy rolling	Dairying	Lime (very strongly), phosphates, possibly potash
Submature podsol	Waitangi silt loam & clay loam	2	Greywacke	Rolling to easy rolling	Dairying	Lime (strongly), phosphates
Complexes with submature podsols dominant	Matauri bouldery loam etc.	3	Quartzite & greywacke	Rolling to steep	Native vegetation	
	Omaiko clay loam etc.	4	Greywacke	Rolling to steep	Sheep & cattle grazing	Lime, phosphates.
Immature podsols	Tahere clay loam	5	Greywacke	Rolling	Dairying, fat lamb raising etc.	Phosphates, lime
	Kapoa sands	6	Blown sands	Easy rolling to flat	Fat-lamb raising, dairying, root crops etc	Phosphate, potash?
Complexes with immature podsols dominant	Marua clay loam	7	Greywacke	Rolling to steep	Sheep & cattle grazing	Phosphates, lime
	Te Ranga clay loam	8	Greywacke	Steep	Native forest	
Brown loam complex (Submature to immature)		9	Basalt	Rolling to steep		Lime, phosphate, potash
Meadow soils	Wairua clay loam etc.	10	Alluvium	Flat	Dairying, maize etc. when drained	Lime, phosphate
Skeletal soils	Keao clay loam	11	Alluvium	Flat	Dairying, maize etc.	Phosphate
	Pinaki sand	12	Blown sands	Easy rolling to flat	Sheep raising, dairying etc.	Phosphate, potash?
Peat		13				
Marine marsh		14				
Mangrove flats		15				
Sand drifts		16				

★ Based on correlations suggested in Annual Report on Soil Surveys 1936 p 9 and refers to pastures demanding high fertility.

The average annual rainfall is 60 in. to 70 in. spread over an average of 170 rainy days per annum. Most of the district was covered with mixed forest, kauri and rimu being generally dominant on the ridge tops, with taraire and other dicotylous trees occupying the valleys. In places, however, the kauri covered the lower country and there is evidence that in the distant past it had a wider distribution.

Most of the soils are derived from greywacke rocks, and the soil pattern is due mainly to the influences of relief and of vegetation.

The immature podsols developed on greywacke have shallow grey-brown crumbly clay loam topsoils and yellowish-brown compact clay subsoils. They are well-drained soils and pastures on them tend to parch during dry spells. The drainage is poorer on the submature podsols. A typical profile is: 7 in. grey structureless silt loam resting on compact grey and brown flecked clay.

The other soil types occupy only a small area and will be described in later reports.

Land Utilization.

The total area surveyed (approximately 2,000 square miles) may be classified as follows:—

	Square Miles (approximate).	Percentage of Area surveyed.
Group 1: Flat to rolling land adapted to dairying, &c.	650	33
„ 2: Moderately steep land adapted to grazing	550	28
„ 3: Land covered with problem soils	150	7
„ 4: Land too steep for permanent farming	400	20
„ 5: Land with soils unsuited to farming	250	12

In a newly settled country such as New Zealand it is often difficult to be sure where we have attained a system of agriculture that is permanent—one that gives us good use of the land and yet preserves its fertility for the use of our children. Too often young countries have found that the systems of farming they have evolved are slowly converting the land into a wilderness.

In North Auckland permanent systems of farming are being developed for the lands of Group 1, but many of the methods of farming the lands of Groups 2 and 4 (the steeper land) cannot be regarded as permanent. The danger appears to be from erosion which tends to be more active on the steeper slopes.

The soils of the hillsides were formerly in balance with the forest cover, but as soon as this was removed and the surface cover of litter destroyed erosion became active. It can be arrested to a large extent by maintaining a tight pasture cover, but so many of the swards are open and overgrazing and constant burning of second growth intensifies the condition. Top-dressing helps to close the sward, but there are many difficulties attending the top-dressing of grazing land and the assured return to the farmer is not such as to tempt him to do this on any large scale.

Much of the hill land has been cleared and grassed without a thought as to what the next step will be. Care and skill are required to maintain permanent pasture on what was once a forest slope.

The problem soils of Group 3 are mainly mature soils derived from basic igneous rocks (*e.g.*, ironstone land) and some of the peaty soils. These soils, although they have certain desirable qualities, have not yet been economically farmed. They should not be settled until sound methods of farming them have been demonstrated.

The lands included under Group 5 as being unsuited to farming are mainly eroded claystone hills and areas covered with sand podsols. The few farmers on them have little chance of success and such areas should not be settled further. It is not in the best interests of the community to have citizens spending their lives in a more or less hopeless struggle against Nature.

SOILS OF KAITAIA DISTRICT.

By C. F. Sutherland.

A reconnaissance survey of 200 square miles of the Kaitaia district was made in order to provide a basis for co-operative work with the Fields Division of the Department of Agriculture.

The assistance given to the survey by the Awanui Dairy Company, the County Clerk, and officers of the Lands and Survey Department and the Public Works Department is gratefully acknowledged.

Topography, Geology, and Climate.

The district is bounded on the south by a range of mountains 1,000 ft. to 2,000 ft. high, composed of greywacke and basic igneous rocks. Five miles east of Kaitaia the range is broken by a northerly-trending valley, three to four miles wide, floored with Tertiary sandstones.

The rolling sandstone country is 300 ft. to 400 ft. above sea-level and is drained by the Takahui River, which flows northward to meet the Awanui River at the lower end of the Victoria Valley.

East and north-east of Kaitaia is a block of hill country 300 ft .to 450 ft. high and underlain by limestones, sandstones, and mudstones, and flanked on the west by flat-topped hills about 150 ft. high, carved from Pleistocene sands and older sediments covered with a veneer of sands. Between the hill country and the sand-dunes bordering the west coast the Awanui River has built a gently sloping fan of silt and clay, the lower western portion of which is covered with peat swamp.

Two belts of dunes border the coast—the inner dunes now fixed by weathering, and the seaward dunes of drifting sand.

The average annual rainfall* at Kaitaia is 55 in. spread over an average of 131 rainy days per year. The mean annual temperature at Monganui, seventeen miles east-north-east of Kaitaia, is 61·3° F.,

* E. Kidson: Meteorological Office Note No. 17, 1937.

the warmest month being February (69·1° F.) and the coldest being August (53·5° F.). Temperatures for the Kaitaia district will be lower as it is more exposed to the westerly winds, and July is probably the coldest month.

Soils.

The soils are classified in seven groups—the podsols, the meadow podsol complex, the brown podsolized soils, the degraded rendzina soils, the meadow soils, and the red-brown soils.

Podsols.—(1) The sand podsols cover over approximately 6,400 acres on the flat-topped hills east of the Kaitaia alluvial fan and are largely developed on Pleistocene sands. The profile on the Awanui–Monganui Road is—

A_1 9 in. dark-grey sand.
A_2 } 4 in. white free sands.
A_2 } 8 in. cemented white sands.
B_1 12 in. blackish-brown sands (humus pan).
B_2 *On* brown cemented sands.

The soils were formed under kauri forest, but the present cover is low manuka, scrub, and wiwi. They are unsuitable for farming.

(2) The podsols with loam and clay loam topsoils cover a few small areas on the low rolling hills of Cretaceous mudstone. Altogether they occupy about 1,600 acres. Where there is no cemented horizon close to the surface, these soils will carry pasture if well manured with lime and phosphate.

(3) The meadow podsol complex covers about 640 acres of low-lying flattish and hummocky ground near Ahipara and Waipapakauri. On the slightly higher parts the soils are sand podsols, whereas in the hollows there are peaty sands resting on cemented sands and peaty sandy loams. These soils are farmed, but the pastures are thin and of low productivity.

(4) *Brown Podsolized Soils.*—Brown podsolized sands form the soil over 4,180 acres on the older fixed sand-dunes near the west coast. The topsoils are dark-grey free sands; the subsoils are slightly compact and more loamy to a depth of 18 in. The area is rolling with some steep slopes.

These soils are well adapted to dairying and fat-lamb raising, but much of the area has been ruined by frequent burning of the scrub cover, which has exposed the soil to the erosive power of the wind.

(5) The brown podsolized sandy clays and clays which cover about 11,500 acres are derived from the Tertiary sandstones. The relief is rolling to moderately steep, with slips fairly common on the steeper slopes. The soils, which are developed under a dicotylous–podocarp forest, are grey-brown and shallow and rest on compact brown clay subsoils.

This land has been farmed, but at present many of the pastures are thinning and much of the area is reverting to bracken-fern, manuka, and rush.

(6) The brown podsolized clay loams and clays were developed under a dicotylous – podocarp forest on moderately steep to rolling land underlain by mudstones and sandstones, some of which are calcareous. The topsoils are shallow, grey-brown crumbly clay loams; the subsoils are dull-brown compact clays with a fine nut structure.

These soils, covering approximately 29,400 acres, are generally better farmed than the brown sandy clays and clays. Neglected areas are reverting to bracken fern.

(7) *Degraded Rendzina Soils.*—The degraded clays are fertile soils derived from argillaceous limestone under a dicotylous forest. They cover about 4,200 acres. On the larger area east of Kaitaia the soils are mostly shallow with numerous outcrops of limestone, but on the area north-east of Kaitaia the soils are deeper and the limestones outcrops are largely confined to the stream-beds and to the steeper slopes.

A typical profile is—

5 in. of blackish crumbly clay;
6 in. light grey-brown flecked compact clay;
On limestone.

Clover grows prolifically on these soils and the pasture comes away early in spring, but they are among the first soils to be adversely affected during a dry spell.

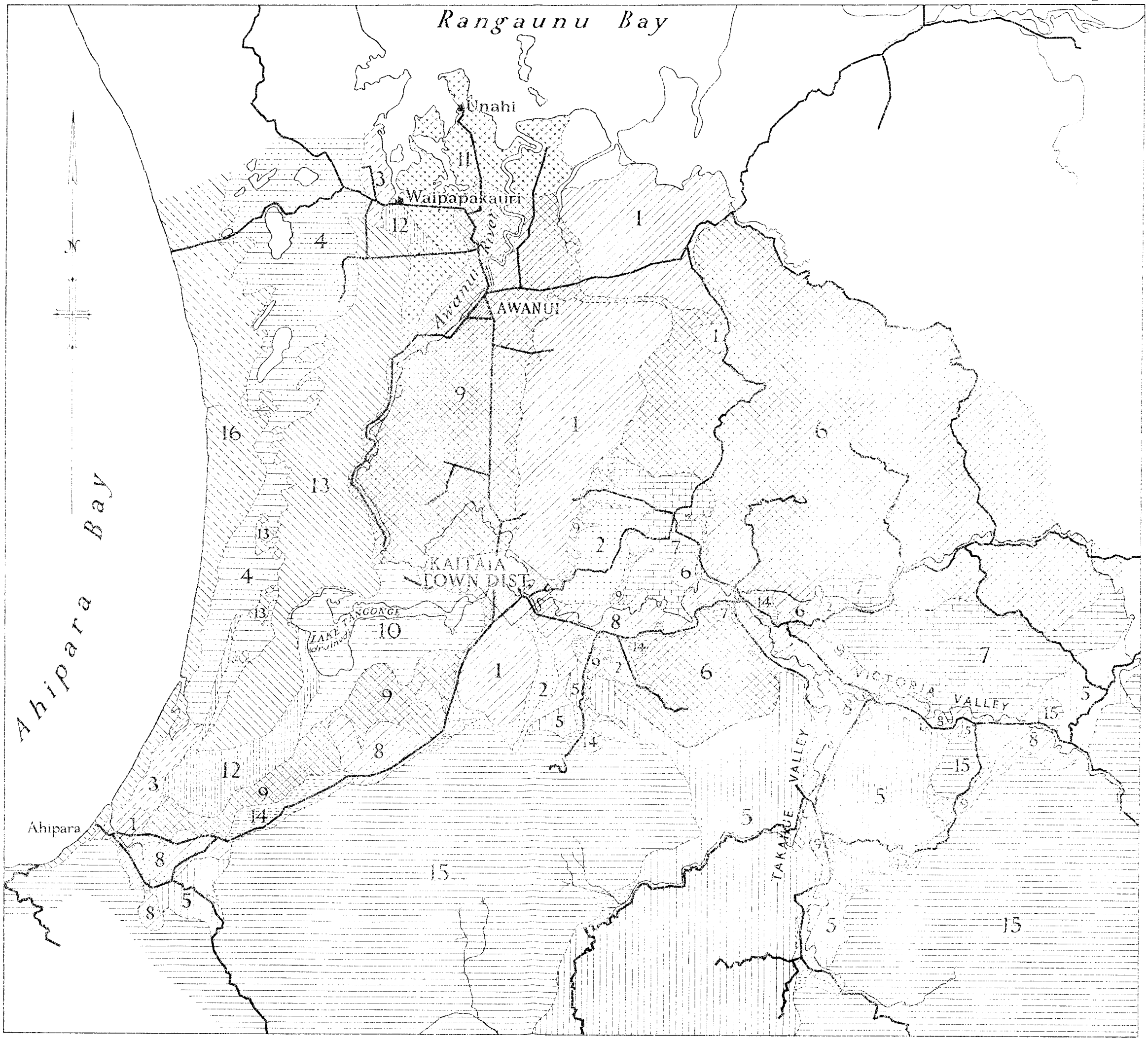
The shallow phase is used mainly for sheep-farming with some dairying, whereas the deep phase is used mainly for dairying.

(8) *Meadow Soils.*—The brown crumbly meadow clays derived mainly from debris from the basic igneous rocks covering the steep ranges to the south cover about 4,000 acres on terraces in the Victoria and Takahue Valleys and fringing the hills west to Ahipara. On the lower terraces where the soils are poorly drained, chocolate-brown friable clays overlie grey-brown compact flecked clays. In other areas covered by more recent alluvium the soil is a deep friable chocolate clay. They are fairly well farmed but the production from them is lower than would be expected from such soils.

On higher terraces where drainage is better the soil is more compact and is brown for 24 in. from the surface. Tiny nodules of manganese are scattered throughout the profile. The higher terrace soils are said to have been fairly productive in the past, but now the pastures are yellowish and contain only a small percentage of stunted clover, while much has reverted to manuka, gorse, and rush.

(9) The grey-brown meadow clays occupying about 10,200 acres are fertile soils which cover the higher part of the alluvial fan of the Awanui River. The topsoils are grey and rest on compact grey and brown-flecked clay subsoils. The native vegetation is said to have been cabbage trees, flax, and manuka.

Although an extensive drainage programme has been carried out, nearly two-thirds of the area is still subject to flooding. On these areas most of the farms are large. Dairying is the principal type of farming on these soils. The pastures are slow to start growth in the spring, but from the beginning of summer to late autumn the growth is very strong.



-LEGEND-

PODSOLS

Sands 1

Loams & clay loams 2

MEADOW PODSOL COMPLEX

Peaty sands etc. 3

BROWN PODSOLISED SOILS

Sands 4

Sandy clays & clays 5

Clay loams & clays 6

DEGRADED RENDZINA SOILS

Clays 7

MEADOW SOILS

Brown crumbly clays 8

Grey-brown clays 9

" " wet phase 10

" " peaty phase 11

PEAT SOILS

Peaty loams 12

Peats with small areas of loamy peats & sandy peats 13

RED-BROWN SOILS

Brown crumbly clays 14

Red-brown crumbly clays (largely skeletal) 15

Drifting sands 16

SOIL MAP OF
KAITAIA DISTRICT

SCALE

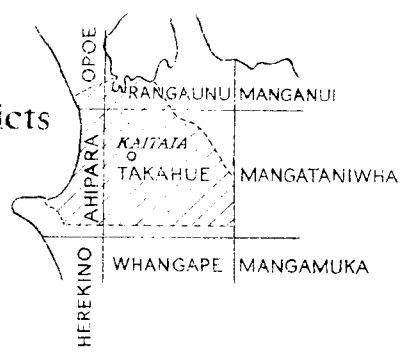
CHAINS 80 40 0 1 2 4 6 MILES

KM. 1 ½ 0 5 10 KMS.

N.Z. SOIL SURVEY

L. I. GRANGE
DIRECTOR.

Key to Survey Districts



Compiled from data obtained from the Lands & Survey Dept. Additional surveys and soils by C.F. Sutherland and H.S. Gibbs of the Soil Survey Division of the Department of Scientific and Industrial Research.

Drawn by K.A. Bell, June, 1937.

Face p.65

(10) The wet phase of the grey-brown meadow clays covers about 13,000 acres surrounding and including the drained Lake Tangonge. Water lies on the surface for a great part of the year. The soils for the most part are grey to bluish-grey clays and clay loams. The present surface cover is raupo, willow weed, rush, and manuka. These soils would be fertile if drained and sweetened.

(11) The peaty phase of the grey-brown meadow clays covers 2,600 acres, more than half of which is subject to occasional tidal flooding and the remainder to river flooding. The soil profile is—

6 in. to 12 in. dark peaty loam ;
On grey-brown flecked clay.

Dairying is carried out on this soil type, but although over most of the area the pastures commence growth earlier than on the grey-brown meadow clays, yet generally the annual production is less.

(12) *Peat Soils.*—The peaty loams occupy only 640 acres. The surface is hummocky with stumps close to the surface in many places and much of it is covered with manuka, gorse, blackberry, and bracken. Parts are covered with a fair sward containing a good percentage of clover.

(13) The peat soils, 6,400 acres in area, are mainly dark-brown, fibrous peats supporting a vegetation of rushes and stunted manuka. A narrow belt of sandy peats borders the sandhills to the west. Adjacent to the river on a lower portion of the swamp dark, loamy, fibrous peats support a cover of flax, rush, and manuka. This latter type is probably more suited to pasture than the rest of the area, but the farming of any peat land is at present problematical.

(14) *Red-brown Soils.*—The brown crumbly clays form the soil over only a small part of the district, chiefly in the Victoria Valley and south of the Ahipara Road. They cover low rolling hills formed mainly from basic igneous alluvium. The topsoils are dark grey-brown crumbly clays ; the subsoils are compact and sticky rusty-brown clays. Nodules of iron and manganese are common in the Ahipara soils, but are rare in the Victoria Valley. These soils are farmed, but the pastures are low producers and become parched during dry spells.

(15) The red and brown crumbly clays cover the steep hills of the range that borders the southern edge of the district. The country is steep and is for the most part covered with dicotylous-podocarp forest. Parts of the area have been sown to pasture for sheep and cattle grazing, but although the pastures may be classed as fairly good, over much of the area they lack clover. Since the bush has been felled many of the hill-sides have slipped and much of the soil has been removed by erosion.

Drifting Sands.

The grey drifting sand-dunes cover about 4,000 acres bordering the west coast. These sands, which are steadily encroaching on the older weathered dunes, have now been fixed by lupins and marram-grass, but the fixing process is hindered by wandering stock and scrub fires.

Cream Supplies in relation to Soil Groups.

The Awanui Dairy Factory operates throughout the year with peak months in December and January, and a very slack period in June and July.

Early in August cream commences to come in from the brown podsolized sands and from the degraded rendzina soils, followed closely by supplies from the brown podsolized clay loams and clays. Early in September cream commences to come in from the brown sandy clays and clays, and from the brown meadow clays. The grey-brown meadow clays are the last to come into production but are always producing well by October.

ANNUAL REPORT ON CHEMICAL WORK AT THE CAWTHRON INSTITUTE FOR THE YEAR ENDING 31st MARCH, 1937.

By T. Rigg, Officer in Charge.

A wide range of work has been covered during the period under review. The progress of the soil surveys in Hawke's Bay, North Auckland, and Samoa has necessitated the examination of a large number of soil samples for texture, exchangeable base status, and plant-food content.

In view of the important part played by soil profiles in the classification of New Zealand soils, special chemical studies have been undertaken on typical profiles from the Waipa County, North Auckland, Hawke's Bay, and the Nelson Province. The examination of profiles representing a range of leached soils has provided much valuable information concerning the chemistry of the leaching process and the maturity of the soils under varying conditions of climate and forest cover.

During the year opportunities were presented for the examination of several soils affected by soluble salts. Samples from Central Otago, Oamaru, and Marlborough were investigated with a view to determining the part played by different salts in lowering the fertility of the soils.

One of the important investigations concluded during the period under review has been the survey of the cobalt status of New Zealand soils by Miss E. B. Kidson, M.Sc. The survey has included all the more important soil types of New Zealand, particular attention being paid to those soils where stock ailment of the bush-sickness type was known to occur.

North Auckland Soils.

A considerable amount of time has been devoted to profile studies of the red-brown soils described by Messrs. Taylor and Sutherland in previous reports. These soils have been derived from the weathering of basalt under varying conditions of climate and forest cover. The chemical data

presented in Table I show that a considerable amount of leaching has taken place even in the youngest soils of this series.

TABLE I.—EXCHANGEABLE BASE STATUS OF TYPICAL RED-BROWN SOILS.

Locality.	Depth of Sampling.	pH Value.	Base Exchange Capacity.	Replaceable Bases.	Base Saturation.
	In.		m.e. per Cent.	m.e. per Cent.	Per Cent.
Ohaiawai	0–2	5·3	86·09	10·23	11·2
	2–8	5·3	57·44	1·12	1·9
	8–16	5·6	42·03	0·17	0·4
	16–32	5·6	57·96	0·18	0·3
Okaihau (ironstone soil) ..	0–3	5·5	31·46	1·90	6·0
	3–10	5·3	23·40	0·22	0·9
	10–17	5·3	22·70	0·10	0·5
	17–19	5·3	35·56	0	0
	19–24	5·3	34·77	0	0

Even the Ohaiawai soil, which represents the more youthful members of the red-brown series, shows a comparatively low percentage of replaceable bases and a high degree of base unsaturation.

The more mature soil from Okaihau shows these features in a more pronounced manner, the lower sections of the profile having no replaceable bases at all. The data indicate the great importance of lime treatment in rebuilding the fertility of these soils.

The Okaihau soils with their low base saturation and high iron content are characterized by a strong power of fixing soluble phosphates, and on this account special attention must be paid to the type of phosphatic fertilizer used in their treatment. Some recent overseas work indicates that "dunite," a magnesium silicate, is beneficial on such soils in maintaining the available phosphate status. Pot trials have been commenced at the Institute with a view to determining the value of powdered serpentine rock (obtained from the Mineral Belt, Nelson) in promoting high efficiency of phosphatic manures on the Okaihau soil.

In the past the presence of soluble aluminium compounds has been suspected as a cause of infertility in ironstone soils, but preliminary work at the Institute on the amount of soluble aluminium contained in the soil solution does not give any support to this suggestion.

HAWKE'S BAY SOILS.

Routine analyses have been continued on soil samples forwarded by the pedologists from different parts of Hawke's Bay. As no final classification of Hawke's Bay soils has yet been decided upon it is not possible to group the chemical data on a basis of soil types. The figures, however, show a wide variation in plant-food content and exchangeable base status and indicate clearly the necessity for the mapping and classification of the soils which is now being done by the pedologists.

In many soil samples the percentage of available phosphoric acid is less than 0·01 per cent., but rises in the fertile Pakowai soils to 0·049 per cent. Similar variations in available potash and pH values have been encountered. While 5·32 represents the lowest pH value, a figure of 8·0 was obtained for a Pakowai sample.

Hawke's Bay soils differ markedly from many North Auckland soils in base status. The percentage base saturation of Hawke's Bay soils is never very low, indicating that the leaching process has never been intense, and suggesting that excellent response from superphosphate will be obtained on many Hawke's Bay soils without resort to lime treatment.

SOILS OF THE WAIPA COUNTY.

A series of profiles representing the more important soil types in the Waipa County have been collected with a view to their chemical characterization. Special studies of base saturation are being made in order to ascertain, if possible, the degree of leaching to which each soil type has been subjected. An attempt is also being made to correlate chemical studies of soil samples taken from the field plots of the Department of Agriculture with fertilizer response.

Table II illustrates the great variation in base saturation met with on different soils of the Waipa County.

TABLE II.

Depth of Sampling.	Soil Type.	Base Saturation.
In.		Per Cent.
0–3	Hamilton clay loam	54·9
0–4	Hamilton clay	40·4
0–2	Waikato sand	28·3
0–3	Whatawhata clay loam	28·3
0–3	Ohaupo silt loam	25·5
0–6	Te Kowhai clay loam	17·6
0–4	Waihi	14·9
0–7	Horotiu sandy loam	13·7
0–5	Te Rapa peaty loam	4·9

Samoan Soils.

A considerable number of soil samples has been received in connection with Dr. Grange's soil survey of Samoa. The soils, with few exceptions, belonged to the silt loam and clay loam textural groups. Available phosphoric acid was generally low in both topsoils and subsoils, an outstanding exception, however, being a sample from an alluvial flat at Solosolo which had the high value of 0·091 per cent. available phosphoric acid.

The soils appeared to be adequately supplied with nitrogen, and the C/N ratios were better than those indicated by Trinidad workers for successful cacao production.

The pH values ranged from 4·9 to 7·3.

Soils affected by Soluble Salts.

During an examination of soils in Central Otago associated with certain pitting troubles of apples, attention was drawn to the possibility of high soluble salt content interfering with the normal development of the fruit trees. Several samples from areas associated with poor growth and "die-back" effects of trees were obtained, and these have been examined in the laboratory with a view to determining the cause of infertility. The chemical analyses showed that high salt content and in certain cases alkalinity were responsible for the detrimental effects noted in fruit trees. This has led to a widening of the scope of the investigations to include soil samples from the Oamaru and Blenheim localities, where the presence of soluble salts was likewise suspected of being connected with poor crop production.

Some of the chemical data obtained in these studies are shown in Table III.

Table III.—Soluble Salts in some South Island Soils.

Locality.	Depth of Sampling.	Total Salts.	Cl′.	SO_4''.	HCO_3''.	Ca··.	Na·.	pH.
	In.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	
Alexandra	0–6	1·29	0·11	0·74	0·01	0·18	0·07	3·8
Conway's Gully ..	0–6	0·29	0·01	0·02	0·11	0·01	0·05	8·5
Blenheim	0–6	0·43	0·20	0·00	0·02	0·00	0·14	5·8
Otekaieke	0–3	1·60	0·28	0·45	0·06	0·04	0·19	8·7

The data show a wide range not only in the percentages of total salts, but also in the amounts of individual salts present in the four soils. It is interesting to note that the samples from Conway's Gully and Blenheim contain much lower percentages of total salts than those from Alexandra and Otekaieke. The detrimental effects on crop production in the first-mentioned soils appear to be connected with the presence of sodium bicarbonate in one case and sodium chloride in the other.

Cobalt Survey of New Zealand Soils.

The spectacular results which have been obtained from the use of cobalt chloride for stock in localities affected by ailment of the bush-sickness type suggested that ailment was caused by an actual deficiency of cobalt in the soil. On this account it was considered desirable to estimate the amount of cobalt contained in the more important soil types of New Zealand. For the purpose of the investigation samples were available from the soil surveys of the Department of Scientific and Industrial Research and the Cawthron Institute in different parts of New Zealand. During the progress of the investigation particular attention was paid to soil samples from all localities in New Zealand where stock ailment of the bush-sickness type was known to occur.

The results of the analyses, using concentrated hydrochloric acid for the extraction of the soils, showed a fairly good correlation of low cobalt supply with soils definitely associated with stock ailment. The Glenhope soil, Nelson, and the Kaharoa and Taupo soils of the Rotorua district, all contained less than 2 p.p.m. of cobalt on the dry soil, in contrast to an average cobalt content of approximately 12 p.p.m. for a wide range of Taranaki soils. The Morton Mains soils, however, gave higher figures (4 p.p.m. to 5 p.p.m.) than might have been expected considering the proved beneficial properties of cobalt supplements for stock on these soils.

Furthermore, certain soils which hitherto have not been associated with stock ailment gave some very low figures for cobalt. The pakihi soil of Westport is an illustration of these departures from the general correlation. This soil, which so far has not been associated with stock ailment, was found to contain less than 1 p.p.m. of cobalt, resembling very closely the Glenhope granite soil in cobalt status.

The results which have been obtained suggest that availability of soil cobalt must be a factor of importance in determining the incidence of stock ailment. Further elucidation of the position is likely to be dependent on the devising of chemical methods for the estimation of available cobalt in soils.

General.

Dr. J. K. Dixon has continued in charge of the soil laboratory and has been responsible for much of the work included in this report. He has been ably assisted by Messrs. A. C. Harris, M.Sc., L. Hodgson, K. Frater, and J. T. Corder. Miss E. B. Kidson, M.Sc., working under the technical direction of Dr. H. O. Askew, has been responsible for the cobalt surveys of New Zealand soils.

SOIL SURVEY OF THE REDCLIFF IRRIGATION AREA, SOUTH CANTERBURY.

By J. K. Dixon*, Cawthron Institute, and K. S. Birrell, Public Works Department.

Introduction.

The irrigation project is situated on the north bank of the Waitaki River, about fifteen miles from Waimate and twelve miles from Glenavy. The area is located on an old terrace level of the Waitaki River on which has been deposited alluvium not only from the Waitaki River, but also from wet-weather streams draining the neighbouring hillsides. In Glinka's classification the soils would be classed as skeletal, although in some cases mild podsolization may be present. The rainfall is of the order of 20 in. per annum.

Rainfall data for 1934–35 are as follows :—

	In.		In.
December, 1934	1·55	July, 1935	1·09
January, 1935	1·73	August, 1935	0·41
February, 1935	1·85	September, 1935	0·55
March, 1935	3·02	October, 1935	1·62
April, 1935	1·35	November, 1935	3·39
May, 1935	0·58		
June, 1935	1·55	Total	18·29

Regular soil-moisture observations by the Public Works Department made over the last two years show that during the summer months considerable soil-moisture deficiencies occur, particularly on some types of the Waikakahi Series and on the stony silt loams of the Waitaki Series. Observations show that these soils may easily reach wilting-point.

Soil Classification.

(1) *Pike's Point Series.*

In this series four soil types are recognized :—

Type.	Description.	Origin.
1	Deep silt loam	Waitaki River.
2	Deep sandy loam*	Waitaki River.
3	Deep silt loam, meadow soil ..	Waitaki River.
4	Deep silt loam	Elephant Hill Stream and Waitaki River.

* Type 1 grades into Type 2 occasionally (*c.f.* 1595).

This series is well exemplified along the Pike's Point Road. The parent material is alluvium derived from greywacke and deposited on a high terrace level of the Waitaki River.

Since the soil material has been deposited by stream action it is to be expected that there will be local variations in texture.

Type 1 has the largest distribution, and a typical profile is—

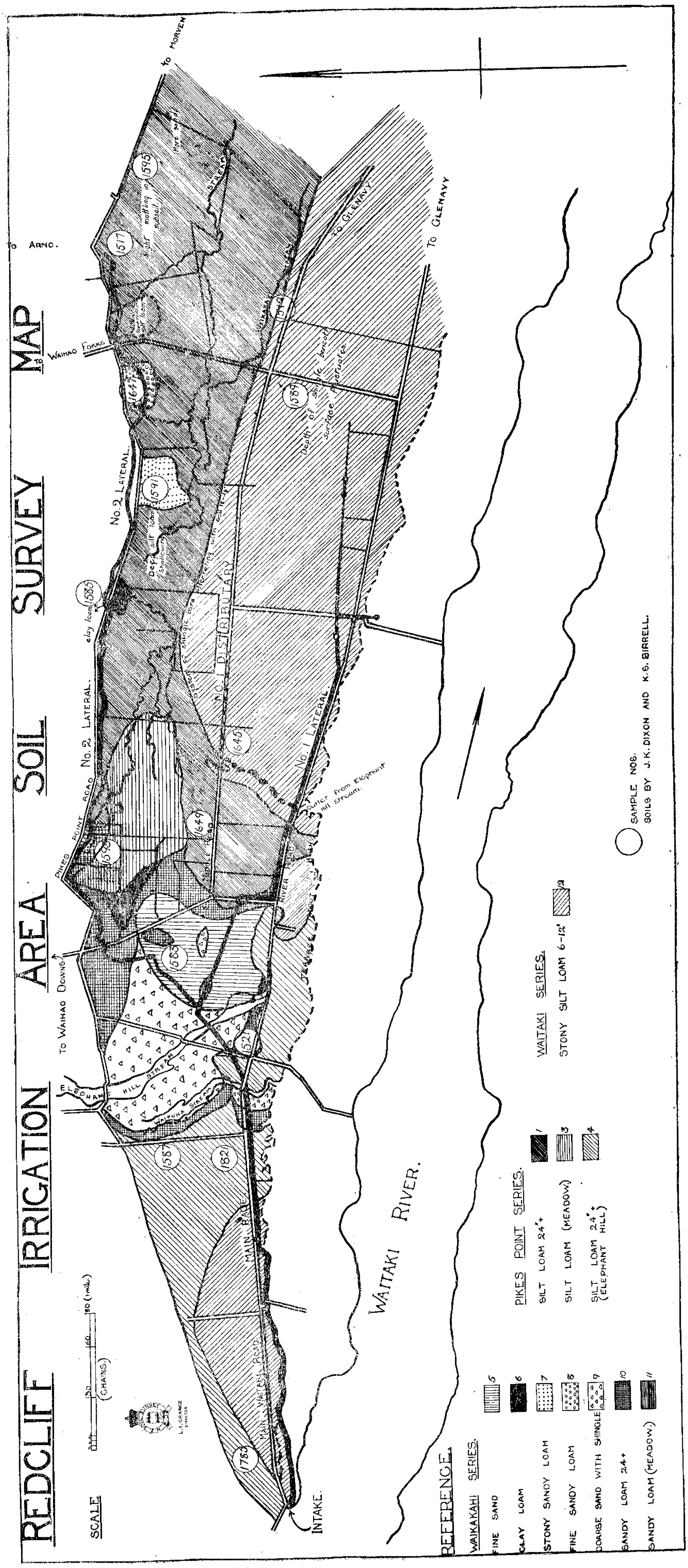
10 in. grey silt loam ;
On 3 ft. + yellow silt loam, occasionally mottled with iron staining.

In certain cases wet-weather streams from the adjacent hills have deposited material on the Waitaki alluvium, so that the resultant soil must be regarded as a composite. At some locations the soils are sufficiently changed to be recognized as a separate type, and these have been picked out and included with the soils of the Waikakahi Series, which are younger than the Pike's Point soils. At the eastern end of the area the subsoil sometimes shows mottling, suggestive of a high water table during parts of the year.

Farther west towards the intake (*e.g.*, 1593) there is a definite meadow type carrying rushes. The centre of the irrigation area is saucer-shaped and the ground-water level is thus much nearer the surface in this locality. The project includes the irrigation of adjoining areas, and it would appear that some increase in drainage may be necessary to obtain optimum results.

An area of silt loam (Type 4) on the western side of the Waihuna Stream (1587, 1821) is very similar to the silt loam occurring eastward along Pike's Point Road (Type 1), but the field evidence indicates that much of the material is derived from the Elephant Stream. This type has therefore been separated from Type 1 to emphasize its different origin, but as far as texture and agricultural development are concerned it can be regarded at present as identical with Type 1.

* Officer of Soil Survey Division, Department of Scientific and Industrial Research, seconded to Cawthron Institute.


REDCLIFF IRRIGATION AREA SOIL SURVEY MAP
SCALE
(CHAINS)
To ARNO.
To MORVEN
To WAIHAO FORKS
To WAIHAO DOWNS
To GLENAVY
To GLENAVY
No. 2 LATERAL.
PIKES POINT ROAD No. 2 LATERAL.
No. 1 DISTRIBUTARY
No. 1 LATERAL
MAIN RACE
WAITAKI RIVER.
INTAKE.
REFERENCE.
WAIKAKAHI SERIES.
FINE SAND 5
CLAY LOAM 6
STONY SANDY LOAM 7
FINE SANDY LOAM 8
COARSE SAND WITH SHINGLE 9
SANDY LOAM 24"+ 10
SANDY LOAM (MEADOW) 11
PIKES POINT SERIES.
SILT LOAM 24"+ 1
SILT LOAM (MEADOW) 3
SILT LOAM 24"+ (ELEPHANT HILL) 4
WAITAKI SERIES.
STONY SILT LOAM 6-12" 2
SAMPLE NOS.
SOILS BY J. K. DIXON AND K. S. BIRRELL.

(2) *Waikakahi Series.*

The following types have been noted :—

Type.	Description.	Origin.
5	Fine sand	Elephant Hill Stream.
6	Clay loam	Hillside.
7	Stony sandy loam	Hillside.
8	Fine sandy loam	Hillside.
9	Coarse sands with shingle to the surface*	Elephant Hill Stream.
10	Sandy loam, 24 in.*	Elephant Hill Stream.
11	Sandy loam (meadow)	Elephant Hill Stream.

* Of no agricultural importance.

The soils of this series are of miscellaneous origin, but they have the point in common that they are of recent formation. The soils are formed from alluvium deposited by the Elephant Hill Stream or by small wet-weather streams from the hillsides. The parent material is mainly greywacke, but in cuttings tertiary sandstones containing occasional deposits of shells are exposed.

The textures of the soils vary from clay loam to shingle, but as these occurrences are of only minor importance in the irrigation area they have all been included in types of the Waikakahi Series.

The lowest area in the project has in the past formed a flood plain to the Elephant Hill Stream, but since a cut has been made to the Waitaki River flooding no longer occurs and the soils are not being added to now by alluvium from the stream. This series overlies the Pike's Point Series, and at one location the old surface soil can be seen about 2 ft. below the present level.

(3) *Waitaki Series.*

Type 12 : 6 in. to 12 in. stony silt loam on shingle.

The underlying material consists of shingle banks thrown up by the Waitaki River, over which has been deposited a veneer of alluvium giving rise to stony silt loams. Systems of shingle bars can be recognized beneath the soil, and the depth of the topsoil in many places is not consistent. At the present stage it has not been considered worth while to separate out such occurrences, although it may yet prove to be desirable, especially for this type, which is most in need of water, since good drainage and a lower retentive power for moisture aggravate the effects of low rainfall.

Chemical and Physical Data.

The mechanical analyses (Table I) show that loams, especially silt loams, are well represented in the area. As silt loams are accepted as the most suitable for irrigation purposes, since they give a good balance between ease of drainage and retentive power for water, the area can be regarded as suited to irrigation. In view of the fact that local configurations favour in certain cases a high water-table, attention must be directed towards the necessity for adequate drainage to ensure the optimum conditions for farm crops. The higher the percentage of stones, gravel, or sand the more often there should be applications of water, but only comparatively small quantities at a time, otherwise there will be considerable washing of nutrients into the drainage waters.

The moistures at the sticky points, an indication of the field capacity for water, show that similar results are to be expected to those at the Levels irrigation area. Silt loams in both cases give similar figures. It should be noted in the case of the soils of the Waitaki Series that stones are sieved out before the estimation is made, and consequently in some cases the holding power for water of the soil *in situ* might only be one half of that indicated by the laboratory determinations.

The chemical data indicate that the Pike's Point and Waikakahi soils are well supplied with phosphate, while the Waitaki soils give a lower figure. Irrigation will justify the use of phosphatic fertilizers on the soils of the latter series, but field experiments will be necessary to ascertain the value of fertilizers on the other types.

There is some fluctuation in the pH figures, values ranging in the topsoils from 4·9 to 6·5. Those soils with a pH below 6·0 should repay liming for a number of crops. Percentage base saturation figures for three typical soils shown in Table III indicate that the soils have already been subjected to leaching. This depletion of bases can be made good by top-dressing.

Available potash and total nitrogen figures are normal. It is hoped that no time will be lost in laying down experiments on the different types. Furthermore, it will probably be desirable, especially on the lighter types, to have repeat experiments every five years or so, for it must be remembered that from now on the soil is to be robbed of its nutrients at a faster rate than hitherto because of losses in drainage water and greater crop yields. It is quite possible that a type showing no response now may definitely respond to fertilizers in a few years' time under irrigation management. The irrigation projects now in hand demand the establishment of a central experimental station for the study of crops, fertilizers, and soil problems attendant on the use of irrigation water.

Acknowledgments.

Grateful acknowledgment is made to Mr. T. G. Beck, Resident Engineer in charge of irrigation works, for facilities placed at our disposal, and to Mr. L. Hodgson, Cawthron Institute, who has made many of the analyses recorded in this report.

TABLE I.—MECHANICAL ANALYSES.*

Laboratory No.	Depth.	Type.	Coarse Sand.	Fine Sand.	Very Fine Sand.	Silt.	Clay.	Loss on Ignition.	Stones.	Texture.
					Pike's Point Series.					
	In.									
1517 ..	0–3	1	0·44	38·84	18·44	24·49	20·57	5·35	..	Silt loam.
1649 ..	0–6	1	1·6	11·95	12·35	38·8	27·9	7·2	..	Silt loam.
1650 ..	9–15	1	1·4	13·45	12·7	35·0	30·3	7·0	..	Clay loam.
1595 ..	0–6	2	0·5	39·6	16·8	17·7	14·7	7·2	..	Sandy loam.
1596 ..	9–15	2	1·4	42·0	16·3	18·0	17·1	3·4	..	Fine sandy loam.
1587 ..	0–6	3	2·2	26·2	18·6	23·8	18·1	6·5	..	Silt loam.
1588 ..	9–15	3	3·2	25·7	21·1	24·8	18·3	4·6	..	Silt loam.
1585 ..	0–6	3	1·9	22·7	20·6	26·6	24·0	7·3	..	Silt loam.
1786 ..	9–15	3	1·9	25·4	22·3	25·7	22·5	4·3	..	Silt loam.
1593 ..	0–6	4	0·9	24·4	16·9	16·95	22·2	13·3	..	Silt loam.
1594 ..	9–15	4	1·05	34·8	24·3	22·0	11·1	3·5	..	Silt loam.
					Waikakahi Series.					
1521 ..	0–3	10	15·26	49·47	9·0	17·75	9·03	3·77	..	Fine sandy loam.
1583 ..	0–6	5	6·6	48·0	14·4	14·3	5·9	5·3	..	Fine sand.
1584 ..	9–15	5	17·5	45·1	11·8	9·7	7·0	4·0	..	Medium sand.
1585 ..	0–6	6	3·5	10·65	7·8	25·2	34·5	15·5	..	Clay loam.
1586 ..	9–15	6	10·0	14·5	9·0	23·6	33·2	5·9	..	Clay loam.
1591 ..	0–6	7	15·8	23·6	4·95	20·8	15·95	14·75	44·5	Stony sandy loam.
1647 ..	0–6	8	0·95	46·7	20·1	17·3	8·85	5·1	..	Fine sandy loam.
					Waitaki Series.					
1519 ..	0–3	12	8·64	24·73	14·38	29·71	22·33	12·05	35	Stony silt loam.
1589 ..	0–6	12	12·1	27·8	10·55	19·75	16·7	11·85	55·9	Stony sandy loam.
1645 ..	0–6	12	7·5	13·35	12·1	27·4	28·3	3·2	47·2	Stony silt loam.

* NOTE.—Results are percentages on an ignited basis and calculated to moisture-free soil.

TABLE II.—CHEMICAL ANALYSES.*

Laboratory No.	Depth.	Type.	Available P_2O_5.	Available K_2O.	pH.	N.	Moisture at Sticky Point.
			Pike's Point Series.				
	In.		Per Cent.	Per Cent.		Per Cent.	Per Cent.
1517	0–3	1	0·048	0·021	6·2	0·27	26·1
1649	0–6	1	0·031	0·013	5·8	..	25·7
1650	9–15	1	0·014	0·007	6·0	..	24·6
1595	0–6	2	0·061	0·017	5·5	..	23·6
1596	9–15	2	0·034	0·006	6·6	..	19·4
1587 .. .. }	0–6	3	0·049	0·017	5·4	0·20	22·9
1819 .. .. }							
1588 .. .. }	9–15	3	0·037	0·008	6·1	0·13	21·6
1820 .. .. }							
1821	0–6	3	0·046	0·020	5·4	..	26·2
1822	9–15	3	0·040	0·010	5·7	..	25·4
1785	0–6	3	0·026	0·016	5·6	..	25·1
1786	9–15	3	0·017	0·007	5·9	..	20·1
1593	0–6	3	0·075	0·026	5·7	..	31·3
1594	9–15	4	0·054	0·011	5·8	..	22·0
			Waikakahi Series.				
1583	0–6	5	0·052	0·032	5·7	0·21	..
1584	9–15	5	0·050	0·013	6·1	0·10	18·7
1585	0–6	6	0·045	0·012	6·7	0·52	32·6
1586	9–15	6	0·047	0·006	7·6	..	23·3
1591	0–6	7	0·059	0·034	4·9	..	28·1
1647	0–6	8	0·034	0·010	6·0	..	23·1
1521	0–3	10	0·039	0·040	6·5	0·16	21·2
			Waitaki Series.				
1519	0–3	12	0·020	0·038	5·5	0·38	28·4
1589	0–6	12	0·023	0·031	5·2	..	27·8
1645	0–6	12	0·029	0·018	5·5	0·35	28·2

* NOTE.—Results are calculated to oven-dry soil.

TABLE III.

Series.	Type.	Laboratory No.	Depth.	Base Exchange Capacity.	Total Exchangeable Bases.	Base Saturation.
			In.	m.e. per cent.	m.e. per cent.	Per cent.
Pike's Point	1	1517	0–3	29·1	14·27	49·1
Waikakahi	5	1521	0–3	24·8	6·89	29·0
Waitaki	12	1519	0–3	28·2	6·9	24·5

THE SOILS OF WESTERN SAMOA.

By L. I. Grange.

The writer in July–August, 1936, spent a month in Western Samoa examining the soils, chiefly in the Reparation Estates. He was accompanied by Mr. W. M. Hamilton, who reported on the agricultural aspects. The investigations were made on behalf of the Department of External Affairs.

The soils of the estates are derived from basalt, the depth of soil lying on rotten rock being about 5 ft. Soil development has proceeded under a high rainfall, from 88 in. to about 140 in. in the plantations; outside the plantations a soil profile was collected where the rainfall is as high as 200 in. In general, the soil is a dark brown-yellow or dark-brown drab. Crumb-structure is usually well developed in the topsoil, and the subsoil is free and powdery to a depth of at least 16 in.

It was extremely difficult to obtain constant profile characteristics which would serve to divide the soils into series. In the main, the classification depends chiefly on chemical analyses. Analyses show that silica is the main constituent that is lost; iron oxide and alumina remain behind. In the most leached soils practically only iron oxide, alumina, and titania remain. The soils are thus undergoing the laterite process of development. This being so, it was thought that total silica in the soil would give a quick lead to classification. It was found that silica ranged from 23·6 per cent. down to 3·0 per cent. within the plantations and that the fertility as observed by growth and yield of tropical crops varied directly with the percentage of this constituent—the least fertile soils were those containing the smallest amounts of silica. This clue shows that certain general characteristics of the soil profile used in the field were correct.

The soil types recognized are—

Saleimoa stony sandy loam.
Falepuna stony silt loam.
Vaitele stony clay loam.
Vaipapa stony clay loam.
Malatula stony clay loam.
Tuasivi clay loam.
Tiavi clay loam.

The soils of the first five types are located in the plantations. The complete list is thought to represent order of fertility, the best being Saleimoa.

Saleimoa stony sandy loam is obviously derived from a young lava flow. It extends from near Saleimoa back to the new Government settlement block. It is the most fertile volcanic soil in Upolu.

Falepuna stony silt loam, located on the western end of Upolu, is another young soil, a fact that is obvious from the great number of angular boulders which lie on its surface. The fertility of this soil is moderate.

The remaining types are of low fertility compared with the above soils.

The Vaitele soil is fairly widespread, occurring at Vaitele, Mulifanua, Central Group, and Fagalie. It has in general a darker yellow-brown compact layer at a depth of 18 in.

Vaipapa soils occur at Vaipapa, near Mulifanua, and at some of the private plantations. A common characteristic of this type is a loose dark-brown drab soil to a depth of about 3 ft.

Malatula soils on the south of Vailele in many places show a dark brown-yellow compact layer at 16 in. below the surface. Tuasivi and Tiavi types in high rainfall areas are still in forest and need not be considered here.

The Vaitele, Vaipapa, and Malatula soils are low in readily available phosphate, but as there is about 1 per cent. of phosphorous pentoxide in fusion analyses there is no doubt a big store of difficultly available phosphate in the form of basic iron phosphate. Potash tends to be low, whereas nitrogen in all the soils is in good supply. Leaf analysis showed potash deficiency, and this is thought to be due largely to the fact that plants are not obtaining sufficient phosphate.

Mr. Hamilton and the writer considered that for coconuts and cocoa the manures which should be used on soil types other than Saleimoa and Falepuna, pending the results of manurial trials, are 2 cwt. to 3 cwt. of basic slag and potash manure at the rate of 50 lb. of K_2O per acre. The most payable results will probably be obtained from the manuring of the Vaitele soil type.

REPORT ON SURVEY OF TUNG GROVES IN NORTH AUCKLAND.

By M. M. Burns and N. H. Taylor.

During December, 1936, and again during February and March, 1937, visits were paid to all the company-owned and privately-owned tung groves in North Auckland. The object of the survey was to analyse and evaluate the factors which have helped to bring about the present condition of the trees and to put forward suggestions as to lines along which an improvement may be brought about.

Location of the Groves.

All the established areas of tung trees are confined to North Auckland, though occasional trees are scattered over the Bay of Plenty and round Auckland City. The major plantings extend from Te Arai, on the east coast near Wellsford, to the extreme northerly point of Parengarenga, with the most extensive acreage near Kaikohe. Although the rate of expansion of the plantings has fallen off considerably in the past year or two the total area planted with tung trees is approximately 5,000 acres, more than nine-tenths of which is company-owned.

Climate.

The climate of North Auckland is quite unlike that of the Yangtse Valley in China, where *Aleurites Fordii* is a native, or of the south-eastern portion of the United States, where it has been fairly successfully established as a commercial crop. The most pronounced differences between the climate of North Auckland and that of either of the great tung-oil-producing areas are associated with temperature and winds.

Temperature.

Whereas the climate of North Auckland is equable, that of the successful tung-oil-producing areas is characterized by marked contrasts between extremely high average summer temperatures and very low winter temperatures.

Table I.—Mean Monthly Temperatures and Rainfall recorded at Auckland, New Zealand, at Gainesville and Tallahassee, Florida, United States of America, and at Chungking,* in Szechwau, and Changteh,* in Hunau (China).

Temperatures.

——	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Year.
Auckland	63·5	66·3	66·7	64·7	61·1	56·5	53·2	51·5	52·0	54·5	57·4	60·2	59·0
	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	Year.
Gainesville	79·3	80·4	80·8	79·0	72·3	62·5	58·2	57·8	58·4	63·7	69·3	75·0	69·7
Tallahassee	79·7	80·2	80·5	78·0	70·0	59·6	54·7	54·1	55·2	61·7	67·6	74·2	68·0
Chungking (6 years) ..	77·4	84·0	85·3	74·7	65·1	57·6	50·5	45·2	49·6	58·6	67·1	72·7	65·7
Changteh (2 years) ..	78·1	86·9	84·9	75·9	61·0	53·2	45·5	35·4	43·7	50·0	59·4	72·7	62·2

Rainfall in Inches.

——	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Year.
Auckland	3·18	2·97	3·57	3·27	3·88	5·15	5·44	5·58	4·61	4·05	4·06	3·59	49·42
	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	Year.
Gainesville	6·57	7·32	6·76	5·65	2·84	2·04	3·22	3·31	2·87	3·21	2·21	3·11	49·11
Tallahassee	6·39	7·38	6·72	5·18	2·96	2·55	4·49	3·95	4·57	4·39	3·32	3·82	55·72

* Compiled from data given in Memoir No. VII, National Research Institute of Meteorology, "A Brief Survey of the Climate of China," by Coching-Chu, 1936.

Both the Yangtse Valley and the Gulf States experience much wider monthly ranges of temperature than does North Auckland. Furthermore, the mean annual temperatures of Tallahassee and Gainesville, both centres of large tung plantings in Florida, are 9° F. and 9·7° F. respectively higher than that recorded for Auckland, which, according to the climatological information available, may be considered representative of North Auckland. The records for Chungking and Changteh, centres of the Yangtse tung industry, approximate more closely with Auckland, but even so the mean annual temperatures recorded for these stations are 6·7° and 3·2° higher. The greatest divergences are confined to the summer months, when the tung tree is maturing fruits.

Regarding the Chinese districts, Coching-Chu writes: "As a consequence of extreme cold in winter and excessive heat in summer, the mean annual temperature range—*i.e.*, the difference between the mean temperature of the hottest month and that of the coldest month—is inordinately large."

These wide differences between the monthly temperatures recorded for North Auckland and for the successful tung-oil-producing areas overseas lends weight to the view that all local plantings should be made from seed gathered from trees in New Zealand which have annually matured a heavy crop of high-quality fruit. The number of such trees is extremely limited and the quality unproven.

In addition to the possible influence of low summer temperatures upon the maturing of the fruit and of the equable winter conditions in delaying the leaf-fall, the possibility of frost damage to the trees during the blossoming season and the setting of the fruit must not be overlooked, especially since quite severe frosts have been recorded during the late spring as far north as Monganui.

Rainfall.

Tung trees are generally considered to have given the best results in sections where the annual rainfall has exceeded 40 in.

Within North Auckland, therefore, there are no planted areas which cannot be considered satisfactory from the standpoint of minimum rainfall. On the other hand, many of the trees which have been planted out on soils with impeded drainage have been seriously affected with a puffing-up and splitting of the bark followed by "die back." There are clear indications that the high annual precipitation which has occurred during the past three years has seriously reduced the vigour of large areas of the trees.

Winds.

Trees in all the groves showed marked symptoms of exposure to strong winds. Indeed, exposure must be considered as one of the three major factors influencing the growth of the trees. Although shelter-belts have now been established on the groves, the stunting effects of long exposure will be difficult to correct.

Indications are that the tung tree is more readily damaged by winds than citrus trees and must be provided with even more shelter. Additional shelter-belts are required on all the groves and the fertility of the soils must be raised, since the greatest damage is always confined to the poorly nourished trees.

Establishment of the Groves.

The most noteworthy observations on the nursery stock were—firstly, the high quality of the stock produced from early importations of American seed as compared with that brought in during the past few seasons; secondly, the high percentage germination and the vigour of the seedlings produced from Australian tung seed, and the variable percentage germination but vigorous seedlings given by New-Zealand-grown seed. The quality of the nursery stock used in the groves has not been uniform, and the rigid selection that is regarded by American growers as being so important has not been practised. The use of two-year-old, uncut, nursery stock has been most extensively adopted, but there is a lack of uniformity between the companies as to the methods of planting out the stock and of shaping the trees. Since the seed sold from the tung groves of the United States over the period 1929–34, and, to a lesser extent, right up to the present season, has been extremely variable, it must be recognized that upwards of 25 per cent. of the older trees will prove to have inherited low fruiting-capacity and will have to be replaced.

Management.

Most of the plantings have been made upon land of rolling topography, and sheet erosion of topsoil, and in some cases the development of gullying, has tended to influence the amount of cultivation given to the groves. As a soil-conservation measure the raising of the fertility of the soils on such planted areas to a point where the establishment of a good pasture sward would be assured is advocated. On unplanted areas the setting-out of the trees on terraced planting lines cut on the contour would be most satisfactory. Cultivation is mostly done with the rotary hoe or by manual labour.

Cover cropping has not been practised to any extent and the quantities of fertilizers applied have been far below those given to trees of the same age in the majority of American groves. Experiments to test the effectiveness of larger applications of various straight and mixed fertilizers, with and without lime, should be established on the most extensive soil types used.

Soils.

In the main the groves which have been planted in North Auckland consist of a mosaic of soil types which are related to topography, vegetation, and previous management, but all types, with but minor exceptions, are comparable in that they are low in available plant nutrients and active calcium. The selection of these impoverished acid soils is traceable in part to the erroneous information on the requirements of the tung tree which was broadcast from unreliable sources in the United States. This information suggested that the tung tree would thrive upon the poorest of acid soils, and accordingly extensive areas of the low-producing lands of North Auckland were planted.

Not only are the soils low in nutrients, but, in addition, nearly all of them drain very slowly. The combined effects upon the trees of low nutrient supply and water-logging of the root systems have been most marked during the past three years, when the rainfall has been exceptionally heavy.

In actual practice the requirements of the tung tree have proved to be almost exactly the opposite to those which were so eagerly seized upon in the early days of the establishment of the New Zealand tung groves. The present view, which has been built upon the results obtained in the tragic years of the haphazard experiment in many countries, is that the tung tree, under suitable climatic conditions, grows and yields in proportion to the fertility and the management of the soil upon which it is grown.

The trees planted out upon the limited areas of freely draining soil types are much superior to those growing on the slow-draining impervious soils, and, given adequate shelter, can be developed into sturdy trees by raising the fertility of the soils through cover cropping with lupins or by the addition of balanced complete fertilizers. The problems to be corrected before the trees planted on the remaining soils can be expected to develop normally are extensive and the remedial measures difficult to apply.

A definite correlation between soil type and the nature of the root systems developed by the trees planted thereon was established. In addition, the incidence of "puffy bark" or swelling of the tissues outside of the wood, followed by die-back of that portion of the tree above the affected section, and of "featherlegging" (production of new growth on the main trunk below the main branches), were found to be related to the soil conditions. There was also good evidence indicating that the practice of mixing blood and bone with the soil packed round the root systems of transplanted nursery stock was partly responsible for the high losses of trees planted on the impervious clay soils through the decomposition of the soft outer tissues of the roots.

On some of the northerly slopes of several of the large groves many trees have been ring-barked by crickets.

Discussion.

The factors which have contributed to the development of the present unsatisfactory state of tree growth may be conveniently divided into four groups: (1) The selection of unfavourable grove sites upon poorly prepared, impoverished soils which are characterized in part by undesirable physical conditions; (2) the use of all nursery stock produced; (3) the planting of the trees upon exposed eroded slopes; and (4) the lack of a definite co-ordinated plan of management.

The unfavourable weather experienced by North Auckland during the past three years has further intensified the effects upon the vigour of the trees brought about by the above-mentioned factors, so that the condition on many of the groves has become progressively poorer each year. Since it has been possible to correlate tree growth with soil types, recommendations on the elimination of areas which must be classified as being wholly unadapted to tung tree culture may be made, and suggestions on methods of raising the fertility level of the most suitable areas put forward.

In view of the present unsatisfactory condition of most of the established groves, and because of a complete lack of knowledge of the adaptability of American seed to New Zealand conditions, it is to be strongly recommended that further planting of tung trees in North Auckland, or in other sections which may perhaps prove to be climatically suited—*e.g.*, Coromandel, Tauranga, or Gisborne—should not be undertaken except upon a purely experimental basis and confined to plots of not more than a few acres established on a soil type that is representative of the whole projected area with respect to fertility, drainage, and exposure.

MOTTLE-LEAF OF CITRUS.

By M. M. Burns, Soil Survey Division, and A. R. Grainger, Department of Agriculture.

The physiological disease known as mottle-leaf has been recognized for a long period in the citrus areas of the United States, but it was not until 1931 that it was shown to be induced by a deficiency of available zinc in the soil, and that sprays containing small quantities of zinc salts would correct the condition. Since the publication of the original papers numerous references have appeared in the agricultural literature of various countries to record the successful treatment of mottle-leaf of citrus, and associated diseases of other crops, by the use of zinc salts.

Citrus groves in many districts in the North Island have been found to contain trees which exhibit physiological symptoms that are closely comparable with those shown by trees affected with mottle-leaf. These symptoms, though not absolutely distinct from those induced by soil deficiencies of magnesium or sulphur, were considered to be sufficiently indicative to warrant the immediate establishment of experimental blocks of affected trees to which zinc sprays could be applied. Additional evidence in support of likely zinc deficiency was gathered from the differences in zinc content of leaves from affected trees as compared with samples taken from healthy trees. These analyses were carried out by the Chemical Laboratory, Department of Agriculture. Accordingly, trial plots were established initially by the Horticulture Division of the Department of Agriculture at Tauranga, and later in co-operation with the Plant Diseases Division of the Plant Research Bureau at Greenmeadows and Avondale, and at Whangarei. Although initial work has been confined to zinc, it is intended to establish a series of field experiments in which the effects of applications of salts of magnesium, sulphur, and others of the so-called minor nutrients can also be checked. It is hoped to lay down these trials in Avondale because of the extensive acreage of citrus planted on similar types in that district together with the widespread occurrence of the mottle-leaf condition on all varieties of citrus and of persimmons.

PUBLICATIONS.

"New Zealand Journal of Science and Technology."

Since May, 1936, the *New Zealand Journal of Science and Technology* has been published monthly instead of bi-monthly as before, in order to provide increased space for the publication of the results of scientific research carried out by the Department and its associated scientific institutions and by other Government Departments and research workers attached to other scientific bodies. Full advantage of the increased facilities for publication in the *Journal* has been taken, sixty-seven scientific papers covering a wide range of subjects having been published by the end of March, 1937.

Bulletins.

The following bulletins were published during the year :—

No. 49 .. An Introduction to the Grasses of New Zealand, by H. H. Allan.

No. 50 .. The Cheese Yielding Capacity of Milk and its Relation to the Method of Payment for Milk for Cheesemaking, by F. H. McDowall (also issued as Vol. XVIII, No. 3 (August, 1936), of the *N.Z. Journal of Science and Technology*).

No. 51 .. The Chilling of Beef for Export, by C. R. Barnicoat.

No. 52 .. Investigations of Feed Flavour in Cream and Butter, by W. Riddet, E. Bruce Levy, J. W. Woodcock, E. R. Marryat, J. N. Hodgson, and P. D. Sears.

No. 53 .. A Preliminary Survey of the Citrus Industry in New Zealand, by W. M. Hamilton.

No. 54 .. Little Barrier Island, by W. M. Hamilton (extracted from the *N.Z. Journ. Sci. & Tech.*, Vol. XVII, No. 2, pp. 465-95; Vol. XVII, No. 6, pp. 717–49; Vol. XVIII, No. 7, pp. 557–78).

IMPERIAL AGRICULTURAL BUREAUX.

The Imperial Agricultural Bureaux were established to act as clearing-houses for the interchange of information between research workers in eight branches of agricultural science throughout the various parts of the British Commonwealth. In New Zealand co-operation with the Bureaux is maintained through the Department of Scientific and Industrial Research, and liaison with the individual Bureaux is effected through official correspondents appointed to deal with specific inquiries. Mr. Nevill Wright, Scientific Liaison Officer of the Department in London, has recently been appointed Chairman of the Executive Council of the Imperial Agricultural Bureaux. Mr. Wright previously held the office of Vice-Chairman.

The Bureaux have continued to be of very great assistance to agricultural research workers in New Zealand through their regular publications and special reports, as well as by supplying information in response to specific inquiries.

A British Commonwealth Scientific Conference was held in London in September–October, 1936, mainly to consider the work, finance, direction, and possible extension of usefulness of the Imperial Agricultural Bureaux; proposals for the formation of new bureaux in dairy science and forestry; and proposals directed to ensure fuller co-operation in scientific research. The New Zealand Government was represented by Professor H. G. Denham, Chairman of the Research Council of the Department of Scientific and Industrial Research; Professor W. Riddet, Member of the Research Council; and Mr. Nevill Wright, Scientific Liaison Officer.

The conference recommended, *inter alia*, that increased finance should be provided by Governments participating in the scheme in order to meet existing commitments and the increasing demand on the services of the Bureaux. Proposals for the establishment of a Bureau of Dairy Science and a Bureau of Forestry were also recommended for favourable consideration by the Governments concerned. Certain other recommendations were made regarding increased finance for specific Bureaux; the necessity for the continuance of research in certain activities aided through the Executive Council—*i.e.*, the transport and storage of foodstuffs, the control of insect infection of stored products, and the utilization of wool—and measures to be taken to secure fuller co-operation in scientific research.

RESEARCH SCHOLARSHIPS.

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

Mr. H. Shattock, M.Sc., Canterbury University College, Christchurch : Relation of Viscosity to Strength of New Zealand Wheat.

Mr. G. I. F. Simkin, M.A., Otago University, Dunedin : An Economic and Psychological Investigation of the Dunedin Confectionery Industry.

RESEARCH WORK AT CANTERBURY AGRICULTURAL COLLEGE, LINCOLN.

Crops and Pastures.

Distribution of Certified Seed Wheat.—The College has continued its activities as a centre of distribution to farmers of certified seed wheat. An arrangement has been made with the Pure Seed Station whereby the latter institution produces nucleus lines of pure disease-free seed of any variety for which there is a reasonable demand. These lines are then passed on to the College, which grows bulk seed for distribution to farmers, who in turn will produce certified seed.

Herbage Plants.

C23 Cocksfoot.—The commercial distribution of the College-bred strain of cocksfoot (C23) has been undertaken by the Farm Advisory Department, and more than 2,000 lb. of seed has been sown this autumn under the Government certification scheme for pedigree cocksfoot.

A further improved strain of this cocksfoot is undergoing propagation and test in plot trials. This strain is built up from eighteen plants from two good families produced by six crosses of C23 offspring.

Phalaris Tuberosa.—In 1936 and also during the past autumn plots of this grass were established both on the College farm and on the light-land farm at Ashley Dene. The establishment of these two areas of *Phalaris tuberosa* on the two different soil types is designed to enable an investigation to be made into the possibilities of this grass for pastures under Canterbury conditions.

Subterranean-clover Investigations.

The College is taking an active part in a scheme to encourage farmers to grow subterranean clover on suitable light land in Canterbury. For this purpose a field day was held, and a pamphlet describing the most successful methods of establishing and managing subterranean clover has been prepared and distributed to over two thousand farmers.

Commercial firms interested in all aspects of Canterbury farming have given financial support to a scheme for establishing a series of trials with subterranean clover on the foothill country of Canterbury. These trials are necessary before we can recommend the widespread utilization of subterranean clover under the climatic and soil conditions of the foothill country.

Strains of Subterranean Clover.—Twelve strains of subterranean clover obtained from Australia two years ago have been under observation for two seasons now. The best of these are Romsey (late), Tallarook (late), Bass (late), Mount Barker (mid-season).

Other strains, particularly the early types, have been almost a complete failure on light land at Ashley Dene. The Grasslands Division of the Plant Research Bureau has co-operated in establishing a comprehensive strain trial on the College's Ashley Dene property.

Establishing Subterranean Clover.—A series of $\frac{1}{4}$-acre plots in duplicate has been laid down at Ashley Dene for the purpose of investigating the establishment of subterranean clover when sown with other species.

Manurial Experiments.

Experiments on the effect of lime on the growth and botanical and chemical composition of pasture which were carried out on an area fairly representative of Canterbury pasture-land have shown the necessity for heavy applications of lime in order to maintain high-producing pastures. The dominance of weeds such as sorrel and the low yield of rye-grass in the absence of clover on the unlimed plot was in striking contrast to the association of dense clover and high-yielding rye-grass on the limed plot. The hay-yield on the limed area was 36 cwt. per acre, as compared with 19 cwt. on the unlimed area. The differences in chemical composition of the pastures on the two plots were in keeping with the botanical analyses, the calcium content of the samples from the unlimed plot being very low.

The effect of lime on lucerne is also being investigated. Quantities of lime ranging from $\frac{1}{4}$ ton to 2 tons per acre have been used. No results are yet available, but marked differences in growth are to be seen.

Sprouted Wheat for Seed.

The value of sprouted wheat for seed purposes has caused some inquiry during this sowing-season. The germination of severely sprouted samples is shown in the following table :—

Group.	Laboratory Germination after Six Days' Drying.	Laboratory Germination after Thirty Days' Drying.	Field Germination.
Green shoots over $\frac{1}{2}$ in. long ..	90·0	57·0	4·0
Green shoots $\frac{1}{4}$ in. to $\frac{1}{2}$ in. long..	90·0	59·0	7·0
Shoots under $\frac{1}{4}$ in. long ..	95·0	80·5	11·0
Shoot just visible	97·0	94·0	24·0

The laboratory germination capacity, which showed a decrease as the seed was dried out, gave no indication of the very low field establishment. However, by machine dressing, these very severely sprouted grains may be removed from a line of wheat. The following table shows the germination

of various commercial machine-dressed lines of wheat which had been harvested from crops showing some degree of sprouting :—

Sample.	Percentage of Sprouted Grains in Sample after Machine Dressing.	Laboratory Germination Percentage.	Field Germination Percentage.
(1) Tuscan	10·0	91·0	81·0
(2) Cross 7	12·0	92·0	80·0
(3) Cross 7	13·0	89·0	76·0
(4) Tuscan	18·0	86·0	73·0
(5) Jumbuck	20·0	75·0	68·0
(6) Cross 7	Unsprouted sample	100·0	92·0
(7) Tuscan	Unsprouted sample	99·0	90·0

The commercial seed from sprouted crops has therefore a lower germination than seed from unsprouted crops. However, the germinations are not unsatisfactory, and the sowing of about 10 lb. of extra seed would compensate for the lower germination.

The Effect of Seed Pickling on Commercial Seed from Sprouted Crops.

The following table shows that the dry-dust pickles have had little effect on the germination of machine-dressed seed from sprouted crops, but the wet pickles have caused an appreciable decrease :—

Seed Treatment.	Wheat Germination.	Barley Germination.
	Percentage.	Percentage.
Untreated	79·0	88·0
Hot water	70·0	72·0
Formalin	14·0	40·0
Clark's	55·0	82·0
Ceresan	79·0	87·0
Copper carbonate	77·0	88·0

Vernalization of Wheat.

During the past few years much interest has been aroused by the method of treating seed to induce early maturity, known as vernalization. Under certain conditions, such as exist in parts of Russia, where winter-sowing of wheat is not practised, this treatment has made it possible to grow winter varieties by sowing them, after treatment, in the spring.

With a view to testing the process when applied to wheat under New Zealand conditions, seed of Tuscan, Cross 7, and Hunter's was submitted to fifteen, twenty, and thirty days' vernalization—*i.e.*, after the seed had been allowed to absorb water to the extent of 30 per cent. of the dry weight, it was held at a temperature of 0° C. to 5° C. for these periods. The vernalized seed was then sown in pot trials, and also under field conditions, in autumn and spring. The results may be summarized as follows :—

(1) Slight increases were observed in field germination of the vernalized as compared with the unvernalized seed, the differences being greater with the longest period of cold treatment.

(2) No difference in vegetative development as indicated by height measurements was observed.

(3) Vernalization resulted in an acceleration of earing by two to three days with Tuscan and Cross 7 and twelve days with the autumn wheat (Hunter's), but even then the vernalized Hunter's was fourteen days later coming into ear than the unvernalized spring variety (Jumbuck).

As a result of this season's observations it is concluded that the process is of no practical value when applied to wheat under New Zealand conditions. If autumn sowing-conditions are unfavourable in Canterbury, there are spring varieties which can be sown and which mature more rapidly than vernalized autumn varieties sown in the spring—*e.g.*, the case of Hunter's and Jumbuck above.

Most experimenters are agreed that the main use of vernalization of seed is in border-line cases where it is risky or impossible to grow a particular crop or variety in a given district. In parts of Russia wheat is such a border-line crop, whereas in New Zealand cereal-growing is now reliable.

On the other hand, the cultivation of maize and soy-beans in Canterbury is rarely successful. An attempt is being made to find a successful method of vernalizing the seed of these, in order to hasten their maturity. Maize and soy-beans were vernalized (Bulletin 17, Imperial Bureau Plant

Genetics, page 88) and sown in September in rod rows, replicated ten times. The results to date may be summarized as follows :—

(1) In each case the field germinations of the treated seed were slightly lower than the controls.
(2) Vernalized soy-beans were in flower three days earlier than the unvernalized. Vernalized maize was five days earlier than untreated.
(3) According to height measurements there were no differences in vigour of growth.
(4) In the case of maize, pollination was not completed until the end of February. In spite of treatment it appears doubtful whether the cobs will ripen. At that time also the pods of soy-beans were still green and immature.

During the coming season vernalization trials will be continued with maize and soy-beans and garden vegetable plants.

Gyrotiller Cultivation and Crop-yields.

During March, 1936, plots on three of the College fields were gyrotilled. These plots have been marked off so that crop-yields can be secured over a period of years, during which time the effect of gyrotilling can be compared with ordinary shallow cultivation. A yield of 61 bushels of Algerian oats was obtained from sample plots gyrotilled to a depth of 16 in., as compared with 56 bushels from those ploughed to a depth of 6 in. without gyrotilling. There appears, therefore, to be a difference of 5 bushels per acre in favour of gyrotiller cultivation, but the increase is not statistically significant. There was an interval of five weeks between gyrotilling and drilling, and this is considered sufficiently long to permit of consolidation and weathering. The cost of cultivation up to the time of drilling has been estimated as £1 6s. 6d. for the non-gyrotilled area, with an additional £2 10s. (1936) for the gyrotilled area. The increased yield of 5 bushels per acre is below the expectations of the contractor, but it is recognized that the effects of gyrotilling may extend over several years, and the results of this season's trials with the first crop must not be taken as the final result.

Crop Diseases.

Cereal Seed Pickling Trials.—During the past few years wet pickling has been giving way to dry-dust treatments. In experiments at the College this year only dry dusts were used, and it was shown that the organic mercurial dusts, Ceresan and Agrosan, which are displacing copper carbonate, gave more reliable and steady increases than the latter in yield of smut-free lines of wheat and oats. That seed-disinfection of oats should be practised much more than it is at present is revealed by a questionnaire to 237 farmers, which showed that 67 per cent. treated their seed and 33 per cent. used untreated seed.

Foot-rot of Wheat.—No serious attacks of foot-rot at the seedling stage were observed in wheat-fields in the Springs County. The highest infection was 5 per cent., compared with over 40 per cent. in past seasons. The present season has been a very favourable one for autumn-sown wheat, and growth has been rapid. Under such conditions foot-root is not a serious limiting factor ; only when crops are checked in growth by an adverse growing-season or by sowing too deeply or on a loosely consolidated seed-bed do the foot-rot fungi in the soil become serious parasites.

Experiments on the effect of time of sowing and depth of sowing on foot-rot in wheat showed that, where there is heavy infestation with the disease, winter-sown crops are more severely affected than those sown in spring, and the deeper the seed the more predisposed is it to attack.

Crop-disease Survey.—With a special grant made by the Department of Scientific and Industrial Research, a survey has been made of the distribution of certain crop-diseases. The area investigated embraces all counties from Cheviot and Amuri to North Otago. Five hundred and eighty crops of wheat, 245 crops of oats, thirty crops of barley, and various crops of rye-grass, cocksfoot, lucerne, and peas were examined. Information has been obtained on the occurrence and degrees of infection of stem rust, leaf rust, loose smut, covered smut, mildew, and take-all of the cereal crops. The results of the survey are being prepared as a special report.

Entomology.

The investigation of the insect and mite pests and vermin of grain-stores and flour-mills was concluded during the year. A report was submitted and recommendations made.

A summary of the results of an ecological investigation of soil fauna was published. This investigation demonstrated that the lucerne flea (*Sminthurus viridis*) did not occur in the areas worked, although a closely related species, which at times is regarded as almost as serious a pest in Australia, was present in Canterbury pastures.

Biological control work on diamond-back moth has been extended to the South Island. A consignment of *Angitia cerophaga* parasites has been introduced into a glasshouse at Irwell, where large numbers of the host insects have been bred on cabbage and rape plants. It is expected that large numbers of parasites will be available next spring if they are successful in passing the winter in an unheated glasshouse under the climatic conditions prevailing in Canterbury.

Field collections of diamond-back moth pupæ and larvæ were made in the vicinity of Lincoln with a view to gaining exact data on the degree of parasitism prevailing in the South Island due to the native insect *Angitia lateralis*. It is already evident that parasitism occurs to a considerably higher degree in the South than in the North Island.

An investigation into the " wheat bug " problem of Otago was undertaken. A survey of the affected locality was carried out, and collections of sucking insects from wheatfields were made. Various bugs which were capable of damaging wheat were experimented with on growing wheat at the College, and it was shown that three species of bug, two being native to New Zealand and one cosmopolitan, attacked wheat. Baking-tests showed that the wheat-samples affected by the insects

experimented with produced the condition known as "sticky dough." The insects responsible for the condition were *Stenotus binotatus*, *Hudsona anceps*, and *Nysius huttoni*. An account of this work has been prepared for publication and is now in the press.

A beginning was made with the survey of the Hessian fly problem in Canterbury.

Farm Advisory Service.

This work has been carried out on the lines described in previous reports. The quantity of work accomplished shows a distinct increase, especially in connection with inspecting, reporting, and valuing farm properties on a productive basis for the assistance of parties going before the Adjustment Commission.

The preparation of College pedigree cocksfoot (C23 strain) on a basis calculated to benefit the College financially has been initiated. To ensure a sound and rapid development, this improved pasture-plant is being grown for seed-production mainly on farms already under complete or co-operative supervision.

Farm Economics.

During the past year, with the co-operation of Messrs. J. R. J. Fleming, A. F. Greenall, C. E. Ballinger, V. B. Wallace, and D. R. Wilkie, a large-scale investigation of methods of land-utilization, management costs, and returns involved in farming in Ashburton County was undertaken. The report, which is now being prepared for publication, covers, on the lines of the Springs County survey, a general land-utilization survey of the main types of farm land for the plains area of the county, together with a detailed description of the main points of management for each grade. Producing-values of the land for an average farm on each major grade of land were also determined, and, in addition, the contract costs of performing most farm operations and growing most crops. Surveys of the main farm-management methods and practices adopted in cocksfoot- and wheat-growing were also carried out. A similar survey for the mountain area of the county was also carried out.

The data arising from these surveys should prove useful to valuers, supervisors of farm credit advances, farm advisers, and for mortgage-adjustment purposes, as well as providing a basis from which variations in management consequent on the introduction of irrigation can be measured. The whole county comprises an area of one and a quarter million acres carrying one million sheep, and it has the largest wheatgrowing and the second largest cocksfoot-growing area of any county in New Zealand.

Animal Husbandry.

In the commercial fat-lamb-raising flock six crosses were made. At three separate killings a record was kept of the number of lambs of each cross killed, and the pelts from each cross were made available to the Leather Research Chemist (Department of Scientific and Industrial Research) for experimental purposes.

Demonstration Controlled Grazing Area.—The grazing on this area was carried out chiefly with old broken-mouthed ewes to determine the possibility of maintaining such ewes for a further season on a dry-feed diet during the winter. While the ewes produced reasonably well, there are definite limitations to the adoption of the practice under general farming-conditions.

The results obtained from the system of controlled grazing adopted for this area—*i.e.*, a fixed number of stock rotated round a number of fields and surplus growth saved as hay or ensilage for winter feeding—have shown the advisability and desirability of controlled grazing. The chief features may be summarized as follows:—

(1) Controlled grazing judiciously carried out will improve a pasture without the aid of top-dressing, but a still greater improvement results from the combination of the two treatments.
(2) The maximum results are obtained from top-dressing only when controlled grazing is practised.
(3) That it is possible to maintain sheep in a perfectly healthy state on dry fodders in the winter, provided they are carefully rationed.
(4) That under careful management heavily stocked areas do not necessarily become "sheep sick."

Reproduction and Foetal Development.—During the year work was begun on certain aspects of reproduction and fœtal development, including some preliminary investigations on artificial insemination of sheep; the length of the gestation period in ewes; and the weight of the fœtus, fœtal membranes, and fluid at various stages of development. Fœtuses were collected at approximately fortnightly intervals.

Recording Work with Sheep.—The work of weighing and recording the fleeces of all stud sheep has been continued. All lambs were weighed and tagged at birth, and a record kept of their parentage. They were also weighed at weaning. This work, which necessarily entails the keeping of complete pedigree records for each sheep, is proving useful in a number of ways. In the course of another generation or two the records should yield valuable information on the question of the production of twins.

Animal Nutrition.

Losses in Haymaking.—Further experiments have been carried out to study, under Canterbury conditions, the losses which take place in haymaking and also the effect of cutting hay at different stages of maturity. This work consisted of weighing the material in the field, at cutting, at baling, and, later, after storage prior to feeding to the stock. Chemical analyses of the hay have also been made, and digestibility experiments with sheep have been continued to investigate changes in quality of the material collected.

Artificial Drying.—A small preliminary experiment in artificial drying has also been carried out. For this purpose the experimental wool-drier installed at the College has been used.

Mineral Metabolism.—Metabolism studies to determine mineral balances have been continued. Interesting results are being obtained with certain foodstuffs, and full details will be published later, when all the analytical data are available.

Pig-feeding Trials.—Further feeding-trials have been carried out in order to compare the feeding-value of new grades of meat-meal with the standard meat-meal hitherto produced. Feeding-trials with mangels have formed part of a scheme for studying means of reducing feeding-costs in pork and bacon production.

Litter Recording.—Litter recording has been continued with the four breeds of pigs in the College herd—namely, Large Blacks, Berkshires, Tamworths, and Large Whites. This work has now been carried out by the College over a period of ten years. During the last six months the work has been extended to include the system of recording recently inaugurated by the Department of Agriculture, and in future will be carried on in collaboration with officers of that Department.

The Nutritive Value of Lucerne Juice.

In connection with preliminary investigations carried out at the College on the artificial drying of grass, lucerne, and other crops, the practicability of partial drying by pressure, prior to heating, has been studied. The most satisfactory method of treatment has been to macerate the material first and then use either a press or pass the macerated lucerne through rollers. In both cases nearly 50 per cent. of the total weight of the original material was removed as lucerne juice. With more efficient methods of extraction it should be possible to increase this. On analysis the juice has been found to be richer in protein minerals and carbohydrates than skim-milk, and would undoubtedly have a high vitamin content. This method of treatment may offer distinct possibilities in future developments in the artificial drying of grass, lucerne, and other crops. The liquid extract, possessing valuable nutritive and tonic properties, should prove very useful where poultry and pig-farming are carried out on an intensive scale, or as a supplement to animals in areas where nutritional deficiencies exist. Recent reports from England indicate that this method of treatment may have commercial significance in any future developments which may take place in New Zealand.

Milk Fever.

Field and laboratory investigations have been continued in the study of outbreaks of milk fever in ewes and in cows under Canterbury conditions. Continued success has been obtained with injections of 20 per cent. calcium gluconate dissolved in 5 per cent. boric acid solution. Subcutaneous injections have proved as effective as intravenous injections when treating ewes.

Sorrel Poisoning in Ewes.

During the last season a number of outbreaks of sorrel poisoning occurred in Canterbury. There have been isolated cases in the past, but losses have been small compared with those of the 1936–37 season. Growth of sorrel was particularly vigorous during the season, and this factor, associated with abnormal climatic conditions conducive to a high oxalic acid content, was undoubtedly responsible for the trouble.

Biochemical studies have been carried out on affected animals. In all cases the lime content of the blood had been reduced considerably below the normal. Injections of calcium gluconate were used. The success of the treatment has been extremely satisfactory. The mortality among affected animals which have been treated has been only 5 per cent. Many of those which recovered were comatose prior to injection with the solution.

As a result of a combined field and laboratory investigation of sorrel poisoning in ewes, it is felt that the following recommendations can be made:—

(1) Ewes producing milk for lambs should be kept off paddocks containing a large proportion of sorrel.

(2) Where it is not possible to avoid grazing paddocks with sorrel, it is suggested that the grazing would be best carried out towards the evening and preferably during hot, sunny weather. The oxalic acid content of the sorrel should be lowest under these conditions.

(3) Where an outbreak of sorrel poisoning does occur, all unaffected animals should be removed from the paddock into one free from sorrel, and the affected animals treated by injecting a 20-per-cent. solution of calcium gluconate under the skin of each animal. Where injections cannot be made, inflating the udder with air may effect a cure.

(4) In those areas where outbreaks of oxalic acid poisoning have been serious, it is suggested that continuous cropping with wheat has helped to develop the trouble. Restoration of the soil fertility by heavy liming and an alteration in the crop rotation might be advisable.

DOMINION LABORATORY.

The work of the year consisted almost entirely of chemical analyses and investigations undertaken for various Government Departments.

The numbers of samples received from the various Departments were :—

Wellington (Main Laboratory) : Customs, 256 ; Police, 61 ; Geological Survey, 164 ; Main Highways Board, 288 ; Mines, 109 ; Health, 2,943 ; Post and Telegraph, 47 ; Research, 206 ; Public Works, 33 ; Railways, 19 ; Stores Control Board, 4 ; Agriculture, 50 ; Defence, 18 ; Prisons, 342 ; Government Printing Office, 14 ; External Affairs, 17 ; other Departments, 191.

In addition to these, 5 samples were received from municipal and other local bodies, and 82 from miscellaneous sources, a total of 4,849.

Auckland (Branch Laboratory) : Agriculture, 10 ; Customs, 1 ; Defence, 2 ; Health, 3,198 ; Lands and Survey, 2 ; Justice (Police), 145 ; Post and Telegraph, 9 ; Public Trust, 14 ; Public Works, 74 : Total, 3,455.

Christchurch (Branch Laboratory) : Health, 2,444 ; Justice (Police), 147 ; other Government Departments, 23 ; Local bodies and miscellaneous, 22 : Total, 2,635.

Dunedin (Branch Laboratory) : Health, 1,090 ; Justice (Police), 62 ; Agriculture, 14 ; Public Works, 1 ; Scientific and Industrial Research, 11 ; Railways, 5 ; Post and Telegraph, 2 ; University Medical School, 6 ; miscellaneous, 1 : Total, 1,192.

The total number of 12,132 samples was received in the main Laboratory and the three branches.

Customs.

The majority of the 259 samples examined for this Department were analysed for approximate composition as a guide in classifying for tariff purposes. A number of materials were examined to ascertain if they complied with the regulations under the Sale of Food and Drugs Act. In cases of non-compliance importation and sale would not be allowed.

Police.

A large number of diverse materials were examined for the police in connection with criminal investigations, and various members of the staff were consulted in cases where their special knowledge might be of assistance.

Wellington.—In each of two cases of poisoning strychnine was found.

A number of samples were examined in connection with alleged illegal sale of liquor.

In a case of suspected incendiarism several samples of fabric were found to have been soaked with kerosene.

Various drugs were analysed in connection with cases of attempts to procure abortion.

A special investigation was made in a case where deceased had taken a very large known quantity of barbitone (veronal). A number of organs from various parts of the body were examined and it was found that the barbitone was very uniformly distributed.

In a "hit and run" case minute green patches on two overcoat buttons of the deceased, and a dull streak on the mudguard of the accused's motor-truck were submitted for examination. It was shown that the green patches on the buttons corresponded with the green paint on a bent bar of the truck. Scrapings from a number of points of the dull streak on the mudguard all gave the characteristic smell of burning rubber, when carefully heated over a small flame. No similar smell was observed with scrapings from any other part of the mudguard. Smears were then made on the mudguard with the rubber grip of deceased's motor-cycle handle and scrapings from these all gave the smell of burning rubber when heated. It was found, however, that after a period of three weeks no such smell could be obtained from these or the original smear. This was probably due to oxidation changes in very thin deposits of rubber. It was therefore concluded that the original smear could not have been more than three weeks old when first examined.

A number of samples of blood and urine were examined for alcohol.

Auckland.—Of the investigations for poisons there was one case each where nicotine, veronal, luminal, and chloral was isolated. Numbers which had been filed off several stolen bicycles were made visible by using a solution of copper chloride in hydrochloric acid containing 5 per cent. of glycerine, the solution being kept saturated by a freezing mixture until application. A small reservoir of dental sheet was made round the number and the solution applied for several short periods.

In the case of a forged receipt which was said to have been through the washtub it was possible to show by means of absorption of eosin from ether by the paper fibres that as little as thirty seconds immersion in water would have removed the sizing of the paper.

A preparation sold as aluminium solder was found to be a mixture of 8 per cent. aluminium powder with melted sulphur and quite useless for the purpose of soldering aluminium.

With a forged pa-ka-poo ticket it was found possible from an examination of the ink and paper to discover the method used by accused.

Christchurch.—The following substances were present in exhibits submitted for toxicological examination : Friar's balsam, Glauber's salts, alcohol, methylated spirits, chloroform, ether, and arsenic.

Friar's balsam had been used in a case of attempted suicide. Glauber's salts or sodium sulphate, a definitely mineral salt, was the main constituent of a "herbalist's" remedy.

In connection with two cases of criminal abortion, numerous medicinal preparations and appliances were examined.

Seven samples of liquor were examined—viz., ale (1), hop beer (1), and cider (5). The cider, which contained 14 per cent. to 20 per cent. of proof spirit, was on open sale in single bottles in various unlicensed premises in Christchurch.

Four cases of animal poisoning were investigated. In one case a horse had been poisoned with grain impregnated with arsenic.

In an inquiry regarding the death of two dogs and illness of two men a lengthy investigation of foodstuffs, including venison, was necessary, the conclusion being that the case was one of bacterial food poisoning.

The death of a number of pigs was finally attributed to mangold poisoning. Examination of the pigs' viscera did not reveal the presence of appreciable amounts of oxalates, and the poisoning was most likely due to nitrates and nitrites present in the mangolds. Several other such cases have been reported from time to time.

The most important of these investigations related to the death of 200 sheep. It was thought that they had been poisoned with strychnine, but an examination of two sheep negatived this. It was found that the feed had not been digested and had formed into hard lumps causing an impacted condition of the bowels. This resulted from the dry condition of the pastures in use. When removed to green pasture other sheep similarly affected rapidly recovered.

Dunedin.—A number of samples of alcoholic liquors were analysed in cases of illicit sale of liquor.

Several samples of urine were examined for alcohol in connection with a number of police investigations.

In recent years several cases of malicious poisoning of horses with strychnine have been investigated, and during this year, it is noteworthy that in one case the strychnine was associated with red dye, as required by the Poisons Act, 1934. This would indicate that the poisoning was not accidental.

In a case of accidental poisoning the poison was promptly identified as sodium silicate, and the patient after appropriate treatment made a good recovery.

Department of Health.

Milk.—A total of 5,934 samples of milk were examined at the main Laboratory and the three branches.

Wellington: Of 1,678 samples taken in Wellington City and suburbs, 4 were deficient in fat, 10 contained added water, and 9 were stale. Of the watered samples 4 were from one vendor. The percentage of samples not complying is again very small, so that the Wellington supply still maintains its high standard.

From the country districts, which include Nelson, Marlborough, Wellington Province (except Wellington City), Taranaki, Hawke's Bay, and Gisborne, 572 samples were examined. Of these, two were deficient in fat and two contained added water.

Auckland: The total number of 2,556 samples is 300 less than last year, due to the cessation of sampling in Auckland City for three months during the spring.

The number of samples with added water is higher than last year and this is due in part to samples taken from hotels and restaurants.

An interesting case of low solids and freezing-point indicating added water was investigated, where the milk in a retail dairy was kept in a cabinet below freezing-point so that the first customers obtained the milk concentrated by freezing and the latter customers the diluted milk. A prosecution was taken to draw attention to this form of unintentional adulteration.

A comparison of the New Zealand official reductase test with the English method of inverting the tube every half hour has been carried out during the year and has indicated that it will probably be desirable to adopt the English modification.

The phosphatase test for pasteurization has been continued throughout the year.

Christchurch: A total of 2,300 samples were examined, of which 1,418 were from Christchurch City and Suburbs, the remaining being from the provincial districts of Canterbury and Westland.

Christchurch City and Suburbs: The percentage of samples not complying with the standard was 4·3, as against 6·8 for 1935.

In this connection it should be pointed out that more than one-third of the samples not complying were naturally poor milks slightly deficient in solids other than fat, and if these are excluded the percentage not complying is only 2·7.

The sale of naturally poor milk which does not comply with the legal standard for solids other than fat presents a somewhat difficult problem in Canterbury and also in Auckland. It must be taken into account that the legal standard of 8·5 per cent solids other than fat is considerably below that of the average quality milk, which is 9·0 per cent.

As stated in previous reports, it matters little to the consumer whether milk is naturally poor or is an average milk made poor by the addition of water. It has also to be considered that low-testing milk costs proportionately less to produce on a quantity basis than high-testing milk.

The legal minimum requirement for the reductase test is that the milk shall not decolorize the methylene blue in less than three hours, but the percentage of samples reducing in five hours or under was only 3·4. This indicates that the legal minimum could with advantage be increased to five hours.

Outside Districts: The number of samples examined was 882, of which 598 were from Canterbury and 284 from Westland. Reductase tests were made of samples from several towns outside Christchurch, including Timaru, Greymouth, Ashburton, Rangiora, and Kaiapoi, and the results indicate a satisfactory position regarding the bacteriological quality of the supplies.

Dunedin: A total of 445 samples were examined, on the whole with satisfactory results. The number submitted for analysis could, however, be increased three to four times with advantage.

After a period during which no milk samples were collected in Invercargill, sampling was commenced in August by the City Council. The results were rather striking. Of the first 22 samples examined, 3 contained added water, 1 was stale, 2 were seriously deficient in milk fat, and one contained visible dirt. Of the remaining 38 samples collected later in the year only two were deficient. The deterrent effect of regular sampling is obvious. From Oamaru, where sampling is regular, 96 samples were examined, none of which failed to comply with the standard.

Reductase Test.—As stated in the report for 1935, this test was reported on by the Ministry of Health, Great Britain, as the most satisfactory method of controlling the bacteriological quality of milk-supplies. This confirmed the results of experience in New Zealand extending over twenty years.

During 1936 reductase testing was extended to several of the larger towns outside the four main centres, and it is the intention to further extend it as circumstances permit.

The milk supplied to schools is being tested to ensure that it is of satisfactory quality from both the nutritive and bacteriological points of view.

The phosphatase test, which when newly introduced about two years ago was thoroughly investigated and adopted as a routine test in the Auckland branch laboratory, is now used also in the main Laboratory and the other two branches. It is proving of great value in ensuring that the pasteurization of milk has been properly carried out, and is being used particularly for testing milk supplied to schools.

Water.—As in previous years many samples of water from existing and projected town supplies were analysed in the main Laboratory and the three branches.

Sewage.—A large number of samples were examined in connection with the proposed scheme of sewage disposal for Auckland City.

Miscellaneous.—Samples of butter and other goods obtained throughout the Dominion were analysed and with few exceptions were found to comply with the regulations under the sale of Food and Drugs Act.

The investigation of iodized salt in regard to the proportions and distribution of iodide in the salt and the rate of loss of iodides under various conditions of storage was completed during the year. It will now be possible to suggest a form of a container which will prevent loss of iodide from the salt on keeping.

Drugs.—All the available brands of acetylsalicylic acid (Aspirin) sold in tablet form were examined, with most interesting results. It was found that without exception they complied with the standard of the British Pharmacopœia and for practical purposes were all equally pure and of high quality.

In some cases the statements in the accompanying literature would by inference be misleading, such as a warning against purchasing impure aspirin when all the brands sold are of equal purity.

One brand was described as more effective than aspirin, but aspirin is simply a synonym for acetylsalicylic acid and the tablets were sold as such.

Several makes were advertised as "Does not affect the heart." The samples being all of the same degree of purity, this statement if correct would apply equally to the other brands.

The different brands varied widely in price although practically identical in quality, and provide an interesting example of the effect of advertising.

A specially prepared flannel said to possess radioactive properties and therefore to be of value in the treatment of various complaints was found to contain no appreciable amount of uranium or thorium and showed no detectable radioactivity.

"Vitality" pills were found to consist mainly of iron (ferrous) sulphate.

Four samples of medicinal preparations from a Chinese practitioner in Christchurch sold as remedies for epilepsy, blood pressure, &c., were found to contain ordinary B.P. drugs.

A number of samples of air taken in connection with the ventilation of the projection-boxes of theatres, tunnels, and living-rooms were examined for various Departments.

Mines Department.

The Dominion Laboratory has, as in past years, carried out the testing and analysis of mineral samples and mine gases. An investigation was also carred out on stone dusts suitable for use in mines.

Prospectors' samples from all parts of the Dominion have been examined for gold and silver and occasionally for other metals (in one notable case, platinum, in the North Island).

The physical and chemical survey of the coal resources of the Dominion which has been under discussion for some time has been commenced, and officers have been appointed to work under a committee comprising representatives of the Dominion Laboratory, Geological Survey, and Mines Department.

The purpose of the survey is to obtain complete information on the coal reserves of the Dominion; to correlate coal-seams of various localities; and to estimate the suitability of the coals for industrial use, oil production, gasmaking, &c. Preliminary geological work has already been carried out on the Blackburn area, and arrangements are in hand for the provision of laboratory accommodation for chemical analyses and investigations.

Government Stores.

Numerous samples were analysed in connection with the purchase and behaviour in use of various materials for the Stores Control Board, Post Office, Public Works, and other Government Departments. These included coal, oils, soap, rope, disinfectants, paints, stamps, transmitting-tape, carbon tetrachloride, fencing-wire, shellac, soldering-fluid, red lead paints, creosote, water for concrete making, turpentine, and insulating-tape.

An investigation was made as to the effectiveness of suggested methods for reconditioning motor oil.

Several cases of corrosion were investigated and remedial measures suggested.

A large number of paints and other painters' materials were again examined. This work is proving of great value, as the Government Departments concerned know exactly what they are using and are in a position to insist on the materials supplied complying with their specifications.

Housing Construction.—Following upon the initiation by the Government of a policy of housing construction, increasing use is being made by the Director of Housing Construction of the facilities available at the Laboratory for the testing of constructional materials. Among the materials examined were clay and concrete roofing-tiles, sanitary ware, enamelled ware, and paints. Advice was given as to the probable durability or resistance to corrosion of a number of recently introduced materials.

Roading Materials.—A large number of samples of various roading materials were examined for the Main Highways Board to ascertain if they complied with the required specifications.

Gas-inspection.

The gas-supplies of the four main centres and of the other principal towns of the Dominion were regularly examined for calorific value, purity, and pressure.

With few exceptions they were satisfactory in all three respects throughout the year.

The systematic testing of gas-meters for accuracy was carried out as in previous years.

Special Investigations.

Mineral Waters and Fumarole Gases.—During the year the chemical analysis of a further series of mineral waters from the Rotorua–Taupo thermal district was carried out, thus bringing to a conclusion investigations extending over many years. The results have been incorporated in tabular form in Geological Bulletin No. 37, "The Geology of the Rotorua–Taupo Subdivision," by Dr. L. I. Grange.

Early in the year a visit was paid by two members of the staff to the Ketetahi thermal area, Tongariro National Park, where comprehensive physical and chemical investigations were carried out along the lines used by Allen and Day at Yellowstone Park and elsewhere in the United States of America. The results of the investigations were communicated later on in a paper presented at the Science Congress held in Auckland under the auspices of the Australasian Association for the Advancement of Science.

The experience gained at Ketetahi proved useful later on in the year, when one of the staff accompained Dr. Grange to Wairakei and collected gases from two of the fumaroles in the district. The analyses of the condensable constituents of the gases were successfully completed in the Laboratory.

The field and laboratory work carried out during the year has not only directed attention to interesting analytical problems, such as the nature of the sulphur compounds present both in mineral waters and in fumarole gases, but also has suggested directions along which further investigations of thermal areas may with advantage be continued.

Coal.—Suitably equipped laboratory accommodation has been provided for carrying out the chemical and related work required in connection with a general survey of the coal resources of the Dominion.

The information obtained should prove of great value not only for the better utilization of our coals, but also will provide the necessary data should the commercial hydrogenation of coal be considered.

Soils.—The clay fractions from numerous samples of soil have been separated and analysed. The information thus obtained is used by the soil survey in the important work of determining soil types.

A particularly interesting series of soils from Samoa were examined during the year.

Water for Fish Hatchery.—An investigation was made for the Acclimatization Society, Christchurch, with regard to their artesian-water supply at Greenpark, as the use of this water, which emerges from a deep bore, had resulted in serious mortality at the hatchery as compared with the use of stream water.

The artesian water was found to be very abnormal in content of dissolved gases, having a deficiency in oxygen and a large excess of nitrogen. An aerating plant was installed which effected the necessary adjustments of gaseous constituents, and no further trouble with the water was experienced.

Pozzolanas.—Investigations upon samples of pozzolanic materials collected from likely sources by officers of the Geological Survey were continued during the year. Although chemical examination suggested strongly that some of the samples possessed considerable pozzolanic activity, the work could be regarded only as a preliminary survey for the purpose of sorting out samples most likely to be suitable for use as pozzolanas in carefully conducted strength tests.

Bentonite.—Following upon the temporary appointment of an officer to the Department to carry out a survey of the bentonite deposits at Whatatutu (Gisborne), a considerable number of samples were tested in the Laboratory for value as bentonite. Most of the samples, however, proved to be of rather poor grade.

A series of samples from the Porangahau district were examined, the results being distinctly promising. While the investigations to date indicate that bentonite is available which, when carefully hand-picked and prepared, possesses swelling power little inferior to that of imported American bentonite, it will not be possible to decide whether the deposits are of commercial value until a thorough chemical examination of the material has been carried out and commercial trials made.

Spray Materials.—In addition to numerous small investigations on the chemical nature of materials used in connection with plant protection two major subjects were dealt with. These were (*a*) the investigation of the amount of spray residue on cauliflowers, cabbages, and apples sprayed at varying intervals before harvesting and (*b*) the determination of the percentage of pyrethrins in New-Zealand-grown pyrethrum flowers.

The field-work in connection with these investigations was carried out by the Plant Diseases Division of the Plant Research Bureau.

The cauliflowers were sprayed with arsenate only before the flower had formed, and in most cases no residual arsenic was detected. The maximum amount of arsenious oxide found was $\frac{1}{7000}$ grain per pound.

The results on the cabbages showed that of one hundred samples in only two cases did the residual arsenic in the heart of the cabbage exceed $\frac{1}{100}$ grain arsenious oxide per pound, but that with the whole cabbage, when only a short period had elapsed between the final spraying and harvesting, the residue might be as high as $\frac{1}{10}$ grain arsenious oxide per pound.

The pyrethrum flowers were found to give a content of pyrethrins varying between 1.0 per cent. and 2.5 per cent. when analysed by the method of Gnadinger and Carl.

Phormium tenax (*New Zealand Flax*).—The programme of work for the chemical investigation of this plant has been further advanced and attention is being directed more particularly to the examination of fibres for varietal differences.

An account of the composition of the leaf, fibre, and cellulose of the variety known as "Ngaro" has been published in the *New Zealand Journal of Science and Technology*, together with a general discussion of the chemical aspects of Phormium research.

Dyeing of Fibre for Weaving Industry, Niue Island.—At the request of the Department of External Affairs, the Laboratory investigated and advised with regard to a range of dyes suitable for the dyeing of Niue "Fou." The fibre when dyed is worked into a pattern on articles of Native handicraft. The dyes were required to give bright colours, to be as permanent as possible to sunlight and water, to be inexpensive, and of such a nature that the dyeing could be done by the Natives. As a result of experimental work the names of certain British dyes, together with details of the dyeing process to be used and cost of materials, was forwarded to the Department concerned. This work was carried out about two years ago, and subsequently a reply was received, together with samples of the dyed fibre, stating that the results were most satisfactory.

Ragwort.—A method has been developed for the estimation of the total alkaloid content of the plant and applied during the year to analyses of samples of ragwort from material used in feeding trials at the Veterinary Laboratory, Wallaceville. The object is to determine to what extent toxicity and alkaloid content are related, with a view to employing the method of alkaloid determination in a survey of toxicity and its variation in relation to age of plant, season, and locality.

Further work has been done on the problem of the chemical constitution of the principal alkaloid found in ragwort.

Kauri-gum.—A general survey of the industry has been completed. Analyses were made of a series of samples of "chip" gum obtained from 8 in. bores over the more important kauri-gum reserves.

Important progress has resulted in the technology of kauri-gum from experimental work carried out in London by an officer of the Department.

Citrus Fruits.—Work on the chemical characteristics of New Zealand grapefruit was continued during the early part of the year, but was suspended in November to give opportunity for the more urgently required investigations into the methods of curing New Zealand lemons.

The lemon work, now in progress, involved the provision of air-conditioning facilities, and for this purpose three specially designed cabinets, each capable of dealing with some three hundred fruit, were erected in the old Museum building. A fourth cabinet was afterwards added. Fruit treated in these cabinets under varying controlled conditions of temperature, humidity, and ethylene concentration, are examined weekly in order to assess the progress of curing. When the work has been carried to a definite conclusion with regard to air-conditioning, it is hoped to deal with the question of mould-prevention during curing and keeping.

Gas Storage of Apples.—During recent years the storage of apples in atmospheres containing carbon dioxide has been carried on commercially in England with considerable success. This method has several advantages, particularly in that the fruit keeps longer and in better condition in store and remains in good condition for a longer period after removal from storage.

With a view to investigating the possibilities of gas storage for fruit for the local market, experiments have been commenced on Washington and Ballarat apples, both cooking varieties. At present these apples do not keep well in cool storage.

For the purpose of this work a small cool store containing three chambers has been equipped with automatic temperature-control, making available three temperatures. Three atmospheres containing varying concentrations of carbon dioxide and oxygen are used and passed over the fruit which is enclosed in gas-tight steel cabinets.

The gas mixtures are made up and stored in gasholders, each of about 100 cubic feet capacity. Provision is also made for controlling the humidity of the storage atmosphere.

As there are a number of factors which affect the life of apples in gas storage, and as the present accommodation for the work is strictly limited, this investigation will probably cover several years, and further there are a number of varieties of apples to be tested.

Quartz Spectrograph.—During the year the Laboratory obtained a Hilger Automatic Large Quartz Spectrograph. A range of accessories for the use of the arc and spark in the emission spectrography of metals, powders, and solutions was also obtained. A spectrographic laboratory and dark

room were improvised in the accommodation available, and, though not ideal, will serve satisfactorily until suitably designed rooms can be provided in a new laboratory building. Work was commenced on the examination of metals for traces of impurities, principally for the Defence Department. Brasses, cupronickel, aluminium, and zinc spelte have been examined. Antimony and tin have also been determined quantitatively with the rotating logarithmic sector, in lead alloy and so-called tin-foil. Samples of platinum have also been rapidly examined without loss of material. Spectrographic determination of strontium seems to be preferable to chemical methods in the analysis of rocks. Work of this type has enabled the chemist in charge to gain experience in the use of the instrument, and to accumulate the necessary data. It is expected that after the preliminary period, much testing of this type will be rapidly carried out with a corresponding saving of time over chemical methods. The instrument will also be useful in assisting in the solution of problems met with in the general work of the Laboratory, such as corrosion questions. For example, it has already been used in examining galvanized wire suspected of being corroded by salt water. Spectrographic methods are expected to be of value in various special investigations. Work has already been commenced on the detection and determination of trace elements in soils. Another field will be the examimation of mineral waters for minor constituents.

Advisory and Consulting Work.

An increasing demand has been made on the Director and other members of the staff for service on scientific and industrial committees where their special knowledge is of value. Much work has been done in connection with the activities of the New Zealand Standards Institute and in preparing reports on raw materials and industrial processes.

The technical library of the Laboratory has been kept up to date as this is essential if the staff is to keep abreast with the latest advances.

During the year a number of scientific and chemical papers have been published in various journals and several lectures delivered before scientific societies by several members of the staff.

GEOLOGICAL SURVEY BRANCH.

REPORT OF DIRECTOR (Dr. J. Henderson).

During the year ended 31st May, 1937, the Director made official visits to Te Aroha, Ohura, Porangahau, and Featherston in the North Island and to Reefton, Kotuku, Wakaia, Glenorchy, and Bendigo in the South. Accounts of the examinations made at the two last-mentioned localities are included in this report, and a note on the Te Aroha Springs will be published in the *New Zealand Journal of Science and Technology*.

Mr. M. Ongley was chiefly engaged in collecting data for the report on the underground water-supplies of the Napier-Hastings flats published below. He supervised and assisted the field-work in the Dannevirke Subdivision and also helped in the Wakaia Subdivision in which persistent bad weather had retarded mapping.

Messrs. A. M. Quennell and D. A. Brown worked throughout the season in the Dannevirke Subdivision, where a considerable area was mapped in detail.

Mr. E. O. Macpherson, assisted by Mr. M. Gage, continued the examination of the Reefton auriferous lodes and their neighbourhood. Exceptionally unfavourable weather so delayed him that the gold-bearing areas of Kirwan's Hill and the Alexander River have still to be covered. Mr. Macpherson also advised on geological points arising from geophysical work at Reefton and Kotuku.

Messrs. J. Healy and R. W. Willett finished the field-work of the Wakaia Subdivision. In order to complete the mapping of the subdivision they were obliged to stay in the field till the end of June. Mr. Healy paid a short visit to Moeraki on his return to Wellington from Southland. During last winter he had a three weeks' abortive trip in the "Matai" on her visit to the southern lighthouses. This was in an attempt to visit the oil-seepages reported on the coast a few miles north of Milford Sound. Unfortunately the sea was too rough to permit a landing either at Madagascar Beach or Martin Bay. He also made a hurried inspection of a deposit of manganese ore near Otau, twenty miles south-east from Auckland.

Dr. J. Marwick and Mr. H. E. Fyfe assisted Dr. L. I. Grange to write part of the bulletin on the Rotorua district, The former also read the proofs of this report as well as those of the bulletin describing the Wangaloa fossils. He paid a short visit to Wanganui, where he examined the locality from which the Wanganui Museum obtained such well-preserved moa bones. His description of the deposit will appear in the *New Zealand Journal of Science and Technology*. He also named the fossil collections the field officers made in their work.

Mr. H. E. Fyfe was chiefly engaged in a rather detailed examination of the Blackburn section of the Westport coalfield and a preliminary investigation of the Greymouth coalfield. More exact estimates of the quantity and quality of the coal in the ground are now necessary and the work Mr. Fyfe has begun will extend over many years.

Mr. G. E. Harris prepared five photolitho drawings of the Wairoa Subdivision, some thirty sections, graphs, &c., for reproduction, and thirty-three field sheets. He also made tracings, coloured prints, lettered plans, drew diagrams, and did other miscellaneous work, much of it for other branches of the Department.

The thirty-first annual report was published during the year, as well as Palæontological Bulletin No. 15, "The Wangaloan and Associated Molluscan Faunas of Kaitangata-Green Island Subdivision," by H. J. Finlay and J. Marwick. Short papers in the *New Zealand Journal of Science and Technology* were contributed by members of the staff. These were: "Natural Pozzolanas in New Zealand" (J. Henderson); "The Geology of Waimumu Goldfield and Notes on Quartz Conglomerates in Southland" (E. O. Macpherson); "The Wairoa Earthquake of 16th September, 1932 (M. Ongley and others); and "Displaced Limestone Blocks" (N. H. Taylor). Most members of the staff of the Geological Survey attended the meeting of the Australian and New Zealand Association for the Advancement of Science held in Auckland last January. Several contributed papers and the excursions during and after the meeting were enjoyed.

A large correspondence on matters more or less connected with the work of the Geological Survey was dealt with, and samples of ore, rock, and mineral examined. The usual periodicals and other publications were received on exchange and some text-books were purchased for the library.

DANNEVIRKE SUBDIVISION.

By A. M. Quennell and D. A. Brown.

The field-work of the second season on the subdivision was carried out between 10th November, 1936, and 30th May, 1937, by the writers, assisted by Mr. B. H. Mason, B.Sc., of Canterbury College, from 23rd November until 12th February, a total of 175 square miles being mapped in detail. Porangahau, Motuotaraia, and Blackhead survey districts have been nearly completed, while Mangaotoro, Takapau, and Pourerere survey districts have been surveyed in part.

Structure and Physiography.

The structural features of the area can be summarized as follows: Porangahau Range (mainly of Cretaceous rocks) fronts the east coast and extends from the south boundary to opposite Blackhead, a distance of fourteen miles. It decreases in width from six miles in the south to two miles near Blackhead, but the original six-mile-wide structural belt continues north-eastward as a folded and faulted zone in the Tertiary sediments. West of this is the Akitio Syncline, six miles wide, and showing Tertiary sediments only. Its axis extends from the south-west corner of Porangahau Survey District,

has direction 30°, and so far has been established for twenty miles from the southern boundary. The Porangahau has eroded a lowland, the Wilder Depression, from the soft rocks it contains. West of the syncline and extending to the north of Porangahau Survey District is the Whangai Range, which bifurcates to the north. The east extension gives place to an easily-eroded belt of soft early Tertiary mudstone, three miles wide, and extending to just north of Wanstead. There the belt is taken up by the Tangatupara Ranges (adopted name), of Cretaceous argillites, and divided medially by an echelon fault-belt, which is occupied by Tangatupara Stream. West of this belt, and in Motuotaraia Survey District, is a succession of Tertiary beds, mudstones, thick massive Tutamoe sandstones, and the fairly hard Te Aute limestone. These beds dip to the west, some at low angles and some at high angles. Farther west in the Takapau Survey District is a block of Mesozoic (?) greywacke, faulted along its east boundary, and succeeded on the west by west-dipping Tertiary sandstone and limestone.

The Porangahau Range, north of Porangahau Gorge, and east of the Wilder Depression, consists almost entirely of Cretaceous beds, dipping steeply to the west. The sequence—Raukumara–Tapuwaeroa–Whangai—is repeated probably three times, the youngest beds being to the west in each case. The blocks are separated by faults, and are probably broken by minor faults between the formations, possibly also within them. South of the gorge the structure is even more obscure. The Raukumara sandstone appears at one point in the gorge, but in the south the rocks can be referred only to the Whangai and possibly the Tapuwaeroa series. South of Porangahau the range consists of two blocks, with the sequence Whangai–Tapuwaeroa from west to east. The blocks are separated by a fault which has a downthrow to the west. This fault continues south, where for a short distance it forms the western boundary of the Akitio Syncline, the block west of the fault cutting out. A parallel and pivotal fault within the eastern block with a downthrow to the east breaks an erosion surface, and, continuing south-west with its direction of throw reversed, also forms part of the boundary of the Akitio Syncline. The block east of the Mangamaire depression is complex and consists in the main of coarser mudstones and sandstones. These beds, however, are correlated with the Whangai Series. Along its seaward margin occur the bentonite beds, correlated tentatively with the Wanstead Series. Farther south and to the east occur Tertiary mudstones.

The Mangamaire valley stretches to the south boundary along the east side of the Porangahau Range. It is a graben floored with Tertiary let down between Whangai rocks, on the west those of the Porangahau Range, and on the east those of the coastal hills. The fault on the west probably continues north-east along the foot of the wave-cut cliff at the back of Porangahau Beach.

North of Porangahau Gorge the western part of the coastal structural belt consists of inlying faulted blocks of Cretaceous sediments separated from the main Porangahau Range by Weber mudstone. The north-eastern extension of one of these ridges forms the eastern boundary of the Akitio Syncline as far north as has been mapped. The syncline pitches north, where outcrops of hard early Tertiary mudstones indicate its presence. The ridge, beginning as a fault-block, grades northward into a fairly sharp, probably broken, anticline. East of this ridge, in the Blackhead and South Pourerere survey districts, is the canoe-shaped, southern end of a very gentle syncline of Ihungia mudstone, east of which is another anticline, possibly faulted. Another syncline, about two miles wide, occurs to the east. A fault in alignment with the fracture along Porangahau Beach bounds it on the east. The beds east of the fault are Cretaceous in age and complex in structure. Their eastern boundary is a curve concave to the east, and the east-dipping Ihungia mudstone to the east has corresponding strikes. Lying on the mudstone and dipping to the east is white tuffaceous sandstone probably representing the base of the Mapiri Series.

The rocks of the Akitio Syncline are relatively non-resistant Tertiary beds. Minor corrugations occur in the extreme south, continuing from the Eketahuna Subdivision into the area for about two miles. Two anticlines, one on either side of the synclinal axis, are indicated by the outcrops, but their continuation southward has not yet been confirmed.

The harder Whangai and Tapuwaeroa beds of the anticline of the Whangai Range are underlain by a comparatively soft and easily eroded mudstone. The axis strikes 10° east of north and pitches gently south. Faults on each side of the axis have depressed the core, fault-traces showing that recent movements of the same nature have taken place. The western fault-zone continues south as the eastern boundary of the range. North-east from Manawaangiangi Stream the boundary of the range is determined, first by two echelon blocks separated by the eastern of the pair of fault zones, and then farther north-east by the simple dipping of the harder Whangai rocks beneath the Tertiary beds of the syncline. Another echelon block, facing north and faulted from the main range, lies two miles south of the north boundary of Porangahau Survey District. Because of the southerly pitch of the anticline, and the softness of the rocks of the core, erosion has produced a considerable basin open only to the north, and enclosed by the harder Whangai rocks. It is drained by the streams flowing north and east, the latter occupying gorges cut through the eastern limb. West of the anticline the rocks are shattered and the structure is difficult to interpret. A thrust-plane dipping 30° west, and showing yellow-stained lower Whangai rocks thrust over younger white argillites, is seen in the Te Uri Gorge. Older beds in the midst of younger occur in a strip to the west of the anticline. This may be due to faulting, or to folding and faulting. This line is indicated on the surface by a very recent fault-trace in places showing as much as 20 ft. downthrow to the west. Te Uri Stream, where it flows eastward through the range, follows a transverse fault with downthrow to the south and with a possible horizontal displacement.

A belt, three miles wide, of soft Wanstead mudstone with inliers of Whangai argillite extends from the east limb of the Whangai anticline for about a mile north-east of Wanstead. On the east a probable bedding-fault coincides with the erosion surface between the Wanstead and overlying Ihungia mudstone of the Akitio Syncline. On the west, Weber and Tutamoe beds overlie, though the contact in its north-eastern portion is probably faulted.

The Tangatupara Ranges, east and west, composed of Cretaceous (?) rocks, are separated by a series of echelon faults, most of which downthrow to the east. In the north near the Mangatarata Stream the West Range disappears beneath early Tertiary mudstone, overlying which are Recent gravels and sands tilted to the west.

The East Range has a complex anticlinal structure. It lies immediately west of the Akitio Syncline and faulting has played a part in its formation, since quite well-defined longitudinal recent fault-traces are in evidence near its margins, especially south of Tamumu.

The Mount Herbert hills, east of Waipukurau, are also composed of Cretaceous (?) sediments and have a roughly anticlinal structure broken by longitudinal faults. In the Tangatupara and Mount Herbert ranges the faults strike 30° E., parallel to the main trends of the region; the older folding is approximately north-east.

The fault along the east scarp of the limestone-capped Tourerere Range extends north along the east side of Mount Vernon, in which direction a sharp warp replaces it. To the south it has not been definitely established. Numerous recent fault-traces occur in places. The Tourerere Range of Te Aute limestone is traversed longitudinally by a fault, down-thrown to the east, which causes a repetition of the beds. Westward the limestone dips beneath grey sandstones of the Petane Series, which dip beneath the Recent gravels of the Takapau Plains. East of Takapau is a block of Mesozoic (?) greywacke, the strata dipping steeply east. It is bounded on the east by a fault which involves neighbouring Te Aute limestone, dragging it into an easterly dip. This fault lines up with the east-bounding fault of Waewaepa Range. The block is tilted west and Tertiary beds cover it.

Some further features of the physiography are worth noting. Remnants of a peneplain can be seen on Porangahau Range, Whangai Range, and West Tangatupara Range, and between the latter and the coast. Faults break this surface in a number of places, notably on the west side of the Akitio Syncline, in Porangahau Range south of Porangahau, east of Wanstead near Eparaima Hill, and along the margins of the East Tangatupara Range.

Porangahau River is actively enlarging its drainage area at the expense of the Tukituki River in the north and of the Wainui and Akitio streams in the south. This suggests that the coast adjacent to Porangahau River was formed by faulting after the rivers to the north and to the south had established themselves.

The depressed area south of Waipukurau is due to faulting and the tilting of the surface to the west, the resulting fault-angle or series of parallel fault-angles being infilled by Recent and possibly Pleistocene silts and gravels. These latter have been involved in further faulting and tilting. Hatuma Lake has been one result of these very late movements, which are evidenced by the recent fault-traces, one belt of which runs south-west through Waipukurau Township. Another fault-trace runs south-west from the western boundary of the Mount Herbert block.

Stratigraphy.

Mesozoic (?) Greywackes.—The greywackes of the block east of Takapau have not yet been examined exhaustively. The structural relations, however, suggest that this block is the north-east continuation of Waewaepa Range in the Eketahuna district.

Raukumara Series.—The hard, dark, coarse, "cannon-ball" sandstones of Porangahau Range were not found in Whangai Range. A very thick, massive, dark-blue, fairly soft, fine mudstone containing round calcareous concretions with centres of well-developed calcite crystals, some with *Inoceramus* fragments or even complete shells, forms the core of the Whangai Anticline. At least two undescribed species of *Inoceramus*, one closely related to *I. bicorrugatus*, occur. This formation is tentatively correlated with the Raukumara Series.

Tapuwaeroa Series.—Rocks lithologically similar to the beds which were referred to in last season's report as being Tapuwaeroa on the evidence of the *Ostrea lapillicola* fauna in the basal conglomerate, were found overlying the Raukumara beds in Whangai Range. The relation to the underlying Raukumara mudstone is seen in the Tangaruhe Stream section. There the underlying mudstone is overlain by fine glauconitic muds, some coarse mudstone, thin bands of glauconitic sandstone containing belemnites and *Inoceramus* fragments, and a glauconitic conglomerate band. This latter contains pebbles of a dark crystalline, deeply-weathered, igneous rock, greywacke, and the underlying mudstone. In Mangangarara Stream, a large thin-shelled *Ostrea* was found in the conglomerate. Near the top of this set of beds an angular discordance of about 5° is thought to exist. Above these beds is a rusty-grey coarse mudstone, with sandstone bands, and usually dark in colour. The rocks show a sulphur-coloured weathering product and almost invariably smell of oil. Barite concretions, cone-in-cone limestone, and calcareous elongated plant concretions are common. This formation grades through a thickness of a few feet into the indurated mudstone of the overlying formation.

Whangai Series.—The name "Mangatu" for the series lying above the last-described rocks is no longer tenable. The Mangatu Series in the north included beds which are correlated on foraminiferal evidence with beds definitely separable in this area from the indurated mudstones described in last season's report under the name "Mangatu." Foraminiferal evidence correlates beds well down in the Mangatu formation of the Gisborne district with beds which overlie, and are separated by a very definite lithological and stratigraphical break from, the beds so far ascribed in this subdivision to the Mangatu Series. This term, therefore, is too all-embracing and is abandoned for this district. The relation of these beds with the underlying formation is seen only in Whangai Range. There is a gradation from blue-grey rusty mudstone classified tentatively as Tapuwaeroa to the argillites of the Whangai Series. This gradation was not seen in Porangahau Range, although the beds show much the same sequence as they do in Whangai Range. They were described in last season's report.

In Whangai Range the lowest beds which can be definitely assigned to the Whangai Series are hard grey argillites, jointed characteristically, usually with a sulphur-coloured stain. Higher, the

beds become more massive and in places contain spherical calcareous concretions up to 6 ft. in diameter. The overlying beds are more siliceous, and are often banded, like some of the rocks near Kate's Quarry. There is a cherty horizon some hundreds of feet below the top of the formation. The series ends with a greensand which perhaps should be included in the overlying formation.

The Tangatupara Ranges show a different set of beds which are included with the Whangai Series on account of their stratigraphical position and the lithological similarity of some of the beds. In the south end of both ranges the beds are harder, and similar to the harder almost white beds of the upper part of the series in Whangai Range. To the north there is what is at present regarded as a lateral change in the sediments. The rocks of the Waipawa Gorge section are typical of the northern area. They are coarser in texture than the southern argillites, and in colour range from grey to banded yellow and grey. In places dark-chocolate mudstones containing worm tubes grade up from green-grey mudstones at the top of the Whangai rocks; in other localities the chocolate mudstone with greensand above and below overlies the argillites.

Wanstead Series.—Above the rocks just described is a series of beds, the stratigraphy of which is still obscure. Lying above the beds assigned to the Whangai Series on both sides of the Akitio Syncline in the south, and also along the coast south of Porangahau, are grey glauconitic sandstones, fine-grained, green, and grey mottled mudstones, coarse grey black-scaled mudstones, bentonites and bentonitic clays, gypsiferous bands and carbonaceous mudstones. They have been squeezed and folded so that, in the coastal area, the sandstones interbedded with the bentonites are contorted, and their strikes and dips bear little relation to the general structure. On the coast, too, are strongly-cemented conglomerates which may represent the base of the series. There is such a remarkable change in lithology that a break in the succession represented at the base of this series is strongly suggested.

The Wanstead beds of last year's annual report are predominantly light-coloured, fine, flaky mudstones. Their principal exposure is between the eastern bifurcation of Whangai Range and the Tangatupara Ranges, their preservation in this locality probably being due to the non-elevation of this area during a pre-Ihungia erosion period.

Weber Series.—These beds range from light-coloured, strongly calcareous, rather hard mudstones, to darker, softer mudstones with some sandstone. Their relation to the underlying formations is not clearly seen in the field, but from the mapping and from the foraminiferal determinations an erosion interval probably separates them from the beds below. They are completely missing in some localities, notably along some portions of the western boundary of the Akitio Syncline.

Ihungia Series.—The beds of this series rest indiscriminately on the older formations. Where they rest on the Weber formation, as in the south of the Wilder Depression, there is evidence of an angular unconformity. At a number of localities along the eastern boundary of the Akitio Syncline is a basal limestone, which contains fossils that indicate an age consistent with the stratigraphical relations as determined in the field. Pebbles of the underlying Weber mudstone, argillite, and chert from the Whangai rocks, and greensand occur in it. At one locality north-east of Ugly Hill these basal limestone beds attain a thickness of hundreds of feet, and are extremely sandy. The Ihungia beds consist of alternating sandstone and mudstone, and massive mudstone, blue-grey in colour and rather coarser than the underlying Weber beds. On Pukekura (Trig. G) in Motuotaraia Survey District, and on the hill to the north-east of it, is a limestone which has not yet been definitely correlated with the basal Ihungia limestone, but is about the same age and contains the same pebbles. It rests unconformably on Weber beds. Ihungia mudstones occur also faulted among the Tutamoe sandstone beds to the west of Pukekura.

Tutamoe Series.—These beds are hard, massive brown sandstones with occasional thin bands of blue-grey mudstone, and in the Wilder Depression occur small outliers probably resting unconformably on the Ihungia mudstone. They are not found along the axis of the Akitio Syncline as they should be if conformable on the Ihunga mudstones. A considerable thickness of these brown sandstones is located between Pukekura and the Tourerere Range, and they yield numerous fossils allowing of correlation with the beds of the Wairoa Subdivision, the typical fossil being *Struthiolaria* (*Callusaria*) *callosa*.

Mapiri Series.—Beds of hard, white, pumiceous sandstone, typical of the Mapiri Series elsewhere, notably in the Eketahuna Subdivision, occur parallel with the Tutamoe beds in Tourerere Range, and also overlie the Ihungia mudstone north of Blackhead.

Opoiti Series.—Next in order in this area come beds of blue-grey, soft sandstone, which contain fossils indicating affinities with the Opoiti Series of the Wairoa Subdivision. They are separated from the foregoing beds by a considerable angular unconformity.

Te Aute Series.—The Te Aute limestone follows, probably conformably, on the Opoiti beds, the separation being made on lithological and palæontological grounds. The Te Aute limestone is a hard, shelly formation, in some places very sandy and showing cross-bedding. It forms the prominent scarps of Tourerere Range west of Waipukurau.

Petane Series.—Overlying the Te Aute formation are soft blue-grey fossiliferous sandstones which have been correlated with the Petane Series. These beds occur only to the west of Tourerere Range.

Mangatarata Series.—East and south of Waipukurau there occur beds of pumiceous silts with some lignites and sands, interbedded with, and overlain by, thick beds of cemented greywacke gravels. In places, especially to the east near Tangatupara Valley, they contain fragments of Whangai argillite and Weber or Wanstead mudstone. They are involved in the recent fault-movements and are, in general, gently tilted to the west. They occur only in the north of the area and rest indiscriminately on all underlying formations from the Whangai upwards. On the similarity in lithology and occurrence they are correlated tentatively with the Mangahao Series of the Eketahuna Subdivision.

Recent.—The Wilder Depression contains a series of river terraces, difficult to correlate, cut in the Tertiary beds, and overlain by 10 ft. to 30 ft. of argillite gravels. These gravels have come from Whangai Range, probably being supplied in greater abundance at intermittent periods by the huge slips characteristic of the drainage basins of Whangai Range. Argillite gravels to a depth of 40 ft. also cover the cut floodplains of Tangatupara Stream. Recent silts and gravels form the floodplains of the Tukituki and other main streams and partially fill the shallow fault-angles formed by recent movements near Hatuma Lake.

Economic Geology.

Limestones.—Five miles south of Porangahau, and forming Mount Pleasant, is a limestone containing 94·5 per cent. of $CaCO_3$.

A lens of basal Ihungia limestone near Epae homestead, south of Ugly Hill, contains 84 per cent. of $CaCO_3$. Other lenses of this limestone occur in the valley north-east of Ugly Hill and farther to the north-east along the same line.

Some scattered blocks of Te Aute limestone occur in the Mangaorapa district, but as this limestone requires grinding before being used for agricultural purposes the working of these scattered masses would need to be carefully investigated.

The limestone capping Pukekura and the adjoining hill, north of Wanstead, contains 70 per cent. to 80 per cent. of $CaCO_3$. This also requires grinding before use as it is very hard where unweathered.

The Te Aute limestone of Tourerere Range is being worked at Maharakeke for agricultural lime. Analyses made of samples from the north of the present area show a range between 60 per cent. and 80 per cent. of $CaCO_3$.

On Mr. Todd's property, Porangahau Road (near Pukekura), calcareous sinter of high grade occurs, but the soil prevents any estimation of the extent of the deposits. This material should be excellent for the manufacture of burnt lime, as the $CaCO_3$ content, as in all sinter deposits, is probably high.

Clays.—A sample of Wanstead clay showed on testing that it was of no value as a fire-clay or for brickmaking. Its $CaCO_3$ content ranges up to 41 per cent. If carefully selected before working it might prove of value in agriculture. A Weber mudstone sample from east of Wallingford showed 44 per cent. of $CaCO_3$; and a sample of Ihungia mudstone from the Mangaorapa district contained 23 per cent.

Rock Products.—The Cretaceous ridge running north-eastward from Porangahau on the east side of the Akitio Syncline is being quarried for road metal at a number of places. The rock is of poor quality, but there is nothing better in this locality.

Rocks of the comparatively high quality of the Kate's Quarry rock occur along the east side of Whangai Range, notably at the mouth of Tangaruhe Gorge.

The rocks of the Tangatupara Ranges are, in general, too soft for roads; in the south they are harder, but more difficult of access.

Pukekura limestone is good roadmaking material, but, unfortunately, the quarry now operating is working on blocks faulted down to the west. After working through a block the greensand and mudstone below are encountered in the face, and a start is then made at a higher level. Preliminary geological investigation would have obviated this mistake.

The Mangatarata gravels near Waipukurau are being worked in a number of pits. But being near the Tukituki River, which yields an abundance of greywacke gravels, these deposits have not the same importance as they would have if they were farther to the south.

Bentonite.—The bentonite beds discovered by Mr. M. Ongley in 1931 occur in the extreme south-east corner of the subdivision and extend south on the slopes above the sea. Bentonite beds at the same horizon are found on both sides of the Akitio Syncline in the south of the subdivision, and other outcrops have been reported. The only deposit so far giving results sufficiently high for working is the first-named.

Pertoleum and Natural Gas.—The possibility of petroleum being discovered in payable quantities in this region has been much discussed. Some new facts have come to light and these are touched upon.

A gas spring on Mr. Manley's property in the south of the Motuotaraia Survey District, near Ugly Hill, issuing from the contact between the Ihungia and the Wanstead beds, was sampled. The sample consisted of:—

Sulphuretted hydrogen	H_2S	Nil.
Carbon dioxide	CO_2	2·8
Oxygen	O_2	0·5
Unsaturated hydrocarbons	C_nH_m	0·2
Methane	CH_4	91·8
Ethane	C_2H_6	0·5
Nitrogen and inert gases		4·2

From Farr and Rogers' analyses (*N.Z. J. Sci. & Tech.*, Vol. 10, p. 305) this spring yielded gas containing 0·035 per cent. of helium. Springs on Mr. Basset's property, 30 chains, and a mile, respectively, north of Trig. AK, Mangaotoro Survey District, showed on analysis:—

Carbon dioxide	CO_2	0·7	0·6
Oxygen	O_2	0·5	0·4
Methane	CH_4	96·5	94·0
Ethane	C_2H_6	1·1	2·0
Nitrogen	N_2	1·2	3·0

Farr and Rogers detected 0·023 per cent. of helium in the gas from one of these springs, presumably from the second. The spring tested by them had an output of over 5,000 cubic feet per day.

A spring on Mr. Williamson's property, in the Wanstead beds west of Ugly Hill, contained :—

H_2S	1·0	CH_4	88·7
CO_2	0·7	C_2H_6	2·8
O_2	1·1	N_2, &c.	5·2
C_nH_m	0·5		

A spring that smells very strongly of sulphuretted hydrogen occurs at the south end of the East Tangatupara Range, but a sample has not yet been analysed.

A sample of oil sent in by Mr. A. Stewart, of Titree Point, in 1933, showed "17 per cent. of a viscous oil, of which 23 per cent. is asphaltic material." This was found on Porangahau Beach, and possibly came from a submarine seepage. No seepage has been noted on the beach itself.

Possible petroleum source beds occurring in the Lower Whangai and Tapuwaeroa series have been described above and also in last season's report. There are three horizons at which possible source beds exist :—

(*a*) The dark, oil-smelling, yellow-stained mudstones of the Tapuwaeroa and Lower Whangai series.

(*b*) The carbonaceous mudstones closing the Whangai series. The chocolate mudstones near Waipukurau and the dark shales near Waipawa bridge are near this horizon.

(*c*) The carbonaceous mudstone of the Wanstead series.

An analysis of a dark mudstone from the coast south of Porangahau is shown in column (1) and that of a chocolate mudstone north-east of Wanstead in column (2).

	(1)	(2)
SiO_2	68·87	73·58
Al_2O_3	10·08	9·33
Fe_2O_3	3·39	1·80
MgO	0·99	0·73
CaO	0·44	0·27
Na_2O	1·63	0·62
K_2O	1·68	1·40
TiO_2	0·47	0·48
P_2O_5	0·15	0·04
MnO	0·01	Trace
BaO	0·04	0·08
S (Total)	1·32	0·17
Water lost at 105°	3·74	5·33
Loss on ignition	7·30	6·26
	100·11	100·09

There is a considerable thickness of these beds in the south part of the district and they extend westward to Whangai Range. In this range, as described above, the beds are bent into an anticline which pitches to the south and has been open in the north for considerable geological time ; it is also crossed by the transverse Te Uri fault, which makes the structure still more open. No oil-seepages are found, but the rocks smell strongly of oil, and gas springs on or near this structure are found.

The two minor anticlines mentioned above as occurring in the south part of the Akitio Syncline deserve further investigation. The beds on their crests are of Ihungia age, and Tapuwaeroa and Whangai beds may well underlie. The same horizons may be present in depth in the two anticlines continuing Porangahau Range north-eastward. The rocks on the crests are Wanstead on the west structure and Weber on the east.

Another interesting locality occurs south and east of Wanstead where the soft mudstones of the Wanstead Series form a thin cover over the Cretaceous, which appears as inliers in the mudstone. The structure of the underlying Cretaceous rocks is unknown, but the gas springs and probability of the presence of the Tapuwaeroa beds suggest that further investigation is worth while.

The thick bed of sandstone at the base of the Ihungia, north-east of Ugly Hill, may be a possible reservoir bed. This sandstone may have a more general occurrence than is indicated by the surface outcrops. Thick sandstone beds occur below the Weber formation in the south part of the Akitio Syncline, and also in the Tapuwaeroa Series in Whangai Range.

Geophysical Prospecting.

The surface geology has been mapped in considerable detail and structures favourable for oil accumulation indicated. The differences in physical properties of adjoining rocks may be sufficiently marked to allow of geophysical prospecting by seismic or other methods. Gravity determinations across the area and west to the Ruahine Ranges would throw valuable light on the tectonic problems of the area.

The presence of helium in two of the gas springs indicates the probable presence of radio-active substances. Investigation into the radio-activity phenomena of the region might yield valuable information regarding the faults.

THE REEFTON GOLDFIELD.

By E. O. Macpherson and Maxwell Gage.

Introduction.

During the past field season the work of the 1935–36 season in the Reefton auriferous region was continued. A detailed re-examination of portions of the Reefton, Mawheraiti, and Waitahu survey districts was made from camps established at the Big River Mine, at Blackwater, and at Fern Flat, near Cronadun.

As explained in the 1935–36 annual report, the lack of fossils and of distinctive strata in the auriferous rock series renders impracticable the usual methods of geological mapping, and the procedure was to study as many cross-sections of the area as possible from outcrops in streams. The attitudes of bedding planes and fracture-cleavage planes were recorded in an endeavour to build up a comprehensive picture of the generalized geological structure. The establishment of a series of sections was aided by the tendency of larger tributaries of the Inangahua and Mawheraiti rivers to flow in general from east to west, cutting across the strike of the rocks. Sections were sought in the following streams and their main branches: Snowy River, Big River, Blackwater Stream, Waitahu River, Boatman's Stream, and Larry Creek. Information was also obtained from water-races and roads. Special attention was paid to the structure of the gold-bearing rocks in the neighbourhood of known lodes in the hope of solving the question of structural control of the ore-bodies.

Stratigraphy.

As in the area dealt with in the 1935–36 report, the rocks studied were the lode-bearing unfossiliferous quartzite, greywacke, argillite, and phyllites called the "Aorere Series" in Bulletin No. 18, and the fossiliferous limestones and quartzites of the Reefton Series (Devonian). Granite intrusions occupy the region to the east, and the Palæozoic rocks are obscured in places by a cover of younger terrestrial and marine sediments, gravels, and fluvio-glacial beds.

The question of the suitability of the name "Aorere" now arises. It was first used by Hector for Cox's "Lower Silurian" unmetamorphosed slates and sandstones in the neighbourhood of the Aorere River, Collingwood, and correlated with similar rocks at Mount Arthur. However, the term was considerably expanded in meaning in New Zealand Geological Survey Bulletin No. 3 (Parapara Subdivision) to include not only unmetamorphosed greywackes, argillites, and "sandstone-quartzites" and fossiliferous carbonaceous argillites of Ordovician age, but also to cover more metamorphosed quartzites, schists, and marbles. On lithological grounds the greywackes and argillites in the Mount Radiant Subdivision (Bulletin No. 11) were correlated with the Aorere Series, and in Bulletin No. 18 the word was used for the auriferous rocks of the Reefton Subdivision. In Bulletin No. 25 (Collingwood Subdivision) the term is restricted to greywackes and argillites of definite Ordovician age, in the original meaning of Hector, this course being again followed in the maps for Bulletin No. 35 (Motueka Subdivision). Keble and Benson, in a paper on the graptolites of north-west Nelson (*Trans. N.Z. Inst.*, Vol. 60, 1929, pp. 840–63), use the term in a still more restricted sense for only a portion of the Ordovician.

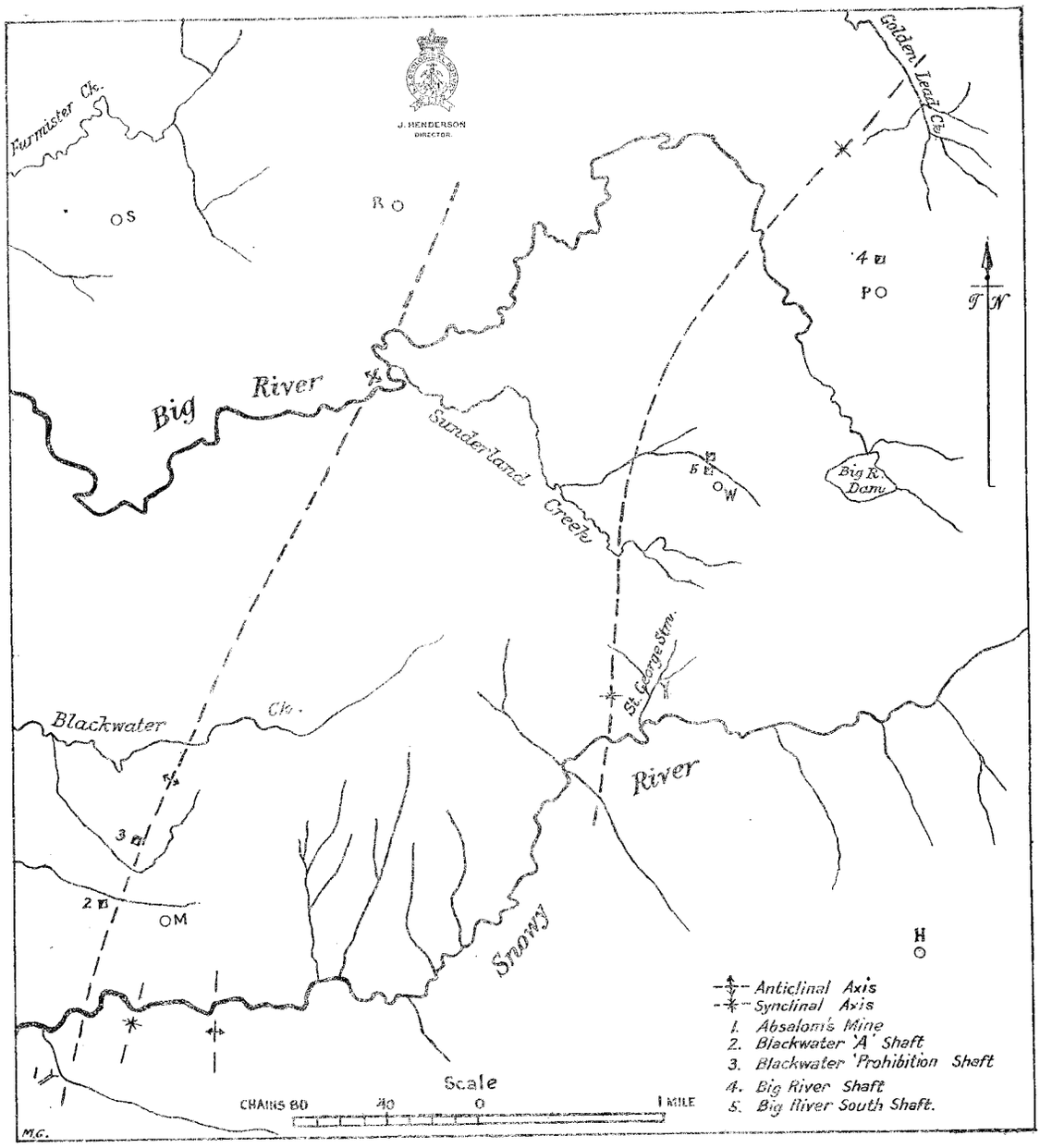
It therefore seems inadvisable to retain the name "Aorere" for the Reefton auriferous rocks. In Bulletin No. 1 (Hokitika Subdivision) greywackes and argillites at Lake Kanieri were named the Kanieri Series, and at Mount Greenland very similar rocks were referred to as Greenland Series in Bulletin No. 6 (Mikonui Subdivision), "Kanieri Series" being abandoned owing to prior use of the term for Tertiary deposits. The Palæozoic rocks at the southern end of the Paparoa Range were given the same name in Bulletin No. 13 (Greymouth Subdivision), and Dr. Henderson considers that it should be extended to cover the auriferous rocks of the Reefton area in place of Aorere Series, as they are of the same lithological type, although differing in trend.

Sections in the Devonian fossiliferous rocks were examined near Big River Mine, in Golden Lead Creek, and in the Waitahu River and two of its tributaries. At none of these localities was the succession within the Devonian clear, and a satisfactory explanation of the relationship of these rocks to the Greenland Series was not established. North of the Waitahu River the Devonian beds appear to lie in two small synclinal structures in the Greenland rocks separated by a small anticline, the whole being bounded on the east by a fault and on the west by a fault that merges to the north into an anticlinal fold. The Devonian appears to lens out northwards before Boatman's Stream is reached. On the evidence of the Waitahu area, the Devonian rocks lie above the Greenland sediments. At Big River there are indications that the Devonian rocks form one or possibly more lenses interbedded with Greenland quartzites, although their structure is very complicated. It was suggested in the previous report that the Reefton Series may be merely a facial change from the normal Greenland type, forming interbedded lenses. Thus some portions of the unfossiliferous sediments may be of the same age as the Reefton beds, having been laid down at the same time in adjacent areas. The intercalation theory has gained support at Big River, and the facts of the Waitahu occurrence also may be explained in accordance with it. No additional fossil localities were discovered.

An estimate of thickness of the Greenland sediments of 17,000 ft. was obtained from the most continuous sections studied—*i.e.*, those in the Big and Snowy rivers. The rocks upon which the Greenland sediments rest were not seen, nor was any upper limit recognizable, so that this figure can only represent an approximate minimum. The monotony of this thick succession is a noteworthy feature. It is generally held that in Palæozoic times processes of denudation and accumulation of sediments were much slower than in more recent geologic periods, so that these Greenland rocks must represent a considerable space of geological time.

Structure.

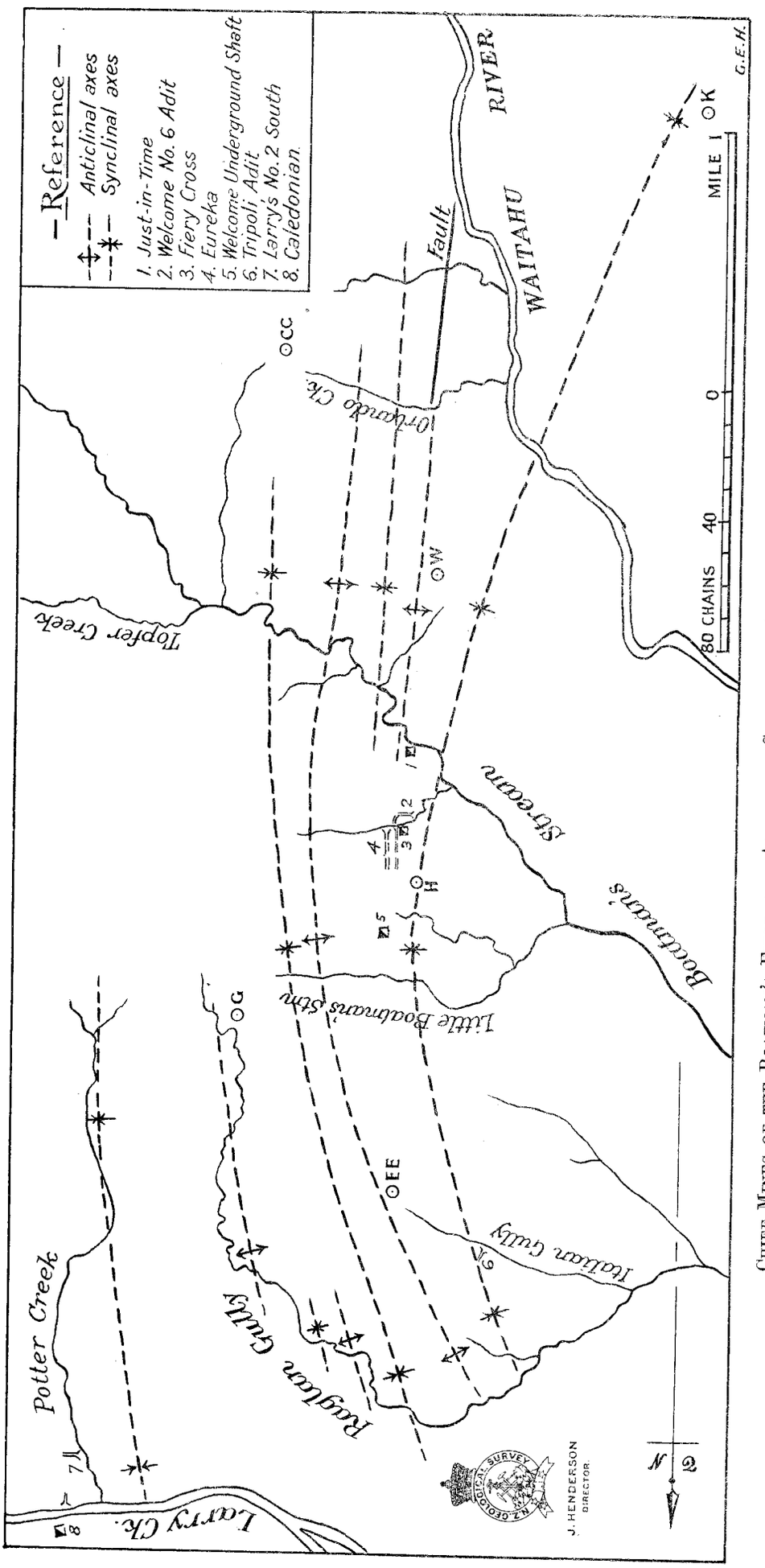
The Greenland rocks, besides being folded, have been subject to thrusting movements. This is demonstrated by the asymmetry and overturning of folds and by the presence of low-angle fault-planes and shears. Eastward-dipping flanks of folds, except near the sheared and complicated crests and troughs, are usually little disturbed and moderate in slope, whereas west-dipping limbs tend to be steep. In places—for example, in the Snowy River near the Waiuta battery and in Italian and Raglan creeks near Capleston—the folds are overturned towards the west. In the Snowy River and at Big River Mine severe crumpling and shearing of the quartzites near the boundary of the granite to the east points clearly to thrusting from the east. Normal faults, which also are recognized in the area, may have been produced during periods of tension.



Blackwater and Big River Groups of Mines and Associated Structures.

A major anticlinical structure was traced north from the Snowy River at Waiuta towards Merrijigs. This fold was recognized in Blackwater Mine, in Blackwater Stream, in Big River at the junction with Sunderland Creek, and northwards. Its crest is complicated at Waiuta, and a small anticline and syncline are superimposed upon it. Northwards it possibly joins up with an anticline mapped at Merrijigs. Steepening and overturning of the west flank is noticeable. East from the axis the east-dipping flank persists with fair regularity to near the St. George Stream. Here the structure is complicated and a syncline is developed on the long east-dipping limb, its trough traceable through to the Big River Mine, which is located within the sheared axial belt. This syncline was also mapped in Golden Lead Creek, but could not be followed farther north owing to a cover of younger rock. Southward from the Snowy River gravels obscure the structure.

The syncline extending from Crushington northwards to the Waitahu River and carrying along and close to its sheared axis the Crushington–Inglewood group of lodes was traced farther north through the Boatman's mining area to Raglan Creek, beyond which it disappears beneath gravels.



CHIEF MINES OF THE BOATMAN'S FIELD AND ASSOCIATED STRUCTURAL AXES IN THE AURIFEROUS ROCKS.

In the Blackwater - Big River section the general strike of the rocks is fairly consistently north-north-east. Between Crushington and the Waitahu the fold follows a decidedly sinuous course, although still with a general north-north-east direction. Northward from the Waitahu the strike swings in an even curve until at Raglan Creek it is about N. 15° W. The main syncline has a regular west flank with moderate dip, but the east flank is steep, sheared, and in places overturned towards the west. Near the axis there is considerable complexity and shearing, small folds being superimposed upon the main one. An anticline east of the main synclinal axis begins near Boatman's Stream, increases in size southward, and farther south is replaced by the fault that forms the western boundary of the Devonian rocks. It was traced to the Waitahu River. A fault, probably the same as that along the eastern margin of the Devonian rocks, separates off a region of great complexity in the Greenland rocks, as observed in the upper portions of Boatman's and Topfer streams. Sudden considerable changes of strike occur bewilderingly. Immediately east of the important syncline at Boatman's a series of rather close folds occurs, and another important syncline follows fairly closely the line of Potter Creek. Between Potter Creek and the granite mass to the east the west-dipping flank of the syncline is comparatively free from complications.

Minor effects of thermal metamorphism are evident near the granite within a restricted aureole. Recrystallized hornfelsic quartzite was observed here. The granite in Larry Creek takes the form of a group of small intrusions, the relationship of which to the bedding planes of the rocks is generally obscure. At the junction with Drysdale Creek, however, two thin intrusions of granite appeared to conform roughly with the bedding, suggesting injection sheets. It is presumed that these are offshoots from the main mass of granite known to lie to the north of the area examined. Numerous pegmatite dykes and veins appear within the granite and near the contact.

Basic Intrusions.

During the season more basic dykes were added to the great many already known. Dykes, hitherto unrecorded, outcrop in two tributaries of the Big River, in Golden Lead Creek, in Blackwater Creek, and in Pactolus Creek near Capleston. Evidence of comparatively late date of intrusion for some of these dykes is afforded by the fact that Tertiary sediments on Kirwan's Track are baked by a large intrusive mass. Many basic dykes were discovered and traced with the Askanea magnetic balance.

The Auriferous Lodes.

Within the area examined this season lie the following important mines: Blackwater; Big River; the Capleston group, including Welcome, Eureka, Fiery Cross, Just-in-Time, and others; and the Larry Creek group. At the present time Blackwater, Big River, and a small concern near Waiuta, called Absalom's, are working.

The Blackwater Mine and Absalom's occur close to the crest of the major anticline traced from the Snowy River northward towards Merrijigs. As the Millerton gold-mine in the Snowy River is situated at the extreme western margin of the Greenland rocks it is not possible to determine fully its position with relation to the structure. If the line of strike of the rocks at the Millerton Mine is projected northwards, it intersects the west flank of the Blackwater anticline, and several shear zones in Blackwater Stream may be closely related to the Millerton lode. The Millerton Mine is one of the few in the field probably occupying a mid-flank position, but its structural setting is obscure. The Big River Mine, a producer of many years' standing, and the St. George lode in the Snowy River both lie close to the same well-defined synclinal axis. The Welcome group of mines is also closely related to the important syncline on which, moreover, are located the Inglewood and Crushington groups of lodes. The Tripoli Mine (also known as the Golden Arch and Garibaldi) in Italian Gully also lies on this fold axis, and in Raglan Creek on the same line there is a well-defined belt of "reef-track" showing thin stringers of quartz and the hydrothermal alteration of the sheared country almost invariably associated with gold-bearing lodes. Thus it is seen that this year's work links up the rich reefs of the Boatman's field with the Inglewood–Crushington groups. Near the axis of another important syncline recognized in Larry Creek and Potter Creek we find the Caledonian and No. 2 South Larry's. Within the areas examined last year it may be recalled that the Scotia–Cumberland lode-system at Merrijigs occurs along a well-defined synclinal axis, while the Bonanza–Anderson's line also lies along a synclinal trough west of the main synclinal ore channel.

Conclusion.

Additional evidence has been gained for the hypothesis of structural control of ore-body distribution suggested by the work of the 1935–36 season. It has been still more clearly demonstrated that valuable lodes are generally located in shears close to the axes of folds. Minor folds on the flanks of major folds may have strong shears with quartz veins, but this quartz is usually barren or low-grade. The majority of the lodes have been found to be along synclinal troughs, but the Blackwater reef is on an anticline. On the other hand, no mines far from fold-axes have been successful.

WAKAIA SUBDIVISION.

By J. Healy and R. W. Willett.

A further 140 square miles were mapped in detail in this district during the field season 1936–37, including the whole of Wakaia Survey District and a small part of Greenvale Survey District. The party was fortunate in having the assistance of Mr. Ongley for the last six weeks of the season in May and June. During the months of December, January, and February, and again for the three weeks in May, assistance was given by Mr. B. W. Collins. The rate of work was considerably retarded by bad weather from January to April, and the scant data on the base map necessitated a large amount of topographic work.

Topography and Structure.

The structure and topography are controlled by the main faults of the district, which trend north north-east, and define the western margins of uplifted blocks, each of which is tilted to the east against the scarp of the fault defining the next block. These blocks form parallel mountain ranges which traverse the entire district; the main streams flow south in the fault-angle depressions between them. The scarps are maturely dissected and the back-slopes almost entirely stripped of their former covering of younger strata by streams now incised in the surface of the older rocks beneath. The "earth-block" structure, however, is still apparent.

The most easterly of these blocks is the Black Umbrella Range the crests of which rise from 3,606 ft. at the Black Umbrella in the south to 4,740 ft. at Mount Whitecoombe, a short distance outside the subdivision in the north. The fault on the west side is well defined, and tributaries of Argyle Stream, which flows a mile or more west of and parallel with the fault, drain its steep scarp. The interfluves form high spurs separated from the main range by deep notches where the weak fault-zone has suffered differential erosion. Argyle Stream flows south until it joins Winding Creek, which flows west-north-west through the gap between the White Umbrella Range and the elevated block known as Round Down to the Whakaea River at Wakaia. The town itself is situated on the fan built by Winding Creek as it emerges on to the flood-plain of Whakaea River.

West of Argyle Stream the White Umbrella Range, a block tilted east and south and rising from 1,705 ft. at Trig. J in the south to 3,728 ft. at Trig. K in the north, forms the watershed between that stream and Whakaea River. The fault-scarp on the west is maturely dissected and along its base a strip of Tertiary strata is preserved in the fault-angle for some six miles or so above the township, beyond which point the throw of the fault decreases and the schist floor, on which the younger beds rest, outcrops along the valley. Immediately north of the township the Tertiary strata are separated from Whakaea River by a low ridge of semi-schist three-quarters of a mile wide and fault-bounded along its western margin.

At the township of Wakaia the flood-plain of Whakaea River narrows to a quarter of a mile between Scrubby Terrace and the alluvial fan built by Winding Creek, but above and below this it widens out considerably. Above the township are extensive terraces about 40 ft. high, while to the south are continued the 100 ft. terraces which fringe Mataura River for many miles. In several places the river is widening its valley-floor at the expense of the bordering terraces. North-west of the river are slopes which rise gently at first and then more steeply to a range over 4,000 ft. high, which separates the Whakaea Valley from the Nokomai Valley. The main streams draining these slopes flow east-south-east into Whakaea River, and in order from the north are Cow Creek, Steven Burn, Station Burn, Steeple Burn, and Dome Burn. The last two have their headwaters farther back in the high range and in their early courses flow south-south-west.

From Freshford a gravel-capped ridge known as Muddy Terrace forms the western boundary of the Whakaea Valley northward to Dome Creek, whence it extends north as Scrubby Terrace for three miles, its surface then merging into the slopes rising gradually away from the main valley. Faults bound these two ridges on the west, that defining Muddy Terrace being offset somewhat to the west; on its downthrown side Tertiary beds underlie the valley-floor of Garvie Burn.

The major fractures of the district appear to be thrust-faults, as indicated by the exposures of the fault-plane of the Wendon–Otama fault described in last year's annual report. At King Solomon Mine the plane is seen to hade to the south-east and is concave upwards, having a downward decrease in dip. The fault along the western side of Round Down appears to be offset a mile and a half to the west of that which defines the western margin of the White Umbrella Range. In Happy Valley, near where this offset occurs, the Tertiary beds are considerably contorted by lateral as well as by vertical movement. The fault-movements were probably spread over a considerable time period as some gravel beds deposited after faulting had taken place were later displaced by further movements.

Stratigraphy.

Tuapeka Series.—The oldest rocks of the district show a gradual transition from semi-schists and phyllites, and even greywackes and argillites in places in the south, to foliated schists and phyllites in the north, though the district does not extend sufficiently far in that direction to include any of the coarsely-crystalline schists of Otago Central. Probably this series represents many stages, but the sediments are unfossiliferous throughout and are grouped together in the Tuapeka Series of uncertain but probable Palæzoic age. There is no evidence for the age of the schistosity, and up till the present there have been no schistose pebbles found in the Triassic or Jurassic conglomerates. Quartz veins up to several feet thick are abundant, some parallel with the planes of schistosity, but most intersecting them. The schistosity planes, in general, strike north-east and dip south-east, though in the Black Umbrella Range, the strike is north-west and the dip north-east.

Clinton Series.—The rocks of this series are not represented in the area examined last season, but fossil casts and fragments of a fibrous shell were found at Otama in rocks which were in last year's report tentatively assigned a Mesozoic age. Dr. Marwick states that the shells are not *Inoceramus* but are probably *Maitaia*, and this suggests that the rocks belong to the Clinton Series of Permian or Carboniferous age. The district does not extend sufficiently far south to connect with beds of the Hokanui System.

Welshman Series.—These rocks comprise quartz sands, conglomerates, and grits interbedded with shales, mudstones, and lignite seams. As described by Macpherson, they are well exposed in Welshman Gully, and are also found three miles south of Wakaia at Landslip Hill, where one of the lignite seams has yielded much fuel. The Welshman Gully beds extend across into Happy Valley and thence up Whakaea Valley for about six miles. They also outcrop at Muddy Terrace.

Little can be said as to their age, apart from the fact that they are at least older than Ototaran, as they underlie marine strata of that age. They were tentatively correlated by Macpherson with Williamson's Hogburn Series of Otago Central, to which an Eocene age was given. Lithologically the fine quartz conglomerates are very similar to those of the Taratu Series of Cretaceous age described by Ongley from the Kaitangata-Green Island district.

Chatton Series.—The beds of this series comprise marine sandstones, grits, conglomerates, and greensands. The fossiliferous localities are few, the best collection in the Wakaia district being from near Landslip Hill. During the period in which the gold dredges were operating large marine shells were brought up from what was apparently a marine sandstone bottom immediately west of Muddy Terrace, while many years ago fossils were collected from the eastern side of Muddy Terrace near Freshford; here weathering has proceeded to such an extent that casts only are procurable. Fossiliferous limestone is found at Balfour, fifteen miles to the south-west, but no limestones have been found within the subdivision.

Maori Bottom Series.—Near Wakaia are several sets of gravels ranging in age probably from the Pliocene to Recent. Their separation is extremely difficult, for although they can locally be distinguished they grade laterally into gravels which are indistinguishable. In all cases the degree of consolidation and weathering are similar. The gravels have their greatest development immediately east and south-east of the township, where large areas were worked for gold many years ago; there appear to be two sets of gravels, the Maori Bottom proper being the older and richer.

The gravels of this formation contain a fair percentage of quartz, most of it as small, well-rounded pebbles, as well as rounded to subrounded pebbles of weathered greywacke and semi-schist, some of which are more than 6 in. across; the whole are set in a sandy matrix and strongly weathered. These beds overlie the rich wash at the lately-worked King Solomon Mine; there is a small strip of similar gravels a mile farther east in the Winding Creek valley. The auriferous gravels at Muddy Terrace appear to be identical with those at Switzers, and the inference is that the beds mentioned should be linked up as the remnants of a continuous deposit laid down by an ancient river. To account for the sudden appearance of gravels of greywacke and semi-schist succeeding beds predominantly of quartz detritus, crust movements and faulting are postulated; and since schistose rocks override the gravels in the King Solomon, and Maori Bottom beds are crushed against the schist at the foot of Round Down a mile and a half south-east of Wakaia, these gravels were at least in part laid down before faulting had ceased.

The surface of all these deposits is maturely dissected and shows a rounded topography retaining no appearance of flat-topped terrace remnants.

There is no very good evidence for the direction of flow of the ancient river. All outcrops were examined carefully to see if the imbricate arrangement of the component pebbles would yield any information, but no definite evidence could be so adduced. Macpherson advanced a theory that possibly the early river flowed down the eastern side of Whakaea Valley to Switzers, whence it flowed through the gap to the east and made its escape to the south down the Wendon-Otama Valley. No supporting evidence could be found, and, indeed, the absence of Maori Bottom gravels in both the upper Whakaea and Wendon-Otama valleys is against this hypothesis. There are practically no pebbles derived from highly altered schists, a fact suggesting that the river which deposited the gravels did not come from the north.

Pleistocene and Recent Beds.—There are widespread areas of gravel deposits, usually preserved as terrace remnants, which probably range through the Pleistocene to the Recent. In many places these gravels contain quartz pebbles, though mostly they contain little or none; but these differences can be explained by the suggestion that where the quartz is present the depositing stream was then eroding an area on which remnants of the early quartz conglomerates still existed. The gravels of these sets of terraces are not richly auriferous. Small patches were worked a short distance south-east of Wakaia, and from the top of the hill at Switzers the flat remnants of their terraced surface show out clearly as compared with the rounded surface of the Maori Bottom gravels nearby. This dissimilarity of the topography extends to the composition of the gravels, as the younger set contains practically no quartz pebbles, and is, without doubt, a deposit of Winding Creek before it had cut the gorge it now occupies between Round Down and the White Umbrella Range.

The most recent deposits are the gravels, sands, and silts occupying the floors of the main valleys and having their greatest extent in the Whakaea Valley. There are also considerable areas of tailings in the vicinity of the township. Various thicknesses of a heavy clay cover all the less-elevated areas. This has formerly been described as a wind deposit and termed loess, but this theory is doubtful, as pebbles of quartz are included, sometimes abundantly.

Economic Geology.

Gold.—Since gold was discovered near Wakaia over seventy years ago the district has been the centre of fairly extensive mining activities until the present day. Recently the closing-down of the King Solomon Deep Lead Co.'s mine marked the cessation of work on what has been one of the richest finds in Southland.

Most of the gold taken from the district came from the gravels of the Maori Bottom beds and in its turn was presumably derived from the quartz conglomerates of the Welshman Series, which are slightly auriferous.

The most important workings in beds of the former age were at Switzers and Muddy Terrace, though small remnants have been worked between Switzers and Welshman Gully. Large areas of a former, much more widely-spread, deposit of Maori Bottom gravels have been removed, yielding further gravels which have been worked extensively in the gullies to the south-east of Wakaia. Such was also the origin of the gold obtained by the dredges which worked from near the township south to Freshford and along

the western side of Muddy Terrace. North of the supposed course of the early river which laid down the Maori Bottom gravels it is noticeable that there is no ground of sufficient area and value to warrant dredging.

The origin of the deposit of gold worked at King Solomon Mine presents an extremely difficult problem. The composition of the wash, much of it consisting of large pebbles and boulders, suggests that it was laid down by a fairly large stream. Jaspilite, quartz, and Chinaman pebbles resembling those of King Solomon are found in many places in the Maori Bottom gravels, but in no other place has a collection of these pebbles such as that found at the mine, been observed. This would suggest that the rich wash was a local concentrate and that there is little chance of tracing a continuation into surrounding districts. This idea is supported by the fact that the deposit is found at the intersection of two fault-systems and was possibly the site of the confluence of as many as three rivers. It was laid down after erosion had proceeded to a well-advanced stage following on the first faulting-movements, but before the movements which displaced also the Maori Bottom sediments, which in age it must immediately precede; possibly both deposits were formed by the same river or rivers.

Between the site of the mine and the Break-'em-all elevator hole is an area 25 chains long and from 5 chains to 10 chains wide which has not been thoroughly prospected. Before the mine closed bores should have been put down along the gully running north from the south air-shaft, as this locality is covered with Maori Bottom gravels beneath which the rich wash may well extend. In addition, there is still a small patch of unworked ground between the most northern and north-eastern workings and the rising ground near Winding Creek, where the wash dipped away below the level of the drives.

A mile east of the mine a strip of Maori Bottom gravels half a mile long and averaging 7 chains in width lies immediately south of Winding Creek. The gravels rest on a schist bottom, which dips to the south against a steeply rising wall. Boring or geophysical survey would disclose the shape of the gutter from which gold was obtained many years ago. The miners were defeated by water as the bottom dips away below the level of the creek nearby. Although it is unlikely that wash the same as that at the King Solomon Mine will be found here, similar gravels proved rich in places near Switzers, four miles to the north-west.

At present sluicing claims are being worked in three places, as follows: Mr. H. Nelson, in Winding Creek opposite the Break-'em-all; Mr. A. Mutch, in Happy Valley; and Mr. J. Mutch, in Welshman Gully. Of these the most extensive operations are being carried out in Happy Valley, where the ground, although not particularly rich, is payable when put through in large quantities; here 14 acres are sluiced yearly with the aid of a good water-supply. The problem of insufficient water-supply has always given trouble in the Wakaia district, and water-race construction and maintenance has accounted for considerable sums of money. It was mainly responsible for the cessation of work at Muddy Terrace, where large areas of low-grade auriferous gravels are still unworked.

As the conglomerates of the Welshman Series originally extended probably over the whole area, their removal by denudation has left residual gold in many places, and numerous fossickers have found small deposits at many points. The deposits of economic importance are all connected with the Maori Bottom and related gravels. Extremely coarse gold has been found from time to time in the Dome Creek, the indications being that a reef or reefs had been eroded to yield the gold, but no auriferous reefs were seen and there are no reports of reefs having been found.

The question arises as to whether it may be payable to rework the tailings from the gold-dredges. This would depend on two factors, and no definite statement can be made concerning either of these. One is that the richest portion of the wash on the bottom may have been sufficiently well consolidated to have been incompletely broken up in passing through the dredges and that exposure to the atmosphere since then has loosened the matrix and freed the remaining gold. The other is that the gold-saving devices on the early dredges were not so efficient as those in modern use and that an appreciable percentage of the gold escaped through the boxes. It can only be said that any attempt to dredge early tailings would need to be preceded by careful boring and testing of the area concerned.

Coal.—Lignite is worked in two places, where the seams occur in beds belonging to the Welshman Series. The coal is mined by sluicing away the overburden both at Landslip Hill, south of the township, and at Woodward's coal-pit six miles up the valley, on the east side of Whakaea River. The seams are less than 10 ft. thick and the lignite is of average quality, though poor in places. It contains much woody matter, while fossil gum is abundant. Sluicing for gold in Happy Valley has exposed several small seams.

Oil-shale.—Adjoining the eastern side of Muddy Terrace, a mile north of Freshford, an oil-shale was mined and used as fuel for some of the gold-dredges. The pit, however, has fallen in and the tailings from Muddy Terrace cover all of the formerly exposed part, so the deposit could not be inspected. In the Mines Statement for 1913 (C.–2, pp. 152–154) is a report on the Wakaia district by Morgan, who gives the following analysis of a sample of the shale:—

Fixed carbon	12·00
Volatile matter	60·25
Water	18·25
Ash	9·50
	100·00
Total sulphur	2·16 per cent.

The report also includes the following extract from the Mines Report of 1912 (C.–2, p. 118):—

> "*Muddy Terrace Coal-mine, Wakaia.*—This property is being prospected by an Invercargill syndicate to prove the shale. Six bores have been put through the shale, and 35 acres proved. The deepest hole, 62 ft., contained 14 ft. shale; other holes have proved seams of from 9 ft. to 19 ft. of shale."

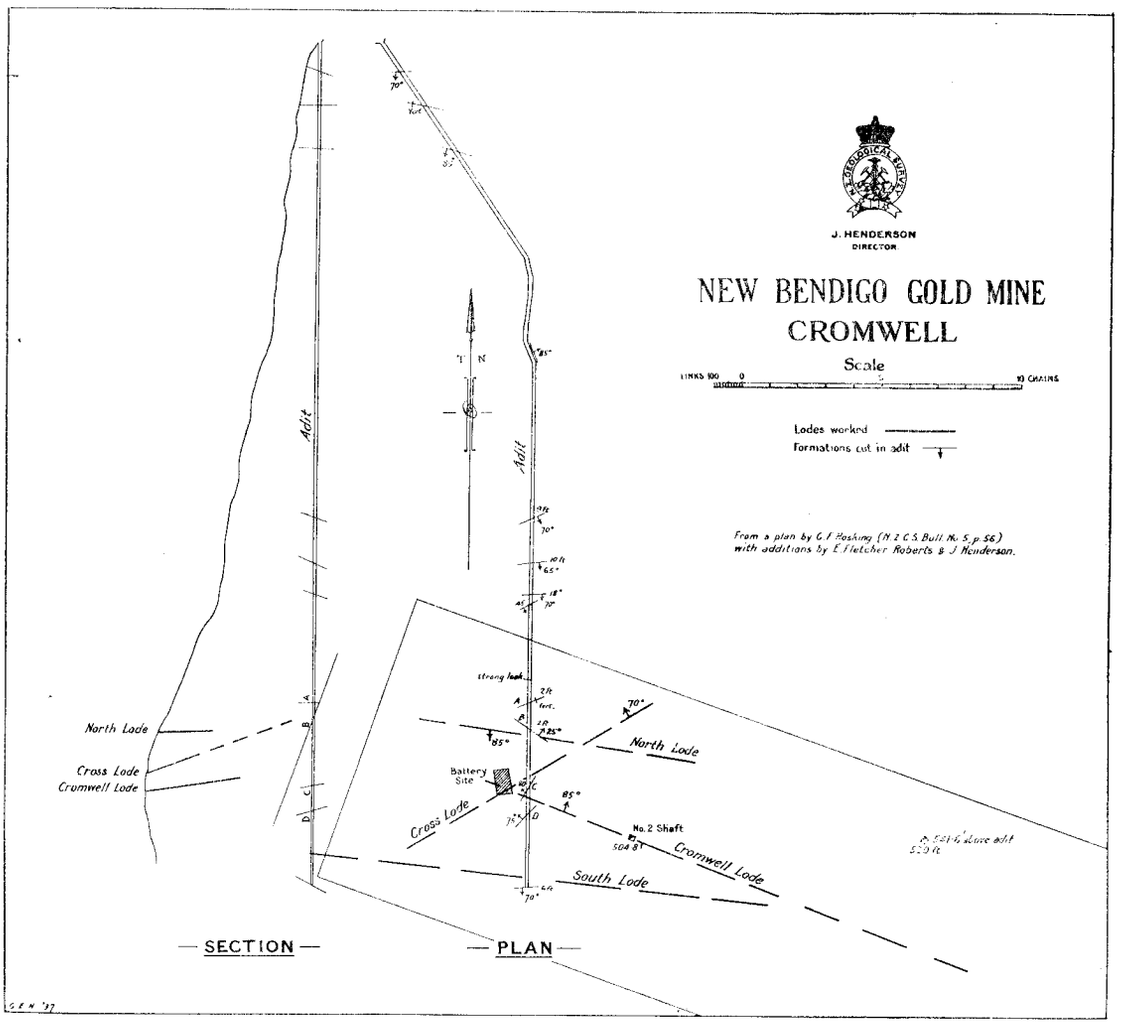
Road-metal.—The district has a practically unlimited supply of gravel suitable for roadmaking. It is usually obtained by a drag-line directly from the river-bed and consists of pebbles of quartz, greywacke, and semi-schist. The less resistant pebbles of the last-mentioned break down under the traffic and form effective binding material for the more resistant part.

NEW BENDIGO MINE.

By J. Henderson.

On the 9th and 10th September, 1936, the writer examined the surface of the claim of the new Bendigo Gold-mining Co. near Cromwell, and also the adit which then extended a distance of about 2,110 ft. from a branch of Bendigo Creek.

The lodes of this area were practically abandoned in 1900 after thirty years' of active work, during which well over £500,000 in gold was won. The greater part of the gold was from the Cromwell lode which strikes about 20° south of east and dips steeply north (according to Ulrich the dip is vertical for 100 ft. and about 75° north to 330 ft., the deepest workings at the time of his visit in 1875). The outcrop is regular, and the strong walls still stand for the most part smooth and unbroken in the open cast after sixty years' exposure. The straight, smooth walls of the Bendigo lodes are quite startling to any one accustomed only to the tortuous courses of the Hauraki veins and faulting and crushed



country of those of the West Coast. The lode consists chiefly of crushed schist traversed by irregular seamed veinlets and stringers of quartz. In parts the quartz extends from wall to wall except for narrow selvages of clay. Fragments of schist are common in the quartz, which is relatively coarse-grained and contains many small vugs. The space between the well-defined walls is reported to range up to 6 ft. and to average about 30 in. The gold was chiefly in the quartz and along the seams and was irregularly distributed. The workings on the lode extend over a length of more than 1,000 ft. and, toward the eastern end, to a depth of 430 ft., at which level the workings on the lode are about 600 ft. long (Mines Reports C.–3, p. 81, 1894); at the west end the depth is less, but the available information is by no means complete. In depth the brown oxidized ore and yellow decomposed crushed schist-filling were replaced by sulphide ore and unweathered crushed schist. The sulphide present is chiefly arsenical pyrite, though Ulrich mentions also galena and zinc-blende (Gold Fields of Otago, p. 201, 1875). The sulphide ore was decidedly more difficult to treat, with the primitive methods used, than the oxidized ore and seems also to be of decidedly lower grade. Thus a sample

from a heap of quartz containing sulphide, stacked near No. 2 shaft, and reported difficult to treat, contained only 1 dwt. 10 gr. of gold per ton and less than 7 gr. of silver.

In 1884 a new company acquired the property and began sinking a shaft toward the eastern end of the workings and about 200 ft. north of the outcrop of the lode. By 1891 this shaft had reached a depth of 534 ft., a level was opened at 520 ft., and a crosscut driven south 197 ft. cut the lode 132 ft. from the shaft (Mines Reports, C.–4, p. 51, 1891). The lode was followed for about 250 ft. east and for a similar distance west; it ranged up to 30 in. wide, but at the eastern end narrowed to 2 in. and at the western end to a mere track (Mines Reports, C.–3, p. 81, 1894). There was comparatively little water, which was dealt with by pumps in three lifts. In the bottom level the quartz carried gold but was of low grade (Mines Reports, C.–3, p. 88, 1895), and prospecting went no deeper. Mr. George Wilson, Inspecting Engineer, reports Mr. F. Evans, at that time a mine-manager very well known in Otago, as stating, "The lode is undermined by a slide and until the exploration is carried below this there is not much chance of the run of gold reforming" (Mines Reports, C.–3, p. 103, 1898).

The reports on the mine are incomplete and the only plans available are: (1) A litho plan and section prepared by Mr. G. F. Hosking and published opposite p. 56 of *N.Z. Geol. Survey* Bulletin No. 5; (2) a tracing of the longitudinal section similar to that above, except that east and west are transposed and that the "main shaft" near the battery is shown as extending to a westward continuation of the 520 ft. level; and (3) a longitudinal section of the mine on a natural scale showing a few assay values (five assays on the 520 ft. level average about 6 dwt. of gold per ton).

The North lode, subparallel with the Cromwell lode and 200 ft. north of it, has a steep southward dip. Park (*N.Z. Geol. Surv.* Bull, No. 5, p. 50, 1907) reports it as from 1 ft. to 3 ft. wide. The Bee lode, 350 ft. south of the Cromwell lode, is also parallel. It is about 2 ft. wide. The Cross lode strikes north-east and dips north-west at about 70°. It joins or crosses the Cromwell lode near the old battery and is shown as extending north to the North lode, but is reported not to reach the Bee lode. This lode is from 2 ft. to 4 ft. wide and, according to Ulrich (p. 203), yielded some very good ore near the surface. A vein known as the South lode lies parallel for many chains with the Cromwell lode from which Hosking's plan shows it separated by about 20 ft. of rock. Eastward it is shown as joining the Cromwell lode, but westward it suddenly diverges and takes a course of 30° south of west (Park, p. 53). This vein dips at about 75° south—that is, away from the Cromwell lode. Several leaders join the Cromwell lode at acute angles, and Hosking's plan shows another vein running between the Cromwell and South lodes for many chains.

Notwithstanding that the several veins strike and dip in different directions near the old battery and eastward, the country between the lodes seems but little disturbed and as far as observed shows the flat dips toward the west and north-west persistent throughout the neighbourhood.

All the veins seem to be similar and to consist of crushed schist traversed by irregular quartz stringers which in parts occupy the whole space between the walls of the fissure. Irregular fragments of more or less silicified schist embedded at many points suggest that the quartz replaces the shattered schist, the crushed material being first replaced. On the other hand, the quartz in places has a comby structure and contains many small vugs, facts suggesting deposition in open spaces. The quartz in appearance and distribution in all the fissures is so much alike that all must belong to the same general period of vein filling; all the known surface fractures about the outcrop of the Cromwell lode must have existed before quartz deposition and mineralization ceased.

When visited, the adit had been driven about 2,110 ft., extending south-east for the first 600 ft. and due south for the remainder of the length. It penetrates schist, which, though traversed by a number of fractures, maintains a fairly uniform strike and dip (10° to 20° to the west and north-west) throughout with master joints striking a little east or west of north. The fractures are filled with crushed and brecciated schist; one near the entrance contains a few quartz veinlets and others farther in, lenticles of calcite and a few grains of pyrite. The walls of the fractures are smooth and slickensided, but the immediate wall rocks in general are solid and unbroken.

Three fractures from 6 in. to 24 in. wide cross the adit at 80 ft., 170 ft., and 295 ft. respectively from its mouth. They strike between due east and 18° south of east and dip south at from 75° to 85°. Another group of fissures cross the adit about 25 chains in, the first at 1,450 ft. is 9 ft. wide, the second at 1,560 ft. is 10 ft. wide, and the third at 1,640 ft. is 2 ft. wide. They strike from due east to 25° north of east and dip from 65° to 75° south. A similar parallel fracture 8 ft. wide crosses the adit at 2,110 ft. from the entrance. Between this break and the previously-mentioned group the adit passes under the workings of the Cromwell and adjoining lodes; the adit being approximately 375 ft. vertically below the outcrop of the Cromwell lode near the old No. 3 shaft at a point 1,910 ft. from its entrance. A nearly vertical fissure striking 67° east of north and filled with plugged schist crosses the adit at 1,685 ft. from the mouth. This will be referred to as fissure "A." About 60 ft. farther in, fissure "B" contains 2 ft. of crushed schist, strikes 30° south of east, and dips north at about 25°. Fissures "C" and "D" respectively, at 1,880 ft. and 1,930 ft., are narrow fractures which strike north-east and dip north-west at about 80°.

The projection of the Cross lode crosses the adit within 20 ft. of fissure "A," to which its strike approximates. The points, both unimportant, against this correlation are the difference in dip and the absence of quartz from fissure "A." Fissures "B," "C," and "D" cannot be satisfactorily correlated with any of the surface lodes; the flat dip of "B" sufficiently distinguishes that fissure, and "C" and "D" under the outcrop of the Cromwell lode strike nearly at right angles to it.

Professor A. R. Andrew, who examined the claim on behalf of the present company, suggests that the flat-dipping fracture "B" is of much structural significance and that movement along it has taken place, the hanging-wall country moving downward toward the north. On this hypothesis the continuation of the Cromwell lode below fracture "B" lies at some unknown distance ahead in the adit. In support of this fault hypothesis the following may be urged: (1) Mr. F. Evans's statement that the lode terminates in depth against a "slide"; (2) Hosking's transverse section

shows a flat-dipping "slide" immediately below the 520 ft. level of the pumping shaft; (3) the longitudinal section of the workings (plan 3 above) shows a "slide" cutting the 520 ft. level about 180 ft. west from the cross-cut; and (4) the flat-dipping fracture "B," if continued east on the same strike as observed in the adit, will pass very close to the position of the "slide" in (3) above. The evidence is fairly conclusive that fracture "B" is the slide below which the Cromwell lode has not been prospected. The amount of movement on this fault cannot be determined from the information available, and the direction of movement on the fault is not known.

According to the Hosking longitudinal section the Cromwell lode immediately over the adit is worked to a depth of about 200 ft. from the surface or to about 170 ft. above the adit. Eastward the workings and explorations are deeper, and about 12 chains north of the adit are at the same level. (The extension of the 520 ft. level west to beneath the battery site as shown in plan No. 2 is not supported by other evidence and is not regarded as real.) The unexplored country beneath the old workings above the adit seems to be well worth prospecting. A rise from a point 160 ft. south from fracture "A" should reach fracture "B" near where fracture "B" cuts off the downward continuation of the Cromwell lode at a height of about 40 ft. above the adit. The rise should be continued to 60 ft. above the the adit, cross-cuts put out north and south to find the Cromwell lode, which could then be further explored.

About 50 ft. back from fissure "A" an inch fracture dipping flatly north, when first reached, discharged much water, which deposited hydrated iron oxide freely. Later the flow greatly decreased, and the water-level in the 520 ft. shaft, 15 chains eastward, fell. The fracture is subparallel with fissure "B" and may have been formed at the same time.

The origin of the lodes of Otago was discussed in the annual report of the Geological Survey for 1935, and it was pointed out that practically nothing is known of their behaviour in depth. The Cromwell lode was by far the most productive in Otago, and the long adit provides an excellent opportunity of getting definite information that cannot but be of value in the investigation of other lodes occurring in the schists of Otago and Marlborough. In the writer's opinion the chances of a payable deposit are small, but almost certainly the majority of other geologists do not accept his views on the formation of these lodes. The work recommended would help to determine if the lodes in schist carry ore below the influence of downward seeping waters; if ore continues in the Cromwell lode to fracture "B," the direction of movement along this fracture would be ascertained.

GLENORCHY DISTRICT.

By J. Henderson.

The Village of Glenorchy is built on the flats at the head of Lake Wakatipu, on the east shore at the mouth of the Rees River. The north arm of the lake, eighteen miles long, has a straight course striking a few degrees west of north. It averages about two miles and a half across, though in places nearly four miles wide. The shores are remarkably straight. On the west side the deltas of the Von and Greenstone rivers project in narrow segments and on the east those of Simpson Creek and the Buckler Burn; but the projections are slight and the neighbouring indentations cannot be described as bays. The underwater contours are not so simple, and Pigeon Island, five miles from Glenorchy, and its two neighbours rise from a subaqueous promontory which extends from the west side half-way across the lake, which is here at its widest, and encloses a deep narrow inlet opening south.

The Dart and Rees rivers enter at the north end and their valleys extend the depression northward; indeed, for five miles their combined delta forms the lowland between the valley walls. The Dart Valley extends north in line with the north arm for a farther ten miles, but that of the Rees diverges slightly toward the east.

Mountains.

Mountains rise steeply on both sides. On the east the Richardson Range extends along the north arm of the lake and the east side of the Rees to Centaur Peak (8,284 ft.), a distance of thirty miles. The divide is generally less than four miles east of the lake and valley, and short torrents cut the highlands into sharp peaks. Mount Larkins, six miles east-south-east from Glenorchy, rises to 7,324 ft., and few of the crests are less than 6,000 ft. above sea-level.

On the west side the mountain rampart is more massive and formidable, the peaks are higher, and the streams larger and more widely spaced. The Greenstone, which enters the lake five miles from Glenorchy, cuts right across the highlands to an easy saddle to the Hollyford; the passes at the heads of the canyon-like valleys of the Route, Rock, and Bean burns, tributaries of the Dart from the east, provide much more difficult access to the same river basin. South from the Greenstone the Thomson Range forms an unbroken wall on the west side of the northern arm of Wakatipu, and continuing south separates the Von and Mararoa valleys. The highlands north from the Greenstone are known collectively as the Humboldt Mountains, and these in the north merge into the Barrier Range, lofty highlands of which the east-west reach of the upper Dart drains the southern flank. The great Bonpland ridge, extending unbroken for fifteen miles between the gorges of the Greenstone and Route Burn, rises to a height of 8,102 ft. in vast precipitous slopes over against Glenorchy. North of the Route Burn, the chief peaks of the Humboldt Mountains, are Somnus (7,424 ft.) and Cosmos (7,340 ft.), the latter by some considered part of the Barrier Range.

The highlands between the valleys of the Dart and the Rees constitute the Forbes Range. The former stream swings round their north and west sides and the sources of the Rees are largely fed from their northern part; the main Rees valley lies east of their irregular southern part, the vast massif of Earnslaw (9,200 ft.). This much-dissected plateau overlooks Paradise Flats, an old course of the Dart, which separates Mount Earnslaw from Mount Alfred (4,548 ft.), the isolated peak rising between the delta plains of the Dart and Rees.

Glaciation.

Ferrar (1928) has summarized the data on the glaciation of the region. At one time ice filled the depression that Lake Wakatipu now occupies and all the larger valleys opening from it. In the Glenorchy district the evidence of former glaciation is impressive. The over-steepened flanks of the mountains, their rectilinear bases, the hanging valleys, and general absence of spurs, the occasional patches of moraine as well as the underwater contours of the lake afford convincing proof. The ice-worn slopes of the Humboldt and Thomson mountains are steeper than those of the opposing Richardson Range; they truncate the schistosity planes of the rocks of the former, whereas they more or less correspond with those of the latter, which dip west at about 45°. The stupendous rock wall of Earnslaw that overlooks Paradise valley is carved from rocks of which the planes are nearly flat. East of Glenorchy the humped Trig. D ridge that extends along the foot of the range for four miles between Precipice Creek and Buckler Burn is probably the worn-down remnant of a massive spur. There is a marked change in topography at the upper limit of the former ice; the sharp peaks and serrated crags of the mountain tops are in strong contrast with the scoured hummocky walls below. The smooth contours of Mount Alfred (4,548 ft.) and Mount Nicholas (4,827 ft.), near the mouths of the Dart and Von rivers respectively, show that the glacier overrode their summits. From the floor of Paradise valley ice-smoothed walls rise 7,000 ft. on the south-west flank of Earnslaw; the thickness of the ice at Glenorchy was quite as much; it was at least 6,000 ft. at the west end of the east-west reach of the lake and the heights of the ice-worn north face of Cecil Peak shows a like thickness at the east end, where the ice overrode Queenstown Hill 4,200 ft. above the lake-floor.

Keith Lucas's (1904) map of the underwater contours of Lake Wakatipu shows the deepest part as a flat floor extending from Queenstown along the south arm for fourteen miles, whence the bottom rises steadily to Kingston six miles farther south. Park (1909, p. 31), chiefly on the evidence of the direction of glacial striæ and the distribution of erratics, considers that the main Wakatipu ice-stream divided at Queenstown "one branch continuing down the valley to Kingston, while the other and perhaps greater branch flowed down the Kawarau valley." On the other hand the increased depth of the lake from Queenstown south, without decrease in width to a point eight miles from Queenstown, suggests that ice was added to the trunk glacier near Queenstown. Such addition could only be from the Shotover-Lake Hayes basin and the shallow Frankton Arm would then be regarded as a hanging valley.

Beaches.

The Buckler Burn, five miles long, discharges from a hanging valley behind the low ridge east of Glenorchy, flows north between it and the mountains for a mile, and then turns east to the lake. The stream, when the lake was at a higher level, formed an extensive fan, the fluviatile gravels resting in part on the schist at the shore of the lake, and in part on a delta built into it. When the Lake was lowered the waves cliffed the delta beds and the stream cut through the fluviatile beds and deeply into the schist and delta. The fore-set beds of the delta, beautifully exposed for 60 chains along the south bank of the Buckler Burn, consist of grits and fine gravels which dip at about 25° towards the lake. The height of the top of the fore-set beds above the present lake is not known. In a rain gully cut in the original surface of the fan, its mouth being about 40 chains south-east from the Glenorchy Post-office, they reach the top of the terrace face (165 ft. above the lake) except for 2 ft. of well-graded pebbles. Another rain gully incised in the delta on the south side of the Buckler Burn shows fore-set beds on a terrace edge 160 ft. above the lake; the top of the terrace rises with unbroken slope to the head of the fan half a mile to the west and 250 ft. above the lake. At the first-mentioned locality the waves of the lake during pauses in its lowering have cut a series of nine or ten benches so regular in slope direction and width that residents know the place as "The Bible." The terrace top (165 ft.) slopes gently to the head of the fan; below it is one 60 ft. wide and 120 ft. above the lake: the next at 95 ft. is 10 ft. wide; and another at 80 ft. is 40 ft. wide. The lower benches, which range in height down from 40 ft. above the lake, are more or less concealed by debris from the rain gully and merge into the Glenorchy flat, which in part consists of the former flood-plain of the Buckler Burn. Park (1909, p. 16), describing an area including the east-west reach of Lake Wakatipu, notes that "tiers of old lake-beaches, seven or more of which can be distinctly traced in different places around the present shore-line, rise to a height of 150 ft. above the present lake-level, and afford convincing proof that the surface of the lake at one time stood much higher that it now does." He gives no further particulars of these beaches, which may well correspond with those at Glenorchy. There are similar series on the south side of the Buckler delta and also on the west shore of the lake a little south of Elfin Bay. Possibly the highest was formed when the lake discharged over the Kingston moraine, which, according to Hutton (1875, p. 140), rises to about 175 ft. above water level.

As stated above, the most extensive fan of the Buckler Burn rises to 250 ft. above the lake near the point where the stream escapes from its schist gorge. Above are higher terraces, remnants of earlier fans which on the road to the battery of the Glenorchy Scheelite Co. partly conceal the schist below the contour 550 ft. above the lake.

On the same road, near the battery, well-graded pebbles, grits, and sands show at two points between the 900 ft. and 1,000 ft. contours. They are wave-sorted beach-beds. McKay (1881, p. 146) wrote, "Surrounding Lake Wakatipu, and occurring at places favourable to their preservation, the highest lake level is frequently marked by well-rounded and wave-worn gravels at 1,000 ft. above the present level of the lake. An example of this is seen, at the height indicated, on both sides of the One-mile Creek near Queenstown." Possibly these beaches were on the shores of small temporary lakes along the edge of the glacier, for it is difficult to explain reasonably by what means a lake, 1,000 ft. higher than the present Wakatipu, was impounded.

Structure.

The schistosity planes of the rocks of the lower basin of the Buckler Burn and those along the east side of the Rees valley strike a little west of north and dip west at about 45°. Park (1909) mapped ten miles of the south end of the Richardson Range and also a twelve-mile strip in the Shotover valley some miles east of Glenorchy. Throughout the known area, which extends for more than twenty miles of the range, the schist planes strike nearly north and dip west at angles that range from 30° to 70°. There is similar regularity of structure in other schist areas of Otago.

West of the Rees the dips of the planes along the south end of the Earnslaw massif flatten from east to west; at the base of the cliffs west of the Rees bridge the dip is about 25°, and along Paradise valley nearly horizontal. On Mount Alfred the schists on the east side dip west at low angles and at Paradise Mine at its north-west toe are almost flat.

The dips recorded in the several accounts of the geology of the region are few and difficult to reconcile. In the Greenstone valley below the Caples junction the schists, according to Cox (1879, p. 54), dip southwest at 40° to 50°, but at the lake are less steeply inclined. McKay (1881, p. 138) notes that the planes on the west shore of the lake and the west flank of Mount Alfred dip east, and considers that a syncline crosses the lower part obliquely in a south-south-east direction from a point between the Rock and Bean Burns. Farther west the dips are much steeper and, in places, vertical (1881, pp. 133–4). McKay's diagrammatic east-west section (1881, p. 132) across the north arm of Wakatipu shows the lake on the trough of a syncline so shallow as to be little more than a structural terrace. The east wing rises into the Richardson Range and the west turns over into a sharp, deep syncline transected by the gorges of the Rock, Route, and Greenstone streams.

Great faults bound the region on the east and on the west. The latter, McKay's Hollyford Fault (1892, p. 23), extends north and south along the valleys of the Hollyford and its main tributary, Pyke River. The fault on the east side of the Richardson Range, the course of which is nearly straight in a north-by-east direction, dips west at about 70°. McKay (1881, p. 136) first traced this fault, and Park (1909) mapped it from Bob's Cove on Lake Wakatipu to Mount Aurum, a distance of more than twenty miles. McKay's name of Moke Creek Fault (1892, p. 23) has priority over Park's (1909, p. 27) name of Moonlight Fault.

Apart from the length and straightness of the shore of the north arm of the Lake Wakatipu and its continuation, the east wall of the Rees valley, there is some positive evidence of faulting along this line. North-striking crush bands are exposed in the gorge of the Buckler Burn a few chains above the bridge; the schists on the road half a mile south of the battery dip irregularly; and shattered rock is exposed for many chains between the Twelve-mile Creek and the Rees bridge. These localities are near the west base of the Richardson Range. Moreover, the depression west of Trig. D. ridge occupied by Chinaman Flat and the north-south gorge of Buckler Burn, together with the subaqueous inlet between the long, nearly drowned ridge of which Pigeon and Pig Islands are the highest points, could well be on the same narrow zone.

The evidence for faulting along the west shore of the north arm and along the lower Dart is chiefly physiographic, though Paradise lode, at the north-west end of the Mount Alfred schist island, strikes a little west of north parallel with the general trend of the supposed fault-zone, and may well be regarded as a subsidiary fracture, and McKay (1881, p. 142) noted on the same line a north-striking fault near the mouth of Von River.

Schists.

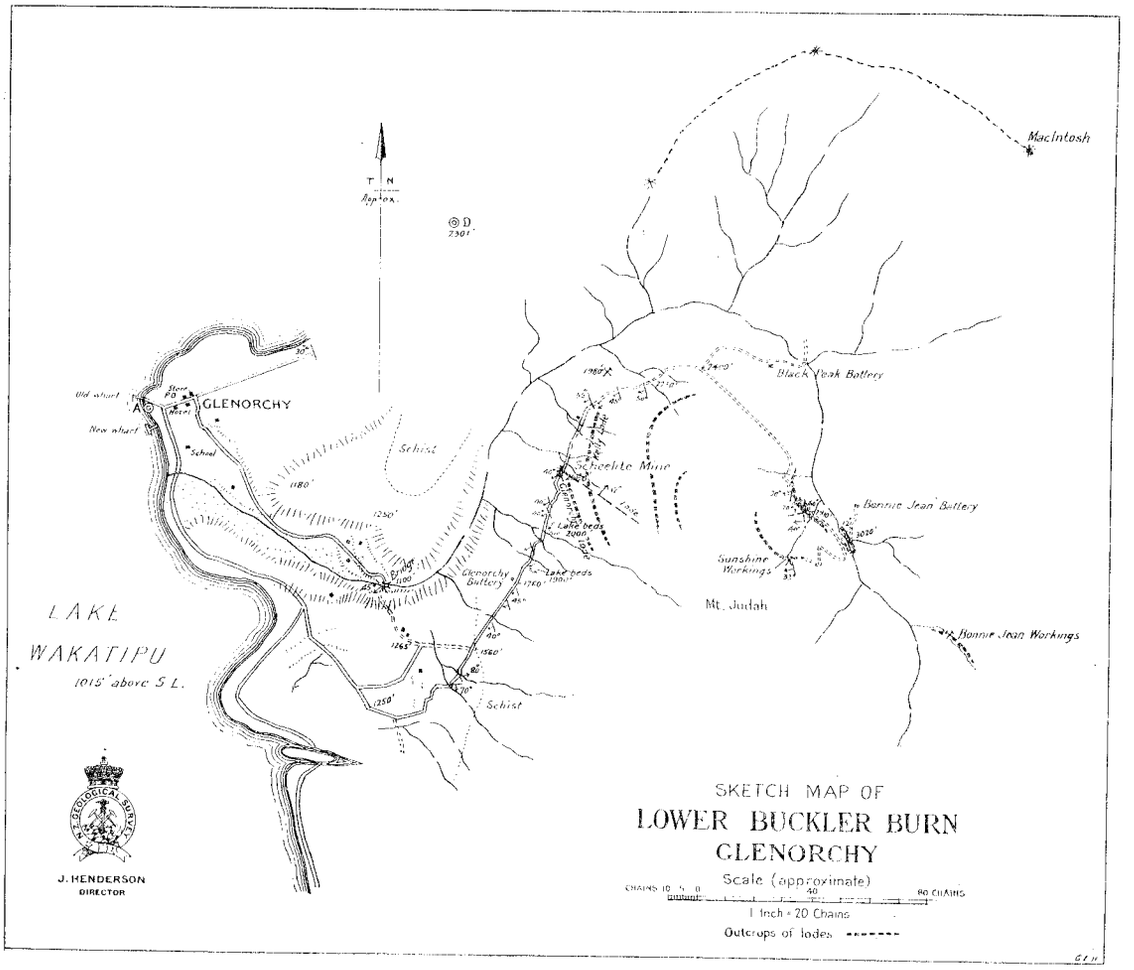
Turner and Hutton (1936), have mapped the schists of the area here considered, placing them in subzones 2, 3, and 4 of the Chlorite Zone. The Humboldt Range consists largely of rocks of subzone 2, those of Mount Earnslaw and the western part of the Richardson Range belong to subzone 3; and those of the eastern part of the Richardson Range to subzone 4. The schists are altered from banded greywackes and argillites and the derived metamorphic rocks differ in hardness, colour, and mineral proportions nearly as much as did the original sediments. The planes of schistosity coincide, so far as known, with those of the original bedding.

Lodes.

The gravels of the streams from the Richardson Range have yielded alluvial gold since the early days of the Otago goldfields and are still worked to a small extent. The Invincible auriferous lode, fifteen miles up the Rees Valley, was discovered in the early "eighties" and was mined for several years with some success. Skey identified scheelite from the Buckler Burn as early as 1864. In 1880 the detrital scheelite which cumbered the riffles of the miners in the Buckler Burn was traced to the scheelite-bearing quartz veins of the neighbourhood. The Glenorchy lode was first tested about 1882–84 by a Dunedin syndicate, of which the late Professor G. F. H. Ulrich was a leading member. When work began good-grade scheelite was worth about £40 per ton, but the price fell greatly and work stopped. Nothing of importance was done till about the end of 1905, when Messrs. George Reid and James Lynch reprospected the lode. From 1906 to 1911 a syndicate, headed by Messrs. George Reid and Robert Lee, worked the lode steadily, obtaining 308 tons of scheelite worth £31,824. The Glenorchy Scheelite Co. was registered in November of 1911, and up to 1919 had produced 632 tons of scheelite worth £99,987. Since 1919 to the present time the company has sold about 173 tons of scheelite. Mr. George Reid, the manager of the company, furnished most of the above details, as well as a copy of the mine plan.

It should be noted that all this scheelite was not obtained from the Glenorchy lode, for the yield from ore and rough concentrates purchased from the parties working other lodes is included. The Glenorchy company itself mined ore from other veins, notably from the Mount Alfred Mine near Paradise and the Junction Mine near the head of Junction Creek, a tributary of the Buckler Burn.

The Glenorchy lode is on the flanks of Mount Judah, east of the gorge of the Buckler Burn, 600 ft. above the stream and about a mile and a half east of the village. It is worked by means of eight adits, the lowest of which is about 2,000 ft. above sea-level and the highest 2,250 ft. It strikes east-south-east and dips northward at about 12°. The dip is so flat that the strong smooth walls, polished by movement and up to 8 ft. apart, might almost be spoken of as roof and floor. The filling consists principally of crushed country and quartz; calcite, scheelite, pyrite and arsenopyrite occur in smaller amount. There is usually a little gold, and at a few points rich auriferous quartz has been found. A battery concentrate from ore mined from adits 10 and 1A contained 42·95 per cent. of WO_3, 8·15 per cent. of pyrite, 16·24 per cent. of arsenopyrite, as well as 19·5 dwt. of gold per ton. Tungstite, the yellow powdery oxide of tungsten, has been seen near the outcrops, but is rare. The quartz is more or less continuous throughout; the face of a drive practically always shows some quartz. It occurs in flat lenses of very different sizes, usually within the lode filling, but in places directly against one or both walls. The lenses may overlap, being separated by bands of crushed country. This latter forms a substantial part of the fissure-filling and consists of schist fragments in a matrix of comminuted rock. It is traversed by veinlets of quartz as well as by many slicken-sided partings blackened with graphite. The whole is hard and compact, though it tends to disintegrate on the dump. There are minor irregularities in the lode as well as breaks heads and small faults.

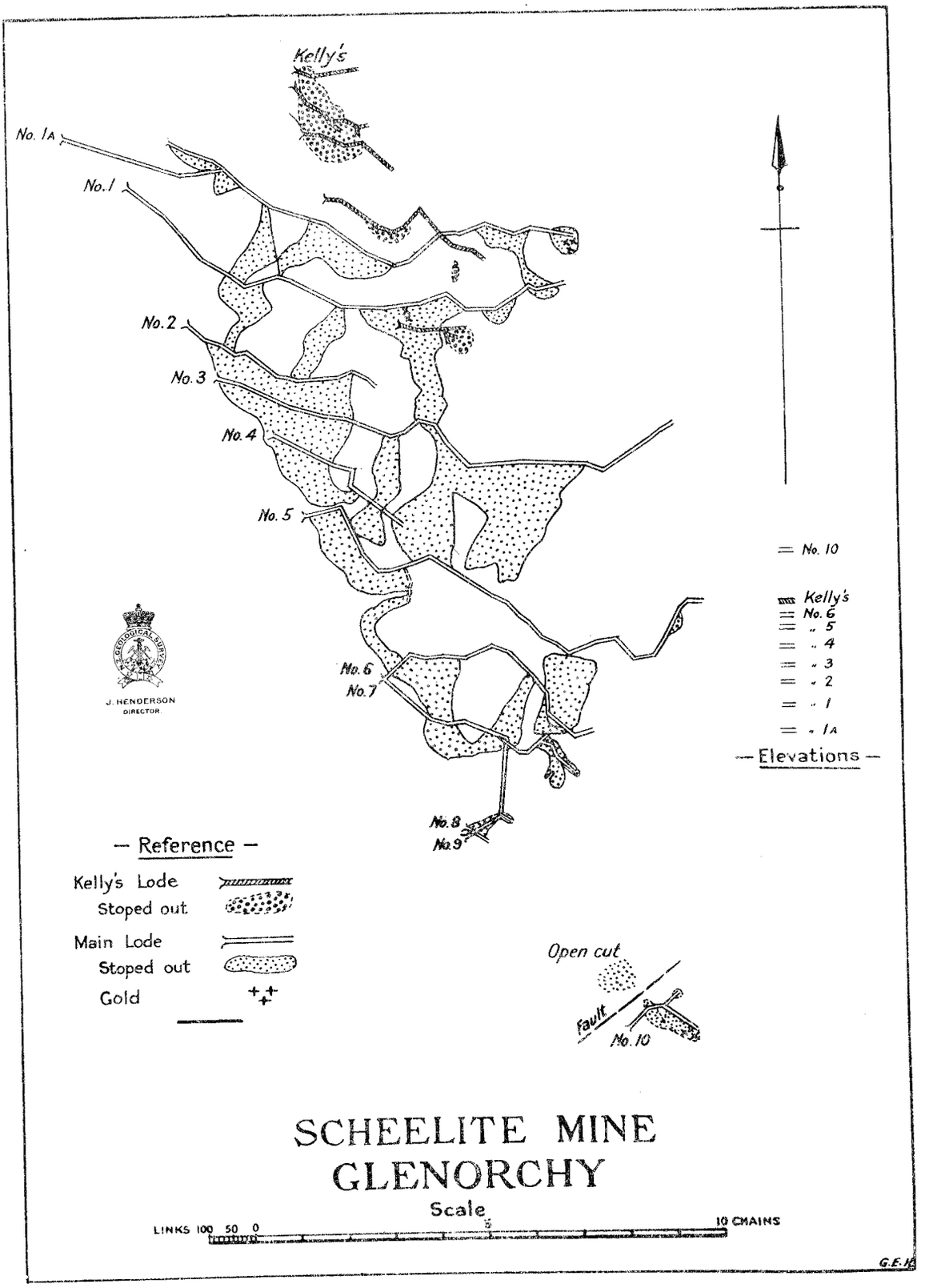


The quartz is generally laminated, owing to the presence of thin dark layers of "mullock," and this may be interpreted as evidence of the replacement of crushed country by lode minerals. The scheelite occurs in small stringers, bunches, and patches in the crushed rock and the quartz, as well as being disseminated more or less irregularly in quartz lenses of considerable size—*i.e.*, 1 ft. thick and 30 ft. to 40 ft. long. It is usually more plentiful near heads, breaks and faults, and in downward "rolls" of the lode. Calcite occurs at many points with the scheelite and is considered a favourable indication for the mineral. Near the outcrop the calcite has been dissolved, and perhaps on this account much of the scheelite near the surface, and indeed the ore as a whole, is more friable and porous. The sulphides occur chiefly with the broken schist, and where found in quartz are usually near the dark graphitic bands.

The ore is distributed along two more or less definite shoots which are separated by a part of the lode which is barren, or at least contains material not worth extracting. Though considerable movement has taken place along the lode fissure, the country, apart from the crushed rock within the fracture itself, is not greatly disturbed and the schistosity planes near the lode maintain their strike of about 20° west of true north and their westward dip of about 40°. In plan the lode fissure, which strikes about 17° south of east and dips northward at, say, 12°, truncates the schist planes on lines which strike about

25° west of north—*i.e.*, parallel with strike in plan of the pitch of the ore-shoots. That the ore-shoots follow particular layers of schist is an hypothesis which seems worth investigating.

Kelly's lode is some 150 ft. to 200 ft. above the Glenorchy lode, with which it is nearly parallel. It seems to have a slightly flatter dip. In its main characteristics the lode and ore are said to be similar to those of the Glenorchy lode. In places oxides of manganese are prominent near the outcrop.



Macalister lode outcrops high on the face of Mount Judah at 3,400 ft. above sea-level; the Lone Star is possibly a northward extension of Macalister lode. The Amateur lies at about 4,000 ft. There are at least two other prospects known. All are flat-lying fractures, though a thin vertical vein of quartz and scheelite is reported to have been worked.

The adit into Grove's lode, which outcrops beside the track on the west side of Junction Creek, is at a point 2,940 ft. above sea-level. Junction Creek drains the east flank of Mount Judah and joins the Buckler Burn about three miles east from Glenorchy village. The lode, which strikes about 10° west of north and dips north at about 20°, consists, at the mouth of the adit, of 2 ft. of crushed schist containing veinlets of quartz up to 6 in. thick and with an inch or so of pug on both walls. The adit was open only a few feet and the roof seems to have been weak. The outcrop of the lode is exposed above the track for 10 chains south-east from the adit, and north-west for 10 chains to a point where it crosses the track below which it was traced another 10 chains northward.

A strong lode striking north-west and dipping north-east at 10° outcrops at a height of 3,020 ft. where the track to the Junction Battery crosses the creek. It is exposed for at least 5 chains. In places the formation is 10 ft. wide and contains 3 ft. to 4 ft. of quartz. A little scheelite has been mined from this lode.

The Sunshine Claim, worked by Thornton and party, lies about 20 chains south of Grove's adit and more than 300 ft. above it. The soil and subsoil have been sluiced off a few square chains of the hill side, several short adits driven, and an open cut made. The formation consists of rather broken schist containing numerous quartz foliæ up to 2 in. thick. Quartz lenses up to 2 ft. wide occupy fractures which strike in general south of west and dip south at small angles. The schist planes strike a little west of north and dip west at 45°. Faulting occurs along the schist planes, the flat scheelite-bearing quartz lenses being displaced downward, 10 ft. to 20 ft. to the west, along some of the faults. Most of them, however, have small throws. Along some are lenticles of scheelite-bearing quartz, which, except for the scheelite, are indistinguishable from foliæ.

A flat fissure carrying scheelite-bearing quartz, prospected half a mile to the north and some 200 ft. above the track along Junction Creek, may continue the Sunshine lode in that direction. South of the Sunshine toward the head of Junction Creek and 350 ft. higher is the Blue Duck Claim, and at about 3,900 ft. the Boozer Claim. On the east side of the creek are the Bonnie Jean workings of the Junction Mine of the Glenorchy Scheelite Co. These are at a height of about 3,500 ft. The lode is up to 9 ft. thick and dips at about 20° to the north. It may be a continuation of the Boozer lode. Still higher up the hill are the Heather Jock, Siberia, and Alaska workings, the last-mentioned being outside the Junction basin. There are workings still farther south on the shoulder of Mount Larkin at a still higher elevation.

A flat shear about 100 ft. above water-level has been prospected on both sides of the Buckler Burn near the entry of Junction Creek. On the north side of the stream, on the flank of Mount McIntosh and about 3,000 ft. above sea-level, Downey's lode has been worked in a small way. The Pin Point Claim east of Downey's and Long Gully Claim to the west have also been prospected. The McIntosh lode, about 5,250 ft. above sea-level, strikes nearly east and west and dips north at about 40°. It has been traced as far north as the Black Peak Claim, where the dip is much flatter. The Black Peak lode, occurring at 6,000 ft. near the crest of Mount McIntosh, has also been extensively worked.

Near Temple Creek several claims have yielded small amounts of good ore, and in Pulpit Basin of Temple Peak much shoad scheelite is known to occur. Kennett's claim, where scheelite occurs in a crushed formation 1,000 ft. above the Rees, is about a mile north of Invincible Creek.

The Mount Alfred lode near Paradise, at the northern toe of the mountain of that name, has not been worked for nearly twenty years. The adits cannot be entered and the treatment plant is falling to pieces. The details given were chiefly obtained from Mr. George Reid and from the reports of the Inspectors of Mines. There are four adits, the lowest is 100 ft. above the Dart and 1,250 ft. above sea-level, and the others are respectively 47 ft., 104 ft., and 135 ft. higher. The outcrop, which is on a low ice-eroded ridge, is about 150 ft. above the lowest adit. The lode, as explored by trenching and driving, is about 800 ft. long and ranges up to 10 ft. thick, averaging perhaps 5 ft. It strikes about 20° west of north, and dips from 30° to 60° east, the average dip being about 50°. The surface trench shows a small displacement of the lode. The lode channel is filled with masses of broken and crushed schist containing lenses and veins of quartz, which carries scheelite, calcite, and sulphides. Where the quartz is thick it usually contains little scheelite. The large quartz lenses appear to have an echelon arrangement. The scheelite tends to occur in small veins and bunches or in tiny patches distributed irregularly through the crushed formation. A small branch lode in the hanging wall contained much better ore than the main lode.

A small flat vein of scheelite-bearing quartz is reported to outcrop back from the top of the Lover's Leap, a section of the cliff at the south end of the Earnslaw massif overlooking the Rees bridge. Another vein is known in Mount Alfred.

The gravels of many of the streams from the Richardson Range are known to contain detrital scheelite. It was found in Few Creek on the Twelve-mile, which drains the south end of the range to the east-west reach of Lake Wakatipu. Masses of a hundredweight or more have been got in Simpson Creek. Invincible, Muddy, and Arthur creeks, branches of the Rees, contain it, and it has been found as far north as Twenty-five-mile Creek, which enters the main river half a mile above Lennox Falls.

So far serious mining has been attempted only on the Mount Alfred and Glenorchy lodes. In the former, exploration has extended over a length of 700 ft. and a vertical depth of 150 ft. In the latter, ore has been worked by means of eight adits, in four of which the end is from 9 chains to 11 chains from daylight. A area of 8 acres or 9 acres of fissure has been explored, of which at least a third, according to the mine plan, carried ore worth extracting, and good ore has been got at a depth of 240 ft. below the surface. Of the other claims visited none had an opening more than 30 ft. from the surface, and the report is that no adit in any of the others extends more than 100 ft. The lodes themselves are on planes of decided movement. The whole series must extend through a great stretch of country. Some of the lodes have been traced half a mile or more, and the Glenorchy lode probably underlies the whole mass of Mount Judah.

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MANGANESE DEPOSIT AT OTAU, BLOCK XIV, WAIROA SURVEY DISTRICT.

By J. HEALY.

The deposit outcrops on land shown as a mining lease on the Franklin County map comprising parts of Allotments E. 75 and 95, of the Parish of Otau, and can be reached from Auckland via Hunua by the road from Happy Valley to Moumoukai Valley, whence a clay road, continued as a track, runs northward to the Mangatawhiri Forks, where the Auckland Tramping Club has recently erected a hut. From the hut a track goes a mile and a quarter up the branch coming from the north-east, at which point a stream comes in from the north, the track leading up the spur separating the main stream from this tributary to the summit of a ridge approximately 600 ft. above the stream-bed. The manganese deposit is at the south end of the ridge. It can also be reached from the north side from the head of Ness Valley, and one of the settlers there has been given a contract to put in a track from that direction to the deposit. The country is thickly bushed.

The only surface outcrop is at a bluff some 200 ft. north of the southern extremity of the ridge, where a solid mass of ore, approximately 25 ft. thick, has been tunnelled through 15 ft. below the cap. Immediately east of this and 50 ft. lower a drive has been put into the ridge from the east for a distance of 100 ft., disclosing several seams of ore at that depth. Two other drives, approximately 200 ft. north and south, have been put in from the western and eastern sides of the ridge respectively. Manganese ore was found in these drives, but insufficient driving has been done to prove the thickness of the ore body at each place.

The drives penetrate surface clay, weathered red, into red siliceous greywacke similar to that at the Bombay manganese deposit. In places this is pugged and shattered by faults, and the lode lies in a faulted zone trending slightly east of north. That the formation of the deposit at least in part pre-dates the faulting movements is indicated by the fact that it is itself involved and crushed. The fault-planes are steeply inclined and hade to the west. Hæmatite occurs with the manganese.

With the exception of one specimen from the drive farthest to the south, the manganese content of the ore is fairly constantly over 50 per cent. The following are the analyses supplied by the Dominion Analyst of specimens sent in:—

	(1.)	(2.)	(3.)
Manganese (per cent.)	8·5	54·9	54·1
Manganese dioxide (per cent.)	13·1	81·8	74·0

No. 1, from the southernmost drive, was a specimen of crushed ore and contained a large amount of hæmatite. No. 2 was from the drive to the east of and 50 ft. below the outcrop on top of the ridge. No. 3 was from a similar outcrop on Mr. Piggott's farm, two miles south of this. Two further specimens contained:—

	Per Cent. (4.)	Per Cent. (5.)
Total manganese (Mn)	58·4	46·0
Manganese dioxide (MnO_2)	88·2	23·2
Manganese oxide (MnO)	3·4	40·4
Silica (SiO_2)	0·5	25·5
Ferric oxide (Fe_2O_3)	1·4	4·8
Alumina ($A_{12}O_3$)	0·8	0·5
Barium oxide (BaO)	0·29	0·02
Lime (CaO)	Nil	1·6
Magnesia (MgO)	0·1	0·2
Copper oxide (CuO)	0·16	0·04
Nickel oxide (NiO)	Nil	Nil
Cobalt oxide (CoO)	0·08	0·06
Sodium oxide (Na_2O)	0·38	2·36
Potassium oxide (K_2O)	0·35	0·06
Water and carbonaceous matter (by difference)	4·34	1·28
	100·00	100·00

No. 4 was from the northernmost drive. No. 5 was from the tunnel through the bluff at the top of the ridge.

The probable extent of the deposit is difficult to state, but it is almost certainly of sufficient economic value to warrant further prospecting. The indications are that it decreases in size downwards; its greatest thickness is approximately 25 ft. at the surface and it is found in a drive over 50 ft. below in several veins, the greatest being 6 ft. in thickness. It is found to the north and south in drives 400 ft. apart, and the 6 ft. of ore in the north adit is distinctly encouraging.

UNDERGROUND WATER, WELLINGTON HOSPITAL.

By J. Henderson.

On 16th March, 1937, the writer visited Wellington Hospital, and was shown round the grounds by the engineer, Mr. Gray, who pointed out the places thought to be water-bearing, stated what was consumed, and gave other information. Next day a copy of the hospital plan was taken, and on the 21st the writer walked around the hills at the back of the hospital.

Part of the water that falls as rain sinks into the soil and becomes the ground water, which fills the pores, cracks, and openings underground. At the Wellington Hospital the openings are likely to be those of the loose unconsolidated surface deposits, and those in the fissured and shattered underlying hard rocks.

The surface deposits are the gravels, grits, sands, and clays of the flatter areas and the slope deposits of the hillsides. Water in these is likely to be most abundant at or near their contact with the hard rock. There is seepage down the folds in the hills at the back of the grounds, and as these gullies continue some distance out under the unconsolidated clays, &c., water will be got in wells and bores sunk in the lower country in the continuations of the little valleys. The seepage at the back of the superintendent's residence, and the water found in the lawn in front, is probably from one gully; the water reported at the eastern corner of the Nurses' Home and the north-east corner of Wards V and VI may be derived from another. The depth of the underground seepage will increase out from the hills toward Riddiford Street, where it may be of the order of 50 ft. As far as the little valleys extend under the flatter country the seepages will tend to be concentrated along them. Where there is no definite depression the seepage may be a slow percolation not organized into a stream.

Fissure water may well be present at depth below the hospital grounds, for the Newtown-Island Bay depression lies on a considerable fracture zone and the shattering of the rocks along its length may extend over a width of 20 chains or more. All the cracks and fissures in this zone are full of water, and a bore penetrating a fracture system or a brecciated mass will yield water. Bores have been sunk, and the little data available are as follow:—

(1) Victoria Laundry, Hanson Street: Bore 6 in., 150 ft. deep. Yields a little less than 2,000 gallons per hour. This bore was drilled a few months ago, is not yet in use, and the rate of yield is not fully determined.

(2) Thomson and Lewis, Tory Street: Bore 2 in., 500 ft. deep. Water rises 3 ft. above top of pipe, and the yield of 600 gallons per hour has not varied over at least ten years.

(3) Frozen Products, Tennyson Street: Bore 2 in., 490 ft. deep. Water flows at about 200 gallons per hour, increased to 600 gallons per hour on pumping, and to 800 gallons by means of an air lift to 350 ft.

(4) Macarthy's Brewery, Tory Street: Bore 3 in., a little over 500 ft. deep. Water rises to within 10 ft. of surface, and 700 gallons per hour is pumped. Two other bores were sunk to about 350 ft. in this property, but without success.

(5) N.Z. Fisheries, Cable Street: Bore 6 in., 600 ft. deep. A little water was got about 150 ft. down, but the bore was quite useless.

Of the above seven wells, three may be considered satisfactory. The Brewery and Thomson and Lewis claim that the water, on bacteriological examination, is sterile. In regard to yield, none is continuously pumped; the rates of yield apply only to daily periods of eight hours. With continuous pumping the daily yield would probably be less than twenty-four times the known hourly rates.

The shallow water as a source of supply for the hospital would, in my opinion, be unsatisfactory and inadequate, because the water is decidedly liable to pollution, and because the amount is dependent on rainfall. The quality of the fissure water would probably be excellent, but the quantity required, about 3,000 gallons per hour continuously, is substantial. The short-period average for the three good known wells is 1,100 gallons per hour. Four and more—probably five—wells of similar yield would be necessary to get a sufficient continuous supply. These would probably cost £1,000 each, and the pumping, storage, and reticulation of the water would be additional. There is the possibility that no water at all would be obtained, for the area is not an artesian basin, and boring for fissure water is decidedly speculative. From the incomplete data available, four of the seven wells in the fissure-belt are unsuccessful and the proportion is probably greater, for the drilling of an unsuccessful bore is not likely to be long remembered except by the few directly interested. Geophysical work which in favourable conditions might give some indication of the position of the fissures is unlikely to give useful information owing to the population density, the many pipes, and the stray electric currents.

WATER-SUPPLIES, HAWKE'S BAY.

By M. Ongley.

Introduction.

To find out what information is available about the water-supply of Hawke's Bay and to collect and arrange it, the writer visited Hastings and Napier and spent from 10th February to 25th March in the district. The results are disappointing. Nature has provided water so generously that man has had little to do to secure a supply and has not had to give much thought to problems in connection with it. The engineers and drillers are fully engaged in their own particular tasks and have not the time to give to the study of water-supply. A well-driller, for instance, is concerned with drilling his well to a bed that will produce water, preferably water that will rise above the surface, and pays little attention to the location of the site, its height above sea-level, or the nature of the beds drilled through, except as they affect his job. He has no pecuniary reason to keep a log of the well or to make his information public. There is no board or authority in charge of the water, and no one checks what is being done.

No one knows how many wells there are, where they are, or anything about them except as they affect their own special interest. Consequently the writer is thankful to those who helped him in his investigation. The drillers, Messrs. A. F. Liepst, H. A. McLean, T. Willan, and C. Heywood, supplied such records of the wells as they keep. Mr. Evans, Borough Engineer, Hastings, Mr. Corbett, Borough Engineer, Napier, and Mr. Anderson, Town Board Engineer, Havelock North, gave information about their town supplies. Mr. Dinnie, Public Works Department Engineer, Napier, and Mr. Rochfort, Hawke's Bay Rivers Board Engineer, supplied maps and gave particulars of their work. Mr. Howard Hill, of Taupo, son of the late Mr. Henry Hill, who took a leading part in endeavouring to create interest in the study of Hawke's Bay water-supply problems, has lent his father's manuscript papers. Mr. Pohlen, Pedologist of the Soil Survey Division, supplied special information and pointed out particulars in the field.

As a result of this preliminary investigation the writer records that it is time the water-supply was brought under control. The unit of administration cannot be a town or a county, but the drainage basin—that is, all the district within the watershed. In the writer's opinion the underground water of Heretaunga Plains is provided by the Ngaruroro River percolating into the porous beds of gravel that underlie the plain, supplemented by other streams, so that waste has mattered little, for as fast as water is drawn out of the wells more flows in from the rivers. This happy state of affairs is something to be thankful for and to be conserved. Very little is known about the water-table and its fluctuations, about the number and capacity of the different water-bearing beds, or about the impervious beds which confine some of the water under pressure and on which the different water-bearing beds are perched.

The surface water is even more neglected. The Rivers Board is doing valuable systematic work along the lines for which it is constituted, but it is not concerned with water-supply. Very little is known and very little work is being done to ascertain precise information on rainfall, evaporation, run-off, or infiltration.

In his paper on National Inland Water Survey published in the *Geographical Journal* for June, 1935, B. Cunningham reported :—

> " A national water survey in the technical (and only satisfactory) sense of the word is a comprehensive and accurate measurement and complete registration so far as may be practicable of all the water to be found in a country, whether contained in lakes, rivers, streams, wells, artificial reservoirs, or subterranean strata and cavities. It should comprise continuous observation of rainfall, close determination of evaporation and soil absorption in different localities, systematic gauging of river and stream flow with computation therefrom of discharge at all stages, historical investigation into the incidence and height of floods, periodical readings of the surface levels of lakes, wells, and artificial reservoirs, and the observation and record of the occurrence, amount, and quality of underground water wherever it issues to the surface in the form of springs and seepage with exploratory boring where desirable. Very briefly a survey is a process of active research which will trace the course of water from its first precipitation or condensation on the ground as rain, hail, snow, or dew to its final disappearance into the sea . . . Water is a national asset. Although in this country [England] happily plentiful, it is not inexhaustible, and its use is accompanied by a good deal of preventable waste, while its distribution is irregular and imperfect. The time has arrived when, owing to increasing demands for supplies to meet industrial and commercial needs, it is essential to take stock, check waste, and husband resources so as to use them best."

The above statement was not written for New Zealand, but we can learn from it. The writer showed that in tackling any water problems we must have the information gathered by the research workers in meteorology, geology, geography, and topography, and then proceed to gather the information relating to hydrology.

Again, in the *Transactions of the American Geophysical Union* for 1936, Part II, p. 481, the following appears :—

> " Before studies can be made on projects involving either the regulation or the utilization of water, or before plans can be drawn for structures, basic hydrologic data must be available. These data include records of measurements and observations of the quantity per unit of time of precipitation, stream flow, evaporation, quality of water, materials suspended and dissolved, elevation of natural water planes on surface and below and the changes thereof."

Of course, a certain amount of work can be done without collecting any information, and that is in general the way development beings ; but, as pointed out by Meinzer,—

> " To begin to develop the ground water supply of a valley without first investigating its underground conditions is as unwise as it would be to start to build a railroad without first having the route surveyed and the financial results are likely to be no less disastrous."

Precipitation.

The meteorological data are collected by volunteers, and observers are scarce in the ranges where the bulk of the rain falls. The estimated rainfall is correspondingly unreliable, but is the best available.

In his " Climatic Notes : New Zealand Districts, 1. Hawke's Bay," Dr. Kidson, discussing rainfall, remarked :—

> " North of Napier the totals are generally above 40 in. They increase as one passes from the coast to the summits of the Maungaharuru and Tangihanga ranges, where they reach over 70 in. and over 100 in. respectively. South of Napier most of the coast has above 40 in., and there is a small area on the Maraetotara Range where the average rises to over 70 in. West of the coastal ranges, however, there is a large area which receives less than 40 in., and one patch in the valley of the Tukituki River has less than 30 in. Further westward, as the land rises, there is a second increase, and 80 in. is exceeded on the summits of the Ruahines."

It is at once evident that in inquiring into the water-supply of Hawke's Bay it is not a matter of dealing with Napier Borough, Hastings Borough, Hawke's Bay County, and so many other districts. The only unit that can be considered is the drainage basin that gathers all the water that falls within the bounding watershed. How much rain falls on Heretaunga Plain is useful to know but in itself is quite insufficient.

Until more meteorological stations are established, especially in the ranges, it is impossible to estimate at all closely the amount of water that falls in the drainage basins of the rivers that flow to Hawke Bay. As shown by Dr. Kidson's map, the rainfall varies between 40 in. and 80 in., and it seems that over the catchment area it averages above 50 in. The Tukituki drains 950 square miles; the Ngaruroro, 930; and the Tutaekuri, 380. As an inch of rain over a square mile amounts to 14,500,000 gallons, it is evident that more rain falls than can be used. Owing, however, to its irregular distribution from month to month and from season to season, and to the impossibility of conserving it all, the great part of the water runs to waste; at times, however, it is not sufficient to meet demands and restrictions are imposed upon its use. This seasonal shortage of water is not the only drawback; in places, owing to the too lavish outpouring of water from wells flowing wild, the ground becomes waterlogged and is rendered useless.

Run-off.

The amount of water that runs off the surface of Hawke's Bay could be measured by stream-gauges, but as this has not been done there are no data to work on. A series of gauges along the Ngaruroro River should give an important check upon the accepted theory that it is water from the Ngaruroro that escapes from the river into the gravel under Heretaunga Plain and so maintains the supply drawn upon by Napier and Hastings and the neighbouring districts. The Tutaekuri, Tukituki, and the small streams flowing from the hills to the plain will also percolate into any porous gravels with which they come into contact, but there are no observations to show which streams are supplying water to the gravel and which are deriving water from it.

Evaporation.

So far no records have been obtained to show how much water is evaporated from Hawke's Bay.

Underground Water.

The amount of water that sinks into the ground in Hawke's Bay and so becomes available as an underground supply is not known. So far no well sunk into bedrock has struck water, all the water being drawn from superficial gravel beds. Until the geology of the district is worked out in detail all the statements are tentative. It has been known since S.P. Smith's 1876 sketch of the geology of the Northern Portion of Hawke's Bay appeared that a wide extensive syncline trends along the Wairoa River and that the west limb of this syncline continues along Hawke's Bay district as a series of extensive gentle dip-slopes descending from the mountains in the west and passing under Hawke's Bay. If any porous bed exists in these dip-slopes, with its open head cropping out in the ranges, it will afford an ideal structure for yielding artesian water. So far no porous bed is known in any of the Tertiary or older formations.

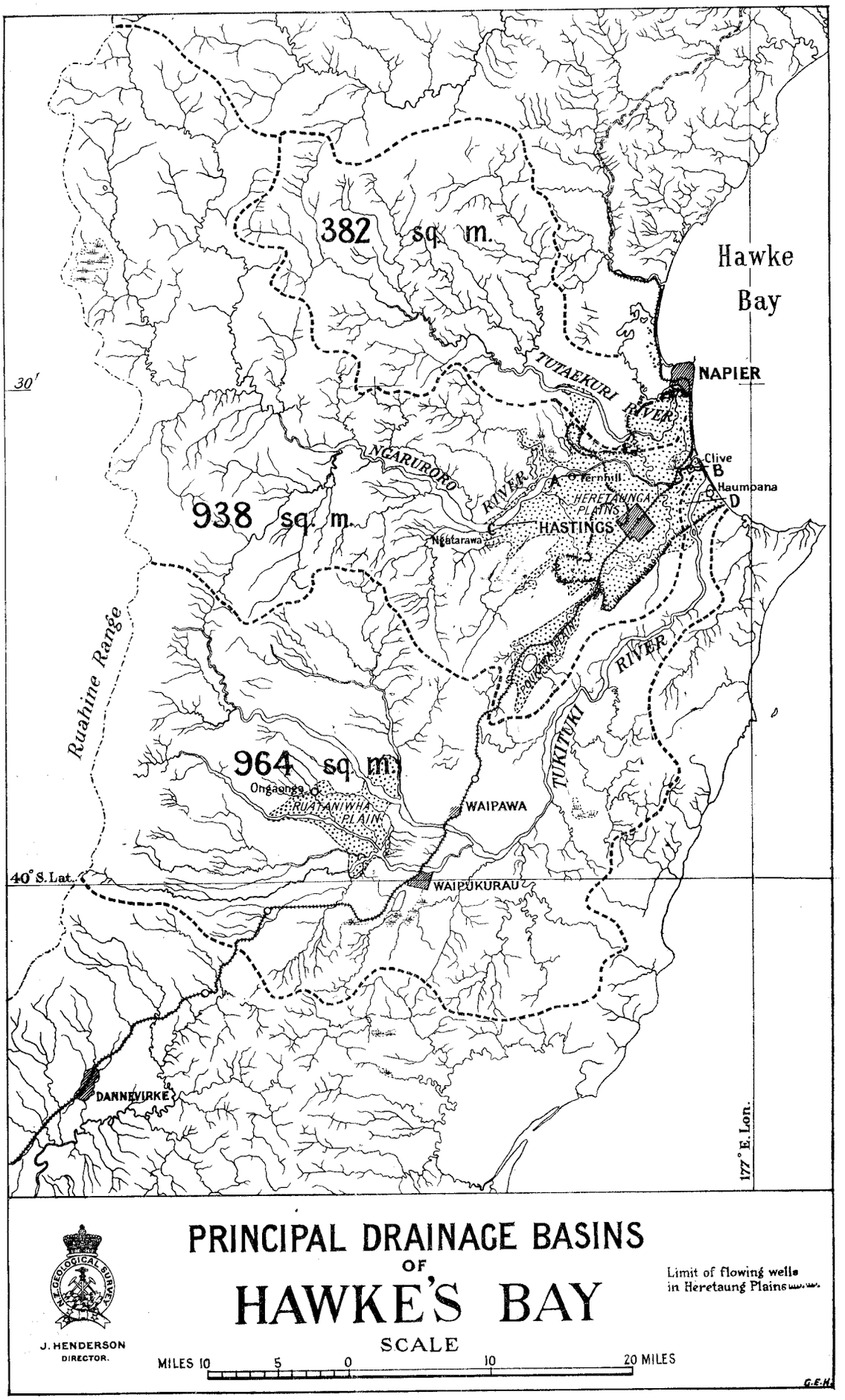
The only known water-bearing beds in Hawke's Bay are in the gravels that underlie Ahuriri or Heretaunga Plain, Ruataniwha Plain, and the other smaller infilled alluvial basins. After the Hawke's Bay earthquake of 3rd February, 1931, a geological map was hastily prepared to show the extent of Heretaunga Plain; and in the old reports of geological explorations published by the Geological Survey there is some information about the alluvial basin plains at Ruataniwha, Poukawa, and Hatuma.

These areas have not been mapped in detail, but are shown roughly on the old geological maps as Recent formations. It is within the limits of these Recent formations that ground water is present in porous beds.

In some of these areas the ground water-level is so high that parts are covered by permanent lakes; and porous beds are so common that it is rare to drill a hole that does not yield water. In some of them where the water in a porous bed is sealed in between less porous beds and the catchment area is higher than other parts, the water is under pressure and forms artesian wells; in some places the pressure is sufficient to make the water flow above the surface. From the earliest time the springs in the plain betrayed the presence of water underground. Mr. Hill has recorded that the first well in Hawke's Bay was sunk in November, 1866, by Messrs. Lord and Bennett, freshly arrived from Christchurch, in Peacock's paddock and though put down 170 ft. did not strike water. The following year, however, in January two wells got water, one at 145 ft. in Davis's paddock and the other at 175 ft. at the Mission Station. The first well in Napier was on the site of Swan's Brewery and struck a good flow at 212 ft. Since that time thousands of holes have been drilled throughout the district to different depths and only a few exceptional ones have not obtained water.

It was soon found that striking water was not merely a matter of drilling deep enough, for some deep wells failed, including one sunk 600 ft. in 1890 for Mr. Tiffen at Greenmeadows; one sunk 753 ft. for Robjohns and Co. in Napier, one sunk 743 ft. for Napier Borough Council in Napier; and another sunk 607 ft. for Hastings Borough Council in Hastings. There is no mention of what beds were bored through in these, except that it is stated that Tiffen's well, after the first 100 ft., was in blue fossiliferous clays. They indicate that it is not advisable to go deep in the expectation that the deeper one goes the more chance there is of getting water.

The drillers soon found that water was widespread in the shallow gravels under the plain and could be reached by putting a hole down in a place near to or similar to a producing hole. Accordingly, more and more holes were sunk wider and wider over the plain and there was no difficulty in getting water.


382 sq. m.
938 sq. m.
964 sq. m.
Hawke Bay
NAPIER
TUTAEKURI RIVER
NGARUROro RIVER
Clive
B
Haumpana
D
A
O.Fernhill
HERETAUNGA PLAINS
C
HASTINGS
Ngatarawa
Ruahine Range
TUKITUKI RIVER
Ongaonga
RUATANIWHA PLAIN
WAIPAWA
WAIPUKURAU
DANNEVIRKE
30'
40° S. Lat.
177° E. Lon.
PRINCIPAL DRAINAGE BASINS
OF
HAWKE'S BAY
Limit of flowing wells in Heretaung Plains
SCALE
MILES 10 5 0 10 20 MILES
J. HENDERSON
DIRECTOR.
G.E.K.

The work was not supervised or any record kept so that now no one knows how many holes there are, or where they are. One attempt was made in connection with drainage work to get a list of the wells in the different streets in Hastings; and Mr. Evans, the Borough Engineer, is having this list, which contains 700 wells, brought up to date and the wells located as to block and section. This work will afford a start for getting a systematic record of the wells. Unfortunately, the drillers' records are defective. Generally they recorded the name of the man for whom they drilled, the depth of the hole, and the date of payment; no locations of wells, no logs of strata pierced, no records of water-bearing beds other than the lowest one reached are kept. Mr. Henry Hill did try to stimulate interest in the work, and at his request some well records were kept; but he could not devote sufficient time to it; interest quickly waned and records ceased to be kept. He wrote in his last article on "Water-conservation and Hawke's Bay Artesian Systems," published in *Trans. N.Z. Inst.*, Vol. 54, page 127, as follows:—

> "For many years this question of artesian-water supply has been studied by me, and records have been kept in the expectation that the time will come when the facts that have accumulated will lead public bodies to unite in the utilization and scientific development of their water-supplies."

His son, Mr. Howard Hill, of Taupo, has kindly lent Mr. Henry Hill's manuscripts relating to water-supply, and though these are useful they are insufficient. At the present time the driller who will do the cheapest job gets the work, or the one who will humour the clients with a display with the divining rod or an alleged water-finding instrument. These many times discredited practices still find favour and pay so well that even a man who knows they are useless has to resort to them or lose the job.

From articles in *The Johnson National Drillers Journal* we see that in the United States in 1935 four States had passed laws requiring drillers to furnish a report on every well they drill. In Utah, for example, applications must be made for the right to take underground water, and every driller is obliged to furnish the necessary details regarding the construction of each well.

The New York law being the briefest, is here quoted:—

> "Every person, partnership, firm or co-partnership engaged or engaging in the business of well-drilling in the counties of Kings, Queens, Nassau and Suffolk shall hereafter be licensed by the State. Licenses therefore shall be issued by the water power and control commission in the department of conservation. Application for license shall be made upon a form to be prepared and issued by the said commission furnishing such information as the commission deems necessary for the purposes of issuance of license. The license shall require that before the commencement of drilling of any well or wells the driller shall file a preliminary report with the commission; it shall also provide that upon the completion of the drilling of any well or wells, a completion report be filed with the commission giving the log of the well, the size and depth thereof, the capacity of the pump or pumps, attached or to be attached thereto, and such other information pertaining to the withdrawal of water and operation of said well or wells as the commission by its rules or regulations may require . . .
>
> ". . . The commission may revoke any license for violation of any of the provisions of this section . . ."

In commenting on the regulations it is stated "that there is a definite trend toward regulation of the well-drilling industry and a recognition of the real importance of ground water conservation."

In discussion of the Wisconsin code it was said that "Unwise location and faulty construction of wells has cost Wisconsin dearly in the past and no doubt many other states find themselves in a like position. Under the new procedure the chief aim in our state will be to insure proper location, construction and finishing of wells and proper installation of pumping equipment." Because Wisconsin's geological picture is so varied, many local problems enter into the proper location and construction of wells. For this reason the legislation included in the law the provision that educational work be conducted in conjuction with the administration of the law. This law offers splendid opportunity for educational work not only on the part of well-drillers, plumbers, and water-system artisans, but also for owners, health officials, and all others interested. One of the Wisconsin regulations is "Except as herein otherwise provided, no person, firm or corporation shall engage in the industry of well-drilling for compensation in this state without having duly registered and obtained a permit therefor as herein provided. No permit shall be required of any person for driving, digging or otherwise obtaining ground water supply for his own personal use on real estate owned or leased by him, but such well and the work done thereon shall comply and be in conformity with law and the rules and regulations prescribed by the board."

Structure.

The Heretaunga Plain would, from the manner of its formation, be inferred to be built of irregular gravels, sands, silts, and muds deposited by different streams under varying conditions, but still with large areas uniform; this is just what is found by drilling. With adequate records it would be simple to study the nature and structure of any particular area and the variations from place to place.

The best information on any part of the plain is that supplied by Mr. Corbett, Borough Engineer, Napier, in the logs of the wells sunk by Mr. J. R. Stewart in the vicinity of Nelson and McLean parks. The logs and the sketches follow and show that the beds below these sites are fairly similar and yet have a few minor differences, insignificant in the Council's wells, but important and disastrous in the adjoining Sunshine Brewery Well.

No. 1, 6 in. Bore, Nelson Park, 7th to 29th May, 1931.

——	Thickness.	Total Depth.	Remarks.
	Feet.	Feet.	
Surface filling	3	..	
Harbour mud	9	12	
Blue shingle	67	79	
Papa clays and sands ..	105	184	
Blue shingle	12	196	Water rises 8 ft. 7 in. over surface. 275 gallons per minute.
Papa clay	29	225	
Sandy shingle ..	20	245	Water rises 11 ft. over surface. 165 gallons per minute.
Papa	18	263	
Shingle	9½	272½	Third flow. 375 gallons per minute.

No. 2, 6 in. Bore, near Memorial Gates, McLean Park, 1st June to 9th July, 1931.

——	Thickness.	Total Depth.	Remarks.
	Feet.	Feet.	
Clay	15	..	
Gravel	66	81	
Papa sand clay	132½	213½	
Gravel	21½	235	
Papa	4	239	
Gravel	14	253	240.
Clay	1½	254½	Slotted.
Gravel	25½	280	280.
Sandy papa	23	303	
Sandy gravels	7	310	
Sandy papa	5	315	317½.
Gravel	7	322	Slotted.
Papa	6	328	
Gravels	15	343	338.
Sandy gravels	5+	348	

Maximum head : 16 ft.
Minimum flow : 450 gallons per minute 1 ft. above surface.

No. 3, 6 in. Bore, near Todd Street, finished 5th August, 1931.

——	Thickness.	Total Depth.	Remarks.
	Feet.	Feet.	
Surface clay	15	..	
Fine gravel	57	72	
Coarse sand	9	81	
Sandy papa and clay	136	217	
Gravel	11	228	
Sandy papa	11	239	239.
Gravel	4	243	Slotted.
Sandy papa	5	248	
Gravel	44	292	
Sandy clay	2	294	294.

Average flow : 500 gallons per minute.

No. 4, 6 in. Bore, McVay Street, finished 9th January, 1936.

	Thickness. Feet.	Total Depth. Feet.
Surface clay and filling	15	..
Gravel	63	78
Sand and fine gravel	3	81
Papa	60	141
Fine sand	10	151
Papa	64	215
Gravel	21	236
Blue sandy shingle	5	241
Clay	4	245
Brown shingle	6	251
Clay with gravel	10	261
Coarse and fine gravel	19	280
Brown sand and gravel	5	285

Head 16½ in. over pipe.

From these wells this area would be regarded as proved to be water-producing, and any one would expect to get water in any well in the vicinity. Yet the well sunk by the same driller close to the Napier Borough No. 2, 6 in. well produced no water. The log is as follows :—

Sunshine Brewery Well, close to Napier Borough No. 2 Well.

	Thickness. Feet.	Total Depth. Feet.
Clay, gravel, and sand	76	..
Sandy papa	128	204
Sandy gravel	5	209
Papa	27	236
Sand and papa	49	285
Hard sandstone with gravel and shell conglomerate	2	287
Sandy papa	123+	410

No water.
Extensive tests at 204 ft. to 209 ft. and 236 ft. failed.

In drawing the sections showing the position of the water under the plain the records used extend over many years. No observations are kept at any well, and seasonal or secular changes cannot be taken into account. It is known that in dry seasons the water-level in some places has fallen—*e.g.*, at Pakipaki—and the wells have had to be sunk deeper; but there is no systematic record of any changes. If in a well the water-level falls 6 ft. in one season information is needed as to whether this is merely a seasonal fall dependent on dry weather or whether it is part of a progressive secular change. Taking no notice of the date or the season the sections can be taken to show the generalized water condition under Heretaunga Plain. They are accordingly useful enough to show roughly the average conditions, but cannot be used as a basis to show changes in the water table or hydrostatic conditions. They show, too, the state of our knowledge of the beds under the plain. By drawing sections in different directions many more wells could be included. Such sections would only show that in favourable places like Clive, Tomoana, Whakatu, and Hastings many wells put down close together tap the same bed over a fair-sized area.

The wells of Hastings Borough Council have been summarized by Mr. Evans as follows:—

ARTESIAN WELLS FROM WHICH IS DRAWN THE WATER-SUPPLY FOR HASTINGS.

The following artesian wells are situated in Eastbourne Street in the vicinity of the power-station:—

Nine wells put down in 1910 (eight, 3 in. diameter; one, 4 in. diameter).
Average depth, 161 ft.
Total flow into pumping-sump, 450 gallons per minute.
Average flow (1935), 55 gallons per minute.

Fourteen wells put down in 1928 (all 3 in. diameter).
Average depth, 161 ft.
Total flow into sump, 1,000 gallons per minute.
Average flow, 67 gallons per minute.

Two wells put down in 1931–32 (both 6 in. diameter).
Average depth, 299 ft.
Total flow into sump, 900 gallons per minute.

Total flow into pumping-sump, 3,400,000 gallons per day.

This record shows plainly that two water-bearing strata are drawn on by the Council. Three and a half million gallons a day are drawn off without affecting the water-level.

CONFINING-BED.

As is shown in the McLean Park wells at Napier, in the Hastings Borough wells, and elsewhere, different water-producing beds are separated by non-producing fine beds that are impervious enough to confine the water to the coarser layers. Usually the deeper the water-bearing stratum the higher the water rises. Not enough is known of the beds drilled through to check the extent of any particular beds. In some wells sand with marine shells is reported; but the reports are too scrappy to be useful. In other records beds of fine pumice sand or pumice flour are mentioned, and such beds will be useful as key beds to check position.

INTERFERENCE AND VARIATION OF WELLS.

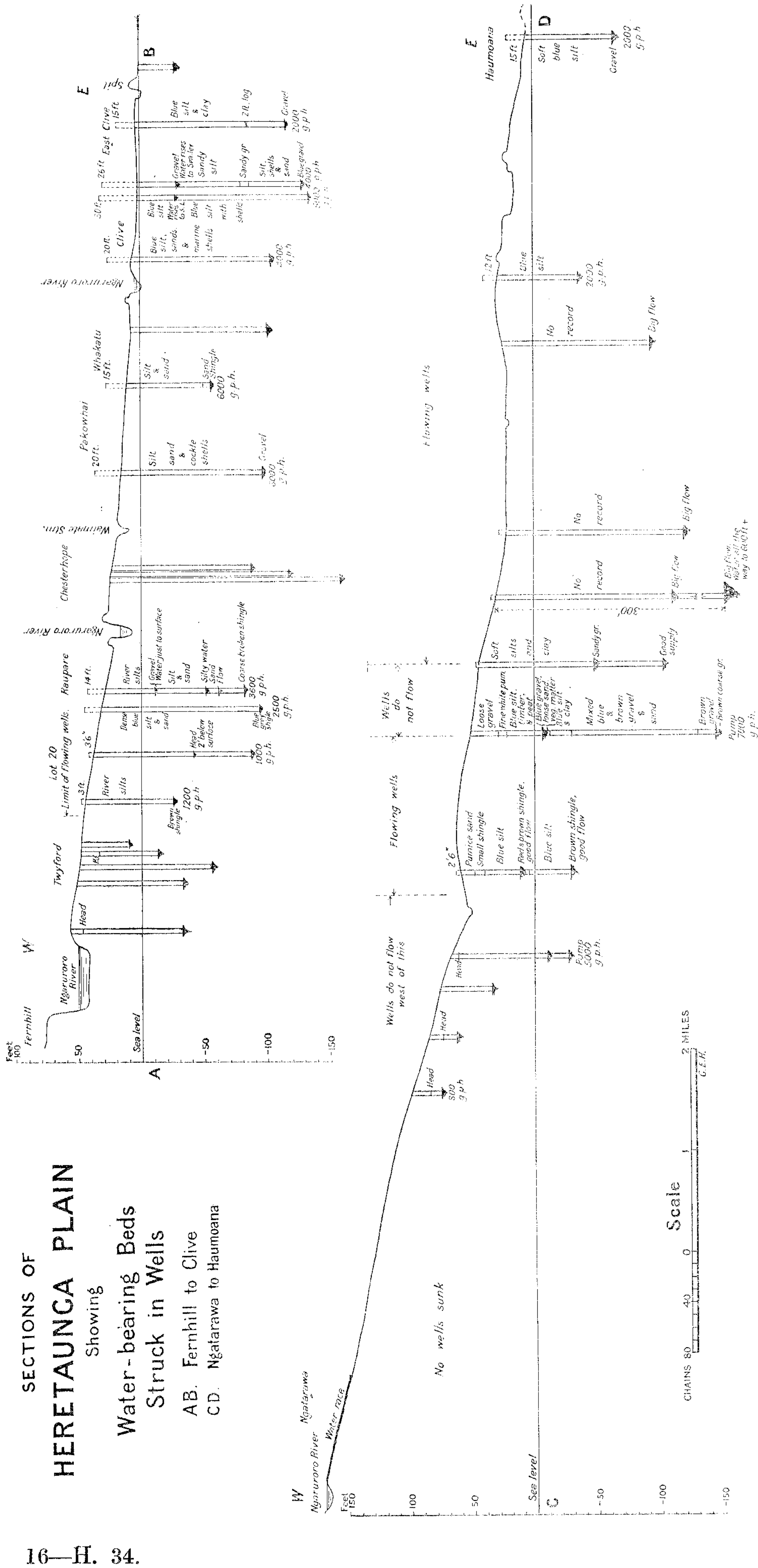
Neighbouring wells are reported to interfere with one another. Mr. Liepst reported that in Hastings, in Eastbourne Street, one well 150 ft. deep was completely dried by another sunk close by in the next section to 170 ft. Mr. Willan reported that the sinking of the Council well at Havelock lowered several neighbouring wells; and that in the houses in Karamu Settlement the water has sunk so that it no longer rises into the hot-water systems.

It is generally reported that the water in the wells sinks in dry seasons, and this is to be expected. This does not mean, however, that the water is being depleted by use. In wet seasons the water in the wells rises again, and rainfall in the mountains, it is reported, affects the water-level in the wells in the plain. All the evidence points to the explanation that the Ngaruroro supplies the water and controls the level to which it rises in the wells in the plain. If this is established it will remove any fear that too much water might be used, and it will mean that as fast as the water is drawn off at Napier and Hastings, more flows into the gravel beds from the Ngaruroro. Systematic observations over a long period are required.

It is reported that wells near the beach and even as far inland as Pakipaki vary with the tides. Such variation with the tide has been verified elsewhere and would not be surprising, but it should be checked by systematic observation.

SUBMARINE OUTLET.

From the structure of the Heretaunga Plain it was inferred that the underground water would escape through outlets under the sea, but on inquiry no reliable information of such submarine outlets was obtained. The fishermen who trawl in the bay know of no submarine springs. The water along the beach is reported to rise 25 ft. above sea-level. This may be caused in several ways. The submarine end of the water-bearing beds may be completely enclosed, or at least so confined by less porous beds as to allow this pressure to accumulate. If the submarine ends of the gravels are open and the head is caused by the difference in gravity between the fresh water and the salt water, points of escape would need to be 1,000 ft. deep to produce a 25 ft. head at the surface.


SECTIONS OF
HERETAUNGA PLAIN
Showing
Water-bearing Beds
Struck in Wells
AB. Fernhill to Clive
CD. Ngatarawa to Haumoana
Fernhill
Ngaruroro River
Twyford
Lot 20
Limit of Flowing wells.
Raupare
Ngaruroro River
Chesterhope
Waitangi Stm.
Pakowhai
Whakatu
Ngaruroro River
Clive
East Clive
Spit
Sea level
Feet
Ngatarawa
Water race
No wells sunk
Wells do not flow west of this
Flowing wells
Wells do not flow
Flowing wells
Haumoana
Scale
CHAINS 80 40 0 1 2 MILES

Irrigation.

As shown in the section that extends to the Ngaruroro, the river at Ngatarawa is higher than any part of Heretaunga Plain. The river water is now used to supply small races on the highest part of the flats, and the greater part of the plain could be readily irrigated by extending the races. In a few places the water from the flowing wells is used for irrigation, and this method can be extended to all the area within the boundary of the flowing wells.

In connection with irrigation the danger of drowning useful ground arises and will have to be provided for.

Excess Water.

Although many difficulties arise from shortage of water, some trouble is caused by excess of water. In places the water-level is so high that the ground is naturally water-logged or covered by a pond or lake. Such conditions have also been brought about artificially in several places by bringing the underground water to the surface. In many parts wells are to be seen flowing wild. The surface water flows naturally or is drained to the lowest areas where it forms swamps and ponds or escapes by evaporation or soakage. Possibly such surface waters in places are perched on impervious beds that have empty or partly empty porous beds below, and if so it may be found practicable to bore through the impervious bed and let the perched water escape.

Underground Salt Water.

It was reported in the Hawke's Bay *Herald* that salt water was struck in two holes bored in 1920 in the tramway yards at Napier, but the depth was not given. In 1937 Mr. McLean reported salt water under Richmond Block in a gravel bed that extended from 35 ft. to 90 ft. down. It rose to sea-level—that is, 6 ft. 6 in. below the surface—and fluctuated with the tides. The same salt-water bed was reported below the Marine Parade and on the west of Riverhead Road. No doubt it is much more extensive. It would be useful to know how far it extends and how it is related to the fresh water above and below. Samples of it should be analysed. It may be connate water that was buried with the gravel as it sank or it may be salt water percolating in from the sea.

Quality of the Underground Water.

Apart from the salt water under Richmond Block and the Parade the water under Heretaunga Plain is fresh. In different parts it is polluted by decaying vegetation and hydrogen sulphide, but over the greater part of the district it has caused no suspicion. Henry Hill's notes contain records of old analyses.

Poukawa.

Outside the Heretaunga Plain other alluvial plains yield artesian water and flowing wells. In the Poukawa depression between Opapa and the hill at the kennels eight miles to the north twenty holes are recorded. Lake Poukawa is evidently perched; and saline and fresh springs along the valley betray escaping ground water. The boundary of the alluvial fill has not been mapped to the south, but the extent of the alluvium is indicated on the map in the earthquake report. Several layers are known to contain water; but until the height of the surface at the sites of the bores is measured the beds cannot be placed in their relative positions. The beds are described as silt, shelly sand, peat, papa, and limestone grit; but not one good log is available. The holes struck water from 28 ft. to 240 ft. below the surface, and the water rose 25 ft. above it at the highest and in other wells did not rise to the surface. That the lake is not the source of the water is shown by the water rising above it; in one well 50 ft. above the lake the water rose 13 ft. above the surface.

Ruataniwha.

Hill (*Trans. N.Z. Inst.*, Vol. 25, pp. 350–53) recorded the discovery of artesian water in Ruataniwha Plain in a well drilled by Mr. Gilberd on the property of Mr. Harding at Mount Vernon about a mile north-east of Onga Onga Township. Mr. Hill described Ruataniwha as an alluvial plain twenty miles long and eight miles wide formed similarly to Heretaunga Plain. The hole penetrated the beds listed below:—

——	Thickness.	Total Depth.	Remarks.
	Feet.	Feet.	
Surface gravel	60	..	Unlimited water standing 6 ft. below surface.
Impervious beds	20	80	..
Gravel	40	120	Unlimited water standing 33 ft. below surface.
Impervious bed	15	135	..
Gravel	101	236	Water standing 60 ft. below surface.
Impervious bed	32	268	..
Gravel	48	316	Flowing water 18 gallons per minute.

Mr. Hill mentioned that water issued from several strong springs near by and from several large springs lower down the plain towards Ashcott Station. In his manuscript Mr. Hill recorded that this was a 3 in. well, located 800 ft. above sea-level, and that the water rose 16 ft. above the surface. The manuscript contains the record of a 2 in. well sunk for Mr. H. W. Watson at Fairfield, Onga Onga,

which struck water at 390 ft., flowed 300 gallons per hour, and rose 5 ft. above the surface; also of a well at Harding's Plantation, of which he gave the log as follows:—

	Thickness.	Total Depth.	Remarks.
	Feet.	Feet.	
Shingle	60	..	Water always 15 ft. below surface.
Shingle and clay	20	80	..
Fine shingle	20	100	..
Fine shingle full of boulders ..	17	117	..
Fine shingle full of boulders and red clay	10	127	..
Shingle	100	227	..
Boulders and blue clay	32	259	Water rose to surface.
Shingle	57	316	Water rose 16 ft. above surface flow 1,000 gallons per hour.

Possibly this refers to the first well mentioned at Harding's with the log corrected.

The water from Fairfield was recorded in Hill's notes as soft water containing—

	Grains per Gallon.
Sodium chloride	.. 1·20
Sodium bicarbonate	.. 2·50
Calcium bicarbonate	.. 4·86
Magnesium bicarbonate	.. 1·60
Silica	.. 3·92
	14·08

Hill recorded two other wells at Onga Onga sunk for Mr. Beamish, the manager of the butter-factory, respectively 75 ft. and 125 ft. deep. From the former the record shows the water rose 5 ft. above the surface.

These wells have not been located on the map, and the area of alluvium in this part has not been mapped.

Otane.

Mr. Leipst reported sinking two 2 in. wells for Mr. Tod at Otane in 1914 and three more in 1915 to the depths of 49 ft., 58 ft., 50 ft., 64 ft., and 52 ft., but gave no log of the wells. Hill's notes contain a list dated December, 1914, giving six 2 in. wells on Mr. Tod's—2 in., 71 ft.; A, 63 ft.; B, 41 ft.; C, 40 ft.; D, 58 ft.; E, 52 ft. Nothing is stated as to the beds, and only the first well has the flow stated—viz., 15 gallons per minute.

Pukehou.

Mr. Leipst reported that in 1915 he tried unsuccessfully for water in Pukehou Swamp for Rev. A. M. Williams by boring a 6 in. hole 75 ft. and thence driving a 2 in. pipe down to 140 ft. and also by driving five other 2 in. holes 65 ft., 65 ft., 80 ft., 80 ft., and 94 ft. Mr. Liepst does not record the beds passed through.

Summary.

The evidence gathered shows that Hawke's Bay is amply supplied with water, but yet suffers dry spells in which rainfall alone does not produce enough water. The Heretaunga Plain is wonderfully constructed to provide innumerable flowing wells of good potable water. This underground water has been hurriedly and somewhat irresponsibly developed, but has not been depleted and probably cannot be until the draw-off exceeds the flow in the Ngaruroro River.

The surface water-supply has been so little studied that little of value is known about it. The Ngaruroro runs above the level of Heretaunga Plain and could be used to irrigate it. The underground water rises above the surface over a large part of the plain and can also be used for irrigation.

Excess water is causing trouble and is likely to give more.

The other alluvial plains resemble Heretaunga Plain; and flowing wells have been established in them at Otane, Ruataniwha, and Poukawa.

BLACKBURN COALFIELD.

H. E. Fyfe and H. Wellman.

Introduction.

Locality and Access.—The State Coal reserve at the Blackburn is an area of 13·5 square miles, comprising parts of Blocks VIII, IX, XII, and XIII of Ngakawau Survey District, Buller County, Nelson Land District. It is on the eastern edge of the Buller Coalfield and roughly midway between Seddonville and Lyell. The only practicable route to the area is from Stockton by way of the Westport-Stockton Coal Co's haulage tramway to the Stockton Mine, a distance of six miles, and thence across country by rough track for an additional six miles. The latter part of this route, from the Stockton Mine to the Blackburn Pakihi, follows the prospector's track to the upper Ngakawau and Mossy Creek basins, and though suitable for packhorse transport in the fine summer months it soon becomes impassable for horses during wet weather.

Field-work.—This report is based on reconnaissance surveys of the greater part of the reserve, as well as of adjacent areas where information bearing on its potentialities as a coal-field could be obtained. In addition, both writers made the detailed geologic and topographic mapping of that portion of the reserve which was considered to offer sufficiently encouraging prospects to warrant such mapping. Field-work began towards the end of January, 1936, and continued to the end of March,

1937, during which period the junior writer mapped, by plane table supplemented by stadia traverses on a scale of 8 in. to the mile, that part of the reserve embodied in the accompanying plan, in all an area of five square miles. Throughout the survey intersections on minor trigs established by theodolite were taken for control.

The senior writer was in the field for a total period of three weeks at the beginning and end of the field-work.

Acknowledgments.—For assistance in transport of camp gear and supplies the Geological Survey is indebted to Mr. C. Schadick, Buller County Engineer; to Mr. T. Maegie, manager of the Westport-Stockton Coal Co.'s Mine; and to the employees of that company who willingly co-operated. The assistance of the District Placement Officer, Westport, Mr. Anthony, in placing tools and equipment at the disposal of the survey is also appreciated.

Previous Observers.—In 1877 Robert Denniston published his "Detailed Notes on the Buller Coal Field" in the "Reports of Geological Explorations during 1874-76," No. 9 of the reports of the old Geological Survey. He described several sections containing coal within the Blackburn Reserve; some of these cannot be accurately located.

In the same volume S. Herbert Cox published his "Report on the Survey of the Buller Coal Field." He referred especially to the area here considered on p. 116 as the "Upper Orikaka Country," and one of the geologic sections accompanying the report that he described as "Section through Orikaka Valley N.S." is a section through the Blackburn.

The most detailed and comprehensive account of the area is that by P. G. Morgan and J. A. Bartrum in "The Geology and Mineral Resources of the Buller-Mohikinui Subdivision, Westport Division," *N.Z.G.S.* Bulletin No. 17 (New Series). This publication makes several references to the Blackburn area, and pages 150-152 deal particularly with it. Reference is made to these publications in the following report.

General Description of the Reserve.

The greater portion of the reserve consists of monotonous broadly terraced land at elevations of from 900 ft. to 1,400 ft., relieved by the northern end of the Mount Berners ridge (2,390 ft.) and the low hills of the divide between the Ngakawau and Mackley rivers. There are two prominent remnants of erosion, Island Hill (1,330 ft.) and Isolated Hill (1,280 ft.), toward the western boundary of the reserve, which includes in addition the lower slopes of the elevated Mount William block to the west. Some 900 acres bordering the Upper Blackburn is poorly drained, swampy, pakihi land up to 20 ft. above stream level, but with the exception of another 150 acres of pakihi between the Blackburn Stream and the Ngakawau, 120 chains south-east of Trig. AS, the remainder of the reserve is covered with beech and rain forest and large patches of manuka.

The area is drained entirely by the Ngakawau and its tributary the Blackburn, which south of Island Hill is a sluggish meandering stream entrenched 3 ft. or 4 ft. in an ill-defined flood-plain that merges into the surrounding pakihi. About 15 chains north-west from Island Hill the Blackburn plunges over resistant sandstones and grits in a 50 ft. fall, whence it flows for 29 chains in a maturely graded reach before plunging over another outcrop of the same resistant rocks in a waterfall 36 ft. high. Downstream from here the Blackburn is entrenched 100 ft. or more below the bordering high-level terrace and flows by three maturely graded reaches separated by two short rapids to its junction with the Ngakawau. Each of the two upper of these reaches is controlled by granite masses on which the stream is superposed; the lowest reach is controlled by base level at the Ngakawau junction.

The two waterfalls in the Blackburn are matched by two corresponding falls in its tributary—Mullocky Creek—and as this latter creek is cut entirely in soft Kaiata mudstone, the falls have receded 30 chains farther headward than they have in the Blackburn, which above the confluence is cut in the more resistant basal Kaiata mudstone and Brunner beds.

The headwaters of the Blackburn from a point 60 chains north-west from Island Hill formerly flowed to the Ngakawau by Erin Creek, a tributary of St. Patrick Stream. Remnants of terraces in the Upper Blackburn some 35 ft. to 40 ft. above present stream-level match an extensive river-planed flat with an abandoned stream channel between the Erin and the Blackburn. This latter throughout its course flows over much less granite than does the Erin and has captured its present headwaters from this stream by more rapid headward erosion.

The catchment area of the Blackburn upstream from Island Hill is about two square miles, and in this portion of its course the stream averages 6 ft. across near the south end of the pakihi and 15 ft. across at the north end. It is entrenched from 3 ft. to 6 ft. below much of the pakihi, the surface of which consists of a shallow cover of alluvium resting on a somewhat imperious mudstone, so that during wet weather there is a relatively rapid run-off with consequent flooding of the pakihi adjacent to the stream. As the greater part of the possible coal-bearing area underlies that portion of the pakihi which is only some 20 ft. at most above stream-level, it would seem that under the present system of coal-mining as practised in New Zealand only a small percentage of extraction would be possible without taking a risk of allowing surface water to enter the workings.

The only other river of importance within the reserve is the Ngakawau, which after emerging from the Glasgow Range flows for two miles and a half across the north-east corner of the reserve.

Structure.

Outline.—The reserve occupies portion of the structural depression between the highlands of the Glasgow Range on the east, and the Papahaua Range (Mounts Rochfort, William, Frederick, Stockton, &c.) on the west. This depression is the northern continuation of what is described in

N.Z. GEOLOGICAL SURVEY

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TOPOGRAPHICAL MAP OF PORTION OF
BLACKBURN STATE COAL RESERVE

Scale 20 Chains to 1 Inch

Reference

Trigonometrical Stations
Edges of Bush
Swamps
Waterfalls

Surveyed and drawn by H. Wellman

Bulletin No. 17 as the Inangahua Graben, but in the area north of the Buller River it has features characterizing a fault-angle depression, and in reality is a combination of these two structural types. Thus the authors of Bulletin No. 17 write, "the western limit" [of the Inangahua Graben north of the Buller] "is somewhat indefinite, or rather, there is difficulty in defining it" (p. 52). The reason for the difficulty in defining it is because the structure is not a simple graben. The north-east-striking Papahaua block, from the higher portions of which much of the Tertiary strata has been removed exposing the granitic undermass, dips south-east towards the Glasgow fault, but a number of minor north-east-striking faults traverse it, and with the exception of the western most faults bounding two small horst-like blocks—the Mount Berners ridge, and the ridge between New and Slug Creeks—the downthrow is to the east. Some of these faults are shown on the Mokihinui-Lyell sheet accompanying Bulletin No. 17, but in addition the contours of the back-slope of the Mount William block suggest the presence of small strike-faults traversing it, not shown on the map. The Blackburn fault-zone is the westernmost of these subsidiary faults traversing the reserve, and though the throw on it amounts to several hundred feet within this area it dies out rapidly in both directions beyond it. To this fault is due the preservation of apparently the most valuable portion of the reserve, for it dropped much of the coal-bearing strata below erosion level. Next in importance are the faults along the Mount Berners ridge, which is of granite upthrown to the east. These faults die out north-eastward before reaching Ngakawau River, and south-westward only the larger of the two reaches the Mackley River, beyond which it is not well established. Minor faults close to the eastern boundary of this Mount Berners block give the impression that it may be a small horst, but some outcrops show the Tertiaries resting on the granite, dipping westward so that the structure of this minor block is a miniature repetition of the Papahaua block. Within half a mile east of the reserve, the Glasgow Fault cuts off the eastward extension of the Tertiary rocks and upthrows the granite and metamorphic rocks of the Glasgow Range some thousands of feet.

Denniston (1877, pp. 121–71) interpreted the broad structural outlines of the part of the depression occupied by the reserve as those of a basin-shaped coal area. Cox (1877, pp. 17–29) did not comment on the structure of the "Upper Orikaka Country" in his report, but his cross-section through "Orikaka Valley N.S." shows that he considered the coal-measures rested on a basement of marked relief.

Morgan and Bartrum (1915) showed in the cross-sections accompanying Bulletin No. 17 that they considered the Blackburn field west of the Mount Berners ridge to be a structural basin or broad synclinal fold much of the east limb of which is cut off by the Mount Berners fault. They pointed out that a moderately irregular or undulatory structure appears in the Blackburn, and they apparently considered that this was superposed on the larger synclinal fold.

The writers interpret the structure as a broad syncline, folded along a north-east axis, and superposed on this broad folding are minor folds and fractures. This interpretation is practically identical with the opinions expressed in Bulletin No. 17, as will be gathered from the following account in which for convenience of description different subsidiary structural blocks referred to on the map are lettered alphabetically.

The western margin of the possible coal-bearing area is bounded by the north-east-striking Blackburn Fault, the throw on which brings up the granite and must amount to several hundred feet. East of this fault are two narrow elongated fault-blocks, B and C, in which coal either outcrops or is probably present at no great depth. These two blocks do not appear to be broken by minor faults, but there is no positive proof of their absence.

Block A: Throughout block A, the northernmost block containing a seam of workable thickness, the strata are either horizontal or dip east and south-east at angles up to 25°. This dip was recorded at the coal outcrop at the northern edge of the block, where a small south-east-striking normal fault dipping south-west at 40° downthrows the coal about 12 ft. Other minor faults may intersect this block.

Block B: Within block B the strata dip probably easterly throughout the southern two-thirds of its length, but north of this the beds are synclinally folded, the strata being more or less horizontal over a small area at its north extremity.

West of Island Hill, within a faulted area, are some westerly dips up to 60°, but these steep dips probably do not persist beyond the east-bounding fault-zone, the throw on which may be as much as 250 ft. to 300 ft., about midway along the block. Assuming that the one recorded easterly dip of 15° midway along the block represents the average dip of the strata south of this, the easterly dip of 30° some 35 chains south-west being disregarded because it probably represents the drag of the fault, the coal horizon is nowhere at a greater depth than 250 ft. to 300 ft. in any part of the block, and throughout much of it this horizon would be at a much less depth, especially if the synclinal structure at its north persists throughout its southern end. By analogy with block C, the structure of which is better displayed, it is thought that the southern portion of block B is homoclinally folded.

Block C: Over the greater length of block C south-easterly dips of from 5° to 10° prevail, but at its southern end the block rises and the strata dip north-west.

Block D: Block D, east of blocks B and C, is roughly two miles long in a north-easterly direction, and about 60 chains wide. It does not appear to be intersected by any major faults. The Tertiary rocks between the flanking faults are folded with little or no fracturing into two synclines and two anticlinas the axes of which pitch north-east, in which direction the folding gives place to a single broad synclinal fold. The structure perhaps may be more correctly interpreted as two basins aligned along a north-east axis. West of the small synclinal and anticlinal folds at the south of the block is a small upfaulted block, which appears to represent an anticlinal fold that has fractured along its limbs. There is little displacement along the faults bounding it, and to the north they die out and the strata assume a regular easterly dip.

Block E: Little can be found out about the structure of block E, as Mullocky Creek, the only watercourse of sufficient size to afford any outcrops that traverses it, flows through Upper Kaiata mudstone which contains no recognizable key bed. The section along Mullocky Creek suggests that the portion of the block east of a line continuing the strike of the north-east fault between blocks D and E as far as the small north-west fault exposed in Mullocky Creek, 60 chains upstream from its junction with the Blackburn, is synclinally folded along a north-east axis paralleling the grain of the area, and that between Island Hill and this small fault there is another north-east-striking synclinal fold, possibly with a pitch to the north. No major faulting was detected along Mullocky Creek except Mullocky Fault, which forms the eastern boundary of block E, and which brings up the granite and basal coal-measures against the mudstones of this block.

Between Mullocky Fault and the main Mount Berners Fault, a few chains to the east, is a small patch of Tertiary rocks low in the sequence. No coal is known to crop out in this area, and though it is possible the coal has been completely eroded from this block, it seems more probable that coal was never present, as in other parts of the reserve the coal is close to the basal rocks.

Within half a mile of the eastern boundary of the reserve is the Glasgow Fault, along which the highlands of the Glasgow Range have been elevated some thousands of feet. Where this fault crosses the Mackley the lower carbonaceous micaceous Kaiata mudstone is dragged up and dips west at high angles. Probably throughout its course east of the reserve there is considerable drag on this fault, but that the effect of the drag extends as far as the reserve is unlikely.

Stratigraphy.

The rocks on which the coal-measures rest are pre-Tertiary granite and gneiss with possibly a little infaulted Palæozoic sediments, but the latter were nowhere observed within the reserve. The surface truncating them is described in Bulletin No. 17 as "sufficiently levelled to be termed a peneplain" (p. 49), on the surface of which "was a shallow freshwater lake or lakes" (p. 60) in which the coal-measures accumulated. Apparently the authors would thus explain the lenticular seams.

As the underlying rocks of the area can be studied only at the south end of block D no definite information can be given about the erosion surface truncating them throughout the reserve. The surface of the granite there is decidedly hummocky, two granite ridges cropping out in the cores of anticlines. These granite ridges are not residuas of erosion around which the sediments were deposited, but are folds in the granite basement, for the overlying sediments conform in dip with the granite surface. They show no trace of faulting.

On the surface of pre-Tertiary granite, which evidently was not highly irregular when the coal-measures formed but which probably contained a number of more or less connected basins, accumulated a series of conglomerates, grits, coal-forming material, grits, and sandstones of a total thickness of from 50 ft. to 100 ft. These Brunner beds were succeeded by the lower Kaiata beds, which are micaceous sandstones, more or less carbonaceous and poorly fossiliferous, and grade up into the typical Kaiata mudstone. The maximum thickness of these beds in the area is 700 ft., giving a total thickness of sediments of about 800 ft. This is the maximum depth that any hole would have to be drilled to reach the granite. The apparently great thickness of the lower Kaiata beds in the lower part of Coal Creek is due presumably to strike-faulting.

The Hawk's Craig Breccia, which is of considerable thickness in other parts of the Buller-Mokihinui Subdivision, nowhere crops out within the reserve. The Brunner beds consist of fine-grained sandstone or grit, with at places a basal conglomerate, the components of which are mainly quartz pebbles with granite, greywacke, or hornfels. The coarsest facies of the conglomerate crops out along the Mount Berners Fault, where the boulders may be as much as a foot through. Grits or sandstones, typically arkosic, may replace the conglomerate and form the basal beds. These grade upward into a micaceous sandstone of varying thickness; usually a thin carbonaceous micaceous sandstone forms the floor of the seam.

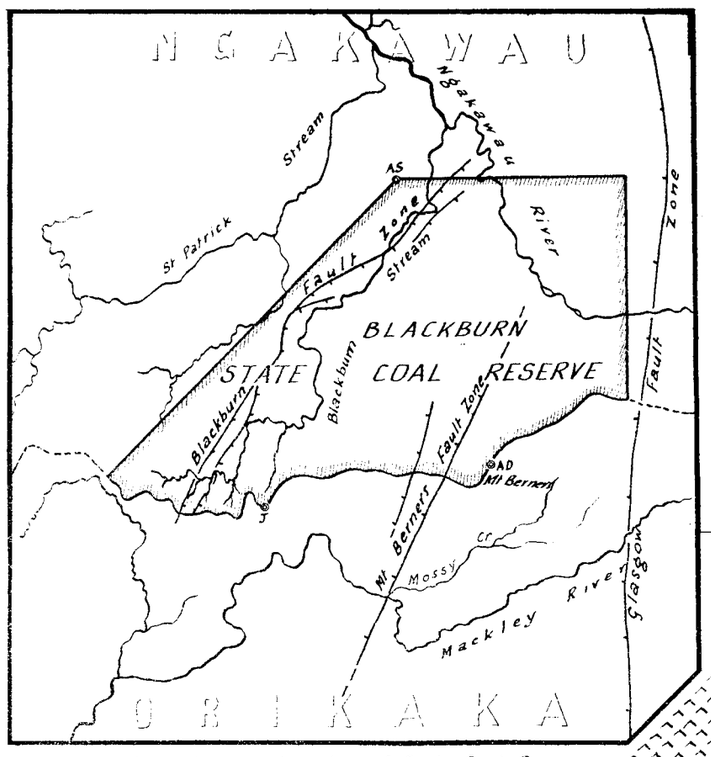
The coal is a hard, bright homogeneous bituminous coal with lumps of retinite scattered sparingly and is in every way similar to that at present mined at Stockton.

Near the outcrop a considerable amount of clayey material has found its way along joint planes to distances of 8 ft. to 10 ft. into the seam, and it is possible that in those blocks with shallow overburden a considerable amount of coal will be similarly contaminated, so that it may be necessary to wash some of the coal before marketing.

Wherever the coal is adjacent to a fault it is intensely slickensided, but usually not crushed, so that it does not disintegrate into excessively small sizes on working.

In some localities thin films of pyrite are fairly plentiful along fractures and cleavages and occasionally as small nests in the coal.

Toward the south-west corner of the reserve, along the western bounding fault-zone, much of the coal shows a cone-in-cone structure. That the structure is due to stresses which have affected the seam can be inferred from the slickensided-like appearance of the exposed conic surfaces, and the structure was probably induced during or prior to the faulting movements, and resulted from the stresses then active. Similar cone-in-cone structure was noted in bituminous coal in West Virginia by Paul H. Price ("Cone-in-cone in Coal," Abstract of paper, *Proc. Geol. Soc. Am. for 1933*, pp. 102–3, published 1934), who concluded that "Conical structures represent planes of maximum shear from vertical stress." Apparently in the area to which Price refers the axes of the cones are vertical, but at the Blackburn they are more or less parallel to the floor of the coal, so that the stresses inducing the structure were probably applied more or less parallel to the bedding-plane. The application of a stress parallel to the bedding is quite possible in the Blackburn, for some of the blocks involved in the fault movements could be wedged between more resistant blocks, and the granite basement being so close to the coal-seam would be strong enough to prevent complete crushing of the coal.



Locality Plan showing boundary of State Coal Reserve

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1550 Chains E

1600 Chains E

1650 Chains E. of Buller Initial

100 Chains North of Buller Initial

650 Chains N.

600 Chains N.

550 Chains N.

Granite Creek

Blackburn Stream

Waterfall

Island Hill

Isolated Hill

Pakiri Stream

Blackburn Creek

Coal Found

Mullocky

Mullocky

Mackley River

GEOLOGICAL MAP OF PORTION OF
BLACKBURN STATE COAL RESERVE

Scale of Chains

10 5 0 10 20 30 40 50

Geology by H. Wellman.

- Reference -

EOCENE

- Upper Kaiata Beds:- Calcareous Mudstones — K2
- Lower Kaiata Beds:- Sandstone — K1
- Brunner Beds — Shales, Sandstones & Grits with Coal Seams, Conglomerate — B
- Granite & Gneiss — G

- Outcrops with observed strike and dip
- Coal outcrops with observed strike & dip
- Coal outcrops with no observed strike
- Shafts and coal cuts
- Continuous outcrops of coal
- Coal Sample Numbers
- Faults with downthrow indicated

H. Wellman Del.

Denniston recognized two coal horizons within the reserve, for his sections refer to an "upper" and a "lower" seam. Apparently Cox accepted Denniston's interpretation, for he used some of Denniston's sections in his report in describing some of the outcrops and he showed two seams in the cross-section incorrectly entitled "Section through Orikaka Valley N.S." This is a section from a point a little east of the junction of the Blackburn with the Ngakawau, south-westerly to the Orikaka valley. Neither of these writers described any one section in which both seams cropped out. Morgan and Bartrum (1915, p. 152) were uncertain whether there are two coal horizons at the south end of the reserve. The writers have seen no reason to consider that more than one coal horizon is present, but there may be several isolated or connected coal seams or lenses at this horizon, and some of these lenses may be split by sandstone bands. When drilling the bores must all be taken to the granite.

At the south end of the reserve the coal-seam is markedly lenticular and thins out from 40 ft. to 1 ft. 6 in. in a north-easterly direction in a distance of 15 chains. Thirty chains south-east of Isolated Hill no coal shows in the basal sandstones. Similar variations may occur throughout the field. This rapid thickening and thinning of the coal will necessitate close spacing of bore-holes to prove the area (say, at 10 chains intervals along any proposed line of holes), though distance between bores may be increased according to the evidence given by the cores as drilling proceeds.

A thin band of shaly sandstone, more or less carbonaceous and occasionally with leaf impression, overlies the coal, and this is succeeded by arkosic sands and grits.

No definite line can be drawn in the field between these terrestrial Brunner beds and the overlying Kaiata marine sandstones into which they grade. Within the reserve the lower Kaiata sandstones are poorly fossiliferous and contain a *Turitella* determined by Dr. Marwick as *Spirocolpus*, and occasionally a massive oyster, the former being more widely distributed. *Spirocolpus* is known to range from Eocene to Upper Oligocene.

The lower Kaiata beds grade into the upper Kaiata mudstone, which is a poorly fossiliferous, massive bluish-grey, slightly calcareous mudstone.

Pleistocene and Recent terrace gravels form a veneer over most of the area, the former outcropping at heights up to 350 ft. above the river-level. These gravels have been prospected in places, but although they contain traces of gold they are nowhere of economic value.

Amount of Coal.

Unfortunately, the positive evidence on which tonnage estimates may be based is decidedly meagre, and in endeavouring to arrive at some figure which may fairly represent the probable amount of coal in the reserve all the area of eight square miles other than that covered by the detailed map, and part of that included in it, is considered barren. The absence of coal outcrops within this area may be insufficient reason for regarding it barren, for over much of it only the Kaiata mudstone crops out; but the definite absence of any coal in the Brunner beds other than the few poor outcrops described elsewhere, in the Mossy Creek-Mackley valley to the south of the reserve, permit of no other assumption, especially when it is remembered large tracts of coal-measures either barren or too poor to work are known in the Buller field (1915, p. 149). On the other hand, it may be argued that as the coal thickens rapidly to workable seams at the south of the reserve, several thick coal-lenses may underlie the area here considered barren. To prove or disprove this will entail a costly boring programme, and as there appeared to be no possibility of obtaining additional information as to the best location for bore sites within it, the "barren" area was not mapped. Proving this "barren" area seems justified only if the probable resources of the remainder of the reserve can be economically mined, and should follow when information from such mining operations is sufficiently advanced to permit some inference as to the possible resources of this "barren" area.

The figures in the following table show that probably 5,085,000 tons of workable coal is present in that portion of the reserve covered by the detailed map. These figures, when considered with the rough estimate of 3,000,000 tons by Morgan and Bartrum (1915, p. 184) for this area, show that any assumption that huge coal resources are buried in the Blackburn Reserve are unwarranted.

For the purpose of estimating the amount of coal in the field the different areas are considered separately. In the table half the actual area of each block is stated in the second column, and this is considered to contain a workable seam which would average out to the minimum thickness as stated in the third column. Thus the seam may be less than the assumed minimum thickness in part of the half-area, but it may be much thicker over other parts of it. The fourth column gives the co-ordinates of the outcrops on which the calculations are based, and the detailed description of these outcrops is given on following pages.

Block.	Area throughout which Workable Seam can be expected.	Average Thickness of Seam.	Workable Coal.	Co-ordinates of Coal Outcrops in Block on which Estimates are based.		Remarks.
		Ft.	Tons.	(N.)	(E.)	
A ..	40 acres	5	300,000	731·3	1,615·0	Block may be considerably broken by minor faults. Only shallow boring necessary to prove area. Maximum depth of hole, 150 ft.
				711·0	1,601·0	
B ..	40 acres	5	300,000	671·2	1,566·5	Minor faulting must be expected in this block.
				614·0	1,522·5	
C ..	25 acres	6	225,000	614·0	1,522·5	..
				590·2	1,509·0	
D ..	220 acres	6	3,960,000	683·6	1,594·5	..
				671·2	1,566·5	
				614·0	1,522·5	
				590·2	1,509·0	

In addition to this tonnage about 300,000 tons of easily won coal is present in the outcrop area south of block C. Total, 5,085,000 tons.

Coal Outcrops.

The observed outcrops of coal are briefly described. Their positions can be readily fixed from the co-ordinates on the geological map :—

711 N. 1601 E.—This outcrop is in Waterfall Creek. A good description of the locality is given in Bulletin 17, p. 151, where it was stated that the thickness of the seam could not be estimated, but was considered to exceed 10 ft. and that the outcrop was 960 ft. above sea-level. A considerable amount of coal shows in the creek-bed, involved in the fault which crosses it within 2 chains of its own junction with the Blackburn. Minor strike faults intersect the sandstone upstream from the main fault. A pit was sunk adjacent to the creek-bed on the coal outcropping at the foot of the waterfall immediately west of the fault.

A section upward from the bottom of the pit showed resting on a sandstone floor 2 ft. 2 in. coal, 1 in. shale parting, 3 ft. 5 in. coal with an irregular eroded upper surface. In the coarse sandstone and grit overlying the seam are some angular fragments of coal up to 4 in. across. At 40 ft. above the coal is the fossiliferous zone of the Kaiata beds with the large *Ostrea*. The average dip in this locality is 10° east and the strike 8° north of east.

731·3 N. 1615 E. (Sample-locality No. 7).—At the head of a small tributary of Coal Creek joining it 20 chains from its confluence with the Blackburn, beneath a few inches of soil and sandstone is a 7 ft. seam of hard bright coal which overlies a band of sandstone 2 ft. 6 in. thick which in turn overlies 3 ft. of similar coal. No floor is showing and the strata strike north 30° east and dip south-east at 25°. A fault striking 31° west of north and dipping south-west at 45° downthrows the coal about 10 ft. to the west. About a chain down this creek another outcrop shows 6 ft. of coal (roof not exposed) overlying 2 ft. 4 in. of sandstone, which rests on 3 ft. of coal with no floor exposed. Apparently the same fault as that traversing the outcrop upstream intersects this outcrop; it strikes 25° east of north, dips south-east at 28°, and downthrows about 10 ft. to the east. The strata west of the fault strike 23° east of north and dip north-west at 13°. Neither of these outcrops gives a definite indication of the thickness of the seam, but there is probably at least 10 ft. of coal here, split by a sandstone band 2 ft. 6 in. thick, the upper split being 6 ft. to 7 ft. thick.

709 N. 1610 E.—This is the locality in the Blackburn referred to in Bulletin No. 17, page 151, two miles and a half above its junction with the Ngakawau. The two outcrops there described refer to a discontinuous outcrop of two thin coal-seams which at one point of observation "strike 204° and dip 10° to the east-south-east, one seam being 3 in. thick and the other 8 in. or 9 in. thick." At the other point is "grit, succeeded in downward order by 10 in. to 12 in. dark shale, 9 in. coal, 2 in. to 3 in. shale, 7 in. coal, 5 in. carbonaceous micaceous shale. The rocks strike 236° and dip at 12° to the south-east." These two sections are representative of the coal-seams of this locality, which are a foot or two from the granite.

698 N. 1599 E.—This outcrop is beneath a waterfall in a tributary of the Blackburn, east of the narrow strip of infaulted granite, where carbonaceous shale and sandstone, somewhat disturbed by the fault, rest on granite. A few feet of sandstone overlie, followed by the lower Kaiata sandstone with the fossiliferous *Ostrea* horizon. The carbonaceous shale is probably the same horizon as the coal of outcrop 709 N. 1610 E.

685 N. 1570 E.—In a bend of the Blackburn on the left bank, north-west of Island Hill, some carbonaceous shaly bands are interbedded with thin coaly layers and sandstone, the whole thickness of these beds being 18 in. These are enclosed in an indurated sandstone showing much jointing sub-parallel to the bedding, and are overlain within a few feet by the lower fossiliferous Kaiata sandstone. These beds dip south-east at 20°. There is no evidence for considering this outcrop a higher horizon than that of the thicker coal-seams elsewhere in the area, though it may possibly be so.

671·2 N. 1566·5 E. (Sample-locality No. 2).—This section is described on p. 151 of Bulletin No. 17. A comparison of the description in that Bulletin with the following shows that over the small distance in which these sections were observed, considerable variation occurs in the sequence within the coal-bearing horizon.

A small pit was sunk on an outcrop of coal at a bend in the Blackburn a quarter of a mile west of Island Hill. The section there exposed is :—

Soil and clay	2 ft. 6 in.
Carbonaceous shale and coaly layers	1 ft. 5 in.
Carbonaceous micaceous sandstone	1 ft. 5 in.
Coal and carbonaceous shale	1 ft. to 6 in.
Micaceous clay with coaly streaks and quartz sands	2 ft. 2 in.
Coal	4 ft. 6 in.
Carbonaceous mudstone (holing dirt)	6 in. to 8 in.
Sandstone floor.	

The coal, which strikes 25° east of north and dips north-west at 30°, is highly jointed and crushed, with clay disseminated along joint planes.

Downstream 50 ft. from here the section is :—

Soil and clay	1 ft. 8 in.
Carbonaceous shale	9 in.
Dirty coal	7 in.
Shale and carbonaceous material	1 ft.
Carbonaceous shale and sandstone with coaly streaks	1 ft. 1 in.
Sandstone	6 in.
Shale and impure coal	9 in.
Carbonaceous micaceous sandstone	1 ft. 8 in.
Micaceous sandstone	1 ft. 8 in.

Possibly the thick coal-seam of the outcrop immediately upstream underlies the lowest sandstone of this section.

683·6 N. 1594·5 E. (Sample-locality No. 1).—This locality is at the north-east base of Island Hill on the rising ground at the west side of the pakihi, where a band of arkosic sandstone makes a somewhat inconspicuous hummock on the gentle slopes. As a number of coal fragments showed in the surface soil a shaft was sunk, and for 20 ft. it revealed coal from a few inches below the surface to the bottom of the shaft, which had to be abandoned on account of water, while still in coal. The beds dip east at 40° approximately, so there is a minimum thickness of 15 ft. of hard, bright coal which contains a few small lumps of retinite. Though jointed, the coal is not crushed except for a small band 10 ft. below the surface, which may represent a band of soft carbonaceous shale along which has been a little movement. Surface trenching and small pits showed coal for 10 chains along the strike, and for 6 chains south of the shaft the seam apparently maintains it thickness though there appears to be some minor faulting interrupting its continuity.

614 N. 1522·5 E. (Sample-locality No. 3).—A shaft was sunk for 14 ft. in crushed coal at the western edge of the pakihi, where the prospecting track from Stockton to the upper Mackley reaches the pakihi. The coal and overlying sandstone dips 20° south-east, and from the crushing of the coal, the outcrop is in or adjacent to a fault. The shaft was abandoned at a depth of 14 ft. on sandstone. On a rough estimate the seam is 13 ft. thick.

590·2 N. 1509 E. (Sample-locality No. 4).—A cut in the south bank of a small intermittent stream 2 chains up from the Blackburn shows a coal-seam 6 ft. 4 in. thick, dipping south-east at about 10°. A micaceous sandstone forms the roof, and beneath the coal is 1 ft. of crushed sooty-coal or "holing dirt." The floor is a carbonaceous micaceous sandstone resting on a fine-grained sandstone. The coal is hard, bright, and jointed, discoloured with clay for 2 ft. from the roof, and occasionally having a thin fiml of pyrites on joint planes. A crushed zone about 2 in. wide extends from roof to floor carrying surface water with clay and mud through the seam, so that the sample from here may be too high in ash to be representative of the seam. Small nodules of retinite are scattered throughout.

553 N. 1489 E.—A cut in the side of a small terrace showed 3 ft. of coal (total thickness not exposed) striking east of north, and dipping north-west at 45°. A minor fault downthrows the coal to the east.

Two chains east of this, slickensided coal with "cone-in-cone" structure outcrops in the small creek which is cutting its channel along a fault. In the Blackburn, 3 chains to the south, a seam at least 2 ft. thick dips at 10° north-west.

"Coal Island" is 30 chains south-west from these outcrops, and consists of a remnant 13 chains by 3 chains wide, of a coal-seam dipping north at 20° and 35 ft. thick. The same seam outcrops north-west across a headwater tributary of the Blackburn, but 4 chains beyond this it is cut off by the Blackburn Fault. This is the locality described in Bulletin No. 17, p. 151, where the coal outcrop "forms a ring round a flat-topped hillock, three-quarters of a mile west of Trig. Station J." The maximum overburden to the coal does not exceed 20 ft., averages about 10 ft., and consists of shale overlain by gritty arkosic sandstone. On the opposite side of the valley south of "Coal Island" the seam has thinned to under 20 ft., sections across it outcrop showing thickness of 8 ft. to 15 ft. of coal, and at a point with co-ordinates N. 517 E. 1454 the seam is less than 5 (?) ft. thick. Coal is mentioned as outcropping here in the bed of a small creek draining into the Blackburn (Bulletin No. 17, p. 151). Eight chains south-west from this point the seam is 6 ft. 6 in. thick and dips southwards at 10° (584 N. 1504 E.). The section there exposed shows the following :—

Soil.	
Fine-grained sandstone	2 ft.
Carbonaceous shale	2 ft.
Coal	6 ft. 6 in.
Carbonaceous micaceous shale	1 ft.
Coarse sandstone and grit floor.	

539·3 N. 1492·7 E. (Sample-locality No. 6).—This point is at the southernmost end of the pakihi on the south bank of the Blackburn, where it makes an acute bend and flows through a ridge of the Brunner beds. The section shows :—

Soil, sand, and gravel, resting on an eroded surface of the coal	8 in. to 18 in.
Coal highly jointed with clayey streaks along joints ; a little retinite	4 ft. 3 in.
Crushed coal band	4 in.
Clean bright coal, lower 15 in. extremely hard, a little retinite	2 ft. 4 in.
Stone band	1 in.
Hard dense coal, brilliant black lustre, a little retinite	4 ft. 9 in.
Sandstone floor.	

In all there is a total of 12 ft. 4 in. of coal, from which an overlying thickness of several feet of coal has been eroded. There is an occasional film of pyrite along joint planes and some of the coal has "cone-in-cone" structure with the axes of the coal more or less horizontal.

Three chains west of this, a cut in the hillside shows a thickness of over 40 ft. of coal, the floor being unexposed. Though this cut was made up to 8 ft. below the surface it failed to reach coal from which a representative sample could be taken, as soil and root-fibres have penetrated beyond the bottom of the cut. The coal is apparently unaffected by its long exposure to atmospheric weathering, the individual fragments being bright and hard on fracture. The coal is slightly crushed and drossy. Nine chains south-west from this cut the seam thins to less than 3 ft.

Northwards the coal crops out round the western and southern sides of the low hill on the north side of and partly encircled by the Blackburn, but it thins to 1 ft. 6 in. 12 chains north-north-east of the cut, and on the southern side of the hill it thins to 1 ft. at a point 12 chains east from the same cut. The outcrop could not be traced completely encircling the hill. The two following sections refer to outcrops in this area.

On the south bank of the Blackburn the seam extends east from locality No. 6 around the hill side and up the head of the tributary joining it 10 chains east of this point. In this valley the strata are synclinally folded, a small fault fracturing the axis of the fold. There are many coal outcrops up to 8 ft. thick, but much of the coal has been stripped off as the seam is at the surface. Reference is made to this area in Bulletin 17, p. 152, where 8½ ft. of hard coal is reported twenty-nine chains west of Trig. Station A.

The westernmost extension of this coal lens is at a point of which the co-ordinates are 542·5 N. 1510 E., where there is a thickness of 1 ft. of coal. Four chains north-west of this the seam is 3 ft. thick, and 6 chains west it is 6 ft. thick.

543 N. 1528 E.—A seam 3 ft. 6 in. thick crops out here, but it pinches out entirely 4 chains to the north. Eight chains south it has thickened to 13 ft. and can be traced for a farther 8 chains round the head of the valley whence it continues to, and thins out completely at, a point 8 chains east of the outcrop showing 13 ft. of coal. This coal lens is synclinally folded, and apparently is not continuous with the coal-seam 20 chains to the west, though apparently they are both at the same horizon.

South of Trig. J, in the Mackley watershed, is an extension of the Blackburn coalfield, the Brunner beds outcropping over an area 50 chains east-west, by 30 chains north-south. The coal ranges in thickness from a few inches to 10 ft.; much of it has been denuded. Possibly, however, the 10 ft. seam may continue east beneath the Kaiata mudstone.

Other outcrops that have a bearing on the possible coal resources of the reserve are mentioned in Bulletin No. 17, where on page 153 the authors refer to the "coaly streaks in sandstone near the Mokihinui-Lyell track, east of Mount Berners." Coal fragments were found in this locality, but no seam was located, and it is probable the fragments came from this or a similar outcrop. Search was also made for the 8 ft. of coal a short distance south of the Mackley, near the point where the Glasgow fault crosses (Bulletin 17, p. 153), but without success.

Samples were taken from seven of the above localities, but the analyses are not yet completed, and reports on these samples will appear in a subsequent annual report of the Dominion Laboratory. The following analyses of coal from this area are taken from *N.Z.G.S. Bull.* No. 17, p. 139:—

Locality.	Fixed Carbon.	Volatile Hydrocarbon.	Water.	Ash.	Total Sulphur.	Remarks.
					Per Cent.	
Coal Island: Head of Blackburn ..	56·99	36·77	5·72	0·52	0·91	From outcrop 25 ft. or more thick. Does not coke. Ash dark brown.
Head of Blackburn: Pakihi ..	53·06	40·50	3·13	3·32	2·45	Outcrop coal. Forms a firm coke. Ash grey.

METEOROLOGICAL BRANCH.

REPORT BY THE DIRECTOR, 1936–37.

General.

The principal concern of the Branch during the year has again been the provision of the ever-increasing services required by aviation. The most difficult problem has been the acquiring of the necessary staff. The same problem is facing the Directors of Meteorological services in almost every country of the world. On the Continent of Europe, where numbers of the universities not only have schools of meteorology, but also provide for post-graduate research, the position is not so difficult. In Britain, although there is one such school, the demand for meteorologists greatly exceeds the supply. A somewhat similar condition obtains in America, where, however, numbers of meteorologists of very high standing have been imported from Europe. It should be understood that a meteorologist of the standard demanded at present in any of the leading services requires a specialized training no less severe than that in others of the learned professions. There is no source of ready-made meteorologists in New Zealand. Through the appointment of a number of University graduates who have specialized in mathematics and physics, and by concentrating on the most essential routine requirements, it has been possible, so far, to cater fairly satisfactorily to the regular commercial air services. The situation will, however, be much more difficult when trans-ocean flying is being carried out, whether by commercial or military units. Furthermore, other branches of the work have had to be neglected, and without the accumulation of a general knowledge of meteorology the advance in any one direction cannot be sound and satisfactory. It will therefore be a number of years before the expanded service can reach normal efficiency.

Observing-stations.

A new climatological station was established at Westport. Observations at the Morrinsville station have been discontinued. Rain gauges have been installed at fifteen new stations, while two stations have been abandoned. A number of new telegraphic weather reporting stations have been provided along the commercial air routes, and the equipment at these stations is being improved.

Although it has been possible to devote little time to inspection, the assistance given by Union, Cook Strait, and East Coast Airways has enabled much time to be saved and a good deal of ground to be covered.

I wish again to express our great appreciation of the efforts of observers and reporters, most of whose work is entirely voluntary.

Forecasting.

Aviation weather services have been introduced since the previous year for East Coast Airways' route from Napier to Gisborne and for the extension of Cook Strait Airways' line from Nelson to Hokitika. During the first exploratory flight by the Pan-American Airways clipper from Honolulu to Auckland Dr. W. A. Macky was stationed at Auckland. Complete reports, as received at Wellington, were sent to him twice daily, and weather charts were drawn. A daily discussion on the situation was held between Auckland and Wellington. On the information thus supplied, supplemented by data from the equatorial regions, Mr. A. Francis, the Meteorologist of Pan-American Airways, based the advice given to the clipper on which its movements were determined. The sequence of weather at the time was a very interesting one and well calculated to illustrate the difficulties the weather over the route was likely to occasion. When the machine was due to leave Pago Pago for Auckland a deep cyclone moved southward on an unusual path from the New Hebrides. At the time first set for it to leave on the return flight, a "cold front," with a squally wind, showers of rain, and cloud down to the ground, crossed the Auckland Harbour, enforcing a delay. Following the departure of the vessel there was a strong outbreak of cold air, and a cyclone developed to the north of New Zealand. In addition, there were several minor distrubances in the tropics. The conditions were therefore such as to expose any deficiencies in the existing weather service.

A good reporting service from the islands of the south-west Pacific is clearly essential for air traffic between New Zealand and the islands themselves, whether or not it is extended to America. What is, perhaps, not so obvious to the layman is that it would not be possible to provide a proper weather service for trans-Tasman flights unless the same information were available, as well as reports from farther south.

The principal weaknesses found in the present service were the interruptions in the reporting system caused by week-ends and holidays, the too frequent failure of wireless communications, and the delay between the making of the observations and the receipt of the collected reports. A few additional reporting stations, also, are required.

Throughout the period when the clipper was south of the Equator special assistance in the collection of reports was given by the Post and Telegraph Department. The High Commissioner for the Western Pacific and the Australian Meteorological authorities also co-operated.

In addition to those for regular air lines, reports supplied for flights of a more sporadic nature, including those of Air Force personnel, amount during the year to some thousands.

The great developments in aviation forecasting should not be allowed to distract attention from the increased services being given in other directions. Special district forecasts are now issued at 1 p.m. from the stations of the National Broadcasting Service in Auckland, Wellington, Christchurch,

and Dunedin. There have been very many cases of persons or institutions asking to be advised of the kind of weather to be expected over an interval of a few days when some particular operations were in hand, or when they may expect a certain desired type of weather. The forecasts supplied in these cases have, in general, been very successful. The increased frequency of reports required for aviation has led to an improvement in the accuracy of the general forecasts.

The total number of separate weather forecasts issued in the course of a year now amounts to between 18,000 and 19,000.

Upper Air Observations.

The usual observations of winds in the upper air by means of pilot balloons were continued at Wellington, and similar data were supplied from the Magnetic Observatory, Christchurch. It has not yet been possible to establish any additional stations.

Aviation Meteorology.

Some reference to this section of the work has been made above. Plans have been prepared for providing weather information for aero-clubs, private fliers, and those engaged in aerial taxi work through Station 2YA of the National Broadcasting Service. The first issue will be before 7 a.m. The scheme of " Air Radio " which has been approved by Cabinet will greatly increase the facilities for the reception and dissemination of weather reports throughout New Zealand. With radio stations at the principal aerodromes it should be possible also to increase the amount and accuracy of the data provided especially for aviators.

Very valuable and cordial assistance has been received from the Post and Telegraph Department, especially in the organizing of new reports, often at very short notice.

Staff.

Since the office is open continuously from 5.45 a.m. to 5 p.m. daily, including Sundays and holidays, practically a double staff is required.

Mr. R. G. Simmers, who holds a Commonwealth Fund Fellowship, has commenced a course of meteorology at the Massachusetts Institute of Technology, Cambridge, Massachusetts. This is, at present one of the leading schools of meteorology in the world, and of the post-graduate students, numbering fifteen to twenty, almost all are members of some official service with some years' experience. They have been sent to the school by the various Governments in order to receive training in the highly technical modern developments.

I wish to express my appreciation of the good spirit displayed and cordial co-operation afforded by the staff during the year.

Publications.

Regular publications have been maintained as follows :—

(1) Monthly in the Government *Gazette*—

Daily observations of pressure, temperature, &c., at the Kelburn Observatory, Wellington.

Notes on the weather of the Dominion for the month.

Summary of temperature observations at climatological stations other than Wellington.

Total rainfall and number of days for all rainfall stations.

Once a year, also, a table is included giving the total rainfalls, differences from average, and the greatest day's fall for all stations during the previous year.

(2) Volume of " Meteorological Observations " : This contains monthly and annual means of pressure, temperature, wind, sunshine, and other climatological data from upwards of forty stations ; monthly means for each hour of the day of pressure, temperature, rainfall, and sunshine at Wellington, and temperature at Alexandra ; table of values of total solar radiation ; and a map showing departure from normal of rainfall over the whole country for the year concerned. The 1935 volume, the last to appear, contains also reproductions of thermograph records for the Polar Year August, 1932, to February, 1934.

The pressure of routine work has been too great to permit of the allocation of much time to investigations. Meteorological Office Note No. 17 dealing with the climates of Hawke's Bay and North Auckland, to which reference was made last year, has been printed. For the Auckland Meeting of the Australian and New Zealand Association for the Advancement of Science, the following papers were prepared and presented :—

E. Kidson : *Water in the Atmosphere* (an address).
The Structure of the Atmosphere (part of a symposium).
Notes on the New Zealand Climate (considered from the health point of view).
M. A. F. Barnett : *The Cyclonic Storm of February 2nd, 1936, over Northern New Zealand.*
W. A. Macky : *Some Comparisons of the Invigorating Effect of the Climate in different parts of New Zealand.*

It is hoped that the two latter will be published in the course of the coming year.

At the request of the Royal Meteorological Society an article on the Climate of New Zealand was prepared by myself and published in its *Quarterly Journal*. This article is one of a series covering the various Dominions and colonies of the Empire. The series is designed to be intelligible to the layman and to be useful to the tourist and settler, as well as the meteorologist. The article in question was illustrated by a number of photographs supplied by the Tourist and Publicity Department.

Short Summary of the Weather for 1936.

January.—In the North Island the weather was very wet, with more than the average cloudiness. In the far north, north-easterly gales and some flooding occurred. In the South Island conditions were reversed, the rainfall being much below average, especially in Canterbury and on the West Coast. Temperatures were slightly above normal.

February was the wettest February hitherto recorded in New Zealand and, indeed, one of the wettest months of any name. Most of Westland, the Mackenzie country, the interior of Otago, and Southland had less than the average rainfall, but elsewhere from two to four times the average was recorded. Flooding occurred at times over practically the whole of the North Island. On the 1st to 2nd it was of record proportions in parts of the Auckland Province. In south Marlborough, Canterbury, and north-eastern Otago also there were severe floods. In Canterbury the floods of the 19th to 21st were the most severe since 1923, and the Ashley River rose to unprecedented heights. There was a great flush of growth of grass, and the milk yield became high. Conditions were, however, unfavourable for fattening lambs or for haymaking. Most crops were adversely affected. Some damage was done to the wheat crop, which would otherwise have been excellent. In many cases the grain sprouted, both standing and in the stook. Temperatures were generally somewhat below normal. On the 1st to the 2nd the North Island was visited by a cyclone of tropical origin, which was the most severe in its history. Very severe damage was done by the wind, which in places reached whole gale force. The Manawatu district, and particularly Palmerston North, suffered the worst. Not only was the precipitation extraordinarily heavy, but, for a rain so widespread, the rate of fall was still more remarkable. The resultant flooding was responsible for serious losses of stock, as well as much other damage. Abnormal tidal effects were produced.

March was a very cold month. Though not nearly so heavy as in February, the rainfall was above average in most districts. Pasture was abundant, but was rank and soft. The growth of other vegetation was generally checked, and conditions were unfavourable for flowering and fruiting processes. The northern half of the North Island was again affected by a severe cyclone of tropical origin between the 25th and 27th. Strong gales and remarkably high tides were experienced from Auckland northwards, causing much damage, but the amount of rainfall was surprisingly small.

April.—For the first eighteen days the weather was warm and, except in western and southern portions of the South Island, there was very little rain. In consequence, stock and vegetation thrived. Pastures hardened considerably in most districts, and, for the first time during the year, lambs began to fatten well. Cold, wet, and stormy weather after the 18th, however, caused a setback.

May.—On the 2nd occurred a south-westerly storm which for extent and severity was one of the most notable in the history of the country. There followed a spell of fine weather unprecedented for the time of year. The winds, though light, were mainly southerly and mean temperatures consequently very low. Frosts and morning fogs were numerous and some snow fell on the ranges, but conditions were not really severe. The month was, on the whole, a good one for stock and pastures.

June was very dry in most districts. Some sharp frosts occurred in the North Island during the first week, but owing to winds being very light, with an absence of severe southerlies, the month was generally a very mild one. Though checked in much of the North Island, there was unusual growth of pasture elsewhere, and, for the time of year, the quality was good. Stock were in good condition.

July.—Rainfall was above average in most districts, but the reverse was the case in the far north, in parts of Taranaki and Hawke's Bay, and on the west coast of the South Island. Temperatures were rather low and, in the North Island, unusually numerous and sharp frosts were experienced. There were several intervals of very stormy weather, with numerous hailstorms and snow down to low levels. On the 6th, following the passage of a cyclone across the South Island, pressure in the extreme south fell to 28·3 in., the lowest value hitherto recorded at sea-level in New Zealand.

August.—A storm which commenced at the end of the preceding month was still raging at the beginning of August. A strong, cold southerly wind was blowing on the 1st, and snowstorms were widespread. Around Wellington the snow was unusually thick and extended to low levels. It was some days before it finally disappeared. Several days of cold weather with sharp frosts followed the snowstorm. Another severe storm occurred towards the end of the month. It caused heavy, general rains, and was followed by southerly gales and much snow and hail. Most of the country had considerably more than the average rainfall. Mean temperatures were amongst the highest ever experienced in August.

September was a typical spring month with a persistence of strong and squally westerly winds and frequent rain in districts with a westerly aspect. As regards total rainfall, conditions varied greatly from district to district, and over the country as a whole the fall approximated the average. Temperatures were rather low. Though growth of vegetation was retarded in western and southern districts of the South Island and much of the North, in Hawke's Bay, about Wellington, and in Nelson and the Marlborough Sounds there was rapid growth. A good lambing season was being experienced.

October, except in the first ten or eleven days, was very mild. A rather sharp frost on the 15th following a cold rain, caused very serious damage to fruit and tomato crops in the Hastings district. Except in parts of the Wairarapa and southern Hawke's Bay, vegetation grew rapidly and there was ample feed for stock. Rainfall exceeded the average over most of the west coast of the South Island and the Nelson and Marlborough Provinces, but elsewhere it was below. Temperatures were well above normal.

In *November* the weather was dull, wet, and changeable. Rainfall exceeded the average in almost all parts, while temperatures were above normal. There was consequently a lush growth of pasture and, except that lambs failed to fatten well on the soft feed, stock were in splendid condition. The wet weather interfered with shearing.

December.—Though the first half was generally fine and much hay was gathered, the last part was wet. Shearing and farm work were again delayed. Stock were in good condition, but feed was soft and rather too plentiful. Rainfall was rather above average and temperatures below. North-easterly gales, heavy rain, and some flooding in the Auckland Province were associated with a cyclonic depression which approached northern New Zealand on the 30th.

Year.—Over the greater part of the country the total rainfall for the year was above average. In considerable areas the excess was 10 in. and upwards. Nevertheless, there were a number of small areas where somewhat less than the average was recorded. Temperatures were slightly below normal in most districts, but a little above in Otago and Southland. In no case did the departures amount to as much as 1° F. The year was remarkable for the variability of weather conditions and the number of new records of intensity created for various types of weather. In temperature, however, there were no great extremes. The amount of bright sunshine was below normal in most districts.

At no time was there serious shortage of pasture over any large portion of the country; over much of it, indeed, there was throughout the year a superabundance. The milk yield was therefore good, and stock fared well. The feed was, however, too soft for lambs to fatten very satisfactorily. The lambing season was an excellent one in spite of the rather low temperatures and the high rainfall. The yield of wheat was high, but much of the crop was damaged by sprouting. The 1936 apple crop was good, but the prospects for the 1937 one were less so. The cold, dull, and wet weather of the late summer was responsible for considerable irregularity in the blossoming of many trees, shrubs, and flowering plants.

DOMINION OBSERVATORY.

REPORT ON THE ACTIVITIES OF THE OBSERVATORY DURING THE YEAR ENDED 31ST DECEMBER, 1936.

Buildings and Equipment.

The Observatory buildings and equipment have been kept in good order and condition. The grounds have been attended to periodically by the Wellington City Council.

A workshop has been established, enabling the manufacture and repair of instruments to be carried out at the Observatory. This should constitute a considerable saving, both in time and money. The workshop is being used at present mainly for the manufacture of three strong-motion seismographs intended for service in various parts of New Zealand.

During the year a co-ordinatograph was purchased from the Lands and Survey Department. This is required for precise measurements of astronomical photographs, &c.

A 4 in. refracting telescope, owned by the late Sir Francis Bell, was recently offered to the Observatory by Miss Bell. The telescope and its accessories were gratefully accepted by the Department, and have been added to the Observatory's astronomical equipment. The telescope will be used for general astronomical work.

Time Service.

Control of Observatory Clocks.—In order to maintain the required accuracy of a quarter of a second, the observatory clocks require checking at least once a day. This is done by recording one or more short-wave radio time signals from observatories abroad. When conditions are favourable a check signal is generally recorded at 8 h. 30 m. and 14 h. 30 m. N.Z.M.T. Occasionally it is found necessary to receive signals at other times also. During 1936, short-wave radio time signals were received from the following stations :—

Pontoise ..	(FYB)	7.30	N.Z.M.T. =	20 h.	G.M.T.
Washington ..	(NAA)	8.30	,, =	21 h.	,,
Saigon ..	(FZR)	9.30	,, =	22 h.	,,
Washington ..	(NAA)	10.30	,, =	23 h.	,,
Monte Grande ..	(LSD)	11.15	,, =	23 h. 45 m.	,,
Washington ..	(NAA)	11.30	,, =	0 h.	,,
Nauen ..	(DFP)	11.30	,, =	0 h.	,,
Washington ..	(NAA)	14.30	,, =	3 h.	,,
San Francisco ..	(NPG)	14.30	,, =	3 h.	,,
Honolulu ..	(NPM)	14.30	,, =	3 h.	,,
Washington ..	(NAA)	16.30	,, =	5 h.	,,
Washington ..	(NAA)	19.30	,, =	8 h.	,,
San Francisco ..	(NPG)	19.30	,, =	8 h.	,,
Honolulu ..	(NPM)	19.30	,, =	8 h.	,,
Pontoise ..	(FYB)	19.30	,, =	8 h.	,,

With the present staff and equipment, it is not possible to control the Observatory clocks by means of transit observations, although such observations are made occasionally as an additional check.

Time Signals sent out.—The time service has been maintained as in previous years except that, after 30th June, 1936, the radio time signals sent out through station ZLW on Tuesday and Friday evenings were discontinued.

The Observatory provides the following time signals, most of which are sent automatically by the signal clock, whose error seldom exceeds a quarter of a second :—

(1) *Time Signals by Radio.*

(*a*) Through Wellington Radio station ZLW daily, at 10 h. 30 m. N.Z.M.T. (= 23 h. G.M.T.). Up to 30th June, 1936, similar signals were also sent out on Tuesdays and Fridays at 20 h. 30 m. N.Z.M.T. (= 9 h. G.M.T.). In transmitting radio time signals the call sign of the Observatory is ZMO, in accordance with the provisions of the Madrid Radio Communication Regulations, Article 14, paragraph 2. Special care is taken to ensure that the Observatory clock is as correct as possible when sending out the signals through ZLW. The errors of these signals are afterwards determined, and are available on application to the Observatory.

The following table indicates the order of accuracy of the ZLW signals during the year 1936 :—

Number of times error did not exceed 0·25 second	391
Number of times error lay between 0·26 and 0·50 second	23
Number of times error lay between 0·51 and 1·00 second	0
Number of times error exceeded 1·00 second	0
Total number of signals sent through ZLW	414

In order to reduce the lag on the ZLW signals a Creed relay was installed on the ZLW time circuit on 1st March, 1936.

(*b*) Through the National Broadcasting Service Station 2YA Wellington, at 10 h. 30 m., 15 h. 30 m., and 19 h. 30 m. N.Z.M.T (= 23 h., 4 h., and 8 h. G.M.T.) on week days; and at 15 h. 30 m. N.Z.M.T. (= 4 h. G.M.T.) on Sundays. The National Broadcasting Service Station 3YA Christchurch, rebroadcasts time signals from 2YA. As the broadcasting of these signals is under the control of Station 2YA, the Observatory cannot guarantee regularity in their transmission. The time signals are occasionally suppressed when special broadcasts are in progress.

(2) *Time Signals by Telegraph.*

(*a*) To the General Post Office and the Railway Department, Wellington, at 9 h., daily, except Sunday. The Post and Telegraph Department transmits this signal to all telegraph-offices throughout New Zealand; and the Railway Department transmits it to all railway-stations in the North Island.

(*b*) To the General Post Office, Wellington, for transmission to Auckland, at 20 h. 30 m. N.Z.M.T. (= 9 h. G.M.T.) on Tuesdays and Fridays.

(3) *Time Signal by Lights.*

(*a*) By signal lights, exhibited at the Observatory, and visible from the Harbour, and most parts of the City of Wellington, daily at 20 h. 30 m. N.Z.M.T. (= 9 h. G.M.T.).

The use of the green signal light on Tuesdays and Fridays was discontinued after 30th June, 1936. In the past the green light was used to indicate that the signals were under the supervision of an officer on duty at the Observatory. As the radio time signals on Tuesday and Friday evenings ceased after 30th June, 1936, no officer has been on evening duty at the observatory since that date.

(*b*) By signals lights exhibited at the Ferry Buildings, Auckland; transmitted to Auckland by telegraph, on Tuesdays and Fridays at 20 h. 30 m. (=9 h. G.M.T.). Tests carried out by the Auckland Harbour Board in April, 1936, showed that the time occupied by the telegraph signal operating the lights to reach Auckland from Wellington is less than one-tenth of a second.

(4) *Time Signals by Telephone.*

Both precise time signals and approximate time signals are given by the Observatory in response to telephone calls. During 1936 precise time signals were given by telephone on twenty occasions, and approximate time on eleven occasions.

Failure of Time Signals.—During the year 1936 there were no complete failures of time signals due to causes in the Observatory. On the following days, however, the radio time signals were incomplete due to faults in the Observatory transmitting apparatus: 20th and 31st January, 2nd and 26th February, 8th May, 19th and 21st June, 18th July, 21st September. Telegraph time signals were faulty on 26th February and 19th June.

Special Time Signals.—In addition to the ordinary time signals, special time signals were sent out during the year as follows:—

(1) On 21st and 24th April series of special signals were sent by telegraph to Auckland at 20 h. 30 m. N.Z.M.T., for the purpose of determining the lag of the telegraph time signals, as received at Auckland.

(2) On 14th December special radio time signals were sent through station ZLW at 9 h., 10 h., and 12 h. N.Z. summer time, for the use of observers of the solar eclipse. By arrangement with the Director of the National Broadcasting Service, these signals were also transmitted by Stations 2YA Wellington, and 1YA Auckland.

Public Clocks.—The Government Buildings clock is checked daily at 9 h. by special circuit between the clock and the Observatory. The rate of this clock is subject to erratic changes, and the error occasionally exceeds half a minute. During the year 1936 the maximum errors observed were 49 seconds fast on 26th April, and 28 seconds slow on 22nd December.

The General Post Office clock is controlled by the Post and Telegraph Department, but the clock is checked at the Observatory nearly every day, by observing the first stroke of the hours as broadcast by Station 2YA. The maximum errors observed during 1936 were 12 seconds fast on 15th December, and 3 seconds slow on 17th December. The comparatively large error on 15th December was due to a fault in the mechanism of the clock.

Owing to the increased use of electric synchronous clocks, a fairly close check is now kept on the running of these clocks. About the beginning of 1933, the Public Works Department installed an electric clock at the Observatory, and the error of this clock has been reported to the Khandallah substation daily at 15 h. 30 m. N.Z.M.T. This checking has resulted in a considerable improvement in the performance of electric clocks running off the Mangahao power supply.

The error of the electric clock is also read and logged at 9 h.

Astronomy.

Solar Work.—Observations of sunspots have been made by Mr. I. L. Thomsen, using the 5 in. refractor of the Wellington Philosophical Society's Observatory. During the year 1936 observations of sunspots were made on forty-eight occasions. Reports of particularly active spot groups are supplied to the press. Results of the sunspot observations are sent to Zurich, and are also included in the reports of the Solar Section of the New Zealand Astronomical Society. On account of its geographical position New Zealand is considered to be a valuable station for solar observations.

Occultations.—The programme of observing occultations at Wellington with the 9 in. telescope of the Wellington City Observatory, by the Dominion Observatory staff, and with the 6 in. telescope at New Plymouth by the local Astronomical Society, has continued. The Observatory is indebted in

this work to voluntary assistance by members of the New Zealand Astronomical Society, and also to the predictions in the Handbook of the British Astronomical Association. During 1936 conditions were not very good for this work, and therefore the number of observations is not as great as in former years. The details of the observations have been forwarded to Dr. L. J. Comrie, Superintendent of H.M. Nautical Almanac Office, London.

Astronomical Discoveries.—By arrangement with the Central Bureau at Copenhagen, this Observatory receives advice of all important discoveries. The information is forwarded by the Bureau through the Melbourne Observatory.

Longitude Work.—The work of reducing the observations for longitude carried out in October–November, 1933, by Messrs. R. C. Hayes and I. L. Thomsen, of the Observatory staff, and by Mr. J. P. Arthurs of the Lands and Survey Department, was completed in 1936. A copy of the detailed results was sent to the Bureau des Longitudes, Paris; and a summary of the results was published in the *New Zealand Journal of Science and Technology*, and reprinted and issued as a Bulletin of this Observatory. The mean results of the transit observations give the longitude of Wellington as 11 h. 39 m. 3·97 s. east of Greenwich; and this value has been adopted until further determinations are made. It is proposed to make a careful comparison between the 1933 value and those obtained in earlier determinations, in order to ascertain definitely whether any movements of the land have taken place.

Auroral Work.—Observations of auroræ have been carried out by Mr. M. Geddes, Southland, and photographs of some auroral displays have been made with the special cameras loaned by Professor Störmer, Norway. On 31st August, 1936, the second of the two cameras was sent to Mr. Geddes, and, with the co-operation of the Post and Telegraph Department, arrangements were made for telephone communication, to enable simultaneous photographs of auroræ to be made at Ermedale and Invercargill. This would provide data for determining the heights of auroral displays.

The telephone communication proved somewhat unsatisfactory, but some trial photographs were obtained of an aurora on 11th November, 1936. These photographs showed definite parallax, but a considerable amount of labour will be involved in working out final results. After due trial, it has been decided to take steps to adopt wireless as a means of communication between the two observing points. Details of the auroral work are published in the *Journal of the New Zealand Astronomical Society*, and Mr. Geddes also reports his observations direct to Professor Störmer, Norway.

Solar Eclipse of 1936, 14th December.—On 5th December, Mr. I. L. Thomsen proceeded to Pukekohe to join the eclipse expedition, organized by Mr. C. W. B. Michie, to observe the annular eclipse of the sun on 14th December. The Department of Scientific and Industrial Research also made arrangements for Mr. M. Geddes to join this expedition, with the 5 in. telescope of this Observatory.

During the eclipse much trouble was experienced with clouds, and observations after mid-eclipse could not be continued. However, sufficient data for the deduction of useful results were obtained.

Mr. M. S. Butterton, of the New Zealand Astronomical Society, observed the eclipse at Tauranga with a 3 in. refracting telescope. In order to carry out this expedition, Mr. Butterton received assistance from the Department, and was granted the loan of a chronometer from the Observatory. He was assisted by Mr. E. L. Morley. Observations were obtained of the four contacts and of Baily's Beads. Observations of the occultations of sunspots were also obtained, and a temperature record was kept during the eclipse.

At Wellington successful observations of the partial phase of the eclipse were made by observers at the City Observatory, and at the Wellington Philosophical Society's Observatory. The observations at Wellington were organized by the Solar Section of the New Zealand Astronomical Society, and were carried out under the supervision of the Dominion Observatory.

Complete reports on the observations of this eclipse will appear in due course.

General Observations.—During May some micrometrical measurements of double stars were carried out by Mr. I. L. Thomsen, using the 9 in. telescope of the City Observatory.

Special arrangements were made for Mr. Thomsen to observe Saturn with the 9 in. telescope during the disappearance of the rings, about the end of June, 1936. Good observations were obtained on 29th and 30th June, and a report on the results has been prepared for publication in the *New Zealand Journal of Science and Technology*. This report will be reprinted, and issued as a Bulletin of this Observatory.

Early in August, the first observations of Comet Peltier in New Zealand and Australia were made by officers of this Observatory. Observations of this comet were also made by members of the New Zealand Astronomical Society, and a preliminary report was published in the Journal of that Society. Observations of Comet Peltier were also made by Mr. M. Geddes, Ermedale, Southland, with the 5 in. telescope, which he has on loan from this Observatory. With this telescope Mr. Geddes has also carried out observations of the sun, and of variable stars. The telescope was also used for comet-searching, and site-test observations.

Reports of Mr. Geddes' astronomical observations are published from time to time in the *Journal of the New Zealand Astronomical Society*.

New Zealand Astronomical Society.—Astronomical research work in New Zealand is carried out largely by amateurs, organized by the observing sections of the New Zealand Astronomical Society. A great deal of valuable work is being done by some of the members of these sections.

The Dominion Observatory is the official headquarters of the New Zealand Astronomical Society, and Mr. I. L. Thomsen devotes a portion of his time to the work of that society. In this way the Observatory assists the New Zealand Astronomical Society in its task of directing amateur astronomical research work in New Zealand.

Seismology.

Seismic Activity in New Zealand during 1936.—Seismic activity in New Zealand has been decreasing during the past three years. In 1936 there were 123 earthquakes reported felt in some part of New Zealand. Of these, eighty-seven were felt in some part of the North Island and forty in some part of the South Island, while four were felt in both Islands. The maximum intensity reported was 6 on the Rossi-Forel scale. This is the lowest maximum reported in any year since 1923. Earthquakes were most frequent in the Gisborne district.

The following table shows the number of earthquakes reported felt and the maximum intensities for each month in the year 1936 :—

Month.	Number of Earthquakes reported felt.				Maximum Intensity (R.-F. Scale).	Locality of Maximum.
	North Island.	South Island.	Both Islands.	Total for New Zealand.		
January	7	1	..	8	4	Te Kuiti, Cheviot.
February	2	5	..	7	5	Masterton, Invercargill.
March	8	2	..	10	4+	Opotiki, Takaka, Reefton.
April	8	..	..	8	5	Rongotea.
May	13	3	1	15	6	Waipiro Bay, Tokomaru Bay, Cheviot.
June	2	3	..	5	5	Wanganui, Opotiki, Hanmer Springs.
July	12	11	2	21	6	Opotiki, Farewell Spit.
August	5	3	..	8	5	Hastings, Half-moon Bay.
September	1	2	..	3	6	Ohakune, Kahurangi Point.
October	12	5	..	17	6	Tokaanu, Kahurangi Point.
November	10	2	1	11	5	Hawera, Karamea.
December	7	3	..	10	6	Waipiro Bay, Kahurangi Point.
Totals	87	40	4	123	6	

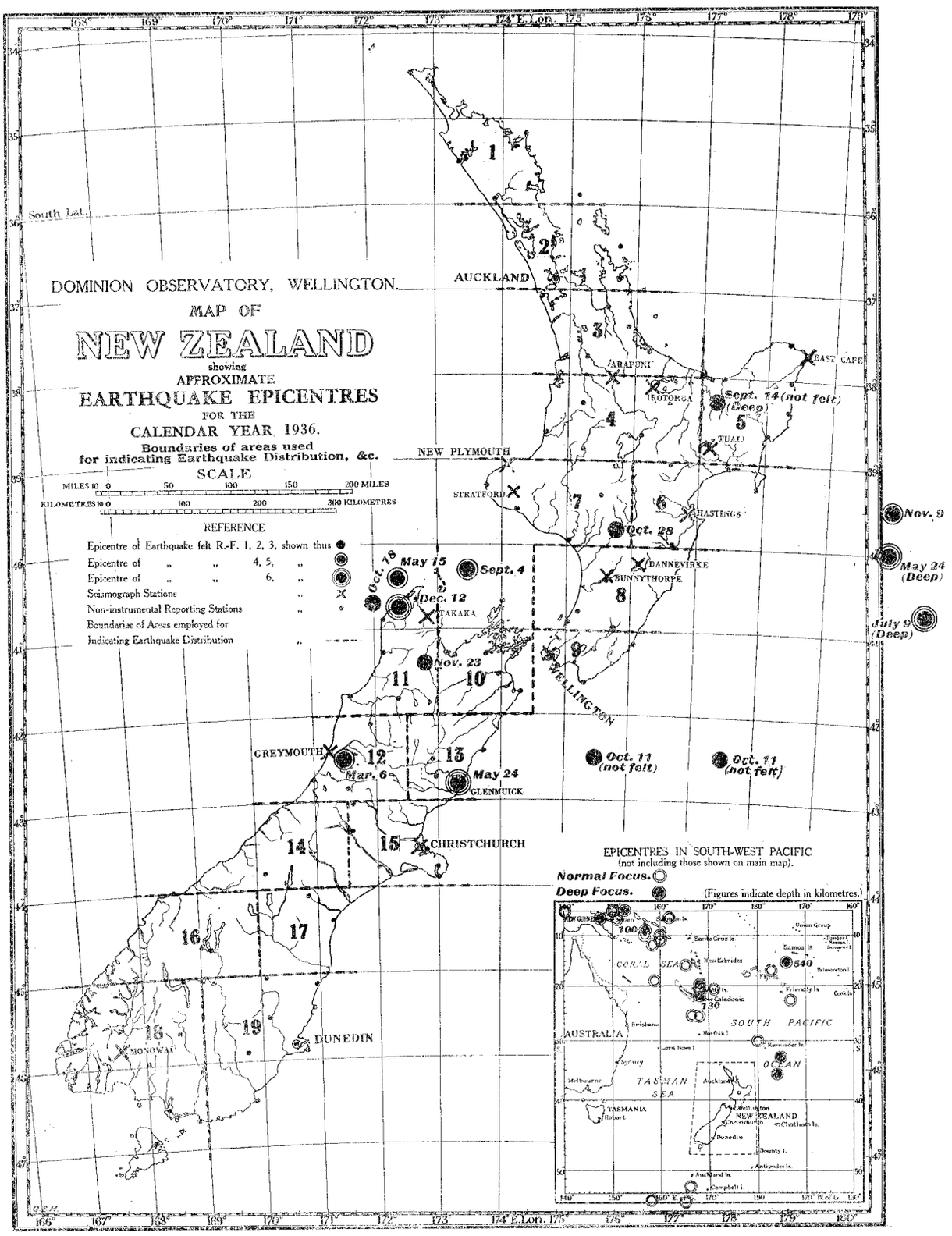
The distribution of felt earthquakes throughout New Zealand during 1936 is indicated in more detail in the following table, which gives the total number of earthquakes reported felt, and the maximum intensity reported, in each of nineteen areas. These areas are numbered and their boundaries are shown on the map accompanying this report (p. 139). The boundaries follow suitably selected lines of latitude and longitude, and have nothing to do with the physical structure of the country.* Those portions of the Provincial Land Districts included in each of the areas are indicated in the table :—

Area Number.	Portion of Provincial Land Districts included.	Total Number of Earthquakes reported felt in 1936.	Maximum Intensity reported felt in 1936.
(1)	North Auckland	0	..
(2)	North Auckland (including Auckland City)	0	..
(3)	South Auckland	1	4
(4)	South Auckland, North Taranaki	7	5
(5)	Gisborne	35	6
(6)	Hawke's Bay	17	5
(7)	Taranaki, North Wellington	17	6
(8)	South Hawke's Bay, Wellington	21	5
(9)	Wellington	11	5
(10)	Marlborough, East Nelson	11	5
(11)	Nelson	25	6
(12)	South Nelson, North Westland, North Canterbury	4	4
(13)	South Nelson, South Marlborough, North Canterbury	5	6
(14)	Westland, West Canterbury	1	4
(15)	Canterbury	4	5
(16)	South Westland, North Otago, North Southland	0	..
(17)	South Canterbury, North Otago	0	..
(18)	Southland (including Stewart Island)	2	4
(19)	Otago	1	4

* This division of New Zealand into areas is very similar to that adopted recently in a survey of earthquake distribution for the period 1848–1934; which was published as Dominion Observatory Bulletin No. 95.

The low activity reported from areas 14, 16, and 17 may be due partly to sparsity of population and consequent lack of reporting-stations. Areas 1, 2, 3, 4, 12, 13, 15, 18, and 19, on the other hand, are adequately covered by reporting-stations, so that the low activity indicated for these areas is more reliable.

The data for the above tables have been obtained from the non-instrumental reports supplied by officers of the Post and Telegraph Department, officers of the Marine Department, and private



observers. These reports are very valuable in the study of New Zealand earthquakes. There are at present 116 non-instrumental reporting-stations distributed throughout the Dominion, the positions of which are shown on the above map.

Of the 123 earthquakes felt in 1936, only eleven were sufficiently well recorded for their epicentres to be determined. The positions of these epicentres are shown on the above map, together with the epicentres of three other earthquakes which were not felt in any part of New Zealand.

Particulars of the most important New Zealand earthquakes during the year 1936 are given in the following table :—

New Zealand Mean Time.	Approximate Position of Epicentre.		Maximum R.-F. Intensity as felt.	Locality of Maximum Intensity.
	Latitude (Degrees).	Longitude (Degrees).		
1936. d. h. m.				
May 24 02 09	42·8 S.	173·3 E.	6	Cheviot.
May 24 03 02	40 S.	180	6	Waipiro Bay.
July 9 21 51	40·7 S.	179·4 W.	6	Opotiki, Farewell Spit.
*Oct. 7 08 14	..	..	6	Kahurangi Point.
*Nov. 24 18 09	..	..	5–6	Hawera.
Dec. 12 07 38	40·7 S.	172·4 E.	6	Kahurangi Point.

* Geographical position of epicentre not known.

The number of earthquakes reaching various degrees of maximum intensity during the year 1936 are given below :—

Intensity (R.-F. Scale).	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Total.
Number of earthquakes ..	..	32	46	26	13	6	..	..	..	..	123
Percentage of total number ..	..	26	37	21	11	5	..	..	..	..	100

The total number of earthquakes reported felt and the maximum intensities reported in each of the years 1921 to 1936 (inclusive) are as follows :—

Year.	Number of Earthquakes reported felt.	Maximum Intensity (R.-F. Scale).	Year.	Number of Earthquakes reported felt.	Maximum Intensity (R.-F. Scale).
1921 ..	91	8	1929 ..	678	10
1922 ..	1,187	8	1930 ..	748	8
1923 ..	76	6	1931 ..	432	10
1924 ..	70	7	1932 ..	313	9
1925 ..	76	8	1933 ..	108	7
1926 ..	173	8	1934 ..	230	9
1927 ..	107	8	1935 ..	150	7
1928 ..	80	8	1936 ..	123	6

While the maximum intensities given in the above table are reasonably reliable, the figures giving the number of reported earthquakes require careful interpretation. In years of major earthquakes, such as 1929 and 1931, many of the numerous aftershocks are liable to pass unnoticed, while during a period of quiescence there is a tendency for all shocks, however slight, to be reported. This leads to an undue emphasis being placed on earthquake activity of what is a comparatively quiet period. The great number of earthquakes reported for 1922 is due to a swarm of shocks which occurred in the Taupo region in the latter half of that year. Also, although there was no major earthquake in 1930, a large number of shocks occurred in that year, due mainly to the continuation of aftershocks of the Buller earthquake of 1929, June 17th.

In addition to the study of New Zealand earthquakes, this Observatory undertakes the determination of provisional epicentres in the south-west Pacific (within the region 0° to 50° S. latitude, and 140° E. to 160° W. longitude). The positions of the south-west Pacific epicentres determined in 1936 are shown on the map (p. 139).

Seismograph Stations.—During the year 1936, continuous seismograph records were kept at the Dominion Observatory, Wellington, the Magnetic Observatory, Christchurch, and at the following subsidiary stations : Arapuni, Tuai, New Plymouth, Stratford, Hastings, Greymouth, and Monowai. Records were kept for a portion of the year at East Cape, Rotorua, Bunnythorpe, Takaka, and Chatham Islands.

The following list gives particulars of the New Zealand seismograph stations which were operating during the whole or part of the year 1936 :—

Station.	Position. Latitude.	Position. Longitude.	Height above Mean Sea-level.	Instruments.	Observer.
	° ′	° ′	Ft.		
East Cape ..	37 40 S.	178 35 E.	505	Milne-Jaggar, E.–W... ..	Lighthouse-keeper, Marine Department.
Arapuni ..	38 5 S.	175 39 E.	212	Milne, E.–W.	Mr. C. A. Thompson, Public Works Department.
*Rotorua ..	38 8 S.	176 15 E.	930	Milne-Jaggar, E.–W... ..	Mr. Tregear, Government Tourist Bureau.
Tuai	38 48 S.	177 9 E.	960	Milne-Jaggar, E.–W... ..	Mr. W. H. Gregory, Public Works Department.
†New Plymouth	39 4 S.	174 4 E.	112	(*a*) Wood-Anderson, E.–W. ..	(*a*) Superintendent, H.M. Prison.
				(*b*) Milne-Jaggar	(*b*) Mr. C. E. Morshead.
Stratford ..	39 21 S.	174 17 E.	1,000	Milne-Jaggar, E.–W... ..	Mr. A. W. Burrell.
Hastings ..	39 38 S.	176 53 E.	35	Milne-Jaggar, N.E.–S.W. ..	Mr. H. de Denne.
‡Dannevirke ..	40 12 S.	176 7 E.	720	Milne-Jaggar	Dr. L. Bastings.
Bunnythorpe ..	40 17 S.	175 36 E.	197	Milne-Jaggar, N.W.–S.E. ..	Mr. W. A. Waters.
Takaka ..	40 51 S.	172 48 E.	25	Imamura, three components, Milne-Jaggar, E.–W.	Mr. W. J. Smith, Post and Telegraph Department.
Wellington ..	41 17 S.	174 46 E.	401	Wood-Anderson, N.–S.; Galitzin-Wilip (vertical); Milne-Shaw, two components; Milne-Jaggar	Dominion Observatory.
Greymouth ..	42 25 S.	171 13 E.	14	Milne-Jaggar, E.–W... ..	Mr. R. T. Smith, Public Works Department.
‡Glenmuick ..	42 54 S.	173 9 E.	247	Inverted pendulum	Mr. C. J. Westland.
Christchurch ..	43 32 S.	172 37 E.	25	Galitzin, three components; Wood-Anderson	Director, Magnetic Observatory.
Chatham Islands	43 57 S.	176 31 W.	210	Milne, N.E.–S.W.	Messrs. A. E. Hayward and W. B. Burt, Post and Telegraph Department.
Monowai ..	45 47 S.	167 37 E.	538	Milne-Jaggar, E.–W... ..	Mr. W. H. Hutton.

* Established 1936, November 27th. † Station (*b*) was dismantled in November. ‡ Privately owned stations: both dismantled during the year.

Of the sixteen stations in the above list, thirteen are under the direct control of this Observatory. The administration of these stations and the handling of their records involves a large amount of routine work.

The following table gives the number of earthquakes recorded at this Observatory, and at subsidiary stations during the year 1936 :—

Stations.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Class I.													
New Plymouth ..	7	1	1	5	8	2	14	1	19	6	8	4	76
Wellington	19	20	13	23	26	24	27	18	31	31	26	18	276
Christchurch	1	12	4	8	10	2	7	3	7	6	5	6	71
Class II.													
East Cape	1	0	0	0	..	..	..	..	..	..	..	..	1
Rotorua	..	..	..	..	..	..	..	..	..	..	..	6	6
Tuai	0	0	0	0	2	0	2	0	1	1	2	1	9
New Plymouth ..	0	0	0	0	0	0	0	0	0	0	..	..	0
Stratford	0	0	0	0	1	0	1	0	1	0	0	0	3
Hastings	0	0	0	2	1	0	8	2	2	6	6	0	27
Bunnythorpe ..	0	0	0	0	..	..	0	..	..	1	1	0	2
Takaka	..	..	2	0	1	..	5	1	10	3	3	0	25
Greymouth	0	0	1	0	1	0	0	0	0	0	0	0	2
Monowai	0	4	0	0	0	0	1	1	0	0	1	0	7
Class III.													
Arapuni	7	7	7	14	8	3	5	3	3	10	7	7	81
Wellington	24	23	16	22	23	17	18	19	19	17	11	27	236
Chatham Islands ..	4	6	..	..	1	3	0	0	0	0	0	0	14

In the above table the stations have been classified according to the type of seismograph. Class I includes stations with sensitive Wood-Anderson local recorders; Class II, stations with strong-motion local recorders, mostly of Jaggar type; and Class III, stations with distant recorders. In Class I the earthquakes recorded are mainly local. The greater number recorded at Wellington may partly be due to more favourable conditions there for recording small local shocks. Of the stations in Class III, Wellington is equipped with more sensitive instruments than either Arapuni or Chatham Islands, hence the greater number of distant earthquakes recorded at Wellington. Wellington and New Plymouth are included in more than one class, since these stations possess instruments of different types. Christchurch should also be included in Class III, but the Christchurch records of distant earthquakes are handled entirely by the staff of the Magnetic Observatory.

Owing to various causes, the records of some of the stations are not complete for the whole year. Owing to a series of breakdowns, the East Cape seismograph was recording only from January to April. The Rotorua station was not established until 27th November, so that no records are available prior to that date. The Jaggar station at New Plymouth (Class II) was dismantled in November; and the Wood-Anderson records at that station were interruped from 14th October to 15th November, owing to clock trouble. The seismograph at Bunnythorpe was out of action from 1st May to 30th June, and from 13th July to 30th September owing to clock trouble. The Imamura strong-motion seismograph at Takaka was under overhaul during January and February. Early in June this seismograph was transferred to Wellington, and was replaced by a Jaggar. On account of this change in instruments, the Takaka records were interrupted during June and July. During March and April the Chatham Islands seismograph was not recording, owing to illness of the observer; and the Christchurch Wood-Anderson records were interrupted from 8th to 22nd January, and from 18th to 31st August, owing to repairs being made to the driving clock.

During the year 1936 steps were taken to improve the timing at some of the stations. In September a chronometer, fitted with minute contacts, was despatched to New Plymouth for supplying accurate timing on the Wood-Anderson seismograph there. Time marking, usually accurate to the nearest second, was thus made available on the three Wood-Anderson seismographs, located respectively at New Plymouth, Wellington, and Christchurch. This should provide more satisfactory data for the study of local earthquakes and problems relating to local crustal structure. Additional stations are to be provided with chronometers in the near future.

Research Work.—Seismological research work carried out during 1936 included some investigations into the occurrence of destructive earthquakes, as connected with pole-shift, and the application to New Zealand earthquakes of Dr. C. F. Richter's method of expressing the magnitude of local earthquakes in accordance with the maximum amplitudes recorded on Wood-Anderson seismographs.

Mr. W. M. Jones carried out some work on the geographical distribution of earthquake epicentres in the New Zealand region, and their association with geological faults. Mr. Jones also commenced a detailed study of the records of local earthquakes, with a view to obtaining further information on the local crustal structure.

Dr. L. Bastings and Mr. K. E. Bullen have been working voluntarily on various seismological problems, in co-operation with the Observatory.

The Observatory is grateful to the officers of other Government Departments, and private individuals, who have assisted in the seismological work by operating instruments and forwarding records and reports of earthquakes.

General.

Geodetic Work.—On 24th September the Public Works Department erected a concrete post on the Tinakori Hills, to act as a north meridian mark for the transit instrument. Systematic observations of this new meridian mark and of the existing south meridian mark were commenced, in order to provide data for the detection of local land movements. Tilting of the ground at the Observatory is measured by the Milne-Shaw seismographs, and by the level on the transit instrument. It is not expected that any definite movements due to geological causes will be detected until these observations have been in progress for several years.

In this branch of the Observatory's work, the co-operation of the Lands and Survey Department, the Wellington City Council, and the Wellington Harbour Board, has been sought.

Geophysical Work.—During the latter part of the year officers of the Observatory carried out geophysical survey work as follows: Mr. C. N. M. Watson-Munro was engaged in seismic refraction observations in the Masterton valley from 24th November to 4th December, in connection with water-supply investigations.

During the period 23rd November to 29th December, Mr. W. M. Jones was engaged in geophysical and geological work in the Tokotoka-Paparoa district, and in geophysical work in the Rotorua-Waiotapu area.

Publications.

Commencing with May, 1936, the quarterly seismological reports and the monthly preliminary seismological reports were replaced by a monthly cyclostyled report, giving complete seismological data from all the New Zealand stations, and including a separate provisional bulletin prepared by the Director of the Magnetic Observatory, Christchurch. These reports are published as promptly as possible, and distributed to the chief seismological observatories and institutions throughout the world.

During the year 1936 preliminary reports were published, for 1935 (December), 1936 (January, February, March, April), and full reports for 1936 (May to November), (inclusive). The latter reports consist of monthly Bulletins E50, E51, E52, E53, E54, E55, E56.

Seismological reports for the whole of the years 1934 and 1935 were published as quarterly Bulletins E40, E41, E42, E43, E44, E45, E46, and E47.

The following Observatory Bulletins were also published during 1936:—

Bulletin 96.—Mean Time and Time Service (from the "New Zealand Official Year-Book").

Bulletin 101.—Seismic Waves and Crustal Structure in the New Zealand Region. (R. C. Hayes.)

Bulletin 105.—Report of the Dominion Astronomer and Seismologist (C. E. Adams) for the year ending 31st December, 1934.

Bulletin 106.—Some Seismological Aspects of the Buller Earthquake: Part II, the P Waves in the Distant Hemisphere. (L. Bastings.)

Bulletin 107.—A New Phase in Deep-focus Earthquakes. (R. C. Hayes.)
Bulletin 109.—Normal and Deep Earthquakes in the South-west Pacific. (R. C. Hayes.)
Bulletin 110.—Earthquakes and Atmospheric Pressure. (R. C. Hayes.)
Bulletin 112.—Annual Report of the Dominion Observatory for the year ending 31st December, 1935.
Bulletin 113.—On Near Earthquakes in the Vicinity of New Zealand. (K. E. Bullen.)
Bulletin 114.—Intensity Distribution in New Zealand Earthquakes. (R. C. Hayes.)
Bulletin 115.—Earthquakes in New Zealand: Including Summaries for the Year 1935 (from the "New Zealand Official Year-Book, 1937").

An article on "Earthquakes in New Zealand" was prepared for the "New Zealand Official Year-Book, 1937"; and articles on the Time Service Arrangements were prepared for the Year-Book, and for the New Zealand Nautical Almanac. An abridged report on the Observatory for the year 1935, was sent to the Royal Astronomical Society for publication; and a report on seismological work during the years 1932 to 1935 inclusive was sent to the Union Geodetic et Geophysique Internationale, for the Edinburgh Conference in September, 1936.

STAFF.

On 30th April, 1936, Dr. C. E. Adams, Director of the Observatory, and Dominion Seismologist and Astronomer, retired on superannuation. Mr. R. C. Hayes, Professional Assistant, was placed in charge of the Observatory as Acting-Director.

R. C. HAYES,
Acting-Director.

APIA OBSERVATORY, SAMOA.

Director: J. WADSWORTH, M.A. Acting-Director: W. R. DYER, B.Sc.

During the year 1936–37 the same geophysical programme was maintained as in previous years, the principal subjects of study being terrestrial magnetism, seismology, meteorology, and atmospheric electricity.

TERRESTRIAL MAGNETISM.

The programme of work in terrestrial magnetism at Apia consists of absolute measurements of horizontal intensity, declination, and the angle of dip, together with continuous recording by means of autographic instruments of the variations in horizontal intensity, declination, and vertical intensity. It has been decided that Tesdorpf magnetometer No. 2025 is too old for extensive repairs, and the instrument, which was sent to Germany last year, is being held there pending finality in the matter. In the meantime the Observatory has magnetometer C.I.W. 9 on indefinite loan from the Department of Terrestrial Magnetism, Washington, and this latter instrument has been used during the year for the absolute observations in horizontal intensity and declination. The Schulze earth inductor was used for all absolute measurements of the angle of dip. The same autographic instruments have been used as in the past—namely, a Godhavn balance recording variations of vertical intensity and two Eschenhagen variometers giving the variations of horizontal intensity and declination. All recording is done photographically.

In all three elements the mean hourly ordinates have been scaled in millimetres, and, after conversion to magnetic units, the results have been presented as departures from the daily means.

SEISMOLOGY.

The seismological instruments at Apia consist of the 1,000-kilogram astatic pendulum and the 80-kilogram vertical seismograph, both designed by Weichert. The vertical instrument is the original type, and is now of very little use. It was out of commission during the latter part of the year.

During the year ending 31st March, 1937, there were 196 seismic disturbances recorded. Many of these shocks were local in origin, but none of them exceeded an intensity of 3 on the Rossi-Forel scale. The horizontal instrument gave good traces of some of the more distant earthquakes. Seismological bulletins were issued quarterly.

METEOROLOGY.

Meteorological work during the year included surface observations twice daily, made at 9 a.m. and 3 p.m. zone time, 165° west meridian. Continuous records also were obtained of the principal meteorological elements. Measurements of upper winds have been made from time to time, using pilot balloons, and altogether 143 ascents were made during the year, the greatest height reached being 54,000 ft. Special flights were made in connection with "International Days." The single-theodolite method of following the balloons has been used in all ascents this year, and, in flights after nightfall, the balloons have been followed by means of small lighted lanterns which they carried.

Rainfall reports were received from eighteen local stations in Samoa and one on Swain's Island.

Synoptic weather maps of the South Pacific were prepared in the Observatory from reports received by wireless at the Apia Radio Station. Two maps were drawn daily during the hurricane season, and one a day during the dry season. During the hurricane season a weather report, with any necessary inference regarding storms, was prepared daily and displayed at two conspicuous points in Apia. Storm warnings were issued when necessary with the general collective broadcast of weather reports from the Apia Radio Station. The Postal and Radio Department established a wireless station at Atafu in the Tokelau Islands, and consequently weather reports made by the meteorological observer there are now received at Apia and included in the collective broadcast.

Since September, 1936, the Observatory has maintained a barograph outside the Customs Office in Apia for the information of shipping and general interests.

METEOROLOGICAL SUMMARY, APIA, 1936.

Month.	Pressure.	Temperature.	Rainfall.	Humidity. (9 a.m.)	Sunshine.	Wind.
	In.	°F.	in.	Per Cent.	Hours.	Miles per Hour
January ..	29·719	80·1	14·78	82	164·1	6·1
February ..	29·743	80·3	11·72	81	166·7	5·3
March	29·805	79·7	10·92	79	201·7	3·9
April	29·805	80·4	8·70	79	197·8	5·6
May	29·823	79·8	7·21	79	223·7	5·1
June	29·878	78·4	4·10	75	218·9	7·9
July	29·882	78·4	3·15	79	234·1	9·6
August	29·844	77·2	7·64	75	234·7	8·8
September ..	29·884	78·3	4·72	74	242·9	9·4
October ..	29·857	79·2	12·97	79	185·7	9·5
November ..	29·778	78·7	7·85	77	222·8	5·3
December ..	29·752	79·5	11·38	79	181·7	6·7
Total	..	..	105·14	..	2,474·8	..
Mean	29·814	79·2	..	78	..	6·9

Notes on Storms, 1936–37.

April, 1936: A cyclone crossed the Cook Islands on the 10th April.

November, 1936: A series of cyclonic disturbances associated with a trough of low pressure affected conditions over the South Pacific region during the first week of November.

January, 1937: A cyclonic disturbance appeared near Norfolk Island on the 12th January, and moved towards northern New Zealand. Another intense cyclone developed north of the New Hebrides on the 19th, and travelled slowly southwards.

February, 1937: An intense depression developed near Santo, New Hebrides, on the 8th February, and moved slowly southward. A cyclone, which developed near Nukualofa on the 20th, was associated with strong winds in Tonga and later in Fiji.

March, 1937: Towards the end of the third week in March a cyclone developed near Santo. After moving slowly at first, this disturbance deepened, and then travelled rapidly southward.

Atmospheric Electricity.

In conjunction with the Department of Terrestrial Magnetism, Washington, a recording Benndorf electrometer was maintained as in the past, and gave continuous records of potential gradient in the atmosphere. The reduction factor of the electrometer was determined on 17th August, 1936, by means of absolute observations on the sand-flats to the south of the Observatory. The stretched-wire method was used for this experiment, and gave a value of 1·05 for the reduction factor.

The monthly mean values, expressed in volts per metre, of the atmospheric potential gradient during 1936 at Apia were as follows: January, 120; February, 116; March, 118; April, 105; May, 99; June, 114; July, 127; August, 120; September, 123; October, 109; November, 119; December, 135. Mean for the year, 117.

Tides.

The recording tide-gauge continued in use at the Lagoon Station, and the results of the measurements were sent to the United States Coast and Geodetic Survey at Washington. In September, 1936, the guage went out of commission through extreme corrosion of the float and float-tube. Considerable delay was experienced in obtaining replacements, and the guage was out of action until March, 1937. The new parts were then fitted, and the instrument again functioned very satisfactorily.

Time Service.

The standard clock, Strasser and Rohde No. 381, was controlled by wireless time signals from Annapolis and San Francisco. Until June, 1936, these comparisons were made by means of a portable chronometer carried between the Observatory and the Radio Station. The transit telescope eye-piece, which had been sent to England for repairs, was returned to Apia in July, and a new Gulbransen all-wave receiver was installed in the same month. The old short-wave receiver was rebuilt during June.

Time marks on the magnetograms and seismograms were provided by the "Synchronome" clock.

Personnel, Buildings, Equipment, and General.

The Director, Mr. J. Wadsworth, left Apia on 20th August, 1936, for Wellington, where he spent several months in the Meteorological Office. He expects to return to Apia during April. During Mr. Wadsworth's absence, Mr. W. R. Dyer acted in his stead.

A locally recruited clerk, Robert Stanley, resigned from the Observatory staff after eight-and-a-half years' excellent service.

From time to time information of general interest has been supplied to the *Western Samoa Mail* for publication.

Various pieces of work were carried out by the Public Works Department during the year, including the construction of a septic tank appurtenant to the Director's residence.

The annual report of the Observatory for 1933 was received from the Government printer, and the material for the 1934 report was sent forward for printing.

MAGNETIC OBSERVATORY, CHRISTCHURCH.

Director: H. F. Skey.

SUMMARY OF OPERATIONS FOR THE YEAR ENDED 31st MARCH, 1937.

During the year the usual magnetic, seismological, and meteorological observations have been carried out, and the additional observations to assist in forecasting for aviation purposes have been continued.

Terrestrial Magnetism.

The Eschenhagen magnetographs at Amberley Substation have been kept recording continuously. From hourly measurements of the magnetograms and base-line values given by twice monthly absolute observations, the mean hourly values of D, H, and Z have been calculated and tabulated. The mean monthly values obtained from the mean hourly values for 1936 are :—

Mean Monthly Values of the magnetic elements from hourly mean values (all days), 1936, at Amberley Substation :—

1936.	D.	H.	Z.
	° ′		
January	18 08·2	22315γ	−55225γ
February	18 08·1	22305	55220
March	18 09·1	22301	55221
April	18 09·5	22290	55228
May	18 09·7	22296	55223
June	18 09·9	22296	55222
July	18 09·9	22298	55225
August	18 10·4	22307	55219
September	18 10·9	22303	55211
October	18 10·5	22298	55213
November	18 11·2	22300	55215
December	18 11·5	22307	55207
Year	18 09·9	22301·2	55219·0
Δ from 1935.. ..	+3·6	−15·4γ	+4·6γ (Numerical decrease).

	Y.	X.	T.	φ
Year	06952·6γ	21189·8γ	59552·3γ	−68° 00′·46
Δ from 1935.. ..	+17·4γ	−21·9γ	−10·0γ	−0·73

It is seen that the secular change rather closely approximates that from 1934 to 1935. Magnetic storminess was greater in 1936 than in 1935, corresponding to an increased sun-spottedness.

A detailed report on the local magnetic disturbance has been got out for times of aurorae furnished by Mr. Geddes, Secretary of the Aurorae and Zodiacal Light section of the New Zealand Astronomical Society, for the years 1932 to 1934 inclusive, and the results are included in a paper read at the Auckland meeting of the Australian and New Zealand Association for the Advancement of Science by Mr. Geddes and Mr. Thompson. Further attention is being given to the subject.

Towards the end of the year some reobservations for checking secular change rates were undertaken at various repeat stations in New Zealand by Mr. W. C. Parkinson, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, assisted in the South Island by Mr. Beagley, of this Observatory, and in the North Island by Mr. Baird. Some difficulty was experienced through some of the stations being so changed that the earlier observation spot could not be exactly reoccupied; but as far as the results have been investigated no abnormal values of secular change have been evidenced.

The results will be published in the Volume of Magnetic Results for 1934, 1935, and 1936, now being prepared for publication.

An intercomparison of standards was also made at the Amberley Substation. This showed a slight increase of corrections to I.M.S., as usually happens with lapse of time.

Mr. Parkinson, who has had long experience at Watheroo Observatory in electrical observation, endorsed the site at Amberley as being eminently suitable for the continuous recording of earth currents, and it is hoped that apparatus for this will become available.

The Bendorf Electrograph has been kept continuously recording.

A fireproof strong-room has been built at the Christchurch Observatory for the safe storage of records, and the old Milne seismograph room has been converted to an additional office room which was urgently required.

Seismology.

During the year the Galitzin seismographs at Christchurch have performed satisfactorily, and their constants with those of the Wood-Anderson short-period seismometer have been determined at intervals. Provisional monthly bulletins were prepared promptly and, with those from the Dominion Observatory, have been provided to co-operating stations overseas. Wood-Anderson records have been lent regularly to the Dominion Observatory. Research upon microseisms, especially their relationship with small air-pressure pulsations, is being continued by Mr. Baird.

Cosmic Ray Meter.

This meter has continued to function well, and a five-day interval analysis of the resulting ionization is in progress. In diurnal variation this will yield a 73 point harmonic dial per twelve months. The work is being undertaken by Mr. J. W. Beagley, who also undertakes the major portion of the attention to this important equipment. It is notable that so far in this apparatus, the average number of "bursts" of ionization recorded at Christchurch is three per diem, and the magnitude of those which occur most frequently is about 22×10^6 ions. A preliminary evaluation of the barometric coefficient has been made—viz., —3·9 per cent. in ionization per +1 in. of mercury pressure. These figures refer to results obtained prior to November, 1936, with a pressure of thirty-one atmospheres of argon. In November the pressure was raised by addition of argon to the normal 750 lb./square inch.

Approximate Cost of Paper.—Preparation, not given; printing (960 copies, including maps and graphs), £220.

By Authority: E. V. Paul, Government Printer, Wellington.—1937.

Price 3s. 6d.]