1936.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(TENTH 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 1935–36.

E. MARSDEN.

MINISTER'S STATEMENT.

We are apt to accept New Zealand's overseas trade in farm-produce as an accomplished fact, without inquiring too closely as to the circumstances which have made this possible. The invention of refrigerating machinery during the latter half of last century by Perkins in America and Harrison in Australia enabled perishable foodstuffs to be exported over long distances. It may not be so generally known, however, that this invention was based on the purely scientific investigations of Carnot on the theory of the heat cycle. It is an arresting fact that New Zealand's overseas trade in primary products to the annual value of tens of millions of pounds is based on the application of pure scientific research. This in itself is a most forceful argument for the prosecution of scientific research with all the means at our disposal.

To quote another example from overseas of the value of scientific research to industry: A total expenditure of about £190,000 on the Swedish plant-breeding station at Svalöf has added £2,750,000 annually to the value of Swedish crops.

It may be mentioned, as an interesting example of the value of scientific research carried out by the Department, that a very small expenditure for research on the storage of bananas changed the "Maui Pomare" from a losing to a paying proposition.

Examples could be multiplied, but these results are sufficient to show the enormous benefits which are likely to arise from the intelligent application of pure research to industry. In this country it is the Department of Scientific and Industrial Research which is largely responsible for organizing scientific research and applying the results for the benefit of industry. The work of the Department is not administrative, but rather advisory. It carries out chemical, physical, and biological testing for other Departments and for various industries co-operating in research. While it is desirable that the Department should be free from regulatory duties in order to conduct scientific work, it is necessary that there should be close contact with those Departments of State and other bodies whose problems are directly concerned with the practical applications of science. This has been achieved to a large extent by associating the work with some of the larger national projects.

A spirit of full co-operation is necessary, since it is apparent that New Zealand's financial resources will not permit the scale of total research activity of Great Britain, for example, although our farming interests are faced with problems similar in nature and magnitude. Our manufacturing industries, moreover, are conducted on a scale which will not permit the overhead for research which is carried by the large organizations in older countries.

PLANT RESEARCH.

Since New Zealand is largely a farming country, it is natural that plant research should play a large part in the activities of the Department. Full co-operation of all branches of research in this field has been effected, and this is due in no small measure to the public-spirited co-operation of the Department of Agriculture, Massey and Canterbury Agricultural Colleges, and Cawthron Institute. The work has been organized under a responsible committee consisting of the Director-General of Agriculture, as Chairman, with the principal executive officers of the Research Department, the Cawthron Institute, Massey and Canterbury Agricultural Colleges, and the Director of the Fields Division of the Department of Agriculture. In this way all the investigations concerned with plant research in the Dominion are brought under a unified control.

The Plant Research Bureau is now so organized that each Division is situated in that part of the Dominion most affected by its activities. The fullest use of existing facilities has been made by associating the Divisions as far as possible with institutions interested in the same work.

In the Grasslands Division at Palmerston North, near Massey College and the Dairy Research Institute, all the pasture problems of the Dominion will be dealt with by Mr. Bruce Levy and his staff. Through the co-operation which has been arranged between Canterbury Agricultural College, the Department of Agriculture, the Cawthron Institute, and the Soils Division it will be possible to extend the investigations to a wider range of the varied conditions of this country.

Similarly, the Agronomy Division, in association with Canterbury Agricultural College, will, under the direction of Mr. J. W. Hadfield, deal with all farm crops other than pastures.

The work on plant-diseases will be centred in Auckland under Dr. G. H. Cunningham, where there will also be opportunity for attacking the problems of the fruit industry, and, in particular, those of the citrus industry.

The entomological work of the Bureau will be carried out at the Cawthron Institute, where excellent facilities are available. The whole work of the Bureau will be co-ordinated by the Plant Research Bureau Committee through the Chief Executive Officer, Mr. F. R. Callaghan. The reorganization has involved the erection of suitable buildings at Palmerston North, Lincoln, and Auckland, and plans for these are well under way.

ANIMAL HEALTH AND NUTRITION.

Following the procedure resulting in the co-ordination of plant research, a meeting of interested Departments and Institutions was held to report on the resources and needs of the Dominion in regard to investigations of problems of animal health and nutrition. General co-ordination was arranged, although the whole question, particularly in its relation to breeding, is still under consideration. It is hoped that a comprehensive scheme of attack on these important problems which are related to the corresponding human questions will be evolved during the year. In the meantime, however, a combined attack on the problems of deficiency of trace elements—for example, cobalt, iodine, &c.—has been arranged between the departmental workers, Cawthron Institute, the Veterinary officers of the Department of Agriculture, and officers of the Health Department. It is in these latter directions that considerable advances in knowledge have been made during the past year.

SOIL SURVEY AND LAND UTILIZATION.

In recent years world-wide interest has been taken in land-settlement as a means of creating employment. Before opening up new areas for settlement or cultivating existing ones more intensively, a sound knowledge of the soil resources and present farm-management practices is essential. A systematic soil survey of New Zealand is in operation, and in the past few years the main soil types of Taranaki, the central portion of the North Island, and Waipa County, together with Ashburton and Levels Counties in the South Island, have been mapped.

Soil survey work was formerly carried out as part of the work of the Geological Survey, but in view of its importance in the whole question of land-utilization a separate Soil Survey Division has been formed.

At the present time soil surveys of North Auckland and Hawke's Bay are being carried out. It is intended that these shall be a basis for a complete investigation of the present position in regard to all aspects of land utilization in these districts. The soil surveys are being followed up by surveys of the types of pasture and farm-management practice, so that as complete a picture as possible of the possibilities of developing industries in these districts will be obtained.

The soil surveys are proving of value in delimiting areas where farming is likely to be uneconomic, but which may be suitable for afforestation. In parts of North Auckland serious consideration may have to be given to protective afforestation in order to prevent erosion of the land-surface which leads to rapid run-off of rain and consequent flooding.

Soil surveys are also an essential part of investigations which are being made in regard to the development of the citrus industry.

A survey of the tung-oil industry shortly to be undertaken by a research officer of the Department will also benefit by the soil survey work already done in North Auckland.

A further use for soil survey has been found in delimiting areas in North Auckland with kauri-gum resources. In conjunction with the Bureau of Industry, the gum resources of various swamps and the efficiency of various washing-plants

are being tested. One of the Department's officers in London is carrying out practical tests on the refining of low-grade kauri-gum chips in the works of a large manufacturer of plant for such purposes.

DAIRY RESEARCH.

A large proportion of the primary produce exported from New Zealand consists of dairy-products. It is essential that the quality of our produce should not only be maintained, but also improved, in order to meet overseas competition more efficiently. To do this requires scientific control of all stages of production, manufacture, and transport. This important work is the function of the Dairy Research Institute, which was the first organization to be established under the Department of Scientific and Industrial Research. Certain major problems in the manufacture of butter and cheese have been attacked with considerable success. For example, strains of starter bacteria which will produce the best type of cheddar cheese have been isolated, and are now constantly available to factories. A great deal of information has also been obtained on the action of bacteria in the ripening of cheese and in the production of faults such as openness and discoloration. Such fundamental research clears the way for a direct attack on the problem of overcoming these defects. A more equitable method of payment for milk for cheese-making based on its cheese yielding capacity has been developed as the result of research at the Dairy Research Institute. Trial on a commercial scale has proved its value and practicability.

WHEAT RESEARCH.

It is the aim of the Wheat Research Institute to improve the quality of New Zealand wheats so that the importation of strong wheats for blending purposes may be avoided. The first step was to breed new wheats with the desired strength by hybridization. The outstanding result of this work is "Cross 7," a hybrid made by crossing Solid Straw Tuscan, a variety which provides the greater part of the wheat grown in New Zealand, with White Fife, an imported variety. This new wheat has been exhaustively tested in the laboratory, and recent commercial trials have justified the claims made in regard to its quality and ability to produce of itself an excellent loaf.

The use of mineral improvers in breadmaking, with the exception of calcium phosphate, is forbidden in New Zealand, but the application by the Wheat Research Institute of fundamental research carried out overseas has shown that lemon-juice has remarkable qualities as a bread-improver. This is but another example of the value of pure research to industry.

The past season has been marked by widespread damage to wheat by sprouting. Excessive sprouting of wheat causes considerable damage to the flour, and in extreme cases the interior of the loaf after baking is a doughy, unpalatable mass. The urgent problem of devising methods of estimating the degree of damage to the flour, in order to be able to advise bakers as to the best methods of treatment, was very successfully overcome.

In addition to its pure research work the Institute is called upon to perform a large amount of routine testing of wheats and flours for millers and bakers, and is thus playing a very important part in maintaining the quality of one of our most important foodstuffs—our daily bread.

FRUIT RESEARCH.

An outstanding feature of the fruit-research work during the past year has been the proving of the successful method of controlling corky-pit disease of apples by the application of boron compounds either to the orchard soil or to the trees themselves. It now can be quite definitely stated that by application of as little as 50 lb. of borax per acre this serious disease can be controlled.

In transport overseas of fruit new methods of storage used in conjunction with improvements in ventilation and refrigeration have shown much promise as a means of landing fruit in better condition in Great Britain. It is interesting also to report that the first trial using gas storage of Cox's Orange Pippin apples in an overseas vessel turned out a complete success.

GEOLOGICAL SURVEY.

The staff of the Geological Survey is being strengthened by additional officers in order to advance more rapidly the structural survey of the Dominion. Increased provision is to be made for printing arrears of Geological Bulletins in order to meet the demand for information in connection with mining and other extractive industries. A special effort is to be made to obtain reliable data in regard to the quantity and quality of our coal resources from the point of view of their suitability for methods of utilization, particularly for oil. The work is being organized in conjunction with the Mines Department, and the chemical tests are to be carried out by special officers of the Dominion Laboratory. Information is being gradually accumulated regarding possible flow oil structures in the Dominion.

In geophysics attention has been devoted mainly to the Reefton area. Extensive geological mapping and geophysical survey of the lode systems have been carried out in this district, comprehensive maps also having been prepared as a basis for a large prospecting programme to be entered upon by the Mines Department. The country is heavy and the work of survey and observations has been difficult, yet much new information has been gained over a wide area, and it is hoped that it may lead to the reopening of several mines and possibly considerable employment in that district.

WEATHER SERVICES AND OBSERVATORIES.

The work of the observatories at Wellington, Christchurch, and Apia has been more closely co-ordinated with the work of the Meteorological Branch. Provision is being made for improved seismological observations and better services in connection with the relative timing of the instruments in various parts of the country, so as to enable a better record to be kept of the epicentres of the various earthquakes.

The staff of the Meteorological Office has been increased to cope with the extra work of forecasting for aviation. Synoptic weather charts are now plotted four times each day, and arrangements are in train for a better service on Sundays and holidays. The weather-forecasting service for everyday purposes and for the special needs of farming should thus be improved, quite apart from the meeting of the responsible duty of providing information rendered imperative by the rapid extension of civil aviation. The Meteorological Office has prepared special climatological surveys relating to those regions which are being covered by the soil and land-utilization surveys.

MANUFACTURING INDUSTRIES.

The manufacturing industries of the Dominion are justly entitled to the benefits of the application of research, and considerable thought has been given to the question of the extension of the technical and research services of the Department for this purpose.

In New Zealand it would appear that this problem could best be met by the formation of a co-operative research association by each branch of industry, some of the funds being contributed from Government sources, the rest by subscriptions from the industrial concerns who are members of the association. Steps are being taken to make such arrangements with a number of industries, in which an endeavour will be made to copy the more successful research associations affiliated with the Department of Scientific and Industrial Research, Great Britain. Because of the limitations of finance likely to be available owing to our relatively smaller industries, every care will need to be taken that the specialists on the staffs of the various research associations, the Dominion Laboratory, and the Universities will be available to give specialized advice to the staffs of other research associations. By this means effective team work will be possible and the best scientific advice brought to bear on the more complicated technical problems of industry.

In addition to the promotion of research associations, steps are being taken to establish a general bureau of technical information regarding problems of industry, which, in addition to having two chemical engineers appointed to its staff, will work in association with the Director of the Dominion Laboratory and his staff.

STANDARDS.

Closely related to the scientific problems of industry is the question of developing industrial standards which define the quality and nature of the raw materials to be put into goods and the processes of their manufacture, thus providing a reliable indication of the durability, service, performance, and suitability of such goods for a given purpose. This is one of the most effective means of securing the practical application of the knowledge gained from research and the experience of other countries. We owe much of what we have already attained in this respect to the valuable leads given to us by other countries, and it is vitally important to the best interests of the nation that we should diligently pursue these leads that have been given to us and be ready to co-operate in the common effort to extend them in the interests of a common advancement and purpose.

In the other countries with which we are preparing to co-operate more fully through a standards organization, it has been found from their longer experience that colossal waste occurs through the production and distribution of too many varieties of the same general class of goods. In the "Encyclopaedia Britannica," for instance, the following passage from the treatment of this subject appears:—

> "Analyses of many different lines of products have shown to the United States Department of Commerce that usually 80 per cent. of the year's total business in any line of products is done in 20 per cent. of the varieties in which that line is offered, the remaining 80 per cent. producing only 20 per cent. of the year's business."

The wastes of over-diversification are unduly large inventories, increased cost to carry them, slower turnover, idle investment, heavy obsolescence, decreased profits, and increased prices. The use of standards of quality and utility is necessary not only to avoid these economic wastes of useless production costs, but equally to protect the interests of the consumer by ensuring to him a full and sound return for his expenditure on goods or services. In purchasing cotton or woollen goods, glassware or hardware, furniture or paint, price should not be decided merely by size, measurement, weight, or quantity, but by these factors in relation to quality. In this connection the purchaser has been dependent in the past on a personal, inexpert knowledge fortified by the reputation of a business house or manufacturer's brand or trade-mark, which cannot be regarded as a sufficient guarantee of quality in relation to price in all cases.

Standardization places on goods a registered quality, distinction, ascertained by independent experts, and so determines quality by a fixed standard. In the same way weights and measures are fixed and controlled by central authority.

This method protects the consumer, ensures that he receives value for money, and removes the hazards of uncertainty. It places tendering on a fair and competitive basis. In addition, it protects the honest trader and manufacturer from spurious competition from within or without the country. It, therefore, provides a basis for international trade on an equitable and co-operative basis.

Summarized, the advantages may be stated to be as follows:—

(1) To the manufacturer: Decreased production-costs and selling-expenses, smaller inventories, faster turnover, and consequently improved profits.

(2) To the distributor: Reduction of inventories to the lines that sell well, thus securing speedier turnover and better profits.

(3) To the consumer: Lower prices, improvements in quality of products and the service of the supply.

These considerations are of such vital concern to the whole community as to become an obvious Government responsibility. Further than this, only the administrative resources of State can adequately cater for the essential needs involved. Hence the decision of the Government to take over the responsibility for carrying out the standards activity and administration in close co-operation with representatives of business, industry, and the consuming public.

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

SECRETARY'S REPORT.

The Council of Scientific and Industrial Research has held five meetings during the year. The personnel of the Council is as follows :—

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

Professors Denham and Riddet were granted one year's leave of absence to enable them to proceed overseas in order to keep in touch with the latest developments in research. Professor Riddet, at the request of the Government, will pay special attention to methods of marketing and handling dairy-produce in the main competitive dairy countries.

The consequential vacancies in the Research Council have been filled by Messrs. L. J. Schmitt and J. M. Ranstead, and Mr. T. Rigg assumed the office of Acting-Chairman.

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

Permanent services—	£
Head Office, publications, Research Scholarships, and miscellaneous	6,868
Dominion Laboratory (with branches)	12,327
Geological Survey	5,708
Meteorological Office	9,255
Apia Observatory	2,329
Dominion Observatory	1,687
Magnetic Observatory	1,822
Lincoln College	5,042
Research investigations	46,306
Total	91,344

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

	£
Imperial Economic Committee	1,358
Industries	11,225
Sales and miscellaneous recoveries	12,363
Consolidated Fund	21,360
	46,306

As in previous years, grants were made to the Cambridge Low Temperature Research Station, Farnham House, the Dried Products Research Station, Slough, and the Wool Research Institute, Torridon.

A grant of £2,500 was received from the Unemployment Board towards the cost of geophysical surveys carried out in gold-mining areas, mainly at Reefton.

The work of the Department is steadily expanding, and the services which it can render to industry are limited mainly by the amount of finance available.

What has been achieved in the past year is due in no small measure to the loyal co-operation of all scientific workers, and the staff of the Department as a whole. Their efforts are here gratefully acknowledged.

DOMINION LABORATORY.

The increasing amount of work which the Dominion Laboratory, with its branches in Auckland, Christchurch, and Dunedin, is called upon to perform for Government Departments is indicated by the fact that the total number of samples dealt with this year shows an increase of 400 over last year's total.

An exceptionally large number of samples for the police were examined, covering a very wide range of criminal investigation work, and, in a number of cases, the analyst's evidence was largely relied upon to secure a conviction.

The Department of Health, in pursuance of its policy of maintaining a strict watch on foodstuffs offered for sale in the Dominion, called upon the Dominion Laboratory to analyse a large number of milks. It is very satisfactory to record that the percentage of samples not complying with the standard was very small, and the record is equally as good as in previous years. The Dominion Laboratory has for many years held the view that the reductase test for the bacteriological quality of milk gives more reliable results than the more complicated and expensive method of plating and counting. It is therefore very gratifying to note that the Ministry of Health, Great Britain, published during 1935 a report on "The Bacteriological Grading of Milk," in which it is stated that the reductase test is the most satisfactory method for controlling the bacteriological quality of milk-supplies.

As in previous years, a number of samples have been examined for the Mines Department, including samples from prospectors, and samples of mine airs. Numerous samples were analysed in connection with the purchase of stores by the Stores Control Board, Post Office, and other Government Departments.

Progress in coal research and utilization abroad is being watched, and the Fuel Chemist during his recent visit to Great Britain made direct contact with those engaged in fuel investigational work, and gained first-hand knowledge of the advances being made.

In addition to its normal technical services, the Dominion Laboratory is carrying out an increasing amount of research work. During the year under review the following investigations were in progress: Examination of volcanic material collected by the Geological Survey, for pozzolanic activity; analytical examination of mineral waters from the Rotorua-Taupo district; experiments to ascertain the effect of storage on the coking properties of bituminous coals; chemical analysis of New Zealand grapefruit juice, with a view to ascertaining a suitable maturity test; chemical examination of phormium leaf; the isolation of an alkaloid from ragwort; and the analysis of clay fractions of soils collected by the Soil Survey Division.

METEOROLOGICAL BRANCH.

The inauguration of regular commercial air services in New Zealand, with the resulting demand for frequent reports of weather conditions along air routes and forecasts of future developments, has led to somewhat revolutionary changes in the organization of the Meteorological Office. A considerable increase of staff and an extension of the system of observation and reporting of the weather were involved. At present no service is given on Sundays or holidays, but the matter is under consideration. It will naturally take some years for the new and untrained personnel to reach their maximum efficiency, but those responsible are to be congratulated on having supplied the pilots of Cook Strait Airways and Union Airways with the necessary information prior to each flight since the inception of their services. This would not have been possible without the co-operation of the Controller of Civil Aviation, the Post and Telegraph Department, and the Marine Department. The cost of the service has been met by the Defence Department.

Schemes have also been drawn up in preparation for trans-Tasman and trans-Pacific air services.

During the year the Director visited Europe in order to attend the Conference of Directors of Meteorological Services at Warsaw in September and the Conference of Empire Meteorologists in London in August. His report, which will be read with interest, illustrates the great value of such conferences and of periodical visits by senior officers to the main centres of civilization.

The Director also draws attention to the necessity of sustained research into meteorological problems, which in most cases require for their solution a great accumulation of data covering a considerable period of years. Generally, this can only be obtained from an official service with its organized network of observatories and observing stations. Some valuable researches have been carried out by persons who are not and have never been associated with official meteorological services, but they usually refer to more or less isolated phenomena, and are generally concerned with the purely physical aspects of the subject.

During Dr. Kidson's absence the work of the Branch was carried on efficiently by Mr. B. V. Pemberton.

The usual regular publications, consisting of periodical summaries of climatological observations, have been maintained, and in addition, monographs dealing with special subjects have been published.

The Meteorological Branch has also assisted the land utilization surveys of North Auckland and Hawke's Bay by preparing notes on the climates of these regions.

The recording and discussion of climatic data, the inspection of stations, the observations of winds in the upper air, and other normal operations of the Meteorological Office have been carried on as usual. Observations of the wind in the upper air by means of pilot balloons are now made thrice daily instead of once, as previously, and the results are included in the reports furnished to air services.

The work of the many meteorological observers, most of which is of a purely voluntary character, is again gratefully acknowledged.

GEOLOGICAL SURVEY.

This year the Geological Survey carried out field work in the Dannevirke, Reefton, and Whakaea districts. Excluding the Reefton area, which was geologically examined over twenty years ago, 450 square miles was mapped in detail.

Geological exploration of the Dannevirke Subdivision, begun this year, continues the systematic examination of the oil-bearing country along the east side of the North Island. Strong gas-vents occur in the district, but bores for oil have so far been unsuccessful.

The work at Reefton is being carried out in conjunction with geophysical investigations. Intensive mapping near the auriferous lodes has shown that these occupy shear planes at or near the axes of folds in old sedimentary rocks. It is hoped to trace the more persistent folds into that part of the Reefton "run" of lodes between Merrijigs and Waiuta, where, for a distance of six miles, no commercial ore-body has hitherto been discovered. This considerable tract is largely gravel-covered, except along deep-cut streams, and presents great difficulties to ordinary surface prospecting. The fortunate discovery of the Birthday lode, now worked by the Blackwater Company, was made in similar country, which may yield comparable results to geophysical examinations localized by close geological work.

The Whakaea Subdivision includes the important alluvial fields of Wakaia and Waikaka from which much detrital has been obtained. The gold occurs not only in the flood plains and terraces of existing streams, but also in ancient gravels that faulting has preserved from denudation. The investigations will make the earth structure clear, and thereby aid mining.

Modern conditions more and more require the intelligent foresight that distinguishes civilized man from the savage. Long-range planning, which introduces scientific practice into public affairs, shows the growing pressure on our natural resources. It is the duty of the Geological Survey to ascertain the facts of mineral occurrence from which the capacity for production and the rate and extent of depletion may be estimated, and essential to this are the detailed areal mapping, the determination of the rock sequence, the working-out of the earth structure, and other investigations usually designated as fundamental research. These must always form a substantial part of the work of the survey if the development and conservation of our mineral resources are to be realized. Of late years other services imposed by special demands of local, temporary, or economic kinds dismembered the staff and have overshadowed the primary function of the survey, more especially the prompt publication of the results. If the economic investigations are to continue on the same scale, the rate of basic research must be increased, and this is only possible by restoring the staff to its former strength.

OBSERVATORIES.

The Department maintains three astronomical and geophysical observatories—the Dominion Observatory, Christchurch Magnetic Observatory, and Apia Observatory—which are worked as far as possible in co-ordination.

The Dominion Observatory controls the time service of the Dominion. Time signals are received from a number of overseas short-wave stations, and the Observatory clocks are also checked frequently by astronomical observations. Seismological observations are an important part of the programme of work, and monthly seismological bulletins are published which give sufficient data for the immediate determination of the epicentres of the most important earthquakes. In addition to these reports a number of special bulletins on the seismology of New Zealand were published during the year.

The Magnetic Observatory at Christchurch carries out magnetic, seismic, atmospheric electricity, and meteorological observations. Additional observations are now being made to assist in forecasting for aviational purposes. The Carnegie Institute of Washington has sent to Christchurch one of its continuously recording cosmic-ray meters, which has been housed in a special building near the Observatory.

Apia Observatory, Western Samoa, carries out comprehensive geophysical and meteorological observations, and earthquake-recording instruments are also installed. The Department is indebted to the Carnegie Corporation for financial assistance in the work of the Observatory.

PHORMIUM TENAX.

Up to the present the main aim in the selection and breeding of flax has been to secure strong, bold fibre for cordage purposes. It now appears that the woolpack industry, and possibly later a sacking industry, will create a large local market for our fibre. The class of fibre which these weaving industries demand is very different from the ideal cordage fibre, and intensive selection and breeding of varieties which possess the desired fineness of fibre is being carried out.

Some 25 acres of the Easton area near Shannon have now been planted with pedigree varieties, and some hybrids which have already been tested have given very promising results.

The Department's chemist at Foxton is investigating problems connected with the softening and lubrication of the fibre for spinning, and experiments already in progress justify the hope that distinct improvements may be made.

A knowledge of the chemical composition of the flax-leaf is essential for a complete understanding of its properties, and an attack on this problem was begun during the year at the Dominion Laboratory.

An investigation of methods of decortication is urgently required, and next year it is hoped to proceed with the design and manufacture of a tail stripper attachment.

MINERAL CONTENT OF PASTURES.

The continuous efforts of the Department in collaboration with the Cawthron Institute to discover the curative element in soil drenches and limonites found to be effective in the treatment of deficiency diseases of sheep at Nelson and Southland have now been rewarded. There were sound reasons for assuming that an element other than iron was effective in curing these diseases, and the

successful treatment of certain deficiency diseases in Australia with cobalt suggested the advisability of trying this element in the treatment of sheep sickness at Glenhope (Nelson) and Morton Mains (Southland). The experiments with cobalt drenches which have been carried out during the past year have been strikingly successful and showed conclusively that these diseases could be prevented and cured by the administration of drenches containing minute amounts of cobalt. There appeared to be no doubt, therefore, that the curative effect of the soil drenches and limonites used previously was due to the presence of cobalt. The importance of this work and the great possibilities in applying the treatment to stock affected with bush-sickness in the North Island can hardly be overestimated. The cheapness of the treatment will greatly facilitate its general use.

The role of cobalt in animal health is as yet very imperfectly understood, and a survey of the cobalt content of New Zealand pastures, soils, and animal organs has commenced, with a view to throwing light on this important problem.

The Department is indebted to the Southland Frozen Meat Co., for financial assistance in the Morton Mains investigations.

PLANT RESEARCH STATION.

During the year the Plant Research Station has been reorganized in order to give greater effect to a fuller measure of co-ordination of effort with the Department of Agriculture, the Agricultural Colleges, and the Cawthron Institute. The Plant Research Station has been replaced by the Plant Research Bureau, which is comprised at present of four main Divisions dealing respectively with plant diseases, grasslands, field crops, and entomology. In order that these Divisions may be located in such centres as will both facilitate their work and give greater measure of service to the Dominion as a whole, it is proposed to establish the Plant Diseases Division in Auckland, the Grasslands Division in close association with Massey College at Palmerston North, the Field Crops Division adjacent to Lincoln College, and the Entomological Division at Nelson, near the Cawthron Institute.

The Bureau will be under a committee representative of the Council of Scientific and Industrial Research, the Department of Agriculture, Massey College, Lincoln College, and the Cawthron Institute, the personnel being chosen with a view to securing the ready and full co-operation of all organizations concerned with agricultural research.

Sound progress has been made during the year in all branches of the work undertaken by the staff of the Plant Research Station. It is significant also that many of the findings of the Station are now being put very fully into actual practice in farm and orchard throughout the Dominion. Scarcely a crop of lucerne is now sown without prior treatment of the seed with bacterial culture prepared at the Station. The work done on orchard sprays has thrown such new light both on the specifics used and their method of application that orchard-spray practices are steadily altering and becoming much more effective. The discovery of the association existing between the boron content of the soil and corky-pit diseases of apples has brought the use of boron dressings to orchard soils in many districts. The successful acclimatization of the parasite (*Pteromalus*) of the white butterfly has made it again possible for crops of rape, turnips, and cabbages to be grown successfully in the Hawke's Bay and Manawatu districts, while investigations are still being pursued with the object of securing still better control of this serious pest and of the diamond-back moth which is so closely associated with it. The response of farmers to the pasture investigations is well indicated by the demand made for certified grass and clover seeds where new areas are being sown down to pasture.

In rye-grass, both perennial and Italian, white clover, red clover, subterranean clover, and cocksfoot, the search for still better strains is being continued, and, ultimately, this work will enable the pastures of the Dominion to be still further improved to a better standard possessed of higher carrying-capacity than at present.

At the same time the influence of all developments upon the quality of the produce of pastures is being closely watched, and in this connection good progress has been made in the understanding of the feed-taint problem which has caused deterioration in the value of dairy-produce at certain seasons of the year. This appears to be attributable to the presence of certain clovers which, under particular growing-conditions, are apt to impart taints. Investigations are now being designed to devise methods whereby this trouble may be reduced to a minimum.

Chemical research into plant characteristics is being designed to ascertain speedier methods of evaluating quality in grasses, clovers, and rape, and thereby help to expedite the rate of progress in plant-breeding.

Marked improvements have been effected in the strains of lucerne, rape, and field and garden peas in consequence of the selection and breeding work done during the year. In some cases these improved strains have almost reached the commercial stage, when they can be made available for use as farm crops.

The Station is also studying the characteristics of all new plants reported as established in the Dominion, and as many of these are weeds, and constitute potential menaces, this feature of the work is of distinct economic importance.

Under the new organization arranged through the Bureau, it is hoped that the investigations relating to the economic crops of the Dominion will be more speedily brought to fruition and translated into actual farm practice.

WHEAT RESEARCH INSTITUTE.

The activities of the Institute are centred about wheat-breeding, wheatgrowing practice, and laboratory investigations, and notable progress in each of these lines of research is reported.

"Cross 7" was made available in sufficient quantity this season to enable it to be grown by about one hundred farmers. Two new wheats, named Taiaroa and Tainui, have been selected as suitable for distribution—the former to Otago and Southland and the latter to Canterbury.

Some interesting experiments on the correlation of wheat-yield and soil-moisture have been continued, and it has been shown clearly that an adequate supply of soil-moisture is more important in October, while the numerous tillers produced in September are developing into ears, than in any other month of the period September to February.

The past season has been remarkable for widespread sprout damage to wheat. The sprouted wheats themselves, when milled and baked, give very poor loaves that are often useless for commercial purposes, but they can be blended in limited amounts into grists of sound wheats. The laboratory was faced with the problem of determining what percentage of sprouted wheat can be blended with sound wheat without damaging the resulting bread. The baking test was found on the whole to give a good indication of sprout damage in flours, and a new system of recording sprout injury has been evolved.

In addition to the large amount of routine work on the testing of wheats and flours, the laboratory has continued its investigations of a number of physical and physico-chemical methods of assessing quality in flour. Experiments on the use of lemon-juice as a bread improver have given notably good results.

DAIRY RESEARCH.

The year under review has witnessed steady progress in all the activities of the Dairy Research Institute, which are directed towards scientific control of every stage in the manufacture and transport of dairy-products. Previous work on the problem of starters for Cheddar cheese has shown that a culture of lactic streptococci which will produce acid at the required rate, and, furthermore, which would continue to grow at the comparatively high temperature of 100° F. produced the best results. This work has been followed up by selecting suitable strains, which are now in constant use in many cheese-factories. The problem of preventing the destruction of lactic streptococci by bacteriophage is a most difficult and baffling one, and although it has been attacked from numerous aspects, with useful results, a complete solution has not yet been reached.

Two important defects of cheese, openness and discoloration, have been traced to strains of lactobacilli, and it appears that the most practical method of controlling openness is the use of pure cultures as starters.

Investigations on the flavour of butter in relation to its diacetyl content have been extended to follow the distribution of this compound and its flavourless precursor, carbinol, during the manufacturing processes, and its fate during cold storage.

Field investigations in connection with feed flavour in butter which were started last year by the Plant Research Station, the Dairy Division of the Department of Agriculture, and several commercial factories in the Waikato were continued, and at the same time more strictly controlled trials were initiated by the Dairy Research Institute. The results confirmed the previous year's findings—namely, that, wherever an appreciable proportion of clover was present in the feed, a taint appeared in the cream. Furthermore, it has been shown that the time of consumption of the taint-producing plants by the animal in relation to the time of milking has a bearing on the development of feed flavours. The way has now been cleared for an investigation of ways and means of minimizing or eliminating feed-taints. This will require an examination of methods of farm-management, systems of feeding, and methods for the processing of cream.

The Institute has published a large number of papers during the year, and close contact with dairy organizations has been maintained through press articles and public addresses.

FRUIT RESEARCH.

With the active co-operation of the various participating bodies in New Zealand and overseas, a comprehensive programme of work has been carried out, covering all aspects of the production, storage, and transport of fruit.

The most important result of the year's manurial trials has been to demonstrate the superiority of "complete" fertilizer dressings, containing phosphate, potash, and nitrogen. Experiments were also carried out on the correlation of manurial treatment with susceptibility of the fruit to breakdown, &c., under cold-storage conditions. Further progress has been made in the various botanical, entomological, and mycological investigations, and also in the standardization of spray applications.

Following the discovery of the effectiveness of boron in controlling corky-pit in apples, which was referred to in last year's report, more extensive investigations have been carried out during the past year by the Cawthron Institute, and by Mr. J. D. Atkinson in the Braeburn district. Top-dressing with borax and injection or spraying with a solution of borax have proved equally successful in curing the disease. Examination of soils top-dressed with borax has shown that the boron penetrates very rapidly, and there does not appear to be any danger of a harmful accumulation of boron compounds. Further investigation is required to discover how long the effects of top-dressing or spraying with borax will last. Determinations of the boron status of soils and fruit have been made, and it has been shown that healthiness of the fruit is accompanied by a substantial increase in the amount of boron contained in it. There is evidence that boron deficiency is also responsible for the occurrence of corky-pit in Otago, and it is proposed to analyse samples of soils and fruit in order to check this.

SOIL SURVEY.

In recent years there has been widespread interest in land-settlement, which has arisen from a desire to absorb as much unemployed labour as possible on the land, and it was natural that a primary-producing country such as New Zealand should endeavour to create new avenues of employment through land-development. It will not be disputed that a systematic soil survey is a sound basis for the study of land-utilization problems. During the past few years the Department has built up an efficient soil survey organization, which has already completed surveys and soil maps of a number of counties. During the past season an extensive programme was mapped out, involving soil- and land-utilization surveys of the Hawke's Bay and North Auckland Districts. These projects were intended to be a guide to developmental policy, and as such received practical help from the Unemployment Board and the active co-operation of the Departments of Land and Agriculture. It was felt that a long-range policy should be followed, and that the actual soil surveys should be followed up by farm-management and pasture surveys in order to reveal the full potentialities for future development of the districts concerned. Field work was begun by the soil survey officers towards the end of the year under review, and at the time of writing the main soil types over nearly 1,500 square miles of territory in both Hawke's Bay and North Auckland have been mapped. Special attention has been given to orchard soils in Hawke's Bay and citrus-growing areas in North Auckland, and some of the main problems and methods of attack have already been clearly indicated. Pasture- and farm-management surveys have been commenced in Hawke's Bay in order to complete the picture which has been delineated by the soil survey.

In addition to the main activities in North Auckland and Hawke's Bay, soil survey work is proceeding in connection with certain irrigation areas in Central Otago.

LEATHER AND PELTS.

In the export of hides, no less than in other export industries of New Zealand, close attention must be given to all stages of production in order that a high and uniform standard of quality may be maintained. The regulations for the export of hides which are now being framed should help a great deal in this respect by laying down approved methods of treatment, particularly in regard to flaying and curing. The Research Chemist, during his recent visit to America and England, closely investigated problems of storage and marketing of pelts in their relation to the processing and grading of the raw products.

During the year the Leather Research Laboratory has carried out some researches of considerable importance to the industry, notably a study of the seasonal variations in lamb-skins. It was shown that the state of the sweat-glands in the skin of the lamb at different periods of the year has a profound influence on the structure of the skin, and consequently on the texture of the leather prepared from it. The results of the work indicate that loose grain may sometimes be inherent in the skin, and not the result of the fellmongers' work. This discovery may explain the differences in quality in New Zealand lamb-skins which have been remarked on by overseas buyers, and will direct attention to the necessity of killing at the right season in order to obtain leather of the best quality.

MISCELLANEOUS INVESTIGATIONS.

In addition to the research work which is recorded under specific headings in this report, the Department has undertaken a number of miscellaneous investigations to assist industry, particularly with a view to creating an export market for a wider range of New Zealand's agricultural products.

Chilled Beef.—It has already been demonstrated that chilled beef can be successfully shipped to the United Kingdom. A shipment which left for England by the "Port Hunter" in November was considered by London experts to reach a high standard of quality. A great deal of work has been done in New Zealand to ensure that every stage in the process of slaughter, preparation, and transport of the beef has been conducted under strict scientific control, and the observations and recommendations which have been made will be published as a bulletin in the near future.

Pork.—Experimental work in connection with the shipment of pork carcasses overseas has been continued. A committee consisting of Dr. Hammond, Messrs. Davidson and Swain, and Mr. Nevill Wright, the Department's Scientific Liaison Officer, has rendered very valuable service in arranging for the examination of carcasses on arrival in London, and in drawing up a scheme of evaluation.

Asparagus.—An experimental shipment of asparagus was sent to England in December. The consignment consisted of thirty-two bundles of asparagus, packed in crates, and held at 33° F. in the ship's egg-store, together with several tins containing asparagus in gelatine and agar-agar. While the shipment did not meet with the degree of success that was hoped for, it was shown that, with closer attention to temperature of transport, stage of maturity, and grading, New Zealand asparagus should find a definite place in the United Kingdom markets.

Chilled Eels.—A half-ton shipment of chilled eels was sent to the Torry Research Station, Aberdeen, with a view to testing the market for this product, for which there appears to be a seasonal demand. If a profitable outlet for eels cannot be found, it is possible that an industry for eel products—*e.g.*, skins, livers, oils, &c.—could be developed.

Overseas Contacts.—The Department's Scientific Liaison Officer, Mr. Nevill Wright, who is attached to the High Commissioner's Office in London, has continued to perform valued service in maintaining contact with research organizations in the United Kingdom; in representing the Government on the Executive Council of the Imperial Agricultural Research Bureaux and other scientific bodies; in making the necessary arrangements for the examination and handling of experimental shipments of various kinds; and in procuring information in connection with numerous scientific investigations.

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, W. E. Hale, A. Linton, T. C. Brash, Dr. C. J. Reakes, Messrs. W. Singleton, J. Murray, Quentin Donald, and Professor H. G. Denham. Director of Research: Professor Wm. Riddet. Secretary: Dr. E. Marsden.

The Director, Professor W. Riddet, left for a visit to America and Europe early in the New Year in order to study modern developments in dairy science and related matters. At the request of the Government, Professor Riddet will also investigate methods of processing and marketing of dairy-produce in the chief dairy exporting countries.

The Dairy Research Institute has made many advances during the year towards the solution of problems concerning the manufacture and transport of both butter and cheese. A clearer picture of the various reactions occurring during the manufacture and ripening of cheese has been formed, and this is gradually leading to the elimination of false ideas and to the substitution of fact for speculation in dealing with the various troubles which beset the manufacturer. Work on butter has been mainly in the direction of attempts to eliminate undesirable flavours (such as those originating from the cows' food) and to preserve the quality of the butter by packing and storing it under the best conditions.

Cheese.—The important question of starters is gradually being clarified. Various strains of starter bacteria which will produce the best type of Cheddar cheese are now constantly available to factories. The trouble caused by bacteriophage is, however, still in evidence, and up to the present no sure method of overcoming it has been found. The rôle of lactobacilli in the ripening of cheese and in the production of faults such as openness and discoloration has been elucidated still further, thus bringing nearer the possibility of controlling the whole ripening process. The new method of paying for cheese milk on the basis of its cheese yielding capacity has been proved practicable in commercial factories.

Butter.—Feed taints in cream used for the manufacture of butter have been traced to specific pasture-plants—the clovers. The co-operation in this work between the Institute, the Plant Research Station, and various commercial factories should prove very profitable in the future, and it is hoped that means will be found to minimize or to eliminate taints which in the past have been very prevalent in some districts. At the same time the facilities provided at the Institute for the investigation of the relation between feed, yield, and composition of milk from individual cows cannot fail to provide valuable information from many points of view. Many of the trials on methods of packing butter for export have been finalized during the year, and definite recommendations on the methods which should be standardized can now be made.

The activities of the Institute and the results obtained in the various sections of the work are outlined in the following statements prepared by various members of the staff:—

Cheese-making Investigations.

(*a*) *Starters.*—Work in past years has shown that the old idea that flavour-producing organisms, necessary in butter cultures, play a part in the production of flavour in cheese is fallacious. It has been established now beyond all doubt that the starter required for the manufacture of Cheddar cheese is a culture of lactic streptococci which will produce acid at the required rate. It was found last year that strains of lactic streptococci which would continue to grow actively even at the comparatively high temperature of 100° F. produced the best results when used as starter in the cheese-vat. This observation has been amply confirmed both at the Institute and in commercial factories during the season. A selection of the most desirable strains has been made, and these are now in constant use in many cheese-factories throughout the country. The use of these pure-culture starters has incidentally proved to have a marked controlling effect on the incidence of slit openness. As will be noted in a later section of this report, the ultimate cause of slit openness has been established. At the present time, however, it is apparent that the use of active pure culture as starters is the most practical means of controlling openness, even when the germs which are the ultimate cause of the trouble are present in the cheese milk.

The only factor which prevents the continual use of the pure-culture starters in all cheese-factories is the occurrence of bacteriophage, the virus which seems to attack all lactic streptococci under certain conditions. There is evidence which suggests that the phage is a product of the bacteria themselves; thus it is not possible to avoid the trouble by taking care to avoid contamination of the starter culture. It appears that the only solution is to render conditions unsuitable for the development of the phage. These conditions seem to exist naturally in some factories, as is evidenced by the fact that in some instances the starters are used with success over long periods. In other places the trouble occurs to a greater or lesser extent, and up to the present it has not been possible to find out why this is so. An undefined difference between milk-supplies is indicated, and it is possible that in the future a correlation will be found between the suitability of milk for starter preparation and the feed and soil types of various farms. Thus the work which is proceeding in various directions may be linked up to provide explanations for many apparently unrelated troubles.

In the meantime several possible ways for avoiding bacteriophage trouble have been tested with little success. Some factories find that cultures remain active for a reasonable period, and in these

cases a regular supply of fresh cultures solves the difficulty in a practical way. A scheme for testing the activity of a bulk starter before it is used in the vat has in some instances proved useful in giving warning to a factory-manager of the imminence of starter trouble. The use of two or three strains of streptococci of an active type in mixed cultures has given less trouble than the use of a single strain in other instances. But all these schemes have failed at one time or another, and it is clear that a complete solution has still to be found.

(*b*) *Cheese-ripening.*—(i) *Effect of Pasteurization of the Milk:* It has been known for several years that the protein in cheese manufactured from pasteurized milk breaks down somewhat more slowly and less completely during the ripening process than does the protein in raw-milk cheese. Previous workers attributed these effects to destruction of bacteria by the heat treatment of the milk. It was assumed that the organisms present in raw-milk cheese were more proteolytic than those in pasteurized-milk cheese, and, consequently, more rapid and complete degradation arose from bacterial action in the former type of cheese. The experiments at this Institute have indicated, however, that this view is probably incorrect. The pasteurization of milk at temperatures above approximately 150° F. has been found to alter its composition in such a way that trypsin and rennet do not decompose the protein in the same manner as they do the protein of raw milk. Application of these results to cheese-ripening has shown that the differences in protein decomposition which occur between cheeses made from raw milk and pasteurized milk can also be accounted for, largely, on the basis of chemical alteration produced in the milk constituents by heat treatment. This alteration affects the proteolytic action of rennet and bacteria upon the cheese-curd.

These findings are of some practical importance in connection with the subject of cheese flavour. During cheese-manufacture care must be exercised to keep the temperature of pasteurization of the milk low, since cheese made from milk pasteurized at a high temperature does not possess a normal cheese flavour. The failure of desirable cheese flavours to develop in such cheese has, in the past, usually been attributed to destruction of the natural milk flora by the heat treatment. The results of the experiments mentioned above raised the question as to whether the change in composition of the milk brought about by pasteurization might not be the most important factor. If the absence of typical Cheddar flavour were due to destruction of the natural flavour-forming organisms in the milk, it should be possible to manufacture good cheese from milk pasteurized at a high temperature simply by inoculating desirable flavour-forming strains of lactobacilli. This has been attempted in practice, and it has been found that, while the flavour of the cheese is improved to an appreciable extent, yet it is still not a good normal Cheddar flavour. Evidently the main factor involved is the alteration in composition of the milk by pasteurization at high temperatures.

(ii) *Cheese Flavour:* From inoculation experiments referred to below further confirmatory evidence has been derived in support of the views advanced in the last report. A large number of additional strains of lactobacilli and cocci have been found to impart characteristic flavours to cheese. A large amount of work remains to be done upon the most suitable amount of inoculum and the method of addition, on the symbiotic relations of the organisms and on the optimum acidity and moisture conditions in the cheese-curd.

(iii) *Openness:* Gas-forming lactobacilli have been shown to be a major factor in the production of slit openness in cheese. It has been found that open cheeses evolve larger amounts of carbon dioxide than do close cheeses. The inoculation into the cheese-vat of mixed cultures from open cheeses invariably reproduces the defect in the "daughter" cheeses. From around the slits in open cheeses organisms capable of forming unusually large proportions of carbon dioxide have been isolated. The inoculation of these bacteria into cheese has consistently produced openness. One of the most striking aspects of the later experiments in this connection is the small amount of inoculum that is effective in producing openness and in modifying flavour: with some strains of lactobacilli the smallest proportion yet employed (one part of clotted culture to 10,000,000 parts of milk) has been found to be ample. These observations explain why so many difficulties have been encountered in keeping control vats free from contamination.

(iv) *Discoloration:* Pure strains of lactobacilli capable of producing typical bleached discoloration in cheeses have been isolated from around the slits in cheeses which were either discoloured or which subsequently developed this defect. Inoculation of these organisms into cheese milk caused discoloration in the resultant cheeses. Except for their power to produce discoloration, the organisms in many cases were indistinguishable in other respects from lactobacilli which do not produce the defect.

(*c*) *Payment for Cheese Milk.*—The previous report recorded the conclusions formed from the investigations, extending over several years, on the relationship of fat and casein in milk to yield of cheese—viz., that the Walker-casein value for a supplier's composite milk sample, used along with the fat test, provided a satisfactory basis for estimation of the cheese yielding capacity of milk. It was recommended that payment should be made according to the cheese test of the milk, with a reduction for a portion of the cost of manufacture, according to the volume of milk delivered. The data on which these conclusions have been based have now been assembled for publication. A study has been presented of the various systems of payment that have been proposed previously. The experimental results are applied to a study of payment on a cheese test as determined from the average relationship between—(1) Casein/fat ratio in the milk and yield of cheese per pound of fat; (2) "casein + fat" in milk and yield of cheese per 100 lb. milk; and (3) fat in the milk and yield of cheese per 100 lb. milk. It is considered that the deduction of cheese test from the average relationship between casein/fat ratio in the milk and yield of cheese per pound of fat is fundamentally the most sound method. Results are given for the application of the casein/fat ratio cheese-test table to the estimation of yields of cheese in commercial factories for some fifty-nine composite sample testing periods. The agreement between the estimated and the actual yields of cheese was satisfactory.

During the past dairying season the "costed cheese" system of payment has been in use in several cheese-factories, and apparently has not offered any technical difficulties either in the factory or in the office. Through the kind co-operation of the factory directorates and managers the system has been given a further trial in some thirteen factories, where the composite samples have been tested for both fat and casein. In these factories the system has also given satisfaction from the technical standpoint. The trial has provided an opportunity of meeting any unforeseen difficulties. It became apparent as the season advanced that a closer check was necessary on the strength of the standard alkali prepared by the factory-managers, and during the later portion of the trial standard alkali has been provided by the Institute. It is considered that the difficulty could be overcome most easily by the purchase of more concentrated alkali from a reputable supply house and dilution of this as required in the cheese-factory for casein testing.

The trial in the factories during the past season is also being used to provide information on the extent of unfairness existing in those factories under the present system of payment. These results are not yet available.

In the report on payment for cheese milk, sections have been included summarizing present knowledge of the effect of various factors on the composition of milk, and also of the effect of factors such as pasteurization on the yield of cheese from milk of constant composition. Figures are given showing the average composition of the milk supplied to the factories concerned in the investigation.

The Walker-casein Test: A burette has been designed which will permit the direct reading of the casein value on the burette, without reference to a table.

(*d*) *Chemistry of Cheesemaking.*—Previous work on cheesemaking has emphasized the importance of the acidity of whey at drying on the quality of the resultant cheese. Small variations in this value in any one type of milk can effect very great changes in the character of the body and flavour of the cheese. Inquiry shows, however, that the practices required to obtain the best-quality cheese at factories in different districts are widely divergent. In some factories—in the Waikato district, for instance—the standard system of cheesemaking necessitates a rapid production of acid and a high drying acidity. Such a procedure at the Institute factory and at many factories in the Manawatu district would mean the production of acid cheese. There is at present no apparent reason for this difference in procedure. By a study of the effects of running the whey at different acidities, an attempt has been made to provide some explanation of these differences. The results have not yet been adequately studied to permit the formation of any conclusions.

(*e*) *Renneting difficulties in Cheesemaking.*—A report on this subject has been prepared for publication. In New Zealand the main difficulty in obtaining a satisfactory coagulation of milk with rennet is of only spasmodic occurrence. In some cases the firmness of the curd can be increased by use of a longer ripening period, but in the most difficult cases this procedure does not effect an improvement. The addition of some calcium chloride appears to be the only corrective method at present available, and this requires careful application. It has been shown that some cows give milk of this slow renneting type persistently throughout the season.

(*f*) *Adulteration of Cheese Milk by addition of Water and Incidence of "Non-acid Milk."*—Work done at the Laboratory of the Federation of Taranaki Co-operative Dairy Factories in collaboration with the Institute has included a study of the above subjects. The data obtained will provide an indication of the extent to which improvements could be made in the quality of milk supplied to cheese-factories.

Buttermaking Investigations.

(*a*) *Butter Flavour.*—The work on the relationship between the diacetyl content of butter and the flavour has been developed considerably. It would appear that while butter made from sweet cream, or from cream ripened without developing any appreciable amount of diacetyl, can have an attractive aroma, the inclusion of a small amount of diacetyl imparts a desirable "bloom" to the product. With larger amounts of diacetyl (up to about one part per million) the butter resembles the Danish product.

Experiments were designed to follow—(1) The distribution of diacetyl and its flavourless precursor, carbinol, during the manufacturing process; (2) the fate of the diacetyl in storage; and (3) the conditions of the factory ripening process which determine the maximum development of diacetyl within the limits of a safe churning acidity.

It has been found that a portion of the diacetyl and carbinol are destroyed in the pasteurizing and neutralizing process, and the proportion of the flavouring substances lost is governed by the degree of neutralization. For example, over-neutralized cream (acidity 0·04 per cent.) had only 60 per cent. of the original concentration of these substances. The diacetyl (and carbinol), whether developed naturally or added artificially to the butter, are included in the butter with the buttermilk, and only a trace is removed in the wash water. The diacetyl disappears, even during churning to some slight extent, through the oxidizing action of the air entrapped in the butter. Butters made with starter, particularly when the starter has been in a state of active growth when the cream was churned, lose less diacetyl in the subsequent processing and storage stages. Obviously a butter with a relatively large initial concentration of diacetyl will have a better "bloom" when taken from storage than a butter kept under identical conditions but with a lower initial amount of diacetyl substances.

Most authorities consider that the diacetyl is formed from its parent substance, carbinol, by oxidation with air entrapped in the butter. This has been found not to be the case. The oxidation which is evidently a bacterial one, is under further investigation.

(*b*) *Vitamin A.*—It has been shown that the vitamin A content of butter from a typical New Zealand herd remains practically constant over a season, a finding which is very different from the observations given in the literature for butter from typical herds in Great Britain. In that country the vitamin A values fall off seriously when the cattle are placed under stall-feeding conditions in winter.

The content of carotene (yellow colour, vitamin A precursor) changes somewhat from time to time and varies over different districts. The difference in carotene content of butter from Friesian and Jersey cattle is not so great as might be expected.

(*c*) *Wrapping and Storage of Butter.*—A fairly critical chemical and physical examination has been carried out on the properties of butter wrapping materials, but none of the other wrappers supplied by vendors of wrapping materials has been found superior to metal foils backed with parchment.

The conditions which govern the development of surface defects, particularly "primrose" colour, have been studied, and attention has been drawn to the important part played by pre-freezing conditions, particularly the elimination of large fluctuations in temperature in the chill-room, on the quality of butter at the surface.

The possibility of developing an export trade in patted butter wrapped in "triple foil"—*i.e.*, aluminium foil sandwiched between two thin layers of parchment—has been suggested and recommendations have been given for overcoming certain possible difficulties which would be encountered in practice.

(*d*) *Butter-boxes.*—The previous indications that rimu would be a satisfactory timber for butter-boxes are being tested out by shipment under commercial conditions of several lots of butter. Arrangements have also been made with a box-testing station in England to have the mechanical strength of rimu boxes compared with that of similar white-pine boxes.

(*e*) *Neutralization of Cream for Buttermaking.*—It has been found that a considerable amount of the over-neutralization of cream has been due to the use in some factories of too high a colour as the phenolphthalein end-point in the titration of the acidity of cream. An attempt is being made to provide a standard colour for the end-point, so that the procedure in use shall be common to all factories.

(*f*) *Pasteurizing Methods for Cream.*—During the past year trials were made of machines which have been proposed as alternatives to the standard flash pasteurizer. The experiments were designed with a view to determining whether these machines improved the quality of the butter made from poor-quality cream and whether they had any deleterious influence on high-quality cream. A pasteurizing and deodorizing unit which has come into common use during recent years was found to improve the quality of the butter made from second-grade cream with no apparent attendant disadvantages. Treatment of high-quality cream by this method had no deleterious effect. On the contrary, the butter made from finest cream treated in the pasteurizing-deodorizing unit was often preferred to butter made from similar cream treated by the flash pasteurizer. In particular the deodorizing treatment did not appear to result in a "flat" flavour in the butter. Caution is needed in translating results such as these into general practice, since cream may not react in the same way in all districts. A full investigation of a deodorizing treatment is very necessary, since some treatment of this type may be required if, as appears likely, it proves impossible to bring about a complete elimination of feed flavours by methods of farm management.

A plate pasteurizer used for the treatment of cream did not appear to offer any advantages over the flash pasteurizer. With poor-quality cream it effected no improvement in flavour and had some disadvantages.

(*g*) *Fat Losses in Buttermilk.*—In the comparisons at the Institute of the treatment of cream in the tandem flash pasteurizer and in the vacreator a careful check has been kept on the fat losses in the buttermilk. Since, however, the vacreator in use at the Institute is much smaller than the standard size, it has been necessary to compare the fat losses at the Institute with those occurring in commercial factories. These results are now being studied, and will shortly be ready for publication.

It has been shown that the butyl alcohol Babcock method gives very satisfactory results for buttermilk-testing.

(*h*) *Feed Flavours.*—The occurrence of feed flavours in the cream from some farms and the greater incidence of such flavours in the cream from some districts led the Institute to take up a study of the whole subject of the origin of feed flavours. In this work the Institute has had the co-operation of the Plant Research Station, officers of the Dairy Division, and several commercial factories. The field investigations started last year by the Plant Research Station in collaboration with several commercial factories in the Waikato district were continued during the season. Coincidently, more strictly controlled trials were initiated at this Institute. Pastures consisting of pure strains of grasses and clovers and of specified mixtures of the various types were established by the Plant Research Station on an experimental area near Palmerston North. An indoor feeding-shed and milking-shed were also provided. Two groups of cows were selected. One group was grazed out of doors on the special pastures, while the other group was housed indoors throughout the season and fed on pure strains of grass or clover for various periods, the herbage being cut, weighed, and fed in a fresh state. The cows were milked by hand and the individual milks were separated, so that cream samples from each individual animal were available for examination. The evening samples were kept in a refrigerator, and the creams were examined daily for the presence of feed flavour, points being awarded according to an agreed scale.

The experiments were not commenced until late in October, yet, even in the short time available this season, positive results were obtained. Cows fed on pure rye-grass produced cream free from feed flavour. All of the five types of clover—viz., subterranean, suckling, Montgomery red, white, broad red—fed individually to the cows indoors caused the appearance of a marked feed flavour which, while never so strong as that found in the worst cases in the Waikato, was essentially of the same type. The taint occurred almost invariably in the creams from the evening milking. This confirms the generally accepted idea that time of consumption of any taint-producing plants by the animal in relation to time of milking has a bearing on the development of feed flavour. Cows eat very little during the night, hence the absence of flavours in the morning creams. The results were most clear-cut with

the group of cows which was housed and fed with the practically pure types of pasture-plants, but confirmatory results were obtained from the cows grazed on the pastures consisting of specified mixtures. Wherever an appreciable proportion of clover was present in the feed a taint appeared in the cream, its intensity varying from day to day with individual animals.

The way has thus been cleared for further investigation with a view to devising means for the minimizing or elimination of feed taints. Methods of farm-management, systems of feeding, and methods for the processing of cream have all to be investigated, and co-operative effort between workers in several different spheres is necessary for the progress of the investigation.

The facilities available for the indoor and outdoor feeding of cows under experimental conditions are being used for the collection of data on the relations between the quantity and type of food consumed by the cow, the volume of milk produced, the daily variations in fat and casein content, and the periodical variations in fat composition.

Ghee.

Commercial tests with ghee so far have not proved very encouraging. The prices offering do not exceed those for whey butter, and, in addition, the working and packing expenses would be fairly heavy. However, the investigation has been continued during the current season in order to clarify the present obscure position.

In 1935 about eighty samples of ghee were made in the laboratory, under conditions giving different flavours and colours in the product. These were submitted for examination to a number of Hindus in Auckland, and their appraisals, which agree with those given by various Anglo-Indians who have kindly examined our products, were somewhat surprising. The Hindus preferred ghee made by the simplest—*i.e.*, our original—method of manufacture, which was merely the evaporation of butter, to any of the others offered. The other samples included ghees made with various degrees of rancid, "cheesy,' "fruity," and vague "fatty" flavours, which simulated the Eastern products sent here from time to time, as well as genuine Indian ghees which had been included in the series unknown to the judges. Their preference for the pure, pleasant-tasting product made by evaporating the water from New Zealand butter without any attempt to imitate the flavour of certain Indian ghees, confirms numerous other opinions expressed in the literature and in correspondence, and the personal judgments of Anglo-Indians in this country.

The position is complicated by the fact that some of the ghees sent from the East are adulterated, or are synthetic products, and it seems doubtful whether the Eastern merchants actually handle, or could recognize, pure cow-butterfat ghee.

The products prepared for shipment abroad early this year include ghees of the following types: (1) Ghee made by evaporation of whey butter with closed steam; (2) ghee made by evaporation of whey butter under vacuum; (3) ghee made by centrifugal separation of the melted fat; (4) bleached ghee made rancid; (5) bleached ghee re-evaporated with ripened cream; (6) ghee made from cream ripened with Indian starter (*dahi*). It is considered that these six types cover a wide range of flavours and colours, and samples have been sent to about twenty merchants for appraisal. The ruling market prices for ghee, however, have been distinctly discouraging for some time compared with the present selling-price of our butter in the United Kingdom.

Dissemination of Results.

The fifth annual factory-managers' week was held during the last week in April. A monthly bulletin was supplied to the *Dairy Exporter*. Addresses were given at various meetings convened by the New Zealand Dairy Factory Managers' Association, and by dairy companies, and at the National Dairy Conference. The following technical publications were issued during the year:—

Institute Publication No.	Title.	Author.	Journal.
	Studies on the Chemistry of Cheddar-cheese Making—		
51	Part 1	F. H. McDowall and R. M. Dolby	J. Dairy Research.
52	Part 2	R. M. Dolby and F. H. McDowall	J. Dairy Research.
54	Part 3	F. H. McDowall and R. M. Dolby	J. Dairy Research.
56	The Role of Rennet in the Ripening of Cheddar Cheese	I. R. Sherwood	J. Dairy Research
61	The Estimation of Diacetyl and Acetyl Methyl Carbinol	C. R. Barnicoat	Analyst.
62	The Function of Pepsin and Rennet in the Ripening of Cheddar Cheese	I. R. Sherwood	J. Dairy Research.
64	The Estimation of Salt in Butter	F. H. McDowall and C. L. McDonald	N.Z. Jour. Sci. & Tech.
65	Diacetyl in Cold-stored Butters	C. R. Barnicoat	J. Dairy Research.
67	Rate of Temperature Change in Butter packed in Boxes of Different Types	F. H. McDowall	N.Z. Jour. Sci. & Tech.
68	The Walker Test for Casein in Milk	F. H. McDowall	N.Z. Dairyman.
69	Bacteriophage Phenomena in Cultures of Lactic Streptococci	H. R. Whitehead and G. A. Cox	J. Dairy Research.
71	The Walker Method of Estimation of Casein in Milk and its Application to Preservatized Composite Samples	F. H. McDowall and R. M. Dolby	N.Z. Jour. Sci. & Tech.
75	Streptococci which produce a Substance inhibiting the Growth of Lactic Streptococci	H. R. Whitehead	N.Z. Jour. Agr.
79	Acidity Determination in Cheesemaking and Buttermaking	F. H. McDowall	N.Z. Exporter.

The following are in the press:—

Institute Publication No.	Title.	Author.
70	Estimation of Casein by Formol Titration after Precipitation with Acid..	F. H. McDowall and A. K. R. McDowell.
72	The Cheese Yielding Capacity of Milk and its Relation to the Method of Payment for Milk for Cheesemaking	F. H. McDowall.
74	Studies on the Chemistry of Cheddar-cheese Making: Part 4	F. H. McDowall and R. M. Dolby
76	Timber for Butter-boxes	F. H. McDowall and J. W. Smith.
77	The Estimation of Carbon Dioxide in Biological Fluids, more particularly Milk and Cream	F. H. McDowall.
78	A Burette for Formol Titration, and Specifications of a Burette for Direct Estimation of Casein in Milk by the Walker Method	F. H. McDowall.
80	Observations on the Ripening of Cheeses made from Raw and Pasteurized Milk	I. R. Sherwood.
81	Investigation of Cream Quality	A. M. Stirling.
82	Butter-boxes and Mould-growth	Wm. Riddet and J. C. Neill.

PLANT RESEARCH STATION.

The Plant Research Station located at Palmerston North has continued as a joint activity of the Departments of Agriculture and Scientific and Industrial Research under the direction of Mr. A. H. Cockayne. Towards the end of the year steps were taken to convert the Station into a Bureau, with Divisions located in proximity to the Agricultural Colleges and Cawthron Institute, with the object of bringing into co-ordination all the research and extension activities of the Dominion. The Station has worked in collaboration with the Dairy Research Institute, Wheat Research Institute, and the Fruit Research Scheme.

During the year the Station received the last instalment of the Empire Marketing Board grant, and was also assisted by a substantial contribution from the Carnegie Fund.

The work done has covered a very wide field of agricultural research, and distinct progress is evidenced in the reports which have been submitted.

Botanical Section.

(By Dr. H. H. Allan.)

Routine work was continued on the lines of previous years. The work of identifying and reporting on specimens, as usual, occupied a great deal of time, full advantage of this service being taken by all sections of the community indicated in previous reports. Well over 3,000 specimens were dealt with. A number of new records of introduced plants were made, the more important of these being dealt with in articles in the *Journal of Agriculture* in the series "Notes on recently observed Exotic Weeds." A paper bringing our knowledge of introduced species up to date and correcting errors of former accounts by various workers was published in the *Transactions of the Royal Society*. Work on the indigenous plants was continued, and a paper dealing with some of the results was published in the *Transactions*, while other papers were contributed to British and American scientific journals. The book on the grasses of New Zealand reached the page-proof stage, and Mr. Zotov has submitted for publication a paper dealing with certain results of his research into the leaf-anatomy of our grasses.

A further botanical examination was made of areas in the Mackenzie country affected by facial dermatitis, particular attention being paid to the following stations: Lake Tekapo, Lilybank, and Mr. Burnett's property adjacent to the southern end of the lake. On all these areas species of *Hypericum* were noted, sometimes in quantity. It was planned to give assistance on the botanical side to experiments to be carried out by the Live-stock Division on the properties of Messrs. Burnett and Murray. In company with Dr. Hopkirk I also visited affected areas in Poverty Bay, where a similar disease is being investigated. *Hypericum* is not a noticeable member of the plant cover of these areas, but a considerable growth of clovers and burr-clovers was observed. These plants have elsewhere been suspected of contributing to such outbreaks, and it appears desirable to have feeding-tests carried out with these as well as with the *Hypericums*. An illustrated article dealing with the various species of *Hypericum* found in New Zealand was prepared for the *Journal*.

Mr. Zotov made a three-weeks study of the grasslands of South Island, and continued this at his own expense during his vacation. Much valuable information and herbarium material were obtained, and we are now in a position to conclude our detailed revision of the grasses of New Zealand. Other minor excursions were made, resulting in considerable accessions to the herbarium. Contributions were also received from a number of European institutions, and a specially valuable set of specimens of marine algæ was presented by Mr. R. M. Laing. In accordance with a request from the Director, sets of specimens are being forwarded as opportunity allows to the Herbarium of the Royal Botanic Gardens at Kew. These will serve to bring up to date the collection of New Zealand plants there, especially of species described by local botanists subsequent to the floras of Hooker.

Preliminary observations were made in the neighbourhood of Te Awamutu, under the guidance of Mr. Melrose, of ragwort-infested areas. Special attention was paid to the area at Terau-a-moa and the Barton Estate. The period of the visit was not suited for extended investigations on the spread of the weed by seed, but preliminary experiments were carried out. These would suggest that although

wind-carriage is a factor it is not the most important one. It would appear that seed is in general not carried far by wind, and spread by this means is comparatively slow. Of more importance is carriage by stock. It is proposed to make more detailed studies next season.

A commencement was made, at the request of the Division of Horticulture, with investigations of anemone and ranunculus bulbs. The object is to secure a better grade of bulbs than has hitherto been available from New-Zealand-grown plants. From the areas planted a supply of bulbs and seeds has been obtained for experimental purposes.

The section of the fruit-research work entrusted to this section has occupied the full time of Mr. Woodhead, and his report is included under "Fruit Research."

Chemical Section.

(By B. W. Doak.)

Marton Experiments.—Routine determinations of the percentage of dry matter in the herbage from all the mowing-experiments have been carried out. In addition, the analysis of herbage from some of these trials has been continued. Soil-samples have been regularly taken from several experiments, and the results of the analyses so far carried out show that some valuable information concerning lime and phosphate fertilizing is likely to be obtained.

Mangels.—An investigation of the dry-matter and sugar content of several varieties of mangels was carried out on material supplied by the Agronomist. These samples showed that the dry matter and sugar of mangels under the conditions prevailing in this trial are considerably lower than the figures given by English investigators for the same vareties. This may be due largely to the difficulty of maturing mangels in this district.

HCN in White Clover.—Determinations of the HCN content of a large number of samples of white clover were carried out in co-operation with the Agrostologist. Although an investigation which had been carried out previously for a complete season to investigate the variation (time of day and day-to-day variation) in the HCN content had shown that the variation was not great, an exception to this was noted during the past season. Samples collected one morning were found to be considerably higher in HCN than those collected during the afternoon of the same day or during the morning or afternoon of succeeding days. No explanation of this can be suggested, but the observation again emphasizes the necessity for an adequate number of controls, since the determination of the HCN in a casual sample of white clover might lead to serious error if any attempt were made to indicate type by HCN determination.

Feed-flavour Investigation.—The analysis of the herbage fed to cows in connection with the co-operative experiment carried out by the Dairy Research Institute and the Plant Research Station has been undertaken.

Mycological Section.

(By Dr. G. H. Cunningham.)

(1) *Brassica Diseases.*—(*a*) Dry-rot (*Phoma lingam*): Some seventy varieties and strains of swedes are under field test to determine their relative powers of resistance to this disease.

(*b*) Club-root (*Plasmodiophora brassicæ*): Field tests of over one hundred varieties and strains of swedes and rape are in progress, following up the results obtained during the previous season in regard to the fixation of the quality of resistance to this disease. The results to date show that in highly infected soil, with favourable conditions for attack, no strain has yet been found that remains free from the disease. However, some varieties and strains have proved much more resistant than others, and future work should involve hybridization of these on an extensive scale to evolve a type highly resistant and suitable to New Zealand conditions.

(*c*) Brown-heart (mottled-heart): This disease of swedes, the cause of which is as yet unknown, has become increasingly prevalent in all swede-growing countries including New Zealand. Elsewhere the use of small quantities of boron has given good control of the symptoms, and trials of the method are in progress in various parts of the Dominion.

(*d*) Turnip-mosaic: This virus disease has assumed epidemic proportions on the brassica crops of the Station, very seriously interfering with the experimental programme. Its effects are particularly destructive to turnips, but almost equally so to swedes, causing stunting and defoliation, followed by an offensive bacterial rot. It reduces the yield of rape by 25 per cent. The virus has been transmitted artificially to cauliflower and broccoli, causing mild mosaic symptoms. A survey is planned to determine the relative importance of this disease in the main turnip-growing districts.

(2) *Cereal Diseases.*—(*a*) Rusts: Investigations on the biotypes of cereal rusts in New Zealand have been continued in collaboration with specialists overseas.

(*b*) Seed-dressings: Extensive field trials on the effects of organic-mercury dusts on wheat, barley, and oat seed sown at weekly intervals have shown that, within limits, they are efficient controllants of such seed-borne diseases as the covered smuts and stripe, and result in an average increase of 10 per cent. in plant-establishment.

(3) *Potato diseases.*—(*a*) Virus diseases: It has been found that the variety "Aucklander Short Top" is a carrier of a masked virus causing severe losses when transmitted to other varieties, a discovery of great practical significance to growers of seed potatoes.

(*b*) Internal brown fleck: Experiments with various minerals for the control of this disease yielded negative results.

(4) *Diseases of Legumes.*—(*a*) Virus diseases: Investigations on the host range and methods of transmission of "pea-mosaic" have been carried out with a view to evolving measures for control. "Pea-streak," a disease which has troubled growers for some years past, has now proved to be of virus origin, and work is in progress to determine its host range and methods of transmission.

(*b*) Bacterial-wilt of beans: Tests are in progress of varieties reported from abroad as being immune to this disease.

Seedling-vigour: Experiments on the effect of organic-mercury dusts and of nodule organism inoculations on pea-seed have yielded conflicting results—in some cases remarkable improvement in crop being obtained, in others little or none. The probable reason for this lies in the balance of seedling vigour and soil flora as governed by temperature and moisture, and this aspect will be considered in conjunction with the general investigation of soil flora now being undertaken.

(5) *Diseases of Tomato and Tobacco.*—(*a*) Damping-off of seedlings: The investigations on methods for the prevention of this trouble, continued from the previous season, have now been completed, and the results published for the guidance of growers.

(*b*) Leaf-mould of tomatoes: The experiments on methods for the control of this disease on tomatoes under glass have also been completed and the results published.

(*c*) Virus diseases: "Spotted-wilt" has been found to occur on tomatoes throughout the North Island, but has not been reported from the South Island. The same virus has been proved to cause the disease known as "Black-wilt" of tobacco, prevalent in Auckland and Bay of Plenty tobacco-growing areas. "Mosaic" of tobacco is becoming steadily more prevalent in New Zealand. Experiments are in progress on its persistence in the soil and on its host range and means of transmission.

(6) *Fruit-diseases.*—(*a*) Strawberry virus: It has been found that this disease may be transmitted by in-arching of runners. Some two thousand plants are under observation at the Station in connection with this disease.

(*b*) Strawberry root-rot: This is the most serious disease of strawberries in New Zealand. Up to the present, attempts to find the causal agent have failed.

(*c*) Bacterial disease of passion-fruit: This disease appears to be widespread in the North. The bacterium has been isolated and its pathogenicity proved.

(7) *Hop-diseases.*—A survey of the hop-growing areas in Nelson has shown that the only disease of economic importance is "black root-rot." Experiments are under way to determine its cause and control. A chlorotic condition occasionally seen is under test on suspicion of being due to a virus.

(8) *Cucumbers, Melons, &c.*—Cucumber mosaic has been prevalent during the past season on cucumbers, melons, marrows, &c., especially in the Gisborne district. In experiments the virus has been transmitted artificially to all these crops and to tobacco and blue lupin, producing in the latter symptoms closely resembling those of "sore-shin."

(9) *Mould Fungi in Industry.*—The study of mould fungi responsible for deterioration and spoilage of food-stuffs, textiles, &c., has been continued and much information acquired on the conditions which govern their occurrence and on means for checking their appearance. Experiments in conjunction with the Public Works Department have demonstrated a practicable method for the prevention of mould damage to tent-calico, which should result in very substantial savings to this and other tent-using Departments.

Free use of the expert advice available has been made by various industrial concerns faced with troubles due to moulds.

(10) *Miscellaneous.*—The supply of pure cultures of the lucerne nodule organism is an important and profitable branch of the Section's duties. During the present season sufficient cultures have been supplied to the farmers of New Zealand to inoculate 122,000 lb. of lucerne-seed. The use of similar inoculum for other leguminous plants, notably red and white clovers, lupins, soya beans, peas, &c., has been the subject of field trials, in collaboration with the Fields Division, with conflicting results. Further investigations are under way to determine the reason why the favourable results obtained with lucerne, and at times with the other crops mentioned, should in many cases fail to appear.

Preliminary work on the technique of biological analysis of soils is in progress, with a view to evolving a standardized method for use in collaboration with the physical and chemical sides of soil-survey projects.

During the year members of the Section associated themselves with Dr. G. H. Cunningham in the issue of the book "Plant Protection by the Aid of Therapeutants." This work covers in condensed form the whole of the available knowledge on the subject, and represents a fund of accurate information of incalculable value to users, traders, and manufacturers of the therapeutants used in all forms of plant-protection.

Agrostology.

(By E. Bruce Levy, Agrostologist.)

The work of the Section throughout the year has progressed steadily and the staff has been kept exceedingly busy, much good work being accomplished. Strain-testing of ecotypes and for certification purposes has been a major feature, and additional grass and clover species are now being studied. Plant-breeding and other work in connection with strain-building to pedigree standard has been steadily continued, and it is obvious that this work will gradually raise the standard of ordinary certified seed and in addition will afford progressive farmers an opportunity to adopt pedigree seeds for the betterment of their grazing areas. The Section has as its objective in building to pedigree standard the production under certification of such quantities of pedigree seeds at such a price that these seeds ultimately will be within reach of every farmer.

Strain-testing, strain-building, and field trials, thanks to the close and energetic co-operation of the field staff of the Fields Division, have been maintained as a continuous process, and too much emphasis cannot be laid on the value of this close inter-relation between research and field extension.

A pleasing feature of the year's work has been the close co-operation of workers in the matter of the investigation into feed flavours in cream. Farmers, dairy factories, cream-graders of the Dairy Division, the Dairy Research Institute, the Fields Division, and the Plant Research Station have all

linked up in the prosecution of this research. The work at Palmerston North and in the Waikato is well forward, and will be presented for publication in the near future.

The ecological field work of the Section has been extended, and for the time being is being concentrated on a mapping of pasture-types survey in the Hawke's Bay district in conjunction with a farm-management survey by the Fields Division, Department of Agriculture, and a soil survey by the Soil Survey Division, Department of Scientific and Industrial Research. This further example of collaborative field work is to be commended.

During the year negotiations with the New Zealand Golf Club were successfully finalized whereby green-keeping research was placed on a sound footing. A field advisory officer and a permanent hand for the research area have been appointed by the New Zealand Golf Council. This will enable research and extension to be fully co-ordinated.

The work of the year in detail is as follows :—

Strain-testing.

Perennial Rye-grass.—(*a*) Certification and other Plot Trials : Eight hundred and twenty-two plots were sown for study or report for certification purposes, all the latter of which have been finalized. Included in the study trials were a number of overseas lots, which were studied particularly to co-ordinate ultra-violet-light test and type test as determined by plot trial. As a result of these trials, it can be definitely laid down that the ultra-violet-light test may not be used as an international test for type determination, and that it is reliable only when taken in conjunction with type as determined by plot trial. Thus it serves admirably as a test for contamination in the Hawke's Bay and Poverty Bay strain, but it does not serve to differentiate between types of true perennial themselves. This is an important finding, and it should have a bearing on the class of certified perennial rye-grass, known as the "commercial class," which has been established on the ultra-violet test alone. None of the overseas strains under trial proved superior to the New Zealand certified rye-grass, and most were distinctly inferior. Some few Australian, some British indigenous, and two Hungarian lines were much superior to the ordinary run of lines.

(*b*) Elite-strain Work : The 1-acre block of selected pedigree rye-grass has been retained, and was again harvested for seed. A yield of 403 lb. of dressed seed was secured, and from this an additional 12 acres have been sown for increased seed-production on a contract basis. This makes 32 acres now sown out on contract from the nucleus area. A crop was secured from the 20 acres sown on contract in 1935, and a yield of 800 bushels was secured. This has now gone into commercial seed-production channels.

The breeding programme in perennial rye-grass includes a study of 6,700 single plants, the seed for the planting of which was secured as a result of crosses and selfings made in the 1934–35 season. Notes have been taken periodically on these, and will continue for another season before selection of the most promising material is made. Further selfings and diallel crosses were made of other promising plants, and studies were initiated to determine the degree of vigour that may be regained in crossing unrelated inbred plants.

(*c*) Low Germination of Perennial Rye-grass : The trial of two hundred lines conducted at Palmerston North and at Winton in connection with the investigation into the low-germination capacity of certified perennial rye-grass when harvested in a wet season yielded no data, as a result of good seed-setting and development under comparatively dry seasonal conditions which are unfavourable for the causal fungus to develop. A preliminary examination of the crop at Palmerston North revealed that there was no fungus present, and consequently it was considered unnecessary to proceed further with the investigation. The crop at Winton was harvested and the samples were forwarded to Palmerston North for threshing and testing. Representative lines were tested, but germination in all cases was high, indicating that the season in the South also was favourable to good seed setting and development. The experiment is to be continued at both places.

Italian Rye-grass.—(*a*) Certification and other Plot Trials : One hundred and fifty-nine plots were spring-sown, and have been reported on for certification purposes. It has been determined that late spring sowings give a very rapid indication of type, owing to the marked differential behaviour of Western Wolths and Italian rye-grass when spring-sown, the former bolting rapidly to seed-head and the latter tending to leafiness rather than stem. Inferior hybrid lots also show this tendency to bolt to seed when spring-sown.

(*b*) *Elite-strain and Breeding-work :* In the early autumn of 1935, 5,000 single plants, obtained by selfing and crossing sixty-two selected original plants, were set out, and notes were taken periodically until last breeding-season, when 105 of the best plants from the eight best F_1 and L_1 families were selected. These plants were selfed and crossed in intra-family groups of four by enclosing heads from the four plants in a large cellophane bag. Seed-setting was good, and 8,400 seedlings have been planted out.

To furnish more information on the relationship between the production of single plants, rows, and plots, seed was collected from seven families of known type but showing an extreme range in type between families. The seed thus obtained was used for single plants, rows, and plots, together with three known controls—Western Wolths, certified Italian, and poor Italian lines. Each lot was replicated four times. They will be cut and weighed at intervals throughout the season.

Five thousand single plants from a number of lines of certified and imported Italian rye-grass were set out for comparative study and to afford a mass of material for selection purposes.

Cocksfoot.—(*a*) Certification and plot trials : One hundred and forty-three plots were sown, and all certification lots have been reported on.

(*b*) Single-plant Study: Twelve hundred single plants of Akaroa and Plains origin and thirty selected tiller-row plants of various types have been kept under observation, and notes kept on superior plants to date. No breeding-work has yet been attempted, but a close study has been made regarding the make-up of Lincoln College C. 23 selection, and ten best plants have been split up and planted out for seed-production in order to obtain a pure line of seed for field trials.

Brown-top.—Four hundred and six lots have been sown out, largely for certification purposes. Those sown in the spring failed to establish, and these have now been resown this autumn.

Prairie Grass.—Investigations in strain within this species have been commenced, twenty-four lots being sown out as broadcast plots, spaced rows, and single plants.

Phalaris tuberosa.—Twenty lines of *Phalaris tuberosa* have been sown as broadcast plots, spaced rows, and as single plants. The majority of these lines are of Australian origin.

Clovers: White Clover.—(*a*) Certification and other Trials: Six hundred and forty-eight lines were spring-sown, and the 845 lines sown the previous spring have been finalized. Herbage tests for HCN on all lines have been conducted by the Plant Research Chemist.

In the plot trials pedigree lines and the good Mother-seed lines are showing marked superiority in growth over all other types right from the time the seedlings commence growth.

(*b*) Elite-strain Work—Breeding: The original eighty-nine tiller rows and the 100 tiller rows planted in 1934 have been retained, and notes on these have been regularly taken.

In the early spring a total of 4,500 single plants obtained from crosses and selfings made last season were put out. Notes have been taken on these plants, but no selections have as yet been made from them.

From the crosses planted in 1934, 125 of the best plants from the six best families were selected for further breeding-work. These have been back-crossed to both parents, and also crossed in intra-family groups of five by isolating five plants of a family in a cage with bumble bees. In addition, six inter-family groups were made by isolating together ten plants from two unrelated families.

Eight original plants were selected from tiller-rows and diallel-crossed to furnish further unrelated families.

Seed-setting has been very satisfactory, and a further 8,500 plants are coming on for planting out in the spring.

Pedigree-seed Production.—There has been quite a wide distribution of pedigree white clover seed, and the area sown already runs into approximately 200 acres. A total of 38 acres is sown out from the nucleus area at the Plant Research Station, and a further 20 acres is to be sown out this spring. Owing to the exceptionally wet summer experienced, only a small acreage of the area sown was successfully harvested, approximately 400 lb. in all being harvested. This has now gone into commercial seed-production under certification.

Montgomery Red Clover.—(*a*) Certification and other Trials: Seventy-five lines were spring-sown, but type differences will not be clearly marked until the following spring. All lines previously sown have been reported on for certification purposes.

(*b*) Elite-strain Work—Breeding: In the spring 2,400 single plants were put out, and notes have been periodically taken, but no selections will be made until next season.

To obtain sufficient seed for plot tests of different types eight crosses have been made, and the seed will be sown in plots in the spring.

The original selection was culled and consolidated and attempts were made to secure a seed crop from this area. The adverse weather conditions throughout the summer reduced the seed-yield, and only 32½ lb. of dressed seed was secured. Sufficient of this to sow 3 acres under contract was released, the remainder being used for comparative field trials.

Subterranean Clover.—Good progress has been made with a study of strains of subterranean clover. Thirty-three lots were planted last May as spaced plants in blocks, and then the plants were allowed to spread and join up to form the equivalent of a broadcast plot. Regular notes and weighings have been taken, and important strain differences have been noted. The different strains fall into one or other of four groups if dates of flowering and seasonal growth are both considered:—

Group I is early-growing, early-flowering, and relatively low-producing.
Group II is early-growing, mid-season-flowering, and high-producing.
Group III is later-growing, mid-season-flowering, and only fairly good producing.
Group IV is very late to commence growth, late in flowering, and very heavy producing in the late spring.

The strains which come within Group II would appear to be the best for New Zealand conditions, since they are able to yield well in the early spring and in the early autumn.

This autumn a further twenty-four lots have been planted out for study, but only six of them are strains which have not been grown at the Station previously.

Seed-production.

Following on the results of strain-testing, nineteen blocks of single plants of the different strains have been planted in order to give increased supplies of seed for field trials and for later distribution commercially. The blocks are approximately $\frac{1}{100}$ acre in size.

Lotus Major.—The tiller-row trial has been continued, and late in the spring a selection of eight plants was put out in an isolated corner. The plants recovered very slowly after transplanting, and as a result did not flower this season. The selection is being kept for seeding this coming summer, and the seed obtained will be increase grown.

Two hundred and fifty L_1 plants obtained by selfing three original plants have been planted out, but no selections were made from these this season.

Ecology.—(*a*) Field Trials: A comprehensive series of strain trials has been arranged for the purpose of species, strains, and seed-mixture trials on various soil types and conditions. Thirty-two trials have been made up during the year, and these have been laid down by the Fields Division, and regular reports have been received. There is now a total of ninety-one trials in progress.

(*b*) Pasture Analyses: The pasture analytical work has increased greatly during the year, and further technique work has been carried out with the following methods: (1) Eye-determination; (2) point analysis; (3) dissection analysis of cut or plucked herbage.

The greater amount of this work has been in connection with the pasture trials at Marton, the feed-flavour investigation at the Dairy Research Institute, Palmerston North, and in conjunction with seed-mixture trials.

Much more of this exact work should be done in conjunction with plot and field trials.

(*c*) Pasture Survey Work: This has for its objective the mapping of pasture types in such a way as to indicate the following three phases of pasture progress: (1) The vegetation that each soil and climatic type will support in its natural or unimproved condition; (2) the modifications that have taken place to date in general; and (3) the potential possible sward that such soils or climatic type will support when fully improved. The pasture survey commenced in the Hawke's Bay County in January of the year under review, and up to the 31st March approximately 150 square miles had been mapped. This later will be correlated up with farm-management and soil type, which surveys are proceeding hand-in-hand with the pasture survey.

Feed-flavour in Cream Investigation.—This has been continued in the Waikato and further extended at Palmerston North in close collaboration with the Dairy Research Institute and the Fields Division of the Department of Agriculture. An extensive programme of work was undertaken, and the work in the Waikato enlarged to include work at Frankton and Te Awamutu as well as at Morrinsville. Forty farms at each centre were botanically surveyed, and the cream-supply from these farms was subject to critical grading on the 0 to 10 basis for feed-flavour intensity. The major points determined in the previous year's work were confirmed. These may be again summarized as follows:—

(1) Grass-dominant farms yield a cream low in feed-flavour intensity.
(2) Clover-dominant farms yield a cream high in feed-flavour intensity.
(3) The lower per-acre producing pasture types, consisting mainly of suckling clover, subterranean clover, and sweet vernal, produce the highest feed-flavour intensity, but the high feed-flavour intensity period is of comparatively short duration.
(4) Dominant white-clover farms, with some rye-grass subdominant, are high in feed flavour, and these extended well through the season.
(5) Dominant rye-grass farms, with white clover subdominant, produced the best-quality creams, these possessing a relatively low feed-flavour intensity throughout the season.
(6) The evening cream gave a consistently higher feed flavour than the morning cream, and this is evidently associated with the time prior to milking that the feed is consumed.

Control of feed flavour would appear to lie along the lines of pasture improvement, and some experimental work was initiated to see how best pasture could be translated from clover-dominant to grass-dominant. Some 200 acres on ten farms were experimentally treated with nitrogenous manures, and paddocks so treated were compared with other paddocks on the farm. Owing, however, to the lateness of the spring and the consequent general feed-shortage, little could be done to ration the herd on these nitrogen-treated fields because they were constantly in use by the herd.

It is contemplated to continue the investigation, and, in addition, to compare heavy phosphated fields with fields treated with nitrogenous fertilizers.

At Palmerston North the work involved the preparation, sowing down, and fencing of special pure and mixed pastures for field grazing, and the provision of pure feeds that were cut and fed indoors to stall-fed cows.

In both trials the herbage consumed was botanically analysed and dry-matter determinations made by the Station Chemist. The general results of these trials went to confirm the field trials in the Waikato in so far as they went to prove—

(1) That pure grass diets yielded a cream almost entirely free of feed flavours:
(2) All clovers fed produced feed flavour in the cream, and the indications were that suckling clover and subterranean clover were more potent in this respect than white clover or red clover.

Further pure sowings covering six acres of ground have been made, and the work involved in maintaining these crops in a pure condition is considerable, all clovers being sown in drill rows and intertilled to control volunteer species and weeds.

Green-keeping Research.—This work has progressed well during the year. The New Zealand Golf Council has appointed a field advisory officer and permanent labour to the research area in order that this work may be more efficiently carried on and that the results may be extended to actual field practice. The actual control of the research area is now vested in the advisory officer, and this has released my assistant for ecological pasture work in the field.

Publications.—The following articles have appeared during the year:—

"Garden Lawns and Playing Greens," by E. A. Madden: *Journal of Agriculture* for June.
Third Annual Report, Greenkeeping Research. Papers were contributed by the following officers to the New Zealand Grassland Association Conference: L. Corkill, S. H. Saxby, L. W. Gorman, E. A. Madden, and E. Bruce Levy.

Demonstrations, Lectures, and Conferences.—The number of farmers and overseas visitors to the research area has increased during the year, and this alone involves a good deal of time of the Station's staff. Such visits, however, are encouraged, and are most convincing as to the value of the work being done.

Staff.—The services of Mr. S. H. Saxby were lost to the Section during the year. The loss of this trained officer to a position in the Service for which he is not so well fitted is much regretted.

Mr. L. Corkill has been engaged as Plant-breeder on a temporary basis, and his permanent appointment should receive early consideration.

It has been very gratifying that all officers connected with this work have again performed a strenuous year's work in a most satisfactory manner. The work at the Station area has been efficiently run under the overseership of Mr. Todd, and it is anticipated that with the permanent labour now available there even better work in the future will be accomplished.

Agronomy Section.

(By J. W. Hadfield.)

The work of the Agronomy Section has been carried out, as in the past, at the Pure Seed Station, Lincoln, and at the Plant Research Station, Palmerston North.

Growing-conditions were favourable at Lincoln, and heavy yields resulted, but the harvesting conditions caused heavy losses, 16·22 in. of rain being recorded for February and March. The season was very late at Palmerston North, and conditions far from ideal for seed-setting.

Wheat.—The policy of producing nucleus lines of pure and smut-free seed has been continued, and it is satisfactory to report that the Canterbury Agricultural College has taken over much of the seed so produced. The balance has gone into the hands of seed-growers, and will be distributed under certification.

Several new wheats were placed under yield trial. Lin Calel, a variety from South America, shows promise in baking-quality and yield when autumn-sown. Ben Cubbin, an Australian wheat, may have merits as a spring-sown variety.

Oats.—The main work has consisted of an extensive yield trial comprising most of the New Zealand commercial varieties and several introductions from overseas. Of the recently imported varieties, Resistance, raised by the National Institute of Agricultural Botany, proved very promising for Canterbury, Otago, and Southland conditions. It is not yet fixed in type, and its high susceptibility to rust renders it quite unsuitable for North Island conditions.

Breeding-work has been confined to the selection of crosses suitable for North Island conditions, with rust-resistance as a special consideration.

F_3 seed has been harvested from Ruakura × Algerian × Lampton × Ruakura;

F_2 seed has been harvested from Lampton × Gartons × Ruakura.

Garden Peas.—Acre lots of nine varieties were grown under order for various merchants to replace their deteriorated stocks. The demand for good seed is very keen, and the area devoted to this crop could well be increased.

Breeding has been confined to two crosses from which F_3 and F_4 seed was harvested. The following results indicate the increases in yield secured:—

Cross 11 (Greenfeast × Harrison's Glory) × Greenfeast.

Cross 8 Greenfeast × Great Crop (Yorkshire Hero).

——	Pod-length.	Peas per Pod.	Weight per 100 Seeds.	Yield of Seed per Plant.
	In.		Grm.	Grm.
Parent Greenfeast	3·75	8·5	28•6	37·5
Parent Great Crop	3·25	5·6	43·4	52·0
16 families Cross 11	3·6	7·1	32·0	64·0
8 families Cross 8	3·5	7·7	34·5	74·0

Field Peas.—A wide range of crosses between varieties of field peas and between field and garden peas is being worked with. Unfortunately, two adverse seasons have been experienced, and, although some progress has been made, it has been impossible to evaluate at all satisfactorily the material on hand.

Potatoes.—Trials are being undertaken of several recent introductions, including the American varieties Chippewa and Katahdin.

Several hundred crosses were made between *Solanum andiginum* (a wild species from South America) and standard commercial varieties. From these about eighty fruits were saved, and it is intended to explore the possibilities of these hybrids next season.

Lucerne.—Breeding commenced in 1931. By inbreeding and selection it has been possible to advance along two lines. In the first, those parents which have given consistently good inbred progenies were grouped according to type, and the parents crossed one with the other. The F_1 progenies of these crosses have been under trial this past season and have given, over a period of three cuts, substantial increases over Marlborough commercial.

Marlborough commercial	= 100·0
14 F_1 families of flat types range from 114·9 to 137·9: Average	= 128·1
14 F_1 families of upright types range from 97·3 to 123·0: Average	= 108·9
40 F_1 families of intermediate types range from 99·2 to 146·1: Average	= 124·1

Plants have been selected from within the best F_1 families, and these will be used for strain-building. In the flat and intermediate groups only those families yielding above 130 will be used, and in the tall only those above 110.

Secondly, the best plants within the best inbred progenies have been grouped according to type, and unrelated plants intercrossed, necessitating 260 separate crosses. Since the plants and families utilized were selected on account of their uniformity and small loss of vigour on inbreeding, it is hoped, by further inbreeding and combination, to build up strains of good type that will lose only the least possible vigour on self-fertilization.

Investigations in connection with the pollination of lucerne have been completed, and the results are being published.

Rape.—Each year an attempt is made to raise mother seed for distribution to growers who are producing seed commercially under certification. A measure of improvement has been attained each year, as indicated by yield trials conducted this past season :—

Best commercial Giant rape	= 100·0
Mother seed distributed for 1934–35	= 107·4
Mother seed distributed for 1935–36	= 116·0
Mother seed distributed for 1936–37	= 122·4
Mother seed for distribution for 1937–38	= 125·6

An attempt has been made to combine in one cross the best features of Giant and Broad-leaf Essex rapes. This has been to a large extent successful. The type has been improved, and is associated with a marked increase in production.

Best commercial Giant	= 100·0
(Giant × Broad-leaf Essex) × Giant	= 122·6
Best commercial Broad-leaf Essex	= 100·0
(Giant × Broad-leaf Essex) × Broad-leaf Essex	= 128·0

Brassica Crosses.—Some 259 intervarietal and interspecific crosses have been made during the past season. Certain of these have as a direct objective the breeding for resistance to club-root.

Hybrid Vigour in Tomatoes.—The combination in F_1 of early maturity in association with high yield that characterized the preliminary work warranted further investigation, and fifty-nine crosses between seven varieties have been made. It is hoped that estimates of hybrid vigour attending these crosses will be undertaken next season.

Miscellaneous Trials.—A variety trial with soya beans was undertaken, and has revealed much preliminary information in regard to yield, maturity, and synonymity.

Several selections of onions were seeded, and sufficient seed is now available for yield trials next season.

Austrian winter field peas have proved to be very resistant to severe winter conditions, and superior in this respect to Partridge. Seed is being increased for distribution.

Trials of vetches and tares indicate that purple vetch and woolly-podded vetch may prove useful varieties in New Zealand.

Safflower, a new oil-bearing plant, was tried out for the first time. It grows to perfection at Palmerston North ; but owing to the spiny and unpalatable nature of the plant it was deemed unwise to extend these trials, and the plot was destroyed.

Maize variety trials were destroyed during a severe storm.

Entomological Section.

(By J. Muggeridge.)

For convenience the work of this Section is dealt with under two headings—(*a*) Routine, and (*b*) Research.

Routine.—During the past year a considerable amount of time was taken up in replying to correspondence concerning the identification of various insect pests and giving information in regard to their control where practicable.

Owing to the abnormally wet conditions in the North Auckland Province there was a serious outbreak of "armyworm" caterpillars. The appearance of the caterpillars in epidemic proportions had the effect of stripping pastures that were being kept for hay or for feeding-off during the late autumn and winter months. The area affected—over 15,000 acres—proved to be low-lying country subject to flooding. A full report on this matter has been presented.

Research.—White Butterfly : Work on the biological control of this pest was continued throughout the year, and it is pleasing to report that there was a distinct falling-off in the prevalence of the pest in the areas where the parasite was well established. At the end of the 1935 season the butterfly was under good control in Hawke's Bay, so much so that it was difficult to find a butterfly chrysalid in places where hundreds might be found before ; in the Manawatu, Taranaki, and Wellington Provinces during this period parasitism of the chrysalids reached as high as 90 per cent., and consequently towards the end of the season in these latter places there was a marked diminution in the prevalence of the pest.

At the commencement of the 1936 season there was every indication that the butterfly was under good control in the areas referred to above. As the season advanced, however, it was noted that it was increasing ; at first in parts of Hawke's Bay and subsequently in the Manawatu and Taranaki districts. The increase did not bring the population up to the original epidemic proportions, but, nevertheless, it was sufficient to be alarming. As far as time would permit field studies were made, and it was found that, apparently owing to wet conditions, there was a differential rate of parasitism between material collected from grass and that collected from posts.

During the 1935 season no such differences were noted, parasitism of the chrysalids being equally high whether they were taken from grass or from posts. It is possible that this trouble may in the future be overcome by the provisions of suitable places in which the butterfly can pupate.

During the 1935–36 season 79,000 parasites were distributed, as follows:—

Canterbury	30,095	Westland	1,460
Auckland	23,285	Wellington	1,340
Marlborough	9,850	Taranaki	300
Otago	8,060		
Nelson	2,610	Total	79,000
Southland	2,000		

Diamond-back Moth: A considerable amount of work in regard to this pest is being carried out both here and in England. From a report on a preliminary survey in connection with the moth and its parasites, it is pointed out that the moth is known in England mainly in epidemic form; frequently it is not noticed and recorded by economic entomologists. A number of parasites have already been found in England, but a considerable amount of work remains to be done before any material can be sent out here.

In New Zealand a considerable amount of time has been devoted to field surveys, life-history studies, and the existing host-parasite relationship. A detailed account of this work as far as it has progressed will shortly be forwarded.

White Fly: Stocks of the white-fly parasite (*Encarsia formosa*) have been kept going throughout the year, and supplies of the parasite have been sent out to various applicants from time to time. This parasite when given time to establish proves a thoroughly effective check to the white fly.

Red Mite: Further experiments were carried out, much on the same lines as those already reported in the *Journal of Science and Technology*, Vol. 16, No. 5, pp. 261–270 (1935). The purpose of the work was to ascertain as accurately as possible the value of applying winter oils against the overwintering eggs of the red mite (*Paratetranychus pilosus*) as a control for this pest. The technique of counting and observing results was the same as that used in the experiments already reported in the publication mentioned above. The results indicate that under the outdoor conditions neither increasing viscosity nor stability of emulsion have any significant increased killing-effect. The oils applied in July and early August had no killing-effect at all, whereas those applied in late August and September gave only about 40 per cent. kill due to oil, taking into consideration the percentage natural mortality, which was high, being in 75 per cent. of the trials approximately 40 per cent. The weather during the period for which the twigs were exposed in the outdoor cage was abnormally wet, and conditions were generally unfavourable to a good control by the oil. From experience in this work it would seem, when the eggs are exposed to outdoor conditions in this way, that the method of estimating results described in experiments already reported in the *Journal of Science and Technology* (mentioned above) might be investigated with advantage. If suitable supplies of eggs can be secured it is proposed to carry out such an investigation this winter, as this is necessary to interpret the results correctly.

In conjunction with the above detailed work a fairly large field experiment was carried out on Delicious-apple trees in a Hastings orchard. Altogether 204 trees were included in the experiment, which was designed to test the effect of viscosity and stability of emulsion on the killing-power of winter oils on red-mite (*P. pilosus*) eggs. The oils were applied in early July on one block and in early September on a second block. The purpose of this was to discover also whether the time of application influenced the kill secured. In July and September overwintering eggs of *P. pilosus* were very plentiful on most of the trees, but at an inspection in the middle of December mites were extremely scarce on all trees, even on the checks, so that it was impossible to detect any difference between the effects of any of the oils. The season had been an extremely wet one, and apparently this accounted for the disappearance of the mites.

Up to the present there seems to be little evidence to show that winter oils against *P. pilosus* give a good kill.

Insecticides for controlling the White Butterfly (P. rapæ) *on Cabbages.*—This work was continued at the area in the 1935–36 season. The insecticides tested were arsenate of lead sprays and dusts, calcium arsenate sprays and dusts, pyrethrum sprays, nicotine sprays, common-salt sprays, lettuce-decoction sprays, and derris sprays and dusts. The results show the superiority of the derris dusts.

The poison-residue problem is also being investigated thoroughly. This is of moment where arsenicals are used. Cabbages were sprayed at various times with lead arsenate and harvested at specified intervals after spraying. The samples have been forwarded to the Dominion Analyst for examination. Results so far show that, even if an interval of six weeks is allowed between the last spraying and the time of harvesting, there is a danger of more than 0·01 grain of arsenic trioxide per pound being present if the whole cabbage is analysed. On the other hand, if only the hearts of such cabbages are used, there is little more than a trace of arsenic present. The figure 0·01 grain of arsenic trioxide per pound of foodstuff was that adopted by the Royal Commission on Arsenical Poisoning in London, 1903. This figure is accepted in most countries, but in New Zealand the regulations under the Sale of Food and Drugs Act, 1908,[§] do not allow the presence of any arsenic or lead at all on fresh cabbages and cauliflowers. The whole position is unsatisfactory as far as recommendations for the use of arsenicals are concerned, especially since lead-arsenate spray will give quite a good control of white-butterfly larvæ. Therefore the present work is designed to clear up the position. This project should be finished after next season.

Red Scale (Chrysomphalus aurantii).—In collaboration with the Horticulture Division an experiment on the control of red scale on lemons was carried out at Tauranga. The object of the work was to discover the nature of the control secured with summer oil at 1–33 on this pest. The 1934–35 season was a bad one for this scale, and growers claimed that it was very difficult to secure a control by oil spraying. The plots at Tauranga were sprayed at specified intervals, and a week to ten days after spraying samples of the sprayed fruit were forwarded to Palmerston North for examination as

to kill. Examinations showed that more adult scales remained alive after spraying than did any younger stage. Particular care was taken to secure a complete spray cover on specimens forwarded, but even so the kill of mature scales varied from 50 per cent. to over 90 per cent. Two consecutive sprayings, on the whole, gave very good control. The results show how important it is to spray thoroughly, because a great number of growers cannot afford to put on more than one spray during the season.

Papers published during the period 31st March, 1935, to 31st March, 1936, were as follows:—

(1) Red Mite Control by Oil Sprays. *N.Z. Journal of Science and Technology*, Vol. 16, No. 5.
(2) Six papers on Economic Aphides and their Control, in the *N.Z. Journal of Agriculture.*
(3) Eelworm Disease of Chrysanthemum. *N.Z. Journal of Agriculture.*
(4) The Use of Insecticides in the Control of the White Butterfly. *N.Z. Journal of Agriculture.*
(5) Experiments on the Control of the Bronze Beetle. *N.Z. Journal of Science and Technology.*
(6) The White Butterfly Menace: Efficient Control by the Pupal Parasite *Pteromalus puparum. N.Z. Journal of Agriculture.*
(7) Thrips: With special Reference to the Greenhouse Thrips. *N.Z. Journal of Agriculture.*
(8) The Potato-tuber Moth. *N.Z. Journal of Agriculture.*

WHEAT RESEARCH INSTITUTE.

(ANNUAL REPORT FOR THE YEAR ENDING 31ST MARCH, 1936.)

Advisory Committee: Dr. H. G. Denham (Chairman), Messrs. J. O. Boniface, C. E. Boon, J. Carr, G. Fleetwood, J. W. Hadfield, C. H. Hewlett, R. K. Ireland, C. C. Lange, R. J. Lyon, W. W. Mulholland, J. P. O'Connor, C. S. Sapsford, and P. R. Talbot. Director: Dr. F. W. Hilgendorf. Secretary: F. R. Callaghan.

STAFF.

During the past year the work of the Institute has progressed favourably in its more commodious buildings. In February Mr. H. E. West, Chief Chemist, who had much to do with the success of the Institute during its earlier stages, resigned his position to take up private work as technical adviser to a number of manufacturing firms. Mr. E. W. Hullett, Assistant Chemist, was appointed to take his place, and one additional assistant, Mr. Melville, at present at Yale University, has been appointed. Dr. Frankel, the Geneticist, spent a few months in England and on the Continent observing recent developments in genetics and plant-breeding.

The levies due by bakers are now to be collected by the Flour Section of the Government's Wheat Committee. The Committee also offers a donation of £300 a year on condition that an itinerant baker expert is appointed to go around bakehouses and advise bakers. The appointment of a baker expert is now pending.

WHEAT-BREEDING.

This work continues to increase in intensity, owing to the good organization of the Geneticist. The outstanding feature of the year has been the growing by about one hundred farmers of Cross 7—a new wheat produced jointly by Lincoln College and the Institute. It appears that Cross 7 will be a valuable addition to the wheats of New Zealand, and that it may largely replace Tuscan. Its qualities are detailed in the report of the research work of Lincoln College, to be found elsewhere in this report.

In addition to Cross 7, two other wheats have been selected as suitable for distribution. They are especially suited for spring-sowing. One is for use in Otago and Southland and the other for use in Canterbury. Both of these wheats give higher yields than others spring-sown and have higher baking scores. They are perhaps slightly weaker in the straw than Tuscan, but this is not likely to be very important in spring-sown crops.

In the plant-breeding plots the usual amount of work has been done; there are some 13,000 plots, and about 85,000 F_2 plants, each of which is examined separately. In the yield trials there were 288 lines tested against Tuscan or Hunters, and an extraordinary number of these—viz., 103—yielded better than or equal to Tuscan. Of these, it was found that the majority have satisfactory grain quality, as measured by baking, distensometer, and fermentation tests. Fifty-seven have to be grown again against Tuscan in fairly comprehensive yield trials. This will entail more work than we have ever undertaken before, and Lincoln College has been good enough to make more land available than has been the case in the past.

It is, of course, a hopeful sign that so many selections have outyielded Tuscan, because it increases the chance of an outstanding success.

LABORATORY WORK.

Routine Work.—The testing of wheats and flours, so as to allow millers to make the best use of the wheats available in New Zealand, has continued on a large scale. Towards the end of 1935 there was a lull in the demands in this direction, but with the new harvest there was an extraordinary influx of samples, owing to the very wet harvest and the abundance of wheat injured by sprouting. The flour-mill worked from 4 a.m. until 8 p.m. during February and March. The total trials for the period 1st January to the 31st May, 1936, are—Wheats milled and baked, 1,938; flours baked, 1,024: total bakings (including duplicates), 3,788. The millings include 305 done for the Plant-breeding Section of the Institute and the Department of Agriculture.

Sprouted Wheat.—The chief charactertistic of New Zealand wheats this year has been the prevalence of sprouted samples. In the baking test all sprouted lines have shown a great doughiness of the crumb of the loaf. The crumb refuses to bake, no matter how well baked the crust is. Very careful blending is necessary to make use of these sprouted wheats.

Starch Tests.—The progress of our research has shown that the baking test is not completely satisfactory as a measure of the quality of a wheat. It is not sufficiently analytical, in that it gives an end result and not the causes of that result. We have therefore spent some time in testing or devising other methods of estimating the qualities of a flour—*e.g.*, the Gottinger test, a straight gassing test in an apparatus devised by Mr. Hullett to give constant pressure to the gas evolved by the yeast during fermentation. Since sprouting injury is due to dextrinization of the starch, the amount of dextrinization is being measured in doughs kept at oven temperatures. A refractometer is being used, but a perfectly suitable instrument has not been available in New Zealand.

Gluten Tests.—These tests were concerned with starch changes, and have diverted our attention from what is usually the more urgent problem—viz., gluten quality. Arrangements have been made, however, to resume work on this matter. There is on order a farinograph costing £400, and a gluten washing machine for the Berliner, and Koopman test. It is hoped that these pieces of apparatus, with the gassing tests, will indicate the directions in which flours are weak and strong, and will therefore be of greater assistance in blending than the straight baking test has been.

Lemon-juice.—The work of Jorgensen in Denmark showed that vitamin C added to doughs has the same effect as bromate, probably in inhibiting the proteolytic enzymes that attack the gluten during fermentation. Since the use of bromate is prohibited in New Zealand this seemed to have an important bearing in our baking practice, and Mr. Hullett tried the effect of vitamin C on our breads, with good results. Since pure vitamin C is an expensive substance, Mr. Hullett then tried natural sources of the vitamin and found that lemon-juice in very small quantities made a marked improvement on the loaf, at a negligible cost. The use of lemon-juice in breadmaking is now adopted by several bakeries.

Wheatgrowing Practice.

Investigations have been continued into wheatgrowing practices with the object of cheapening production.

(1) The Government Statistician has been good enough to furnish, for the third year in succession, details of yields of wheat by counties and varieties. These details have been analysed, and information is being built up on the most productive varieties for the same districts.

(2) A questionnaire on wheatgrowing practices was sent out to young farmers' clubs, and useful information was obtained.

(3) A survey of wheatgrowing practice in the Ashburton County is being made by an honours student of Lincoln College. The survey is being guided by the Institute, and its results will be available for our records.

(4) For the third year in succession a trial of the effect of feeding-off wheat by sheep was made by Lincoln College and the Institute in conjunction. The results show either no increase or a diminution of yield consequent in feeding-off, so that one is now able to say that wheat should not be fed off except for some definite purpose—*e.g.*, to supply feed urgently required by sheep, or to prevent the wheat from lodging.

(5) Soil-moisture determinations during the growing season of the wheat have been made for the fourth year in succession with the object of correlating soil-moisture with wheat-yield. The results are promising.

(6) An experiment on soil-moisture and wheat-yield has been conducted for the third year in succession by growing wheat in plots with controlled soil-moisture. This season's results indicate very clearly that adequate soil-moisture in October is of the greatest importance, in January less important, and in the other months—September, November, December—quite unimportant within the limits to which our soil-moisture is ever likely to fall.

Co-operation with the Department of Agriculture.

The Department of Agriculture has continued to be of the greatest assistance to the Institute both 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 that should be conducted.

Phormium Research.

(REPORT OF WORK AT THE MASSEY AGRICULTURAL COLLEGE.)

(By Dr. J. S. Yeates.)

The past year has been an eventful one in this work in that operations have been extended to larger-scale planting. In May and June the planting of some 25 acres in the Easton area near Shannon was completed. The total area of land leased for this work is approximately 70 acres, and it is intended to plant the remainder when plants of the right types are available. The varieties now planted are mainly Ngaro, which covers about 20 acres. The remainder is made up of varieties S.S., No. 22, and No. 37.

The Easton area represents an attempt to overcome the most difficult stage in applying plant-breeding results—namely, the transition stage between the nursery and the commercial plantation.

By retaining control of selected plants until enough can be distributed to plant hundreds of acres, the risk of a good variety being dissipated and lost through small quantities being given to private owners will be minimized. In addition, by the use of due care, the rate of increase of the plants can probably be greatly hastened as compared with the best that private owners would do.

The Easton area will serve another purpose also. The planting and cultivation of phormium is a new branch of agriculture for which new methods of planting, cultivation, and harvesting must be evolved by large-scale experiment. Should it ever be considered feasible to establish a full-scale experimental and demonstrational plantation and mill, the Easton area will provide a valuable nucleus of both plants and experience. The area was chosen because it is conveniently situated right in the greatest flax-growing area of New Zealand. Removal of plants from the Easton area to any of the other flax areas in the district will therefore be comparatively easy whenever the question of extending the planted area arises. The plants at present set out should provide in three years' time enough to plant from 300 to 400 acres.

It was a most unfortunate year in which to carry out the transplanting. Floods in the Manawatu River in nine months were as frequent as in the whole of the previous nine years. The stop-bank surrounding the property was repeatedly broken, mainly because new earthwork had no time to consolidate between floods. The floods which poured through the broken banks washed many plants right off the property, and buried hundreds more under silt. The result has been a somewhat severe loss of plants, particularly of the Varieties S.S., No. 22, and No. 37. The remaining plants are, however, making excellent growth. The stop-bank has been well repaired, and the trouble is unlikely to recur.

College Flax Area.

The Ngaro which was removed to the Easton area gave an excellent yield of leaf—namely, 38 tons per acre—although it was cut very high to spare the roots for transplanting. The leaf yielded 1 ton of fibre from less than 6 tons of leaf, as compared with 9 tons which is usual at Foxton. The fibre was of excellent quality, and bales have been sent overseas for reports.

In the College area there are still several hundreds of mature plants of different varieties which have never been subjected to the crucial test of stripping at a flax-mill. The cutting, transport, and milling of these plants has been too expensive a matter to undertake hitherto, but it is hoped that the work will be carried out in the next month or two. Once the milling tests have been carried out many plants which are useless can be discarded and attention devoted to propagating as fast as possible those which prove satisfactory.

Hybrid Plants.

The growth of hybrids between the varieties Ngaro and S.S. has been very satisfactory. The best of these plants appear to have rather better growth than the better-growing parent and the superior fibre qualities of the other. Several thousands of these plants are being grown by private millers under an arrangement with us. This arrangement relieved us of the need for large areas of land, but in other respects it is not too satisfactory. More rapid and certain progress can be made in growing, testing, and propagating the plants when we control the whole of the operations.

During the past summer enough seed of this same cross was produced by hand cross-pollination to raise approximately 100,000 plants—enough for 100 acres.

Milling tests of one or two plants of another cross—Paretaniwha × S.S.—have given very gratifying results. Neither parent is a very tall plant, but many of the hybrids are. The fibre of the hybrids tested had not only good colour and strength, but was very fine and probably suited to textiles.

This character of fineness is one to which we have not hitherto given special attention, as our main aim in selecting varieties has been to secure strong, bold fibre for cordage purposes. It us now plain that industries such as the manufacture of woolpacks, sacks, and shop twines can use New Zealand hemp as raw material Fineness of fibre is a most important quality in these industries, and we are therefore devoting much attention to selecting varieties which possess this character.

Pedigree-plant Work.

The work of inbreeding good varieties in order to secure true-breeding types and to study the inheritance of important characters is proceeding as fast as the nature of the plant will allow. The fact that about six years is the approximate length of time between generations renders this work very slow. Some thirty seedlings of the Ngaro variety were inbred this year. The risk of cross-pollination makes it necessary in *Phormium* to use a somewhat roundabout and laborious method in this work. Some of the resulting seed was lost as a result of the hurricane on 2nd February.

Collection of New Varieties.

About twenty new varieties have been added to our collection during the year. The bulk of these were obtained from the East Coast and the eastern Bay of Plenty. A visit to those districts was made in early December in search of new material. Thanks to assistance given by Sir Apirana Ngata, it was possible to inspect most of the Phormium varieties growing there, and specimen plants were secured. Sources of supply of quantities of a good variety have been noted, in view of the possibility that this variety may be wanted for planting on a commercial scale.

New Zealand Woolpack and Textiles, Ltd.

In view of the importance of this industry to the flax-milling industry, very close contact has been maintained with the above company's works at Foxton. An appreciation of the problems involved in manufacturing fibres is a definite help in any endeavour to produce more suitable raw materials.

Chemical Examination of Phormium at the Dominion Laboratory.

A beginning was made during the year with the chemical investigation of Phormium fibre. Analyses have been made of the whole leaf (butt and blade) and of the fibre as well as of the isolated cellulose. Several samples of leaf of one variety of various ages are being examined to ascertain the degree of lignification with age. It is proposed to determine the physical properties of different varieties, including moisture content under varying conditions of humidity, and also the physical and chemical constants of the isolated cellulose, which will indicate the degree to which the cellulose has been degraded. Should any significant differences in the purity of the cellulose in Phormium varieties be disclosed, it would be of importance from the standpoint of selection. It might also explain variations in the resistance of the hemp to water.

General.

In connection with chemical investigations on Phormium being conducted at the Dominion Laboratory, samples of leaves of different ages and varieties have been collected and despatched to Wellington at intervals. Inspections and tests have been carried out on new processes for fibre-extraction.

A notable event to the fibre industry was the visit early in 1936 of an overseas expert, who has has a wide experience of textile-manufacture and of the fibre-producing countries throughout the world. Not only are the views of such a visitor on our own aims and methods extremely valuable, but through him it has also been possible to establish valuable overseas points of contact.

Thanks are due again this year to various flax-millers who have always co-operated heartily in our work, and to the donors of plants of special varieties.

MINERAL CONTENT OF PASTURES.

(EIGHTH ANNUAL REPORT OF THE MINERAL CONTENT OF PASTURES INVESTIGATION AT THE CAWTHRON INSTITUTE, PERIOD 1935–36.)

(By T. Rigg, Officer-in-Charge.)

During the past year the investigation of sheep-ailment at Glenhope, Nelson, and of lamb-ailment in Southland, has been continued. Dr. H. O. Askew has been in charge of the field work at Glenhope, and Dr. J. K. Dixon has been responsible for the conduct of the drench experiments at Morton Mains, Southland. Miss E. B. Kidson, M.Sc., has made an examination of the cobalt content of drench materials used in previous years in the experiments at Glenhope and at Morton Mains. In addition, a survey of the cobalt content of New Zealand soil types, particularly those affected with bush-sickness or stock-ailment, has been commenced.

The field experiments have been marked by outstanding results both at Glenhope and at Morton Mains, in that cobalt chloride at the rate of 1 mg. cobalt (Co) per day has proved completely successful in preventing the appearance of ailment and in curing affected sheep.

Glenhope Investigations.

In previous reports mention has been made of the great value of Nelson soil in overcoming bush sickness at Glenhope. It has been shown that a drench of Nelson soil suspension in water was completely effective over a period of two years in preventing the incidence of Glenhope bush sickness. Furthermore, an acid extract of the Nelson soil containing but a small quantity of iron was shown to be as effective in the prevention of ailment as the soil suspension. The result of this experiment gave confirmatory evidence that in the case of Glenhope bush sickness factors other than iron operate in overcoming the ailment.

The publication by Australian workers of the results of their experiments in which cobalt proved of great value in overcoming "coast" disease in South Australia and enzootic marasmus in Western Australia, suggested the advisability of definitely testing the value of cobalt both at Glenhope and at Morton Mains, in the prevention and cure of the sheep-ailments. It was known that the Nelson soil which had proved so successful in previous years contained both cobalt and nickel in good supply, suggesting thereby that the presence of one or both of these minor elements might be responsible for the good effects which had been secured from the use of Nelson soil.

Drench Experiments.

Three groups of sheep affected more or less seriously with bush sickness were therefore arranged so that each group was similar in average live-weight and in the number of sheep suffering acutely from ailment. One group served as a control, receiving no drench treatment. A second group received a nickel salt supplying 8 mg. of nickel (Ni) per week. The third group received a drench of cobalt chloride, each sheep receiving the equivalent of 8 mg. of cobalt (Co) per week. In Table I are presented the average live-weights in pounds per sheep for the three groups covering the whole period of the test.

TABLE I.—GLENHOPE BUSH SICKNESS: DRENCH EXPERIMENT (1935–36).
(Average live-weights in pounds.)

Date.	Control Group.	Nickel Group.	Cobalt Group.
14th September	69·4	64·6	66·0
22nd September	65·8	63·4	67·0
7th October	64·8	62·4	69·4
24th October	56·2	63·5	75·8
13th November	53·0	63·2	78·6
11th December	50·7	59·0	85·6
12th January	65·0	74·0	97·2
14th February	66·5	75·5	99·5
13th March	66·5	77·5	103·0
15th April	59·0	73·5	104·2

NOTE.—Dose of cobalt and nickel = 8 mg. per week of cobalt or nickel respectively.

In the control group, three sheep died during the season and the weights of the remaining sheep fell off, the sheep becoming badly affected with bush sickness. In the nickel group one sheep died, the remainder making slow gains in weight. At the conclusion of the season some sheep in the nickel group were definitely affected with ailment. In the cobalt group a marked improvement was quickly apparent as a result of the cobalt drenching, and rapid gains in weight were made. Two sheep in this group, which at the commencement of the test were badly affected with bush sickness, improved wonderfully in appearance, although in one case the final weight was considerably below that of the other sheep in the group. The sheep drenched with cobalt made an average gain of 38 lb. during the season, compared with a gain of 9 lb. per head with the nickel drench, and a loss of over 10 lb. per head in the case of the surviving sheep in the control group.

COBALT CONTENT OF DRENCH MATERIALS.

The wonderful result secured with cobalt chloride in the Glenhope experiment suggested that this element was the potent one in connection with the successful use, in former years, of other drench materials such as Nelson soil and Whangarei limonite (Reyburn's). An examination of the cobalt contents of drench materials showed that this was the case. In Table II the cobalt content of different drench materials is shown.

TABLE II.—COBALT CONTENT OF DRENCH MATERIALS USED AT GLENHOPE.

Classification.	Substance.	Cobalt Content (Co.).
		Parts per Million.
Group I (completely successful)	Nelson soil	43
	Acid extract of Nelson soil ..	17·5
	Limonite, Whangarei (Reyburn) ..	55
Group II (beneficial but not effective in prevention of ailment)	Ferric ammonium citrate ..	24
	Nelson soil after extraction ..	24·5
	Wakatu soil	7·5
Group III (not satisfactory)	Limonite Parapara	8·0
	Limonite Onekaka	12·5
	Limonite Whangarei (Crawford) ..	2·0

The data presented in Table II show quite definitely that those materials which have proved effective, such as Nelson soil and Reyburn's limonite, contained 43 and 55 parts of cobalt per million. Materials such as Parapara, Onekaka, and Crawford's limonites contained comparatively small amounts of cobalt, and these materials were found unsatisfactory in the experiments of previous years. It is interesting to note that certain drenches which proved beneficial, but not effective in preventing the incidence of ailment, contained moderate amounts of cobalt.

The analytical data shown in Table III confirm the results obtained with cobalt drenches during the present season, and definitely indicate that cobalt is the potent element in overcoming bush sickness at Glenhope.

MORTON MAINS EXPERIMENTS.

In a previous report mention has been made of the beneficial properties of both Nelson and Bluff soils in overcoming lamb ailment in Southland. With a view to ascertaining the potent element contained in these soils, a hydrochloric-acid extract was made of the Bluff soil, and this extract was then separated into groups of elements as is customary in qualitative analyses. Drenches of Bluff soil and of acid extracts representing different groups of elements were used in the experiments of the past season at Morton Mains. In addition, it was thought desirable to include a straight-out test of cobalt chloride by itself. A flock of 100 lambs was employed in the main experiments. Ten groups, each containing ten lambs, were arranged so that the average live-weight was approximately the same for each group. Drench treatments were given twice a week, the lambs being weighed every fortnight.

Table III shows the live-weight increases for a selected number of the drench treatments.

TABLE III.—EFFECT OF COBALT AND OTHER DRENCHES ON LIVE-WEIGHT INCREASES, MORTON MAINS, SOUTHLAND.
(Average pounds increase per sheep.)

Date.	Control.	Cobalt.	Bluff Soil Suspension.	Bluff Soil Acid Extract (1).	Bluff Soil Acid Extract (2).
19th December, 1935	5·75	6·95	5·45	6·50	5·75
2nd January, 1936	9·75	16·35	12·30	13·50	12·35
16th January, 1936	14·80	22·40	17·35	19·10	18·40
30th January, 1936	15·85	26·00	21·70	21·65	20·20
13th February, 1936	16·25	27·40	21·90	22·65	22·90
27th February, 1936	16·50	29·50	24·70	24·70	27·45
13th March, 1936	17·05	30·55	25·35	27·30	27·95
26th March, 1936	19·15	35·95	29·15	33·10	34·15
9th April, 1936	19·65	37·00	29·55	34·20	34·65

Control = no drench.
Cobalt drench = two doses per week each of 4 mg. cobalt (Co).
Bluff soil suspension = two doses per week each of 100 c.c. soil suspension.
Bluff soil extract (1) = two doses per week each of 50 c.c. of a hydrochloric-acid extract of the soil.
Bluff soil extract (2) = two doses per week each of 50 c.c. of a hydrochloric-acid extract of Bluff soil, freed from iron and organic matter.

The increases in live-weights for the control group show that during the past season climatic conditions were not so favourable for the development of the ailment. The control sheep gained during the period of the test an average weight of 19·6 lb. per head. The cobalt group, on the other hand, gained 37 lb. per head during the same period. The Bluff soil suspension, and the two acid extracts of Bluff soil, while not giving such spectacular increases in the early part of the season as was the case with the cobalt drench, yet showed steady gains, and at the conclusion of the season were only slightly inferior to the lambs of the cobalt group. The results obtained with the acid extract of Bluff soil, from which iron and organic matter was removed, indicate clearly that iron is not the potent element in connection with the ailment at Morton Mains, Southland. The results from other drenches not tabulated in this report indicated clearly that as long as the acid extract contained cobalt successful results were obtained. Where cobalt was removed from the acid extract failure in effectiveness resulted.

Supplementary experiments later in the season conducted on lambs which were obviously affected with ailment showed likewise a rapid improvement in condition as soon as cobalt was supplied in drench form.

Analytical data in regard to the cobalt content of drench materials used at Morton Mains, both in the experiments of the past and previous seasons, confirm the association of comparatively high cobalt content with effectiveness of the drench materials in overcoming lamb ailment at Morton Mains.

It can therefore be said that the experiments of the past season at Morton Mains have demonstrated very definitely that minute doses of cobalt are completely effective, both as a preventive and a cure of lamb ailment.

DOSE OF COBALT FOR SOUTHLAND AILMENT.

One of the striking features of the drench experiments was the exceedingly small supplement of cobalt which has been required during the past season to overcome the incidence of the ailment. In the case of the Bluff soil extract the weekly dose was as low as 0·4 mg. cobalt (Co). A drench supplying as small a quantity as 0·29 mg. cobalt per week was effective in improving stock health, but drenches supplying less than this amount per week showed inferior results. Although no statement can be made concerning the optimum amount of cobalt which is required in an average season to overcome ailment, the data which have been obtained suggest that the amount required will not be less than 0·4 mg. cobalt per week.

COBALT SURVEY OF NEW ZEALAND SOILS.

The spectacular results obtained in the drench experiments at Glenhope and at Morton Mains suggested the desirability of a survey of cobalt in New Zealand soils, fertilizers, and drench materials, and this work has been put in hand.

In the case of drench materials the analytical data have shown that all substances which have proved effective at Glenhope and Morton Mains contain comparatively large amounts of cobalt. Materials which have not proved successful contain comparatively low amounts.

The survey of cobalt in New Zealand soils has not proceeded far enough for any definite statement to be made concerning the value of the analytical work in demarcating areas where cobalt supplements are required. Concentrated hydrochloric acid has been used for the extraction of soils. In this extract the amount of cobalt for bush-sick soils of the North Island has been found to be lower than two parts per million. In the case of the Glenhope soil the amount was 0·4 parts per million.

Certain areas of New Zealand are associated with comparatively high cobalt content of soils. In Taranaki soils amounts varying between 9 and 13 parts per million have been found. The clay soils at Hamilton likewise contain high amounts of cobalt, the figures varying from 12 to 22 parts per million.

Although the low cobalt content of bush-sick soils of the North Island indicates the desirability of testing the value of cobalt supplements, it must be stated that certain other soils which so far have been regarded as being free from bush sickness likewise have a low cobalt content. At the present time no statement concerning these anomalies can be made. It seems possible, however, that availability of cobalt in the soil may be an important factor, and that the use of more dilute acids for the extraction of cobalt may give a clearer picture of the cobalt status of New Zealand soils.

PAKIHI SOILS RESEARCH.

(EIGHTH ANNUAL REPORT OF THE PAKIHI INVESTIGATIONS CONDUCTED BY THE CAWTHRON INSTITUTE, PERIOD 1935–36.)

(By T. Rigg, Officer in Charge.)

Introduction.

The past year has been marked by a great forward move in the reclamation of pakihi land at Westport. Impressed by the successful pasture establishment of a 25-acre block sown down by the Institute at Sergeant's Hill, the Unemployment Board and the Lands Department agreed to facilitate the reclamation of a block of 210 acres of pakihi land known as the Buller Domain.

At the conclusion of pasture establishment on the Buller Domain, reclamation was further extended to an adjoining block (Archer's) of 240 acres, and a commencement was made with ditching and drainage operations with a view to the sowing down of this second area next season.

The conduct of reclamation work on such a large scale has involved the appointment of Mr. C. Lemon as full-time overseer in charge of the unemployed men who have been engaged for the work. At the request of the Unemployment Board and the Lands Department, Mr. T. Rigg, of the Cawthron Institute, has acted as advisory officer in general charge of the developmental work, and Mr. A. F. Waters, Commissioner of Crown Lands, has been made responsible for the purchase of supplies and materials. In addition to the conduct of developmental work, the usual attention has been paid to the maintenance of the small-plot tests in connection with pasture establishment, culture of *phormium tenax*, hedge plants, and shelter-trees.

Reclamation of Buller Domain.

Proposals for the reclamation of the Buller Domain block were submitted by the Cawthron Institute to the Under-Secretary for Lands and the Commissioner for Unemployment in August, 1935. These proposals were approved, and a commencement was made with the work early in September. The operations were greatly facilitated as a result of a detailed survey of the block made by the Institute prior to the commencement of the reclamation scheme. This survey showed that the Buller Domain is fairly typical of the 25-acre farm already grassed by the Institute, and that equal success could be obtained in connection with the handling of the whole block.

In view of the number of unemployed requiring work at Westport, it was decided to utilize unemployed labour to the fullest possible extent. Owing to wet weather, so prevalent in a district of high rainfall, and inexperience of the men, costs have been higher than those submitted by the Institute in connection with its pasture establishment. During the course of the work some 300 chains of open ditches have been dug, and stream courses have been straightened to secure a rapid run-off of surface water. In order to facilitate the distribution of fertilizers, a dirt road of 17 chains was made in the centre of the block by removing soil and subsoil to the pan-level. The whole block has been fenced with a five-wire fence, involving in all 130 chains of fencing.

The liming of the block was a big undertaking, as it involved the distribution of over 240 tons of ground limestone. This work was done almost entirely by hand operation owing to our desire to give as much employment to the men as possible, and owing to the difficulty in securing suitable lime-distributors for work on the somewhat irregular and wet surface of the pakihis. Despite the large quantity of ground limestone required, liming was completed by the end of December, 1935, and a start was made with the top-dressing of superphosphate. Superphosphate was applied at the rate of 5 cwt. per acre, and such good progress was made that this work was completed early in February.

After burning of the pakihi rush, and cutting tea-tree where it was not required for shelter purposes, the sowing of a grass and clover mixture was commenced towards the end of February. The sowings were continued during the first three weeks in March, whenever favourable weather was experienced. Owing to dry weather at certain periods in March, germination of the seed was delayed. Early in April good rains fell, and very fair germination was obtained over the greater part of the area. Certain portions of the block are extremely good, but others where the surface was dry have not so far shown to advantage. Considering the large scale of the developmental work, it is thought that the pasture establishment will be very satisfactory.

During the coming winter, arrangements will be made for the subdivision of the Domain area and for the planting of shelter trees and shrubs. Grazing will not be commenced until early summer, enabling thereby a satisfactory cover to be obtained before the introduction of stock.

Small-farm Trial.

The 25-acre block sown down by the Institute in 1932–33 has continued to give very satisfactory results. As indicated in previous reports, annual top-dessing with superphosphate at the rate of 2 cwt. per acre is most important in the maintenance of the pastures. This treatment was therefore carried out in the early spring. In addition, 11 acres sown down in 1932 were limed at the rate of ½ ton of ground limestone per acre. For hay, a mixture containing 2 cwt. of superphosphate 1 cwt. of muriate of potash, and 1 cwt. of ammonium sulphate per acre was employed, and has given excellent results. The block of 24 acres has been grazed with young stock, many of which have been on the block since weaning. In the 1934 season data show that the 24-acre block carried an average of fourteen head of young stock over the whole year. In the 1935 season the pastures were not grazed so hard and more provision was made for hay, which will be required for winter use. An average of ten and a half head of young stock was carried for the whole year. In addition 11 tons of hay were harvested. The stock have continued in splendid condition, and some of the heifers took prizes at the Agricultural and Pastoral show at Westport. The hay crop was an excellent one, averaging over 2½ tons of hay per acre.

Small Plot Tests.

These plots continue to provide valuable information concerning the treatment of pakihi land for pasture and for the growth of *Phormium tenax*, trees and shrubs. The pasture plots under the treatment now recommended by the Institute have maintained their production in a remarkable way, and show no signs of deterioration. The plots of *Phormium tenax* emphasize the great importance of phosphates in the growth of this plant on pakihi soil. Without this plant-food the growth is quite unsatisfactory, being little better than that on the untreated plots. The best result with flax has been secured by the use of lime and a complete manure.

In connection with trees and shrubs the small plots indicate that *Eucalyptus globulus* and *rostrata* should do moderately well, provided manurial treatment is given. It would appear that the introduction of rather liberal quantities of phosphate is just as important in the treatment of trees and shrubs as it is in connection with pasture establishment. In the plantings of the coming winter basic slag will be used in all the holes prior to planting.

General.

The reclamation work at Westport is now attracting a great deal of attention, and many visitors have been received seeking for information concerning the treatment of pakihi lands for pasture establishment.

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.

During the past year the Director went abroad to make contacts and exchange views with tanners and research workers in other countries.

The importance of a good supply of well-flayed, well-cured hides and skins was clearly demonstrated in Canada and the United States of America, which are large buyers of New Zealand's surplus of hides and sheep-skins. In the past the standards of quality of the New Zealand product, especially in regard to flaying and curing, have not been as high as those in some other hide and skin producing countries, and the time has arrived when greater efforts should be made towards improving the quality of this valuable export commodity. The proposed regulations for the export of hides, based on the accepted standards overseas, are a step in this direction.

While Canadian and American methods of tanning are somewhat different from those used in New Zealand, the same general principle was followed—namely, that careful attention to detail in every process is essential for the production of a good article; uniformity of quality demands uniformity in methods of production.

As a result of the visit to North America, a much wider outlook on the manufacture of leather was developed. In these regions climatic and economic conditions demand a specific type of leather. Mass-production methods were more fully understood and appreciated.

The importance of research work in Great Britain is reflected in the various activities of the Trade Research Associations. Co-operative research is to some extent being carried out through co-ordination of the activities of the different Trade Research Associations. The advantage resulting not only from the formation of Research Associations, but also from the co-ordination of the efforts of several of these associations is worthy of the consideration of the manufacturers of New Zealand.

The practice of overseas firms of providing a system of service for the goods they sell is growing extensively. Men with expert practical knowledge of the use of particular materials are available to the manufacturer when new processes are being installed or when some difficulty has arisen. This is only available to a limited extent in New Zealand. The information derived from contacts with men of this type is of the highest value. New methods of using new and old materials were discussed, and valuable information was obtained.

The manufacture of leather is a combination of physical and chemical processes. The physical processes are to a large extent carried out by machinery, and an investigation of modern methods of tanning must take the mechanical aspects into consideration. Advantage was therefore taken of the opportunity of seeing all the latest types of machines in operation, and of meeting the manufacturers of leather-producing machinery.

The requests from British tanners to visit the factories for exchange of ideas and experience indicated the value placed on co-operative effort.

While the results of the trip have had immediate value, the effects of a broader outlook and new conceptions of the problems confronting the tanner will become more evident as opportunities present themselves.

Action of Perspiration on Leather.

An investigation of the rotting action of perspiration on vegetable-tanned leather was carried out during the year. The conclusion was reached that probably one of the causes of rotting of leather by perspiration is the action of ammonia, found directly or indirectly in perspiration, in reducing the acidity of the leather and thus allowing oxidation of both tanning material and hide to take place more quickly.

Regulations for the Export of Hides.

Serious complaints from overseas and local tanners have been made and substantiated regarding the standard of quality of New Zealand hides. In conjunction with the Departments of Agriculture and Industries and Commerce a proposed set of regulations for the export of hides based on standards of quality in the hide-producing countries has been drawn up for consideration.

Quality of Sole-leather.

During recent years many efforts have been made to correlate chemical analysis with the so-called quality of sole-leather. Quality in sole-leather as estimated at present is merely an expression of opinion, and no reasonably quick method exists of checking these opinions with actual performance in ordinary wear. Consequently the failure to correlate chemical analysis with varying opinions is not surprising. In addition, one important item of the official chemical analysis—*i.e.*, water-solubles—is based on an empirical test, which, owing to its nature, is unsatisfactory. The preliminary work on the true estimation of water-solubles has opened up a wide sphere of investigation which will, it is hoped, throw some light on the functions of the water-soluble content of sole-leather in its relation to the essential quality—*i.e.*, wearing-value.

General.

The usual routine work of the laboratory dealing with current works problems was efficiently carried out by the Assistant Research Chemist during the absence of the Director.

Pelt Research.

The value of sustained and co-operative research on industrial problems is very well illustrated by the results achieved by the Pelt Research Association. Each year has been marked by definite progress, and the total result was expressed at a Joint Leather Conference held in Leeds in February, 1936: "The speaker, a practical sheep-skin tanner, pleaded for a closer co-operation between fellmonger and tanner, and gave as an example of what co-operation would do the successful issue of the work done by the New Zealand Government Pelt Committee. The occurrence of 'mottle' and 'leopard grain' would now be reduced, and these faults had been so bad at one time that several tanners had in the past refused to handle New Zealand pelts. Fortunately these troubles had been solved and the work brought to a very satisfactory conclusion." (Leather Trades Review, 18/3/36.) In addition, the following resolution was passed at a meeting of the New Zealand London Pelt Committee: "That the Committee is of the opinion that the research on New Zealand pelt problems carried out in New Zealand and the United Kingdom has resulted in a marked reduction in defects due to processing, and therefore urges that every effort should be made to enlist the energetic support of all freezing companies in New Zealand to enable the effective investigation of pelt problems to be carried out."

The effect of this increase in the quality of some New Zealand pelts has been to divert them, at higher prices, into special lines of leather for which hitherto they were considered unsuitable. The following quotation is made from a recent English trade circular: "The unusual relation between prices realized for Canterbury and North Island lambs is due to the fact that the former are not so suitable for the special gloving demand in this country as the latter. United States of America buyers have operated sparingly, and many of them regard present prices of North Island lambs as beyond their reach." A few years ago a flat rate more or less ruled throughout New Zealand, when all pelts, irrespective of quality, were made into the lower quality types of leather.

These results have been obtained by close co-operation, during the past five years, of certain freezing-works, tanners overseas, Research Associations in Great Britain and New Zealand, co-ordinated by the efforts of the Department's liaison officer in London.

Deliming.

During the year the investigation on the best conditions of deliming has been continued, and the beneficial results obtained in the works have confirmed laboratory experience.

Storage of Pelts.

The conditions affecting the effectiveness of the pickling while the pelts are stored in wooden casks has been investigated, and suggestions have been made to prevent the growth of mould which sometimes occurs on pelts in contact with the wood.

Seasonal Variation in Pelts.

Difficulties have been experienced in past years in connection with experimental trial shipments of pelts. These were possibly due to the inherent variation in the quality of the skins and to the consequent impossibility of obtaining comparable material for the tests. It was considered at the time that these inherent difficulties would be overcome by the large number of skins in the trial. This was not confirmed in practice, and the conclusion that seasonal variations in the quality had to be investigated was made. This work has been carried out over a period of some months both in the laboratory and in the works. The laboratory results obtained so far are very striking, and show how the quality of the skin is to a large extent determined by climatic conditions in their effect on glandular growth necessary to control body temperature. A shipment of skins is being arranged to demonstrate the effect of these changes on the leather produced from skins taken at monthly intervals during the season.

Grateful acknowledgment is made of the continuance of the grant instituted by the Empire Marketing Board and the grant from the New Zealand Meat-producers Board during the past year. Without these grants the results obtained would have been more restricted.

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, Dr. G. H. Cunningham, W. M. Hamilton (Secretary).

General.

The Fruit Research programme has continued as a co-ordinated activity, the participating bodies being Plant Research Station, Cawthron Institute, Horticulture Division of the Department of Agriculture, and the Department of Scientific and Industrial Research. The Dominion Laboratory, Soil Survey Division, and the Meteorological Office have also undertaken investigations associated with fruit research.

Overseas co-operation has also been effected with the Low Temperature Research Station, the Imperial Bureau of Fruit Production, the East Malling Fruit Research Station, and with the Australian Council of Scientific and Industrial Research.

The Fruit Cold Storage Committee has continued to deal with all problems affecting the handling, storage, and transport of fruit. The Fruit Research Workers' Committee has met periodically to consider details of the investigations inaugurated and to examine the progress made in each.

The field work connected with the investigations 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 attached to the Plant Research Station, Palmerston North; (4) the Hawke's Bay Fruitgrowers' Association experimental orchard, Havelock North; and (5) in a series of selected orchards distributed through the various fruitgrowing districts of the Dominion.

The work has been greatly facilitated by the ready assistance rendered on numerous occasions by the New Zealand Fruit-export Control Board, the New Zealand Fruitgrowers' Federation, and the shipping companies operating in New Zealand waters.

1. 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, blossom, &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.

Owing to heavy incidence of black spot and eye-rot, the early promise of a heavy crop for export was not fulfilled, only 6,826 cases being available for shipment. This is, however, markedly heavier than the export of 3,134 cases for the 1935 season, which was the year of light crops, but falls far short of the record shipment of 10,333 cases in 1934. It is proposed that the problem of biennial bearing should now be made the subject of research because of the importance it has in regard to marketing and also wastage and deterioration in fruit quality during the "off" years.

Because excessive rainfall experienced during October and November made effective spraying difficult, black spot was more prevalent than has been the case during the past five years. Notwithstanding additional applications of spray, the infection continued to increase throughout the season, and, particularly in the case of Dunn's, Sturmers, and Delicious, resulted in the loss of much fruit. Eye-rot (*Botrytis*) was fairly prevalent in Jonathans and to a lesser extent in Cox's and Delicious, and was responsible for the rejection of much fruit when grading for export. Leaf-roller caterpillar was prevalent in Jonathan and Sturmers, particularly in heavily-laden and dense trees and in the test areas on which the fruit was all retained unthinned for recording purposes. Cox's, Delicious, and Jonathan varieties, in common with other orchards in the district, suffered to some extent from russeting. Woolly aphis was fairly prevalent, particularly on Cox's and Dunn's, but during February and March *Aphelinis mali* multiplied considerably and exerted a restraining influence on the pest.

Owing to the large amount of unexportable fruit depressing prices to unpayable levels on the Dominion markets, a considerable quantity of reject fruit was donated to charitable institutions and the mental hospital.

Manurial Experiments.

The outstanding feature of the 1935 season's results has been the yield increases that have followed the application of so-called "complete" fertilizer mixtures in the case of the main Sturmer block. The block receiving a "complete" dressing of phosphate, potash, and nitrogen showed a highly significant increase in yield of 77 per cent. over the unmanured plot, while the plots receiving phosphate and nitrogen in combination have also shown significant crop increases. These trees have also maintained a healthy and vigorous growth, while those on the unmanured plots or those receiving phosphate alone are falling off in condition. The trees receiving nitrogen alone are intermediate in condition.

In both Cox's and Delicious the plots that are in receipt of nitrogen have shown considerable crop increases, but on account of the variability of the trees they have not yet passed the limits of experimental error.

The heavy potash treatment has not affected the colouring of any of the varieties, but appears to have increased the size of the individual fruits in both Jonathan and Sturmer. Any effect that there may have been in Cox's was masked by the differences existent in crops of individual trees on the various plots.

During the 1935–36 season the effects shown were, in general, very similar to those recorded for the previous year, except that in most instances the advantage of potash inclusion in the treatment is not apparent to the eye. This, however, cannot be interpreted as due to ineffectiveness of the potash treatments, as several disturbing factors have been contributory. All trees were invigorated by the heavy pruning and thinning-out of limbs, while during pruning limbs showing die-back were removed in preference to healthy wood on trees showing this disorder. The abnormally heavy and well-distributed rainfall throughout the growing period has also probably enabled the trees to utilize to the full any plant-food reserves in the soil. As a result, plots treated with nitrogen alone appear to be little if at all inferior in vigour and condition to those receiving phosphate, or potash and phosphate, in addition. At the same time, however, the contrast between trees receiving nitrogen and those receiving no nitrogen is more marked than ever.

The uniform system of pruning adopted in the past over all the treatments led to considerable congestion of leaders, subsidiary wood and yearling growths on all trees receiving nitrogen actually reducing their useful cropping-capacity. In order to permit the retention of fruiting-wood, improve the colouring of the fruit, and facilitate spraying and other operations, a pruning system modified to suit the requirements of individual trees has been adopted and a photographic record kept of the type of pruning adopted on trees of varying vigour in the several varieties.

In the iron, manganese, and hydrated-lime test on Jonathans, every tree that has received manganese is showing to a greater or lesser extent an apparent toxic effect, manifested as a severe bark-canker on one or more branches, and affecting wood of all ages right up to the current season's growth. The treatment is being discontinued, and the result will be followed up to ascertain, if possible, the cause of the trouble.

Cold-storage Trials of Fruit from Manurial Plots.

(*a*) In fruit from Jonathan Block E, 2 lb. and 4 lb. ammonium-sulphate treatments have again given progressive increases in breakdown compared with no application, contrasting with the result in the 1934 (heavy-crop) season when breakdown was almost completely absent from all three lines.

(*b*) In Dunn's similar rates of application of nitrogen have not increased breakdown susceptibility this season. As far as breakdown is concerned there has apparently been a fairly complete recovery from the initial disturbance by the nitrogen treatments.

(*c*) There was, however, an appreciable incidence of deep scald in long storage this season, and it showed an increase proportional to the amount of nitrogen applied. Fortunately this trouble is extremely rare in Dunn's, and, in contrast to its incidence in Jonathan, does not appear till late in the storage season, so is not of significance in commercial practice.

(*d*) Nitrogen treatment increased the susceptibility of the Jonathan to deep scald under low-temperature storage conditions, and heavy potash treatment gave rise to a most striking increase in scald incidence. At the moment it is not suggested that these are direct effects, as it is quite possible that they are due to disturbances of maturity. This point is being further investigated.

(*e*) In Delicious, manurial treatments again do not appear to have had any bearing on storage quality.

(*f*) In the case of Sturmer, it appears that nitrogen by itself has again shown a tendency to increase breakdown susceptibility on long storage.

(*g*) No significant differences in storage characteristics can be recorded for the heavy potash experiment of Cox's Block 1, nor in the case of the main block of Cox's.

(*h*) A comparison of the storage qualities of the three commercial grades of Cox's has given very significant evidence on the association of breakdown and water-core in this variety.

Pruning-experiments.

Under the auspices of the Horticulture Division a series of pruning-experiments have been laid down on Cox's Orange, Sturmer, and Dunn's varieties, comprising heavy, medium, and light pruning. Tree-measurements and crop-weights are being recorded.

Nursery Stock.

The fruit-trees in the nursery have been lifted and ninety-six trees selected from the M. 1, M. 12, M. 15, and Northern Spy stocks for testing purposes, the varieties selected being Cox's, Jonathan, Delicious, and Granny Smith. These have been planted out on a new area at the orchard, giving six replications of each variety on each individual stock, trees of the Delicious variety being used to fill in the surrounding spaces. In all, about 125 trees have been added to the total of the orchard.

Grafting-experiments.

Five Statesman trees have been grafted over to the Cox's variety, four on the refurnishing-system with a multiplicity of scions and one on the orthodox method low down as a check tree.

Six Sturmer trees have been reworked to Hawke's Bay Red Delicious and Richared Delicious strain from U.S.A. These, when producing fruit, should be of interest to compare with the general strain of Delicious in the orchard.

To test the efficacy of in-arching in imparting additional vigour to Sturmer trees, East Malling stocks M. 1 and M. 12 have been in-arched on six trees using respectively 2, 3, and 4 scions to the tree. In the course of four or five years these should indicate whether or not the method is likely to be of benefit under local conditions.

Improvements.

Owing to decreasing pressure in the spray pipe-lines approximately 1,600 ft. of ½ in. piping has been replaced by ¾ in. pipe, and has resulted in facilitating the spraying with increased efficiency. The fencing of the orchard to exclude rabbits and hares has been completed.

2. Botanical Investigations.

Stocks.—(*a*) Apples: A further block of approximately 1 acre at the Plant Research Station has been planted with 119 trees received from the Research Orchard, Nelson. These consist of the varieties Cox's, Delicious, Jonathan, and Sturmer on Northern Spy and East Malling stocks.

Growth records of the trial blocks of apple-trees on several East Malling stocks and the Northern Spy stock which were established nearly three years ago indicate that with one exception the East Malling stocks are, up to the present time, superior in vigour to the Northern Spy. Obviously, until the trees reach bearing-age rootstock influence can be judged only from the aspect of vigour. Other equally important factors such as influence on cropping and on the quality and colour of the fruit will be investigated when the trees commence to crop.

Trees of Cox's, Delicious, Gravenstein, Jonathan, Sturmer, and Red Statesmen have been raised on their own roots, and will be used for comparison with trees of the same variety growing on East Malling and Northern Spy stocks.

(*b*) Peaches: So far there appears to be little difference between trees on the three stocks being tested, although Brompton seems slightly superior. The plum stock seems to have a dwarfing influence on the peach.

(*c*) Plum and cherry: Additional material from East Malling has been propagated and budded to furnish material for trials.

"*Strain*" *Investigations.*—The varieties now being investigated for possible strains comprise Cox's, Sturmer, Delicious, Jonathan, and Granny Smith. Fruit of the three first-named varieties should be available for study next summer. It is hoped that among the many strains of Delicious now under trial a type may be discovered having a closed calycine sinus and consequently less susceptible to "mouldy core." Four red strains of Cox's and twelve red strains of Delicious are under trial.

Root-wounding Experiment.—During 1932 an experiment was laid down at the Research orchard, Nelson, to ascertain whether the development of fibrous roots by apple-trees on Northern Spy stock could be increased by mechanical injury to the roots, and, if so, whether such treatment resulted in increased vigour to the trees. Three trees each of the varieties Statesman and Dunn's were selected and treated with (1) open scalloped incisions, (2) notches, and (3) tongue clefts. It was found after three years that in no case had there been any development of fibrous roots at or in the region of the wounds made. It would appear that wounding of roots in the manner described is of no benefit to trees so treated.

Walnuts.—Twenty trees of the varieties Wilson's Wonder, Franquette, Freshford Gem, and Kelvin have been planted at the Station. With the exception of Kelvin these varieties are reputed to be resistant to bacterial blight (*Pseudomonas judlandis*).

Filberts.—Trees of *Corylus maxima* do not appear to be thriving, except in the Auckland District.

3. Entomology.

Woolly Aphis.—An estimation of the amount of parasitism throughout the season by *Aphelinus* has been made from material forwarded by Orchard Instructors. The factors influencing the fluctuations in populations of aphis and *Aphelinus* are complex, and little progress can be made in the elucidation of this matter without more precise work on the reactions of both insects to climatic conditions. Preliminary experiments showed that the use of winter oils may materially reduce the overwintering population of *Aphelinus* but would probably reduce the aphis population to a proportionately greater extent.

Pear Midge.—Routine estimations of parasitism by *Misocyclops* showed that about 10 per cent. of the first-brood larvæ were parasitized at Auckland. As in the previous season, there was no evidence of parasitism of first-brood larvæ in Nelson. In Hastings the parasite was present but parasitized only 1 per cent. of the first-brood larvæ.

Leaf-roller Caterpillar.—Field work has been carried out in Central Otago during the past season, using bait traps. The results of catches confirm the results of rearings of leaf-roller larvæ taken from damaged fruit. These indicate that *Tortrix excessana* is the numerically dominant species. Of sixty-two adults reared from several localities and different fruits, 82 per cent. were *T. excessana* and 12 per cent. were *Ctenopseustis obliquana*. *T. excessana* is a native species with a wide range of food-plants. It normally overwinters as a larva on evergreens, and has at least two and probably three broods during the year, fruit-trees being subject to infection as soon as they come into leaf. At present the most promising method of control is the development of a stomach poison, arsenical or non-arsenical, which does not injure the leaves.

Leaf-hopper.—A shipment of 1,250 cocoons of the Dryinid parasite *Aphelopus typhlocybae* were received from the New York Agricultural Experiment Station in November, and a total of 370 adults emerged. Of these, 240 were liberated in the field and the remainder used in the laboratory to ascertain whether the parasite could develop successfully on the leaf-hopper. A number completed development on the hopper and spun their cocoons in the soil, proving that there was no inherent inability of the parasite to develop on *Typhlocyba froggatti* (Baker). It is hoped to secure a further supply of material during the coming season.

Black-currant Pests.—Two pests of black currant which do not appear to have been previously reported are recorded. These are an eelworm, *Aphelenchoides ribes* (Taylor), which causes bud-disease, and the mite *Eriophyes ribes* which causes " big bud " of black currants.

Red Scale of Citrus.—Following an inquiry from the Auckland Citrus Growers' Association an attempt was made to introduce from Australia the coccinellid predator *Lindorus lophanthae*, which has proved to be useful in California. The adult beetles sent were all dead on arrival, and arrangements are now in progress for supplies to be forwarded from California.

4. Mycology.

Mouldy Core.—Work has continued throughout the year on the identification of fungi isolated from apples affected with mouldy core.

Eye-rot of Apple.—The work on eye-rot has been proceeding on similar lines to that on mouldy core.

Silver-leaf.—Investigations are being conducted both in Hawke's Bay and Palmerston North. Various types of wound-dressings are being tested, and 200 apple-trees have been inoculated with the disease with a view to producing material for control experiments.

Small-fruit Diseases.—Investigations have been proceeding with a view to providing an effective controllant for damping-off and similar glasshouse diseases, and also in connection with spotted-wilt transmission and the raising of a line of virus-free strawberry-plants.

5. Spraying Investigations.

Spraying investigations have been continued at the Hawke's Bay Fruitgrowers' Association experimental orchard at Havelock North and at the Plant Research Station, Palmerston North, while chemical analyses have been undertaken by Mr. P. J. Clark, of the Dominion Laboratory. Experiments have shown that the standardization of spray application depends on three factors—(1) Volume delivery in gallons per minute; (2) spraying-pressure; and (3) nozzle type. Further tests confirm the results obtained last year that increasing volume delivery increases disease-control. It has also been shown that the degree of spray damage to foliage is largely dependent on the volume of spray applied. This has also been correlated with chemical estimation of coverage as shown by analyses of spray deposits. Trees sprayed at varying pressures of 100, 200, and 350 pounds failed to show any constant differences in black-spot or codling-moth infestation. It has been shown that increasing the spraying-pressure increases the fineness of the mist produced, increases volume delivery, and hence allows more rapid working. Chemical estimation of spray residue showed that spray applied as a fine mist under high pressure results in a greater deposit of spray than a coarse spray at low pressure. Spray applied under high pressure as a driving mist at close range does not give such a good coverage as the same spray applied as a drifting spray at long range. Apparatus has been constructed for investigating the factors in nozzle-construction which determine mist-production, and a number of new nozzle types have been imported for testing and comparison. Salicylanilide sprays have given no better results than standard lime-sulphur/colloidal-sulphur sprays for the control of brown-rot in peaches.

6. Physiological Diseases.

Following on the success attending the use of boron as a corrective for corky-pit in apples, further field and chemical work was undertaken during the past season. Papers covering the 1934–35 season's results have already been published by Atkinson(1) and Askew(2), and further reports on the results for the 1935–36 season has been prepared for publication by the same workers.

In the Braeburn district less pitting has been in evidence than in the two previous seasons, and eight of the plots treated with boron in the autumn of 1935 were rendered valueless this year as the check trees did not develop corky-pit. However, the remaining plots developed appreciable amounts of pitting and have shown that trees treated with boron by injection or soil dressings remained practically free from pitting while untreated trees showed from 59 per cent. to 87 per cent. of affected fruit. Borax and boric acid applied at the rate of 6 lb. and 8 lb. per tree proved toxic, but dressings of 4 lb. or less appeared to have no detrimental effects. Damage also occurred in several cases where trees were injected with the larger amounts (8 grm. and 16 grm.) of borax or boric acid irrespective of the volume of solvent used.

At the Cawthron Institute the examination of the boron status of soils and fruit has been continued and extended to include a partial survey of the boron status of orchard soils and experiments on methods of top-dressing, injecting or spraying trees with borax. Top-dressing at the rate of $\frac{1}{2}$ lb. to $\frac{2}{3}$ lb. of borax per tree, injections into the tree of solutions of borax, or spraying the trees with up to 1 per cent. solutions of borax have all proved successful in combating the trouble, and chemical data show that healthiness in the fruit has been accompanied by a substantial increase in the amount of boron contained in it. It is not yet known how long the effects of top-dressing or spraying will last, and this point requires further investigation. Soil examinations have shown that borax has penetrated to a depth of at least 18 in. during the course of the growing-season, and there does not appear to be any danger of harmful accumulation of boron compounds as a result of top-dressing. In regard to spray treatment, it would seem that annual treatment would be required to prevent the ailment reappearing.

(1) J. D. Atkinson: "Progress Report on the Investigation of Corky-pit in Apples." *N.Z. Jour. of Sci. & Tech.*, *XVI*, 5, 316–319; March, 1935.

(2) H. O. Askew: "The Boron Status of Fruit and Leaves in Relation to 'Internal Cork' of Apples in the Nelson District." *N.Z. Jour. of Sci. & Tech.*, *XVII*, 1, 388–391; July, 1935.

Analyses indicate that boron deficiency is also responsible for the occurrence of corky-pit in Central Otago. Soil samples from Auckland and Hawke's Bay from orchards reputedly free of corky-pit showed a much higher boron content than soils from Nelson.

7. Manurial Trials.

Manurial trials have been conducted (1) at the research orchard, Appleby, (2) in the Cawthron Institute orchards, and (3) in private orchards throughout the fruitgrowing districts. These orchards are selected by the Horticulture Division of the Department of Agriculture.

The report of the trials at the research orchard appear in a previous section of this report.

Cawthron Institute.

The manurial trials include fertilizer trials on Jonathans at Upper Moutere, Cox's Orange at Waimea West, and Sturmer and Dougherty apples at the Annesbrook orchard of the Institute.

The experimental treatment has been continued over a period of twelve years at Upper Moutere, seven years at Waimea West, and approximately fifteen years at Annesbrook. The results are here briefly summarized.

Upper Moutere.—The experiment was laid down in 1923, and for the first five years the quantities of manures applied were comparatively small, and differences due to manurial treatment were slow in making an appearance. From 1928 onwards the quantities of manure were increased and differences at once became marked. Over the six-year period 1930–35 a "complete" manure has given an average increase of two hundred cases of fruit per season over the "no-manure" plots, or an increase of 77 per cent. Sulphate of ammonia alone at the rate of 3 lb. per tree has increased yields only 26 per cent., and does not approach the increase secured by a "complete" fertilizer, while the fruit is small, liable to cracking and much russeting. In conjunction with phosphate and potash, dried blood has not proved quite so effective as sulphate of ammonia, when equal quantities are used.

Comparing the effects of 1 lb. and 4 lb. of muriate of potash in a "complete" fertilizer, it is interesting to note that four seasons elapsed before a specific difference could be detected in the trees and in fruit-yield as a result of the increased potash manuring. The trees receiving the heavier dressing of potash are now superior in both appearance and yield. An application of 24 lb. of muriate of potash per tree in 1934 was followed by a marked improvement in growth and an apparent improvement in yield of fruit.

The highest colour of fruit at export shipping date was associated with the blocks receiving dried blood or "no manure." The blocks receiving 3 lb. of sulphate of ammonia per tree, whether given in association with minerals or alone, were backward in colour. The data suggest that a high supply of nitrogen in the tree retards colour and adversely affects the bloom of the fruit.

The blocks receiving "no manure," or nitrogen alone, gave the highest percentage of small fruit, while the blocks receiving a "complete" fertilizer gave the best export size of apples. The block receiving 4 lb. of muriate of potash with nitrogen and phosphate was outstanding for the large percentage of big-size fruit produced. Russeting was most severe on the "no manure" and "nitrogen only" blocks.

Waimea West.—This experiment on Cox's was commenced in 1928, and is situated on a poor hill-slope which shows good response to nitrogenous fertilizing, and was designed to test the influence of different rates of ammonium sulphate with phosphate and potash. The use of 3 lb. of ammonium sulphate per tree has given during the course of seven seasons about 350 lb. of fruit per tree more than from trees treated with 1 lb. Cool-storage tests have shown a greater amount of internal breakdown in the case of fruit from the plots receiving the heavier dressings.

The same type of experiment carried out on deeper soil located on the flat of the Moutere Hills showed no advantage with the heavier dressing of nitrogen in comparison with the 1 lb. dressing.

Annesbrook Orchard.—On the untreated rows die-back in Dougherty trees is very pronounced, and a reduction in yield of fruit and size of tree has become very noticeable. Superphosphate alone and superphosphate plus potash have given considerable benefit, although the best result has been secured with the complete manure. The good results secured by the use of super and potash without nitrogen on the Annesbrook experiment is probably due to the fact that the soil is comparatively well supplied with organic matter and had at the commencement a much higher nitrogen status than the Moutere Hills soil.

General.—Chemical analyses show that, while there has been a large accumulation of phosphate in the top 6 in. of soil, the phosphate has penetrated below the 12 in. depth, and there does not appear to be any question that small quantities, at any rate, of the phosphatic manures applied are actually reaching the rooting-zone of the trees. Wherever comparatively heavy dressings of potash have been given similar results are recorded.

Plots which have received annual dressings of ammonium sulphate show a marked increase in soil acidity. Concurrently on all manured plots there has been a great improvement in the nitrogen status of the soil in comparison with untreated soils. This is no doubt partly due to the use of blue lupins for ploughing in, but also is possibly connected with the use of ammonium sulphate and the retention of ammonia compounds in the soil due to slow nitrification under the acid soil conditions which prevail in many Moutere Hills orchards.

Co-operative Trials.

Seventy-five co-operative trials arranged through the Horticulture Division and treated in the various fruitgrowing districts of the Dominion have been continued. The trials have included treatment with NPK and lime alone and in association with various groupings. Though yield records have been taken in some cases, most of the trials have been assessed by general observations of visual response.

Soil-injection Trials.

So far no significant differences have been observed between any of the treatments, nor were there any significant differences in yields recorded when the crops were weighed in the 1935 season.

Results, by Districts, of Manurial Trials.

Auckland District.—Apples: On appearance, the complete manure plots are distinctly ahead of the remainder of the treatments in vigour and yield. In another experiment on young Granny Smith trees there are no visible effects from the use of varying quantities of nitrogen at 3 lb. and 6 lb. per tree respectively.

Two out of the three liming-experiments continue to show a good response to liming.

Peaches: The trees receiving nitrogen were outstanding in vigour and quantity and quality of fruit.

Tauranga District.—Lemons: The interim results of the two trials being conducted have been published in the *N.Z. Journal of Agriculture*, August and September, 1935. The trial of various combinations of phosphate, potash, and nitrogen has now been brought to a conclusion, and the final results will be published at an early date.

The liming trial is being continued for a further year. At the end of the first five-year period the limed plots had yielded 1,106 lb. of fruit per tree, as compared with 990 lb. from the unlimed plots.

Hastings District.—Apples: In none of the experiments in this district has any difference been recorded from the various manurial treatments applied.

Mapua District.—Apples: Nitrogen has increased yields in two replicated experiments, while in the other trial no determination of manurial responses was obtainable owing to severe spray injury. The difference in yield and in trunk-circumference measurements in the limed and unlimed plots has not been significant. No differences in responses have been observed from concentrated versus broadcast applications of fertilizer.

Motueka District.—Apples: In two observational experiments the trees receiving complete manure are superior in vigour to the remainder, while no differences between "lime" and "no lime" treatments were observed.

Christchurch District.—Apples: A "complete" manure has given the best results. Lime appears to show no response.

Roxburgh-Ettrick District.—Apples: No significant differences in yield were recorded on the replicated trial, but on observational plots nitrogen appears to have given a marked improvement in the vigour of the trees and potash also appears to have been beneficial where applied in association with nitrogen.

Peaches: On bearing peach-trees the response from nitrogen was outstanding, and there has also been a response from potash in combination with nitrogen.

Apricots: Plots receiving nitrogen were superior in appearance and growth to the remainder of the treatments. Lime appears to give no response.

Central Otago.—Apples: In three observational experiments responses to nitrogen have been marked both on foliage and upon yields. In one experiment where varying quantities of nitrogen—viz., 2 lb., 4 lb., and 6 lb. of sulphate of ammonia—were used on Dunn's the larger quantities resulted in a good setting of fruit in spite of the fact that this season was what would normally have been the "off" cropping-season.

In one other experiment no response to nitrogen was observed, but insufficiency of soil-moisture is considered to have been a limiting factor.

Peaches: Nitrogen appears to improve foliage and growth, which is also reflected in improved quality and yield of fruit. In one experiment lime has appeared to increase size of fruit and advance ripening.

Apricots: Plots not receiving nitrogen have commenced to degenerate, whereas on nitrogen plots there is improved foliage, growth, and amount of fruit. In two of these trials benefit was also secured by the lessening of frost injury on the nitrogen plots. When varying dosages of nitrogen were used—viz., 3 lb., 6 lb., and 9 lb. of sulphate of ammonia—the degree of frost resistance and the subsequent fruit-setting was proportionate to the quantity of nitrogen applied.

General Comments.

In this series of trials, with the exception of Hawke's Bay, nitrogen appears to be the most important element in fruit-tree manuring. Since, however, the complete manure plot is invariably the best in the majority of trials, it would appear that the elements phosphate and potash are also contributing to the improvements which have been obtained. This has been particularly noticeable during the past season, and it would therefore appear that the effect of phosphate and potash are slow to become apparent in contrast to nitrogen which shows up fairly quickly in nitrogen-deficient soils. In Central Otago responses to nitrogen have been outstanding, but more particularly on stone-fruits.

Carbonate of lime has given very little response, except in certain cases, such as in some North Auckland experiments, where the beneficial effect of lime upon the growth of the trees and upon the establishment of cover crops has also been noted.

In Hawke's Bay during the five years the experiments have been in progress no responses whatever have been obtained from the treatments applied.

The various experiments comparing the concentration of fertilizers about the trees with the broadcasting of the applications have so far given no results.

No results have yet been secured from the experiments investigating the effects of injecting fertilizers in solution into the soil.

During the coming season it is intended to reduce the number of co-operative trials from seventy-five to twenty-one, and the results achieved are being carefully tabulated and examined with a view to making such recommendations to orchardists as appear justified and to defining the policy of future experimental work. It is proposed to concentrate the manurial experiments in two or three central areas where precise methods of measuring yields and other relevant data may be employed and the fundamental problems of orchard-manuring investigated.

Donations of Fertilizers.—The potash and sulphate of ammonia were donated by Pacific Potash, Ltd., and Imperial Chemical Industries, Ltd., respectively, during the past season. These donations have materially assisted in the carrying-out of the programme of work which had been undertaken.

8. Citrus Research.

A comprehensive economic survey of all aspects of the citrus industry is in course of preparation for publication in bulletin form. This is a continuation of the survey conducted by Hamilton in 1935, and work during the present year has consisted in adding a further season's data regarding costs of production, prices, &c., and making the necessary alterations to the text. The survey should prove valuable as a summary of the present position of the industry and an indication of the future lines along which research and development of the industry should proceed.

In conjunction with the Horticulture Division of the Department of Agriculture and the Soil Survey Division a report has been prepared for the Bureau of Industries on the suitability of the various soil-types in the Kerikeri-Kaikohe district for the growing of citrus fruits.

At the request of the Horticulture Division of the Department of Agriculture a preliminary report has been made on the causes of wastage in Tauranga lemons. Wastage due to *Penicillium* rots is a serious source of loss to the industry, and further research is required into methods of curing and processing lemons for marketing in order to improve the keeping-quality of locally grown fruit. The major cause of wastage at the present time, however, is mechanical injury to the fruit in the orchard or during the curing process.

Mr. Hyatt, of the Dominion Laboratory, has been conducting tests on seasonal changes in the composition of New Zealand grapefruit, and a paper dealing with the results of the tests will be published shortly in the *Journal of Science and Technology*.

A small grant for maintenance of the Mount Albert Citrus Test Area has been continued.

FRUIT COLD STORAGE RESEARCH.

Advisory Committee: Messrs. J. A. Campbell (Chairman), R. Sutherland, W. Benzies, F. W. Grainger, T. Rigg, H. G. Apsey, L. W. Tiller, A. M. Robertson, J. T. Cross, H. C. Heays, and W. M. Hamilton (Secretary).

The programme of fruit cold storage has been continued during the last year, the work being done in cool stores in Wellington, Nelson, and aboard selected transporting-vessels. The co-operation of the Horticulture Division, shipping companies, the Cambridge Low Temperature Research Station, and the New Zealand Fruit Control Board has played a very important part in the conduct of the investigations. The assistance of the New Zealand Dairy Produce Board in granting the loan of its distance-recording thermometer was much appreciated.

Transport Trials.

Influence of Fertilizer Treatment on Keeping-quality.—Cox's from trees receiving 4 lb. of muriate of potash per tree developed more bitter-pit in storage, and for all three varieties tested (Cox's, Jonathans, and Sturmers) a heavy application (4 lb. per tree) of sulphate of ammonia appeared to have an adverse affect on keeping-quality of the apples.

Wraps and Scald on Sturmers.—Oiled wrapper gave slightly better control of superficial scald than standard wraps, but the nature of the scald was so slight as to be of very little commercial significance.

Wraps and Botrytis Rot in Pears.—Further trials were conducted on Winter Cole pears wrapped in plain and copper-sulphate-treated wraps. These indicate that the spread of the fungus may be reduced considerably by the use of treated wraps, and confirm the 1934 season's results.

Cox's: Transport Temperatures.—Further trials were conducted during the 1935 season at 34° F. and 37° F. These showed that wastage from rotting and breakdown was slight at both temperatures, while bitter-pit was slightly more extensive in the sample from the higher temperatures. The total wastage figures indicate that the lower temperature was slightly better than the higher temperature.

This confirms previous results—viz., that the optimum temperature for transport will vary according as to whether the bulk of the cargo is more susceptible to bitter-pit, breakdown, or rotting. A temperature of 34° F. is preferable for fruit liable to bitter-pit or rotting, but 38° F. for fruit liable to breakdown.

No-dunnage Trial on "Rangitane."—A trial shipment of apples was sent to England without dunnage in a 'tween deck with vertical air-flow. While a small lag in cooling occurred in certain parts of the hold, this was not pronounced, and the fruit opened out in excellent condition. The final report on this trial is not yet to hand.

Tower-dunnage Trial on "Port Fairy."—This shipment opened up in good condition, but the final report by the examining officers has not yet been received.

Cox's: Effect of Position on Tree.—No definite conclusions could be drawn as to the effect of the position on the tree on the development of bitter-pit, but the results suggest that it has no marked influence.

Sturmers: Storage Temperatures.—Two lots of four cases of Sturmers grown in Hawke's Bay were stored for eight months at 34° F. and 37° F. Both samples were 100 per cent. sound and free from wastage, but those stored at the lower temperature were slightly less coloured than those held at 37° F.

Cox's: Gas-storage Trial.—A small-scale trial of the transport of Cox's in refrigerated gas storage was despatched during 1936 season, and an interim report indicates that the fruit opened up in excellent condition. If the use of gas storage can allow the landing of Cox's and other varieties of apples on the English market in better condition, it should be of incalculable value to the industry.

Overseas Transport, 1936 Season.—Experimental shipments sent forward during the 1936 season have been designed to test the value of the tower method of dunnage both in holds with vertical and with athwartship circulation, and also no dunnage in a hold with vertical air ciculation. The Deardon system (modified tower) was tried out in one shipment. Other shipments, or fruit held in local cool store, are designed to test the influence of position on the tree in regard to the incidence of bitter-pit in Cox's Orange Pippin; the conditions required for successful shipment of Winter Cole pears; the influence of oiled wrappers and maturity in the control of superficial scald; the influence of copper-sulphate-treated wraps in controlling the spread of Botrytis rot in Winter Cole pears; the influence of fertilizer treatments of the soil on the keeping-quality of apples; and the value of gas storage of four varieties of apples in England after shipment in ordinary cool storage.

SOIL SURVEY.—SIXTH ANNUAL REPORT.

The most important development during the past year was the commencement of land-utilization surveys of the Hawke's Bay and North Auckland districts. As a result of a meeting of the Research Council, together with representatives of the Unemployment Board, the Lands Department, and the Department of Agriculture, it was decided that the projected soil surveys of Hawke's Bay and North Auckland should form part of a wider scheme embracing the more important aspects of land-utilization. The Unemployment Board, which agreed to provide substantial financial assistance for the scheme, was mainly interested in the development of these regions with a view to providing avenues for the absorption of unemployed labour, either through the establishment of new and appropriate industries or through more intensive development of existing ones.

The Departments of Land and Agriculture, because of their obvious and considerable interests in any such survey, agreed to co-operate fully along such lines as lay in their respective powers.

A comprehensive scheme under the Directorship of Dr. L. I. Grange was drawn up, providing for: (*a*) Soil surveys to be carried out by the Soil Survey Division of the Department of Scientific and Industrial Research; (*b*) chemical investigations of soils to be undertaken by the Cawthron Institute under the direction of Mr. T. Rigg; (*c*) farm-management and pasture surveys by officers of the Department of Agriculture. The following committee was appointed to act in an advisory capacity to the Research Council, and to assist in co-ordinating the activities of the various workers concerned:—

Land Utilization Committee: Mr. T. Rigg (Chairman), Mr. A. H. Cockayne, Mr. G. A. Pascoe, Mr. W. Robertson, Prof. W. Riddet, Mr. R. B. Tennent, Mr. E. J. Fawcett, Mr. R. P. Connell, Dr. L. I. Grange, and Mr. F. R. Callaghan (Secretary).

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

The programme of the soil survey has undergone a good deal of change since the last report was made. The highly detailed mapping in the Waipa County had proceeded far enough to take in all the main types on the Waikato lowlands; farm-management improvements which emerge from follow-up work could readily be applied to other parts of the Waikato by agricultural officers after making themselves familiar with the soil profiles. The closing-down of the Waipa work afforded an opportunity to recast our methods in order to speed up the mapping. As a result of a perusal of systems followed in other countries it was felt that methods somewhat similar to those adopted by Professor Stremme for mapping soils in Germany, in which genetic types are mapped, would best suit our needs. The method differs from that used in the United States of America in that more attention is paid to the soil processes operating, although perhaps in the long run both systems end up with somewhat similar soil types, for they are seeking areas in which natural fertility, &c., are similar. In the present survey some details have to be omitted; for instance, on alluvial flats the accurate mapping of the boundaries of all the different soil textures cannot be attempted. These may sometimes be surveyed in detail separately for specific purposes—*e.g.*, the highly detailed survey of Heretaunga Plains for orchard soils. There is, however, the difficulty that the mapping may be too general to be useful; this can be balanced by maintaining close contact with the farm-management surveyors.

Two areas in the North Island were selected for general surveys, and a start was made in November, 1935:—

(1) Hawke's Bay, under the direction of Dr. L. I. Grange, assisted by Messrs. I. J. Pohlen and A. M. Quennell.

(2) North Auckland, under the direction of Mr. N. H. Taylor, assisted by Mr. C. F. Sutherland.

Brief accounts of the progress to date are contained in this report.

The genetic surveys will provide a basis for land-utilization studies. When all agricultural knowledge concerning the farming on different soil types is gathered, it will be possible to suggest improvements in farm-management and give guidance for future settlement. It should be possible then to advance our farming by organizing scientific knowledge rather than by the expensive trial and error method.

During the field season, surveys apart from genetic surveys have been made for various objects. Mr. H. A. Hughes is carrying out a detailed soil survey of the Heretaunga Plains. Practically all the orchard areas have been examined, and Mr. Atkinson is now exploring the possibilities of correlation between orchard conditions and soil types. Messrs. Taylor and Sutherland made a detailed survey of the Kerikeri citrus block and a reconnaissance of some of the likely localities suitable for an extension of citrus orchards in North Auckland. Mr. Taylor finally co-operated with Messrs. L. Paynter and W. M. Hamilton in compiling a comprehensive report on a selected area. He also mapped the soils on the coastal belt near Dargaville, and his report (with map) will be in Mr. E. B. Glanville's article on the development of the district to be published shortly in the *Journal of Agriculture*.

Representative soil-samples were collected during the progress of the surveys and forwarded to the Dominion Laboratory and Cawthron Institute. At the Dominion Laboratory the work undertaken by Messrs. F. T. Seelye and L. H. Davis consisted chiefly of analysing the clay fractions which were obtained by repeated sedimentation in water. The silica/sesquioxide ratios of the clays are used to obtain a clearer picture of the soil processes operating. At the Cawthron Institute analyses were made under the general direction of Mr. T. Rigg by Dr. J. K. Dixon and Messrs. A. C. Harris and L. Hodgson, for pH, available phosphoric acid and potash in order to make comparisons in natural fertility. Mainly for the purposes of classification and to ascertain the degree of leaching, the base exchange capacity and percentage base saturation were determined.

Other activities of the chemical workers at the Cawthron Institute include chemical reports by Dr. J. K. Dixon on the soils of Levels and Red Cliff areas (which will shortly be irrigated) and on certain soils of Central Otago; and a report by Mr. T. Rigg and Miss E. B. Kidson on the cobalt status of some New Zealand soils. At the time of writing, the pasture and farm management surveys, which have so far been confined to Hawke's Bay, were not sufficiently far advanced for a report to be incorporated here.

Acknowledgment is made of the financial assistance given by the Unemployment Board for all classes of soil work carried out during the year. All maps used in both Hawke's Bay and North Auckland were kindly supplied, free of charge, by the Lands and Survey Department.

FIELD-WORK ON SOILS OF HAWKE'S BAY.

(By L. I. Grange, I. J. Pohlen, and A. M. Quennell.)

Introduction.

The mapping of the genetic soil types in the Hawke's Bay Province was commenced in November, 1935. Soil types have been delineated on the lowlands extending west to the ranges from the railway between Napier and Ormondville and in the coastal area lying between Waipukurau and Porangahau —a total area of about 1,400 square miles.

Rainfall and Vegetation.

The rainfall in the area surveyed ranges from less than 30 in. to 60 in. per annum. A low-rainfall belt (up to 35 in.) extends south-west from Napier to Waipukurau. Westward to the ranges the rainfall gradually increases, and the bulk of the soils there examined come within the area receiving less than 50 in. Towards the coast from Waipukurau the rainfall ranges between 35 in. and 50 in., with the exception of a small strip extending south from Wanstead, where the fall is less than 35 in. Pastures dry out in the summer on all types of soil where the rainfall is less than 40 in.

When the first settlers arrived forest, in the area dealt with, was almost entirely confined to the Norsewood and Ashley Clinton districts. The remainder was in fern, &c., but, on the evidence of the soil profile, it is thought that up till very late times forest covered practically the whole area.

Soils.

In Hawke's Bay parent material determines to a large extent the nature of the soil, and for the present report can be used as the basis of classification. The final classification, however, will be truly genetic, the series being grouped according to the characteristics of the soil profile.

The soils are derived from—

(1) Tertiary mudstones and muddy sandstones;
(2) Tertiary limestones;
(3) Cretaceous argillites, mudstones, and sandy mudstones;
(4) Alluvial deposits; and
(5) Volcanic ash.

(1) *Soils derived from Tertiary Mudstones and Muddy Sandstones.*—The profile developed on these sediments depends on the topography. On rolling and flat country the soils are stable, and a podsol profile has developed. Such profiles occur over a considerable area west of the railway between Hastings and Waipukurau, the largest area occurring in the Matapiro, Sherenden, and Crownthorpe districts, north-west of Hastings. A typical profile is—

A { 9 in. black-grey free sandy loam;
6 in. light-grey free sandy loam;
3 in. lighter grey free sandy loam.

B { 12 in. light-brown compact clay loam;
$\frac{1}{8}$ in. dark-grey pan;
24 in. light-brown cemented sandy loam;
On mudstone.

From this profile it is seen that a good deal of clay has moved down from the A horizon. Chemical analyses show that although soil processes have been active there is little change in the composition in the clay of the A and B horizons. According to Dr. Dixon's figures, the topsoil is only slightly acid; this is unexpected, for podsols are distinctly acid. The most likely explanation is that the podsol was developed under forest vegetation, which in comparatively recent times gave place to scrub. Owing to the presence of the hard pan and to the downward movement of clay the podsols are badly drained; rushes are common, and pugging in the winter is liable to occur.

Other soils derived from Tertiary sediments are located on steeper country and are not so leached. On blue mudstone between the railway and the coast there are three distinct profiles, depending on topography. On fairly steep country the profile is—

6 in. dark-brown free silt loam;
On compact bright yellowish-brown silt loam or clay loam.

Such soils have a better base status than the podsols and are consequently more fertile. In places there is a combination of steep and easy slopes, as to the south of Wanstead. There the soils on the easy upland surfaces show a slight greying of the subsoil and are not as fertile as those on the steep slopes. On the very steep country the soil, subsoil, and mudstone have slumped considerably, with the result that mudstone fragments occur throughout the profile. These unstable soils, occupying a small area, are, as would be expected, the most fertile of the mudstone soils. A grey mudstone older than the blue mudstone gives a distinct profile:—

6 in. dark-brown to blackish clay loam, with nut and crumb structure;
6 in.–9 in. light yellowish-brown sticky clay, with some mottling;
On mottled sticky clay.

These soils are heavier in texture and of slightly better fertility than those on the blue mudstone. On the gentler slopes the subsoil is heavier and is bleached to a cream colour at 18 in. below the surface. It is more leached than its representative on steeper slopes and carries a fairly open pasture.

(2) *Soils derived from Tertiary Limestones.*—The Tertiary limestone soils differ greatly from others in Hawke's Bay, being usually characterized by a dark-brown or chocolate-brown heavy subsoil which drains readily. The common profile is—

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

On the Pakipaki hills south of Hastings the limestone soils are more leached, having a greyish layer between the black topsoil and the brown subsoil. In the world-groups both these soils are most closely related to the rendzinas. A third profile is that on very steep slopes: a black sandy loam topsoil resting on cream sandy loam consisting mainly of fine fragments of limestone. The common limestone soils, according to tests made at the Cawthron Institute, are neutral in reaction, but, although containing more phosphorus than most of the other soils, can be considered deficient in that element. The limestone soils on the steep slopes, occupying a relatively small area, dry out badly during summer, but are moderately well supplied with plant-foods.

(3) *Soils derived from Cretaceous Argillites, Mudstones, and Muddy Sandstones.*—The most widespread soils of this group are those derived from white argillites which form belts of high steep country. The profile, which may be regarded as skeletal, is—

4 in. dark-brown clay loam;
14 in. dull-brown free clay loam containing many fragments of white argillite;
On white argillite.

These soils form an exception to the rule that those on steep slopes are the most fertile. Their infertility is due to the fact that the white argillites themselves contain only small amounts of plant-food. The marine sediments forming the white argillites were derived from well-leached soils on a land of low relief. Owing to the shallowness of the soils, the pastures suffer during a dry spell and maintain an open sward even in the moist seasons. Rusty-coloured hard mudstone and muddy sandstone in the Porangahau district belonging to the Cretaceous period give a profile somewhat like that on the blue mudstone on moderately steep country. Points of difference are (*a*) a powdery topsoil and (*b*) a pinkish-grey, fairly free silt loam or clay loam at 26 in. A shallow phase of this soil lies on very steep country. Another formation in the Cretaceous series in the Porangahau district is a greenish mudstone which gives a profile like that on the Tertiary grey mudstone; the main difference is the greater amount of mottling in the subsoil. Both the rusty and green mudstones are agriculturally inferior to those on the blue mudstone. This may be due to differences in parent material—a point that will be checked by chemical analyses.

(4) *Alluvial Soils.*—The alluvial soils exhibit marked differences in their profiles, and can be divided into two groups according to parent material:—

(*a*) Soils derived from Cretaceous white argillites:
(*b*) Soils derived from greywacke and Tertiary mudstones.

Soils derived from white argillites cover the greater part of the extensive flats west of the road between Wanstead and Porangahau. In most profiles white-argillite gravels lie at 12 in. to 36 in. and more below the surface. This is really a soil complex. Where the gravels are at shallow depth the subsoil is a free light-brown silt loam; where they lie about 36 in. below the surface the subsoil is a compact light-brown silt loam; and where they lie at greater depths the subsoil is a mottled-white

and yellowish-brown clay loam. All the soils are as infertile as those on the steep white-argillite country. Alluvial soils derived from greywacke and Tertiary mudstones have been divided into three sub-groups :—

(1) Young soils on river-flats covered by floods within historic times :
(2) Old soils lying on terraces well above flood-level :
(3) Old soils on dissected uplands.

(1) The greatest areas of young soils occur on the Heretaunga Plains and on the Ruataniwha Plains bordering the Tukituki and Waipawa Rivers. Silt loams, clay loams, and clay are the principal textures. The general profile is dark-brown topsoil on mottled-grey and yellowish-brown subsoil, indicating the presence of a high ground-water level. On higher ground, where the ground-water level is well below the surface, the subsoil is yellowish-brown in colour. These soils are but little leached and are the most fertile in the province. On the best of them excellent rye-grass - white-clover pastures are maintained without top-dressing. Sharply contrasting with them are the gravelly sand strips marking recent channels of the rivers, these being of little value agriculturally.

(2) The soils on terraces above flood-level are podsolized, the profiles resembling those on the mudstone soils.

(3) The dissected uplands in the Norsewood are carved out of fluviatile deposits consisting of greywacke gravel and fine-grained material. The usual soil profile is—

6 in. dark-brown silt loam ;
18 in. – 30 in. (and over) compact yellowish-brown silt loam ;
On gravels.

The underlying gravels allow of good drainage.

(5) *Soils derived from Volcanic Ash.*—The volcanic soils lie on the western side of the railway. Several subdivisions within them have been made, the chief being—

(*a*) Shallow dull-brown soils on gravels :
(*b*) Deep golden-brown soils :
(*c*) Buff soils (Taupo pumice).

The brown soils are derived from andesitic ash blown from Tongariro volcano, whereas the buff soils are derived from rhyolitic ash blown from Lake Taupo at a more recent date.

The shallow dull-brown soils occur on wide flats bordering the Ngaruroro and the Tukituki and Waipawa Rivers on the Ruataniwha Plains, and on the Takapau flats. The profile is—

6 in. dark-brown sandy loam ;
12 in. free dull-brown sandy loam ;
6 in. compact dull-brown sandy loam ;
On gravel.

Like the other brown volcanic soils, they differ from those previously described in having a free subsoil. The soil is easily worked and quickly warms up ; its physical condition is ideal. The chief drawback is its droughtiness ; it is probably the most suitable type in Hawke's Bay for irrigation.

Closer to the range on flattish upland surfaces the volcanic ash is more than 3 ft. thick. The profile is similar to that on the dull-brown soil except that the colour of the subsoil is golden-brown and the compact horizon extends to more than 3 ft.

Both types, the dull-brown and golden-brown, can be classed as brown podsols, the profiles being typical of podsols developed on basic and intermediate igneous rocks. They are about as infertile as the grey podsols, and cattle grazing in the days before top-dressing occasionally exhibited the symptoms of phosphate deficiency. The brown podsol of Hawke's Bay is one of the volcanic soils on which stock do not suffer from bush sickness. If deficiency of cobalt in the soil is the cause of this disease one could predict healthiness, for the brown podsol contains 13·2 parts per million of cobalt, whereas the unhealthy Taupo pumice has only 2·0 to 2·5 parts per million.* Also the particularly healthy limestone soils of Hawke's Bay contain 7·5 parts per million of cobalt.

The Taupo pumice soil covers the uplands to the west of Napier and Hastings. The topsoil and subsoil is a sandy silt and the subsoil is compact. Being a young deposit it is only slightly podsolized, and is consequently more fertile than the brown podsol. Experiments in the Rotorua district on Taupo pumice soil by the Department of Agriculture show that the pastures respond markedly to phosphatic top-dressing.

Discussion.

From the above it is seen that there are distinct groups of soil depending for their fertility on—

(1) The rock from which they are derived ;
(2) Their age ; and
(3) Topography.

The white Cretaceous rocks give rise to the poorest soils, and there is an upward gradation through Cretaceous mudstones to Tertiary mudstones to limestones. The influence of age is well exemplified by the alluvial deposits : the older deposits on high-level terraces are excessively leached, whereas those of very recent age have suffered practically no loss of fertility. Again, the brown soils derived from adesitic ash were originally better supplied with plant-nutrients than the buff rhyolitic ash, but the position is now reversed owing to the much greater age of the former. Topographic influence is seen to advantage in the Tertiary mudstones, which are podsolized on the rolling and flat country.

* Analyses by Dr. J. C. Andrews, of Hellaby's Ltd.

weakly podsolized where there is a combination of rolling and steep country, very little leached on the steep slopes, and most fertile on the steeper slopes where slumping has taken place.

Thus natural differences in the value of the soils owing to various causes can be mapped out, and it remains to be seen to what extent farm-management surveys and fertilizer trials can make use of them to improve farming in Hawke's Bay. Observational top-dressing experiments should now be laid down on the various soil types in order to find out what fertilizers are required for each type.

ORCHARD SOILS ON THE HERETAUNGA PLAINS.

(By Dr. L. I. Grange.)

A detailed survey of the soils of Heretaunga Plains was undertaken with the object of assisting the orchard industry. The plan was to map the soil types and then to ascertain by an examination of orchards already existing which were the types suitable for the growing of apples, peaches, pears, and plums. When this information was obtained it would then be possible to advise where future plantings should be made. The soil map would be of value if it is desirable to grow more of the small fruits. For these local experience offers some guidance, and this, coupled with experience in other countries, should allow the orchardist to be of service when an extension is contemplated. The soil map will be a guide to all workers on orchard problems. Advice on manuring can be given intelligently when responses can be linked up with soil types. Workers on fruit diseases must have in advance all information on the soils in order to judge whether or not the soil is a factor in the problem.

As the holdings are small it was necessary in the first place to construct a good topographic map. Aerial photographs taken by Mr. P. van Asch along with the standard surveys of the Lands and Survey Department were used for compiling 10-chain maps showing every subdivision fence, creek, house, orchard, &c. On these, soil types have been delineated.

The parent material of the soils in the Twyford, Stortford Lodge, Longlands, Pukahu, and St. George Road districts—forming much the greater part of the area so far examined—is the sediments deposited by the Ngaruroro River while in its old course. The old channel was abandoned in 1867, and later sediments have been laid down in a fairly wide belt following the present course. The soils are thus very young, and in the case of the heavier-textured soils are of remarkably high natural fertility. The soils with a high water-table, although young, exhibit mottling.

Drainage is the major factor on which the soils are divided into series—this factor, of course, being all-important where orchard trees are concerned. The drainage of the soils is reflected in the soil profile. Three series are recognized :—

(1) Very well drained soils occupying a little less than a third of the area :
(2) Moderately well drained soils covering less than a third :
(3) Badly drained soils occupying somewhat more than a third.

The very well drained soils occur in or close to old channels of the Ngaruroro. Included in these soils are stony sands and sands, shallow loams on sands, and silt loams. The stony sands and sands dry out badly in summer, and are unfit for orchard purposes. In the few areas where planted, the apple-trees are stunted. Comprising most of this series are the shallow sandy and silt loams lying on fine sands and the silt loams which have unbleached subsoils. These are eminently suitable for the growing of apples and peaches. The free, well-drained subsoil allows of good root development.

The moderately well drained soils lie chiefly on either side of the very well drained soils following the main road between Stortford Lodge and Twyford. The soils are chiefly clay loams and silt loams, and their subsoil is grey, mottled somewhat by iron-staining. On one of the types bordering the old Ngaruroro River the humus-coloured soils extend to a depth of 18 in. The ground-water level in the autumn is 3 ft. or more below the surface. These soils are favourable for the growing of fruit.

The badly drained soils are in low-lying localities and generally heavy in texture, most of them being clays. The subsoil is mottled—blue-grey and light-brown. In the autumn the water-table was only about 18 in. below the surface. Cold air drains into these low-lying areas, and killing frosts occasionally occur in the late spring. Such a soil type must be considered unfavourable for orchard purposes.

Preliminary investigations show that there is room for considerable expansion in orcharding on the Heretaunga Plains, if market conditions warrant it. Three areas examined were found to contain a total of 2,600 acres that could with advantage be utilized.

FIELD-WORK IN NORTH AUCKLAND.

(By N. H. Taylor and C. F. Sutherland.)

During the 1935–36 season a soil map has been prepared of approximately 1,000 square miles lying between Kaeo, Kaihu, and Kawakawa, and, in addition, a sketch-map has been prepared of about 200 square miles of land lying between the Kaihu and Wairoa Rivers on the east and the sea on the west. An account of this latter area is being published in a separate report.

Throughout the course of the work the Fields Division of the Department of Agriculture co-operated closely with the Soil Survey, and grateful acknowledgment is made of the ever-ready help of Mr. P. W. Smallfield and his field officers.

Much of the area mapped has been previously examined by the Geological Survey, whose maps have formed a very useful basis for the soil work.

Topography, Geology, and Climate.—The area lying between Kawakawa and Kaeo is largely rolling to steep country carved from Mesozoic sediments which are in part overlain by basalt-flows.

The basalt-flows belong roughly to two periods. The older basalts form remnants of a flat-topped upland, 700 ft. to 900 ft. above sea-level, extending from Okaihau northwards ; the eastern part close west of Kerikeri Inlet has been down-faulted and stands at a lower level (200 ft. to 300 ft.). The down-cutting of the rivers has caused the ancient upland to be converted locally into rolling

country such as occurs at Waimate North and at Kerikeri. The younger basalts occupy the present valleys. Scoria cones, with their attendant basalt-flows, floor the broad valleys at Pakaraka, Ohaeawai, Kaikohe, and north of Waitangi. These young basalt-flows have dammed back the local drainage and hence are bordered by swamps and lakelets.

Between Kaikohe and Kaihu lies the Tutamoe Plateau: a huge complex of basic igneous rocks 2,000 ft. or so above sea-level.

The rainfall is highest on the Tutamoe Plateau, where it is over 100 in. per annum, and lowest on the east coast near Kerikeri, where it is less than 50 in. Similarly, temperatures are lower on the western side of the district than on the east owing to the greater height above sea-level and to its being more exposed to the prevailing westerly winds.

Soils.

The soils of the district show well the relation of the soil profile to (1) the original rock material, (2) the climate, and (3) the vegetation under which the soil developed. A close relation also exists between topography and soil profile, the soils being generally more mature on the easy country.

The soils are classified in four main divisions.

(1) The podsols are best developed on easy country where kauri groves formerly flourished, and, in the area mapped, have formed on clays weathered from sedimentary and acid volcanic rocks. They are characterized by a well-developed grey leached layer below the topsoil with humus and other pans below. In many places the grey layer is itself cemented to form a hard silica pan.

These soils have poor natural drainage, are acid and of low fertility, and generally now support low scrub and rushes. They require large amounts of lime and phosphates before good pastures can be established, and where the clay is well leached from the topsoil responses to potash are to be expected.

(2) *Immature Podsols.*—The immature podsols are developed on sedimentary and acid volcanic rocks under a cover of mixed bush. They are tentatively divided into three types according to the degree of profile development.

In type A a grey leached silt loam layer, 6 in. or so thick, overlies a yellowish clay subsoil. This soil is best developed on rolling to moderately steep country under bush containing kauri and a fair proportion of rimu and allied trees. Like the mature podsols, these soils are naturally acid and infertile, but the grey layer when cultivated forms a good seed bed for clover establishment, and in this respect the type is superior to the other soils of this division, which have sticky clay topsoils.

Type B, developed under a similar forest cover to type A, generally on slightly steeper slopes. The topsoil is a clay and the subsoil is mottled light-brown and grey.

Type C, which has developed under mixed bush containing much taraire and puriri, is naturally more fertile than the two preceding types. The subsoil is brown and generally not mottled.

All the immature podsols respond well to lime and phosphates. For good pasture establishment liming is essential, especially on the more mature soils, which are generally to be found on the easy country.

(3) *Red-brown Soils.*—The red-brown soils are derived from basic igneous rocks. A complete range of types exists from "young" free silt loams to "mature" compact clays. Differences in soil profile are due to differences in (1) the actual age of the parent rock, (2) the topography, and (3) the type of bush cover.

The clay fraction of the red-brown soils is high in sesquioxides, and hence the soils all have low plasticity and a strong granular structure, which makes them friable and easy to work. They also have the power of absorbing and reverting to comparatively insoluble form large quantities of water-soluble phosphates, and it is this property that gives rise to the popular saying that much of the volcanic land is "a sink for manures."

The young soils of this division are fertile and respond well to phosphates, basic phosphates or a mixture of superphosphate and lime being better than superphosphate alone. The more altered soils need additional lime treatment. Slight to moderate responses to potash are to be expected on all of these soils.

The seven soil series recognized in this division are given in order below, the more mature being shown first:—

(*a*) *The Okaihau clay and stony clay*, which has been mapped over 64 square miles, developed under a bush cover on the flattish to gently rolling surface of the older basalt-flows. Much of the land is at present scrub-covered. The soil, which has been described by Grange (*N.Z. Journal of Science and Technology*, Vol. XVI, pp. 9–18, 1934), is popularly known as "ironstone soil," and is characterized by a layer of ironstone nodules 3 in. to 12 in. thick. The soil is a dull-brown crumbly clay, a typical profile being—

12 in. dark dull-brown clay;
9 in. compact dull-brown clay with iron nodules;
7 in. compact dull-brown clay;
On compact brown clay.

In many places the nodule layer is thin and is 18 in. from the surface, but in other places it is thick and extends to the surface.

Where little or no fertilizer has been applied, the root growth of plants is generally poor, owing probably to the toxic effect of the soluble alumina in the highly acid soil.

(*b*) *Kerikeri clay and bouldery clay*, which cover 7,000 acres in the neighbourhood of Kerikeri, are closely related to the Okaihau soils but are developed on rolling country, and although small nodules

of iron oxide occur throughout the profile a definite layer of ironstone nodules is nowhere developed. On the shallower phases, however, a layer of alumina nodules is developed.

Many good citrus orchards are now established on this soil.

(*c*) *The Ngapuhi clay* covers 1,900 acres of flattish to gently rolling country near Ngapuhi Railway-station.

A typical profile is :—

6 in.–8 in. dark-brown clay ;
22 in. brown compact clay with alumina concretions ;
On reddish-brown compact clay with alumina plates and fragments of decomposed basalt.

This land was formerly covered with good mixed bush containing taraire, puriri, kohekohe, totara, &c. It is capable of carrying good pasture, but much of it is at present poorly farmed.

(*d*) *The Waimate clay,* which covers about 3,000 acres close to Waimate North, has developed on the rolling surface of the older basalts under a cover of mixed bush containing a large proportion of puriri and taraire. It is a deep, friable, well-drained clay similar to Kerikeri clay, but of more reddish-brown in colour. Nodules are rarely developed, and the soil is naturally more fertile than the Kerikeri soil.

Dairying and sheep-farming are carried out on this soil.

(*e*) *The Te Puke soils* are deep-reddish clays and loams covering the scoria cones and mounds. They occupy only a relatively small area.

(*f*) *The Kaikohe clay loam* covers the flats (4,800 acres) near Kaikohe. It is developed from the younger basalt-flows and is more fertile than the Kerikeri, Waimate, and Ngapuhi soils. The topsoil is a brown, free, crumbly clay loam ; the subsoil is duller brown and more compact.

The area is used for dairying.

(*g*) *The Ohaeawai silt loam and building silt loam* are derived from basalt-flows younger than those that give rise to the Kaikohe soils. They are shallow soils, with a free, fine powdery structure, and are comparatively rich in plant-foods. They are used for dairying and sheep-farming.

(4) *Transition Soils.*—The soils of this division show the transition between the red-brown soils and the podsols. They are developed from basic igneous rocks, most of them under the poorer types of mixed forest and the more mature soils under kauri forest. They occur typically in Awarua Valley and on the Tutamoe Plateau.

The topsoils are usually grey-brown crumbly clays ; the subsoils are compact sticky clays, generally brown in colour but grading into a flecked greenish-brown in the more mature soils. In some places a grey leached layer exists below the topsoil, but the single grain structure of the true podsol is not developed.

These soils are extremely acid and deficient in plant-foods. On areas recently covered with forest the ashes from the bush burns improve the soil for a few years, but the open scrubland from which the forest has long disappeared needs heavy dressings of lime with phosphate for good pasture establishment.

Tentatively included in this division are the reddish-brown and brown clay soils covering the steep country surrounding the Tutamoe Plateau. On account of soil-erosion these soils are less mature and more fertile than the other soils of the division. They are used for sheep and cattle grazing.

Fertilizers.

It is evident that in order to farm the district efficiently much larger amounts of fertilizers should be used. The chief need is for lime and phosphates.

A comparison between the responses shown on the pasture top-dressing trial plots of the Department of Agriculture and the profiles of soils in various places suggests the following correlation : With podsols and podsolized soils the need for lime becomes more evident as the profile becomes more mature. Only skeletal and slightly podsolized soils respond well to phosphate alone. Where the podsols are so mature that the clay is well leached from the topsoil, potash responses appear, and increase with the maturity of the soil.

A similar correlation appears to exist with the red-brown soils, but basic phosphates or mixtures of lime and superphosphate seem superior to superphosphate even on the young soils, and responses to potash are to be expected on all the soils of this division when applied in conjunction with lime and phosphates.

Land-settlement.

The unoccupied lands of North Auckland have often been commented upon, and, indeed, the possibility of settling easy rolling country in a climate which gives such a long growing period is worthy of attention. It must be remembered, however, that most of the unoccupied lands are problem soils, and for this reason attempts at settlement should be preceded by carefully controlled experiment, and the settlement itself should be carefully planned and supervised until success is assured. Many pitfalls await the uninitiated.

THE KERIKERI CITRUS AREA.

(By N. H. Taylor.)

During the past few years it has been definitely established that citrus fruits, particularly sweet oranges, can be successfully grown at Kerikeri, North Auckland. The oranges compare very favourably with imported varieties, and it seemed reasonable that some effort should be made to supply our own needs during at least a part of the year.

With a view to providing the necessary information in regard to soil types as a preliminary to further development of the industry, a reconnaissance soil survey of the Kerikeri citrus area was carried out as part of the general soil survey of North Auckland.

The Kerikeri citrus area is a roughly rectangular tract about five miles long and one mile and a half wide lying between Puketotara River and Kerikeri Inlet. It is bounded on the north, south, and east by rolling scrub-covered hills upon which are developed podsol soils (Waitangi silt loam and clay), and on the west by a scrub-covered gently undulating plain upon which are developed the Okaihau (ironstone soils) and Waipapa clays.

The area itself is rolling with broad flattish-topped spurs, the sides of which descend steeply towards the deeply entrenched streams. It is on these flattish-topped spurs with their well-drained soils and gentle contours that the best citrus orchards are situated.

The rainfall of the district is probably between 50 in. and 60 in. per annum. The area is not naturally well sheltered, and many of the earlier orchards planted without sufficient shelter-belts suffered a setback on this account. Slight frosts are experienced in the winter months.

Soils.

The Kerikeri soils belong to the red-brown group, formed from basalts. The clay fraction of the red-brown soils is high in iron and aluminium oxides, and hence the soils all have low plasticity and a strong granular structure, which make them friable and easy to work. The term "clay" applied to these soils is misleading, for, although chemical analysis shows them to be composed largely of clay particles, their field characteristics are more nearly those of a loam.

The soils of the Kerikeri series are divided into two types—the *Kerikeri clay,* which covers the gently rolling country, and the *Kerikeri bouldery clay,* &c., which covers the steep slopes.

For the purposes of a citrus investigation the *Kerikeri clay* is divided into four phases:—

(1) The deep phase.
(2) The shallower phase.
(3) The light-brown phase.
(4) The mid-brown phase.

(1) The *deep phase* of the Kerikeri clay occupies about 1,000 acres and is developed on the flattish spur tops. A typical profile is:—

6 in.–9 in. dark-grey fine granular clay;
18 in. compact dull-brown granular clay;
On brown, very compact granular clay.

When worked the soil breaks down to an extremely fine tilth.

The soil drains readily, but after a heavy shower the fine cultivated top becomes saturated with water and is easily moved by streamlets flowing on the compact subsoil below. Orchards have been seen where slight erosion has occurred on slopes of even two or three degrees. However, since only slight slopes occur on this soil phase, erosion is not marked.

The soil does not appear to have a high moisture-holding capacity, and in a dry season oranges, particularly the later varieties, are likely to be adversely affected.

The moisture-holding capacity of a soil can be improved by building up the humus, but the ploughing-in of cover crops, although an excellent method of adding nitrogen, does not appear to increase the soil-humus. At some level a balance is reached and the organic matter breaks down as fast as it is added.

Summer cultivation, by suppressing weed-growth, helps to conserve the soil-moisture.

This soil, in common with other soils of the group, fixes phosphates readily. The land should be well limed and phosphates applied either in the form of basic super, a mixture of super and lime, or as basic slag. Experiments are needed to determine the best method of manuring both the cover crop and the citrus-trees direct.

The best citrus orchards in Kerikeri are situated on this phase of the Kerikeri clay.

(2) The *shallower phase* of the Kerikeri clay covers the gently rolling country. The soil is generally of a brighter-brown colour than that of the deeper phase, and from place to place decomposed basalt and alumina concretions are encountered from 6 in. to 18 in. below the surface. In other places, however, the decomposed basalt is not encountered at 3 ft. It was found impracticable to map these areas separately; symbols *d* (deeper) and *sh* (shallower) are used on the map to indicate deeper and shallower areas of this phase.

Erosion is an ever-present danger on this soil. Rolling country, a compact subsoil overlain by a topsoil that does not form clods but breaks up readily into a fine tilth, together with heavy summer showers after the cover crops have been ploughed in, make for conditions where erosion is likely to be serious. Subsoiling, the growing of permanent cover crops which can be mown and the trees mulched, contour planting and cultivating, and even contour banking are possible solutions of the difficulty. Experiments are needed.

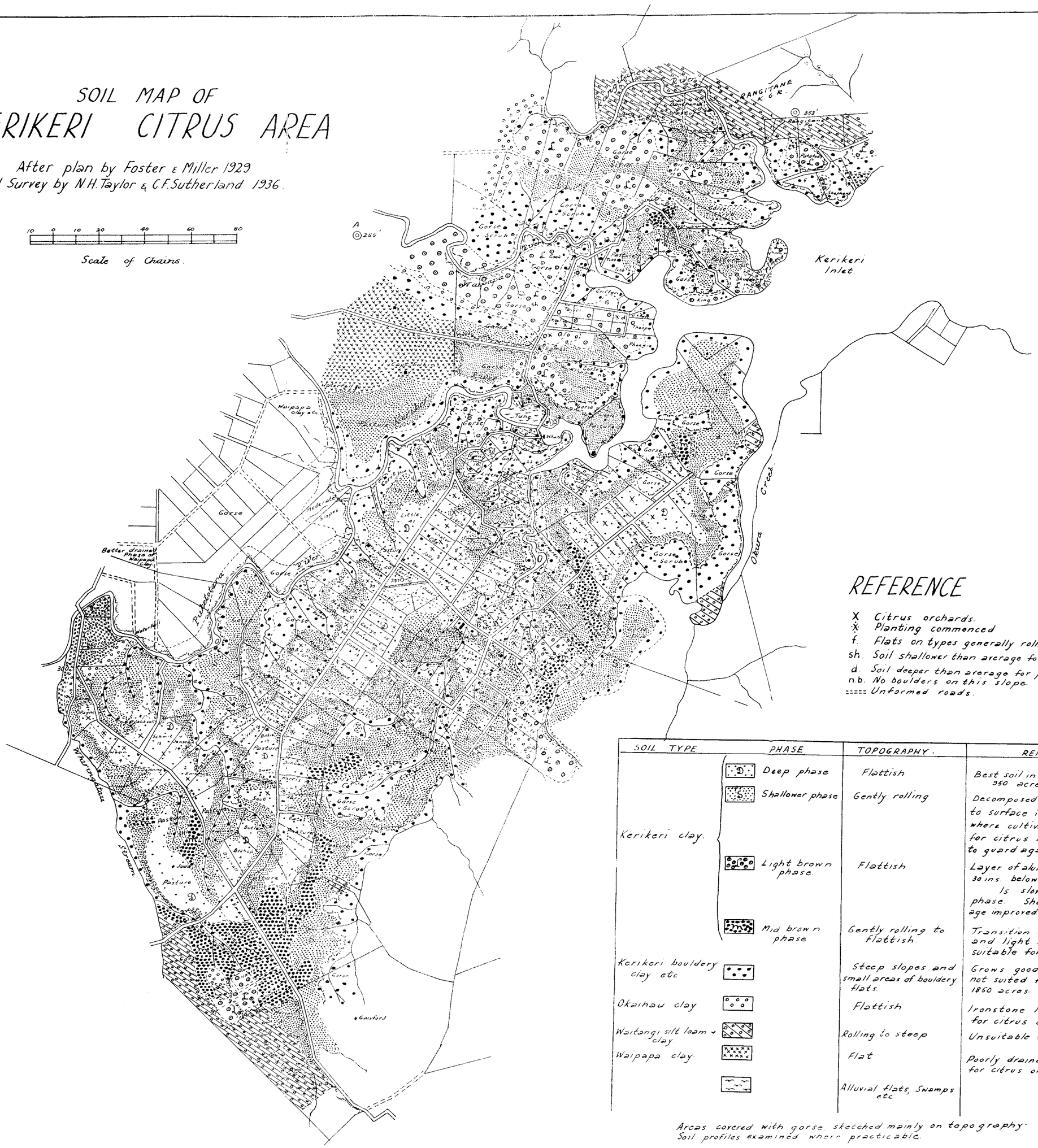
Many good citrus orchards are situated on this soil, but the present orchard practice must be modified to minimize the danger of erosion.

Exceptionally good passion fruit are said to be grown on this phase of the Kerikeri clay.

SOIL MAP OF KERIKERI CITRUS AREA

After plan by Foster & Miller 1929
Soil Survey by N.H. Taylor & C.F. Sutherland 1936.

10 0 10 20 40 60 80
Scale of Chains.



REFERENCE

- X Citrus orchards.
- ⁂ Planting commenced
- f. Flats on types generally rolling.
- sh. Soil shallower than average for phase
- d. Soil deeper than average for phase.
- n.b. No boulders on this slope.
- ===== Unformed roads.

SOIL TYPE	PHASE	TOPOGRAPHY.	REMARKS.
Kerikeri clay.	D Deep phase	Flattish	Best soil in Kerikeri for citrus orchards 350 acres approx.
	S Shallower phase	Gently rolling	Decomposed basalt approaches close to surface in places. Soil erodes badly where cultivated. Generally suitable for citrus if precautions taken to guard against erosion. 1700 acres.
	Light brown phase.	Flattish	Layer of alumina concretions 18ins to 30ins. below surface in many places. Is slower draining than deep phase. Should grow citrus if drainage improved 460 acres.
	Mid brown phase	Gently rolling to flattish.	Transition between deep, shallower and light brown phases. Generally suitable for citrus. 300 acres.
Kerikeri bouldery clay etc		Steep slopes and small areas of bouldery flats.	Grows good isolated citrus trees, but not suited for commercial orchards. 1850 acres.
Okaihau clay		Flattish	Ironstone land. Not well suited for citrus culture.
Waitangi silt loam & clay.		Rolling to steep	Unsuitable for citrus culture.
Waipapa clay.		Flat	Poorly drained. Generally unsuited for citrus on account of drainage.
		Alluvial flats, Swamps etc.	

Areas covered with gorse sketched mainly on topography.
Soil profiles examined where practicable.

SOIL SURV 11

H.F.T.

(3) The *light-brown* phase covers about 400 acres of flattish land lying mainly to the north of Kerikeri River.

A typical profile is :—

6 in. blackish granular clay;
12 in. compact light-brown clay ;
On 48 in. + compact bright-brown crumbly clay with many plates of alumina and fragments of bluish and reddish decomposed basalt.

In some places the layer of alumina nodules is not so well developed and the overlying clay is deeper. This soil is slower-draining than the other phases of Kerikeri clay, especially where the alumina layer is well developed. In parts of one orchard visited, two days after rains, water was lying a foot below the surface on top of the compact subsoil. In these wetter patches the citrus-trees were much smaller than were those in the remainder of the orchard. Attention should be paid to the drainage of this soil before it is planted in citrus-trees.

The note appearing on the accompanying map, to the effect that this soil should grow citrus if the drainage is improved, applies to the soil phase as a whole; there are localities where the drainage appears to be satisfactory.

(4) The *mid-brown phase* covers about 300 acres of gently rolling and flattish land. Nodules of alumina and fragments of decomposed basalt are commonly encountered in the subsoil. The soils are transitions between the other three phases and appear to be generally suitable for citrus. Erosion is likely to be troublesome in places, but not to the same extent as on the "shallower phase."

Kerikeri bouldery clay, &c., covers the steep slopes. Most, although not all, of the slopes are strewn with basalt boulders. Small areas of bouldery flats are also included in this soil type. Although isolated citrus-trees grow remarkably well on this soil, the steepness of the slopes and the boulder-strewn surface make it unsuitable for commercial orchards.

ANNUAL REPORT OF THE CHEMICAL WORK AT THE CAWTHRON INSTITUTE FOR 1935–36.

(By T. Rigg, Officer in Charge.)

The past year has been marked by great development in the work of the chemical section of the Soil Survey as a result of the decision of the Soil Survey Committee to prosecute land-utilization surveys in the Hawke's Bay and North Auckland territories.

The chemical staff has been greatly strengthened by the secondment of Dr. J. K. Dixon to act as Senior Soil Chemist at the Cawthron Institute. It was found necessary, owing to the great increase in the chemical work, to appoint Mr. A. C. Harris, M.Sc., as an Assistant Soil Chemist. Mr. K. Frater was appointed as Laboratory Assistant to facilitate the preparation of samples for analysis.

During the year a wide range of work has been covered in the chemical laboratory. This work has comprised the completion of the soil examinations in connection with the Levels and Redcliff irrigation areas, the examination of a large number of soil samples from the Hawke's Bay land-utilization survey, a special study of Central Otago fruit soils, a preliminary examination of fruit soils in North Auckland, and a survey of the cobalt status of a large number of New Zealand type soils.

Soils of the Levels Irrigation Scheme, South Canterbury.

The examinations have dealt with the texture, nutrition status, and water relationships of soils in the Levels area. All the soils appear to be suitable for irrigation. No striking deficiencies in connection with plant-food supply have been revealed by the examinations, but the phosphate status of the Levels soil type is low, and top-dressing experiments with phosphatic manures should be conducted in order to ascertain the amounts of phosphate which are required to give optimum returns under irrigation. Many of the Levels soils show rather low pH values and a low lime status. Lime treatment appears to be desirable for many farm crops in the Levels area.

Soil Survey of the Redcliff Irrigation Area.

The survey has shown that the three major soil types in the Redcliff area are silt loam, stony silt loam, and gravelly or sandy loam. The field capacities for water of the Redcliff soils resemble those in the Levels area. The chemical characteristics in regard to phosphate and lime status likewise resemble closely those of the Levels district.

Chemical Studies of Hawke's Bay Soils.

The work has comprised the usual mechanical and chemical analyses for the characterization of the soils, but, in addition, special studies have been made to determine the degree of podsolization on a selected range of soils where the leaching process is clearly observable in the profile. The chemical studies have shown that the leaching process is developed over a fairly wide range of soils, but the chemical data do not show such marked difference in pH values and percentage base saturation as might have been expected from the profile data recorded by the field workers.

As the great majority of New Zealand soils show podsolized characteristics it is very important that definite stages in the leaching process should be recognized and that chemical studies should be undertaken with a view to the elucidation of the leaching process and the accurate classification of these soils.

Orchard Soils of Central Otago.

The work has shown that in certain orchards high pH values and high soluble salt content are probably detrimental to the growth of apple-trees. The preliminary work which has been done points clearly to the desirability for soil and orchard surveys of the Central Otago district with a view to the classification of the soils and the elaboration of methods for the removal of soil factors which operate detrimentally to fruit-production.

Cobalt Survey.

This work is an important development arising out of the mineral deficiency investigations at Glenhope, Nelson, and Morton Mains, Southland. The results of the drench experiments conducted in these two areas have shown that cobalt in minute amounts is successful in overcoming and in preventing lamb and sheep ailment. It is a matter of great importance to the stock industry of New Zealand that the cobalt status of soils should be correlated with stock ailment in different parts of New Zealand. The chemical determinations made by Miss Kidson have shown low figures for cobalt not only at Glenhope, but in connection with the bush-sick soils of the North Island. The survey has not proceeded far enough to enable any final statement to be made concerning the value of the analytical work in demarcing areas where cobalt supplements for stock are required. Certain areas are associated with comparatively high cobalt contents—Taranaki soils have figures varying between 9–13 parts per million of soil. The clay soils of Hamilton likewise contain large amounts of cobalt, the figures ranging from 12–22 parts per million. These are two striking illustrations of high cobalt figures in comparison with the low supply at Glenhope (0·4 parts cobalt per million) and the comparatively low cobalt content (0·5–1·5 parts cobalt) in connection with the bush-sick soils of the North Island. Further work is required to determine whether availability of soil cobalt is a factor of importance in connection with the interpretation of the chemical results.

North Auckland Fruit Soils.

Preliminary work has been done on the citrus soils of the Kerikeri district and the apple soils of Henderson and Huapai. Some of the results are shown in the following table :—

North Auckland Fruit Soils.—Chemical Analyses.

Laboratory No.	Depth of Sampling.	Available Plant Food.		pH Value in H_2O.	Total Exchangeable Bases.	Per Cent. Base Saturation.
		Phosphoric Acid (P_2O_5).	Potash (K_2O).			
		Kerikeri Citrus Soils.				
	In.					
1573	0–6	0·005	0·008	5·1	1·60	6·61
1579	0–6	0·001	0·017	5·4	2·05	8·74
1581	0–6	0·004	0·011	5·2	1·20	5·79
413	0–9	0·002	0·015	5·1	..	..
		Henderson and Huapai Apple Soils.				
1059	0–9	0·018	0·005	4·5	..	..
1061	0–8	0·015	0·009	4·7	..	..
1063	0–8	0·003	0·029	5·5	..	..

Four samples typical of the citrus soils of the Kerikeri district have been examined. They all show great poverty of plant food, the phosphate supply being particularly low. The figures for potash are rather on the low side, and the pH values show that the soils are markedly acid. The exchangeable bases occur only in small quantities, and the figures for base saturation support a definite need for lime treatment. The data indicate that the future of citrus culture in the Kerikeri district is bound up with satisfactory manurial treatment of the orchards. Field experiments are urgently required to ascertain the most suitable methods for manurial treatment on these soils.

The apple soils of Henderson and Huapai are likewise markedly acid and frequently have low supplies of both available phosphoric acid and potash. The data for Henderson and Huapai soils are somewhat similar to those of the Moutere Hills soil at Nelson, where manurial treatment has been found absolutely essential for the maintenance of growth and high yield of fruit. The use of nitrogenous manures alone on the Moutere Hills has failed to maintain growth of tree, yield and quality of fruit. A complete manure containing suitable quantities of phosphate, potash, and nitrogen has proved most successful for the Moutere Hills soil type.

Detailed reports dealing with the Levels and Redcliff irrigation soils and Hawke's Bay and Central Otago soils are appended to this report.

PRELIMINARY REPORT ON THE CHEMICAL STUDIES OF SOME TYPICAL SOILS OF HAWKE'S BAY.

(By J. K. Dixon and A. C. Harris.)

In this preliminary report it is intended to discuss some of the chemical data obtained in the examination of typical soils collected during the progress of the Hawke's Bay soil survey. Owing to the fact that both the field-work and laboratory examinations are incomplete it is impossible at this stage to make any statement concerning the final classification of the soils.

(1) At Waipukurau, opposite the Pukeora Sanatorium, an interesting soil type has been called by Dr. Grange a rendzina. A rendzina has been defined by G. W. Robinson as a humus carbonate soil, generally of a dark colour with a humus content varying from 3 per cent. to 12 per cent. L. G. Kotzmann states that a rendzina is a dark grey-black soil with a loose crumbly structure containing fragments of limestone, and that organic matter in the A horizon varies considerably and may amount to 20 per cent. to 25 per cent. A high base status prevents an acid type of humification, for the humus is saturated with calcium and possesses complete stability. The exchange capacity depends primarily on the humus content and varies from 30 mg. to 50 mg. equivalents per 100 g. soil. The pH value has been found to vary from 7·8 to 8·4, while the soils are saturated to over 90 per cent. of the base exchange capacity.

The data presented below follow fairly closely the above-mentioned requirements of a rendzina soil.

Rendzina Soil.—Opposite Pukeora Sanatorium, Waipukurau.

Sample No.	Depth.	Available.		Loss on Ignition.	pH.	Base-exchange Capacity.	Exchange Bases.	Exchange H.	Base-saturation.
		P_2O_5.	K_2O.						
	In.	Per Cent.	Per Cent.	Per Cent.		m.e. Per Cent.	m.e. Per Cent.	m.e. Per Cent.	Per Cent.
1563 ..	0–6	0·017	0·047	14·01	7·1	39·9	37·5	2·4	93·6
1564A ..	9–12	0·005	0·017	9·41	7·5	..	..	..	..
1564B ..	15–19	0·002	0·010	8·66	7·6	..	..	..	..

Sample 1564B contains free calcium carbonate. The field description is a black, crumbly clay loam on a yellow clay, which is chocolate on drying out in a road cutting. The lower part of this horizon contains fragments of limestone. The soil type has developed under fern and manuka scrub, but is now carrying danthonia and rye pasture.

It is worth noting the way in which available phosphate and potash decrease in the lower horizons, the phosphate being of particular interest, since the top 6 in. gives a fairly low figure and this decreases to a deficiency level in the 9 in. to 12 in. and 15 in. to 19 in. sections.

(2) Podsolized soils: Certain soils have been characterized by Dr. Grange as podsolized, and in these he has been able to recognize in the field varying degrees of podsolization. It is desirable to confirm this from the chemical data, since it is important in connection with manurial treatments to determine if a soil is well or mildly podsolized. The typical podsolized soil is well leached, and the fact that a podsolized profile shows at all is an indication that the majority of bases have been removed and that the phosphate content will have been reduced to a low level, whatever may have been the nutrient status in the parent material. A mature podsol, then, should definitely respond to lime and phosphates and possibly to potash. Where the podsolization process has not gone so far lime and phosphate will not be needed in so great a quantity, and it is probable that field experiments will be necessary to determine what top-dressings are economic. Apart from the field classification there are certain accepted chemical characteristics of podsolization that make it possible to examine the field evidence critically.

These criteria are:—

(*a*) Low pH, especially in the top horizons of the profile. The A 2 horizon usually has the lowest pH.

(*b*) The A 2 horizon is lower in base-exchange capacity than A 1 or B, while the B horizon usually has a higher capacity than the C horizon. The base-exchange capacity in B is a function of three effects, as the transference of humus downwards and the mechanical washing-down of clay colloids increase the exchange-capacity, while the precipitation of sesquioxides tends to decrease the capacity of the soil complex. Usually, however, the first two effects are the greater, but where it is possible to differentiate the eluvial horizon into B 1 and B 2 horizons these factors can be better evaluated.

(*c*) Percentage base saturation is higher in A 1 and B than in A 2.

(*d*) A low base content in A 1 with a relatively high content in C is indicative of strong podsolization.

(*e*) The B horizon should attain a more loamy structure than the A layers owing to a downward mechanical movement of the clay particles.

The following provisional classification has been based on the field evidence :—

(*a*) Podsols with a Pan, Low in Humus.

Sample No.	Horizon.	Depth.	Avail. P_2O_5.	pH.	Clay.	Loss on Ignition.	Base-exchange Capacity.	Exchange Bases.	Exchange H.	Base-saturation.	Texture.
						Fern Hill.					
			Per Cent.		Per Cent.	Per Cent.	m.e. Per Cent.	m.e. Per Cent.	m.e. Per Cent.	Per Cent.	
1499 ..	A1	0–6″	0·007	6·0	22·6	10·2	19·8	11·0	8·8	55·5	Sandy loam.
1500A ..	A2	12–15″	..	..	17·5	4·0	13·4	7·6	5·8	57·0	Sandy loam.
1500B ..	B	18–20″	..	..	26·6	4·8	19·8	13·7	6·1	69·1	Silt loam.
						Mangatatari.					
1543 ..	A1	0–6″	..	5·8	20·4	9·4	18·7	13·5	5·2	72·1	Sandy loam.
1544A ..	A2	10–14″	0·002	6·4	17·1	5·5	14·9	8·5	6·4	57·2	Sandy loam.
1544B ..	B	17–21″	0·000	6·7	17·4	4·4	13·8	9·9	3·9	71·5	Sandy loam.
1544C ..	B	27–36″	..	6·1	..	4·0	..	..	..	..	..
						(*b*) Moderately Podsolized Soils.					
						Havelock North.					
1493 ..	A1	0–3″	0·011	5·9	20·2	9·9	18·5	13·1	5·4	70·4	Silt loam.
1494A ..	A2	9–12″	..	..	22·9	4·7	14·7	9·7	5·0	66·2	Silt loam.
1494B ..	B	12–16″	..	..	27·1	4·1	15·2	11·3	3·9	74·3	Silt loam.
1495 ..	A	0–6″	0·009	5·6	25·0	13·6	22·5	11·4	11·0	50·9	Silt loam.
1496 ..	B	9–12″	..	..	25·8	4·5	13·8	6·3	7·5	45·4	Stony silt loam.
						Knight's Road.					
1513 ..	A	0–6″	0·005	5·8	18·8	13·2	25·4	14·3	11·1	56·2	Sandy loam.
						Tukituki Road.					
1529 ..	A1	0–6″	0·006	5·6	22·7	11·4	20·7	14·6	6·1	70·5	Loam.
1530A ..	A2	7–12″	0·002	6·2	18·7	4·9	14·8	7·6	7·2	51·4	Loam.
1530B ..	B	13–19″	0·000	6·4	30·6	4·8	17·2	11·9	5·3	69·3	Loam.
						Waimarama Road.					
1533 ..	..	0–6″	0·008	5·6	22·0	11·9	20·5	14·5	6·0	70·6	Silt loam.
1534 ..	..	7–12″	0·003	6·1	20·6	5·0	16·4	8·8	7·6	53·0	Sandy loam.
1531 ..	A1	0–6″	0·009	5·3	22·5	12·2	19·3	10·4	8·9	53·9	Silt loam.
1532A ..	A2	7–13″	0·002	5·2	23·8	4·5	18·1	6·1	12·0	33·7	Silt loam.
1532B ..	B	15–18″	0·001	5·3	39·1	4·4	27·1	10·3	16·8	37·9	Clay loam.
						Waipukurau.					
1565 ..	A1	0–6″	0·005	6·4	20·5	7·5	15·9	11·5	4·4	72·3	Fine sandy loam.
1566A ..	A2	6–10″	..	5·0	19·0	3·0	14·8	4·9	9·9	32·9	Fine sandy loam.
1566B ..	B	12–16″	..	5·2	45·1	4·6	31·8	15·8	16·0	49·6	Clay.
1566C ..	C	3′+	..	5·0	37·2	4·3	34·0	17·7	16·3	52·1	Clay loam.

1565 : Available K_2O = 0·24 per cent.

(*c*) Mildly Podsolized Soils.

						Te Pohue.					
1547A ..	A1	0–6″	..	5·4	..	16·3	19·8	8·4	11·4	42·3	..
1547B ..	A2?	6–9″	..	6·0	..	10·5	15·6	7·3	8·3	47·1	..
1548 ..	B	9–12″	..	5·8	..	10·5	31·1	6·9	24·2	22·2	
						Mangarouhi Stream.					
1569 ..	A	0–6″	0·007	5·4	..	10·0	..	..	..	..	..

1569 : Available potash = 0·02 per cent.

(*d*) Brown Volcanic Soils.

						Patoka.					
1511 ..	A	0–3″	0·01	6·0	8·0	14·7	21·8	9·7	12·1	44·4	Medium sand.
1512 ..	B	10–12″	0·011	6·4	5·7	12·3	40·7	6·2	34·5	15·2	Medium sand.
						Napier–Taupo Road.					
1555/1557	A	0–6″	0·016	5·9	12·9	19·0	28·9	14·3	14·6	49·4	Sandy loam.
1558 ..	B	9–12″	..	6·0	..	10·7	30·4	5·4	25·0	17·7	..
						Ongaonga.					
1545 ..	A	0–6″	0·013	..	..	14·0	..	..	..	..	..
						Ngaruroro Flats.					
1501 ..	A	0–6″	0·014	5·9	12·3	14·0	..	..	..	..	Sandy loam.

1555 : Available potash = 0·032 per cent. 1545 : Available potash = 0·023 per cent.

(*e*) Immature Soils.

						Patangata.					
1497 ..	A	0–3″	0·01	5·8	29·1	12·1	24·6	19·5	5·1	79·1	Silt loam.
1498 ..	B (C ?)	13–16″	..	..	40·2	4·5	28·5	25·1	3·4	88·1	Clay loam.
						Havelock North.					
1553 ..	A1	0–6″	..	5·6	..	11·4	26·9	19·9	7·0	74·1	..
1554 ..	A2?	8–11″	..	6·1	..	..	41·7	30·5	11·2	73·2	..

When the above tables are examined in the light of the characteristics of podsolization it will be seen that in group (*a*), the best developed of the profiles, the base-saturation is still fairly high, indicating that the profiles are not extreme ones. The data presented do not conform wholly to the requirements of podsolization even for the A 2 layer, which is regarded as the most characteristic of a podsol profile. In the first case there is evidence of clay-movement with a resulting increase in the base-exchange capacity of the B horizon, while in the second case practically no clay has moved and the capacity is lower in B than in A 2. The pH values are high, considering the profile development. The available phosphate figures are very low.

In the second group (*b*), the moderately podsolized soils, the data presented are very similar to those of group (*a*). There is evidence of clay-movement, and the requirements for the A 2 layer are satisfied with regard to base-exchange capacity and percentage base-saturation. The soils are heavier in texture than in group (*a*), and it is to be expected that podsol-development would be slower. Very low phosphate figures are again shown. Group (*c*) is not strongly enough represented to enable comment to be made.

In class (*d*), those characterized as brown soils, leached volcanic ash is dealt with. Dr. Grange has explained that although the leaching process has gone on the soils are so high in iron that no bleached layer (A 2) shows up, despite downward movement of the sesquioxides. It will be seen from the table that the chemical data do not give support to podsolization, although there is evidence of leaching in that the percentage base-saturation is fairly low. The remarkable drop in this figure in the B horizon cannot be accounted for at this stage. This class is also low in phosphates, though not quite as badly off as the preceding classes. The immature soils, group (*e*), are those developed under a similar climate to the other soils, but their development has not gone far enough for a definite profile to be recognized. In these classes the zone of illuviation may be in the C horizon, with the result that little evidence of podsolization will be seen. With a base-saturation of 70 per cent. to 80 per cent. they cannot be regarded as badly leached, and it is possible that phosphate responses will be seen on these types without the necessity of adding lime. The available phosphate content is still low.

In conclusion, it can be said that there is some evidence of podsolization in the soils of groups (*a*), (*b*), (*c*), but the chemical data do not differentiate them to any extent. Group (*d*) seems definitely of a different soil type, and further work will be necessary on these soils. The immature soils show no evidence of podsolization. The low content of available phosphate in these soils must be stressed, and top-dressings with lime and super or basic slag are necessary on the soils with low base-saturation, while on the soils with high base-saturation phosphates alone should be quite effective.

SKELETAL SOILS.

Sample No.	Depth.	Available P_2O_5.	pH.	Clay.	Loss on Ignition.	Texture.
			(*a*) ON CRETACEOUS ARGILLITE.			
			Mount Vernon.			
	In.	Per Cent.		Per Cent.	Per Cent.	
1561	0–6	0·005	5·8	38·0	10·3	Clay loam.
		Available potash, 0·033 per cent.				
			(*b*) ALLUVIUM.			
			Stortford Lodge.			
1523	0–6	0·064	6·6	28·4	11·7	..
1524A	6–12	0·063	5·8	27·2	7·4	..
1524B	18–24	0·052	5·5	18·1	7·7	..
1525	0–6	0·053	6·8	45·8	12·5	Clay.
1526A	6–12	0·054	5·6	..	8·5	..
1526B	18–24	0·040	5·9	..	5·4	..
			Hastings.			
1485	0–6	0·043	5·7	40·0	11·8	Clay loams.
			Havelock North.			
1487	0–6	0·044	5·6	..	10·5	..
			Pakowai Road.			
1527	0–6	0·036	7·5	25·5	7·7	Clayey silt.
1528A	6–12	0·034	7·3	21·9	6·7	Clayey silt.
1528B	18–24	0·047	7·0	31·0	7·2	Clayey silt.
			Hastings.			
1483	0–6	0·043	5·4	48·6	12·1	Clay.
			Stortford Lodge.			
1489	0·6	0·046	5·2	46·5	15·5	Clay.

A clay loam derived from a white argillite (3A) gives a poorish pasture which should respond well to phosphates because of the low phosphate-level in the topsoil and parent material.

When the soils surrounding Hastings (3B) are examined it will be seen that, in marked contrast to all the other soils considered, they are well supplied with phosphates. The phosphate-level is well sustained into the subsoil, as is to be expected from soils that have been added to in recent times by flooding.

Summary.

(1) A rendzina soil has been described.

(2) Evidence for podsolization in a number of soils has been examined.

(3) These podsolized soils are characterized by a fairly high base status and low available phosphate-level.

(4) Lime and phosphate will be needed on the above-mentioned soils where the base status is low, but where the base status is high phosphate alone should be sufficient.

(5) The high phosphate content in the recent alluvial soils near Hastings has been noted.

Acknowledgment.

Thanks are due to Mr. L. Hodgson, who supplied the clay and texture figures contained in this report.

PRELIMINARY CHEMICAL REPORT ON THE ORCHARD SOILS OF CENTRAL OTAGO.

(By J. K. Dixon.)

Introduction.

During the course of an investigation relating to the occurrence of "internal cork" in certain orchards in Central Otago marked differences in the growth of apple-trees were encountered. These differences in the behaviour of trees in some orchards did not appear to be connected with decided variations in the manurial programmes followed by orchardists, but appeared to be associated with inherent qualities of the soil or soil water. It was considered that a chemical examination of typical soil-samples might thrown some light on the variation in growth of the fruit-trees, and on this account a number of soil-samples from both good and poor areas were examined in the laboratory.

Soils.

The soils examined can be divided provisionally into three groups:—

Group 1: A deep soil which may vary from a fine sandy silt to a silt loam. From the viewpoint of possible soluble salt interference with apple-growth the depth must be emphasized as the main characteristic, since conditions are favourable for a high concentration of salts in the profile.

Group 2: Stony sandy alluvial soils with the stones on or near the surface.

Group 3: Soils derived from weathering of the country rock (mica schist) but somewhat resorted by cloudbursts.

Analyses.

Table I.—pH Values, Available Phosphate and Potash.

Laboratory No.	Depth.	Locality.	Texture.	Description.	pH Value.	Available Phosphoric Acid (P_2O_5).	Available Potash (K_2O).
	In.					Per Cent.	Per Cent.
1601	0–6	Alexandra ..	Fine sandy silt ..	Rather poor growth of trees	6·0	0·083	0·027
1602A	6–12	..	..	..	5·2	0·076	0·020
1602B	12–18	..	..	..	8·5	0·059	0·016
1602C	18–22	..	..	..	8·6	0·056	0·007
1602D	24–28	..	Fine sandy loam ..	..	8·4	0·034	0·006
1603	0–6	Alexandra ..	Stony med. sand ..	Poor trees	6·5	0·065	0·011
1605	0–6	Earnscleugh ..	Silt loam ..	Good apple-trees ..	6·9	0·068	0·046
1606A	6–12	..	..	..	6·1	0·062	0·012
1606B	12–18	..	..	..	6·4	0·070	0·008
1606C	18–24	..	..	..	6·4	0·074	0·007
1606D	24–33	..	Silt loam ..	..	6·3	0·071	0·008
1607	0–6	Earnscleugh ..	Sandy loam ..	..	5·9	0·027	0·012
1608A	6–12	..	..	..	6·2	0·029	0·009
1608B	12–18	..	..	..	6·2	0·040	0·007
1609	0–6	Clyde ..	Stony med. sand ..	..	7·3	0·076	0·052
1610	6–12	..	..	..	7·7	0·068	0·025
1611	0–6	Cromwell ..	Fine sandy loam ..	..	6·5	0·061	0·022
1612	6–12	..	..	..	7·1	0·046	0·009
1613A	0–6	Lowburn ..	Sandy loam ..	..	6·4	0·041	0·013
1613B	6–9	..	..	..	6·5	0·062	0·009
1615	0–6	Lowburn ..	Sandy loam ..	Good trees	6·2	0·056	0·033
1616A	6–12	..	..	..	6·0	0·046	0·019
1616B	12–22	..	..	..	6·1	0·044	0·014
1617	0–6	Lowburn ..	Sandy loam ..	..	6·0	0·037	0·023
1618A	6–12	..	..	..	6·0	0·029	0·012
1618B	12–18	..	..	..	5·8	0·027	0·010
1619	0–6	Mutton Town Gully	Sandy loam ..	Poor trees	5·5	0·062	0·026
1621	0–6	Earnscleugh ..	..	Poor trees	6·2	0·062	0·015
1623	0–6	Cromwell ..	Sandy loam ..	..	6·3	0·044	0·017
1009	0–6	Ettrick ..	Silt loam ..	..	7·0	0·066	0·016
1010	9–15	..	..	..	6·2	0·044	0·007
1013	0–6	..	Fine sandy loam ..	Unhealthy peach-trees ..	8·4	0·048	0·026
1014	9–15	..	..	..	8·3	0·051	0·009

Table I shows that all the soils are well supplied with available phosphate, even in the subsoil samples. The potash figures show only a moderate status, with a tendency to decrease to a low level in the subsoil. With few exceptions the pH values of the soils are over 6·0 for the 0–6 in. depth; and in three cases the values are definitely greater than pH 7. These high values suggest that in certain cases alkalinity may be a detrimental factor in connection with tree-growth, since apples give optimum growth in the region pH 5·5–6·0. Under these circumstances the application of lime must be strongly discouraged.

Sample 1013, with a pH value of 8·4, was taken from a peach orchard in which poor growth of trees occurred. In certain cases it appears probable that alkalinity of subsoil and substrata may likewise be unfavourable to apple-culture. Samples 1601 and 1602A–D illustrate the variations in pH values which may occur in the profile of a deep sandy silt type. On this soil trees were making rather poor growth. Samples 1605 and 1606A–D represent the profile of a good soil—that is, one which was associated with satisfactory tree-growth.

In view of the high pH values and the semi-arid climate it was considered worth while to investigate the soluble salt content of typical soils, and in Table II are presented data relating to water-soluble salts in these soils.

TABLE II.—WATER-SOLUBLE SALTS.

(All results expressed as percentages on oven-dry soil.)

Laboratory No.	Depth.	Locality.	Total Salts.	CaO.	Cl'.	SO_4''.	HCO_3'.	pH Value.
	In.							
1601	0–6	Alexandra	0·13	0·017	0·003	0·026	0·009	6·0
1602A	6–12	„	0·116	0·018	0·003	0·028	0·009	5·2
1602B	12–18	„	0·286	0·010	0·018	0·093	0·079	8·5
1602C	18–22	„	0·238	0·008	0·015	0·057	0·075	8·6
1602D	24–28	„	0·243	0·015	0·021	0·039	0·071	8·4
1603	0–6	„	0·056	0·004	0·001	0·005	0·006	6·5
1605	0–6	Earnscleugh	0·098	0·010	0·004	0·013	0·008	6·9
1606A	6–12	„	0·028	0·004	0·002	0·009	0·006	6·1
1606B	12–18	„	0·042	0·007	0·003	0·019	0·009	6·4
1606C	18–24	„	0·056	0·004	0·002	0·004	0·012	6·4
1606D	24–33	„	0·046	0·004	0·003	0·006	0·010	6·3
1607	0–6	„	0·088	0·008	0·001	0·004	0·015	5·9
1609	0–6	Clyde	0·152	0·020	0·017	0·026	0·012	7·2
1611	0–6	Ripponvale	0·101	0·011	0·001	0·025	0·008	6·5
1613	0–6	Lowburn	0·075	0·009	0·0005	0·008	0·006	6·4
1615	0–6	„	0·052	0·005	0·002	0·006	0·010	6·1
1617	0–6	„	0·100	0·007	0·001	0·005	0·010	6·0
1619	0–6	Mutton Town Gully	0·233	0·045	0·002	0·072	0·010	5·5
1621	0–6	Earnscleugh	0·073	0·006	0·001	0·005	0·008	6·2
1623	0–6	Cromwell	0·071	0·006	0·001	0·008	0·012	6·3

NOTE.—CO_3 absent in all soils.

In certain cases a high salt content is associated with alkaline soil conditions, but in at least one case (sample 1619) this correlation does not hold. In this instance the orchardist had put on ammonium sulphate recently, and in view of the high sulphate content of the sample it is understandable that high total salts are associated with a lowered pH. Where salts are high in the soil profile it is doubtful whether soluble nitrogen compounds such as the ammonium sulphate or sodium nitrate are the best forms of nitrogen to use on soils that are admittedly low in nitrogen. It may be that organic nitrogenous manures will prove much safer in use than the inorganic forms. In the former class must be included the growing of cover crops of leguminosæ.

It is difficult at this stage to express any definite opinion in regard to the effect of the different radicles present in the soils. Sodium carbonate (black alkali), which is very harmful to cultivated plants, has not been found in any of the samples. Mr. W. R. Lloyd Williams, Orchard Instructor at Alexandra, states, however (private communication), that he has seen patches of black alkali in the district, and this suggests that possibly the samples were not obtained at the best time for testing for this phenomenon. The sulphate figures shown in Table II vary greatly for different soils and for different depths in the profile. In certain cases the percentages approach 0·10 per cent., suggesting that "white alkali" (sodium sulphate) operates detrimentally in some orchards.

The figures for chloride, with one exception, are low enough to suggest that chloride exercises only a minor effect on tree-growth.

It is of interest to summarize the findings of other workers in connection with the adverse effect of soluble salts on plant-growth.

Tsukunga (*Proc. Inter. Cong. Soil Sci.*, 1928) states that 0·2 per cent. total salts impedes germination, while 0·09 per cent. is regarded as favourable, 0·14 per cent. intermediate, 0·33 per cent. unfavourable, and 0·40 per cent. impossible to vegetable-growth. Later he states that an average SO_4'' content of 0·12 per cent. (0·04–0·17) is favourable to growth, while 0·7 per cent. (0·26–0·90) is unfavourable, but it is not made clear whether these concentrations are effective in the presence of other salts.

Hilgard and Loughridge's (*Univ. of Cal. Bull.* 128, 133, revised) data is somewhat confusing, as they record Jonathans doing poorly on 0·041 per cent. total salts while Red Bietigheimers gave good results on 0·101 per cent. total salts. However, sodium carbonate appears to have been present in their soils, and it is difficult to assess how much of this effect was due to sulphates.

G. W. Shaw (*Cal. Exp. Sta. Bull.*, 119) records fair growth of beet with 0·127 per cent. total salts (0·004 per cent. carbonate), while poor progress was made where the total salts were 0·79 per cent. (0·039 per cent. carbonate).

Kearney (*U.S. Dept. Agric. Farm. Bull.*, 496) states that if 0·5 per cent. soluble salts are found only decidedly resistant plants can be grown. In a classification he records the degree of "alkalinity" as follows:—

Medium	0·4–0·6 per cent.
Weak	0·1–0·4 per cent.
Negligible	0·1 per cent.

The Central Otago soils under review would thus come into the weak alkali class.

Hilgard (*Univ. of Cal. Bull.*, 128) records that apple-trees have done well on 0·25 per cent. total salts.

Tinsley (*New Mex. Bull.*, 42) gives 0·4–0·5 per cent. total salts as the maximum limit for growth, while 0·25 per cent. damages crop-growth to a great extent. Young apple-trees showed distress with a little over 0·30 per cent. total salts on 3 ft. to 5 ft. soil.

In Australia work has also been done on soluble salt effects.

Taylor, Penman, Marshall, and Leeper (*C.S.I.R. Bull.*, 73) imply that a detrimental effect from sulphate is to be expected when the concentration of the sulphate ion reaches 0·08 per cent.

Read (*Jour. Agric. Vic.*, *29*, 1931, 551) presents the following table:—

TABLE III.

Depth.	Total Salts.	Cl'.	SO_4''.	CO_3''.	HCO_3''.
In.	*Type I: Good Growth of Trees.*				
0–6 ..	0·13	0·004	0·012	..	0·049
6–12 ..	0·124	0·012	0·024	..	0·055
12–24 ..	0·092	0·014	0·017	..	0·067
24–36 ..	0·100	0·008	0·016	0·006	0·061
	Type II: Growth affected.				
0–6 ..	0·306	0·087	0·032	..	0·072
6–12 ..	0·260	0·070	0·028	..	0·072
12–24 ..	0·190	0·038	0·018	..	0·08
24–36 ..	0·180	0·024	0·018	..	0·106

Marshall and Hooper (*C.S.I.R. Bull.*, 56) state that it is only above 0·1 per cent. total salts that soluble salts become of any concern. They give a number of figures dealing with salt injury to crop-growth, but the pH values are much higher than found in Central Otago, and it is therefore difficult to use their data. This point should also be mentioned in connection with the earlier data on salt injury. Many of the apparent anomalies would probably disappear if the workers had been able to record pH values as well as soluble salts on their soils toxic to growth.

To sum up, it is evident that no precise limit can be given beyond which certain crops do not make optimum growth. It is obvious that the limits will vary not only for different plants, but will depend also on the nature of the salts present and especially upon the water content of the soils at different times. The recorded figure for a soil gives only an indication of the effect likely to be produced in the field. A certain salt concentration may be harmless if the soil is kept sufficiently moist, but may be toxic if the soil dried out. There are indications that some orchards are always short of water in the summer, and this must intensify the problem.

Taking 0·15 per cent. total salts as an estimation of the limit for favourable growth, the suggestion must be made that a soil such as 1602 is definitely in the danger zone, and it appears probable that a thorough investigation of the use of irrigation water is necessary. A comparison with samples 1605–1606A–D suggests that soluble salts can be reduced to less dangerous limits under ordinary orchard conditions. It is not desired to overemphasize the problem, as the type concerned, that of deep fine sandy silt, is not the best represented in the district. More common types are shallow soils on sloping foothills or alluvial soils mixed with gravel; in these cases drainage may be sufficient to carry salts away permanently from the zone of root-penetration. Nevertheless, the deep sandy silt would be regarded as the most suitable for development purposes, since it is a deep soil and easily workable, and because of this and Mr. Lloyd Williams's report the possible interference by soluble salts assumes a greater significance.

SUMMARY.

(1) A preliminary report has been presented on certain Central Otago orchard soils.

(2) Analyses show that high pH values and soluble-salt contents are probably a detrimental factor in the growth of apple-trees in certain orchards.

(3) Investigations are needed not only to show how to reduce the existing salt content by the suitable use of irrigation water, but also to demonstrate in what way water is best used in irrigation schemes to prevent soluble salts from becoming an injurious factor in tree-growth.

ACKNOWLEDGMENTS.

Grateful acknowledgment is made to Mr. W. R. Lloyd Williams, Orchard Instructor at Alexandra, who conducted the author round the orchard and who supplied many particulars relating to the soil-samples and orchard practice; and to Messrs. A. C. Harris and L. Hodgson, who were responsible for the analyses recorded in this paper.

SOILS OF THE LEVELS IRRIGATION SCHEME, SOUTH CANTERBURY: REPORT ON THE ANALYTICAL DATA.

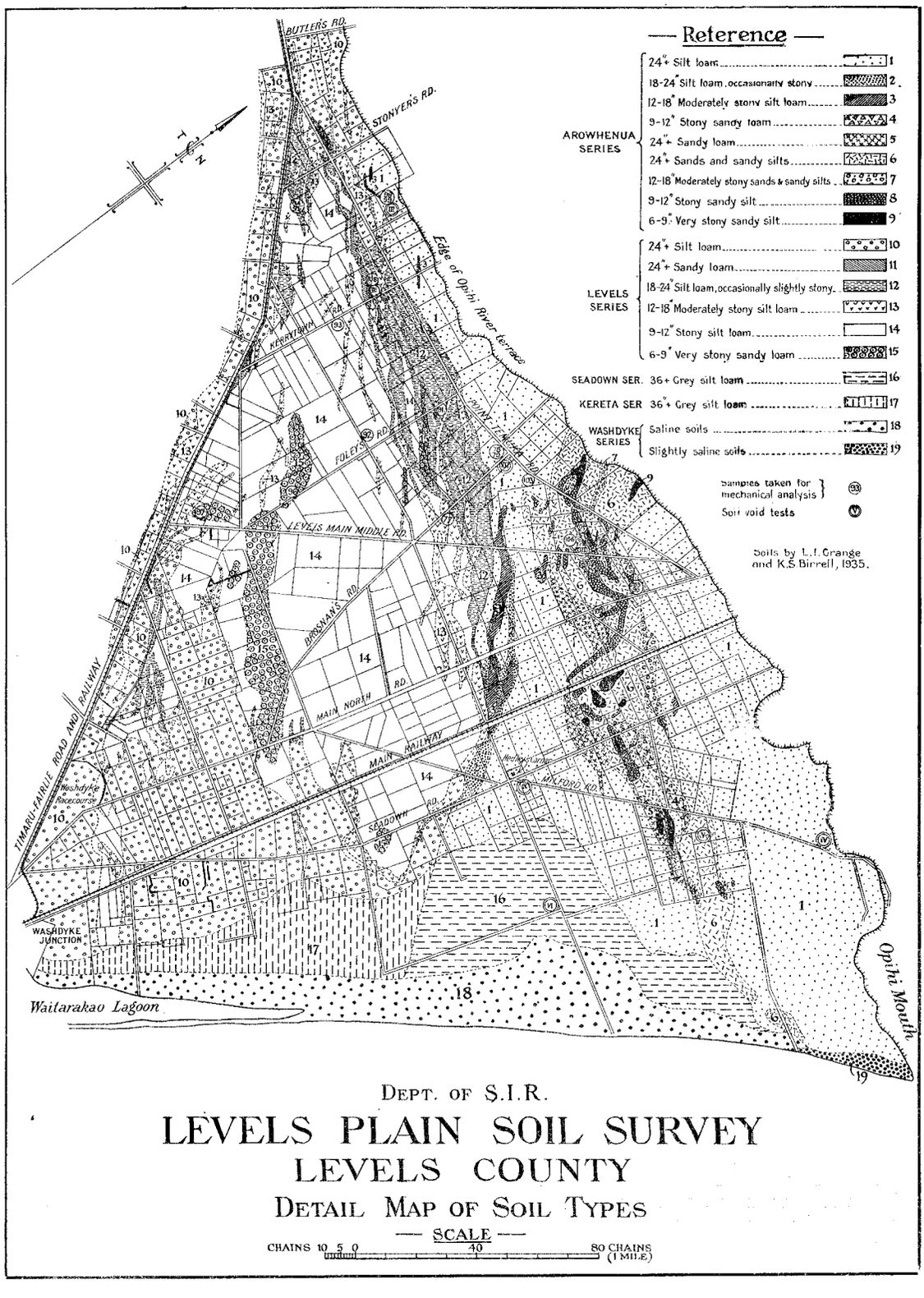
By J. K. Dixon and L. Hodgson, Cawthron Institute.

Introduction.

A preliminary report on the field aspects of the problem has been supplied by L. I. Grange (5th Annual Report of the Soil Survey, 1934–35, pp. 2–3), while, more recently, a detailed soil map of the proposed irrigation area has been completed by Dr. Grange and Mr. K. S. Birrell (see page 6). The map has been used as a foundation for this report, which is based not only on visits to the area but also on a number of typical soil-samples collected by Grange, Birrell, and one of the authors (J.K.D.).

Analytical Data.

It is proposed to discuss the problem under three main headings: (1) Texture, (2) nutrient status, (3) relationship of soil types to water.



1. *Texture as shown by Mechanical Analyses.*

(*a*) *Levels Series.*—In this series six types can be characterized. Where only a light covering of soil has been deposited, especially on the higher parts, the underlying shingle is well mixed with the topsoil, so that, although the soil between the shingle is still a silt loam in texture, the percentage of stones in the whole sample is sufficiently high to characterize the type as a stony silt loam (14) and to considerably affect irrigation practice. This type is well exemplified on Burns's and Scott's properties. It will be noted that, compared with the typical silt-loam type, both fine gravel and coarse sand are higher in the stony silt loam. In the Levels series, therefore, stony silt loams will be less retentive of water and will allow a faster drainage rate.

The most productive type of the Levels series, a deep silt loam (10), is well developed within the scheme, and typical samples can be seen at the Washdyke corner of the irrigation area. The type is very uniform, and only small variations from average figures are found.

(*b*) *Kereta Series.*—Where the Levels silt-loam type occurs near the coast, the small difference in level between the soil and sea has resulted in a banking-up of ground-water, so that there is a strip of meadow soils running parallel to the sea-coast. These are still silt loams in texture, and, if they are drained as proposed by Mr. T. G. Beck, there is no reason from a permeability viewpoint why the use of irrigation water should not be as successful as on the same type farther up the plain. No opinion is ventured, however, on the economic aspects of the problem.

Table II shows that the subsoils in all cases are silt loams. It can be concluded therefore that all types are suitable for irrigation.

(*c*) *Arowhenua Series.*—The soils of the Arowhenua series, much more recent in origin than the Levels series, are river deposits. As is to be expected, more variation is encountered, for alluvial soils usually change rapidly in texture. There are nine types in this series, while the Seadown series, with the same parent material, are meadow soils formed in the same way as the Kereta series previously mentioned. The coarser type (5), shown on Kane's and Gaffney's properties, is a fine sandy loam in texture, and what has been said in connection with the stony silt loam can be said here on the relationship of these soils to water. They will not be so retentive of water, drainage will be quicker, and they will need to be irrigated more often with smaller quantities of water to give the optimum results.

The main type of this series is again a silt loam (1). The analyses show, however, that the percentage of the coarse and fine sand fractions are somewhat lower in the Levels silt loam, with a corresponding rise in the percentage of the silt fraction. Sample 1175, which is just in the silt-loam class, would probably have been classified as type (8) had a more detailed survey been possible.

(*d*) *Seadown Series.*—The meadow soils of the silt-loam type show no obvious difference in texture, and the soil should be irrigable since the meadow type is not due to impermeability of subsoil but to a high water-table.

(*e*) *Washdyke Series.*—In the Washdyke series two samples have been collected, one more saline than the other. The texture of sample 1001 is a silt loam, but the salinity of the soils would be an effective bar to their agricultural utilization without extensive flooding, drainage, and the use of lime.

Table II shows that the textures of subsoils in the Arowhenua series are such as to allow drainage through them. They follow in each case the corresponding topsoil.

To sum up, it can be said that the texture of all soils in the irrigation scheme indicates that they are eminently suitable for irrigation.

2. *Nutrient Status.*

(*a*) *Phosphate.*—A study of Table III shows that the main point of interest is in the big difference in the available phosphate status between the Levels and Arowhenua series, a difference so marked as to be a more reliable criterion of the Arowhenua and Levels types than any field examination. It will be seen that the older deposits of the Levels series, either because of leaching or of an original low-phosphate status in the parent material, are much lower in phosphate than the more recent river-deposited Arowhenua series—a dissimilarity apparently reflected in farming results, since the Arowhenua series is reported to be more fertile (Grange). Top-dressing programmes, however, do not indicate that there is a great deal of difference in the phosphate used in the two series, and this fact suggests that top-dressing experiments should be laid down on the two types to demonstrate the optimum dressings that should be applied.

In the Levels series the phosphate level, with one or two exceptions, is definitely low, and increased crops as a result of irrigation practice will necessitate the use of much heavier dressings than have been customary in the past.

In the Arowhenua series, with its high phosphate level, there should not be the same necessity for heavy top-dressings, but until fertilizer experiments are laid down it will not be possible to say what rate of top-dressing is most suitable from an economic viewpoint. Certainly the chemical analyses show a high enough level to suggest that no extra phosphate is necessary, but, unfortunately, the chemical method does not always give a clear picture of the soil phosphate readily available, and the use of an easily soluble top-dressing like superphosphate may be beneficial. For instance, in Ashburton, a top-dressing of 1 cwt. superphosphate per acre gives results on the high-phosphate soils of the Ashburton River (Soils of the Ashburton County Chemical Report, Rigg, Kidson, and Hodgson, 5th Annual Report of the Soil Survey, 1934–35, p. 27). Similarly A. W. Hudson records (*N.Z. Jour. Agric.*, 1929, *38*, p. 338) that on the farm of J. W. Topham, situated on the Arowhenua silt loam, there was no increase from superphosphate one year, but in the next there was a significant increase of seven bushels of wheat per acre. Again, from experiments on the farm of M. J. Fitzgerald also on the Arowhenua silt loam, Hudson and Montgomery (*N.Z. Jour. Agric.*, 1930, *41*, p. 350) state that a slight response was visible to superphosphate.

The sandy loams of the Arowhenua series have less available phosphate than the silt loams of the same series, but this is only to be expected, since they have a greater proportion of unreactive material.

(*b*) *Potash.*—Available potash figures show medium values on the average, with some figures definitely low and others quite high. There does not appear to be any definite correlation between potash status and soil type, and, with no farm records available, no explanation can be advanced on this point.

The available potash is slightly lower in the Levels series than in the Arowhenua, but with phosphate brought to a satisfactory level on the former type one would expect that potash would be required in about the same amounts in both cases. The total potash figures are of the same order as the available, but are high enough to suggest that there is a good reserve of potash in the soils. The indications from the two top-dressing experiments mentioned above are that very little response has been obtained from potash dressings.

(*c*) *Lime Status.*—The pH values show that all soils have a medium degree of acidity. Although the occurrence of acidity in the soils of a proposed irrigation scheme can be regarded as a good fault, since there will be no likelihood of alkaline salts in the subsoil being redistributed by upward movement of irrigation water, nevertheless the figures show that liming is necessary in many cases, especially where lucerne or crops susceptible to club-root are contemplated.

(*d*) *Magnesium.*—Replaceable magnesium values are all high compared with the replaceable calcium. Sample 1005 gives a very high figure, but this is to be expected, since soils affected by sea-water always show abnormally high magnesium figures.

(*e*) *Nitrogen.*—Total nitrogen figures are normal, and while a nitrogen response can be expected, only top-dressing experiments can tell if the use of nitrogenous fertilizers is likely to be a profitable one on irrigated soils.

3. *Relationship of the Soil Types to Water.*

A number of laboratory experiments have been made to ascertain what difference varying textures in the soil types will make in the duty of water. While recognizing that these laboratory tests could not hope to fulfil the function of properly conducted field tests, it is to be anticipated that the same difference found on a laboratory scale can be demonstrated in the field, even though the absolute figures obtained are not the same.

The moisture equivalent was estimated on all soils. The value obtained, which is only approximate, can be regarded as a similar figure to field capacity, since it measures the retentive power of the soil for water against an external downwards pull, such as gravitation or suction. From the analyses it will be seen that the silt-loam types of both the Arowhenua and Levels series have similar figures, but with slightly higher values for the heavier silt loams of the Arowhenua series. Sand, of course, reduces the moisture equivalent, while humus, as exemplified by sample 1005, increases it considerably. A low-moisture equivalent indicates that the soil will have a low power of retention of water; that for the same amount of water, movement will take place sooner into the subsoil; and that, since the storage capacity is less, more frequent applications, but of smaller amounts, will be needed than with the soils showing higher values.

Similar information is given by percentage moisture at the sticky point, maximum water-holding capacity, and pore space. Clay content and humus largely govern the figures obtained, so that a knowledge of the mechanical analysis is helpful in predicting the water relationships.

A comparison of the average field capacity of 27·6 on the silt-loam type at Ashburton (Grange, 5th Annual Report of Soil Survey, 1934–35, p. 21) with the laboratory-determined moisture equivalent of 31·5 for the loessic silt loam of the Levels County suggests that the duty of water as determined at Seafield may be utilized in irrigation control on the Levels scheme, since climate and rainfall are similar, but it must be remembered that the Seafield soil is a shallow one, and that, despite the similarity of material used for analysis, the presence of stones near the surface must considerably affect the storage capacity of the soil for water. One would predict that on the Levels silt loam less frequent application of water would be necessary, but greater quantities could safely be used each time.

In conclusion, it must be stressed that laboratory results are not enough in themselves and that field experiments both on the duty of water and the optimum combinations of lime, phosphate, potash, and nitrogen are necessary, and should be started before irrigation is practised on an extensive scale by the farmers. It must be realized that the successful utilization of irrigation water will be dependent upon the greater use of fertilizers than has been customary in the past under dry farming methods.

Summary.

(1) A report has been made on the soils of the Levels Irrigation Scheme from the viewpoints of texture, nutrient status, and water relationships.

(2) The soils are all suitable for irrigation.

(3) No obvious deficiencies that would hamper the optimum use of irrigation have been disclosed, but the phosphate status of the Levels series is low enough to warrant immediate commencement of top-dressing experiments. Liming should be practised wherever crops not tolerant of acid conditions are proposed.

Acknowledgments.

Grateful acknowledgment is made to Mr. T. G. Beck, Resident Engineer in charge of the Irrigation Scheme, for facilities placed at our disposal, and to Mr. K. S. Birrell for assistance in the field work.

TABLE I.—MECHANICAL ANALYSES OF LEVELS COUNTY SOILS.

Topsoils, 0 in.–6 in.

Laboratory No.	Farmer.	Coarse Sand.	Fine Sand.	Very Fine Sand.	Silt.	Clay.	Loss on Ignition.	Stones.	Fine Gravel.	Texture.
	LEVELS SERIES.									
	Stony-silt Loams. Type 14 (grading to 16).									
1185	Scott	19·9	16·5	11·7	26·3	18·2	8·3	46·5	4·8	Stony silt loam.
983	Kelman	18·0	20·6	12·4	27·5	16·3	6·4	51·7	2·9	Stony silt loam.
985	Foley	11·4	14·0	10·3	35·4	20·4	7·8	33·7	2·5	Stony silt loam.
843	Burns	15·3	22·9	12·5	27·5	16·3	6·1	15·5	2·9	Stony silt loam.
1167	T. W. Brosnan	11·5	15·1	9·9	35·1	21·9	6·7	8·2	1·6	Stony silt loam.
	24 in.–36 in. + Silt Loam. Type 10.									
1171	Mehrtens	4·3	26·2	16·8	28·9	16·9	6·9	..	0·4	Silt loam.
1169	Cargo	5·9	22·7	11·9	33·2	21·2	6·8	..	0·6	Silt loam.
993	Daly	3·2	22·0	20·3	33·3	16·5	6·0	..	..	Silt loam.
1181	Walsh	2·3	19·6	23·8	31·6	16·8	6·2	..	..	Silt loam.
	18 in.–24 in. Silt Loam, occasionally slightly stony. Type 12.									
987A	Foley	4·6	14·0	13·6	39·1	21·5	7·2	2·9	0·7	Silt loam.
1179	T. M. Brosnan	4·2	19·2	14·0	35·2	20·5	7·3	..	0·4	Silt loam.
	12 in.–18 in. Moderately Stony Silt Loam. Type 13.									
991	Orbell	6·5	22·5	17·4	30·1	17·0	6·1	..	0·8	Silt loam.
1177	Oliver	4·9	26·4	17·5	28·4	15·8	5·9	..	0·7	Silt loam.
999	Jackson	3·8	26·0	14·2	31·2	19·1	6·0	..	..	Silt loam.
	KERETA SERIES.									
	Meadow Soils.									
1003	Donald	0·9	20·5	21·5	31·9	17·8	8·2	..	..	Silt loam.
	AROWHENUA SERIES.									
	24 in. and over, Sands, Sandy Loams, and Sandy Silts. Type 2.									
989	Gaffney	12·1	49·7	8·4	15·5	9·2	4·5	..	..	Fine sandy loam.
1165	Kane	4·7	48·1	11·3	20·1	11·0	5·8	..	..	Fine sandy loam.
	24 in.–36 in. + Silt Loam. Type 1.									
997A	Hall	1·6	14·1	7·5	43·0	22·9	8·2	..	..	Silt loam.
1133	Smith	1·8	17·4	15·8	39·4	19·5	7·7	..	..	Silt loam.
841	Robins	0·8	16·2	13·4	43·2	20·7	6·3	..	..	Silt loam.
995	McCully	0·3	13·7	13·1	44·5	20·7	8·2	..	..	Silt loam.
1175	Taylor	5·5	36·2	13·2	24·7	13·5	7·6	4·1	0·8	Sandy loam.
	SEADOWN SERIES.									
	Meadow Soils.									
1173	Brosnan	1·3	7·7	9·9	45·8	20·7	12·9	1·7	..	Silt loam.
	WASHDYKE SERIES.									
	Saline Soils.									
1001	Hall	2·3	13·1	9·4	44·3	22·2	8·3	..	..	Slightly saline silt loam.
1005	Colomb's Road	..	..	..	..	..	..	..	..	Peaty saline silt loam.

NOTE.—Results are percentages on an ignited basis and calculated to moisture-free soil.

TABLE II.—MECHANICAL ANALYSES: SUBSOILS.

Laboratory No.	Farmer.	Depth of Sampling.	Coarse Sand.	Fine Sand.	Very Fine Sand.	Silt.	Clay.	Loss on Ignition.	Stones.	Gravel.	Texture.	Soil Type.
	LEVELS SERIES.	Inches.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.		Per Cent.		
994	Daly	9–18	6·4	26·7	19·6	25·8	18·5	2·9	..	0·9	Silt loam	10
987B	Foley	6–12	4·2	13·7	14·9	40·4	21·7	4·3	..	..	Silt loam	12
992	Orbell	9–15	8·1	28·0	16·1	25·9	17·7	3·7	..	0·7	Silt loam	13
1000	Jackson	9–15	5·5	27·6	14·4	28·3	20·4	3·6	..	..	Silt loam	10
	KERETA SERIES.											
1004	Donald	9–15	2·1	26·7	20·7	27·4	19·2	2·8	..	..	Silt loam	17
	AROWHENUA SERIES.											
990	Gaffney	9–15	14·6	63·7	5·1	8·3	5·5	2·1	..	..	Fine sand	2
997B	Hall	6–12	1·8	15·8	8·5	44·1	22·5	5·6	1·7	..	Silt loam	1
996	McCully	9–15	1·1	14·6	14·3	42·1	23·0	5·2	..	0·4	Silt loam	1
	WASHDYKE SERIES.											
1002	Hall	9–18	1·9	17·1	9·3	43·3	23·5	4·9	..	..	Silt loam	..

A subsoil of even number corresponds to a topsoil of the preceding odd number. Samples 987B and 997B correspond with 987A and 997A respectively.

NOTE.—Results are percentages on an ignited basis and calculated to moisture-free soil.

TABLE III.—CHEMICAL ANALYSES.

Topsoils, 0 in.–6 in.

Laboratory No.	Farmer.	Available Plant-foods (1 per Cent. Citric Acid).		pH.	Lime Requirement corrected to 0·015 N ($CaCO_3$).	Replaceable Bases.		Total Nitrogen (N).	Plant Foods soluble in Hydrochloric Acid (S.G. 1·12).	
		Phosphoric Acid (P_2O_5).	Potash (K_2O).			Lime (CaO).	Magnesia (MgO).		Phosphoric Acid (P_2O_5).	Potash (K_2O).
	LEVELS SERIES.									
	Stony Silt Loams. Type 14 (grading to 16).									
		Per Cent.	Per Cent.		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1185	Scott	0·022	0·046	5·7	0·20	0·15	..	..	..	..
983	Kelman ..	0·009	0·020	5·6	0·21	0·09	0·05	0·22	0·054	0·59
985	Foley ..	0·012	0·058	5·9	0·14	0·18	0·07	0·28	..	..
843	Burns ..	0·008	0·012	..	..	..	..	..	..	..
1167	T. W. Brosnan..	0·013	0·014	5·7	0·14	0·14	..	..	..	..
	24 in.–36 in. plus Silt Loams. Type 10.									
1171	Mehrtens ..	0·010	0·034	6·0	0·12	0·10	..	..	..	..
1169	Cargo.. ..	0·011	0·010	5·5	0·12	0·10	..	..	..	..
993	Daly	0·010	0·026	5·7	0·17	0·11	0·054	0·21	0·051	0·55
1181	Walsh ..	0·014	0·009	5·6	0·21	0·09	..	..	..	..
	18 in.–24 in. Silt Loam, occasionally slightly Stony. Type 12.									
987A	Foley ..	0·009	0·025	5·9	0·17	0·19	0·06	0·24	..	..
1179	T. M. Brosnan ..	0·012	0·021	5·8	0·18	0·16	..	..	..	..
	12 in.–18 in. Moderately Stony Silt Loam. Type 13.									
991	Orbell ..	0·024	0·017	5·7	0·17	0·13	0·052	0·22	..	..
1177	Oliver ..	0·014	0·024	6·0	0·13	0·12	..	..	..	..
999	Jackson ..	0·016	0·016	5·6	0·19	0·15	0·056	0·20	..	..
	KERETA SERIES.									
	Meadow Soils.									
1003	Donald ..	0·028	0·034	5·4	0·22	0·13	0·094	0·28	0·061	0·55
1449	Aitken ..	0·014	0·008	..	..	..	..	..	..	..
	AROWHENUA SERIES.									
	24 in. and over, Sands, Sandy Silts, and Silt Loams. Type 2.									
989	Gaffney ..	0·045	0·012	5·8	0·11	0·10	0·044	0·14	..	..
1165	Kane ..	0·047	0·021	5·7	0·09	0·11	..	..	..	..
	24 in.–36 in. plus Silt Loams. Type 1.									
997A	Hall	0·058	0·028	5·6	0·19	0·17	0·077	0·28	0·126	0·76
1183	Smith ..	0·059	0·021	5·7	0·17	0·16	..	..	..	..
841	Robins ..	0·057	0·028	..	..	..	..	..	..	..
995	McCully ..	0·060	0·024	6·2	0·11	0·30	0·080	0·30	0·137	0·75
1175	Taylor ..	0·068	0·045	6·3	0·06	0·20	..	..	..	..
	SEADOWN SERIES.									
	Meadow Soils.									
1447	Springs ..	0·037	0·052	..	..	..	..	..	..	..
1445	O'Connor ..	0·036	0·021	..	..	..	..	..	..	..
1173	Brosnan ..	0·080	0·033	6·2	0·12	0·31	..	..	..	..
	WASHDYKE SERIES.									
	Saline Soils.									
1001	Hall	0·048	0·029	5·4	0·20	0·14	0·081	0·28	..	..
1005	Colombs Road ..	0·031	0·220	5·0	0·63	0·51	0·74	2·12	..	..

NOTE.—Results calculated to oven-dry soil.

TABLE IV.—RELATIONSHIPS OF THE SOIL TYPES TO WATER.

Laboratory No.	Farmer.	Depth of Sampling.	Percentage of Moisture at Sticky Point.	Apparent Density.	Maximum Water-holding Capacity.	Pore Space.	Specific Gravity.	Index of Texture.	Moisture Equivalent Bouyoucos.	Hygroscopic Moisture at 50 per Cent. Humidity.
		Inches.								
LEVELS SERIES.										
Stony Silt Loams. Type 14 (grading to 16).										
1185	Scott	0–6	..	..	..	..	..	..	32·4	..
983	Kelman ..	0–6	25·7	1·13	51·5	54·7	2·38	15·4	26·7	2·2
985	Foley ..	0–6	29·9	..	..	..	..	21·7	31·0	..
843	Burns ..	0–6	..	..	..	..	..	..	28·4	..
1167	T. W. Brosnan..	0–6	..	..	..	..	..	..	32·4	..
24 in. – 36 in. plus Silt Loam. Type 10.										
1171	Mehrtens ..	0–6	..	..	..	..	..	..	34·0	..
1169	Cargo.. ..	0–6	..	..	..	..	..	..	34·8	..
993	Daly	0–6	..	..	..	..	..	..	29·1	..
1181	Walsh ..	0–6	..	..	..	..	..	..	31·0	..
18 in. – 24 in. Silt Loam, occasionally slightly Stony. Type 12.										
987A	Foley ..	0–3	30·4	0·99	59·0	58·1	2·29	23·9	31·8	2·8
987B	,, ..	6–12	25·3	1·15	47·6	54·3	2·38	18·6	29·2	2·0
1179	T. M. Brosnan ..	0–6	..	..	..	..	..	..	35·7	..
12 in. – 18 in. Moderately Stony Silt Loam. Type 13.										
991	Orbell ..	0–6	26·1	..	..	..	..	16·6	29·7	..
1177	Oliver ..	0–6	..	..	..	..	..	..	30·2	..
999	Jackson ..	0–6	..	..	..	..	..	..	27·9	..
KERETA SERIES.										
Meadow Soils.										
1003	Donald ..	0–6	..	..	..	..	..	..	33·5	..
1449	Aitken ..	0–6	..	..	..	..	..	..	38·9	..
AROWHENUA SERIES.										
24 in. and over, Sands, Sandy Silts, and Sandy Loams. Type 2.										
989	Gaffney ..	0–6	20·8	1·33	39·1	48·9	2·48	6·5	21·5	1·3
1165	Kane	0–6	..	..	..	..	..	..	26·5	..
24 in. – 26 in. plus Silt Loam. Type 1.										
997A	Hall	0–6	34·4	0·99	68·6	61·6	2·45	29·6	36·0	2·5
997B	,, ...	6–12	30·3	..	..	..	..	25·0	..	..
1183	Smith ..	0–6	..	..	..	..	..	..	35·0	..
841	Robins ..	0–6	..	..	..	..	..	..	34·0	..
995	McCully ..	0–6	35·0	0·94	70·7	..	..	29·5	35·5	2·5
1175	Taylor ..	0–6	..	..	..	..	..	..	34·1	..
SEADOWN SERIES.										
Meadow Soils.										
1447	Springs ..	..	..	..	..	..	..	..	46·0	..
1445	O'Connor ..	..	..	..	..	..	..	..	41·4	..
1173	Brosnan ..	..	..	..	..	..	..	..	53·6	..
WASHDYKE SERIES.										
Saline Soils.										
1001	Hall	..	..	..	..	..	..	..	35·5	..
1005	Colombs Road	..	..	..	..	..	..	..	79·0	..

NOTE.—Moisture at sticky point determined by the method of Keen and Coutts. (*Jour. Agr. Sci.*, 1928, *18*, 740–765.)

Index of texture = moisture at sticky point $-\frac{\text{Percentage of sand.}}{5}$ (Hardy: *Jour. Agr. Sci.*, 1928 *18*, 252–256.)

Apparent density, water-holding capacity, pore space, and specific gravity determined by Keen-Raczkowski method, Coutts modification. (*Jour. Agr. Sci.*, 1930, *20*, 407–13.)

SOIL SURVEY OF THE REDCLIFF IRRIGATION AREA: PROGRESS REPORT.

(By J. K. Dixon.)

On the Redcliff irrigation area a soil survey has been carried out with the assistance of Mr. K. S. Birrell, who has made a detailed map of the scheme, while at the Cawthron Institute analyses of typical samples have been made. The map and results will be the subject of a later report.

Three main soil types can be recognized in this area:—

Type 1: A deep silt loam. A typical profile is—

10 in. grey silt loam;
On 3 in. + mottled yellow silt loam, crumb structure.

The type occurs along the Pike's Point Road, and is very even except where flood-water from neighbouring gullies has deposited small fans varying in texture from clay loams to stony sandy loams.

Type 2: A stony silt loam. A silt loam deposited on a high shingle bank of the Waitaki River. The stones are visible on the soil surface.

Type 3: Gravels to sandy loams derived from recent alluvium brought down by the Elephant Hill Stream. The centre portion of the irrigation scheme served as a flood-plain to this stream before another outlet was made to the Waitaki River. In certain cases the old surface soil can be located 2 in. below the present level.

All the types appear suitable for irrigation purposes, although an area near the Public Works Camp carries rushes, and it may be necessary to drain this more efficiently. Since the main types vary from silt loams to stony sandy loams it is obvious that the duty of water will not be the same in each case, and experiments will be necessary to determine the optimum treatment for each type. The stony sandy loams will require less water at each application, but applications will need to be made more frequently than on the heavier types. A comparison of the "moisture at sticky point" figures compared with similar types from the Levels area indicates that the field capacities of the related soils should be of the same order.

As far as the nutrient status is concerned the analyses show that the deep silt loams and recent alluvial soils are well supplied with available phosphate. The Waitaki type (stony silt loam), however, has a lower figure. It is to be expected that this type will show a definite response to phosphate top-dressing under an irrigation scheme.

Available potash and total nitrogen are present in average amounts on all types. The pH values for typical soils range from 4·9 to 6·7. Soils with the lower pH value should give a marked response to lime for a wide range of crops. In the case of soils with pH values greater than 6, there should not be any necessity for immediate treatment with lime. Nevertheless, the lime status of the soils should be carefully watched, for it must be remembered that a much greater leaching of bases, particularly on the stony phases, will take place than has been customary in the past, and a developing acidity is to be anticipated.

In conclusion, it can be said that the nutrient status is high enough at present to assume that water has been the limiting factor for growth in the past; in the future, under irrigation, the nutrients will become the limiting factor, and it is necessary that the optimum top-dressings be ascertained for each type.

"NEW ZEALAND JOURNAL OF SCIENCE AND TECHNOLOGY."

The *New Zealand Journal of Science and Technology* has continued to act as a valued medium for the publication and dissemination of the results of research work carried out by the Department of Scientific and Industrial Research and other Government Departments, as well as by other scientific institutions in New Zealand. During the past year the issue of the *Journal* at two-monthly intervals was continued. It was felt, however, that increased publication space was necessary, both for encouragement of workers and for quicker dissemination of results, so that the work would be brought more directly to the notice of those interested. The Research Council unanimously recommended that the *Journal* be published at monthly intervals, and it is hoped that this resolution will be carried into effect next year.

IMPERIAL AGRICULTURAL BUREAUX.

The Imperial Agricultural Bureaux were established to collect, collate, and disseminate information on research in selected branches of agricultural science, and generally to assist research workers in the Empire with information on their particular subject. The Department of Scientific and Industrial Research acts as the New Zealand co-operating Department with the eight Imperial Bureaux, each of which has its official correspondent in the Dominion. There is abundant evidence that the publications and services of the Bureaux are of the greatest value to research workers in New Zealand, who are thus brought into much closer contact with research work overseas than would otherwise be possible.

RESEARCH SCHOLARSHIPS.

A National Research Scholarship, with an annual value of £100, was awarded during the year to Grace E. Wall, Victoria College, for research on "Entomological problems in connection with the growing of *Phormium*." Miss Wall will work under Dr. Yeates at Massey College in connection with yellow leaf and leaf-eating caterpillars.

RESEARCH WORK AT CANTERBURY AGRICULTURAL COLLEGE, LINCOLN.

I. Plant-breeding.

(*a*) *Cereals.*

1. *Wheat.*—The College has continued the work of wheat-breeding and selection in co-operation with the Wheat Research Institute, the College supplying the land, horse labour, and laboratory and other facilities.

The outstanding event of the year has been the distribution of about 3,000 bushels of Cross 7 wheat to about 100 farmers from Blenheim to Oamaru. This wheat was produced from a cross between Tuscan and White Fife, one of the best Canadian wheats. The cross was made by the College in 1923, and its progeny handed over to the Wheat Research Institute on its inception.

Reports from most of the 100 farmers that grew the wheat are generally very favourable, and all of them state that they will grow the wheat again. The merits of the wheat are as follows :—

(1) It yields as well as Tuscan (which accounts for 70 per cent. of Canterbury wheat) on all land suited to that variety. The 1936 harvest reports generally state that it yielded better than Tuscan, but this has not been the case in experimental plots.

(2) It gives 3 per cent. more flour on the experimental mill, and one commercial trial gives indications in the same direction.

(3) It gives a 10 per cent. better loaf and the price is therefore 2d. per bushel above that of Tuscan.

From the farmer's point of view it has the following merits :—

(1) It grows as well and as quickly as Tuscan, and there are indications that it will at least equal that variety for use as a spring wheat and for feeding off.

(2) It ripens about a week earlier than Tuscan. This helps the wheat to escape the effects of the dry weather in midsummer, tends to spread out the harvest rush of work, and often secures the best weather for heading.

(3) Its straw is about 4 in. shorter than that of Tuscan. This reduces the labour of harvesting by about 5 per cent.

(4) The straw has less flag, packs into neater sheaves, and so is easier to stook and stack.

(5) The straw is much stronger than that of Tuscan, so that it stands up in heavy land or in wet seasons instead of being laid and tangled. This reduces harvest work very greatly, and often makes the difference between a good crop and an almost total failure. The advantage is greatest in South Canterbury, where crops are often laid, and one competent observer has calculated that this year one-third of the wheat sown in South Canterbury will be Cross 7.

(6) The grain is securely held by the chaff so that the new variety resists the threshing action of the wind as well as Tuscan does. It is also reported to thresh more easily on the threshing-mill. These apparently contradictory statements can be reconciled by supposing that the chaff of Cross 7 is tougher at the binder-ripe stage, but becomes more brittle at the threshing stage.

The disadvantages of the variety are fewer and less important. They are as follows :—

(1) All impurities show up more plainly, because all other varieties are taller than Cross 7, and therefore advertise their presence. This is really an advantage, although it looks bad.

(2) The variety is almost certainly more susceptible than Tuscan to loose smut. This makes difficulties from the aspect of certification of the seed, and may make treatment with hot water necessary at more frequent intervals. The loss on the worst-affected crops this year was, however, only about ½ bushel per acre.

(3) In a very wet harvest such as that of 1936, Cross 7 sprouts very easily in the stook. This may be a result of easier germination, but it is more likely the result of the neat and well-packed sheaves and stooks that Cross 7 builds. When the stooks get thoroughly wet through they dry out more slowly than those of other varieties, and therefore the heads in the middle of the sheaves sprout more. This objection is a very real one, and has caused considerable loss this year. Harvests in which any sprouting occurs are very rare. In North Canterbury there have been only two such seasons in the last thirty years.

On the whole, the new variety promises to be a pronounced success. Its chief merit is perhaps that it combines a satisfactory yield with improved quality.

Five investigations on wheat-growth, although not plant-breeding, are most conveniently described here.

(1) Observations on the soil moisture in wheat-fields have been carried on for the fourth season. It is hoped that soil moisture during the growing-season may be a means of forecasting the yield. There is a fair prospect of success, but this is a long-range investigation.

(2) For the third season, wheat has been grown in pots in the open, all pots being treated alike except that the water content of the soil was controlled. During the growing and ripening season all the pots were kept dry—*i.e.*, the soil contained 20 per cent. of the amount of water required to produce saturation—but sufficient water to bring the moisture content up to 60 per cent. saturation was added to one pair during September, to another pair during October, and so on. The results for

1935–36 are summarized in the following table, which shows the months in which the water content was raised to 60 per cent. saturation, and the corresponding yields of grain :—

Month.	Yield of Grain (in Ounces).	Month.	Yield of Grain (in Ounces).
1935.		December	1·29
September	1·87	1936.	
October	4·18	January	2·50
November	1·01	February	1·90

This indicates very clearly that sufficient soil water in October is more important than in any other month of the year. This corresponds with the period in which the wheat-stalks are lengthening. Water at that period allows many of the tillers to grow and produce heads. There is apparently another month in which an adequate water-supply is important, though much less important than October—namely, January, when the grains are filling. The heads produced by the October moisture are thus enabled to produce large grains, and consequently a high yield. It thus appears that the highest grain-yields should be obtained when there are useful rains in October and in January, and that drought in the other months is relatively unimportant.

This investigation is being undertaken in the hope of correlating these findings with soil-moisture in the field.

(3) For the third season, trials have been made of the effect on yield of feeding off wheat by sheep. A very good trial was made this year on a College paddock, four areas of about $\frac{1}{10}$ acre each being fed off, and four similar areas being left unfed. There was no difference in the yield. Thus in two seasons there has been no difference in yield, and, in one, feeding off depressed yield by about 4 bushels per acre. This is contrary to the statement often made, that feeding off increases tillering and therefore increases yield. It would be truer to say that wheat should never be fed off unless (*a*) the feed is needed for sheep, or (*b*) it is feared that the crop will go down.

(4) *Wheat-pickling.*—A line of Hunters free from smut was treated with various pickles. A field trial of four replicated half-drill strips of each pickling was sown, and the yields are given below. The yields are the average of the four replicates.

Treatment.	Yields in Pounds per Acre.	Treatment.	Yields in Pounds per Acre.
Ceresan	23·00	Formalin	23·00
Agrosan	24·25	Bluestone	22·25
Copper carbonate ..	23·50	Untreated	22·00

There are no significant differences, but there is a tendency to increased yields from the organic-mercury dusts. This is in accordance with the results of previous seasons.

(5) *Thickness of Sowing.*—In the course of his work on the foot-rots of wheat, Mr. I. D. Blair (whose results are published in the *New Zealand Journal of Agriculture*, March, 1936) sowed wheats at different thicknesses with the following results :—

Rate of Seeding (Pounds per Acre).	Yield in Bushels per Acre.	Rate of Seeding (Pounds per Acre).	Yield in Bushels per Acre.
90	37·16	150	37·60
120	37·06	150	40·70

This is in accord with the results of Mr. A. W. Hudson's work, showing the benefits of thicker sowing with our present commercial drills.

2. *Oats.*—The cross-breds Algerians by Gartons and Algerians by Duns have been abandoned. Selections in Algerians are showing some promise. Eighteen selections were sown in field trials, and of these six have been retained. Their performance was as follows :—

Selection.	Difference from Control.	Selection.	Difference from Control.
	Per Cent.		Per Cent.
Control (College B 49)	..	1/10	+11·0
5/6	+16·3	1/12	+ 3·0
11/19	+15·0	3/6	— 2·8
12/19	+ 8·0		

These have been selected because of high yield, low percentage of husk, and suitability of straw. Fifteen acres of these strains have been sown for final selection.

A variety trial has been carried on for three seasons, and two varieties and two strains have given outstanding results. They are—

Winter grey averaged 26 per cent. more than B 49.
Warrigal averaged 44 per cent. more than B 49.
475 averaged 11·4 per cent. more than B 49.
397 averaged 7·7 per cent. more than B 49.

All the others yielded less than B 49. The above four have been sown again in field trials.

Oat-pickling.—A line of Algerians free from smut was pickled with various substances to see if we get here the good results from organic mercury reported elsewhere. The means of the five replicates in the field trials were as follows:—

Treatment.	Yield in Pounds per Plot.	Treatment.	Yield in Pounds per Plot.
Agrosan	39·2	Formalin	38·8
Ceresan	38·1	Untreated	39·1

(*b*) *Herbage Plants.*

1. *Perennial Rye.*—Selection, self-pollination, and cross-pollination are being carried out as usual. In strain-building, about 3 bushels of strain 131 were harvested, and the grain is being further tested by mowing and grazing.

Propagation.—A $\frac{1}{8}$ acre block of strain 131 was harvested for seed, and the seed is being sown for bulk seed-production. Strain C 131 is a strain selected for drought resistance and production in the autumn and winter months. It is superior to certified lines of rye-grass in February and March (from field data) and in winter (from observation—yield data are not yet available), while it is inferior to them in total production in November and December. However, it is distinctly less stemmy than these lines, and this may compensate for lower total production in the spring and early summer months.

2. *Cocksfoot and Red Clover.*—The work on cocksfoot and red clover is on similar lines to that reported for rye-grass. Offspring tests, strain-building, and propagation plots have been established. This work is on the lines of that indicated in previous reports.

Propagation of Cocksfoot C 23.—The Farm Advisory Service has arranged to grow the seed harvested this year on certain farms under its control. The seed is being grown on contract. The fields on which the seed is to be sown are specially fallowed and free from rye-grass and weeds. Deep organic soils are chosen. There will be 40 acres of this seed available for next harvest.

II. Animal Nutrition.

The large-range experiments on the feeding of sheep on different kinds of pasture are being continued. Eight hundred Corriedales are being used in trials for various purposes on light land.

Feeding trials on pigs are being continued with different materials as the need arises.

An elaborate trial of the digestibility of various feeds is in progress. Four iron metabolism cages have been built to Dr. Franklin's design, and it is thought that these embrace all the good qualities of the designs seen at the various stations overseas. Each cage holds a sheep, which lives in its cage for several weeks on end. All its food is weighed and analysed, and all the urine and dung is similarly weighed and analysed; the digestibility of the foods—that is, their use to the sheep—is thus determined. These trials furnish an important lead to field trials, and may often point the way to improvements in feeding methods.

In the first trial turnips and meat-meal were the subject of investigation, and co-efficients of digestibility of all the food materials were established.

In a second trial sheep were kept for twelve weeks on hays made of grass, clover, oats, vetches, and lucerne cut at different stages and harvested by different means. The losses in food substances due to different methods of harvesting were determined, and indications are given for the best stages for the cutting of hay, not from the point of view of the amount of dry matter, but from that of the amount of digestible food per acre.

There is an immense amount of detailed analysis involved in such work and experiments, but it appears to be well worth while, as a guide to farming practice.

Another investigation has been started on the quality of protein in certain grasses. This is being done as a guide to palatability, and Hawke's Bay rye-grass as grown in Canterbury is one of the materials under investigation.

III. Entomology.

Investigations of the insect fauna of grain-stores were commenced, and many stores and flour-mills have been visited. A list of the insects observed, with their frequency and the damage they do, has been prepared, and a survey of the methods used for their control has been completed. It was found that in most cases insects and mites were fairly easily controlled, largely because there is no long period of storage. Grass-seed cleanings held in store to await farmers' instructions are, however, a fertile source of trouble, and recommendations are being made to grain and seed merchants to consider alteration of their procedure in this matter.

Two cases of very serious trouble in the storage of vegetable products were traced, and the advice given resulted in the extermination of the pest.

The structure of many of the older buildings makes control of insects difficult without constant work, and advice was given as to the design of new buildings where they are contemplated.

While most grain-stores have the insects under fair control, it was found that all of them are infested with rats and mice, which cause considerable worry to the storemen. Cats are relied on to a great extent, and poisons are disliked because they tend to kill the cats as well as the rats. Trials with red squill, a poison which is fatal to rats but harmless to cats, have proved quite efficaceous, and arrangements have been made to import several hundredweights of the poison for distribution to grain stores and mills.

Mr. Morrison visited the Australian Entomological Stations during January and observed the methods used there for control of the insect and other pests found in New Zealand.

IV. Farm Economics.

The ordinary researches into farm management, costs, and production are being continued.

A special survey of the farm activities of the Ashburton County is being made with the aid of five honours students, who are carrying out the following investigations:—

(1) A general farm-management survey of the whole of the plains district, and especially of that area of 25,000 acres which is to come under irrigation.
(2) Wheatgrowing methods and practices.
(3) Cocksfoot-growing methods from the points of view of both grazing and seed-production.
(4) Sheep-farming on the plains area.
(5) Sheep-farming methods, costs, production, &c., on the mountain runs.

The figures and experience gained from these surveys will give a basis for a national survey of land-utilization in the island, and a means of measuring changes that take place.

V. Wool Research.

All the fleeces of all the stud ewes and rams have been weighed as usual, with the object of tracing the method of inheritance of wool-production, and of selecting the best sires and dams. The results for seven years are now available. They show considerable variation from year to year, but the fleeces shorn in 1935 of all except the Southdowns averaged over 10 lb. This is no indication that the hogget produces any heavier fleece than the same sheep when mature, and there is again no indication that the third fleece of any sheep is its heaviest. Feed conditions are the governing factors in wool-weights.

Scouring of fleeces is being continued as a check on wool-weights, since different sheep of the same flock carry different proportions of grease, and the weight of clean wool is wanted. It has sometimes been assumed that the proportion of grease in the shoulder wool will give a correct measure of the proportion of grease of the whole fleece. This we have proved incorrect, and we are now engaged in finding out what quantities of the wool from different parts of the fleece are necessary to give a reliable sample for the whole.

VI. Soil-texture Research.

The means of describing soil texture are at present inadequate. The terms loam, sandy loam, &c., are inexact, and give little indication of their suitability for the numerous purposes to which soils are put—*e.g.*, foundations for buildings, bases for roads, stop-banks, irrigation ditches, irrigation watering, as well as for cultivation by agricultural implements. There are very few overseas workers on this subject, and the tables they have published are short and incomplete.

Five or six years ago, therefore, work was started on this subject, and a great number of determinations have been made on the physical properties of thirty soils of different types collected in various parts of Canterbury and Otago. The constants determined are—(1) grain density, (2) angle of friction, (3) loss on ignition, (4) lower plastic limit, (5) lower liquid limit, (6) sieve analysis.

A report on this work has been completed, and the remainder of the work dealing with other constants is in course of preparation. It is hoped to show that a soil can be completely described for all engineering purposes by the numerical expression of a very few factors.

VII. Farm Advisory Service.

The work has continued along the lines of previous years. Eleven farms are under complete control and twenty-one are under co-operative supervision. These researches into methods of management of farms as units have now reached the stage at which generalizations can be made, and great use of these generalizations can be made in the training of students. Agricultural students usually learn a good deal about crops, and stocks, and soil, but they have little chance to learn about farms and their organization. The research into farm-management then reaches its fruition in the students who go out into life as agricultural instructors. A considerable number of farms on different types of soils must be kept under supervision to produce the necessary material for this teaching-work, and to give examples from current experiences.

The Service suffers from lack of funds. Every assistant so far trained has left after about two years for much more lucrative employment, since other employers realize that the training received in the Service is of the very highest value.

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, 181; Police, 104; Geological Survey, 159; Main Highways Board, 304; Mines, 177 Health, 2,806; Post and Telegraph, 52; Research, 61; Public Works, 50; Railways, 51; Stores Control Board, 14; Agriculture, 188; Defence, 14; Prisons, 258; Government Printing Office, 48; External Affairs, 23; other Departments, 33.

In addition to these, 21 samples were received from municipal and other local bodies, and 572 from miscellaneous sources, a total of 5,116.

Auckland (Branch Laboratory): Health, 3,442; Police, 248; Public Works, 100: total, 3,790.

Christchurch (Branch Laboratory): Health, 2,260; Police, 190; other Government Departments, 41; miscellaneous, 23: total, 2,514.

Dunedin (Branch Laboratory): Health, 1,081; Police, 231; other Government Departments, 43; miscellaneous, 18: total, 1,373.

A total of 12,793 samples was received in the main Laboratory and the three branches.

Customs.

The majority of the reports made to this Department were for use for tariff purposes. In addition, a number of materials, including flour, fats, iodized salt, tea, cream of tartar, and liquid paraffin, were examined to ascertain if they complied with the regulations under the Sale of Food and Drugs Act. In cases of non-compliance with the regulations importation and sale would not be allowed.

Police.

As in the previous year, a large number of diverse materials were examined for the police in connection with criminal and other investigations, and various members of the staff have been consulted from time to time when it was considered that their special knowledge might be of assistance.

Wellington.—In one case of poisoning arsenic was found, in another, strychnine, and in a third, heroin. Two samples of chocolates seized by the police were found to contain poison.

A number of wines and "home brew" were examined in connection with alleged illegal sale of liquor.

Samples of whisky and schnapps were analysed to ascertain if they were true to label.

Medicines employed for attempted abortion, preparations suspected to contain dangerous drugs, and opium prepared for smoking were examined in connection with various police cases.

Certain stains on a bank-note were shown to be due to mineral oil.

In one case it was important to decide whether some human hair was from a European or a Maori. Some American workers had reported that hair from different races reacted differently to ultra-violet light, and that this provided a method of distinguishing hair according to race. Investigation showed that such was not the case, and that the proposed method was valueless for the purpose.

An interesting investigation was made in connection with the identification of glass fragments found on the clothing of a suspect. It was shown that they corresponded in specific gravity, reaction to ultra-violet light, and refractive index to glass from a broken motor-car wind-screen, but differed in these respects from a hundred other samples of glass from various sources.

Auckland.—During this year a very considerable amount of analytical work in connection with poisoning and other investigations was carried out for the police.

Lysol was found in three cases of death by poison, and prussic acid in another case.

In one case of poisoning, large amounts of barbitone (veronal) were found in various exhibits, and a charge of murder resulted, in which the accused was convicted.

A case of death by quinine poisoning was investigated. The deceased had taken at least $\frac{1}{2}$ oz. of quinine for the purpose of procuring abortion, and died in three hours.

A number of exhibits submitted by the police were articles of clothing and dust from the pockets of suspects. Gold filings were found in the dust from one pocket, and the owner was convicted of receiving the proceeds of a burglary.

In a case of arson it was possible to identify by chemical means the wood of the matches found at the fire.

In an investigation as to the identity of an unknown body it was found that the characteristic fluorescence of hair under ultra-violet light was destroyed by putrefaction in salt water.

Liquor samples examined were chiefly from the proclaimed area in the King-country.

Christchurch.—The following substances were present in exhibits submitted for toxicological examination: Nicotine, potassium cyanide, chloroform, phenobarbitone, ether, alcohol, zinc, and carbon monoxide.

A number of samples of "home brew" were examined, also cider sold illegally, which was found to contain 15 per cent. to 23 per cent. of proof spirit.

Four samples of ground grain for animal-feeding were submitted by the police as the result of complaints from a number of farmers. It was found that the grain had been mixed with 20 per cent. to 30 per cent. of ground limestone.

A number of preparations used for the purpose of procuring abortion were examined.

Bullets were submitted for examination of markings, and a pair of socks for the presence of wax derived from a waxed floor on which footmarks were observed.

Several bottles of toilet preparations on retail sale were analysed, and it was found that valueless material had been substituted for the original content.

In a case involving a charge of murder, the investigation of which was commenced during the previous year, a box containing twenty-five chocolates was forwarded by post, and examination proved that about half of these had been carefully charged with strychnine, the amount per chocolate varying from $\frac{1}{6}$ gr. to $\frac{1}{3}$ gr. The victim, an adult, died within an hour, and approximately $\frac{1}{7}$ gr. of strychnine was recovered from portions of the body. The case is remarkable in that the fatal dose was probably not more than $\frac{1}{3}$ gr. to $\frac{1}{4}$ gr. of strychnine.

Dunedin.—The year was remarkable for the very large amount of work received from the police, much of it being of a difficult and time-consuming nature.

Potassium cyanide was detected in one case of poisoning, and in another, phenobarbitone.

In a murder case, which involved an exhumation and the examination of a large number of specimens, barbitone was found in the body materials and in certain other specimens.

Many samples were examined in connection with breaking-and-entering cases.

Opium and other drugs seized by the police at an opium-den were examined, and also liquor-samples taken in connection with "sly-grog" cases.

Strychnine was found in two samples of chaff which had caused fatal poisoning of horses.

In a case of fatal bacterial food-poisoning, arsenic was found in quantities considerably greater than would be expected under normal circumstances, but much smaller than is usual in fatal arsenical poisoning. This rendered necessary the analysis of a large number of specimens of material from the home of the deceased, without a conclusive result. An extended investigation is being carried out with the object of ascertaining the amounts of arsenic which may be considered as normal in various organs of the body.

In an inquiry regarding an accidental death, sufficient alcohol was found in the urine to indicate that the deceased was intoxicated at the time of the accident.

Department of Health.

Samples of milk, numbering 8,681, were examined at the main Laboratory and the three branches. This is an increase of 860 on the previous year's figures.

Milk.—Wellington: Of 1,886 samples submitted from Wellington City and suburbs, 14 were deficient in fat, 2 were deficient in solids other than fat, 3 contained added water, 14 were stale, and 1 contained excessive dirt. The percentage of samples not complying is very small, and the record is equally as good as in the previous two years. It is again satisfactory to note that Wellington milk-supply maintains its high standard, both in regard to its nutritive value and cleanliness.

From the country districts, which include Nelson, Marlborough, Wellington Province (except Wellington City), Taranaki, Hawke's Bay, and Gisborne, 914 samples were examined. Of these, 3 were deficient in fat, 8 contained added water, 2 contained excessive dirt.

Auckland: Of 2,320 samples from Auckland City and suburbs, 21 contained added water, 18 were seriously deficient in fat, 4 contained appreciable amounts of visible dirt, and 35 were stale (as shown by the reductase test). Of 29 other samples, 18 were slightly deficient in fat, 8 were below the standard for solids other than fat but did not contain added water, and 3 were somewhat stale.

As a result of prosecutions during the previous year, the number of samples containing visible dirt and of those below the standard in solids other than fat was considerably reduced. As regards the number of samples containing added water, those of low-fat content, and those which were stale, there is no improvement as compared with the previous year.

During the year reductase tests have been continued on milk-samples at Hamilton, and tests have also been made at Whangarei. The results were satisfactory.

The newly introduced phosphatase test for the detection of effective pasteurization was investigated, and was found to give definite and reliable information. It is now used as a routine test and will be of great value in the control of pasteurized milk.

Christchurch: The number of samples examined was 2,103, of which 1,359 were from Christchurch City and suburbs, the remainder being from the provincial districts of Canterbury and Westland.

Christchurch City and Suburbs: Of the 1,359 samples from this area, 18 contained added water, 45 were slightly deficient in solids other than fat, 16 deficient in fat, and 14 were stale (as shown by reductase tests). The percentage not complying with the regulation was 6·8, compared with 7·2 for 1934. This includes 45 samples, out of the total of 1,359, which were slightly below the standard in solids other than fat, but did not contain added water. A special investigation of these low-testing milks has been commenced. As stressed in the previous annual report, the legal standard is a very reasonable one and readily attained, as shown by records of the average composition of milk sold over a long period of years. There is the additional consideration that from the consumers' point of view it matters little whether poor-quality milk is naturally so or has been made so by the addition of water.

With regard to the reductase test the legal standard is at present three hours, but investigation over a number of years shows that this could be raised to five hours. The percentage of samples during 1935 which reduced the methylene-blue in less than three hours was only 3·6. This indicates that as regards freedom from bacterial contamination the condition of Christchurch milk-supply is most satisfactory.

Outside Districts: The number of samples examined was 744, of which 517 were from Canterbury and 227 from the West Coast Districts. Of these, 25 were slightly deficient in solids other than fat, and 13 were deficient in fat.

Reductase tests were made of samples from several outside towns, including Timaru, and the results showed that these were satisfactory from a bacterial standpoint.

Dunedin: The total number of samples submitted was 924, of which 408 were from Dunedin City and suburbs and the remaining 516 from the country districts of Otago and from Southland. The sampling for special bacteriological testing has interfered seriously with proper sampling for chemical examination. Now that it has been shown that the reductase test gives more uniform and reliable results than bacteriological counts, more samples are being taken for the former test. The number of samples taken in Dunedin City and suburbs could with advantage be increased to about 1,500 per year. Of the Dunedin samples, 7 were deficient in fat, 6 were stale, and 19 were slightly below the standard in solids other than fat but did not contain added water; of the samples from the country districts, 6 were deficient in fat, 1 contained added water, and 16 were slightly below the standard for solids other than fat but did not contain added water. Attention has been drawn above to the question of poor-quality milk not containing added water. It is significant that in the Wellington District, where a large number of milk-samples have been examined over a long period, very few samples received are naturally poor milk.

Reductase Test.—It is pleasing to note that the Minister of Health, Great Britain, published during 1935 a report on "The Bacteriological Grading of Milk," in which it is stated that the reductase test is the most satisfactory method for controlling the bacteriological quality of milk-supplies.

The experience of this Laboratory, extending over twenty years, is that the test is of very great value in checking the sale of stale milk. There is no doubt that its use has in a large measure contributed to the improvement which has taken place in the bacteriological quality of milk sold for town supply in New Zealand.

The Ministry of Health report, which is based on a prolonged investigation, confirms the opinion held in the Laboratory for many years and shows that in addition to the advantages of low cost and simplicity the reductase test gives for milk more reliable results than the somewhat complicated and expensive method of bacteriological counting by plating out.

Water.—A total of 393 samples, mostly from existing and projected town supplies, were analysed in the four laboratories.

A special investigation is being carried out on the Waitara water-supply by the Medical Officer of Health, New Plymouth, and it is expected that the resulting data will be of value in connection with the control of the purity of Taranaki water-supplies.

Miscellaneous.—A large number of various articles used as food and drink were examined. They included apricots, bacon, baking-powder, beer, blanc-mange powder, bread, bread improvers, cake, cheese, chocolate, coconut, corned meat, coffee, coffee and chicory essence, cream, cream of tartar substitutes, ice cream, icing-sugar, iodized salt, olive oil, split peas, pepper, potatoes, rennet, teas, tinned fish, tripe, vinegar, and whole-meal bread.

A sample labelled "Ships' Coffee" was found to be coffee and chicory.

Of 260 butter samples examined in the main Laboratory and the three branches, 8 contained water in excess of the maximum allowed (16 per cent.). No boric acid was found in any of the samples.

A number of samples of enamelware examined for antimony and other poisonous metals were found to be free from these metals. However, in some cases it was found that the enamel was of inferior quality in that it was somewhat easily attacked by weak acid solutions and would not be durable in use.

Samples of earthenware ovenware were examined for the presence of lead in the glazes, but in no cases were significant amounts of lead found.

One sample of the ware was remarkable in that treatment with dilute acid at cooking temperatures dissolved considerable amounts of zinc from the glaze. Dilute hydrochloric acid (normal) kept at the temperature of the water bath for thirty minutes dissolved zinc equivalent to 0·4 grm. of the metal per 100 mil. acid.

Zinc oxide is used in glazes to give a matt effect, which was apparent in the sample. Although zinc is not as toxic as lead, it is evident that in this glaze its solubility is such that acid foods cooked in the dish would dissolve undesirable amounts of zinc.

An extensive investigation was made of all the available brands of iodized salt on the market, in regard to the proportions and distribution of iodide in the salt and the rate of loss of iodides under various conditions of storage. It was found that the iodide content of iodized salt sold in 5 lb. bags is as satisfactory as that in tins or cartons.

The investigation will be completed at an early date, and it may then be possible to suggest a form of container which will prevent loss of iodide from the salt on keeping.

A variety of drugs were examined to ascertain if they complied with the requirements of the regulations under the Sale of Food and Drugs Act. They included extract of cascara, talcum powders, camphorated oil, ointments, tinctures, oil of turpentine, aspirin tablets, castor-oil, fruit saline, lime-water, liquid paraffin, lysol, olive-oil, corn cure, and dextrose. They were found, with few exceptions, to be of satisfactory quality.

A number of samples of air taken in connection with the ventilation of workrooms and theatres were examined during the year.

Mines Department.

The Dominion Laboratory has, as in past years, carried out the testing and analysis of mineral samples and mine gases. Prospectors' samples from all parts of the Dominion have been examined for gold and silver and occasionally for other metals. Among the samples of mine airs forwarded by the inspection staff of the Mines Department, a number were taken for the purpose of checking the readings given by a McLuckie gas-indicator.

The experiments undertaken by the Department in co-operation with the Laboratory with a view to determining the effect of storage on swelling properties of various coals were completed. It had been suggested that the swelling might be reduced after exposure to the air, thus rendering the coal more suitable for use in continuous vertical gas retorts.

From this point of view the results were disappointing, as very little if any alteration in the swelling properties of the coals tested was detected after eight months' exposure to the weather.

During the year consideration has been given to the possible exploitation of cinnabar and asbestos, but so far no actual experiments have been made.

Progress in coal research and utilization abroad is being closely followed, and during his recent visit to Great Britain Mr. W. A. Joiner, the Fuel Chemist of the Laboratory, had the opportunity of spending a month at H.M. Fuel Research Station, and of visiting the new coal-hydrogenation plant erected by Imperial Chemical Industries, Ltd., at Billingham, this company's coal-testing laboratories at Winnington, the Safety in Mines Research Stations at Buxton and Sheffield, and other places of interest in connection with the utilization of coal. In this way it has been possible to make direct contact with those engaged in fuel investigational work in Great Britain, and to gain some first-hand knowledge of the advances being made.

It has recently been proposed that a physical and chemical survey of the coal resources of the Dominion should be commenced, and the matter is under discussion at the present time.

Government Stores.

As in previous years, numerous samples were analysed in connection with the purchase of stores by the Stores Control, Post Office, and other Government Departments. These included concrete, cleaning-compounds, cancelling-inks, calico, fencing-wire, fuel oil, formalin, galvanized iron, motor-spirit, red lead, rope, soldering-mixtures, shellac, sulphuric acid, transformer oils, type-metal, and switchboard materials.

Several interesting cases of corrosion were dealt with during the year. In an investigation, lasting some months, into a particularly severe type of corrosion of lead cable-sheathing, the corrosive nature of the impregnated jute wrapping was strikingly demonstrated.

A comparative examination was made of a series of tent-canvasses to ascertain the nature of the various waterproofing and anti-mildew treatments which they had received. The suitability of each for the collection of rain-water for drinking purposes was also examined. One sample (iron-chromium process), being free from any water-extractable constituent of a toxic nature, was recommended as the best for this purpose.

The facilities available at the Laboratory for the testing of paints and painters' materials are being made use of to an increasing extent by the various Government Departments. Owing to the many new products that have become available, the possibility arises not only of gross adulteration of paints, but also of inferior results being obtained through the mixing of incompatible materials. In this, as in other fields, the excellent technical and reference library that has been built up over a period of years is proving invaluable.

Gas-inspection.

The gas-supplies of the four main centres and of the other principal towns were examined regularly for calorific value, purity, and pressure. With one exception, they were all of satisfactory quality throughout the year.

Research.

Pozzolanic Material.—During the year a further series of samples of volcanic material collected by the Geological Survey was examined for pozzolanic activity. The work is being continued.

Mineral Waters, Rotorua-Taupo District.—The analytical examination of these waters was completed during the year, and the results will be incorporated in a bulletin to be issued by the Director, Geological Survey.

Spray Research.—Work for the Plant Research Station, Palmerston North, included many analyses of apples and apple-leaves for arsenic residue from trees which were sprayed under varying conditions of pressure and of fineness of the spray-mist.

Several samples of lead arsenate were examined during the year. In one case a sample which had been supplied as lead arsenate and had caused severe damage to fruit-trees proved on analysis to be arsenious oxide (white arsenic).

Further samples of tobacco grown for the purpose of studying the effect of cultural practices on the nicotine content were examined. The results will be published at an early date in the *Journal of Science and Technology*. The highest percentage of nicotine found in the leaf was 15·9, calculated on the dry weight.

With a view to checking the ravages of white butterfly, cabbages were sprayed with lead arsenate. It then became necessary to investigate the amount of spray residue. With whole cabbages the amounts of arsenic found were as high as 0·2 gr. arsenious oxide per pound, but when the outside leaves were removed the amounts became almost negligible, being of the order of 0·0003 gr. per pound.

Coal.—Large-scale storage experiments extending over a period of eight months were carried out with bituminous coal from various collieries in order to ascertain the effect of storage on the coking properties of the coals. It was hoped that the excessive swelling which characterizes some of the coals would be reduced by oxidation consequent on open storage, and that the range of usefulness of the coals would be increased, particularly for gas-making in vertical retorts. The results, however, disclosed very little difference in the coking-qualities of the coals after storage for eight months.

Citrus Fruits.—The principal investigation dealt with changes in composition of the juice of New Zealand grape-fruit from early season to maturity, with a view to ascertaining a suitable maturity test applicable to fruit prior to marketing. Fruit from four selected orchards was examined at three-weekly intervals from June to October. The results are to be published in the *Journal of Science and Technology*. The tests are being repeated this season, and should be continued for at least two further seasons.

Some work was also begun on extraction, de-aeration, and commercial preservation of the juice.

Phormium (New Zealand Flax).—Chemical examination of phormium leaf has been commenced, and analyses of the whole leaf (butt and blade) and of the fibre, as well as of the isolated cellulose, have been completed. The degree of lignification with age is under investigation, also the constants of the cellulose from established varieties.

Ragwort.—An alkaloid, possessing the empirical formula $C_{18}H_{25}O_6N$, was isolated from ragwort (*Senecio jacobæa*) growing in New Zealand. It is probably identical with the alkaloid jacobine isolated from Canadian ragwort by Manske. The acetate produced cirrhosis of the liver when injected subcutaneously into rats, and was very toxic. A full account of the work, including biological experiments by Drs. C. S. M. Hopkirk and I. J. Cunningham, was published in the *Journal of Science and Technology*.

Soil Research.—Clay fractions of soils collected by the Soil Survey Division have been separated and analyses made to determine type. Fusion analyses were made for the Director, Cawthron Institute, of a series of river-till fractions from the Ashburton and Rakaia Rivers.

Advisory and Consulting Work.—The services of the Director of the Laboratory and other members of the staff have frequently been required on scientific and industrial committees or in connection with reports on industrial processes. The demands for such work increase each year, and a good technical library must be maintained. Arrangements are made for the circulation of various scientific journals among the staff.

During the year a number of scientific and chemical papers have been published in various journals.

GEOLOGICAL SURVEY BRANCH.

REPORT OF DIRECTOR (DR. J. HENDERSON).

During the year ended 31st May, 1936, official visits were paid by the Director to Tokatoka, Pahi, Te Aroha, Porangahau, and Wanganui in the North Island, and two visits to Reefton in the South Island.

Mr. M. Ongley began the detailed examination of the Dannevirke Subdivision, and, working from Porangahau and Wanstead, has mapped three survey districts in whole or in part. Mr. M. Gage assisted in the early part of this work, and Mr. A. M. Quennell in the later. Before starting at Porangahau, Mr. Ongley mapped a small area near Blairlogie, east of Masterton, and traced the fault on which movement occurred in 1855 from Mauriceville to Makuri. Towards the end of the season he examined a deposit of calcareous sinter out from Hastings and reported on the prospects of underground water in an area near Dannevirke.

Mr. Macpherson, who for some years has made detailed examinations of gold-bearing deposits, continued this work on the West Coast in conjunction with the geophysical party. Most of his work was in the Reefton district, but he also visited Hokitika, Kumara, Kotuku, and Ahaura. The important gold-bearing Reefton district was mapped more than twenty years ago, and geological knowledge and geophysical technique has now advanced sufficiently to render a resurvey advisable. Mr. Macpherson and Mr. Modriniak will continue this work next season.

Mr. Healy, assisted for short periods by Mr. E. A. Cuttriss and Mr. R. W. Willet, continued the geological mapping of the Whakaea Subdivision begun last season by Mr. Macpherson. He worked chiefly from Waikaka and Wendon, and mapped in all some 250 square miles. He also reported on auriferous deposits near Port Molyneaux and Wetherstones and examined the low-level adit of the Bendigo Mine, near Cromwell.

Dr. L. I. Grange some years ago examined the Rotorua-Taupo district, but was transferred to other work before he was able to complete his report. Last summer Dr. J. Marwick and Mr. H. E. Fyfe spent a few weeks in the district, and they will assist Dr. Grange in finishing his manuscript.

Dr. Marwick and Mr. Fyfe also hurriedly covered the Te Kuiti district, which Dr. H. T. Ferrar mapped in detail some years ago. Mr. N. H. Taylor, who assisted the late Dr. Ferrar, has been transferred to the Soil Survey Division, and Mr. J. H. Williamson, who also assisted for a year, has left the Service. Dr. Marwick hopes to be able to prepare the bulletin describing this district.

Before leaving for the field Dr. J. Marwick was able to complete, in collaboration with Dr. H. J. Finlay, a palæontological memoir on "The Wangaloa and Associated Faunas of the Green Island: Kaitangata Subdivision." This important work, which occupied several years, is now in the hands of the printer.

Mr. G. E. Harris made three large drawings and eleven blocks for photolithic reproduction, and prepared twenty-three field sheets for the field geologists. He also made nineteen tracings and coloured over a hundred prints for the geophysical parties, and did some miscellaneous work for other branches of the Department.

The thirtieth annual report was published during the year, and several maps were printed for bulletins yet to be issued. Dr. Marwick contributed a paper entitled "Some New Genera of the Myalinidæ and Pteriidæ of New Zealand" to the *Transactions of the Royal Society of New Zealand*. At the Science Congress held during May, 1935, at Dunedin, Mr. Ongley read papers on "The Taieri Mouth Breccia" and "The Old Man's Bluff Flow-slip," and Mr. Fyfe on "Sandstone Dykes at Hurunui Mouth." The Department of Scientific and Industrial Research issued a bulletin entitled "Water-supplies of Farms and Dairy Factories in Hamilton Basin and Hauraki Lowlands," by Mr. N. H. Taylor.

An extensive correspondence on matters of geological interest has been dealt with, and many samples of rocks, minerals, and ores have been examined. The usual periodicals and exchanges have been received and placed in the library.

DANNEVIRKE SUBDIVISION.

(By M. ONGLEY.)

Dannevirke Subdivision was examined by M. Ongley from 2nd January, 1936, to 3rd June, 1936, assisted from the beginning to 13th February by Mr. M. Gage, B.Sc., Assistant in Geology at Victoria University College, and from 16th March to the end by Mr. A. M. Quennell, B.Sc. The work was advanced by a visit from Dr. Henderson, Dr. Marwick, and Mr. Fyfe, who spent a day examining critical sections, and by several visits from Dr. Grange, Director of the Soil Survey Division, and his assistants Mr. Pohlen and Mr. A. M. Quennell, the latter of whom on 16th March was transferred to the Geological Survey. In the district Mr. E. L. Hunter, of Rangitoto, and Mr. L. Cowan, of Porangahau, kindly assisted the work. Three-quarters of Porangahau Survey District, half Motuotaraia, and the small Blackhead district have been examined and mapped, the area examined being 200 square miles.

STRUCTURE.

Dannevirke Subdivision adjoins the north of Eketahuna Subdivision, of which the geological map was published in the annual report for 1935, and is geologically similar. As was shown in that map, the grain of the country trends east of north, and the folds and faults continue through Dannevirke Subdivision. The big Akitio syncline, eight miles wide, mapped and described in the 1935

report, dominates the structure of the west half of Porangahau Survey District, and is conspicuously marked by being eroded into an extensive physiographic depression. In Eketahuna Subdivision this fold was complicated by minor corrugations such as the Ti Tree and Mount Arthur anticlines; but in the lowland along its northward extension in this subdivision outcrops are too poor to allow detailed structure to be made out, for it is only in the foothills along the bounding ranges that the rocks crop out. There the Tertiary beds, containing in their base conglomerates with pebbles of the underlying Cretaceous rocks, stand nearly vertical, parallel with the Cretaceous beds; out from the ranges they dip more and more gently into the syncline. But, as already stated, away from the margins the rocks crop out so rarely that the structure cannot be followed in detail. Again, all the beds along the contact are slickensided and shattered, showing that they have moved differentially; but with both sets vertical it is impossible to diagnose the movements further than to recognize that they are bedding faults.

This Akitio syncline, occupying the depression with its margins vertical in contact with the Cretaceous ranges, suggests that the ridges are anticlinal; but the Tertiary cover is eroded off the ridges, and the undermass of the ridges does not form anticlines but complex blocks intricately faulted. Owing to the lack of fossils and distinct lithologic markers, the Cretaceous rocks are puzzling and in many places cannot be satisfactorily resolved; but in a fair section in Porangahau Gorge the nature of the Cretaceous structure is indicated. There, at the east end of the gorge, alternating sandstone and mudstone strike north-east and dip 70° to the north-west for three-quarters of a mile and rise on the west into lighter coloured argillite and glauconitic sandstone, forming the well-known Kate's Quarry beds. These contain trails and fucoids, but nothing that dates them. They have previously been classed as Opouawe (= Lower Mangatu), and from their material and state of induration they appear to belong to the upper Cretaceous. In the quarry the beds are vertical and have their tops turned over to the west. West of them is a wide crush-zone in which the rocks slump along short fault-line gullies. West of the broken belt is a hard, dark, coarse sandstone, very shattered, and resembling the greywacke, but without the usual alternating beds of argillite, and containing the "cannon-balls," smooth round, dark, concretions, 6 in. to 12 in. through. No fossils were found in these; but on lithology they are correlated with the Raukumara sandstone of Waiapu Subdivision, which has been mapped also in the Eketahuna Subdivision, where it yielded the characteristic *Inoceramus bicorrugatus*. Broken specimens, identified in the field as *I. bicorrugatus*, were found in two places, not in this section, but in similar rocks. No section was found to indicate the thickness of these beds, but they stand nearly vertical and extend continuously half a mile across the strike in Note Creek in the north-east part of Porangahau Survey District.

In Porangahau Gorge these Raukumara beds are bounded on the west by another fault-belt of broken country eroding by mud-flow and slump into fault-line gullies. West of this the beds are soft, fine chocolate and black mudstone interbedded with green sandstone, with fossils in three places that are characteristic of the Tapuwaeroa Series of Waiapu and Eketahuna Subdivisions.

As field-work has shown that the normal sequence of the formations is Raukumara at the base followed by Tapuwaeroa and Mangatu, this section through Porangahau Gorge shows that the undermass of the ridges between the synclines does not form simple anticlines.

The ridge of Cretaceous rocks west of the Akitio syncline, of which the south end was mentioned in last year's report as the Mount Cerberus - Ossa Ridge, continues across Porangahau Survey District as the Whangai Range. The ridge east of the depression, hitherto nameless, as far as can be found out, is called Porangahau Ridge. Between the two ridges the wide depression occupying part of the Akitio syncline is only part of the Porangahau basin, and so has to get a distinct name, and is called, from the Wilder Settlement in it, the Wilder Depression.

In last year's report it was mentioned that the ridge east of the Akitio syncline, the Porangahau Ridge, was at the north folded into an incipient syncline. This was followed in the south-east part of Porangahau Survey District and found to die out two miles north of the boundary.

Stratigraphy.

The rocks of the Dannevirke Subdivision are similar to those of the Eketahuna Subdivision and fall into the same classification, except that so far no rocks have been found corresponding to the three lowest formations, the Tararua, Taitai and Waewaepa Series—that is, no rocks lower than the Raukumata Series (Cretaceous) are known in the part mapped so far.

Only rarely have fossils been found, so that the mass of the rocks have to be classified on lithology and continuity, and the mapping will probably have to be revised as more evidence is obtained.

Raukumara Series.—In Note Creek and in Porangahau Gorge unbedded dark coarse sandstone, indurated and shattered, forms a belt half a mile to a mile wide, extending north-east as far as a mile past Old Hill Road. Similar rocks crop out along the west of Porangahau River south-east of Trig. 23 and also a mile upstream. Two small outcrops of similar rock, one on the east of Porangahau River east of Trig. 23 and one half a mile to the north-east, contained the large shells of Inoceramus that were not collected but in the field were taken as *Inoceramus bicorrugatus*. On the lithology and on the fossil determination the rocks were classed as belonging to the Raukumara Series. In many places the sandstone contains hard round concretions 6 in. to 12 in. through, which give it a prominent feature easily recognizable in many places.

Tapuwaeroa Series.—The characteristic Tapuwaeroa fauna was found in Maclennan Creek in the north-east part of Porangahau Survey District, and also in a bounder in the south branch of Note Creek; and in a very weathered conglomerate a quarter of a mile west of the Old Hill Road 30 chains south of Green's homestead decomposed shells and markings were taken for the same fauna. The extent of the beds that should be classified with the fossiliferous beds is difficult to decide, for the structure is complicated and the rocks are not distinct. Below, the Tapuwaeroa beds are limited by their contact with

the harder more shattered Raukumara sandstone. Above them in some places is the white mudstone of the Tertiary Weber formation; in some places hard shattered sandstones indistinguishable from the Raukumara occur. The Tapuwaeroa Series is predominantly black mudstone that weathers white or rusty and sulphur-coloured. In many places it is interbedded with green sandstone, the beds of black mudstone being 1 ft. to 2 ft. thick and the sandstone 2 in. to 3 in. thick. Generally the beds are contorted and twisted. They slump easily and do not afford good outcrops. From a distance they can be recognized by their pinkish decomposed outcrops in contrast to the darker Raukumara and the light Mangatu and Tertiary rocks.

Mangatu Series.—In last year's annual report the beds above the Tapuwaeroa rocks were described as the Mangatu Series, and on the map, because of the difficulties of strict correlation with the Mangatu series of Waiapu they were shown as Tinui Series. Notwithstanding these objections the name "Mangatu Series" is here again used. Last year, too, the Mangatu Series was classified as Lower Tertiary and Upper Cretaceous, and it was stated that no Tertiary fossils had been found in it. No Tertiary fossils have yet been found, and so far as the Dannevirke Subdivision is concerned no fossils at all. It is accordingly impossible to say definitely what age the beds are. There is an important break above them: below the break only Cretaceous fossils are known and above it only Tertiary. This break is taken as separating the Cretaceous and the Tertiary. Accordingly the Mangatu beds are here again classified as Cretaceous.

Some of the beds of the Mangatu Series are not distinct from the Tapuwaeroa, and until more evidence is obtained the conclusions are tentative. The characteristic part of the Mangatu Series is a thick set of light-coloured fine mudstone beds. These are interbedded with beds of white sandstone, spotted green with glauconite, and occur with beds of dark mudstone, chocolate mudstone, and grey sandstone not distinguishable from the Tapuwaeroa. Accordingly, where the white mudstone is conspicuous the beds with it are classed as Mangatu.

The beds at Kate's Quarry are taken as the characteristic outcrop of the Mangatu; and from that point they were followed along the strike north-east for five miles. Similar rocks, a mile and a half wide, back the coast behind Porangahau Station and extend north-east across Blackhead Survey District into Pourere Survey District. A mile north-west of this ridge another parallel ridge, a quarter of a mile wide, formed of the same rocks, extends from Hunter's Road south-west across Old Hill Road to Porangahau River. Again, the Whangai Range, on the west of the Wilder Depression, is formed of similar rocks and is here included in the Mangatu Series. It is probable that the extensive Whangai Range has in it more than one series of beds, but so far no evidence of breaks and no fossils have been found there. Several small inliers of similar rocks have been mapped in the south-west part of Motuotaraia Survey District, and part of a big block extending north-east from the middle of Motuotaraia is formed of the same rocks.

Wanstead, Weber, and Ihungia Series.—In last year's annual report the lowest definitely Tertiary formation described was the Weber Series, which was said to grade up into the Ihungia beds. The Soil Survey distinguished not only these two groups but recognized a third type of soil named by them the "Wanstead type." The formation on which the Wanstead soils occur was difficult to place stratigraphically, for no section could be found showing the sequence. In fineness of grain and absence of fossils the Wanstead resembles the Cretaceous, in texture and absence of jointing and slickensiding it resembles the Tertiary. Several contacts of Wanstead and Mangatu show pieces of shelly pebbly limestone, indicating that the Wanstead is unconformable to the Mangatu; and the absence of any definite boundary between the Wanstead and the Weber indicates that these formations grade. It appears that, after the Mangatu land was exposed, the first wash off its decomposed surface formed the Wanstead beds and the later disintegration of the deeper harder Mangatu formed the Weber.

As mentioned in last year's report, the Weber beds grade up into the Ihungia. The Wanstead is a very fine, flaky white clay with irregular blotches; the Weber is a coarser, firmer white clay with traces of greensand in many outcrops and some fine conglomerates; the Ihungia is a dark massive arenaceous mudstone.

Along the west side of the Porangahau Range the boundary of the Mangatu and the Weber was followed with care, south of Porangahau Road by Mr. Gage, and north of it by the writer, and the erosion break between the Mangatu and the Weber is satisfactorily established. Thick coarse conglomerates of the basal Weber containing pebbles of the Mangatu were found in many places and can be seen on the roadside east of Porangahau River, between Note Creek and Maclennan Creek, in Porangahau Gorge, and north of Hunter's Road.

Tutamoe Series.—No work was done on the beds of the Wilder Depression occupying the Akitio syncline, but, as Weber and Ihungia beds crop out along the margin, the middle will be younger and probably consist of Tutamoe beds. No fossils were found to confirm this or no erosion breaks, for the rocks are not exposed in the parts examined. In Motuotaraia Survey District the ridges between Purimu Lake and Nicholls Road are coarse sandstone with the characteristic Tutamoe fauna. At Pukekura Quarry a basal conglomerate containing pebbles of the underlying mudstone separates these beds from the mudstone below.

Economic Geology.

Petroleum and Natural Gas.—Black carbonaceous mudstone, the so-called kerosene shale, forms thick beds in the Tapuwaeroa and Mangatu Series. It weathers with a striking yellow efflorescence often referred to as sulphur. It is widely distributed in the district and is best exposed along the coast three to four miles south of Porangahau, where a tidal bench 6 chains wide is cut on the black mudstone and is backed by the cliffs of black mudstone. If this black shale is broken the fresh part smells of petroleum, and samples of it have been shown to yield a little oil on distillation. It is not an oil-sand, and as a shale is of no value.

Two samples of natural inflammable gas from five miles south of Wanstead in Motuotaraia Survey District have been sent to the Dominion Laboratory to be tested.

No structure favourable for forming an oil-field has been found.

Rock-products.—A tremendous amount of sand forms the spit, the beaches, and the land near the coast between Porangahau and Blackhead. No rock as hard as greywacke crops out, and rock of even second class is scarce. Besides the rocks already in use, the boulder beaches south of Porangahau and north of Blackhead will afford large amounts of sorted material. Rocks similar to those now in use form large parts of Whangai Range and small exposures nearly everywhere in the Cretaceous.

Greensand.—Greensands occur in many places in the Mangatu Series, but generally impure and silicified into hard rock. Near Wanstead a soft bed of it was found, and a sample has been taken for testing for its base exchange properties.

Clay.—The Wanstead soil of the Soil Survey grades down into a fine white clay and into the underlying white mudstone. With its fine texture, light colour, and immense quantity, this promises well. A sample has been sent for testing.

THE REEFTON GOLDFIELD.

(By E. O. Macpherson.)

In the 1935–36 field season geophysical surveys were completed in the following gold-mining districts: Nelson Creek, Mosquito Creek, Loopline and Citirini area. Maps and reports on these were prepared, and the areas were prospected and abandoned or prospecting is in progress.

The intensive geophysical study of the Globe-Progress mining-area was completed, a report on the various geological and geophysical findings was written for the Consolidated Goldfields of New Zealand, and three bore sites were selected. Mainly as a result of this survey, the company intends to drill six or eight diamond-drill tests to a maximum depth of 1,700 ft. in search of the faulted continuation of the Progress lode.

The main task this year was a restudy of parts of the Reefton goldfield, and a belt of country extending from Waitahu River in Reefton Survey District southward to Merrijigs was geologically examined and selected parts were studied by electrical and magnetic methods. In this belt is situated the Inglewood, Golden Fleece, Ajax, Energetic, Keep-it-Dark, and other mines of the Ajax-Crushington group, the Progress group, and, in its southern part, the goldmines of the Merrijigs group.

The geology and mines of Reefton goldfield are described in New Zealand Geological Survey Bulletin No. 18, and, as this publication includes a complete bibliography of important writings on the geology, goldmines, and mineral resources of the region, it is only necessary to discuss additional information collected during this re-examination.

Geological Structure.

A topographical map (scale 8 in. = 1 mile) was made, and on it geological information plotted. The main object of the survey was to determine if any persistent structure controlled the position of the ore-bodies. Attention was therefore centred on the attitudes of bedding planes and induced fractures of the rocks which enclose the ore-bodies.

The rocks of the region are quartzite, phyllite, argillite, and greywacke; they have been divided into two series, a lower group named the Aorere Series, and an upper fossiliferous group, the Devonian Series. The true order of superposition cannot be clearly demonstrated in any section. Henderson discusses the arguments of several observers at considerable length in N.Z. Geological Bulletin No. 18, pp. 74–78; he tentatively suggests that the fossiliferous Devonian rocks overlie the Aorere Series and that their present distribution is defined by faults which depressed an earth-block of Devonian rocks longitudinally through the middle of the Reefton and Waitahu Survey Districts. This view was based on regional field studies and a critical examination of the evidence of J. Hector and A. McKay who, however, thought the fossiliferous Devonian rocks underlay the Aorere Series. Additional information from the survey on the rock sequence is meagre, for the present work was not regional in scope, and many critical sections were not studied; but the impression was gained that the Devonian rocks may be a facial change of the Aorere Series. The close folding of the Aorere Series westward from the belt of fossiliferous rocks indicates that if these rocks originally overlay the Aorere rocks they should be involved in the folding and remnants should be preserved in synclinal areas. It is unlikely that patches of Devonian rocks are present to the westward and were not observed for they are conspicuously different from the Aorere greywacke and quartzite. This may suggest that the stratigraphic position of the fossiliferous rocks is not above the Aorere, and they may either be below them or a facial change, possibly a shore-line variation of the Aorere Series. The regional distribution of the Devonian rocks indicates that they lens out northward and southward, and, although faulted, it is doubtful if faulting can wholly account for their distribution; it is thought that this distribution tends to support the view that they are a shallow facies of the Aorere Series.

To give additional information on the lodes it was necessary to study the structure of the Aorere rocks that enclose them; this seemed to be an aspect that had not received due attention from previous observers. These rocks are jointed, sheared, and closely folded, and any attempt to work out the regional structure must discriminate between the induced planes and bedding planes. This is not always simple, especially where the areas of rock exposed are small. For example, in any exposure of banded quartzite and phyllite three planes and in some places four are equally conspicuous —tension fractures in the rigid quartzite bands, fracture and flow cleavage planes in phyllite bands, as well as bedding planes. At many exposures, in addition to these, there is present a group of tension fractures and shears that cannot be resolved into any known system.

The fundamental attitudes to observe are bedding planes and fracture-cleavage planes; bedding planes observations give a comprehensive view of the geological structure, and fracture-cleavage observations indicate the position and attitude of the axial planes of major and minor folds; the angle the fracture cleavage makes with the bedding will indicate whether the particular limb where the observation was taken is overturned or in its normal position.

Attitudes were measured along many sections, and these and other data, when plotted on the topographic maps, showed that the Aorere Series is closely folded along north-east to south-west lines. In the district between the Waitahu and Inangahua Rivers two main anticlines with their corresponding synclines were mapped, also several shorter folds that could not be traced far along their trends.

The most easterly and major syncline in the belt examined was traced from the Waitahu River southward to Trig. A.H. and Murray Creek, and thence to the Inangahua River. An excellent section of this syncline can be studied a short distance north-west from Crushington to Lankey Creek. The synclinal axis continues southward up the valley of Union Creek. Toward Cornishtown and Globe Hill the eastward-dipping flank is complicated by minor folds and shears; farther southward the axis persists and was traced in the heads of Union, Devil, and Fossicker Creeks to Inkermann Mine, and thence through the Scotia at Merrijigs to the Golden Lead.

At several places the structure and position of the synclinal axis is complicated and obscure, but this is believed to be due to lack of clear sections and good rock exposures. The axis is sinuous, but the sinuosity tends to straighten where opportunity for good and close observation is possible. The beds along the flanks of this major syncline dip at high angles, 50° to 80°, but the dips tend to lessen toward the axis. In many places the flanking beds are overturned, this overturning is particularly characteristic of the east flank along its length extending from the Inangahua River northward to the Waitahu; here the beds on the east-dipping flank have been overturned through 90° and dip at 70° to 80° to the west. The overturning is accompanied by eastward-dipping thrusts faults of small displacement. Along the axis and for 300 ft. or 400 ft. east and west from it the rocks are extremely sheared and fractured.

This syncline is the major structural feature of the area examined. The position of its axis is important economically, for the main gold-bearing lodes lie in shears and tension fractures on or close to its axis. There is little doubt that the synclinal trough, in the main, defines the position of the lodes.

West from the major syncline is a sharply asymetric anticline with the steep limb dipping westward. A section is well exposed along the Crushington Road, south-east from Black's Point. The fold was traced northward into the heads of Anderson, Ajax, and Inglewood Creeks, and may be present in the Waitahu Valley. Southward it is doubtfully present in the head of Auld Creek, but it was not mapped in the bush country separating Auld from Devil Creek, and could not be identified with certainty in lower Devil Valley.

A second sharp syncline, extremely sheared and deformed, is present west of this anticline. A section of it is well exposed south-west from Black's Point where Auld Creek joins the Inangahua Valley. It can be traced southward up Auld Creek and north-east into Anderson, Ajax, and Inglewood Creeks, and is possibly present in the Waitahu Valley, the axis coincides in part with the Black's Point fault. Anderson's and the Bonanza lodes occur on or close to the sheared axis of this second syncline, and prospecting along it may reveal new ore-bodies.

A major anticline can be traced in the Inangahua Valley, half a mile east from Reefton; its axis trends north-east, and, though obscured below terrace gravels, can be observed in the lower reaches of Anderson and Inglewood Creeks, on the Painkiller–Murray Creek Track, and in the Waitahu Valley. Southward from the Inangahua Valley this axis was not traced, and it seems to plunge in this direction. This anticline is crushed along its axial area, and in places has barren quartz lodes, but no important ore-body has yet been found along it.

Auriferous Lodes.

The gold-bearing lodes, and especially the valuable ones, lie along the main synclinal trough on the eastern limit of the area examined. From north to south these lodes are the Inglewood and possibly some minor ore-bodies to the north—Golden Fleece and Ajax, Golden Treasure, Perseverance, Royal, Venus, Energetic, Keep-it-Dark, and No. 2 South Keep-it-Dark. From the Inangahua Valley southward along the axis gold-bearing lodes have not been found for two miles, but in the vicinity of Cornishtown and Globe Hill the important Globe-Progress lode was mined. The relation of this ore-body to the major syncline is not wholly clear, apparently the eastern portion of the lode, where it strikes north-south is along a shear on the complicated western limb of the syncline and the east-west striking portion cuts across the regional structure. Apparently a north-south branch from the main lode continues northward at least 400 ft., lying along the overturned and sheared axis of the major syncline. Southward from Cornishtown, the Gordon, Inkermann, Scotia, Cumberland, and Golden Lead lodes occur in shears close to, or on, this major synclinal axis.

Minor anomalies to this generalization are noted, but it is reasonably well demonstrated that the richer and larger ore-bodies are emplaced along the synclinal trough, irregularities tend to disappear where clear exposures can be studied and the structure better understood. In shear zones and minor folds far from the axis only low-grade and barren quartz lodes occur, and these are small and few compared with the large bodies of barren and auriferous quartz along the synclinal trough.

Anticlinal axes were not favourable sites for quartz deposition, although this statement may not apply to the whole of Reefton-lode belt; for example, a brief examination of the rocks close to the Blackwater Mine suggests that this valuable ore-body occurs along the sheared crest of a north-south anticline and one small low-grade lode, the Last Chance, is on the axis of the major anticline a short distance east from Reefton.

Why the lodes show preference for synclinal axes rather than anticlines cannot be satisfactorily answered at this stage of the survey, the only reason apparent is that synclinal axes are more thoroughly sheared than anticlinal axes, and the shears possibly extended to depths where they tapped magmatic solutions. It may be that at depths the down-folded axial parts of synclines were ruptured by tension fractures that would provide channels for ore-bearing solutions, whilst the axes of anticlines were in compression and the axial fractures closed.

Geophysical Prospecting.

Electrical and magnetic surveys were made during this field season and are still in progress. It is not the intention here to describe this work in detail. The lesson to be learned from it is that intensive geological studies must be completed and working theories formed on the possible sites of ore-bodies before geophysical work can be usefully employed.

Electrical methods with the ratiometer and megger were tried along the sheared synclinal axis at Black's Point in search of possible northward and southward extensions of Anderson's lode and in the main syncline southward from the Keep-it-Dark Mine toward Progress battery. Electrical work was also done on the north continuation of the anticline eastward from Reefton.

In the Merrijigs district a rectangle, a square mile in area, was surveyed along the axial part of the main syncline. The rectangle was subdivided by co-ordinate and electrical and magnetic observations taken along these co-ordinates. When this work was completed electrical studies were extended north and south beyond the rectangle. This work is now in progress. Narrow zones of low resistivity, perhaps mineralized shears, were traced; trenching and pitting is now required to establish what these electrical indications signify. The relation of the diabase dykes of the region to the lodes and their relative ages are doubtful. Magnetometer observations were carried out at Inglewood Mine, Murray Creek, Devil Creek, and Merrijigs, in an attempt to find the relation of dykes to the lodes. Several additional dykes were found, and the limits of some previously recorded were extended.

Conclusion.

The structural control of the Reefton lodes outlined here is economically important, and future search for lodes in this region, either geophysical or direct methods, must be guided along favourable geologic structures, preferably the axes of major synclines and, less attractive, along anticlines. Haphazard prospecting now has a poor chance of success.

The major folds should be mapped and their axes carefully studied. Payable ore-bodies seem all to occur within 300 ft. or 400 ft. on either side of these axes, and quartz lodes beyond these limits seem to be barren or of low grade. This eliminates wide tracts of rough country and narrows down the search. Particular places along the axes seem to be preferred sites for quartz deposition, probably along the more thoroughly fractured stretches and where the sinuous axes alter slightly in direction. But these are not the only controlling factors, and others, so far unknown, may be more fundamental.

WHAKAEA SUBDIVISION.

(By J. Healy.)

During the past field season an area of approximately 250 square miles was mapped in detail, comprising the survey districts of Chatton, Otama, and Wendon. The area, the southern boundary of which is three miles north of Gore, lies immediately to the east of the Mataura River and stretches northwards as far as Wakaia Township. It includes the township and goldfield of Waikaka, the scene of extensive dredging operations during the period 1900–15.

Topography.

The district is readily divisible into two topographic units, separated by a fault tending north-east and passing a mile north of Waikaka and two miles north of Chatton. To the south-east is low, terraced country; to the north-west three elevated ridges, lying north and south, rise to heights exceeding 2,000 ft. at the northern part of the present district. Mount Wendon (2,769 ft.) is the highest point, and is part of the southerly continuation of the Black Umbrella Range, from which it is separated by the low saddle between a tributary of Waikaka Stream and the Leithen Burn.

A low ridge, of average height 600 ft. to 650 ft. above sea-level, runs for four miles north-east from Chatton, and a similar ridge, of average height 750 ft., trending north and south marks the east boundary of Chatton Survey District. Between these ridges is a flat terrace sloping gradually inwards towards the wide valley of Waikaka Stream, 200 ft. below. Remnants of 150 ft. and 20 ft. terraces border the main valley, indicating at least two periods of rest during the last movements of uplift. North-east from Chatton the ridge falls away into the broad valley of Okapua Creek, which flows south-west and joins the Mataura River near Knapdale.

The valley between the elevated block of which Mount Wendon forms a part and the ridge to the west is drained by the upper portion of Waikaka Stream, which flows south along a wide valley until, west of Waikaka, it enters a two-mile gorge from which it emerges into a wide valley. The gorge is apparently a superposed feature. Waikaka Stream has been beheaded by Winding Creek, which escapes westward through a gap in the mountains and joins Whakaea River near Wakaia Township.

Otama, Pyramid, and Wendon Streams, south-flowing tributaries of Mataura River, and Stony Creek flowing north to Winding Creek drain a meridional depression midway between Waikaka and Whakaea Valleys. At the western border of the area is the broad flood-plain of Whakaea River, which flows south and joins Mataura River near Wendon, whence the Waimea Plains stretch away to the north-west.

Skirting the Mataura and Whakaea Rivers are well-preserved and extensive terraces at heights of 100 ft. and 25 ft. to 30 ft. as well as minor remnants of terraces at 150 ft. The main streams are entrenched to a depth of 4 ft. to 6 ft. in their flood-plains and appear to be actively engaged in down-cutting.

Structure.

The two units distinguished in the above section similarly show totally different structural features. From a few chains west of Trig. I at Knapdale a fault with down-throw to the south-east trends in a north-easterly direction through Chatton and passes north of Waikaka to Greenvale, where it terminates against a fault striking north and south. This fault separates marine beds to the north-west from lignite-bearing strata to the south-east. These latter, which near the fault are disposed at fairly high angles, form an asymmetrical syncline the axis of which passes a mile south of Waikaka, whence south-east they rise gradually to the surface, but for the most part are veneered by weathered gravels. The presence of basalt, elsewhere usually associated with faulting movements, about a mile south-west of Maitland suggests that the structure may be complicated by minor faulting. Along a fault passing from a point half a mile south of Trig. F to a point a quarter of a mile south of Trig. K, west of Waikaka, Tertiary strata are faulted down against the older greywacke, metamorphics, and igneous rocks to the north-west.

The Upper Waikaka and Otama–Wendon Valleys have somewhat similar structure, each being fault-angle depressions along major faults trending north and south and with down-throw to the west. In each the structure is complicated by minor sub-parallel and transverse faults. The elevated blocks, besides being tilted to the east, have also a slight tilt downwards towards the south, where they are truncated by the faults mentioned above. Tertiary sediments are preserved in strips along the eastern margins of the depressions, and in the Otama Valley, as also possibly in the Waikaka Valley, are bounded on the west by faults parallel to the main fractures but of relatively small throw. West of Mount Wendon two minor transverse faults trend away for some distance to the south-west, defining a small upthrust wedge one mile wide which truncates obliquely the Tertiary strata occupying the Upper Waikaka Valley. A similar fault-bounded wedge is found in the depression to the west, immediately east of the Wendon Stream; the faults are sub-parallel to the main fracture and die out towards the head of that stream. The western of these two faults, with down-throw to the west, can be traced with increasing throw southwards to the Pyramid Bridge. There appear to be minor transverse faults in the Wendon Creek–Stony Creek depression.

Another important fracture along which Tertiary sediments are down-thrown and preserved on the west follows the eastern side of the Whakaea Valley from Wendon to Wakaia. A subsidiary parallel fault with similar, but considerably less, throw lies about a quarter to half a mile west.

The amount of throw along the main north–south faults can be measured in thousands of feet; the fault planes dip to the east towards the up-throw side, showing the movements to have been caused by thrust from the south-east. Toward the north the fracture-lines bend round slightly towards the east. In the King Solomon Mine, near the confluence of Stony Creek and Winding Creek, the schist can be seen to override the Maori Bottom gravels. All evidence indicates that the movements extended over a fairly lengthy period, with two major phases of dislocation. Faulting probably commenced in the late or late-middle Tertiary, as a thick series of shales, lignites, and conglomerates were deposited on marine beds of Otataran age before disruption commenced; and Maori Bottom gravels, deposited subsequent to the first displacement, have been involved in later movements.

Stratigraphy.

Tuapeka Series.—Rocks of this group from the basement of the district and comprise quartzites, fine conglomerates, argillites, and greywackes, which towards the north grade into schists, semi-schists, and phyllites. Folding has been generally along east and west lines, though local variations in strike and dip are common. There is no direct evidence of their age, but they occur between unmetamorphosed beds of probable Mesozoic age to the south and the Otago schists to the north, and are probably Palæozoic.

Clinton Series.—Macpherson found fragments of fibrous shell resembling *Inoceramus* or *Maitaia* in boulders approximately a mile and a quarter south of Pyramid Bridge, but the writer saw no similar rocks in place.

Mesozoic (?) Beds.—Near Knapdale and Chatton in Okapua Creek valley and stretching north-west to Chatton are unaltered, well-compacted mudstones and sandstones, generally striking east and west and dipping at high angles to the north. In Okapua Creek valley they are overlain unconformally by fossiliferous marine strata of the Chatton Series. Their contact with the greywackes and argillites to the north is obscured by the Otama intrusive and associated metamorphics, but their unaltered condition separates them lithologically from the rocks of the Tuapeka Series. As they contain no fossils their age is problematical, but they closely resemble rocks of the Hokanui Series outcropping farther south near Gore, and they are tentatively assigned to the Mesozoic.

Welshman Series.—South of Waikaia are shales, white sands, quartz-conglomerates, and grits, with lignite seams underlying the marine sandstones of the Chatton Series. They are missing in the Okapua Creek area, but are found again near Waikaka and farther north in the upper Waikaka Valley. A small patch of the fine quartz-conglomerate occurs a mile south-east of the Pyramid, and here, as also near the head of Otama Stream and seven miles north of Waikaka, residual blocks are found cemented by limonite into a compact rock.

They are apparently terrestrial beds and underlie Otataran marine strata, which places their age as early Tertiary or Upper Cretaceous. Macpherson has correlated them tentatively with the quartz conglomerates of Otago Central, making them the equivalents of Williamson's Hogburn Series.

Chatton Series.—Marine sandstones are found in practically all the Tertiary areas in the district. North–south strips occur along the Whakaea, Otama-Wendon, and Upper Waikaka Valleys; a further strip runs from Chatton to north of Waikaka, and the rocks also appear near Greenvale. The beds include greensands, sandstones, fine conglomerates, quartz sands, and grits, while some miles north of Waikaka a seam of lignite is interbedded.

Fossils of a shallow-water type are abundant in several localities, and these, together with the conglomeratic beds and lignite, suggest that submergence was oscillatory and generally not to a great depth. The included fossils are of Ototaran age.

Waikaka Series.—Resting on the marine beds are a thick series of argillaceous sandstones, shales, and mudstones, usually greasy to the feel and containing abundant plant remains and impressions; lignite seams from a few inches up to 20 ft. in thickness are common. They are found as small strips in the north–south depressions, but have their main exposure from Chatton through Waikaka to Greenvale, whence they stretch away to the south for over ten miles. The upper members in the Waikaka district, comprising quartz-conglomerates interstratified with clays, are preserved in a syncline, south of which the lignite-bearing shales come to the surface.

These beds are post-Ototaran, but pre-deformational. Their contact with the underlying beds is visible in Otama Valley, where the marine sandstone is seen to pass gradually upwards into plant-bearing argillaceous sandstone of the Waikaka Series, which would suggest a middle-Tertiary age for the latter series.

Maori Bottom Beds.—Rusty gravels and sands containing schist, greywacke, and quartz form a veneer, approximately 40 ft. to 50 ft. thick, over beds of the Waikaka Series south of Waikaka; again a mile and a half east of the Pyramid, in the Winding Creek–Wakaia gap, and in several patches southward, thence along the eastern side of the Whakaea Valley, are patches of similar gravels. They were probably laid down by streams consequent on the uplift and deformations at the close of the Tertiary. They were later involved in faults and are probably late-Tertiary in age.

Recent and Pleistocene.—Recent deposits are confined to flood-plain accumulations of gravel, sands, and silts, together with tailings. In the western part of the area, skirting the Waimea Plains, are extensive terraces of well-consolidated river gravels, quite distinct from the rusty Maori Bottom gravels. They represent large accumulations of rivers in the depressions caused by post-deformational earth movements; owing to later uplift the streams have cut down through them, periods of rest being indicated by well-defined terraces at several levels. Along the foot of the hills are accumulations of angular schist and greywacke debris of similar age shed from the fault-blocks as slope deposits and alluvial fans. They are early Pleistocene and possibly even late-Pliocene in age.

Loess of varying thickness covers uplands and valleys alike in the lower portions of the area, but it is absent from the higher parts of the elevated blocks.

Igneous Rocks.

Glassy vesicular basalt was traced northwards for five miles from a point near Waikaka Township, the outcrops being usually a quarter of a mile west of the main fault. It is either intruded along a subsidiary fault or has come to the surface from the main fault along a zone of weak shale which it has baked to porcellanite and hornstone along the contacts. At an old lignite-mine a neck of scoriaceous basalt seems to mark the site of a former volcano.

A small outcrop of similar basalt occurs one mile south-west of Maitland. North-east from Chatton, basalt has come to the surface for a mile along the fault, trending thence towards Waikaka, again baking shales to porcellanite. Porcellanite half a mile north of Trig. P at Wendon indicates a similar intrusion at this point, where lignite-bearing beds are faulted in against greywacke.

The intrusions are apparently connected with the faulting movements that occurred during the late Tertiary.

From Pyramid Bridge eastward to the gorge in the Waikaka Stream, a distance of eight miles, are outcrops of plutonic rocks referred to by Macpherson as the Otama intrusive. The northern boundary passes from Wendon School eastwards to within a mile of Wakaia Hill, and its southern boundary is in the vicinity of Trig. F. A fault along the Otama Valley crosses it, and Tertiary beds have been infaulted against the igneous rock on the east. Petrographical work has not yet been done on the rocks present, field classifications being used in this report.

The greater part of the mass consists of diorites and gabbros. Syenites and more acid types occur as lighter belts, one passing from the Pyramid to Wakaia Hill and another farther south occurring at the Geodetic Station near Otama. Quartz-lodes are present, mostly connected with the lighter belts. The elongation of the lighter belts and the intrusion as a whole is east and west. The quartz-lodes strike in the same direction and usually dip steeply to the north. Pegmatites and mineralized belts are common, and basic dykes not infrequent.

Patches of hornfels and almost unmetamorphosed rocks surrounded by igneous rocks indicate roof pendants and suggest that the present surface is not far from the roof of the batholith. A zone of highly altered rock, quartzites, and hornfels surrounds the mass, and near the actual contact it is hard in the field to distinguish between intruding and intruded rocks.

The more basic portions are highly sheared and crushed along east–west lines, though the lighter rocks are comparatively fresh, suggesting that earlier basic injections were sheared and crushed during the later injections of more siliceous magma; the pegmatites and quartz veins mark the closing stages in the history of the formation of the batholith.

Until further work is done, in the field, to establish the age of the mudstones to the south and, petrographically, to ascertain whether they have been affected by the intrusion or whether they post-dated its injection, little can be said about the age of the Otama Intrusive. It was intruded into rocks of the Taupeka Series occurring to the north, and eroded with them to form the surface on which the Tertiary sediments were deposited.

Economic Geology.

Gold.—During the period 1900–15 gold to the approximate value of £1,000,000 was dredged from the Waikaka Valley district, as many as twenty-eight dredges being in operation at the peak of the boom. The dredges worked to an average depth of 15 ft. to 20 ft. over the floor of the Waikaka Valley, where the gravels rested on a bottom of mudstone, shale, and lignite of the Waikaka Series. North of Maitland the bottom was the interstratified quartz-conglomerates and clays of the upper members of the same series, and in places good gold was obtained by dredging to a depth of 50 ft. in the conglomerates themselves. Similar conglomerates of the Waikaka Series are being sluiced by Mr. R. T. Stewart near Waikaka, where they contain fairly rich gold, which occurs rather irregularly. These conglomerates were worked extensively by Chinamen many years ago at Waikaka and Chatton.

The conglomerates of the Welshman Series are auriferous and the Maori Bottom gravels also contain gold, most of that won in the Wakaia field having been derived from the latter beds. Throughout much of the district the stream-beds contain a small amount of residual gold derived by erosion of the auriferous strata which have in many cases been completely removed.

Five miles south-east from Wakaia is a patch of Maori Bottom gravels, beneath which is a deposit of richly auriferous gravels being worked at the King Solomon Mine. The gold occurs in coarse river gravels laid down on a bottom of Tertiary sandstones and water-worn schist. Apparently it was concentrated by a large stream flowing along a depression due to fault movements. Macpherson has advanced a theory that this river came from the direction of Wakaia through Winding Creek gap and made its escape to the south along the fault-angle depression of Otama Valley, later movements having caused an adjustment of drainage whereby this ancient Whakaea River was diverted to its present course. The evidence for two periods of movement can be clearly seen in the mine workings, where several faults involving the Tertiary strata obviously preceded the deposition of the auriferous gravels, which later were faulted and overriden by the schist. The mine is situated at the intersection of two faults, and the workings show numerous minor breaks. The whole area seems to be down-faulted into its present position and the gravels thereby preserved. If the lead originally continued southward along the Otama Valley, later faulting apparently caused the relative elevation of the gravels, thus enabling their removal by erosion, for no trace of their existence can be found resting on the strip of marine beds following the fault southwards to Otama.

Coal.—Lignite has been worked extensively throughout the district both from beds of the Waikaka Series and from those of the Welshman Series. The former have been mined at Greenvale, Waikaka, Chatton, Knapdale, Willowbank, and Otama, and the latter lignites have been sluiced for many years a short distance south of Wakaia. The gold-dredges used these supplies. The lignite is of good quality, and there are still vast quantities available throughout the area. The seams are up to 20 ft. thick, and contain much woody matter, together with fossil gum.

Copper.—Assays made many years ago of samples collected by Mr. S. Graham, of Knapdale, revealed the presence of low-grade copper-ore in the Otama Intrusive south of Wakaia Hill. The occurrence is not regarded as being of commercial value.

Cinnabar.—Concentrates from many of the main stream-beds reveal the presence of small quantities of cinnabar derived by erosion from the greywackes and schists of the Tuapeka Series. A small outcrop was prospected at Greenvale, where several winzes were put down and an adit driven for some distance into the hill along the strike of a weakened zone of greywacke yielding a small amount of cinnabar as occasional thin films on the partings of crushed rocks. The ore was not present in sufficient quantity to warrant its commercial exploitation. A similar outcrop is reported from the top of the range dividing the Wendon from the upper Waikaka valleys.

PALÆONTOLOGICAL WORK.

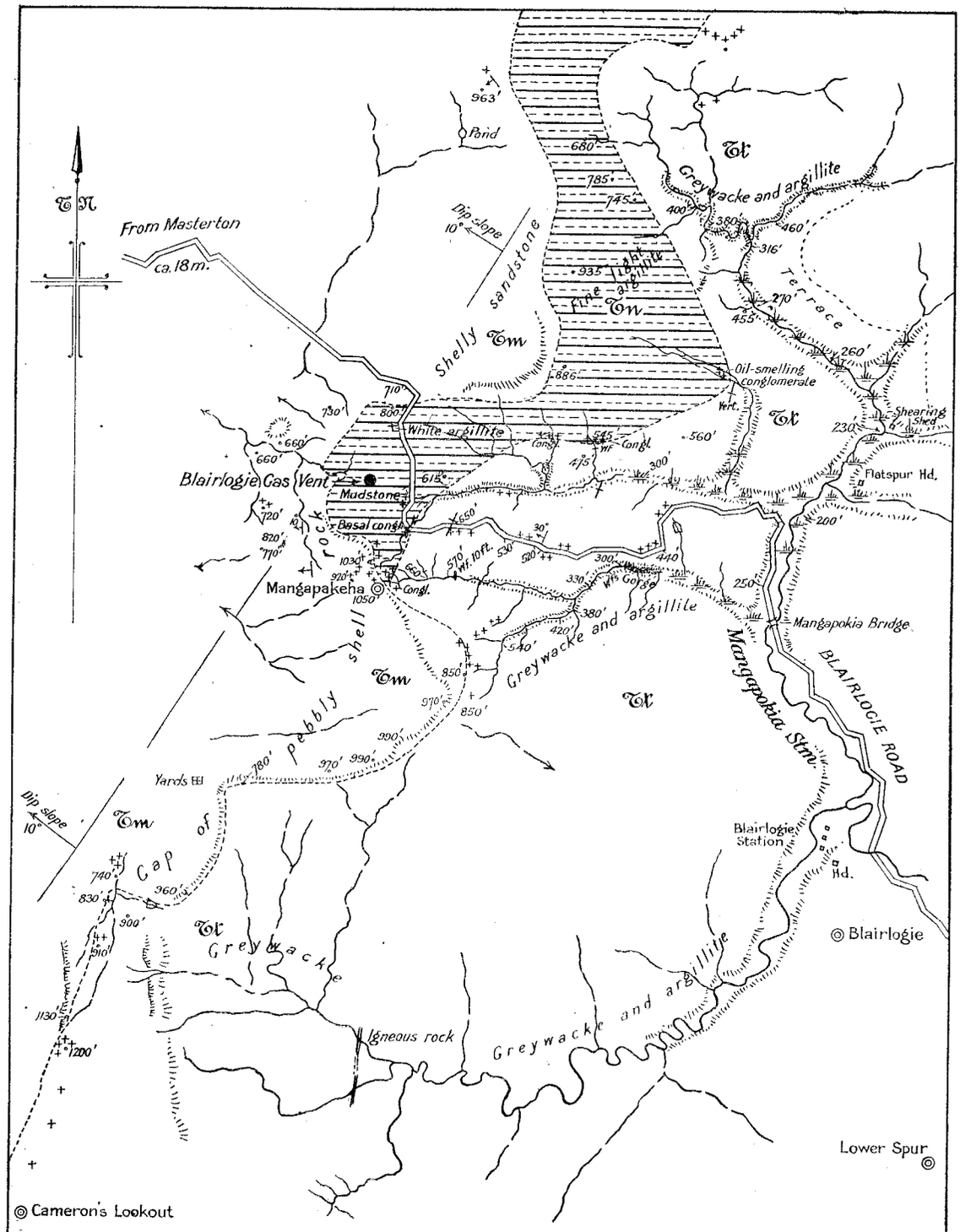
(By J. Marwick.)

Routine work of correspondence and the examining and reporting on fossils collected by the field officers occupied much of the past year. Palæontological Bulletin No. 15, which describes the Wangaloan and associated faunas of the Kaitangata Subdivision was completed and sent to the printer. The latter part of the year was spent with Mr. Fyfe in a physiographic reconnaissance of Rotorua-Taupo Subdivision and a geological reconnaissance of Te Kuiti Subdivision.

BLAIRLOGIE GAS-VENT.

(By M. Ongley.)

The map of the Eketahuna Subdivision published in the annual report for 1935 did not reach as far south as the Blairlogie gas-vent, and, as information was required about that, a month was spent there at the beginning of this season, from 6th November to 4th December, by the writer assisted by Mr. M. Gage, assistant in geology at Victoria University College. This spring has been referred to by Park in the reports of geological explorations during 1887–88, No. 19, and by Morgan in the Eighth Annual Report of the Geological Survey, 1915, by the name Blairlogie; and, though it is not on the present Blairlogie Station but on Awatoitoi, it is still called the Blairlogie gas-vent. It is in the north-west quarter of Rewa Survey District, 30 chains north of Mangapakeha Trig.—that is, two and a half miles up Blairlogie Road from the junction with the Masterton – Castle Point Road. It was described by Park in 1888 in these words: " . . . the gas was bubbling with considerable force through the surface-water . . . The gas is carburetted hydrogen, and when ignited burns fiercely, forming a flame 12 in. or 15 in. high, which, notwithstanding the presence of the water, can only be extinguished with great difficulty. As an approximate estimate



MAP
Showing Geology near
BLAIRLOGIE GAS VENT
Block 2, REWA S.D.

Scale

CHAINS 10 5 0 40 80 CHAINS (1 MILE)

J. HENDERSON DIRECTOR

Reference

MIOCENE	UPPER CRETACEOUS	JURASSIC &c.	
Tm	Tm	Tt	Outcrops with observed strike and dip — 10° Vertical
Tutamoe Series	Tinui Series	Taitai Series &c	Outcrops with no observed strike and dip

Geology by M. Ongley, 1935.

G.E.H. '36

it is, I think, probable that the flow of gas could easily be carried by a 1 in. pipe without much pressure." It was described by Morgan in 1915 as follows: "The well-known Blairlogie gas-spring occurs on Mr. H. Morrison's Awatoitoi Estate, between Carswell's and Blairlogie. The spring is on the eastern slope of a ridge known as Kerosene Ridge, at a barometric height of 910 ft. above sea-level. At the time of the writer's visit, which took place during heavy rain, gas was bubbling vigorously through the water in a small hole about 6 in. in diameter, whilst over an area of several square yards there were numerous small escapes. The gas ignited readily and burnt with a bluish-yellow flame. The water in the hole tasted strongly of kerosene. . . ." These accounts indicate a spring more vigorous than it was in 1935, when no gas bubbled out, but only a smell of petroleum could be detected. It was this spring that attracted attention as a possible indication of a gas or oil field and so led to the survey being made to see if the geology was favourable. As a result of the examination it has been found that there is very slight chance of either gas or oil occurring there in quantity. The evidence for the conclusion is set out in this report.

Topography.

The watershed between the Taueru River on the west and Mangapokia Stream runs north through Cameron's Lookout (1,280 ft.) and Mangapakeha (1,050 ft.) to Mount Clyde (1,630 ft.). The heads of the westward-flowing streams are senile, weak streams of low grade draining low gentle slopes with many marshes. In sharp contrast with the low features of this cycle are the fresh narrow gorges and steep bare cliffs of the rejuvenated headwaters of Mangapokia Stream, which are cutting 500 ft. below the old wide flats.

Stratigraphy.

The rocks that crop out in this district are the same as in the adjoining Eketahuna Subdivision and belong to the formations classed in last year's annual report as Taitai (Jurassic), Tinui (Lower Tertiary and Upper Cretaceous), and Tutamoe (Miocene).

Taitai Series.—The beds here classed as Taitai are continuous with the Taitai of Mangapaheka Survey District, and like them consist of greywacke, argillite, and sandstone, dark, indurated and shattered, with some belts crushed and polished. From their different resistance to erosion they fall into one set that forms pinnacles, the so-called "taipos," and another set that forms the surrounding low country; but, as no fossils at all were found, all these beds that lie below the possible oil-bearing beds are put into the one set. Red- and green-banded tuff and coarse igneous rock, too, crop out in the greywacke, but all are here included in the Taitai. All are too indurated, slickensided, shattered, and crushed to be worth consideration as part of an oil-field.

The attitude and distribution of the "taipos," jagged hills of hard rock towering above the surrounding even upland, recalls the Taitai, Aorangi, and other pinnacles of Waiapu Subdivision, explained by Ongley and Macpherson in N.Z. Geological Survey Bulletin No. 30 as erosion remnants of a younger harder formation overlying a softer older one, and by Ongley in the N.Z. *Journal of Science and Technology*, Vol. XI, April, 1930, following the suggestion of Washburne, as remnants of an overthrust sheet. In Wairarapa these similar features are seen to be inliers in complexly folded and faulted country. This suggests that further examination is needed in Waiapu Subdivision.

Tinui Series.—The beds classed as Tinui Series in Eketahuna Subdivision extend south for two miles in a strip a quarter of a mile wide into Rewa Survey District, but afford only a few good outcrops. The work on Blairlogie Road has exposed the conglomerate at their base resting on the underlying greywacke and made up of pebbles from it. It contains rare Belemnites. The matrix is argillaceous, dark, and in many places slickensided and polished. The conglomerate stands vertical in contact with vertical greywacke and extends horizontally 100 yards along the road. It grades up into pebbly blue-grey mudstone with fragments of *Inoceramus*, which is fairly soft and slips readily. Above this, on the hill-face with the relations obscured, occur boulders of green sandstone and hard white siltstone with flint. These are the rocks nearest to the gas-vent.

Tutamoe Series.—Capping the watershed from Cameron's Lookout to Mangapakeha and away north and south is a hard gently dipping thick bed of coarse sandstone, generally with a bed of pebbly shell-rock at the base marking an unconformable contact. This rises into finer sandstone and into a very thick fine mudstone, which extends miles along the road near the road junction. These beds overlie the beds from which the gas escapes, unconformably, and have no connection with the gas.

Structure.

The structure of the country near Blairlogie gas-vent is not simple, but enough has been found out to show its main features. Two blocks of Jurassic (?) greywacke three miles apart trend west of south in Mangapakeha Survey District and extend into Rewa Survey District. Each has a fault along the east and is tilted to the west. Between them is a strip of Tertiary dipping gently west and lying on the toe of the eastern block, and between the Tertiary and the eastern greywacke is a narrow strip of Cretaceous conglomerate, argillite, green sandstone, and white siltstone a quarter of a mile wide and two miles long, in Rewa Survey District. This is shown on the road to have its base vertical in contact with the greywacke; but its outline, with both its margins the same shape, indicates that it dips, like the overlying Tertiary, gently westward. This is not established, for no good outcrops can be seen; but the evidence indicates a narrow Cretaceous homocline dipping westward.

Prospects of Gas and Oil.

The Blairlogie gas-vent has long been known, and as a result of this work it is now known that it is not related to any favourable oil or gas structure. The source of the gas is the basal Cretaceous conglomerate which rests unconformable on the greywacke. This is exposed in the new cutting on the road and was followed south to where it pinched out, and north for two and a half miles. A mile and a quarter north-east of the road it was found to contain a slicken-sided, black, glossy, argillaceous matrix with Belemnites and Inoceramus, and to smell fairly strongly of oil. It is not an oil-sand into which oil has migrated, but is evidently a foul bottom conglomerate that contains enough organic material to yield a smell of petroleum. Samples of it broken under water did not give a scum. This bed was not seen at the gas-vent, the only rock visible there being a streaky clay, evidently a pug, but it crops out 10 chains east of the vent and evidently dips west below it. When crushed in the faulting this conglomerate, it is thought, is producing the gas that escapes at the vent.

THE LIMESTONE DEPOSITS OF BLOCK I, KIDNAPPERS CROWN GRANT DISTRICT, AND SECTION 2R, BLOCK IV, KIDNAPPERS SURVEY DISTRICT.

(By M. Ongley.)

The limestone deposit is on a property of 13 acres in Block I, Kidnappers Crown Grant District, and part of Section 2R in Block IV, Kidnappers Survey District, about a quarter of a mile east of Tukituki River, at the junction of the Elsthorpe and Waimarama roads. It lies north of the road between the road and a small stream that flows west, a quarter mile north, into the Tukituki. South of the stream are three terrace-like flats 10 ft., 60 ft., and 130 ft. above it, and above the top flat rise the slopes of the hills. Mudstone crops out north of the stream, but parts of the bed of the stream and the three terrace fronts are calcareous sinter. The 10 ft. and 60 ft. flats have sinter appearing through them in places, and their flat, even form indicates that they are uniform and composed of sinter. No work to verify this has been done, as no importance is attached to them. The front of the upper terrace is sinter from end to end—that is, for 15 ch. to 16 ch. and 50 ft. to 120 ft. high. At a cave 20 ft. below the surface a tunnel penetrates 50 ft. and is through sinter all the way. At the quarry a cave extends 20 ft. into the sinter about 50 ft. below the surface. At the surface the holes sunk with a crowbar struck sinter 3 ft. to 5 ft. down at points indicated on the sketch and paced as 25 ft., 50 ft., 50 ft., 75 ft., and 100 ft. back from the terrace-front. The thickness of the sinter below the holes is not known.

The evidence set out indicates a big deposit of sinter and suggests that all the terraces consist of sinter from the surface down to stream-level. This has not been tested and cannot be relied on and should not be used in estimating the quantity, for it is well known that many sinter deposits are in the form of thin crusts or are merely skins over rock. It would be simple to sink shafts or bore from the top terrace or to put in adits from the low levels and so secure data to allow the quantity to be measured. Half a dozen low-level adits spaced along the high terrace front would provide valuable evidence, and could be quickly and cheaply driven. I understand that the sinter in sight is considered sufficient for a generation, and that it is planned to go ahead with the quarrying. This certainly looks all right and will probably turn out successful, but it is taking an unnecessary risk that can be avoided cheaply.

The stone is like nearly all sinters, slightly brownish in colour. Much of it is blanket formation or like curtains, much is in thin branching stems, and parts of it are stalactitic and stalagmitic. It is all chemically deposited sinter, and like most such sinters will probably be 99 per cent. calcium carbonate. I saw no impure or mixed sandy or earthy deposits and consider it all chemically deposited high-grade sinter. Altogether it is a surprisingly big deposit of high-grade sinter.

AURIFEROUS DEPOSITS AT PORT MOLYNEUX.

(By J. Healy.)

A gold claim was inspected at Port Molyneux on Section 1, Block II, South Molyneux district, where auriferous deposits are being worked by the owner, Mr. Tilson. The claim abuts on the main road running along the sea-coast from Port Molyneux, and the present workings are some 150 yd. back from the road, on rising ground immediately north of a small stream.

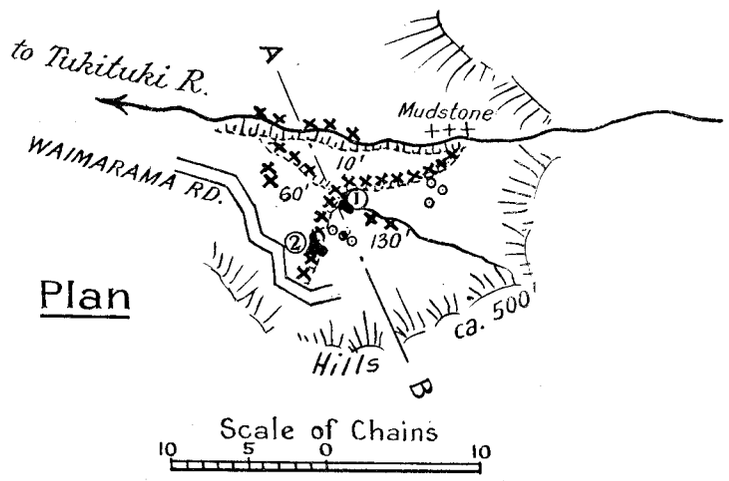
The richest wash, a blue-grey gravel of unknown but probably inconsiderable thickness, rests on a solid rock. Above it is 4 ft. to 5 ft. of considerably oxidized conglomerate consisting mainly of pebbles up to 2 in. in diameter, though occasional boulders reach a foot; the matrix is blacksand, which is also found as lensoid pockets throughout the bed. This wash passes up into a 4 ft. layer of finely bedded blacksand showing cross-bedding in places, above which is a light-coloured sand stained slightly brown. The blacksand and underlying conglomerate are auriferous, all the gold being very fine. The upper surface of the sand is fairly level and about 20 ft. above sea-level, the overburden being a stiff, brown clay very similar to the loess from the Waikaka district. Its thickness increases as the slopes rise landward, where a terrace 80 ft. to 90 ft. above sea-level extends for a short distance to the south and south-west.

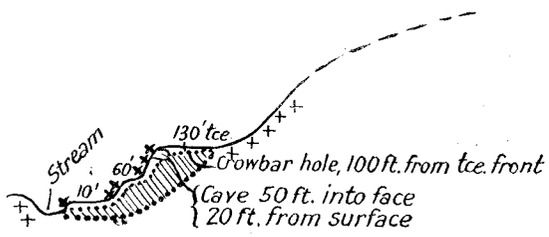
Two hundred yards north-east of the workings is a rock-platform 30 ft. above sea-level, but half a mile to the south the rock rises to a much greater height, as a ridge which stretches away to the north-west and defines the probable boundary of the auriferous deposit, though its exact extent is obscured by the thick clay on top. Solid rock is found in many places at low level, and apparently forms a fairly uniform surface on which the gravel rests. The gold has been derived from the ancient Molyneux River, and the gravels and sands are either the remnants of a former estuarine deposit or of a beach formed when the land was some 20 ft. or more lower than at present.

WETHERSTONES GOLD-MINE, LAWRENCE.

(By J. Healy.)

An inclined shaft has been driven to a vertical depth of 650 ft. below the portal, and at its end a vertical shaft was sunk to a further depth of 40 ft. at the time of inspection. The drive dips approximately to the east and passes through well-cemented schist-conglomerate, oxidized to a reddish-brown colour near the surface, but bluish-grey where fresh. A geophysical survey indicated that the schist surface beneath the "cement" dipped gradually downwards to the north-east, where





— Sinter Deposit —
— Block IV, Kidnapper S.D. —
— Hawke's Bay. —

a step-up of 200 ft. to 300 ft. towards the north-east occurred along a fault, beyond which the schist gradually rose towards the surface. The workings have now reached a depth of 690 ft. below the surface.

The incline is parallel with the schist surface beneath the conglomerate, and two drives at different depths to the west from it encountered the schist at approximately the same distance. However, farther down, the schist surface departed from its supposed regular dip and appeared in the main shaft above which it rose for a distance of 50 ft. to 60 ft., but fell again for a short distance. It rose

again above the roof of the drive, and finally dropped away very steeply as indicated by a bore sunk in the floor of the incline a few feet beyond the point of disappearance of the schist. The dip of the main incline was steepened, and a further drive to the west at greater depth encountered the schist still sloping steeply to the east. This contact and the last one in the main incline are crushed and slicken-sided and suggest the presence of a fault, whereas at the first-mentioned two contacts the conglomerate apparently rests normally on the schist.

At the top of the vertical shaft brown "cement" has been encountered at a depth of over 600 ft. from the surface, its contact with the blue conglomerate being crushed and suggestive of faulting. Evidently the fracturing was not along a single fault, but was complex and along several breaks. The in-faulting of a small wedge would account for the brown "cement" at such a great depth. The conglomerate at the bottom of the winze is crushed and the pebbles well polished, suggesting that the workings are very close to one of the fractures.

CROMWELL GOLD-MINING CO.'S LOW-LEVEL ADIT, BENDIGO.

(By J. Healy.)

An adit has been driven southwards through schist for a distance of about 1,800 ft., in which distance several minor lodes have been crossed. At the present face, and again 75 ft. to the north, are lodes of 18 in. thickness striking north-east and dipping at angles of 60° and 50° to the north-west. They are stated to be respectively the Bee and Cromwell lodes, although at the surface these two lodes strike east-south-east.

A strong crush-zone, 9 ft. wide and with well-defined slicken-sided walls, crosses the adit about 940 ft. from the entrance, and a similar zone, 14 ft. wide, occurs at 1,045 ft. These, as well as several other fractures, strike about north-east and dip steeply south-east. A few small calcite veins and more rarely quartz veinlets traverse the crushed rock of the breaks. A few other fractures were observed which strike east-south-east and dip north or south generally at low angles.

PAHI GREENSAND.

(By Dr. J. Henderson.)

At Pahi, Kaipara district, greensand, exposed between tides, clearly underlies the argillaceous limestone forming the south end of the peninsula. This has been noted by Hector, Cox, Park, McKay, and Marshall. The late Dr. H. T. Ferrar, in N.Z. Geological Survey Bulletin No. 34, p. 31, 1934, maintained that this greensand "is down-faulted, overturned, and stratigraphically overlies the limestone," and he adduces evidence from other parts of the neighbourhood showing that greensand overlies the limestone. The writer, who recently spent a few days in the district, saw no evidence of the three faults by which Ferrar lets down the greensand on the foreshore, though rock exposures are exceptionally good. On the west shore of the peninsula, a mile north from the point and on the outer edge of the tidal bench, greensand rests, as Ferrar states, on hydraulic limestone, which in fact is exposed at low tide on the seaward side of the bench edging the greensand of the peninsula along both the Paparoa and Pahi arms. This sandstone is much disturbed, and the underlying limestone is traversed by so many joints and other partings that its bedding is rarely determinable.

In the writer's opinion there are two glauconitic sandstones in the area, one below and the other above the hydraulic limestone. The lower, which in places grades laterally into glauconitic mudstone which grades upward into hydraulic limestone, is occasionally fossiliferous, is black-green when wet, and is gritty at many points, and in places pebbly. Pyrite is abundant, and the rock is traversed by many irregular rusty partings, though visible bedding is rare. A sample examined under the microscope contained mammillary aggregates of glauconite up to a millimetre across and constituting about 40 per cent. of the rock. The abundant pyrite was moulded on the glauconite and angular grains of feldspar. The higher greensand has a decidedly lighter-green colour, and is everywhere well-bedded, the thicker greensand layers being separated in the lower part of the sequence by narrow bands of white clay. No pyrite was seen, and the rock is decidedly finer in texture. In places there are thin lenticular bands largely made up of small angular fragments of argillaceous limestone. The fragments, which average about a millimetre across, are probably, like the white clay mentioned above, derived from the underlying Onerahi beds of which the hydraulic limestone is an important member. Under the microscope the glauconite particles were seen to be scaly and not to exceed $\frac{1}{10}$ millimetre across.

There is no evidence to determine the age of the higher green sandstone, which may belong to the lower part of the Waitemata Series (Upper Oligocene) rather than to the Whangarei Series as Ferrar maps it. All the greensand, shown on the map on page 32 of N.Z. Geological Survey Bulletin No. 34, south of the strong fault crossing the peninsula about 60 chains north of the township belongs to the older group (Eocene).

OIL-DIVINING.

(By Dr. J. Henderson.)

On several occasions during the past year the press has given wide publicity to statements by diviners that petroleum is present in commercial amount at a number of localities (Tokatoka, Waipukurau, Wanganui). "Divining" is a subject of perennial controversy. Some enthusiasts claim that the rod is effective in discovering oil, ores, or buried treasure, and is even able to analyse alloys, and to diagnose disease; but except for searching for water its use is now generally abandoned.

In New Zealand, where most parts receive a generous rainfall and where water at shallow depths saturates the detritus of lowlands and is present in the innumerable joints and fissures of the more compact rocks, most random bores will get some water, and, with intelligent selection, the results would be better and certainly sufficient to keep the belief in dowsing alive or even to cause it to flourish. So far as is known, however, the diviners in New Zealand have totally failed to locate any commercial deposit of gold, coal, or oil; in the last few years eight positive clear-cut cases have come under the notice of officers of the Survey in which sites, selected by dowsers, three for coal and five for gold, and explored in depth by drill or drift, yielded nothing of value to the miner or even of interest to the prospector. Some ten years ago the Anglo-Persian Oil Co. carried out an exhaustive series of tests in oil-divining. Sir John Cordman regards the results as a "complete fiasco" (J. W. Gregory, Water Divining, p. 12, Public Works Roads and Transport Congress, 1927). Inexplicable failures of the rod to trace water-flow at shallow depths have occurred; at Arapuni several diviners are said to have failed to locate leaks in the headrace, and at least one walked over the Waikato flowing through the diversion tunnel without his rod responding.

More than with any other mineral product the prospecting for petroleum and the selection of bore-sites is peculiarly the province of the geologist. The world's oil-supply depends entirely on his efforts. The basis of his work is the collection of relevant and verifiable facts. He may trench and bore to get some critical facts and collaborate with several kinds of technical experts to get others. The mass of facts set out on maps and the geologist's discussion of his deductions and recommendations are considered by other geologists of long experience and proved capacity. Then, if the facts are sufficient, the deductions valid, the recommendations reasonable, and the factors of finance, markets, &c., favourable, boring is undertaken and may be successful. The procedure involves much hard work and costs a great deal of money. Now divining has been practised for many centuries, it would obviate vast expenditures, and surely if it had the slightest value the intelligence of directors and the cupidity of shareholders are enough to ensure that a diviner would be on the staff of every oil company; indeed, he would be the key man of the business. But practical tests innumerable, as well as more rigid scientific trials, have amply demonstrated that the short-cut to achievement offered by the diviner, though it may be alluring, is wholly illusory.

The scientist cannot refute the dowser's claims; magic and witchcraft were not disproved and never will be, but most people have simply ceased to believe in their cruder forms. Perhaps the most important characteristic of scientific method is the constant reference back to verifiable facts, but the diviner's reactions cannot be verified. Divining, indeed, is a form of magic, the dowser arrives at his results by methods wholly alien to those of science, though he may make use of the latest scientific jargon. The advances of science, often comprehensible only to the expert, tend to become invested with the very qualities of magic that science in making her discoveries had to abjure. Witness the cranks who, juggling with radio-electricity, the quantum theory, and other uncomprehended terms, purport to discover perpetual motion, the death-ray, and the manufacture of gold.

People like to hear of vast untapped oil-fields and other sources of wealth, and the press will devote columns of space to diviners' "discoveries"; the geologist's bald statement that there is no evidence may get a few lines. The rod's "location" of abundant underground streams or of a lost water-main has news value, but the uninteresting fact that drilling has failed or that the main is not where stated is not recorded. Undoubtedly this uncritical attitude of the press combined with the obvious sincerity of the great majority of the diviners has a great deal to do with the persistence of the wide-spread belief in divining in spite of the repeated and complete exposure of its fallacy.

METEOROLOGICAL BRANCH.

REPORT BY THE DIRECTOR, 1935–36.

General.

Early in the year a number of additions were made to the staff in view of the imminent necessity of providing a Meteorological Service for Aviation. Dr. M. A. F. Barnett, Ph.D. (Cantab.), M.Sc. (N.Z.), was appointed to take charge of this section of the work. Another appointment was that of Dr. W. A. Macky, Ph.D. (Cantab.), M.Sc., who had received training in the British Meteorological Office. The Director attended a Conference of Empire Meteorologists at London in August and subsequently the International Conference of Directors of Meteorological Services (Organisation Météorologique Internationale) at Warsaw, Poland. At the time of his appointment Dr. Barnett was in London, and was able to be present at the Empire Conference. Through the courtesy of the Director of the London Meteorological Office, Sir George Simpson, he was able to visit the various branches of the Meteorological Office, and particularly to study the organization and working of the service for Aviation. He also made a brief visit to Bergen, Norway, in order to gain some insight into the methods of synoptic meteorology being developed there. At the European conferences many matters regarding routine procedure, particularly in connection with aviation and maritime meteorology, were dealt with, and much co-ordinating work was done. Mr. B. V. Pemberton was appointed Acting-Director during the Director's absence.

The first commercial air services commenced at Christmas-time, and the necessary meteorological advice to pilots has been provided.

An increasing interest is being taken in the relation between meteorology and public health. This is apparently being stimulated by the Otago Medical School, and special information has been supplied to numbers of students who were preparing theses for various medical degrees.

Mr. R. G. Simmers, M.Sc., of the Meteorological Office staff, has been awarded a Commonwealth Service Fellowship, and will shortly be proceeding to America to undertake advanced studies in Meteorology.

Routine publications have been maintained and a few short studies on special questions printed.

The cordial co-operation of members of the staff throughout the year is gratefully acknowledged.

Observing-stations.

A new climatological station was established at Morrinsville in connection with Dairy Research. The station at Cambridge is shortly to be discontinued. Co-operation has been maintained with the Public Works Department in the collection of rainfall data in Canterbury, where an intensive study of irrigation problems is being pursued. Twenty-two new rainfall stations have been established and six abandoned. All the principal lighthouses now have rain gauges.

A considerable amount of inspection has been carried out, particularly along the regular air routes. A number of new reporting stations were provided. A large number of old Fortin barometers have been reconditioned by Mr. R. G. Simmers and used at airways and other stations.

Two soil-moisture meters, of the type devised by Mr. W. S. Rogers at the Apple Research Station at East Malling, Kent, and a number of earth thermometers of a new type were purchased in London, and should prove useful at the various agricultural research stations.

Forecasting.

The development of aviation is calling for frequent and detailed reports and forecasts from the early hours of the morning onwards. As the services extend, and particularly with the inauguration of trans-ocean services, these demands will increase greatly. One of the most pressing problems of the Meteorological Office, therefore, is to produce a number of additional forecasters within a short period. Unfortunately, at the time forecasts are made they have to be got out promptly, and there is little time for discussion. Again, long experience is one of the principal assets of a forecaster. It will, therefore, be some years before full efficiency can be expected. In the meantime members of the staff are getting practice in plotting charts, drawing fronts and isobars, &c. Daily discussions on the charts are held, and special types of weather are described in detail, occasionally in printed memoranda. In the scale and type of charts used, the methods of plotting data, and drawing isobars and fronts, international practice is being followed. In the collection of data, also, international conventions are being adopted wherever possible. It is not yet possible to introduce international codes in their entirety, since, at present, there is little opportunity of instructing the reporting observers. The latter have, in general, done very well with the brief written instruction which it has been possible to give them, and we take pleasure in acknowledging the care and keenness with which the great majority do their work, in nearly every case without any prospect of personal gain therefrom.

The advantages of using international methods are that they are in the long run likely to be the most efficient, that by so doing the service is prevented from stagnating and becoming out of date, and, finally and most important, our charts will be intelligible immediately to other services and to pilots on international airways.

As soon as the various aviation services are in smooth running order it should be possible for the Meteorological Office to publish its daily weather charts. These will certainly be of much

interest to the public and will have great educational value. Unless charts are actually seen, it is very difficult for any one to have more than a very unsubstantial idea of the significance of descriptions of the weather situation, which must necessarily refer to such phenomena as depressions, cyclones, anticyclones, &c. Those specially interested, also, will be able to follow weather changes much more intelligently, understand the forecast, and so make greater use of it, if able to get the comprehensive view of the situation given by the chart.

A district forecast is now being provided in the evening for Southland, and the "Farmers' Forecast" is to be continued throughout the winter.

Upper-air Observations.

Observations of the wind in the upper air by means of pilot balloons are now made thrice daily at Wellington instead of once as previously. The results are included in the reports furnished to the Air Services. The Magnetic Observatory at Christchurch provides corresponding data for that centre. As soon as quarters are available at the Air Base at Auckland, a pilot-balloon station will be established there also.

Aviation Meteorology.

It was not until very shortly before Cook Strait Airways commenced their operations between Nelson, Blenheim, and Wellington, at Christmas time, that the funds necessary for providing a weather-reporting service became available. Preparations, therefore, were extremely hurried. With the active co-operation of other Departments, however, a scheme was evolved, and from the inception of the Air Service pilots received meteorological advice prior to each flight. In the latter half of January Union Airways commenced the route from Palmerston North to Dunedin. In the past, for the purpose of drawing weather-charts and preparing forecasts, the Meteorological Office has received reports of meteorological observations made at a network of stations at 9 a.m. and 4 p.m. The morning messages included reports from a number of Australian stations and from ships at sea. These were not usually complete until between 2 p.m. and 3 p.m. owing to the difference of time between Australia and New Zealand. In the afternoon, observations were received from Sydney and Hobart as well as from New Zealand stations. Forecasts were issued at noon and at 5 p.m. Since the first flights were to commence at 7.45 a.m., considerable innovations were clearly called for. In order to ensure that a report should be available to pilots before setting out, observations had to be made not later than 6 a.m. At this hour telegraph offices were closed, so that it was necessary to collect reports by telephone or wireless. This restricted the number of possible stations, but fairly satisfactory arrangements were made. Again, the time between 9 a.m. and 4 p.m. is too long to go without fresh reports, and by the time the 4 p.m. data could be distributed flying operations for the day would have ceased. The time of the afternoon observation was, therefore, advanced to 3 p.m. and an additional observation was fixed for noon. We thus have the 9 a.m. observation practically unaltered and remaining the principal one for the day. The 3 p.m. one is next in importance, but few reports are received from Australia or from ships. At 6 a.m. and noon reports are received from stations along the air routes and a sufficient number of others to enable the general weather situation over New Zealand to be appreciated. Based on the reports received, weather charts are drawn four times a day, two of them being of a restricted nature. Before a pilot on a regular service leaves one of the main aerodromes he receives the reports of the existing weather at the stations *en route* to his next important stop, including wind direction and force, visibility, amount and height of low cloud, &c., such information as is available regarding winds in the upper air, and a forecast of expected changes.

At present for these services use has had to be made of the telephone and telegraph facilities available to the public. The amount of traffic involved is considerable and must increase as aviation expands in New Zealand. It is therefore hoped that some more economical means will be found. In the establishment of the service we have had very great assistance from the Post and Telegraph and the Marine Departments, on whom we depend not only for the means of collecting and distributing information, but also for most of the observers. I am glad to acknowledge the cordial co-operation of these Departments. The work has, of course, been carried out in close co-operation with and with the assistance of the Controller of Civil Aviation. The additional funds required have been provided from the Defence Department vote.

In order to expedite the receipt of telegrams an operator, seconded from the Post and Telegraph Department, has been installed at the Meteorological Office. At present no service is given on Sundays or holidays, but the matter is under consideration. Furthermore, the present scheme does not cater for aero clubs and those undertaking irregular flights and taxi work. Amongst the suggestions which have been made is that each of the principal aerodromes should be provided with a wireless station capable of communicating direct with Wellington as well as undertaking the control of traffic in the air. Should such a plan be adopted, it would be possible to broadcast from Wellington, four times daily, route weather reports and forecasts for the whole country. These could be intercepted at all aerodromes and displayed for the benefit of pilots. It is hoped that at the principal aerodromes it will be possible ultimately to display this information by means of wall charts (weather charts on a large scale) as is done in England. Another useful development would be to broadcast weather reports and forecasts by telephony, say, from 2YA. This issue could be made to serve the general public, including farmers, mariners, and motorists, as well as aviators.

Two members of the staff have licenses as "A" Pilots, and several others are making preparatory studies.

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.

A paper (Meteorological Office Note No. 16) was prepared on the summer of 1934–35. This was by far the warmest summer hitherto experienced in the Dominion. December was an extraordinarily warm month for this region, and November, January, and February were also very warm. It was not until May that the monthly means fell below normal. This state of affairs was confined to the New Zealand area, Australia having a cold summer, while in the Pacific Islands conditions were approximately normal. A severe drought prevailed over most of the country, especially the more settled areas, from November to January. In February the drought was gradually broken. Throughout most of the period pressure was low over northern Australia and high over the New Zealand area, particularly in the south and east. In consequence, there was a prevalence of warm northerly winds, and depressions advancing from the west lost intensity as they approached the Dominion.

In connection with soil surveys in those districts, we were requested to prepare notes on the climates of Hawke's Bay and North Auckland. It was, therefore, decided to commence a series of studies of divisional climates in New Zealand. The first two, covering the areas mentioned, will appear in Meteorological Office Note No. 17, which was ready for the printer at the end of the financial year. In both North Auckland and Hawke's Bay the rainfall is rather unreliable compared with New Zealand conditions generally, and in both the rains are much heavier in winter than in summer. There is a liability to heavy rain at any time of year, but particularly in autumn and winter. In Hawke's Bay the dry period commences earlier in the spring than in North Auckland. The agricultural pursuits and practices depend very largely on these rainfall regimes. In Taranaki and the Manawatu, for exemple, the rainfall is more reliable than in Hawke's Bay, and the spring considerably wetter on the average. Thus, Taranaki is predominantly a dairying and Hawke's Bay a grazing district. In Hawke's Bay the lambing season is early owing partly to the dry spring.

The paper discusses dry and wet spells, and in this connection the correspondence between Australia and New Zealand is rather close. Temperatures, frost, wind, &c., are also considered.

Empire and International Conferences.

The Conference of Empire Meteorologists was opened in London by Colonel Sir Henry Lyons, F.R.S., Vice-Chairman of the Meteorological Committee, on the 12th August, 1935. There were thirty-five delegates present, all the Dominions and the important colonies being represented. In the evening a reception was given by Sir George Simpson, the Director of the London Meteorological Office, and Lady Simpson, at the Meteorological Office at South Kensington. Here a comprehensive exhibition of meteorological instruments, diagrams, and tables had been arranged, A very beautiful and instructive exhibit was a series of stereoscopic photographs of clouds taken from aeroplanes by Commandant Jaumotte, of Belgium. Professor D. Brunt, of the Imperial College of Science, gave an account, illustrated by experiments, of researches being undertaken at his direction on the formation of clouds. Using glass chambers and tobacco smoke with various heating and cooling devices, Professor Brunt is able to reproduce some of the more complicated cloud forms. His researches should throw considerable light on the nature of air movements in clouds and of atmospheric processes generally.

The programme having been arranged, the regular meetings of the Conference began the next day. The first point to impress one was the great developments that had taken place in the Meteorological Services of the Empire. Between Cairo and the Cape, for example, there are four separate services, each well equipped and staffed, each given ample facilities for the collection and distribution of weather information by telegraph and wireless, and for the tabulation and publication of climatic data. During the past few years the development of aviation has forced rapid development of weather reporting and forecasting, but apart from this there has been marked growth of climatological services in response to the demands of agriculture and industry. New Zealand has undoubtedly lagged behind other countries as regards the practical application of meteorological knowledge.

Owing to the enormous developments taking place in aviation, and the vital influence which the weather has on the latter, it was not surprising that questions relating to aviation meteorology should take the most prominent place in both the Empire and the International Conferences. The 13th August was devoted to these problems. First of all a representative of the Air Ministry gave a confidential account of the British Government's policy with regard to Empire air mails. A world-wide service is, of course, contemplated with flying by both day and night. The assistance of the various Directors in carrying out the service was sought. Sir George Simpson, in conveying the thanks of the meeting to

the Air Ministry, emphasized the fact that much fundamental meteorological research would be required to provide the information that would be necessary.

Mr. Corless, Superintendent of the Forecast Division of the London Meteorological Office, gave an account of the service provided for aviation in Great Britain. Delegates were subsequently given an opportunity of seeing this system in operation at the Croydon Aerodrome.

Amongst other subjects considered in this section were Ice Accretion on Aircraft and Meteorological Aids required for Blind Flying.

On the 14th August the subject was "Synoptic Meteorology." This relates to the collection of data for weather charts, the methods of plotting the data on the charts, of analysing it and of deducing the forecasts from it. Next comes the passing of the information to the various branches of the public, such as shipping, aviation, and agricultural interests, in the most convenient and concise form. It involves the devising of numerous codes and symbols, the interchange of data between nations, the choice of suitable scales and projections for charts, &c., as well as fundamental meteorological principles. Since synoptic meteorology in some form or other constitutes the major part of the work of meteorologists, the discussion at the Empire Conference was very valuable and a useful preparation for the International Conference.

On the 15th August the meteorological organizations for the Army and Navy were considered. These matters need not be discussed here, but meteorology plays an important part in modern warfare. Operations are influenced very greatly by the weather; the Naval and Air Services are engaged in both combating and exploiting it; the artillery require accurate data regarding winds and temperature in the upper air; and gas warfare depends on an extremely precise and detailed knowledge of atmospheric conditions.

The afternoon of the 15th was devoted to the consideration of meteorological instruments. The Conference was informed of recent improvements, given hints for specifying and ordering equipment, &c.

The next day was occupied with Marine Meteorology. Since so large a fraction of the earth's surface is covered by ocean, weather reports from ships are of great value to forecasters, and their value will increase with the extension of trans-ocean air services. An interchange of reports is extremely useful also to the vessels themselves, since it enables them to estimate their future speed, to take any necessary precautions against bad weather, and to take advantage of good. In order to avoid unnecessary duplication of work and to reduce wireless transmission to a minimum, it has been arranged internationally that ships should observe at certain fixed hours and broadcast the results in one code and according to a schedule determined by their position. This scheme has proved to be of great benefit to mariners and others, but some of us had experienced serious difficulties in connection with it. As a result of action taken at the Conference, it is expected that these difficulties will disappear. On Saturday, the 17th August, the subjects for discussion were (1) the Classification of Meteorological Literature; (2) Organized Research in Meteorology; and (3) the Responsibility of Meteorology for Geophysics. The classification of its literature is a question that is troubling most technical sciences to-day. In meteorology it looms expecially large, because there is so much routine publication, such as of daily weather charts, tables of climatological data, &c., from all parts of the world. None of this material can be neglected, but it accumulates at an alarming rate. A classification based on the decimal classification adopted by the International Institute for Documentation was explained by Dr. Brooks. The proposals outlined had been drawn up by one of the Commissions of the International Meteorological Organization, and they were subsequently adopted at Warsaw. They will greatly simplify the work of those in charge of meteorological libraries.

The question of research in meteorology is a very important one and of far more than academic interest. Some valuable researches have been carried out by persons who are not and have never been associated with official meteorological services. They usually refer, however, to more or less isolated phenomena, and are generally concerned with the more purely physical aspects of the subject. As an instance, one might mention the work of Professor C. T. R. Wilson at Cambridge on atmospheric electricity, and particularly the electricity of thunderstorms. But even in this case, it is difficult for Professor Wilson to get sufficient thunderstorms to work on, and for most problems a great accumulation of data covering a considerable period of years is required. Generally this can only be obtained from an official service with its organized network of observatories and observing-stations where work is continually going on under close supervision. Furthermore, the problems are seldom isolated, but involve continuous lines of research in which many different types of physical process are concerned. Their solution, therefore, requires persistent effort extending over many years. One might refer, for example, to the work of Dr. H. U. Sverdrup, of Bergen. At first sight the papers published by him during the last quarter of a century may appear to cover a rather wide range of unrelated subjects, but a little consideration will show that he has throughout been concerned with the fundamental question of the heat economy of the earth and the processes by which it makes use of the heat given out by the sun. His attack on the subject is on a wide front, and he has made some very notable advances. Finally, the atmosphere is a most complex body, the calculation of whose behaviour has so far resisted the attempts of mathematicians. The meteorologists who have devoted many years to the observation of its characteristics and the watching of its movements will have accumulated a store of knowledge which it is very difficult to secure in any other way. Progress has, therefore, been due almost entirely to the researches of such persons. This is the case as regards not only pure meteorology but also the practical applications, as, for instance, in agriculture. The value of such research is illustrated by the revolution in the methods of preparing weather charts and of deducing future changes therefrom which have been developed as the result of prolonged investigations by the Norwegians. Their methods are gradually being adopted by all nations. Even in a small and isolated country such as New Zealand, a service is bound to stagnate and become inefficient unless the staff display a true interest in meteorology for its own sake and a desire to carry out original investigations.

The discussion on organized research at the Empire Conference and the subsequent observations relating thereto which one was able to make at Warsaw and elsewhere were, therefore, of very great interest. The problems arising out of the discussion may well be considered in connection with the meteorological organizations at London and at Bergen. At London the total staff is in the neighbourhood of one hundred and forty. In addition, there are approximately forty branch establishments attached to the service, but located in other parts of Britain and in and about the Mediterranean area. This organization has grown and is growing rapidly, principally as a result of the requirements of aviation. At London there are over fifty officers in the Forecast Division alone, of whom seventeen are professional officers. This staff has been provided to meet specific demands for information, and there is practically a continuous flow of weather forecasts and reports from the office by telegraph or telephone either over land lines or by wireless transmission. The officers concerned have their time fully taken up by routine work. They are stationed in the cramped quarters of an office building in the centre of the city, and a large amount of time is consumed in going to and from work. There is little opportunity for meeting and exchanging views or leisured thought. The position would be improved were there more positions available at the universities for meteorologists. A certain proportion of the professional officers might then take up chairs or lectureships at the universities, where they could continue their own researches under more favourable conditions, prepare students for the official service, and generally create schools of thought in meteorology. At present there is only one such position, that of the Chair of Meteorology at the Imperial College of Science. Professor D. Brunt now occupies this position, and is doing valuable work. But it is only possible to deal adequately with certain lines of research and to cater for a small percentage of the professional meteorologists in this way. In my opinion, a healthy tone can only be maintained in a service if there is some provision for research during office hours, and if definite steps are taken to encourage it by leadership and provision for free discussion. The surroundings, also, must be congenial. In addition to problems associated with general meteorology and forecasting, there are numerous avenues for work at observatories and in the practical applications in connection with agriculture, engineering, and so forth.

At Bergen, conditions are in marked contrast to those in London. Though he has to work from early morning to late at night to do it, all the outgoing forecasts can, up to the present, be handled by one man, who alone is responsible for the drawing of the working charts of the daily weather. Climatology is handled by the Central Meteorological Institute at Oslo. There are a number of forecasting officers at Bergen, each of whom, in turn, becomes responsible for the forecasts during a certain period. While on this duty he has to concentrate severely and work long hours, but in between times he has considerable leisure. The Meteorological Institute (the Government Service) is located in the building of the Geophysical Institute, which has a fine open situation overlooking the harbour and surrounding country. The Geophysical Institute itself has Professors of Meteorology, Hydrography, and Terrestrial Magnetism. The professor of Meteorology is Dr. J. Bjerknes, who was formerly in the Government Service, and who still associates himself closely with it. He was mainly responsible for the discoveries which have put the Norwegians in the forefront of meteorological developments. Also in the same building is the Chr. Mikkelson Institute, with its research departments, including those of Professor Sverdrup, mentioned above, Professors of Mathematics, Mathematical Physics, &c. Much of the work of all these people is of a concerted character and co-ordinated also with that of institutes in other parts of Norway. In the forecast room at Bergen visiting scientists are welcomed. A discussion is held at midday on the morning weather chart and forecast, and there are frequent informal meetings at which more general discussions are held. There is an atmosphere of enthusiasm and confidence, and continual progress is being made.

The discussion on the responsibility of meteorology for geophysics centred round such subjects as terrestrial magnetism, seismology and atmospheric electricity. These subjects can scarcely be included in meteorology proper, but their study requires an organization similar to that of the meteorological services of the world. They are consequently frequently undertaken by meteorological institutes. But they are liable to be the cinderellas of science and suffer neglect. This is rather the case in New Zealand, where the maintenance of the Apia Observatory and those in the Dominion in full activity has for years been a difficult matter. The other countries of the Empire have allied problems, and as a result of the discussion some measures of mutual support were evolved.

The subjects for Monday, 19th August, were Climatology and Agricultural Meteorology. A great deal of work is being done throughout the Empire in correlating weather and yields from the soil, the forecasting of frosts, and so forth.

Mr. W. S. Rogers, of the Horticultural Research Station at East Malling, Kent, showed an instrument he had devised for recording soil moisture. This instrument appears to work quite satisfactorily, and, since such an apparatus has long been desired and sought for, it should be widely used. Mr. Yates, of Rothamstead, related how apparatus of this type had been used on a sugar beet field, where it was shown that the growing plant was depleting the soil of moisture to a depth of 6 ft.

Dr. Balls explained the use of an underground tunnel lined with glass, which had been constructed in Egypt for studying root-development. It was found that the roots of wheat also extended to 6 ft. The effects of temperature and soil moisture were investigated.

It appears on the whole, however, that more intense research in climatology and agriculture is being carried out in the United States of America, the U.S.S.R., and some European countries than in Great Britain and the rest of the Empire.

In connection with climatology generally, an important discussion followed the reading of a paper by Dr. Brooks, of the London Meteorological Office. Dr. Brooks said that climatological observations must be regarded as standards of reference and must therefore be strictly comparable. There were three main ways in which the practice at climatological stations differed—viz., exposure of instruments, methods of working up data, and hours of observations. It appears that the greatest

obstacles to standardization are met with in connection with the times of observation, where business hours and the general routine in a country exercise so great an influence. For climatological purposes, the ideal thing would be to use standard hours of local time, but this is often impossible.

A valuable result of the discussion was that Sir George Simpson promised that in future, before new editions of the London Meteorological Office's "Observer's Handbook" were published, Empire meteorologists would be consulted. The handbook should thus become a standard one for the Empire and help greatly in securing uniformity.

The meeting on the 20th August considered the questions of Air Masses as Units in Climatology, the Computation of Meteorological Averages, and Seasonal Forecasting. The first two subjects are of rather a technical nature. Regarding seasonal forecasting, Dr. Brooks produced a valuable memorandum on the work done hitherto, and considerable discussion followed. The outcome of the discussion was that though results were rather promising for the tropics, anything so far achieved for the temperate regions was of little practical value, and the future was not very bright. The demand for seasonal forecasts in agricultural countries is very strong, and there have been numerous attempts to force the Meteorologist's hands. The situation is exploited, too, by quacks of all sorts. The subject, however, bristles with difficulties. Even were the general character of a season to be correctly anticipated, the time factor and the local variations are so important that the net value of the knowledge is very problematical.

The subjects for the last day of the Conference were the Measurement of Evaporation, with Special Reference to Water-supply and Agriculture, and the Construction of Rainfall Maps.

The Conference was entertained at dinner on the 16th August by the British Government, Sir Philip Cunliffe-Lister, Secretary for Air, presiding. In a speech at this dinner Sir Philip emphasized the Government's determination to carry out the scheme of Empire airways as soon as possible. He expressed his realization of the fact that the success of the scheme depended more than anything else on the efficiency of the meteorological services, and, on behalf of the Cabinet, promised the British service all the assistance it required.

During the course of the Conference excursions were arranged to the Kew Observatory and to the Croydon Airport. Everything possible was done throughout by Sir George Simpson and his staff to make the meeting the success it was.

The International Conference of Directors of Meteorological Services.

Along with most British delegates I proceeded to the International Conference at Warsaw, Poland, on the 31st August.

The previous meeting of the Conference of Directors was at Copenhagen in 1929, and more frequent meetings would be impossible to arrange. It has, however, a permanent secretariat under the control of the president. It also elects from its members the International Meteorological Committee, which manages affairs between conferences, and of which meetings may be called as required. In addition, a number of commissions have been appointed to consider the needs of various branches of meteorology and make recommendations to the committee or the Conference. The whole organization is known as the "Organization Météorologique Internationale," or, shortly, the O.M.I. The Conference did not begin till the 5th September, but there were meetings at Warsaw of the Commissions of Synoptic Weather Information, Climatology, Study of Clouds, Maritime Meteorology, Exploration of the Upper Atmosphere, Terrestrial Magnetism, and Atmospheric Electricity, and various sub-commissions. It is at the meetings of the commissions that technical matters are mainly discussed, and in connection with them that one gets the most benefit, scientifically, from the Conference. This refers not only to the actual meetings, but still more perhaps to the private discussions between members which are stimulated by them.

In the report of the Empire Conference reference has already been made to the growth of meteorological services as a result of the development of aerial transport. The establishment of forecasting and reporting services of a high standard is being forced upon all countries. This has, in turn, demanded close co-operation between neighbouring countries and the planning of a uniform organization throughout the world. Another consequence has been an increased appreciation of the importance of the meteorology of other parts of the world, particularly the tropics, by European meteorologists. The world is, indeed, rapidly becoming a single meteorological unit. In Europe hourly reports of the weather along air routes are available for aviators, while complete weather charts and forecasts are prepared every three hours. Something of a similar nature is required along all the main air routes. This involves an enormous amount of traffic over telegraph lines and especially over the air. And since to be of use weather reports must be received and the resulting broadcast report and forecast issued soon after the observations are made, it is all urgent traffic. One of the principal duties of the O.M.I., therefore, is to so organize routine, codify reports, and arrange time-tables as to reduce this traffic to a minimum. The modern forecaster requires reports in great detail from a close network of stations extending to great distances on all sides of the area to which his predictions refer. In each region there are local weather variations, varying local demands for information, different degrees of organization of telegraph and other services, and so on. Left to themselves, different countries would observe at different times, record different things, use different types of instruments, and issue reports with varying frequency. In some countries the weather service demanded is of less value to the country itself than to foreign aviators who pass over it. Then again there is the difficulty of defining phenomena accurately, especially in different languages, so that a certain coded message will mean the same thing whatever country it emanates from.

Another important thing in connection with forecasting is that it should be possible to plot as much as possible of the information received on to one chart so that each item can be considered in relation to all the rest and to the general weather situation. This means that symbols must be devised

which are as compact as possible, yet simple and such as in themselves to suggest the phenomenon they represent. For example, distinction has to be made between drizzle, showers, steady rain, snow and rain, soft hail, hail, and snow, and the various intensities of these forms of precipitation. The codes and symbols must be capable of ready interpretation by the aviator, who has to pass quickly from one country to another, from plain country to mountainous, or over the sea, and through regions where different types of weather are prevailing.

If chaos is to be avoided, therefore, there must be intense and detailed co-ordinating work on the part of the O.M.I. Codes have been invented which consist of groups of five figures. In six five-figure groups of the international code it is possible to convey as much information as would require upwards of fifty words of plain language.

One of the more urgent matters dealt with by the Conference was a demand from the Italian Air Ministry that the constitution of the O.M.I. should be changed so as to give representation at the Conference a more official character and make its resolutions binding. The general feeling of directors, however, is that nothing is to be gained by attempting to force its resolutions on any country. The members of the Conference are already all Government officials and are sent by their Governments. A resolution is seldom passed unless an overwhelming majority is in favour of it, and most resolutions are unanimous. Any change to which an important, even if small, minority is opposed is usually dropped. The resolutions must appeal to Governments by their reasonableness, and the members of the Conference must, in general, be the best persons to advise their Governments on meteorological questions. Nevertheless, the force of some of the arguments adduced by the Italians was realized, and a Commission of six, of whom I was one, was set up to undertake a revision of the statutes of the O.M.I. One result of this was that a special Commission for Aeronautical Meteorology was created and its constitution incorporated in the statutes of the O.M.I. This Commission will arrange meetings with regional Aeronautical Commissions, the International Convention for Aerial Navigation, and other bodies controlling international aviation, and, in consultation with them, determine the practical details of meteorological services along particular air routes. It will also study the relations between meteorology and aviation from the scientific aspect.

The principal feature of the meetings of the Commission for the Exploration of the Upper Air was the great development shown to have taken place in the design of the radio-sonde, an instrument which is carried to very great heights in the atmosphere by a rubber balloon, and which signals down the pressure and temperature of the air at different levels by radio. During the last few years the Russians, Germans, and French have made great progress in increasing the accuracy and compactness of the sondes, while reducing the weight and cost. But the instrument with which the Conference was most impressed was that designed by Dr. Väisälä of the Finnish Services. Whereas a few years ago an ascent with a radio-sonde cost about £40, one can now be made for £10, and the results are more reliable. This is very important, because a knowledge of conditions in the upper air is a very great aid to the forecaster. At present aeroplanes have to be used very largely for getting this information. They are very expensive, and the radio-sonde should soon greatly reduce the cost, while at the same time making the results more readily available.

Another interesting recent apparatus is one designed by the French for observing the wind in the upper air in cloudy weather or at night. In this case a balloon carries up a wireless transmitter, and its position is continuously located by direction-finding. This enables the upper winds to be calculated, and will be a great boon in bad weather.

The President of the Polar Year Commission, who has to accumulate an enormous mass of meteorological data and make copies of it available to individual investigators, gave an interesting exhibition of the means he is using to copy and store records. A large amount of material can be placed together and photographed on standard cinema film. Both the original negatives and positive copies can be made very cheaply. A cinema projector of the "baby" pattern can be employed for showing the data when use is to be made of it. In this way a year's continuous registration of temperature, for instance, can be shown on a few films and a thick year-book full of tables condensed into a small roll.

The Chairman of the Commission of Agricultural Meteorology, Professor W. Schmidt, of Vienna, has made a number of studies in microclimatology. In one of these a valley of the Alps was thoroughly explored and the variations of wind, temperature, sunshine, &c., over the whole area closely recorded. These studies enable the value of the land in various parts to be accurately assessed and help greatly in deciding what use it should be put to, what crops should be grown in each part, and so forth. Though it is not possible to make such detailed surveys everywhere, much could be learnt from isolated cases, and by the use of proper physical reasoning their results could be applied to other areas. Sir George Simpson felt that work of this character was rather outside the scope of the official meteorologist, but it is difficult to see who else could do it so satisfactorily.

The speed of air traffic is now so great that those associated with its control will require to know the daily progress of machines on various routes. Postal authorities and business men generally will also be concerned. Since such delays as occur will be due mainly to adverse weather, a demand has arisen in Europe for information from along the air routes in practically all parts of the world. This demand is certain to grow. At the same time meteorologists wish to extend the area from which they receive reports, since it is found that conditions at a great distance may have an influence on the local weather. Tentative arrangements were, therefore, made for the issuing of weather reports covering the whole world for at least one time of day from a few powerful radio stations. If the plan matures Sydney, for example, would broadcast a comprehensive list of reports from Australia, New Zealand, and the surrounding areas which could be heard in Europe or any other part of the world. We in New Zealand should be able to receive reports from Africa and South America if required. It is possible that such reports may sometimes enable us to anticipate the prevalence of a certain type of weather for periods of considerable length.

A knowledge of the climatic conditions which have been prevailing in agricultural areas is of value, especially to Governments and financial institutions, for estimating the probable supplies of meat, grain, and other products. A scheme has been drawn up for the broadcasting from radio-stations such as those mentioned above, during the first week of each month, of a brief coded summary of the previous month's weather. It is hoped that the countries concerned will bring this scheme into operation. So far as we are concerned, it would probably mean the sending of a message of only moderate length once a month to Sydney for incorporation in a more general issue from that station.

The Conference elected as its president for the ensuing six years Dr. Th. Hesselberg, Director of the Norwegian Meteorological Services. The membership of the International Meteorological Committee was increased to twenty-five, of whom seven, including myself, come from the British Empire.

The spirit exhibited throughout by delegates was most friendly and cordial. The Conference, indeed, was a model of what an international conference should be.

We were greatly indebted to the Polish Government and Meteorological Service, who spared no effort to make the Conference a success and to enable the delegates to see something of their country and institutions.

From Warsaw I travelled to Bergen, Norway, where Dr. Barnett had preceded me. The Acting-Director of the Meteorological Service placed a room at our disposal, and we were at all times allowed to enter the forecast room as if we were members of the staff of the Institute. The forecasters discussed with us each of the five weather charts produced during the day, their methods of analysing the chart, drawing the fronts, isobars, &c., and the developments they expected. It was again found that the Bergen meteorologists were much in advance of those of other countries in their treatment of synoptic meteorology. In addition to the usual charts, there was drawn at midday, each day, a rough chart for the following day, based on calculations only. During the course of our stay the charts thus drawn were remarkably similar to those drawn on the following days on the basis of the actual reports. The practice was also followed of drawing charts for the levels of two and three kilometres above ground. These were based on the data supplied from aeroplane ascents to about 20,000 ft. made at about seventeen European stations. The upper-air charts were very useful for checking the deductions from ground-level charts, delineating cold and warm air masses, &c.

During our stay short lecturettes were arranged every day on subjects of mutual interest, including recent researches, some of which were unpublished.

We could not have been more kindly treated, and are especially indebted to Professor J. Bjerknes, of the Geophysical Institute, Messrs. Finn Spinnangr (Acting Director), and J. Holmboe, of the Meteorological Institute, and Professor H. U. Sverdrup, of the Chr. Mikkelson Institute.

Summary of the Weather for 1935.

January, for the Dominion as a whole, was probably the hottest January hitherto experienced. Rainfall was much below average over a large part of the country, and the continued rain shortage, combined with the very high temperatures, had a detrimental effect on pastures and stock.

Heavy rains were recorded in the western portion of the South Island, and parts of eastern Otago and South Canterbury and of the high country in Taranaki and Wellington also had beneficial falls. Over the remainder of the Dominion, however, conditions were extremely dry, the position being most acute in the Waikato, Bay of Plenty, and East Coast districts of the North Island, and most of Canterbury and Marlborough.

In *February* temperatures were as much above normal as in January, but fortunately good rains terminated the drought which had been experienced in most districts. There was a large excess of rainfall over the whole of the North Island, many places having more than double the average. In the South Island most of Nelson and Westland, the Alps, and the eastern foothills had more than the average, but elsewhere there was still a deficit, which in Marlborough and southern Otago and Southland was a large one. Although the disturbances ruling were all of slight intensity they were responsible in addition to frequent thunderstorms and local downpours, for a number of heavy and widespread rains. At various times severe local flooding was experienced—viz., in Auckland City on the 15th, at Hokitika on the 19th, and in parts of Taranaki and North Auckland on the 22nd.

The warmth and rains caused a good growth of grass, and consequently stock improved in condition and the milk-yield recovered somewhat.

March was a very satisfactory autumn month. Owing to the continued warmth and lack of strong winds, there was again a rapid growth of vegetation. Stock generally maintained their good condition, but during the first part of the month dull, damp weather on the east coast of the North Island north of Hawke's Bay had an adverse effect on sheep, a considerable amount of facial eczema being reported in that area. There was little rain during the first half of the month except in the Auckland and Hawke's Bay districts, but in the latter half general rains occurred with heavy falls in many places. Totals below normal were experienced in Central and, especially, North Canterbury, and also in Hawke's Bay and parts of the interior of the North Island. Over most of the rest of the Dominion there was an excess, many places in North Auckland, Taranaki, Nelson, Marlborough, and Otago having as much as double their normal quantity. Late in the month Taranaki experienced floods for the third time within five weeks.

In *April* mild conditions prevailed and there was again an absence of severe storms. Rainfall was irregularly distributed. Parts of western Taranaki and most of the Wellington Province had less than the average, but over practically all the remainder of the North Island there was a considerable excess. Many places in the Bay of Plenty and Hawke's Bay had more than double. In the South Island much of Nelson and Marlborough and parts of Southland had more than the average rainfall, but elsewhere it was a dry month. The most general rains occurred during the periods from the 10th to 14th, 21st to 24th, and 26th to 28th. In the first two there were many heavy falls, and considerable flooding was experienced in many parts of the North Island, the Hawke's Bay, Bay of Plenty, and Waikato districts suffering most.

Except for two periods of fine, mild weather—viz., between the 11th and the 15th and from the 25th to the 27th, the month of *May* was a cold, unsettled one, with a predominance of southerly winds. Except in the far North, temperatures, which in the preceding six months had been above normal, fell below it in May. The total rainfall was below average in parts of the Auckland Province and in the East Coast areas. Over the remainder of the Dominion it was above, the greatest excess being on the west coast of the South Island and in the Wairarapa. A number of intense and extensive depressions occurred, and there was a good deal of stormy weather. On the 5th there was heavy snow on the ranges of both Islands and considerable falls occurred, also, on the low levels. In Taranaki parts of the plain country had an unprecedented fall for the time of year. On the morning of the 20th a violent north-west gale swept Canterbury and caused widespread damage. Severe thunderstorms, heavy rain, and some flooding were experienced in the Taranaki and Wellington Districts on the 21st.

During the first five days of *June* the weather was fine generally, but otherwise the month was an unsettled one. There were several severe storms accompanied by continued strong winds from between west and south-west and rain was frequent.

Rainfall was below the average in a small area about Cook Strait and in parts of the western districts of the South Island, while over the remainder of the Dominion an excess was experienced.

In Canterbury a severe snow-storm occurred on the 9th, and considerable damage to telegraph and power lines resulted. At the same time there were widespread thunderstorms in the North Island. Otago had particularly heavy southerly rains on the 18th, with much flooding in low-lying areas.

In *July* cold spells occurred between the 7th and 10th and from the 24th to the close, but the remainder of the month was mild for the season of the year. Appreciable growth of pasture was reported. Very heavy rain occurred in North Auckland between the 6th and 8th and again from the 21st to 25th. The total rainfall was above average, also, over all the North Island except parts of the Taranaki Bight and central areas. The whole of the South Island recorded less than the average. Temperatures did not differ greatly from normal.

The month of *August* was remarkable for the prevalence of strong and squally westerly winds. On this account the finest and mildest weather was experienced in districts east of the main ranges. Rainfall was below normal in the East Coast districts of the South Island, and also, but to a less extent, in those of the North. Most of the remainder of the Dominion had more than the average, the Nelson Province reporting more than double.

Temperatures nearly everywhere exceeded the average, the departure being greatest in the eastern half of the North Island. Frosts were less frequent and generally less severe than usual at this time of the year.

After a comparatively mild winter *September* proved a very cold month. Low temperatures associated with a prevalence of southerly or easterly winds and extreme dryness had the effect, in many parts, of retarding growth of pasture. The only districts where rainfall was above the average were the far northern and East Coast portions of the North Island and Marlborough. North Auckland experienced extremely wet conditions, with considerable flooding at times.

October was a good spring month, mild conditions and a plentiful rainfall causing a vigorous growth in vegetation. Rains above average were experienced over most of the North Island, deficiencies occurring only in North Auckland and isolated parts of the Gisborne, Hawke's Bay, and Taranaki Districts.

In the South Island an excess was recorded north of Greymouth and Akaroa. Thence southwards totals were generally slightly below average.

There was a reversion to almost wintry weather in *November*, the outstanding features being its coldness, a deficiency of sunshine and, in most districts, an excess of rainfall. The month was, in fact, in many parts one of the coldest Novembers on record. Though there was fair growth of pastures and stock remained in good condition, lambs failed to fatten well and shearing was interfered with.

In *December* the weather was remarkably fine, with temperatures much above normal. Rainfall was, in general, considerably below the average, but after a wet, cold spring this was not a disadvantage. The only periods when general rains occurred were from the 17th to 19th and the 28th to 30th. Conditions were most favourable for all farming operations, and there was an abundance of feed for stock.

Year.—The summer of 1934–35 was much the hottest recorded hitherto. With the period from November, 1934, to February, 1935, there has previously been nothing comparable, and temperatures remained above normal in March and April. Very dry conditions prevailed over most of the country until the end of January, and for the farming community the position was very unsatisfactory. In February the drought was gradually broken, and excellent conditions ruled throughout the autumn. The wheat crop was light and there were many failures. The grain produced, however, was of a high quality, and there were some excellent individual crops. The milk-yield was poorer than for several years previously. The apple crop also was light, and much of the fruit too large for export.

The winter was, on the whole, mild, with ample feed for stock, which maintained its condition well. Crops were sown under favourable conditions.

Cold and wet weather made the spring a late one, but December was a very fine month, and at the end of the year stock and crops were in very good condition. The lambing season was considerably poorer than in the two preceding years.

The rainfall for the year was considerably above normal over most of the North Island. In the South there was usually little departure, but falls less than the average predominated.

DOMINION OBSERVATORY.

REPORT ON THE ACTIVITIES OF THE OBSERVATORY DURING THE YEAR ENDED 31ST DECEMBER, 1935.

Buildings and Equipment.

The Observatory buildings and equipment have been kept in good order and condition. The Observatory grounds have been attended to periodically by the Wellington City Council.

Astronomy (Time Service).

Time Signals received.—The Observatory signal clock has been controlled mainly by the reception of radio time signals. The following radio time signals were received :—

Station.	Call Sign and Wave.	Hour. (G.M.T.).	Hour. (N.Z.M.T.).	Number of Times received.
		h.	h. m.	
Saigon	FZR (SW)	19	6 30	18
Pontoise	FYB (SW)	20	7 30	14
Washington	NAA (SW)	21	8 30	145
Monte Grande	LSD (SW)	23·8	11 15	94
Washington	NAA (SW)	00	11 30	51
Norddeich	DAN (SW)	00	11 30	43
Nauen	DFY (LW)	00	11 30	11
Honolulu	NPM (LW)	00	11 30	37
Malabar	PKX (LW)	01	12 30	12
Washington	NAA (SW)	03	14 30	27
San Francisco	NPG (SW)	03	14 30	158
Honolulu	NPM (SW)	03	14 30	52
Washington	NAA (SW)	05	16 30	5
Washington	NAA (SW)	08	19 30	91
San Francisco	NPG (SW)	08	19 30	11
Honolulu	NPM (SW)	08	19 30	6
Pontoise	FYB (SW)	08	19 30	22
Bordeaux	FYL (LW)	08	19 30	6

Total number of signals received : 803.

It is not possible to make regular use of the British time signals from Rugby Radio, owing to the unsuitable times of transmission (5 h. 30 m. and 21 h. 30 m. N.Z.M.T.).

Transit Observations.—The clocks at the Observatory were also checked frequently by observations with the transit instrument. Observations were taken on forty-two days, the number of separate transits being as follows : Sun, 24 ; stars, 99 ; Venus, 2 ; Mars, 1 : Total number of transits, 126.

Time Signals sent out.—The time service was maintained as previously, and the regular time signals sent out. The routine at the Observatory provided for the following time signals, most of which were sent automatically by the Observatory clock, the error of which seldom exceeded a quarter of a second of time.

(*a*) Automatic signals :—

(1) Through the Wellington Radio Station ZLW, daily at 10 h. 30 m. (=23 h. G.M.T.).

(2) Through the Wellington Radio Station ZLW, on Tuesdays and Fridays at 20 h. 30 m. (=9 h. G.M.T.), except on Government holidays.

(3) Through Radio Broadcasting Board's station 2YA at 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. on Sundays. The Board's station 3YA at Christchurch rebroadcasts the signals from station 2YA. As the broadcasting of these signals is controlled by 2YA, the Observatory cannot guarantee regularity in the time service through stations 2YA and 3YA. The time signals are sometimes suppressed when special broadcasts are in progress.

(4) To the General Post Office and the Railways Department, Wellington, by telegraph daily at 9 h., except on Sundays and Government holidays.

(5) To ships, and to the general public at Wellington, by electric lights at the Observatory, daily at 20 h. 30 m.

(6) To the Auckland Harbour Board, by electric lights at Auckland, on Tuesdays and Fridays at 20 h. 30 m., except on Government holidays.

(7) To the South Island Telegraph offices, by telegraph, on Tuesdays and Fridays at 15 h. 30 m., except on Government holidays. 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.

(*b*) Non-automatic time signals :—

(1) The Observatory automatic time signals sent to the General Post Office are distributed by telegraphic hand signals to some 2,300 telegraph and telephone offices distributed all over New Zealand, at 9 h. daily.

(2) Similar hand signals are also sent to all railway offices in New Zealand at 9 h. daily—by telegraph to 221 offices, and by telephone to 257 stations.

Number of Time Signals sent out.—The following list gives the number of time signals sent from the Observatory during the year 1935 :—

	Number of Signals.
Radio time signals through ZLW	462
Radio time signals to 2YA	989
Time signals by telegraph	417
Time signals by lights at Wellington	365
Time signals by lights at Auckland	105
Time signals by telephone	5
Total number of signals sent out in 1935	2,343

The time signals by telephone were given to Government House, Post and Telegraph Department, and Defence Department.

Accuracy of Radio Time Signals sent out.—The following table indicates the accuracy of the radio time signals sent out from the Observatory during 1935. These corrections apply to the signals sent out through stations ZLW, 2YA, and 3YA at 10 h. 30 m. N.Z.M.T., and through station ZLW at 20 h. 30 m. N.Z.M.T. :—

Number of times correction did not exceed 0·25 second	441
Number of times correction between 0·26 and 0·50 second	20
Number of times correction between 0·51 and 1·00 second	1
Number of times correction exceeded 1·00 second	0
Total number of time signals sent out	462

Failures of Time Signals.—Time signals from the Observatory failed to be sent out on the following dates :—

1935.

September, 4, 10, and 12	Signals were not broadcast from ZLW owing to faults at that station.
November 21	One signal to 2YA failed.
November 23	One signal from ZLW failed owing to a fault at that station.
December 11	Three signals from ZLW failed owing to a fault at that station.

There were many occasions when signals supplied by the Observatory were not broadcast by 2YA, owing either to failures at 2YA or to special broadcasts being in progress. As 3YA rebroadcasts the signals from 2YA, a failure of 2YA results in a failure of 3YA. On November 11, at 11 h. (New Zealand summer time), the radio time signals between 11 h. and 11 h. 2 m. were suppressed for the observance of the Armistice Day two minutes' silence.

Government Buildings Clock.—The Government Buildings clock has been kept under fairly close control. A record is obtained at the Observatory each day by direct circuit from the clock, and adjustments are made as required. The greatest errors of this clock were—Thirty-one seconds fast on October 9 and twenty-nine seconds slow on October 26.

General Post Office Clock.—The General Post Office clock is checked by W/T daily, at 15 h., except on Saturdays, Sundays, and Government holidays. The greatest errors observed were six seconds fast on February 8 and five seconds slow on February 28.

Astronomy (General).

Solar Work.—Observations of sunspots were continued during the year by Mr. Thomsen with the 5 in. Grubb refractor belonging to the Astronomical Section of the Wellington Philosophical Society. The results have been sent regularly to Zurich, according to arrangements with the International Astronomical Union. New Zealand is considered by the authorities to be a very valuable station for this work, on account of its geographical position.

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 been continued. The Observatory is indebted in this work to the voluntary assistance by members of the New Zealand Astronomical Society, Inc., and also to the predictions in the Handbook of the British Astronomical Association. During 1935 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 courtesy of the Central Bureau at Copenhagen, arrangements have been made for this Observatory to receive advice of all important astronomical discoveries. The information is forwarded by the Bureau through the Melbourne Observatory.

Longitude Work.—Progress was made during the year with the reduction of the longitude observations made in 1933, October and November. Mr. R. C. Hayes completed his reductions, and by comparison with results already published by other observatories the following longitude differences were found, as compared with values obtained in 1926, October and November :—

——	1926.	1933.	Difference (1933–1926).
	h. m. s.	s.	s.
Greenwich-Wellington ..	11 39 4·03	3·99	−0·04
Paris-Wellington	11 29 42·96	43·08	+0·12
Algiers-Wellington	11 26 55·43	55·62	+0·19
Washington-Wellington ..	7 12 40·25	40·16	−0·09

Later, when the work was being checked, a slight systematic error in the application of the level corrections to the transit observations was found. Although this correction is not likely to seriously affect the above results, it has delayed the work somewhat in its final stages.

The work by Mr. I. L. Thomsen was nearing completion, but no results were available by the end of the year.

Property on Loan.—The 5 in. altazimuth refractor is still on loan to Mr. M. Geddes, of Otekura. This instrument is being used very well by Mr. Geddes. The conditions of loan for instruments are that they must be periodically returned to the Observatory for inspection, and that the borrowers must insure them against loss by fire or damage, and make regular reports of the use made of telescopes.

One chronometer has been lent to Mr. H. de Denne, Hastings, to check the time on the seismograph.

Seismology.

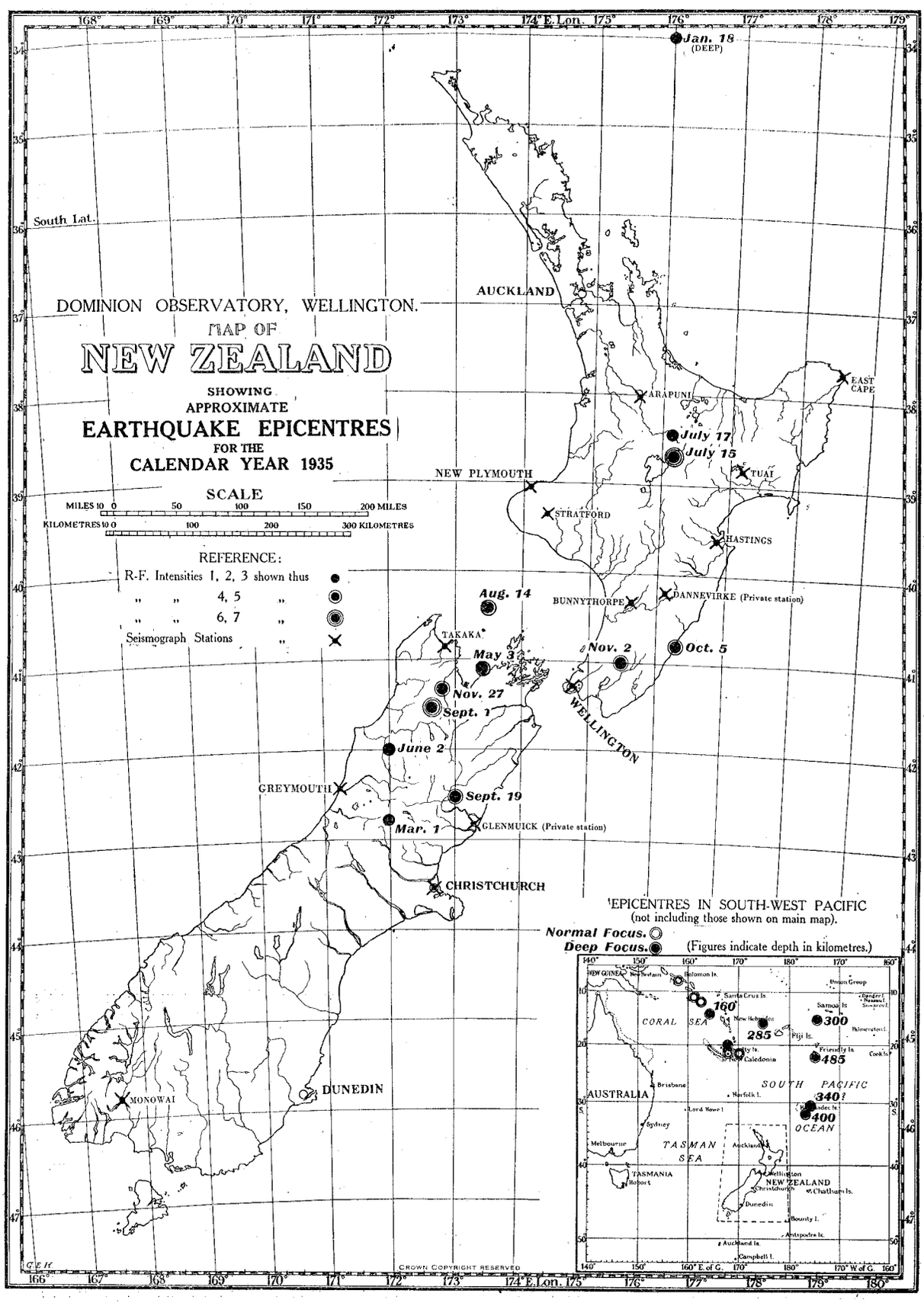
General.—Seismic activity in New Zealand was lower in 1935 than in 1934, being more comparable with 1933 in respect to the number and intensity of earthquakes felt. The most severe earthquake in 1935 occurred near Taupo on 15th July, when a maximum intensity of R.-F. 7 was reported. This was the maximum intensity reported during the year.

Seismograph Stations.—During the year 1935 continuous seismograph records were kept at the Dominion Observatory, Wellington, the Magnetic Observatory, Christchurch, and at the following subsidiary stations: East Cape, Arapuni, Tuai, New Plymouth, Stratford, Hastings, Bunnythorpe, Greymouth, and Chatham Islands.

The Imamura seismograph at Takaka was not recording during the latter part of the year. This was due to extensive overhaul and alterations. A special stand and case were made for the seismograph, and it was found that this necessitated extensive alterations to the clock and driving-gear. The clock had to be sent to the Observatory for the necessary alterations, and portion of it had in turn to be sent to Christchurch for the construction of a new part.

In July a Milne-Jaggar seismograph was installed at the Lake Monowai Power Station, Southland. The seismograph was placed in charge of Mr. W. H. Hutton, Chief Engineer, Southland Power Board.

Two seismograph stations which are privately owned have continued to assist the Observatory by forwarding information regarding earthquakes recorded by their seismographs. Thanks are due to these voluntary workers, and also to officers of other Government Departments and private individuals who operate seismographs.


DOMINION OBSERVATORY, WELLINGTON.
MAP OF
NEW ZEALAND
SHOWING
APPROXIMATE
EARTHQUAKE EPICENTRES
FOR THE
CALENDAR YEAR 1935
SCALE
MILES 50 0 50 100 150 200 MILES
KILOMETRES 100 0 100 200 300 KILOMETRES
REFERENCE:
R-F. Intensities 1, 2, 3 shown thus
" " 4, 5 "
" " 6, 7 "
Seismograph Stations "
South Lat.
AUCKLAND
NEW PLYMOUTH
STRATFORD
ARAPUNI
EAST CAPE
TUAI
HASTINGS
BUNNYTHORPE
DANNEVIRKE (Private station)
TAKAKA
GREYMOUTH
GLENMUICK (Private station)
CHRISTCHURCH
WELLINGTON
DUNEDIN
MONOWAI
Jan. 18 (DEEP)
July 17
July 15
Aug. 14
May 3
Nov. 27
Sept. 1
June 2
Sept. 19
Mar. 1
Nov. 2
Oct. 5
EPICENTRES IN SOUTH-WEST PACIFIC
(not including those shown on main map).
Normal Focus.
Deep Focus. (Figures indicate depth in kilometres.)
CORAL SEA
160
285
300
485
340
400
SOUTH PACIFIC OCEAN
TASMAN SEA
AUSTRALIA
NEW ZEALAND
Fiji Is.
Brisbane
Sydney
Melbourne
Auckland
Wellington
Christchurch
Dunedin
Hobart
TASMANIA
CROWN COPYRIGHT RESERVED

The following is a complete list of seismograph stations operating in New Zealand and surrounding islands on 31st December, 1935 :—

Station.	Position. Latitude.	Position. Longitude.	Height above Mean Sea-level.	Instruments.	Observer.
	° ′	° ′	Ft.		
Apia	13 48 S.	171 47 W.	7	Wiechert, three components	Director, Apia Observatory.
East Cape ..	37 40 S.	178 35 E.	505	Milne-Jaggar	Lighthouse-keeper, Marine Department.
Arapuni ..	38 5 S.	175 39 E.	212	Milne, E.-W. component ..	Mr. C. A. Thompson, Public Works Department.
Tuai	38 48 S.	177 9 E.	960	Milne-Jaggar	Mr. W. H. Gregory, Public Works Department.
New Plymouth ..	39 4 S.	174 4 E.	112	(*a*) Wood-Anderson ..	(*a*) Superintendent, H.M. Prison.
				(*b*) Milne-Jaggar	(*b*) Mr. C. E. Morshead.
Stratford ..	39 21 S.	174 17 E.	1,000	Milne-Jaggar	Mr. A. W. Burrell.
Hastings ..	39 38 S.	176 53 E.	35	Milne-Jaggar	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	Mr. W. A. Waters.
Takaka† ..	40 51 S.	172 48 E.	25	Imamura, three components	Mr. W. J. Smith, Post and Telegraph Department.
Wellington ..	41 17 S.	174 46 E.	401	Wood-Anderson, N.-S. ..	Dominion Observatory.
				Galitzin-Wilip (vertical) ..	
				Milne-Shaw, two components	
				Milne-Jaggar	
Greymouth ..	42 25 S.	171 13 E.	14	Milne-Jaggar	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 ..	Director, Magnetic Observatory.
				Wood-Anderson	
Chatham Islands	43 57 S.	176 31 W.	210	Milne	Mr. A. E. Hayward, Post and Telegraph Department.
Monowai‡ ..	45 47 S.	167 37 E.	538	Milne-Jaggar	Mr. W. H. Hutton.

* Privately-owned stations. † Not recording during the latter part of the year owing to extensive alterations. ‡ Established in July, 1935.

Of the sixteen stations in the above list, twelve 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 amount of research work which can be carried out with the present staff is thus very limited.

The following list gives the number of earthquakes recorded at this Observatory and at subsidiary stations during the year 1935 :—

Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
East Cape	0	0	0	0	0	0	0	0	0	0	0	1	1
Arapuni	4	3	3	3	3	3	5	3	12	5	3	15	62
Tuai	0	0	0	0	0	0	1	0	0	0	0	0	1
New Plymouth ..	5	7	14	9	9	3	15	8	9	13	9	7	108
Stratford	0	0	0	0	0	0	1	2	0	0	0	0	3
Hastings	5	3	1	0	5	1	8	2	0	0	3	1	29
Bunnythorpe ..	0	0	0	0	0	0	0	0	0	1	1	0	2
Takaka*	1	1	0	0	0	..	..	..	..	..	..	..	2
Wellington	31	22	44	49	60	38	51	45	48	40	54	52	534
Greymouth	0	0	0	0	0	0	0	0	0	0	0	0	0
Christchurch (Wood-Anderson)	6	2	10	12	4	2	6	5	12	2	10	8	79
Chatham Islands ..	2	1	0	0	0	0	0	4	3	3	0	3	16
Monowai†	..	..	..	..	..	..	0	0	0	0	1	0	1

* Under extensive alterations from May to December. † Established in July.

Reference to the list of seismograph stations will show that the instruments are of widely varying sensitivity. Wellington is provided with a range of instruments capable of recording not only weak local shocks, but also all the main earthquakes occurring in other parts of the world. This fact accounts for the relatively large number of shocks recorded at Wellington. The figures for Christchurch are from the Wood-Anderson seismograph only, and therefore do not represent the total number of earthquakes recorded at that station.

Non-instrumental Reporting-stations.—Officers of the Post and Telegraph Department, officers of the Marine Department, and private observers have continued to furnish valuable reports of the effects of earthquakes as felt in various parts of New Zealand. There are at present 110 of these non-instrumental reporting-stations distributed throughout the Dominion.

The following summary gives the number of earthquakes reported felt in New Zealand during the year 1935, and the maximum intensity reported in each month :—

Month.	Number of Earthquakes reported felt.				Maximum Intensity (R.-F. Scale).	Locality of Maximum.
	North Island.	South Island.	Both Islands.	Total for New Zealand.		
1935.						
January	7	5	1	11	5	Tokomaru Bay, Hastings.
February	12	7	1	18	5	Puysegur Point.
March	8	5	..	13	6	Hicks Bay.
April	6	1	..	7	5	Wanganui, Milford Sound.
May	16	3	1	18	5	Farewell Spit.
June	10	3	..	13	5	Taupo.
July	11	9	..	20	7	Wairakei.
August	7	6	1	12	6	Waipiro Bay.
September	6	6	1	11	5	Whakatane, Lake Grassmere, Cheviot.
October	4	5	..	9	6	Milford Track (Quinton Huts).
November	7	3	1	9	5	Wanganui, Paraparaumu, Paekakariki.
December	9	1	1	9	5	Paekakariki.
Totals	103	54	7	150	7	Wairakei.

It will be seen that 150 earthquakes were felt in some part of New Zealand during the year 1935. Of these earthquakes, 103 were felt in some part of the North Island, and 54 in some part of the South Island. Seven were felt in both Islands.

The following list gives the number of earthquakes in which the maximum intensity reported reached the various degrees of the Rossi-Forel scale :—

Month.	Rossi-Forel Scale.										Totals.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
1935.											
January	..	1	4	4	2	..	..	..	..	..	11
February	..	2	9	6	1	..	..	..	..	..	18
March	..	2	6	4	..	1	..	..	..	..	13
April	..	2	2	1	2	..	..	..	..	..	7
May	..	1	9	7	1	..	..	..	..	..	18
June	..	1	3	7	2	..	..	..	..	..	13
July	1	2	4	8	4	..	1	..	..	..	20
August	..	1	4	6	..	1	..	..	..	..	12
September	..	1	2	4	3	1	..	..	..	..	11
October	..	2	4	3	..	..	..	..	..	..	9
November	..	1	3	3	2	..	..	..	..	..	9
December	1	..	5	1	2	..	..	..	..	..	9
Totals	2	16	55	54	19	3	1	..	..	..	150

The total number of earthquakes reported felt, and the maximum intensities reported in each of the years 1921 to 1935 (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			

The figures in the above table 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 be passed 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 upon earthquake activity of what is a comparatively quiet period. The great number of earthquakes reported in 1922 is due to the swarm of local 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, 17th June.

Earthquakes in 1935.—The following table gives particulars of the most important earthquakes in New Zealand during the year 1935. The list includes (1) earthquakes reported to have reached or exceeded an intensity of R.-F. 6 and (2) earthquakes which were felt over a wide area.

New Zealand Mean Time.	Approximate Position of Epicentre.		Maximum R.-F. Intensity as felt.	Locality of Maximum Intensity.
	South Lat.	East Long.		
1935. d. h. m.	°	°		
*Mar. 11 2 50	..	..	6	Hicks Bay.
July 15 23 29	38·7	176·2	7	Wairakei.
*Aug. 13 11 45	..	..	6	Waipiro Bay.
Sept. 1 22 25	41·6	172·7	6?	Lake Grassmere, Marlborough.
Oct. 5 18 9	40·8	176·3	4+	Pahiatua, Foxton.
Nov. 2 15 31	41	175·5	5	Paraparaumu, Paekakariki.
„ 27 7 6	41·3	172·8	4	Farewell Spit.

* Geographical position of epicentre not known.

The approximate positions of all earthquake epicentres determined by this Observatory in the South-west Pacific (within the region bounded by latitudes 0° and 50° S., and by longitudes 140° E. and 160° W.) are shown on the accompanying map. The epicentres were determined from the records of New Zealand seismograph stations in conjunction with reports from other seismological stations in the Western Pacific.

Marine Survey of East Coast.—Owing to recent seismic activity off the east coast of the North Island, and other changes which have been reported along the coast, it is strongly recommended that a detailed marine survey be carried out of the whole east coast, including soundings in the seas east of New Zealand.

It is possible that reliable contours of the ocean-floor will have an important bearing on the solution of geophysical problems in the New Zealand region.

Publications.

The Observatory has continued to publish preliminary seismological bulletins each month, giving sufficient data for the immediate determination of the epicentres of the most important earthquakes. These bulletins include a report on errors of time signals sent out from the Observatory, and also a preliminary seismological report from the Magnetic Observatory, Christchurch.

Besides the preliminary bulletins, the complete seismological reports for the whole of the year 1933 were published during 1935. These reports were published in quarterly bulletins: E. 36, E. 37, E. 38, E. 39.

The following bulletins were also published during 1935:—

Bulletin 93.—Report of the Dominion Astronomer and Seismologist for the Year 1933.
Bulletin 94.—The Focal Depth of the Pacific Earthquake of 6th September, 1933. (R. C. Hayes.)
Bulletin 95.—Earthquake Distribution in New Zealand, 1848–1934. (L. Bastings and R. C. Hayes.)
Bulletin 97.—Seismology in New Zealand. (Article by the Dominion Astronomer and Seismologist, published in the "New Zealand Official Year-Book," 1935.)
Bulletin 98.—A New Type of Seismological Table for Distant Earthquakes. (L. Bastings.)
Bulletin 99.—A Summary of New Zealand Earthquakes for the Period 1903 to 1920. (R. C. Hayes.)
Bulletin 100.—Shear Waves through the Earth's Core. (L. Bastings.)
Bulletin 102.—Seismology in New Zealand. (Article by the Dominion Astronomer and Seismologist, published in the "New Zealand Official Year-Book," 1936.)
Bulletin 103.—Destructive Earthquakes in New Zealand, 1835–1934. (L. Bastings.)
Bulletin 104.—Earthquake Frequency in New Zealand. (R. C. Hayes.)

An article on Earthquakes in New Zealand was prepared for the "New Zealand Official Year-Book," 1936; and articles on the Time Service Arrangements were prepared for the Year-Book, and for the "New Zealand Nautical Almanac."

Staff.

The staff during the year 1935 was as follows:—

Dr. C. E. Adams, F.R.A.S., Dominion Astronomer and Seismologist.
Mr. R. C. Hayes, Professional Assistant.
Mr. I. L. Thomsen, Clerk.
On 25th March, Mr. C. Watson-Munro joined the staff as an Assistant.
Dr. L. Bastings has continued to work as an Honorary Research Associate in Seismology.

R. C. Hayes, Acting Director.

APIA OBSERVATORY, SAMOA.

Director: J. Wadsworth, M.A.

The same programme of work in geophysical subjects was followed during the year 1935–36 as in the past, the principal subjects of study being terrestrial magnetism, seismology, meteorology, and atmospheric electricity.

Terrestrial Magnetism.

The study of terrestrial magnetism in Samoa comprises absolute measurements of declination, dip and horizontal intensity, and continuous recording of the variations in declination, horizontal intensity and vertical intensity by means of autographic instruments. The instruments used are a Tesdorpf magnetometer (No. 2025) and a Schulze earth inductor, a self-recording Godhavn balance, and two self-recording Eschenhagen variometers; but early in 1936 the Tesdorpf magnetometer was sent away to Germany for repairs and standardization, and its place was taken meanwhile by magnetometer, C.I.W. No. 9, which the Observatory holds on loan from the Department of Terrestrial Magnetism in Washington. Experiments for intercomparison between the two magnetometers were made during the last three months of 1935. The results show that the Tesdorpf magnetometer required the following corrections to be applied to it to reduce its results to the international magnetic standard:—

Declination	Minus 2·5 minutes of arc.
Horizontal force	Minus 0·00063H.

A discontinuity arose in April, 1935, in the base-line value of the variometer for declination, which has been traced to a defect in collimation in magnet 13.

In tabulating the hourly values of the magnetic elements the ordinates of the graphs drawn by the variometers have been measured in millimetres, and the final results obtained after converting to magnetic units have been presented as departures from the mean of the day.

Seismology.

The instruments in use for seismological work are the 1,000 kilogram astatic pendulum and the 80 kilogram vertical seismograph of Wiechert. The number of earthquake shocks recorded during the year ending on 31st March, 1936, is 279. Nine of them were slight local shocks which ranged in intensity between 2 and 5 on the Rossi-Forel scale, and there is also a record of the disastrous earthquake of 30th May, 1935, at Quetta. The vertical seismograph is unsatisfactory, and is only used to obtain the first movements in near earthquakes of moderate intensity.

Atmospheric Electricity.

Records of the gradient of potential in the air were obtained from a Benndorf self-recording electrometer. The reduction factor of the electrometer was determined on 31st May and again on 13th September by means of absolute observations on the sand-flats to the south of the Observatory. Spiders, which are a constant source of trouble, interrupted the records of the electrometer from time to time.

A certain amount of time was devoted to the Gerdien and Ebert apparatus for measuring the conductivity of the air and the number of ions. The results were disappointing, and it was decided that the instruments themselves are too old to give satisfactory service.

The upper insulator of Wulf electrometer, C.I.W. No. 30, had to be replaced by a new one. The old insulator had completely lost its insulating properties, having become opaque and filled with tiny cracks.

The monthly mean values of atmospheric potential gradient during 1935 at Apia are as follows, expressed in volts per metre: January, 100; February, 94; March, 111; April, 100; May, 99; June, 115; July, 126; August, 140; September, 117; October, 107; November, 106; December, 116: mean for the year, 111 volts per metre.

Mr. H. B. Sapsford completed in November, 1935, a paper on maxima of potential gradient at Apia, for insertion in the *Journal of Terrestrial Magnetism*.

Meteorology.

The work in meteorology at Apia during the year 1935–36 consisted of surface observations twice a day and some measurements of the upper winds from time to time, using pilot balloons. The times of the daily observations are 9 a.m. and 3 p.m. zone time, 165 degrees west meridian. The method used with pilot balloons has been normally the method of the single theodolite. During the week 16th to 21st March, 1936, ascents have been made at 7 h. G.M.T. in conjunction with the International Meteorological Organization. The balloons had to be observed on this occasion by means of small lanterns carried by them, because the adopted time of observation is after nightfall in Samoa. The total number of pilot balloon ascents during the year under review is 90.

The Observatory continued to receive reports of rainfall from about twenty local stations in the Samoa Islands, and to issue these reports to the *Samoa Herald* for publication. In addition the Observatory supplied this newspaper with predicted tide-tables and the phases and times of rise and set of the moon.

The Observatory also continued to prepare synoptic charts of the weather in the South Pacific, using the weather reports received every day by the radio station. The area covered by these reports

stretches from the region of the New Hebrides and Solomon Islands eastwards to the Society Islands, the Marquesas, and the Gambier Islands, and includes about twenty stations or more that send in regular reports. During the hurricane season the Observatory prepared a daily weather report for display at the Post Office and Customs Office, and issued warnings of cyclones.

A conference on synoptic meteorology in the South Pacific took place on 20th June, 1935, at the Observatory at which the Commodore Commanding New Zealand Station was represented by officers from H.M.S. "Dunedin." A decision was made to issue collective weather messages from Apia simultaneously on long and short waves and to change the time of the evening broadcast to 09.20 G.M.T. The afternoon observations are suppressed in the dry season, and the morning observations are then to be broadcast after dark at 09.20 G.M.T. The Commodore kindly arranged for meteorological stations to be inspected during the visit in August, 1935, of H.M.S. "Dunedin" and H.M.S. "Leith" to neighbouring Pacific Islands.

In January, 1936, the motor-launch which takes the mail from Apia to Pagopago foundered on the way, though without loss of life. Mr. Baird, the Acting Director of the Observatory at the time was called upon to give evidence concerning the weather at the inquiry.

METEOROLOGICAL SUMMARY, APIA, 1935.

Month.	Pressure.	Temperature.	Rainfall.	Humidity (9 a.m.).	Sunshine.	Wind.
	In.	°F.	In.	Per Cent.	Hours.	Miles per Hour.
January	29·740	78·8	40·88	79	82·3	7·9
February	29·771	80·1	4·24	82	221·0	7·1
March	29·786	79·8	22·56	81	166·8	7·1
April	29·812	79·5	4·02	82	229·9	7·4
May	29·855	79·0	4·84	81	221·0	6·5
June	29·873	78·7	2·71	81	246·6	9·5
July	29·843	79·1	3·05	81	250·9	7·9
August	29·888	78·2	8·73	80	227·3	8·2
September	29·858	79·5	7·00	82	245·3	7·9
October	29·851	80·7	3·61	83	259·3	8·8
November	29·802	79·8	15·45	82	170·9	5·4
December	29·757	79·2	16·40	81	160·6	7·7
			Total.		Total.	
Year	29·820	79·4	133·49	81	2,481·9	7·6

Notes on Storms, 1935–36.

April, 1935: A shallow depression south-east of Fiji moving eastwards was associated with squally north-west winds and rain in Samoa at the end of April.

December, 1935: A tropical cyclone occurred near Vila on the 11th.

January, 1936: A cyclone to the north of Samoa moved southwards and was associated with strong westerly winds in Apia on the 16th. Another cyclone occurred near Vila on the 28th and moved away towards the south-south-east.

February, 1936: Early in February a depression occurred to the north-west of Samoa and moved towards Tonga.

TIDES.

The self-recording tide-gauge at the Lagoon Station continued in use, and the results of the measurements were sent to the United States Coast and Geodetic Survey at Washington, D.C., U.S.A.

TIME SERVICE.

The standard clock, Strasser and Rohde No. 381, was controlled from time to time by wireless time signals obtained from Annapolis, U.S.A., and later, when the wireless set failed, by transit observations of the sun with the Heyde transit telescope. Since March, 1936, the Observatory has had to rely on time-signal comparisons which have been made at the radio station with the aid of a portable chronometer, the transit eye-piece having been sent away to London for a new fitting. The "Synchronome" clock provided time signals for the magnetographs and seismographs. The chronometer, Davison No. 1781, was sent to Wellington during the year for repairs.

PERSONNEL, BUILDINGS, AND EQUIPMENT.

Mr. Wadsworth left Samoa on furlough on 30th July, 1935, and returned on 13th February, after having been delayed in New Zealand by illness. He was relieved during his absence by Mr. H. F. Baird, who arrived in Samoa on 24th July, 1935, and left again on 8th February, 1936. Mr. Sapsford also returned to Samoa on 24th July, 1935, after having been to the Meteorological Office in Wellington for a short time. Two members of the locally recruited staff, Siaosi Sumeo and Arthur Rasmussen, have left the office, and they have been replaced by Francis Betham and Tanielu.

Various pieces of work were done by the Public Works Department during the year under review, the principal item being the Assistants' Residence, which was repaired and painted late in 1935.

MAGNETIC OBSERVATORY, CHRISTCHURCH.

Director: H. F. Skey.

SUMMARY OF OPERATIONS IN 1935.

During the year the usual magnetic, seismological, and meteorological observations have been carried out. Additional observations have also been made since last January to assist in forecasting for aviational purposes.

Terrestrial Magnetism.

The Eschenhagen magnetographs at Amberley Sub-station have been kept recording continuously, and the resulting magnetograms have been developed, &c., and measured for mean ordinates during every Greenwich hour. The ordinates have been reduced, and, by the aid of twice-monthly absolute magnetic observations at the sub-station, the mean hourly values have been calculated. Any short occasional failure of the Eschenhagen records has been made good by the help of the Adie D and H magnetograms. In May the Adie instruments were removed to Amberley and installed in the underground chamber there.

Calculated from these mean hourly values, the mean monthly values obtained for 1935, Amberley, are :—

Mean Monthly Values of the magnetic elements from hourly mean values (all days), 1935, at Amberley Sub-station :—

1935.	D.	H.	Z.
	° ′		
January	18 04·7	22324γ	−55219γ
February	18 05·2	22319	55218
March	18 05·0	22310	55213
April	18 05·8	22311	55217
May	18 05·8	22317	55224
June	18 06·1	22318	55224
July	18 06·9	22317	55226
August	18 07·2	22323	55223
September	18 07·3	22310	55225
October	18 06·8	22312	55229
November	18 07·0	22320	55232
December	18 07·7	22319	55233
Year	18 06·3	22317	55223
Δ from 1934	+3·4	−14·6γ	+6·3γ (Numerical decrease).

	Y.	X.	T.	ϕ
Year ..	06935·2γ	21211·7γ	59562·3γ	−67° 59′·73
Δ from 1934	+16·1γ	−20·9γ	−11·3γ	−0′·66

The secular change in the magnetic elements has been somewhat greater than during the previous year; sunspottedness is now approaching its epoch of maximum.

Improvements have been made to the Amberley Sub-station, and some necessary repairs have been made to the Observatory buildings at Christchurch.

Seismology.

During the year there have been recorded 191 seismic disturbances at Christchurch. In February, 1936, the Galitzin seismographs and the Wood-Anderson seismograph were removed to the underground cellar, formerly occupied by the Adie recorders.

The Galitzins have continued to record with equal magnification on all components, and constants have been determined at intervals. Provisional monthly bulletins were issued promptly to the Dominion Observatory, Wellington, and to co-operating stations overseas. Wood-Anderson records have been lent regularly to the Dominion Observatory. They have been of considerable assistance here in interpreting other records. It is hoped in the near future to acquire a Benioff vertical seismometer, with both long- and short-period galvanometers, to help more especially in the interpretation of results of Wood-Anderson recordings.

From 31st July, 1935, to 8th February the assistant, Mr. H. F. Baird, was relieving Mr. Wadsworth, Director of the Apia Observatory, Western Samoa.

The Carnegie Institute of Washington has sent to Christchurch one of its continuously recording cosmic-ray meters. This has been housed in a special insulated building near the Observatory and is functioning well.

The usual programme of atmospheric potential-gradient observations was continued satisfactorily.

Approximate Cost of Paper.—Preparation, not given; printing (964 copies, including map and graphs), £140.

By Authority: G. H. Loney, Government Printer, Wellington.—1936.

Price 2s. 3d.