1939.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(THIRTEENTH ANNUAL REPORT OF THE).

Presented to both Houses of the General Assembly by Leave.

CONTENTS.

MINISTER'S STATEMENT.

In a few months New Zealand will be celebrating in a fitting manner the hundredth anniversary of her foundation. The central feature of these celebrations will be the Centennial Exhibition, in which the rapid industrial and social progress of the Dominion during the past hundred years will be brought under review. Many factors have contributed to this progress, but an outstanding place must be given to the application of scientific knowledge. The past century has witnessed the beginning of what will go down in history as the scientific era—an era in which scientific knowledge has come to be studied not only for its own sake, but is deliberately directed towards increasing the quantity and variety of goods for man's sustenance, recreation, and enjoyment. New Zealand has benefited very greatly in the past, and will continue to benefit in the future, from the wealth of scientific knowledge accumulated in the older countries of the world. But there will always be problems peculiar to our own country, and we must be prepared to take steps to solve them by our own efforts. Twelve years ago, the Department which is now under my charge, was established for this very purpose. This step was in line with the policy already established in Great Britain, Australia, and Canada, which was designed to bring the advantages of science more directly to the aid of industry, and to promote the public welfare through the direct participation of the State in organized research. In that comparatively short period many important problems have been attacked and brought to solution, and a research organization and scientific personnel have been built up of which we have just cause to be proud. The story of this Department and the results achieved have been written in a special bulletin produced by my direction under the title of "Scientific and Industrial Research 1927–38." This Bulletin presents in a convincing way the substantial contributions that organized scientific research has made towards the industrial progress of the Dominion, at a cost which is a very small fraction of the value of our annual production.

Our future prosperity, as in the past, is bound up with the soil and its products. But soil fertility is not inexhaustible, and practical experience shows that declining fertility brings with it deterioration of the vegetative cover, leading to erosion of the soil itself and general deterioration in the quality of the land. Every country in the world is experiencing the evil effects of uncontrolled soil erosion, and New Zealand has its own problems of this kind. Two prominent scientific bodies in New Zealand, the Royal Society of New Zealand and the Royal Agricultural Society, drew my attention to the problem of soil erosion in New Zealand, and at the same time suggested that steps be taken to investigate the position. I accordingly set up an expert technical committee to investigate and report on the incidence and seriousness of soil erosion, and to make recommendations regarding preventive measures. The Committee's report has disclosed that the position is sufficiently serious to warrant steps being taken to prevent irremediable damage to our farming lands through uncontrolled erosion. The remedy lies in the maintenance of a stable vegetative cover, in which grassland, forest, and scrubland are in their proper balance. The attainment of this ideal, however, involves difficult economic, administrative, and social problems, which will need to be very carefully weighed and considered in order to decide what line of action in regard to preventive measures is practicable under existing conditions.

A new research activity which is of considerable importance to the Government and to the country as a whole was initiated during the year, and is concerned with the protection of timber from the depredations of boring insects and fungi. The losses resulting from damage to wooden buildings by these pests are very heavy, and warrant an organized scheme of research for the purpose of discovering the most effective preventive measures. A number of Government Departments have combined to institute such a scheme of research which is to be put into effective operation during the coming year. The discovery of serious damage by the white ant has created an additional problem for urgent investigation.

A survey of the activities of my Department during the past year reveals that they are associated with almost every industrial activity of the Dominion—both agricultural and manufacturing.

The farmer is being helped by soil surveys, pasture studies, and research on field crops, plant and animal diseases, and dairy problems.

The first bulletin of a series describing the results of the soil and land utilization survey of Hawke's Bay has now been published. It deals with land-utilization of the Heretaunga Plains, and presents information in regard to the potentialities of the Plains for increased and more diversified production. This is already proving its value in connection with proposed expansions in the canning industry.

Pasture surveys, experiments on the nutritive value of pastures, the production of improved strains of fodder crops such as lucerne and rape, and investigations on diseases such as bush-sickness and facial eczema are all of vital interest to the pastoralist. The dairy industry is being served by investigations on all aspects of the production of milk and the manufacture of dairy products. Work on the important problem of maintaining the activity of cheese starters has been carried a stage further during the year by the discovery that atmospheric contamination is an important factor in causing failures. New information is being provided for the fruitgrower regarding alternative uses for his fruit—*e.g.*, by the manufacture of fruit juices, and improved methods of storing fruit for the local market by the use of carbon dioxide gas have been worked out. Tobacco-growers are receiving guidance as to the control of disease and methods of curing their leaf. Research which is of direct interest to the seedgrower is proceeding on methods of drying seed and on losses of vitality of seed through attack by insects or fungi.

Contact with manufacturing industries is maintained through the research associations established specifically for the tanning and shoe manufacturing industries, and for wool manufacturers, as well as in a variety of other ways. The Wool Manufacturers' Research Association, which was established last year, has proved of real assistance to one of our largest manufacturing industries, and indirectly also to a major primary industry. The flax-miller has benefited by the designing of a tail-stripper which gives a greatly improved performance in comparison with the machines which have been in use for the past half century.

The search for raw materials for industry, particularly gold, coal, oil, iron, and other important minerals, is being assisted by geological and geophysical surveys. A most important section of this work is the survey of the quantity and quality of the various types of coal in New Zealand, which has provided indispensable information in connection with the Government's proposal to establish an iron and steel industry.

The study of the human element, as the central and most important factor in our industrial life, is the special work of the Social Science Research Bureau. A survey of the standards of living of selected groups is in progress, and the first of a series of reports on this work is in course of preparation.

The rapid extension of civil and military aviation services has necessitated much increased forecasting work on the part of the Meteorological Office, and made imperative the building-up of additional highly trained personnel to ensure adequate and reliable weather information being always readily available.

This necessarily brief survey indicates the wide impact of research on all phases of industrial activity in New Zealand and the extent of the service that is being provided.

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

SECRETARY'S REPORT.

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

I have the honour to submit herewith the annual report of the Department for the year 1938–39.

E. MARSDEN, Secretary.

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

The personnel of the Council is as follows :—

Professor H. G. Denham, M.A., D.Sc., Ph.D., F.I.C., F.R.S.N.Z., Professor of Chemistry, Canterbury University College, Christchurch (Chairman).
Dr. J. C. Andrews, Ph.D., M.Sc., Freezing-works Manager, Auckland.
Mr. A. H. Cockayne, I.S.O., Director-General of Agriculture, Wellington.
Professor J. Malcolm, M.D., Ch.B., Professor of Physiology, University of Otago, Dunedin.
Dr. R. O. Page, D.Sc., Tannery-works Manager, Christchurch.
Mr. G. A. Pascoe, Department of Industries and Commerce.
Mr. J. M. Ranstead, Matangi, Farmer.
Professor W. Riddet, B.Sc.(Agric.), N.D.A., N.D.D., Massey Agricultural College.
Sir Theodore Rigg, M.A., M.Sc., F.I.C., F.R.S.N.Z., Director, Cawthron Institute, Nelson.
Dr. E. Marsden, M.C., C.B.E., D.Sc., F.R.S.N.Z. (Secretary).

Professor J. Malcolm, who was a foundation member of the Council, retired during the year, and his resignation was accepted with very great regret. I desire to place on record, on behalf of the Council and the Department, very warm appreciation of the valuable services rendered by Professor Malcolm over a period of some ten years, which includes the important developmental stages of the Council's work.

Dr. R. R. Milligan, of Christchurch, was appointed by the Hon. Minister to fill the vacancy created by Professor Malcolm's retirement.

During the absence of Mr. A. H. Cockayne in England Mr. E. J. Fawcett acted on his behalf.

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

Following the presentation by Dr. John Hammond of his report on the organization of animal research in New Zealand, numerous discussions were held between the Departments of Scientific and Industrial Research and Agriculture and other interested scientific institutions and farmers' organizations regarding the implementation of Dr. Hammond's report. It was decided to establish an Agricultural Division of the Research Council as provided for in the Scientific and Industrial Research Amendment Act, 1931, for the purpose of implementing as far as was practicable the recommendations contained in the Hammond report in regard to animal research, and at the same time to direct and co-ordinate the activities of the Plant Research Bureau and the Soil Survey Division, which are closely interrelated with problems of animal production and nutrition.

The personnel of the Agricultural Division of the Council was as follows :—

	Representing.
Sir Theodore Rigg ..	.. Council of Scientific and Industrial Research and Cawthron Institute (Chairman).
Professor H. G. Denham	.. Chairman, Council of Scientific and Industrial Research (*ex officio*).
Mr. E. J. Fawcett ..	.. Acting Director-General of Agriculture.
Professor W. Riddet	.. Council of Scientific and Industrial Research.
Mr. Norton Francis	.. Council of the School of Agriculture.
Mr. J. D. Ormond, jun.	.. Meat Board.
Mr. C. A. Marchant ..	.. Dairy Board.
Mr. A. Linton ..	.. Dairy Board.
Mr. W. Mulholland	.. New Zealand Farmers' Union.
Mr. Alan Grant ..	.. Farmers' Representative.
Dr. E. Marsden ..	.. Department of Scientific and Industrial Research (Secretary).

Three meetings of the Agricultural Division were held, at which research work in relation to animals, plants, and soils in New Zealand was fully reviewed, and an Animal Research Management Committee was set up to consider and submit proposals for the implementation of the Hammond report. Three sub-committees, dealing respectively with sterility, parasitology, and sheep diseases in Canterbury, were set up by the Animal Research Management Committee, and following upon their recommendations grants were made to Massey College and Canterbury Agricultural College for specific animal research projects.

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

	£
Permanent Services—	
Head office: Publications (including the *New Zealand Journal of Science and Technology*), Research Scholarships, and grants to Royal Society of New Zealand, Imperial Institute, and Australian and New Zealand Association for the Advancement of Science (for completion of printing of report of Canberra meeting) ..	12,466
Dominion Laboratory (with branches)	21,610
Dominion Observatory	3,138
Geological Survey	8,487
Meteorological Office	19,136
Apia Observatory	3,967
Magnetic Observatory	2,640
Grant to Imperial Agricultural Bureaux	6,931
Research Investigations	126,546
	204,921
Recoveries	46,136
Net expenditure	£158,785

GENERAL.

As in previous years, grants were made to the following research organizations in Great Britain participating in the inter-Imperial Agricultural Research Scheme: The Imperial Agricultural Bureaux headquarters, £1,438; Cambridge Low Temperature Station, £2,000 (of which the Meat Board contributed £1,000); Bureau of Dairy Science, £113; Farnham House Entomological Laboratory, £750; Imperial Institute of Entomology, £450; Imperial Mycological Institute, £350; British Wool Industries Research, Torridon, £300.

Collaboration with Australia.

During a visit to Australia in January for the purpose of attending the Canberra meeting of the Australian and New Zealand Association for the Advancement of Science, Professor H. G. Denham, Chairman of the Research Council, Sir Theodore Rigg, member of the Research Council, and Mr. F. J. A. Brogan, Assistant Secretary, met the Executive of the Australian Council for Scientific and Industrial Research in order to discuss ways and means of giving fuller effect to the principle of co-operation in research-work between Australia and New Zealand, particularly by the further exchange of officers. In so far as Australia is concerned, active co-operation has been given by seconding Dr. Wiley to the Dairy Research Institute, an arrangement which has proved very successful both from the point of view of the Australian Council for Scientific and Industrial Research and the Dairy Research Institute. There are a number of research problems of mutual interest in which Australia and New Zealand could profitably collaborate, and it was agreed that the field of animal research offered a good starting-point. The Executive of the Australian Council for Scientific and Industrial Research offered further co-operation with New Zealand by agreeing to allow Dr. R. B. Kelley, of the Division of Animal Health and Nutrition, to visit New Zealand in 1939 to confer with research workers, departmental representatives, and farmers' organizations in connection with sterility problems, which are matters of outstanding importance to both countries. The Dairy Board and the Meat Board in New Zealand have agreed to meet the cost of Dr. Kelley's visit, and I wish to take this opportunity of acknowledging the ready co-operation of these bodies. The Executive also offered facilities for collaboration with Australia in connection with standards activities, particularly in regard to the provision of testing-facilities for fundamental standards. It is felt that there are a number of useful directions in which New Zealand can reciprocate through an exchange of suitable officers and by other means, and these are now being explored with a view to action being taken in the coming year.

Technical Information Bureau.

While in Melbourne in January the Assistant Secretary took the opportunity of obtaining as much information as possible concerning the Technical Information Section established by the Council for Scientific and Industrial Research as an essential part of its programme of research for the benefit of secondary industries. A report on this subject was presented to the Research Council in New Zealand, who agreed as to the desirability of establishing a similar type of organization in New Zealand to act as a clearing-house for the dissemination of technical information relating particularly to the development of industries, and also to take charge of the Department's library and publicity work.

New Research Activities.

(1) *Facial Eczema.*—Arrangements were made during the year for the full co-operation with the Department of Agriculture of the Soil Survey, Grasslands, and Plant Diseases Divisions of the Department in an intensive co-operative investigation of the facial-eczema problem under the general direction of the Facial Eczema Management Committee. In order to provide special staff and facilities for research relating to the chemical composition of pastures and the changes occurring under varying environmental conditions, the chemical laboratory attached to the Grasslands Division of the Plant Research Bureau was reorganized under the title of "Plant Chemistry Laboratory" and placed in charge of Dr. J. Melville, formerly of the Wheat Research Institute.

(2) *Timber Protection Research.*—A Timber Protection Research Committee of the Council of Scientific and Industrial Research was established during the year to direct and co-ordinate research relating to the preservation of timber from the attacks of wood-boring insects and fungi. The depreciation of building securities resulting from the attacks of these pests presents a serious problem in New Zealand, and the Committee's function is to establish a research organization which can collect the fundamental scientific knowledge upon which effective control measures must be based.

(3) *Soil Erosion and Land Deterioration.*—Following representations from the Royal Society of New Zealand and the Royal Agricultural Society of New Zealand, the Council of Scientific and Industrial Research recommended the establishment of a Committee of experts to report on the measures necessary to maintain the vegetative cover in New Zealand so as to prevent irreparable damage being done as a result of uncontrolled soil erosion. This Committee was accordingly set up by the Hon. the Minister in Charge of Scientific and Industrial Research Department and has prepared a valuable report and recommendations for future action.

Carter Observatory Board.

The Carter Observatory Act was passed by Parliament during the year, as a result of which the Carter Bequest held by the Royal Society of New Zealand was handed over to a Carter Observatory Board for the establishment of an astronomical observatory in Wellington, to be known as the "Carter Observatory." The Act provides for an annual grant from the Government to the Carter Observatory Board to be included in the appropriations of the Department of Scientific and Industrial Research. The astronomical work hitherto carried out by the Dominion Observatory will now be transferred to the Carter Observatory.

Visit of Scientific Liaison Officer.

After an absence from New Zealand of ten years, Mr. Nevill Wright, the Department's Scientific Liaison Officer in London, arrived in New Zealand in December to renew contact with research activities in New Zealand. Since his arrival Mr. Wright has been engaged in special duties relating to the development of secondary industries, and has also taken the opportunity of visiting all the research institutions and making personal contact with the research workers. During Mr. Wright's absence, Mr. W. M. Hamilton is Acting Scientific Liaison Officer in London.

Special Meetings for Implementation of Research Work.

The annual dairy-factory-managers' week was held at the Dairy Research Institute at Massey College for a discussion of the results of the current research work of the Institute.

A half-yearly meeting of the Field Crops and Herbage Plants Committee was also held. The personnel of this Committee is composed of research workers, teachers, and instructors, and through its activities close co-ordination of effort is maintained between the staffs of the Plant Research Bureau, the agricultural colleges, the Department of Agriculture, and the Cawthron Institute.

The first of the refresher courses, which it is intended to develop for horticulture extension officers of the Department of Agriculture, was initiated early in August, when over thirty instructors from the Horticulture Division spent three days with officers of the Plant Diseases Division at Auckland listening to lectures dealing with the latest developments on the control of pests in orchards. The course proved a most successful one, and provided an excellent method of transmitting to field officers new information regarding advances made in this sphere of research.

Publications.

A special bulletin reviewing the results of the research work carried out under the direction of the Research Council since its establishment was printed and widely circulated. This publication is intended to give in as concise and as non-technical a form as possible a broad review of the Council's work and the benefits to industry which have accrued from its applications. A number of special bulletins dealing with a variety of subjects has been published during the year.

Staff.

Resignations.—Dr. J. Hosking, who has been conducting research in London relating to the commercial development of his process for the refining of kauri-gum, tendered his resignation as from 15th March, 1939, in order to take up a commercial appointment in England.

The Director of Apia Observatory, Mr. J. Wadsworth, resigned on the 9th August, 1938. Mr. H. B. Sapsford has been appointed as Acting-Director.

New Appointments.—Dr. P. R. McMahon, Wool Metrologist, seconded to Massey Agricultural College to work with the wool-research team there, and will also be available for consultation with the Wool Manufacturers' Research Association.

Dr. S. Townend, Textile Research Officer, arrived in October, 1938, to take up his duties with the New Zealand Wool Manufacturers' Research Association.

Dr. E. R. Cooper, Physicist, attached to Head Office staff.

Dr. K. Kreielsheimer, Senior Physicist, Radio Research Committee.

Dr. I. Reifer, Chemist, Plant Chemistry Laboratory.

Dr. G. T. S. Baylis, Assistant Mycologist, Plant Diseases Division, Plant Research Bureau.

Dr. C. O. Hutton, Petrologist, Geological Survey Branch.

Dr. A. R. L. Lillie, Geologist, Geological Survey Branch.

Transfers.—Dr. J. Melville was transferred from the Wheat Research Institute, Christchurch, to the position of Plant Biochemist and Officer in Charge of the Plant Chemistry Laboratory, Palmerston North.

Buildings.

The new laboratories for the Plant Diseases Division of the Plant Research Bureau at Auckland were opened by the Right Hon. the Prime Minister on the 25th March, 1939. These up-to-date laboratories and the adjacent experimental area will enable the work of the Plant Diseases Division to be carried out under the best possible conditions.

A new building for the Grasslands Division of the Plant Research Bureau at Palmerston North was completed by 1st February and officially opened on 31st March. The building is commodious and well equipped, and being located in the centre of the main experimental area greatly facilitates the work of the staff. Close proximity to Massey College and the Dairy Research Institute is conducive to full collaboration with both.

Owing to the fact that the premises in Christchurch occupied by the laboratory of the Wheat Research Institute are required for the accommodation of Government Departments, new premises are being provided by the Accommodation Board for the Institute, and these will enable the work to be carried out under greatly improved conditions.

Good progress was made with the erection of the various buildings required by the Tobacco Research Station at Motueka, three kilns and a curing-barn having been completed by February.

Acknowledgment.

The loyal and efficient co-operation of the staff in carrying out the programme of work for the year is gratefully acknowledged.

DAIRY RESEARCH INSTITUTE.

The intensive studies by the Institute on cheese starters were brought last year to the stage at which it appeared that the use of heavy inoculations of single-strain starters under carefully controlled aseptic conditions had solved the problem of starter failures. The occurrence of several unaccountable failures of starters in commercial factories at the beginning of the present season, however, made further investigations necessary. Faulty technique and peculiarities in the milk-supply were eliminated as possible causes of failures. Parallel experiments conducted under exactly identical conditions at the Institute and two factories then demonstrated that environment must be playing a part, and it was subsequently found that in commercial factories contamination of the starters with phage occurred even when a normal bacteriological technique was practised. The problem then resolved itself into finding a means of preventing air-borne contamination of starters by bacteriophage, and with this object experiments are being carried out in a specially designed starter-room adjacent to, but quite separate from, a commercial factory. An extensive investigation of the bacterial flora associated with New Zealand cheddar cheese, which has been completed, showed that different strains of lactobacilli produce widely different effects in the flavour and texture of cheese. It is therefore important to devise means of preventing organisms which produce undesirable effects from gaining access to the cheese-milk, and work along these lines is proceeding.

Research on buttermaking included the following projects: The estimation of fat losses in buttermilk by indirect methods; factors influencing the oxidation of the fat of butter in cold storage; the production of diacetyl in starters, and its role in the flavour of butter; factors influencing the hardness of butter. An investigation of land-cress taint in cream and butter, which is prevalent in certain districts of the North Island, led to the isolation of benzyl cyanide as the main constituent of an essential oil steam-distilled from the plant.

Mycological investigations have been continued for the purpose of determining the factors causing mould contamination in dairy factories. The resistance to mould attack by different paint pigments and the effects of various paint vehicles have been examined. Promising results have been obtained with aluminium paint, which has been found to offer considerable resistance to mould attacks.

In collaboration with the Grasslands Division of the Plant Research Bureau, projects have been continued to determine the food value for milking-animals of certain common New Zealand pasture plants, and in particular to ascertain the effects of these on the production and composition of milk. With the assistance of the Wallaceville Veterinary Laboratory, a study was also made of the influence of continuous feeding of perennial rye-grass, and perennial rye-grass and white clover, respectively, on the health of dairy cattle.

The annual dairy-factory-managers' week was held from 2nd to 5th May, and was attended by over seventy factory managers and first assistants from all parts of the Dominion.

A considerable number of scientific papers were published, or prepared for publication, during the year.

PLANT RESEARCH BUREAU.

The Plant Research Bureau Committee was strengthened during the year by the appointment of Messrs. C. A. Marchant and Alan Grant as representatives of the North and South Island farmers respectively. These appointments bring the Bureau into a much closer association with the farming industries which it is intended to serve. The Committee, during the year, has had an opportunity to give attention to some of the major problems affecting the pastures and farm crops of the Dominion, and where co-operative action has been required the organization of the Bureau has insured this.

The Agronomy Division's trials with pedigree Liral Crown linen flax have been continued, and the yields obtained over a much wider area of the South Island have continued to be very satisfactory. Based on this and other information which it has been possible to acquire from small-scale processing trials, steps will be taken to establish a small semi-commercial unit in the Rangiora district during the coming year.

The breeding and selection work on field and garden peas has shown definite promise. Actual tests made with boiling-peas indicate that a superior type has been evolved, and steps will be taken to multiply this type. After submission to semi-commercial tests the variety will be increased for commercial production.

An acre of an improved strain of lucerne showing an increased yield of some 15 per cent. above Marlborough has been planted with a view to providing nucleus seed-supplies.

The Entomology Division at Nelson has continued its work on the introduction of parasites for the control of the diamond-back moth. Work is being concentrated on a species of *Diadromus* which has acclimatized itself better than previously and is exerting some measure of control where liberated in the Nelson District. *Diadromus* attacks the diamond-back moth in the pupal stage. Two larval parasites *Apantales* sp. and *Angitia* sp. have shown little promise in the field trials arranged this season.

During the year the Associate Director of the Division visited Europe and made extensive studies of parasites of the diamond-back moth. It is remarkable that nowhere in Europe does the diamond-back moth appear to constitute a serious pest and though present everywhere it apparently is kept in check by a range of parasites.

Lucerne flea is under constant surveillance, but as yet does not anywhere appear to cause any serious damage to pasture plants.

The section of the Division located at Lincoln College has continued its studies of the insect pests of wheat. There is evidence that different varieties of wheat exhibit a considerable variation in their resistance to Hessian fly and the Argentine stem-weevil. The aggregate losses occasioned by these pests in Canterbury wheat crops has been surveyed, and in many districts it is perhaps more severe than has been suspected.

The survey of insect pests affecting the tussock-grasslands was also completed. Fortunately, the damage done, which is attributable to indigenous species of *Melanchra* and *Persectania*, only becomes serious where the tussock pastures have suffered through burning or excessive grazing.

Trials have been commenced, also, on the effect of various locally made sheep-dip fluids upon sheep-ticks.

The appearance of white ants in certain North Island towns has necessitated extensive investigations being made of the behaviour of this pest. The Entomological Division is working in association with other interests with the object of controlling this pest and the longhorn beetle and the common house-borer, which continue to take heavy toll of wooden structures in the Dominion.

The Botany Division has continued investigations on two major economic problems—viz., South Island tussock-grasslands and ragwort. An interim report covering the seriousness of depletion in the South Island tussock region was published, and during the year a concentrated investigation was made in a district in North Canterbury covering a large area of tussock pastures in all stages of growth from excellent pastures to those which were seriously deteriorated.

Ragwort investigations have been mostly concerned with the influence of pulling as a means of controlling the weed and upon the extent to which spread by wind-borne seed is a serious factor. The Division has also taken over the botanical and cultural work relating to phormium research which is in progress on the Easton and Batchelar areas. In both these a complete stocktaking of the different phormium selections has been made and propagation of those varieties chosen for the proposed new plantation areas has been actively continued.

The chemical laboratory attached to the Grasslands Division was during the year reorganized and expanded, and under the title of " Plant Chemistry Laboratory " is now a distinct unit of the Department. This arose from the need for a fuller understanding of the composition and nutritive value of New Zealand pasture species, particularly in connection with facial eczema and other diseases which are considered to be nutritional in origin.

The pasture survey of Hawke's Bay has continued, and altogether some 3,000 square miles have now been completed.

In association with Massey College, tests of the feeding-value of the newer strains of rye-grass and clover upon sheep have been initiated. This work will give an indication whether the Grasslands Division is proceeding along right lines in its selection of species such as will lead to improvement in the quality of carcass and wool and also in sheep health and thrift.

Soil-erosion problems have come to the fore during the year, and necessitated the Division participating in the preparation of a report dealing with the influence of vegetative cover upon loss of soil fertility.

Plant-selection work has yielded a natural Italian-perennial rye-grass cross ecotype which shows definite promise for short-rotation arable land, such as occurs in the South Island. Seed from this type of rye-grass is likely to find a ready demand in all markets abroad where short-rotation pastures are the rule.

Much useful new work has been done in the introduction of pasture species suitable for the second- and third-class country in New Zealand.

The Division is indebted to the Plant Industry Division, Canberra, for much practical assistance, and for supplies of new species which have been established at Palmerston North, some of which have been planted out in regions of higher altitude for testing in a more rigorous environment.

During the year it has been possible to establish a substation of the Grasslands Division at Lincoln College in close association with the Agronomy Division.

The Plant Diseases Division has at last been brought together in its new headquarters building at Owairaka, Auckland, where there are permanent well-equipped buildings and an experimental area of 17 acres. Officers have been stationed at Palmerston North and at Lincoln College repectively to serve the southern portions of the Dominion on immediate problems. The Division continues to carry out most of the fruit-research work of the Bureau, so a considerable portion of the area has been planted in fruit-trees. Further experiments are carried out in orchards at Huapai, Havelock North, and in the Research Orchard at Appleby, Nelson.

Investigations relating to the devising of biological tests for spray specifics against various fruit diseases are being actively pursued. Special attention has also been devoted to methods of spray application, in view of the results showing that the effectiveness of control is in most cases closely associated with the completeness of spray coverage.

The demand for lucerne culture during the year has greatly increased, and despite the removal of the laboratory it has been possible to maintain a rapid service to all parts of the Dominion.

Much progress has been made in the understanding of the blind-seed disease of rye-grass, which has now been found to be caused by *Helotium* fungus. Active collaboration in the further study of this disease with a view to its possible control has been undertaken in co-operation with the Seed-testing Laboratory, Department of Agriculture, and the Grasslands Division.

PLANT CHEMISTRY LABORATORY.

The chemical changes in herbage brought about by variations in the temperature and moisture content of the soil, which depend in turn on the meteorological factors of rainfall and the quantity and quality of solar radiation, are as yet little understood. It seems probable, however, that important changes in the constituents of the plant proteins, carbohydrates, and other substances do occur, particularly under abnormal meteorological conditions, and that they may have an important bearing on certain types of animal diseases, of which facial eczema is an example.

The importance of having a much fuller knowledge of the chemical composition of the pasture species used for grazing-animals, and the changes in composition occurring under varying environmental conditions, led to the expansion of the laboratory previously associated with the Grasslands Division into the Plant Chemistry Laboratory. Although this laboratory has been established as a separate unit, it still works in close collaboration with the Grasslands Division and the Dairy Research Institute.

The past year has been largely one of preparation for an attack on the difficult problems to be studied. Methods of analysis for the various plant constituents that are to be studied have been developed, and special equipment is being obtained. A considerable number of pasture samples collected in connection with facial-eczema investigations have been prepared and stored for analysis.

The laboratory has also assisted the Dairy Research Institute in studies of the relation of pasture plants to the quality and quantity of dairy-produce by carrying out chemical analyses required.

Some very interesting work on plant-growth substances (hormones) and their effectiveness in promoting the rooting of cuttings has been carried out. A considerable improvement in the rate of rooting of cuttings of certain species has been obtained, particularly with β-indole-butyric acid which has proved the most effective chemical of its kind. Preliminary trials with vitamin B in conjunction with appropriate hormone treatment have also been encouraging.

ANIMAL RESEARCH.

Following consideration of the report on the organization of animal research submitted by Dr. John Hammond at the conclusion of his visit to New Zealand, an Animal Research Management Committee was established under the ægis of the Agricultural Division of the Council of Scientific and Industrial Research. This comprised representatives of farmers' and research organizations, and met on two occasions. Its activities have been suspended meanwhile, pending the finalizing of plans for the complete organization of animal research.

Facial-eczema investigations under the direction of the Facial Eczema Management Committee have been conducted in association with the Departnent of Agriculture. Soil surveys have been made in the eczema areas of the Waikato district, and the nitrate and ammonia-nitrogen content of selected soil samples has been determined. Physical and meteorological observations are also being taken in order to provide fundamental information regarding the climatic conditions associated with outbreaks of the disease. Detailed botanical examinations have been made of the pastures on farms where serious outbreaks have occurred, and chemical analyses of the herbage are being made at the Plant Chemistry Laboratory. Not only is this work essential to the elucidation of the fundamental causes of facial eczema, but it will be of considerable value in the study of the more general problem of stock thrift.

Grants have been made to Massey Agricultural College for the conduct of a series of important animal research projects. A long-term breeding experiment is in progress to determine the basis of inheritance of length in bacon pigs. Ram sterility investigations have been continued, and a convenient field test for sterility has been devised. Studies of environmental influences on the plane of fertility of rams have also been continued. A start has been made on an important sheep-grazing experiment designed to test the nutritive value of selected pastures under high and low levels of soil fertility. The wool research team at the college has been strengthened by the secondment of an officer newly appointed to the Department who is trained in wool metrology. This strengthening of the staff will expedite the elaboration of further tests for deficiencies in wool quality. A grant was made to Canterbury Agricultural College to enable one of the lecturing staff to be freed for work on the nutritional aspects of sheep diseases.

SOIL AND LAND-UTILIZATION SURVEYS.

During the year substantial progress has been made with the two regional soil surveys, each covering several thousand square miles, in North Auckland and Hawke's Bay. In North Auckland approximately 250 square miles of detailed soil mapping were completed. In Hawke's Bay 950 square miles have been mapped, and there remain some 500 square miles in southern Hawke's Bay and a small area in northern Hawke's Bay to complete the soil-mapping for the whole province. The writing-up of description of the soil-types in the mid-Hawke's Bay district is well forward, and the four coloured soil maps for this area are in the hands of the printer. A bulletin dealing with the soils of this area, followed by two complementary bulletins describing the pastures and land-utilization, respectively, will be published during the coming year. In March, Bulletin 70, which gives a comprehensive account of the climate, soils, agriculture, and horticulture of the Heretaunga Plains, was published, and has been in good demand from landholders in the district.

A soil survey of the Waikato lowlands between Hamilton and Morrinsville, and of the Kereone district, was commenced in order to supply data for the facial-eczema investigations. The writing-up of the soils and agriculture of the adjacent Waipa County was completed, and is now in the course of publication as a departmental bulletin. A survey of the soils of the north bank of the Manawatu River, near Foxton, has been made in order to provide information on their suitability for growing *Phormium tenax*.

SOIL EROSION.

A special Committee was set up during the year to report on the maintenance and preservation of vegetation, with special reference to the problem of soil erosion. The Committee's report, which has been finalized, and is now in the course of publication, provides a valuable survey of the extent to which deterioration of vegetation and soils has been occurring throughout New Zealand. Preventive measures are advocated so that acceleration of erosion, and consequent land deterioration which will otherwise occur, may be halted before irreparable damage is done to our farming lands.

In addition to the above report, a special survey of the tussock-grasslands of the South Island was made by an officer of the Botany Division of the Plant Research Bureau. The results, which have been published, show that serious deterioration in these tussock areas is occurring, and point to the necessity for regenerative measures.

MINERAL CONTENT OF PASTURES.

Remarkably successful results continue to be obtained from the use of cobalt in the treatment of animal diseases of the bush-sickness type. Under the direction of the Cobalt Committee, which includes representatives of the Department of Agriculture and the Cawthron Institute, a comprehensive programme of research has been undertaken during the past year. Special grants from the New Zealand Wool Publicity Committee and the New Zealand Meat-producers Board were utilized for the purpose of surveys of the cobalt content of pastures in the North and South Islands by the Department of Agriculture and the Cawthron Institute respectively.

In the South Island the districts covered by the survey comprise Ashburton County; certain districts in Southland; the Sherry, Westhaven, and Takaka districts, of Nelson; and parts of the West Coast (Karamea, Westport, Greymouth, and the Grey-Reefton Valley).

A low cobalt content was found in all samples from established pastures on the pakihi lands at Westport, and also in pastures from dune and recent-blown sands near the coast at Karamea, from limestone country at Cape Foulwind, and from leached gravel terraces of the Grey–Reefton Valley and at Karamea.

The success which has attended the use of cobalt licks and cobaltized fertilizers on pakihi pastures at Westport suggests that cobalt supplements will prove beneficial to stock over a large area of pasture land at Karamea, Westport, and in the Grey–Reefton Valley.

Further trials with cobaltized fertilizers have confirmed their efficacy in maintaining stock in a healthy condition on pastures which were originally unhealthy for stock.

Some interesting experiments with field crops at Southland and Nelson have shown that their cobalt status is greatly improved by the use of cobaltized fertilizers.

Uniformly good results have been obtained in animal trials at Nelson and on the West Coast from the use of cobalt licks, and these results are parallelled by those obtained by the Department of Agriculture in their experiments in the North Island.

WHEAT RESEARCH INSTITUTE.

In December, 1938, the Wheat Research Institute completed its first ten years of service to the wheat industry. The legislation under which the Wheat Research Institute operates and derives its finances requires renewal every five years, and it is a tribute to the work of the Institute that all sections of the wheat industry unamimously agreed to the renewal of this legislation and the contribution of levies for a further five years.

Among the most promising of the wheats evolved from the Institute's wheat breeding-work is "Tainui," a spring wheat, which this season (1939) was harvested at Canterbury Agricultural College over an area of 25 acres, with a yield of 52 bushels per acre. From this harvest over 1,000 bushels of seed will be available for distribution to farmers. The popularity of Cross 7 continues to increase rapidly, the acreage having increased from 84 acres in 1934 to 64,000 acres in 1938.

A considerable amount of investigational work was carried out in the chemical laboratory in connection with the drying of wheat. With the rapid increase in the rate of harvesting during the past ten years there is a tendency for farmers to deliver wheat out of condition to the stores, with the result that the wheat is either rejected by the merchant or goes mouldy in the store. It was to combat this difficulty that the Institute's investigations were undertaken along three lines—namely, (*a*) testing the moisture content of wheat with a view to devising the best time for harvest, (*b*) advising the farmer how to dry his wheat after harvesting and before delivery, (*c*) devising a method of drying wheat which had been delivered to stores out of condition. The Chief Chemist during his recent visit to Europe investigated all systems of drying wheat in stores, and with the special knowledge obtained was able to devise a form of drier which could be cheaply and easily constructed from plant normally present in a flour-mill store.

The Institute's travelling baker has continued to give valuable service to bakers on a wide variety of baking problems, and has also been in charge of the school of baking, which is held in the Institute's laboratory for two months in each year. This school has proved very successful, most of those attending being of the grade of foreman or master baker.

FRUIT RESEARCH.

The opening of the new laboratories and experimental area of the Plant Diseases Division of the Plant Research Bureau at Auckland will enable fruit diseases to be studied more intensively and under much better conditions than hitherto.

At the Research Orchard, Appleby, and the experimental orchards of the Cawthron Institute, fertilizer experiments have been continued. The 1938–39 season has been characterized by further significant increases in crop weights from certain manurial treatments, further evidence being obtained regarding the value of complete manures.

Premature defoliation of fruit-trees has been occurring to an increasing extent on certain of the Cawthron Institute manurial blocks, particularly in the Jonathan variety, and the important discovery was made during the year by the Institute that this defoliation is due to a deficiency of magnesium and can be controlled by the injection of magnesium salts.

In addition to its wide range of work on fruit diseases, the Plant Diseases Division has continued and expanded its certification scheme for sprays and other plant therapeutants. The success of this scheme may be measured by the numerous requests that have been received for the certification of other products.

The Entomology Division has continued its studies of the insect pests of fruit, including the raspberry-bud moth, the raspberry saw-fly, and various diseases of citrus.

Experimental work on boron in relation to physiological diseases has been directed towards the persistence of boron dressing in the soil. It appears that a soil dressing of ½ lb. borax per tree gives commercial control of internal cork for at least three seasons. Experiments by the Cawthron Institute in co-operation with the Department of Agriculture have shown that definite control of brown spotting of apricots can be obtained by the use of 0·1 per cent. borax spray or ½ lb. borax applied as a top-dressing round the tree. Chemical analysis of the fruit confirmed boron deficiency as the primary cause of the ailment.

Experiments on the preparation of unfermented apple-juice from six varieties of New Zealand apples have clearly indicated that a palatable and attractive juice can be prepared from some of these varieties, and that others which lack certain desirable qualities will nevertheless be of value for blending purposes. The tests are still proceeding, and certain sections of the work will be repeated for confirmatory purposes.

Research on a number of fruit cold-storage problems has been continued. Further experiments with copper-treated wraps confirmed their value in controlling the spread of grey mould in Winter Cole pears. A small-scale experiment with pears demonstrated that it was desirable that every effort should be made to store pears as promptly as possible. Studies on the effect of fertilizer treatment on the keeping-quality in cold storage of various varieties of apples were continued during the 1938 season and a considerable amount of additional knowledge was obtained.

Previous experimental work has shown that the use of top-dressings of more than ½ lb. of borax per tree had a detrimental effect on the keeping-quality of Jonathan apples. Experiments are being extended in the 1939 season to other varieties of apples, as it is probable that different varieties will react in a different way to a high boron content in the fruit.

Gas storage trials with Ballarat and Washington apples were continued. The first season's tests indicated that a reduction in carbon-dioxide concentration was desirable, and as a result of the 1938 season's work it was found that Ballarats stored best in a temperature of 2·5 per cent. carbon dioxide and 18·5 per cent. oxygen at a temperature of 39° F., while it appears that the Washington variety can be stored for periods up to six months in an atmosphere containing 5 per cent. carbon dioxide and 16 per cent. oxygen at a temperature of 39° F.

TOBACCO RESEARCH.

Negotiations for the lease of approximately 18 acres of land at Umukuri (near Motueka) were completed in May, 1938, and the work of establishing the Tobacco Research Station was begun immediately. The research work of the Station is divided between the Tobacco Research Officer and the Cawthron Institute according to the facilities available. The Tobacco Research Officer has been fully occupied during the year in field experiments, which commenced with an extensive series of seed-bed trials designed to test various fertilizer treatments (including the addition of boron), the

use of different seed-bed-covering materials, and different methods of raising the seedlings. At the same time observations on the incidence and severity of mosaic disease were made, from which results of very considerable practical importance in the control of mosaic were obtained. It was shown that not only did plants raised directly from seed without pricking out make considerably better growth than those raised by the usual glasshouse method, but they also showed less than 10 per cent. mosaic infection, as compared with 90 per cent. in the pricked out plants. Arrangements have been made for growers to try out for themselves this method of raising seedlings which has proved so successful at the Tobacco Research Station.

The erection of three flue-curing kilns and a bulking-shed was not completed until the middle of February, with the result that owing to overmaturity of the crop it was not anticipated that the best results would be obtained with the curing. From information just to hand, however, it appears that the cured leaf is grading better than was expected.

The Cawthron Institute, in addition to collaborating in the mosaic investigation, carried out a soil survey of the tobacco lands at Nelson, in the course of which 3,400 acres were mapped. The soil survey has shown the presence of considerable areas, now utilized for other purposes, which appear suitable for tobacco. On the other hand, areas have been found where the nature of the soil seems to render the production of high-grade leaf from the crops they are now growing most improbable. In connection with the chemical investigations of soils and tobacco-leaf, data have been obtained which suggest that boron may prove beneficial in the manurial treatment of tobacco, particularly on the coarse sandy types of soil. Analysis of tobacco-leaf also suggests the possibility of deficiency of magnesium as well as boron in certain samples.

PHORMIUM RESEARCH.

Research work on phormium has been continued during the year from the botanical, chemical, and mechanical aspects. The botanical work, which has been carried out since its inception by Dr. J. S. Yeates, of Massey College, has now been placed in charge of the Botany Division of the Plant Research Bureau. To Dr. Yeates, who was obliged to relinquish this work on account of pressure of other duties, a debt of thanks is due for his very valuable contributions to this branch of phormium research for a period of some ten years.

The Botany Division has been occupied chiefly with stocktaking of the plants in the various research areas and with the planting-out of selected varieties in various localities for ecological and yield tests. The Division has also initiated studies on the life-history of the phormium plant, with special reference to the rooting-system, and has co-operated in large-scale stripping tests with selected varieties using the improved tail-stripper.

Investigations relating to the mechanical decortication of phormium have been concerned with the designing of an improved flax-stripper. A four months' trial of an improved tail-stripping machine indicated that further improvements could be effected, and a second machine was designed which after continuous tests over a period of six months definitely confirmed its superiority over previous strippers. Patent rights have been taken out by the Department for this machine.

The Dominion Laboratory investigated various processes for the chemical treatment of phormium leaf for the production of fibre or pulp. The chemical examination of several varieties of phormium has also been undertaken, from which it appears that varietal differences are accompanied by differences in the chemical composition of the leaf. Further work in this direction is being done.

TIMBER PROTECTION RESEARCH.

The serious damage being done to wooden structures in New Zealand, as in other countries, by boring insects and wood-rotting fungi is a matter of national concern, affecting not only the Government, which has large sums invested in building securities, but also all owners of wooden buildings. The State Advances Corporation, as one of the largest holders of building securities, became seized with the necessity for an organized attack on the problem, based on scientific principles, and requested the Council of Scientific and Industrial Research to set up a Timber Protection Research Committee to direct and co-ordinate the necessary investigations. The Committee, which was accordingly established, includes representatives of the State Advances Corporation, the Housing Construction Department, and the Department of Scientific and Industrial Research. The programme of work provides for field surveys by officers of the State Advances in collaboration with officers of the Entomology Division, Plant Research Bureau, and laboratory investigations on the effectiveness of wood preservatives and fungicides to be undertaken by the Plant Diseases Division and the Dominion Laboratory.

While useful preliminary work along these lines has been done, additional staff and facilities are required to carry out the full programme of research that is considered necessary. In order to enable this object to be achieved, a number of interested Government Departments, in addition to the State Advances Corporation and the Department of Scientific and Industrial Research, have agreed to provide jointly the necessary funds and other resources available.

Since the initiation of research work a new and urgent problem has been presented by the discovery of extensive damage to houses by white ants, particularly in the Auckland District. Ways and means of combating this serious pest will accordingly form an important part of the Committee's activities during the coming year.

LEATHER AND SHOE RESEARCH ASSOCIATION.

The work of the Leather and Shoe Research Association during the year has demonstrated in a practical manner the important advantages to be gained by the participating industries in arriving at a clearer understanding of each other's requirements through a fuller knowledge of the qualities of leather, on the one hand, and the principles underlying the manufacture of leather goods, on the other.

As a result of research on leather carried out during the year a number of factors affecting the waterproofness of sole leather, the tensile strength, stretch, and " crackiness " of chrome upper leather, and the fineness of " break " of upper leather have been determined.

Shoe research has been directed towards a general survey and examination of some of the materials used in shoe-manufacture and the general principles underlying some of the processes. The fact that one hundred and ten factory problems, distributed among the majority of the firms, were submitted for investigation during the year indicates that members of the Research Association are fully appreciative of the technical service provided.

As before, close contact has been maintained with the industries concerned by periodical visits to tanneries and shoe-factories, and the results of the research work, together with general technical information, has been circulated in the form of monthly letters.

WOOL MANUFACTURERS' RESEARCH ASSOCIATION.

The Textile Research Officer took up his duties in New Zealand in October, 1938, after having spent nearly four months in Europe investigating different sections of the wool-textile industry and recent improvements in textile machinery. The valuable information he obtained concerning overseas developments in the wool-manufacturing industry has been passed on to members of the Research Association in New Zealand through the medium of monthly letters. Immediately after his return to New Zealand the Textile Research Officer visited the mills of all members of the Association and has investigated a number of special problems.

In the chemical laboratory the study of the raw-wool-scouring process has been continued and reports sent to the mills. An important investigation on woollen-batching oils has also been completed and a report circulated. Numerous service problems submitted by the mills have been dealt with.

Investigations on the problem of damage to wool by micro-organisms have been continued at the bacteriological department of the Otago University, and some interesting results have been obtained from experiments on the action of trypsin on wool fibres. For example, it has been found that elongation of the fibre greatly increases the susceptibility to enzyme attack.

A number of monthly letters on various aspects of the research work of the wool industry generally have been circulated during the year.

RADIO RESEARCH.

After an initial period of difficulties associated with the securing of suitable qualified research workers and the special equipment necessary had been successfully overcome, the research work under the direction of the Radio Research Committee has made very satisfactory progress.

In March, 1939, Dr. L. V. Berkner, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, visited New Zealand. Dr. Berkner, who is a research worker of high standing, particularly in the field of ionospheric research, spent some time in discussions with local research workers on radio research problems, and his visit proved of very great benefit.

As stated in my previous report, the radio research work is being directed chiefly along three lines—namely, (1) ionospheric investigations; (2) research on the reception of distant signals; (3) research on the propagation of radio waves.

Ionospheric observations are now being made regularly at Christchurch and at less frequent intervals at Wellington. Automatic recording-equipment for this purpose has been installed at Canterbury University College. The information obtained from these observations is being exchanged with observatories in other parts of the world in order to obtain a world picture of the changes that are taking place. Research on the reception of distant signals is being carried out at Auckland University, and this work will be considerably accelerated by the recent appointment of Dr. K. Kreielsheimer, who is specially qualified in this branch of the work. Arrangements were made for Dr. Kreielsheimer to remain in Australia for some weeks before proceeding to New Zealand, in order to study recent developments of the work being carried out by the Australian Radio Research Board.

Very interesting results were obtained from a survey of the field strength of local broadcasting-stations carried out by Mr. G. Searle, who was seconded for the purpose by the Post and Telegraph Department. A detailed study of the disturbance produced by various types of obstruction was made, and the results were published in the *New Zealand Journal of Science and Technology* and reissued as Radio Research Publication No. 1.

SOCIAL SCIENCE RESEARCH BUREAU

During the year the Bureau has been concerned mainly with the analysis and preparation for publication of the data obtained from the survey of the standards of living of dairy-farmers, the field-work for which was completed last year. This survey has yielded a large amount of interesting and valuable data which are being incorporated in a special report.

The field-work of the urban survey dealing with the standards of living of boot and shoe and tramway workers has now been completed, and good progress has been made with the analysis and interpretation of the data.

A feature of the year's work has been the increased facility of the staff in dealing with the large mass of data which is secured by comprehensive surveys such as the two that have been conducted. The dairy-farm survey was a pioneer effort by the Bureau staff, and the experience obtained from this has been used in good stead to obtain a better organization and treatment of the urban surveys.

DOMINION LABORATORY.

In addition to the large volume of work carried out by the Dominion Laboratory during the year for various Government Departments, a number of investigations of special importance are in progress.

Coal Survey.—The physical and chemical examination of coal samples from the West Coast areas has been continued, and the field survey work, coupled with the analytical examination in the laboratory, has produced information of very considerable value in assessing the possibility of establishing an iron and steel industry in New Zealand.

Kauri-gum.—Research work carried out by Dr. J. Hosking in England in connection with the commercial development of his process for the refining of crude and "chip" grades of kauri-gum have established beyond doubt the value of gum refined by this process for the preparation of varnishes of excellent quality. A promising field also appears to be open for the production of lacquers with a matt surface. A number of samples of chip gum have been analysed by the Laboratory in connection with an investigation of washing and cleaning processes for chip gum with a view to improving their efficiency.

Phormium Tenax.—Several processes for the production of phormium fibre or pulp were examined and reported on. Spinning tests were made on fibre produced by the improved tail-stripper, with very favourable results.

Curing of Lemons.—This investigation was completed during the year, and the results are being published in the *New Zealand Journal of Science and Technology*. The best results were obtained by storage in a slow current of air at a temperature of 70° F. and a relative humidity of 90 per cent. for a period of five to six weeks. Coal-gas equivalent to 1 part of ethylene in 30,000 of air was introduced into the air system for the first three weeks. Commercial trials under the conditions recommended are needed to complete this work.

Gas Storage of Apples.—Further work on the gas storage of apples of the Washington and Ballarat varieties has indicated the temperatures and relative concentrations of carbon dioxide and oxygen at which the greatest improvement in their quality and length of storage life is likely to be obtained.

Quartz Spectrograph.—The large quartz spectrograph has been in continuous use for a variety of purposes ranging from the analysis of metals to the distribution of trace elements in biological materials. For example, the manganese content of citrus leaves affected with mottle-leaf was found to be definitely lower than that of healthy leaves. The examination of a number of pasture samples for their minor element content has begun.

Grass-seed Dryer.—The Chemical Engineering Section of the Laboratory has devised and patented a machine for the drying of grass-seed to the optimum moisture content required to obviate deterioration in storage and transport. The semi-commercial dryer constructed at the Laboratory has worked very satisfactorily, and designs are now being prepared for a dryer of commercial size.

Paints and Paint Materials.—A very large quantity of paint and paint materials is used each year on Government-owned buildings. The value of work done by the Laboratory in checking the quality of the paints used is being recognized to an increasing extent, and arrangements are being made through a special Paint Investigation Committee for large-scale trials on actual buildings in order to correlate the composition of the paints and the actual painting procedure with their protective value and durability.

METEOROLOGICAL BRANCH.

There has been further expansion of the meteorological services to meet the demands created by the opening-up of new air routes and the institution of more frequent services by commercial air lines. The preparations for the trans-Tasman service have reached an advanced stage. Accommodation for the meteorological staff with its organization has been provided in the Terminal Building at Auckland. Australia, meanwhile, has established an observatory on the "Awatea" and placed special observers at Norfolk and Lord Howe Islands. A twenty-four-hour service should shortly be in operation for trans-ocean flying. The final details of the organization of the trans-Tasman route were settled at a Conference in Melbourne in December, at which the Meteorological Office was represented. Close co-operation has been maintained, also, with the Air Department in reference to the requirements of military aviation.

The intensive developments now taking place in connection with land-utilization, requiring the closer application of scientific methods to all aspects of the problem, have caused much greater attention to be directed to climate and its variations. This applies to both large-scale climatic effects and to the very local variations referred to as micro-climatology. It takes many years, however, to obtain anything approaching a complete account of a climate. A much longer period is required to indicate climatic cycles, trends, or the range of conditions which may be expected. The value of past records of climate is therefore being much more keenly appreciated. Unfortunately, at very few of the main centres have meteorological observations been maintained continuously at the same site and under the same conditions. The variations from place to place, over even a comparatively small area, of such elements as temperature and rainfall are of about the same magnitude as the variations from year to year. It is, consequently, to a large extent impossible to compare current conditions with those obtaining, say, forty or fifty years ago. It would be of very great value to the country if local authorities would realize the importance of maintaining climatological observations continuously at the same site and under constant and standard conditions.

The Director's report refers to the number and distribution of stations observing rainfall and the more complete climatological data.

At the Conference of the Australian and New Zealand Association for the Advancement of Science in Canberra, in January, 1939, the Director of the Meteorological Office was one of the Department's representatives. On the physical side the most important feature of the meeting was the great development shown to have taken place in Australia in exploring the atmosphere at very high levels by means of radio waves and correlating the results obtained with activity on the sun, variations in the earth's magnetism, and weather processes.

Attention is again directed to the publications of the Meteorological Office, in which useful statistics will be found.

GEOLOGICAL SURVEY.

Regional surveys have been continued in the Amuri and Glenorchy subdivisions, 180 square miles in each of these areas having been mapped in the last field season. Aerial photographs of the latter subdivision, which is of a rugged and mountainous nature, were used to assist in the mapping.

Field-work in the Greymouth coalfield in connection with the survey of coal resources was continued in the Rewanui area. Adverse weather conditions greatly hampered the surveys and in the circumstances very satisfactory progress has been made.

Geophysical surveys were carried out in the Big River and Bendigo areas and at the proposed site of the Cobb River dam. At the Big River area, which is about fifteen miles south of Reefton, information was obtained regarding the Waiuta anticline and associated structures, and the thickness of the gravel cover of the area was estimated. In the course of a geophysical reconnaissance survey of the Bendigo area an attempt was made to define the continuation of the Cromwell lode and another quartz reef, and certain tentative conclusions were drawn.

The Director made a special visit to Rotorua with a view to estimating the probable resources of thermal water and the possibility of the supply being depleted through the use of increased quantities. From the information available concerning the geological structure of the area and the rate of flow of some of the larger springs, it was concluded that considerably more water than is at present being used could be taken without appreciably depleting the underground supply.

A considerable amount of material from Taranaki, Gisborne, Hawke's Bay, East Wellington, and the West Coast was examined by the micropalaeontologist for the oil companies at present carrying out boring operations.

Two geological bulletins dealing with the Naseby and Kaitangata subdivisions, respectively, were completed and set in type. Officers of the Survey are at present engaged in writing bulletins dealing with the Te Kuiti and Wakaia subdivisions.

OBSERVATORIES.

From the 1st June, 1938, the new six-dot form of time signal was brought into operation by the Dominion Observatory through Station 2 YA of the National Broadcasting Service. This form of signal, which is a considerable improvement over the system formerly used, is similar to that adopted by the British Broadcasting Corporation, and is designed to cause a minimum of interference with broadcasting programmes.

The report of the Acting-Director presents a comprehensive review of seismic activity in New Zealand during the year, and opportunity is again taken to thank officers of other Government Departments and voluntary observers for operating subsidiary seismograph stations and supplying data regarding felt earthquakes.

An additional Wood-Anderson seismograph has been put into operation at the Dominion Observatory, and the efficiency of the chain of recording-stations will be increased by installing one of these instruments also at Tuai during the coming year. Seismological research at the Observatory included the completion of a preliminary analyses of the Observatory tilt records for the period 1930–34, some preliminary work on the measurement of the vibration of railway-trains in motion and of buildings in strong winds, and studies on local earthquakes. A considerable number of bulletins by officers of the Observatory and collaborating seismologists were published.

The Director of the Apia Observatory, Mr. J. Wadsworth, resigned on 9th June, 1938, and Mr. H. B. Sapsford was appointed Acting-Director. Meteorological work at Apia has been increased to meet the need for additional meteorological data for the Pacific region, particularly in connection with trans-ocean airways, and in this connection several of the resolutions passed at the Meteorological Conference in Wellington in 1937 have been put into effect.

The Magnetic Observatory at Christchurch has continued its regular programme of magnetic observations, and has also co-operated with the other observatories in seismological work. Research work in progress includes observations of cosmic-ray intensity and the study of microseisms.

NEW ZEALAND STANDARDS INSTITUTE.

The New Zealand Standards Institute has now been transferred to the Department of Industries and Commerce. The Institute's activities during the past year are contained in a separate report (H.–34A).

OVERSEAS CONTACTS.

The Department's Scientific Liaison Officer, Mr. Nevill Wright, and his assistant, Mr. W. M. Hamilton, who are attached to the High Commissioner's Office in London, have continued to perform valuable services in maintaining contact with research organizations in the United Kingdom; in representing the New Zealand Government on various scientific bodies; in making the necessary arrangements for the examination of experimental shipments of meat, fruit, and dairy-produce; and in procuring information in connection with scientific matters in general. Mr. Wright visited New Zealand during the latter part of the year in order to obtain first-hand knowledge of the Department's activities.

Mr. L. H. James, Government Analyst at Dunedin, visited England and the United States of America to study the latest advances in analytical chemistry, particularly with reference to the examination of foods and water-supplies and the disposal of wastes.

Mr. Modriniak, Geophysical Surveyor, visited the United States of America to purchase special equipment for use in geophysical surveys by the reflection method, and also to obtain up-to-date information regarding geophysical-survey work in America.

Following on the successful field trials of linen flax in New Zealand, and the satisfactory results from tests of New Zealand fibre carried out by the Linen Industries Research Association, Great Britain, Mr. J. W. Hadfield, Director of the Agronomy Division, Plant Research Bureau, visited Australia during the year, where he gained much useful information regarding linen-flax production and processing in Victoria.

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

DAIRY RESEARCH INSTITUTE.

Dairy Research Management Committee.—Mr. A. Morton (Chairman), Professor H. G. Denham, Messrs. T. C. Brash, A. H. Cockayne, G. A. Duncan, H. E. Johnson, A. Linton, C. A. Marchant, A. J. Murdoch, J. Murray, W. M. Singleton. Secretary: Dr. E. Marsden. Director: Professor W. Riddet.

The Committee held meetings during the year at approximately two-monthly intervals. At each it reviewed in detail research work in progress and projected at the Institute, gave careful consideration to matters affecting the advancement of dairy research in New Zealand, and accordingly made recommendations to the Research Council. The Committee suffered a serious loss during the year through the passing of one of its members, Mr. Q. Donald, who had been one of the Research Council's representatives on the Committee since its inception. The contribution of Mr. Quentin Donald to the work of the Committee was warmly acknowledged by both the Committee and the Institute staff. The Research Council appointed Mr. H. E. Johnson, Tokaora, to fill the vacancy on the Committee.

Research Work.—Material progress was made during the year towards the solution of many problems affecting the manufacture of dairy products and the production and composition of milk.

Cheesemaking investigations related mainly to studies on starters and the isolation and classification of bacteria influencing the ripening of cheese. In past reports the importance of devising methods of preserving the vitality of cheese starters has been emphasized, and it has been shown that the sudden loss of vitality is commonly caused by the action of bacteriophage. During the present year very important observations have been made as to the means by which starters become contaminated with phage, and steps have been taken to apply these findings in dairy-factory practice. The influence on cheese quality of employing selected single strains of lactic organisms as cheese starters has been carefully examined. At the request of the New Zealand Co-operative Dairy Co., and with the financial and whole-hearted assistance of the company, an effort was made at their Eureka cheese-factory to determine whether starter failures could consistently be avoided and whether the use of single-strain cultures could improve the quality of cheese. The Massey Agricultural College very kindly loaned the services of Mr. T. Jensen, B.Agr.Sc., to superintend this work, and he worked at the Eureka factory from October, 1938, until February, 1939. Considerable time has been devoted to the isolation and classification of those organisms in Cheddar cheese which affect its ripening, because it has been shown that some strains are the primary cause of "slit" open texture, a defect causing much New Zealand cheese to be classed as first grade instead of finest. The work now completed provides a valuable foundation for determining the common sources of these organisms and methods of controlling their numbers in produce, so that finally some practical methods of avoiding slit openness may be evolved.

Complementary to the work of the Dairy Board herd-recording department and the Department of Agriculture in determining the incidence of mastitis in herds under group herd test by using the bromthymol blue test, an extensive investigation was made of factors affecting the bromthymol blue test, of changes in the composition of milk coincident with a positive reaction to bromthymol blue, and of the influence on cheese quality of employing milk reacting to this test. Mr. P. O. Veale, M.Sc., Hawera, took part in some of this work, for which he was given a grant.

Work on butter problems was pursued in a number of projects. Rapid methods of estimating butterfat losses were compared; the respective parts played by acidity, starter organisms, pasteurizing temperature, and the flavouring substance diacetyl in the oxidation of salted and unsalted butter held in cold storage were worked out; the role of starters in affecting the flavour of New Zealand butter was demonstrated; and changes in the diacetyl production of starters were studied. Some progress was made with the identification of the substance in land cress that imparts an objectionable flavour to cream and butter; a study was made of methods of assessing the hardness of butter, and these were used in a preliminary series of trials designed to obtain definite information on manufacturing procedure affecting the body of butter. Working at Minnesota University, where he held a Commonwealth Fund Scholarship, Dr. C. R. Barnicoat completed his research project on the "Chemistry of incipient oxidation defects in butter." On the basis of this work and of his other publications he was awarded the Ph.D. degree. Preliminary to a study of factors accounting for variation in the quality of butter made in different districts, samples of butter produced in several localities have been examined at monthly intervals, in particular for details of the characters of the fat.

A series of mycological investigations were carried out to determine the commonest sources of contamination of dairy products with moulds and to devise methods of reducing this contamination to a minimum.

In collaboration with the Grasslands Division of the Plant Research Bureau, projects have been continued to determine the food value for milking-animals of certain common New Zealand pasture plants, and in particular to ascertain the effects of these on the production and composition of milk. (This work was extended this year to study also the influence of grass ensilage.) With the assistance of the Wallaceville Veterinary Laboratory, a study was also made of the influence of continuous feeding of perennial rye-grass, and perennial rye-grass and white clover, respectively, on the health of dairy cattle while in milk and dry. Various other projects of lesser importance were undertaken.

The following statements prepared by officers in charge of the projects give a brief account of the progress made. More detailed information on some of these is contained in published technical communications, a list of which is given at the end of this report.

Cheesemaking Projects.

(*a*) *Cheese-starters* (H. R. Whitehead and G. J. E. Hunter).—Failures due to Bacteriophage Action: Last year it was believed that the problem of starter failures had finally been solved. As a result of long experience at the Institute and of many trials in commercial factories it appeared that the adoption of an aseptic technique, together with the use of a large inoculum in the propagation of starter, eliminated the failures which had commonly been experienced. This belief proved to be ill-founded. At the beginning of the present season several failures of single-strain starters occurred in commercial factories under circumstances which made it reasonably certain that faults in the recommended technique were not responsible. Continued success with the same cultures at the Institute led to a revival of the old suggestion that peculiarities in certain milk-supplies were responsible for the starter failures. The difficulty of transporting adequate supplies of milk for experimental purposes rendered it impossible to explore this hypothesis adequately, but the few trials that were made did not give positive results. Colostrum milk, mastitis milk, and milk from different localities all seemed to give equally good results when used as media for the growing of single-strain cultures at the Institute. No failures were experienced.

Finally some light was thrown on the problem during a trial in which a single-strain culture was maintained at the Institute and in two commercial factories on milk reconstituted from skim-milk powder. As usual, no trouble was experienced at the Institute, while in the two factories failures occurred repeatedly at intervals of a few days. It thus became clear that environment must be playing a part, since culture, medium, and technique were identical in the three places. A few further experiments served to show quite clearly that, in the commercial factories, contamination of the cultures with phage occurred through the atmosphere even when a normal bacteriological technique was practised. This explained many of the anomalies in results which had previously been ascribed to differences in procedure.

It is evident now that the technique normally considered adequate to prevent infection of cultures is not efficient under certain circumstances in preventing the access of bacteriophage to cultures. There are still many points about the occurrence in factories of air-borne contamination with phage which cannot be explained—*e.g.*, why does contamination occur more readily at some periods than at others?—but from a practical point of view it is evident that means must be devised, if possible, to prevent the occurrence of the contamination.

With this object in view it is proposed that a special starter-room be built at a certain commercial factory where starter trouble is very prevalent. The room will be quite separate from the factory, and will be designed with the express object of eliminating air-borne phage contamination from the starter. If this can be successfully accomplished, there seems to be no reason why the single-strain starters should not give just as much satisfaction in the commercial factory as they do in the Institute experimental factory.

(*b*) *Single Strains as Cheese Starters* (H. R. Whitehead, G. J. E. Hunter, W. Riddet, and E. A. Sawyer).—Continued experience with the use of single strains of *Str. cremoris* as cheese starters seem to indicate that each strain has a specific effect which leads to slight but definite differences in the cheeses made with the use of different strains. It is not yet certain whether these differences are due to the specific acid-producing characteristics of each strain or to some other property of the streptococci. From the practical point of view, however, it is evident that satisfactory cheese of true Cheddar type can be made with single-strain starters, and that such starters have very many advantages over mixed cultures if they can be safeguarded from failure.

(*c*) *Role of Organisms in Cheese-ripening* (I. R. Sherwood).—During the period under review an extensive investigation of the bacterial flora of New Zealand cheese has been completed. The cheeses studied were selected from all the important cheese-producing districts in New Zealand and they covered a wide range of quality. Thirty-six cheeses, representative of the different types examined, were subjected to a detailed bacteriological analysis. The following is a summary of this analysis:—

Aggregate Flora: In agreement with the work of other investigators on the flora of Cheddar cheese made from clean milk, it was found that the bacteria present in New Zealand cheese made from flash-pasteurized milk were almost entirely lactic acid bacteria. Whereas, however, frequency distribution studies on American and English Cheddar cheese by other workers indicated extremely important roles for *Sbm. casei* and for different types of cocci, in the present investigation it was found that the flora of New Zealand cheese was dominated by *Sbm. plantarum*. *Sbm. casei* occurred much less frequently. The Genus *Streptobacterium* (*Sbm. casei* and *Sbm. plantarum*) comprised approximately 90 per cent. of the aggregate flora of the pasteurized-milk cheeses. The remaining 10 per cent. was made up largely of betabacteria, although betacocci occurred occasionally. Other types of lactic acid bacteria were only rarely isolated from the pasteurized-milk cheeses, but occurred frequently in the raw-milk cheeses examined.

The Relation of Different Types of Lactobacilli and Betacocci to Cheese Quality: The fact that different strains of lactobacilli produce widely different effects in cheese has been noted in previous reports. The present studies have greatly clarified the position, in that a relation has been demonstrated between the types of lactobacilli (and betacocci) and the effects which these organisms produce in cheese.

The strains of *Sbm. plantarum* isolated were divided into four varieties on the basis of their biochemical characteristics. The first two varieties produced undesirable effects in cheese—bad flavours and discoloration—while salt-tolerant strains also caused open texture. The third variety, on the other hand, was definitely beneficial to cheese quality. The fourth variety had very little apparent effect.

None of the strains of *Sbm. casei* examined caused the appearance of any serious defects. Most strains improved cheese quality.

A certain number of organisms intermediate in their characteristics between *Sbm. plantarum* and *Sbm. casei* were isolated. Two varieties were distinguished, neither of which produced undesirable flavours or discoloration; the second variety, however, was very tolerant of salt and caused open texture.

Betabacteria, when added in fairly large numbers to the cheese milk, invariably produced bad flavours, discoloration, and openness.

Betacocci were found to cause slit openness. Most varieties also produced objectionable flavours and discoloration.

The Flora of Good quality Cheese: The flora of good quality cheese was usually found to be less diverse than that of poor quality cheese. The types present in the former were chiefly *Sbm. plantarum* variety 4, *Sbm. casei*, and variety 1 of the group intermediate between *Sbm. plantarum* and *Sbm. casei*. A *small proportion* of the flora often consisted of other types—*e.g.*, betabacteria. Indeed, there was some evidence that the presence of small numbers of betabacteria actually improved the flavour of the cheese.

Those cheeses, however, which included in their flora a high proportion of (*a*) betabacteria, (*b*) most varieties of betacocci, or (*c*) the first two varieties of *Sbm. plantarum* mentioned above were invariably of poor quality. Clearly, therefore, it becomes a matter of practical importance to devise means of preventing any relatively large numbers of these undesirable organisms from gaining access to cheese milk. With this ultimate object in view, the sources of the different types of lactobacilli are at present under investigation. Progress along these lines should be considerably expedited as a result of the work described in this report, since it is now possible to forecast from laboratory examination of a given lactobacillus approximately what effect that organism is likely to produce in cheese.

(*d*) *The Composition of Milk Reacting to Bromthymol Blue, and its Effects on Cheese Quality* (F. H. McDowall).—A study has been made of the factors influencing the bromthymol blue test for mastitis. It has been shown that the high pH in the milk, corresponding to a positive bromthymol blue test, persists in an appreciable volume of the foremilk with some affected quarters, but only for a very small volume with other quarters. In the latter case the result of the test would depend to a great extent on the quantity of milk taken. The test is also affected by the quantity of indicator added and the interval between time of drawing the samples and time of reading. An investigation in the field, in collaboration with Mr. J. P. James, M.R.C.V.S., of the Veterinary Laboratory, Wallaceville, and Mr. A. H. Ward, of the herd-recording department of the New Zealand Dairy Board, has indicated that a positive reading of the bromthymol blue test means a high leucocyte count in the milk, but at least 50 per cent. of the milks with high cell count are not shown up by the test.

Work at the Institute and that carried out by Mr. Veale has shown that there is usually a significant difference between the composition of milk from quarters reacting positive to the bromthymol blue test and that of milk from sound quarters of the same cow. While previous work has shown that milk from quarters showing active mastitis has an influence on the flavour of cheese, it is still open to question whether milk from quarters affected with latent mastitis has any effect on cheese quality (its effect on the quantitative aspects of cheesemaking will, of course, be related to the effect on milk composition). By means of a specially designed milking-machine bucket and claw which permitted the separate collection of milk from the individual quarters, sufficient milk was collected from affected and corresponding sound quarters to permit a comparison of the cheesemaking qualities of the two samples. The comparison was carried out with 100 per cent., 25 per cent., and 10 per cent. mastitis milk. The cheese, when graded three weeks after manufacture, showed no appreciable difference. The gradings of the mature cheese are not yet available.

Buttermaking Projects.

(*e*) *Fat Losses in Buttermilk* (W. J. Wiley).—The percentage of fat in buttermilk may give an erroneous impression as to the efficiency of churning; the figure that is desired is the percentage of the fat present in the cream which is lost in the buttermilk. It is generally impracticable to weigh the buttermilk, and recourse must be made to indirect methods of calculating the loss. These indirect methods are based on assumptions as to the composition of the butter. During this season a series of experimental churnings was made in which the losses were estimated directly by weighing and analysing the cream, buttermilk, and wash-water. The results agreed closely with those obtained indirectly by a method proposed by Udy in New Zealand and by another method proposed by Bird and Derby in the United States. Both these indirect methods were proved to be sufficiently accurate for factory control work and for much experimental work.

(*f*) *Oxidation of the Fat of Butter in Cold Storage* (W. J. Wiley).—The experiments on the oxidation of the fat of unsalted butter in cold storage mentioned in the last report have been continued, and extended to include salted butters. It was found that both salted and unsalted butters made from ripened cream oxidized more rapidly than corresponding butters made from cream acidified to the same extent with pure lactic acid. Salted butters oxidized more rapidly than corresponding unsalted butters. The more rapid oxidation in the case of the ripened-cream butters was not due to the presence of diacetyl or acetoin, as these compounds were found to have no influence on the oxidation. Low pasteurization temperatures favoured the oxidation of the butterfat. The results indicate the presence in ripened pasteurized cream and in unripened raw cream of a fat oxidizing enzyme which is most active at low pH values (about 5) and high salt concentration.

(*g*) *Starters for Butter* (W. J. Wiley, G. A. Cox, and H. R. Whitehead).—Starters are not used in New Zealand with the object of "ripening" the cream, as it is well established that butter from ripened cream deteriorates in cold storage. Some factories, however, which receive sweet cream add a small proportion of starter (about 0·5 per cent.) to the pasteurized and chilled cream and hold overnight at a low temperature before churning to improve the flavour of the butter. There is no development of acidity in the cream under these conditions, although the resultant butter has a somewhat "brighter" flavour than if made from sweet cream alone. Experiments carried out during the year showed that there is an appreciable development of diacetyl in the cold cream and that it is this diacetyl which brightens the flavour of the butter. The diacetyl is produced in the cold cream by the action of *Str. cremoris* in the starter, and not by the betacocci, which at higher temperatures are responsible for the production of diacetyl in starters. It follows that there is no necessary relationship between the flavour and aroma of a starter grown in the usual manner at 21° C. and its ability to produce diacetyl at low temperatures. A single strain of *Str. cremoris* can be as effective as a good mixed butter-starter.

The rate of production of diacetyl by starters at 21° C. has also been studied. Typical mixed cultures of *Str. cremoris* and betacocci produce diacetyl rapidly during their period of logarithmic growth rate. After reaching a peak value the proportion of diacetyl falls rapidly, and about 90 per cent. is destroyed in about twelve hours. This somewhat unexpected phenomenon has hitherto escaped the attention of workers interested in butter cultures. Examination of "ripe" starters twenty-four hours or more after inoculation gives no indication of the rapid formation followed by equally rapid destruction of diacetyl, which has occurred within the first twenty hours or so. No explanation of the phenomenon is forthcoming at present. It has been shown, however, that the betacocci are primarily responsible. Pure cultures of betacocci when grown in milk at 21° C. do not produce any appreciable quantities of diacetyl over long periods of time. When grown in milk acidified to pH 4·2, however, they produce and destroy diacetyl in a similar manner to the mixed butter cultures.

(*h*) *Land Cress Taint in Cream and Butter* (F. H. McDowall).—During the spring months of the dairying season trouble is frequently experienced in butter-factories through the presence of land cress taint in cream. The trouble is very prevalent in the east coast districts of the North Island, but each year it appears to become more widespread in other districts. The plant (*Coronotus didymus*) is an annual which germinates in open soil conditions. It is particularly in evidence, for example, in young grass, or in areas around a gate that have been trodden bare of grass during the winter. The taint is often difficult to detect in cold cream, but is accentuated by the pasteurization process. During the year under review some attention has been given to a study of the problem. Steam distillation of the plant, and extraction of the steam distillate with petroleum ether, yielded 0·02 per cent. to 0·03 per cent. (based on the undried material) of an essential oil with an odour strongly reminiscent of cress. The main constituent (at least 70 per cent. to 80 per cent. of the oil) has been identified as benzyl cyanide, but there are also some unidentified constituents, one or more of which contain sulphur. While both the oil and artificial benzyl cyanide have an odour somewhat resembling land cress taint, they do not give the true land-cress taint when added to cream or butter. It was shown that the vacreator could remove a considerable portion of the cress oil or artificial benzyl cyanide added to cream. With natural cress tainted cream, however, great difficulty is experienced in effecting any improvement. Now that some idea has been gained of the nature of the tainting substances it is proposed to work with naturally tainted creams, and to study the relationship of time of consumption of cress by the cow and quantity consumed to degree of taint in the milk and cream. For this purpose arrangements have been made with the Grasslands Division of the Plant Research Bureau for the seeding of an area with land cress so that adequate material will be readily available.

(*i*) *Hardness of Butter* (R. M. Dolby).—The body of butter is an important characteristic from the point of view both of its "standing up" qualities and of its spreading capacity. The estimation of body by subjective methods is unreliable even when samples are compared at accurately controlled temperatures, as the observer is frequently influenced as much by the texture as by the firmness of the butter. A method involving measurement of the properties is therefore necessary for comparing different samples of butter.

An instrument designed by Dr. Scott Blair, of the National Institute for Research in Dairying at Reading, has been used to make a preliminary survey of the effect of various factors on the hardness of butter. While the method used is open to criticism on some points, notably that the readings are affected to some extent by crumbliness as well as by the hardness of the butter, it has given useful indications in this survey. It was found that the most important factor influencing the hardness of butter was the rate of cooling the cream after pasteurization. The more rapidly the cream is cooled the harder the butter. Variations in churning temperature produced much smaller differences. Variations in wash-water temperature produced very little effect, but there was a slight tendency for the hardness to be increased where warmer wash-water was used. The amount of working of the butter had surprisingly little effect on the hardness. Overworking tended to make the butter slightly softer, but the difference largely disappeared after the butter had been stored for some time.

Cold storage for four or five months at 15° F. was found to produce a slight increase in the hardness of all the butters examined.

A striking feature of the results was that seasonal and even daily variations were greater than variations produced by the different methods of treatment. Butter made in the early spring was very soft. The hardness increased rapidly as the season advanced, reaching a maximum about December, and declining again in the later months.

(*j*) *The Chemistry of Incipient Oxidation Defects in Butter* (C. R. Barnicoat).—This study was made at the University of Minnesota, United States of America. The butters used were made from sweet cream pasteurized for ten minutes at 160° F., churned, worked and salted by hand, and were graded after storage at 40° F. for one day, and then after one and two months. The following conclusions were drawn from an extensive series of experiments.

Incipient off-flavours such as "flat," "bitter," "stale storage," and "metallic" may be promoted by oxidation catalysts, including traces of copper and iron; but ferric iron is inactive.

These incipient oxidation changes may occur long before there is any evidence of oxidation in the butterfat, and the addition of oxidized fats or fat-soluble peroxides to butter fails to produce off-flavours of the foregoing types, but tends to promote "oxidized," "oily," or "tallowy" flavours, due to oxidation of the unsaturated fatty acids of the triglycerides.

It would appear that oxidation of the lecithoprotein (present in cream as the natural emulsifying "membrane" substance surrounding the fat globules) is responsible for these incipient off-flavours. This oxidation of the lecithoprotein is readily transferred to the fat, with which the lecithoprotein is in intimate contact.

The oxidation of the lecithoprotein "membrane" appears to proceed more easily in the presence of catalysts such as metals and also in the absence of certain natural antioxygenic substances which exist in the plasma (or skim-milk) fraction.

Most of the antioxygenic effect found in milk plasma would appear to be due to the presence of soluble phosphates and citrates, but the proteins also possess this property to some extent. Of the seven vitamins tested, only vitamins C and E appeared to have antioxygenic properties. Most of the current research is centred around vitamin C, which in this investigation was not found to be consistently antioxygenic even in high concentrations. The results observed with other plasma ingredients, particularly the inorganic salts, were much more striking.

(*k*) *Survey of District and Seasonal Variations in Butter* (W. J. Wiley, R. M. Dolby, and G. A. Cox).—Samples of butter were obtained at monthly intervals from certain factories, believed to be typical of most, from north to south in the Dominion. On arrival at the Institute these samples were graded, and thereafter were examined analytically, especially for variations in the composition of their fat. Samples showed seasonal variations clearly and also consistent variations in hardness between one factory and another. Differences in the chemical composition of the butterfat were sufficient to account only partially for the variations in hardness of the butters. Investigation of these points is continuing.

Mycological Projects.

(*l*) *Control of Moulds in Dairy Products* (T. R. Vernon).—In order to secure some definite information on the amount of air-borne contamination, a survey has been made throughout the year of the numbers and types of moulds present in the atmosphere in and near dairy factories. Outside the factory the spore load is influenced by many factors, but, generally speaking, it is during the summer months that the spore load is greatest. Inside the factory the spore load depends mainly on the sanitary condition of the factory itself, and it has been demonstrated clearly that simple precautionary measures may materially reduce the amount of contamination.

From the commercial point of view it is unfortunate that butter and cheese manufactured when the spore load is greatest tend to be sold when conditions are most favourable for growth.

The moulding of paint-work in dairy factories is largely attributable to inadequate ventilation and the use of unsuitable paints on unsuitable surfaces.

Work is in hand on a study of the resistance offered to mould attack by different pigments and the effect of various paint vehicles and driers. The use of aluminium paint, particularly on rough surfaces, is meeting with some success. It offers considerable resistance to mould attack, it reflects light well, and in curing-rooms may be of value in reducing the rate of heat transmission.

Experiments are being carried out to determine the value of ozone in suppressing mould growths in cheese-curing rooms, and a commercial ozone-producing apparatus is being tested.

High humidities encourage moulding; low humidities increase shrinkage losses. In practice it is necessary to compromise. With the object of mould control in view, a study is being made of conditions in cheese-curing rooms. Data on temperature, humidity, and air movements are being collected which will be of value both in relation to mould control and the problem of shrinkage losses.

Dairy Husbandry Projects.

(*m*) *Relation between Pasture Plants and Dairy Products* (I. L. Campbell).—(1) Experimental Grazing Herd: A long-term study is being made in which the performance of one group of dairy cows grazing on pure perennial rye-grass swards is being contrasted with that of another similar group grazing mixed swards of the dominant perennial rye-grass - white clover type. Hay and silage made from the respective pastures supplement the ration in times of shortage. Records are being kept of the condition and health of the animals, the calcium, phosphorus, and magnesium levels in the blood, milk and fat yields, the flavour of cream, and changes in the composition of the milk and fat followed from analyses. This trial has been in progress since July, 1938, and to date the performance of both groups has been similar and apparently normal. Since, however, the main object of the experiment is to study the effects of these diets continuously fed to the same animals over several lactations, it is too early to draw final conclusions.

(2) Stall-feeding Trials: From August to November, 1938, two groups of cows kept in stalls were fed *ad lib* quantities of perennial and Italian rye-grasses (in alternate twenty-eight-day periods), in an experiment to contrast the value of these two pasture plants for milk production, to note the effects of these diets on the health and blood composition of the animals, and gather data on the palatability of the grasses, the dry matter ingested, and the nutritive value of the two rations. From the weight of the animals and the chemical composition of the milk and feeds, the balance between each cow's consumption and her requirements was calculated in terms of energy and protein equivalent.

It was found that, provided the fibre content of the grasses remained low, both feeds were eaten readily and in sufficient quantity to provide for the animal's energy and protein requirements. A short digestibility trial showed that the constituents of both grasses were highly digestible. During the last few weeks of the experiment, when the fibre content rose to a level of 25 per cent. or more, the milk and fat production fell off significantly and the iodine values of the butterfat tended to rise slightly, although the dry matter ingested by them remained at a high level. The increase in fibre was especially pronounced in the case of perennial rye-grass, and the above results were more marked with animals on this feed.

With the commencement of lactation the animal's nutritive requirements rise sharply, and although the net ingestion figures show clearly that the appetite of the cow increases to meet this need, the data indicates that there is a lag period, during which the energy balance of the cow may be negative and the body reserves depleted. Due to the high nitrogen content of short early spring grasses a protein-positive balance may be readily maintained.

(*n*) *Value of Grass Silage for Milk-production* (W. Riddet, I. L. Campbell, and F. H. McDowall).—Previous work at this Institute has shown that a subnormal plane of nutrition reduces a cow's milk yield and causes a decline in the solids-not-fat content of her milk in addition to raising the iodine value of the butterfat. It is therefore essential to know whether silage, a supplementary feed commonly used in this country, is by itself sufficient to support a normal plane of milk production. Experimental work designed to ascertain the value of high-grade silage for milk production was commenced in December, 1938, using six stall cows. The silage used was made from leafy rye-grass white clover pasture cut early in October, to which molasses at the rate of 30 lb. per ton green material was added, and generally would be considered to be of excellent quality. This trial is not yet completed, but the results to date indicate that this silage alone, or as a supplement to fodders of high fibre content, does not provide sufficient nourishment to maintain a high plane of milk production. Chemical analyses of the milk, determination of iodine values of the fat, and of certain mineral constituents of the blood have been carried out to ascertain the effects of silage on these.

(*o*) *Relation of above Feeds to Incidence of Mastitis* (Dairy Research Institute, in collaboration with Veterinary Laboratory, Wallaceville).—The animals of the experimental herd have been tested for mastitis continuously throughout the season using the bromthymol blue, leucocyte count, and cultural methods. With the exception of one cow which definitely experienced an udder injury, all animals have been maintained free from mastitis. The average leucocyte count of the bulk milk of the herd has kept exceedingly low, averaging between 40,000 and 100,000 cells per ml. when examined by Breed's method.

(*p*) *Detergent for Milking-machines* (J. D. Sargent and I. L. Campbell).—A three-month experiment contrasting the value of caustic soda and sodium metasilicate as detergent solutions for washing milking-machines was carried out. Over this period the silicate gave results quite as satisfactory as caustic soda both in respect of its effect on the rubberware and the sanitary conditions of the milking plant.

Collaboration with the New Zealand Standards Institute.

Several members of the staff have acted on the Standards Institute Committee which deals with standards for dairy requisites. Drs. F. H. McDowall and H. R. Whitehead are joint secretaries of the Committee.

Pasteurization and Bottling of Milk for Schools.

At the request of the Department of Health, the Institute has continued to pasteurize and bottle milk supplied to schools in the Palmerston North district. During the year the zone of the supply was extended to include Feilding schools and those country schools lying between Palmerston North and Feilding. The entire cost of this work has been borne by the Department of Health. Throughout the period over five thousand bottles (½ pint) of milk have been supplied daily during school terms, and a high standard of quality has been maintained, which has been appreciated by all.

Staff.

Dr. C. R. Barnicoat resumed duties at the Institute in November, 1938, after spending, as a Commonwealth Fund Scholar, two years at Minnesota University, where he was awarded the Ph.D. degree. He was also elected an F.I.C. during the year.

S. L. Green, B.Agr.Sc., was appointed to the staff in November, 1938, as Assistant Dairy Husbandman.

Dr. W. J. Wiley, an officer of the Australian C.S.I.R., worked on the staff as a seconded member during the whole period, and took a prominent part in the research investigations.

Dissemination of Results of Work.

As in past years, the research work carried out during the season was reviewed at the Dairy-factory Managers' Week. This took place from 2nd May to 5th May, and was attended by over seventy factory managers and first assistants from all parts of the Dominion. During the year addresses were given by members of the staff at the National Dairy Conference, and at meetings convened by the New Zealand Dairy-factory Managers' Association, by the South Island Dairy Association, and by dairy companies.

A monthly article on dairying was contributed to the *New Zealand Dairy Exporter*, and the following technical publications have been issued during the year:—

Institute Publication No.	Title.	Author.	Journal.
111	Solubility of Cheddar Cheese in Sodium Chloride ..	F. H. McDowall and L. A. Whelan	*J. Dairy Research.*
112	Storage of Cheese at Freezing Temperatures ..	F. H. McDowall ..	*N.Z. Jour. Sci. & Tech.*
113	Starter Cultures for Cheese-manufacture: Maintenance of Acid-producing Activity in Cultures of Lactic Streptococci	H. R. Whitehead and G. J. E. Hunter	*J. Dairy Research.*
114	Annual Report, 1937–38.		
116	The Costs and Capitalization of North Auckland Creameries during 1935–36	J. F. Tasker.	
117	The White Particles in Mature Cheddar Cheese ..	F. H. McDowall and A. K. R. McDowell	*J. Dairy Research.*

The following are in the press:—

Institute Publication No.	Title.	Author.
118	Oxidation of the Fat of Butter during Cold Storage	W. J. Wiley.
119	Payment for Milk for Cheesemaking: A Trial of the Costed Cheese System in Seventeen Commercial Factories	F. H. McDowall.
120	The Relation of Certain Lactic Acid Bacteria to Open Texture in Cheddar Cheese	I. R. Sherwood.
121	Bacteriophage-organism Relationships in the Group of Lactic Streptococci ..	H. R. Whitehead and G. J. E. Hunter.
122	The Bacterial Flora of New Zealand Cheddar Cheese	I. R. Sherwood.
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As in the past, the Institute is much indebted to the Massey Agricultural College for the use of the College herds, buildings, and plant, and it is desired to express to the Board of Governors the thanks of the Institute for this privilege. It is also desired to acknowledge the ready co-operation afforded by the Dairy Board, by the Director and staff of the Dairy Division of the Department of Agriculture, the Grasslands Division of the Plant Research Bureau, the Primary Products Marketing Department, and by a number of commercial organizations. To all of these it is desired to express the grateful thanks of the Institute.

PLANT RESEARCH BUREAU.

Plant Research Bureau Committee.—Mr. A. H. Cockayne, Chairman; Dr. F. W. Hilgendorf, Vice-Chairman; Professor G. S. Peren, Massey Agricultural College; Professor E. R. Hudson, Canterbury Agricultural College; Sir Theodore Rigg, Cawthron Institute; Dr. E. Marsden, Department of Scientific and Industrial Research; Mr. R. B. Tennent, Fields Division, Department of Agriculture; Messrs. C. A. Marchant and Alan Grant, representing North Island and South Island farmers respectively.

The Plant Research Bureau now comprises five Divisions, viz.:—

——	Location.	Director.
Plant Diseases Division	Owairaka, Auckland	Dr. G. H. Cunningham.
Grasslands Division	Massey College, Palmerston North ..	Mr. E. Bruce Levy.
Entomology Division	Cawthron Institute, Nelson	Dr. D. Miller.
Agronomy Division	Canterbury Agricultural College, Lincoln ..	Mr. J. W. Hadfield.
Botany Division	58 Bowen Street, Wellington	Dr. H. H. Allan.

Participating in the Bureau are: (1) the Department of Agriculture and its various Divisions; (2) the Department of Scientific and Industrial Research and its several research sections; (3) Massey Agricultural College; (4) Canterbury Agricultural College; and (5) Cawthron Institute.

The Bureau is organized so as to arrange for co-ordination of all researches relating to plants at present being conducted throughout New Zealand and to associate this work appropriately with the teaching and extension work of the Agricultural Colleges and the Department of Agriculture.

The buildings to accommodate the Plant Diseases Division, at Owairaka (Mount Albert), Auckland, were completed and officially opened by the Prime Minister, Right Hon. M. J. Savage, and the Minister of Scientific and Industrial Research, Hon. D. G. Sullivan, in March, 1939.

The Plant Research Bureau Committee has met quarterly during the year and has continued its function of co-ordinating and promoting research into plant problems in New Zealand. During the absence of the Chairman abroad for the greater part of the year Dr. F. W. Hilgendorf acted as Chairman of the Committee.

AGRONOMY DIVISION.

Director: Mr. J. W. Hadfield.

This Division is concerned with all phases of crop improvement, and this objective is approached by plant introduction, plant breeding, and pure-seed production.

Cereal and Pulse Crops.

Wheat.—The production of pure and smut-free seed wheat continues each year to be a useful service performed by this Division. Seed of the following varieties was grown and distributed this past season: Velvet, Hunters, Solid-straw Tuscan, Dreadnought, Cross 7, Montana King, Marquis, and Lin Calel.

Oats.—About 112 varieties have been introduced from overseas and placed under trial, and some particularly promising rust-resisting material has been under observation by the Plant Diseases Division. The indications are that Victoria, Bond, Ingold, Green Russian, and White Tartar, either individually or when crossed with one another, are highly resistant, and steps are being taken to utilize these for crossing purposes. A fairly extensive breeding programme is now in its sixth year. There appears to be some useful material arising out of these early crosses, but prospects are more promising in the case of crosses made recently by the utilization of overseas material that has now been tested in this country.

Barley.—Investigations in this crop consist at present of plant introduction only. Some forty varieties of malting barley originally introduced have been now reduced to twenty-four for further trial. Particular attention is being paid to feed barleys, and fifty-nine varieties of six-rowed barley are at present under trial. Some smooth-awned varieties show great promise as green feed, coming away more quickly than Black Skinless and recovering after grazing better than Cape. Grain quality and yield appear promising.

Field Peas.—The export trade in field peas, which at present amounts to some £150,000 and £200,000 annually, could be expanded if it were possible to produce economically in New Zealand superior quality white peas for splitting and blue peas for boiling. A fairly extensive programme of breeding designed to improve the yield and quality of field peas is now in its sixth year, and trials so far indicate considerable improvement in both yield and quality. This has been attained in some cases by crossing field with garden peas, an avenue which does not seem to have been explored by other workers. Except in the case of the Partridge pea, new introductions have shown no superiority over standard varieties. One variety of the Partridge type is, however, promising.

Garden Peas.—The export trade in garden-seed peas is remunerative and worth fostering. Merchants who grow on contract have great difficulty, however, in maintaining the high standard of purity demanded by overseas buyers, and this Division has for a number of years produced nucleus stocks which have been welcomed by merchants to replace their own stocks which have, for one reason or another, become impure. Breeding in garden peas has been limited to a study of segregates resulting from crosses between Greenfeast and Yorkshire Hero, which in some cases have been again crossed with William Massey.

Forage Crops.

Lucerne.—Two main lines of approach have been developed in the improvement of this crop. The first by the combination of parent plants selected on the behaviour of their inbred progenies. There has resulted a marked improvement in quality, and under single-plant trials an increase in yield of 15 per cent. to 20 per cent. above Marlborough. This strain is now under trial in the field, and an acre has been planted out for seed-production. The second approach has been by the combination of inbred material. This strain is not as far advanced as the first and has yet to undergo yield trials next season. Lucerne is admittedly a difficult crop in which to effect improvement in yield combined with improved quality, and advancement is necessarily slow.

Rape.—Marked success has attended the selection work carried out over a period of years in producing an improved rape. Several hundred acres of these new strains are now being grown for seed-production under certification in co-operation with the Department of Agriculture, and New Zealand certified seed is rapidly replacing imported seed. A new strain of rape resulting from a cross between Giant and Broad Leaf Essex back-crossed to Broad Leaf Essex is likely to be distributed commercially in the near future. An attempt to improve on existing types by inter-specific hybridization has resulted in some interesting material. The crosses (Swede × Rape) × Rape and Rape Kale × Rape are perhaps the most promising late-rape types and have outyielded Giant Rape.

Marrow-stem Kale.—Work is progressing in the study of marrow-stem kale with a view to selecting types most suitable for New Zealand requirements. One area has already been sown out for the production of mother seed in anticipation of commercial seed-production under certification.

Lupins.—The blue lupin is becoming increasingly important in Canterbury as a soil renovator. and, despite its obvious defects of low palatability owing to high alkaloid content, is used extensively for feeding. In Russia and Germany new strains of sweet lupins have been produced containing a very low alkaloid content. Only one variety has so far been introduced—namely, the Yellow Sweet Lupin, The yield of the yellow is not as great as that of the blue, but is characterized by a high degree of palatability, and this, in some other variety of sweet lupin, is likely to prove of great economic importance to New Zealand.

Root Crops.

Turnips and Swedes.—These crops are of outstanding importance in New Zealand farming, but are gradually becoming less popular owing to the serious losses occasioned by dry-rot and club-root. The work being undertaken is largely an effort to produce varieties less susceptible and at the same time maintain yield and quality. Some varieties are relatively resistant to club-root, and a recent introduction by this Division is a soft turnip, " Immuna," which has proved exceptional in this respect. Crosses have been effected between resistant and high-yielding non-resistant varieties, but progress is slow owing to many difficulties arising, such as those of overwintering roots and a satisfactory technique in the determination of resistance. Better facilities are, however, likely to be available in the near future, and greater progress may be possible.

Potatoes.—Attention is being devoted to the introduction of varieties from overseas, but past experience does not offer much prospect of improvement in this direction. The main objective is therefore an attempt at improvement by hybridization between standard varieties and material collected by various expeditions to the potato-growing regions of South America. These South American species are unimproved, and many are quite useless as food. Certain of them, however, possess such characteristics as frost-resistance, disease-resistance, and a wider range in other characteristics than is to be found in the commercial potato. Therefore by hybridization it should not be impossible in the course of time to introduce into the commercial potato important characteristics which previously were entirely non-existent. Several hundred crosses are at present under trial, but more effective work will be possible when glasshouse facilities become available.

Industrial Crops.

Linen Flax.—Investigations conducted over the past three years have proved that satisfactory crops of linen flax can be grown over a wide area of the South Island and that the fibre yield and fibre quality is satisfactory. Numerous trials have been conducted in co-operation with the Fields Division of the Department of Agriculture, and the produce retted and scutched by this Division. Samples have also been forwarded overseas, and reports thereon have been satisfactory.

Great Britain and Ireland require vast quantities of fibre for the spinning and weaving industry, and linen is essential for certain purposes associated with national defence. There has, however, arisen an acute shortage of raw material, and every endeavour is being made to stimulate production within the Empire. As a result of the acute position that has arisen and the favourable prospects of development, arrangements are now being made to establish linen-flax production on a commercial basis in New Zealand.

Linseed.—The possibility of re-establishment of this industry in New Zealand is receiving consideration, especially in view of the fact that if a linen industry is established there is likely to be a surplus of seed which can be used only for oil-extraction and feed purposes. A number of varieties have recently been introduced and are undergoing preliminary trial.

Vegetable Crops.

Investigations into vegetable crops was commenced this past season. These preliminary trials were designed to study varietal differences and to gain some idea as to the general standard of varietal purity and should lead to more specialized studies in the future.

Other Investigations.

A rotation trial laid down two years ago mainly to investigate the supposed impoverishment of the land by linseed is to be continued. So far there is no evidence that linseed is any more drastic in this respect than wheat.

Some investigations are being carried out on the effect of colchicine in the induction of polyploidy and hormones in the stimulation of root growth.

Periodic sowings are being made of wheat varieties to determine the latest date that they can be sown in the spring, and of all brassicas to determine the most favourable date for sowing for seed-production. In this connection vernalization of brassica-seeds has been undertaken in co-operation with the seed-testing station. The results obtained, although in certain cases positive, are not so far of economic significance.

BOTANY DIVISION.

Director: Dr. H. H. Allan.

During the year the Headquarters of the Division were moved to more commodious premises at 58 Bowen Street.

A. Routine.

1. *Identification of Specimens and Advice thereon.*

This work has followed the usual lines and has come from the usual sources. As in previous years, the Department of Agriculture has taken full advantage of this service. It is a pleasure to record the care with which its officers have sent in their material. Other Divisions of the Department of Scientific and Industrial Research have sent in specimens freely, while numerous plants have been received from schools and private persons. The number from commercial firms has not been so large as usual. It is evident from the work of the past few years that interest in our indigenous flora is steadily increasing.

Over twelve hundred specimens have been dealt with, including several new records of alien plants. The most important of these were Greek thistle (*Chamaepeuce afra* (Amberley)), cow-parsnip (*Heracleum sphondylium*), (near Invercargill), and two species of hawkweed (*Hieracium*), (Lake Tekapo, Pembroke). With the trials of species of *Lespedeza*, wormwood (*Ambrosia artemisiifolia*), a serious hay-fever plant, has frequently put in an appearance, but as yet does not seem to have established itself. There is evidence that several species are steadily increasing their range—*e.g.*, Australian fireweed (*Erechtites atkinsoniae*) and *Eupatorium adenophorum* (*E. glandulosum*). Cases of poisoning reported include trouble from Irish yew and waoriki (*Ranunculus rivularis*).

A disqueting feature is the number of charlock (*Sinapis arvensis*) specimens received, mainly from swede crops.

2. *Herbarium.*

Considerable additions have been made by members of the staff and others interested. Large sets of mosses and lichens were received from Messrs. G. Simpson and J. Scott-Thomson, of Dunedin. Valuable material was also received from Miss L. M. Cranwell, Botanist to the Auckland Memorial Museum, Auckland. Exchanges with herbaria abroad have been continued, and our accessions include a useful set of poplars from the British Museum of Natural History and of Argentine plants from the herbarium of the Museum of La Plata.

3. *Quarters and Equipment.*

Since the housing of the Division at 58 Bowen Street work has proceeded with much greater convenience and necessary additions to the equipment secured, enabling all members of the staff to carry out their duties more comfortably and efficiently. With the completion of the glasshouse our major needs, apart from the provision of an area of land, will have been met.

4. *Visitors.*

Outside workers have continued to make use of the herbarium and library facilities, and various botanists have made brief visits. During the southern portion of his excursion in New Zealand Professor Dr. C. Skottsberg, of the University of Gothenburg, made his headquarters here, and was assisted by the staff both in the field and in his herbarium work. He wishes to be recorded his appreciation of the facilities offered and of the assistance given.

5. *Introduction of Plants.*

Numerous seed samples were received from abroad in connection with tussock-grassland improvement work, especially from the Soil Conservation Service of the United States of America. These have been, in part, forwarded to the Grasslands Division for growing on and multiplying, and in part sent direct to the Department of Agriculture for trial at their Pisa Flat Experimental Area.

Included in other seeds sent for trial were samples of Valonia Oak from Mr. R. O. Dalrymple, of Bulls, and *Ephedra* from the Royal Botanic Gardens, Kew. In addition, samples of indigenous grasses and herbs have been gathered for our own trials.

6. *Library.*

Several additions have been made to the stock of standard works on the various branches of botany with which our work is concerned. As usual, we have received numerous original papers from abroad in exchange for our own publications.

7. *Lectures and Public Services.*

Where appropriate, members of the staff have given lectures before various bodies on botanical subjects. Mr. Poole was a member of the committee set up to survey and report on the Moutoa Swamp area; and the Director delivered the Banks Lecture before the Institute of Horticulture. He also served on the committee set up to report on the preservation of the Vegetation of New Zealand, on the Loder Cup Committee, and on the Councils of the Institute of Horticulture, the Wellington Philosophical Society, and the Royal Society of New Zealand.

8. *Staff.*

During the year the staff was greatly strengthened by the addition of Misses L. B. Moore, M.Sc., and R. Mason, B.A., B.Sc., and of Mr. D. Cairns, M.Sc. Messrs. G. Briggs and J. Swindlehurst were attached to the staff as officers superintending the phormium areas at Palmerston North and Shannon. Miss Moore, in addition to her special work on weeds, has taken charge of all cryptogamic work. Miss Mason has rendered general assistance and has taken up the work on seeds and seedlings. She will also relieve Miss Travers of some of the more technical typing, thus enabling her to give full time to the increasing clerical work of the Division. Mr. D. Cairns has been temporarily stationed at Ruakura to complete the ragwort experiments in progress there.

B. Research.

The research projects in hand have been further developed and new ones added.

1. *Tussock-grassland Survey.*

Mr. Zotov has worked up and reported on the results of his preliminary survey of the South Island. Part of his report has been published, while the more technical aspects are being dealt with in separate papers. His report emphasizes the evil effects of overburning and overgrazing, and gives an account of the degradation of the vegetative cover. It is shown that the restoration of a tussock-cover, with a bottom of other grasses, is an essential part of any scheme of improvement. His investigations dealt especially with the use of native species in this connection, and with the part played by exotic species.

A survey of the Lochiel Station has just been completed and a report prepared. This provides valuable evidence as to the effect of controlled burning and grazing. Mr. Zotov paid much attention to the phenomena of soil erosion, and his findings have proved of great value to the Committee set up to deal with the problem of dealing with soil erosion. Further intensive work is planned for the coming year with trials of seed on selected areas.

2. *Ragwort.*

Mr. Poole has continued in charge of this work, assisted by Mr. Cairns. The botanical work is now almost completed, and a bulletin covering the results of the investigations is now in preparation. The series of articles dealing with various botanical aspects of control is being continued. Important information has been gained concerning such matters as regeneration from root segments after pulling, cutting, and other treatments, spread of seed by water, animals, and wind, and germination of seed under various conditions. An article explaining how far and under what conditions the pulling of plants is an effective measure of control will appear shortly. Material has been regularly supplied for the tests being carried out on the alkaloid content of the plants at various periods and at different stages of growth.

3. *Phormium.*

The botanical side of the phormium investigations has recently been entrusted to this Division, under the charge of Mr. Poole. Life-history and morphological studies have been carried out by him and Miss Moore. Investigation into fibre content and quality are proposed, and a more extended programme will be put into operation when decisions have been reached as to the scope of work that is necessary or advisable. Mr. Poole has also assisted in preparation of the report on the Moutoa Swamp and has completed a reconnaissance survey of the phormium areas of the West Coast from Greymouth to Karamea, and reported thereon (see page 80).

4. *Hard-fern.*

Mr. Poole has made some preliminary observations and Miss Moore has devoted a great part of her time to a botanical survey from the control point of view. Her laboratory work has cleared up important points on the life-history and morphology of the plant, and on spore germination at different periods and under different conditions. Her field observations and experiments at Haywards, with kind permission of Mr. Buchanan, include an ecological study of growth under the different conditions there found, and observations on the effect of different treatments, including cutting and burning. During the coming year, the work will be extended and include investigations in other areas.

5. *General Weed Studies.*

Further studies have been made on various important weeds, and a book on the naturalized plants of New Zealand has been submitted for publication. A series of more popular articles on the major weeds, on the lines of those previously published, will be continued during the coming year. A publication is in preparation on the poisonous plants of New Zealand. Miss Moore has made good progress in an investigation on tutsan, and has already cleared up certain points that were previously obscure. She will take up St. John's wort and other hypericums during the coming year. This work on hypericums is so designed as to assist the experimental feeding work proposed at the Veterinary Laboratory, Wallaceville.

6. *Vegetative Cover in Relation to Soil Types.*

Some preliminary work has been carried out and arrangements made for co-operation with the Soil Survey Division, the Whangarei areas being dealt with first.

7. *Leguminous Plants.*

A book is in preparation on the important legumes of New Zealand, somewhat on the lines of the book on grasses already published.

8. *General.*

Miss Mason has charge of the seed herbarium, and has already increased its scope and usefulness as an aid in researches on weeds and other plants.

Taxonomic and ecological studies have been made on both introduced and native species as time and opportunity have permitted, and several papers are in the press or have been submitted for publication.

Mr. Zotov's important paper, in collaboration with others on the vegetation of the Tararua Ranges, has appeared and attracted considerable attention. He has also studied the grasslands erosion problems of the Kaimanawa and adjacent ranges.

9. *Publications.*

During the year the following have been published :—

" Fruit Characters in an Artificial Coprosma Hybrid." (H. H. Allan.)
" Remarks on Hybrids between Leucogenes and Raoulia." (H. H. Allan.)
" Germination of Ragwort-seed in Water." (A. L. Poole.)
" Survey of the Tussock-grasslands of South Island." (V. D. Zotov.)
" Vegetation of the Tararua Ranges." (V. D. Zotov and Others.)
" Vegetative Propagation of Ragwort." (D. Cairns.)

Submitted for publication are :—

" The Grass Genus Puccinellia in New Zealand." (H. H. Allan and P. Jansen.)
" Notes on Floristic Botany No. 7." (H. H. Allan.)
" A Handbook of the Naturalized Plants of New Zealand." (H. H. Allan.)
" Natural Hybridism in relation to Taxonomy." (H. H. Allan, in a book to be issued in England under the title, " The New Taxonomy.")

PLANT DISEASES DIVISION.

Director: Dr. G. H. Cunningham.

Though the new laboratory and office buildings were not completed till the end of March, 1939, they were sufficiently advanced to permit of the transfer of the staff from Palmerston North in February. All the staff are now at the new headquarters at Owairaka (Mt. Albert), Auckland, with the exception of one officer, at Palmerston North and Lincoln respectively. Mr. W. D. Reid was granted leave of absence for a further period of twelve months to enable him to complete his studies at the University of Edinburgh.

I. Plant Diseases Investigations.

(*a*) *Brassica Diseases.*

(1) *Dry-rot.*—This disease of swedes and turnips, due to the fungus *Phoma lingam*, has been further studied during the year. It was isolated from seedlings of marrow-stem kale, a first record of early infection on this host. The fungus has been isolated from moist soils two months after infected plants were removed, but has not been recovered after a further period, showing that the organism does not persist in the soil for long unless associated with plant tissues. Further test of seed disinfectants were carried out to ascertain if some more effectual process than the standard hot-water treatment was available. Organic mercury and copper oxide dusts, calcium nitrate, and lime sulphur steep proved ineffectual. Plants sprayed with bordeaux mixture before being inoculated with spores of the organism remained free from disease. Bordeaux may therefore prove effectual in protecting brassicas being grown for breeding and other experimental purposes.

(2) *Club-root.*—The proprietary product " Brassisan " is being tested on both a plot and field scale for control of club-root, due to the myxomycete (*Plasmodiophora brassicae*). Preliminary trials showed that while it exercised some measure of control, a considerable number of plants became infected in the trial areas. Four strains of rape, selected for their resistance to the disease, have been seeded in small isolated plots. Approximately 1 lb. of seed has been secured from each. Also there has been harvested F_1 seed of reciprocal crosses between two strains of club-root-resistant rape. Seed from crosses of cabbage × broccoli, resistant to the disease, has also been harvested. Yield trials with resistant strains of rape and swedes have been sown at Palmerston North, Te Kuiti, Gore, and Invercargill. In some are being tested, additionally, manures which have been found by past work to reduce infection.

(3) *Diamond-back Moth.*—At Owairaka there have been carried out a series of tests with arsenates, derris, and nicotine sprays and dusts for control of this pest. Results were inconclusive owing to the small amount of infestation. A second block of late summer cabbages has been planted so that the work may be continued. As heavy infestation is present on these, further trials are being undertaken.

(b) Cereal Diseases.

(1) *Rusts.*—On behalf of the Agronomy Division 114 oat hybrids and selections and 54 introduced varieties were examined for susceptibility to the rusts *Puccinia coronata* and *P. graminis*. Similar work on wheat was undertaken for the Wheat Research Institute, 325 selections and hybrids being examined for susceptibility to *Puccinia graminis* and *P. elymi*.

(2) *Smuts.*—Mass inoculations with *Ustilago tritici* were carried out on the 325 wheat selections to ascertain for the Wheat Research Institute their susceptibility to this smut. Attempts are being made to ascertain what physiologic races of this fungus are present in New Zealand. Studies have been made of the influence of date of sowing and soil temperatures on incidence of smuts of oats, wheat, and barley on the mature crop.

(3) *Maize Beetle.*—Owing to attacks on germinating maize-seed by the beetle *Clivina rugithorax* in Hawke's Bay numerous tests of repellents are being undertaken. For the purpose were used several tars, naphthalene, paradichlorobenzene, orthodichlorobenzene, and turpentine, with some of which were incorporated lime or paris green. Studies are also being made of the effects of these products on germination of the seed, several—recommended as repellents overseas—causing considerable injury.

(c) Grass Diseases.

(1) *Blind-seed.*—Low germination of rye-grass has been found to be due to a fungus, a species of *Helotium*. Samples of seed from Sweden, Ireland, Scotland, Wales, England, and Tasmania have been found to contain similarly infected seeds, which carry the disease from season to season. Experiments are being conducted to ascertain the longevity of the fungus in infected seeds under various conditions of drying and storage, as this may be a factor in control. Over three hundred plants of various strains and hybrids of rye-grass produced by the Grasslands Division have been inoculated with the fungus in an endeavour to find a factor for resistance to the disease that may be incorporated into the best agronomic strains.

Several other related fungi have been isolated during the progress of this investigation, and are being studied with a view to ascertaining if they, too, are harmful to rye-grass. Likewise the rye-grass endophytic fungi which are present in the tissues are being studied with a view to ascertaining if they are factors in inducing nutritional disorders in stock.

(2) *Ergot.*—A simple and effectual means has been evolved for testing grass strains for relative resistance to ergot. Numerous strains of the fungus have been obtained in culture and are being used for the purpose.

(d) Potato Diseases.

Work has been commenced to ascertain the identity of the numerous virus diseases present in New Zealand. It has been found that a mild mosaic of Dakota Red may, when transferred to certain other varieties, induce severe streak.

(e) Legume Diseases.

(1) *Bacterial-wilt of Bean.*—Trials have been continued for resistance to this disease. Selected varieties which showed promise last year have been sown at Owairaka, and are being considered not only for resistance to this disease but also for yield and type.

(2) *Bean-mosaic.*—Tests of the effects of this disease on yield have shown that early season infection caused a reduction of 66 per cent., 72 per cent., and 78 per cent. respectively in three varieties tested.

(3) *Pea-mosaic.*—Eleven newly introduced varieties of field peas were tested for immunity to this disease, one being immune. Numerous crosses were tested for the Agronomy Division.

(4) *Pea Leaf-spot.*—This recently introduced disease has proved to be of bacterial origin. Identification, means of dissemination, and control measures are being studied.

(5) *Pea-streak.*—It has been ascertained by numerous host-range studies that, in addition to numerous members of the Leguminosæ, this disease also attacks several species of the Cucurbitaceæ, or marrow family.

(6) *Lucerne Nodule Organism.*—Cultures of the lucerne nodule organism, sufficient to inoculate 107,640 lb. of lucerne-seed, have been distributed to farmers scattered throughout the Dominion.

(f) Vegetable Diseases.

(1) *Carrot Soft-rot.*—A disease of carrots, producing fœtid decay of the roots, has been found to be of bacterial origin. The organism has not yet been identified.

(2) *Onion-smut.*—A survey of the onion-growing areas has shown that the fungus *Urocystis cepulae* is present only in the Marshland (Canterbury) area, and there limited to about 100 acres. Experiments were conducted on the infected areas to work out an effectual control and ascertain the longevity of the organism in the soil. The formalin-drip process gave adequate, but not complete, control, and will become current practice next season.

(3) *Yellow-dwarf.*—This serious disease was recently discovered in the Marshland area, and its virus origin proved experimentally. Examinations have been made of all onion-growing areas, but the disease has been found only in one area outside Marshland, in seed onions grown from Marshland-raised plants. Attempts are being made to eradicate the disease from the onion crops of New Zealand.

(g) Timber-preservation Investigations.

From numerous specimens forwarded by the State Advances Corporation have been isolated the common wood-rooting fungi causing decay of dwellings. The most common cause of decay is the fungus *Poria ferruginosa* (see page 82).

(*h*) *Fruit-tree Diseases.*

Work undertaken during the year is covered under a separate report. (See Fruit Research report, page 68.)

(*i*) *Small-fruit Diseases.*

(1) *Tomato Diseases.*—A new wilt, caused by *Phytophthora cryptogea*, has been isolated from seedling plants procured from a Timaru glasshouse. Plants wilt and collapse near ground level four days after inoculation.

Bacterial wilt, due to the organism *Aplanobacter michiganense* has been recently discovered in the Dominion, and studies are being made of methods of control.

A widespread disease of unknown cause, called "cloudy-fruit," is being studied at the area. Earlier work has shown it is not due to a pathogen or virus.

Tomato-mite, which made its appearance two years ago and proved a serious problem to tomato-growers, has now been practically eradicated.

(2) *Gooseberry Diseases.*—A stem-wilt of gooseberry from Greytown has been found to be due to the fungus *Verticillium dahliae*, hitherto recorded in New Zealand only on tomatoes.

(3) *Passion-fruit Diseases.*—A common disease, prevalent throughout the commercial areas, and known as "woodiness," has been shown to be of virus origin. It has been transferred by artificial inoculation from diseased to healthy plants.

(4) *Grape Diseases.*—Mealy bug has been controlled by live-steam treatment, steam being generated by a small boiler under slight pressure. Complete kill of the pest without injury to the vine may be secured.

(*j*) *Plant-protection.*

(1) *Therapeutant Testing.*—During the year work has been directed chiefly towards developing a suitable testing technique and standardizing same. An apparatus has been designed and built for securing standard spray coverage. By its aid known and constant amounts of spray are applied to test plants.

Various pathogens and insect pests have been studied with the object of finding those which may be used as suitable indicators of the therapeutant values of materials under test. Choice of suitable fungi has been influenced by such factors as ease of culture and of measuring infection, relative prevalence, &c., of insects by ease of handling, rapidity of breeding, suitable food plants, and the like. It has been found necessary, too, to select host-plants which may be grown readily in large numbers, are susceptible to certain diseases, and not unduly intolerant of the various sprays or dusts used. Climatic conditions, likewise, have had to be standardized in as far as is possible with present equipment. For testing of seed disinfectants standard dosages have been relatively easy to obtain, the major problem being to develop a technique whereby a constant high degree of infection is secured. Apparatus has been constructed to facilitate this, since with it the factors of soil temperature and moisture content may be controlled during susceptible germination periods. The equipment will not be in working-order, however, until the air-conditioning plant has been installed. In testing dusts for field crops the main problem has proved to be the standardization of dosage. An apparatus is at present being tested with this object in view.

Parallel with these controlled glasshouse tests are being run trials under field conditions. The effects of rainfall and wind on therapeutant performance is being measured by means of an artificial weathering apparatus.

(2) *Improvements in Spray Programmes.*—Advanced programmes, based on detailed experimental work of previous seasons, have been tested at the experimental orchards in Hawke's Bay, Nelson, and Auckland. Their objects are to (i) provide orchardists with demonstration areas, (ii) correlate treatments for different varieties, which vary in susceptibility to spray damage and disease, and (iii) correlate influence of weather conditions in different localities. Records for the year's work have not been completed.

(3) *Spray Coverage.*—At Havelock North orchard it has been ascertained that increase in volume delivery by increasing spray coverage may induce a greater degree of foliage injury or fruit russet. This indicates that dilutions of sprays should be based on maximum coverage at a point where tree damage is avoided.

Lectures on spray coverage were given in the main orchard centres, and accompanied by demonstration.

(4) *Certification of Therapeutants.*—The fourth list of certified sprays was issued in January. It contained thirty-one products, an increase of two over the previous list. Numerous requests have been received for certification of other products, notably derris and pyrethrum dusts and sprays. Work on these has been held up pending the development of standard biological means of testing them. Check analyses, from samples taken from the field, have been made of many of the certified products. It is pleasing to add that all have been found to agree with the original samples upon which the products were certified.

(*k*) *Pomology Investigations.*

(See Fruit Research report, page 66.)

(l) Miscellaneous.

(1) *Iris Mosaic.*—This disease, of virus origin, has been identified as causing serious losses in bulbous iris.

(2) *Pyrethrum production.*—Flowers with high pyrethrin content can be secured by growing selected clonal lines, as has been shown by further analyses. Work is being undertaken to ascertain the effects of locality on the pyrethrin content. Flowers have been harvested from ten selected pure clonal lines growing at Auckland, Ruakura, and Palmerston North, and samples forwarded to the Dominion Laboratory for analysis. Plots containing three strains of pyrethrum have been established at nine localities in the North and South Islands to test further the effect of locality on pyrethrin content.

(3) *Kumara Varieties.*—For the purposes of ascertaining the best varieties for cropping, culinary purposes, and disease resistance all available lines have been imported from Australia, Pacific Islands, and the United States of America and grown at Owairaka. Those grown differ markedly in leaf character and growth habit, and when harvested will doubtless display wide differences in type of tuber. The two varieties grown in New Zealand—Tauranga Red and Blackberry—were at first more vigorous in growth than any of the imported ones; but with the advent of warmer weather some of the latter are now equally vigorous.

ENTOMOLOGY DIVISION.

Director: D. Miller.

Diamond-back Moth and White Butterfly in New Zealand.

The researches upon these two insects have been concerned with their ecology and parasitic control. In regard to the ecological aspect, the principal avenues of investigation are:—

(1) The recording of the variation in population density of the insects in the field throughout the year in relation to associated climatic factors.

(2) Laboratory studies under controlled conditions of the climatic factors promoting or preventing epidemics of the insects.

The 1938–39 season has been remarkable for the low level of population of the insects in field crops, and many of the crops are in poor condition due to lack of rainfall. The work so far has been principally directed towards determining their distribution within the crop so as to enable the development of an accurate sampling technique which can later be used for periodic estimates of population density on one crop throughout the season. Attention has also been given to the methods of recording climatic factors in the area under observation.

Some preliminary experiments have been made with the object of determining the relative weights of food consumed by the diamond-back moth and the white butterfly. The white-butterfly larva, being much larger than that of the diamond-back moth, consumes more food and does more damage. In comparing the relative importance of the two insects it will thus be necessary to apply a food-weight factor to the population densities.

Diamond-back Moth.

A point which emerges from the investigation is that in the early stages of infestation by diamond-back moth the population appears to be significantly larger on the margin of the crop than in the centre, and this complicates the taking of an accurate sample. In the later stages of an infestation, when the population density is higher, it appears that the population density is fairly even over the whole of the field.

In the crops which were surveyed in the Wairarapa the population density of both diamond-back moth and white butterfly has been low this season and little damage has been done. The same position is reported to occur in Canterbury. In Hawke's Bay on some crops the diamond-back moth population was higher than any seen in the Wairarapa, but even so little damage was done. In Hawke's Bay in February many of the crops were severly damaged by the cabbage aphis, and this later appeared in the Wairarapa to a lesser extent.

The behaviour of adult diamond-back moths under the influence of various feeding solutions has been the basis of a series of experiments carried out during the winter months. It has been found that moths fed on suitable solutions can live for over a hundred days. Throughout this period eggs were laid whenever the atmospheric temperature was moderately high, and moths mated freely during the first few weeks of confinement in the experimental tubes.

These results show that the moth is able, under certain conditions of climate and nutrition, to survive the colder months of the year in the adult state. Whether or not these conditions can be expected in the field has not been determined, and the prospect of survival of any eggs or larvæ hatching from them must form a basis for further experimental work. These points lead to a determination of the means by which the parasites, which are primarily dependent for their existence on the moth in its various stages, are able to overwinter.

With reference to the researches into parasitic control, against the diamond-back moth two parasites are being utilized at present—the pupal parasite (*Diadromus collaris*) and the larval parasite (*Angitia cerophaga*). Another larval parasite (*Apanteles plutellae*) was imported, but failed to develop.

In the case of *Diadromus collaris* sufficient supplies for study were first reared in the laboratory from the small amount of material that survived the journey from England, with the result that approximately 50,000 adults have been bred during the period under review; of this number some 24,000 have been liberated in various localities and the remainder held for laboratory studies.

Field collections have been made to determine the approximate percentage of parasitism and rate of spread. The maximum percentage of parasitism was found to be high, which, however, was not representative, as other results in the same locality were insignificant. The point of interest is that progress at this early stage has been made in that the parasites have been recovered in the field wherever the insect was liberated. The field-work has been carried out most extensively in Hawke's Bay, where the percentage of paratism has shown a steady increase throughout the latter half of the season. The greatest distance from a centre of liberation that *Diadromus* has yet been recovered is approximately six miles.

Studies of *Diadromus* under various conditions reveal that the period of development of the parasite within the host pupa from egg to adult varies from fourteen to twenty-five days under summer conditions; indeed, the insect will continue to breed under fairly low temperatures, and it would seem that its activity against the moth will be possible throughout the season. Its reactions under winter field conditions have yet to be determined however.

In regard to *Angitia cerophaga*, this parasite was reared in large numbers during the 1937–38 season and extensively liberated in the Blenheim and Nelson districts and in Canterbury, while further liberations were made in Canterbury during the present period and several thousands sent to Canberra for establishment in the Commonwealth. Field collections and studies made during the period under review revealed that *Angitia* has established in both Blenheim and Nelson districts. In the Nelson district, where the position was carefully studied by weekly observations at several foci throughout the season, parasitism reached a maximum during January, followed by a steady decrease. Though the maximum reached in some of the observations was very high, these figures can only be accepted as an indication of the parasite's possibilities, and are not yet a true indication of the final influence the parasite will have in controlling the moth, since much more intensive study is required. The fundamental factors causing the decrease of parasitism after January have not yet been fully elucidated. In regard to the range of spread so far studied *Angitia* has been recovered about twenty miles from the centres of liberation.

White Butterfly.

In 1937–38 the first epidemic of the butterfly occurred since its suppression by the parasite *Pteromalus puparum*, but toward the end of the season the percentage of parasitism rose to a high point, During the present season the butterfly has been, on the whole, again suppressed, and it has been difficult to secure sufficient pupæ from crops in the survey for estimating the percentage of parasitism. What material was secured, however, reveals the parasitism to be still high, and since the latter part of the summer has been apparently favourable for increase of the butterfly it would seem that its scarcity is largely due to the parasite.

During the year a consignment of the cocoons of the larval white-butterfly parasite (*Apanteles glomeratus*) was received by courtesy of the United States Bureau of Entomology. This parasite has been imported from England a few years ago and failed to establish, but it was thought, since the United States material was secured from our species of butterfly (*Pieris rapae*) and not *Pieris brassicae*, as was the case with English supplies, that more success might be expected. During the rearing of this *Apanteles* a severe outbreak of polyhedral disease amongst the parasitized butterfly caterpillars in the laboratory compelled the field liberation of large numbers of adult parasites. Field recoveries have been made, one instance being a mile and a half from the point of original liberation, though no recoveries have been secured during the last months of the season.

Diamond-back Moth and White Butterfly in Europe.

During his visit to Europe in 1938 Mr. J. Muggeridge secured data of incalculable value to the researches into the control of the moth and butterfly. Information secured from entomologists and crop specialists showed that the diamond-back moth was not considered a pest in Europe, and this was borne out by Mr. Muggeridge's observations at widely separated localities. The fact that no insecticides are necessary to control the moth and of the variety of climates under which it does not occur as a pest points to its subjection by parasites. Of the latter a number occur, concerning which records were secured together with field collections, the latter being sent to Farnham Royal for identification and study. In this parasite complex are *Angitia cerophaga* and *Diadromus collaris*, the two species already imported to and being studied in New Zealand.

Equally important data regarding the parasites of the white butterfly (*Pieris rapae*) were secured. As mentioned above, an attempt is being made to establish in the Dominion the larval parasite, *Apanteles glomeratus*, secured from the United States, but Mr. Muggeridge formed the opinion that another species, *Apanteles rubecula* and not *A. glomeratus*, was probably of major importance in the control of *Pieris Rapae*, this matter having been overlooked in the past. It would seem that *A. glomeratus* is primarily dependent upon the other white butterfly (*Pieris brassicae*), and that it is the overflow from this host that attacks *P. rapae*; on the other hand, *A. rubecula* is apparently not dependent upon any other host than *P. rapae*. This matter is being studied in England.

Farnham House Laboratory.

The assistance of this institution is, and has been, essential to the maintenance of our work in New Zealand. Work of direct bearing on the problems of the Division is concerned with a study of the position regarding *Apanteles glomeratus* and *Apanteles rubecula* in relation to white-butterfly control. Also, detailed ecological studies of the diamond-back moth and its parasite complex are necessary for the success of the work in New Zealand, as it is upon this that the selection for importation of the most suitable parasites is based.

Lucerne-flea.

In the North Island the main area where this insect occurs is an eastern region south of Dannevirke to Pirinoa in lower Wairarapa, and a western region from Palmerston North to Bulls, with two isolated areas—one at Maraekakaho in Hawke's Bay and the other at Pokeno, just south of Auckland. In the South Island the insect has not been found outside the region south of the Rangitata River from Temuka to Gore.

Periodic inspections have been made of the infestation on subterranean clover at Maraekakaho and during the autumn, winter, and spring of 1938 a heavy infestation, which at its peak numbered 1,300 fleas per square foot, developed on this area. The loss of leaf-weight attributable to the flea was 38 per cent., and there was evidence that both cattle and sheep tended to discrimination against the affected pasture. The heavy infestation which developed here was undoubtedly due to the unusual climatic conditions prevailing during the summer of 1937–38 in that the normal period of summer dryness was much shortened and temperatures in summer and autumn were much above the average. The result was that adequate soil moisture and favourable temperatures extended over a longer period than usual. Owing to the extended period of drought during the past summer 1938–39, conditions have not been conducive to a heavy infestation, and it is thus anticipated that the population level on this area during the coming winter and spring will be much lower than last year.

The lucerne-flea, though it is widely distributed and has apparently been present for some years on areas of mixed pastures in the North Island, has given no evidence of its being a serious pest on this type of pasture under normal conditions with regard to grazing. Similarly, there is no evidence of a serious threat to the lucerne. The potential seriousness of the pest lies in its relation to subterranean clover in the low rainfall areas, particularly in Hawke's Bay, in which this plant finds its greatest use. The evidence so far accumulated points to the insect being a serious pest on subterranean clover in this area in years of exceptional climatic conditions. In normal years it seems likely that the depredations of the pest will not be sufficiently great to warrant chemical control measures.

Apart from chemical control by the use of lime-sulphur sprays, the bdellid mite (*Biscirus lapidarius*) is considered in Australia to be a valuable agent in the control of the flea. This mite has been found to be naturally distributed in several widely separated localities in the North Island.

Consideration was given by the Department of Agriculture and the Entomology Division to the practicability of eradication of the flea on the isolated area at Maraekakaho, but no action was taken. A detailed report on the insect was published in the *Journal of Science and Technology*.

Insect Pests of Wheat.

With the object of determining whether there was any marked difference in varietal resistance, a series of wheat-variety trials was carried out in regard to the incidence of Hessian fly (*Mayetiola destructor*) and the Argentine stem-weevil (*Hpyerodes griseus*), Hunters 1, Cross 7, Dreadnought, Bencubbin, Variety 31·05, and Solid-straw Tuscan being the wheat varieties used. The results reveal that Solid-straw Tuscan, Variety 31·05, and Bencubbin, this year show a degree of low Hessian-fly infestation (3·8 per cent., 3·9 per cent., and 7·4 per cent.) in marked contrast with the other varieties (28·9 per cent. to 60·7 per cent), while in the case of the stem-weevil the infestation shows no such marked contrasts. Further, the data based on damage due to stems broken down by the weevil larvæ shows no great extremes, but the study is being extended this coming season.

Cocksfoot-seed Midge.

A study of the life-history of this midge (*Stenodiplosis* sp.) reveals that hibernation occurs as full-grown larvæ in seed-heads; these larvæ pupate in October, and the first generation of midges emerges from about the end of October to mid-November, at which period eggs and young larvæ occur. This generation of larvæ pupates in December and gives rise to midges during the same month. Several generations follow and overlap so much that they cannot be distinguished under field conditions, though there is a peak emergence of midges in January; the midges are to be found to the end of March.

Experiments to ascertain whether meadow-foxtail midge would infest cocksfoot and the cocksfoot-midge-meadow foxtail proved inconclusive. In an attempt to delay flowering as a means of control it was found that after cutting the crop at different periods flowering occurred at the normal time and the flowering was reduced; in the latest cutting which was done during November, however, the grass failed to head normally. Some spraying experiments were carried out on a small scale, but with negative results. It will be necessary to extend this research.

Sheep-dipping Trials.

This recently inaugurated research is an activity of the Canterbury Agricultural College, where a member of the Division of Entomology is co-operating in regard to the biology of the insect parasites and influence upon them of the various fluids experimented with.

Insect Life of Tussock Grasslands.

In relation to the deterioration of tussock grasslands, an ecological study of the insect factor was commenced in February. Certain species of moth larvæ and a species of beetle larva have been found attacking the foliage and roots respectively. The species of moths, at least, are widely distributed. However, no conclusions can be reached at this early stage of the investigation, though there are indications that insects are not a primary factor in deterioration.

Subterranean-grass Caterpillars.

This problem, which concerns the depredations of certain species of *Porina* upon pastures, is one of major agricultural importance, and a special study of the problem has been inaugurated. This activity embraces a survey of the extent of infestation and of the species concerned, together with a detailed study of the insects and their environment, with a view to formulating some practical means of control.

Sheep Maggot-fly Problem.

This activity embraces (1) a taxonomic study of the blow-flies in New Zealand, (2) a survey of the flies responsible for strike throughout the country, and (3) a study of the seasonal sequence of blow-flies. The taxonomic aspect has been completed and the results issued as a monograph by the Cawthron Institute; this publication deals with the taxonomy of both the adult flies and their larvæ. The survey of "strike" shows that *Calliphora laemica* and *Lucilla sericata* are the dominant and primary maggot-flies, and that under New Zealand conditions by far the most outstanding cause of "strike" is dirty wool, pointing to management as being the main factor in control as regards sheep. There are definite indications that the incidence of *C. laemica* and *L. sericata* is correlated with climatic zones, since as one proceeds from the Auckland Province in the North to Otago in the South *C. laemica*, as the dominant species, gives place to *L. sericata*. The seasonal sequence study has been based on trapping the flies over a period of twelve months. For this purpose thirty West Australian traps were used on an area of 300 acres of sheep country, the flies from each trap being collected at fortnightly intervals. The examination of this trapped material has yet to be made.

Timber-borers.

In collaboration with the other activities of the Timber Protection Research Committee established during the year, this Division has undertaken the biological study of the major species of boring insects that infest constructional timbers. These insects are the common house borer (*Anobium domesticum*) and the native two-toothed longhorn beetle (*Ambeodontus tristis*). Of these, special attention is to be given to the latter owing to the fact that insufficient data are available concerning it.

Since this project was commenced a very outstanding timber problem has been discovered in the presence of certain species of earth-dwelling Australian white-ants or termites in New Zealand. There are probably more than one of these species present in the country, but it is definitely known that *Coptotermes lacteus* and possibly *C. acinaciformis* are established. During last summer a survey was made in the north, and these termites were found to be established in Auckland and New Plymouth, where they were seriously damaging wooden buildings, fences, and power-poles.

The survey also revealed that the native termites (*Stolotermes ruficeps* and *Calotermes brouni*), which are not earth-dwelling forms, are fairly wide-spread in houses, &c., in the Auckland Province, especially where puriri (*Vitex lucens*) has been used for foundations.

GRASSLANDS DIVISION.

Director: Mr. E. Bruce Levy.

The activities of the Grasslands Division have multiplied and increased during the year under review and, while there has been an increase in personnel the Division is much understaffed to carry out essential research work. On the one hand we are faced with land-deterioration problems where certain hill country, particularly, is going out of production, and, on the other hand, problems related to animal thrift on the sown and improved pastures are looming largely to the fore. In the former, loss of virgin-soil fertility, increase of erosion, and spread of secondary growths are among the more important aspects of deterioration, and associated with these are economic considerations based largely on the maintenance-costs for the efficient farming of that country. In connection with the sown and improved pastures the dietetic balance, or imbalance, associated with growth condition changes from wilted to lush, rapidly-growing pastures, calls for serious consideration. Between the lush pasture and the deteriorated pasture are hosts of problems bearing on pasture improvement, pasture management, and pasture supplementation—better strains of seed, more efficient seed-mixtures, mineral balance in fertilizers, more efficient management, grazing utilization, or conservation. Weeds that reduce production in grassland should have more detailed ecological study, and in regard to pasture species themselves their inter-relation with soil, climate, and their reaction to the grazing animal calls for particular study, and in this connection work on the tussock grasslands is long overdue. Herbage-seed production and problems related to seed storage need closer examination. Collaborative work on the entomological and mycological aspects of grasslands is important, especially so in regard to some reduction or alleviation of the menace of grass-grub and subterranean-grass caterpillar.

The Division throughout the year has endeavoured to work collaboratively with other Departments and organizations whose functions also connect up with grasslands, and in this regard has done all in its power to assist those organizations on the more technical aspects of the grasslands themselves.

Strain Ecology.

It is becoming more and more apparent that strain and the concept of strain adaption to various ecological conditions ranks equally important with the species themselves; in fact, it would appear as though there is more likelihood of securing plants of special agronomic value working with the strains of the standard grassland species than in searching for new species that might fill, or contribute towards, a specific role in a grassland structure or a grassland use. Actually agriculture itself, by instituting a specific ecological condition over a period of time, has done much to segregate strains peculiarly suited for the style of agriculture employed. What has been lacking, however, in the past has been scientific

guidance to that evolution and a realization of the fact that the strains, once segregation has taken place, have a limited value outside the ecological conditions under which they have been evolved. Strain ecology is that study of grasslands that aims to classify strains and to designate those strains for a specific role in agriculture. Certification is a tool of strain ecology and provides the machinery necessary for the carrying on of its function. Seed-certification is a function of the Department of Agriculture. The strain-testing work of the Grasslands Division is designed to set standards for certifications and to check up on lines submitted to see that such standard is maintained. During the year the following plot trials have been conducted :—

Perennial rye-grass	585	White clover	816
Italian rye-grass	172	Subterranean clover	33
Cocksfoot	394	Other species	95
Browntop	119		
Red clover	273		2,487

Pedigree Strains and Pedigree-seed Production.

The building-up of improved pedigree strains and the multiplication of nucleus stocks of seeds has continued to be an important part of the Division's activities, and as further species and strains are bred this work will increase. It is confidently expected that the production of nucleus pedigree-stock seed must, quite rapidly, become a lever, as it were, in raising the general quality of all New Zealand certified seeds, and the constant flow into production, for increase purposes, of nucelus pedigree stock seed will ensure a continuity of a high standard of quality for all time. Since the introduction of pedigree seed the seasons as a whole have not been favourable for seed-production in the main seed-producing districts, and the season just past proved no exception in this regard. The following quantities of pedigree seeds were produced under certification : 5,300 bushels perennial rye-grass ; 1,056 lb. of pedigree white clover ; 360 lb. of pedigree Montgomery red clover. An area of pedigree Italian rye-grass harvested under adverse weather conditions was spoiled by rain.

At the Station itself, despite the unfavourable season, the following nucleus stock seeds were harvested and distributed : 18 bushels perennial rye-grass ; 10 bushels Italian rye-grass ; 105 lb. white clover ; 80 lb. Montgomery red clover ; 100 lb. *Lotus major*. For the most part these stocks are insufficient to meet the demand, and an increase area of most will have to be envisaged in the near future.

Strain Trials.

Field-strain trials are carried out in collaboration with the Department of Agriculture and these serve two very useful purposes :—

(1) To provide information on the behaviour of species and strains, including pedigree strains, on varying soil and climatic types and under normal grazing conditions.
(2) They serve as demonstration plots for agricultural instruction in the districts where they are sown.

Up to last year some 200 strain trials had been laid down, and during the past year an additional 134 trials have been sown out. These include 101 subterranean clover strain trials. Two extensive strain trials have been laid down in high altitude country, one in the Central Plateau of the North Island at Tangawai at an elevation of 2,295 ft. above sea-level. The second is sown out in the McKenzie Country of the South Island at the Grampians Station, 1,700 ft. above sea-level. The seed for these latter strains was specially selected from the colder European countries by the Director during his trip abroad.

Plant Introduction and Plant Exchange.

The possibility that there exist, somewhere in the world, herbage plants that could profitably be sown out in New Zealand is being fully explored. One hundred and thirty-two lots were sown out and later planted, and from the more promising of these sufficient seed has been harvested to make further broadcast trials on the Station area prior to wider trials in the field. An additional 118 lots have been received during the year, and these are now sown out. It is too early yet to state whether any new introductions will be of agronomic value, but certain *Bromus* and *Agropyron* species among the grasses and a *Lotus* species among the clovers show some promise. A register is being kept of all introductions, and wherever it is decided to discard a species the reason for such action will be noted.

There have been frequent exchanges with other countries of New Zealand certified seeds, and such exchanges are later followed up to learn how the New Zealand material is behaving.

Low Germination of Perennial Rye-grass.

In regard to the control of blind-seed disease, which, during this season, has seriously affected the seed-production of perennial rye-grass, the Division is working co-operatively with the Plant Diseases Division and the Department of Agriculture. It appears that the most hopeful means of control is the production of a strain resistant to the disease. Unfortunately, the best agronomic types of perennial rye-grass are, on the whole, more susceptible to the disease than the poorer agronomic types. There is some evidence that Italian rye-grass is less seriously affected than perennial rye-grass. Search is at present being made for plants that show resistance to the disease to serve as the basis for the production of a resistant line. This season some five hundred plants were inoculated with cultures of the disease supplied by the Plant Diseases Division, and the seed harvested will be examined microscopically for degree of infection. These inoculations include various types of perennial rye-grass, and hybrids from crosses between perennial and Italian rye-grass. Field trials of a large number of rye-grass lines have been made at Palmerston North and at Winton in Southland. Seed from each line has been harvested and submitted to the Seed-testing Station for germination tests. A report on these trials has been prepared for publication.

Plant Breeding.

(1) *Perennial Rye-grass.*

Work is being continued with perennial rye-grass to obtain further improvement in the pedigree class, more particularly in regard to extension of the growth period, palatability, and in the direction of disease resistance. A further 120 single plants have been selected from New Zealand and overseas lines, and these have been planted out as tiller rows for further study. From the material at present under study a further selection has been made and a seed crop produced under glasshouse isolation. From this seed a fresh nucleus increase area will be established during the coming autumn.

Trials will also be made from a mass selection of a specific perennial rye-grass type that has been segregated as a type distinct from that in the make-up of the pedigree line.

The controlled pollinations this year have yielded twelve thousand single plants that are now ready to be planted out for progeny study.

(2) *Short Rotation Rye-grass.*

The attempt in this project is to evolve a rye-grass type intermediate in growth form and persistency point of view between perennial rye-grass and Italian rye-grass. Agronomically a true-breeding rye-grass of this type would have a very high value wherever rotational farming is practised. Overseas one cannot help being struck with the significance of rotational farming where land is left in pasture for three to four years at the most. In the South Island of New Zealand, also, this type of farming is extremely common, and it has been felt for some time that the true perennial type of rye-grass is not ideal for the purpose, and Italian rye-grass and the false perennial rye-grasses of the South are both too short-lived. A rye-grass that will establish rapidly, will give a high yield of palatable herbage, and will persist well into the third and fourth year is the objective to be secured in the short rotational rye-grass type. Some five thousand single plants from a natural Italian-perennial cross ecotype are at present under critical study, and some very promising material is being isolated. Artificial Italian-perennial rye-grass crosses of selected plants of pedigree origin have also been made, and some of the hybrid plants have been back-crossed to perennial rye-grass. The results to date would indicate good potentialities in hybridization where such hybridization is controlled and scientifically guided.

(3) *Italian Rye-grass.*

During the year sixteen thousand single plants have been critically studied, and from these a number of unrelated inbred progenies have been isolated together in the glasshouse to provide seed for a nucleus pedigree area of Italian rye-grass. This crop has now been harvested and sown in a nursery prior to planting out at a later date. Further crosses have been made with plants selected from commercial lines and from F_1 and inbred families. Approximately thirteen thousand plants from these crosses are being planted out. Some two thousand plants from controlled pollinations will also be planted, for comparative purposes, at Lincoln.

(4) *White Clover - No. 1 Type.*

It is considered that the pedigree line of white clover at present being increased for seed-supply is of sufficiently high standard that further work on this type need not at present be continued. The present pedigree area was harvested for seed and yielded comparatively well in view of the unfavourable season.

(5) *White Clover - No. 2 Type.*

The No. 1 type of white clover is essentially a high producer, and therefore must have available for its maximum development highly fertile conditions. Such conditions do not universally obtain. It has been felt, therefore, that there is room agronomically for a somewhat lower-producing but persistent type that would be more agronomically suited for sheep grazing under a somewhat lower plane of soil fertility. For the purpose of the ultimate production of this type some nine thousand plants from crosses of selected plants conforming to the Type No. 2, and crosses between Type No. 1 and Kentish Wild White were planted out in the spring of 1938. Observations on these plants have been continued, and the best plants will form the basis of a pedigree Type 2 selection. A small area of typical Type No. 2 plants was isolated and a crop of seed harvested. A yield of 50 lb. of seed was secured, and this seed will be used for field trials under varying soil conditions in comparison with the present Type No. 1 pedigree selection.

(6) *Montgomery Red Clover.*

The field experience with this strain of red clover is clearly indicating the agronomic value of this comparatively new introduction, particularly so in the South Island. It is confidently expected that after a sojourn of some years in New Zealand, and particularly under selection and breeding, a higher production and a longer seasonal growth-spread of production will be secured. The breeding-work at present in hand has these objectives in mind. Various experimental crosses with a range of plant types have been made and used for plot tests to determine the behaviour of each type under sward conditions. Observations on these plots, which exhibit wide differences, have facilitated the selection of single plants for further study. Further intra-family crosses and crosses between unrelated selected plants have been made.

A seed crop was harvested from the nucleus pedigree area and some 80 lb. of seed is available for the production of Government stock seed.

(7) *Early Flowering or Broad Red Clover.*

An intensive study has been made of strains from a world-wide collection of Broad Red Clover. In these trials New-Zealand-grown samples have proved to be the most suitable, but some promising material has been received from Great Britain, particularly in the Cotswold and Essex strains.

Single-plant study has revealed wide variation in plant type within commercial lines of Broad Red clover. Approximately four thousand plants have been studied and eighty-seven of these have been selected for further breeding-work. The plantings are being extended this coming autumn and a further four thousand plants from the best available lines are being set out for selection purposes. For some years a study has been made of New Zealand material from the point of view of type uniformity, and a commencement has now been made with the certification of New Zealand Broad Red clover.

(8) *Other Species.*

The following species, other than the major ones referred to, are under observation and trial from a strain point of view: Cocksfoot, timothy, meadow fescue, crested dogstail, fine-leaved fescues, prairie-grass, *Phalaris tuberosa*, subterranean clover, alsike, *Lotus major*, *Lotus corniculatus*, and strawberry clover.

ESTABLISHMENT AT LINCOLN.

An important development has been the transfer of an officer of this Division to establish a substation at Lincoln for the testing and demonstration, under South Island conditions, of plant materials concerned in the building of pedigree lines. The question of plant types for South Island conditions will also be studied at Lincoln and, as a result of this work, specials strains, or modifications in the present-type materials, may be advisable. The land and facilities for this extension work at Lincoln have been granted by the Agronomy Division, and this assistance and collaboration is greatly appreciated.

PASTURE SURVEY.

(1) *General Pasture Map of the North Island.*

The field survey for the compilation of a map depicting the major grassland and scrub associations of the North Island has now been completed. The actual conversion of the data to map form has been no mean task, and in this regard the final draughting to a reduced scale has been done by the Department of Lands and Survey, to which Department the thanks of the Division are due. The map is now in the hands of the Government Printer. A short descriptive text of the major grass associations and the correlation of these to rainfall, temperature, soil type, pasture management, &c., is in the course of preparation and will be issued along with the map itself.

(2) *Detailed Pasture Survey in connection with Land Utilization Survey of the Hawke's Bay Province.*

This survey is being done in very much greater detail than as for the general pasture survey, and the objective is to clearly define pasture association boundaries and to correlate these clearly with rainfall, elevation, temperature, soil type, and particularly in regard to the influence of pasture and farm management, top-dressing, stocking, &c. For this purpose a detailed survey, farm by farm, is required. Up to the present practically the whole of southern Hawke's Bay and central Hawke's Bay has been completed, and a commencement made on the northern Hawke's Bay portion. To date approximately 2,650 square miles have been mapped.

Considerable work has been involved in preparing the preliminary maps, but many of these are now well forward. Maps of Kidnapper, Te Mata, Oero, Waimaramara, Weber, Tautane, Pourerere, and Blackhead survey districts have been finally draughted and are ready for the printer. The completed maps have been draughted by the Lands and Survey Department throught the courtesy of the Surveyor-General.

Aerial surveys, preliminary to the detailed ground work, have been undertaken, and these have greatly facilitated the work, particularly so in the back-country, where access by road is difficult. It is estimated that aerial surveys would cut down the time of the field surveys by approximately two-thirds of the time. Aerial photographs are also proving of very great value in mapping.

It is clear that pasture surveys are really the only accurate means of gauging progress or deterioration over long periods of time. They represent a stock-taking of pasture development which is tantamount to a stock-taking of land-development in New Zealand, and they are really necessary as a basis for a true appraisal of land deterioration by secondary growth, erosion, loss of soil fertility, &c.

GENERAL GRASSLAND ECOLOGY.

During the year the work of accurately determining botanical composition and the placing of sampling on a statistically sound basis has been undertaken, and this has had a very important bearing on botanical and chemical work relating to the facial-eczema investigation. The training of a female technical assistant staff for herbage dissection work in the laboratory is complementary to the work, as is also the technique for accurate sampling in the field. Both these aspects of the Division's work have been well advanced during the past year.

HILL COUNTRY.

During the year much publicity has been accorded the deterioration of hill country in New Zealand, particularly in regard to the spread of secondary growth in the North Island and depletion of tussock country in the South Island. Some aspects of the economy of hill-country farming, particularly from the point of view of maintenance costs, have had some consideration by the Division, but this work has not been pursued as vigorously as is warranted by the present position

owing largely to an insufficient and inadequately trained staff to undertake the work. A review of the re-grassing trials conducted in the back Taranaki country was recently made, and these trials have shown fairly conclusively that these sowings are on the correct lines but that they must be followed up with efficient stock control and application of labour to maintain ascendancy over the return of secondary growth. Perhaps no country illustrates better than the back Taranaki country the absolute need of a full appraisal and full appreciation of the essential fact that maintenance costs must be met as these arise in the process of hill-country development. Unfortunately, too few settlers tackling hill country have the resources at their disposal to meet maintenance costs for, say, the first twenty years of development, and in consequence each year sees the country more and more overrun with noxious growth. Wherever those maintenance costs have been met and the country efficiently farmed the back Taranaki and similar hill country is shown to be a sound farming proposition.

The tussock hill country is essentially an ecological study and must be faced from either of two angles—(1) establishment of species and strains of grasses and clovers that can persist under the present grazing management, including rabbit grazing, burning, &c., and (2) the control of grazing, burning, &c., so as to allow the tussock plants endemic to the country the ecological conditions necessary for their persistence.

It is obvious at the moment that the tussock-growth form is incompatible with the type of grazing management practised, and its extinction must ultimately be its fate unless some control of the grazing factor is instituted. The work is of paramount importance, and one or more experienced research workers should be secured.

Facial-eczema Investigation (see page 44).

Fundamental Chemical Work in Relation to Grasslands.

During the year the Plant Chemistry Laboratory has been established as a separate unit from the Grasslands Division. It is, however, housed in the same building and a close collaborative policy has been instituted.

Dairy Pasture Research.

This work is being conducted at Palmerston North in close collaboration with the Dairy Research Institute. The work commenced in 1934, more particularly in regard to feed-flavours in cream. Since then its scope has been enlarged to cover some of the fundamentals in dairy feeds and feeding, and, in particular, reference to pasture species and strains—their ability to produce milk and their effect on the quality of the animal product—butter, cheese, milk, and cream, &c. Animal thrift on any one feed is also being studied. The following feeds are being tested: Pure perennial rye-grass, pure Italian rye-grass, perennial rye-grass, and white clover.

During the past year areas of pure cocksfoot and cocksfoot and white clover have been established and fenced into ½ acre paddocks. These feeds will be included in the programme for the coming year.

Sheep Pasture Research.

This work is being conducted at Palmerston North conjointly with Massey Agricultural College on the sheep-farm of the College. During the summer and autumn the full programme has been implemented, some 50 acres being ploughed and sown to special pastures for the work. The trials fall into two main groups—(1) a test under field and controlled grazing conditions of pedigree seeds versus certified mother seeds, and (2) manurial trials in which (*a*) a high and low plane of fertility is maintained and (*b*) comparative trials under a high-fertility upkeep of super, basic slag, super and lime, and super, lime, and potash. Each treatment, whether strain or fertilizer, will be separately fenced and each replicated five times, the replicates being so disposed as to offset any change of soil conditions unduly favouring any one treatment. The individual fields, separately fenced, will ensure that any residual effects of stock droppings will be confined to their appropriate blocks and thus obviate any errors through transfer of fertility between one treatment and another.

Both the dairy pasture research and the sheep pasture research is designed to give fundamental information on thrift in the animal itself, and this will have a particular and specific bearing on such problems as facial eczema, grass staggers, &c. Actually, maintenance of thrift in stock on highly improved lush pastures is one of the most pressing problems confronting grassland farming to-day, and such maladies as facial ezcema and grass staggers are a challenge to grassland workers and grassland farming itself, and unless the challenge is taken up may prove a permanent bar to any further progress in so far as increase in per-acre production is concerned. The pasture laid down in the sheep-pasture-research trials are all simple mixtures of perennial rye-grass and white clover, and these will be maintained on a high-fertility plane.

Soil-erosion.

Soil-erosion as an aspect of hill-country development was given some consideration during the year, the Director of the Division acting on a committee set up to report the present state of affairs in regard to erosion. In the process of ecological work in the field, and in the making of pasture surveys particularly, aspects of erosion have been studied in relation to grassland cover. Sward density is an important factor in erosion-control, and in this regard it is clear that pasture improvement plays an enormous part in inhibiting serious erosion. The matter is essentially linked up with the need to arrest pasture deterioration on hill country, and this question has been dealt with earlier in this report.

Greenkeeping Research.

The scope of this work has been enlarged and a new series of trials arranged in collaboration with the Greenkeeping Research Committee, set up by the New Zealand Golf Association, the work being financed by the latter body. The area at Hokowhitu has now been going on for seven years and some extremely interesting data on greenkeeping is now being recorded. The outstanding success of New Zealand brown-top and chewings fescue and the validity of the acid theory in relation to greenkeeping are some of the outstanding features. The new programme of work includes the testing of strain differences apparent in single-plant studies of brown-top to see the significance of these under sward conditions. Such a trial is being arranged for guidance regarding the standards for certification purposes.

The research work is promulgated by a full-time advisory officer, and each year greenkeepers meet at Hokowhitu for their annual conference. A diploma course in greenkeeping has now been arranged.

Lectures and Demonstrations.

During the year considerable time has been spent, as opportunity offered, to delivering lectures, and in this regard the young farmers' clubs have been very active. Visitors to the Station have increased, and much time has been spent in showing them round.

Establishment.

The new grasslands building has proved a great boon, and the space is now fully taxed. The question of additional storage room and the conversion of the present barn into a chemical laboratory have been gone into, and plans are in the course of preparation by the Public Works Department. Additional glasshouse space will be required to cope with the work relative to the study of wilted and lush growth in connection with the facial-eczema investigation.

RESEARCH WORK AT AGRICULTURAL COLLEGES.

Grants were made by the Department during the year to Massey College and Canterbury Agriculture College for the following projects under the ægis of the Plant Research Bureau:—

CANTERBURY AGRICULTURAL COLLEGE.

Subterranean Clover.

Systematic investigations to ascertain the place of subterranean clover as a pasture species for the lighter lands of Canterbury were commenced during the year at Ashley Dene, where 72 acres were subdivided into twenty-four fields of 3 acres each. This provides for four fertilizer treatments, each of which is replicated six times. A separate flock of sheep is to be grazed on each of the fertilizer treatments, the six replicates being grazed in rotation. The flocks are to be studied for a period of at least five years, and the results are to be measured in terms of fat-lamb returns, live-weight increases, wool yields, and sheep health and thrift.

The fertilizer treatments are as follows:—

(1) 1 cwt. super to 5 cwt. lime applied in alternate years.
(2) 2 cwt. super applied annually.
(3) 1 ton of lime (initial), followed by 2 cwt. super annually.
(4) 1 ton of lime (initial), followed by 2 cwt. super plus 1 cwt. potash annually.

The trial areas have been reticulated with water. Sheep-yards have been constructed and weighing-scales installed. A uniform flock of 4-tooth Corriedale ewes is being selected for the experimental flocks.

Owing to an exceptionally dry autumn delaying the clover growth, the inauguration of grazing has had to be postponed. Evidence has already been secured that distinct advantages in clover establishment are secured by initial applications of lime applied at a rate of 5 cwt. per acre.

MASSEY AGRICULTURAL COLLEGE.

Mole Drainage.

During the year a grant was made to Massey Agricultural College to enable research work to be commenced upon mole drainage, an investigation which is likely to have considerable value over much of the stiffer loam country located throughout New Zealand, large areas of which are to be found in the Manawatu and Southland districts. The investigations were carried out under the immediate direction of Mr. A. W. Hudson, who has been assisted by Mr. H. G. Hopwell, B.Agr.Sc., of the staff of the Fields Division, Department of Agriculture.

In addition to the laboratory investigations, two experimental installations were arranged in the field at Massey College following careful surveying and levelling. Attention was particularly devoted to the types of plug attached to a specially designed mole plough, and the trials comprise duplicate premises occupying about 3 acres. Arising out of the preliminary work much interest attaches to the greater success in drainage achieved by the use of a specially designed fin-plug which prevents a closure of the cut made by the knife of the drain plough.

The work is proceeding in the direction of having careful measurements made of the inflow and outflow of water coming from various types of drains, and a great deal of valuable fundamental information is likely to be derived as the work progresses and the drains reach a stage when they can function under more typical conditions, as will happen when the ground becomes consolidated.

Root-development Studies.

By W. A. Jaques, Massey Agricultural College.

Root-development studies are being continued at Massey Agricultural College in collaboration with the Plant Research Bureau. In brief, the work is designed to give information concerning the rooting-systems of various species and strains of common pasture plants under varying environmental conditions. Preliminary work has included the development of a satisfactory and convenient technique for root sampling. Work is now proceeding on studies of development of rye-grass and white-clover roots in different soil types, the effect of fertilizer placement at different levels in the soil profile on root-development, the length of life of roots, the effect of mixed sowings and of defoliation on the root-development of the individual species, and the influence of autumn and spring sowings and top-dressing on root-development. Some of this work is essentially of a fundamental nature, but much of it will be of direct application in grassland management—*e.g.*, time of establishment and top-dressing of pastures, harrowing, and intensity of grazing at different times of the year.

PLANT CHEMISTRY LABORATORY.

Officer in Charge: Dr. J. Melville.

Until August, 1938, the chemical laboratory attached to the Grasslands Division of the Plant Research Bureau was engaged chiefly in a study of the relationship between soil and pasture, particularly with regard to the availability and transference of lime and phosphates. In addition, the conventional analyses of pasture for feeding trials of milking-cows were carried out for the Dairy Research Institute. These projects are being continued.

It must be stressed, however, that such analyses give a very limited picture of the synthetic mechanisms of the green leaf, and this was thrown into relief by the widespread outbreaks of facial eczema last year. The fact that this disease is apparently the result of flush growth brings it into the category of stock ailments which are related to rapidly growing pasture. With a view to obtaining a better insight into the chemistry and physiology of herbage under as wide as possible a variety of environmental conditions, it was decided to reorganize and extend the scope of work of the existing laboratory, which has now been given the title of Plant Chemistry Laboratory.

The proposed investigations in plant biochemistry, which will deal at first largely with the soluble organic constituents of the leaf, are in their initiatory stages. Certain special equipment has not arrived, while extra accommodation which has been arranged is not yet completed.

The following is a report on the current activities of the Laboratory.

Soil and Pasture Studies (Marton).

The work on this project has been continued. Much useful information regarding the rate of conversion of carbonate of lime (applied as top-dressing) into the exchangeable form has been obtained. Indications are that, under Marton conditions, carbonate of lime does not need to be ground as finely as has been sometimes recommended. It has been shown that, although limes from various localities differ considerably with regard to the rate of reversion of superphosphate, there was little difference between a hard and a soft limestone as regards availability when applied as a top-dressing to pasture.

Further evidence has been obtained supporting the movement of added phosphates under Marton conditions.

Phytohormones.

Investigations of the effect of various chemicals on the rate of rooting of cuttings have been carried out, and a report on this work has been published in the *New Zealand Journal of Science and Technology*. Considerable improvement in the rate of rooting has been obtained with some treatments when given to cuttings of certain species, but other species, normally very difficult to propagate from cuttings, have so far failed to respond to hormone treatment. β-indole butyric acid has proved the most active chemical of those tried. α-naphthalene acetic acid and β-indole acetic acid have also been satisfactory. Considerable difficulty has been found in getting species known to respond to treatment to give consistently good results. There are at least two factors involved: (1) The condition of the wood, and (2) the temperature and humidity at the time of soaking. These factors affect the amount of chemical absorbed. With wood which is too soft, or under conditions of low humidity, an excessive amount of chemical may be absorbed, resulting in the death of some or all of the tissues.

Preliminary trials using vitamin B_1 in conjunction with appropriate hormone treatment have been encouraging, and support the contention that in the absence of vitamin B_1 root growth does not take place although root primordia have been produced as a result of hormone treatment.

The Relation of Pasture Plants to the Quality and Quantity of Dairy Products.

The Dairy Research Institute and the Grasslands Division of the Plant Research Bureau have for a number of years been conducting nutritional experiments with milking-cows, and full reports of the investigations will be found in the reports of these units. The conventional analyses of the ration fed have been conducted by this Laboratory. It is hoped that by certain modifications these analyses will be made more informative, particularly with regard to the non-digestible fractions. These trials will also provide excellent material for metabolic studies of pure-strain grasses.

Nitrogen Metabolism.

The non-leguminous plants obtain their supplies of nitrogen almost exclusively from the inorganic ammonium and nitrate salts of the soil, and from these simple materials, together with the carbohydrates derived from atmospheric carbon dioxide, the plant synthesizes protein. The importance of the peculiar ability of the green leaf to effect this synthesis cannot be overemphasized, since the continued existence of the whole of the animal kingdom is entirely dependent on it.

The transformation of inorganic nitrate into protein is a very complex process. It appears that simple organic units have first to be built up from ammonia and carbohydrate derivatives and that these units are then condensed to protein. For a study of the factors underlying protein syntheses it is obviously necessary to investigate these simpler units which are present in solution in the cell sap. Our knowledge of these materials is still at a very elementary stage, since of the total nitrogen present in the soluble fraction it is unusual to be able to ascribe more than 40 per cent. to definite chemical groups or 10 per cent. to chemical individuals.

The immediate investigation to be undertaken on the soluble constituents of the plant cell will follow two main lines: (*a*) The analyses of herbage for those substances, both carbohydrate and nitrogenous in origin, which are capable of accurate estimation; and (*b*) the elaboration of methods for the determination of the substances not included under (*a*). It must be emphasized that the soluble nitrogen fraction shows large variations in quantity and in composition according to environmental conditions. It is hoped that it will be possible to establish the limits of variation of the more important of these simpler constituents, and in so far as possible this will be correlated with the health and production of the stock grazing on the pastures on which the analyses are performed.

Cyanogenetic Glucoside.

The presence in white clover of a material which readily yields hydrocyanic acid is a matter of great scientific and practical importance. A method for the more rapid determination of the glucoside is in process of elaboration, using an enzyme which occurs in linseed.

With the large-scale equipment which it is hoped will be available by next growing season, the isolation of reasonable quantities of the glucoside will be attempted, in order that its properties may be more exactly defined. At the same time, it is of the greatest importance to be able to feed the pure glucoside to animals in order that its toxicity may be determined.

Facial Eczema (see page 44).

Methods of Analysis.

The Plant Chemistry Laboratory is fortunate in having on its staff an officer who has been trained in micro-technique in a big mid-European university hospital. Methodology in clinical chemistry has advanced to a far greater degree than is the case in plant chemistry, and the application of the newer methods will lead to savings in both material and time, with no sacrifice in accuracy.

ANIMAL RESEARCH.

Animal Research Management Committee.—Sir Theodore Rigg, Chairman (Cawthron Institute); Dr. N. L. Edson (Medical School, University of Otago); Mr. W. W. Mulholland (New Zealand Farmers' Union); Mr. A. Linton (New Zealand Dairy Board); Mr. J. D. Ormond, jun. (New Zealand Meat Producers' Board); Professor G. S. Peren (Massey Agricultural College); Professor E. R. Hudson (Canterbury Agricultural College); Professor W. Riddet and J. M. Ranstead (Council of Scientific and Industrial Research); Dr. J. F. Filmer and L. W. N. Fitch (Department of Agriculture); M. M. Cooper, Secretary (Department of Scientific and Industrial Research).

The above Committee was set up in August under the Agricultural Division of the Research Council to supervise and co-ordinate animal research activities in New Zealand. Only two meetings have been held, the Committee's functions being postponed pending the reorganization of agricultural and industrial research, a matter now under consideration. At the first meeting a full review was made of the more pressing needs of animal research, and three sub-committees were set up, the first a local advisory committee representative of farmers, the Department of Agriculture, Canterbury Agricultural College, and the Council of Scientific and Industrial Research to assist in the conduct of investigations into the causes of sheep-mortality in Canterbury, the second a sterility sub-committee, and the third a parasitology sub-committee. The last two sub-committees presented reports on their particular problems, and these were considered by the Animal Research Management Committee at its second meeting. The sterility report was implemented by the provision of finance for the further conduct of the ram-sterility research which had been in progress for some three years previously at Massey Agricultural College. This and other animal-research work undertaken with assistance from the Department of Scientific and Industrial Research by way of finance, staff, or facilities is described below. A grant was made to Massey Agricultural College, working in association with the Grasslands Division of the Plant Research Bureau, to initiate sheep-grazing experiments. These are described on page 38 of this report. A grant was also made to Canterbury Agricultural College to enable one of the staff to be released from lecturing for research into the nutritional aspects of sheep-mortality in Canterbury.

An invitation was extended to Dr. R. B. Kelley, of the Division of Animal Health and Nutrition, Council for Scientific and Industrial Research, Australia, to visit New Zealand to consult with research workers in animal breeding and sterility and discuss problems of mutual interest. This invitation has been accepted, and Dr. Kelley will probably arrive in New Zealand in October.

Facial Eczema.

The Department has co-operated with the Department of Agriculture in the comprehensive facial-eczema investigations which were commenced in the autumn of 1938 during the serious outbreak of this disease. The Department has been concerned in the following aspects of the study—(*a*) Meteorological and other physical work, (*b*) soil survey and soil chemistry, (*c*) agrostology, and (*d*) plant chemistry.

These sectional activities are described below :—

(*a*) *Physical Studies.*

Dr. E. R. Cooper.

The physical work being done as part of facial-eczema investigations covers meteorological observations at a number of stations in the Waikato district and special investigations at the Ruakura Farm of Instruction regarding the daily variation of solar radiation, the measurement of soil temperature, and the development of a physical method for the rapid determination *in situ* of soil-moisture content at depths of 1 ft. or less.

Meteorological Observations.—Observations of minimum grass temperatures, earth temperatures at 4 in. and 8 in. depths, and of rainfall are being made at fourteen farms, including Ruakura Farm. At Gore's Farm and at Ruakura there are two complete meteorological stations. An examination of the data obtained at Ruakura over the past seventeen seasons has shown that the air temperature and the earth temperature at 3 ft. were higher during the late summer and autumn of 1937–38 than for any one of the remaining sixteen seasons. The 1934–35 season is next outstanding in this respect. Since these two seasons produced the most serious facial-eczema outbreaks it is hoped that observations of these temperatures in the future may help to form a criterion whereby the incidence of facial eczema in any particular season may be anticipated.

Solar Radiation.—The variation of solar radiation is being measured in conjunction with chemical work on the pastures at Ruakura. The total sky radiation, including the sun's direct rays as received by a horizontal surface, is being continuously recorded. Special attention is being paid to the ultra-violet region of the spectrum. So far two instruments are in continuous operation, the one measuring the total sky radiation of all wave-lengths, and the other measuring red radiation only.

Soil Temperature.—Thermometers have been installed at 1 in. and 3 in. depths on each of three different soil types at Ruakura. Six thermometers are located at each station, three at each depth. Soil-moisture determinations are being made by sampling at each of the three sites.

Soil Moisture.—No satisfactory physical method for measuring soil-moisture content *in situ* at shallow depths less than 1 ft. has yet been devised. Various methods are available, but none possesses the accuracy and certainty of the direct method of sampling. Experiments are being made to develop a porous pot which will operate at shallow depths, but the difficulty here lies first in obtaining a suitable porous material. An experiment of great interest is proceeding at present, using an electrical conductivity method. The electrodes are concentric stainless-steel cylinders, the outer cylinder being perforated and the space between the two cylinders filled with plaster-of-paris. The moisture content of the plaster-of-paris alters with that of the soil and also the electrical conductivity. The method has been favourably reported on elsewhere.

(*b*) *Soil Survey and Soil Chemistry.*

Soil Survey Division.

Soil Survey.—A soil survey of the Waikato lowlands between Hamilton and Morrinsville and of the Kereone district was commenced in June in order to provide data for the facial-eczema investigations. All the soil types occurring in the adjacent Waipa County have been recognized, the chief difference between the two counties being the relative areas of each kind of soil. Probably the most extensive type is the meadow soil—Te Kowhai silt loam and clay loam; Horotiu soils occupy a fairly large area, but the soil is, in general, coarser in texture than in Waipa County; Hamilton clay loam is of small extent. The soil types that have been distinguished in the Waipa survey do not take into account the differences in fertility induced by the use of fertilizers. In the present survey, however, an attempt is being made to subdivide the types according to their present fertility, and, as a beginning, samples in quadruplicate have been collected from fields in which the top-dressing programme is known for many years back.

Soil Chemistry.—From mid-September onwards, samples of soils have been collected, mostly at intervals of a fortnight, from soils on sixteen farms representing the seven main soil types occurring in the Waikato District. They were packed in jars in a double box, the jars being surrounded with ice, and forwarded to Wellington for the estimation of nitrate and ammonia nitrogen. In this work close contact was maintained with officers of the chemical laboratory of the Department of Agriculture, who were determining the nitrogen in the soils of farms on which animal experiments were being conducted.

The Ohaupo silt loam showed the greatest amount of and fluctuation in nitrate nitrogen (Figs. 1–4). The Kereone silt loam also showed fluctuations, but to a lesser extent. Some locations on the Horotiu sandy loam and one on the Hamilton clay loam (sandy phase) also displayed marked variation. On the other hand, nitrate in soils such as the Whatawhata clay loam, Te Kowhai loam, Kaipaki peats, and the other Hamilton clay loam soils did not vary to any significant extent, the nitrate nitrogen remaining on the whole fairly low. The higher nitrate levels reached by the Ohaupo, Kereone, and Horotiu soils are doubtless connected with their superior aeration and drainage.

With regard to soil ammonia values, no such striking differences between one soil type and another were observed, either for peak values or for the general level of ammonia nitrogen in the soil. Higher levels of ammonia nitrogen than the average occurred at one location on the Kereone silt loam, two locations on the Horotiu sandy loam, and one on the Kaipaki peats.

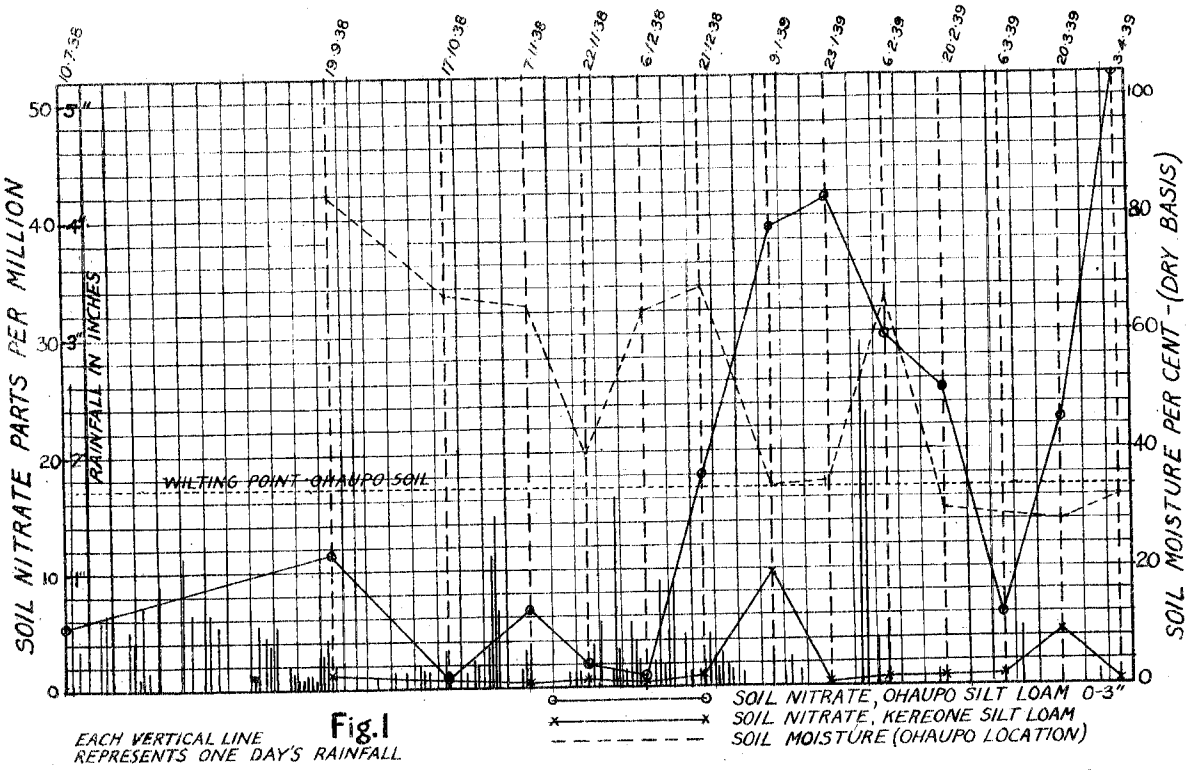


Fig.1

EACH VERTICAL LINE REPRESENTS ONE DAY'S RAINFALL

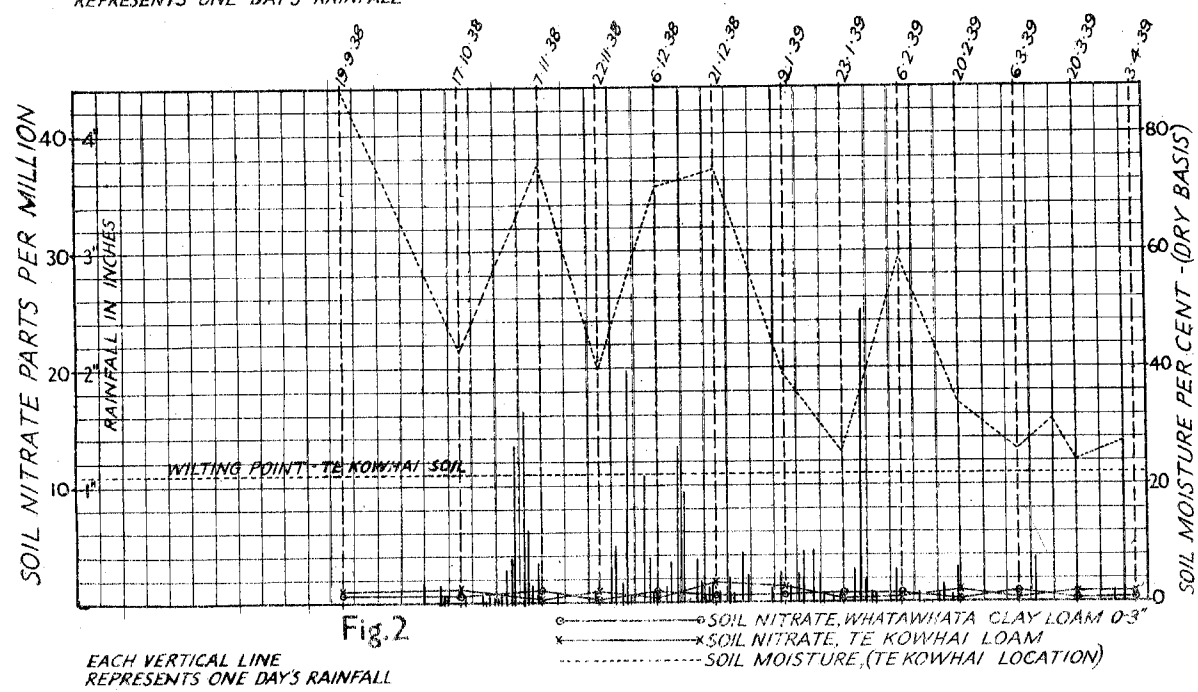


Fig.2

EACH VERTICAL LINE REPRESENTS ONE DAY'S RAINFALL

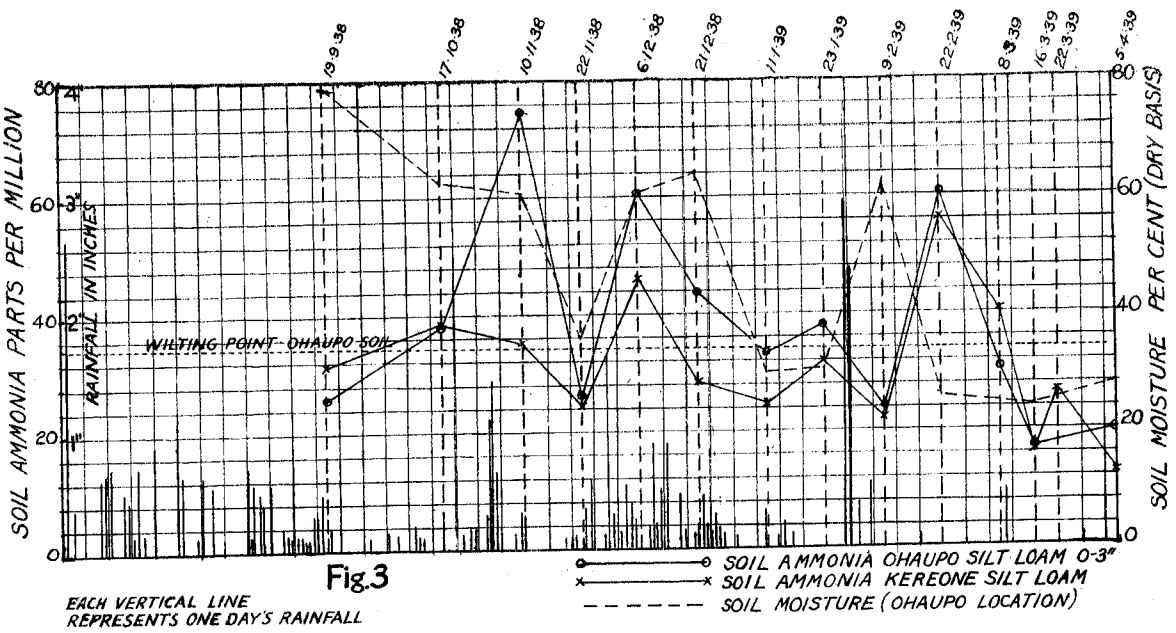


Fig.3

EACH VERTICAL LINE
REPRESENTS ONE DAY'S RAINFALL

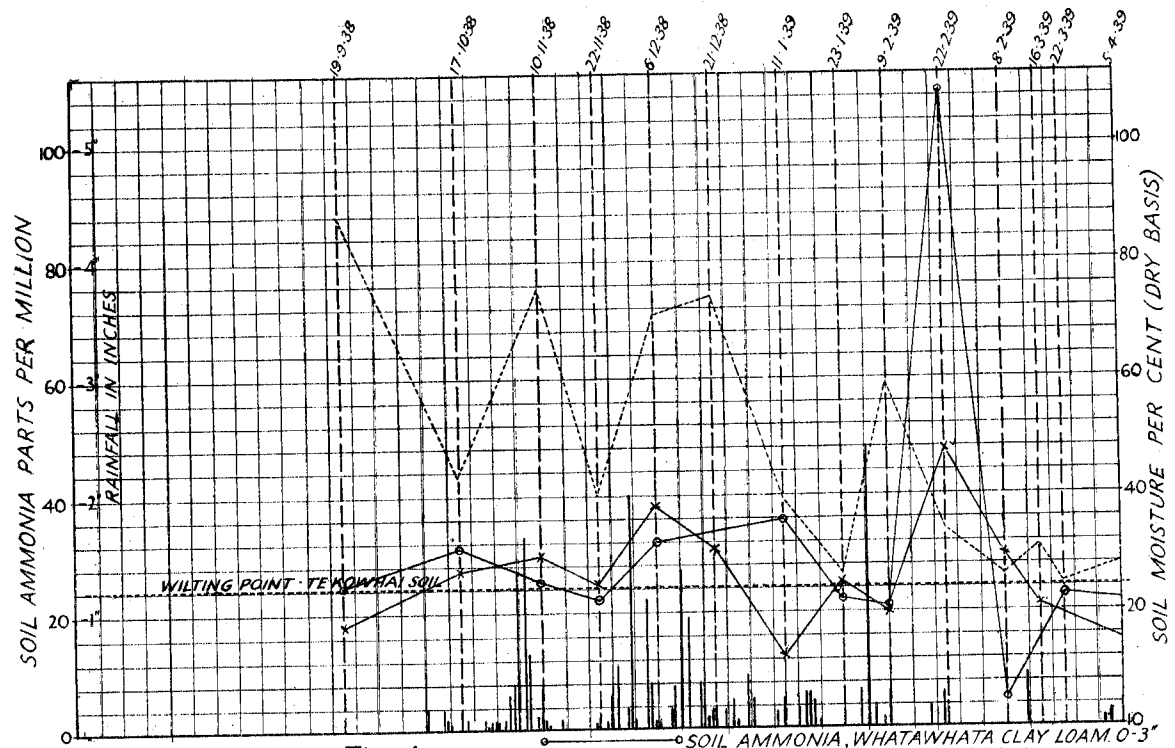


Fig.4

EACH VERTICAL LINE
REPRESENTS ONE DAY'S RAINFALL

The interpretation of the nitrate values is complicated by the fact that the amount changes in marked fashion during the course of the day. The variation in the Ohaupo soil nitrate is great, but as the Te Kowhai figures are fairly uniform throughout the day it may be said that the daily fluctuation does not upset the conclusion that the Ohaupo, Kereone, Horotiu, and Hamilton sandy clay loam soils contain more nitrate than the Te Kowhai and Whatawhata soils. These daily fluctuations, however, make it difficult to correlate the fortnightly variations of the Ohaupo nitrate with rainfall and soil moisture. Nevertheless, it appears that there is no correlation, for during the dry weather from late February on to April, when the soil moisture was below wilting-point, the nitrate content was at first moderate, then low, then moderate, and finally high. Certainly in the Te Kowhai and Whatawhata soils there was no variation with moisture content.

TABLE I.—FLUCTUATIONS DURING THE DAY IN SOIL NITRATE AND AMMONIA IN TOP 3 IN. OF SOIL.

Type.	Time.	Nitrate.	Ammonia.
		P.p.m.	P.p.m.
Ohaupo silt loam	10 a.m. ..	15·1	110·0
	12 noon ..	2·0	77·1
	2 p.m. ..	1·3	63·8
	4 p.m. ..	11·9	67·4
Te Kowhai	10 a.m. ..	0·41	17·4
	12 noon ..	0·51	19·9
	2 p.m. ..	0·45	19·4
	3.30 p.m.	0·46	23·5

The ammonia figures can be interpreted with more certainty, as the daily fluctuations are less. In general, the results showed that a high soil moisture was accompanied by a high ammonia content.

The values for both nitrate and soil ammonia reached in some of the soils growing pastures are, by comparison with soils in other countries, very high. Russell* states that pasture and heavily dunged arable soils contain rather less than 20 p.p.m. of nitrate and 10 parts of ammonia. Annett† records 71 p.p.m. of nitrate in a cropped soil in India which had received 4 tons of cattle-dung and 65 lb. of nitrate of soda per acre.

Phosphate Fixation.—The methods used for evaluating phosphate fixation were Heck's (*Soil Science*, 1934, *37*, 479) and Beater's (*Soil Science*, 1937, *44*, 277).

TABLE II.

Soil Type.	Depth.	Heck's Method: Percentage Fixation.	Beater's Method.	
			Percentage Soluble Phosphate absorbed.	Percentage Fixation.
	In.			
Hamilton clay loam	0–3	75·0	98·0	87·0
Ohaupo silt loam	0–6	..	94·0	90·0
Kereone silt loam	0–3	92·0	99·0	94·0
Horotiu sandy loam	0–3	94·5	94·0	83·0
Te Kowhai loam	0–6	..	98·0	82·5
Whatawhata clay loam	0–6	..	97·5	90·0
Kaipaki peat	0–3	88·0	98·0	77·0

All types show a high fixation by both methods.

Fertility Samples.—Sets of four composite samples from one paddock on each of the principal soil types where the soil type does not vary were analysed for plant-foods and exchangeable bases. pH and base-exchange values did not show much significant alteration throughout the set. Potash and phosphate values showed occasional variation within the group, but not more than one value in the four differed markedly from the others. Also, different paddocks on the same type gave values of the same order.

Wilting-point and Field Capacity Tests.—These were carried out on the principal soil types included in the Waipa bulletin, and are summarized in Table III. The values in terms of oven-dry moisture are much higher than those for greywacke alluvial soils of similar texture.

TABLE III.

Soil Type.	Field Capacity.	Wilting-point.	
		Wheat-seedling Method (Briggs and Shantz).	Spatula-cohesion Test.
Te Kowhai loam	91	22·0	19·0
Horotiu Sandy loam	73	29·2	..
Kereone silt loam	53	18·0	..
Ohaupo silt loam	89	33·0	..
Hamilton clay loam	67	..	25·4
Rotokauri peaty clay loam	78	61·0	..
Kaipaki peat	159	90·0	..
Whatawhata clay loam	..	..	35·0

* E. J. Russell: "Soil Conditions and Plant Growth," 5th Ed., 179–180.

† H. E. Annett (1928): "Memoirs of Department of Agriculture in India," 9, No. 6, 163.

(c) *Agrostology Studies.*

Grasslands Division, Plant Research Bureau.

A great deal of time was spent during the year in correlating botanical composition, stand, and stage of pasture growth, with the incidence and severity of facial eczema. Early in the epidemic of last autumn intensive pasture surveys were made in the Waikato and Manawatu districts in collaboration with the Department of Agriculture, and throughout the year there has been close collaboration in the research programme drawn up by the Facial Eczema Committee, of which the Director of this Division is a member. That work has involved periodic visits to the Waikato, and a member of this Division has been stationed full time at Morrinsville to deal in particular with a group of farms in the Kereone district. During the summer and autumn period two officers were for the most part full time in the Wairoa and Gisborne districts, where special farms and special areas were under close observation. In the Manawatu district several farms were carefully observed, and collaborative work on Massey Agricultural College sheep and dairy farms was carried out conjointly with the Massey Agricultural College and the Department of Agriculture. The above work called for special technique in pasture surveying and sampling for the purpose of (1) determination of botanical composition and (2) securing of representative botanical samples for chemical analysis. A full report from the botanical aspect of the investigation is in course of preparation.

(d) *Plant Chemistry.*

Plant Chemistry Laboratory.

The Plant Chemistry Laboratory, which was established during the year, is concerned with the analyses of plant material collected by the Grasslands Division from areas in which the climatic conditions are such that facial eczema is likely to occur. At the present time, pending the arrival of necessary equipment, it is not possible to complete these analyses, and so the collected plant material has been dried and stored in such a way as to minimize post-mortem changes. Useful material was collected in the late summer from Poverty Bay, where a slight outbreak of facial eczema occurred. In the Manawatu autumn rains resulted in a resumption of pasture-growth after a prolonged period of drought, but conditions were such that a rapid flush could hardly be expected. Samples of this new herbage growing under different environmental conditions were collected and stored for analyses. At the time of writing this report it is not known whether the herbage, which is being sampled, is dangerous for stock, although the indications are that there will be no eczema in the district. Nevertheless, the analysis of this material will provide valuable information on pasture metabolism during a period which is known to be highly critical for stock thrift.

Animal Research at Massey College.

Wool Metrology.

Dr. P. R. McMahon was appointed to the position of Wool Metrologist in August, 1938. After spending a short time in the Wool Manufacturers' Research Association laboratories at Leeds he arrived in New Zealand in December, and was seconded to Massey Agricultural College to work in collaboration with the Fleece Testing and Wool Biology Departments.

The work which is being undertaken is aimed to fill an urgent need for the application of accurate scientific methods for measurement of wool characteristics to the grading of individual stud sheep. A statistical examination of the present system of fleece-testing in use at Massey Agricultural College is in progress, special attention being paid to the sampling procedure and the method of grading which has been adopted. Analyses so far carried out indicate that the number of samples taken is more than sufficient for the purpose of grading an individual fleece into one of six classes, as at present. Although it is not yet possible to issue a final recommendation, it is likely that a considerable saving in time with no appreciable loss in accuracy will be achieved by a reduction in the number of samples taken. By studying the relationship between parent and progeny for staples from different parts of the body an indication has been obtained that it may be possible to increase the efficiency of the grading system as an index of the genetic ability of the animal by 50 per cent. through the use of suitably-selected staples. This work will be extended by the results of the coming testing season, and experimental designs based on medullation are being applied to other features of the architecture of the fleece. Through the courtesy of Dr. F. W. Dry, of the College staff, the inheritance of halo hair gradings is being studied for some 350 matings, and the results to date are in very satisfactory agreement with those from medullometer readings. If similar relations hold for other fleece characters and there is good reason for believing that this will be so, a very powerful aid for use in selection for wool improvement will have been provided.

Arrangements are being made with the Wool Manufacturers' Research Association, Dunedin, for the commercial processing of wool having known and accurately measured characteristics. Some material has already been collected, and in this connection it is interesting to record that two bulk lots of wool differing only in medullation, but by an amount of medullation not obvious to the eye, were found to exhibit a marked difference in handle and brightness and, when submitted to an overseas wool-buyer, differed in value by 1d. per pound. This work will fill the large gap between the producer and the consumer of the Dominion's wool-clip and will provide the breeder, more especially the stud breeder, with accurate knowledge of what wool-types are the most satisfactory for the large unchanging demands of the standard types of processing.

Pig Research.

Work has been concentrated upon one major project—that of investigating the genetic aspects of length of carcass in bacon pigs. This is essentially a long-term breeding study aiming at evolving practical methods for the improvement of this important character in New Zealand pigs. Coincident with this study the material obtained has been employed to obtain data on the nature and extent of the variability within litters, in carcass-quality characters for the purpose of determining the size of sample necessary for efficient application of the progeny test in pig-improvement work.

The technique employed in both studies has involved subdivision of the College's Tamworth stud into "long" and "short" types, of selective inbreeding within each type with a view to accentuating and fixing the respective "long" and "short" character, and of crossing the two types to measure variability and to indicate the mode of inheritance of the character involved. Selection and breeding has been based on the progeny test, the complete litters of each mating being carried to bacon weight when slaughter has been followed by detailed examination of each carcass on a measurement basis. X-ray data on rib number have been obtained on the original breeding-stock.

Data obtained to date from 140 slaughtered animals have been subjected to preliminary analysis only. In general terms it is clear that length in pigs can be controlled through selective breeding methods, though it would appear that it is easier to develop short types than long types by such methods. Crossing of long and short types, as is frequently practised by farmers, is productive of great variability. Rib number does not appear to be closely connected with length of carcass. The degree of inbreeding so far developed is as yet insufficient to determine its precise influence in reducing variability and fixing the character concerned. Inbreeding will be intensified during the coming year.

The variability in carcass characters within a litter of normal oestrous pigs is so high as to throw considerable doubt on the adequacy of two pigs per litter as a sample in progeny test improvement methods, and suggests that a larger number will need to be employed if such methods as practised or contemplated in New Zealand are to be effective.

Sheep-sterility Investigations.

W. M. Webster, M.R.C.V.S., B.Sc.

Breeding-experiments.—This work, designed to determine the causes of the high incidence of infertility amongst rams of the Romney Marsh breed, was continued in 1918 along the same general lines of previous years. The four original groups of experimental rams were continued under contrasting nutritional regimes, but no significant differences in fertility were observed. During the season the appraisal of fertility, based upon the various laboratory tests, was checked against the actual results obtained by artificial insemination for which a standard technique was developed. The type of artificial vagina used differs considerably from those used by workers elsewhere and has given most satisfactory results.

In the course of laboratory examination considerable data have been accumulated covering the volume of ejaculate, density of sperm, duration of motility under storage conditions, morphology of sperm, and pH of semen. This material will assist in the establishment of accurate "normals" under the above headings, and it is in the course of preparation for publication.

pH Values of Seminal Fluid.—From the determinations of pH values of semen and the percentages of conceptions obtained by artificial insemination a close relationship between pH and fertilizing power was established. Acid samples were fertile with few exceptions and, within observed limits, the fertility increased with increasing acidity. In no single instance did a sample giving a pH reading greater than 7·0 prove fertile when tested by artificial insemination. From these observations a relatively simple field test was evolved for the use of breeders. A complete testing outfit was put up with printed instructions, and some sixty were distributed to stud breeders with the proviso that the testing technique was still in the experimental stages and in the light of further experience might require modification or amendment. Contacts are being maintained with these breeders and their experiences with the test will be obtained in the spring after lambing is completed.

Acid Drift of Seminal Fluid.—During the past year observations have confirmed the recorded results of other workers of the steady development of acidity in semen. This acid drift had been observed previously, but did not appear to be of any great magnitude under the conditions obtaining—viz., after the semen had been held for approximately two hours at air temperatures before making pH determinations. Early in the 1939 breeding-season it was found that pH determinations made immediately after collection were invariably considerably higher than two hours later. Rams, tested immediately on ejaculation, with semen ranging from pH 6·5 to 7·5 appeared on morphological and motility tests to be highly fertile. It was found that after the first half-hour of storage under oil at air temperatures semen giving initial pH readings of the above range fell to a range of 5·5 to 6·0. The rapidity of this drift varied with temperature and was greatest on warm days, but slowed up very considerably after the first half-hour. On the other hand, semen from infertile rams almost invariably gave an initial pH reading of 7·5 to 8·0 and showed a relatively slight fall during the first thirty minutes of storage under oil. On the establishment of the foregoing facts appropriate amending instructions were issued to breeders using the sterility-testing outfits. An explanation of the above phenomenon has been derived from biochemical tests, which show that the seminal plasma has a high glucose content and the rapid acid drift is associated with a marked diminution of the glucose and a corresponding increase in the lactic-acid content of the plasma. The intense activity of the large number of spermatozoa in the semen of fertile rams leads to a rapid katabolism of the glucose to lactic acid. On the other hand, semen from infertile rams has a lower sperm count and only sluggish motility of sperms with a corresponding low level of metabolic activity.

Nitrogen Metabolism.—During the year a urine-collector was developed to enable complete collections of urine excreted by rams under natural grazing conditions. By this means it was possible to carry out exploratory work in regard to the various types and proportions of the nitrogenous excretory products. It is thought that an excessive nitrogen metabolism may exert some influence upon the reproductive function. The fractional analyses involved have presented many technical difficulties, but the preliminary period of perfecting technique is now past.

Complete nitrogen balances have been worked out for five experimental rams grazed on regularly top-dressed perennial rye-grass - white-clover pasture. These preliminary results indicate an abnormally high intake of crude protein as compared with the results of animal nutrition research workers elsewhere.

New Experimental Groups.—In January, thirty two-tooth rams were purchased to inaugurate a new comparative test of food and environment on fertility. Half of these sheep were Manawatu-bred and had been raised on high-class pastures, the remainder were obtained from the Wairarapa. Half of each lot were placed upon irrigated rye-grass - white-clover pasture, and in addition to this fresh grazing, received a small daily concentrate ration of peas and linseed nuts. The remainder were placed on hill-country grazing of second-class pasture and, owing to the dry conditions, were forced to range extensively for food and so lost considerable condition. When the breeding-season commenced towards the end of March it was found that of the rams grazing on the high-class pasture all the Manawatu-bred rams were, with one exception, fertile, while the Wairarapa-bred rams, with one exception, were sterile. On the hill-grazing the reverse was found to be the case. Only one of the Manawatu rams was fertile, while the majority of the Wairarapa rams were in breeding-condition. Evidence of similar experience obtained from stud-breeders strongly suggests that Romney rams may be much more susceptible to environmental changes than has been hitherto supposed. This aspect is receiving close attention, and every endeavour is being made to obtain further data.

SOIL SURVEY.

Land Utilization Committee.—Sir Theodore Rigg, Director, Cawthron Institute (Chairman); Mr. A. H. Cockayne, Director-General, Department of Agriculture; Mr. E. J. Fawcett, Assistant Director-General, Department of Agriculture; Mr. R. B. Tennent, Director, Fields Division, Department of Agriculture; Mr. R. P. Connell, Land Utilization Officer, Department of Agriculture; Professor W. Riddet, Massey Agricultural College; Mr. G. A. Pascoe, Industrial Adviser, Department of Industries and Commerce; Dr. L. I. Grange, Director, Soil Survey Division, Department of Scientific and Industrial Research; Mr. R. G. McMorran, Acting Assistant Under-Secretary, Lands and Survey Department; Mr. F. R. Callaghan, Chief Executive Officer, Plant Research Bureau, Department of Scientific and Industrial Research; Dr. I. W. Weston, Agricultural Economist, Canterbury Agricultural College; Mr. F. J. A. Brogan, Assistant Secretary, Department of Scientific and Industrial Research (Secretary).

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

During the year excellent progress has been made in the two major surveys each covering several thousand square miles—namely, (1) regional survey of North Auckland; (2) regional survey of Hawke's Bay Province.

Messrs. N. H. Taylor and C. F. Sutherland, who are in charge of the North Auckland survey, were absent from the district for several months on soil-erosion and facial-eczema investigations and on the writing of the bulletin on the soils of Waipa County. Good progress has, however, been made with the compilation of the soil map and data for the report on the soils of Whangarei County.

The report on the soils, pastures, and agriculture of Hawke's Bay arising from the land-utilization survey of that province is to be published in three bulletins dealing with Mid, Southern, and Northern Hawke's Bay respectively. Field-work on the soils of Mid - Hawke's Bay, which is in the charge of Messrs. I. J. Pohlen, H. S. Gibbs, and J. D. Raeside, has been completed and a description of soil types is being written. Two of the four maps of the mid district are in the press.

WAIKATO LOWLANDS.

A soil survey of the Waikato lowlands between Hamilton and Morrinsville and of the Kereone district has been initiated in order to provide data required for the facial-eczema investigation. Mr. Sutherland commenced mapping in June, and in September his place was taken by Mr. H. A. Hughes. This work, together with the accompanying soil chemistry studies, is described under "Facial Eczema" (see page 42).

FOXTON DISTRICT.

A survey was made by Mr. C. S. Harris of the soils on the north bank of the Manawatu River near Foxton to provide information on their suitability for growing *Phormium tenax*. The soils are of recent alluvial origin, and most types can be classed as groundwater soils, for in the winter months water lies at or close to the surface.

On the levee of the Manawatu, which extends back about 40 chains from the river, soils, which are called the Manawatu series, are principally sands and sandy silts, with silt loams and clay loams in the slight depressions. Farther back from the river are the Kerekere soils, consisting of 6 in. to 18 in. of dark-grey silt loam resting on hard grey-brown slightly peaty loam. Still farther away from the river and forming the northern margin of the alluvial soils is the Whirokino slightly peaty silt loam.

It lies only about 4 ft. above mean sea-level. The slightly peaty soil, dark grey-brown in colour, ranges in depth from 18 in. to more than 3 ft., and rests on blue-grey clay. The organic matter gives it a puffy appearance, and, on draining, this soil compacts a good deal owing to the closing of pore spaces and to oxidation of the organic matter.

All the soils are fairly acid but are well supplied with plant-foods, and the soluble salts present do not reach a toxic level. The peaty soils had a high loss of ignition and showed a considerable shrinkage on drying.

Publications.

The following surveys in which field and chemical work was almost completed by March, 1938, went forward for publication, and all except the last on this list have been issued :—

D.S.I.R. Bulletin No. 65, Soil Survey Division Publication No. 1 " Soil Survey of Duvauchelle Bay, Wainui District, Banks Peninsula."

D.S.I.R. Bulletin No. 66, Soil Survey Division Publication No. 2 : " A Survey of Tung Groves in New Zealand."

D.S.I.R. Bulletin No. 71, Soil Survey Division Publication No. 3 : " Soil Survey of Westport District."

D.S.I.R. Bulletin No. 72, Soil Survey Division Publication No. 4 : " Soil Survey of Wairau Plains, Marlborough."

D.S.I.R. Bulletin No. 70 : " Land Utilization Report of the Heretaunga Plains " (includes an account of the soils of the plains).

D.S.I.R. Bulletin No. 76, Soil Survey Division Publication No. 5 : " Soils and Agriculture of Part of Waipa County " (in collaboration with the Fields Division, Department of Agriculture).

To the account of " Soils of Westport District " may be added the results to date of surface-sowing of pastures on the sandy loam of the Wilson series undertaken by Mr. Harris in co-operation with the Cawthron Institute. White clover, subterranean clover, and Cawthron Institute pasture mixture for Sergeant soils were surface-sown on the native vegetation after removal of the few small manuka bushes. Lime and super plus lime were the fertilizers used. On the white-clover plot top-dressed with super and lime a good establishment was obtained. This is in line with Cawthron Institute results on Sergeant soils, and provides evidence that even sandy, well-drained soils can be surface-sown in areas of heavy rainfall.

The mapping of soils in the Waipa County was completed several years ago, but an opportunity to write the report did not occur till this year. The delay in publishing has been advantageous, in that Mr. P. W. Smallfield, Fields Superintendent, Department of Agriculture, has been able to supply a section of the agriculture of the county based on several years' experience of the soil survey.

The following papers in which members of the staff were authors or part authors were published: " Land Deterioration in the Heavier Rainfall Districts of New Zealand," by N. H. Taylor, *New Zealand Journal of Science and Technology, 19,* D.S.I.R. Bulletin No. 62 ; " The Laterites of Western Samoa," by F. T. Seelye (Dominion Laboratory), L. I. Grange, and L. H. Davis (Dominion Laboratory), *Soil Science* (U.S.A.) ; " Mechanical Shaker for Soils," by K. S. Birrell, *New Zealand Journal of Science and Technology, 20.*

General.

In the chemical laboratories at Cawthron Institute and at Fairlie Terrace, Wellington, many soil samples have been analyzed. In addition, special investigations have been carried out including studies of podsolized soils, determination of soil colours, preliminary work on tests for drainage quality of soils and a method for determining small amounts of chromium. The Institute is responsible for the chemical results and interpretations contained in four of the bulletins published during the year, and from the chemical angle has actively helped in the major surveys in progress. Fusion analyses of soils and their clay fractions were made at the Dominion Laboratory. At the drafting office, which is located at Hastings, the staff drafted the maps which appeared in the bulletins and papers which have been issued during the year and maps for the Mid-Hawke's Bay report.

Accounts of the progress of the major surveys and of the chemical laboratories are made the subjects of separate reports. In the compilation of the agricultural notes on the various soil types the North Auckland pedologists co-operated with Mr. E. B. Glanville, local Instructor of the Department of Agriculture; Dr. J. K. Dixon and Messrs. A. S. Metson, and L. Hodgson (Cawthron Institute) and K. S. Birrell have supplied the chemical portion of the Hawke's Bay report. Mr. K. S. Birrell is responsible for the report on the soil work undertaken at the Wellington chemical laboratory.

NORTH AUCKLAND SOIL SURVEY: PROGRESS REPORT.

During the season about 250 square miles were mapped, mainly in the eastern part of Hobson County, and co-operative work with the Departments of Agriculture and Health has been continued. The following brief account of the middle part of the North Auckland Peninsula sets out the main soil types studied, together with their chief characteristics. The north-west and southern parts of the area shown in the accompanying sketch map have not yet been examined in detail.

The Middle Part of North Auckland Peninsula.

The area referred to in this report as the middle part of the North Auckland Peninsula stretches from the southern shores of Hokianga Harbour and the Bay of Islands in the north-west to Kaipara North Head and Bream Tail in the south-east. It is approximately seventy-five miles long by fifty miles wide, and covers slightly more than 2,000,000 acres.

Topography and Geology.

The area falls into six natural divisions :—

(1) The greywacke hills of the east coast, with peaks rising to 1,500 ft. ;
(2) The doleritic mass in the north-western part of the district rising to the plateau of Tutamoe (between 2,000 ft. and 2,500 ft. above sea-level) ;
(3) The lower-lying hilly areas between these highlands carved mainly from sandstones, claystones, and limestones ;
(4) The flattish, basalt-covered areas lying north, south, and east of Kaikohe, north-west of Kaihu, and west and north of Whangarei ;
(5) The belt of loose and consolidated sands bordering the west coast ; and
(6) The low-lying flats bordering the Wairoa, Waipu, and Ruakaka rivers and the Wairau River in the Hikurangi Swamp area.

Basalt cones and hills of andesitic and rhyolitic rocks give additional variety to the landscape.

Climate.

The mean annual rainfall ranges from less than 50 in. south of Whangarei to more than 100 in. in the neighbourhood of Tutamoe Plateau. In general the rainfall is heavier on the west coast than on the east. The mean annual sea-level temperature at Whangarei and at Waipoua on the west coast is approximately 57°.

Native Vegetation.

Much of the area was formerly covered with mixed kauri - podocarp - broad-leaf forest. In some districts—*e.g.*, north of Kaihu—kauri was locally the dominant tree, but in general the forest was a mosaic, kauri and the podocarps being more in evidence on ridge tops and steeper slopes, and the broad-leaved trees (with taraire dominant) occupying the lower slopes and gullies. Certain fertile areas supported forest composed almost entirely of broad-leaved trees, such as puriri, kohekohe, and taraire. The wetter flats were covered largely with kahikatea semi-swamp forest.

Large areas were covered with scrub. These scrub areas are of two main types : The " ironstone " lands of the basalt plateau west of Kerikeri which were formerly covered with mixed forests, and the gumlands formerly in kauri. The date when the forest retreated from these lands is not known. On some areas the change has been comparatively recent, for pits left by the overturning of trees and even logs of the pre-existing forest are yet to be found, but in other areas the kauri-gum and roots of trees cemented in the soil horizons are the only remaining traces. The appearance of the soil profile and the great accumulation of moa " cropstones " on some of the gum-land areas favours the conclusion that they have been scrublands for a long period. Other scrub-covered areas almost certainly owe their origin to early Maori occupation.

The vegetative cover has affected the soils markedly, the mohr-producing trees having allowed of greater leaching than the broad-leaved, mull-producing types. The greatest amount of leaching has gone on under the kauri, whereas under such trees as the kohekohe, and puriri the soil fertility has been maintained.

Soils.

The soils have been classified tentatively in six main groups :—

A. Recent soils of the alluvial flats.
B. Rendzina and associated podsolized soils derived from limestone.
C. Podsols derived from sedimentary and acid volcanic rocks.
D. Brown and red loam derived from basic volcanic rocks.
E. Brown granular clays from basic and intermediate rocks.
F. Ground-water soils.

A. *The Recent Soils.*

The Recent soils are here classified as a single type. They cover areas along stream-valleys subject to present-day floods, and are derived from alluvium of sedimentary and basic igneous rocks. Some areas are well drained, but in others the drainage is poor. They are for the most part fertile brown clay loams yielding good crops and growing good pasture. The best-known areas are near Kaihu and at the northern end of Hikurangi Swamp.

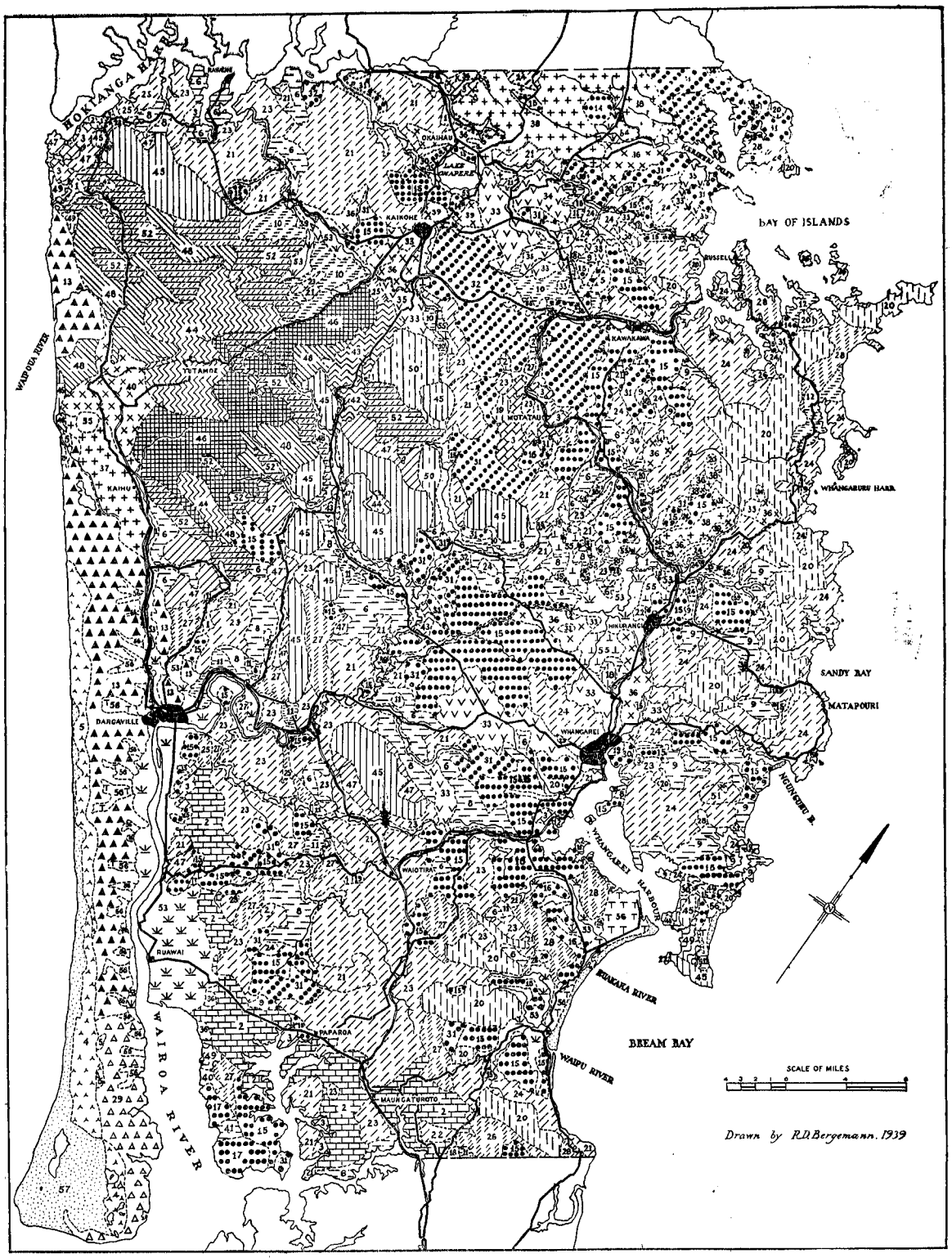
B. *Rendzinas and Associated Podsolized Soils.*

The rendzina and associated podsolized soils are derived from limestone and from calcareous sediments. They originally supported a broad-leaf forest with a large percentage of high " fertility " species. Cabbage-trees grow abundantly, especially in coastal areas. Where the rainfall is approximately 50 in., a deep dark-brown topsoil occurs containing fragments of limestone wherever the limestone is close to the surface. These lime-humus soils are classified as rendzinas. Where the rainfall is heavier (as at Motatau) the topsoil is browner and shallower. Associated with the fertile rendzina soils are wide areas of podsolized soils developed where the calcareous rocks are covered by a thick mantle of residual clay. These soils are less fertile than the rendzinas, but the complex as a whole is a fairly fertile one.

Most of the soils are heavy clays with a marked granular structure, and many of them are poorly drained. They are used for dairying and for sheep-farming. Water is difficult to obtain on many areas. The soils of this group are mapped as two types : The easier country where the clays are generally deeper (type 2), and the rolling to moderately steep country containing a greater proportion of the more fertile rendzina soils (type 3).

C. *The Soils of the Podsol Group.*

The soils of the podsol group are derived from blown sand, mudstone, sandstone, greywacke, and from acid and intermediate volcanic rocks. They are classified according to degree of podsolization into young, immature, semi-mature, submature, and mature stages. Type 4 is a *young podsol* developed on sandhills fixed by scrub vegetation. The topsoil is dark; the subsoil loose and light brown. Where farmed, the soil is used for sheep and cattle grazing. The pasture suffers from drought during dry spells.



[*Soils by N. H. Taylor and C. F. Sutherland.*

SKETCH-MAP SHOWING SOILS OF MIDDLE PART OF NORTH AUCKLAND PENINSULA.

(For key to soil types see numbers in legend on p. 50.)

The *immature podsols* are all moderately leached soils with dark-grey topsoils and brownish subsoils. They may be divided into two classes: (*a*) the sands, and (*b*) the clays and clay loams. The sands (type 5) are formed on sandhills fixed by weathering. The natural cover is scrub, but when cleared and liberally manured with phosphates they grow excellent rye-grass - clover pastures which respond

LEGEND FOR SOIL MAP OF MIDDLE PART OF NORTH AUCKLAND PENINSULA.

Soil Classification.	Type No.	Local Name.	Relief.	Adapted to	Top-dressing for Mixed Pastures.
RECENT SOILS	1	Good alluvial flats ..	Flat	Dairying, maize, turnips, &c.	Basic slag; superphosphate + lime.
RENDZINA SOILS and associated podsolized soils	2	Good and poorer limestone clays	Easy rolling	Dairying and fat-lamb raising	Basic slag; superphosphate + lime.
	3	Good limestone clay	Rolling to moderately steep	Sheep and cattle grazing	
PODSOLS.					
Young	4	New sandhill soils ..	Rolling	Sheep and cattle grazing	Superphosphate.
Immature	5	Good sandhill soils	Rolling	Dairying, fat-lamb raising, and root crops	Superphosphate.
	6, 7, 8, 9	Good clay ..	Rolling	Dairying and grazing ..	Lime and superphosphate; basic slag.
Semi-mature	10, 11, 12	Poorer clay ..	Rolling	Dairying and grazing ..	Lime (heavier) + superphosphate; basic slag.
Submature and mature ..	13	Sandy gum land ..	Rolling to moderately steep ..	Largely not adapted to farming; poor dairying in part	Heavy liming + basic slag.
	14	Sandy and pipeclay gum land	Easy rolling	Dairying	Heavy liming + superphosphate or basic slag.
	15 and 16	Pipeclay gum land			
	17	Volcanic gum land	Easy rolling	Dairying (?)	Heavy liming + basic slag (?).
HILL COMPLEXES. Largely skeletal and immature	18, 19, 20	White clay hills .. Brown clay hills ..	Steep	Largely afforestation; some grazing	..
Largely immature ..	21, 22, 23, 24	Brown clay hills .. White clay hills .. Brown clay hills ..	Rolling to steep	Sheep and cattle grazing	Basic slag; basic superphosphate or rock phosphate.
Largely semi-mature ..	25, 26, 27, 28	Poorer clay hills .. Poorer white clay hills Poorer brown clay hills	Rolling to steep	Sheep and cattle grazing	Basic slag; basic superphosphate or rock phosphate. (Needs lime, but is costly to apply.)
	29	Poorer sandy hills ..	Rolling to steep	Sheep and cattle grazing in part	Basic superphosphate.
Largely eroded submature ..	30, 31	Gum-land hills ..	Rolling to steep	Largely not adapted to farming	..
	32	Very poor clay hills			
RED AND BROWN LOAMS.					
Young and immature ..	33	Good volcanic ..	Flattish to easy rolling ..	Dairying, fat lambs, and turnips	Lime; superphosphate + potash.
	34	Good deep volcanic	Easy rolling		
	35	Thin and bouldery volcanic	Flattish	Grazing	Basic phosphates.
Semi-mature	36	Poorer volcanic ..	Flattish to easy rolling ..	Dairying	Lime + basic slag + potash; rock phosphates.
Submature and mature ..	37	Light ironstone soil	Easy rolling	Grazing	Heavy lime + basic slag + potash.
	38	Ironstone soil ..	Flattish to easy rolling ..		
HILL COMPLEXES: Largely semi-mature	39	Poor volcanic ..	Rolling to steep	Grazing	Basic slag.
	40	Poor volcanic ..	Rolling to steep	Grazing and dairying in part	Lime; basic slag, superphosphate + potash.
BROWN AND GRANULAR CLAYS.					
Immature	41	Fairly good volcanic	Easy rolling ..	Dairying, &c. ..	Lime + superphosphate.
Semi-mature	42	Poor volcanic ..		Grazing and dairying ..	Lime + basic slag.
Lowland submature ..	43	Very poor volcanic		Grazing	Heavy lime + basic slag + potash.
Upland submature ..	44	Poor wet volcanic	Easy rolling upland ..	Afforestation; poor dairying	Basic slag; rock phosphate. (Lime needed, but too costly.)
HILL COMPLEX. Largely skeletal and immature	45	Volcanic hills ..	Steep	Afforestation; grazing in part	Basic slag
Largely skeletal and upland submature	46				
Largely immature ..	47	Volcanic hills ..	Rolling to steep ..	Grazing	
Largely immature and upland submature	48			Grazing and afforestation	
Largely semi-mature ..	49	Poorer volcanic hills	Rolling to steep	Grazing and afforestation	
GRANULAR CLAY: PODSOL COMPLEXES.					
Skeletal and immature ..	50	Good brown clay hills	Steep	Afforestation; grazing in part	Basic phosphates.
Largely immature ..	51	Reddish clay hills ..	Rolling to steep	Grazing	Basic phosphates.
Skeletal to semi-mature ..	52	Bouldery clay slopes	Rolling to steep (hummocky)	Grazing and dairying ..	Lime + superphosphate; basic slag.
GROUND WATER SOILS.					
Meadow clays	53	Wet clay flats ..	Flat	Dairying and fattening ..	Lime + superphosphate; basic slag.
Meadow granular clays ..	54			Dairying and grazing ..	Lime + basic slag.
Peats and loamy peats ..	55	Peat		Poor dairying ..	Lime + superphosphate + potash; rock phosphate.
Peat-sand complexes ..	56	Sandy peat flats ..	Flat to easy rolling ..	Dairying	Lime + superphosphate + potash, or basic slag + superphosphate + potash.
Bare sand drifts	57	..	..	..	..

well to top-dressings of superphosphate. They hold moisture better than the soils of type 4, and are used for dairying and sheep-farming. The clays and clay loams (types 6 to 9) are moderately fertile soils originally supporting mixed forest with a large proportion of broad-leaved trees. They are farmed extensively as dairying and grazing land.

The *semi-mature podsols* (types 10 to 12) are more strongly leached and consequently are less fertile. The original vegetation was forest rich in podocarp species and kauri. The topsoils are shallow and the subsoils greyish flecked clays. There is a greater need for lime to accompany phosphate top-dressing of pastures on these soils.

The *submature and mature podsols* (or podsols proper) are strongly leached soils showing the characteristic sequence of horizons. A shallow grey topsoil overlies a whitish siliceous horizon, which in turn overlies a pan of clay or cemented sandstone. In some places both humus and iron pans are present in the subsoil. The soils have undergone severe leaching, and in their natural state large areas support a scrub cover of stunted manuka and short rushes. Many of the soils of this group are proving to be valuable farm lands, but large areas are as yet unfarmed partly because of the difficulty of obtaining water.

Type 13, derived from lightly consolidated sandstone, is a particularly infertile soil. The topsoil is a coarse to medium sand which readily looses moisture during a dry spell and becomes saturated during rains owing to the humus and iron pans obstructing subsoil drainage. The predominating land forms are broad, flattish ridge-tops and steep V-shaped valleys, but in parts the ridge-tops are narrow and discontinuous. Much of the area is still in scrub, and where the pans are close to the surface farming is impracticable.

Types 14 and 15 have generally a light-grey to whitish silt loam topsoil overlying a heavy clay. Agriculturally, these are the most valuable of the gum lands, and when fertilized with heavy dressings of lime and phosphate they support good pastures. Where the topsoil is clay (type 16) the sowing to pasture is more difficult. Types 15 and 16 are so intermingled that they cannot be separated on a small-scale map.

Type 17, derived from andesitic rocks, resembles type 15, but the structureless silt loam topsoil is bluish-grey and the clay subsoil is brown. These soils appear difficult to farm, and their problems have not yet been studied.

Hill Complexes.—The hills covered with podsolized soils fall into four main divisions:—

Types 18 to 20 are largely a complex of skeletal and immaturely podsolized soils covering the steeper hills. In their natural state the topsoils are highly fertile, but sheet erosion and slipping consequent upon attempts at grassing rapidly lowers the fertility, and as the areas are difficult to top-dress invasion of second growth takes place rapidly. Areas of these soils are farmed as grazing-land, but they cannot be classified as permanent grassland.

Types 21 to 24 are complexes of soils (largely immature podsols) covering the rolling to steep hills. They are used extensively for grazing, but much land has reverted to second growth. Types 25 to 28 cover similar country, but are more leached, being largely semi-mature podsols. Being less fertile, the second-growth problem is more acute. These soils need lime, but the application is too costly.

The complex of soils included in type 29 are derived from lightly consolidated sandstone, and are less leached than type 13. The area is more dissected, and the flattish ridge-tops so typical of the latter type are less in evidence. The native vegetation is manuka scrub, and where this has been repeatedly burned the sandy soils have been much wind-eroded.

Types 30 and 31, the " gum land hills," are for the most part eroded podsols, and large areas have little or no agricultural value. Type 32 includes poor clay and gravelly clay soils derived from shattered silicified claystones. The land originally supported scrub with patches of light bush, and although attemps have been made to farm parts of the area the greater part has reverted to scrub and bracken fern.

D. *Red and Brown Loams.*

The soils of the red and brown loam group are derived from basaltic rocks. The red loams appear to be formed over scoriaceous rocks where the drainage is good, and the brown loams on flattish basalt sheets where drainage is intermittent. In periods of light rainfall the brown loams drain freely, but, having a low moisture-holding capacity, they dry out during rainless spells. During heavy rains, however, the underlying basalt sheet impedes drainage to such an extent that the soil becomes saturated and in many places the water-table rises above the surface of the ground. This feature is most noticeable on the shallower, immature types.

Although clay content is high, these soils have a free granular structure which imparts to them the properties of a loam. Being high in iron and alumina, they have the property of rendering soluble phosphates comparatively unavailable to plants. When adequately manured with lime and phosphates the soils of this group respond to potash.

Types 33 to 35 comprise the young and immature soils of this group. Type 33 is a fertile bouldery loam and makes good dairying-land. The boulders are cleared from the surface of the land and employed in the building of stone walls, giving the farms on this type a characteristic appearance. In type 34 the soil is deeper and boulders only break the surface on the slopes. The native vegetation on these two types was generally a rich broad-leaf forest with much taraire, puriri, and kohekohe.

The soil is thin and very bouldery on type 35. It is used for grazing, but the excessive number of surface boulders detracts from the value of the land. Pastures parch readily on these shallow soils. Type 36, the semi-mature soil, is more leached than the preceding types, and pastures show a more marked response to lime than on the less-leached brown loam.

Types 37 and 38, the submature and mature soils, are the most leached soils of the brown-loam group. A great part (especially of type 38) is scrub-covered, but patches of the original forest cover still remain. On flattish areas the soils and subsoils are so leached that the original forest must, for a long period, have derived its mineral nourishment almost entirely from the decay of its own leaf litter.

These soils are locally known as the " ironstone " soils because of the characteristic layer of ironstone nodules in the subsoil. In type 37 the iron nodules are generally small and they rarely form a definite band, whereas in type 38 the nodule layer is marked and in places it thickens and extends to the surface. The nodule horizon appears to have been formed not from iron leached from upper horizons, but to have grown *in situ* owing to extreme fluctuations of soil moisture. The " ironstone " soils are definitely problem soils, and although both grazing and dairying is practised on selected areas much is still unfarmed.

The only hill-soil complexes which can be shown on a map of this scale are the semi-mature types 39 and 40. Much of type 39 is bouldery and where farmed is used for grazing. Type 40 is only tentatively placed in this group, and is probably more nearly related to the brown granular clays described below. The soils on the flattish ridge-tops are greyish-brown and the soil granules are coarser than those of a typical brown loam; on the slopes the soils are more fertile and a brighter brown in colour. The original forest cover contained much kauri. The area is used for grazing and dairy-farming.

E. *The Brown Granular Clays.*

The brown granular clays are soils formed from rocks which are largely intermediate in composition between the basalts that give rise to the brown loams, and the rhyolites and dacites which give rise to normal podsolic soils. They are high in alumina and iron and consequently are closely related to the brown loams, but the soil clay is generally more sticky and the soil crumbs coarser, especially on the more leached types. Under special conditions of heavy leaching the most mature phase of these soils is the peculiar podsol described under type 17.

The immature and semi-mature soils cover easy country (types 41 and 42). They occupy only small areas.

The lowland submature type (43) is a brown to greenish-brown infertile granular clay developed under a rainfall of 70 in. to 80 in. per annum. It is used in part for grazing, but pastures are poor and need heavy dressings of lime and phosphate. The upland submature type (44) is a purplish to greenish-brown mottled granular clay occupying the flattish to easy rolling summit of Tutamoe Plateau (2,000 ft. to 2,500 ft. above sea-level), which receives an annual rainfall of over 100 in. per annum. The underlying rock is in many places close to the surface and the soil is saturated for a great part of the year. Much of the area is still covered with the original forest, but in places pastures have been established. Most of them are poor, and contain much moss, flatweed, and rush.

Hill complexes covered by soils of this group occupy a large area. Type 45, a complex of skeletal and immature soils, covers the steep hills. When first converted into pasture these soils are fertile, but the soils on the steeper slopes are, however, shallow and erode easily. The rainfall is heavier over the areas covered by type 46, slips are more common, and the steep hills are more difficult to farm.

Much of the forest covering of types 45 and 46 has been cleared, but it is doubtful if the pasture can be permanently retained. Types 47 and 48 cover the rolling to steep slopes; they are naturally fertile soils, and where cleared make good grazing-land. The soils of type 48 appear to be more leached than those of type 47, but the distinction is tentative.

The soils of type 49 are lighter brown and more leached than the preceding types. Some areas are grazed, but pastures are for the most part thin and poor and there is much reversion to second growth. Types 50 to 52 are complexes of brown granular clays derived from igneous rocks and podsolized soils derived from sediments. They are fairly fertile soils used for grazing and dairy-farming.

F. *The Ground-Water Soils.*

All the meadow clays derived from alluvium are included in type 53, although the soils near Ruawai and Dargaville are more fertile than those near Waipu and Hikurangi. The topsoils are grey and the subsoils whitish and mottled. Dairy-farming is carried out on these soils, despite the fact that natural drainage is poor and the soil tends to poach badly in winter. The areas lying within the Hikurangi Swamp are subject to frequent flooding and are consequently but poorly farmed. Adequate drainage is the prime need on this type of land. The meadow granular clays are derived mainly from basaltic alluvium, and both topsoil and subsoil have a strong granular structure. When drained these soils will support good pastures if adequately manured.

Type 55, the peats, have little agricultural value except in some marginal areas where alluvium is intermixed. Drainage of the peat is of little use unless accompanied by consolidation. Type 56 is a complex of sand ridges and peat-filled hollows. The areas on the west bank of the Wairoa River are mainly sandy peats which in many places contain much timber. The soils near Ruakaka are more complex. Close to the sea, ridges of young sand podsol alternate with hollows of peaty sandy loam; farther inland the sand ridges are older and the soils more leached. This area has recently been developed for dairying.

HAWKE'S BAY SOIL SURVEY: PROGRESS REPORT.

The mapping of genetic soil types in Hawke's Bay was continued during the 1938–39 field season. About 650 square miles were mapped in the northern and north-western portion of the province between Wairoa and Tarawera, and about 300 square miles in the western and southern districts near Makaretu, near Woodville, and between Weber and the coast. The work of adding greater topographic detail to earlier soil maps by means of air photographs has now been completed in Mid-Hawke's Bay. In Southern Hawke's Bay further details in the soil mapping are required on about 500 square miles, and a small area in Northern Hawke's Bay remains to finish the mapping of the province. Progress has been made with the writing-up of the soil types in Mid-Hawke's Bay district.

Description of Area mapped, Topography, Geology, Climate, and Vegetation.

The area mapped between Tarawera and Wairoa in the northern district is a continuation of the Napier-Mohaka area described in the last annual report. It is divided topographically into the same three units:—

(1) Western ranges and dissected country;
(2) Central easy rolling country broken by deep gorges;
(3) Coastal belt of steep country.

The western ranges and dissected country contain the Kaweka and other ranges, which are formed of indurated sandstones and mudstones called greywacke and argillite, probably of Trias-Jura age. Included here, also, are the deeply dissected hills formed of highly dissected beds of Tertiary sandstones, mudstones, and limestones which flank the ranges on the east. Taupo pumice, a volcanic-ash shower ejected from Lake Taupo, overlies the whole of this topographic division. It reaches a thickness of over 2 ft. in the west, but thins out to a few inches farther east.

Rimu-matai and beech forest is found on the western greywacke ranges, while fern and scrub appear to have once covered most of the remainder of this area. In general the rainfall ranges from 60 in. to 70 in.

The central easy rolling country is a continuation of the belt about four miles wide trending north-east and centred on the Napier–Wairoa road between Tutira and Putorino. North of the Mohaka River, moderately steep slopes occupy a good deal of this belt. The topography is determined by gently tilted sandstones and mudstones with a little limestone and conglomerate broken by deep gorges. Covering the surface is the Gisborne shower, a pumice-ash shower ejected from Lake Taupo before the Taupo pumice. The rainfall ranges from 50 in. to 60 in.

The coastal belt contains very steep country which gives place to fertile alluvial flats near Wairoa, and to broad gently sloping terraces along the banks of the Mohaka and Waihua rivers. The rocks consist mainly of Tertiary mudstones and muddy sandstones. Volcanic ash of the Gisborne pumice shower is found only on gentle slopes. The rainfall is generally below 60 in., and the original vegetation was probably tall bracken fern.

The northern area therefore includes high ranges on the west and steep country on the east, while a comparatively small area of rolling ploughable hills is situated in the east-central portion and along the sides of the main streams. Infertile volcanic ash covers the western area and gradually thins out towards the east, where, near the coast, it is only found upon gently sloping country.

The area mapped near Woodville and between Weber and the coast in Southern Hawke's Bay practically completes the southern continuation of the country described in the 1936–37 report. The three topographical units described in this report are represented. They are—

(1) Western ranges;
(2) Central plains; and
(3) Coastal belt of steep and rolling country.

Just north of the Manawatu Gorge a narrow belt of Tertiary mudstones overlies the greywacke and argillite rocks of which the *western ranges* are formed and gives rise to more fertile soils, resembling those in the coastal belt. The flats about Woodville represent the southern continuation of the *central plains*, but they are heavier and more fertile than the northern terraces. In the *coastal belt* Tertiary mudstones, sandstones, and limestones form the parent material of most of the soils. Much of the country is steep, but a considerable area of rolling, ploughable hills is found on the east and north-east of Waewaepa Range. The soils on these rolling slopes are derived from Tutamoe muddy sandstones, and are fairly poor, except in a few areas where forest formerly flourished. In the central and eastern portions of the coastal belt, hard white mudstones (white argillites) are the parent material of the soils. The Waewaepa Range, on the other hand, consists of greywacke, and the soils resemble those derived from similar rocks on the west of the province.

Classification of Soils.

The soils of Hawke's Bay have been divided into five major groups: *Rendzina*, *New*, *Brown-yellow*, *Podsol*, and *Recent Groups*. All but the *New Group* are recognized in other parts of the world, so that information accumulated abroad concerning them can be utilized in dealing with them in Hawke's Bay.

The division of each major group into types according to the amount of leaching or loss of plant nutrients undergone gives a classification of agricultural value, because each kind of soil is characterized by definite physical and chemical properties. The amount of leaching, &c., depends

on the slope of the land, so that slope enters into the soil classification; and it is found that soils derived from the same parent material under the same climate and vegetation have fairly uniform characteristics when found within the following ranges of slope :—

(1) *Very steep.*—Over 35° or 40°—*i.e.*, over 70 per cent. or 85 per cent. slope.
(2) *Steep.*—Between about 30° and 35°—*i.e.*, 60 per cent. and 70 per cent. slope.
(3) *Moderately Steep.*—Between about 21° and 30°—*i.e.*, 40 per cent. and 60 per cent. slope.
(4) *Rolling.*—Between about 4° and 21°—*i.e.*, 7 per cent. and 40 per cent. slope.
(5) *Flat.*—Below 4°—*i.e.*, 7 per cent. slope.

These slope divisions are not rigidly defined. For example, a soil derived from claystone, because it is broken by slips, may lie on slopes classified as moderately steep, although the average angle of slope is not more than 18°. On the other hand, a well-drained, stable soil may lie on slopes that are classified as rolling, although they may slightly exceed 21°. Slope divisions of this nature are of agricultural value when included in the soil classification. The rolling slopes are normally ploughed in Hawke's Bay for pasture or cropping purposes, while the moderately steep slopes are only ploughed occasionally with the use of modern hillside-ploughing equipment. Steep slopes seriously hinder access or the transfer of equipment and they might prove dangerous to stock, especially in wet weather. Slopes included in the very steep division are too steep to allow access or the transfer of equipment, except with extreme difficulty. Such slopes hinder the movement of stock from one area to another, and in many cases they are bare of soil.

Altogether sixty-nine soil types and seventy-five phases have been recognized.

Description of Soil Groups.

The *Rendzina Group* contains soils derived from limestone. Fragments of limestone are found throughout the profile where the soils lie on very steep slopes and belong to the *recent* stage, and in the subsoil or deep subsoil when the soils rest on moderately steep or rolling slopes and belong to the *young* or *semi-mature* stages. The soil types are all well supplied with lime and other bases and they are usually neutral or only slightly acid. The types on gentler slopes are fairly low in phosphate and medium to high in potash, but those on steeper slopes are high in both these plant nutrients.

The *New Group* soils of Hawke's Bay have been described in other reports. The soils are usually derived from sandstones and mudstones. Soil types of the *recent* stage lie on very steep slopes and the profiles are constantly being renewed by slipping. They are neutral to slightly acid and are usually high in potash and bases, but the phosphate content ranges from medium to low. The *young* stage contains types found on steep slopes, and the profiles are renewed by slipping less frequently than those belonging to the *recent* stage. Usually the soils are slightly to moderately acid, moderately high in potash, and well supplied with bases, although in one or two cases where they are derived from non-calcareous rocks the base content may be low. The phosphate content is invariably low. In the *immature* stage the types have fairly compact subsoils and lie on moderately steep slopes that are not normally ploughed, while in the *semi-mature* stage the soils are ploughable and the subsoils are compact and often cemented to form a hard pan. In these stages the types are low in phosphate and medium to high in potash. In general, it may be said that the immature soils are neutral to moderately acid and fairly well supplied with bases, while the semi-mature soils range from slightly to strongly acid, and several types are sufficiently low in potash and lime to expect responses from fertilizers containing them. Usually New Group soils develop under a rainfall of less than 60 in. Where the rainfall rises above this figure forest is often found and the soils are strongly leached of bases, in contrast with the normal soils developed under lower-rainfall conditions under a cover of bracken fern.

The *Brown-yellow Loam Group*, which contains forest soils fairly high in iron oxides and alumina, is prominent on the western and southern portions of the province, and is subdivided into stages in the same way as the New Group. Most of the soils are light and fluffy and they are usually low in plant nutrients. They are all low in phosphate, and a good deal of the soluble phosphate added becomes available with difficulty to the plants. The *recent* and *young* stages contain soils lying on steep and very steep slopes. They are moderately to strongly acid, moderately low to very low in bases, and usually low in potash, so that potash responses might be expected. The *immature* soils are found on moderately steep slopes or upon old terraces. They are slightly to moderately acid and are low or very low in bases. The potash content ranges from medium to low. In the *semi-mature* stage the soil types recognized are found on rolling ploughable slopes. They are moderately acid and of moderate to very low base content, while the potash content is usually medium. On the chemical evidence it is to be expected that lime responses would be obtained on the semi-mature soils.

The *podsolic soils* of pumiceous origin are divided into two divisions according to whether the volcanic ash is over or under 3 ft. in depth. Within these two divisions the soils are grouped according to the slopes on which they are found and the vegetation under which they have developed. Where forest formerly grew, the soils are more fertile in the natural state, but this natural fertility is usually transient unless kept up by artificial top-dressing. These volcanic pumice soils are very light in texture, moderately to slightly acid, moderately low to very low in bases, and moderate to low in phosphate and potash.

The *recent alluvial soils* are derived from sediments of mudstone, sandstone, and limestone laid down on the flood plains of rivers within comparatively recent times. They range in texture from heavy clays to sands and stony gravels. Where the soils are still within the zone of flooding they are very high in lime and other plant nutrients and little response is obtained from artificial fertilizers. Where, however, they have been removed from the zone of flooding for some time a certain amount of leaching of plant nutrients has occurred and a slight response from phosphate top-dressings may be obtained.

Three other minor groups of soils are recognized. They are—

Meadow soils, which are poorly drained and acid;
Organic soils, which are peaty and of fairly high fertility; and
Saline soils, which are found on salt areas recently reclaimed from the sea.

Hawke's Bay Bulletins and Land-type Map.

Now that the writing-up of the work is well in hand, attention has been given to presenting soil information in a form which can be easily understood and appreciated by farmers and others. It has been found that the individual farmer requires to know the main soil types on his property before the soil map can be of reasonable practical value to him. Soils are shown, therefore, by means of sixty-nine colours and hatchings. Maps showing so many types are too detailed to be of reasonable practical value to administrative officers and others who are concerned with the district in a more general way than the individual farmer. To provide for this section of the community a *land-type map* is being constructed under the guidance of the farm-management branch. All soil types and phases are grouped into about thirty *land types*. Each land type includes soils having a definite range of slope and range of fertility. The general character of the land in any part of the province can be seen at a glance from such a map. The pumice areas, range country, steep country, gorges, good rolling hills, light terraces, heavy fertile flats, &c., stand out conspicuously.

CHEMICAL WORK AT THE CAWTHRON INSTITUTE.

Sir Theodore Rigg, Officer in General Charge.

Introduction.

During the past year routine analyses of soil samples collected by the pedologists carrying out soil surveys in Hawke's Bay, North Auckland, and Waipa County have formed the principal part of the work undertaken in the soil laboratory. Determinations of available plant-food, base-exchange capacity, and base saturation have been made on a large number of samples. Mechanical analyses for the designation of textural types have likewise been carried out on a wide range of soils.

Podsolization of highly leached West Coast soils has been further studied, and data bearing on the podsolization of recent sands at Westport are included in this report.

In view of the importance to soil surveyors and agricultural instructors of chemical tests which would give a reliable indication of the plant-food content of soils under field conditions, considerable attention has been given to the careful examination of Bray's method for estimating phosphate and Spurway's method for estimating potash in soils. The data presented in this report show that both methods have considerable value in discriminating between soils containing a low or good supply of these plant-foods.

A great deal of time has been spent by the chemical staff in assembling information for the soil-survey reports dealing with the Heretaunga Plains, Banks Peninsula, Westport, and the tung plantations of North Auckland.

Soils of the Heretaunga Plains.

During the year the chemical analyses of soil samples from the Heretaunga Plains have been completed, and in collaboration with the pedologists responsible for the classification and mapping of soils the results have been written up as a section of Bulletin No. 70, "Land Utilization Report of the Heretaunga Plains."

The chemical analysis show that the soils of the Heretaunga Plains, for the most part, are highly fertile. Available plant-food is notably high and there is a satisfactory base saturation, seldom being less than 40 per cent. and sometimes reaching 100 per cent. Soils of the Hastings and Pakowhai series—used extensively for fruit—are outstanding in available plant-foods and base content. In these soils the percentage of available phosphoric acid and potash seldom falls below 0·040 per cent., while the pH values range between 6 and 7, indicating that the soils are neutral or only slightly acid. Determinations of plant-food in the subsoil show that the soils have a natural high fertility, due to the very recent origin of the deposits.

The Pakipaki and Ngatarawa soils may be quoted as exceptions to the high fertility of Heretaunga Plains soils. In these soil groups available phosphoric acid tends to be low and the supply of potash is only moderate.

In the Farndon and Meeanee series the reaction of the soils is frequently alkaline, and high content of soluble salts in some interferes with optimum crop production. These soils in the past have been under tidal influence, and, although few are now affected by fluctuations in the sea-water level, soluble salts from sea-water inundation still persist in the soils.

The problem of improvement of these soils appears to be largely a matter of thorough leaching and of under-drainage. There is no evidence that calcium has been displaced from the clay complex by the action of sea-water. On this account the structure and drainage qualities of the soil have not been seriously affected, and soils of high fertility should result as soon as the soluble-salt content has been reduced to a satisfactory level.

Soils of the Waipa County.

During the past five years many chemical analyses of Waipa soils have been made, and a report covering the field classification and the chemical data of the soils is now in the press. The Waipa County is noteworthy in that soils of naturally low fertility have been so improved by top-dressing that the carrying-capacity has been raised at least sixfold. Phosphatic fertilizers, mainly superphosphate, have been responsible to a great extent for pasture-improvement and the accompanying increase in carrying-capacity. As a general rule, 3 cwt. to 4 cwt. of superphosphate per acre has been the amount of the annual top-dressing, but on some farms the rate of application has exceeded these amounts for several years in succession. The following figures illustrate the improvement in plant nutrients which has resulted from the top-dressing of two typical soils :—

Soil Type.	Available Phosphoric Acid.	
	Unmanured.	Manured.
	Per Cent.	Per Cent.
Hamilton clay loam	0·001	0·019
Te Kowhai loam	0·005	0·050
	0·004	

Some of the Waipa soils resemble some of the red-brown loams of North Auckland in that a high percentage of ferric oxide in the soil tends to lower the efficiency of the superphosphate top-dressing as a result of a reaction between the iron compounds of the soil and soluble phosphates. On such soils basic phosphates and the more liberal use of lime deserve special consideration.

So far, potassic manures have not been extensively used in the Waipa County. There is, however, increasing evidence to show that as a result of depending on phosphatic top-dressings the reserves of potash are being depleted. This is particularly true of pastures which are frequently cut for hay or ensilage. The Horotiu and the Te Kowhai soil types now show rather low figures for available potash. For instance, two soils receiving a yearly application of 2 cwt. to 3 cwt. of superphosphate now contain only 0·012 and 0·016 per cent. available potash, as compared with 0·034 per cent. on an adjoining unmanured field.

Waipa soils, in general, are of medium acidity, with pH values ranging between 5 and 6. This, combined with a rather low percentage of base saturation, suggests that more attention should be paid to lime treatment of the pastures. Base-saturation figures show that, of the different soils, Hamilton clay loam is least in need of lime. This soil type is followed by the Waikato, Whatawhata, Ohaupo, Te Kowhai, and Horotiu series, with the Rotokauri and Te Rapa series most in need of lime supplements.

Westport Soils.

Further studies have been made of the podsolization process which is so characteristic of highly leached soils on the West Coast. In a previous report data have been presented illustrating podsolization in pakihi soils near Westport. The leached condition of the topsoil and the presence of an iron-humus pan at a depth of 12 in. to 20 in. are typical features of all pakihi soils at Westport.

During the past season a study has been made of podsolization which is even now taking place on the recent sands adjacent to the sea-beach at Sergeant's Hill and at other localities on the West Coast. Samples of sand from the sea-beach have been compared in the chemical laboratory with samples of older sands which have been subjected to leaching for considerable periods. For the sake of comparison a typical pakihi soil of the same textural type has been included in the studies. The results of the chemical examinations are shown in Tables I and II.

Table I.—Podsolization Studies on West Coast Sands.

Laboratory No.	Depth of Sampling	Horizon.	Available.		pH Values.	Base Exchangeable Capacity.	Total Exchangeable Bases.	Base Saturation.	Remarks.
			Potash.	Phosphoric Acid.					
	In.		Per Cent.	Per Cent.		m.e.	m.e.	Per Cent.	
2224 ..	..	..	0·015	0·082	6·2	..	..	..	Medium sand from sea-beach.
2225 ..	0–6	A_1	0·007	0·010	4·4	12·8	1·1	8·6	Consolidated sand-dunes close to beach.
2226A ..	10–20	A_2	0·002	0·007	4·6	9·0	0·2	2·2	
2055 ..	2–6	A_1	0·005	0·005	4·6	10·2	0·4	4·4	Sandy flats, Utopia Road, with high water-table, and pan at 18 in.
2056A ..	6–15	A_2	0·006	0·004	4·4	9·2	0·3	3·8	
2056B ..	15–27	B	0·003	0·072	5·0	6·6	Nil	Nil	
2056C ..	27+	C	0·004	0·069	4·9	3·1	0·1	3·2	
2211A ..	0–3	A_1	0·010	0·003	4·2	18·6	1·2	6·5	Typical pakihi terrace with pan at 18 in.
2211B ..	3–9	A_1	0·006	0·002	4·4	14·4	0·6	4·2	

In Table I data are presented for sea-sand from the beach, for samples of sand from consolidated sand-dunes adjacent to the beach, and for older sandy flats which before drainage had a water-table at a depth of 18 in. Samples 2211A and B are taken from a pakihi terrace behind the sandy flats. This terrace represents an earlier sea-beach of this locality. The sea-sand (sample 2224) shows a high content of available phosphoric acid, a moderate supply of available potash, and a pH value of 6·2. Samples

2225 and 2226A, from the consolidated sand-dunes, reveal to a noteworthy extent the effect of leaching during what geologically must be considered a short period. A very great reduction in the percentages of available potash and phosphoric acid has taken place. The reduction in plant-food is accompanied by marked soil acidity and by poor base saturation.

Samples 2055 to 2056C, taken from sandy flats behind the sand-dunes, are of particular interest in that the podsolization process has reached the mature stage. Throughout the whole profile leaching of potash and other bases has taken place. Every horizon in the profile is markedly acid and has a very low base saturation. The percentages of available phosphoric acid in the different horizons show a marked difference between the very leached horizons, A_1 and A_2, and horizon B, where pan formation has taken place. Horizon C, below the pan, likewise has a high content of available phosphoric acid. The percentages of phosphoric acid in horizons B and C compare favourably with that found in the unleached sea-sand, sample 2224.

Samples 2221A and B, from the pakihi terrace, reveal in their contents of phosphoric acid the full extent of the leaching process. Here not only are the soils markedly acid, but the percentages of phosphoric acid have been reduced to the low levels of 0·003 and 0·002 per cent. respectively.

TABLE II.—PODSOLIZATION STUDIES ON WEST COAST SANDS.

Laboratory No.	Depth of Sampling.	Horizon.	Available Phosphoric Acid.	pH Values.	Total Exchangeable Bases.	Iron as Fe_2O_3*	Organic Carbon.	Remarks.
	In.		Per Cent.		m.e.		Per Cent.	
2055 ..	2–6	A_1	0·005	4·6	0·4	1·4	2·7	Sandy flats, Utopia Road, with high water-table, and pan at 18 in.
2056A ..	6–15	A_2	0·004	4·4	0·3	2·1	2·1	
2056B ..	15–27	B	0·072	5·0	Nil	4·0	1·0	
2056C ..	27+	C	0·069	4·9	0·1	Trace	0·4	

* Iron determined by Drosdorf and Truog's method.

In Table II further data for the mature podsol developed on the sandy flats illustrate the accumulation of iron in the B horizon or "pan" layer. The "pan" layer not only has a greatly increased content of iron, but retains the high percentage of phosphoric acid. Organic carbon is present in the pan to the extent of 1 per cent. All horizons in the profile are equally low in exchangeable bases.

Fertility of Pakihi Soils under Pasture.

In the establishment of pasture on pakihi land at Westport, the investigations of the Cawthron Institute have shown that an initial treatment of 1 ton of ground limestone and 5 cwt. superphosphate per acre is essential for satisfactory results. Under grazing-conditions a top-dressing of 2 cwt. superphosphate per acre has maintained good pasture-production over a period of several years. Experience has shown that further lime treatment is desirable at the end of the second year after establishment, otherwise there is a rapid decline in growth of clovers, lotus, and of total grass-production.

In view of these circumstances it was considered of interest to examine a series of soil samples taken from pasture plots which had been treated in different ways. In each case the soil samples were taken six years and a half after the original treatment of the land and the establishment of pasture. The chemical data from a series of three plots are presented in Table III :—

TABLE III.—PAKIHI SOILS : FERTILITY STATUS UNDER PASTURE.

Laboratory No.	Depth of Sampling.	Available Plant-food.		pH Values.	Base Exchangeable Capacity.	Total Exchangeable Bases.	Base Saturation.	Remarks.
		Potash.	Phosphoric Acid.					
	In.	Per Cent.	Per Cent.		m.e.	m.e.	Per Cent.	
2211A ..	0–3	0·010	0·003	4·2	18·6	1·2	6·5	No treatment.
2211B ..	3–9	0·006	0·002	4·4	14·4	0·6	4·2	
2213A ..	0–3	0·011	0·010	4·3	18·1	3·4	18·8	1 ton lime and 5 cwt. super. 1931, with annual top-dressing 2 cwt. super.
2213B ..	3–9	0·009	9·004	4·3	16·1	1·0	6·2	
2215A ..	0–3	0·009	0·007	4·7	21·3	5·8	27·2	2 tons lime and 5 cwt. super. 1931, with annual top-dressing 2 cwt. super.
2215B ..	3–9	0·005	0·003	4·2	18·1	2·4	13·3	

NOTE.—Soil samples collected November, 1937, six years and a half after original lime application.

The results show that, while the phosphate content of the treated plots has been increased, the increase is confined very largely to the top 0 in. to 3 in. of soil. In the case of the plot treated originally with 1 ton of ground limestone per acre, the pH value now approximates closely to that of the untreated plot, while the amount of exchangeable bases is very low.

Samples from the plot treated originally with 3 tons of ground limestone per acre do not show such a large accumulation of phosphate, but the amount of exchangeable bases and the pH value both show a much better lime status of the soil.

Field Tests for Plant-foods.

In recent years methods have been devised by overseas chemists for the rapid estimation of both phosphoric acid and potash in soils. These methods have been found of special value in the field where immediate information is required concerning the approximate percentage of these plant-foods in different soils. It was considered desirable, therefore, to test out the rapid methods against standard laboratory procedure, with a view to their adoption by the pedologists if the results were comparable

Phosphate Estimation.—The method adopted for the rapid estimation of phosphoric acid in soils was that of Bray (*Brit. Chem. Abs.*, 1930, 295). A large number of soil samples representing many contrasting types in New Zealand were examined by Bray's method and also by the standard citric-acid method which has been adopted by British soil chemists. The results of the tests showed that the Bray method was successful in grouping the soils into low, medium, and high groups. Adopting the following group limits for the citric-acid results—namely, *low*, less than 0·02 per cent; *medium*, 0·02 per cent. to 0·04 per cent.; *high*, greater than 0·04 per cent. for 0 in. to 3 in. soil samples—a good correlation was obtained for the results by the two methods for soils with a low phosphate content. The correlation of the results for soils in the medium and high groups was not so good, due possibly to the influence of organic phosphates, which would be more soluble in citric-acid solution. The fact, however, that soils low in phosphate are readily picked out by Bray's quick test is of great value, as it will assist pedologists and agricultural advisers in rapidly assessing the fertility of the soil.

Typical results with Bray's method in comparison with the standard citric-acid method are shown in Table IV:—

Table IV.—Comparison of Bray's and Citric-acid Method of Phosphate Estimation.

Laboratory No.	Grouping by Bray's Method.	Citric acid P_2O_5.
		Per Cent.
1986A	Low	0·010
2007	Low	0·003
2028B	Low	0·002
2029	Very low ..	0·010
2031	Low	0·007
2055	Very Low ..	0·005
2465	High	0·077
1973	High	0·066
2433	Medium-low ..	0·030
2461	Medium	0·036
2459	Medium	0·046
2460	High	0·042
2497*	Medium	0·099
2509	Very high ..	0·062

* Loss on ignition, 25 per cent.

Potash Estimation.—Spurway's rapid method for potash has been tested against both the citric-acid and the replaceable-potash methods. In previous reports mention has been made of the satisfactory correlation of results obtained with the citric-acid and the replaceable-potash methods, and this has been confirmed again in a series of tests made on a large number of New Zealand soils. Exchangeable potash approximates fairly closely to 1·6 times the amount of available potash determined by the citric-acid method.

Determinations of potash made by Spurway's method gave results about one-third of those with the citric-acid extraction. The correlation was sufficiently close as to warrant the transposition of the results using the above ratio. Table V illustrates the close agreement of the final results:—

Table V.—Comparison of Spurway's and Citric-acid Potash Results.

Laboratory No.	K_2O. Spurway's Method, X 3·3	K_2O. Citric-acid Method.
	Per Cent.	Per Cent.
2404	0·006	0·005
2441	0·012	0·016
2447	0·066	0·074
2217	0·012	0·019
1365	0·070	0·058
1909	0·009	0·011
2397	0·040	0·041
Average, thirty soils	0·028	0·029

Tobacco Soils of the Nelson District.

The chemical examination of a number of soil samples collected in the survey of tobacco lands in the Nelson District has commenced. Mechanical analyses of samples from the Motueka-Riwaka area have confirmed the tentative field classification of the soils.

General.

During the past year Dr. J. K. Dixon has remained in charge of the soil laboratory and has been responsible for much of the work included in this report. He has been ably assisted by Messrs. A. Metson, L. Hodgson, and J. T. Corder. Mr. A. C. Harris, who was responsible for the chemical analyses of the Westport soils included in this report, resigned his position at the Institute early in 1938 in order to take up an appointment in Australia.

CHEMICAL WORK AT SOIL SURVEY LABORATORY, WELLINGTON.

The work of this laboratory during the period under review has been of a widely varied nature. The bulk of it has centred on the Waikato District, where, since July, a continuous study of nitrate and ammonia in soils has been made. The analyses of soil samples from New Zealand dependencies in the Pacific, where data were required for a variety of purposes, have also occupied some time. Routine analyses have been made on samples collected during the course of soil surveys in the Hawke's Bay, Manawatu, and Marlborough districts. In addition, much time has had to be spent in trying out methods and apparatus before technique could be standardized.

Hawke's Bay.

Some of the chemical analyses of the soil samples collected by the pedologists in Hawke's Bay have been made in this laboratory. Conclusions drawn from the analyses are incorporated in the report on the province which appears on page 53.

Pacific Island Soils.

Five composite samples from the Kermadec Islands and two pit samples from the Cook Islands (to 54 in. depth) were tested for acidity and exchangeable bases. The Kermadec samples on the whole showed a high fertility, the soils being almost uniformly base saturated and fairly well supplied with plant-foods. The Cook Island soils likewise had a high content of available plant-food, almost complete base saturation, and a slightly alkaline reaction. The soils contained appreciable amounts of free carbonate, which did not have the expected effect on the base-exchange determinations. The presence of siderite (hydrated ferrous carbonate) was accordingly postulated as a possible form in which carbonate might be present in these soils. The soils of these tropical islands have a distinctly higher fertility than those of Western Samoa and Niue Island.

Analyses made by officers of the Dominion Laboratory had shown the presence of appreciable amounts of chromium in some laterite soils from Western Samoa and Niue Island. The total chromium in these soils was of the same order as in some South African soils where this element was having a toxic effect on citrus trees. Further investigations were made in order to ascertain the amounts of this element present in hydrochloric acid soluble and in exchangeable form. Satisfactory methods were worked out for the rapid determination of hydrochloric soluble and exchangeable chromium. Chromium (and also nickel) in exchangeable form was not found in the soils from Western Samoa, Niue, or Cook Islands, but a laterite soil from Siota, in the Solomon Islands, which is derived from serpentine rock and is apparently infertile, showed appreciable amounts of the two elements in this form. Hydrochloric-acid-soluble chromium was of the same order in both the fertile and infertile soils.

Although the total chromium figures for Samoan and Niue soils are in excess of what have been considered toxic in other parts of the world, there is little doubt that more reliance should be placed on the exchangeable-chromium figures, as these are by analogy with major elements much more likely to indicate the amounts that can be taken up by plants. This may furnish an explanation of the fact that there does not seem to be any markedly toxic effect observed in Samoa and Niue which could be ascribed to chromium compounds in the soil.

Aerodrome Soils.

Soil samples from a proposed aerodrome-site were examined, with particular reference to drainage properties. Although the position with regard to drainage tests on soils as revealed in the literature is rather unsatisfactory, drainage rates under suction were observed in the laboratory, and heat of wetting determinations were made in view of a correlation which has been worked out by H. Janert (*Imperial Bureau of Soil Science Technical Communication No. 27*) between this value and the necessary spacing of tile drains at a specified depth. The soils were closely compared with a soil from the Palmerston North aerodrome, which is known to be satisfactorily drained. Laboratory drainage tests were complicated by the fact that the Palmerston North soil puddles easily, whereas the soils under test possessed a good water-stable structure, although their texture as given by mechanical analysis was rather heavier than that of the Palmerston North soil. Experiments are being made with an apparatus which it is hoped will give value for drainage rates under field conditions.

General.

Saline Area near Dillon's Point, Wairau Plains.—In order to finalize the soil survey of this area which was made in 1937, a number of samples of soil and ground water were collected in August, 1938. On the areas where reclamation would be profitable, the problem is simply one of removing from the soil the soluble salts in which chloride preponderates. Except possibly where the land is subjected to flooding by sea-water or has a permanently high and very strong saline ground water, the proportion of sodium in exchange complex is not sufficiently high to affect the physical character of the soil, but such places are not considered suited for any immediate scheme that may be put forward. On the land more suitable for reclamation where the ground water is still strongly saline initial deep drainage would be necessary, but on account of the low-lying nature of the country this would need to be coupled with some extensive pumping scheme.

Soil Colours.—The colours of a number of soils from Hawke's Bay and North Auckland were determined by means of the Maunsell spinning-disk method. This has been done to obtain a uniformity in names used by pedologists in New Zealand and to compare our soils with those in other countries to which standard names have been given. Colours are important in soil-work, since they give valuable information regarding certain characteristics.

TABLE IV.—SOIL COLOUR ANALYSES.

Soil Type.	Colour Group. (American System.)	Colour Analysis : Colour Percentage.			
		Red.	Black.	Yellow.	White.
Rendzina, Te Onepu Road, Hawke's Bay	Red-brown ..	18·0	52·0	19·0	11·0
Brown silt loam, Takapau Plains, Hawke's Bay ..	Brown-black ..	8·5	77·5	9·5	4·5
Pumiceous sands, Rissington Road, Hawke's Bay ..	Yellow	19·0	20·0	35·0	26·0
Kaihu sand, North Auckland	Grey	17·0	27·0	11·0	45·0

SOIL EROSION.

In October a Committee of specialists was set up by the Government under the ægis of the Department of Scientific and Industrial Research to inquire into and report on measures necessary for the preservation of vegetation in New Zealand, with special reference to the incidence, control, and prevention of land erosion. The setting-up of the Committee followed representations from the Royal Society of New Zealand, the Royal Agricultural Society, and the Council of Scientific and Industrial Research. The following was the personnel of the Committee: N. H. Taylor, Pedologist, Soil Survey Division, Department of Scientific and Industrial Research (Chairman); H. H. Allan, Director, Botany Division, Plant Research Bureau, Department of Scientific and Industrial Research; R. P. Connell, Land Utilization Officer, Department of Agriculture; C. A. Cotton, Professor of Geology, Victoria University College; E. R. Hudson, Director, Canterbury Agricultural College; E. B. Levy, Director, Grasslands Division, Plant Research Bureau, Department of Scientific and Industrial Research; C. M. Smith, Chief Inspector, State Forest Service; J. M. Smith, Fields Superintendent, Department of Agriculture.

The Committee held two meetings, and the individual members reported on the subject from their own specialized knowledge. The full report is in the process of publication as Bulletin 77 of the Department of Scientific and Industrial Research. The report states that in many areas soil erosion has reached a serious stage and, if uncontrolled, will accelerate rapidly. An alarmist attitude is deprecated, however, as in few cases is the damage beyond repair.

A recommendation is made that statutory and administrative measures should be taken at the earliest opportunity to inaugurate a programme to handle the serious soil-erosion, soil-conservation, and land-utilization problems that are now apparent. In such a programme the preservation and establishment of a stable vegetative cover of a due proportion of forest shrubland and grassland will be of great importance. This programme would require the active collaboration and co-operation of foresters, agrostologists, botanists, agriculturalists, engineers, and soil technologists.

MINERAL CONTENT OF PASTURES.

COBALT INVESTIGATIONS AT THE CAWTHRON INSTITUTE, PERIOD 1938–39.

Sir THEODORE RIGG, Officer in General Charge.

In previous reports mention has been made of the successful use of cobalt salts in overcoming stock ailment at Glenhope, Nelson, and at Morton Mains, Southland. During the past year investigations relating to the use of cobalt have been continued at both these centres and work has been established in the Sherry Valley, Nelson, and at Sergeant's Hill, Westport, where stock ailment of the "bush-sickness" type has been identified. Studies relating to the manufacture and use of cobaltized fertilizers have been continued, and further work has been done on seasonal variation of the cobalt content of typical pastures in the Nelson district and at Morton Mains, Southland.

With the aid of a special grant from the New Zealand Wool Publicity Committee and the New Zealand Meat-producers' Board a survey of the cobalt content of representative pastures in the South Island has been commenced and valuable information has already been obtained concerning the cobalt status of different pasture areas in the South Island.

I. COBALT SURVEY OF PASTURES IN THE SOUTH ISLAND.

During the past year pasture sampling has been carried out in the Ashburton County, Canterbury, in Southland and in the Sherry, Westhaven and Takaka districts of Nelson. On the West Coast pastures have been sampled at Karamea, Westport, Greymouth, and in the Grey–Reefton Valley. Surveys of a less detailed nature have been made in North Canterbury and in Marlborough. Although cobalt analyses have not yet been completed for all pasture samples, the results available have already shown a low-cobalt status in several pasture areas.

(*a*) *Ashburton County, Canterbury.*

Previous investigations of the Institute have shown that Ashburton soils possess only a medium supply of cobalt. The loess soils, which are so well represented on the Plains, contained approximately 7 p.p.m. of cobalt, two of the stony soil types being as low as 5·5 p.p.m. of cobalt. The more recent soils of the Ashburton and Rangitata rivers had rather higher figures, ranging from 7 p.p.m. to 10 p.p.m. cobalt. Under these circumstances it was thought that pasture samples might show in certain cases a somewhat low cobalt status. This has not proved to be the case, however, for all samples of pasture have given satisfactory cobalt figures.

Typical pastures representative of the more important soil types have been sampled at two different periods. For the loess soils pasture samples have given an average cobalt content of 0·17 p.p.m., with minimum and maximum figures of 0·10 p.p.m. and 0·27 p.p.m. cobalt respectively. Pastures associated with the recent soils of the Ashburton and Rangitata rivers gave an average cobalt content of 0·23 p.p.m. The lowest figure for cobalt was found at Anama, where one pasture sample contained 0·08 p.p.m. In no case did the cobalt figures approach the low values associated with cobalt deficiency at Glenhope, Nelson, or at Westport.

(*b*) *Southland.*

Three samplings have been made of selected pastures in the Winton, Edendale, and Otara districts of Southland. Cobalt analyses have not yet been completed on all the samples and interpretation of the available results is rendered difficult by seasonal variation of cobalt status and in some cases by soil contamination of the pasture samples. The results, however, do show that pastures located on recent alluvial soils possess a satisfactory cobalt status. In no case did the cobalt content of these pastures fall below 0·11 p.p.m.

Pastures associated with the loess soils of the Invercargill district, however, tended to give low cobalt figures. At Morton Mains cobalt contents of 0·04 p.p.m. to 0·05 p.p.m. were not infrequent. Again, certain pastures at Waipango, Otara, Waimahaka, and Tuatapere gave cobalt contents of 0·05 p.p.m. to 0·06 p.p.m.

The cobalt figures for pastures associated with the loess soils suggest that cobalt supplements should prove beneficial to stock. At the present time, however, it is difficult to give a satisfactory explanation for differences in stock health which have been noted on different farms located on loess soils in the Invercargill district.

(*c*) *Survey of Pastures in the Nelson–Collingwood Districts.*

A very detailed cobalt survey of soils and pastures in the Sherry–Wangapeka district and of pastures in the Westhaven–Collingwood district has been made.

The survey has shown that soils derived from granite in the Sherry, Wangapeka, and Dart valleys contain approximately 1·0 p.p.m. cobalt, while the pastures associated with them contain only 0·04 p.p.m. cobalt. These figures definitely indicate cobalt-deficiency as a major factor militating against good stock results in this district. Soils derived from limestone, basic rocks, and Ordivician slates gave much higher figures for cobalt, but the pastures associated with them did not always show a correspondingly high level of cobalt.

In the Westhaven district the cobalt estimations on typical pastures located on conglomerates, sandstones, and dune sands have shown a low cobalt status with figures ranging from 0·03 p.p.m. to 0·06 p.p.m. Pastures located on sandy limestone—reputedly healthy to stock—gave a cobalt figure of 0·08 p.p.m., while a cow pasture on alluvial soil at Collingwood contained 0·13 p.p.m. cobalt.

(*d*) *Survey of West Coast Pastures.*

Samples of typical pastures on the West Coast have been collected at Karamea, Westport, Greymouth, Hokitika, Murchison, and in the Grey–Reefton Valley. The analyses have shown that pastures associated with the recent alluvial soils of the Karamea and Oparara rivers, of the Buller and Matakitaki rivers, and of the Grey and Hokitika rivers have a satisfactory cobalt status. The average cobalt content for this group of pastures exceeds 0·20 p.p.m. In the case of pasture samples from Greymouth and the Kokatahi flats the cobalt contents were much higher.

Low cobalt figures were associated with all samples from established pastures on the pakihis at Westport, the average cobalt content for sixteen samples being 0·06 p.p.m. Pastures associated with dune and recent blown sands near the coast at Karamea and Westport and pastures associated with limestone country at Cape Foulwind were all low in cobalt, figures varying from 0·03 p.p.m. to 0·06 p.p.m. being characteristic of these pastures.

Several pasture samples from the leached gravel terraces of the Grey-Reefton valley and at Karamea were likewise low in cobalt. On one farm stock ailment resembling bush sickness had been experienced.

The success which has attended the use of cobalt "licks" and cobaltized fertilizers on pakihi pastures at Westport suggests that cobalt supplements will prove beneficial to stock over a large area of pasture land at Karamea, Westport, and in the Grey-Reefton Valley.

II. Cobaltized Fertilizers.

Our work on the commercial manufacture of cobaltized fertilizers has been continued. Through the courtesy of Messrs. Kempthorne and Prosser, Dunedin, a new batch of 15 tons of cobaltized superphosphate containing 0·10 per cent, cobalt has been prepared. Cobalt monoxide was used in the manufacture of the cobaltized superphosphate, which on analysis showed over 90 per cent. of the cobalt to be present in a water-soluble state.

Pasture trials have again shown the value of cobaltized fertilizers in increasing over lengthy periods the cobalt content of the pastures and in maintaining stock health on pastures which formerly were unsatisfactory for stock.

Some interesting data are now available concerning the effect of different amounts of cobaltized fertilizers in increasing the cobalt content of pastures and of supplementary fodder crops.

On a pasture at Stoke, Nelson, a top-dressing containing 2 lb. of cobalt chloride per acre gave a very marked increase in the cobalt content of the pastures for at least one year, while top-dressings containing 10 lb. of cobalt chloride per acre resulted in enhanced cobalt figures for the pasture over a period of more than two years.

At Sergeant's Hill, Westport, the use of 1 cwt. cobaltized superphosphate (containing 0·20 per cent. cobalt (Co)) per acre resulted in a fourfold increase in the cobalt content of the pasture five months after top-dressing. In this experiment the cobalt content of the pasture a year later was found to be double that of the untreated pasture.

At Morton Mains pasture analyses have shown the great value even of small dressings of cobalt salts in increasing the cobalt content of the pastures. Typical results are shown in Table I :—

Table I.

Treatment per Acre (applied 24/11/38).	Cobalt Content of Pasture, on 2/2/39. p.p.m.
Control (no cobalt)	0·04
¼ lb. cobalt chloride	0·08
½ lb. cobalt chloride	0·16
2 lb. cobalt chloride	0·37

Interesting results have been obtained in connection with the use of cobaltized fertilizers for supplementary fodder crops such as oats, rape, turnips, and swedes. Experimental plots at Morton Mains, Southland, and at Stoke, Nelson, have shown that the cobalt status of these crops is greatly improved by use of cobaltized fertilizers. Typical results are shown in Table II :—

Table II.

Treatment per Acre.	Crop.	Cobalt Content (p.p.m. Dry Matter).
2 cwt. super	Garton oats	0·005
2 cwt. cobalt-super (0·2 per cent. cobalt)	Garton oats	0·03
2 cwt. super	Rape	0·03
2 cwt. cobalt-super (0·2 per cent. cobalt)	Rape	0·07
2 cwt. super	Turnip tops	0·04
	Turnip bulbs	0·03
2 cwt. cobalt-super (0·2 per cent. cobalt)	Turnip tops	0·16
	Turnip bulbs	0·15

III. Seasonal Variation in Cobalt Content of Pastures.

Studies of the seasonal variation in the cobalt status of typical Nelson pastures have been continued. Periodical samplings have been made from enclosed pasture plots on four healthy soil types. With one exception the cobalt status of the four pastures was somewhat similar, the average cobalt content falling between 0·08 p.p.m. and 0·11 p.p.m. In the fourth case the average cobalt content for the season was 0·21 p.p.m., the higher cobalt content being in keeping with a much higher cobalt status of the soil.

For the greater part of the season the samples from any one of the selected pastures did not show a great variation in cobalt content. The early spring samples tended to be higher and the autumn samples lower than the seasonal average content of cobalt. Variations of 0·17 p.p.m. to 0·06 p.p.m. cobalt represented extreme values for three out of the four pastures.

IV. Animal Trials.

Excellent results have been obtained at Glenhope, the Sherry Valley, and at Westport by the use of cobalt supplements and cobaltized fertilizers.

At Glenhope bush-sick sheep have been cured of ailment and maintained in perfect health for a period of two years by top-dressing the pastures with 2 cwt. of superphosphate containing the equivalent of 2 lb. of cobalt chloride per acre. Good results have likewise been obtained from cobalt phosphate which was used on a small portion of another grazing area at the rate of 5 lb. per acre.

The chemical examination of soils, pastures, and animal organs has shown that Glenhope sheep ailment is caused solely by a deficiency of cobalt, the analyses negativing any suggestion of a dual deficiency of copper and cobalt or of iron and cobalt.

In the Sherry Valley cobaltized licks have enabled breeding-ewes to be maintained with success on pastures which in previous years have been affected with ailment. Over a period of two seasons lambing percentages have been excellent, and the lambs have made very satisfactory live-weight gains.

At Westport very good results have been obtained by the use of cobalt drenches and cobalt licks. Calves affected with bush sickness have been completely cured and restored to normal live-weights by the use of a cobalt drench supplying 40 mg. cobalt (Co) weekly.

All classes of stock grazing the established pastures on the pakihi development have eaten greedily a lick containing equal parts of steamed bone-meal, dairy salt, and Nelson soil plus 16 oz. cobalt chloride per ton of lick. Since the provision of this lick the stock have done extremely well and no case of ailment has developed. During a recorded period of twenty-six weeks, 127 one-year-old steers ate 2,912 lb. of lick. This averages out at the rate of nearly 1 lb. of lick per head per week, giving a weekly cobalt supplement of 50 mg. (Co).

At Morton Mains, Southland, climatic conditions in both the 1937–38 and the 1938–39 seasons were not favourable for the development of typical lamb ailment. The 1937–38 season was unusually dry, resulting in a shortage of feed on the experimental plots. Mainly on this account the live-weights of the lambs at the end of the experimental period were considerably lower than those attained in the previous season. The lambs, however, even on the control plots, remained free from ailment, and the average live-weights of the control lambs compared favourably with those on the cobalt-treated plots. The favourable effect of dry seasons in reducing the incidence of bush sickness has been noted in the early investigations of the Institute at Glenhope, but no satisfactory explanation is yet available of the part played by different factors in producing this result.

Although no sickness developed in any of the experimental lambs in the 1937–38 season, determinations of cobalt in the livers of the experimental lambs showed a pronounced effect from the cobalt top-dressings. In the case of lambs grazing plots top-dressed with ½ lb. to 2 lb. of cobalt sulphate per acre the corresponding livers showed cobalt contents of 0·25 p.p.m. and 0·23 p.p.m. respectively. The livers from the control lambs, on the other hand, gave an average cobalt content of only 0·11 p.p.m.

During the present (1938–39) season the rainfall at Morton Mains was much higher, particularly in the spring and early summer, but there has not been the obvious flush of pasture growth which is usually associated with high incidence of lamb ailment. Up to the present no case of ailment has developed and the lambs on the experimental plots are showing satisfactory live-weight increases. However, the cobalt content of the untreated pasture plots in February was only 0·04 p.p.m., which in other districts has been definitely associated with sheep ailment. The reasons for the non-appearance of lamb ailment under these circumstances are not known, but it is probable that under Morton Mains conditions several factors operate in determining the incidence of ailment. It is possible that in the present season the lambs included in the experiment possessed a greater reserve of cobalt, which, so far, has enabled them to make normal growth.

An interesting feature of the cobalt determinations made on pasture samples from the experimental plots has been the marked increase in cobalt content associated with the use of ground limestone at the rate of 3 tons per acre. This result was contrary to expectation and appears to be due to the fact that the ground limestone was a carrier of cobalt to the extent of 5 p.p.m. A survey of ground limestones in Southland is now being made with a view to ascertaining their effect in increasing the cobalt content of Southland pastures.

General.

During the past year the following papers relating to cobalt investigations at the Institute have been published :—

" Cobaltized Superphosphate," by H. O. Askew, T. Rigg, and D. J. Stanton. *N.Z. Jour. Sci. & Tech., 20*, No. 2A.

" Effect of pH Value on Solubility of Cobalt Phosphate," by H. O. Askew. *N.Z. Jour. Sci. & Tech. 20*, No. 2A.

" Cobalt Deficiency at Glenhope, Nelson," by H. O. Askew. *N.Z. Jour. Sci. & Tech., 20*, No. 5A.

" The Value of Cobalt Supplements for Breeding-ewes at Sherry River, Nelson," by H. O. Askew. *N.Z. Jour. Sci. & Tech., 20*, No. 3A.

" Successful Use of Cobalt Salts for Pasture Top-dressing in the Treatment of Stock Ailment at Glenhope, Nelson," by H. O. Askew. *N.Z. Jour. Sci. & Tech., 20*, No. 5A.

" The Effect of Cobalt Compounds on the Cobalt Content of Supplementary Fodder Crops," by E. B. Kidson and P. W. Maunsell. (In the press.)

In conclusion, mention must be made of the very valuable assistance rendered by all officers associated with the conduct of the cobalt investigations in the South Island. Dr. H. O. Askew has been in charge of all analytical work, and, in addition, has supervised the field-experimental work and pasture surveys in the Nelson district. He has been ably assisted by Misses E. B. Kidson, M.Sc., and P. W. Maunsell, M.Sc., and by Messrs. D. J. Stanton and D. G. Annear. Dr. J. K. Dixon has been in charge of the field programme at Morton Mains, Southland, and has supervised the conduct of the pasture surveys in Southland and in Ashburton County. The field programme has been greatly facilitated by the co-operation and efficient service rendered by Mr. T. Blackmore at Morton Mains, Mr. N. McConochie at Glenhope, and Mr. C. Lemon at Westport.

The investigations have been generously assisted by grants from the Department of Scientific and Industrial Research, the New Zealand Wool Publicity Committee, and the New Zealand Meat-producers' Board.

WHEAT RESEARCH INSTITUTE.

ANNUAL REPORT FOR THE YEAR ENDED 31ST MARCH, 1939.

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

In 1938 the Institute completed its second five-year period of service. All the interests—wheat-growers, millers, and bakers—who pay levies for the support of the Institute, as well as the grain-merchants, who collect the growers' levies, signified their willingness to continue paying and collecting these levies for a further five years. The Government thereupon renewed for a further five years the legislation under which the Institute is organized.

In December a luncheon was held to celebrate the ten years of service that the Institute had rendered, and this was attended by all the leading wheatgrowers, millers, bakers, and grain-merchants.

STAFF.

During the year Dr. J. Melville was appointed to the Plant Chemistry Laboratory of the Department at Palmerston North, and his place as Second Chemist was filled by the promotion of Mr. L. H. Bird. The position of Junior Chemist thus left vacant has not yet been filled, but it has been offered to Dr. Rosa Stern, of Vienna, who has had considerable experience in a cereal laboratory and who, it is hoped, may bring new ideas to bear on the bread industry in New Zealand.

At Lincoln it has been almost impossible to obtain casual labour for seed-time and harvest, and more permanent hands have had to be engaged to secure the necessary labour at these two important times of year.

ACCOMMODATION.

The premises occupied for the past seven years were purchased during the year by the Government, and they are required for the accommodation of other Departments. A new building is therefore being erected to meet the Institute's requirements. It will be slightly larger than the space at present occupied and somewhat more convenient, as well as providing a permanent home for the Institute.

At Canterbury Agricultural College a new field, contiguous to the old, was made available for the wheat plots, and this will ensure that wheat is grown upon any particular area only one year in three, instead of every second year, as has been the case in the past. Plans for draining this field did not reach fruition, and there is danger of specially valuable crops being lost through winter flooding.

For the purpose of hastening the wheat-breeding process a glasshouse in which one or two generations can be grown during the winter is essential. Plans for a suitable glasshouse have been drawn, but the building has not yet been erected.

The genetics laboratory which Canterbury Agricultural College has made available to the Institute for the past ten years is likely to be no longer available when the College rebuilding plans are developed. Representations have therefore been made as to the advisability of erecting a permanent genetics laboratory for the Institute's use.

WHEATGROWING PRACTICE.

The Institute is becoming to an increasing extent the clearing-house for information of all kinds in regard to wheat growing and utilization, and has to thank various bodies for placing their information at its disposal. The threshing returns, extracts from which are provided by the Government Statistician, are each year analysed, so that information can be disseminated to growers about varieties, areas, and yields in their special districts. The effect of this has been a movement towards the growing in each locality of the varieties that have proved most suitable there. The Statistician has also modified his form of collecting sowing statistics so that information is now available to millers, before harvesting starts, of each variety that will be available for purchase for their new season's flour. The officers of the Department of Agriculture have also given valuable information in regard to wheat-growing practice.

In addition to this, special researches are conducted by the Institute's officers. Some matters that have been studied are the effect of grazing seedling wheat by sheep, the effect of soil moisture on yield, and the methods of field drying of wheat after the header. The economics of header harvesting have been studied for some years, and figures have kindly been provided by the agents of various makes. From these it appears that 57 per cent. of the wheat on the flat land of Canterbury is now harvested by the header.

WHEAT-BREEDING.

Cross 7, the first new wheat to be produced specially for New Zealand conditions, was originated by Canterbury Agricultural College and finally selected and distributed by the Institute. Its spread has been very rapid, and this shows in no uncertain way its suitability to farmers' methods and the requirements of millers and bakers. The areas sown since it was first distributed are as follows:—

1934	84 acres.
1935	1,300 acres.
1936	12,000 acres.
1937	34,000 acres.
1938	64,000 acres.

Tainui, a spring wheat produced by the Institute, continues to give promise. Canterbury Agricultural College this year (1939) harvested 25 acres of it for a yield of 52 bushels per acre. This will provide over 1,000 bushels of seed for distribution to farmers this year.

Two other lines of new wheats have approached the conclusion of their trials, and will be grown on a field scale by Canterbury Agricultural College this year.

A number of later crosses hold promise of raising both yield and quality, but they are not far enough advanced for field trials. The extent of the breeding-work is indicated by the fact that over sixteen thousand cross-bred grains were made in December, 1938, and that the number of different plots for the harvest of 1939 was over twenty-seven thousand.

Laboratory Work.

The quality of the wheat from the 1938 harvest was exceptionally good, and the flour throughout the year was of higher quality than for some years past. This might have been expected to lead to decreased demand for testing services, but, on the contrary, those demands increased, owing to the better appreciation of the service the Institute is able to render. The technique of testing flour has been improved owing to Mr. Hullett's visit overseas, and the method of reporting tests to millers has improved as the result of experience.

The rate of harvesting has increased greatly during the past ten years, this being due to many causes. A general shortage of wheat and new methods of marketing have played some part in this change, and the wide use of the " tin " mill, and especially the use of the header harvester, have worked in the same direction. There is therefore a tendency for farmers to deliver wheat out of condition to the stores, and the result is that the wheat is either rejected by the merchant or goes mouldy in the store. To combat this, action along three lines has been taken by the Institute.

The first is to test the moisture content of the wheat before it is harvested and advise the farmer when it should be harvested. Over three thousand samples were thus tested last year and, beside the work done in Christchurch, a branch testing station was opened at Ashburton and carried on for four or five weeks.

The second is to advise the farmer how to dry his wheat after harvest and before delivery. For this purpose observations were taken on the change in moisture content of wheat in sacks stored in various types of stacks in the field or under cover, and sketches of the best form of stack and grain drying shed were distributed to farmers.

The third was to devise a method of drying wheat which had been delivered to stores out of condition. This required investigation on a considerable scale. The method could be suitable only if it required little capital expenditure, because there are very few years in which drying is necessary, and if an expensive device were adopted a large amount of capital would be lying idle for most of the time. High running-costs would be much preferable to high capital cost.

With this in mind, Mr. Hullett, when on the Continent of Europe, investigated all systems of drying wheat in store, but paid special attention to those that involved only cheap modifications of plant that is normally present in a flourmill store. In the light of these investigations he devised a modification of an ordinary miller's bin, filled it with wheat, and blew air through the mass of wheat on all suitable days. A careful study of the moisture content and temperature of both air and wheat was necessary to secure the best results. In summer no heating or drying of the air is necessary in our climate, though both might be necessary if this method of wheat drying were to be used in winter.

As opportunity offers, new devices for testing the chemical, and especially the physical, characters of wheats are being elaborated. One of the chief of these is a kind of extensimeter, which is being constructed piece by piece as experience with its various parts shows that each is performing the service required of it.

Travelling Baker Expert.

In collaboration with the Wheat Committee, the Institute maintains a travelling baker expert, who visits periodically all the bakehouses in the country and gives advice as the general procedure in making the best use of New Zealand flours, and especially when cases of difficulty arise. An extension of this work is the School of Bakery, which is held in the Institute's laboratory for two months in the year. Each course lasts a month, and the students bake different flours under different experimental conditions, as well as listening to lectures, watching demonstrations, visiting flourmills, &c. Indications of the success of the school are afforded by the facts that there is a waiting list of sixty prospective students, and that so far most of the students have been of the grade of foreman or master baker.

Co-operation with other Bodies.

While the Wheat Research Institute has as its chief interests the best utilization of the wheats already in New Zealand and the breeding of new wheats of superior quality, it is inevitably interested in all aspects of the wheat industry except marketing. It is constantly referred to by growers and merchants on all sorts of problems regarding wheat, and it is advisable that it should have all the information needed or know where it is to be obtained.

For this reason the Institute some years ago set up a specialist committee, consisting of all the scientific workers on wheat from all Government Departments and from Canterbury Agricultural College, and this committee discusses all aspects of wheatgrowing. The Department of Agriculture gives assistance in three directions—(*a*) making of field trials of yield in great numbers and in many localities; (*b*) discussing and reporting on the progress of its seed-certification scheme as far as wheat is concerned; (*c*) providing monthly reports on the wheatgrowing conditions from all its field officers located in the districts concerned.

The Plant Research Bureau is equally helpful in the following ways: (*a*) The Agronomy Division confers with the Institute in its programme of maintaining supplies of pure seed; (*b*) the Entomology Division confers and reports on its work on insect pests of wheat; and (*c*) the Plant Diseases Division acts in the same way as regards fungous diseases.

Canterbury Agricultural College, too, assists in the advance of wheatgrowing, by growing on a commercial scale and distributing to farmers under controlled conditions new wheats produced by the Institute.

In addition to all these, the Wheat Committee gives valuable financial assistance in the maintenance of the travelling baker and, with representatives of the Institute, forms a Technical Committee to discuss those matters in which its interests impinge on those of the Institute.

The valuable help given by the Government Statistician has been previously mentioned.

All this assistance the Institute acknowledges with gratitude, and realizes that its successful working depends in a large degree on the help so generously given by other organizations.

FRUIT RESEARCH.

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

INTRODUCTION.

The organization of fruit research in New Zealand was outlined in last year's annual report and no fundamental change has occurred during the past twelve months.

The period has seen the establishment and opening of the new headquarters of the Plant Diseases Division at Owairaka, Auckland, where part of the fruit-research programme is being carried out.

Both experimental and routine spraying operations at the Appleby Research Orchard have been very greatly facilitated by the installation of electric drive of increased power for the spray-pump, and by the replacement of portion of the underground piping-system with pipes of increased diameter. At the same time the remainder of the power and lighting requirements of the area have been converted to electric supply, making for greatly increased convenience and economy of working. Climatic conditions at this orchard have been distinctly abnormal, in that the October rainfall was low, December high, and January to March, 1939, inclusive, exceptionally low, being only 1·35 in. Night temperatures during September to December were lower than usual, and as a result there has been little trouble from the usual early infestations of black-spot and red mite.

Huapai Experimental Orchard has continued to maintain its improvement in growth and yield, due to proper pruning, spraying, and manurial treatments, and especially to improved cultivation and drainage. Successful control of codling-moth has again been obtained in a season when climatic conditions favoured the development of the pest. Thorough cultivation plus the use of arsenate sprays has reduced the incidence of bronze-beetle.

Crop-record data given are those of the 1938 harvest, and tree-growth observations are for the period preceding the 1939 harvest.

The fruit cold-storage investigations and storage-quality aspects of the nutritional work are reported as a separate section, under the ægis of the Fruit Cold Storage Committee.

APPLES.

Fertilizer Experiments.

Research Orchard.—The 1938–39 season has been characterized by the development of further significant increases in crop weight on plots receiving certain manurial treatments in the Cox's, Dunn's, and Delicious varieties. All varieties under experiment now show improvement in crop weight as well as in foliage development and tree growth.

Phosphate (P) has been applied as 44–46 per cent. superphosphate, nitrogen (N) as ammonium sulphate, and potash (K) as potassium sulphate.

Cox's Orange: N has given 100 lb. more fruit per tree than on the untreated (U) controls, and PK has produced almost as great an increase. The "complete" (PNK) mixture has given a total increase of 180 lb. fruit per tree as compared with the controls. Vegetative development continues to be marked where nitrogen applications have been made. PK has had practically no effect on foliage development or shoot growth, except when also accompanied by N.

Dunn's Favourite: The usual vegetative response to N has been maintained and is accompanied by increased yield of fruit. Four pounds ammonium sulphate have given a higher fruit yield than 2 lb. ammonium sulphate, but the increase is only about 50 per cent. greater than that induced by the 2 lb. treatment. With this variety, also, the PNK combination has given a somewhat higher yield than N alone.

Delicious: N and PNK treatments have given an increase in yield of fruit of 63 lb. per tree and 138 lb. per tree respectively. Growth and foliage development show corresponding improvements.

Jonathan: In conjunction with a base dressing of PK, 2 lb. ammonium sulphate have given a 79 lb. per tree increase in yield and 4 lb. ammonium sulphate have given a 103 lb. increase. Colour grading has been adversely affected by the N treatments, and fruit size has been slightly increased. Trees that received two heavy applications of sulphate of potash, followed by normal dressings subsequently, have produced 168 lb. more fruit per tree than those without potash. Fruit colouring at the same time still shows some improvement, and the potash-treated fruit continues to be a size larger than the no-potash control. Foliage and growth have been benefited by both N and K.

Sturmer: Trees receiving N alone are maintaining their growth and crop superiority over untreated trees, although distinctly inferior to PN trees in both respects. The best growth and yield performance is still that of the PNK trees, although the margin over PN trees as regards yield is very small this season. The mean yield on PNK plots is 132 lb. more fruit per tree than that on U plots.

Cawthron Institute.—The manurial experiments on Jonathan at Upper Moutere and on Sturmer and Dougherty at the Annesbrook Orchard have been continued, and the results in both orchards emphasize the importance of complete manures containing P, N, and K for many Nelson soils. At Upper Moutere spectacular results have followed the manuring of trees that have been untreated for twelve years. Neither PN nor NK gave such good results in growth, foliage-development, and fruit-production as the complete manure.

Rootstock Experiments.

Research Orchard.—The new area noted in last year's annual report is making good growth, but will not reach bearing age for several years. Differences are not very noticeable at present, but it is considered that M.XII and M.XV are perhaps somewhat stronger than M.I and Northern Spy.

Cawthron Institute.—With the Cox's Orange variety, Northern Spy stocks continue to show superiority over seedling stocks. Several trees on the latter type are now badly affected with "sour-sap," while those on Northern Spy show no detrimental effects.

Jonathan and Sturmer varieties, however, have given better results on Double Vigour and Epps' Seedling stocks than on Northern Spy.

Plant Diseases Division.—Tests have been continued with East Malling and Northern Spy stocks in the experiments laid down collaboratively with the Department of Agriculture in 1934. Records of growth to date indicate that performance of trees on Spy stocks compares favourably with that on Malling stocks. Trees are now coming into bearing, enabling a study to be made of stock influence on quantity and quality of fruit.

M.IX (Jaune de Metz) is proving a valuable dwarfing stock for intensive experimental work.

Inarching Experiments.

The inarched material at the Appleby Orchard has been so severely attacked by woolly-aphis as to preclude any possibility of its success. Clonal stocks inarched into stunted Jonathan trees at Huapai in 1937 are well established, but no increase in vigour has yet been noted.

Varietal Investigations.

The Plant Diseases Division has added eleven varieties to the thirty already in the nursery, and forty others are shortly due to arrive from England. The latter include several new varieties recently awarded certificates of merit by the Royal Horticultural Society. The purpose of this work is to form a standard collection of varieties comparable, though on a smaller scale, to that of the Royal Horticultural Society at Wisley in England. The collection should also serve as a standard for comparative trials of new varieties raised in the Dominion or imported from abroad.

The Division is simultaneously carrying out work on the different strains of apple varieties. Fruits of many types of Delicious apple on trees growing at Owairaka have been available for the first time. Fruit colour is at present the most conspicuous point of difference between types, and much variation is shown, ranging from normal through intermediate types to an extreme represented by a deep red. Variation in other external characters, though evident, is much less marked. Some strains appear to be more vigorous than others, but nothing definite can be accepted for some years yet.

Three markedly different types of Northern Spy apple have been produced on trees grown from buds selected in 1933. The strains of the other varieties under test—Jonathan, Cox's Orange, Granny Smith, and Sturmer—have not yet fruited.

At the Appleby Orchard, Bramley's Seedling scion wood imported from England and cool stored locally has been successfully grafted on to headed-back Statesman frames. Scion material provided by the young established cider trees has enabled the varieties Reinette Obry, Sweet Alford, and Knotted Kernel to be likewise grafted on Statesman.

Pruning Experiments.

Research Orchard.—Various departures from standard pruning practices are being tested in an endeavour to reduce the extent of the biennial bearing habit of certain varieties and to improve fruit quality. An attempt is being made to convert Cox's Orange to an almost completely spur-bearing habit; Dunn's Favourite is being heavily spur-reduced prior to both "on" and "off" years; Jonathan is being thinned out and opened up by several methods.

Cawthron Institute.—An opportunity was taken to test what is known as the Hawke's Bay system of pruning, in which main leaders are reduced to three or four in number and nothing further is done beyond the cutting-out of interlocking growth. Both Cox's Orange and Jonathan were tested under this system, but the results showed that it was unsatisfactory under Nelson conditions. With the Jonathan variety growth was outstandingly weak and gave little promise for future fruit-production

Plant-protection Experiments.

I. *Entomological Studies.*

(*a*) *Biological Control.*—At the Cawthron Institute detailed studies are being made of the life-cycles of both woolly-aphis and its parasite, *Aphelinus mali*, with a view to securing better control of aphis in the spring and early summer, when a definite lag seems to occur in the activities of the parasite. During the present season five cycles of woolly-aphis have been observed, each cycle lasting nineteen to twenty-two days.

(*b*) *Chemical Control.*—The Plant Diseases Division has carried out tests on the following two insect pests :—

(i) Bronze-beetle : A series of experiments was run at Huapai to ascertain the value of derris sprays and nicotine-bentonite as against lead arsenate for the control of this pest. Although counts have not yet been taken, observation indicates that no advantage has been secured with these more costly products. Nicotine-bentonite caused severe russetting of the fruit.

(ii) Red-mite : Derris sprays were tested for control of these pests in commercial orchards. Promising results were secured with certain products, though it is doubtful if they will come into commercial use unless considerably reduced in price. *Bryobia praetiosa* proved more difficult to kill than *Paratetranychus pilosus*.

II. *Mycological Studies.*

(*a*) *Mouldy-core.*—The identification of the fungi commonly associated with the condition known as mouldy-core has been continued at the Cawthron Institute and the percentages of the various fungi have been assessed. The data are now being tabulated, and a summary of the results is being prepared for publication.

The Plant Diseases Division has examined the incidence of mouldy-core in the numerous strains of Delicious apple grown on the M.IX dwarfing stock at Owairaka. All deeply coloured varieties are heavily infected, and of the others but one strain, a striped variety from Otago appears to be free.

Some evidence is now available showing that the strain is influenced by locality and that one with a closed passage between calyx and core may become more open under Auckland conditions.

(*b*) *Eye-rot.*—Quantitative and qualitative studies similar to those on mouldy-core have been continued at the Cawthron Institute.

(*c*) *Black-spot.*—The Cawthron Institute has maintained its customary notification service in connection with the maturity of black-spot ascospores for the benefit of Nelson orchardists.

(*d*) *Apple-canker.*—In further work on the control of this canker, caused by the fungus *Nectria galligena*, zinc-chloride, mercuric-chloride, and mercuric-cyanide solutions have been tested by the Plant Diseases Division. None has proved effective as a controllant. It has been found that the fungus spreads in the vascular tissues to a considerable distance beyond the area of the superficial canker. Quite satisfactory control was secured by removing the discoloured woody tissues and painting the wound with bituminous paint.

(*e*) *Bitter-rot.*—Several spray programmes were carried out in various parts of Auckland for control of this serious disease, which is caused by the fungus *Glomerella cingulata*. As the disease failed to appear this season no information on its control could be secured. Results showed that a 1½–3–50 Bordeaux applied late in the season caused discoloration and blotching of the fruits, except when applied in combination with a certain wetting and spreading agent.

III. *Physiological Studies.*

(*a*) *Internal Cork.*—Plant Diseases Division : Work is being continued on the durability of boron dressing in the soil, but the results of the past season have been inconclusive owing to the climatic conditions experienced. Check trees showed only 5 per cent. or less of the disease, and trees given ¼ lb. dressings in 1935, and showing 40 per cent. of disease last year were carrying clean crops this season.

Cawthron Institute : Field and chemical studies showed that a soil dressing of ½ lb. borax per tree gave commercial control of internal cork for a period of at least three seasons. In certain instances, however, the boron content of both soils and fruit indicated that the supply was being reduced to a low level. The experiments are therefore being continued during the 1939 season.

In view of reports that foliage injury has occurred from the use of borax sprays in the control of cork, further tests have been conducted with a wide range of spray combinations. In no case has any sign of damage to foliage or fruit resulted. It would appear that borax sprays used at strengths of 0·10 per cent. and 0·20 per cent. are perfectly safe if care is taken to mix the spray solution thoroughly and to use lime in conjunction with lead-arsenate sprays.

A note on the effect of boron on storage quality of fruit is given in the Fruit Cold Storage section of this report.

(*b*) *Bitter-pit.*—On the few available Cox's Orange apple-trees at Huapai Orchard heavy and early thinning was carried out to test the possibility of ensuring pit-development. Treatments with various chemicals were made on several trees, but results are not yet available.

(*c*) *Premature Defoliation.*—During the past three seasons early defoliation has occurred to an increasing extent on certain of the Cawthron Institute manurial blocks on the Jonathan variety at Upper Moutere. The defoliation commences before the end of December, and therefore adversely affects the size and colour of the fruit and also the formation of the next season's fruit-buds.

On the blocks in question the trouble is most severe where heavy potassic manuring has been employed. A survey of the Moutere Hills and Moutere Valley has shown, however, that defoliation is not wholly confined to trees treated with liberal amounts of potash.

The results of a large series of injection experiments and of chemical analyses of leaf samples indicate that the premature defoliation of the trees is due to a deficiency of magnesium. The injection tests have shown that magnesium salts control defoliation, while the leaf analyses confirm the results of the injection experiments in showing a very low magnesium status of the leaves of affected trees. Low figures for magnesia are associated with high figures for potash. The role of potash in relation to defoliation requires further elucidation.

A premature defoliation of Cox's Orange and Delicious occurred at the Appleby Orchard this season for the first time, but in this instance it was clear that the severely affected trees were those in poor vegetative condition. Where treatments such as nitrogen, or especially phosphate, nitrogen, and potash, had been given, and the trees were consequently in healthy, vigorous growth, the injury was relatively slight. It is not known whether this instance was associated with a deficiency of magnesium.

IV. *Spraying Experiments.*

The provision of efficient spraying-equipment at the Research Orchard, Appleby, will enable this area to play an active and effective part in the programme of field spraying experiments laid down by the Plant Diseases Division, thereby widening very considerably the scope and applicability of the work.

Advanced programmes, based on detailed experimental work of previous seasons, have been tested at the experimental orchards in Hawke's Bay, Nelson, and Auckland. Their objects are (*a*) to provide orchardists with demonstration areas, (*b*) to correlate treatments for different varieties which vary in susceptibility to spray damage and disease, and (*c*) to correlate the influence of weather conditions in different localities. Records for the year's work have not been completed.

At Havelock North Orchard it has been ascertained that increase in volume delivery may, by increasing spray coverage, induce a greater degree of foliage injury or fruit russet. This indicates that dilutions of sprays should be based on maximum coverage at a point where tree damage is avoided.

Field tests to ascertain the causes of russeting and the most susceptible periods have been undertaken at the experimental orchards at Huapai, Havelock North, and Nelson. The studies are designed to cover the effect of lime-sulphur on fruit drop, the influence of adverse weather conditions on lime-sulphur injury, the possibility of injury from sulphur dissolved in summer petroleum oil, and the effects of wind-borne salt spray on orchard sprays. Results of this season's work are not yet available.

V. *Therapeutant Testing.*

Certification.—The fourth list of certified sprays was issued by the Plant Diseases Division in January. It contained thirty-one products, an increase of two over the previous list.

Numerous requests have been received for certification of other products, notably derris and pyrethrum dusts and sprays. Work on these has been held up pending the development of standard biological means of testing them.

Check analyses have been made of random samples of many of the certified products. It is pleasing to note that all have been found to agree with the original samples upon which the products were certified.

Testing Technique.—During the year work has been directed chiefly towards developing a suitable testing technique and standardizing same.

An apparatus has been designed and built for securing standard spray coverage. By its aid known and constant amounts of spray are applied to test plants.

Various pathogens and insect pests have been studied, with the object of finding those which may be used as suitable indicators of the therapeutant values of materials under test. Choice of suitable fungi has been influenced by such factors as ease of culture and of measuring infection, relative prevalence, &c., and of insects by ease of handling, rapidity of breeding, suitable food plants, and the like.

It has been found necessary to select host plants which may be grown readily in large numbers, are susceptible to certain diseases, and are reasonably tolerant of the various sprays or dusts used.

Climatic conditions likewise have had to be standardized as far as is possible with present equipment. The effects of rainfall and wind on therapeutant performance are being measuerd by means of an artificial-weathering apparatus.

STONE-FRUITS.

Standard Collection.

Work on the collection of standard varieties of stone-fruits is being continued by the Plant Diseases Division.

Plant Protection Experiments.

I. *Entomological Studies.*

Leaf-roller Caterpillar.—In co-operation with the Department of Agriculture a series of experiments on the control of this pest on stone-fruits has been laid down in Central Otago. Materials under test are basic lead arsenate, nicotine-bentonite, and nicotine-tannate. Results have not yet been forwarded.

II. *Mycological Studies.*

Silver-leaf.—Two hundred young peach-trees at Owairaka were inoculated with the fungus *Stereum purpureum*, and 98-per-cent. infection was secured. Infected trees were injected during the spring and summer months with various chemicals with a view to finding some means of combating this disease. Results have been inconclusive.

Brown-rot.—A block of one hundred Paragon peach-trees was used by the Plant Diseases Division for testing various spray programmes in the control of this fungous disease. Best results were secured with the standard lime-sulphur plus colloidal-sulphur spray, but complete control was not given by any spray.

In a further series of dipping tests only partial control was secured. Owing to the cost and difficulty of application it is not proposed to continue with this work.

The Cawthron Institute has maintained its notification service in regard to date of ascospore discharge in the Nelson District.

III. *Physiological Studies.*

Brown-spotting of Apricots.—In co-operation with the Department of Agriculture, the Cawthron Institute has continued investigations into the control of this disease at Alexandra, Central Otago. Definite control of the ailment has been effected by the use of a 0·1-per-cent. borax spray or of ½ lb. borax applied as a top-dressing round the tree in the spring. Control plots (without borax) yielded only 2 per cent. of healthy fruit, while the sprayed or top-dressed trees bore 94 per cent. to 95 per cent. Chemical analyses of the fruit gave confirmatory evidence of boron deficiency as the primary cause of the ailment. In the control fruit the boron content was only 5·7 p.p.m., as against 34·5 p.p.m. and 46·5 p.p.m. in the fruit from the sprayed and top-dressed trees respectively.

Pitting of Cherries.—This project has been carried out in the Alexandra district in parallel with the apricot brown-spotting work. Field experiments during the past season have not shown a clear-cut result, as pitting did not develop on the control trees. Analytical data, however, showed a definite association of low boron content with the incidence of pitting in other orchards.

SMALL FRUITS.

Standard Collection.

The plants introduced from England are now well established in the nursery and will serve as parent plants for material that can be distributed to appropriate districts for further test under field conditions.

Raspberry.

The Entomology Division at the Cawthron Institute has continued its study of the two major insect pests attacking this fruit.

(*a*) *Raspberry-bud Moth (Carposina adreptella).*—This insect must be regarded as one of the major pests of the raspberry. Investigations have shown that the moth lays its eggs between the unopened bud leaves and that the developing larvæ attack the terminal and lateral buds, frequently boring into the terminal shoots. The moth hibernates as a larva, pupation frequently occurring in the soil. The raspberry-bud moth also attacks the native lawyer (Rubus australis) and is commonly found on blackberry. It is attacked by two species of parasites.

(*b*) *Raspberry Saw-fly (Priophorus tener).*—This European insect was found in Canterbury, where some damage was being done to the foliage of raspberries. A study of the life-history of the saw-fly shows that there are two broods during the year and that a partial third brood may develop in late autumn. The adult flies are on the wing in September and December. The eggs are laid in the stems of raspberries and blackberries.

Gooseberry.

Work on this and the following two fruits has been carried out at the Plant Diseases Division. A stem wilt of gooseberry from Greytown has been found to be due to the fungus, *Verticillium dahliae*, hitherto recorded in New Zealand only on the tomato.

Passion-fruit.

A common disease, prevalent throughout the commercial areas, and known as "woodiness," has been shown to be of virus origin. It has been transferred by artificial inoculation from diseased to healthy plants.

Grape.

Mealy-bug has been controlled by live steam treatment, steam being generated by a small boiler under slight pressure. Complete kill of the pest without injury to the vine may be secured.

CITRUS.

Various aspects of citrus work are being studied at the Plant Diseases Division at Owairaka, Auckland, and in addition the Department makes a contribution towards the cost of operating a small area devoted to rootstock and variety tests at Mount Albert, Auckland. This area is controlled by a special committee of the Auckland District Council of the New Zealand Institute of Horticulture.

Rootstock Experiments.

Nursery trials of four rootstocks—citronelle, sweet orange, sour orange, and *Poncirus trifoliata*—on basalt soil at Owairaka have shown that citronelle and sweet orange become established most readily and make most rapid growth.

At the Mount Albert area the trees are in a transition stage (now in their fifth year from planting), and, moreover, the soil has not proved suitable to the growing of oranges, except the Poorman or New Zealand grapefruit type, although better suited to lemons. In the preliminary stages citronelle has given rather better tree-establishment than the other stocks.

Entomological Studies.

(*a*) *Red Scale (Aonidiella aurantii).*—Work is being continued on this citrus pest, especially with reference to its life-history under local conditions and to improved methods of control. Summer petroleum oils have been found to give adequate control, provided concentration and time of application are considered.

(*b*) *White-wax Scale (Ceroplastes sinensis).*—Spraying tests for the control of this pest were carried out during the year. Adequate control was secured with a summer petroleum oil only when used at a 3-per-cent. concentration, even against young stages.

(*c*) *Dicky-rice Weevil (Maleuterpes spinipes).*—This pest, new to Auckland, has been the subject of intensive investigation. Approximately five hundred lemon and orange trees were banded with grease-proof paper and adhesive material, and complete protection to fruit was secured on all treated trees. Further work is in hand to ascertain if cheaper materials can be developed for banding. In addition, attempts are being made to produce a poison bait which will reduce the weevil population.

Mycological Studies.

A co-operative link has been established with the Australian Council of Scientific and Industrial Research, as a result of which shipments and experimental consignments of oranges imported from Australia are examined in New Zealand according to standards laid down by the Australian workers. A shipment of Valencias was thus reported upon, and it was found that when fruits were stored for more than ten days after discharge wax-treated samples retained a much better appearance.

At the request of the New Zealand Internal Marketing Department shipments of Jamaican oranges were examined for mould wastage.

Physiological Studies.

Mottle-leaf.—Manganese sulphate applied in combination with hydrated lime as a spray has been found to suppress leaf symptoms of mottle-leaf on both oranges and lemons. One application has proved effectual, but only for the growth cycle immediately following, since trees which showed a response twelve months ago are again showing mottled leaves. Soil applications of the same chemical have so far failed to produce any response.

OTHER FRUITS.

Pear.

Pear-bud Wilt.—From pear blossom-buds taken from an Auckland orchard the Plant Diseases Division has isolated the canker-forming fungus *Gloeosporium perennans*. Hitherto this pathogen has been found only on apple-branches in New Zealand and in its place of origin, the Pacific coast of North America.

Cherry.

At Owairaka a small block has been planted with St. Margaret cherry worked on six East Malling selections of Mazzard stock. The purpose of the test is to ascertain the most suitable cherry stock for New Zealand conditions.

MISCELLANEOUS INVESTIGATIONS.

Unfermented Apple-juice.

Certain phases of the tests initiated last season have not yet been completed, and two sections are being repeated in the 1939 season, so it is not possible at this stage to report in detail on the results. It is clear, however, that a juice of attractive character can be prepared from some of the varieties of apples commonly grown in this country, while it is equally clear that certain other varieties will need blending to give a satisfactory product.

Suggestions had been put forward that New Zealand varieties of apples would not yield the quantity of juice that is accepted as a reasonably good standard in other countries. These suggestions have been shown to be entirely erroneous, for all varieties tested, other than Dunn's Favourite, have given fresh-juice yields of the order of 3 gallons or more per 40 lb. fruit. An essential factor in obtaining high yield appears to be the type of press employed; this should be of the pack type, with racks and cloths, rather than of the basket or other more primitive type. This point is of significance to manufacturers of fermented cider.

In general the hot-processed and fully cold-processed juices have shown the characteristics recognized in other countries—viz., the cold-processed are brisk and fresh-flavoured, though somewhat light in body, while the hot-processed have more of a full, sweet, and heavy character.

Brief general notes on the individual varieties as far as they have been evaluated at present are as follows :—

Cox's Orange.—From some of the samples it appears that the variety should normally give a very good juice, but the fruit was rather forward in condition, and difficulty from fermentation was experienced in two treatments. The variety is being tested again in the 1939 season.

Dunn's Favourite.—This does not appear to be a very satisfactory variety. Yield of juice is somewhat low, and the juice lacks body and aroma without at the same time showing a fresh sharp character. It could, however, probably be used in a composite blend of several varieties.

Jonathan.—This shows promise of yielding an excellent single-variety juice of attractive aroma, good flavour, and suitably balanced acid and sugar.

Delicious.—The variety gives a juice of only moderate flavour and quality, exceptionally low in acid. The type might possibly appeal to a few palates, but for most consumers would be too sugary and insipid. Blending with sharp and fuller-flavoured varieties is definitely indicated.

Statesman.—A juice of fair quality was obtained from this variety, but it rather lacked acidity. The flavour was clean but thin, and aroma moderate.

Sturmer.—The variety yields a very heavy, full-flavoured juice, high in both acid and sugar. For most tastes the straight juice would probably be rather heavy in character, and so should prove an ideal type for blending.

PUBLICATIONS.

The following papers dealing with fruit problems have been published during the year by officers of the Department or of co-operating organizations. The abbreviation "*N.Z. Jour. Sci. & Tech.*" denotes the *New Zealand Journal of Science and Technology*, "*N.Z. Jour. Agri.*" the *New Zealand Journal of Agriculture*, and "*O.N.Z.*" the *Orchardist of New Zealand*.

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——— Outline of Experimental Work in Hand at Havelock North. *O.N.Z.*, *11*, 126.

——— Wound Dressings for Fruit-trees. *O.N.Z.*, *11*, 126–127.

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Chittenden, E., and Thomson, R. H. K. (1938): Effect of Borax Top-dressing on the Storage Quality of Jonathan Apples. *N.Z. Jour. Sci. & Tech.*, *19*, 541–546.

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Askew, H. O., and Lloyd Williams, W. R. Brown-spotting of Apricots: A Boron-deficiency Disease. (In press.)

Askew, H. O., and Thomson, R. H. K. Boron Status of New Zealand Apples. (In press.)

Jeffreys, F. J. A New Pest of Raspberry in New Zealand (*Priophorus tener*). (In press.)

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FRUIT COLD STORAGE.

Fruit Cold Storage Committee.—Messrs. W. K. Dallas (Chairman), H. G. Apsey, W. Benzies, F. R. Callaghan, J. T. Cross, F. W. Grainger, J. L. Mandeno, A. Powell, Sir Theodore Rigg, A. M. Robertson, H. E. Stephens, L. W. Tiller, and H. C. Heays (Secretary); the late Mr. J. A. Campbell acted as Chairman of this Committee up to the time of his death in October, 1938.

The Committee desires again to acknowledge the invaluable service rendered by officers of the Department of Scientific and Industrial Research in England and by the staff of the New Zealand Government Offices in London. It wishes to record appreciation of the assistance given by the administrative and other officers of overseas and local shipping companies, the New Zealand Fruit Export Control Board, the Fruitgrowers' Federation, the Wellington Harbour Board, the managing directors of certain commercial cool stores, and, also, the helpful co-operation of the Horticulture Division of the Department of Agriculture, the Primary Products Marketing Department, and other Government Departments.

Information from Abroad.

During the year up-to-date information relating to fruit and vegetable production, transport, storage, preservation, and research was made available to the Committee and proved of much interest to individual members.

Experimental Cool Store.

The refrigerated gas-store which was specially constructed and equipped in 1937 for research work on a small scale has been continuously loaded to full capacity. Within the limits of space it has given every satisfaction, while the experience gained and the results already obtained indicate beyond question that more extensive work of this nature and also other experimental cold-storage research on New Zealand fruit should be undertaken so soon as may be possible.

Experimental Consignments to England.

No special experimental or demonstration consignment of fruit to England was made in the 1938 season, but, by arrangement with the respective shipping companies, thermographs are to be used to record the temperatures at selected stations in the hold of each of two vessels, one carrying a commercial consignment of pears to London and the other a shipment of apples; both lots of fruit are being picked later in the 1939 season.

Cold Storage for Export Fruit.

In the report for 1937–38 reference was made to the provision of improved facilities for the pre-cooling and storage of export fruit in Wellington and other main terminal ports. Negotiations along these lines have been continued during the whole year, and the Committee is hopeful that adequate provision of storage facilities for all export perishable foodstuffs will be made in the near future and that in the complete scheme provision will also be made for research facilities such as will help to maintain and improve the quality of these exports.

Staining of Pears by the Wrapping-pads.

Pears of the Winter Cole and Winter Nelis varieties were specially packed for experimental purposes in bushel cases with all-round protective pads of four different kinds, and upon examination after a relatively short storage period showed that much of the fruit in contact with the wrappers was stained by ordinary corrugated pads in which sodium silicate is used as the adhesive, but not by pads treated with dextrin, nor by contact with either plain white lining-paper or shredded white paper. The effect of the plain cardboard pad remained uncertain.

Use of Copper-treated Wraps in the Control of the Spread of Grey Mould in Winter Cole Pears.

The experimental work on copper-treated wraps for Winter Cole pears, which was described in last year's report, was extended by the special storage and examination of eight cases at Hastings. The fruit was picked and packed on the 12th March, 1938, was placed into a local cool store the following day, and was first examined after fourteen weeks' storage, and again after eighteen and twenty-two weeks. As was the case the previous year with similar pears from the Canterbury, Nelson, and Motueka districts, there was no development of grey mould (*Botrytis* sp.) in these Winter Cole pears, and so the experiment was terminated and the fruit sold.

Another small-scale test was independently carried out by the Fruit Research Officer as a check upon the previous experiences with Winter Cole pears in "copperized" wraps for the control of contact-spread of grey-mould fungus, and in this case equal opportunity for infection in all the test fruit was ensured by placing it adjacent to fruit artificially inoculated with an active culture of the fungus. Over a storage period of approximately seven months it was found that the control fruit in untreated paper became completely infected, while the treated paper (a standard commercially prepared sample) reduced the amount of contact-spread of the mould to a low figure.

The Effect of Prompt Storage of Pears.

Chiefly with the view to demonstrating to growers that the prompt storage of pears is desirable, a small-scale experiment with Buerre Bosc, Doyenne du Comice, Winter Nelis, and Winter Cole varieties was undertaken at Hastings. The relative condition of the stored fruit in each of the respective groups reflected the "into store" time interval, and clearly showed that the "no delay before storage" was the best and, also, that a delay of three days was less harmful than one of six days. From the economic aspect every endeavour should be made towards the earliest possible storage of our export pears.

The Control of and some Factors influencing Superficial Scald on Granny Smith Apples.

Each season from the year 1934 special storage of an experimental nature has been conducted on Granny Smith apples, and during the 1938 season sixty-four cases from the Auckland district (two localities) and twenty-four cases from an orchard in the Nelson area were carefully studied. In general, the effect of oiled wraps was to slightly retard the development of discoloration, but after removing the fruit from cold storage the apparent beneficial effect of oiled wraps, compared with plain wraps, was not then well sustained. As the effect of immediate storage as against delayed storage on the tendency to scald, and the influence of maturity at time of picking, were not conclusively determined, further work of this nature is again in hand.

The Effect of Fertilizer Treatment upon the Keeping-quality of Cox's and other Varieties of Apples.

The relation of nutrition to cold-storage quality of apples from the Department's research orchard in the Nelson District was carried through another stage during the year, and a brief summary of the results for the 1938 season is as follows:—

(*a*) The quality of the Cox's Orange Pippin (forty-eight half-cases) was little influenced by the manurial treatments even after protracted storage, while for a shorter period, corresponding to overseas transport to the English market, there was no storage trouble of any kind.

(*b*) For the short storage period with Dunn's Favourite (thirty-six half-cases) no storage disorder was evident, but on long storage the fruit from trees which received 4 lb. ammonium sulphate developed more fungous trouble than from those given 2 lb. or no nitrogen, and both 2 lb. and 4 lb. treatments per tree showed a higher incidence of superficial scald of a mild character.

(*c*) The Delicious, as formerly, was unaffected by the manurial treatments (eighteen half-cases).

(*d*) Fruit from Jonathan trees in the potash treated group was again more resistant to breakdown, fungous disease, and superficial scald on prolonged storage, while the adverse effect of nitrogen appeared to be much greater in the "off" year than in the "on" year. Nitrogenous applications up to 4 lb. per tree did not noticeably affect the storage quality over a period of two months, but on prolonged storage the 4 lb. ammonium-sulphate treatment appreciably increased the fungous disease, breakdown and Jonathan-spot as compared with the 2 lb. or no-nitrogen treatments (thirty half-cases).

(*e*) In short storage there was no evidence of deterioration of Sturmers (thirty half-cases) from treated trees, but in long storage treatment with nitrogen alone again showed a higher incidence of breakdown.

(*f*) A seasonal extension of the research work begun in 1936 to determine the effect of fertilizer treatment on Cox's from the individual tree standpoint and in relation to bitter-pit was undertaken in conjunction with and on the same fruit as (*a*) above, but the data are as yet too inadequate to enable any conclusions to be drawn.

The Influence of Position on Tree for Cox's Orange Pippin.

As the results from former experiments to determine the influence of position on tree on incidence of storage disorders in Cox's Orange Pippins were conflicting, a further study of the problem was made in the 1938 season on sixteen half-cases of Cox's from the research orchard.

The last year's work (1937) had shown that storage-pit was very much more severe in shaded fruits. This result conflicted with the results of the previous two years' overseas experiments and with the findings of Long Ashton Research Station, but it was in accord with an experiment carried out by the Research Orchard, Appleby, in 1935. In 1937, pit development was less severe in the second picking than in the first.

The results from the 1938 experiment show that storage-pit was more severe in the fruit from the sunny exposed positions, the figures for "sunny" and "shaded" being 12 per cent. and 4 per cent. respectively in fruit of the first picking. No pit of commercial significance appeared in fruit of the second picking. In view of the inapplicability of the results to commercial practice, it has been decided not to pursue the work further at this stage, but in view of its academic interest it is hoped that a further investigation will be made at a later date.

A determination of the rate of respiration of selected samples of the test fruit in these two groups failed to indicate any difference in the breathing-rate between the exposed and the shaded samples.

Effect of Borax on the Cool-storage Quality of Apples.

As a result of using top-dressings of borax greater in amount than ½ lb. per tree on Jonathans in recent years, it was ascertained that this treatment had a detrimental effect on the keeping-quality of the apples. The experiment is being extended for the 1939 season to other varieties of apple-trees, because the indications were that different varieties would, under storage conditions, react in different ways to high boron content of the fruit. Cool-storage tests during 1938 season of the Jonathan fruit from trees sprayed with borax at 0·20 per cent. and 0·10 per cent. strengths showed no reduction in keeping-quality. If anything, the percentage of "internal breakdown" was slightly less for the fruit from sprayed lots as compared with that from the adjoining control trees without borax sprays.

Carbon Dioxide Gas Storage of Ballarat and Washington Apples.

Gas-storage trials begun in the 1937 season were continued on the apple varieties Ballarat and Washington. The first season's tests had indicated that a reduction in carbon-dioxide concentration was desirable, and consequently the atmospheres chosen for the 1938 fruit were 2·5 per cent., 5·0 per cent., and 7·5 per cent. of carbon dioxide with 18·5 per cent., 16·0 per cent., and 13·5 per cent. of oxygen respectively, and each at the three storage temperatures of 36° F., 39° F., and 42° F. The fruit was of 125 count and of good even quality.

The Ballarats stored best in the atmosphere containing 2·5 per cent. carbon dioxide and 18·5 per cent. oxygen at a temperature of 39° F. Under these conditions they had a storage life of about seven months, and kept well for two weeks out of store at a temperature of 70° F. and relative humidity 85 per cent. to 90 per cent. Wastage was chiefly from fungi, and amounted to only 8 per cent. even after two weeks under these rather severe post-storage conditions. The gas-stored samples were firm, green, and of good texture, while the corresponding air-stored samples were much softer and more yellow.

For a shorter storage period of about five or six months it is probable that a higher concentration of carbon dioxide—viz., 5 per cent.—could be used. This keeps the fruit harder and greener, but increases the risk of damage of the coreflush type.

The Washington appeared to be much more susceptible to damage than the Ballarat. At the temperature of 42° F. superficial scald was very serious later in the season. At 36° F. coreflush and breakdown were evident early in the storage life, indicating that this temperature is too low for Washington. Further, in 7·5 per cent. carbon dioxide, and especially at 36° F., a type of scald different from that mentioned above made its appearance.

This season's experiments suggest that the Washington can be stored for periods up to about six months at a temperature of 39° F. in an atmosphere containing 5 per cent. carbon dioxide and 16 per cent. oxygen.

Research and Experimental Work in 1939 Season.

Earlier in this report it has been mentioned that no experimental consignment or demonstration shipment of an overseas vessel has been made during the current season (1939). It is thought that since shipowners fully appreciate the improved efficiency and advantages of the newer vessels for the transport of perishable food cargoes they will be prepared to make every endeavour to effect in less efficient vessels such changes as may be reasonably economic or practicable to the holds themselves or to the plant and equipment required for quickly producing, maintaining, and effectively controlling the desired air temperatures.

The local work for 1939 on fruit storage and preservation embraces the following five groups, most of which are by way of extensions of earlier and incomplete experiments :—

(*a*) The effect upon Granny Smith apples in plain and oiled wraps of maturity and of delayed storage.

(*b*) The influence of storage temperature upon Jonathan apples with a tendency to "scald."

(*c*) A comparison of two distinct cooling-systems for the storage of fruit. This experiment could not have been undertaken without the provision of special space, power, equipment, and other facilities afforded by the management of a commercial cool store in Wellington, and the Committee welcomes this opportunity to express its appreciation of this generous treatment.

(*d*) The effect of fertilizers on storage quality of selected varieties of apples.

(*e*) The storage of Jonathan and Sturmer apples in various CO_2 gas atmospheres.

TOBACCO RESEARCH.

Advisory Committee.—Sir Theodore Rigg (Chairman), Dr. E. Marsden, Mr. J. A. Campbell, Mr. W. K. Dallas, Mr. L. J. Schmitt, Mr. H. L. Wise, Mr. I. Hamilton, Mr. C. C. Nash, Mr. J. F. Balck, Mr. B. T. Rowling, Mr. F. A. Hamilton. Research Officer and Secretary, Mr. J. M. Allan.

During the year the Committee suffered a severe loss in the death of Mr. J. A. Campbell, Director of Horticulture. Mr. Campbell was an original member of the Tobacco Research Committee and rendered invaluable assistance in the inception of the Tobacco Research Organization.

During the year the Research Committee attained its objective of establishing a Tobacco Research Station in the Motueka-Riwaka district. An area of approximately 18 acres of land situated at Umukuri was secured on long-term lease, with the option of purchase at the end of five years. The soil is of a type most suitable for tobacco culture and is representative of large areas of tobacco-land in the district. The property is centrally situated, and excellent facilities for irrigation are provided by the Brooklyn Creek, which runs through the property. Possession was obtained on the 1st May, 1938, and the work of establishing the Station commenced immediately. Later, 2 acres of the area were purchased from the lessor as a site for the buildings.

In January, 1938, Mr. L. G. L. Copp, formerly of the Cawthron Institute, was appointed assistant to the Tobacco Research Officer, and in August Mr. R. C. Mickell was appointed to the position of Farm Foreman.

Three meetings of the Research Committee were held during the year. Every effort was made to secure the functioning of the Research Station during the 1938–39 season and to inaugurate the full research programme. Working-expenses were provided for from the annual grant from the Tobacco Board, calculated at $\frac{1}{8}$d. per pound on the previous season's tobacco crop, and an equivalent grant from the Government. As no provision had been made for capital expenditure, the Committee approached the Government through the Department of Scientific and Industrial Research, and in September a grant of £2,250 was made available for buildings and equipment.

Sufficient working-equipment was obtained during the year to enable the research programme to be put into effect. A two-roomed whare was built to provide temporary office accommodation for the Research Officer. The erection of three flue-curing kilns and the bulking and grading sheds was commenced in December, 1938, and was completed by the middle of February. Three automatic stokers were very kindly supplied on loan by Messrs. Vale and Co., heating and combustion engineers, Christchurch, for use with the kiln. A further contract for buildings was put in hand in March, the buildings to be completed in May. These buildings comprise a glasshouse, pumping plant, garage, tool-shed, and minor buildings.

The first field-day was held at the Research Station in January, 1939, and was well attended by about one hundred and fifty tobacco-growers and interested persons.

RESEARCH ACTIVITIES.

The Research Committee approved a very extensive programme of research to be shared between the Research Station and the Cawthron Institute according to the facilities available. The work of the Research Station was confined for the time being to field experiments, and that of the Cawthron Institute to cover a soil survey of the tobacco soils of the Motueka-Riwaka district and chemical and mycological investigations.

Tobacco Research Station.

The research programme commenced in August with an extensive series of seed-bed experiments. The experiments included varying fertilizer treatments, the inclusion of trace elements in the fertilizer formula, the use of different seed-bed-covering materials, and different methods of raising the seedlings.

The field programme was an extensive one, and in all 11 acres were placed under experiments, with the experiments arranged on uniform soil types on the property with the aid of the detailed soil map made by the Cawthron Institute.

The experiments are as follows:—

(1) *Rate of Fertilizer Application.*—Standard fertilizer was applied on two soil types at rates equivalent to 600, 800, 1,000, and 2,000 lb. 3–8–6 mixture.

(2) *Variation in the Percentage of Nitrogen and Potash in the Fertilizer.*—Nitrogen and potash was varied from half to double, both singly and in combination in the standard fertilizer (3–8–6).

(3) *The Addition of Lime, Magnesia, and Boron to the Fertilizer.*—Lime was applied at the rate of $\frac{1}{2}$, 1, and 2 tons per acre; magnesia as magnesium carbonate 100 lb. per acre; and boron as hydrated borax 20 lb. per acre.

(4) *The Use of Fish-meal as a Source of Organic Nitrogen.*—Fish-meal was used as an alternative to dried blood as a source of organic nitrogen in the fertilizer.

(5) *Chlorine and Sulphur Content of the Fertilizer.*—As the inclusion of a percentage of chlorine in the fertilizer is beneficial to the quality of tobacco, varying percentages of chloride were added to the standard formula. High sulphur content of the fertilizer adversely affects the quality of tobacco. In this experiment ingredients of low sulphate content were used.

(6) *Variety Trials.*—Seed from 107 different varieties and strains were used. Comparisons were also made with seed of the same strains grown overseas and in New Zealand.

(7) *Topping and Lateralling Trials.*—The effect of variations in both time and method of topping and lateralling were investigated.

(8) *Comparison of Glasshouse-raised and Bed-raised Seedlings.*—Seedlings grown in the glasshouse until about 1 in. high and then pricked out into the seed-bed until sufficiently large to transplant into the field were compared with seedlings grown from seed in the seed-bed without pricking-out.

(9) *Mosaic Investigations.*—Observations on the mosaic disease were made over all the experiments.

Report of Tobacco Research Officer.

The Research Officer has been fully occupied with the activities at the Tobacco Research Station, leaving no time for work among the growers. The year has proved a difficult one, both on account of the adverse climatic conditions and the fact that during the first year of work many obstacles had to be overcome and much temporary and makeshift equipment utilized.

The year may best be regarded as a preliminary to the actual work of the Research Station, which has been most useful in training the staff to deal with research work and to smooth out the details of the long-range programme so that, after trial, it can be set out to give the best results. By next season the Research Station should be well equipped in every way to deal competently with the full programme.

Seed-bed Experiments.

The work of the Research Station commenced with building seed-beds and preparing them for subsequent sowing and pricking-out. The beds were ready early in August. Eight seed-beds were sown between the 11th and 14th August, and two others on the 21st and 28th of the month. Germination commenced twelve days after sowing, and a good strike was obtained in all beds. Insect damage was practically non-existent. The early growth of the seedlings was slow, but in the later stages soon caught up to and exceeded that of the pricked-out seedlings. Even those beds that were sown a week and a fortnight later, respectively, were ready for transplanting at the same time as the earlier-sown beds.

Of the seedlings raised under glass, approximately one-half were grown in a commercial glasshouse at Nelson and the rest at the Cawthron Institute. Those grown in the commercial glasshouse were sown a few days earlier than those in the seed-beds, while those at the Cawthron Institute were sown about the same time and later as the seed came to hand.

Pricking-out commenced at the end of September and continued as the seedlings were ready. All precautions were taken to prevent the transference of mosaic during this operation.

The results obtained from the seed-bed experiments were not very marked, except where no fertilizer, a half application, and a full application were compared. Those seedlings receiving no fertilizer had hardly made any growth at all at transplanting-time and remained yellow and stunted; those receiving a half dressing had made almost the same growth as those with the full application, but when almost ready for transplanting began to yellow and show starvation symptoms, which became more apparent as time went on, whereas the latter remained green and continued to grow rapidly.

In the experiment where seed was sown in the glasshouse in an endeavour to produce 500, 1,000, 1,500, and 2,000 seedlings per box (16½ in. by 11 in.), the actual numbers obtained were approximately 600, 1,200, 2,000, and 2,700. Of these, the 1,200-lot boxes were the most satisfactory. They gave the best percentage strike on pricking-out and made much more rapid growth. The 600 lot were equally good, but the number per box was not an economic proposition. Fair results were obtained with the 2,000 lot, but many of the weaker seedlings did not survive transplanting; and with the 2,700 lot a considerable percentage died.

Field Experiments.

Transplanting commenced under favourable conditions on the 4th November and was completed on the 16th. The strike was good, but soon after the planting was completed a period of strong winds set in and was responsible for the destruction of about 1 acre of plants on the light sandy area along the Brooklyn Valley Road. This area was replanted, along with the misses throughout the crop, early in December.

Mosaic made its appearance in the beds containing pricked-out seedlings just before transplanting, and by the time the replanting was finished a large number of affected plants had been found. In those beds in which the plants had been raised from seed without pricking-out, only four affected seedlings were seen. At replanting-time in the field 11 per cent. of mosaic was found in the latter plants. These were pulled and replanted. In the pricked-out plants practically 90 per cent. were found to be affected. As it was not possible to replant all, only the most severly affected were pulled and replanted.

With regard to the percentage of mosaic occurring in both seed-bed and field, it must be borne in mind that a heavily infected crop was grown on the entire area the previous season. The old stalks were supposed to have been completely removed in the following June, but when working the land prior to planting much old tobacco refuse was turned up. Therefore much visible infective material was present in the soil. The amount of mosaic in the pricked-out seedlings in the beds indicated that considerable infection must have occurred from such tobacco refuse during pricking-out. The absence of mosaic in the plants raised directly from seed without pricking-out indicated that where there were no injured tissues and no handling infection did not occur. The subsequent infection found in the plants in the field might well be traceable to the infective material present there.

The season was a very unfavourable one for tobacco, being too cold in the early part of the season, and the crop was severely damaged by wind. During the latter part of the season it was too dry, and much of the leaf when harvested was badly wilted, which was not conducive to good results in curing. During the early part of the season growth was poor, and what growth was made took place when the crop had already started to mature. Differences were not apparent in the field in the majority of the experiments, even when there was considerable difference in fertilizer or other treatment.

As the three flue-curing kilns and the grading and bulking shed were not completed until the middle of February, much of the tobacco-leaf was too mature before the kilns were ready for use. Owing to overmaturity the best results were not obtained in curing, as it was too late in the season before all the more mature leaf could be harvested and attention turned to leaf at the correct stage of maturity. Harvesting-operations commenced on 11th February and were completed on 20th April. Grading of the leaf is yet to be done, and differences may become apparent in the experiments when the plot-yields and quality indices are available when the grading is completed.

The only experiment in which obvious results were apparent was that in which plants grown directly from seed in the seed-bed were compared with plants raised by the usual method in the glasshouse. Not only did the former make considerably better growth, but also showed less than 10 per cent. mosaic infection, as compared with over 90 per cent. infection in the latter. Growers have shown very keen interest in this experiment and many intend growing some seedlings for themselves next season. The results of this experiment should prove to be of considerable practicable importance in the control of mosaic.

District Experiments.

The only actual plot experiment outside the Research Station during the past season was one on the property of Mr. J. T. Heath, Pokororo, to determine the effect of lime and magnesia on the tobacco crop grown on land believed to be deficient in these plant-foods. Acute deficiency symptoms had been shown by the crop in the previous season on this area. Lime was found to have little or no effect on the appearance of symptoms, but magnesia supplied as 100 lb. of magnesium carbonate per acre completely prevented the trouble.

It was found impossible in the first season to undertake more outside plot experiments owing to the work of establishing the Research Station and initiating the full programme there. Also, a number of difficulties have yet to be surmounted before yield and fertilizer experiments can be undertaken in co-operation with farmers.

Co-operative experiments were entered into with the two main manufacturing companies, Messrs. W. D. and H. O. Wills (New Zealand), Ltd., and The National Tobacco Co., Ltd., and their growers to try out the use of New Zealand seed selected by the Tobacco Research Officer during the previous season, and for growers to try for themselves the method of raising their own seedlings that proved so successful at the Research Station.

General.

Considerable work was done in getting the Research Station in order, including the destruction of weeds, cleaning up the stream-banks, levelling the site for the buildings, and, when possible, proceeding with the erection of fences.

CAWTHRON INSTITUTE REPORT.

The Institute has been responsible for several important aspects of the tobacco investigations. These include a soil survey of tobacco-lands, chemical investigations relating to soil properties and quality of tobacco-leaf, mycological studies relating to the incidence of mosaic and seed-borne diseases, and entomological studies relating to insect pests of tobacco.

Soil Survey of Tobacco-lands.

With a view to the extension of the tobacco industry on the most suitable soils of the Nelson District, the Tobacco Control Board recommended that a detailed survey of tobacco-lands be undertaken. This recommendation was approved by the Research Committee, and work was commenced by the Institute in the Motueka-Riwaka district in June, 1938.

So far, the soil survey has been confined to the alluvial flats and gentle slopes within the Motueka, Umukuri, and Riwaka districts. The major soil divisions, based on the nature of the parent material—*e.g.*, granite, limestone, and basic rocks—were first drawn, and these main groups of soils were then separated into sub-types based on textural variations—*e.g.*, sand, sandy loams, silt loams, &c. Consideration has been given, in delineating soil types, to the presence of underlying gravel, height of water-table, &c. So far, 3,400 acres of land have been mapped and the boundaries of the various types delineated.

The soil survey has already shown the presence of considerable areas, now in other annual crops or in pasture, which are suitable for tobacco. On the other hand, instances are not infrequent of land being used for tobacco where the nature of the soil renders the production of high-quality leaf unlikely.

With a view to the best utilization of the land at the Research Station, a detailed soil map has been made for the guidance of the Tobacco Research Officer.

Chemical Investigations.

In connection with the soil survey of tobacco-lands, a considerable number of soil samples has been collected and examined in the chemical laboratory for texture and plant-food constituents.

Special attention has been paid to the boron status of representative soils at the Tobacco Research Station, and a commencement has been made with chemical determinations on tobacco-leaf.

The boron determinations on soils at the Research Station show that the coarse sands are very low in this constituent, the figures being 0·03 p.p.m. boron for the coarse sands as against 0·075 p.p.m. and 0·06 p.p.m. boron for the fine and medium sands. These figures suggest that hydrated borax may prove beneficial, particularly on the coarse sands, in the manurial treatment of tobacco and other crops.

Some nineteen samples of tobacco-leaf grown at the Institute and in the Riwaka district have been examined for lime, magnesia, iron, manganese, boron, nitrogen, and phosphoric acid. The average figures for six samples of Riwaka leaf are as follows:

	Per Cent.
Lime (CaO)	4·86
Magnesia (MgO)	0·81
Iron (Fe)	0·014
Manganese (Mn)	0·0048
Nitrogen (N)	2·05
Phosphoric acid (P_2O_5)	0·49
	P.p.m.
Boron (B)	24

In these six samples of tobacco-leaf, magnesia varied from 0·20 per cent. to 1·83 per cent. on the dry matter, suggesting that in certain cases magnesia is in deficient supply; manganese varied from 0·0026 per cent. to 0·0070 per cent.; nitrogen varied from 1·54 per cent. to 2·77 per cent.;

and boron varied from 18 p.p.m. to 32 p.p.m. The amounts of lime and phosphoric acid showed relatively small variation. The work which has been done, although only of a preliminary nature, suggests the possibility of both magnesia and boron deficiency in certain samples, and emphasize the desirability of securing standard data for high-quality American and New Zealand leaf.

Arrangements have now been made for the collection of typical samples of Riwaka leaf for chemical examination in respect to quality of tobacco.

Seed-germination Studies.

Previous studies of the germination of tobacco-seed used for the commercial crop in the Nelson District have shown great variation in the percentage germination of different lines of seed. The data have suggested that period of storage and the presence of seed-borne diseases may influence greatly the number of vigorous seedlings obtained from different lines of seed.

With a view to obtaining more information on these points, studies have been undertaken relating to (*a*) the effect of age on the germination of tobacco-seed, and (*b*) the effect of disinfectants on seed-germination.

(*a*) *Effect of Age on Seed-germination.*—For the purpose of the investigation, seed less than one year old, seed one year and two years' old, and seed eleven and fifteen years' old were available. Using a standard procedure in every germination test, the studies have shown that in the case of twenty sets of seed four months' old at the commencement of the experiments little difference in germination was found during an ensuing period of four months. In eight sets the final germination rate was approximately the same as the initial rate, in ten sets the final germination rate was appreciably greater, and in two sets the final germination rate was appreciably less.

In the case of eight varieties of tobacco-seed imported fresh from the United States of America in 1937, germination tests a year later showed only minor differences in the germination rates for the two years. With one exception the germination percentage in the second year stood as high as 90 per cent.

In the case of seed stored for eleven and fifteen years, respectively, marked reduction in the germination percentages was found. For nine varieties stored for a period of eleven years the germination percentage varied from 33 to 88, with an average of 65 per cent. This percentage would be still further reduced if the germination figures at fourteen days from sowing were taken. In the case of seed stored for fifteen years the percentage germination was 5·5 per cent. at fourteen days and 33 per cent. at 30 days from sowing.

(*b*) *Effect of Disinfectants on Seed-germination.*—Alcohol, silver nitrate, and Uspulun have been compared in relation to the effect they exert on the germination of tobacco-seed after treatment with these chemicals. Six varieties of tobacco-seed of high germinating-power were used for the experiments. The results of tests made on treated and untreated tobacco-seed showed that none of the chemicals exerted an appreciably adverse effect on the germination of the seed. On the contrary, alcohol gave an increase in germination rate in four out of six varieties, silver nitrate gave an increase in three out of six varieties, and Uspulun gave an increase in one out of six varieties. In no instance was the reduction after treatment with chemicals greater than 3·5 per cent.

One important aspect of the studies has been the effect of storage after treatment with disinfectants on the germination of tobacco-seed. Two lines of tobacco-seed were used in this experiment, and germination tests were carried out at weekly intervals during a period of twelve weeks following disinfection of the seed. Storage of the seed prior to the germination tests under these conditions made relatively little difference to percentage germination of the seed. In five cases out of six the final figures showed a slight increase in percentage germination over the initial figures.

Mosaic Investigations.

(*a*) *Factors affecting Mosaic Dissemination.*—In co-operation with the Tobacco Research Officer, the results of last season's work relating to the incidence of mosaic disease were prepared for publication. The data pointed clearly to the tobacco-seedling bed as the most important factor in the spread of mosaic.

(*b*) *Effect of Manurial Treatment on Susceptibility of Tobacco-plants to Mosaic Disease.*—It is well known that under certain conditions excessive use of nitrogenous manures increases susceptibility of plants to fungus attack, while the liberal use of potash reduces the severity of certain diseases. It was considered possible that mosaic disease might show a somewhat similar reaction to variations in the manurial programme. A series of pots in the glasshouse and of field plots on adjoining land were arranged to give information on this point.

The manurial treatments included in the test were (1) complete fertilizer (N + P + K); (2) complete fertilizer plus trace elements; (3) complete fertilizer plus one additional dose of nitrogen; (4) complete fertilizer plus one additional dose of potash; (5) complete fertilizer with only one-half dose of nitrogen; (6) complete fertilizer minus potash.

Tobacco-plants of the Harrison Special variety were used throughout the tests. Inoculation with mosaic virus was carried out when the plants were 12 in. high. In the glasshouse all pots inoculated, irrespective of treatment, developed typical mosaic symptoms. In the field, out of 260 plants which were inoculated under different treatments, all but one developed mosaic. The experiments have shown fairly conclusively that variations in the manurial programme as outlined above do not inhibit the incidence of mosaic in tobacco-plants.

An interesting feature of the experiment, however, was the growth and appearance of the mosaic plants under the different manurial treatments. In every case mosaic retarded the development of the plants, but this was more noticeable with some treatments than with others. Mosaic plants were characterized by paucity of leaf-development on the stem and of sucker-development in the leaf axils. At maturity mosaic plants were considerably shorter and more spindly in appearance than the corresponding controls. Dwarfing and sparseness of leaf were especially noticeable in plants receiving an extra dose of potash.

On the other hand, plants receiving an extra dose of nitrogen did not exhibit such marked stunting and reduction of leaf area. Mottling of the leaves was clearly evident in most mosaic plants under the high-nitrogen treatment, but the failure in chlorophyll-development did not appear to be so complete as in the case of mosaic plants under other manurial treatments. The behaviour of plants treated with complete fertilizer less potash tended to be similar to plants receiving additional nitrogen, suggesting that within limits a certain ratio of N/K rather than nitrogen alone operates in overcoming the dwarfing tendency produced by the virus.

Insect Investigations.

Examination of tobacco-leaf held in store by one of the manufacturing companies revealed the presence of two cosmopolitan pests of stored tobacco. The insects were the tobacco moth *Ephestia elcutella* and the cigarette beetle *Lasioderma serricerne*. Larvæ of *Ephestia* remained in the larval stage over winter and commenced to pupate about the end of September. The moths emerged at the beginning of November.

Suggestions were made for the treating of infested leaf and the cleaning-up of all sheds used for the storage of tobacco.

PHORMIUM RESEARCH.

In September, 1938, Dr. J. S. Yeates relinquished his position as Director of the Plant-breeding, Testing, and Selection Section of the Department's phormium-research activities. This work has been taken over by the Botany Division of the Plant Research Bureau. Dr. Yeates has been associated with phormium research since its inception, and the Department desires to place on record its sincere appreciation of Dr. Yeates's valuable work over a period of some ten years, during which he has contributed a great deal towards the improvement, by judicious breeding and selection, of the quality and yield of the phormium plant.

During the year Miss G. E. Wall completed her investigations on the insect pests of phormium, as a result of which it has been possible to make suggestions for the field control of three major pests.

Since taking over the botanical and cultural phases of phormium research the Botany Division has been engaged chiefly in a stocktaking of the plants on the various propagation and research areas, in maintaining and improving these areas, and in planting out selected varieties in various localities for ecological and yield tests. Studies on the life-history of the plant have been initiated, and special attention has been given to the roots and rooting systems. Three large-scale stripping tests with selected varieties were carried out, using the new Sutton stripper.

In collaboration with officers of the Departments of Agriculture and Public Works, an inspection and report was made on the principal phormium area in the Manawatu district. Other inspections have been made on various phormium areas established in the South Island.

Mechanical investigations in connection with phormium research have been in the charge of Mr. L. Ledger, who has been engaged at Foxton in the testing and further improvement of decorticating machinery.

Detailed reports on these various aspects of phormium research follow.

BOTANICAL RESEARCH.

A. L. Poole, Botany Division, Plant Research Bureau.

Batchelar Area, Massey College.

The initial stocktaking at the Batchelar Area indicated that there were—(1) Approximately one hundred selected varieties of phormium, being either from original parent plants—Maori selected plants from various parts of the Dominion—or from their selected progeny and hybrids; (2) some twenty thousand eighteen-month-old seedlings from selected crosses; (3) about one hundred thousand seedlings in seed-beds from 1938 sowings. These were from seven different crosses.

Because of the large number of selected varieties, and the quantity of material available for making further selections if necessary, it was decided to cease all crossing-work except in cases where it might possibly yield better strains than had already been obtained. The bulk of the work on this area has therefore been maintenance-work of a general nursery character, though green leaf for fibre-yield tests has been taken from certain of the trial plots. A number of plants have been distributed for shelter-belt purposes and also to growers.

Easton Area.

A stocktaking of this area showed that there were 20 selected varieties in larger quantities (50 plants and over), and 69 varieties, mostly untested crosses, in smaller quantities. The variety Ngaro occupied about 20 acres, with nearly 12,000 four-year-old plants, while S.S. had 4,000 two-and-a-half-year-old plants, and P.T. 3,000 two-and-a-half-year-old plants. All the other varieties were in considerably smaller quantities.

The Easton plantation has, since its inception, been kept under cultivation by the means of a small rotary hoe and by the manual labour of varying numbers of relief men, who have given very good service. During the year the small rotary hoe proved unequal to the task of maintaining some 60 acres free of tall fescue and goat's rue, and recently has been replaced by a larger cultivation unit.

All vacant areas, amounting to about 5 acres, were filled with selected varieties, and gaps in existing rows were replanted. A further 3,300 fans of Variety 56 were transplanted from the Batchelar Area. The stop-bank along the south-west boundary was shifted closer to the river, resulting in an additional area of 7 acres becoming available for further plantings of material from the Batchelar Area. One acre is entirely flood-free and will be useful for a temporary nursery-site, thus bringing all the nursery and plantation work together on to the one area. The 1938–39 season was a phenomenal flowering season for phormium. Large quantities of seed were set, and the opportunity was taken of collecting seed from a number of varieties on this area.

Planting at Flock House.—In order to relieve the congestion of plants at the Batchelar Area an area of about 3 acres at Flock House was planted in selected varieties. The area was of good river silt, well worked up, and was planted with fans in October. The varieties and numbers of each were as follows :—

Variety.	Number of Fans.
56	700
273	316
Tihore	317
P.T./S.	110
205	137
212	112
S.S./S.	198
Ng. x S.S.	155
P.T. x S.S.	770
	2,815

Distribution of Plants for Ecological Trials.—For the purpose of following the development of the various varieties under different conditions of soil and climate about three fans of several varieties were planted out permanently at Flock House, Waikuku, Invercargill, and at the Otari Native Plant Museum, Wellington. Further plantings will be made in suitable areas, and observation will be made on them from time to time.

Studies on the Development of the Plant.—A series of observations was commenced on the development of the plant, commencing with seedlings and continuing through to the adult plant. These will be continued, and later, by piecing them together, it will be possible to obtain the complete life-history of phormium. Studies of roots and rooting systems have also been made. The most notable feature of the system is the presence, in adult plants, of large numbers of surface roots.

Stripping-tests.—Three large-scale stripping-tests were carried out on the new Sutton stripper, using selected varieties, with the following results :—

Variety.	Locality grown.	Age.	Green Leaf.	Fibre.	Green Leaf : Fibre.
			Tons cwt. qr.	Tons cwt. qr.	
56	Batchelar	Four years	2 0 0	..	1 : 6
273	Batchelar	Four years	2 0 0	..	1 : 5·7
Ngaro	Easton	Four years	95 18 2	14 0 1	1 : 6·85

The Ngaro was cut from 6 acres, which yielded 16 tons of green leaf per acre. The lowness of the yield is attributed to bad establishment in the first year of growth owing to flooding, to wide spacing of plants in the rows, and to the fact that they had not reached full maturity at the date of cutting.

The following is a report by Mr. L. Ledger on the fibre from the Ngaro leaf :—

> "Due to the cleanness and freedom from disease of the leaf, the rate of feeding was considerably higher than any previous test on ordinary swamp flax, and at the same time the percentage of rejected fibre was much lower than with swamp flax. The yield of fibre was not as high as anticipated, being practically the same as that for swamp flax—namely, a yield of 1 ton of fibre from 6 ton 17 cwt. of flax-leaf. The reason for this is, possibly, that the leaf was cut before maturity. There was a large proportion of small leaves one to one and a half years old, which would have a smaller percentage of fibre than leaves of three years, with the result that the fibre percentage for the whole test was lower than expected. Although the fibre received the same treatment as ordinary fibre, a much whiter product resulted."

Entomological Investigations.—During the year Miss G. E. Wall finished her investigations on the insect pests of phormium. This work had reached such a stage that it was possible to make suggestions for experiments on the field control of the three major pests—the leaf-eating caterpillars (*Melanchra steropastis* and *Xantherhoe praefectata*) and the scale *Leucaspis stricta*. These suggestions embrace: (1) The cultivation of soil and keeping grass away from the base of phormium plants at the time *M. steropastis* and *X. praefectata* pupate. These times are September to November, and February and March. (2) The removal of dead leaves in which the larvæ of *M. steropastis* and some *X. praefectata* take shelter during the day. These leaves also provide a place of pupation for *M. steropastis* and should be removed when green ones are cut for milling. (3) Spraying the grass immediately around the base of phormium-plants is recommended as an alternative method of attacking *M. steropastis* during the grass-eating stage. (4) The use of a flame-thrower to destroy the grass around the plant. This practice can hardly be recommended owing to fire danger. (5) In the case of *L. stricta*, spraying with red-oil spray immediately it appears is the best method of control.

A full account of all the insect work is being prepared for publication.

Future Investigational Work.—It is considered that ample varieties of phormium have been collected on the Batchelar and Easton Areas. Any further breeding-work will therefore practically cease, as it is not likely to yield plants better than those already selected. Future investigational work will mainly take the form of experiments connected with the formation and maintenance of plantations. These will include further manurial trials, cultivation trials, cutting trials, &c. Life-history and ecological studies of the various varieties will also continue.

MECHANICAL INVESTIGATIONS.

Mr. L. Ledger.

Investigations relating to the mechanical processing of phormium have been concentrated on the improvement of a flax-stripper which will permit complete stripping of the phormium-leaf.

The first tail-stripping machine was tested out in Foxton on the premises of Messrs. A. Ross, Rough, and Co., Ltd., at the beginning of 1938. The first four months' tests showed that the initial design could be improved upon principally in the direction of delivering the stripped fibre to the washing-apparatus. A new design incorporating a number of improvements was evolved, and a second stripper, known as the "Sutton Tail Stripper," was built. This machine was completed in November, 1938, and subsequent tests have shown that, while not yet perfect, it is a distinct advance on previous strippers. This stripper has been in continuous operation for six months.

The experimental work involved the testing of the first tail stripper; the drawing of plans and supervision of construction of the second machine, together with its subsequent testing; and, finally, the preparation of full working drawings incorporating further modifications for future tail strippers.

A portion of Messrs. Ross, Rough's mill has been leased to the Flax Plan Industrial Committee as a site for the development of further machinery for the treatment of phormium fibre. Work on the construction of an improved washing-machine has been commenced.

CHEMICAL INVESTIGATIONS.

At the Dominion Laboratory chemical investigations on phormium have followed two main lines: (1) The examination of various processes for the decortication of phormium fibre; (2) the chemical examination of several varieties of phormium, in an attempt to correlate varietal difference with differences in the quality of the fibre, as measured by chemical methods. This work is described in fuller detail in the Dominion Laboratory section (p. 94).

TIMBER-PROTECTION RESEARCH.

Timber-protection Research Committee.—Mr. V. Lough, State Advances Corporation (Chairman);* Mr. R. L. Andrew, Assistant Dominion Analyst; Mr. F. J. A. Brogan, Assistant Secretary, Department of Scientific and Industrial Research; Mr. F. R. Callaghan, Chief Executive Officer, Plant Research Bureau; Dr. G. H. Cunningham, Director, Plant Diseases Division, Plant Research Bureau; Mr. H. C. Gayford, Housing Construction Department; Mr. N. A. Marris, Dominion Laboratory; Dr. D. Miller, Director, Entomology Division, Plant Research Bureau; Mr. A. F. Clark, State Advances Corporation (Secretary).

At the request of the State Advances Corporation a Timber-protection Research Committee was set up by the Council of Scientific and Industrial Research in June, 1938, to direct and co-ordinate investigations relating to the preservation of timber from the attacks of insects and fungi. Field surveys by officers of the State Advances Corporation have revealed that the incidence of insect and fungus attack on wooden buildings in New Zealand is sufficiently serious to warrant a full investigation of the problem in order to obtain the fundamental scientific knowledge upon which to base effective control measures. At present there is a lack of knowledge concerning the life-history and habits of the insects and fungi attacking timber in New Zealand and the effect of various types of wood-preservatives on New Zealand timbers and on the insect themselves. It was for the purpose of providing an effective research organization to investigate problems of such importance as these that the Timber-protection Committee was established.

The discovery, as a result of a recent survey by officers of the State Advances Corporation and the Department of Scientific and Industrial Research, that the white ant is causing serious damage to buildings in the Auckland district has made it necessary for the Committee to give immediate attention to this as a new and urgent problem.

* Deceased.

The Committee suffered a severe loss during the year by the death of their Chairman, Mr. V. Lough, Chief Property Supervisor of the State Advances Corporation. Mr. Lough's wide knowledge of the building-trade and of the particular problems with which the Committee is dealing fitted him in a special way for the office of Chairman. His place as Chairman has been filled by Mr. L. E. Brooker, who now holds the position of Chief Property Supervisor of the State Advances Corporation.

The Committee has planned its research programme along the following main lines:—

(1) *Entomology Division, Plant Research Bureau*—
  (*a*) Biological studies of wood-infesting insects, with special attention to the white-ant problem.
  (*b*) Supplying the Plant Diseases Division with insect material for the biological testing of wood-preservatives.

(2) *Plant Diseases Division, Plant Research Bureau, Auckland*—
  (*a*) Penetration tests for wood-preservatives.
  (*b*) Toxicity tests with insects and fungi.
  (*c*) The testing of timbers and of wood substitutes for resistance to attack by insects and fungi.

(3) *Dominion Laboratory*—
  (*a*) The analysis of wood-preservatives.
  (*b*) The chemical aspects of penetration tests.
  (*c*) The devising of field tests for wood-preservatives, to enable treated and untreated timber to be distinguished.

The following is a brief summary of the work that has been carried out during the year:—

(1) *Plant Diseases Division.*—From numerous specimens forwarded by the State Advances Corporation the common wood-rotting fungi causing decay of buildings have been isolated, and the most common cause of decay was found to be the fungus *Poria ferruginosa.*

(2) *Entomology Division.*—The Entomology Division has begun the biological study of the two major species of boring insects that infest constructional timbers—namely, the common house borer *Anobium domesticum* and the native two-toothed longhorn beetle *Ambeodontus tristis.*

(3) *Dominion Laboratory.*—A number of wood-preserving materials were chemically examined, and some preliminary work was done with a view to devising a field test by which the application of wood-preservatives could be detected.

In addition to the laboratory work, the Entomology Division has co-operated with officers of the State Advances Corporation in field surveys, particularly in connection with the discovery of the depredations by the white ant, and special reports were prepared for the press drawing attention to the serious damage being done by this pest and the necessity of taking all possible steps to combat it.

As the work under the direction of the Committee passed the preliminary stages, it became apparent that increased staff and equipment would be necessary to implement the research programme as fully as was considered desirable. Furthermore, it was considered that the problems being investigated by the Committee were of direct importance to a considerable number of Government Departments in addition to the State Advances Corporation, and that these Departments should be made aware of the scope and value of the work under the Committee's direction, with a view to securing their support. A meeting of all the interested Departments was therefore called in February, 1939, at which the Committee's work was fully explained. The departmental representatives were in general agreement with the seriousness of the problems and the necessity for organized research relating to timber-protection, and a decision has been reached to combine funds and other resources to undertake research under the direction of the Timber-protection Research Committee.

LEATHER AND SHOE RESEARCH ASSOCIATION.

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

In the annual report for 1938 it was pointed out that co-ordination of Leather and Shoe Research would enable each industry to work more together towards a common end—viz., the supplying of the public with the shoes and leather it requires. As a result of the work of the Research Association the leather industry has obtained a clearer view of the requirements of the shoe-manufacturer, and the latter has obtained a clearer view of the qualities of leather and the principles underlying some of the processes he uses. This knowledge has been of help in the processes of manufacture and has enabled progress to be made.

It must be remembered that quality in both shoes and leather is really a summation of many qualities, the total remaining more or less constant. Consequently, if one of these constituent qualities is made more dominant it can only be done at the expense of one or more of the others. This fact is not always realized, especially when price is made the predominant feature.

LEATHER RESEARCH.

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

The work carried out during the year has been mainly on chrome upper leather in connection with the characteristic known as fineness of "break."

Waterproofness of Sole Leather.

The waterproofness of sole leather is not measured by the wearer in terms of how much water the leather will absorb, but how long it will keep the foot dry. Factors affecting waterproofness of sole leather were investigated and found to be related to the degree of tannage, the amount of water solubles present, and the effects produced by rolling.

Tensile Strength, Stretch, and Crackiness of Upper Leather.

A short investigation on tensile strength, stretch, and crackiness of chrome upper leather was carried out. The effect of some factors on these qualities were determined.

Fineness of "Break" of Upper Leather.

The fineness of "break" of upper leather depends on the natural tightness of the skin. A method of measuring the natural tightness of the grain has been determined, and some of the effects of the following processes on this tightness have been ascertained: (*a*) Liming, (*b*) deliming, (*c*) bating, (*d*) pickling, (*e*) tanning, (*f*) neutralizing, (*g*) fatliquoring, (*h*) drying and stretching.

Many of the recognized principles underlying successful chrome tannage have been explained by the methods adopted. The results obtained so far justify a continuation of the investigation so as to cover more of the numerous conditions which may arise from the possible combinations of the above processes.

British Leather Manufacturers' Research Association.

As in the previous year, the results of the work carried out have been submitted to the British Leather Manufacturers' Research Association. At the latter's request one of the monthly circular letters was published in the *Leather World*. This was reprinted in the *Le Moniteur de la Cordonnerie et du Cuir*, Brussels.

Defence Department.

The Director, as in previous years, was asked by the Defence Department to report on the condition of the leather equipment and its storage at Trentham.

General.

During the year the staff has again maintained close contact with the factories. The necessary practical outlook on factory problems and the application of the results of research to their solution has been obtained on the periodical visits to the tanneries. These visits are important not only from the point of view of the staff, but also from that of the practical man as they maintain and expand his interest in research.

The monthly circular letters have been continued and have, as before, provided a basis for discussion on the visits of the staff.

The usual routine work of examining and testing raw materials, the finished product, and the processes used has been carried out as in previous years.

Publications.

"Some Further Factors on the Absorption of Water by Sole Leather." *N.Z. Jour. Sci. & Tech.*, 1938, Vol. XX, 24B–30B. (Also printed *J.I.S.L.T.C.*, 1938, XXII, 383.) "The Functions and Quality of Modern Sole Leather." *N.Z. Jour. Sci. & Tech.*, 1939.

SHOE RESEARCH.

Advisory Committee: Mr. P. Edwards, Mr. W. Denby, Mr. W. S. Livingstone.

The manufacture of shoes consists of a series of intricate processes each necessary to produce the finished article. It has been stated that "perfection in shoes is the result of attending to details, but that perfection in itself is no detail."

The work carried out during the year has been along the lines given in the introduction to this report—viz., a general survey and an examination of some of the materials used in shoe-manufacture and the general principles underlying certain of the processes. As a result of this work attention has been drawn to some of the details of shoe-manufacture, and so many steps have been made towards the ultimate goal of perfection.

Waterproofness of Boots.

As a result of the work carried out, attention was drawn to the need of making the mechanical construction waterproof as well as using waterproof materials.

Threads.

The different threads which are used in shoe-manufacture were examined in their relation to the purpose for which they are used. It was pointed out that as the chain is only as strong as the weakest link, so the thread is only as strong as the weakest point.

Effect of the Sewing-needle on the Leather.

The needle or awl used in sewing leather cuts some of the fibres and so reduces its strength. The effects of different needles on the stitch and breaking-strengths of the leather were determined. It is important to know the maximum number of stitches to the inch which may be used for each size of needle and which will still leave sufficient strength in the leather to give a seam strong enough to meet reasonable requirements.

Seam Strength.

The results obtained showed that if the leather was not unduly damaged by the sewing-needle the strength of the seam was proportional to the number of stitches to the inch and the strength of the thread. Under ordinary conditions of sewing the use of a thick strong thread does not of necessity produce a seam of maximum strength.

Tension of the Sewing-thread.

The importance of having the right amount of tension on both needle and shuttle threads was emphasized. If this is not the case the two pieces of leather joined together may move relative to each other. The result of this movement is a scissors action which will eventually cut the thread.

Welt Insoles.

Some of the factors affecting the stitch strength of the channelled welt insole leather were determined. The results on seam strength were confirmed by those obtained on other kinds of seams.

Fabric Linings.

The qualities of fabric linings in relation to shoe manufacture have been examined.

Elasticity and Plasticity of Leather.

The elasticity and plasticity of leather have been examined as a preliminary investigation of the pulling-over and lasting processes. The results obtained will serve as a basis for the investigation of the major problem of shoe shape.

Factory Problems.

One hundred and ten factory problems were submitted for investigation during the year. These problems were distributed amongst the majority of the firms. As more information on the basic principles underlying shoe-manufacture is obtained this aspect of the work of shoe research will become still more valuable than it has been during the year.

Circular Letters.

The monthly circular letter, containing as it does the results obtained in the research investigations, information of a general character, and the results of the investigation of factory problems, is greatly appreciated. Not only does this letter fulfil an educational function, but it also serves as a basis of discussion, and brings the practical man into closer touch with the Research Staff.

PELT RESEARCH.

Effect of Pickling and Storage in the Pickled Condition.

The effect of storing pelts in the pickled state is to make the leather which is made from them very soft and therefore unsuitable for certain purposes. It was considered possible that the large amount of salt used in the pickling process to enable the pelts to be kept for at least two years was the cause of this softness. An investigation was carried out, using less salt in the pickle liquor in the presence of different fungicides. The results, which have yet to be tested on a commercial scale, show that the amount of salt in the pickle liquor can be reduced if a suitable fungicide is added.

WOOL MANUFACTURERS' RESEARCH ASSOCIATION.

Wool Manufacturers' Research Association Committee.—Mr. J. Evans (Chairman), Mr. W. R. Carey, Professor H. G. Denham, Mr. T. E. Donne, Mr. H. Lee, Dr. R. O. Page, Mr. W. L. Wood, Dr. E. Marsden (Secretary).

Director.—Professor F. G. Soper.

Dr. S. Townend took up the appointment of Textile Research Officer on 1st May, 1938. He spent nearly four months in Europe before sailing for New Zealand, arriving on 8th October, 1938. During this time different sections of the wool-textile industry, and textile-machine and testing-equipment makers in England, Scotland, and on the Continent were visited. He also spent a number of weeks in the laboratories of the Wool Industries Research Association at Torridon in order to gain a broader knowledge of the activities of the Association, giving special attention to the trade problems handled in the consulting departments.

Information concerning developments overseas and differences in processing procedure that was of practical interest to members has been passed on through discussion and by means of three monthly letters. He has visited the mills of all members, and in a number of cases a second visit has already been made. Tests have recently been carried out in two mills—in the first with the object of reducing shade irregularities in grey mixtures, and in the second with the objects of increasing production and of reducing unevenness in the yarn.

The study of the raw-wool-scouring process, mentioned in last year's annual report, has been continued by the Research Chemist, Mr. R. V. Peryman, and detailed reports sent to the remaining eight mills. In continuance of this work numerous chemical analyses of scoured wool for grease, soap, and alkali contents have been carried out. The analysis of wool oils has been another major investigation, and an interim report has been circulated. The work on oils is still proceeding.

Studies have also been made by Mr. H. D. Purvis, M.Sc., in the Bacteriological Department of Otago University in connection with the problem of wool-damage by micro-organisms. The animal enzyme trypsin was found to act similarly to the proteolytic enzymes of bacteria, as judged by microscopical examination of wool fibres. The native wool fibre was found to be quite resistant to the action of trypsin except for local points of weakness. Ultraviolet light and treatment with alkaline solutions render the fibre susceptible to the action of trypsin. It is found that these two types of damage can be readily differentiated microscopically by staining reactions. The most interesting results have been obtained from the observation of the effect of mechanical stretching on the resistance of wool fibres to trypsin, for which purpose a special technique has been developed. Among other results it has been found that elongation of the fibre greatly increases the susceptibility to enzyme attack. These experiments are being continued.

Numerous service problems have been submitted by the mills, including the diagnosis of stains; acid and alkali damage; insect and bacterial damage; and the analysis of carbonizing liquor and boiler-feed water. A constant-temperature-constant-humidity room is now in operation for routine test work.

Bulletins are circulated each month dealing with information of interest to members. During the year the subjects discussed have included "Bacterial Attack of Woollen Goods," "Stains," "Comfort in Clothing," "Wool Oils," "Notes on the Wool Industry," "Bleaching of Wool," "The New Rubberizing Process," "Carbonizing Liquors."

There has been one alteration in the staff. Miss Davies, M.H.Sc., desiring to continue her studies at Melbourne University, resigned the secretaryship, and Miss Fenwick, B.A., was appointed on 14th March, 1939.

RADIO RESEARCH.

Advisory Committee: Professor James Shelley (Chairman), Professors P. W. Burbidge (Auckland), D. C. H. Florance (Wellington), R. Jack (Dunedin), F. W. G. White (Christchurch), Squadron-Leader E. M. F. Grundy (Air Department), Captain G. H. Heal, N.Z.S.C., Army Headquarters, Messrs. E. H. R. Green (Post and Telegraph Department), J. R. Smith (National Broadcasting Service), and Dr. M. A. F. Barnett (Department of Scientific and Industrial Research).

When allowance is made for the difficulty which has been experienced in the appointment of officers with the requisite specialized qualifications for the investigations to be undertaken, very satisfactory progress has been made during the year with the radio research programme.

At the meeting of the International Scientific Radio Union held at Venice in September, 1938, the Committee was represented by Mr. J. A. Ratcliffe, of Cambridge University. Mr. Ratcliffe forwarded a very useful report of the proceedings of the Union, and this is at present being circulated to members of the Committee.

During March, 1939, Dr. L. V. Berkner, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, spent a short time in the Dominion and visited the four main centres. Dr. Berkner is a radio research worker of high standing, particularly in the ionospheric field, and his visit proved of very great benefit. He gave a lecture in each centre and spent a considerable time in discussing radio research problems with the New Zealand workers.

As regards the actual research work, three main lines have been pursued, and these will be reviewed briefly in turn.

Ionospheric Investigations.—The critical frequency of the F region and E region of the ionosphere has been measured at Christchurch at hourly intervals from 9 a.m. to 6 p.m. and on international days during the twenty-four hours, while at Wellington noon measurements have been made every day and less regular observations carried out at other periods. Automatic-recording equipment which was made in Australia has been installed at Canterbury University College. Data have now been accumulated from October, 1937, onwards, and arrangements are being made for a systematic exchange of this information with observatories in other parts of the world. A satisfactory solution of the physical problems involved can result only from a study of a world picture of the changes that are taking place. It is proposed to publish the present data in a bulletin which will describe the observed phenomena to date.

During the year Mr. T. W. Straker, a part-time worker at Canterbury University College, investigated the diurnal variation of the absorption of wireless waves in the E region. The measurements were carried out in mid-winter and in mid-summer. It was found that the changes in absorption were in conformity with Appleton's theory as regards the daily variation, but that the annual effect from summer to winter did not follow the theoretical law. A paper describing this work and suggesting an explanation of the discrepancy has been sent to England for communication to the Physical Society of London.

From the point of view of an ionospheric observatory in New Zealand it is important to know the relative positions of the observatory and the zone of maximum auroral frequency. With the object of determining the position of this zone Professor F. W. G. White has made an examination of the information collected by scientific expeditions to the Antarctic. Although the data are not altogether suitable the desired result has been achieved to some extent. A collection of the early observations up to 1900, has been published in the New Zealand *Journal of Science and Technology*, under the

title "Early Observations of Aurora Australis." This will be issued as Radio Research Publication No. 2. A paper entitled "Photographic Determination of Height and Position of Aurorae determined in New Zealand in 1937," by Mr. M. Geddes, is also being published in the *New Zealand Journal of Science and Technology* and will be issued as Radio Research Bulletin No. 3.

Research on the Reception of Distant Signals.—Preliminary work in this investigation has been confined to Auckland and has been carried out under the direction of Professor P. W. Burbidge. A suitable reception site has been selected at West Tamaki and temporary wooden huts and masts erected.

Mr. E. Collins, a part-time assistant, has made good progress with the development of equipment for measuring the field strength of high-frequency overseas signals. Using a vertical aerial for reception, regular measurements are now being made of the strength of signals radiated by the British Broadcasting Corporation stations. It is hoped shortly to be able to improve the accuracy of the measurements of absolute intensity.

A small portable rotating Adcock direction-finder has been constructed and will be used to determine the effect of wire fences and other obstacles and also variations of contour of the neighbouring terrain. A start has been made with the development of the three aerial system of direction finding and receivers for this purpose have already been built.

Towards the end of March Dr. K. Kreielsheimer was appointed as Research Physicist for the distant-signals work. The appointment was made in Sydney, and Dr. Kreielsheimer will spend four or five weeks familiarizing himself with the recent developments in the work being carried out by the Australian Radio Research Board. His arrival in New Zealand early in May should mean a great acceleration in the distant-signals work, as up to the present only a part-time assistant and honours students have been available to attempt the large projects which were planned.

Grateful acknowledgment is made of the valuable assistance and co-operation afforded by Professor Madsen, Chairman of the Australian Radio Research Board, by Dr. Smith-Rose, Director of Radio Research work at the National Physical Laboratory, and by the British Broadcasting Corporation.

Research on the Propagation of Radio Waves over the Earth.—A scientific study of the field strength of local broadcasting stations was made by Mr. G. Searle, who was seconded for this work for one year from the Post and Telegraph Department. Mr. Searle made a detailed study of the distortion produced in the radiated field by different types of obstruction—trees, fences, power-lines, hills and valleys, and so on. A knowledge of the general magnitude and extent of the distortion produced by such obstacles as power-lines or telephone circuits, for instance, is a necessary preliminary to any scientific field-strength survey. Results of very great interest were obtained and have been published in the *New Zealand Journal of Science and Technology* in a paper entitled "Some Ground Wave Field-intensity Measurements taken in New Zealand." This has been reissued as Radio Research Publication No. 1.

Since Mr. Searle returned to his duties in the Post and Telegraph Department the work on local field-strength measurements has been in abeyance pending the appointment of a suitable successor.

SOCIAL SCIENCE RESEARCH BUREAU.

ANNUAL REPORT FOR THE YEAR ENDING 31ST MARCH, 1939.

Social Science Research Committee.—Mr. Evan Parry, LL.B. (London), Barrister and Solicitor (Chairman); Mr. F. B. Stephens, M.A., B.Com., Department of Internal Affairs (Vice-Chairman); Dr. C. E. Beeby, M.A., Ph.D., Assistant Director, Department of Education; Professor H. Belshaw, M.A., Ph.D., Professor of Economics, Auckland University College; Dr. Elizabeth Gregory, M.H.Sc., Ph.D., Home Science Department, University of Otago; Dr. Elizabeth Gunn, M.B., Ch.B. (Edin.), Director of School Hygiene, Department of Health; Mr. E. H. Langford, M.A., Private Secretary to the Hon. the Minister of Scientific and Industrial Research; Mr. George Lawn, M.A., Economic Adviser and Director, Reserve Bank; Dr. E. Marsden, M.C., C.B.E., D.Sc., F.R.S.N.Z., Secretary, Department of Scientific and Industrial Research; Mr. T. H. McCombs, M.P., M.Sc., A.I.C.; Dr. D. G. McMillan, M.P., M.B., Ch.B.; Professor R. W. Souter, M.A., Ph.D., Professor of Economics, University of Otago; Dr. W. B. Sutch, M.A., B.Com., Ph.D., Private Secretary to the Hon. the Minister of Finance and Marketing; Mr. D. O. Williams, M.A., Director, Bank of New Zealand; Mr. Ormond Wilson, M.A.; Mr. G. E. F. Wood, M.A., Census and Statistics Department; Mr. W. T. Doig, M.Com., Secretary and Executive Officer.

SURVEY OF STANDARDS OF LIFE OF DAIRY-FARMERS.

During the year an analysis has been made of the large amount of information obtained in this survey, and a report of the results has been written by the Secretary. The survey will provide some very interesting material relating to the conditions of living of dairy-farm families. Included in the study are sections dealing with the farms and their production, household and family composition, occupational history of the farmer, schooling, housing and household equipment, work and leisure, expenditure and consumption. The results should prove of interest not only to farmers themselves but to administrators, sociologists, economists, educationists, and all others concerned with rural social and economic problems.

This first survey, undertaken by the Bureau in association with the New Zealand Council of the Institute of Pacific Relations, shows that where the information required is of a personal or even intimate nature full assistance and co-operation can be obtained if the purpose of the work is carefully explained to the people concerned.

Survey of Standards of Life of Tramway Employees and Boot and Shoe Operatives.

While the statistical work on the dairy-farmers' survey was proceeding, field-work was begun on a similar survey covering two urban groups—tramwaymen, and operatives in boot, shoe, and slipper factories. With experience gained in the field in connection with the first project of the Bureau it was possible to draw up a more comprehensive and satisfactory schedule, and a great amount of highly interesting material was obtained. The survey was conducted in Auckland, Wellington, Christchurch, and Dunedin, and 477 families were interviewed. An interview lasted from two to three hours, during which time items of information numbering sometimes as many as four hundred were given. Those interviewed were married men only. Very few refusals were met with, and field-workers found a very encouraging willingness to impart confidential information. Later, the employing authorities, with the consent of the men concerned, supplied full details of the working-hours, wages, and reasons for lost time for each of the men interviewed, for a period of eighteen months. Of the 477 schedule interviews, 472 were found to provide material suitable for analysis. The great majority of families interviewed also agreed to keep a monthly household budget, and 285 of these were returned. Not all of these have yet been fully examined, but it is already evident that only a small proportion will have to be rejected as being unsuitable for analysis.

Careful checking of all this material has been completed, and the work of analysis is proceeding. In order that the material may be available as soon as possible the results will be published sectionally in the form of bulletins. The first, dealing with the hours, wages, and sources and amounts of other income of boot operatives, is ready for publication, and the second, which covers the same ground with reference to tramwaymen, is well forward.

The fullest possible information has been obtained on each topic dealt with. Separate bulletins will deal with such sections as leisure-time activities, housing, household equipment, the meeting of emergencies, consumption habits, industrial history, family composition, and so on. For example, the bulletin on leisure-time activities will deal with radio ownership, the place occupied by music in the home, with a comparison of the musical interests of parents and children; attendances at various forms of entertainment and sport; hobbies, the playing of games, social contacts, holidays, and facilities for holiday-making; reading, cultural activities, and community service, and membership in various types of organization. Finally, the cost of all these leisure-time activities will be reviewed, and some examination of their type and extent will be attempted in the light of income and other relevant factors. The material is sufficiently embracing to enable each of the topics dealt with to be treated in a similarly thorough fashion.

The experience gained as a result of the analysis of the first survey will enable the urban section to be dealt with more rapidly; and there is no doubt that the results will be of real sociological value.

Unfortunately, it will not be possible to estimate how typical these results are of the community as a whole. Every precaution was taken to make the sample representative of the industry concerned, but whether it is also representative of those engaged in other industries can only be ascertained by further surveys.

General.

The year has been an excellent one from the viewpoint of experience in methods of research. Since social science research on a comparatively large scale is new in this country the first period of the Bureau's existence has necessarily been devoted to the training of staff in the techniques of investigation and analysis. The experience gained in the surveys conducted will enable the staff to handle future work more expeditiously.

DOMINION LABORATORY.

Director: W. Donovan.

The Dominion Laboratory is maintained primarily to furnish Government Departments with such chemical services as they may require. The number of Departments serviced increases each year, and so also does the range and scope of the samples and subjects on which information is required. The year under review has been no exception. The samples received from the various Departments are listed as follows:—

Wellington (Main Laboratory): Department of Agriculture, 4; Customs, 182; Defence, 33; External Affairs, 4; State Forest Service Department, 24; Government Printing Office, 27; Health, 3,029; Housing, 169; Labour, 451; Lands and Survey, 21; Main Highways Board, 220; Mines, 85; Police, 11; Post and Telegraph, 132; Prisons, 300; Public Trust, 40; Public Works, 114; Railways, 32; Research, 63; Geological Survey, 98; Plant Research, 144; Soil Survey, 28; State Advances, 41; Stores Control Board, 15; Other Departments, 41; Miscellaneous sources, 254: Total, 5,562.

Auckland (Branch Laboratory): Customs, 1; Dairy-produce Board, 3,885; Health, 5,116; Justice (Police), 147; Native, 1; Naval, 3; Post and Telegraph, 4; Public Trust, 63; Public Works, 49; Scientific and Industrial Research, 24; State Advances Corporation, 6: Total 9,299.

Christchurch (Branch Laboratory): Food and drugs (Health Department), 3,872; Justice (Police) Department, 158; Other Government Departments, 173; Local bodies and miscellaneous, 21: Total, 4,224.

Dunedin (Branch Laboratory): Health, 1,955; Justice (Police), 45; Agriculture, 4; Post and Telegraph, 1; Public Works, 1; Miscellaneous, 7: Total, 2,013.

The total number of samples received during the year in all the laboratories was 21,098.

Customs.

Analyses are often helpful and in some cases necessary in determining correct classification of imports, and when required are made by the Laboratory. A very great variety of samples is submitted.

Police.

Wellington.—No poison was found in exhibits submitted by the police, except in one case, in which arsenic was present in amount sufficient to cause death. Some samples of alcoholic liquor were analysed in connection with suspected sly-grog selling. A mild explosion which was investigated was proved to be due to nitrogen iodide.

Auckland.—The cases of poisoning investigated included two of barbiturate and one each of strychnine and arsenic. Two motor-collision cases were investigated, one where the car was identified from the pattern of the running-board on the clothing of the victim, and the other where the contact of two cars was proved by the transfer of Duco lacquer. In a case of burglary of a safe, clay from the shoes and trousers of the accused was shown to be identical with clay from the place where the safe had been blown open. The work on etching fluids for the restoration of filed-off numbers (see seventieth annual report, page 7) has been continued, and it is interesting to record that solutions recommended have been tried out at Shanghai in similar cases and with good results.

Christchurch.—The following were present in exhibits submitted for toxicological examination: Arsenic, carbon monoxide, chloroform, morphia, oxalic acid, paraldehyde, strychnine, sulphonal. Chloroform was examined in the case of an anæsthetic death. In connection with motor-car accidents, a considerable number of specimens of blood and urine were examined for the presence of alcohol. Parsnip wine submitted contained 23 per cent. of proof spirit, and a cider 20 per cent.

Dunedin.—Small amounts of strychnine and arsenic were found in the organs in a suicide case. In a case involving a charge of manslaughter the residues in two tumblers were identified as beer. Traces of strychnine were found in the stomach contents of a cow. Samples of home-made wines, sold illicitly, contained large percentages of alcohol.

Department of Health.

Milk.

The total number of milk-samples taken by Health Inspectors and analysed at the four laboratories during the year was 11,831.

Auckland.—The total number of milk-samples is greater than in any previous year, and shows a more adequate inspection. Of 3,476 samples taken in the city and suburbs, 14 were low in fat, 43 contained added water, 26 were stale, and there were 39 minor deficiencies. Of 820 samples taken in country districts, 24 were low in fat, 15 contained added water, 8 were stale, and 27 were slightly sub-standard.

Particular attention has been given to milk supplied to school-children under the milk-in-schools scheme, and the pasteurization has been checked regularly throughout the province. The phosphatase test has shown that the Auckland City milk is always correctly pasteurized, but in the absence of labelling the purchaser does not know whether it is pasteurized or not. In 166 cases Inspectors were wrongly informed on this point when purchasing samples.

Wellington.—Of 1,588 samples from Wellington City and suburban suppliers, 17 were low in fat, 25 contained added water, 19 were stale, and 3 deficient in milk solids without containing added water. Of 980 samples from country districts, 21 were low in fat and 12 contained added water. Special attention was paid to school supplies for children.

Canterbury and Westland.—The number of samples taken in Christchurch City and suburbs as 1,738, of which 36 were low in fat, 25 contained added water, and 32 were stale, while 58 were slightly deficient in some respect. Of 944 samples taken in country districts, including the West Coast, 16 were low in fat, 15 were watered, 35 were stale, and 53 slightly sub-standard. The general quality of the supply in Christchurch City and suburbs has shown improvement as the result of regular sampling and co-operation with the Department of Agriculture. A considerable proportion of the milk now sold is pasteurized and the phosphatase test is applied as a routine measure. A few cases of failure to label pasteurized milk were observed.

School Milk-supply: Samples of the milk have been taken both before and after pasteurization, and also regularly at the farms. The farm inspection has led to the elimination of unsatisfactory supplies.

Otago and Southland.—The number of samples was considerably greater than in the preceding year, and the proportion which did not comply with the regulations was also greater. In an unusually large number of cases the addition of water as detected. Formalin was found in one sample. Of 1,096 samples taken in Dunedin City and suburbs, 17 were low in fat, 36 contained added water, 12 were stale, and 79 were slightly below standard. Of 631 samples taken in country districts, 29 were low in fat, 11 contained added water, 3 were stale, and 74 slightly below standard.

School Milk-supply: Phosphatase and Storch tests applied to samples of the milk supplied to school-children showed that pasteurization was being efficiently carried out.

Water.

The waters submitted during the year were principally from proposed or existing town supplies, but also included several from school tanks and wells, from Public Works camps, and from Maori settlements. Two interesting samples came from Te Whanga Lagoon, Chatham Islands, and from Raoul Island, Kermadec Group. Special waters were examined for suitability for washing flax, also for use in a hospital laundry. The effect of water on copper hot-water cylinders was investigated for the Housing Department, and a preliminary report given. Sewage effluents from meat by-products and woolscouring works were examined.

Group Investigations.

Special series of investigations were undertaken during the year with regard to the following groups:—

Cornflour.—Reports from abroad indicated that in some countries cornflour was treated with sulphur dioxide in the process of manufacture. Several brands on the local market were therefore examined, but found to be free of this bleaching-agent and preservative.

Dried Fruit.—As many brands as possible of dried fruit sold locally were also examined for the presence of sulphur dioxide, a small amount of which, seven grains per pound, is permitted by regulations. Most of the samples were entirely free, and in three cases only were the amounts found appreciably in excess of the permitted quantity.

Iodized Salt.—Eighty-eight samples of iodized salt, representing all available brands, twenty-four in number, on the local market, were obtained from various townships in the Wellington, Palmerston North, Taranaki, and Gisborne Health Districts. The proportion of iodide required by the regulations is one part by weight of potassium iodide in 250,000 parts of salt. In a few cases different samples of the same brand showed considerable differences in iodide content, due possibly to insufficient care in bulk mixing. In another case deficiencies were considered to have resulted from loss due to prolonged storage in bags. Irregularities in the composition of one brand were traced to loss of iodide by absorption in the cardboard of the container. The respective manufacturers were informed in each case, and will, no doubt, take measures to ensure full compliance with regard to iodide content. The greater proportion of the samples complied reasonably with the regulations.

Liquid Paraffin.—Twenty-six samples were examined. One had a lower viscosity than is required by the British Pharmacopœia, and three others did not give satisfactory colour test with sulphuric acid. The remainder were satisfactory in all respects.

Lime Water.—Thirty-eight samples were submitted to the Wellington Laboratory. Three contained chloride, indicating probably that tap water had been used instead of distilled, in the preparations. Four were appreciably deficient in lime, and another four slightly deficient. In view of the frequent use of lime water in infant feeding it is most important that every care should be taken in its preparation and storage prior to sale.

Solid and Powdered Dentifrices.—The solid dentifrices consisted of precipitated chalk with either magnesia or very fine clay, incorporated in a soap and slightly perfumed. No harmful abrasive substances were detected in any of them, and in no case were any accompanied by extravagant advertising matter.

The powdered dentifrices consisted of white or coloured precipitated chalk, with the addition, except in one case, of magnesia. All were slightly perfumed. One gave a strong reaction for peroxide, which is regarded as safe and satisfactory in cleansing teeth and gums. Of two others labelled as containing peroxide, one definitely contained none and the other a mere trace. In none were harmful ingredients detected, and the advertising matter contained no extravagant claims.

Wholemeal Bread.—Wholemeal bread sold throughout the Auckland Province was examined, and warnings issued in a number of cases for non-compliance with the regulations.

Mince-meat.—Complaints in Christchurch led to an investigation of the use of preservative in mince-meat in that city. Of 42 official samples, 12 contained sulphur dioxide in excess of the permitted amount (3·5 grains per pound), one sample containing as much as 23 grains per pound.

Tincture of Iodine.—A large number of samples were taken in Christchurch and Dunedin. Three were deficient in iodine, one was twice the correct strength, seven were deficient in potassium iodide, and another had been decolourized and its antiseptic properties destroyed.

Ammoniated Tincture of Quinine.—Twenty-nine samples were examined in Christchurch, and eight found deficient in ammonia, the reason given being longer storage, due to falling-off in demand.

Camphorated Oil.—Twenty-seven samples taken in Christchurch all complied, with the exception of one, which contained an excess of camphor.

Labelling.

Barley Sugar.—Three of the samples submitted contained only from 10 per cent. to 12 per cent. of glucose, but were accompanied by statements as to the benefits following the consumption of glucose, which, in view of the small proportions of glucose present, were very misleading. While during recent years glucose has been recognized as possessing valuable dietetic and medicinal properties under certain conditions, it is improbable that for ordinary consumption a mixture containing 10 per cent. of glucose would have any advantage over a similar quantity of pure cane sugar.

Tooth-paste.—A sample of tooth-paste examined was unique in being put out in three varieties, in differently coloured tubes. The proprietors claim that through the prolonged use of one tooth-paste the gums become tolerant of its action, and that each type of their preparation acts on the gums in a different way, preventing "tissue tolerance." Except for the presence of a minute amount of different essential oils in each, the three varieties were practically identical in composition. The term "tissue tolerance" has little scientific foundation as applied to tooth-pastes, and would appear to be on the same plane as "night starvation" and "body odour" which on equally slender foundations figure largely in advertisements for certain other products.

Tablets "Astreena."—Extravagant claims are made for the tablets, which agree substantially in composition with that of Compound Aspirin Tablets of the British Pharmaceutical Codex. This is a case of a well-known preparation being sold as a secret remedy, which emphasizes the desirability of requiring the true composition of proprietary preparations being declared on the label.

Preservative.

A tripe bleach, examined both in Wellington and Dunedin, proved to be sodium perborate, the use of which is prohibited by the regulations. Even after prolonged washing boron compounds were still present in tripe bleached by its use.

Hydatids.

In connection with the campaign against hydatids in dogs the composition of the veterinary tablets was checked, and the purity of the arecoline hydrobromide used as the effective ingredient confirmed.

Miscellaneous Foods.

Bread-improver.—This consisted of condensed skim-milk, which would increase the protein and mineral content of bread, improve its keeping-qualities, and be altogether a desirable addition.

Butter.—Of 150 samples of butter examined, ten contained more than the permitted percentage of water.

Coffee and Chicory Essence.—The addition of caffeine to a cheap grade was detected and admitted by the manufacturer.

Ice-cream.—All samples complied with the regulations except two, which were markedly deficient in fat, and three others slightly deficient.

Lime-juice Cordial.—One sample was coloured, in contravention of the regulations.

Strawberry Jam.—One sample was artificially coloured with a coal-tar dye.

Whisky.—The two samples received both gave evidence of refilling.

Other samples received were Aspirin tablets, baby food, baking-powder, cocoa, cordials, corn-syrup, eucalyptus, fish, jam, margarine, passion-fruit juice, pea-flour, pickled onions, preserved eggs, tomato-soup, tripe and onions suspected of metallic contamination, rennet tablets, sago, santonin tablets, canned savouries, vanilla essence.

Other Materials.

Enamelled Dish.—The dish was unsuitable for use in the cooking or serving of food, as the enamel contained antimony oxide.

Metal Disk.—This was made of zinc, and was definitely unsuitable for use with milk-cans.

Tinning-metal for Dairy Equipment.—This contained lead, and therefore was unsuitable for the purpose.

Cork Linoleum.—Cork preparations were reported as having many advantages compared with other floor coverings for hospital wards.

Cementones.—These are preparations of various colours for use in colouring concrete. They consisted of light and finely divided powders which in the dry form gave rise to considerable dust, but did not contain any substances specially injurious to health.

Mines Department.

The Dominion Laboratory has continued to carry out the testing and analysis of mineral samples and mine-gases for the Department and to act in an advisory capacity when required.

Prospectors' samples tend to be fewer each year. Those containing gold came from such well-known localities as Kuaotuna, Poerua, and Skippers; lead and zinc ores were examined from previously worked areas at Te Aroha and Wairongomai, and galena (lead sulphide) and copper pyrites from Murchison; molybdenite was present in a small specimen from Merrivale, Southland, a locality from which it has not been previously reported; a sample of asbestos from D'Urville Island was examined, and was of promising quality; the best of the manganese ores received came from Red Island, south of Waimarama, Cape Kidnappers, and from Otau, near Bombay, the former being exceptionally good; numerous samples of diatomaceous earth were reported on and consideration given to possible uses; a number of borings were examined for scheelite for the Employment Department.

Some chemical assistance was given to the Director of the Thames School of Mines, who was investigating the treatment of refractory ore from Reefton. The development of the production of iron and steel in the Dominion would have a profound effect on mineral industries generally, and in this connection the analysis of numerous samples of iron ore from Onekaka, also coal and limestone, by the Laboratory should be noted.

In connection with the fuller utilization of slack coal, samples from Liverpool, Merrijigs (Reefton), and Rotowaro were submitted to the Laboratory for report during the year. Coals that had given trouble at gasworks were also examined, the difficulties in most cases being due to the high swelling-properties of otherwise excellent coal. Coals with low-swelling-properties and low sulphur content are relatively scarce in the Dominion.

Defence.

Several series of components for ammunition were examined for the Ordnance Services. Samples submitted from the Air Force consisted of compass fluid, detector-ink fluid, dope remover, and lubricating-oils.

External Affairs.

Supplies of fuel and lubricating oils were examined for compliance with specifications.

Forestry.

Samples of creosote were examined for compliance with specifications, and the blending of creosote with various crude mineral oils investigated.

Housing Construction.

Numerous concrete roofing-tiles of New Zealand manufacture were submitted for test. Other materials examined were bricks, wallboard, concrete, linseed-oil, and wash for galvanized-iron roofing. In some cases means were suggested by which improvement in manufacture could be brought about. Paints, of which 334 samples were submitted by this Department and by the Property Divisions of Public Trust Office and State Advances Corporation, are referred to later.

Industries and Commerce.

Samples were examined as follows: Casein paint, coffee and chicory grounds, fibre for porous plaster, used motor oil, whiting.

Post and Telegraph.

The samples were chiefly from the Engineering Division, and comprised alum, beeswax, carbon tetrachloride for fire-extinguishers, caustic potash, gas-leak indicators, insulator washers, lead cable sheathing corroded by use, glass-cleaner, floor-wax, lubricating-oils, paints, petroleum jelly, polishing and floor oils, manila rope, rectified spirit, shellac, switchboard wire, tar, tobin bronze, zinc plates.

Printing Office.

A three-colour printing process was investigated, and a remedy suggested for difficulties which had arisen in its use.

Public Works.

Materials examined for the Public Works Department comprised detergents, furnishing materials such as carpets, linoleum, and rubber-cementing solution, lubricating-oils, paints, sand for concrete. A report was furnished on the efficiency of a special oil-filter attachable to motor-vehicles. Two series of air and exhaust gases from the Waikoura Tunnel, East Coast Main Trunk Railway, were analysed.

Reserve Bank.

A doubtful florin and a bronze coin of light weight were examined.

Soil Survey Division.

The work for the Soil Survey Division consisted of the separation and analysis of clay fractions from numerous soils. Such work is tedious and exacting.

Stores Control.

Samples of lubricating-oils and motor-spirit submitted on tender were checked against specifications.

Other Departments.

Samples examined for other Government Departments included "borakill," deposit in water-pipe, kauri-gum dust and reject material, experimentally treated lemons and oranges, scissors, socks, tannic-acid solution for burns, and eleven carbon-dioxide recorders from various ships engaged in the transport of chilled beef.

Gas-inspection.

The major town gas-supplies of the Dominion were examined regularly throughout the year for calorific value, purity, and pressure, and with one or two exceptions, for which there was adequate explanation, complied with the standards on all occasions.

Gas-meters tested totalled 21,309.

Special Investigations.

Coal Survey.

The physical and chemical survey of the coal resources of the Dominion has been actively pursued during the year. The work is directed by a Coal Survey Committee of representatives from the Dominion Laboratory, Geological Survey, Mines Department, and Iron and Steel Department, and the staff is drawn from the Laboratory and the Geological Survey.

The field staff has adhered to a rigid sampling procedure based on British standard specifications. All samples have been located on a map, and full details of the seam have accompanied the sample to the Laboratory. In the Laboratory proximate and ultimate analyses are made, and in most cases low-temperature carbonization assays also, with analyses of the resulting gases. The swelling-properties of the coking-coals have been investigated, and an examination of the sulphur forms. British standard specifications for the sampling and analysis of coal, ultimate analyses, crucible swelling test, and agglutinating value have been followed throughout. Work so far has been concentrated on West Coast areas. The Blackburn and Liverpool areas have been surveyed, and estimates made of the recoverable coal.

While proceeding with the main programme, every effort has been made to obtain other information when urgently required. The field staff has been able to conduct preliminary surveys of certain areas in order to decide on their suitability for co-operative mining purposes. In the Laboratory Westport coals were given precedence, at the request of the Iron and Steel Department. The use of coal from the slack dump at Rotowaro was investigated, and some examination made of coals that had given trouble at gas-works.

In his investigation of the possibility of an Iron and Steel Industry in New Zealand, Dr. Colclough has had the full assistance of the survey on the fuel side, and has expressed appreciation both of the systematic and thorough way in which the work is carried out, and of the clear and informative nature of the reports submitted to him.

Refined Kauri-gum.

Hosking Process.—The solvent, of Hosking, process for the refining of crude "chalk" and grades of "chip" gum has now been finally elaborated by Dr. Hosking in London. Additional work by him at the Paint Research Station, Teddington, has established some promising fields for the utilization of the refined resins. The most extensive application the resins are likely to find in commerce is their incorporation in oil varnishes, both pigmented and unpigmented. The "chalk" gum, like "bush-bled" kauri, has the added advantage that it is directly soluble in raw linseed-oil, without previous running (fusing) and consequent discoloration and loss in weight. Kauri resins can also be incorporated in varnishes prepared with the recently developed linseed-oil and tung-oil monoglycerides. All grades are soluble in these oils without the usual preliminary "running" and the products possess excellent durability, water resistance, and gloss.

Kauri resin was found to offer difficulties, when not previously fused, in standard nitrocellulose-lacquer formulations, as matt surface films were produced. It was found, however, that combinations of kauri resin with castor oil and glycol gave resinous products which, without difficulty, furnished lacquers of good gloss and greater durability than the straight kauri lacquers. These products showed promise and warrant further investigation. A very promising field is open for the use of kauri to produce lacquers having a matt surface. Such surfaces are in the ordinary course difficult to produce and are of value where non-reflecting surfaces are desired.

With the aid of several new solvents which have been found for kauri it has been possible to prepare varnishes similar in type to spirit varnish and possessing a glossy hard film. The products obtained by combining kauri with glycol and those obtained by combining mixtures of kauri and Congo gum with glycerol indicated a promising field for further trials on a larger scale.

A considerable amount of work has been done in an endeavour to find a method for the removal of the colour from the darker grades of kauri, but it appears very unlikely that any satisfactory process will be found for this purpose. While it is possible to remove some degree of colour, the cost of the process would never be repaid by the slight increase in value of the products.

Sufficient work both on laboratory and commercial scales has now been completed to place beyond doubt the fact that purified kauri is a valuable resinous product for the manufacture of varnishes and allied materials.

Recovery Process.—To assist in an investigation of "chip" washing and cleaning processes a number of chip gums were analysed in the Wellington Laboratory.

Phormium Tenax.

Chemical Examination.—Several varieties have been examined chemically with a view to determining differences in fibre quality. Differences have been found to occur, and the work is being extended to other varieties.

Processes for Treatment.—Reports were made as follows: (1) The explosion process for stripping. The fibre produced was of less value than ordinary unscutched stripper fibre for textile purposes, and very little cheaper. It was not suitable for the manufacture of finer grades of paper. (2) Process for softening fibre by bacterial retting for a short period. The claim that the product produced a softer and finer fibre, suitable for spinning fine yarns, was not substantiated. (3) Tail stripper. Spinning tests were made on fibre produced by this process. The strength had not been impaired and the losses in processing were no greater than those experienced with ordinary tail-clipped fibre. The yarn produced created a favourable impression.

Ragwort.

Samples collected at monthly intervals during one year from areas near Hamilton have been analysed for alkaloid content. Samples collected from the Hutt Valley over a period of eighteen months have been similarly examined. Certain variations have been observed and the work is being continued.

Curing of Lemons.

The laboratory work on curing of lemons was brought to a conclusion during the year, and a full report is being published in the *New Zealand Journal of Science and Technology*. The best results were obtained by storage in a slow current of air at a temperature of 70° F. and a relative humidity of 90 per cent. for a period of from five to six weeks. Coal-gas to the extent of 0·1 per cent., equivalent to ethylene 1 part in 30,000, was introduced into the air stream for the first three weeks.

Fruit so treated had shrunk somewhat, giving greater resilience, the skin was reduced considerably in thickness and was tougher, the colour was improved, and the juice content had increased in quantity and was of more mature flavour compared with fruit not so treated. To complete the work a large-scale storage trial under the conditions recommended should be made.

Gas-storage.

Work has been continued on the gas-storage of apples of the Washington and Ballarat varieties. A considerable amount of information has been obtained on the behaviour of these apples in atmospheres containing carbon dioxide. It appears that some improvement in quality of fruit and in length of storage life is obtained by storing the Ballarats at 39° F. in an atmosphere containing 2·5 per cent. to 5 per cent. of carbon dioxide and 18·5 per cent. of oxygen, and the Washingtons in 5 per cent. of carbon dioxide with 16 per cent. of oxygen. Under most of the other conditions tried various physiological disorders developed. For fuller details reference should be made to the section "Fruit Cold Storage Committee" (see page 73).

Spraying-materials.

Analyses of spray materials for the Plant Research Bureau have been continued, samples of lead arsenate, lime-sulphur, nicotine sulphate, and spray oil being tested for certification. Over one hundred samples of New-Zealand-grown Pyrethrum flowers were analysed for their content of Pyrethrins 1 and 2, the method used being that of Gnadinger and Corl. The amounts of Pyrethrins found varied from 0·7 per cent. to 1·9 per cent. A series of the commercial spreaders on the market was examined with a view to ascertaining their approximate composition. Most proved to be of the casein type, whilst the remainder were sulphite lye or sulphonated organic products.

Paints.

A very large quantity of paint is used each year on Government-owned buildings by the Post and Telegraph and Public Works Departments. The Property Divisions of the Public Trust Office and the State Advances Corporation also require large aggregate amounts for use on residential and other buildings under their care. With the setting-up of the Housing Construction Department the State purchases of paint were further increased. Work in previous years had demonstrated the value of analysis in checking up the quality of supplies, and there was a decided increase in the number of samples submitted during the year under review. Each paint is examined for composition and proportion of pigment, and nature and proportion of oils and thinners, which must be in accord with specifications issued by the Department concerned. As a check, the weight per gallon is also determined. Both pigment and oils used must comply with the respective British standard specifications. Several samples of paint scrapings were also examined with a view to ascertaining the cause of paint failure in specific cases. A Paint Investigation Committee, composed of representatives of the various interested Departments and of the Laboratory, has been set up to arrange for large-scale trials, by which it is hoped to correlate the composition of paint, and also varying painting procedure, with protection of the underlying material and durability.

Quartz Spectrograph.

During the year the spectrograph was in continuous use for general laboratory work and for investigational purposes. From time to time examinations were made of various metals for the Defence Department and the Post and Telegraph Department. In miscellaneous work, where the greatest sensitivity is not desired, the use was developed of the interrupted arc with high-frequency pilot (Pfeilsticker arc). This has been regularly used for the estimation of strontium in rock analysis. Various corrosion products were examined. In the case of corrosion thought to be due to sea-water the ratio of sodium to other metals in the corrosion product was found to be much higher than in sea-water, but the clearest indication was given by the absence of strontium, easily detected in sea-water, so that the evidence pointed to some other corrosive agent. For the investigational work on trace elements in biological material the arc on graphite electrodes is used. The examination was completed of the ash of samples of milk from various areas of good and poor soils in the North Auckland district. No definite correlation was found between the amount of any minor element and the character of the soil. An investigation was made of the leaves of citrus trees suffering from mottled leaf. The manganese content of the mottled leaves was definitely less than that of the healthy leaves. Pears were examined in connection with the "corky-pit" trouble. In pears, in contrast to apples, this is not amenable to boron treatment. A qualitative examination did not show any marked differences in the minor elements in sound and unsound fruit, and it will be necessary to make quantitative estimation of the various elements detected. Towards the end of the year work was begun on the first of the series of pasture samples from eight districts, under the programme of the Spectroscopic Committee.

Thermal Regions, White Island.

In November a member of the staff visited White Island to co-operate on the chemical side with Dr. P. Marshall, who is carrying out further investigations on the thermal regions. During a stay of one and a half days temperatures of fumaroles were measured with a pyrometer, and samples of gas, condensed steam, and water were brought back for analysis in the laboratory.

CHEMICAL ENGINEER.

An investigation is in progress on the design of a commercial dryer for grass-seed. The work was undertaken on behalf of the Plant Research Bureau and follows that carried out by Messrs. Foy and Hyde (*New Zealand Journal of Agriculture*, *49*, 10, 1934, and *51*, 40, 1935) on the prevention of deterioration of Chewings-fescue seed by drying and storage in suitable containers. In order to prevent deterioration it was found by these workers that the seed should be dried to a moisture content below approximately 9 per cent. or 10 per cent. After a considerable amount of experimental laboratory work a semi-commercial dryer has been built. The dryer works on a counter-current principle and has a capacity of 70 lb. to 80 lb. dried seed per hour. This dryer, the design of which is covered by a provisional patent, has functioned satisfactorily, and the results so far obtained appear sufficiently encouraging to warrant the preparation of designs for a dryer several times larger. The question of providing suitable moisture-proof containers for the dried seed is also under consideration.

In addition, the chemical engineering staff has also been engaged on the problem of measuring the outflow from agricultural drains in connection with field-drainage experiments being carried out at Massey College, the design of special apparatus for the Plant Research Station, Palmerston North, and in furnishing reports on various industrial and technical subjects, including the processes mentioned in the paragraph headed "*Phormium tenax*."

LIBRARY.

The appointment of a librarian has been fully justified by the greater use now possible of reference books and journals. The books are being reclassified on the basis of the Universal Decimal System, which should give more ready access to information on any desired subject. A system of indexing useful articles in periodicals and journals has been inaugurated, and is affording a valuable key to current literature. Already there are approximately five thousand entries. Accessions during the year total 250 volumes, bringing the number of books up to 2,000, exclusive of bound journals and serial publications. Eight periodicals have been added to the list of publications regularly received.

ADVISORY AND CONSULTING WORK.

The senior members of the staff have been frequently consulted on scientific and industrial matters. They have also represented the Laboratory on various Standards Institute and other interdepartmental committees.

METEOROLOGICAL BRANCH.

REPORT BY THE DIRECTOR, 1938–39.

General.

Further expansion of the meteorological services has been called for owing to the accelerated development of civil and military aviation. Within New Zealand several new air routes have been opened up and the frequency of services on the existing routes has been increased. The principal responsibility of the Meteorological Office during the year has, however, been the preparing of the very special organization required for trans-ocean flying. Communications, particularly by radio, play a vital part in any such organization and in the provision of these the Meteorological Office has received the utmost assistance from the Post and Telegraph Department and the Aeradio Committee. We are further indebted to the Post and Telegraph Department, as well as to the Marine Department, for arranging for members of their staffs to undertake the observations at the great majority of the reporting stations. We are thus ensured of regularity in the reports which it would otherwise be possible to obtain only at great expense.

Conditions have in many ways been difficult owing to the need to train so many freshly appointed officers at the same time. As soon as one officer has mastered the rudiments of any branch of the work he has had to make way for another. It will, naturally, be some years before the new staff can reach full efficiency. In the meantime, an added burden is placed on those who have had more than a year or two's experience. It is particularly difficult for the forecaster, who is unable to have the daily weather chart to himself for any long period, and so to make his own analysis and to keep in close touch with the changes from one chart to another. On the other hand, the additional reports received have been of considerable assistance to the forecaster.

The need for uniformity in the methods of making and recording meteorological observations and of coding them into weather reports for transmission to forecasting centres has repeatedly been stressed. The only way in which a meteorologist can understand the existing situation and so anticipate future changes is to plot the information received on charts so that it can be taken in by the eye, and the relation of the different elements grasped. He has to form a mental picture of the state of the weather over a very wide area. If reports come in different codes, if different elements are reported, or different units used, the difficulty in charting is very much increased. Not only that, but aviators pass rapidly from one country to another and the charts used in different centres must be intelligible to them. The same applies to a somewhat lesser degree to mariners. The methods of plotting reports and drawing maps must, therefore, also be uniform. The charts themselves must be on uniform and suitable projections and the number of different scales used reduced to a minimum. To meet all these needs very full regulations have been laid down by the International Meteorological Organization and are revised from time to time as experience dictates. There is no means of forcing countries to adopt the procedure recommended by the International Meteorological Organization—the only compulsion arises from the obvious advantages of doing so. In recent years it has been the practice of the New Zealand Meteorological Office to conform as nearly as possible with international rules. This has greatly simplified the collection of information from other countries and ships at sea. It also enables New Zealand meteorologists to read the charts of other countries which follow the same practice with the minimum of difficulty. At the same time, people from the Northern Hemisphere can follow our charts as if they were their own. The need for uniformity of this kind becomes extremely important amongst allied nations in war-time, when operations are so largely affected by the weather. It means that practically no difficulty is experienced from differences of language or social organization.

One of the results of the international organization of weather reporting has been that all issues of collected weather reports by radio are in international codes. These are used by the various weather services and by ships at sea. According to these codes air-pressure is always given in millibars. The millibar has been in use in most European countries for many years. In England it was introduced before the Great War. Gradually it is being brought into use by countries all over the world. The millibar is 1,000 dynes per square centimetre and so expressed in terms of force units. It is, therefore, a much more logical unit of pressure than the artificial one of the inch or millimetre of mercury. If the millibar is to be the official unit, it is most desirable that every one should think of pressure in millibars. It is therefore equally desirable that other units should be dropped, especially just now, when so many people are taking up the study of meteorology for the first time in connection with aviation. In the future, therefore, all reports and publications from the New Zealand Meteorological Office will give pressure in millibars. Many other difficulties would be removed if English-speaking countries could be induced to adopt the metric system for all purposes.

The past few years have seen a very great intensification of the application of scientific methods to the organization of all forms of business and production. This has necessitated much more precise study of all the factors involved. The influence of weather on so many activities has, consequently, been brought forcibly to the notice of those planning them. With this has come the realization that the weather must be studied scientifically if proper use of, or allowance for, it is to be made. The demands for advice, information, and equipment have thus grown at an unprecedented rate and it has been difficult to keep pace with them.

Observing-stations.

Rainfall Stations.—Approximately 520 stations in the Dominion have been supplied with rain gauges by the Meteorological Office, and their monthly and annual rain totals, together with the number of wet days and the maximum day's fall, are published in the Government *Gazette*. The distribution of these stations is now fairly satisfactory, though a better network could still be obtained in some districts. In addition, approximately fifty gauges are maintained for special purposes by the Public Works Department. Thus there is a close network on the plains of South Canterbury, where a special study of irrigation problems is being made. Gauges have also been installed by the Public Works Department at numerous aerodromes. Similarly, the Department of Agriculture is making a special investigation in the Hamilton district in connection with outbreaks of facial eczema. These supplementary stations number, in all, about sixty. Rainfall is included in the observations at climatological stations, while returns are received annually from a number of private people. Thus data are tabulated for a total of about 650 rain stations.

Climatological Stations.—At the fuller climatological stations there is recorded every day the temperature and humidity at 9 a.m., the maximum and minimum temperature during the preceding twenty-four hours, the minimum temperature on the grass, and the rainfall. A certain proportion record also air pressure, the duration of bright sunshine, the temperature of the soil, and the run of the wind. Including those at some of the islands under New Zealand Administration, the number of climatological stations for which data are tabulated and published is about sixty.

At Auckland, Wellington, and Christchurch continuous records of pressure, temperature, humidity, rainfall, and wind direction and velocity are kept and hourly values tabulated. A thermograph is installed at Alexandra also, and hourly values tabulated. At Wellington hourly totals of sunshine are measured.

In addition to those at Auckland, Wellington, and Christchurch, Dines anemometers, recording both velocity and direction of the wind, have been installed at Paraparaumu and Ohakea. The Public Works Department is establishing additional instruments at various parts of the country. The Railways Department has another instrument at Shannon. Hourly readings will be made from the records of all these instruments, so that we shall shortly have a much better knowledge of the strength and character of the winds in New Zealand than has hitherto been available.

Telegraphic Reporting Stations.—Reports are telegraphed daily from seventy-eight New Zealand stations, including those at Chatham Islands, and the Kermadecs. The number of reports furnished by each station varies, the more important making four a day, while some send only one or two. The equipment is not yet quite satisfactory at all these stations. The intention is to provide each with a Kew-pattern mercury barometer, a small Stevenson screen with wet and dry bulb thermometers, and a rain gauge. Numbers of stations still have Fortin barometers and are without proper thermometer screens. Those in key positions have barographs and report the tendency of the barometer. The data from these stations are all tabulated and summarized for climatological as well as forecasting purposes. In order to appreciate the significance of a report of pressure or temperature, for example, it is necessary to know the normal value for the time of day and season of the year. All of the classes of stations mentioned keep weather diaries of varying degrees of completeness. From these the average amount of cloud and the frequency of such phenomena as thunder, hail, snow, fog, gales, &c., is determined. They also enable special weather series to be investigated in detail.

It is distressing to report that there have been several cases of theft or wanton damage of equipment at observing-stations. There have, of course, been isolated cases in the past, but the increasing frequency of them is causing concern. In very few cases is there any recovery or restitution of the losses.

Forecasting.

For many years daily weather forecasts were telegraphed at noon to the more important towns and seaports throughout the Dominion, the number varying between one hundred and two hundred at various times. The majority of these forecasts have been dropped as an economy measure, it being considered that most people now listen to the forecasts issued from the radio-broadcasting stations. For those centres to which the noon forecast is still sent a considerable improvement has been introduced in that the message is now sent in plain language, instead as heretofore in a word code which was quite inadequate to express all the possible variations of wind and weather. Similar forecasts are sent to the afternoon newspapers through the Press Association.

Special district forecasts for the following twenty-four hours are issued from the four main centres both at midday and in the evening. The Dominion forecast is also broadcasted in the evening. A number of morning newspapers have district forecasts telegraphed to them at 5 p.m.

The "farmers'" forecast which covers the weather not only for the succeeding twenty-four hours, but for as long ahead as conditions warrant, is now issued at 3.30 p.m. or 4 p.m. from each of the four main centres. With it is now included a forecast of frosts.

During the period when spraying was most active in the Nelson orchards a forecast indicating probability or otherwise of rain was issued each morning at 6.50 a.m. from 2YA.

The number of special forecasts requested by individuals or institutions continues to increase.

Aviation Service Stations.

The sectional meteorological offices at Auckland and Christchurch have been maintained.

In view of the extensive and very special meteorological requirements of regular trans-ocean air services and the conclusion of the preliminary agreements for a service by flying-boats across the Tasman Sea, it was decided that it would be necessary for the Auckland office to be located near the flying-boat base. A commencement was made with the erection of the trans-Tasman terminal building, in which quarters are provided for the Meteorological Office staff. In the meantime a temporary location has been provided in Auckland City. The move from the Hobsonville Air Base to Auckland took place on the 7th November. It is anticipated that the terminal building will be available early in the coming financial year.

In view of the increased duties shortly to be imposed on the Auckland station, increases have been made in the staff. The principal work of the office during the year has been the training of the staff, particularly in forecasting for trans-ocean flights. The New Zealand and Australian weather reports have been received by radio and two weather charts per day drawn. These have been analysed by the professional members of the staff in turn and practice forecasts prepared. The individual forecast has then been discussed at a conference of all professional officers.

Forecasts and route reports have been given to local Air Force and civil pilots as required. Other telephonic requests for forecasts also have been answered.

Pilot-balloon observations for wind in the upper air have been made twice daily and reported to Wellington.

Clerical cadets have been trained in observational work, the plotting of weather reports and the tabulation of hourly values from the records of self-recording instruments.

Assistance has been given to anti-aircraft batteries by the provision of upper-air data. Stations in North Auckland and the Bay of Plenty have been inspected and instruction given to telegraphic reporting stations in those areas. A good deal of the time of the officer in charge, Dr. W. A. Macky, has been spent in supervising constructional work involved in the moving of the office to new quarters.

At Wigram Aerodrome Mr. L. N. Larsen has continued in charge of the Meteorological Office. Some seventy Air Force trainees have been instructed and examined in meteorology, the standard attained comparing favourably with that demanded by the Royal Air Force.

Charts are drawn and analysed thrice daily and regular forecasts issued for local and cross-country flying, for night flying, photographic work, army co-operation, and bombing exercises. Forecasts are supplied on request to civil aircraft and the general public.

For observing conditions in the upper air, approximately 125 flights have been made by the Meteorological Officer in all weathers to heights averaging 16,000 ft. Observations of pressure, temperature, humidity, the extent of cloud layers, and the nature of cloud particles have been recorded. Experience gained in these flights has been especially valuable for local cloud forecasting. Photographs of clouds taken by personnel of the R.N.Z.A.F. have been used for instructional purposes.

Some preliminary work has been done on special problems of local weather forecasting.

Hourly values of the various meteorological elements have been prepared for publication. Pilot-balloon ascents for determining winds in the upper air are made twice daily on all days.

A number of stations in Canterbury and Westland have been inspected and instruction given to observers.

Aviation Meteorology.

There has been a steady increase in the demand for forecasts and reports for internal aviation services, and extensive developments are being made in preparation for the trans-Tasman service.

At the end of the year twenty-two special forecasts and reports were issued each day for scheduled commercial flights in this country, and there has been a greater demand also for forecasts and reports for irregular cross-country flights, aerial photography, and so on. There is evidence that increasing use is being made by the general public, as well as aviation interests, of the aviation reports which are broadcast at 6.50 a.m., 10 a.m., and 1 p.m. each day through station 2YA of the National Broadcasting Service.

The prospect of an early establishment of trans-ocean air services has made imperative the introduction of very considerable extensions in the organization of all the meteorological services concerned in this area. At the same time it has been necessary to arrange even closer co-operation between adjacent services than has existed in the past.

At the Meteorological Conference for the South-west Pacific held in Wellington at the end of 1937, and to which reference is made in last year's annual report, the general principles were laid down on which the extended organization and co-operation required could be built. From the 12th to the 16th December, 1938, a conference of representatives of the Australian and New Zealand Governments was held in Melbourne with the object of reporting in detail on the radio and meteorological services necessary for the trans-Tasman Air Route. Dr. M. A. F. Barnett attended this conference as the meteorological representative for New Zealand. The report of this conference embodies the procedure to be followed to ensure the fullest co-operation between the meteorological services at the terminal airports and also gives in detail the plan to be followed in supplying all the necessary forecasts and reports to the operating aircraft. The arrangements agreed upon follow very closely the corresponding scheme which has been evolved for a trans-Atlantic air service and which is being adopted internationally.

Reference has already been made, under the heading of "Aviation Service Stations," to the developments which have been made in the Auckland office in preparation for Tasman Empire Airways, Ltd. To provide the meteorological service required it will be necessary for the terminal office at Auckland and the Meteorological Office at Wellington to have officers on duty during the full twenty-four hours each day. This has entailed a considerable increase in staff. It will also be necessary to arrange for reports at 6 p.m. and midnight to be supplied by a selected network of stations and preliminary steps have already been taken towards this end.

Staff.

R. G. Simmers, who for the preceding two years has been holding a Commonwealth Service Fund Fellowship, returned to Wellington in August. He had been successful in attaining the degree of Doctor of Science in Meteorology at the Massachusetts Institute of Technology.

The cordial and loyal co-operation of the staff is again acknowledged with pleasure.

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 during the previous year for all stations.

(2) Volume of *Meteorological Observations:* This contains monthly and annual means of pressure, temperature, wind, sunshine, and other climatological data from approximately sixty stations; monthly means for each hour of the day of pressure, temperature, rainfall, and sunshine at Wellington, temperature and pressure at Auckland and Christchurch, and temperature at Alexandra; and a map showing departure from normal of rainfall over the whole country for the year concerned.

The great pressure of routine and organization work and the training of new staff have again prevented much time being devoted to special investigations. Extensive data are, however, being accumulated, and there should be a greater output of original work in a few years' time.

The following note has been published:—

Meteorological Office Note No. 22 on "The Cyclonic Storms in Northern New Zealand on the 22nd February and 26th March, 1936," by Dr. M. A. F. Barnett.

This paper discusses the origin and development of two cyclones of tropical origin which affected the North Island of New Zealand. The first was of exceptional severity.

For the Centennial Atlas new charts, ready for the draughtsman, have been prepared of annual and monthly rainfall, number of days of rain, annual and monthly mean temperatures, mean pressure, average amount of cloud at 9 a.m., and average amount of sunshine.

The demand for the publications of this Branch, from business firms, other departments, private individuals, and foreign sources, has been very much in excess of that of previous years, and the stocks of the majority have been exhausted.

Office Accommodation.

For the second time since the Office at Kelburn was completed, additions have been necessary. A new and enlarged library and meeting-room and four small rooms for professional officers were added in 1938. The old library was converted into ordinary office accommodation. A large part of the transmission and reception of weather messages by radio at Wellington is now done direct from the Forecast Room. Telegrams also are received direct from the Post Office in Morse code. Broadcasts, via Station 2YA of the National Broadcasting Service, of weather reports for aviators are made from a small cabinet in the Forecast Room.

Notes on the Weather for 1938.

January.—A very warm and humid month. Sunshine more than average. Though the rain was above average in most districts and very heavy in some areas, there were comparatively few wet days and in the middle of the month occurred almost a fortnight of brilliantly fine weather with little wind. Some very high temperatures were recorded. There was an abundance of pasture. Stock were in good condition, though lambs remained generally on the light side. The milk-yield was well maintained. The condition of the wheat crop improved and most other crops were doing well. Between the 22nd and the 25th a cyclonic storm approaching from the west across the Cook Strait area was responsible for severe southerly gales, which did some damage. General rain accompanied the storm and was heavy everywhere except in the southern part of the South Island. Severe flooding occurred in southern Hawke's Bay, where the falls in the low levels were unprecedented. A number of places recorded over 9 in. of rain in twenty-four hours.

February.—As regards both temperature and humidity, conditions resembled those of the tropics. The rainfall, also, especially in the North Island, was frequently tropical in its intensity and its erratic distribution. Considerable damage was done to roads in the North Island by heavy rain. Slips were numerous. Rainfall was much above average from Nelson and Marlborough northwards, twice to three times the normal being experienced over large areas. Many very heavy falls in a single day were recorded. Dry weather persisted in most of Otago and Southland. In spite of the very humid conditions and lack of sunshine the month was the hottest February hitherto experienced in New Zealand, the mean temperature being about 5½° F. above normal. Stone-fruit suffered through the high humidity prevailing. There was abundant growth of pasture, and stock were doing well. Conditions were congenial for insects and fungous pests. A cyclone in the north caused easterly gales in the Auckland Province on the 4th. Heavy rain fell from Nelson and Marlborough northwards. The gale caused damage to fruit crops in northern districts. On several occasions, particularly from the 15th to the 19th, sudden, heavy rains occurred at many places in the North Island. There was much flooding, particularly between Hawke's Bay and East Cape. The damage caused was very severe, and at a workmen's camp in the Wairoa district grave loss of life occurred.

March.—Again very warm, the mean temperature being, with one possible exception, the highest experienced since records commenced in New Zealand. Rainfall in general much below average, but, owing to the previous heavy falls, the continued high humidity, and the absence of wind, the shortage was not felt. Drought continued in parts of Otago and Southland. Sunshine was above average in most places. Pasture was still abundant and stock and crops doing very well, except that lambs again failed to fatten satisfactorily. Harvesting and farm-work was carried out under good conditions. There was extremely little storm activity, high pressure and anticyclonic weather predominating.

April.—Extremely dull, wet, and warm with very little wind. Much flooding was experienced, and that of the 24th to 25th in Hawke's Bay was a major disaster for that province. There were grave losses of stock and damage to roads, bridges, and property. Rich pasture lands, particularly in the Esk Valley, were covered by deep deposits of silt. All previous records for warmth were again exceeded. In the North Island and western districts of the South, mean temperatures exceeded the normal for April by 6° to 8° F. Elsewhere the departures averaged about 3° F. Sunshine was much below average. Dry conditions still prevailed in the far south. There was prolific growth of pasture, but it was very soft. Though stock generally were in good condition, the reverse was the case in much of the South Island. Lambs failed to fatten well. The completion of harvesting was delayed and farm-work interfered with. The conditions prevailing were responsible for serious outbreaks of facial eczema in sheep and cattle, especially in the Waikato and east coast districts of the North Island. As regards storm systems, the month was remarkable for the absence of westerly depressions. Anticyclones travelled in unusually high latitudes. Several cyclones moving from the north affected the Dominion and caused heavy rain. One of these, occurring just before Easter, was responsible for considerable flooding and the disorganization of traffic in the South Island. Another storm, moving down the east coast, gave rise to the phenomenal rains and floods of the 25th, Anzac Day. The total rain produced by the storm amounted in places to over 40 in.

May.—Another very warm month, but extremely dry. There was very little wind, and though frosts were fairly frequent no day was very cold. On not more than two occasions previously had the mean temperature in May been so high. There was little snow on the mountains. Pasture was still abundant and had hardened up considerably, especially in the South Island. There were further outbreaks of facial eczema in the North Island. Otherwise stock were doing well. A cyclonic storm in the north caused further flooding in the Auckland and Hawke's Bay provinces on the 4th and 5th. Anticyclonic conditions prevailed, however, during most of the month and, in the South Island particularly conditions were very quiet.

June.—Though the temperature was about the average there was a big fall from the previous month, and all forms of life appeared to feel the change rather severely. Rainfall was about normal. A considerable amount of snow fell on the ranges. Sunshine was slightly below average. Abundance of feed was still available for stock, which, with the exception of young sheep, were in good condition. The ground was soft, making farm-work difficult. A number of low-pressure centres formed off the west coast during the month, causing stormy weather.

July.—Dull, wet, and cold. It was the frequency of the rain and the lack of sunshine as much as the amount of precipitation that kept things damp. In Canterbury, Otago, and Southland it was the coldest July on record. Frosts were frequent and sometimes severe. The soil was saturated and farm-work held up. Stock were reported to be in fair to good condition. A deep depression crossed the Auckland Province between the 10th and 14th. On the 13th there was a very boisterous and widespread south-easterly gale which caused minor damage in many places. Snow fell on the Canterbury Plains and in Central Otago. A series of somewhat similar depressions followed. Flooding occurred in the Auckland and Hawke's Bay provinces on three occasions during the month, and a considerable amount of snow fell.

August.—After the first ten days there was a spell of mild and sunny weather, which brightened the outlook generally. At the end of the month dull and wet weather again set in. Rain was much above average over the northern half of the North Island and in western districts of the South. Elsewhere it was below the average, and from Canterbury southwards a very dry month was experienced. Mean temperatures were slightly above average everywhere. The dry areas of the South Island had more sunshine than usual, but elsewhere conditions were irregular. The state of stock and pastures varied considerably from district to district, but, on the whole, was less favourable than usual.

Vegetation was showing signs of growth, but had not entirely recovered from the cold and we weather of the preceding months and the season was somewhat backward. At the beginning of the month two depressions of the type which had been so frequent earlier in the year crossed the North Island. These caused heavy rain over the North Island, with snow on the high levels. There was some flooding again in Auckland and Hawke's Bay. Thereafter westerly weather prevailed. On the 10th a northerly gale in the central provinces caused much damage to telegraph and power lines, fences, &c.

September.—Dull, cold, and wet weather prevailed again during the first few days, but from the 10th onward, and especially after the 18th, there was a marked improvement. Temperatures became mild, the atmosphere was dry, and there was little rain in most districts. The total rain was, on the whole, below the average. Mean temperatures for the month were everywhere slightly above normal, and though there were several snowfalls there was no severe cold. Sunshine was, on the whole, somewhat below average. For the farmer the month was generally a good one. The soil, which had in many places been water-logged, dried out. Chiefly due to difficulties earlier in the year, the percentage of lambs was considerably below that of the preceding two years. Southland and parts of Otago continued to experience dry weather. On the 2nd to the 3rd a very boisterous southerly gale blew in Cook Strait and on the east coast of the South Island. Unsettled and rather stormy conditions occurred at intervals until the 18th, but thereafter anticyclonic conditions prevailed and disturbances were of only slight intensity.

October.—Until about the 20th the weather was dry with a prevalence of strong westerly winds. Thereafter it was humid and good rains fell, especially in the South Island. At the end of the month, however, there was still a considerable shortage of moisture in most districts and the growth of pasture was distinctly backward. There were good rains in Canterbury and Otago, which were very opportune, but elsewhere totals were below average. Mean temperatures were almost everywhere above normal and there were few frosts. Sunshine was generally much above average. Conditions were very favourable for stock, especially lambs, but the milk-yield was below normal. Apart from pastures, vegetation flourished, and the spring, though late, was a very active one. A depression passing between the 9th and 11th was responsible for severe north-westerly gales, especially in Wellington and Canterbury. On the 11th there was snow on the hills of Banks Peninsula. Otherwise there were no storms worthy of special note.

November.—November completed one of the best springs of recent years. Temperatures were warm and there was enough rain to ensure vigorous growth of vegetation. The distribution of rainfall was rather irregular, but most districts had more than average. Except on the Canterbury Plains, mean temperatures were considerably above normal and no extremes of heat or cold were experienced. Sunshine was below average except in the far south. In a few places growth was still rather backward, owing to drying winds or previous lack of rainfall, but generally the country was looking particularly well and pasture was abundant. Numbers of native trees produced a remarkable amount of blossom. This was especially noticeable with the cabbage-tree and the beech. The beech forests have seldom displayed such a warmth and variety of colour. Stock were thriving, although some trouble was experienced with lambs, chiefly owing to parasites. The milk-yield was well up to standard. On the 8th and 9th there were some severe local downpours in Central Otago. One at Coal Creek, near Roxburgh, did serious damage to a number of orchards. In other cases large areas of pasture were destroyed. On the 21st there were boisterous south-westerly gales, and a heavy fall of snow occurred on the high levels in Otago and Southland.

December.—A most unseasonable month ; cold and wet with persistent strong winds in many places. Rainfall was much above average. The southern half of the South Island and areas in the centre of the North had the wettest December on record. Night temperatures were very low, and there were numbers of frosts. Snow fell relatively frequently on the ranges. Sunshine was below average. Thunderstorms were unusually numerous. On two occasions remarkably persistent thunderstorms, lasting for hours and accompanied by continuous rain, occurred in the central provinces, especially on the west coast. A number of cloud-bursts were again experienced in the South Island. The exceptionally frequent rains interfered with haymaking, while shearing and cultivation operations were much delayed, especially in the higher country. The growth of pasture was well maintained. Stock were in good condition, but lambs were not fattening well. The cold and damp retarded the progress of crops and garden plants. Blights were rather prevalent. The storms experienced were mainly of the westerly type. Severe north-westerly or northerly gales occurred on the 8th and the 10th. On the first date a tree was blown into a train at Styx, while on the second a 75-ton crane was overturned at Greymouth.

Year.—The outstanding feature of the year was the almost tropical conditions of warmth and humidity which prevailed from January to April inclusive. May, also, was very warm, but in contrast with the preceding months it was very dry. The only previous period experienced in New Zealand since records began which is comparable in warmth with the summer of 1937–38 and the autumn of 1938 was the summer of 1934–35. On the latter occasion the warm spell began earlier and was of shorter duration. Furthermore, drought prevailed for a large part of the time. From the end of the first week in June until the beginning of August in 1938, cold, wintry weather prevailed. In the southern part of the South Island the cold was severe, and eucalyptus trees, for example, suffered much damage from frost. Elsewhere, though the departures from normal were not large, and in many cases were positive, coming after the continued warmth of the earlier months, the fall of temperature was felt very much. Growth of vegetation ceased almost entirely. From August until November mild weather predominated, and the spring, though rather belated, was an excellent one, especially in the South Island. There was abundance of pasture, and the flowering of trees and plants was unusually prolific. December was cold, wet, and windy.

The year was a very wet one. This was particularly the case from Hawke's Bay to East Cape, along the Auckland coast from the Bay of Islands to the Bay of Plenty, and in northern Westland and south-west Nelson. The only considerable areas with less than average were in southern Westland and Southland. A protracted period of dry weather had set in over Southland in 1937, and it was not until October, 1938, that it was definitely ended.

The warmth and humidity of the first part of the year was responsible for a rank growth of pasture. With these conditions was associated the serious outbreak of facial eczema which occurred in the autumn. The milk-yield was well maintained until the incursion of the facial-eczema epidemic, when there was a sharp fall. In the spring there was a recovery. Lambs seldom fattened well. The percentage of lambs was much below that of the preceding two years. There have been no very serious losses of stock in recent winters through excessive snowfalls or combined cold and wet weather.

The wheat crop of the 1937–38 season gave a moderate yield, and that of the following season was doing fairly well at the end of the year. Owing to the wet weather, however, a smaller area had been sown. The 1938 apple crop was a very good one, but stone-fruit suffered from the effects of the damp weather. Most other small crops did well, though some trouble was experienced from fungous diseases, expecially with potatoes and tomatoes.

The year was remarkable for the frequency of floods in the Auckland and, especially, the Hawke's Bay provinces. In the latter they were very severe, and the damage was of disastrous proportions.

GEOLOGICAL SURVEY BRANCH.

REPORT OF DIRECTOR (DR. J. HENDERSON).

During the year ended 31st March, 1939, official visits were paid to Rotorua, Te Aroha, Awakino, New Plymouth, Opunake, Patea, and Palmerston North in the North Island, as well as to Top Valley, Takaka, Maruia, Reefton, Greymouth, and Waiho in the South. The visits to the Taranaki District and to Takaka were in connection with the investigation of the iron-ore resources of New Zealand, which Messrs. Brassert and Co., of London, carried out, and on several occasions with the representatives of the firm. A note on the visit to Rotorua appears in this report.

Dr. J. Marwick was chiefly engaged in writing the bulletin on the Te Kuiti Subdivision, which was mapped some years ago by the late Dr. H. T. Ferrar and other officers no longer with the Geological Survey. He also made many fossil determinations for the field officers and visited most of the petroliferous areas of the North and South Islands with geologists employed by the New Zealand Petroleum Co. and the Superior Oil Co., of California.

Messrs. H. E. Fyfe, M. Gage, W. E. Hall, and R. J. Bagge continued the close systematic examination of the Greymouth coalfield begun in 1936 in order to determine as accurately as possible the amount of available coal. Mr. Fyfe visited the Westport coalfield to make estimates of the amount of coal and to supervise sampling. He also conferred with the representatives of Brassert and Co. on the question of the reserves, in both districts, of coal suitable for iron-smelting. Mr. Gage accompanied the same representatives to Takaka and discussed with them, on the ground, the origin of the iron-ores of Parapara.

Mr. J. Healy worked on the manuscript of the bulletin describing the Wakaia Subdivision, and paid a short visit to that district, but for most of the field season he was in the Amuri Subdivision, which district he will complete now that Mr. Fyfe, who has already mapped part of it, has been transferred to the Greymouth area.

Mr. R. W. Willett, for two months assisted by Mr. H. W. Wellman, was able to finish the examination of the Glenorchy district. Aerial photographs were taken of this rugged mountainous area to assist in the mapping.

Dr. H. J. Finlay, Micropalæontologist, identified the foraminifera in many samples collected in the Dannevirke, Amuri, and Greymouth districts. In accordance with an arrangement made with the oil companies, he also examined much material from Taranaki, Gisborne, Hawke's Bay, East Wellington, and the West Coast.

Dr. C. O. Hutton, Petrologist, examined and collected from the Otama intrusive mass of the Wakaia Subdivision. He also visited the Queenstown district in connection with his account of that region now in the press and to be issued as a geological memoir. But he was chiefly engaged in finishing this memoir and in sorting over and listing rock specimens collected at different times during the last thirty years.

This year Mr. N. Modriniak visited the United States of America in order to purchase apparatus suitable for geophysical reflection work, together with the necessary trucks and drill. He returned in April, since when he has been in the Takaka district endeavouring to ascertain the depth to which the deposits of iron-ore extend. At the end of last field season he was studying the sub-surface structure of the Kotuku oil-bearing rocks by refraction methods, and it was because he could go no further with the available material that the purchase of reflection apparatus was decided upon.

Mr. F. A. McNeill worked most of the year in the Reefton district where, by electrical methods, he followed the folds containing the Blackwater lode north beyond Big River. He paid visits to Top Valley and Bendigo, where by similar methods he traced the continuation of the Jubilee and Cromwell lodes respectively. In Top Valley he also determined cross-sections of the in-filled valley of the main stream.

Mr. H. W. Wellman returned from leave in November and for two months assisted Mr. Willett in the topographical survey of the Glenorchy district. In February he went to the Cobb valley, Takaka, where he examined by seismic methods the proposed dam-site and the valley for a short distance up-stream.

Mr. A. W. Hampton prepared drawings for photolithographic reproduction, drew several blocks, graphs, &c., and did much miscellaneous draughting work.

A few text-books were purchased, and many valuable exchanges were received. The library, which is invaluable for reference to members of the staff and others interested in geology, requires a good deal of attention and much space.

Last year the thirty-second annual report was issued, and Bulletins 38 and 39 were set up and will be shortly published. The Head Office published Geological Memoir No. 4, containing an account of the geophysical work undertaken over several years. Members of the staff wrote the following papers that appeared in the *New Zealand Journal of Science and Technology:* "Te Aroha Thermal Water," and "Copper Resources of New Zealand," by J. Henderson; "German Hill and Blacks Nos. 2 and 3 Mining-fields, Otago," and "Round Hill Goldfield, Southland," by E. O. Macpherson; "Calcareous Sinter Deposit near Kaeo," by R. W. Willett; and "The Geology of the Coastal Strip from Big Bay to Professor Creek, North-west Otago," by J. Healy. To the "Transactions of the Royal Society of New Zealand," J. Marwick contributed "*Notocallista* and its Allies" and "*Maccoyella* and *Aucellina* in the Taitai Series"; H. J. Finlay "New Zealand Foraminifera: Key Species in Stratigraphy—No. 1," and "New Zealand Foraminifera: The Occurrence of *Rzehakina*, *Hantkenina*, *Rotaliatina*, and *Zeauvigerina*"; and C. O. Hutton "The Significance of Tourmaline in the Otago Schists." The last-mentioned also published "The Stilpnomelane Group of Minerals" and "A Chemical and Optical Study of Low-grade Metamorphic actinolitic amphibole from Coronet Peak, Western Otago, New Zealand," in the *Mineralogical Magazine.*

There were some changes in staff during the year. Mr. O. L. Bruhn, who was clerk to the survey for ten years, was promoted to a better position with the Public Works Department. Mr. D. H. K. Ross, who filled the vacancy, has a good knowledge of photographic work, and in order to allow him to use his skill on survey work Miss I. Bailie was appointed to assist him. Dr. C. O. Hutton took up the position of Petrologist in October, 1938, and Dr. Arnold Lillie, appointed as geologist, arrived from England late in April, 1939. Messrs. M. Ongley and E. O. Macpherson were granted leave for further terms.

AMURI SUBDIVISION.

By J. Healy.

Owing to Mr. Fyfe's removal to the West Coast on coal-survey examinations after four field seasons in the Kaikoura subdivision, to the writer, who had assisted Mr. Fyfe during his last season, has been assigned the duty of completing the work. Field-work began on 9th January, 1939, and by the end of March the writer, assisted for six weeks by Mr. J. H. Sticht, B.Sc., had mapped 180 square miles in the Culverden-Waiau district. Some time was spent in examining the unfamiliar geological succession in critical areas. Notwithstanding that Dr. Finlay determined the foraminiferal faunas of several members of the Tertiary sequence, there is little to add to Mr. Fyfe's account of the geology of the district.

Structure.

Most of the area examined is contained in the Culverden-Waiau basin, a depression determined by north-east-trending structure lines. The Lowry Peaks Range in the south-east part of the area continued north as Mount Parnassus Block, forms uplands of the older rocks, against which the Tertiary and Cretaceous beds in the basin are down-faulted. Near the entrance to the Hurunui gorge in the south end and near the Stanton River in the north this faulting is complex, and strips of younger rocks are involved in the older greywackes, though this may in part be due to several periods of movement having affected the area.

The younger sediments of the depression have been thrown into a series of north-easterly-trending folds broken by minor faults and were apparently later further faulted. Through the centre of the district, from Isolated Hill, Mount Highfield, and The Humps to Mount Stewart and Mount Percy, a core of greywacke is exposed along a central anticline bordered on each side by a syncline. Along the Highfield ridge the anticline is decidedly a-symmetric and steeply flexed on the north-west; southward it is lower and the greywacke does not outcrop. It reappears at Isolated Hill in a further up-arching, but again disappears as the anticline plunges south-west below the plains. A short distance north-west of Isolated Hill is a large slightly-transverse fault which probably accounts for the decreased height of the greywacke.

Physiography.

The Culverden-Waiau Plains extend from the Hurunui River north-east to the Waiau, and thence for some distance up the valley of the Mason River. Between Rotherham and Culverden the flats are from 600 ft. to 650 ft. above sea-level, the highest point being at the road turn-off to Hanmer. Thence the plains slope gently downwards towards Lowry Peaks. North-east, up the Mason valley, the level rises. The plains are broken by the Isolated Hill block, which is completely surrounded by gravels and rises to a height of 1,280 ft. at Isolated Hill itself.

The fault mentioned in the previous section divides this block into two physiographic units. The north-western part has a regular surface 800 ft. to 850 ft. above sea-level, etched into parallel ridges with broad, rounded surfaces, by streams incised in narrow V-shaped valleys, which are parallel to the strike of steeply-dipping, alternately hard and soft sandstones. South-east of the fault is the dome-shaped mass of Isolated Hill, which is traversed from north to south by a prominent limestone escarpment. The western portion of this dome shows the sharply hummocked topography typical of greywacke. South-east of Isolated Hill the surface drops to a lower level, broken by the ridge formed by the more resistant Sugar Loaf sandstone.

Highfield ridge somewhat resembles Isolated Hill in that it has a prominent limestone escarpment north-west of which the greywacke is characteristically eroded. The greywacke continues north-east as a ridge towards Mount Stewart; several prominent peaks on this ridge at the head of the Bourne Stream are quite aptly named The Humps.

Throughout the strip of Tertiary country that extends from Waiau north-east for some fifteen miles the remnants of a former high-level, gravel-covered plain, cut in the younger rocks and near the Leader River extending right across the greywacke, are easily traced. The gradual flattening of the slopes at the south end of the Highfield ridge and the coarse-gravel deposits of this locality are probably due to erosion at this base level. At lower levels are well-dissected remnants of terraces intermediate in height. The highest is approximately 450 ft. above the present level of the Waiau River.

The high-level surface is best shown farther to the north-east in the Bourne and Stanton basins, and on part of the headwaters of the Leader where fairly steep-walled valleys are incised to a depth of 300 ft. to 400 ft. There are intermediate terraces along the main streams. Usually the interfluves are broad, gravel-capped ridges, and viewed from any one of them the former extent of the planed surface is evident. From a height of 800 ft. above sea-level, between the Bourne and the Stanton, the level of this surface rises gradually north-east to 1,600 ft. beyond the Leader. It overlaps on the lower end of the Mount Stewart Block and apparently extends right across the greywacke block north of Solomon's Throne. The streams have largely reached grade and are now commencing to widen their valleys by lateral corrosion, especially in the area composed of Tertiary rocks. These soft mudstones and sandstones are eminently prone to weathering, and in the deep gullies where bush is largely removed there are many slips and soil erosion is increasingly prevalent.

The surface described above appears to have been deformed during or after uplift, as there are several distinct irregularities in its slope, some sufficiently sharp as to suggest faulting. A series of heights is being taken on ridges to obtain quantitative data. Adjoining the gap by which the Waiau River leaves the depression there is, in the greywacke divide, a wide bench, probably corresponding to the high-level surface cut in the Tertiaries, its greater elevation being presumably due to faulting.

The Castaly River, a tributary of the Leader from which it is separated by Solomon's Throne, has at its head an air gap beyond which it has been beheaded by a tributary of the Stanton River. Adjustments bought about by the movements postulated in the previous paragraph enabled the Stanton to cut down rapidly in the soft mudstones and capture the Castaly headwaters at the point where formerly, after flowing south-east across those same mudstones, the latter entered a greywacke block, which it crosses before joining the Leader.

Geology.

Pre-Cretaceous Rocks.—Throughout the district the pre-Cretaceous rocks are mostly indurated greywackes and argillites. In some places conglomerates are interbedded, and in others, notably in the lower Stanton, thick finely-bedded argillites contain "cannon-ball" concretions. Interbedded pillow lavas occur which are usually well crushed and contain bands of jaspilite and red siliceous greywacke considerably stained with iron.

The rocks are tightly folded and strike, in general, in the same direction as the Tertiary beds and the main structure lines—that is, north-east. Consequently the finer sediments are in many places considerably sheared along the the bedding-planes. Near the main faults they are usually much crushed, though they are generally quite fresh close to the younger beds, so that the fracture lines dominating the structure may be ancient in origin.

Cretaceous Rocks.—Cretaceous rocks rest unconformably on the greywackes. They vary greatly throughout the district, both in thickness and type, suggesting considerable instability about the time of their deposition. In a tributary of the Bourne Stream draining the southern slopes of Mount Highfield the Stanton Conglomerate, about 200 ft. thick, rests on the greywacke, though a quarter of a mile to the north it has pinched out, possibly owing to faulting. A short distance to the west a small thickness of sandstone with calcareous bands underlies the conglomerate, which contains at its base pebbles of soft sandstone. Above the conglomerate is a massive brown sandstone of finely-speckled appearance. A similar sandstone outcrops a mile south of Isolated Hill close to the greywacke, though here it may be a sandstone dyke as it is considerably seamed and contains fragments of sheared conglomerate from a bed apparently overlying. It resembles, lithologically, other sandstones occurring as dykes in the area and could well be a source bed.

Near the confluence of Stanton River with the Waiau a small patch of Cretaceous and Tertiary beds rests on greywacke. The basal bed is a thin breccia-conglomerate, which passes up into sulphur-stained sandstone. The sulphur-stained sandstones persist farther north-east near Solomon's Throne and are separated from the greywacke by a phosphatized layer containing sandstone pebbles. In the headwaters of Bourne Stream east of The Humps there is a fair thickness of sulphur-stained mudstone, at the top of which is 7 ft. of dark glauconitic sandstone overlain by beds of the "chalk marl" facies. The sandstone below the contact is bored and the overlying beds contain a few fossils that have not yet been identified.

Eocene Beds.—The lowest of the younger series of beds which is found throughout the entire district is a whitish-coloured mudstone, in places indurated. It contains extensive foraminiferal faunas that range from Lower to Upper Bortonian in age, and the rocks are thus correlative with the chalk marl of the Amuri district. Sandstone dykes intrude the chalk marls in several localities and indicate a wide development of this phenomenon in beds of this age in the Amuri area.

This claystone passes up into the glauconitic sandstone described by Fyfe* and correlated by him with the Amuri limestone. This was apparently taken to be a facies of the claystone above, and the writer observed nothing to disprove this. Fyfe also describes a phosphatic layer at the upper surface of the sandstone.

Weka Pass Stone.—Fyfe correlates the Isolated Hill limestone with the Weka Pass stone of Duntroonian age, and the evidence of the foraminifera in the rocks above and below tend to support this correlation. So far no marly layers have been found in the limestone from which samples containing foraminifera could be obtained. Tuffs are interbedded, and in places, such as a short distance south of Mount Highfield, volcanic activity was so pronounced that the limestone is represented solely by a thick deposit of coarse, calcareous tuff.

Sugar-loaf Beds.—These beds are found above the limestone east of Isolated Hill and continue north-east along the south-eastern slopes of Highfield. They form the steep bluffs fronting the Rotherham–Waiau road, and also outcrop on the south bank of the Waiau near Lowry Peaks Range. South of the river they are fine sandstones with calcareous bands, which in the Rotherham district are much coarser and quite shelly. To the north they appear to become generally finer in texture. Foraminifera indicated their age to be Hutchinsonian. The Awamoan stage is apparently missing, or, if present, must have small development.

Taranakian Beds.—The presence of Taranakian strata is based on foraminiferal evidence. The samples were obtained from beds overlying the Sugar-loaf sandstones. The rocks outcrop on the south bank of the Waiau, north-east of Isolated Hill, and in the Bourne Creek, two miles above its confluence with Waiau River. The same difficulty here arises as in the East Coast of the North Island, where several stages are represented by strata lithologically indistinguishable, making mapping of boundaries extremely difficult.

* N.Z.G.S. 25th Ann. Rep., 1931, p. 6.

Bourne Conglomerate.—The Bourne conglomerate consists of fine sandstones in which are embedded large blocks of the several earlier series, including greywacke, limestone, glauconitic sandstone, the two facies above the chalk marl, white claystone, calcareous sandstone, sulphur-stained sandstone, and basalt.

The conglomerate overlaps the older beds and in places possibly rests on the greywacke, but mostly the basal contacts of this conglomerate are on steeply dipping slopes or fault-planes and they themselves have been involved in later faulting. The large blocks of older rock cannot have travelled far, and apparently the area was closely folded and faulted to allow of rapid erosion, and the Bourne conglomerate is a shallow-water accumulation of a marine transgression, during which faulting continued at intervals. Its age is probably Pliocene.

Highfield Beds.—Argillaceous sandstones in the lower Bourne and Stanton valleys have yielded Waitotaran foraminiferal faunas. Here also probably belong the considerable thickness of sandstone farther north-east, overlying the Bourne conglomerate. These might be placed with the Bourne conglomerate, which is merely the basal phase of the series.

Above these sandstones come gravels representing one or more of the upper stages of the Pliocene. They overlie the sandstones near the Waiau, east of the township, and in the township itself are found in the face of the terrace along the east margin. They are tilted, but not to the same extent as the Bourne conglomerate at the base of the Pliocene.

Lyndon Gravels.—Two and a half miles north-east of Rotherham in a bluff alongside the main road south-easterly-dipping gravels overlie the Sugar-loaf sandstones with marked angular unconformity. These may be the equivalent of the Highfield upper gravels, but if so the sandstones below are missing. Above them are loosely consolidated sandstones, which also are found in the valley to the east. The gravels outcrop for two miles to the south and south-east.

Pleistocene.—The river gravels of the 300 ft. to 400 ft. planed surface are considered to be of Pleistocene age. They have undergone minor displacements, together with some of intermediate position.

Recent Deposits.—These include the gravels of the present river systems and lower terraces, with which are associated silts and wind-blown deposits.

GREYMOUTH COALFIELD.

By H. E. Fyfe, M. Gage, and W. E. Hall.

Introduction.

During the late autumn of 1938 field operations in the Greymouth Coalfield continued in the Rewanui area. By the use of the theodolite and trigonometrically-fixed points surveying accuracy necessary for the 5-chain-scale field-sheets has been achieved. This comparatively large scale was necessitated by the closely detailed observations required for mapping the complexities of structure occurring in many parts of the region.

Geological field-work ceased early in June, but a field party carried on through the winter months completing trigonometrical work in the Rewanui area and extending it into the adjacent coastal area. Two men were also constantly employed during the winter and spring on sampling the Millerton, Denniston, and Stockton mines in the Westport field as well as the Liverpool, Dobson, and Paparoa mines in the Greymouth field. This aspect of the work is nearly completed in the Greymouth field. Where field observations were held up by bad weather during the winter progress was made with the replotting of the Rewanui traverse data in the preparation of the new 5-chain field-sheets referred to above. Geological data were collected by H. E. Fyfe during two brief visits to the field in this period.

The geological field-work recommenced at the beginning of November, but for over three months was greatly hampered by persistently bad weather. Despite this, what little remained to do in the Rewanui district—chiefly the Otto Creek Basin—was completed, and operations were commenced in the lower Ten-mile and Nine-mile watersheds and Coal Creek. Improved weather has permitted much progress to be made during the past two months. Nevertheless, the bad weather also held up the completion of the trigonometrical breakdown of the coastal area between Rapahoe and the Ten-mile, so that the geologists have been further hampered by lack of field-sheets for this area.

Geological traverses have been made of the Ten-mile Stream and its branches on the south side as far up as Bishop Creek, and numerous observations made of the geological sections offered by the precipitous bluff overhanging the stream. Data have also been collected from the Nine-mile Stream and its branches and from along the sea-coast and the Westport Road. None of these areas is yet completed.

Coal Creek has been traversed from Camp Railway-station to the source of the main branch on the slopes of Mount Davey. About fifteen years ago a thorough and detailed study of the geology of the middle reaches of Coal Creek was carried out by Mr. H. E. Ellis for the Mines Department. Mr. Ellis's geological data, shown on 5-chain-to-an-inch plans, are being checked over this season for correlation purposes and will be incorporated in the new plans. There remains to be done a considerable area in Coal Creek basin not covered by Mr. Ellis, involving a good deal of additional surveying.

During the prolonged spell of bad weather geological data from the Rewanui area were transferred to the new plans and searching-out of bore-hole data carried out. Outcrop-sampling in the Rewanui area is as yet incomplete.

Stratigraphy.

The reader is again referred to Bulletin 13, N.Z.G.S., for a general account of the lithology, &c., of the coal-measures. In the previous annual report, owing to the incompleteness of the work, Morgan's classification was of necessity adopted without alteration. Now, however, it is possible to place more confidence in new correlations, mostly based on lithology, involving minor modifications of Morgan's units. Though not supported by palæontological evidence, these lithological correlations, owing to the widespread persistence of the shales and other distinctive horizon markers and to the excellent bluff sections, are considered to be reliable.

Mawheranui Series.

Paparoa Beds.—The lower limit of these beds is the surface of the underlying Greenland Series rocks and the upper is determined by a break below the Point Elizabeth coal horizon, above which the beds seem to be markedly less disturbed than below. An indication that an important unconformity exists within Morgan's Paparoa beds, necessitating the splitting up of the Paparoa beds, is afforded by eroded upper surfaces of the Bishop Creek coal-seam, by the absence of distinctive horizons, and by the occasional presence of water-worn coal pebbles in conglomerate lenses in the overlying beds. It is anticipated that more will be known about this break when the Blackball area has been covered.

The following is the classification of the Paparoa beds at present adopted:—

(*a*) *Basal Conglomerates:* These correspond with Morgan's "basal conglomerate and minor sandstones."

(*b*) *Lower Mudstone* and (*c*) *Lower Coal-measures:* Together equivalent to Morgan's lower sandstones and shales.

(*d*) *Middle Mudstone* and (*e*) *Upper Coal-measures:* Together equivalent to Morgan's middle sandstones and minor shales, probably plus some of the shales included by him in his upper sandstones and shales.

(*f*) *Upper Mudstone:* Corresponds with Morgan's upper sandstones and shales.

Morgan believed in the existence of only two chief shale horizons. His correlation of the upper sandstones and shales with a mudstone in the Ten-mile Stream is now regarded as incorrect, and this is placed in the lower mudstone.

Brunner Beds.—Morgan's description and subdivision of the Brunner rocks is still adhered to as little has been done by this survey in several extensive areas of these beds. It may be noted that Morgan's opinion that the Brunner beds followed the Paparoa beds quite conformably is now regarded as incorrect, as indications are present in the Ten-mile and Nine-mile area to show that much of the upper part of the Paparoa beds may have been eroded before the Brunner beds were deposited.

Correlation of Coal-seams.

Although the coal-producing parts of the stratigraphic column, considered in the broad sense, appear in many cases to be continuous throughout the whole field, the individual seams have not been traced for great distances along their outcrops or underground, except in one or two outstanding examples. These correlations have been established by reference to persistently distinctive stratigraphic units—the Paparoa Basal Conglomerate, the several Paparoa shales, the Brunner Conglomerate, and the Island Sandstone. In the present incomplete state of the survey the seam correlations must be regarded to a large extent as tentative.

The lowest coal horizon is at the top of the Basal Paparoa Conglomerate in the western half of the region, but the coal is stony wherever encountered and is unlikely to be mined. The lowest-producing seam is that now worked by Kaye and party in the Ten-mile. Lying a little above the Lower Mudstone, it has been found to persist with remarkable freedom from stone-bands over a wide area, having been identified in several north-flowing branches of the Ten-mile Stream, including Doherty and Bishop creeks and their tributaries, on the Edward Ridge near Blackball Peak, and in the Otto Creek basin. Where worked by Kaye and party the thickness is about 10 ft., and the seam maintains an average height at about this figure, although local variations from about 3 ft. to 18 ft. occur. In a few places, as for example, in Bishop Creek, the seam is split by stone-bands, but on the whole these are unimportant. At one place there is a gap due to the above-mentioned erosion interval.

Separated from the above seam by about 300 ft. of sandstones, &c., is another coal horizon including in the Ten-mile and Bishop Creek area two main seams, which increase in thickness westwards from about 9 ft. of clean coal to as much as 20 ft. in places, and are associated in places with more or less prominent stony seams. These seams, now being worked by Armstrong's and other parties in the Ten-mile, are believed to be identical with those being developed in the Strongman Mine. In the Rewanui Mine the Morgan seam is the equivalent of the Armstrong horizon. But as the strata below the Morgan seam in the Rewanui area have not been investigated, and are not uncovered, it is uncertain whether the lower Armstrong seam persists eastwards or is a split of the Morgan seam.

Included in the Upper Paparoa Coal-measures are the Kimbell seam and the Bins section seams at Rewanui, the latter being worked by O'Brien and party, and also probably by Goldlight and party, and in the Moody Creek Mine. Several seams, up to 6 ft. thick, which outcrop in the upper reaches of Waiomo Creek are referred to this horizon and also, but with somewhat less confidence, a large seam in Spring Creek. The Spark and party lower seam at Rewanui is equivalent to the Kimbell seam.

The Brunner Coal-measures, as pointed out by Morgan, contain two main coal horizons. The lower one is separated from the Upper Paparoa shales by about 300 ft. of grits and sandstones and covers about 300 ft. of the section, including several seams. The most important seams, attaining 12 ft. or more, were worked in the old Point Elizabeth collieries, and the extensions of these seams are now being worked by Boote, "New Point E," and Baddeley's co-operative parties. A seam showing about 7 ft. of coal in Coal Creek is referred to the same horizon. Above the Brunner Conglomerate is the uppermost workable horizon in the field, containing but one main seam, the James, worked in the James Mine and by Moore and party, and other co-operative mines along the coast. Throughout most of the Coal Creek basin the Brunner seam is represented only by a thin seam of stony coal.

Structure.

The Rewanui area of the Greymouth coalfield, which was explored last field season, showed as a predominating feature an appearance of block-faulting due to the strata folding to a considerable extent before fracturing. In the coastal area from the Seven-mile Stream northward to the Ten-mile Stream the block appearance of block-faulting of the central area is not so apparent. The principal faults have a general north-north-easterly strike and are chiefly normal faults upthrown to the east. From the coast-line eastward the first outstanding fault crosses the Westport road seaward of the Ten-mile Stream bridge. Here the Island Sandstone is seen downfaulted to the west against the Brunner Conglomerate. As the James seam is found to have thinned out east of this point, the fault does not affect the economic situation.

Proceeding eastward, the next faulting of importance is found in a group of three faults in the Ten-mile Stream. The first is the Twin Rock Fault, about 250 ft. above the tramway bridge. The second is the Howard Fault, about 600 ft. farther up-stream, and the third is the Fred Fault about another 700 ft. up-stream. The Twin Rock Fault has an estimated throw of 100 ft. and is encountered on the Moore and party's inclined tramway about 300 ft. below the mine-mouth. Here the Brunner Conglomerate is downfaulted to the west, and conglomerates and sandstones, presumably belonging to the same series, are found to the east. This fault constitutes an eastern barrier to any working of the James seam which may be carried out west of Moore and party's mine. The Howard Fault has the Brunner Conglomerate downfaulted on its west side. Conglomerates, sandstone, and coal are found on the east side and are thought at present to belong to the Lower Paparoa Coal-measures; but it is possible that these may later be found to correlate with the Lower Brunner beds. This fault has been tentatively correlated with the McTaggart Fault, which crosses the Strongman Mine road. Here the Island sandstone has been downfaulted to the west against the Brunner Conglomerate. At this point the displacement does not exceed 100 ft. This tends to support the second suggestion for correlation at the Ten-mile Stream end. The Fred Fault correlates with the fault which crosses the Strongman Mine road about 700 ft. upstream from the McTaggart Fault, where it has a downthrow to the west of 150 ft. to 200 ft. At the Ten-mile Stream this fault has upthrown Fauth and party's seam on the east side. With the work in this area still in progress it appears at present more probable that an unconformity rather than large-scale faulting accounts for the absence of the considerable thickness of intervening beds.

The next important faulting is in the area worked by Armstrong, Kaye, and party and by Hunter and party. These mines are bounded on their east and west sides by faults, the largest of which, having an upthrow of 300 ft. to the east, cuts off the eastward extension of the Armstrong seams. This fault is exposed in the cliff section above the Ten-mile Stream, and is correlated with that encountered about half-way along the Strongman Mine stone-drive. At the end of this stone-drive (15th October, 1938) there is another fault with 90 ft. upthrow to the east, but this as yet has not been traced elsewhere.

East from the co-operative mines in the Ten-mile valley for approximately 1,000 ft. along the cliffs an unfaulted section is presented containing the Kaye and party seam and the two Armstrong seams. This section is interrupted by the Doherty Creek Fault where the lower Paparoa Mudstone is downfaulted on the west against the Paparoa Conglomerate. Here the movement is estimated as at least 1,000 ft. This so affects the lower Paparoa coal-seams that they are encountered only in Doherty Creek 2,000 ft. from its junction with Ten-mile Stream.

The Bishop Creek faulting, more or less along the line of the lower part of Bishop Creek, marks the eastern limit of this season's work in this area. Here a shear zone hundreds of feet wide, consisting of innumerable small faults, involves the Paparoa Conglomerate for the most part and possibly also part of the underlying Greenland Series.

Of transverse faults the only noteworthy example in the area is that which follows the Ten-mile Stream from the co-operative mines to Doherty Creek, where it is cut off by the Doherty Creek Fault. The throw of this fault is estimated at, roughly, 50 ft.

In the Otto Creek basin the two faults that were traced last season from upper Davy Creek to near the junction of Wills and Toms ridges are found to be taken up by a wide zone of small-throw, en echelon faults of slightly east of north strike and westward distribution. The Roa Fault was traced to the west of Mounts Watson and Leitch and found to be dying out in this direction.

Where folding occurs in the above-mentioned areas the folds are gentle and open with the same general north-north-easterly alignment as the faulting system. A good example of this is to be seen between the Trigonometrical Stations XY and FB. Just west of XY is the crest of an anticline. About half-way between the two stations is the trough of a syncline. This structure continues in a slightly east of north direction across Waterfall Creek.

From the above data it will be seen that, inland from the coast, many repetitions of parts of the stratigraphic column are encountered owing to the numerous roughly parallel faults upthrown to the east.

It is possible at present to make a few general statements regarding the structure of the Coal Creek area. The western slopes of the ridges between Taylorville and Mount Davy form an even, undisturbed dip slope, remarkably free from complications. At the foot of this slope a fault mapped by Morgan and Ellis, and described by the latter as the Saddle Fault, forms a prominent scarp. It is believed that this north-south fault, with upthrow to the west, changes southwards into a synclinal fold. Between this structure and a fault, or group of faults, to the west, more or less parallel with the Saddle Fault, and related to the Spring Creek Fault zone, the rocks are folded into a gentle southward plunging anticline. Broadly considered, the area is one of comparatively little disturbance, the folding being mainly open and simple and the faults all of small throw, with the exception of the two referred to above. It is to be noted, however, that throughout the Coal Creek basin only the Brunner beds and the uppermost Paparoa beds, as far down as the upper Paparoa shales at one place, are exposed, and if, as now believed, an unconformity exists below the Brunner, then the underlying Paparoa beds may possess a more complex structure.

GLENORCHY SUBDIVISION.

By R. W. Willett.

During the past field season the geological survey of the Glenorchy Subdivision was continued over the uncompleted portions of the Glenorchy and Earnslaw survey districts. Some 180 square miles was mapped in detail covering the eastern half of the Earnslaw Survey District and the eastern and southern parts of the Glenorchy Survey District. From the 28th November, 1938, to the 10th February, 1939, Mr. H. W. Wellman carried out survey work and fixed points to enable the air-photo minor control strips to be tied in. After several delays due to unfavourable weather conditions Mr. van Asch completed the air-mapping of the subdivision on the 31st January.

Topography.

The eastern slopes of the Richardson Range are drained by three major streams—Moonlight Creek, Flood Burn, and Sixteen-mile or Forest Creek—all of which discharge into the Shotover River.

Moonlight Creek, which drains the southern end of the Richardson Range, has two large branches, the Right-hand Branch and the Left-hand Branch, which join below the northern flank of Ben More to form the Moonlight proper. The Right-hand Branch rises on the eastern slopes of Mount Larkins and flows due south along a glaciated valley. Its chief tributary, Wire Creek, flows from Wire Saddle between Major Peak and Mount Larkins, eastwards to the Right-hand Branch. Lake Luna, the source of the Left-hand Branch, is a long, narrow wedge-shaped lake about one and a quarter miles in length and ranges in width from a quarter of a mile at the northern end to 50 yards at the southern end. The lake occupies the head of a glaciated valley, 2,500 ft. above sea-level, and owes its origin to the blocking of the valley by large alluvial fans from the western slopes of the valley. A bathymetrical survey showed that the lake bed possesses the characteristic U-shaped cross-section of a glaciated valley; its floor is fairly even over a considerable area lying within the 120 ft. contour, and a longitudinal section shows a steep gradient at the northern or deeper end and a more gentle gradient at the southern or shallower end. This is a feature common to all the lakes in the Wakatipu district—a gentle slope at the end of the lake basin at which the glacier entered and a rapid slope at the opposite. Park mentions this feature in his bulletin on the Queenstown Subdivision, 1909, and compares it with a similar state of affairs found in the lochs of Scotland. From Lake Luna the Left-hand Branch of Moonlight Creek meanders northward along an alluviated glaciated valley, whence by way of a narrow valley it joins the other branch of the Moonlight. The tributaries of this, the Left-hand Branch, drain the western slopes of Ben More and the eastern slopes of Major Peak, the highest point at the southern end of the Richardson Range. Below the junction the Moonlight flows in a deep gorge practically due east, close to the south boundary of Glenorchy Survey District. At the south-east corner the stream turns and flows due south, deeply entrenched in a gravel-filled valley, to Moke Creek, a tributary of the Shotover. The western slopes of the gravel-filled Moonlight valley are drained by three eastward-flowing streams—Ben More or Dead Horse Creek, Butcher Creek, and Thomson Creek.

The sources of Flood Burn drain the central portion of the Richardson Range, which occupies the southern part of Earnslaw Survey District. The main stream of the Flood Burn does not flow through the Glenorchy Subdivision, but drains the northern part of Skipper's Creek Survey District and joins the Shotover at the Branches; it is the Right-hand Branch that drains Earnslaw Survey District. The headwaters of this stream arise in the snowfields of the central Richardson Range, flowing first along glaciated hanging valleys, which discharge over high waterfalls to larger glaciated valleys below. These are generally about two miles long, and the streams then continue their courses through deep, rugged schist gorges, the entrances to some of which are blocked by large post-glacial slips, over which the streams discharge in rough cascades. Post-glacial slipping on a grand scale is prominent in the northern and more mountainous part of the subdivision, and in many places has completely obscured the typical shape of the original glaciated valleys. The Right-hand Branch of the Flood Burn flows in a southerly direction, and after receiving several tributaries from the west crosses the southern boundary of the Earnslaw Survey District and joins the main stream below the northern slopes of Mount Aurum.

The most northerly of the three major streams draining the eastern slopes of the Richardson Range is Forest or Dilston Creek, locally known as the Sixteen-mile Creek, which at a point some two miles west from the Shotover River divides into two main streams—the Right- and Left-hand branches. The larger stream, the Right-hand Branch, rises under the snowfield on Centaur Peaks (8,284 ft.) in a glacial hanging valley, from which the stream discharges over a large waterfall—the Alexander McKay Falls—1,100 ft. above the main valley. The first and largest leap of these falls is 548 ft. high, thence the stream continues in series of rugged cascades, and a final leap of 134 ft. to the valley below. Below the falls

the stream meanders along a typical glaciated valley, some two miles long, whose U-shaped cross-section has been somewhat obscured by post-glacial landslides and slips. After leaving this valley the stream flows down a narrow rocky gorge over many cascades to its junction with the Left-hand Branch, which is 700 ft. below the alluviated glaciated valley mentioned above. The chief tributary of this branch is a mountain torrent flowing from the range between it and the Lake Creek from Lochnagar and having its source on the eastern face of the Centaur Peaks. This creek has built a large alluvial fan out into the main valley. The valley of the Left-hand Branch is strikingly similar to that just described, although not quite as extensive. Two huge landslides block the mouth of the glacial valley, and over them the stream cascades to the junction some 700 ft. below. Where the Left-hand Branch discharges from the small glacial valley at its source, practically at the same height above the main valley as that of the Right-hand Branch, it does so over a gentler cascade and smaller falls than the Alexander McKay Falls. Talus deposits at the base of the main valley's walls are much in evidence and in places meet across the valley, the stream meandering in a narrow channel. From the junction of its two branches Sixteen-mile Creek continues down a deep schist gorge containing several large waterfalls, and joins Shotover River, the eastern boundary of the Earnslaw Survey District. At the junction there is a well-marked series of terraces, ranging from 108 ft., the height of the first series above the Shotover River bed, to 230 ft., the top of the main and highest series of these terraces. The surface of the 230 ft. terraces rises gently toward the base of the hills, where it is then 300 ft. above the Shotover, and this fact, coupled with the general fanlike appearance of the terraces, suggests that the gravels were originally deposited as a vast alluvial fan by the Sixteen- and Seventeen-mile creeks, at a time when the general base level was some 200 ft. to 250 ft. higher than it is to-day. Such a condition was probably due to the blocking of the main river valleys by the recessional moraines of the dying glaciers and vast outwash fans from the glacial streams. The formation of the alluvial fans by the tributary streams in the Shotover valley has forced the main stream hard against the opposite bank, where in several cases the Shotover has cut a deep (80 ft.) gorge in the toe of a schist spur; this can be seen to advantage just a few chains below the point where the Sixteen-mile Creek joins the Shotover. Corresponding to the series of terraces at the mouth of the Sixteen-mile Creek is a similar series at the junction of the Flood Burn and the Shotover, and again in the valley of Moonlight Creek, along the eastern boundary of the Glenorchy Survey District, just west of Trig. BB.

Glaciation.

Throughout the district there is strong evidence of extensive valley glaciation, but none for anything in the nature of an ice-sheet. The main streams draining the eastern slopes of the Richardson Range flow through glaciated valleys in their upper reaches for a distance of some three miles; this is to be seen in the upper valleys of Flood Burn, Sixteen-mile Creek, and Moonlight Creek. At the heads of these valleys are well-developed cirques, each about 1,000 ft. high, above which are small hanging valleys, lying in the same direction as the main valley below. These hanging valleys along the main valleys are characteristic of the glacial topography of the Earnslaw Survey District.

The evidence of the ice action in the Rees Valley on the eastern slopes of the Richardson Range is by no means as marked as on the western slopes, although there is a general correspondence of the major glacial features on both sides of the range. On the eastern side of the range, as in the other parts of the subdivision, all the cirques face south-west, south, or south-east, and similarly the height to which signs of ice action can be observed—namely, about 4,500 ft. Many of the characteristic features of the valleys are obscured by immense post-glacial landslides and slips. To a large extent the major slipping has been along the schistosity planes, and an excellent example of this can be seen at Lochnagar, just outside the north-east corner of the subdivision, where an immense slip blocks the valley and forms the lake; the schistosity plane on which slipping occurred forms a conspicuous feature on the landscape.

The evidence for two periods of the glaciation is fairly strong and consistent. In addition to the features described in last year's annual report from the western portion of the subdivision, there is the evidence of ice advance in the upper valleys after the main glaciation as shown by the hanging-glacial valleys at the head of all the main valleys draining the eastern slopes of the Richardson Range. Another feature that lends support to the "two-period" theory, although outside the subdivision, is worth mention—that is, the moulding and carving of an old moraine by a second and later glacier in the upper reaches of the Left-hand Branch of Skipper's Creek. Park (1909, p. 30) describes part of the Miller's Flat moraine as planed to an even surface by the Shotover Glacier.

Structure.

The major structural feature of the district is the Moonlight Fault, which crosses the subdivision in the subdivision south-east corner of Glenorchy Survey District. Infaulted along the line of the Moonlight Fault is a band of Tertiary rocks, which has been traced from Bob's Cove to the Flood Burn described by Park (Bull. No. 7, 1909). Where the infaulted Tertiary crosses the Glenorchy Survey District it can be seen in Dead Horse or Ben More Creek, in Moonlight Creek, and on the ridges between these streams. The fault strikes a few degrees east of north and dips west at 63°. It is well exposed in the face of the bluff on the south side of Moonlight Creek at the point where the Moonlight Sluicing Co. have driven a tunnel through the Tertiary for their water-race. Here on the east side of the fault the schist is thoroughly crushed, sheared, and strongly contorted; the Tertiary is about 200 ft. thick and consists of bands of hard, dull-grey limestone, calcareous sandstone, and a hard quartz conglomerate, together with a small thickness of fault breccia. The plane of contact on the western side of the fault is clear cut and well defined. Poor but determinable fossils have been described from the Tertiary beds which belong to the Oamaru Series (Park, 1909, p. 67).

In the north-east portion of the subdivision a continuation of this Moonlight Fault was discovered crossing Sixteen-mile Creek at a point about 100 chains from the Shotover River, striking N. 4° E. and dipping west at 84°. Here on the west side of the fault is a hard band of chloritic schist, on the east the schist is crushed and contorted, and the crushed rock was traced south over the ridge to the Flood Burn, where it lines up with the Moonlight Fault. Northward the fault was followed along the face of the bluffs on the west side of the Shotover at the Seventeen-mile Creek and thence to the eastern boundary of the Earnslaw Survey District. No Tertiary was found along the fault north of the Flood Burn. Thus the Moonlight Fault can be traced from Bob's Cove in the south to the upper Shotover Valley in the north, a distance of some thirty-two miles, and the infaulted Tertiary as far north as the Flood Burn.

Parallel to this dominant fault are numerous minor fractures generally shown by shearing and crushing of the schist, or in some cases by the drainage pattern. With the crushed schist are generally numerous small quartz veins and stringers, parallel to the schistosity; larger quartz veins usually cut across the schistosity to a certain extent and have steeper dips to the west.

Schists.

The schists that make up the eastern slopes of the Richardson Range belong to subzone 4 of the Chloritic Zone as mapped by Turner and Hutton (1936). In the southern portion of the subdivision the general strike is a few degrees west of north and the dip west at fairly high angles. Northward the schists are very regular and there is little change in the average dip and strike, until the eastern part of the Earnslaw Survey District is reached; here the schistosity planes strike on the average N. 33° E. and dip west at 48°. This general tendency for the strike of the schists to swing from about 15° to 20° W. of N. in the southern portion of the subdivision to about 30° E. of N. in the northern part is in keeping with the general structural swing of the country in the Western Otago Division. This change in the direction of the strike of the schists is borne out by observations in other parts of the Otago area.

Economic Geology.

Gold.—Apart from the activities of the Moonlight Valley Gold Co., there is no gold-mining at present being carried on in the area under consideration in this report. The gravels of the Moonlight valley lying just west of Trig. BB have been the scene of a considerable gold-winning activity since the late "sixties," but there has been a general decline since the close of last century, with a renewed burst of activity during the years 1930 to 1935. At present the Moonlight Co. have an extensive sluicing plant at the mouth of Butcher Creek, a tributary of the Moonlight that flows from the slopes of Trig. L eastwards to the main stream, and are working the gravels with quite an encouraging degree of success. The gravels, some 250 ft. thick, are well consolidated and consist of quartz and schist cobbles, with an occasional boulder of Tertiary sandstone, horizontally bedded, and here and there a band or lens of fine-grained silt. The usual prospecting-work has been carried on in most of the creeks with varying measures of success, especially in the upper reaches of the Moonlight, the Flood Burn, and where the Sixteen-mile Creek enters the Shotover Valley.

Scheelite.—Scheelite-mining at the head of Lake Wakatipu still occupies the attention of several parties, together with the Glenorchy Scheelite Co., and the rate of production has been steadily increasing. The two major producing mines are the Glenorchy Scheelite Co. and the Heather Jock; the activities of the other prospecting parties can best be described by the American mining term of "gophering." No new reefs have been opened up except a small one at the head of the Bonnie Jean Creek, which yielded some fine ore but did not continue; in fact, several workings have closed down—namely, the Twelve-mile Claim, the Precipice Creek Alluvial Claim, and a claim on the southward extension of the Glenorchy Lode. The reason for the closing-down of these workings seems to be due primarily to the lack of good ore and to the promoters being unable to bear the cost of further development work. The future of the industry is, of course, dependent upon the overseas demand and price-level, but also on the method of mining, for as it seems that the scheelite is fairly consistent throughout the proved lodes the possibilities of developing the industry on a large scale merits the greatest consideration. At present the inability of small parties to afford to carry out the essential development work leads to uneconomic and prodigal working.

PALÆONTOLOGICAL WORK.

By J. Marwick.

The greater part of the year was occupied in writing the bulletin on Te Kuiti Subdivision. This work has now been completed. A short paper on the molluscs *Maccoyella* and *Aucellina* in the Taitai Series was written and published in the "Transactions of the Royal Society of New Zealand," Vol. 68, Pt. 4 (March, 1939). A paper that had been written the previous year, on the Venerid group *Notocallista* and its Allies, was published in the "Transactions," Vol. 68, Pt. 1 (June, 1938). A paper was also prepared on the correlation of the different formations that have been proposed in the Wairoa, Gisborne, and Waiapu subdivisions.

Proof-reading of Naseby and Kaitangata bulletins occupied several days.

Numerous collections of fossil Mollusca were sorted and identified, chiefly from Hawke's Bay, North Canterbury, and North Otago; and exchanges of Tertiary Mollusca were carried out with three overseas correspondents.

Mr. Baker has given useful help in preparing fossil specimens, arranging, collecting, and making card indexes.

REPORT OF MICROPALÆONTOLOGIST.

By H. J. Finlay.

The usual samples from officers in the field have been examined and reported on. Mr. J. Healy forwarded a set of samples from North Canterbury, where the obscure stratigraphy and lack of macro-fossils makes reliance on micro-faunas imperative. Good faunas from nearly all the samples showed the uppermost beds to be Waitotaran, underlain by Taranakian beds with *Bolivinita* and *Siphogenerina pohana* present, and a Hutchinsonian-Awamoan complex below. Awamoan is doubtfully present, but *Ceratocancris clifdenensis* places several of the beds as Hutchinsonian, and equates the Sugar-loaf and Highfield beds. The Ototaran in this area yielded no faunas, but the claystones below showed definite Upper and Lower Bortonian faunas with *Zeauvigerina* and *Globorotalia* n. spp. exactly as in the chalk marls below the Amuri Stone at Hurunui Mouth.

Mr. H. E. Fyfe sent a set of samples covering the Kaiata Mudstone, which confirmed the local zones previously noted in those gathered by E. O. Macpherson, and the reference of the whole series to the Lower Ototaran. In the lowest sample *Hantkenina* occurred commonly; this is but the fourth occurrence in New Zealand, where the range now corresponds very well with that known in America and French Morocco for this curious genus—Middle Eocene to Lowest Oligocene.

The many samples collected last year by Mr. A. M. Quennell in the Dannevirke area have now been almost all examined, and the many good faunas mounted for reference. They could not be exactly placed until a large standard section was available; this has been made possible by access to the material collected by the Shell Oil Co.'s geologists, and the Survey's collections can now be correctly interpreted.

A number of reports have been asked for by individual workers in other areas. A report on the Tertiary foraminifera from the Chatham Islands has been forwarded to Dr. R. S. Allan for incorporation in his account of the geology. Mr. B. H. Mason has sent in numerous samples from the East and West Grey Rivers (North Canterbury), where the interpretation of the fossil evidence rests almost entirely on the micro-faunas. Most interesting faunas were here obtained, demonstrating the Tapuwaeroa age of the Loburn clays (the underlying saurian sulphur sands being as usual unfossiliferous), the Lower Bortonian age of the Ashley mudstones above, followed by Upper Bortonian quartz glauconitic sands, all of this being below the Amuri Stone. The latter yielded for the first time a few faunas near its base, one of which was definitely Lower Ototaran. An interesting Hutchinsonian sequence was obtained from the West Grey, the faunas above and below a brachiopod limestone being identical and containing several key forms of the Waitemata beds and other true Hutchinsonian horizons. Mr. B. W. Collins has begun to send in samples from a more southern area in the Motunau district, and those already examined show that a similar but less full succession of horizons exists there also.

Two foreign samples have been received and mounted for reference, one from the Mid-Oligocene of Manta, Ecuador (by courtesy of Dr. A. A. Olsson), and the other from the Upper Pliocene of New Guinea, from Mr. M. Ongley, to whom a report was forwarded for the use of the Island Exploration Oil Co.

A complete collection of New Zealand representatives of the family Pleurostomellidae has been mounted and forwarded to Mr. W. J. Parr, of Melbourne, a specialist in this group, for examination and description.

Much time has been taken up by the part-time agreements with the New Zealand Petroleum Co. and the Shell Oil Co. A very large collection of samples from the Taranaki area is being examined and reported on for the former, as well as shallow-core samples from the Greymouth area and odd samples and slides from Poverty Bay in connection with the drilling at present being carried out there. Sections throughout the Taranaki Tertiaries have also been gone over with Dr. Büning, of the Shell Co., and local ranges of important species examined. An extremely valuable section in Hawke's Bay, from Cretaceous to Mid-Tertiary, has also been jointly examined in detail, and throws much light on the ranges and value of many forms previously known from Dannevirke and Poverty Bay; it also confirms the easy division of the Bortonian by micro-faunas into Upper and Lower, as already noted for the type Hampden section in last year's report.

Several papers have been prepared for publication during the year. "The Occurrence of *Calcarina mackayi* in Australia and New Zealand" was sent to the Canberra meeting of the A.N.Z.A.A.S. For the "Transactions of the Royal Society of New Zealand" two papers were written: "The Occurrence of *Rzehakina*, *Hantkenina*, *Rotaliatina*, and *Zeauvigerina*" and "Key Species in Stratigraphy, No. 1." The latter contained an appendix on New Zealand Tertiary stage names at present usable from the evidence of both macro-fossils and foraminifera and their suggested equivalence with European divisions. Both these have now been published, and No. 2 of "Key Species in Stratigraphy" is at present in press.

PETROLOGICAL AND MINERALOGICAL WORK.

By C. O. Hutton.

Petrological and mineralogical work has only been carried out for six months, hence much preliminary work—namely, collection of equipment and designing of laboratory accessories—has been necessary. The formation of a rock specimen and thin section collection has occupied much time. To date 1,400 specimens, many of them sliced, have been labelled and placed in cabinets, and this small collection has already proved of value to the officers of the Survey. In addition to the collection of New Zealand type material, there is being developed a wide range of foreign rocks and minerals brought from Europe by the writer. This will prove most useful for purposes of comparison. A catalogue and card index of these rocks are now being prepared.

A period of nearly four weeks was spent at Otama, Southland, making collections of rocks from critical points in and around a basic intrusion. As the detailed investigation of these rocks has not yet been undertaken no comments can be made, except that among the altered gabbroidal rock types, coarsely granophyric rocks, closely comparable to some specimens collected from Trias-Jura conglomerates, have been noted.

Ten days were spent at Patea, in South Taranaki, during which time some iron-sand dunes were mapped and sampled. A mineralogical investigation of these sands is to be carried out.

Routine determinations of mineral and rock specimens forwarded to the Survey Office have occupied several days.

Two months have been occupied in preparing for publication the results of six years research on the low-grade metamorphic rocks and minerals of Western Otago. This work is to be published as Memoir No. 5 of the Department of Scientific and Industrial Research. A short paper on "The Significance of Tourmaline in the Otago Schists" has been written and published in the "Transactions of the Royal Society of New Zealand" (Vol. 68, Pt. 4). A second paper on the Bob's Cove Tertiary Beds and the Moonlight Thrust Fault has been written for the "Transactions of the Royal Society of New Zealand" (Vol. 69, Pt. 1); it is at present in the press.

GEOPHYSICAL SURVEY OF BIG RIVER AREA.

By F. A. McNeill.

The country covered during the 1938–39 season lies near Trig. R, Waitahu Survey District, about fifteen miles south of Reefton. The area is bounded on the south and east by Big River and extends west to the sources of Furmister Creek, and north towards Merrijigs.

In order to connect with the Waiuta area examined last season three days were spent by Mr. M. Gage and members of the Survey in geologically examining two streams flowing roughly north-west and entering Big River from the east, respectively 25 chains and 60 chains below Sunderland Creek. This part of the area is too difficult of access to allow of geophysical survey. As a result of this examination the fold structures defined in the Waiuta area were mapped northward to Big River. The purpose of the field-work this season was to trace these main structural features north towards Merrijigs.

The area observed consists of rocks of the Greenland Series, screened in places by Pleistocene gravels. The steep dips of the sediments give rise to complicated potential-ratio curves, even through the gravel cover, though the anomalies caused by the main folds are easily recognizable.

Results to date show—(1) That the Waiuta Anticline loses its electrical characteristics on the north side of Big River, where it should cross Keneru Creek. Whether or not it reasserts itself north of Trig. R will be determined before the season ends. (2) The syncline immediately to the west continues nearly three miles north-north-west of the river. It follows a somewhat sinuous course, passing about 5 chains east of Trig. R, and continues along the upper reaches of Gage Creek. (3) An anticline still farther west has also been traced, largely by geological mapping. (4) The syncline immediately east of the Waiuta Anticline re-enters the gravel country about 40 chains east of Trig. R, and if the Waiuta Anticline has not died out it should be between this syncline and that mentioned in (2). (5) The gravel cover has been mapped and measurements of thickness made in several places. The average depth is probably from 30 ft. to 50 ft.; in only one place did they appear to exceed 150 ft. Geological evidence suggests a greater thickness farther north.

GEOPHYSICAL SURVEY OF THE COBB RIVER DAM-SITE.

By H. Wellman.

A geological magnetic and seismic survey of the area around the proposed dam-site was made during the latter part of February, March, and the early part of April. The geological survey indicated that the geology was complex and that bedrock was largely covered with scree material and moraine. The magnetic survey showed that magnetic anomalies up to 5,000 gamma occurred over a serpentine belt which was delineated by this method.

Eight seismic lines were run, and the following velocities found:—

	Kilometres per Second.
Scree material	0·3–0·5
Moraine	1·0–1·2
Carbonates	3·2–3·6
Weathered carbonate	2·0–2·2
Serpentine	3·2–3·4
Quartzite ?	5·0–5·3

At the proposed dam-site six shafts had been sunk without reaching bedrock, and the seismic survey indicated that they were about 6 ft. from bedrock, a determination in one case checked by drilling. A fair indication of the depth to bedrock for a distance of 20 chains along the valley floor was found, and the bedrock velocities also indicated the continuation of the geological boundaries under the overburden.

The results of the survey show that a more suitable dam-site than that originally proposed can be found and that, although there is good foundation along the centre of the valley, the western side is covered with a considerable depth of weathered carbonates.

CROMWELL LODE SYSTEM.

By J. Henderson.

The adit under the workings of the Cromwell lode at Bendigo (see N.Z.G.S., 31st Ann. Rep., pp. 14–16) disclosed only one fissure that can reasonably be considered to belong to the Cromwell vein-system. This is Fissure A of the thirty-first annual report of the Geological Survey, 1937. It crosses the adit 1,685 ft. from the entrance and probably corresponds with the cross-lode of the upper workings. About 60 ft. farther in a flat shear, B, is encountered, and though the adit was extended to 2,110 ft. it is unlikely that the three strong fissures penetrated correspond with any of the lodes worked from the surface. Therefore movement along the flat-dipping shear is inferred by which the Cromwell lode system above the shear is displaced relatively to its continuation below the shear.

The adit penetrates probably six sets of fissures :—

(1) Three strong sub-parallel fissures between 80 ft. and 300 ft. from the entrance.
(2) Three strong sub-parallel fissures between 1,450 ft. and 1,640 ft. from the entrance.
(3) A steeply-dipping fissure at 1,685 ft. parallel with and close to the projected position of the cross-lode worked on the surface, and inferred to be this cross-lode.
(4) A fissure striking north-west and dipping north-east at 25° at 1,745 ft. This is thought to be a shear along which displacement, later than the lode-formation, occurred.
(5) Two sub-parallel vertical fissures nearly directly under the outcrops of the Cromwell lode, but striking nearly at right angles to its general course. These are probably transverse breaks between more important fissures.
(6) A fracture at the end of the adit (2,110 ft.) dipping steeply south and striking sub-parallel with the North and Cromwell lodes worked on the surface and also with the three fissures of the second group of the adit.

If the movement that displaced the lodes was normal—that is, down the shear-plane and approximately in a north-south direction—the downward continuation of the Cromwell lode system is in a block of country the top of which reaches above the level of the adit and lies farther south than its present end. The fissure at the existing face may represent the north lode of the Cromwell group, the northernmost fissure of the second group cut in the adit, or some fissure not connected with either. On the other hand, if the overlying block of country was thrust up the shear-plane toward the south, as on theoretical grounds is likely, the downward continuation of the lode system is displaced relatively northward and lies below the level of the adit. Again, there may be a lateral component in the movement along the shear-plane and the lode system may then have an east or west displacement. One of the reasons last year for suggesting that a rise be put up to the projection of the Cromwell lode on the shear was to endeavour to get some idea of the direction of the displacement. The geophysical work already undertaken shows that fissures in the Bendigo area can be readily traced on the surface even under gravels 100 ft. thick. But the problem of locating the displaced part of the Cromwell lode-system is more difficult. Above the shear there are three groups of fissures, each of which would react similarly to geophysical tests, and at least four groups below the shear. The direction and amount of movement are quite unknown. Compared with the conditions at the Progress lode, near Reefton, where months of geophysical examination yielded rather inconclusive results, the problem at Bendigo is more complex, and possible interpretations are likely to be more numerous and more speculative. Probably extensive boring or other prospecting would be necessary to prove or disprove any one of them.

The probable reward if the displaced Cromwell lode system is located in depth must also be considered. The Cromwell lodes yielded much highly profitable ore, but the known ore-bodies throughout the greater part of the mine did not extend as deep as the shear that cuts off the system. Near the deep shaft auriferous quartz occurs down to or at least close to the shear, but this veinstone was narrow and of low grade ; it does not seem to have been stoped. This distribution of the ore-bodies in the Cromwell lodes, combined with the fact that all mines on auriferous quartz-veins traversing the schists of Otago were abandoned at shallow depth, suggests that ore-bodies comparable in value with those near the surface at Bendigo are not present in depth.

The following conclusions seem reasonable :—

(1) The Cromwell lode extends under the gravels farther west than it has been so far prospected and may contain ore-bodies in this part of its course.
(2) The Cromwell lode may contain ore-bodies between the shear plane and the lowest workings above the adit.
(3) Geophysical work to locate the Cromwell lode system below the shear is not worth undertaking in the present state of geophysical technique.

GEOPHYSICAL RECONNAISSANCE OF THE BENDIGO AREA.

By F. A. McNeill.

An examination of the drive put in by the New Bendigo Gold-mining Co. showed that a geophysical examination in the drive itself would be useless while the iron tram-rails, air and water pipes remained *in situ*. From the geological evidence of the nature of the "slide" it was not considered feasible to attempt to define the line along which the slide might reach the surface, as the irregular topography and presence of numerous other fissures and reefs would obscure any results obtained from the "slide" itself.

An attempt, however, was made to define the continuation of the Cromwell lode, which has been traced by surface prospecting to the edge of a comparatively flat area of gravels to the west of the main workings. Some success was obtained here by observing over parallel traverses 100 ft. apart and running roughly normal to the lode itself. Four of these traverses were examined during the three days spent on this work, and the results show that the reef-fracture, presumably present up to the schist-gravel interface, definitely continues over the distance of 400 ft. covered by the traverses.

The lode fissure apparently swings slightly more north of west than its course where the reef was worked. From the limited work done the fissure appears to strike at about 300° mag. and dips almost certainly less than 70° to the north-north-east. But it must be emphasized that there was not sufficient work done to state that these results are absolutely correct.

The overburden of gravel, which appears to be between 50 ft. and 100 ft. thick, did not offer much difficulty in this examination. This rough estimate of thickness is not conclusive, but 100 ft. may be taken as the limit over the area examined.

A reconnaissance was also made over a quartz reef which appears in the adit about 330 ft. from the entrance. It was located almost over the drive itself, but did not definitely appear on two parallel traverses farther east, though whether this lack of definition was due to the thickness of the overlying gravels on the latter two traverses or to the absence of any well-defined electrical difference between schist and lode-fissure at these points is unknown. On the two eastern traverses, moreover, another fracture was located about 200 ft. north of the line of reef, and this could well be correlated with the fissure seen in the drive about 80 ft. from the entrance.

As with the Cromwell lode, the work on this reef was not complete as circumstances did not permit of the lengthy stay necessary to do the detailed and extensive examination essential to form a basis for unqualified conclusions.

ROTORUA THERMAL WATER.

By J. Henderson.

The Town of Rotorua is built on lake-beds deposited when the lake was at a higher level than now. Its main part is on flats that rise gently to about 20 ft. above the lake, but Pukerua (the hospital hill) and the terraces west and south of the railway-station are remnants of beds that accumulated when the water was at least 80 ft. above its present level. On the other hand, the submerged tree-stumps at Kawaha and Waiteti on the west side of the lake, on both sides of Hamurana Springs on the north side, and near Te Ngae on the east shore are evidence that the lake was once lower.

The low-lying flats along the lower valleys of the Utuhina and Puarenga streams are the sites of estuaries infilled since the lake rose to its present level, the 30 ft. of peat penetrated by a bore at Kuirau suggesting the order of the deepening.

The lake-beds consist of pumiceous gravels, sands, silts, and muds, the last mentioned in places containing diatoms. The gravels and sands are usually well sorted and fine textured. Good exposures of the coarser beds occur at the pumice-pits, two miles along the road to Whakatane, and of the finer in Rangiuru Street at the east base of the hospital hill. At the latter an irregular contact with the underlying breccia is showing, and here also thermal waters have altered the beds and deposited silica.

Thermal action is manifest at many points in and near the town. The steam vents, hot springs, and mud pools continue south from Ohinemutu on the west side of the hospital hill, and hot subsurface water marks its extension farther south along Ranolf Street. East from Ohinemutu warm water, sulphur patches, and sinter layers are common to Motutara Point and the sanatorium grounds, thence south to the Puarenga estuary and to the extensive Whakarewarewa thermal area. Over some three or four square miles, in part occupied by the town, thermal action, or the evidence of former thermal action, is widespread. Even in patches where there is no surface evidence shallow bores have disclosed hot-water or siliceous crusts. Thus on the block east across Fenton Street from the post-office most of the numerous bores for foundations bottomed on silicified rock at about 20 ft. from the surface and several struck hot water. Again at Wyllie Street, two bores on Mr. F. A. Kusabs' property reached hot water. The bores are on a terrace perhaps 60 ft. above the lake. The water in the first bore, which is 76 ft. deep, stands at about 50 ft., and on pumping reaches 104° F. The second bore, 194 ft. deep, penetrated loosely consolidated sands, silts, and pumice rubble with silica crusts near 120 ft. At about 180 ft. boiling water and steam shot violently and intermittently to a height of over 100 ft., but now, probably owing to the collapse of the hole below 38 ft., to which depth it is cased, only steam and gas, which extinguishes a match, issue.

Wells and springs in all regions are sufficient proof of the universal presence of ground-water—that is, water filling pores, joints, and other openings in rocks. This water is clearly connected with rainfall, since in dry periods its level sinks in wells, and springs diminish or entirely fail. The surface of the ground-water, or water-table, is not a horizontal plane, but in general follows in simplified and subdued contours the confirmation of the ground above it. This is largely due to the fact that the ground-water is constantly, though slowly, moving; it seeks a lower level and, but for capillary action and friction in the narrow spaces, its level quite soon after rain would approach that of adjacent streams and lakes. Rarely, however, does it flow in definite channels, but it seeps through large rock masses by way of innumerable close-pressed joints and interstices between sand grains. Its movement is analogous to that of water in pipes, and its rate depends on friction and the hydraulic gradient. The surplus water which cannot be accommodated in the rock partings and pores appears on the surface as lakes, swamps, and streams.

Lake Rotorua occupies a depression in a great sheet of volcanic fragmental rocks which, being brittle, fractured during the down-warp. The line of springs and pools extending south-south-east from Koutu Railway-station suggests a definite fracture, but thermal manifestations in other parts of the area show little alignment. Probably the lake-beds rest on an irregular mosaic of blocks, with steam and hot gas emanating from many points along the breaks. These gases heat the ground-water with which they come in contact, and at the same time increase its rate of movement. Where the sequence of lake-beds contain impervious silts and muds, no surface evidences of thermal action are to be expected unless a strong emanation underlies; a silica crust later covered by other lake-beds

would also form a barrier to the uprise of warm water. Hence the absence of surface evidence does not prove that hot water does not underlie. On general grounds one would expect the whole mass of ground-water under Rotorua town to be warm, and to this conclusion the known wide-spread occurrence of surface manifestations lends strong support.

There is little precise information as to the amount of hot water actually used. Hot water for the Blue Bath at Rotorua comes from Roto-a-Tamaheke at Whakarewarewa, nearly two miles away, through a 6 in. main with a 6 in. booster pump halfway. If silica deposition has reduced the effective area of the main to 4 in. a discharge of 200 gallons per minute may be reasonably assumed. According to Grange (N.Z.G.S. Bull. 37, 1937, p. 89), the outflow from Roto-a-Tamaheke amounts to about 120 gallons per minute of water above blood-heat; this is in addition to the amount going to Rotorua and that used in the Spout Bath and by the Maoris. Grange (p. 91) states that 100,000 gallons are daily pumped from the Rachel Spring for use in the main bathhouse of the sanatorium. Mr. H. E. Fitzgerald, the Tourist Department's overseer, has noted that pumping this amount during the night by a 3 in. pump lowers the water 6 ft. He also recollects a trial some twenty-five or thirty years ago when two 6 in. centrifugal pumps lowered the spring about 10 ft.—that is, to near lake-level; two pumps of this type would probably discharge together from 80,000 gallons to 100,000 gallons per hour. The Rachel Spring yields an alkaline water; the acid water used comes from the New Priest Spring, about 3,000 gallons per hour being pumped. This spring rises and falls with the lake.

From the above imperfect records it appears that hot water at an aggregate rate of 22,500 gallons per hour is drawn, during parts of most days, from Roto-a-Tamaheke at Whakarewarewa, and from the Rachel and New Priest Springs at Rotorua. There is no evidence to show that the amount available from these sources is, or has ever been, overdrawn; indeed, there is a substantial outflow from Roto-a-Tamaheke, and the test of Rachel Spring suggests that considerably more water could be pumped without depleting the supply. In addition, hot water rises in substantial amount at Whakarewarewa, Kuirau, Ohinemutu, and along the lake-shore. Obviously the amount of hot water reaching the surface is several times the amount at present used in public and private baths and by the Maoris. The heat is derived from a subjacent mass of hot rock of unknown size, and is brought to the surface by the gases and steam liberated during crystallization. These gases pass directly to the air or through water saturating the ground, or lying on its surface, and to this water the gases give up most of their heat. The water so heated diffuses through larger and larger bodies of lake and ground water, and the heat is ultimately dissipated by conduction and radiation. The amount of hot water available from Roto-a-Tamaheke could readily be closely estimated, but the quantity that could be taken from the reservoir of hot ground-water supplying the Rachel, New Priest, and other springs without perceptibly affecting them could be only very roughly ascertained even after extensive and long-continued trial and observation; it is probably very large.

IRON-STAINED ROCKS, HÆMATITE STREAM, NORTH CANTERBURY.

By J. Healy.

In accordance with instructions dated 10th March the writer visited the above locality on 20th March in company with Mr. A. C. Barnes, of Spotswood. Hæmatite Creek flows from the south-west into the Waiau River, four miles west of Spotswood. Thirty chains up the creek from its mouth is a large tributary from the north-west, and the samples analysed were collected from points along this tributary and along the main creek at short distances above these forks.

Hector, in his report on the Cheviot Estate (1893), writes as follows (p. 12):—

> "North of Wart Hill I was informed that a lode of hæmatite extends for several miles and is so obvious as to have given the name to the creek where it occurs, but whether it belongs to the older or newer formations was not ascertained. Its analysis is as follows (Laboratory No. 6386):—
>
> "Two samples of hæmatite:—
>
> "No. 1, the darkest sample, contains only 1·10 per cent. of siliceous matter; iron, per cent., 65·89.
>
> "No. 2 is a mixture of pure hæmatite with an argillaceous hæmatite; iron, per cent., 37·14."

The deposits are restricted entirely to the pre-Cretaceous greywackes and argillites of the Lowry Peaks Range. The hæmatite does not occur as a lode but in bedded deposits, which here strike at right angles to the course of the stream. The occurrences are closely spaced and show up as a succession of dark red bluffs, giving the idea, from a distance, that a lode follows the line of the creek.

In Hæmatite Creek itself the strike of the beds is south-east with steep dip to the south-west, and there has been considerable shearing-movement along the bedding-planes. In the tributary the strike is at right angles and the dip north-west. Faulting here has been transverse to the bedding.

The writer has seen similar rocks farther north-west on the Waiau side of Lowry Peaks Range, where they are associated with pillow lavas interbedded in the greywackes. Igneous rock was found at Hæmatite Creek at only one point, but the similarity of the occurrences suggests the deposits to be all associated with igneous extrusions of the pillow-lava type. The deposits are of two kinds and comprise the "Red Rock" of Mr. Fyfe's 1932–33 annual report. The less common type consists of crushed quartz and jaspillite beds, with a development of iron-staining along the joint planes. The more common type is a red, siliceous rock occurring in alternating bands of hard and friable material, and interbedded with the greywackes nearby. It also shows crushing along the bedding-planes. The outcrop in the tributary is of the latter type, though bounded by faults transverse to the bedding.

Six samples, collected and forwarded to the Dominion Analyst for analysis, yielded percentages of iron ranging from 2·1 to 12·4, the average being 7·5. These may be regarded as representative of the deposits, which, therefore, cannot be regarded as of economic importance. Similar rocks outcrop in many places north and west of the area visited.

DOMINION OBSERVATORY.

Acting-Director: R. C. Hayes.

REPORT FOR THE YEAR ENDING 31st DECEMBER, 1938.

Buildings and Grounds.

The Observatory buildings have been kept in good order. During the year two men from the Employment Bureau were engaged in renovating the interior of the Observatory building and generally improving the surroundings. The Wellington City Council has given the usual attention to the Observatory grounds.

Time Service.

Control of Clocks.—During 1938 a total of 302 short-wave radio time signals were received from abroad for checking the Observatory clocks. Normally the clocks are checked every day, but frequent interruptions have continued to occur owing to disturbances in short-wave radio transmission. Also, since conditions are usually unfavourable for the reception of time signals until the late afternoon, there is difficulty in obtaining the daily checks during week-ends and holiday periods. These circumstances have resulted in a slight decrease in the accuracy of time signals during 1938 as compared with previous years. On 30th December a rather strong earthquake stopped No. 6 signal clock, and threw the Synchronome clock (No. 13) out of adjustment, but no interruptions in the time-signal service resulted.

A new chronograph by Thomas Mercer, London, was obtained during the year and installed in the transit room.

Time Signals sent out.—Time signals have been sent out as previously; except that on 1st June, 1938, the old form of signals was replaced by the six-dot signals for transmission through station 2YA. The Observatory provides the following time signals:—

(1) Time Signals by Radio (sent automatically by the Observatory signal clock)—

(*a*) Through Wellington Radio Station ZLW, daily at 10 h. 30 m. N.Z.M.T. (= 23 h. G.M.T.). In transmitting these time signals the call sign of the Observatory is ZMO.

The following table shows the order of accuracy of the ZLW signals during the year 1938:—

Number of times error did not exceed 0·25 sec.	336
Number of times error between 0·25 and 0·50 sec.	27
Number of times error between 0·50 and 1·00 sec.	2
Number of times error exceeded 1·00 sec.	0
Total number of signals sent out	365

The corrections to individual signals can be obtained on application to the Observatory.

There were no failures in the ZLW time signals during the year 1938.

(*b*) Through the National Broadcasting Service Station 2YA daily at 10 h. 28 m., 15 h. 28 m., and (except Sundays) at 19 h. 28 m. and 22 h. 28 m. New Zealand Civil time. The time signals are superimposed on the station programmes, and in the event of failure or suppression of the signals at scheduled times they are sent out thirty minutes later if circumstances permit.

(2) Time Signals by Telegraph (sent automatically by the Observatory signal clock)—

To the General Post and the Railways Department, Wellington, at 9 h. daily (except Sundays) for transmission to telegraph offices throughout New Zealand and railway-stations in the North Island.

(3) Time Signals by Telephone (non-automatic)—

Time signals are given by telephone in response to calls. If specially required, the time is given to the nearest second; otherwise to the nearest minute only. During 1938, time to the nearest second was given on fourteen occasions and to the nearest minute on eleven occasions.

(4) Public Clocks—

The Government Buildings clock was checked daily at 9 h. The rate of this clock is subject to erratic changes, and the error occasionally exceeds half a minute. During 1938 the maximum errors observed were 30 sec. fast and 60 sec. slow. The clock was readjusted by the Post and Telegraph Department on 22nd December.

The General Post Office clock was also checked daily at 9 h. by observing the first stroke of the hour as broadcast by station 2YA. The maximum errors observed during 1938 were 8 sec. fast and 5 sec. slow.

The synchronous electric clock was checked daily at 9 h. and 16 h. The maximum variation observed during the year was 28 sec., and this occurred during a period of thirty-six days (from 15th June to 21st July). The longest uninterrupted run of the clock was eighty-one days (from 9th February to 1st May), and the variation observed during this period was 17 sec.

Astronomy.

Solar Observations.—Solar observations have been carried on by Mr. I. L. Thomsen as part of the Observatory's official astronomical work. During 1938, seventy-six observations of sunspots were made with the 5 in. telescope of the Wellington Philosophical Society's Observatory. Results of the sunspot observations are sent to Zurich, and reports are published by the New Zealand Astronomical Society. Reports of particularly active spot groups are also supplied to the local press. Some solar observations were also made by Mr. M. Geddes in Southland, using the 5 in. telescope on loan from this Observatory.

Mr. Thomsen has made a special study of solar phenomena, and during the year published a paper in the *Journal of the Royal Astronomical Society of Canada* on the tendency of sunspots during 1937 to favour certain longitudes on the sun.

A paper by Messrs. Thomsen and Geddes embracing the results of a preliminary study of solar and terrestrial relationships was also prepared for publication.

Occultations.—Occultation observations have been continued by Mr. Thomsen, using mainly the 4 in. telescope located at his residence. The New Zealand Astronomical Society, the New Plymouth Astronomical Society, and the Wellington City Observatory also co-operate in this work. The New Zealand occultation observations are sent to the Computing Section of the British Astronomical Association.

Auroral Work.—Auroral observations have been carried on in Southland under the direction of Mr. M. Geddes, assisted by Mr. D. C. Berry. The installation of radio transmitting and receiving apparatus at the two observing stations was completed early in 1938. This greatly increased the facilities for obtaining duplicate photographs of auroræ. Auroral activity was high during 1938, and, in addition to numerous minor displays, prominent auroræ were observed on January, 22, 25, 26, March 22, 23, 24, April 16, 23, May 29, July 15, 30, August 4, September 15, 26, and October 25. The displays on January 22 and April 16 were abnormally large: while that of September 15 was probably the most remarkable, although not the brightest, display yet observed in New Zealand. The main aurora was of a normal type, but for about an hour an extremely rare type of high arc developed north of the zenith. Such arcs have been recorded on eight occasions since 1870 in the Northern Hemisphere, but not previously, as far as can be traced, in the Southern Hemisphere. A total of 1,130 successful photographs of auroræ were obtained during the year, including 193 simultaneous sets for the determination of heights. Good progress has been made with the laborious work of measuring the aurora plates, and a paper by Mr. Geddes on the 1937 results was in the press before the close of 1938. Reports on the aurora work are forwarded to Professor Störmer, Norway, and summary reports are published locally by the New Zealand Astronomical Society.

Solar Eclipse of 1937 June 8.—Mr. Thomsen has carried out a considerable amount of work in connection with the measurement of the plates of the total solar eclipse of 1937 June 8 and the reduction of the results. The plates are being measured in considerable detail by photometric methods. Preliminary results indicate that the brightness of the corona varies inversely as the fourth power of the distance from the centre of the sun.

General.—In addition to the above, astronomical work carried out by Mr. Thomsen with the 4 in. telescope included observations of Jupiter, Saturn, various star fields, and a region of the moon which has attracted attention as not yet having been adequately charted. Mr. Geddes did a small amount of comet-sweeping with the 5 in. telescope.

In astronomy, this Observatory has continued to co-operate with the New Zealand Astronomica Society, the Wellington Philosophical Society, and the Wellington City Observatory. During the last quarter of 1938, astronomical work in many parts of New Zealand was hindered by prevalent cloudy skies and high winds.

Seismology.

Seismic Activity in New Zealand during 1938.—Seismic activity in New Zealand during 1938 was notable chiefly for a series of rather severe earthquakes towards the close of the year. A total of 132 shocks was reported felt during 1938, 80 of which were felt in some part of the North Island and 60 in some part of the South Island. Eight shocks were felt in both Islands. Although the number of shocks felt was less than in 1937, the maximum intensity reported (R.-F. 8) was the highest since 1934. The activity in 1938 may be summarized as follows:—

(1) Occasional small shocks felt at Whakatane. These may be due to vulcanological activity on or near White Island, but no data are available from the island to confirm this.

(2) Periodic activity in Hawke's Bay region, with four prominent shocks during the year, two of which reached minor destructive intensity. The first shock occurred on January 18 (No. 4 on the map), and had an epicentre not far from that of the Pahiatua earthquake of 1934. The second shock occurred on June 14 (No. 19), and originated near the point where the most recent work has placed the origin of the Napier earthquake of 1931. It indicates that the block which moved in 1931 is still undergoing seismic strain. The shocks of December 15 and 30 (Nos. 47 and 60) originated close to the Mangatoro fault, along which traces of comparatively recent activity have been reported by the Geological Survey. These two shocks reached intensity R.-F. 8 in the epicentral region.

(3) A continuation of moderate activity in the Wanganui region, with a marked disturbance centring round November 23. Particulars of this disturbance are given in the list of the most important earthquakes in 1938 (see page 121). The active zone centred near Wanganui has extended as far north as Whangamomona and Ohakune, and south into the South Taranaki Bight. It is possible that the shocks in this region are due to magmatic movements. A magnetic survey might furnish some definite information on this point.

(4) A continuation of mild activity in north-west Nelson. About forty shocks were reported during the year, but none exceeded R.-F. 6, and most of them were very local.

(5) Two earthquakes, on October 31 and November 1 (Nos. 33 and 34), are noteworthy on account of their focal depth, which was of the order of 200 km. As is usual in deep-focus shocks, some interesting anomalies in surface intensity were recorded. The epicentres of both shocks were to the north-east of Taupo, and although the first and stronger one was felt generally in the eastern districts of the North Island and on both sides of Cook Strait, it was not reported felt at several places comparatively close to the epicentre, such as Taupo, Rotorua, and Tauranga. The second shock was reported felt only at Waipawa and Paraparaumu.

(6) After a long period of comparative quiet, the south-west portion of the South Island was shaken by a powerful disturbance on December 17, the maximum intensity reported being R.-F. 6–7 at Queenstown. The origin of this shock was deeper than normal, and an intensity R.-F. 6 was experienced in most parts of western Otago and Southland. It was followed by numerous aftershocks during the latter half of December, and some activity continued well into the following year. One hundred and seventy-five shocks were recorded on the Jaggar seismograph at Monowai up to the end of December, 1938. As the region is not adequately covered by seismographs, the epicentres of these earthquakes must be regarded as very approximate.

The accompanying map shows the distribution of earthquake activity in 1938. The sixty epicentres determined from seismograph records are shown as black circles, with a reference number. The accuracy of these epicentres varies, but most of them are probably correct within twenty miles, with the exception of the group near the south-west coast of the South Island. The approximate locations of seventy other shocks which were reported felt are shown as crosses.

Information regarding felt earthquakes is furnished by officers of the Post and Telegraph Department, officers of the Marine Department, and several private observers. There are about 120 non-instrumental reporting stations distributed throughout the Dominion.

The following is a monthly summary of earthquakes reported felt during 1938:—

Month, 1938.	Number of Earthquakes reported felt.				Maximum Intensity (R.-F.).	Locality of Maximum.
	North Island.	South Island.	Both Islands.	Whole of New Zealand.		
January ..	14	2	1	15	7+	Wairarapa.
February ..	3	4	0	7	5–6	Wanganui, Queenstown.
March	6	4	0	10	6	Kahurangi Point.
April	5	2	0	7	4	Taranaki, Hawke's Bay, Upper Takaka.
May	3	8	0	11	5	Taranaki, Upper Takaka.
June	10	5	0	15	7	Hawke's Bay.
July	2	4	1	5	5	Upper Takaka.
August	5	2	1	6	4–5	Wairoa.
September ..	7	3	0	10	5–6	Palmerston North.
October	9	3	2	10	6	Kahurangi Point.
November ..	10	4	1	13	6+	Hawera.
December ..	6	19	2	23	8	Southern Hawke's Bay and Northern Wairarapa.
Totals ..	80	60	8	132	8	

DISTRIBUTION OF EARTHQUAKE ACTIVITY IN 1938.

H. 34

SHOWING

- ● Epicentres determined (mostly correct within 20 miles).
- \+ Small shocks felt in localities indicated (Epicentres not determinable but unlikely to be more than 30 miles from position indicated).
- ▲ Seismograph Stations.

SCALE

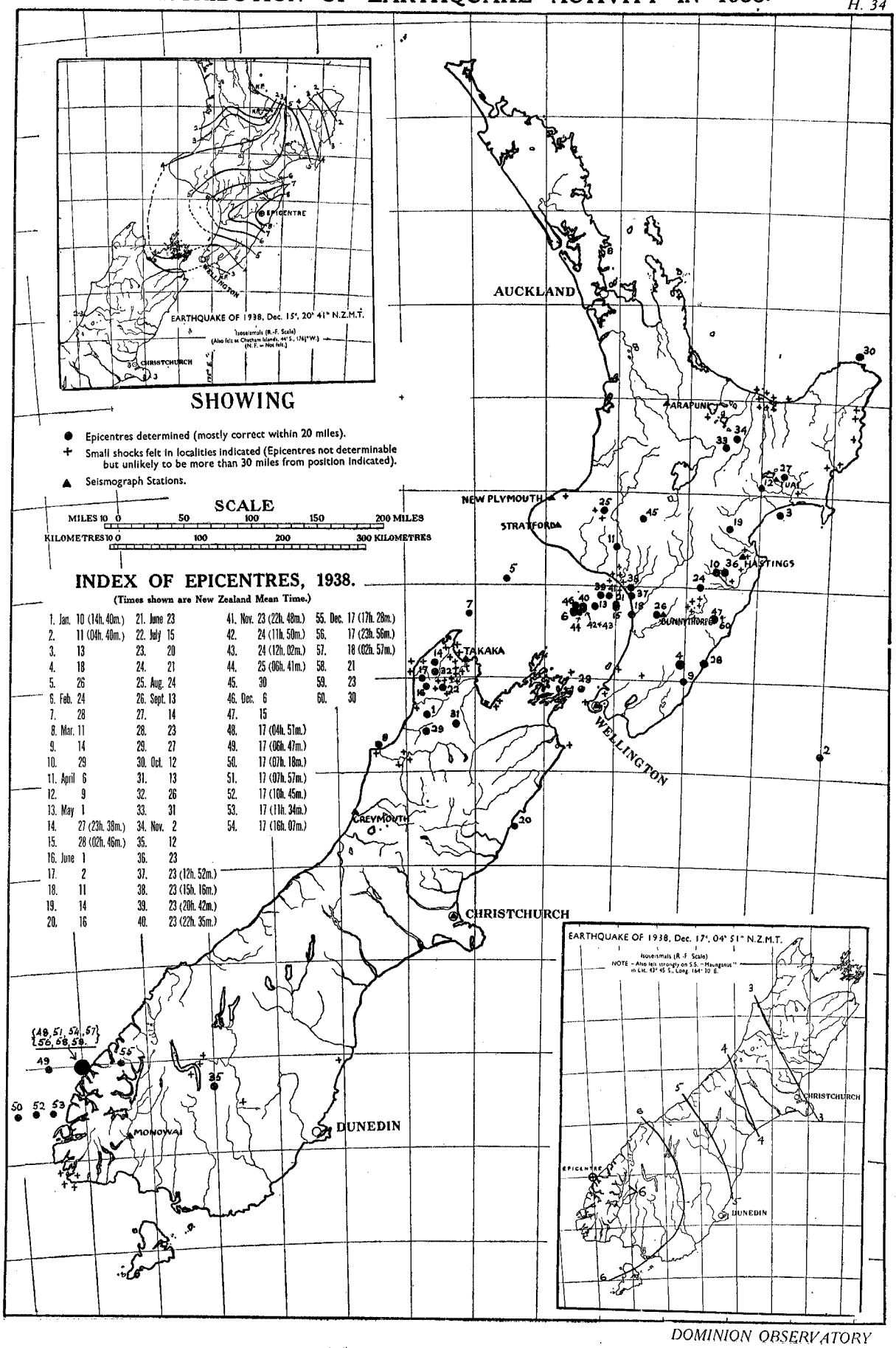
MILES 10 0 50 100 150 200 MILES

KILOMETRES 10 0 100 200 300 KILOMETRES

INDEX OF EPICENTRES, 1938.

(Times shown are New Zealand Mean Time.)

1.	Jan. 10 (14h. 40m.)	21.	June 23	41.	Nov. 23 (22h. 48m.)	55.	Dec. 17 (17h. 28m.)
2.	11 (04h. 40m.)	22.	July 15	42.	24 (11h. 50m.)	56.	17 (23h. 56m.)
3.	13	23.	20	43.	24 (12h. 02m.)	57.	18 (02h. 57m.)
4.	18	24.	21	44.	25 (06h. 41m.)	58.	21
5.	26	25.	Aug. 24	45.	30	59.	23
6.	Feb. 24	26.	Sept. 13	46.	Dec. 6	60.	30
7.	28	27.	14	47.	15		
8.	Mar. 11	28.	23	48.	17 (04h. 51m.)		
9.	14	29.	27	49.	17 (06h. 47m.)		
10.	29	30.	Oct. 12	50.	17 (07h. 18m.)		
11.	April 6	31.	13	51.	17 (07h. 57m.)		
12.	9	32.	26	52.	17 (10h. 45m.)		
13.	May 1	33.	31	53.	17 (11h. 34m.)		
14.	27 (23h. 39m.)	34.	Nov. 2	54.	17 (16h. 07m.)		
15.	28 (02h. 46m.)	35.	12				
16.	June 1	36.	23				
17.	2	37.	23 (12h. 52m.)				
18.	11	38.	23 (15h. 16m.)				
19.	14	39.	23 (20h. 42m.)				
20.	16	40.	23 (22h. 35m.)				



DOMINION OBSERVATORY

The following list gives some particulars of the most important New Zealand earthquakes in 1938 :—

New Zealand Mean Time.	Approximate Epicentre.		Maximum Intensity (R.-F.).	Remarks.
	Latitude.	Longitude.		
1938. d. h. m.	°	°		
January 18 14 14 ..	40·8S.	175·95E.	7+	Felt extensively in southern half of the North Island, with maximum in Wairarapa; also felt in Nelson and Marlborough.
February 24 05 59 ..	40·3S.	174·4E.	5	Felt in western districts of North Island south from New Plymouth, with maximum at Wanganui.
June 14 13 56 ..	39·4S.	176·6E.	7	Felt extensively in southern part of North Island, with maximum in Hawke's Bay.
August 6 05 01 ..	37·0S.	177·5E.	4–5	Felt in eastern and central parts of North Island and about Cook Strait. Focal depth greater than normal.
September 13 06 00 ..	40·3S.	175·6E.	5–6	Felt in southern parts of North Island, with maximum at Palmerston North.
October 26 03 10 ..	40·9S.	172·3E.	6	Felt in north-west portion of South Island, also feebly at New Plymouth.
31 00 16 ..	38·5S.	176·5E.	5	Felt extensively in North Island from Bay of Plenty southwards (chiefly in eastern districts), with maximum in Hawke's Bay. Also felt in northern part of South Island. Focal depth, 150–200 km.
November 23 12 52 ..	40·1S.	175·2E.	6+	Felt in western areas of North Island south from Awakino; slightly at Collingwood. Maximum in South Taranaki and about Wanganui. There were several after-shocks over a period of two days.
December 15 20 41 ..	40·3S.	176·4E.	8	Felt over whole of North Island except Auckland Peninsula, with maximum in southern Hawke's Bay. Also felt at isolated points in South Island as far south as Greymouth and Banks Peninsula, and at Chatham Islands (see inset map).
17 04 51 ..	45·0S.	167·0E.	6–7	Felt extensively in South Island as far north as Westport and Christchurch, with maximum in region of Milford Sound. Intensity 6 widely distributed in Otago and Southland. Deeper than normal (see inset map).
30 13 51 ..	40·3S.	176·4E.	8	Felt extensively in North Island, with maximum in southern Hawke's Bay and northern Wairarapa. Also felt at isolated points in northern part of South Island.

Seismograph Stations.—In addition to the Dominion Observatory, Wellington, and the Magnetic Observatory, Christchurch, eleven subsidiary seismograph stations have been maintained during 1938. Of these, seven are operated by officers of other Government Departments, two by officers of Electric-power Boards, and two by private individuals.

The following table gives the number of earthquakes recorded at the New Zealand seismograph stations for each month of the year 1938 :—

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.
Class I.													
New Plymouth ..	12	13	20	17	10	15	6	7	12	19	31	20	182
Wellington ..	32	24	37	31	20	32	47	25	27	21	34	55	385
Christchurch ..	9	7	13	6	17	8	12	5	9	10	9	94	199
Class II.													
Rotorua	0	0	0	0	0	0	0	0	0	0	0	0	0
Tuai	2	2	0	1	0	1	0	0	1	1	1	2	11
Stratford	0	1	0	0	0	1	0	0	0	0	1	0	3
Hastings	2	2	1	3	0	6	0	1	4	5	5	1	30
Bunnythorpe ..	2	0	0	0	0	2	0	1	1	1	1	2	10
Takaka	1	0	0	0	1	1	0	1	0	0	1	4	9
Greymouth	0	0	0	0	0	0	0	0	0	0	0	..	..
Monowai	0	0	0	1	0	0	0	0	0	0	1	175	177
Class III.													
Kaitaia	4	..	..	..	..	..	..	..	..	..	..	..	..
Arapuni	8	2	3	3	5	1	6	4	2	5	9	6	54
Wellington	30	21	14	15	22	24	21	19	12	25	41	28	272
Christchurch ..	29	14	8	14	28	16	27	18	20	36	49	26	285
Chatham Islands ..	4	2	3	3	6	3	5	1	4	1	4	3	39

In the above table, stations in Class I possess sensitive Wood-Anderson local seismographs; those in Class II, local strong-motion recorders, mostly of Jaggar type; and those in Class III, teleseismic instruments only. Wellington and Christchurch possess both local and teleseismic instruments, and hence these stations appear in both Classes I and III. The figures show that there has been an improvement in the continuity of records as compared with previous years. No earthquakes were recorded during the year at Rotorua and Greymouth. The Greymouth records, however, are incomplete for December, the seismograph being out of action when the severe shock occurred on December 17 near the south-west coast of the South Island. The aftershocks of this earthquake are responsible for the large number of local shocks recorded at Christchurch and Monowai in December.

After prolonged trials, the Milne-Shaw seismograph at Kaitaia had to be abandoned early in the year. Arrangements are being made for this seismograph to be established at Auckland early in 1939. Arrangements are also in hand for establishing a Wood-Anderson seismograph at Tuai in place of the Jaggar. In June a second Wood-Anderson seismometer was put into operation at the Dominion Observatory. The two seismometers have been arranged to record on the same drum.

Tiltometer.—The Ishimoto tiltometer in the Observatory cellar has continued to record the E.-W. component of tilt. The records show diurnal and seasonal variations of tilt, apparently controlled mainly by temperature and precipitation. No connection has yet been established between tilting and the occurrence of local earthquakes, or other geological movements.

Research Work.—Seismological research work carried out during the year includes—

(1) Completion of a preliminary analysis of the Observatory tilt records for the period 1930 to 1934 by Mr. R. C. Hayes, and the publication of a report on the results.
(2) Some preliminary work on the measurement of the vibrations of railway-trains in motion and of buildings in strong winds by Mr. C. Watson-Munro.
(3) Some further work on the study of local earthquakes by Mr. W. Jones.

Dr. K. E. Bullen, of Auckland University College, has continued working on New Zealand seismological problems, in close co-operation with the Observatory. Dr. L. Bastings, as Secretary of the Seismological Research Committee of the Australian and New Zealand Association for the Advancement of Science, has conferred with the Observatory from time to time in regard to the location of south-west Pacific earthquakes outside the New Zealand region.

Workshop.

Originally started as an adjunct to the Observatory, the workshop now carries out a considerable amount of work for other branches of the Department. In addition to the ordinary maintenance work, the only Observatory job completed during the year was the making of two Wood-Anderson seismometers. Work was commenced in August on the making of two seismograph recorders. Additional equipment was added to the workshop during the year, and a milling-machine has been ordered.

Owing to the large amount of work in hand, additional assistance had to be obtained. Improved accommodation is also urgently needed.

Publications.

The Observatory has continued to publish monthly seismological reports giving readings from all the New Zealand stations, a summary of non-instrumental earthquake reports, and epicentres in the South-west Pacific generally. Reports published during 1938 covered the period 1937 December to 1938 November, and consisted of bulletins E. 69 to E. 80. The following special bulletins were also published during 1938:—

Bulletin 122.—The Pahiatua Earthquake of 1934, March 5. (R. C. Hayes.)
Bulletin 128.—Earthquakes in New Zealand (1936). From "Official Year-Book," 1938.
Bulletin 129.—Some Seismological Aspects of the Buller Earthquake—Parts V and VI. (L. Bastings.)
Bulletin 130.—Mean-time and Time Service. From "Official Year-Book," 1938.
Bulletin 131.—The Phase S* in New Zealand Earthquakes. (K. E. Bullen.)
Bulletin 132.—An Analysis of the Hawke's Bay Earthquakes during February, 1931. (K. E. Bullen.)
Bulletin 133.—Tilting of the Ground at Kelburn, Wellington. (R. C. Hayes.)
Bulletin 134.—Tables for Reduction of Apparent Travel-times of the Seismic Pulses PKP, PKP_2, SKS. (K. E. Bullen.)
Bulletin 135.—Report on the Dominion Observatory for the Year 1937.
Bulletin 136.—The Wairoa Earthquake of 1932, September 15. (K. E. Bullen.)
Bulletin 137.—On the Epicentre of the 1934 Pahiatua Earthquake. (K. E. Bullen.)

An article on "Earthquakes in New Zealand" was revised for the "New Zealand Official Year-Book," 1939, and revised articles on the time service were prepared for the "Year-Book" and the "New Zealand Nautical Almanac."

APIA OBSERVATORY, SAMOA.

Acting-Director: H. B. Sapsford.

The usual programme of work in geophysical subjects was continued during the year 1938–39 at the Apia Observatory. The principal subjects of study were terrestrial magnetism, seismology, meteorology and atmospheric electricity.

Terrestrial Magnetism.

Absolute observations of horizontal intensity, declination, and the angle of dip were made, using magnetometer No. 9 C.I.W. (on loan through the courtesy of the Carnegie Institution of Washington) and the Schulze earth inductor No. 2. The variations in horizontal intensity, declination, and vertical intensity were recorded continuously by photographic registration. The instruments used in this connection were Eschenhagen variometers for declination and horizontal intensity and a Godhavn balance for vertical intensity.

Seismology.

The Wiechert horizontal seismograph (mass 1,000 kilograms) and the Wiechert vertical seismograph (mass 80 kilograms) gave satisfactory service during the year. Nearly all the major earthquakes which were reported from other stations were recorded at Apia. In particular, good traces were obtained of the shock near Alaska (10th November, 1938) and of those in Chile (25th January, 1939) and the Solomon Islands (30th January, 1939). The instruments are not designed to record strong local shocks, and when these occur the pens are usually thrown off. A local shock-recorder would be very useful for the study of near earthquakes in this region.

Meteorology.

Surface observations of the meteorological elements were made three times a day, and frequent measurements of the upper winds were taken by means of pilot balloons. Regular daily pilot balloon ascents were commenced in July, 1938. Two synoptic charts of the weather in the South West Pacific Region were plotted every day, and collective broadcasts of weather reports were issued. During the hurricane season local reports were posted in Apia, and the Observatory frequently supplied forecasts and information, at all hours of the day and night, to various people. Several of the resolutions whuch were passed at the Meteorological Conference in Wellington in 1937 have been put into effect.

Meteorological Summary, Apia, 1938.

Month.	Pressure.	Temperature.	Rainfall.	Humidity. (9 a.m.)	Sunshine.	Wind.
	In.	°F.	In.	Per Cent.	Hours.	Miles per Hour
January ..	29·737	80·2	20·64	79	210·7	5·7
February ..	29·760	79·3	13·35	80	142·0	5·3
March	29·815	79·2	10·80	76	185·9	6·0
April	29·819	79·1	6·57	80	202·5*	4·1
May	29·836	78·5	8·79	79	210·5	6·4
June	29·872	79·0	3·73	79	236·3	7·0
July	29·890	79·8	5·86	76	290·8	9·7
August	29·891	78·7	5·26	79	254·7	9·8
September ..	29·896	79·0	2·13	72	297·6	8·3
October ..	29·899	79·0	8·04	73	288·8	6·4
November ..	29·765	77·9	33·35	84	99·4	5·9
December ..	29·791	79·6	20·94	80	237·5	7·9
Total ..	..	..	136·46	..	2,656·7	..
Mean ..	29·831	79·1	..	78	..	6·9

* One day missing.

Atmospheric Electricity.

The measurement of potential gradient, using a Benndorf electrometer, was continued, as in former years, under the guidance of the Carnegie Institution of Washington, which provides a grant-in-aid for this purpose. The reduction factor was checked from time to time by absolute observations on the sandflats to the south of the Observatory.

The mean values of the potential gradient at Apia during 1938, expressed in volts per metre, are as follows: January, 128; February, — (no days of character, 0); March, 123; April, 118; May, 103; June, 132; July, 140; August, 139; September, 111; October, 102; November, 102; December, 138. These figures refer to days during which no negative potential occurred.

Time Service.

The "Synchronome" clock, which provides the time marks for the seismographs and magnetographs, was controlled by comparisons with the standard clock, Strasser and Rohde No. 381. The latter was checked regularly by wireless time signals from Honolulu, San Francisco, and Saigon.

Tides.

The tide-gauge at the Lagoon House remained in operation until November, 1938, when the clock became erratic. It was sent to America for repairs, and has not been returned yet.

Buildings.

A new building, including a workshop, balloon room, and two other small rooms, was completed in February, 1939.

Staff.

The Director, Mr. J. Wadsworth, resigned on 9th June, 1939, and Mr. H. B. Sapsford was appointed as Acting-Director.

MAGNETIC OBSERVATORY, CHRISTCHURCH.

Director: H. F. Skey.

SUMMARY OF OPERATIONS FOR THE YEAR ENDED 31st MARCH, 1939.

During the year the usual magnetic, seismological, and meteorological observations have been made.

Terrestrial Magnetism.

The Eschenhagen magnetographs at Amberley Substation and the Adie and high-speed La Cour magnetographs have been kept recording continuously. From twice monthly absolute observations and hourly measurements of the magnetograms, the mean hourly values of D, H, and Z have been computed and tabulated. The mean monthly values of the magnetic elements obtained from the mean hourly values for all days of 1938 are :—

1938.	D.	H.	Z.	ϕ
	° ′			° ′
January	18 16·6	22262γ	−55202γ	−68 02·2
February	18 17·6	22267	55209	68 02·1
March	18 17·1	22264	55191	68 01·9
April	18 18·2	22256	55202	68 02·5
May	18 18·5	22252	55209	68 02·9
June	18 17·9	22269	55199	68 01·8
July	18 19·2	22263	55202	68 02·2
August	18 19·9	22266	55199	68 01·9
September	18 19·6	22261	55195	68 02·1
October..	18 19·8	22258	55202	68 02·4
November	18 20·3	22270	55182	68 01·3
December	18 20·8	22272	55179	68 01·2
Year	18 18·8	22263·3γ	−55197·6γ	−68 02·3
Δ from 1937	+4·7	−19·4	+9·4 (numerical decrease)	−0·83 (numerical increase)
	Y.	X.	T.	G.
Year	06984·1γ	21135·8γ	59518·3γ	0·3546 cgs.
Δ from 1937	+11·6γ	−28·0γ	−16·0γ	

The rate of change of the mean value for the year, or secular change, in D, H, and Inclination is again slightly larger than for the previous year, but in Z, Y, and T the rate of change is slightly less.

The magnetic constant G for 1938 (Amberley) has the value 0·3546. For 1937 the value was 0·3547, and for 1936, 0·3549, a very slight diminution being indicated.

The magnetic tabulations for 1938 also include the hourly H disturbance character figures, assigned hourly from value 0 (calm) to value 8 (highly disturbed). The results for the year fully confirm the minimum of disturbance at 10 h. a.m. (N.Z. summer time) and the maximum at 16 h. to 18 h.; also it is found that figures for individual months confirm this. The indications are that while the actual time of minimum has no seasonal variation, there is in winter a tendency clearly shown for the subsequent rapid increase of disturbance (which continues up to 16 h. in summer) to rapidly diminish shortly after noon, and for the maximum to be more extended throughout the afternoon. In 1938 there is a small peak of disturbance at 21 h. shown alike in the four summer months, the four equinoctial months, and the winter months, tending to be more pronounced in winter. The average diurnal range of the H disturbance figure is 50 per cent. larger in the summer months of this year than in the winter months.

These figures (for ~ H hourly) really are relative estimates of the *power* of the H disturbance, or range × frequency, which has to run down, either in the higher atmosphere or the earth itself. They are approximately I.C.F. × 4 in value.

A number of copies of magnetograms of disturbed days were made in response to requests from local and overseas investigators.

Electric Potential Gradient.

From the Bendorf Electrometer registrations at Christchurch the mean hourly values of the potential gradient have been tabulated and the diurnal variation obtained shows clearly that the two maxima of the variation approach each other as winter comes on. For 1938 also the mean monthly values show a higher potential gradient during winter.

Seismological.

The teleseismic Galitzin seismographs have recorded satisfactorily throughout the year, while the single component Wood-Anderson seismometer has also continued to record near shocks of suitable sizes. Research into the apparent relationship between microseisms and local air pressure oscillations with the same period is being continued.

Cosmic Ray Meter.

Cosmic Ray Meter No. 5 has been operated continuously, and the records obtained therefrom measured and kept up to date. Reduced measurements have been forwarded periodically to the Carnegie Institute of Washington, where they are being collated with the results obtained from similar meters operating at other Observatories.

From the measurements made at five of these stations evidence has been obtained already by Forbush that, except for the twelve-month waves, the major changes in cosmic ray intensity are world wide. The Christchurch results, when taken in conjunction with those from Cheltenham (United States), indicate that the variation with latitude of the world wide effect is probably symmetrical about the equator.

Investigations commenced last year in connection with the "magnetic storm effect" and also the seasonal variation of the cosmic radiation are being continued.

In November, 1937, the ionization chamber was returned to Chicago, in order that the gas leak, which has persisted since the meter was installed, could be repaired. Recording was continued with a chamber of the same type which had shown no indication of leakage during the last two years.

MISCELLANEOUS INVESTIGATIONS.

PUMICE IN CONCRETE AND SPECIAL CEMENTS.

Experimental work with New Zealand pumice as the aggregate in Portland-cement concretes and with pozzolanic and other natural materials as admixtures with the cement has been continued at intervals during the year along the lines initially laid down by the special Advisory Committee, the personnel of which remains as was given in the Department's report for 1937–38. [As it has been possible to give only a relatively small amount of attention to this work, the progress made during the period under review has not been great, and should not be taken as a measure of the relative importance of this developmental work.]

During the year several mixtures of pumice concrete cast into specially prepared specimens 14 in. by 6 in. by 2 in. have been closely studied under controlled conditions of temperature and humidity, while their comparative linear movements have been observed to the nearest $\frac{1}{10,000}$ of an inch. It would appear from the results that while maturing in air at constant temperature and humidity, an irregular expansion of the specimens takes place during the first few days, and this is followed by a contraction at a gradually diminishing rate. A later immersion in water of the dry mature specimens until their re-expansion practically ceased, followed by storage for approximately ninety days in a controlled atmosphere to dry out for a second time, effected a relatively considerable reduction in the total contraction of the respective specimens as compared with that for the initial curing-period. Another wetting and drying of these small test slabs is in progress to determine whether or not the overall contraction by repeating such treatment will be further reduced in a similar manner.

In order to investigate the effect of a change in humidity, the specimens were preconditioned in an atmosphere of 35 per cent. relative humidity, which was then increased quickly to approximately 100 per cent. humidity while the temperature of the atmosphere was held constant. It was found that during the succeeding three days the expansion of the specimens (due to the extra moisture) was very small and is not likely to be of any real concern to those engaged in building design or construction.

During the year approximately one hundred standard specimens (6 in. diameter by 12 in. high) of various mixtures with pumice as the aggregate were tested "at twenty-eight days" for compression strength; similarly, two hundred specimens (1 square inch cross-section) from the same respective mixtures of the concretes were tested for tensile strength. However, since this work was almost wholly of an exploratory nature, particularly with regard to the water content for good workability of the pumice aggregate and to the desirable amplitude of vibration, the actual figures obtained can be accepted only temporarily as a guide for future experiments with pumice concretes.

STRENGTH OF FIBROUS BOARDS.

By C. N. Watson-Munro.

In response to requests by the Housing Department and the Public Works Department, experiments were made to determine the relative flexural strengths of various types of fibrous boards on the New Zealand market.

The method used was that adopted by the United States Bureau of Standards, in which a specimen 14 in. by 3 in. is supported flatwise on two parallel iron pipes placed 12 in. apart and a load applied at midspan through a third pipe parallel to the other two. The depression of the midspan of the specimen was recorded as the load was increased in successive stages to rupturing load. From considerations of the stress-strain diagram it was possible to compute the flexural strength, elastic limit, and modulus of elasticity of the fibrous boards.

The following average results were obtained :—

Type of Board.	Thickness (In.).	Flexural Strength (lb.).	Elastic Limit (lb.).	Elasticity (lb/inches × 10^6).
Soft wallboards (insulating boards)	0·46	11	8	0·032
Hard wallboards	0·18	18	11	0·45
Asbestos sheet material	0·15	15	10	2·05
Plaster boards	0·35	14	9	0·38

Fuller details are to be published in the *New Zealand Journal of Science and Technology*.

MAGNETIC SURVEYS IN NORTH AUCKLAND.

By W. M. Jones, Dominion Observatory.

Six weeks were spent in the Dargaville-Kirikopuni district, and three in the Silverdale-Warkworth district, in examining the variations of vertical magnetic intensity associated with the basic and ultra-basic rocks of these areas. The results are summarized as follows:—

(*a*) The magnetic disturbance extending for twenty miles from Pahi to Pukehuia, mapped by McNeill (Geol. Survey Memoir No. 4) continues to the dolerites of Maungaru, and there can be little doubt that it represents the continuation below the surface of the Maungaru-Tangihua doleritic body.

(*b*) Parallel to the axis of this disturbance a belt of low intensity follows the valley of the Wairoa River from Dargaville to Repia, but the values increase again by about 150 gammas between this line and the western coast.

(*c*) In the vicinity of Kirikopuni the extensions below the Onerahi sediments of two exposures of dolerite were readily traceable by the magnetic effects. The ranges found over exposed rock were from −1,200 to +2,000 gammas (expressed as anomalies on a base at Mangawhare), and over the buried portions up to 1,200 gammas. Turiwhiri Hill, also of dolerite, a mile east of Dargaville, gave similar effects, and a disturbance of 800 gammas on the river-flat alongside the Arapohue Road to the south-west, with some fragments of dolerite on the surface, may represent an extension of this dolerite body, although the possibility of a large slip must also be considered.

(*d*) At the summit of the sharp peak of Tokatoka (hornblende andesite), a range from −1,200 to +3,750 gammas was encountered over only 10 yards, and variations of 8 degrees in declination were also measured.

(*e*) Ten of the small outcrops of serpentinite intruding into the Onerahi sediments in the Silverdale-Warkworth district were examined, and in all cases vertical anomalies of the order of 1,000 gammas were found. The variations were usually very rapid at the actual exposure, but faded away within a chain or two, the indication being that the lateral dimensions of the outcropping bodies are small, and that the bodies are pipes or narrow bosses which have penetrated the sediments for some considerable distance from the parent body. That this body is not very near the surface over much of the district is indicated also by a reconnaissance along the roads. The contrast also of the ranges encountered with those found in the Upper Takaka and D'Urville Island serpentinites (10,000 to 20,000 gammas), is consistent with a greater depth of the main body.

(*f*) The quartz-porphyrite quarried on the road between Parakakau and Makarau showed rather greater magnetic effects, with a range of −750 to 2,400 gammas. An areal anomaly of up to 300 gammas to the east of Kaukapakapa may represent a southerly continuation of this rock.

(*g*) A few measurements around the crater of Mount Eden, Auckland, showed positive anomalies of 1,500 to 3,850 gammas, and indicate that at a sufficient distance from the disturbing effects of the town area magnetic survey could help in the tracing of the underground extensions of the Auckland basalts.

(*h*) The Albany conglomerates near Cut Hill, north of Takapuna, appear to give variations of about 30 gammas, superposed on an areal anomaly of some 250 gammas, but more detailed work is desirable to be sure that these variations are not merely fluctuations in the areal anomaly, in view of the proximity of the Takapuna basalts.

Practical Applications.

The tracing of the basic igneous rocks of North Auckland by magnetic survey has a number of possible practical applications. General and local structural features so disclosed have an evident bearing on the search for oil in the district. Convenient supplies of road-metal may be indicated. Some consideration is now being given to the use of the serpentinites in conjunction with fertilizers, and it will be useful to be able to state whether a visible outcrop represents an extensive body of accessible material. The relations of the Ngawha basalts to the cinnabar deposition have been already discussed by the writer in the *New Zealand Journal of Science and Technology* (1939, V. 20, No. 5B). Finally, the function of igneous rocks, lava-flows, or dykes as collecting-grounds for water is of some importance, especially for small-scale farm-supplies. The problem is to locate an underground configuration of the igneous rock which can give the required catchment, and at the same time be within reasonable boring range. In particular cases a combination of electrical or seismic methods with magnetic survey might be worth while.

MAGNETIC WORK IN CENTRAL NORTH ISLAND.

By C. N. Watson-Munro.

A continuation of the magnetic work in the thermal and volcanic regions was made by extending the observations southwards to include central North Island and Hawke's Bay. The actual measurements were made with one of the vertical variometers, and the observations were connected with the Magnetic Observatory bases at Taupo, Eketahuna, and Woodville. Although the magnetic map is still very incomplete, it is interesting to note that values of vertical intensity several hundred gammas above normal persist across the sheet rhyolitic material from Taupo along the Taupo–Napier Road to past Rangitaiki. This regional anomaly cannot be completely explained from the magnetic properties of rhyolite and is probably associated with an underlying rock of magnetic properties, such as a dacite, andesite, or basalt. Before a definite conclusion can be reached, however, reconnaissance observations require to be extended over a much wider area.

RADIOACTIVITY INVESTIGATIONS.

By Dr. E. Marsden and C. N. Watson-Munro.

(1) Natural Radioactivity of New Zealand Rocks and Soils.

At a conference of the Imperial Animal Nutrition Bureau in Britain in September, 1936, suggestions were put forward, based on German and Italian experiments, that conditions relating to the regional incidence of goitre were not wholly determined by the iodine contained in soil and water, but that a part might be played by the radioactive emanation arising from the regional soils, high radioactivity being presumed to have a positive influence on goitre incidence.

In connection with this problem, an extensive examination of the radioactivity of New Zealand rocks and soils has been made, from which it has been found that the activities are in general dependent upon the lithologic type. For example, the average alpha-ray activities in ionization currents in amperes x 10^{-18}/cm^2 for six types of rock were as follows :—

Basalts	4·5	Granites	20
Andesites	8·5	Greywackes	22
Rhyolites	6·5	Limestones	5

A complete account of this investigation will be published shortly in the *New Zealand Journal of Science and Technology*.

(2) Artificial Radioactivity.

Since the discovery of artificial radioactivity in 1934, artificially radioactive elements (notably phosphorus, iodine, and sodium) have been successfully applied to the solution of certain biochemical problems. This method of attack offers unique advantages over the ordinary chemical procedure, as it is possible not only to determine to what part of the plant or animal the added radioactive element goes, irrespective of the amount of the same element already present, but in addition very small amounts may be measured accurately.

Thanks to the generosity of Dr. Seaborg and Dr. Livingood, of the University of California, small supplies of radioactive manganese and radioactive cobalt, prepared by the bombardment of iron by deuterons in a cyclotron, were made available to this Department. A special gamma-ray ionization vessel has been constructed, with which it has been possible to measure down to an accuracy of 10^{-9} gm. of cobalt and 10^{-8} gm. of manganese. It is intended to apply the former to the problem of the role played by cobalt in the maintenance of animal health, and the latter in connection with manganese deficiency in citrus fruit.

RESEARCH SCHOLARSHIP.

A National Research Scholarship was awarded to Mr. W. R. Geddes, of the University of Otago, for a research on "Accident Causation, with Special Reference to Illumination." The object of this research is the accurate determination of certain fundamental visual conditions of motor-driving, with a view to providing information which will assist the efforts being made to eliminate traffic accidents.

IMPERIAL AGRICULTURAL BUREAUX.

The Imperial Agricultural Bureaux were established to act as clearing-houses for the interchange of information between research workers in various fields of agricultural science throughout the world, but more particularly within the various countries of the British Commonwealth. During the past year two further Bureaux have been established, one for dairy science at Shinfield, Reading, in association with the National Institute for Research in Dairying, the other for forestry at Oxford in association with the Imperial Forestry Institute. Mr. W. G. Sutton, formerly of the staff of Massey Agricultural College, has been appointed Deputy Director of the Imperial Bureau of Dairy Science.

In New Zealand co-operation with the Bureaux is maintained through the Department of Scientific and Industrial Research, for which purpose there is a special liaison officer. In addition, contacts with individual Bureaux and the appropriate fields of research one maintained by official correspondents who deal with specific inquiries. During the latter part of the year there was arranged a meeting of official correspondents to discuss and clarify their functions. This was the first occasion on which official correspondents had met and was made particularly valuable through the presence of Mr. Nevill Wright, Scientific Liaison Officer of the Department in London, who had been Chairman of the Executive Council of the Imperial Agricultural Bureaux during the previous two years. The following is the list of Bureaux and the official correspondents in New Zealand :—

Bureau.	Official Correspondent.
1. Soil Science	Dr. L. I. Grange, Director, Soil Survey Division, Department of Scientific and Industrial Research.
2. Animal Health	Dr. C. S. M. Hopkirk, Officer in Charge, Veterinary Laboratory, Department of Agriculture, Wallaceville.
3. Animal Nutrition	Dr. I. J. Cunningham, Veterinary Laboratory, Department of Agriculture, Wallaceville.
4. Plant Breeding and Genetics ..	Dr. F. W. Hilgendorf, Wheat Research Institute, Christchurch.
5. Pastures and Forage Crops	Mr. E. B. Levy, Director, Grassland Division, Palmerston North.
6. Horticulture and Plantation Crops ..	Mr. W. K. Dallas, Director, Horticulture Division, Department of Agriculture, Wellington.
7. Animal Breeding and Genetics ..	Dr. F. W. Dry, Massey Agricultural College, Palmerston North.
8. Agricultural Parasitology	Dr. C. S. M. Hopkirk, Officer in Charge, Veterinary Laboratory, Department of Agriculture, Wallaceville, and Dr. D. Miller, Division of Entomology, Plant Research Bureau, Cawthron Institute, Nelson (Joint Correspondents).
9. Forestry	(To be appointed.)
10. Dairy Science	Dr. H. Whitehead, Dairy Research Institute, Palmersto
New Zealand Liaison Officer for Imperial Agriculture Bureaux.	Mr. M. M. Cooper, Department of Scientific and Industrial Research, Wellington.

PUBLICATIONS.

The monthly publication of the *New Zealand Journal of Science and Technology* has been continued during the year. Since last June, commencing with Vol. 20, the alternate numbers have been devoted to two different classes of papers. Section A of the *Journal* is composed entirely of agricultural science articles, and this fulfils a need for a special agricultural science publication which arose through the changed character of the *New Zealand Journal of Agriculture*. Section B deals with a variety of subjects, including chemistry, physics, geology, seismology, economics, and industrial technology.

There has been a big increase in the number of departmental bulletins issued, and there are a number more in the course of publication. The following is the full list of publications issued during the year :—

No. 61 : " The Soils and Agriculture of Western Samoa," by W. M. Hamilton and L. I. Grange.
No. 62 : " Land Deterioration in the Heavier Rainfall Districts of New Zealand," by N. H. Taylor.
No. 63 : " Report on the Organization of Animal Research in New Zealand," by J. Hammond.
No. 64 : " Genetics and Live-stock Production," by F. W. Dry.
No. 65 : " A Soil Survey of Duvauchelles Bay - Wainui District, Banks Peninsula," by C. S. Harris and A. C. Harris.
No. 66 : " A Survey of Tung Groves in New Zealand," by M. M. Burns and N. H. Taylor.
No. 67 : " A List of Plant Diseases in New Zealand," by R. M. Brien.
No. 68 : " Fifth Annual Report of the Wheat Research Institute."
No. 69 : " Scientific and Industrial Research, 1927–38."
No. 70 : " Land Utilization of the Heretaunga Plains."
No. 71 : " Soil Survey of the Westport District," by C. S. Harris and A. C. Harris.
No. 72 : " Soil Survey of Wairau Plain, Marlborough," by C. S. Harris and K. S. Birrell.
No. 73 : " Survey of the Tussock-grasslands of the South Island of New Zealand," by V. D. Zotov.

Of the above bulletins, No. 69 is of particular interest in that it is a record of the Department's activities since its inception in 1927. No. 70 is the first of a series of bulletins dealing with a comprehensive land-utilization survey of the Hawke's Bay Province. Bulletin 63 gives the full text of Dr. John Hammond's report on the reorganization of animal research, drawn up at the conclusion of his visit to New Zealand in January and February, 1938.

Among the bulletins in an advanced state of publication at the end of the year were No. 75, presenting the results of a standard of life survey among dairy-farmers, No. 76 describing the soils and agriculture of Waipa County, and No. 77, which was the report of a special committee set up to inquire into the preservation of vegetative cover with reference to soil erosion.

STAFF.

The following is a list of the administrative and professional officers of the Department as at 31st March, 1939 :—

Head Office, Wellington.

Secretary : E. Marsden, C.B.E., D.Sc., F.R.S.N.Z.
Assistant Secretary : F. J. A. Brogan, M.Sc., A.I.C.
Fruit Research Officer : L. W. Tiller, B.Sc.
Chief Clerk and Accountant : R. D. McGillivray, A.R.A.N.Z.
Assistant Professional Officer : M. McG. Cooper, B.Agr.Sc., B.Litt., Dip. Rur. Econ.
Physicist : E. R. Cooper, M.Sc., Ph.D.
Wool Metrologist : P. R. McMahon, Ph.D., M.Agr.Sc.*

New Zealand House, London.

Scientific Liaison Officer : N. L. Wright, F.I.C., D.I.C.
Assistant Scientific Liaison Officer : W. M. Hamilton, M.Agr.Sc., Dip.Hort.

Plant Research Bureau. (Headquarters : Wellington.)

Chief Executive Officer : F. R. Callaghan, M.A., F.R.E.S.

Plant Diseases Division (Auckland).

Director : G. H. Cunningham, Ph.D., D.Sc., F.R.S.N.Z.
Chief Mycologist : J. O. C. Neill, B.Sc., A.O.S.M.
Plant Pathologist : J. G. Gibbs, M.Agr.Sc., Ph.D.
Agricultural Bacteriologist : W. D. Reid, B.Sc.
Entomologist : W. Cottier, M.Sc.
Assistant Entomologist : D. Spiller, B.Sc.
Mycologist : E. E. Chamberlain, M.Sc.
Assistant Mycologists—
R. R. M. Brien, Dip.Agr. (Lincoln).
G. G. Taylor, M.Agr.Sc.
G. T. S. Bayliss, Ph.D., M.Sc., D.I.C.
K. M. Harrow, M.Agr.Sc.
Plant Physiologist : J. D. Atkinson, M.Agr.Sc.
Pomologist : C. E. Woodhead.
Assistant Pomologist : H. M. Mouatt, B.Sc.

Grasslands Division (Palmerston North).

Director : E. B. Levy, B.Sc.
Agrostologists—
E. A. Madden, H.D.A.
L. W. Gorman, M.Agr.Sc., C.A.C.Dip.
Plant Breeder : L. Corkill, B.Sc., M.Agr.Sc.
Assistant Plant Breeder : H. F. Rhodes-Robinson, B.Sc.
Assistant Agrostologists—
J. P. Lambert, B.Agr.Sc. (stationed at Lincoln).
J. Wishart, B.Agr.Sc.
G. S. Harris, B.Sc.
P. D. Sears, B.Com.
R. E. Rose, B.Agr.Sc.
F. B. Sill, B.Agr.Sc.
W. G. Thurston, B.Agr.Sc.
F. E. T. Suckling.

Entomology Division (Nelson).

Director : D. Miller, M.A., Ph.D., F.E.S., F.R.S.N.Z.
Associate Director : J. Muggeridge, B.Sc.
Assistant Entomologists—
L. J. Dumbleton, B.For.Sc.
B. B. Given, B.Sc.
Miss A. Hamilton, M.Sc.
R. D. Dick, M.Sc.

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* Seconded to Massey Agricultural College, Palmerston North.

Agronomy Division (Christchurch).

Director : J. W. Hadfield, H.D.A.
Plant Geneticist : R. A. Calder, B.Agr.Sc., B.Sc.
Assistant Agronomist : R. Thomson, H.D.A.
Crop Ecologist and Plant Introduction Officer : M. A. Black, Dip.Agr. (Cambr.), M.A.
Plant Breeder : C. M. Driver, M.Agr.Sc.
Research Officer : K. Cottier, B.Agr.Sc.

Botany Section (Wellington).

Botanist : H. H. Allan, M.A., D.Sc., F.L.S., F.R.S.N.Z.
Assistant Botanists—
A. L. Poole, B.For.Sc.
D. Cairns, M.Sc.
Miss L. B. Moore, M.Sc.
V. D. Zotov.
Miss R. Mason, B.A., M.Sc.

PLANT CHEMISTRY LABORATORY (PALMERSTON NORTH).

Plant Biochemist : J. Melville, Ph.D.
Plant Chemist : B. W. Doak, M.Sc.
Chemist : I. Reifer, D.Sc.
Assistant Chemist : N. O. Bathurst, M.Sc.

DAIRY RESEARCH INSTITUTE (PALMERSTON NORTH).

Director : Prof. W. Riddet, B.Sc., N.D.A., N.D.D.
Bacteriologist : H. R. Whitehead, D.Sc., A.I.C.
Chemists—
E. H. McDowall, D.Sc., A.I.C.
C. R. Barnicoat, Ph.D., M.Sc., F.I.C.
Assistant Chemists—
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* Seconded to Cawthron Institute, Nelson.

Approximate Cost of Paper.—Preparation, not given; printing (1,000 copies, including graphs and maps), £180.

By Authority: E. V. PAUL, Government Printer, Wellington.—1939.

Price 2s. 9d.]