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JUNE, 1952

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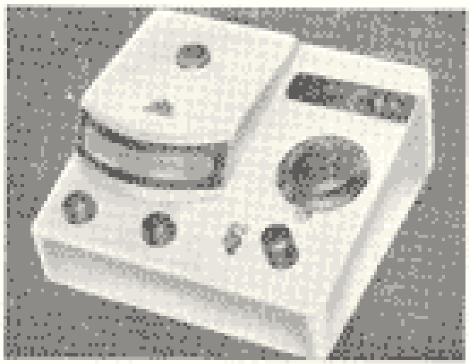

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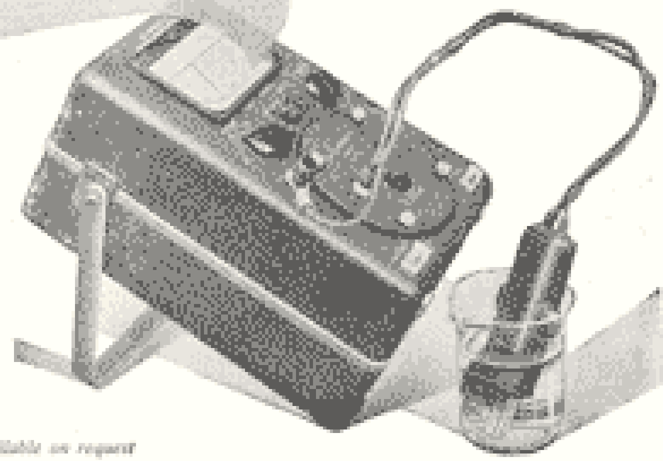

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NEW ZEALAND Science REVIEW

Volume 10 Number 6

JUNE, 1952

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N.Z.A.Sc.W. NOTES

SPECIALIZATION

This issue publishes a report of the first conference of the N.Z. Ecological Society; in the next will be reported the first conference of the Entomological Society of N.Z. Both bodies were inaugurated last year and their formation followed Closely on that of other specialist societies

These smaller, more closely-knit groups reflect the increased intensity and maturity of science in New Zealand and their development involves both the advantages and disadvantages of specialization. However, it is encouraging to note that the organizers of the various societies are obviously aware of the dangers of too confined an interest, and have endeavored to see that as many points of view as possible are brought to bear on the common subject. Thus, in the first symposium in this issue, speakers were drawn from the fields of biometry, botany, zoology, and marine biology. This coordination of interests is one of the most valuable functions such bodies can perform and the conference method is one of the most immediate means of stimulating interest and development in the various fields. Most scientific workers know this and have gained greatly from participation in past congresses. For that reason they will view with considerable misgivings any attempt to prevent attendance at such meetings for reason of financial expediency.

LABORATORY WORKERS AND UNIONS

At a hearing before the Industrial Conciliation Commissioner on May 7 of an application by the Grocers' Sundries (General) Union for a new award, the Union asked to have laboratory workers included in the award. The Clerk to the Com. missioner confirmed that the rules of the Union would not allow of the addition of laboratory workers unless the Union first obtained a statement from a number of laboratory workers that they wished to join the Union. During consideration of the work done by qualified and unqualified laboratory workers, it was submitted by the Employers' Assessors that the nature of the work done by different laboratory workers and the value of overseas diplomas and degrees could not be competently assessed without consultation with the New Zealand Association of Scientific Workers.

An interesting statement on the same matter is contained in the report of a lecture by Richard L. Kenyon (*J. Roy. Inst. Chem* (1952), 76, 55). The insistence of the (American Chemical) Society that technical men should not be included in heterogeneous labour unions was fought successfully through legal channels, and the decision formed a precedent for subsequent court decisions.

CHANGE OF SECRETARY

At a recent meeting of Council, N.Z.A.Sc.W., a resignation was received with regret from R. M. Cassie who has been hon. secretary of the Association for the last two years. Council expressed appreciation of the work Mr. Cassie had done in that time and hoped that the condition of his health which had led to his action would rapidly improve.

To fill the vacancy, P. C. Coates was appointed. Mr. Coates has served on Council for the last two years, this year as Canterbury Branch dele gate. He is Director of the Launderers, Drycleaners and Dyers Research Institute of New Zealand, Wellington, phone 49-280/837.

WELLINGTON BRANCH A.G.M.

The 1952 annual general meeting of the Wellington Branch, N.Z. A.Sc.W., has been fixed for August 20, at 7.30 p.m., in the English Speaking Union rooms, Nathan's' Building, Grey Street, Wellington, C.1. Members of other branches who will be in Wellington at that time are cordially invited to attend.

CUSTOMS DUTY AND SALES TAX

In the article on the above subject in the April issue (p. 52) reference was made to the application of the British preferential tariff which, it was stated, "can amount to a substantial saving, not only in customs duty, but also in sales tax and importers' margins, both of which are based upon the landed cost into store."

One of the leading importers of scientific equipment has drawn our attention to the fact that, on practically all *indent* orders, their margin is the discount allowed to them for resale by the supplying house and is therefore not affected by the amount of customs duty or sales tax paid on the particular goods. However, it is not certain that this is general practice, and the point could well be watched when placing indent orders with importing houses.

REPORT OF FIRST ECOLOGICAL CONFERENCE

The decision to form the New Zealand Ecological Society was made at a special meeting held during the Science Congress in Christchurch in May, 1951. The Society, which plans to hold conferences annually, came into action existence with a two-day meeting held at Victoria University College, Wellington, On May 20 and 21, 1952. One of the main objects of the Society is to promote a wider understanding among ecologists of the ideas and methods of workers in other branches of the subject. To further this aim, the meeting was organized in the form of three sessions each devoted to a single topic of wide ecological interest. The first session "Methods of Estimating Populations," was held on May 20, and the other two "Ecological Problems of Restricted Areas," and "The Western Taupo Project," were held in the morning and afternoon, respectively, of the following day. At each session discussion was opened by a series of invited speakers who reviewed the subject from various angles. These occupied about half the session, and the second half was left free for, and was very fully occupied by, informal discussion. About 100 people attended the meeting, and by the time it closed the Society had over 150 members.

METHODS OF ESTIMATING POPULATIONS

CHAIRMAN: I. D. DICK

ESTIMATION OF POPULATION

DR. R. M. WILLIAMS

MOST of the difficulties in estimating animal or plant populations arise because the plants or animals are not distributed randomly over the area whose population is to be esti mated, but may, for example, cluster in groups. A fully random sample provides both an unbiased estimate of the density of the population and an unbiased estimate of its sampling variance, but because of the clustering tendency of the data it may often have a large sampling variance. Better methods of sampling—*e.g.*, systematic sampling—can often be found if we have further information about the way this clustering (occurs; but if we use non random methods we can retain our estimate of the sampling variance only if we make some further assumption about the distribution of the data; this is justifiable only if we have examined the particular distribution first.

In a simple case, such as estimatin; the number of plants in a seed bed where the soil has been thoroughly mixed and the seeds sown as uniformly as possible, we can estimate the population by estimating the density per unit area from a number of areas taken at random, and multiplying by the total area. If we knew that there were no non-random features—*e.g.*, edge effects–a systematic sample would do just as well; but if we suspect that edge effects may be present, a systematic sample, while it may give as good an estimate or better, will no longer provide us with an estimate of its accuracy unless we are prepared to make some assumption about the way the edge affects the density.

An analogous case in estimating animal populations is the method called the Lincoln (or Petersen) index, in which a known number of animals in the population are marked, and the ratio of marked to the total population is estimated by random sampling. In the case above we will have a small sampling variance if the plant density varies little over the whole area, so here we should ensure that the number of 'animals per marked animal is as uniform as possible throughout the population; also, to ensure an unbiased estimate, we must ensure that the re-trapping is random with respect to the original marking. If the process of trapping is a continuous *one,* this means that the traps should be rearranged at random at each resetting. These requirements are essentially the same as for botanical estimation, but in addition there are two special difficulties:

(1) Some animals are trap-shy or trap-prone; there seems to b no way of eliminating the bia: due to this.

(2) If the proportion of marked animals is not uniform throughout the population, some bias can be introduced if the change of capture is not proportional to the population present; it should be possible to avoid this by suit able trapping methods.

Where the distributions are seriously non-random, we have to find some model which describes the distribution in order to decide the best sampling technique. In one such model (applicable where the area is divided into regions by physical boundaries such as creeks or fences) we assume the density is the sum of two components; one being the same over any given region (usually having a large variance), the other I with a smaller variance) changing from point to point in the region. A small number of points in each of a large number of regions will give the best result here, though we may be limited by the greater time taken in travelling between regions than within them. This model assumes fundamental differences between neighbouring points on opposite sides of a boundary which do not occur between points in the same region; in the absence of natural boundaries we may need another model. For line transects one such model is provided by assuming that the correlation between any pair of points depends only on their distance apart. By examining, we can decide what is the most efficient method of sampling. This method has been discussed by Madow and Madow* and Cochran.†

*MADOW and MADOW (1944): *Ann.Math. Stat.*, p. I.

†COCHRAN (1946): *Ann.Math.Stat.*, p. 164.

THE BOTANIST'S VIEWPOINT

C.M. SMITH

In presenting the botanist's viewpoint in this series of papers, C. M- Smith aimed at simplicity, saying that we should learn to walk before attempting to run, and that many biologists who attempt to run with the mathematician neglected to walk in their company. Mr. Smith then went on to say that he had searched for definitions of "population" and that he uncovered the following from an engineering glossary: "A set of data to be analvsed whollv or in part by methods o ƒ statistics"; from a taxonomic zoologist: "The population has become the basic taxonomic unit."

It does not seem to me that either of these definitions was what an ecologist meant by a "population." and I was unable in a short search to find an ecologist's definition; nor could] discover when it first came into general use in plant ecology. Baulked of finding a definition here, I turned to the biometricians and found that Fisher says that "Populations are to some extent abstractions." that "Statistics is the study of populations" but (as far as I pursued the search) he rather avoids a definition. Perhaps a good]exicographer could make a definition by inverting Fisher's statement and saying that "Populations are what statisticians study," which leaves us very much where we were, and is very unsatisfying to the ecologist to whom populations are far from being "abstractions" or even "sets of data," and who is as eager to study concrete plant populations as any statistician is eager to study abstract ones.

I am now left with the task of explaining what a plant ecologist means by a "population." It seems to me that the plant ecologist means by a population no more than "the vegetable organisms of specified kinds living within a specified area at a specified time." This is essentially what the man in the street means by the population when he

talks of the population of a town or of a country, and estimating the population in both cases means taking a tally or count or a census thereof. This tally may in some few and special cases be taken by a direct count.

We also have what may be termed crop ecology, the study of plants which grow in manipulated rather than natural environments. The pedantic ecologist sometimes uses two invented terms for the communities belonging to these manipulated and natural environments-the *feral arch* and the *hemerarch*. The animal ecologist will readily appreciate that they correspond in the plant world to the wild animal and domesticated animal subdivisions in the animal world.

This bring us back to our earlier definition- You will have observed that it demands that, before a plant population estimate can be attempted, the estimator must be supplied with specifications of:

(a) The kinds of plant and plant . communities involved.
(b) The time at which the estimate was made or is to be made.
(c) The area involved—*i.e.*, the area to which the estimate is to apply.

Until these descriptive postulates are laid down, it is impossible to proceed to the process of "sampling" on which the whole of estimating rests, and I venture to assert that much of the error in sampling that has always occurred in estimating plant populations has been due to samplers' failures to set out clearly exactly what is to be sampled.

Beyond this point, I propose to indicate only very briefly the important points and difficulties that occur when one sets out to define a plant population under this rigorous analysis.

Kinds of Plants.—This means much more than a mere statement of species; size of plants and their life form and habits must be considered —*e.g.,* are we to include newly germinated seedlings and giant adults in our population? Are fungi to be included or phanerogams only? What about rhizome propagated plants, mosses, bacteria, epiphytes. and bulbous plants during the non-leafing period?

Time of Making Estimate.–As an ideal the time should be recorded for:

(a) The season of the year
(b) The age of the plants enumerated.
(c) The age of the community that is under enumeration.

Area to which the Population Estimate Applies.–In some cases, it will be necessary to replace "area" by "space" or "volume." So much depends on the homogeneity of the- total area which samples are supposed to represent that it is impossible to do other than express the fear that in plant population estimations relevant areas are often defined and measured with a degree of negligence that is wholly at variance with the degree of accuracy lavished on recording Aoristic lists.

ESTIMATION OF ANIMAL POPULATIONS

J. S. WATSON

The determination of population size is technically the central problem in population research but is one that presents very many difficulties and has rarely been solved satisfactorily. Many different methods have been tried and these have been determined by the particular aspect of a population being studied. Estimates have been made to discover the total numbers of a particular species at a given time or to record fluctuations in the relative numbers from year to year. The commonest use is probably in conjunction with detailed studies on sample areas to provide figures for density of population, details of its structure and composition and the quantitative relationship with food, predators, and parasites, all these points being considered in relation to space and time. Estimates are also used as a tool in wild. life management but these of necessity must make use of some fairly simple way of indicating relative abundance rather than absolute numbers; and the methods if they are' to be widely applied must be first tested in conjunction with a detailed study of the type just mentioned.

Direct visual counts have provided relatively reliable figures for some bird and a few mammal populations; the use of aeroplanes, particularly in conjunction with photography, has greatly enlarged the possibilities in this field. Counts of birds or mammals along a setline or, a popular variant, along roads from a moving car are often done without paying due attention to the many variables which may bias the figures, Some of these possible variants are: different observers, changes in weather, changes in the animals' behaviour at different seasons, the amount of cover provided by vegetation.

Most small mammals are nocturnal and have therefore to be investigated by some form of trapping. The earlier work on these lines consisted of attempts to trap out all the animals *on* a sample plot of known size, but it is more usual today to try to catch, mark, and release all the animals on a study area. The traps are usually laid in the form of a grid so that the range of activity can be calculated from the various traps in which individuals are caught. This has the disadvantage that the traps themselves restrict the animals' movements, and the closer they are laid the smaller will the range appear to be. A further development in this type of work has been the use of nest boxes instead of traps. Populations can also be calculated from the proportion of marked to unmarked animals in various samples, the so-called Lincoln index of ornithologists and mammalogists. This index is named after F. C. Lincoln who used this method in an attempt to calculate the duck population of the U.S.A, from the number of banded birds in the hunters' kills, fish populations; however. the calculation of population size from the ratio of the number of individuals with a certain character in a sample and in the total population to those without it was tried as early as the middle of the seventeenth centurv by Graunt in order to work out the number of families living in London.

Various signs and products of animals can also be used to give an indication of their numbers. The most satisfactory of these are birds' nests which have been used either to give the absolute numbers breeding on a particular area or to give an index of fluctuations in the population over a period as in the annual heron survey in Britain. Counts 'of faeces have but the method was used 35 years earlier by Petersen for estimating provided estimates of the population of a number of animals including rat, hare, fox, deer, and man; but in order to reach a satisfactory figure of the number of animals from dropping counts it is necessary to know the number produced per day, making allowance for differences due to sex, age, and diet, the rate at which they decay, and so, how long they remain visible; there is the additional problem of obtaining adequate random samples to overcome the difficulty that the pellets themselves are not usually distributed at random. Indices of abundance have also been worked out from tracks and trails (deer and wolves) and from the quantity of food eaten (rats).

New techniques for estimating populations have to be devised for every animal being studied and they must be worked out in conjunction with other ecological studies in order that their reliability can be ascertained. Census methods can have very little value until all the extraneous factors which may bias the results can be recognized and allowed for.

METHODS OF ESTIMATING POPULATIONS OF MARINE ORGANISMS

G. A. KNOX

ONE of the difficulties of the marine ecologist is the nature of the medium in which the animals and plants he studies live. Sampling of the marine environment, especially the depths of the ocean. is difficult and the data obtained are not always highly reliable statistically; however, if the methods used are strictly com. parable, there is afforded a basis for the comparison of different areas.

The seas provide a multiplicity of habitats (Fig. 1). The populations inhabiting these divisions may be divided into three large groups.

(1) The *benthos,* which includes sessile, creeping. and burrowing organisms found on the sea bottom.

(2) The *nekton*. composed of swimming animals found in the nekto-planktonic division,

(3) The *plankton,* which includes all the floating and drifting life. often microscopic, of the nekto-planktonic division. There are two major groups of plankton, the *phytoplankton* or floating plants, and the *zooplankton* consisting of small animals.

The different regions of the marine environment, and the different populations within these regions, require their own special techniques for population sampling. Techniques for the sampling of plankton and for fish, among the nektonic communities, are much further advanced than those for benthic organisms.

The Population and the Community

The subject matter with which the ecologist deals can be grouped into three broad levels of increasing complexity—the individual organism, the population. and the community.

The analyses of both single and mixed species populations demand quantitative methods. For all populations information is required regarding density, age, and sex. For mixed species populations additional information is required in the number and kind of species comprising the group.

Sampling Benthic Communities

As far as sampling. is concerned, the benthos can be divided into two sections, the inter-tidal (littoral) zone and the rest of the benthos where the sampling methods are of necessity indirect. On the rocky shore, the usual quadrat methods can be used, while *on* sandy and muddy shores various sieving and sorting techniques can be used.

For sampling the continental shelf and the rest of the benthos various types of dredges and grabs are used. Dredgings and trawlings give only a rough picture of the bottom fauna. The need for quantitative information *on* benthic communities has led to the development of various types of bottom sampler—*e.g.*, the *Petersen* grab—and various other apparatus of greater *or* less efficiency. Recent developments in submarine photography and underwater television may also have their uses.

Methods of analysing the Results of Sampling

Much of the work on benthic populations is of necessity purely descriptive on account of the difficulties of sampling, and so far little has been attempted in working out the distributions, etc., of species *on* the sea bottom. It has been suggested that

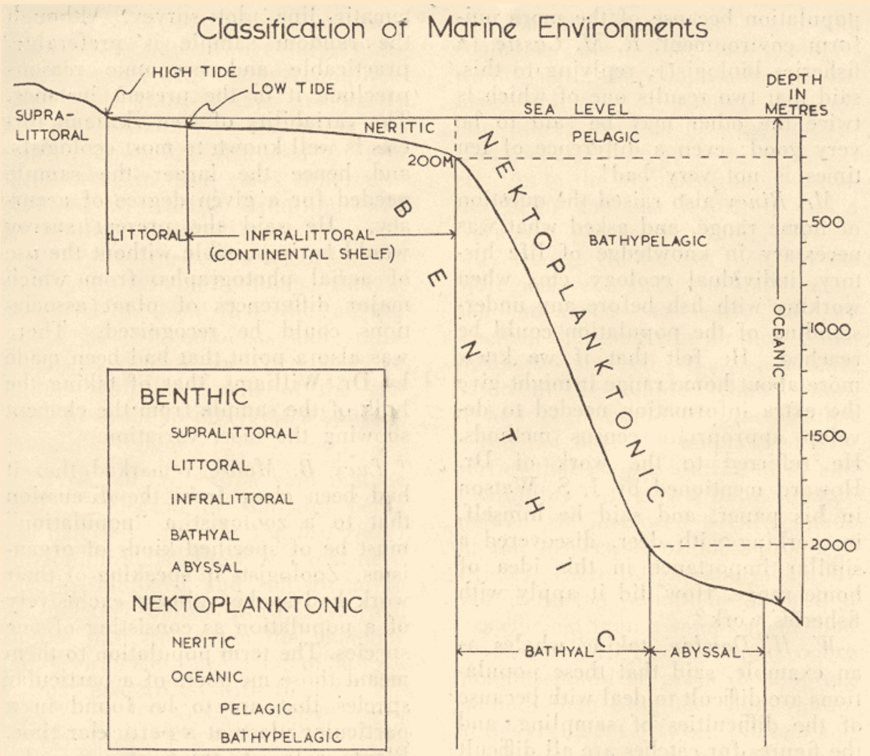


Fig. 1.—Schematic representation of the principal region into which the marine environment is divided.

benthic organisms could be grouped as follows:

(l) *Macrobenthos,* which is equivalent to the macrofauna of the bottom, plus the attached algae where they occur.

(2) *Meiobenthos,* comprising the forms of intermediate size, such as small crustacea, small polychaetes, and lamellibranchs, nematodes, and foraminifera.

(3) *Microbenthos,* comprising all the small organisms. protozoa, bottom diatoms, and bacteria.

The majority of benthic investigations have been concerned with the macrobenthos, the latter two groups having been comparatively neglected.

The Growth Form of Populations

The interactions between natality, mortality, and dispersion confer on populations a "growth form," which over an entire life-cycle can be conveniently broken down into six periods–positive. growth, equilibrium, oscillation, fluctuations, decline (negative growth), and extinction. Information about the growth form is fundamental to the study of any population. Many investigations of the benthos have described the composition of the community at the time of sampling; few have followed it over the period required for life-cycles; and fewer still over the longer period required to trace the changes that occur in the relative proportions of the species populations. Marine communities are traditionally regarded as rather static in composition; in some communities, especially in soft-bottom areas, changes may be quite rapid, especially where deposition or erosion is taking place.

A useful approach to this problem has recently been outlined in the application of *life-tables* to the analysis of populations. From life-table data survivorship curves can be constructed, and it is shown that there are several possibilities with respect to age:

Organisms which are born at the same time and die almost simultaneously.

(2) A constant mortality for all age groups.

Heavy mortality beginning in early life, but the few individuals which survive to advanced ages have a relatively high expectation of life.

Populations and Productivity

Probably the most important ultimate objective of ecology is an understanding of community structure and function from the viewpoint of its metabolism and energy relationships. An approach to this problem is the estimation of production by expressing densities as weights per unit area.

Finally it is worth remembering the following statement*: "Is it worth while making all the calculations necessary to show the exact quantitative composition of the community, when the degree of exactitude is highly dependent on the method used? In man v cases the reader, and even the author of the' treatise, will not remember that the *exact* amounts of the animals are only rough approximations." This should he borne in mind, but, in most cases, if the investigator recognizes this, and makes clear the sampling limits, the results can he invaluable.

DISCUSSION

THE discussion after the luncheon interval was opened by *Thane Riney,* who said that the main goal of research workers, whether ecologists, mathematicians, zoologists. or botanists, was increased understanding of one kind or another, and that their various angles of approach would give different understandings to the problem.

A question by the chairman (I. D. Dick), who recalled Mr. Smith's use of the terms *feralarcb* and *hemerarch,* was answered by *P. B. Lynch* who, speaking as one who had to deal with cultivated rather than naturally-growing plants, said that he would agree with Mr. Smith on the need to define the kind of thing one is counting before starling on population study work. With cultivated non-spreading plants *(e.g.,* wheat), estimations of density and so on were straightforward tasks; on the other hand, with spreading plants *(e.g.,* Californian thistle) the task was not so simple.

K. R. Allen, recalling the necessity to define "population," mentioned

*BACKLAND, H. O. (1945): "Wrack Fauna of Finland, Ecology and Chorology." *Opuscula.,..to Entomologica Suppl.,* pp-1-236.

that complications could be met with in dealing with migratory species such as the salmon. A number of different problems could be visualized which would necessitate defining the population in several different ways; if the problem was that of food supply in relation to total growth rates, the population must be that of young fish which were feeding in the river; if the focus of interest is on the return to the commercial fisherman the population then becomes the mature fish in the sea on their way back to the river; if the stock in the river is to be considered, and whether it is surviving the pressure of angling, then the population consists of the mature fish returning and spawning in the river. It can be seen that, according to the nature of the problem, our population of the species varies, and so therefore must the methods of enumeration. This speaker concluded by saying that the important thing was to think out dearly just what was wanted before trying to decide what the population to be enumerated really was.

Dr. K. Strzemienski asked Dr. R. M. Williams about a suggestion he had heard of a simplified method of estimating densities of plants. The basis of the method was to mark out the area in a large number of squares and to record the number of squares in which the species was present and the number in which it was absent. *Dr. Williams* replied that the method was applicable only in certain cases; it required a random distribution of the species. The basis of such a method would be that the numbers of plants in each square should have a Poisson distribution. Such a distribution would occur when the objects to be counted had this random distribution with a large number of possible occurrences but a very small probability of each occurrence—*e.g.*, the method could be used for counting the cells in much diluted blood on a squared slide, and counting the number of squares with 0, I, 2, 3, etc., cells. Mr. Dick said he had not found the method practicable.

Mr. Riney felt that, in making an estimate of population (*e.g.*, deer), several methods all adapted to the particular problem should be used. He instanced wide differences in population numbers obtained by different methods, and assumed that the differences would be less in a fish population because of the more uniform environment. *R. M. Cassie* (a fisheries biologist), replying to this said that two results one of which is twice the other may be said to be very good; even a difference of ten times is not very bad!

Mr. Riney also raised the question of home range, and asked what was necessary in knowledge of life history, individual ecology, etc., when working with fish before any understanding of the population could be reached. He felt that if we knew more about home range it might give the extra information needed to develop appropriate census methods. He referred to the work of Dr. Howard mentioned by J. S. Watson in his paper, and said he himself, in working with deer, discovered a similar importance in this idea of home range. How did it apply with fisheries work?

W. H. Dawbin, taking whales as an example, said that these populations are difficult to deal with because of the difficulties of sampling:, and the figures for catches are all difficult to interpret because it is all selective catching. On the whole, he thought that the results obtained showed that the whale population is declining.

Mr. Cassie then spoke of the possibilities of marking by tagging, and recapture; he also said that, by taking series of measurements, statisticians had identified whole fish populations which did not intermingle. C. *A. Fleming* mentioned a method of fish tagging described to him by Dr. Bruun; a dominant mutant which gives a fixed pattern in plaice, individuals with the mutant are placed in the natural populations, and their proportions determined by sampling. *Mr. Allen* said the problem of home range was more manageable in small streams and lakes; he said that allowance must be made for the movement of marked and unmarked individuals, *into* and out of the observed and unobserved areas, and some means of assessing these movements devised.

K. Westerskov, reverting to the discussion about the term "population," said that to him it included all the specimens of the species under consideration, instancing his own work on grouse in Denmark.

After the adjournment for afternoon tea, *A. P. Thomson* spoke of a survey of the total indigenous forests in New Zealand by means of a systematic line plot survey. Although the random sample is preferable, practicable and economic reasons preclude it in the present instance. The variability of New Zealand forests is well known to most ecologists, and hence the larger the sample needed for a given degree of accuracy. He said the present survey would be impossible without the use of aerial photographs, from which major differences of plant associations could be recognized. There was also a point that had been made by Dr. Williams, that of taking the bulk of the sample from the element showing the most variation.

Lucy B. Moore remarked that it had been clear from the discussion that to a zoologist a "population" must be of specified kinds of organisms. Zoologists in speaking of their work had spoken almost exclusively of a population as consisting of one species. The term population to them meant those members of a particular species that are *to* be found in a particular place at a particular time. Plant ecologists think of a population as all those organisms that occur within a certain area—*e.g.*, in the forest survey, the forest is the population. Miss Moore then asked if workers with pollen grains and spores in peats could contribute to the discussion. *R. A. Couper* said that their work was mainly concerned with the relative abundance of various species, say beech and conifers, or the relative number of grasses and sedges to the forest" a whole. Both he and N. T. *Maar,* who spoke later, agreed that it might be possible to get a fairly good idea of the elements within the population, but not an idea of its density.

R. K. Dell said that it appeared there were four main types of population to be studied:

Organisms that we can see and that are stationary—*e.g.*, trees.

Animals that we can see and that move—*e.g.*, deer.

Animals that we cannot see and that are stationary—*e.g.*, mollusca.

Animals that we cannot see and that move—*e.g.*, fish and nocturnal mammals.

As far as sampling is concerned, he said it was not difficult to evolve a technique which will give comparative results.

R. I. Kean said that with some animals the home range largely become. linear, with further complications with animals that are partly arboreal. Another difficulty is the small population scattered over a large area; in these cases either random or systematic sampling will be of little value. It will be necessary to site the traps according to the habits of the animals, and it appeared to him that the answer would be for ecologists and statisticians to discuss the correlation of figure with the habits of the animals in order to arrive at a suitable sampling system.

Dr. W. M. Hamilton said that he felt that instead of statistics being (as had been quoted) the *last resort* for the biologist, there was real need for the biologist and statistical to get together *before* work is started. In the past, too often the tendency has been: "Here are a lot of figures—what can we do with them?"

The chairman (Mr. Dick) said that, to close the discussion, he would endeavour to sum up. He said there was not really so much difference between the statisticians' and the ecologists' definitions. The ecologist would write his population as so many animals (or plants) at a certain place, whereas he (the statistician) would write $x_1 + x_2 + x_3 \ldots$ etc. As to the argument about statistics being the last resort, it was a German physicist who showed *only* resort! He did not feel that the biologists, ecologists, and statisticians had advanced sufficiently to say whether that was true or not. Some speakers stressed the sacrosanct nature of the complete enumeration. It had been found in practice that it did not have the unqualified properties that people ascribe to it, and a sampling will give a more reliable answer. He instanced a check made on the inspection of mass produced articles, where fatigue and monotony had rendered complete inspection less efficient than a sampling method of inspection. He felt that more thought should be given to sampling methods than complete enumeration. In the argument between random and systematic sampling methods, most statisticians would in their hearts agree that the randomization theory had been forced upon them simply by the theoretical difficulties of any other hypothesis. He thought there was reasonable hope that within the next ten to fifteen years they will be able to handle systematic sampling theory and practice very much more capably than they have up to now. It also appeared that the biologist was expecting two things from the mathematician; these should be differentiated and remembered. One was a description, in concise mathematical terms, as to what his population looked like; his other need is some sort of causal mechanism. Mathematicians within the last few years have been working with models, which, when they are set up and the equations are set up and developed, may give some idea of how a population may develop. This again requires collaboration between mathematicians and biologists. If that could be achieved, workers would be getting somewhere in applying statistical method to biological problems.

Other speakers who took part in the discussion were P. C. Bull, N. J. Butler, D. F. Hobbs, G. A. Knox, and E. G. Turbott.

ECOLOGICAL PROBLEMS OF RESTRICTED AREAS

CHAIRMAN: PROF. B. J. MARPLES

SOME ASPECTS OF LIMNOLOGY IN N.Z.

PROF. E. PERCIVAL

THE paper dealt exclusively with South Island lakes, and many examples were given to illustrate their diversity. Some are brackish and some fresh; some in mountain valleys, some in open country; the surrounding rocks are greywacke principally in the north, schist in the south; most have both inlet and outlet streams, a few have neither. There are examples of twin and constricted glacial lakes. Depth, shape, and size all vary greatly. The country in which a lake lies and from which its water is gained exercises a profound influence on the deposit and growth. Single sample. taken in six lakes at about the same date showed phosphate contents from 0.0007 to 0.029 P_2O_5, mg/I. In flowing water is sometimes many times richer in dissolved matter (*e.g.*, phosphate, nitrate, silicate) than the open water of the lake itself, and may differ greatly in temperature. The amount of transported solid matter varies from negligible to quantities that take weeks or months to settle. What effects these intermittent changes have on flora and fauna are still to be determined. Lake Ellesmere, shallow and strikingly turbid, has abundant bottom life, plankton and fish, and large nocks of ducks and black swans draw sustenance from it; conditions are variable but favourable towards the few tolerant species. Turbidity in some deep glacial lakes like Tekapo and Pukaki is due to silt and seems to be associated with poor plankton and bottom life. Some lakes are very transparent, others are at times turbid, not with silt, but with plankton. The great variety in lake basins can he roughly linked with productivity, but much work is required in this country to show the basis of this linkage. Generally, shallow lakes are more productive than deep, those with a relatively extensive shallow sub-littoral zone than those with a relative]y limited sub-littoral zone.

The absolute quantities of living matter in the plankton can be quoted for only three South Island lakes, Lyndon, Pearson, and Ellesmere, based on collections made from time to time through the year; proportional amounts of plankton in Lake Hayes have been studied by Miss V. H. Jolly. Little is known about the kind and distribution of bottom fauna and flora. What is striking in the plankton is the limited range of animals, much narrower than is reported from the northern hemisphere. The distribution of planktonic species and genera is interesting. A species of *Bosmina* appears to be widely spread but otherwise the species and genera of crustacea are erratic in occurrence. Adjacent waters may have different species of the same genus, species of a genus may be absent, there may be no crustacea, the animal plankton may consist only of rotifera, and, perhaps, protozoa. In samples taken about the same time of year species of crustacea, or of rotifera, may be abundant in some lakes, absent in others not far distant. These differences are to be distinguished from seasonal variations in the same waters which are essentially repeated year after year and may be connected with breeding cycles or with changes in physical or chemical conditions. In New Zealand the only work on phytoplankton is Dr. F.. A. Flint's study of Lake Sarah.

Variations in distribution of plank. ton animals are not only seasonal in' a given body of water: but may be daily. Miss Jolly has showed diurnal variations in numbers of copepods and cladocerans at the surface. With more or less obvious maxima about dusk and dawn, and more or less minimal numbers in the middle of the day. At Lake Lyndon collections throughout the column of water showed' a downward concentration of crustaceans in the late morning, greatest at noon. After noon there was a seething upwards lasting till early morning; after dawn redistribution took place. The samples indicated a rather static distribution of rotifera.

There is a question whether thermal stratification is common in South Island lakes. Very many lakes are affected by a strong wind blowing from the mountains along the lakes creating an overturn which could bring about regular mixing so as to prevent stratification. Wind can also cause evaporation which takes part in maintaining lowered temperature. The level of a lake can vary, sometimes through seepage as well as through evaporation. Lake Lyndon, for instance, can fall to half its calculated total volume; the dissolved salts vary in concentration, but in Lake Lyndon there was no clear connection with changes in volume.

Each piece of water has its own features, in spite of the' fact that a number may lie in the same geological formation. Commonly there is only one species of a genus of animals present in one lake, particularly among the crustacea, or one species of a genus may follow another. Some genera are restricted to the southern hemisphere and some may be cosmopolitan, so that the student is rapidly involved in allsorts of problems beyond those represented by individual lakes. That is, by problems of zoo- and phytogeography. New Zealand is well provided with lakes of great variety, from primitive glacial lakes to very advanced. What sort of comparison or contrast can be made with those of other areas remains to be seen.

ISLAND ECOLOGY

E.G. TURBOTT

NEW ZEALAND islands can be divided into two kinds; the inshore islands, less than forty miles from the mainland, include the Three Kings, the groups off the North Auckland coast and in the Bay of Plenty, and those in Cook Strait' and in the seas about Stewart Island; the outlying island run in a broad eastern arc of some hundreds of miles from the Kermadecs to the Chathams and the subantarctic islands. Size ranges from very small to many thousands of acres.

A distinction can be drawn between islands as habitats relatively little modified by man and his introduced animals (*e.g.*, Little Barrier Island and Adams Island in the Auckland Group) and as areas possessing aspects that appertain to insular conditions and to these alone. The investigation of goat damage to the vegetation of Great Island, of the Three Kings, is not ecologically a typically island problem, but the island does permit the survey to be made within known limits of area. Apart from the "protective" aspect of islands, the study of plants and animals of islands can be approached from the ecological viewpoint of restricted area, as distinct from the other approach based on the distributional relationships of the fauna and flora and the development of endemics.

The actual size of islands may lead to contrasts in vegetation, for example, Little Barrier Island of 7,000 acres has several kinds of forest, comparable with inland as well as with coastal forests of the mainland, while the Poor Knights, where the largest island is 318 acres, has almost exclusively coastal forest. Area affects animal populations of islands both indirectly through restriction of types of vegetation and directly by limiting the size of the animal populations. Animals such as forest birds which on the mainland move freely from the coast inland may, on islands, be restricted to a relatively specialized habitat. On the other hand, species of animals, such as some insects and other invertebrates that belong normally to the coastal forest, would not be markedly limited except on very small islands.

A census has been made of the birds on Hen Island which bears mixed coastal vegetation including tall forest, and on the Poor Knights which are clothed in a relatively poor coastal forest and scrub. The total population density was higher on the Hen, but on the Poor Knights, where there are fewer species, some species have rather more individuals per unit area, Suggesting that less rigorous competition may have resulted in an increase in the density of these species. The absence of number of species from the Poor Knights (*e.g.*, pigeon, kaka) is probably related less to difficulties of access from the mainland than to inadequacy of the poor vegetation in respect of food (if only for part of the year) or nesting sites. Less easily explained is the absence on the Poor Knights of such birds as grey warbler, fantail, and silvereye all present on Hen Is. and able to adapt themselves readily to a variety of modified habitat; on the mainland. The evidence suggests that the lower limit for the existence of an established population varies from species to species, and this probably according to aspects of behaviour including the breeding pattern, but confirmation is required. The red fronted parakeet is an example of a bird which, though normally inhabiting forests on the mainland, on smaller islands feeds on the ground and nests freely in crevices in rocks or on the subantarctic islands, in holes beneath tussocks.

It is not possible to separate ecological aspects of islands from evolutionary problems. Isolation is itself a fundamental factor influencing evolution. Out of the wide range of problems relating to powers of dispersal and population genetics prevented by islands of every size. Those of particular interest ecologically relate to the effect of area in limiting animal populations, whether indirectly or directly.

It has been claimed that the small size of an insular population (perhaps due to a small initial colonization) may cause rapid evolutionary change -i.e., the so called "Sewall Wright effect." On the Three Kings, the presence of a mutant form of fantail along with the norm1 form is explained as possibly due to the Sewall Wright effect; in 1946 (when the goats were destroyed) the total number was probably less than 50. From Great Island of Three Kings a new species of the carnivorous bug *Cermalllills* was described by Woodward in 1950. It is distinct from the species found on the New Zealand mainland which also occurs in Australia and Tasmania. Woodward considers that the generally relatively low population of predaceous insects, the long non-breeding period, the possibly small proportion of males to females, together with possible effects of environmental modification on the island would all be factors which would produce a small population and he states: "The isolation of such a small population could easily have provided suitable conditions *(e.g.,* by periodic or even a single extreme reduction in the numbers of the effective breeding population in the area) to permit action of the Sewall Wright effect . . . while on the mainland the population has remained conspecific with the Australian form." These conclusions are tentative in the absence of direct information on the present numbers and biology of the species.

The bellbird is an apparently adaptable species found on many in. shore and a number of outlying islands. It has diverged to subspecific level on the more distant islands (Chathams, Aucklands, Three Kings) but not on any of the nearer inshore islands, though the total number on the Three Kings, for instance, would be greater than that on the Poor Knights. The effect of the period of isolation after an initial colonization followed by little subsequent interchange is clearly seen here. Mainland populations in North Auckland are now so greatly reduced that the possibility of interchange is further restricted.

Subspeciation associated with a change to a different habitat is illustrated by the Snares Island fernbird which is a scrub dweller, not mainly a low swamp vegetation species as on the mainland.

Great Island, the 'formerly goat infested island of the Three Kings has been regarded largely as a problem in the effects of modifying factors (Maori occupation, goats) upon a native vegetation. lts special interest to the animal ecologist lies in the indirect response of animal elements to seral conditions. The changes envisaged are:

(1) Abundance of species may change with regeneration; bird numbers have been estimated, and quantitative work on leaf mould invertebrates from samples obtained by Berlese funnel is in progress.

(2) Long-term observation on the birds may provide evidence of the re-establishment of species absent at the time of the destruction of the goats. These may include species known to have died out on the island owing to its progressive modification.

(3) Marked changes in abundance, which will probably occur as re-generation proceeds may result in evolutionary change, where they represent fluctuations in isolated populations.

It is to he hoped that increasing attention will be given to all phases of biological study on our islands; parallel studies on the mainland must, of course, he important for comparison.

SOME ASPECTS OF PLANT ECOLOGY ON ISLANDS

DR. G. T. S BAYLIS

THE Maori probably modified the vegetation of New Zealand more extensively than has been generally allowed *(e.g.,* Cockayne: "Vegeta-tion of New Zealand," p. 353). This applies particularly to coastal islands which, though deserted in European times, would have supported large Maori populations in the days when fish and seabirds' eggs were major foods and tribal warfare put a premium on isolation. The effects of forest destruction in those times can persist in localities which have subsequently been undisturbed. This is exemplified by Southwest Island in the Three Kings, a place so deserted today that it is hard to overcome a prejudice that its vegetation must be virgin. Yet the puka *(Meryta sinclairii)* forest that covers it appears to he a seral community following clearing of the island in pre-European times. Moreover, it seems that the great reduction of the flora which then occurred will lead to the development of a climax forest dominated only by pohutukawa, karaka, and parapara, whereas the original forests of the area appear to have been very rich in tree species.

Dispersal mechanisms are specially important when the land is broken up into islands. The forest regeneration now proceeding on South-west Island and on Great Island shows that none of the species involved is so effectively dispersed as to prevent position of the seed-source from being a major factor in deciding its presence or absence. The position of odd trees that survived destruction promises to impress itself for centuries upon the composition of the forest. This leads one to realize that, in forest ecology generally, a substantial part can be played by catastrophes such as natural fires, slips, and windthrows; their occurrence may be rare, but if their effects are prolonged much forest may be in some stage of recovery from them.

It is unwise to endeavour by infer-ence to extract ecological information from the writings of early botanists who had no ecological concepts. For instance, Cheeseman did not think it worth recording that goats were landed at the Three Kings on the occasion of his visit in 1889, nor did he mention the presence of goats on the Kermadec Islands which he also visited about this time; yet it is apparent from the (to him puzzling) fact that Macauley Island was grass-covered that goats must already have been the dominant factor there.

HISTORICAL FACTORS AFFECTING THE ECOLOGY OF ISOLATED AREAS

C. A. FLEMMING

THE geologist sees constant changes in all environments, but islands and other similar areas are even less permanent than other biotopes. Differences in age of insular areas (islands, lakes, ponds, mountain tops, valley bottoms, sand dune complexes. etc.) have obvious influence on the ecology of the plants and animals that live in them.

The major classification of islands as continental and oceanic arose from two lines of approach, geological and biological. The islands of "continental" geology are, however, often "oceanic" in biology, and other "continental" islands (*e.g.,* New Zealand itself) support a fauna partly "continental" in origin but partly "oceanic." Some of our outlying islands too, though continental in their geology, may be entirely oceanic in their biology. The faunas of other ecological "islands" (lakes, mountain tops, etc.) fall into the same group as those of true islands:

(l) They may be "continental" *i.e.,* derived at a time when the restricted area was part of a larger area (*e.g.,* dwindling ponds in the bed of a former lake; alpine communities once widespread in lowlands during a glacial age, etc.).

(2) They may have been derived entirely by transport across a barrier (*e.g.,* population of a lake suddenly formed by landslip or of volcanic terrain new-formed).

(3) They may be of dual origin inheriting some elements from a period of continuity across the barriers that later surround them, but gaining other elements during the subsequent period of isolation.

Barriers that form ecological islands impose restrictions on transfer from one population to another; a barrier acts as a sieve, allowing vagile organisms access and barring others so that the communities of restricted areas of the "oceanic" type are unbalanced, or incomplete in comparison with analagous communities of near lands. Examples are: New Zealand, a land without mammals or snakes; the Auckland Islands with some but not all the elements of Stewart Island coastal rata forest; the Snares with three indigenous land birds in a community which would support a dozen or more in Stewart Island. This selective effect of trans. barrier colonization of any ecological island allows us to test hypotheses of the origin of a local fauna or flora by examining its completeness in comparison with that of neighbouring areas.

As long as they persist, islands are subject to invasion, and if the barrier is relatively impenetrable a few organisms will invade repeatedly. In the periods between successive invasions evolutionary change goes on, accelerated by insular conditions, and later immigrants of a stock may not interbreed with their predecessors, but behave as separate sympatric species. The phenomenon of double invasion is quite characteristic of oceanic islands. In Antipodes Island, New Zealand parakeets have given rise by early immigrations to the endemic *Cyanorhamphus unicolor,* by later ones to a subspecies of the parent form C. *novae-zelandiae* (Fig. 2). In Norfolk Island three colonizations by silvereyes *(Zosterops)* have produced two endemic species and a subspecies of the common Australian species. The Chatham Islands have been colonized by at least two invasions of the shallow water subantarctic gastropod *Eucominia;* possibly the tree daisies *Olearia semidentata* and *O. chathamica* are similarly derived from stock represented in New Zealand by *O. operina* and *O. angustifolia.* Mayr quotes cases of double invasion of islands by butterflies and of isolated mountains peaks by birds, and it seems likely that the species swarm of cichlid fishes in Lake Nyassa and of gamma rid crustacea in Lake Baikal are due to multiple invasions during the long history of these fresh

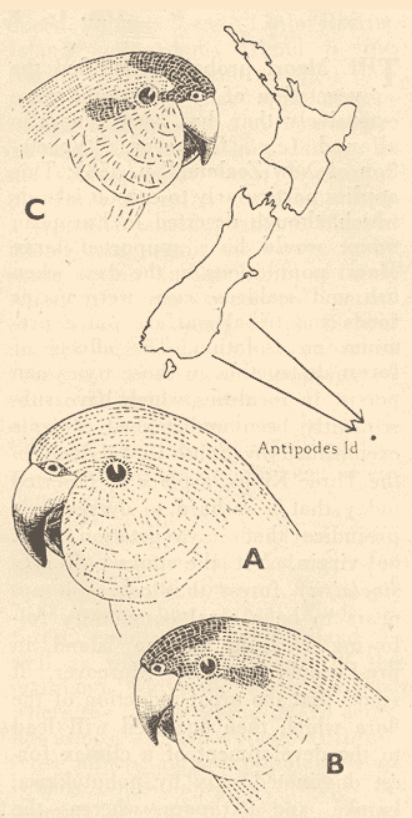


Fig. 2.—Double invasion of Antipodes Island by the red-crowned parakeet (Cyanoramphus novae-zelandiae). *The first invasion gave rise to the endemic species* C. unicolor *(A), the second to a subspecies* (C. n. hochstetteri, B) *of the parent form (C).*

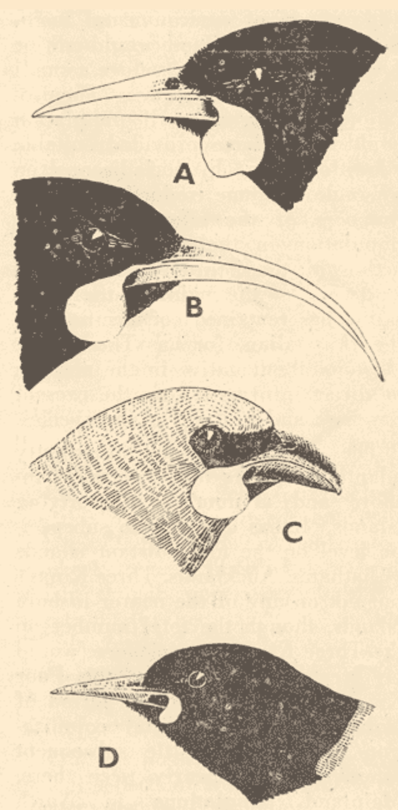
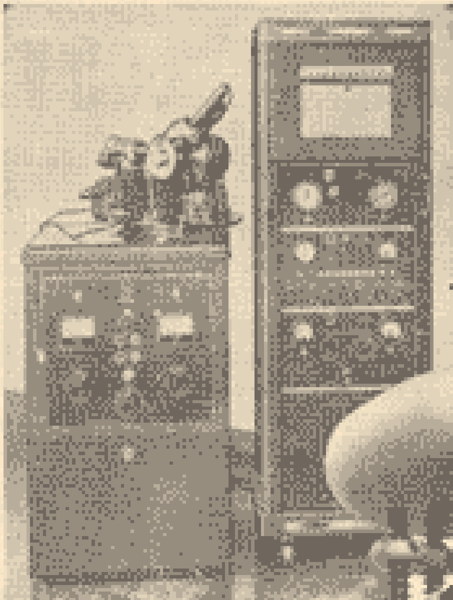


Fig. 3.—Adaptive radiation of the endemic family Callaeidae in the ancient New Zealand archipelago. (A, B) Neo-morpha, *the huia, male and female;*
(C) Callaeas, *the kokako; (D)* Philesturnus, *the saddleback.*



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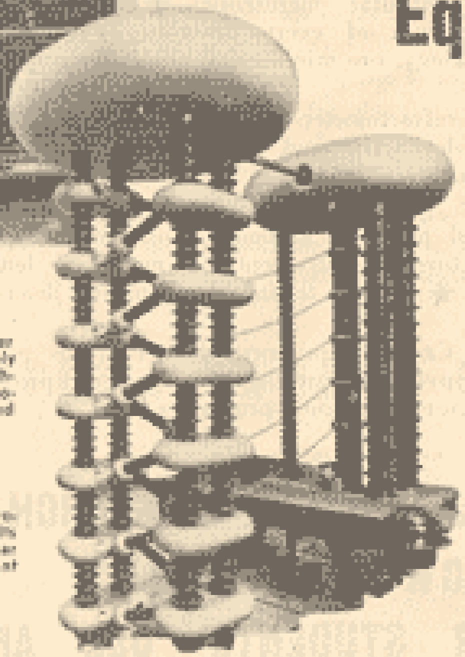

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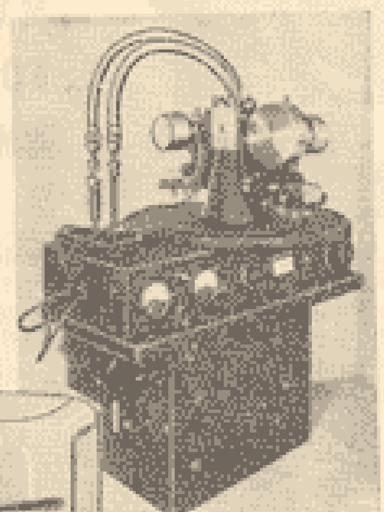

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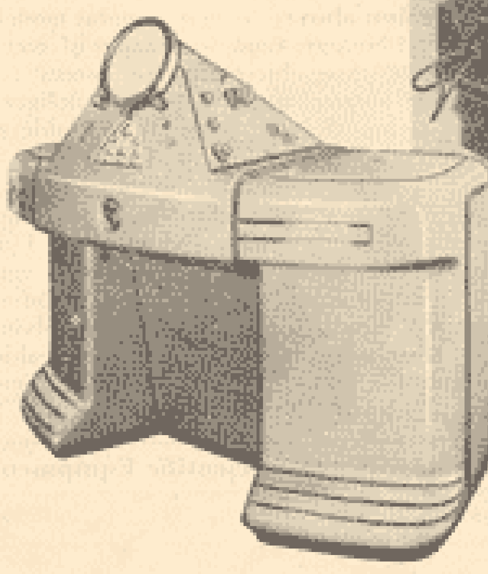

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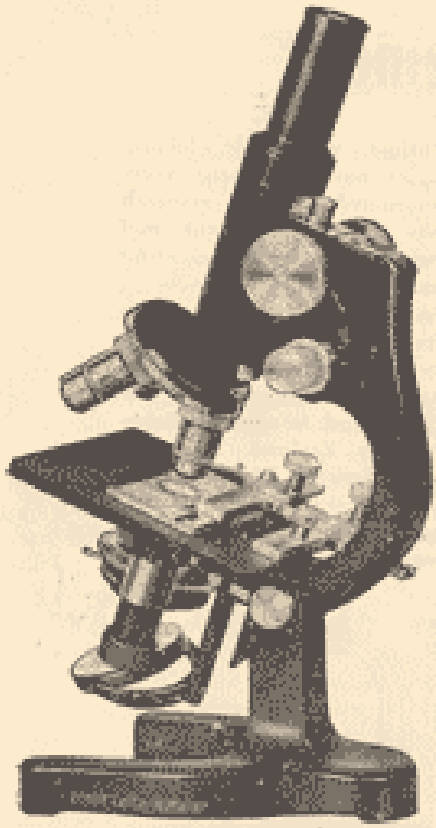

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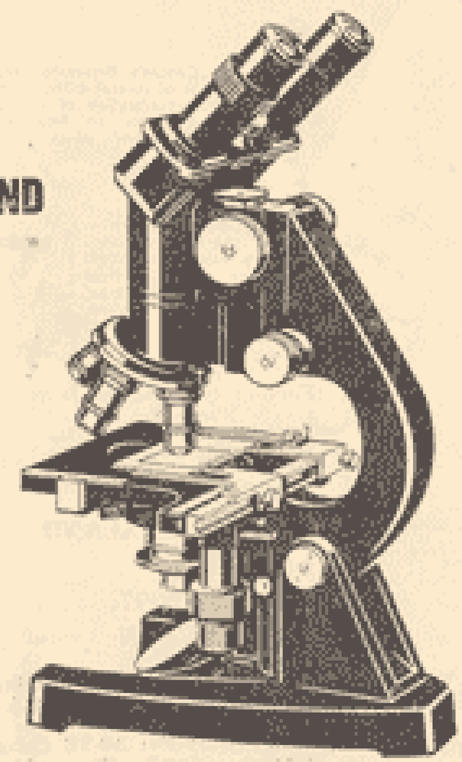

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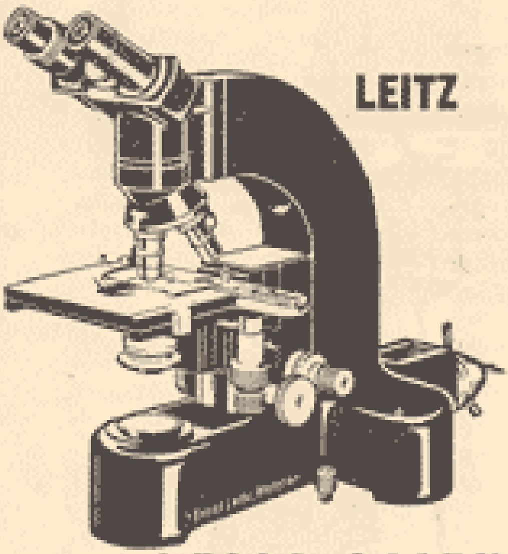

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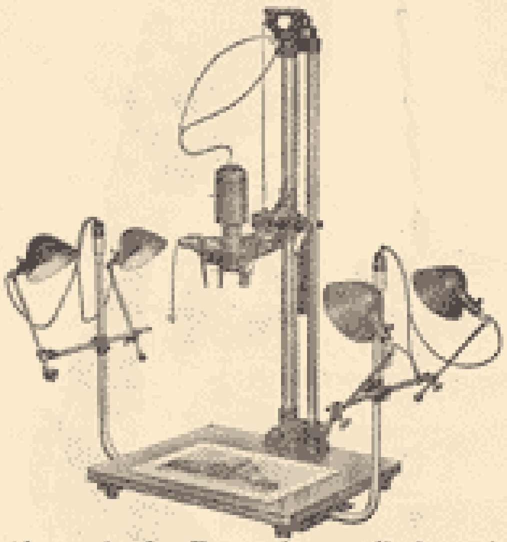

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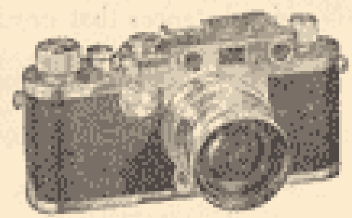

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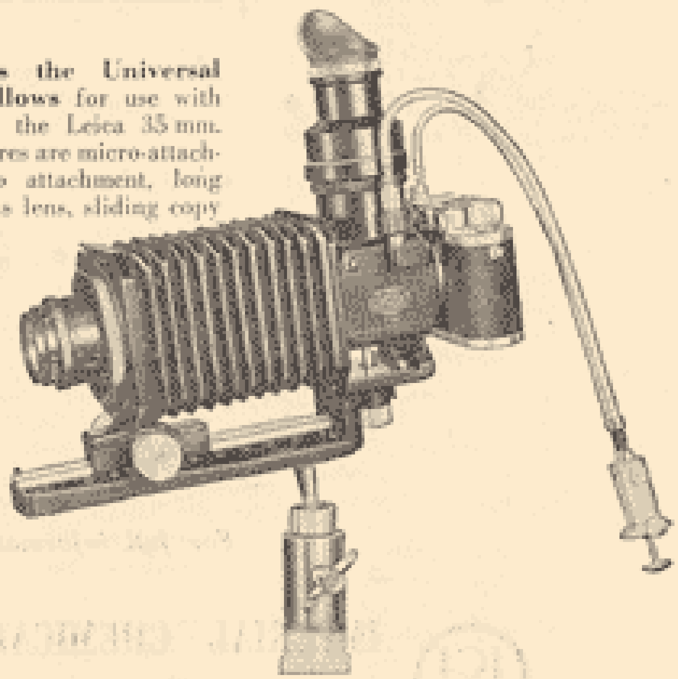

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water "islands." Isolated archipelagos, through repeated invasion and back-invasion of relatively few stocks that have colonized them, end up with a diversity of related species and subspecies developed by adaptive radiation. Examples are Darwin's finches (Geospizinae) of the Galapagos and honey-creepers (Drepaniidae) of the Hawaiian Islands. The moas (Dinornithi-formes) and wattle. birds (huia, saddleback, and kokako) may be the result of adaptive radiation in a distant archipelagic stage of New Zealand's history (Fig. 3). The alternative hypothesis of "ecological speciation" of a single invading stock is unacceptable to those who believe that a stage of geographic (spatial) isolation is necessary for speciation,

Such phenomena in the ancient history of faunas of restricted areas are significant to the ecologist whose interest is the present relationship between organisms and their environment. Even without the presence of an allied species to stimulate ecological divergence through the Gause principle (that no two organisms can co-exist with precisely the same ecological requirements), an isolated population will diverge from other populations of the same species because no two isolated areas are exactly the same in their ecology. We should thus not expect the ecology of an isolated population to agree with that of other populations of the same species.

The genetic effects of isolation in restricted areas are well-known. "Drift" leads to non-adaptive divergence from the parent stock, and the selective peculiarities of the insular environment also bring about adaptive changes. Where competition is low, predators scarce or absent, and genes favouring low dispersal are at a premium, vertebrates can take the physiologically economical course towards larger body size. In island birds parallel changes to wards gigantism, sedentary habits, ground feeding, flightlessness, rounded wings, enlarged legs, and small egg-clutches all seem to result from decreased selection pressure. Members of ancient island faunas thus occupy restricted "adaptive peaks" and extinction follows changes to which continental populations can adapt themselves.

Restricted areas are loci not only of *primary endemism,* as already considered, but also of *secondary endemism,* through the persistence in isolation of organisms formerly widespread such as *Sphenodon* in New Zealand's outlying islands, Dipnoi and ganoids in ancient river systems. The age of the distribution pattern of a species must not be confused with the age of the species itself. The island snipe *(Coenocorypha)* are confined to the outlying islands of New Zealand (islands off Stewart Island, Chatham, Antipodes, Snares, and Auckland Islands), but a former distribution on the main islands of New Zealand must be inferred in any rational explanation of this peripheral distribution. The genus is represented by separate races on. each of the island groups it inhabits and these are the local effects of *primary* endemism. *Stilbocarpa* seems a comparable case in plants.

We study the organisms of an environment that is constantly changing. As ecologists we see but a single frame or two in a motion picture and our single frame can give a misleading idea of relation of organic distribution to environmental factors. The gradual process of extinction often involves the break-up of a continuous range to form, in fact, 'transitory "relict areas," of short potential duration. Instances are the "islands" of *Nothofagas truncata* in North Auckland, the limited distri- bution of the native frogs *(Leiopelma)* in the North Island and Stephen Island, and the restricted area in which *Notornis* survives in the Murchison mountains of Fiordland. Are these areas restricted for any other reason than that they represent residual distribution islands of a dwindling range–a single frame in our motion picture film? Doubtless there are ecological reasons for the precise localization of relict populations of a species within its once continuous range, but it is probably misleading and incorrect, for instance, to correlate the distribution of *Notornis* with the particular combination of topograph-ic, climatic, and vegetational charact-ers of its last remaining habitat, when there is ample evidence for its former wide distribution in many other types of environment (lowland, coastal, North Island, etc.).

DISCUSSION

In reply to a question by *G. A. Knox* whether there is evidence of subspeciation or double invasion in New Zealand lakes, *Professor Percival* replied that, though information is scanty in both rotifera and copepods, there are restricted local representatives of some cosmopolitan species. Lakes, like islands, can be classified according to their stage of evolution rather than by their temporal age. Pearsall showed how they are affected both by the wearing down of surrounding country and, in recent centuries, by human habitation. In New Zealand, primitive glacial lakes and highly evolved shallow ones can occur in the same region.

I. D. Dick's inquiry as to exactly which Sewall Wright effect had been referred to was answered by *Mr. Tarbott,* who emphasized the requirement of an extremely small isolated population.

Mr. Fleming said that the initial sample of the parent population colonizing an island is small and may be atypical. A small population has a small pool of variability for selection to work on. Fluctuating population may give the same opportunity.

Dr. Rattenbary pointed out that it is the size of the breeding population not the number of individuals that is important. Islands give opportunities for random fixation, especially if subdivision reduces the breeding possibilities.

Dr. W. M. Hamilton drew attention to the fact that in crops man induces a degree of insularity by his system of breeding, aiming at retaining sufficient variability for selective adaptability in any district.

Forest on Little Barrier Island has been considerably modified from its virgin state, especially in the more accessible parts. The kauri forest there resembles that of Coromandel Peninsula rather than that of North Auckland. Many plant species abundant on the mainland 15 miles distant or on Hen Island 20 miles away are absent.

Dr. Baylis remarked that, if an island community that originally established by long range dispersal is opened up, one might expect the same species to arrive again, but instead something quite different may come—*e.g.*, the tree *Meryta sinclairii* and the Australian grass *Chloris truncata* on the Great Island of Three Kings, though neither of these has colonized disturbed areas on the main land opposite. *Dr. Hamilton* instanced the appearance on tracks on Little Barrier Island of mainland plants not known elsewhere on the island.

Mr. Knox pleaded for more investigation of the effects of organisms on one another, but *R. A. Couper* thought a study of temperature requirements of plant species a more urgent need. On this point, *Mr. Fleming* questioned whether temperature requirement of a single plant species is really significant (*e.g.*, in defining the natural southern boundary of kauri) or does the community (kauri forest) progress as a whole? Does double invasion occur in plants?

Commenting on this, *Dr. W. R. B. Oliver* said he thought plant associations could travel as a whole, instancing Lord Howe Island which derived its flora by a previous land bridge from the direction of New Caledonia.

V. D. Zotov based his conclusion that species travel independently of one another on a comparison of the grasses of the subantarctic islands with those of the alpine vegetation of the mainland; the number of species per square mile is about what would be expected on the basis of randomness of distribution.

Mr. Fleming considered the forest vegetation of the Auckland Islands as transoceanic, containing only parts of the parent communities. The endemic tussock and fell-field may have a more ancient history. Woody vegetation could not exist during glaciation which was extensive and it is unlikely that there has been a land connection, since that time. The rata forest is therefore the result of independent colonization by its component species.

Mr. Elder regarded the Volcanic Plateau as an ecological island or series of islands, with species migrating into it and some endemics round the southern and eastern borders, and *S. H. Saxby* pointed out that ecological islands can be recognized in farmed land. Every pasture is in fact a separate ecological island, with a distinctive history and plant cover.

Miss L. B. Moore referred to the endemic carnivorous bug recorded on the Great Island of the Three Kings by Dr. Woodward and wondered if the probable habitats throughout the North Auckland Peninsula had been as carefully searched as has the limited and now rather well-known area of the Great King. However, *Mr. Turbott* gave an assurance that there was little likelihood of the bug having been missed on the mainland. The session ended with some further discussion of the Sewall Wright effect as illustrated by this bug.

THE WESTERN TAUPO PROJECT

CHAIRMAN: DR. J. T. SALMON

THE SOILS OF WESTERN TAUPO

I. L. BAUMGART

THE Western Taupo region is not well known to most people and the accompanying map (Fig. 4) will help to introduce this programme. The main geographic features of the region are:

(1) *Roads*

(a) Tokaanu-Taumarunui road, running west from the south-western corner of Lake Taupo.

(b) State Hydro access road running from the Taumarunui road northward to Tihoi, parallel to the western shore of Lake Taupo.

(2) *The cliffed western coast of Lake Taupo. The* cliffs are mainly 300 to 400 feet high and' are broken by the deltas of the Tokaanu, Kurutau. Whanganui and Waihaha rivers.

(3) *The forest edge*. Fingers of forest run down the valleys right to the lake edge from the main forest mass.

(4) *The crest of the Hauhangaroa Range,* which is the western boundary of the area studied and is the western watershed of the Lake Taupo catchment area.

Geology

The Hauhungaroa Range has a greywacke *core* overlain by Tertiary sediment, on the west side and ignimbrites and rhyolites on the east. There are steep slopes immediately to the east of the crest and moderately steep hilly country on the dissected sloping ignimbrite further out. Nearer to the lake the pattern of dissection is wider, with the streams flowing in narrow steep-sided gorges, with broad flat plateaux in between. The plateaux terminate in cliffs, generally attributed to faulting, at the lake margin.

On this landscape fell a series of volcanic ash showers. The Mairoa ash, from the west—a yellow brown sandy loam—was overlain by an andesitic shower from Mount Tongariro—a reddish-brown sandy loam which outcrops on the surface in many places. The Tongariro shower varies in depth from four feet in the south to six inches in the north of the area under discussion. At a much later date, a series of violent rhyolitic eruptions from several vents around Taupo deposited layers of hot pumice ash over the whole of the central North Island. Over the area under discussion there is an almost continuous mantle of Taupo pumice, thick and coarse near the southern end, thinner and finer and much eroded to the north and north-west. A typical section through an undisturbed pumice deposit is vertically sorted according to particle size—gravels, underlying sand dunes underlying fine sands and silts.

The great Taupo eruptions apparently destroyed all the vegetation in the area. Surface water rapidly eroded the loose pumice; except on flattish surfaces the pumice ash was washed off, collecting in valleys and depressions, choking streams and causing them to build high terraces, Broad, wash-filled flats and high terraces, into which the streams have rapidly re-entrenched, are characteristic of the landscape.

Mount Ngauruhoe is still depositing fine andesitic ash over the southern end of the region. It is about four inches deep near the Kurutau river and about one inch deep at Karangahape.

Soils

South of the four-inch Ngauruhoe ash-boundary, topsoils are formed from andesitic ash and subsoils from rhyolite ash. North of the one-inch boundary, the soils are virtually formed from rhyolite ash. Between the four-inch and one-inch boundaries, the soils intergrade between the two suites.

On lake edge cliffs and steep valley sides the soils are constantly moving and being renewed. These are skeletal soils.

On the plateaux the ash showers are practically undisturbed. A typical profile on a plateau has five feet of pumice sand on two feet of pumice gravels. The vegetation is sparse and open. There is a shallow light grey topsoil and the soil is moderately leached.

On rolling and moderately steep slopes much Taupo pumice was washed away and broadleaf forests became established on the underlying ash showers. Following burning, bracken, tutu, manuka, and some five finger and kamahi are now found. Topsoils are deep and rich in raw humus and the soils are only weakly leached.

The wash-filled flats and river terraces are formed of unsorted pumice. The vegetation is mainly *Poa* tussock and *Dracophyllum subulatum.* The pumice fragments are frequently tightly compacted, forming an impervious layer about eight inches below the surface. The vegetation and micro-climate cause strong leaching and iron and humus move down, to be redeposited on the compacted layer, still further cementing it. The soil profile is very shallow.

Near the forest margin, under bracken and manuka on rolling slopes, the soils are browner and there are patches of strongly leached to weakly podsolized soils, similar to the condition just inside the forest edge, indicating that the forest edge has been pushed back, presumably by burning.

Where the forest edge is advancing through ecotones, soils are strongly leached to weakly podsolized.

Fig.4.—Sketch map of the Western Taupo area which was the subject of discussion.

Behind the ecotone, where there is a fairly close stand of podocarps, the soils are moderately podsolized under strongly mor-forming trees (*e.g.,* Hall's totara, rimu) and weakly podsolized under *Suttonia, Pseudowintera,* kamahi, etc.

Higher up the range, there is a two tiered podocarp-broadleaf forest.

Under the podocarps the soils are strongly podsolized. Many of the broadleaf species would be expected to have reconditioned the podsolized soil, but this is not so. Apparently the severe climate has kept the process more or less in equilibrium.

On the summit of the Hauhungaroa Range, under the low wind-shorn scrub, the soils are very strongly leached with deep and diffuse iron and humus accumulations. Rainfall is high, and weak gley conditions show throughout the profile, indicating that the soils are close to the zonal gley group. This "end point" indicates the direction in which climate alone, apart from the effects of vegetation, is carrying the soils.

THE VEGETATION OF WESTERN TAUPO

A. P. DRUCE

PODOCARP-BROADLEAF forest extends down the eastern side of the Hauhungaroa Range, generally ending about five miles from the lake shore. The forest canopy is irregular, with podocarps unevenly distributed and smaller broadleaf trees between the larger rimu, matai, miro, and totara. This irregularity is most marked above 2,800 ft. where *Podocarpus hallii* projects through a dense forest of *Griselinia,* kamahi *(Weinmannia racemosa),* etc. The highest parts of the range are covered by dense scrub. Apart from some black beech *(Nothofagus solandri)* on the cliffs near the lake, there is only one small pocket of beech (silver beech, *N. menziesiil* in a tributary of the Waihaha river.

Between the podocarp-broadleaf forest and the lake are many different types of vegetation, notably *Dracophyllum subulalum* scrub, silver tussock (in the north), low turf, forming vegetation, manuka scrub, bracken, tutu scrub, kamahi forest, and monocotyledonous mire vegetation. Everywhere there is evidence of burning, with vegetation at many different stages of development. Identical or similar types of vegetation recur at frequent intervals and generally may be correlated with topography and the time since the last burning. Grazing animals have also affected certain types of vegetation. Silver tussock *(Poa caespitosa), Dracophyllum* scrub and low turf-forming vegetation are found on flats and gently undulating country, manuka scrub on medium slopes and flat tops, bracken-tutu on steep slopes, mire vegetation in valleys and kamahi forest in all stages of development from manuka and bracken-tutu scrub.

Bracken, manuka, and broadleaf trees and shrubs are almost absent from flats and manuka is often seen dying back on the edges of flats. The peculiar nature of the vegetation on the flats (Fig. 5) has been attributed to severe frosts, but it has been shown that this vegetation type is not confined to flats and can be correlated with the resorting of pumice by water. The manuka appears to die because of physiological drought, although there may be adequate moisture in the soil. Branches die off more on the windward (westward) side of the shrubs than on the leeward.

–R. M. Greenwood, photo.

Fig. 5.–Upper Waihaha, Western, Taupo. Manuka scrub. (mainly Leptospermum scoparium*) on gentle slopes surrounding an area of* Dracophyllum subulatum *scrub on a small flattish area, that has resulted from the infilling of a valley with pumice from adjacent slopes. Podocarp forest in the background.*

Dacophyllum scrub and silver tussock may be regarded as edaphic sub-climax types of vegetation, degrading to low turf-forming types if burnt and grazed but never developing to higher types until podocarp forest advances across them. Manuka and bracken-tutu scrub develop into kamahi or kamahi-rewarewa forest if left unburnt for a sufficient time: *Gaultheria antipoda, Hebe salidolia* and kamahi are early associates of manuka, whereas in bracken tutu development *Nothopanax arboreum* and *Pittosporum (P. tenui folium-colensoi* complex) are prominent.

Within the main podocarp forest there are "clearings," isolated areas of vegetation similar in nature to the types found outside the forest. The largest "clearing" is Whenuakura Plain which is about five miles long and half a mile wide. Within this plain are a number of "islands" of forest.

Examination of the ecotones (transition zones) between the podocarp-broadleaf forest and the other types of vegetation at the main forest boundary and around the "clearings" and "islands" shows that the forest has been advancing in the recent past, and despite extensive interference by burning and by browsing and grazing animals, is still doing so in places. The ecotones characteristic of advancing forests are generally narrow 'belts showing a number of successional stages from one type of vegetation to another *(lineal* ecotones, as opposed to *mosaic). Pyrllocladus alpinus* and/ or *P. trichomanoides* are invariably present and prominent towards the outer part of these ecotones. *P. alpinus* is the only tree of importance that can lead to the development of "islands" of podocarp forest away from the main forest.

Seed dispersal is not the limiting factor in podocarp broadleaf forest spread on the pumice country. The proximity of a forest could modify the light intensity, humidity. soil moisture, surface litter (and hence' soil micro-organisms and pH of the' soil), and mycorrhiza, thus preparing the way for its advance.

Marginal forest advance, where forest advances across other vegetation, is to be contrasted with development over a wide area, where forest develops through other vegetation and the limiting factor is seed dispersal. Entirely different forest types result from the two types of development in the Western Taupo area.

The principal types of podocarp forest in the area may be designated as matai dominant, *Podocarpus hallii* dominant. Matai-miro dominant and rimu dominant. These main forest types are generally found, respectively, on flats, on all slopes in the higher country, on undulating country, and on steep slopes and knolls. Each type of forest has its own distinctive ecotone, and it would appear that, as the forest has advanced, the ecotones and the forest developing within the ecotones have changed according to the topography, particularly as it affects the depth and nature of the pumice deposits.

History of the Vegetation since the Taupo Rhyolitic Pumice Showers

It is almost certain that all the vegetation was destroyed by the hot pumice showers. Forest was present before the pumice fell but its extent is unknown.

The first sub-climax types were probably *Dracophyllum* scrub and tussock grassland. Manuka may have come in at the lower levels, particularly on cliffs and steep faces, but most of the present manuka country was probably tussock-grassland before human interference. Bracken has probably become prominent only through repeated burning. Forest development most likely began in gullies on the slopes of the Hauhungaroa Range, at first non-marginally and comparatively rapidly, later marginally and more slowly. The "clearings" are relict areas of *Dracophyllum* scrub, tussock and mire vegetation on pumice plains that are still in the process of being invaded by forest.

The characteristic irregularity of the podocarp canopy is the result of restricted regeneration of podocarps. Everywhere broadleaf forest is tending to replace podocarp forest. No extensive regeneration of podocarps can be expected on land that has already had podocarps on it for some time. New podocarp forests can develop, by marginal spread, only on "new" country.

BIRDS AND MAMMALS OF WESTERN TAUPO

P. C. BULL

THE Western Taupo region bas a varied assemblage of introduced mammals. There are wild cattle, horses, cats, and dogs which are perhaps a legacy from abandoned farms. The remaining mammals have spread into the region from more distant points of liberation. They consist of pigs, deer, hares, rabbits, stoats, ferrets, rats (black and brown), mice, and opossums. Opossums have a very restricted distribution and hedgehogs have not yet been recorded although they are present nearby. A species of that has been seen in two localities but has not been identified.

There is a rich bird life including most of the common native species and some of the rarer ones, such as kakas, parakeets, robins, fernbirds, grebes, and blue duck. Kiwis are now very rare or absent. and wekas, once numerous, were not found. Except for magpies and mynas, all the common introduced passerine species are present, but most of them are far more numerous in more closely settled areas nearby. Blackbirds, red polls, thrushes, and chaffinches are the only species which are numerous and widely distributed. In several species (especially fantails) there appears to be a winter movement to lower altitudes. It is of interest to link such birds as native robins in fairly large numbers, despite the presence of introduced predaceous mammals. According to an old inhabitant, the wekas all disappeared following the arrival of stoats in the region, about 1912.

Maoris have lived in the area since pre-European times but during more recent years they have drifted away to larger centres of population, until the only ones remaining are to be found in timber mills and public works camps. There was a brief out. burst of farming activity after the first world war but the farms were later abandoned and their stock probably gave rise to the present wild cattle and horses.

Probably the main influence of Maoris was the use of fire for clearing ground for cultivation and for keeping tracks open. The Rush of new growth after fire would probably provide attractive food for the herbivorous animals. It is likely that the present distribution of rabbits is related to fires of the past. In connection with rabbits, the distribution of the rabbit stomach worm, *Graphidium strigostrum,* is of interest. It is absent in rabbit populations south of Tokaanu and only ten miles separate *Graphidium*-positive from *Graphidium*-negative populations. It may be at present spreading northwards. Pigs were doubtless introduced by the Maoris at an early date.

Since the last war there has been a fresh outburst of activity in the area. State Hydro interests have built a road, new timber mills have sprung up and land development schemes are in progress. The increased human population has resulted in a severe hunting pressure On the larger mammals such as deer, cattle, and pigs. Fire protection has allowed the encroachment of scrub on areas of short vegetation and land improvement has produced a limitless supply of high quality food for grazing animals. All these factors may be expected to alter the numbers and distribution of the various species of birds and mammals. For instance, will the native robin, which persists in good numbers at present, despite the presence of rats, cats, and stoats, continue to thrive after timber mills have worked through the forest. There is already evidence that the skylark advances to the detriment of the native pipit wherever land development has replaced scrub country by grasslands.

To sum up, the main features of the area as regards birds and mammals are:

(1) A rich and healthy native avifauna from which only a few species have been lost, despite the presence of introduced predaceous mammals and introduced birds.

(2) A diverse collection of introduced birds, of which only four species appear to be thoroughly at home in this environment, and a similar number recorded occasionally.

(3) A varied assortment of introduced mammals.

Future prospects include the removal of timber trees, the conversion of some scrub covered country to pasture, and increased hunting pressure resulting from a larger human population and better access.

In general, the changes in vegetation are likely to favour introduced species and there is thus an opportunity now of studying faunal changes which passed unrecorded in other parts of New Zealand several decades ago. The setting aside of a substantial reserve as a control is essential if full advantage is to be taken of the opportunities which now offer for ecological research.

SUMMING-UP AND CONCLUSIONS

A. C. S. WRIGHT

THE ecological reconnaissance of Western Taupo was initiated for several reasons, The first was simply to tryout the idea of using soil data –a soil map– as the base map for an ecological survey. I have, on occasions, felt disturbed to find that painstaking ecological work has been done in other countries without reference to soil pattern, or invoking soil data only to explain some unconformity at a late stage in the investigation. In setting out our project, I made this assertion: that the soil map is the only logical base map f*o*r ecological surveys dealing with land habitats and even land-locked bodies of water. Now that you have heard the findings of my colleagues, I hope that my initial assertion will provoke comment.

The second reason involves tl obvious suitability of the area for ecological research. There can be few places in the world with a distinctive (and restricted) flora and fauna. modified by man in quite recent times. Then abandoned by him, and now very recently reinvaded. Western Taupo is a region where communities and habitats can be discerned without difficulty. Where the indigenous ecological factors can be evaluated closely and where the effects o f induced factors can be clearly distinguished. What better place for trying out our survey technique?

Thirdly, there was ample evidence that much of this region was shortly to succumb to the onward march of farming. At either end, large areas were being converted from fern and scrub to rye-grass and clover pastures. It is not inconceivable that problems will arise whose origins relate back to obscured indigenous factors, the key to which will be found readily from our ecological maps. These maps. which unfortunately could not be completed in time for this conference; comprise:

(1) A map showing soil types.
(2) A map. showing the existing vegetation pattern.
(3) A map showing the main types of habitats classified according to their ecological relationships.

Future work in this area will largely depend on ideas brought out in the discussion. At present, it is unlikely that any further Government-sponsored research will be undertaken in the area. I hope that some of you may be tempted to carry on where we must leave off. To cite an example: to me it seems evident that we should know more about the adverse soil factors which restrict the spread of ecotone species and prohibit the growth of other species where the rhyolite pumice has been resorted by water. You will have noted several other problems mentioned, in passing, in the papers given by my colleagues–there are plenty worthy of investigation by microbiologists. botanists. and zoologists. .

This brings me to an important consideration- Should we not make a move to have a portion of this region set aside for biological studies? Is the area so large that we can safely assume that we will always he able to, find some area representative of the habitat that we wish to study, or should we recommend that some portion embracing a large number of ecological units be declared a reserve? Any move would have to be made in concert with the Forestry Department. which has jurisdiction over most of the forested watershed. And indeed, any chosen area might, with the concurrence of the Forestry Department. he declared a Forest Reserve. If this proposal meets with your approval, I would recommend that a strip from one to two miles in width extending along the banks of the Waihaha River from its mouth to its source be considered for reservation. A fire break would and southern boundaries of the reserve, at least as far inland as the edge of the forest.

If discussion indicates that there is general approval for a move to secure a reserve in this area, you might consider the suggestion that a small subcommittee be elected to open discussions with the Forestry Department and report progress to the members of this Society at a subsequent meeting.

DISCUSSION

A. L. Poole: Emphasizing Mr. Wright's third point in his summary. I would like to add that the prime reason for commencing this project was because the outline of the, original vegetation pattern can still be seen in an area where development, either for forestry or for agriculture, will be shortly taking place. Thus, there is the opportunity of studying for the same area, the two states of communities. feralarch and hemerarch, mentioned bv Mr. C. M. Smith in his address. A 'soil survey of the open country of West Taupo has been carried out. and it was considered opportune to have vegetation survey to accompany it. The study of the feralarch communities of the open country is, however, complicated by the amount of burning that has taken place.

An example of the successful use of this type of comparison is to be seen in J. Ure's work in the Kaingaroa State Forest *(N.Z.J.Forestry, 6* (2),1950). This forester, using simplified plant sociological methods, compared the natural vegetation to be found in fire-breaks, etc., with exotic forest tree growth. He found that the natural vegetation is a certain indication of the forester's site qualities—quantity and thriftiness of tree growth—in the stands of exotic trees. Whether or not the method can be used in agriculture remains to be seen.

Considering the vegetation itself, the main feature is that the pumice showers must have destroyed most of the vegetation, possibly largely forest, except for isolated pockets. The first vegetation to reappear apparently consisted of low-growing communities—tussock grassland, etc. But the climate is essentially a forest climate and forests have been advancing across the country ever since.

These forests vary in nature according to the type of pumice deposit they have migrated across. An important point is that they alter the soil *as* they advance and form their own soils. The advance of the forest is through specialized communities—ecotones. In commenting on Mr. Druce's classification 'of ecotones, *lineal* and *mosaic,* he might well have classified them *into natural* and *interfered with*—or *feralarch* and *hemerarch*—because his categories correspond with these conditions.

The recognition of this basic vegetation pattern and estimating its effects are important in attempting to do anything with the forests. For instance, foresters would like to know the mechanism of the ecotones because the podocarps regenerate in them and not in the forest behind. We would like to know the rate of progress of forest migration; and so forth. Thus a list of problems arise from this project.

D. F. Hobbs: Some economic justification for the proposed reserve might be helpful. The proximity of the Taupo fishery and the work and problems in connection with it might be helpful. With the exception of the Whareroa stream, which is an important spawning stream, all the streams in the area are impassable to migrating trout. There is the botanical interest, concerned with the necessary vegetative cover on the stream banks to ensure food supply. The dense vegetation on the banks of many of the streams protects trout from anglers and poachers. The amount of fish which is buried every year on the beaches provides food for rats and pigs, which also feed on dead trout.

V, D. *Zotov:* Referring to Mr. Druce's observations on the advance of the forest, there is evidence from the floristic side. In the volcanic plateau below the timber line, there are a number of species of the tussock country type the same or similar to those found in South Island tussock country. It is impossible to compare the species statistically, since the boundaries of the original grasslands are not known, but the evidence suggests that the grasslands were always present in the area on to which the forests are now advancing. Referring to the proposed reserve, it would be better to select a whole catchment area, without reference to any particular stream, or the fish in it.

In reply to a question from Mr. Elder, *Mr. Druce* said that, besides its importance in the ecotones, the means by which podocarp forest advances, *Phyllocladus alpinus* is also capable of non-marginal spread. A *Phyllocladus* forest may develop through other types of vegetation on an alluvial flat, but it is noteworthy that in this case *no* young podocarps come up through it. *Phyllocladus alpinus* forest can also develop *non-marginally* on pumice banks and cliffs. From these situations it spreads out *marginally* on to flatter ground and young podocarps begin to appear. New areas or "islands" of podocarp forest are thus initiated.

Prof. E. Percival: Referring to the proposed reserve, it would be advisable to make use of the proximity of the Taupo fishery as the Society may thus secure the backing of other bodies interested in the fishery.

Mr. Hobbs: The more support that can be obtained the better. But fisheries should not necessarily be the focal point of interest. In the region are some of the few streams in New Zealand where trout have *not* been liberated and anything that the Society could do to get them set aside as a reserve would be very useful.

Mr. Poole: Part of the forest in the area is owned by the New Zealand Forest Service and part of the open country by the Lands and Survey Department; a substantial part of the forest and open country is Maori land and it would probably be easier to obtain land for reserve from the Forestry or Lands and Survey Department.

R. K. Dell moved that the Council be instructed to approach the New Zealand Forest Service with a view to setting aside a certain area in the Western Taupo area as a forest reserve. He was seconded by *K. R. Allen. Miss L. B. Moore* moved an amendment, seconded *by J.* S. *Watson,* that the meeting should appoint a small committee from among those present to investigate and report back to the Council. The amendment was lost and, after some further discussion the original motion with some minor alterations in the wording, was passed in the following form: "That the Council be instructed to investigate the possibilities of approaching the appropriate Departments with a view to setting aside a certain area in the West Taupo region as a biological reserve, and to take appropriate action."

The *chairman* (Dr. J. T. Salmon) in closing the discussion, said that the points raised by Mr. Hobbs and the survey which had been presented by Mr. Baumgart and his colleagues showed that the investigation of the microbiology of this area should yield some interesting and valuable results, and he hoped that the investigation would be able to be continued and that further reports would be presented at subsequent meetings of the Ecological Society.

BUSINESS MEETING

CHAIRMAN: K.R. ALLEN

THIS was held at 4.30 p.m.m on May 20 at the close of the discussion on "The Estimation of Populations." Despite the rather inconvenient time, about fifty members attended the meeting. Most of the time was occupied by discussion of the Rules under which the Society would operate. As finally adopted, they contained only minor amendments in the draft submitted by the Provisional Committee. Of the two alternative methods for the election of Council, that of election at the annual general meeting was chosen.

The election of officers and council for 1952-53 resulted as follows:

President: K. R. Allen.

Vice- presidents: Miss L. B. Moore, Prof. V. J. Chapman.

Secretary-Treasurer: K. E. Lee.

Council: G. A. Knox, Prof. B. J. Marples, Dr. R. V. Mirams, G. B. Rawlings, S. H. Saxby, J. S. Watson.

Hon. Auditor: Mrs. R. M. Allen, A.R.A.N.Z.

Two vice-presidents were elected because of the vacancy caused by the non-existence at present of an immediate past-president.

Discussion on the location of the next annual conference resulted in a decision to leave the matter to the discretion of the council.

It was announced that so far only about eighty members had completed the questionnaire as to their ecological interests and activities, and that, if the proposed register were to be effective, a much more complete return was essential.

The meeting closed with a hearty vote of thanks to the Victoria University College authorities' for making available the excellent accommodation which had contributed so largely to the success of the meeting.

PERSONALS

Appointments:

Prof. J. C. ECCLES, M.B., B.S., M.A. D.Phil., F.R.S.. F.R.S.N.Z., Professor of Phisiology at the University of Otago, will take the physiology chair at the John Curtin School of Medical Research at Canberra in August.

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The Minister-in-charge of scientific and Industrial Research recently approved the appointment of five new members to the Technical Advisory Committee of the Dominion Physical Laboratory. The Committee was previously reorganized just after the last war, and its purpose is to advise and assist the Director of the Laboratory on matters of engineering and physical research. The new committee consists of L. B. HUTTON (chairman), F. T. M. KISSEL (deputy-chairman), R. SLADE, K. PALLO, A. P. O'SHEA, P. LAING, G. R. HOPE, Dr. E. R. COOPER, and Professors F. C. CHALKLIN, R. R. NIMMO, and N. A. MOWBRAY.

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C. S. M. HOPKIRK, D.V.Sc. (Melb.), Veterinary Adviser to the New Zealand High Commissioner in London since 1948, who had retired after 40 years service with the Department of·Agriculture, in which he Was formerly Superintendent of the Wallaceville Animal Research Station, has accepted an appointment. as Mission Chief in Ethiopia for the Food and Agricultural Organization of the United Nations. His appointment in Ethiopia is for one year, with the option of renewing it for a further term. In 1945 Dr. Hopkirk was appointed senior veterinary officer for Unrra in Europe and China. One of his most important tasks was to plan the establishment of a veterinary division in Ethiopia. Dr. Hopkirk was invited to implement his plan, but declined the position then offered him.

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Honours and Awards:

R. H. THORNTON, who was granted a National Research Schollarship in - 1949, after graduating M.Agr.se. at Lincoln College, has gained a doctorate of agricultural science at Nottingham University. He is expected to return to New Zealand in Septem-ber to rejoin the staff of the Soil Bureau, D.S.I.R.

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Lt.-Com. B. M. BARY, M.Sc., formerly Lecturer in Zoology, at Victoria University College, and a. presenter in England as a member of the Defence Scientific Corps (R.N.Z.N.), has been awarded a Ph.D. bv the University of New Zealand.

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C. A. FLEMING, B.A., M.Sc., F.R.S.N.Z., Senior Paleontologist, New Zealand Geological Survey, and first N.Z.A.Sc.W. Research Medallist, has been awarded a D.Sc. by the University of New Zealand.

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W. A. MCGILLIVRAY, M.Sc., Ph.D., Lecturer in Biochemistry at Massey Agricultural College since 1946, has been elected a fellow of the New Zealand Institute of Chemistry.

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A. G. MACDIARMID, who is at present studying for a Ph.D. degree at the University of Wisconsin on a Fulbright grant, has been awarded a Dupont Research Scholarship at the University. Mr. Mac Diarmid graduat-ed M.Sc. with first-class honours in chemistry from Victoria University College in 1950.

CORRESPONDENCE

BEES AND CLOVER

SIR,—

Shortly after reading Professor Montgomery's paper on bumble bees and red clover [April, 1952, issue. p.47] 1 read Haldane's book "Every thing has a History." A section of this book is devoted to this subject. Haldane states that, as bumble bees are generally not in sufficient numbers to fertilize red clover, it is necessary to place throughout fields of red clover glasses containing a sugar solution and red clover blossoms. Some ordinary bees are attracted to this scented sugar solution, which they report to their hive mates. Some of these find the sugar solutions. but most of them discover the flowers of the surrounding red clover. Consequently, most of the red yield of clover seed greatly exceeds the expenditure on sugar. As I know little about this subject, I am not competent to judge the efficacy of this method. Perhaps it is a well. known method among the farming community in this country. I put it forward because it does seem to have some merit. At any rate, I hope that this letter does start a discussion on this interesting subject.—Yours etc.,

W. V. HEAZLEWOOD.