in check mainly as a result of flooding and by parasitic wasps and flies, which reduce the numbers of subterranean larvæ.

The high level of hedgehog population can also be attributed to the long mild summer, which enables them to have two or three litters a season. Large numbers of snails, millipedes, and slugs provide them with an abundance of food and contribute to their success. It is difficult to estimate which factors hold the hedgehog population in check. There is some evidence which suggests that most hedgehogs die during the winter. This cannot be the result of starvation because of the abundance of food at that time of the year. Predation and parasitism play a negligible role. Diseases such as pneumonia probably play an important part, and it is likely that many hedgehogs are drowned in their nests during hibernation.

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Discussion

The eight speakers of the morning session formed a panel under the Chairmanship of MR. GIBBS, and the discussion, which was inaugurated by N. T. MOAR, took the form largely of questions from the floor and answers by the panel, and the following additional points were covered.

MR. COWIE said that the size of sand grains is controlled by the velocity of the wind: the higher the velocity the larger the grain that can be moved; but he had no special information on wind direction or on average wind velocity. In the north the grains are composed mainly of ferromagnesium and magnetite; south of the Manawatu River you have greywacke and tertiary quartz. On the formation of dunes, he said that in the low rainfall areas, where the regeneration of plants is not good, there will always be some drifting; further south, with increased rainfall, the dunes are more parabolic and tend to be parallel to the foredune. The most stable dunes are parallel to the prevailing wind. Where vegetation has been removed, you get crescent-shaped dunes and not much development of the sand plains. Fairly strong wind, from a steady direction, and patchy vegetation, are necessary for the development of these dunes in this district by blowing out. Where there is an increased supply of sand, and where the wind is stronger, the dunes become longer and stream out inland. The dunes are widest from about Santoft down to the Manawatu River, but further south, with better vegetation and higher rainfall, they seem to be backed up and not to have streamed in so far. He said he had no regular measurements of moisture in the soil. In the wetter parts water would be not more than 2 ft. below the surface; in the higher parts up to 7 ft. below.

MR. HOCKING said, without having actual measurements, he thought the sand was coarser up towards Wanganui, possibly because of the remoteness of the hills further south. On the local effect of vegetation on the water-table, he said you could permanently lower the water-table in wet flats and swamps by planting the surrounding hills in trees, provided water is not creeping in from an extensive source beyond the sand. You might thus change a swamp site into very favourable conditions for growing trees. Where the water is coming in off the back country the trees probably have no effect.

MR. SAXBY said that, because of the differences in vegetation produced by slight variations in the water-table, the farming practice was to sow the same mixture over an area, and it would sort itself out. From the pasture point of view, control of abrasion was very important; crops must be established before sand started blowing. Pasture associations were sometimes sown with very quick-growing annuals so as to lessen the movement of sand and the danger of abrasion to young plants.

C. W. S. VAN KRAAYENOORD described an experiment now in progress to measure the water-table and maximum and minimum temperatures in the soil, and to correlate these with vegetation. He emphasized that, although drains had to be cut in the very wet places, there was very real danger of over-draining; it is possible to spoil 50 acres of good pasture in trying to drain a wet patch of five acres. He suggested that boards might be placed across the drains in September or October to conserve water and retain the level. He spoke of smoothing off dunes into the hollows: he knew a farmer who bull-dozed off the tops with their vegetation, into the hollows, and so improved the organic content of the soil in the bottoms.

N. L. ELDER described a private venture which had met with considerable success in bringing in raupo country in Hawke's Bay. They attributed their success to getting the depth of the drains just right, not getting the peat dried out, or the subsoil drained, too completely.

MR. CARNAHAN said that botanically the dunes do not differ much from Kaipara to Manawatu. In the north *Cassinia retorta* replaces *C. leptophylla*, *Viscaria* disappears, and pohutukawa comes in as climax. Dominants are largely the same and any other changes are very minor.

MR. BROCKIE said the nests of hedgehogs have a general pattern, which may be modified by habitat or available material: usually in a dry depression, sometimes overgrown by dense shrubs, such as flax or lupin, or, in suburban areas, under or behind buildings, they are lined with grass, dried leaves, paper or rags. Nests are sometimes made in rabbit burrows. The hedgehog rolls round until enmeshed, leaving himself no exit. In sand dune country these sites are restricted to gullies

and flats behind the dunes, and with the winter rise of the water-table many nests are flooded and the occupants drowned. Most hedgehogs hibernate when the temperature drops below 50° F., the duration varying with latitude and altitude, in England six to seven months, in New Zealand three to four. Answering a query from DR. K. WESTERSKOV about the mortality from frost, he said that the hibernating hedgehog is at the mercy of the cold; if the covering blows off the nest they will not wake up. They have a very thick layer of fat under the flap, which is a protection against cold. On hibernation their temperature drops to air temperature, and varies with it. Droppings collected during the winter may be almost entirely composed of segments of millipedes; thus their stink glands evidently do not make them unpalatable to hedgehogs.

MR. CARNAHAN, replying to a point raised by DR. K. A. WODZICKI, said that competition between introduced and native appears to be less dynamic on the dunes than in other ecosystems. Dune vegetation round the world is very similar, and the introduced species have the same life forms, and the same requirements as the natives. When they come in it is assimilation rather than competition; there is co-operation between native and introduced species and to-day there is quite an intricate mixture of natives and introduced. This is in striking contrast with the rest of New Zealand, where usually the introduced and native species have different life forms and different ecological requirements, and introduced species usually only succeed where man's influence is strong. Native species come back when man's influence is removed. Only one tree—*Pinus*—and a few shrubs can survive without man.

MR. SAXBY said the number of rain-days was more important than the actual amount of rain that falls. The area out of Bulls had a lower number of rain-days, the number rising as you go south, where the shrub vegetation is right on top, or even on the seaward side, of the sand dunes.

E. A. MADDEN, also answering DR. WODZICKI, said that by ploughing, topdressing and stocking his farm, Major Wilson had provided a good example of what man's influence on the land could be with the application of knowledge, the utilization of plants, and the study of the ecological set-up. It was very different from the adjoining farm, where nothing of the sort had been done, the sand was moving in, and it was in a worse state than it was 30 years ago. Originally the two properties were the same, but one was worked and the other let go. They were in nearly the lowest rainfall area in the sand country.

MR. CUNNINGHAM said that, in the lakes, there were changes in the emergent vegetation, *Typha* being more common in the south, and being replaced by *Cladium* and *Eleocharis* in the north. *Zizania latifolia* also appears. His data on the feeding habits of shags were specific to Lake Waingata, where the little shag was common. The main foods were native fish and koura, and frogs and tadpoles when these were abundant. His only specimen of the large black shag was feeding similarly.

DR. FALLA said that these results on the little shag's feeding habits completely paralleled other stomach-contents investigations done in Rotorua, South Canterbury and the Manawatu. In two cases material from earlier investigations was found on re-examination to be native fish, and not trout. The numbers of blackbirds in the area could be reckoned to be the maximum the bird usually achieves. Thrushes were never very common in areas where blackbirds are common. As far as is known there were no indigenous amphibians in these areas. The ecological niche has been filled by the introduction of three species of the Australian genus *Hyla*. *H. aurea*, which is widespread in this country, is found in all suitable localities throughout the sand country. *H. cerulea*, which is established in South Taranaki, around Wanganui and Turakina, spreads into the northern extremities of the sand country. In 1946 an unsuccessful attempt, using live frogs, was made by Major Wilson to introduce *H. ewingi* from Westland where it is already established. Some two years later another attempt, using eggs, was immediately successful, and this species has now spread northwards twenty miles from Himatangi. The frogs seem to be important in connection with the establishment of certain birds, such as spoonbills, berons, and ibis. These have been drifting over from Australia for centuries, and their period of establishment has coincided with the introduction of frogs, which are an important item of their diet.

P. C. BULL said that the numbers of blackbirds could be explained in terms of food available to them; they are about equally fruit and animal eaters (invertebrates and berries). Their territorial limits tend to break down after the breeding season; in many cases they appear at this time to move down to the seashore at low tide.

MR. VAN KRAAYENOORD described experiments with annual lupin; not the tree lupin—*arboreus*—but *angustifolius*. The object was to find a rapid cover for areas too small to be planted in marram grass with mechanical aids. In the Wanganui area 150 acres of sand with some organic matter in it had been sown with 80 lbs. of blue lupin to the acre, and after one year it was possible to bring it back into rye grass and clover sward; it now carries three sheep to the acre, plus cattle. Blue lupin provides a complete cover, and speedily, but it is a primary cover, not a sand-binder. If it is left to seed it continues to increase for two or three years. Trials appeared to show that bare sand can be brought in provided the area is of sufficiently regular contour to be sown with a drill; irregular areas must be smoothed before sowing. Marram grass is essential for the first half-mile behind the foredune, but further inland on smoother areas blue lupin can be used, followed by drought-resisting grasses. Blue lupin can also be used where trees are later to be planted, and, being a nitrogen fixer, gives increased growth since nitrogen is the limiting factor. It may be necessary to use tree lupin to provide shelter from the wind, but it would be better to leave it out if possible; in Northland trees have been planted direct into marram grass. They were also seeking a perennial for the dry hills, replacing the subterranean clovers that die out in summer. Several strains of *Lotus* spp., *e.g.*, *L. corniculatus* (birdsfoot trefoil), are being tested on the bare sand. With their deep taproot they do not die down in summer, and also start growing much earlier. Lucernes also reduce the danger of opening up the sward again by trampling.

MR. SAXBY said that an annual that would establish quickly was very desirable and *Brassica* has been used in pasture for this purpose. Anything that will provide temporary stability while permanent sward is establishing is very useful, and blue lupin would seem to do this.

MR. CUNNINGHAM, answering a question from DR. D. E. HURLEY, said that the basin lakes between the moving dunes and the more consolidated country would be very temporary if the sand was not stabilized. The lakes are shallow, often long and narrow, and at the present time are filling slowly with wind-blown sand. Water levels are going down. To a question from R. TAYLOR about presence of native fish and koura, he said that at

some time there have been out-flowing streams going through to the sea; water levels within the basins have dropped and the outlets have become blocked. A species of *Galaxias* was present in a lot of these lakes which appeared identical with the sea-going form, *G. attenuatus*, but was apparently living happily in the lake without going to sea.

K. R. ALLEN said that overseas experience showed that with careful management of the fishing pressure such lakes could be productive down to a half or quarter acre. All these lakes are within the productive size range; it was simply a problem of fisheries management.

MR. CARNAHAN, replying to a question by MR. ELDER about the permanency of tree lupin, said it was essentially a successional plant, and as the cover becomes closer some of the higher plants shut it out. Ultimately fairly close shrub cover or coastal forest cover develops. If dunes continue to advance, lupin should continue to hold its position in the zone behind the foredune.

MR. BROCKIE said hedgehogs were most abundant in suburban areas, in intensively cultivated areas outside towns, and in sand dunes. Cover was probably the most important factor for these densities, and then food, of which snails were probably most important. Not much was known about numbers per acre, but a Russian study gave two or three to an acre as likely in the most densely populated area. They were introduced into the South Island in the 1870s, and into the North Island in the early 1900s, and spread rather slowly. They were recorded in Palmerston North in 1923, and in the 1930s began to appear in the sand dunes. In Britain there are one or two litters in a year, in Germany sometimes two. In New Zealand the breeding season, from September to June, is much longer than in Europe. The gestation period is quite short, and they have every opportunity to have several litters.

J. S. WATSON questioned whether, if the present vegetation of the sand country had existed for about 50 years, the advent of the rabbit, which had apparently only become a nuisance in the dunes comparatively recently, might have coincided with a change.

MR. CARNAHAN said there had been few changes since 1909 when Cockayne's reports and photographs were published. There could have been considerable quantitative changes, but the composition does not seem to have changed. In the South Island rabbits tended to be associated with wild irishman. North of the Rangitikei River this plant normally occurs in fair-sized bushes, but south of the river there is very little of it, miserable specimens on little mounds frequented by rabbits.

MISS MOORE said that Cockayne's reports gave no indication of a change just before they were made, and so the reports might have applied equally well in the 1880s. She had found the report of competition between *Mariscus* and the rye-grass-plus-white-clover pasture surprising; she had thought it associated with poorly drained places, and restricted to that type of habitat. A precise knowledge of the ecology of *Mariscus* would have both practical and theoretical interest.

MR. SAXBY said that at Flock House *Mariscus* appeared to be invading country which would support the best pasture. MR. CARNAHAN said it was growing on grazed areas on Kapiti, and he had seen *Carex secta* growing up a hillside on grazed ground. Both these plants are usually found on swampy places, but under grazing are invading drier ground.

DR. FALLA said that black swans are present on all but the smallest lakes in the sand country and plentiful on the estuaries. They fly up seasonally from the large concentrations on Lake Ellesmere, following two flight lines, one to the Manawatu, and one to the Wairarapa. The resident population is small through lack of extensive shallows. The revival of seeds from the droppings of birds was known to occur, and he gave instances of the arrival of Australian birds that had been blown over.

MR. MADDEN said that, apart from the forestry, the tendency in pasture land development seemed to be to concentrate on two or three species, but the symposium had shown that with the range of habitats occurring we should not attempt to grow two or three species only, but should utilise those species of grass and clovers that suit the habitat. If the habitat was modified, another set of species could be introduced. Greater use of the land and higher production could be achieved.

Answering a question from MRS. M. M. DAVIDSON, MR. COWIE said that filling in the hollows instead of draining had been tried on several farms; he had no information about cost, but thought it would not cost more than drainage. There is one catch about leaving the wind to blow the top off—often the wind blows in the wrong direction.