The basis of all pasture mixtures sown for high production is a high-producing leguminous plant. Because of the great variation in the moisture content of the undulating sand country, it is necessary to employ three of these on much of the country. On country which is liable to be flooded repeatedly or for long periods in the winter, strawberry clover is the only one which can be relied on to survive. In the well but not over-drained areas, white clover is the most suitable. Because these two types of country often occur in small adjoining areas both clovers are sown overall. On country that is too dry for the permanent survival of white clover, the only useful legume is subterranean clover. This legume, valuable as it is, has the serious disadvantage common to all annuals of dying in the summer and leaving open spaces which can lead to severe wind damage.

The Dry Sand Ridges

The dry sand ridges are particularly prone to damage by animals. For example, a small scar caused by a burrowing rabbit on a poorly grassed ridge can rapidly develop into a major "blow."

Pasture improvement on the ridges consists primarily of the introduction of subterranean clover as the only useful legume. This is reasonably satisfactory if the accompanying grasses are able to provide protection from wind damage by being fairly tall, rhizomatous or stoloniferous. If, however, the accompanying grasses are shallow rooted and have no sand-binding properties, the use of subterranean clover can result in increasing damage as the stock-carrying capacity increases.

Spelling of pastures by shutting them up for hay or by growing lucerne on the flats can assist materially in repairing damage to ridges, provided the damage is not severe. Where it is severe it may be necessary to plant with marram grass, or to reduce sand movement by pegging down branches of trees and oversowing with grasses and clovers.

The planting of trees on the ridges also has the effect of stabilizing the sand. It also has the great disadvantage of requiring fencing which if the ridges are plentiful can be very expensive.

The Coastal Dune Lakes

B. T. Cunningham

New Zealand has no native fish of interest to sportsmen. Apart from eels, which are large and abundant, the native species are small and rarely occur in large numbers. Angling is for introduced species, mainly brown and rainbow trout or quinnat salmon and these fish are established in nearly all waters suitable for salmonids. Interest in angling is increasing rapidly and it is necessary to develop additional waters. One group selected for study was the western coastal dune lakes of the North Island.

There are about 170 dune lakes in two series between Otaki and Hawera, and Waiuku and North Cape. The lakes are small and shallow, usually being under 400 acres in area and less than 15 m. in depth. All lakes have a common feature of an impounding barrier of sand. The lakes are of two types—basin and dammed valley lakes. Basin lakes lie between the foreshore dunes and the consolidated sandstones (*e.g.*, Lake Kereta) or fill depressions in the consolidated dunes (*e.g.*, Lake Waingata). Streams draining the consolidated dunes have been blocked by moving sand to form dammed valley lakes (*e.g.*, Lake Herengawe). Water levels appear to be maintained by rainfall and seepage from the drainage basins. Levels fluctuate about two feet annually. Few have inflowing or outlet streams and outlet streams are often intermittent in flow. The mean annual rainfall varies from 30-50 inches, which is spread over the whole year, with a drier period over the summer. The mean monthly air temperatures range from 47° to 63° F. The majority of the lakes are exposed to the prevailing westerlies and water turnover occurs at all seasons. Less frequent eastern storms also assist water turnover.

Water temperature of the open water varies from about 9° C. to 24° C. The surface waters in the Northland lakes may be above 20° C. for four months. Temporary thermal stratification occurs in some lakes and temperature differences of 2° C. to 5° C. were found between surface and bottom waters. The maximum difference was 8° C. The thermocline is usually between

3 and 5 metres in Northland lakes.

The oxygen concentration of the surface waters is always close to saturation. When stratification occurs there may be deoxygenation of the hypolimnion and oxygen concentrations may fall to 10 per cent. saturation.

The lake margins vary considerably from free-running sand, or exposed open wave-cut banks, to sheltered shores supporting dense stands of emergent vegetation. Exposed shores carry beds of rushes and sedges (*e.g.*, *Typha*, *Eleocharis* and *Cladium* spp.) which extend out to a depth of about 2 metres. The lake beds of the littoral region are usually sandy. The sub-littoral areas consist of soft organic muds, often of a considerable depth. The sub-littoral vegetation is usually well developed, with bottom plants growing over most of the area. Transparency is low and usually under 4 metres. Principal plants are *Potamogeton ochreatus* and *Chara* spp. but in some lakes *Anacharis canadensis* and *Ottelia* have been introduced.

The plankton is sparse with little seasonal change. Phyto-plankton consists mainly of diatoms, peridinians or volvocales. The zoo-plankton is usually copepods and cladocera.

The bottom fauna of most lakes is moderate in density and is usually dominated by chironomid larvæ or "bloodworms." Molluses, usually *Potamopyrgus*, are common among the weed beds. The average density is about 3-600 animals per square metre. Most lakes have dense beds of the freshwater mussel (*Hyridella* spp.). In some lakes, particularly in the Northland series, there are dense populations of crayfish (*Paranephrops* spp.). The freshwater crab (*Hymenosoma lacustris*) is also common in a few northern lakes. Small native fish (*Galaxias*, *Retropinna* and *Gobiomorphus* spp.) occur in all lakes, but are rarely abundant. The first two are mid-water forms and probably feed partially on plankton, whereas the last is a bottom feeder. Long-finned and short-finned eels (*Anguilla* spp.) are present in all lakes with a temporary or permanent outlet. Most southern lakes have an outlet whereas only about half the northern lakes have outlets. Short-finned eels are dominant and long-finned eels may reach 20 lbs. Shags (*Phalacrocorax*) frequent the lakes but it appears that the little shags feed on native fish and koura. At Lake Waingata no shags' stomachs contained trout remains. Perch and goldfish (*Carassius*) are present in several lakes and are self-supporting. Perch have become stunted in some lakes but in others fish up to $1\frac{3}{4}$ lbs. are present.

Stones and gravel are absent and therefore there are no spawning facilities for trout. Trout (usually rainbow) are maintained in some lakes, near Marton, near Waiuku, and at Lake Waingata, by artificial liberations.

Since 1953 increased liberations of fingerlings have been made at Lakes Guddops and William, near Marton. The fish caught by anglers during the last fishing season (1956–57) were probably released as fingerlings in 1954. The rate of catch is low at about 0.3 fish per hour and the lakes last season yielded nearly 6 lbs./acre of fish. The average length of fish caught was 16 in. at Lake Guddops and 19 in. at Lake William. The yield of fish is still probably below that which the lakes are capable of carrying.

At Lake Waingata in Northland a stock of rainbow has been maintained since late 1953 at the rate of 30 lbs./acre. An attempt was made to stock the lake initially with an ideal population composed of fry, yearlings, two- and three-year-old fish (*i.e.*, ranging from 1–15 in. in length). Since 1953 fry have been released annually. Transportation was by truck from Rotorua in aerated cans up till 1956 when an experimental release was made using an aircraft, dropping the fry directly into the lake. Air-dropping is now the standard method for releasing fish at Lake Waingata.

Fish have been caught by seine and gill nets to follow the growth rate. Tagged fish have also been released. About 15 per cent. of the tagged fish have been recaptured to date. The numbers of fish released in 1953 were smaller than was planned and these fish in the virgin water grew rapidly. However, once the population was built up to about 30 lbs./acre growth rates have slowed, but two-year-old fish are about 11 inches in length.

Lake Waingata has been declared a fisheries experimental water and angling is allowed provided a licence and permit are held and the conditions on the permit are followed. It was found that during the open season fish could only be caught at the beginning or end of the season—at other times the water temperature was too high. The lake is now open all the year round, with a special season over the winter. Ninety-four fish, averaging 17 in., were taken during the first winter season. The rate of catch was 0.7 fish/hour. During the 1955–56 open season 65 fish were caught in October, November and April, at a rate of catch of 0.5 fish/hour. The mean length of these fish was 13.0 inches.

The environment of these lakes has been studied and work on the carrying capacity for trout is proceeding. The selection and acclimatisation of a self-supporting fish for these lakes should be completed soon.