fertile fronds. One of the largest kauris had quite a lot of Bulbophyllum pygmaeum growing on the trunk, as well as Dendrobium cunninghamii. It was interesting to see that several smaller plants had developed from the larger one in succession down the trunk. As it was fairly late we decided to have lunch in a small clearing among the kauris. Just sitting there we saw several species including a poroporo in berry, a Griselinia with narrower leaves than usual growing on a kauri, Hedycarya arborea, Carpodetus serratus, Corokia cotoneaster, Dianella intermedia, Geniostoma ligustrifolium and Myrsine australis.

After lunch we were pleased to see plenty of the tiny orchid, Acianthus fornicatus var.sinclairii in bud. The party split up, the main group going with Mr. Butler down towards the stream, the rest with Mr. Warren, making for the back boundary of the reserve. Mr. Warren pointed out the only plant of Lindsaea trichomanoides that we saw during the day. At one point we found hundreds of small Carmichaelia seedlings with juvenile foliage.

We reached the fence after passing through some teatree scrub amongst which there were quantities of Olearia furfuracea and some rather fine Lycopodiums. We failed to find the milk tree we had come to see, even after following the fence line for some way on either side of the stream and we began to make what we thought was our way back. Once unsure of the direction in which we should have been heading we found it difficult to find the best way back to the bus and struggled through large areas where supplejack and bush lawyer made the going unpleasant. We finally spotted the group of kauris we should have been making for and arrived safely back at the bus, somewhat behind the main party. Other plants of interest noted during the day included white maire, tanekaha, Alseuosmia macrophylla, Coprosma areolata, Dodonaea viscosa, Knightia excelsa, Nestegis montana, Vitex lucens and Lindsaea linearis.

A.D.P.

....

PHYTOPHTHORA CINNAMOMI IN NEW ZEALAND. ----- Prof. F.J.Newhook.

In a large and important genus of plant destroyers Phytophthora cinnamomi commands special interest because of its wide host range (over 300 species), its widespread occurrence and its remarkable uniformity.

Some of its spectacular "successes" are littleleaf disease of Pinus echinata in south-eastern U.S.A., avocado root rot in California and pineapple root rot in Hawaii and Queensland. It has been suggested that it was P.cinnamomi that caused the disappearance of chestnuts in the south-eastern U.S.A. It is now in a position to do the same for jarrah (Eucalyptus marginata), the main timber tree in Western Australia. In 4-5 million acres of native jarrah forest, 100,000 acres have been invaded by the fungus which has not only killed the dominant timber tree but also over 90% of the other species in this forest. These belong mainly to the very susceptible families, Epacridaceae, Leguminosae, and Proteaceae. The affected areas have been inadvertently inoculated with contaminated gravelly soils used for the construction of logging roads.

In New Zealand P.cinnamomi regularly causes serious losses of ornamentals in nurseries and gardens and severe losses in coniferous shelterbelts and peach orchards in some seasons. It is associated with littleleaf disease in plantations of exotic pines on clay soils. It is also established in may indigenous plant communities where it could have important ecological signifi ance.

Nursery Losses

Nurserymen throughout the country regularly suffer heavy losses in a number of species. Amongst ornamental hosts, members of the Proteaceae, Epacridaceae and Ericaceae are particularly susceptible. The indigenous kauri and many conefers are severely affected.

Pinus radiata has been killed by the fungus in forest nurseries in many parts of the country. Heavy losses at Thames were controlles by fumigating the soil with a mixture of methyl bromide and chloropicrin. In most forest nurseries fumigation has not been practised, although losses may be heavy in years of high summer rainfall. Vigorous root regeneration in surface soil frequently ensures recovery of infected seedlings.

Farm Plantings.

Phytophthora spp., especially P.cinnamomi, cause spectacular mortality in small farm woodlots and in shelter-belts of Pinus radiata, Cupressus macrocarpa, Chamaecyparis lowsoniana and other conifers, especially in years of unusually heavy autumn rainfall, when soil temperatures are suitable for sporulation.

Exotic Forests.

The bulk of New Zealand's $1\frac{1}{4}$ million acres of exotic forests are planted with species susceptible to P.cinnamomi. Despite the apparently widespread distribution of the fungus, there are only a few plantations where it is associated with significant loss. In the Nelson Province, root and collar rot result in sapling losses of Pseudotsuga menziesii and Larix spp. Over much of the area of Pinus plantings on heavy clay soils, promising early growth may be seriously checked by a combination of P.cinnamomi and poor soil physical conditions. On eroded and poorly aerated ridge tops, decline may commence soon after the pines are planted. At Cornwallis for example, some 44 year old P.radiata is only 4-6 ft. high

Littleleaf disease.

A decline was reported of P. echinata in Waipoua State Forest, with symptoms indistinguishable from those of little-leaf disease in south-eastern U.S.A.; P.radiata showed similar but less severe symptoms; P.taeda and P.palustris were symptomless except on eroded ridge tops. The seriousness of the disease is determined largely by edaphic factors. At Cornwallis, where P.cinnamomi populations are high it has been shown that vigour is correlated with internal drainage and aeration of soil on the three main soil types.

Indirect control of littleleaf disease

It has been shown experimentally and by aerial application that on the P - deficient clay soils of North Auckland a single top-dressing of 5 cwt of superphosphate per acre produces a spectacular improvement in stand health. This response, which has persisted at Riverhead for 16 years, is not due to destruction of P.cinnamomi, since populations of the fungus in both treated and untreated forests have remained high. Control of the disease seems to be due to a complex series of changes which improve growth conditions for the host and at the same time limit opportunities for infection by zoospores of P.cinnamomi. This may be illustrated by an account of the situation in treated and untreated stands of 35 to 42 year old P.radiata at Riverhead.

In much of the untreated forest the pines have suffered a drastic check in growth. The open-canopy stands have trees with sparse crowns and chlorotic foliage and, frequently, dead tops. The under-storey is characterised by Leptospermum spp. There is almost no litter, F,H, or A horizon. The B horizon is a structureless massive clay which is at or near saturation for much of the year; when dry in summer it is almost rock hard. Fine root development is almost entirely restricted to the top inch. Mycorrhizas are rare and usually restricted to a few Gasteromycete associations. These factors, coupled with P.cinnanomi root rot, aggravate an already serious P - defficiency.

By contrast, trees in treated parts of the forest have dense crowns with dark green foliage and vigorous shoot growth. The canopy closes usually within three years of treatment. A deep litter accumulates, with a well developed F-H layer. Rootlet growth is extensive, with considerable mycorrhizal association both in the F-H layer and to a depth of 2-3 ft. or more in the cracks between the aggregates. In these cracks there is a copious development of buff or white Basidiomycete mycelium. Fructifications of Amanita spp and Boletus spp are seasonally plentiful.

The improvement in crown health follows so soon after application of fertizer that the initial response to the nutrients in superphosphate is obviously direct. This leads over the next few seasons to the marked improvement in roots and mycorrhizas described above, which ensures better uptake of water and nutrients. x It was shown that there was an increase in foliar levels of P and, in living bark, improved levels of other elements, notably N, K, and Mn as well as P. As there has been no increase in soil macroporosity, it is apparent that the enhanced root and mycorrhizal growth is made possible by improved aeration due to reductions in the frequency and length of periods of waterlogging. This undoubtedly results from the increased transpiration and the reduction in the amount of rain reaching the forest floor that follow the improvement in crown cover. Healthy pine crowns are capable of intercepting large amounts of rain, e.g. up to 32% of the annual rainfall, while litter also retains a large quantity.

The improved soil moisture situation limits activity by P.cinnamomi zoospores and at the same time favours root regeneration and mycorrhizal development, with the nutrient benefits already noted and possibly mycorrhizal protection of rootlets against further infection.

The importance of transpiration and rain interception in modifying the site for pine growth is further illustrated by increased waterlogging of the s il and accelerated deterioration of little-leaf stands from which the under-storey has been removed.

Indigenous Communities

P.Cinnamomi is widespread under many indigenous plant communities including:

1. Leptospermum scrub at several widely separated places in Auckland and Nelson Provinces.
2. Cutover forest dominated by Coprosma arborea and Leptospermum ericoides at Cornwallis.
3. Submontane forests dominated by beech, Nothofagus fusca and southern rata, Metrosideros umbellata respectively.
4. Dense rimu forest on wet terrace soils in south Westland.
5. Kauri at several localities including stands near the northern and southern limits of its range as well as on Little Barrier Island sanctuary.

In all but one of these situations, there was no obvious evidence of plant damage attributable to P.cinnamomi. On the Cascade Ridge in the Waitakere Ranges however there is a patch of dying pole-sized kauris in regenerating Agathis forest. Many kauris are dead as well as Phyllocladus trichomanoides and Cyathodes fasciculata, from which P.cinnamomi was isolatred. Chlorosis and stunting are common in almost every other component of that community.

Discussion

In New Zealand, P.cinnamomi causes major root and collar rot in a few species, but in the majority of susceptible hosts, infection is limited to rootlet invasion. Thus severity of host reaction depends not only on the variations in site conditions outlined above but also on the degree to which transpiration reduces plant moisture reserves before rootlet regeneration restores the root-shoot balance. This is clearly illustrated by the reactions of P.radiata to severe rootlet loss in the autumn in shelterbelts, in untreated, and in superphosphate treated forests.

The deep, exposed crowns of vigorous shelterbelt trees rapidly deplete water reserves, leading to severe defoliation or death. By contrast, mortality is negligible in little-leaf areas where transpiration losses from sparse crowns are low. In treated forests where crown improvement has occurred following application of superphosphate, depletion of water reserves is nevertheless insufficient to cause outward symptoms, even in the worst years for shelterbelt mortality. Transpiration losses from treated forest trees would be intermediate between those of little-leaf and shelterbelt trees because crowns are shallow and afford mutual protection from sun and wind.

Root-shoot balance and moisture stress probably play a similarly important role in stands of Agathis and perhaps other indigenous communities infected by P.cinnamomi. Deaths are not common amongst mature plants but crowns of kauri and several under-storey species frequently show symptoms analogous to those of little-leaf disease. These host reactions and the high susceptibility of some species to damping-off by P.cinnamomi undoubtedly influence ecological succession within these communities.

The lack of extensive mortality in infected native plant communities might also be interpreted as evidence that P.cinnamomi is an indeginous pathogen to which the flora is adapted. Much of the incidence of the fungus, however, can largely be accounted for by inadvertent transport by man and animals. Even the occurrence on the almost inaccessible northern slopes of Little Barrier Island could be accounted for by autonomous dispersal for vast distances from early Maori settlements. The rates of spread required by this explanation are well within those demonstrated in the jarrah forests of Western Australia.

....

At the May meeting of the Society, Professor Newhook gave a talk entitled "Root Rots in Forests". The above article formed the basis of this talk and was kindly provided by Professor Newhook for inclusion in the Newsletter.

x P (phosphorous) K (potassium) N (nitrogen) Mn (manganese)