F.R.I. PROJECT RECORD
NO. 1534

BORON DEFICIENCY AND BORON FERTILISER USE IN NEW ZEALAND PINE PLANTATIONS - AN HISTORICAL REVIEW

G.M. Will

REPORT NO. 6 MAY 1987

BORON DEFICIENCY AND BORON FERTILISER USE IN NEW ZELAND PINE PLANTATIONS - AN HISTORICAL REVIEW

G.M. Will, Forest Research Institute, Rotorua

The establishment of pine plantations in New Zealand was begun in the early 1900's, and large scale plantings took place in the 1920's and 1930's. Radiata pine (Pinus radiata) which made up a large part of most plantations appeared to grow well on a wide range of soils: any stunted or poor growth was attributed to frost or exposure and in most cases it was. Little or no silviculture was carried out prior to the mid 1940's and it is true to say that it was only after the second world war that a more critical assessment was made of the health and vigour of tree growth. During the 1940's reports were received of the success achieved in Australia in applying phosphate and zinc to unhealthy plantations of pines.

In the late 1940's, full realisation of just how poor tree growth was in many parts of Riverhead Forest led to intensive studies which, in the early 1950's pin-pointed phosphorus deficiency as the cause. While this had nothing to do with boron deficiency but it did stimulate a much closer inspection of tree vigour throughout New Zealand and a more general appreciation of the essential role of adequate tree nutrition.

In 1949 an abnormally high rate of mortality was affecting 8-11 year-old stands on pumice soil in Rotoehu Forest. Boron and potassium were applied in trials. The basis for choosing these two nutrients is not known and there is no record of any positive effect.

In 1950 "short needled, comparatively backward trees" in Eyrewell Forest were treated with boron. Phosphorus, manganese, copper and zinc were also applied but again there is no record of any response.

A major influence in tree nutrition investigations in New Zealand in the 1950's was Dr T.N. Stoate. His experience with phosphorus and zinc in Australia led him to recommend trials with these nutrients in a number of forests in New Zealand. In 1955, in a letter to the NZ Director General of Forests, he suggested boron as a possible cure for multiple leaders in trees growing on pumice soils. Some four years later a sample of Solubor fertiliser was obtained from England and trials were laid out in Kaingaroa and Woodhill Forests. No visual response was ever recorded.

NELSON DISTRICT

To document the first recognition and correction of true boron deficiency in New Zealand we must turn to the Nelson district.

At least from the late 1940's, some dieback and stunting of trees had been noticed and after Dr Stoate's visit to New Zealand in 1952, Peter Baigent tried treatments of copper and zinc but without success. Later in the 1950's John Slow and Graham Will applied a heavy rate of superphosphate to an area at Kaiteriteri that superficially looked like some of the worst areas at Riverhead Forest, i.e. fused needles and dead and dying tops to trees; again there was no response. Eric Appleton carried out a number of fertiliser trials in second rotation stands in Baigents forests but by and large the stands he worked in did not have the extreme dieback that was becoming recognised as affecting stands particularly at Kaiteriteri and Waiwhero.

1962 saw the arrival of Dr Earl Stone in New Zealand; he spent 12 months here on a Fulbright Fellowship. Knowing of the correction of dieback in pines in Africa by the application of boron (reported in 1961), the history of trace element deficiencies (including boron) in horticulture in the Nelson district, and a re-evaluation of the symptoms and other nutrient additions that had failed, Stone, Appleton, Slow and Will set out boron fertiliser and foliage spray trials at Kaiteriteri and Waiwhero in early 1962. Within a few months it was apparent that these treatments had prevented the usual late summer dieback that previously had occurred in the flush of new growth produced each spring.

From these trials it was possible to show that the shoot and bud death were caused by boron deficiency. Typical symptoms were (1) bud death or shoot death followed by bending into an inverted V or J shape, (2) the leader and primary branches were affected first and more severely, (3) the pith in the region immediately below the dead shoot was often, but not always, affected by brown spotting.

The recognition of boron deficiency in pines on the granite soils at Kaiteriteri was followed by the sighting of dieback in pines on an extension of the granite belt near Murchison. Soils at Waiwhero are derived from parent material which is a mixture of granite and Moutere gravels. Later as further land was bought for the establishment of Motueka forest most of it had granite as the predominant parent material and was found to be subject to boron deficiency.

The Moutere gravel soils in the Nelson district have exhibited less severe and widespread boron deficiency but it is not uncommon particularly in stands whose growth has been stimulated by nitrogen and phosphorus fertilisers or where there is severe gorse competition.

WESTLAND

Soon after boron deficiency was recognised in the Nelson district, similar symptoms were seen in stands on dredge tailings in Westland. As in Nelson severe competition by gorse appeared to intensify symptoms and in many cases the gorse itself was showing dieback symptoms.

Unlike Nelson (and most other parts of the country where it occurs) boron deficiency in Westland is not associated with low rainfall- quite the opposite. However, it must be remembered that dredge tailings are very free draining soils and the content of fine soil particles is very low.

MARLBOROUGH

In 1962 when boron deficiency was identified in Nelson forests surveys were made in Rai Forest but no dieback was found. In 1969 forest plantings began on the north bank of the Wairau River and by the early 1970's ridges were recognised as potentially boron deficient areas. By the mid 1970's forest managers were becoming aware that, as trees were closing canopy and had high nutrient demands, boron deficiency was much more general in plantations.

Farmers with shelterbelts in the district have been much slower to acknowledge the need for boron and even today some are not convinced that their trees with dieback would benefit from boron.

CANTERBURY

In 1970 dieback was seen in trees in the Whitecliffs - Coalgate district and boron deficiency was soon confirmed as the cause. Since then boron deficiency has been identified in hill-country forests stretching from Hanmer in the north, through the Ashley area to South Canterbury.

Further boron deficiency has been found in plantations on coarse soils on the banks of the Waimakariri River. In this situation most severe symptoms are seen in 2-3 year-old trees and as root systems extend to greater depths the dieback disappears.

OTAGO

Naseby Forest is subject to extremes of climate: the dieback, that occurs in a number of the pine species planted there, was originally attributed to frost and exposure. After boron deficiency dieback had been recognised in Nelson, similarities with dieback in Naseby became obvious and by 1970 the widespread nature of boron deficiency in Naseby was established.

Boron deficiency in Otago appears to be confined to the low rainfall areas of Central Otago. Apart from Naseby Forest pine plantations are not common but boron deficiency also affects woodlots in the Cromwell area and other parts of Central Otago.

SOUTHLAND

Nelson members of the Farm Forestry Association when attending their conference in Invercargill in 1963 recognised boron deficiency dieback in some Southland pine plantations. Boron deficiency has not proved to be a major problem in Southland but, particularly in woodlots and shelterbelts, there are scattered areas where trees are affected by dieback; examples are some areas of Rankleburn Forest and shelterbelts in the Te Anau district.

ROTORUA

Dieback in pines growing in forests on the North Island's volcanic plateau has been known from the mid 1930's when Birch suggested fungal attack associated with frost damage. In the 1960's boron deficiency was suggested as a cause of the dieback. Low foliage levels of boron were found in several localities but in 1971 the position was summarised: in some locations 'a partial correction of dieback has been achieved by application of boron', but in others 'boron deficiency appears to be the direct cause of only a small part of the dieback and malformation'. This rather confused state still exists today in areas such as the river flats in Lake Taupo Forest and an experimental area on a scalped site in Tahorakuri forest. In such areas boron levels are low but there are other factors definitely involved. Diplodia attack is a major contribution to dieback in some locations.

The only case of uncomplicated boron deficiency dieback in the North Island occurred in the Crater Block plantation on the southern slopes of Mt Tarawera in 1982-83. These were drought years and the dieback was extensive. A large area was fertilised and complete recovery followed. Howvever, in an unfertilised control area the trees also recovered during the heavier rainfall years 1984-85. Recently dieback has been seen on a few trees in the unfertilised area and young 2-3-year-old trees in nearby plantations on Tarawera scoria soils have also suffered dieback.

It should be noted that an intensive harvesting-litter raking experiment near Wairapukao has shown that the nutrient most affected by such practices is boron. This suggests that with successive rotations boron deficiency is likely to become more widespread on pumice soils.

RECOGNITION

The dieback symptoms, which appear in the late summer, are in the majority of instances a very good indication of boron deficiency. These symptoms have been fully described and colour photographs are readily available to aid identification. In all cases however it is essential to carry out a confirmatory foliage analysis: the reason for this is that, in the central North Island in particular, fungal attack by Diplodia can confuse the position.

Before dieback is develops, foliage analysis can give a prior warning that it is likely to occur particularly in a drought season. Low or more importantly falling boron foliage levels in young trees will usually indicate that dieback is highly likely a few years later; that is when the stand will be approaching canopy closure and the associated period of high nutrient demand.

In general less than 8 ppm boron in foliage has been defined as a deficiency situation with levels between 8 and 12 regarded as marginal. Perhaps more than with other nutrients the interpretation of foliage analyses is not always clear cut. For example, plantations in Southland with foliage levels of 6-8 ppm do not suffer from the dieback that would be expected in stands with similar foliage levels but growing in Nelson. It appears that in cooler, wetter climates lower levels of boron are adequate to ensure healthy tree growth. Another factor is age: while a foliage level of 8 ppm in 1-year-old trees could be taken as a strong indication of future dieback problems during periods of peak nutrient demand, the same level in 15-year-old trees may well be adequate for sustained healthy growth.

There is now a good information base in published form and local experience to identify those climate zones and soil types where boron deficiency is likely to affect tree growth.

Gorse and broom also suffer from dieback caused by boron deficiency. When showing dieback, on unplanted sites and in young stands, they can be used as indicator plants.

CORRECTION

While boron is an essential plant nutrient, as a trace element it is only required in small amounts compared to nutrients such as nitrogen, phosphorus and potassium. Plants require about 1000 times more nitrogen than boron. It should also be remembered that, of all the esssential plant nutrients, boron has the narrowest range between deficiency and toxicity. Borates which are widely used as fertilisers are also very effective weed killers!

The care needed in applying boron fertiliser is well illustrated by events in a new planting on dredge tailings in the 1960's. Gorse in the area suffered from dieback and 2 oz of borated superphosphate per tree was recommended. When 2 oz of borate was applied to each tree survival was nil.

Early fertiliser trials in Nelson showed the hazards in trying to apply adequate boron fertiliser in spot applications at time of planting. Broadcast, applications were soon adopted as the best way of treating stands of all ages.

Trials showed that effective dieback prevention and correction can be achieved by broadcast application of about 8 kg per hectare of boron (most borate fertilisers contain about 12-14% boron). Exceptions to this are sandy and gravelly soils with low organic matter and silt-clay contents. On these soils the application rate should be no higher than about 4 kg/ha: at higher rates toxicity is likely to cause foliage burn if not death.

After many years of using the soluble type of sodium borate fertilisers used in agriculture, forest managers realised that these were not ideal fertilisers for forestry. Two major disadvantages were (1) the effective life of a fertiliser application was only about 4 years, and (2) the consequences of overdosing or double application could be disastrous.

Trials showed that finely ground Colemanite could be an effective boron fertiliser (Colemanite is an insoluble calcium borate which is gradually made soluble by the natural acidity in soils). However, the formulation of the dusty Colemanite into granules suitable for aerial application proved a frustrating exercise: although much time and effort were spent trying to produce a reliable cost effective product, full success was never achieved.

More recently 2-5 mm chips of Ulexite have proved to be an ideal boron fertiliser for forestry use. Ulexite is a sodium-calcium borate, less soluble than the sodium borates so toxicity problems are unlikely: it is more soluble than Colemanite so the need to finely grind the material is eliminated.

The adoption of Ulexite as a boron fertiliser has coincided with large improvements in the aerial spreading of fertilisers. The development of an improved bucket and spinner and the use of electronic guidance has meant that application using a helicopter flying evenly spaced parallel flight lines is now a precise and efficient operation. This could not be said when unguided fixed wing aircraft spread fertiliser in narrow swaths. Accurate even spread of fertiliser is most important in forestry where one fertiliser application should last for many years or even the lifetime of a crop.

DEVELOPMENTS IN OTHER COUNTRIES

The recognition and correction of boron deficiency in pine plantations in New Zealand followed experience in Africa. Subsequently boron deficiency has been found to affect radiata pine plantations in Australia and Chile.

More recently growth problems in conifers in Finland, some other parts of Europe and North America have been found to be associated with low levels of boron.

REFERENCES TO THE REGOGNITION AND CORRECTION OF BORON DEFICIENCY IN NEW ZEALAND

Ballard, R. and Will, G.M. 1981: Removal of logging waste, thinning debris and litter from a <u>Pinus radiata</u> pumice soil site. N.Z. J. For. Sci. 11: 152-63.

Hedderwick, G.W. and Will, G.M. 1982: Advances in the aerial application of fertiliser to New Zealand forests: use of an electronic guidance system and dust free fertiliser. FRI Bulletin No. 34.

Mead, D.J. 1978: Boron deficiency and toxicity in radiata pine in New Zealand. In: Plant Nutrition 1978. NZ DSIR Imformation Series No. 134.

Stone, E.L. and Will, G.M. 1965: Boron deficiency in *Pinus radiata* and *P. pinaster*. For. Sci. 11: 425-33.

Will, G.M.; Appleton, E.J.; Slow, L.J. and Stone, E.L. 1963: Boron deficiency - the cause of dieback in pines in theNelson district. NZ FRI Research Leaflet No. 1.

Will, G.M. 1971: The occurrence and treatment of boron deficiency in New Zealand pine forests. NZ FRI Research Leaflet No. 32.

Will, G.M. 1985: Nutrient deficiencies and fertiliser use in New Zealand exotic forests. FRI Bulletin No. 97.

Will, G.M. 1985: Field guide to nutrient deficiencies in radiata pine. FRI Bulletin No. 97 Supplement.

Will, G.M. and Fitzgerald 1985: Correcting boron deficiency in radiata pine. FRI What's New No. 136.