SHELTERBELT MORTALITY IN SOUTH CANTERBURY, OTAGO AND SOUTHLAND

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SYNOPSIS

The widespread floods of 1957 were followed by the death of many shelterbelt trees located throughout South Canterbury, Otago, and Southland. The species damaged are listed under four damage categories; in general the conifers were far more susceptible to injury than hardwoods. Shelterbelts on level sites sustained more damage than those on sloping sites, those on low-lying alluvial soils being particularly affected. Trees over 12 years of age were more susceptible than younger ones. Deaths of many trees seemed to be associated with a flush of nitrogenous material after floods, others with dry periods before and after floods. It is concluded that the risk of damage would be reduced if well maintained fences were located at a reasonable distance from shelterbelt trees and if hardwoods, particularly Populus nigra *var.* italica, *were used on the gleyed and low-lying soils.*

INTRODUCTION

In October 1957, the trees in a *Pinus radiata* shelterbelt, located near Herbert township, north Otago, were reported to be dying. This was the first of many similar reports from South Canterbury, eastern Otago, and Southland. Mortality continued to occur throughout 1958 but by early 1959 no new deaths were observed. It appears that the excessively high rainfall of 1957, with associated widespread flooding, was the primary cause of these mortalities. The dry summers of 1955-56 and 1958-59, before and after the floods, probably contributed to the losses.

In 1959 a survey was made of affected shelterbelts and trees in an attempt to delineate the area affected, and to determine the relative susceptibility to damage of the different species. A further survey was subsequently made to investigate the effects of site. The purpose of this paper is to record the results of these surveys, the influence of site, and the nature and extent of the damage suffered. Deaths have occurred in 19% of the inspected *Pinus radiata* and *Cupressus macrocarpa* shelterbelts; more than 50% of the stems having been killed in some 5% of these.

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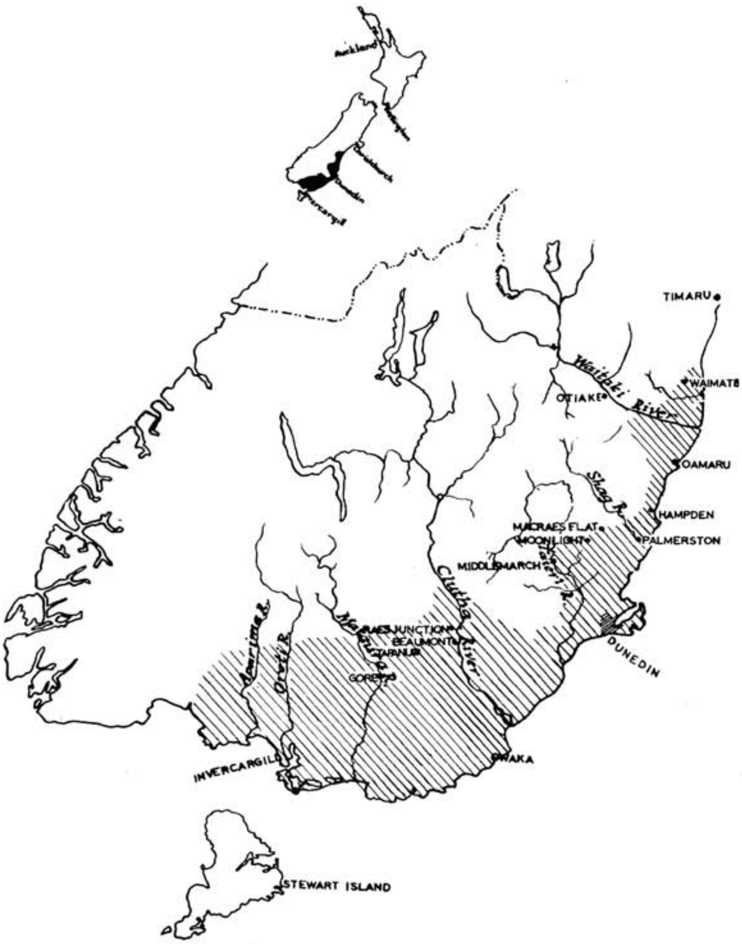

FIGURE 1

Tree Mortalities occurred in area shown thus....

AREA, TOPOGRAPHY, AND SOILS

The affected area is largely coastal, extending from just south of Timaru through Otago and into Southland (see fig. 1). Although in Canterbury and Otago mortality occurred mainly within 10 miles of the coast, there are striking occurrences some 20-30 miles inland at McCraes Flat, Moonlight, and Middlemarch. Further instances were found up to 30-40 miles inland along the Clutha River in south Otago and the Waiareka Creek in north Otago. Affected stems were numerous near Tapanui and in neighbouring districts. In Southland occurrences were found up to 40 miles north of the coast.

Although the terrain throughout the area varies from flat to precipitous, most of the shelterbelts are on flat to easy rolling country at altitudes less than 750ft. The highest altitude at which affected trees were recorded is 1500-1900ft at McCraes Flat.

Soil types throughout the area vary from the brown-grey earths of the semi-arid regions to the yellow-brown earths of more humid areas. Gleyed soils and recent alluvial soils are widespread. Heavy, poorly drained soils are, in general, typical of the coastal areas.

Climate and the 1957 Flooding

The average annual rainfall for the area varies from 25 in. to 60 in. but is, for more than 80% of the area, less than 40 in. The mean annual variability, at less than 12%, is lower than in most other parts of New Zealand. The rainfall is fairly evenly spread throughout the seasons, summer usually being the season of maximum fall. Because of cool temperatures the effectiveness of rainfall is high. Although, on the average, there are more than 125 wet days a year the incidence of heavy rainfall is low. The area is cloudy, sunshine values being the lowest for the whole country. In north Otago and South Canterbury the area is characterized by more frequent north-west winds, lower humidities, lower rainfalls and greater average annual extremes of temperature than those first described. At a few localities (e.g. Middlemarch, McCraes Flat, and Moonlight) the climate approaches that of inland Otago. Here temperature ranges are high and rainfall low.

In 1957 the rainfall was well above normal, with frequent and widespread flooding; some areas were under water for months at a time. Rainfall for January and February was approximately normal but March was wet, with flooding in Dunedin and Palmerston. Rainfall for April was again high and in May was three to five times above normal with floods at Oamaru, Hampden, and other localities in north Otago, at Palmerston, Middlemarch, the Taieri Plains, and numerous localities throughout Southland. June was wet with bad floods in Southland, particularly on the lower reaches of the Mataura River. July was wetter than usual but August and September were dry. October was very wet, readings for November at Invercargill being the highest for 50 years. In this month the Mataura, Oreti, and

Aparima Rivers were in flood. At this time, stopbanks on the lower reaches of the Clutha River were breached and disastrous flooding occurred. December was twice as wet as usual with flooding of north Otago rivers. In January 1958 parts of east Taieri, Middlemarch, and north Otago experienced floods, and in February 1958 the Clutha was again in flood. Rainfall for March 1958 was below normal.*

The rainfall for seven stations from South Canterbury to Invercargill for the months April to December inclusive, 1957, and for the years when rainfall for the same period has exceeded that of 1957, is recorded in table 1.

TABLE 1
RAINFALL FOR THE MONTHS APRIL-DECEMBER INCLUSIVE

Station and Year Records commenced		*Rainfall 1957 (April-Dec.) in.*	*Percentage of Normal*	*No. of years when rainfall exceeded that of 1957*
Waimate	(1911)	23.60	146	2*
Otioke	(1913)	22.04	147	Nil
Raes Junction	(1937)	34.91	159	Nil
Beaumont	(1939)	40.58	143	Nil
Gore	(1907)	30.73	128	4†
Invercargill	(1890)	41.54	133	4‡
Owaka	(1930)	39.80	147	Nil

* 1938, 1946
† 1913, 1918, 1919, 1941
‡ 1891, 1895, 1898, 1919

It appears that although there have been years when locally the rainfall has been higher than in 1957, there has never been a single year when equally high rainfall has been so widespread. For the area as a whole 1957 has probably been the wettest year for which records are available (see fig. 2).

Nature and Extent of Injuries and Records of Previous Similar Damage

Local flooding has, of course, frequently killed groups of trees within shelterbelts. On parts of the Taieri Plains subjected to frequent floods it has been almost impossible to establish *P. radiata*; where success was achieved initially the trees have died within five years of planting. In spite of this there are no records for Otago and Southland of previous tree mortality as widespread as that which followed the 1957 floods. Sutherland, Newhook, and Levy (1959) refer to records of mortality to *P. radiata* in parts of the North Auckland peninsula in the spring of 1924, 1936, and 1946 after prolonged rainfall. Further mortality is reported for 1953 and 1954 in the

* Accounts of flooding from *Otago Daily Times*, 1957 and 1958

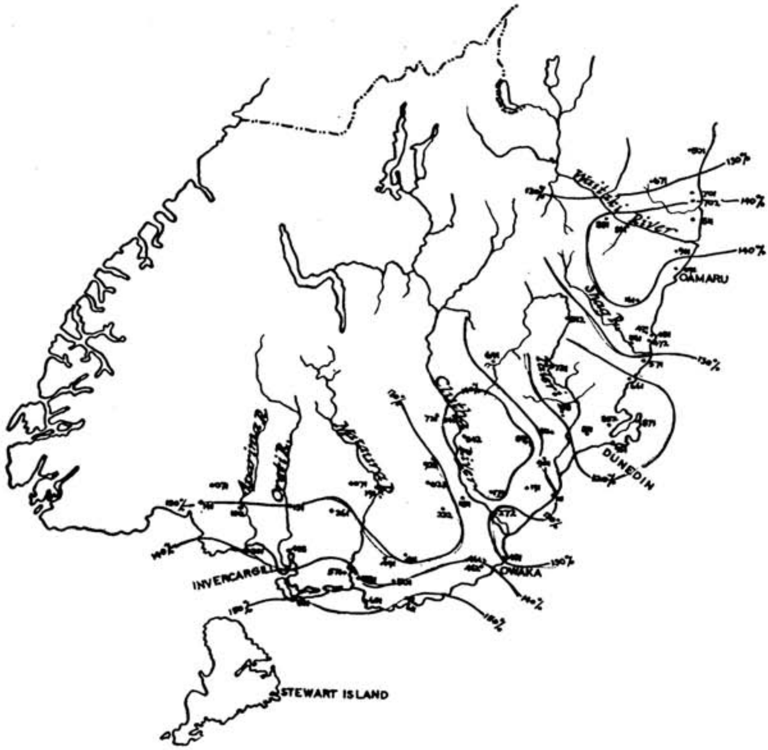

FIGURE 2
Rainfall April to Dec. 1957 as % of normal

vicinity of Auckland and in 1956-57 throughout much of the North Island. A survey in 1957 revealed that *Cupressus macrocarpa, Chamaecyparis lawsoniana, Pinus muricata*, and *P. pinaster*, as well as *P. radiata* were affected. Newhook (1959) reported that there was a correlation between the presence of *Phytophthora* spp. and of disease symptoms in North Island shelterbelts.

In South Canterbury, Otago, and Southland mortality was largely confined to shelterbelt trees. No abnormal mortality of a similar nature was recorded within the fairly extensive areas of State exotic forests; woodlots were largely unaffected also. Deaths occurred in a small plantation at Oamaru, but the symptoms suggest that this was in no way comparable with the shelterbelt mortality. Isolated trees in parks and gardens were affected, but these occurrences were rare.

Trees 30 ft or more in height were much more susceptible to injury than younger stems, but in areas subject to prolonged flooding stems of all ages were affected. Only 8% of the shelterbelts less than 12 years old were affected, compared with 21% of those that were older. Occasionally the affected trees were scattered at random throughout a shelterbelt but far more commonly occurred together in groups. In some cases only a few stems were initially affected but subsequently the symptoms spread to adjoining trees and, occasionally, to the whole shelterbelt.

There was often sudden browning of the foliage and death of the trees within a few weeks. Needle fall was common, giving a thin-crowned appearance to many stems. There were, of course, all degrees of wilting from slight to severe. The above-ground symptoms were no doubt secondary and reflected the presence of root damage.

SPECIES AFFECTED

More than 75% of the shelterbelts in the area comprise either *Pinus radiata* or *Cupressus macrocarpa*, the bulk of the remainder being *Populus nigra* var. *italica*. The sparsity of other species in shelterbelts makes it difficult to investigate their relative susceptibility to injury, but there are some shelterbelts in which a few specimens of other species have been planted among either *P. radiata* or *C. macrocarpa*. By studying the condition of the less common species when associated with affected *P. radiata* or *C. macrocarpa*, it has been possible to determine the relative susceptibility to injury of a reasonably wide range of species. In the following paragraphs the species are grouped into four damage categories. The number of affected occurrences that were inspected is recorded after each species name.

Category 1

The species listed here are strongly susceptible to injury. This category includes all the coniferous species investigated during the survey.

Pinus radiata (68)
Pinus laricio (1)
Pinus ponderosa (3)
Pinus muricata (4)
Pinus coulteri (1)
Pinus sylvestris (1)
Cupressus macrocarpa (42)
Cupressus arizonica (1)
Pseudotsuga taxifolia (6)
Chamaecyparis lawsoniana (2)
Picea abies (5)
Picea sitchensis (1)
Sequoia gigantea (3)
Podocarpus totara (1)
Araucaria imbricata (1)
Larix decidua (1)

Category 2

Although less susceptible to damage than species in category 1, the following were the most severely damaged of the hardwood species.

Acacia dealbata (3)
Eucalyptus spp. (mostly *E. globulus*) (6)

Category 3

Even though some trees were occasionally damaged the species in this category remained healthy in many areas where species in categories 1 and 2 were severely damaged.

Sorbus aucuparia (1)
Fraxinus excelsior (1)
Tilia europaea (1)
Crataegus monogyna (3)
Ulmus campestris (1)
Fagus sylvatica (1)
Quercus pedunculata (2)
Betula alba (3)

Category 4

Although abundant in badly flooded areas the following species remained healthy, even when in close association with dead and dying *P. radiata* and *C. macrocarpa*.

Populus nigra var. *italica*
Salix fragilis
Salix vitellina
Cordyline australis

It is clear that some variation occurs within categories. *P. radiata* appears to be more susceptible to injury than *C. macrocarpa* – some 14% of the *C. macrocarpa* shelterbelts contained dead trees, compared with 34% of the *P. radiata* and 25% of the mixed *P. radiata*/*C. macrocarpa* shelterbelts. Although on the average *C. macrocarpa* is more abundant in shelterbelts, *P. radiata* has been planted on a greater range of sites.

DAMAGE IN RELATION TO SITE

To investigate the effects of site a survey was made of *P. radiata* and *C. macrocarpa* shelterbelts throughout the area. All shelterbelts of these two species situated within a quarter mile of the roads traversed on this survey were investigated. The percentage of trees killed in each shelterbelt, and the slope and aspect were recorded.

TABLE 2: THE EFFECTS OF SLOPE ON *P. radiata* AND *C. macrocarpa* SHELTERBELTS

Slope	*No. of Shelterbelts with Dead Trees*	*No. of Shelterbelts Inspected*	*Percentage with Dead Trees*
Level ground	96	354	28
Less than 10°	13	176	7
10° or more	5	99	5

Slope, so far as it influences drainage, would be expected to affect mortality. The data of table 2 indicates that shelterbelts on level ground are more subject to the type of damage under investigation than those on slopes. Indeed, the difference is much greater than these figures alone would indicate: more than half of the stems are dead in 14% of observed shelterbelts on level ground, but in only 2% on slopes. In addition to those listed in table 2, 38 shelterbelts were partly on sloping and partly on level ground. Of these, 20 are undamaged; in 14 there are dead trees on the level ground only, in three on the slopes only, and in one on both the sloping and level ground.*

Dead trees were found on a surprisingly wide range of soil types. In table 3 are listed, for the different broad soil groups, the total number of shelterbelts inspected and the number and percentage of these with dead trees. Soil information was obtained from the 4-mile-to-1-inch provincial soil maps of the South Island.

TABLE 3

THE EFFECTS OF SOIL – SHELTERBELTS WITH DEAD TREES

Soils	*Number*	*Percentages*	*Total Number of Shelterbelts Inspected*
Yellow-brown Earths	4	10	40
Yellow-grey Earths	57	15	371
Brown-grey Earths	15	40	36
Gley, including gleyed Recent	11	22	51
Recent and unclassified young soils	38	31	124
Unclassified soils formed on basic rocks	6	12	42
Miscellaneous (peat and lime-rich soils)	1	–	3
Over all*	132	19	667

* *Includes Yellow-grey soils and soils intermediate between Yellow-grey and Yellow-brown.*

On gleyed soils dead trees are present in 22% of the shelterbelts inspected – a relatively high figure. Losses are similarly high on Recent soils, there being dead trees in 31% of the shelterbelts inspected. These low-lying alluvial soils are subject to flooding.

Dead trees are present in 40% of the shelterbelts on Brown-grey Earths, which occur only in semi-arid regions. The affected shelterbelts are mostly confined to the vicinity of McRaes Flat and Moonlight, and the drought that occurred there after the floods may have contributed to the mortality. The symptoms appeared much later

* The percentage of affected shelterbelts in this group is higher than in those listed in table 2. These shelterbelts are longer; the percentage of affected stems would be much the same as in shelterbelts listed in table 2.

than in other localities and the young trees were as much affected as the old.

In many instances where only part of a shelterbelt has been damaged the local terrain, the vegetation, and the soil mottling indicate that the ground on which mortalities have occurred is more subject to flooding than that elsewhere.

Drains are often located within a few feet of damaged shelterbelts; this might be considered to contribute to the mortalities; but on some parts of the Taieri Plains farmers have found that shelterbelts can be established only in close proximity to drains.

The survey data revealed no correlation between aspect and the susceptibility of shelterbelts to the type of injury under investigation.

Most shelterbelts have inadequate fences, permitting the trampling of the ground by camping sheep. This leads to packing of the surface of the soil and to an accumulation of nitrogen in the surface layers. If flooding occurs the normally dry or near-dry soil becomes wet, and there is a distinct possibility that much of the nitrogenous material will be dissolved and carried down to the vicinity of the roots, which will thus be suffused with nitrogenous compounds.

In three areas it appears certain that such a flush of excess nitrogen did in fact contribute to the death of trees; for, where compost heaps had been built under a *P. muricata* shelterbelt that appeared quite healthy, and where sheep manure had been heaped under two *P. radiata* shelterbelts, the trees adjacent to the compost or manure died after the areas became flooded whereas other stems remained healthy.

Possibly *Phytophthora* species had an important influence in many areas, for the outbreak has characteristics similar to those of the North Island described by Newhook.

A number of damaged shelterbelts are of mixed hardwood and coniferous species, but the proximity of conifers to healthy hardwoods did not appear to reduce the susceptibility of the conifers to injury.

CONCLUSIONS

It is not the writer's intention to become involved in contentious discussions as to the cause of the damage, but it is claimed that the weather prior to the outbreak was quite exceptional. Extensive areas were flooded for prolonged periods; this alone could account for much of the mortality, and dry periods before and after the floods could well have contributed to it.

As with similar outbreaks elsewhere, a number of factors, each of which would vary in importance from stand to stand, probably contributed to the mortality. Many of these factors cause severe injury to trees only in the presence of some abnormal condition, such as severe drought or flooding.

Compost or manure may be stacked under trees for long periods without causing apparent injury, but if flooding occurs these trees die, adjoining stems remaining healthy. At Moonlight the flooding was apparently not sufficiently severe to kill trees, but when it was followed by drought (droughts are frequent in this area and do not usually cause much damage) numerous deaths occurred. In both these examples severe flooding was the abnormal condition.

That the deaths were numerous in shelterbelts, but rare in parks and gardens and absent in woodlots and plantations, is the most notable feature of the outbreak. No final explanation of this can be offered, but attention is drawn to the fact that sheep camping occurs under most shelterbelts but seldom takes place in parks, gardens, woodlots, or plantations. Furthermore, shelterbelts have an extremely poor build-up of litter, which may well be one reason why they are more susceptible to wet conditions. In woodlots and plantations the mycorrhizae and fine roots in a quick-draining litter could well sustain the trees while soil is draining.

Recommendations

(1) It is essential that well maintained fences be located at a reasonable distance from shelterbelt trees.

(2) It is on flat areas of heavy soils, subject to frequent flooding (gleyed and low-lying alluvial soils) that special measures are most essential. Although on certain of these fertile soils *P. radiata* and *C. macrocarpa* will, for a time, remain healthy and display considerable vigour, the long-term risk of injury seems to be excessive. With the exception of *Eucalyptus* species (mostly *E. globulus*) and *Acacia dealbata* the hardwood species appear to be able to survive flooding reasonably well. *Populus nigra* var. *italica* and *Salix vitellina* will survive when nearly all other species are killed, the former being the most commonly planted shelterbelt tree in many areas, e.g., parts of the Taieri Plains and Inchclutha. The risk of damage will be reduced if these hardwoods are used on gleyed and low-lying soils.

(3) Consideration must be given to other factors that can seriously limit the number of species which can be planted. For instance, in parts of Southland, *C. macrocarpa* is the most commonly planted shelterbelt tree in areas exposed to strong salt-laden winds.

Acknowledgements

Thanks are due to the Meteorological Service for the weather data provided.

REFERENCES

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