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SHORT COMMUNICATION

SLOW RECOVERY OF *BEILSCHMIEDIA TAWA* AFTER SEVERE FROSTS IN INLAND TARANAKI, NEW ZEALAND

Summary: Extensive damage to native forest followed a prolonged period of severe frosts (12 days; lowest minimum - 15ºC) in inlandTaranaki. In Tangarakau Scenic Reserve, damage was most severe near the boundary between bush and pasture. Some species such as rimu *(Dacrydium cupressinum)* and miro *(Podocarpus ferrugineus)* were not affected; others like mamaku *(Cyalhea medullaris)* recovered within a year. Mahoe *(Melicylus ramiflorus)* took more than 14 months to recover. Tawa *(Beilschmiedia lawa)* was the most seriously affected; many trees had most of their leaves killed. By December 1986 (53 months after the frost) affected trees had bare, dead upper branches with new sprouts arising from lower on the tree. Frost-damaged trees produced little radial increment for several years after the frost. The slow recovery of tawa shows that occasional rare events may have an important role in determining forest composition, and that a small change in the frequency of such events could alter the balance between species.

Introduction

Plant distributions and species abundance can be strongly affected by rare, severe events, but such events are, by definition, not often observed. Recently Jane and Green (1983) showed that severe droughts in 1914 and 1946 caused damage to forests in the Kaimai Ranges which had been previously attributed to introduced herbivores. Grant (1984) made the same point for the Ruahine Range, which also suffered drought in 1914. Clearly, observations made following such uncommon events can be valuable.

In the first half of July 1982, during a spell of anticyclonic weather, much of the North Island experienced unusually low minimum temperatures. Auckland Airport recorded - 0.7ºC on the 12th, which was the extreme July value since 1965; other places to record low temperatures included Warkworth, Hamilton, Rotorua, New Plymouth and Napier (N.Z. Meteorological Service, 1982). Margaret Bulfin reported in the Botany Division, DSIR, Newsletter in August:

> 'Frosts experienced in the North Island this year were the heaviest for some 40-50 years and the effects were obvious both in gardens and in natural vegetation from Auckland to the Pureora forest south of Rotorua. Young pohutukawas on the coast south of Auckland have been killed.... In the Kaueranga Valley tree ferns and bracken were frosted.....' (Bulfin, 1982).

This paper documents the effect of these 1982 frosts on the bush of inland Taranaki.

Materials and Methods

Temperature data were supplied by the Meteorological Service for Te Wera (30 km southwest of Tangarakau Scenic Reserve) and Taumarunui (30 km to the northeast) (Fig. 1). A local farmer, Richard Fisher, kindly supplied temperature data from Heao, 2 km northeast of the edge of the reserve.

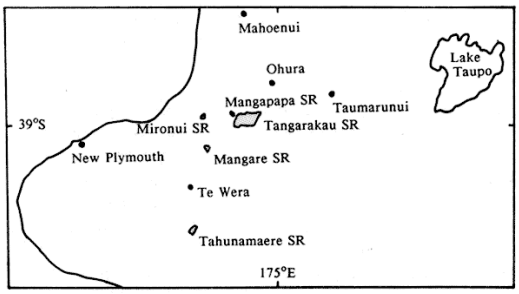

Figure 1: *The location of the studied scenic reserves and climate stations in the central North Island. New Zealand. SR = Scenic Reserve.*

The extent of damage to tawa *(Beilschmiedia tawa)* was recorded in Tangarakau Scenic Reserve (Grid reference N100 390010) during a biological survey of the reserve. This reserve is centered on Tangarakau Gorge, where the Tangarakau River flows through a narrow winding gorge averaging 500 m wide and surrounded by steep slopes or cliffs rising 200 m above the river. Several tributaries cut through these cliffs to flow into the river, as shown in Fig. 2. 708 tawa trees in 34 groups throughout the reserve were rated in September 1983 as to whether or not they showed extensive leaf death in the upper canopy. Notes were made in nearby scenic reserves on the

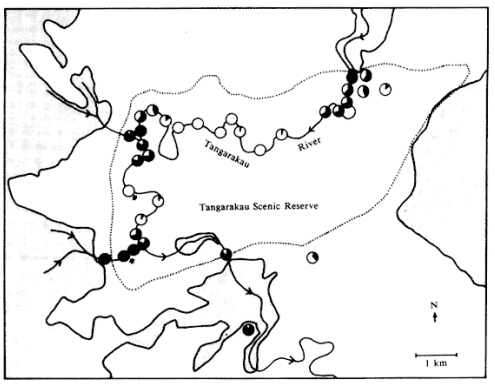

Figure 2: *The spatial distribution of frost damage to tawa* in *Tangarakau Scenic Reserve, recorded* in *September* 1983. *The river runs through a gorge* in *this area (see text). The filled segment of each circle represents the proportion of tawa trees at that spot which were damaged. 708 trees were examined* in 34 *groups. Dotted line: boundary of scenic reserve; shaded areas: pasture; arrows: direction of river flow; asterisk: sites where core samples were taken.*

presence of similar damage to tawa. During a return visit to Tangarakau in December 1986 the extent of recovery in the trees was assessed. Eight cores were taken from four trees in an area of heavy frost damage (Fig. 2) and six more cores from three undamaged trees 2 km to the north. The widths of the 15 outermost rings were measured for each core, and then standardized (by subtracting the core mean and dividing by the core standard deviation), before averaging for each ring position over all cores at a site.

Nomenclature follows Edgar and Connor (1983), except for the podocarpaceae, and Allan (1961).

Results

Climate

Daily minimum screen temperatures for early July 1982 are given in Table 1 for Heao, Te Wera and Taumarunui. Frosts were recorded on 12 consecutive nights at Heao and Te Wera. The lowest temperatures at Te Wera and Taumarunui (-6.5 and - 5.6ºC) are only 0.5º above the extreme minima recorded at those sites over long periods (-7.0 for Te Wera between 1955 and 1980, and -6.1 ºC atTaumarunui between 1947 and 1980: New Zealand Meteorological Service 1983). Temperatures at Heao were much lower over this time, reaching -15ºC on July 10th, although minimum temperatures in June 1982 had been similar at all three sites.

Table 1: *Daily minimum air temperatures* (ºC) *at screen height at three sites* in *inland Taranaki during July* 1982.

Day	Heao	Te Wera	Taumarunui
2nd	0>x>-2	-3.8	0.5
3rd	0>x>-2	-2.0	1.7
4th	0>x>-2	-1.4	-0.3
5th	-2>x>-6	-2.0	-0.7
6th	-2>x>-6	-5.0	-1.3
7th	-2>x>-6	-6.5	-4.2
8th	-12	-4.8	-4.6
9th	-12	-5.9	-4.7
10th	-15	-6.5	-5.3
11Ith	-12	-6.5	-5.6
12th	-10	-4.8	-3.3
13th	-2>x>-6	-1.9	-1.1

Vegetation

On 29 July 1982 tawa trees along the banks of the Awakino River, adjacent to Mahoenui Scenic Reserve were observed to be severely frost damaged, with the top one-third of the trees killed (B.D. Clarkson, pers. comm.). In August 1982 vegetation in scenic reserves near Ohura "looked as if it had been sprayed with herbicide" (J. Peacock, pers. comm.). Photographs taken at that time show extensive damage to tawa and tree ferns (probably mamaku, *Cyathea medullaris),* while kahikatea *(Podocarpus dacrydioides),* rimu *(Dacrydium cupressinum)* and cabbage trees *(Cordyline australis)* appeared unharmed. Similar damage was noted in Tangarakau Scenic Reserve (J. Peacock, pers. com.).

In September 1983 many tawa trees in Tangarakau were still covered with dead leaves. Damage was most extensive near the boundaries between bush and pasture, while tawa in the centre of the reserve were unaffected (Fig. 2). Mahoe *(Melicytus ramiflorus)* plants near the bush edge had dead tips to the branches with new leaves arising from lower down. Live mamaku and wheki *(Dicksonia squarrosa)* in the area seemed healthy, but some dead trunks of unknown age were present. Rimu and miro *(Podocarpus jerrugineus)* showed no sign of damage. Damaged tawa were also seen in Mangare, Mironui and Tahunamaere Scenic Reserves (Fig. 1).

By December 1986 tawa trees in Tangarakau had shed their damaged leaves, exposing dead branches. New shoots were arising from lower down the plant. Many trees had lost all the foliage from the top one-

third of their crowns (as shown in Fig. 3), but only one or two trees had completely died. Trees in the frost-damaged area had narrow rings at positions 4, 5 and 6 (Fig. 4). All three rings were significantly smaller than the average, which is zero for standardized data (t= 2.51, 3.13 and 3.87 respectively, n= 8). In contrast, at the undamaged site 2 km away, rings 4 to 6 were not significantly different from the mean (t= 1.29, 1.16 and 0.83 respectively, n=6).

Figure 3: *A tawa tree in Tangarakau Scenic Reserve showing extensive canopy dieback from the 1982 frosts and resprouts arising from lower down the branches. Photograph taken 23 December 1986.*

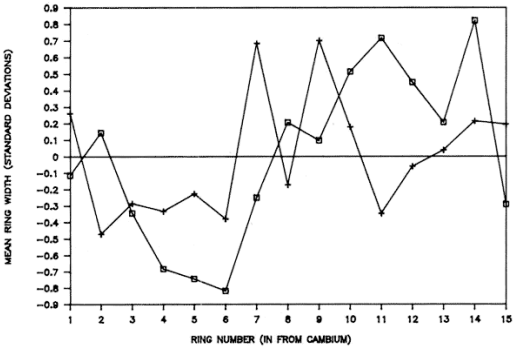

Figure 4: *Mean width of the most recent rings in tawa trees from Tangarakau Scenic Reserve. Two wood cores per tree were taken in December* 1986 *from* 4 *trees in a frosted area and* 3 *trees in a non-damaged area* 2 *km away (sites marked in Fig.* 1). *Ring widths are standardized (see Methods section).□ damaged site; + undamaged site.*

Discussion

The timing and widespread nature of the damage implicate the frosts of early July 1982 as the cause. At least three native species were damaged but tawa was by far the slowest to recover. Many tawa trees had produced little regrowth more than four years later. In contrast, recovery after volcanic disturbance in the Tarawera eruption was rapid (Knowles and Beveridge 1982, p 47).

Radial increments in the frosted area were significantly narrower for the 4th, 5th and 6th most recent rings. If rings were strictly annual, ring 6 would be *before* the 1982 winter, but tawa may form false rings after frosts (Ogden and West, 1981), in which case ring 6 could follow the 1982 frosts. Rings 4 and 5 certainly follow the frosts, so for several years afterward growth rates were lower than the site average, which again suggests that the frost damage could have long-term effects.

MacKenzie and Gadgil (1973) collated reports by N.Z. Forest Service staff of dieback in tawa, which they attributed largely to winter frosts. They found that damage was much more likely when the canopy was opened up. Whole potted tawa seedlings exposed to low temperatures for 4 hours in a growth chamber had all their leaves killed at - 6ºC but the leaves of only one seedling in five were killed at -3∞C. Several other authors have suggested that tawa is sensitive to frost (Hinds and Reid, 1957) especially after logging (McKelvey, 1954). My results, showing damage was concentrated at the edges of Tangarakau Scenic Reserve, support those conclusions and emphasize the importance of large undisturbed areas as biological reserves. (In fact, Tangarakau at 2642 ha is the largest

scenic reserve in the Taranaki Land District: Bayfield *et al*., 1986). The pattern of damage in Tangarakau suggests that cold air drainage down-valley from grassed areas on still nights may have been particularly harmful to the trees. The damage was most severe where the steep gorge walls were cut by tributaries with grassed catchments, while few trees in the centre of the narrow gorge were damaged.

Tawa is a widespread and common forest tree throughout the North Island of New Zealand. Its seedlings are shade-tolerant, viable seed is plentiful, trees coppice after damage and it is unpalatable to introduced herbivores (Knowles and Beveridge, 1982). This inland Taranaki site (39°S, 150 m altitude) is far from its latitudinal (42°20'S) and altitudinal (850 m) limits. In such areas it seems that, given a long period free of disturbance, tawa might gradually increase at the expense of other forest trees. The data in this paper show that occasional heavy frosts can have a long-lasting effect on tawa while other species are less affected. This may alter the balance of competition and prevent tawa from becoming dominant. On a Quaternary scale, it shows that tawa would be very sensitive to an increase in the frequency of heavy frosts.

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