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Short communication

Decline of tree lupin (*Lupinus arboreus*) on Kaitorete Spit, Canterbury, New Zealand, 1984–1990

B. P. J. MOLLOY
T. R. PARTRIDGE*
Botany Institute
DSIR Land Resources
Private Bag, Christchurch
New Zealand

W. P. THOMAS
DSIR Plant Protection
Private Bag, Christchurch
New Zealand

Abstract The decline of a large stand of tree lupin (*Lupinus arboreus*) at Kaitorete Spit was observed between December 1984 and May 1990. Originally a healthy population, the stand was defoliated by larvae of kowhai moth (*Uresiphita polygonalis maorialis*) in January 1985 and virtually all plants were killed. As populations of the herbivore declined through larval starvation, the tree lupin partly recovered in 1986. In May 1987, the stand was again devastated, but by disease, probably caused by the fungus *Colletotrichum gloeosporioides*. The stand partly recovered by May 1989, but repeated attacks have virtually eliminated the tree lupin from its original area. In 1990 tree lupin survived only as short-lived individuals that established around the margin of the infected area before being overwhelmed by the disease. It is considered that the plant has an uncertain future within the area.

Keywords tree lupin; *Lupinus arboreus*; kowhai moth; *Uresiphita polygonalis maorialis*; *Colletotrichum gloeosporioides*; fungus; Ascomycetes; insect attack; disease; population decline; sand dunes; Kaitorete Spit; New Zealand

*Author to whom correspondence is to be addressed.
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INTRODUCTION

Tree lupin (*Lupinus arboreus* Sims) is an abundant introduced legume shrub of sand dunes in New Zealand (Gadgil et al. 1984). It is known to be susceptible to attack from biotic agents and environmental events that can severely damage populations (Williamson 1953; Esler 1974; Davidson & Barbour 1977). In many cases, in both New Zealand and overseas, populations recover within a short time. This paper describes the long-term decline, from 1984 to 1990, of a large population of tree lupin on Kaitorete Spit, Canterbury, resulting from the combined effects of grazing by kowhai moth (*Uresiphita polygonalis maorialis* Felder) and disease, probably the result of infection by the fungus *Colletotrichum gloeosporioides* (Penzig) Penzig & Saccardo. Kowhai moth larvae are known to feed on kowhai (*Sophora* spp.), tree lupin, and other legumes in New Zealand, and regular defoliations of tree lupin on dune systems in the Auckland region have been described by Williamson (1953), Esler (1974), Mulvay (1978), and Gadgil et al. (1984). More recently, considerable damage to coastal tree lupin populations has occurred throughout New Zealand (Williams 1988). This damage has generally been attributed to the fungus *Colletotrichum gloeosporioides*.

Kaitorete Spit is a 27 km long sand and gravel bar separating Lake Ellesmere from the Pacific Ocean. On its seaward side are extensive coarse-grained sand dunes with diverse and unusual plant communities, and endemic plants and insects. On typical fine-grained sand dunes of the South Island, the native sand binder pingao (*Desmoschoenus spiralis* (A. Rich.) Hook. f.), has been almost totally replaced by adventive marram grass (*Ammophila arenaria* (L.) Link.) and tree lupin, but at Kaitorete Spit, pingao still dominates, making these dunes an area of great conservation value. However, several dense stands and scattered plants of tree lupin occur sporadically, particularly along the western half of the dune system. Although spreading slowly, tree lupin threatens the native communities as it out-

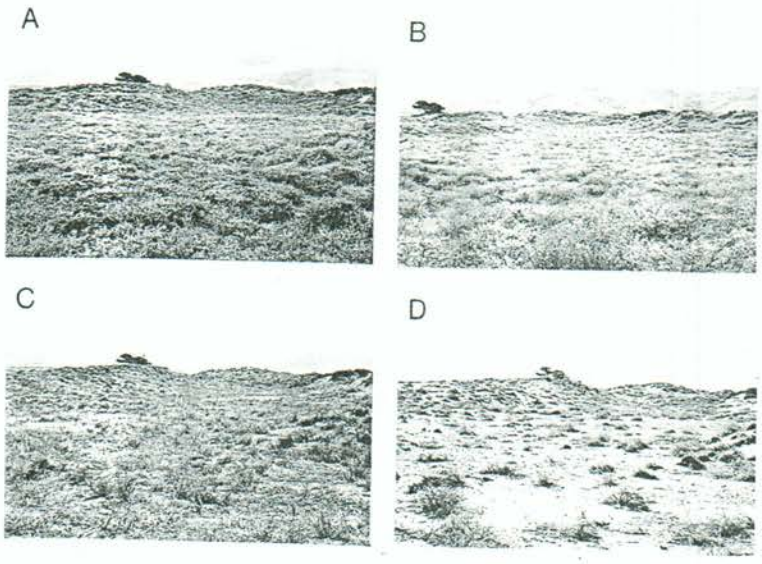

Fig 1 Stand of tree lupin (a) December 1984, before attack, (b) January 1985, during kowhai moth larval attack, (c) December 1985, after the attack showing dead, plants, (d) May 1990, after 3 years of *Colletotrichum*.

competes most native sand-binding species, pingao in particular. This study commenced when there was great concern about the effect that tree lupin was having on the native communities.

CHRONOLOGICAL DESCRIPTIONS

This section presents brief descriptions of the events observed at a large stand of tree lupin at the western end of the Kaitorete Spit Scientific Reserve between December 1984 and May 1990. As far as we can ascertain from aerial photographs, this stand has been present from at least 1952.

28 December 1984. A photographic record was made of the dense 1–1.5m tall tree lupin (Fig 1a). At this time the stand was considered to be a serious threat to botanical values of the dune system. Many plants of tree lupin were in full flower at the time.

28 January 1985. All lupin plants observed were being severely grazed by the kowhai moth (Fig 1b). The same event was observed in other tree lupin stands along Kaitorete Spit. Pods and seeds were the only aerial plant parts not grazed. Larvae were found on plants, on bare sand, fence posts and wires, and occasionally were being blown along by wind gusts. Nearby a single tree of kowhai (*Sophora microphylla* Ait) had been affected by drought, its leaves brown but ungrazed by kowhai moth. Other legumes present e.g., *Cytisus scoparius* (L.) Link., *Ulex europaeus* L., *Carmichaelia appressa* Simpson, *Trifolium repens* L., *T. dubium* Sibth., *T. arvense* L., and *T. glomeratum* L. were not being eaten. A number of larvae were collected, grown on to adults and identified by one of us (W.P.T.) as kowhai moth (*Uresiphita polygonalis maorialis*).

1 May 1985. Virtually all tree lupin plants at the site were dead (Fig 1c). A few plants, however, remained healthy, and appeared not to have been much grazed. Along a marked transect 100m long and 1m wide established at this time, no seedlings (plants < 1yr old) were found. The woody shoots of dead lupins were decaying and large whole plants were easily pulled out.

Tree lupin seed was collected from surviving live plants at the site and from another infected site elsewhere on Kaiorete Spit, and 100 from each collection sown on to soil the next day. Germination was followed until July 1986. After an initial 1.5 month dormancy, the germination rate peaked and was followed by a series of flushes and periods in which little seed germinated. Total germination was 74% and 61% respectively. A similar pattern of tree lupin germination from a healthy stand was noted in California by Davidson & Barbour (1977).

30 December 1985. A search for kowhai moth pupae was made around the base of dead tree lupins. No healthy pupae were found and pupal cases were old, empty, or infected by saprophytic fungi. A small proportion of old tree lupin plants had partly recovered and new shoots that had arisen from the rootstock were flowering as were some one-year-old plants. Along the transect, 93 seedlings were recorded.

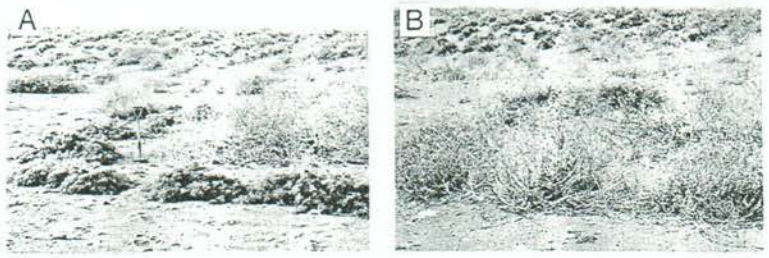

Fig 2 (a) Partial recovery of tree lupin as seedlings surrounding a dead adult in May 1989 and (b) death of those seedlings by December 1989.

28 January 1986. On this date, the anniversary of the kowhai moth population explosion, there were no signs of adults, eggs, or larval kowhai moths. Surviving tree lupin plants and many first year plants had finished flowering and the first seeds were being shed. One hundred and three tree lupin seedlings were observed along the marked transect.

To examine seed persistence in the sand on the site, three surface samples of 0.25 m^2 and 2 cm depth and one subsurface sample of 0.10 m^2 and a further 10 cm depth were collected. These were sown into seed trays and kept moist by standing in water. Over the next seven months only two tree lupin seedlings emerged, whereas other species from the site such as *Bromus diandrus* Roth, *Sonchus oleraceus* L., and *Rumex acetosella* L. germinated in considerable numbers from the surface samples, and in very small numbers from the subsurface sample.

1 May 1986. The tree lupin population had recovered to such an extent that it appeared little different from that observed before the kowhai moth larval attack.

26 May 1987. The site was visited to search for signs of renewed insect infestation. Most of the young tree lupins recorded the previous year were dead, and the remainder were dying. All of these plants had suffered shoot and root die-back. The dead plants still retained their shrivelled leaves and there was only minor sign of larval grazing damage. Many of these plants had seeded before they died, but the pods were few and invariably small. Along the marked transect only six adult plants and two seedlings remained alive, though all were affected by die-back. From the symptoms described, it was considered that the plants had probably died as a result of attack by the root fungus *Colletotrichum gloeosporioides* (Pennycook 1989) (identified by Forest Research Institute, Rotorua, D. Rooney pers. comm.).

1988. The site was not examined in 1988.

10 May 1989. The stand at this date consisted of large, dead plants and small, live ones, many of the latter showing dieback similar to that observed in 1987. New plants were establishing in abundance a short distance beyond the dead ones (Fig 2a). The oldest live plants were two years old, and some had flowered and produced a limited number of seed pods. There were numerous seedlings throughout. Along the marked transect there were 62 live plants (adults and seedlings) and 45 dead ones.

28 December 1989. Most plants, including virtually all those alive in May 1989, were dead (Fig 2b). Only three live adult plants were found along the transect. A few kowhai moth larvae were observed grazing, but were not considered to be having a noticeable damaging effect.

31 January 1990. On the main area previously dominated by tree lupin, most plants were dead, with only four seedlings along the transect, all being grazed by kowhai moth larvae. On more coastal dunes beyond the original stand, there were, however, many small tree lupin plants amongst the pingao, some affected by both moth larvae and disease. A second transect was set up there and two adult plants (flowering and fruiting) were recorded, along with 298 seedlings.

10 May 1990. Most tree lupin plants on the original site were dead (Fig 1d). Along the original transect there were eight seedlings, while along the new transect there were only five small plants and 13 seedlings. Seedlings were nevertheless found in abundance beyond the margins of the area previously occupied by tree lupin.

DISCUSSION

The period from late 1984 to mid 1990 has seen the decline of a large healthy stand of tree lupin to an area virtually devoid of vegetation. The decline commenced in January 1985 with the sudden, destructive effects of grazing by kowhai moth larvae. This herbivore grazed with such intensity that it effectively destroyed all living material, and very few plants survived the attack. The herbivore also

disappeared, as no pupae were found in December 1985, nor were there any signs of kowhai moth the following year. It appears the larvae were so numerous that they exhausted the food supply before the critical intake level of maturation and pupation was reached. It is suspected that synchrony of larval hatching followed by starvation probably accounted for this very sudden population decline.

In the following summer of 1985–6, tree lupin recovered by partial regeneration of a few grazed plants, but mainly by seed. The vigorous growth of these few survivors and new seedlings was probably greater than normal as there was virtually no competition. At this stage, re-establishment of the original stand seemed inevitable.

The appearance of *Colletotrichum* disease, on or before May 1987, commenced a second, slower decline that has continued to 1990. The initial attack resulted in the death of nearly all live plants, but there was, over the following two years to May 1989, at least one period of recovery. This recovery seems to have involved the establishment of seedlings beyond the dead parents and presumably beyond the immediate effects of the disease (Fig 2). It became clear, however, that by the summer of 1989–90, the disease had spread to these plants as well. The response of the tree lupin was then to establish only beyond the margins of the original stand. Even then the disease has caught up with these plants, pushing the establishment zone further outwards.

This process has left the area originally occupied by healthy tree lupin as a virtual sand desert littered with decaying stems, and only vegetated by an annual flush of growth of *Bromus diandrus, Lagurus ovatus* L., *Lepidium africanum* (Burm. f.) DC, and *Sonchus oleraceus*. Seedlings of tree lupin can be found, but succumb to the disease very rapidly. The former outer margin of the stand has returned to pingao dominance, and the tree lupin plants that established there have also succumbed to the disease, at an age before they were able to displace pingao.

It is difficult to make predictions regarding the long-term future of this tree lupin stand. Present trends suggest that the areas once occupied by vigorous tree lupin will remain bare, while the disease will follow the establishing plants further out amongst the pingao. These observations have, however, demonstrated that the area is subject to sudden and unexpected change. Much will depend on two factors: the balance of available seed, and longevity of disease in the soil in the absence of a host. Tree lupin seed germinates fairly rapidly, certainly mostly within a year, so the population is dependent upon regular flowering and fruiting. At present, very few plants flower and seed set is poor, so the population appears to be gradually declining in its potential to reproduce. Re-establishment on bare areas may take place if the disease loses its viability and such an event could start to recycle the process we have observed. Other sand dune species may occupy the site, but there is no evidence for this so far. Re-appearance of kowhai moth, as in January 1990, even at low numbers would probably further stress the tree lupin population so severely that its future viability would be in question.

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