Flax planting trials to assess flax weevil damage to plants of different provenances

Mana Island, June 2017

Background

Eighty adult flax weevils (*Anagotus fairburni*) sourced from Maud Island, Marlborough Sounds, were translocated to Mana Island on 12 May 2004, followed by a further 70 animals on 15 June 2006 (Miskelly 2010). The translocation was undertaken to implement a recommendation made in the *Mana Island ecological restoration plan* (Miskelly 1999). Flax weevils feed only on native flaxes (both harakeke *Phormium tenax* and whaririki *P. cookianum*), with adults eating foliage at night, and larvae feeding on the roots.

The 150 adult weevils were introduced to a dense sward of flax (believed to be hybrid plants *Phormium tenax* X *P. cookianum*) in the south-west of Mana Island, about 40 m south-east of the 'FW01' label in Figure 1. They rapidly established, and by late 2009 it was "easy to find ten or more weevils in as many minutes at the release site" on calm nights (Miskelly 2010, p.29).

Figure 1. The two sites where flaxes were planted in June 2017 as part of a trial to assess whether plants sourced from Maud Island have greater resistance to weevil damage. 'FW01' is near where flax weevils from Maud Island were released in 2004 & 2006; FW26 is just beyond their current distribution.

The weevils reached higher densities at the release site, and caused more damage to host plants, than had been recorded previously. Deaths of mature flaxes were noted by 2013 (Miskelly 2013). Adults caused obvious damage to the edge of leaves (Figure 2a), and prevented flowering of heavily infested plants by devouring unopened flower spikes (Figure 2b). However, the fact that large plants that still had numerous leaves collapsed and died (Figure 2c) points to the lethal damage occurring below ground level, where flax weevil larvae burrowed into the root stocks (Figure 2d).

a b
c d

Figure 2. Impacts of flax weevils on host plants on Mana Island: (a) feeding sign caused by adults, June 2017; (b) adult flax weevils feeding on unopened flower spikes, November 2013; (c) a dead mature flax plant, June 2017; (d) flax weevil larvae within the root stock of a dying plant, November 2013. All images: Colin Miskelly.

Flax on Mana Island provides the almost exclusive habitat for goldstripe geckos (for which Mana Island is the world stronghold), and provides an important nectar source for bellbirds, tui, and at least two species of gecko. Loss of flax to the extent already apparent in the south-west of the island would severely impact on all these species.

Two hypotheses for the super-abundance of flax weevils on Mana Island have been proposed:

1. That Mana Island flaxes were more susceptible to weevil browse than those on Maud Island, with browse resistance lost during cultivation (of the windbreak *P. tenax* planted during the MAF farming era in the 1970s) and/or through hybridisation between the two species.

2. That a natural bio-control agent that affects flax weevil larvae was left behind on Maud Island when the adult weevils were translocated, with the most likely candidate being an as-yet unsearched for pathogenic (and species-specific) strain of *Metarrhizium anisopliae* fungus.

In order to investigate the first hypothesis, seeds from *P. cookianum* were collected on Maud Island in early 2015, and propagated in the Mana Island nursery. Unfortunately no effort was made to collect locally-sourced seed on Mana Island at the same time, and so the trials described here used transplanted juvenile flax plants sourced from near the planting sites, planted in equal numbers with Maud Island plants.

Field observations, June 2017

During 16-18 June 2017, flax weevil feeding sign was noted on every flax plant inspected in the south-west of Mana Island, in a radius approximately 500 m from the release site (including near the shore, halfway along the South Coast Track). There was also an infestation of flax weevils around the Lockwood, which has evidently resulted from deliberate or accidental translocation of these flightless weevils to the site, as there was about 400 m of unaffected plants separating the Lockwood infestation from the main weevil infestation.

Both *P. tenax* and *P. cookianum* were eaten, with the weevils showing a preference for the smaller and softer-leaved *P. cookianum* when the two species were growing in close proximity. However, fully mature plants of both species had been killed by the weevils, as well as several hectares of presumed hybrid plants around the release site. Flaxes growing in wet sites appeared to survive better than plants in dry sites. There are two possible (non-exclusive) explanations for this. Plants in wet sites may still be able to obtain sufficient water through a damaged root system, and so be better able to survive periods of drought stress, and a high water-table may kill or discourage weevil larvae from living among water-logged roots.

Planting trial methodology

Two sites with differing exposure to flax weevils were selected. The southern site was just inland of the junction between Southern Track and the Petrel Station Track (Figure 1), close to where flax weevils were released. All 100 flaxes planted at this site were planted within 20 m of established flaxes showing weevil feeding sign. All 50 transplanted flaxes used at this site were gathered from within 200 m of the site, and all had weevil feeding sign (and so may have had weevil eggs or larvae among their roots and plant bases). The northern site was just north of the junction between Tirohanga Track and Central Track (Figure 1), on the eastern side of the small pond there. None of the adult flaxes around the pond had flax weevil feeding sign, but some sign was evident within 100 m to the south and north (the latter minor infestation is likely to have been assisted dispersal). None of the 50 transplanted flaxes used at this site had any weevil feeding sign on them. It is expected that flax weevils will reach this site within 1-2 years.

At each site, 25 waratah stakes were rammed into the ground at least 3 metres apart. All the stakes were individually tagged with yellow Allflex tags labelled 'Weevil s 2017' and numbered 1 to 25 (southern site; Figure 3) or 26 to 50 (northern site, Figure 4). Four flaxes were planted in a cross centred on each stake (north, east, south and west), with each plant approximately 1 metre from the

stake. Two Maud Island (nursery reared) and two Mana Island (transplanted) flaxes were planted around each stake, in a randomised pattern (Appendix 1). A c.30 cm long yellow Novacoil tube was partially buried around each plant to provide protection from pukeko and takahe (Figure 5), and all plants were watered (approx. 0.5 litre) on the day of planting.

Figure 3. Spatial arrangement of marked plots at the southern study site. Southern Track at left, with Petrel Station Track junction at upper left.

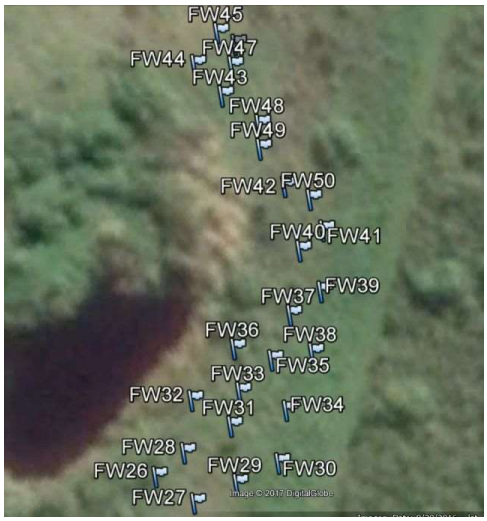

Figure 4. Spatial arrangement of marked plots at the northern study site. FW46 is not labelled, but shows as a grey flag between FW45 and FW47. Tirohanga Track at right, pond at lower left.

Recommendations for monitoring the flax plantings

FOMI members are requested to monitor the plantings during each working bee weekend, and to record the health of all 200 plants in the trial. This is likely to take about an hour for 1-2 people at each of the 2 sites. Each team will need a compass, or other means of assessing the orientation of the four plants around each post. A data form is included as Appendix 2. Each plant should be scored as one of:

H/UnE	Healthy/Uneaten
H/E	Healthy/Eaten = weevil feeding sign apparent
UnH/UnE	Unhealthy/Uneaten
UnH/E	Unhealthy/Eaten
D/UnE	Dead/Uneaten
D/E	Dead/Eaten
Dead	(if it is not possible to determine whether the plant had been eaten or not)
Abs	Absent = no plant remains detectable

Figure 5. An example of a flax planting plot, showing three of the four flaxes (in Novacoil tubes) planted one metre from a central, tagged waratah stake. Other tagged stakes can be seen in the background.

Recommendations for planting and marking the remaining Maud Island flaxes

There are at least 800 Maud Island-sourced flaxes still in root trainers in the Mana Island nursery. There are also a further 50 waratah stakes and 50 labelled Allflex tags that were purchased for the trial. It is recommended that these flaxes be planted out in clusters at 10 different sites around the island (approximately 80 plants per site), to assess whether different microhabitats (e.g. differing water-table conditions) influence plant survival following weevil infestation.

Five waratahs stakes should be rammed in and tagged at each site, with four Maud Island flaxes planted in a cross, centred on each stake, at north, east, south and west compass points approximately 1 metre from each stake. The GPS location of each plot should be mapped, and also the spatial layout of the 5 stakes within each plot (see examples in Figures 3 & 4). This will allow the locations of 20 plants per plot to be checked over time, even if every plant in the plot dies. The remaining 60 or so plants should be planted at least 1 metre apart, centred on the 5 waratah stakes marking the plot. All plants should be protected with a Novacoil tube (installed during planting) for approximately 1 year after planting.

Acknowledgements

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Literature cited

Miskelly, C. 1999. *Mana Island ecological restoration plan*. Wellington, Department of Conservation. 149 pp.

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Miskelly, C. 2013. A plague of flax weevils – a conservation hyper-success story. Te Papa blog published 13 November 2013 (http://blog.tepapa.govt.nz/2013/11/13/a-plague-of-flax-weevils-a-conservation-hyper-success-story/)

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Appendix 1. Configuration of flax plants around marked stakes FW01 (= Weevil s 2017 1) to FW50 (= Weevil s 2017 50) at the two study sites.

Southern study site				
Plot	North	East	South	West
FW01	Mana	Mana	Maud	Maud
FW02	Maud	Mana	Mana	Maud
FW03	Mana	Mana	Maud	Maud
FW04	Mana	Maud	Mana	Maud
FW05	Maud	Mana	Maud	Mana
FW06	Mana	Maud	Mana	Maud
FW07	Mana	Maud	Mana	Maud
FW08	Maud	Maud	Mana	Mana
FW09	Mana	Mana	Maud	Maud
FW10	Maud	Mana	Maud	Mana
FW11	Maud	Maud	Mana	Mana
FW12	Mana	Mana	Maud	Maud
FW13	Maud	Mana	Mana	Maud
FW14	Mana	Mana	Maud	Maud
FW15	Maud	Mana	Maud	Mana
FW16	Maud	Maud	Mana	Mana
FW17	Maud	Mana	Maud	Mana
FW18	Maud	Mana	Maud	Mana
FW19	Maud	Mana	Maud	Mana
FW20	Maud	Maud	Mana	Mana
FW21	Maud	Mana	Mana	Maud
FW22	Maud	Maud	Mana	Mana
FW23	Mana	Mana	Maud	Maud
FW24	Mana	Maud	Maud	Mana
FW25	Maud	Mana	Mana	Maud

Northern study site				
Plot	North	East	South	West
FW26	Maud	Mana	Maud	Mana
FW27	Mana	Mana	Maud	Maud
FW28	Mana	Mana	Maud	Maud
FW29	Maud	Maud	Mana	Mana
FW30	Mana	Maud	Mana	Maud
FW31	Mana	Mana	Maud	Maud
FW32	Mana	Maud	Maud	Mana
FW33	Mana	Mana	Maud	Maud
FW34	Mana	Mana	Maud	Maud
FW35	Mana	Maud	Mana	Maud
FW36	Maud	Maud	Mana	Mana
FW37	Mana	Maud	Maud	Mana
FW38	Maud	Mana	Maud	Mana
FW39	Mana	Maud	Mana	Maud
FW40	Mana	Maud	Mana	Maud
FW41	Mana	Maud	Maud	Mana
FW42	Maud	Mana	Mana	Maud
FW43	Maud	Mana	Mana	Maud
FW44	Maud	Mana	Maud	Mana
FW45	Maud	Maud	Mana	Mana
FW46	Maud	Mana	Maud	Mana
FW47	Maud	Maud	Mana	Mana
FW48	Maud	Mana	Mana	Maud
FW49	Maud	Mana	Mana	Maud
FW50	Mana	Mana	Maud	Maud

Appendix 2. Monitoring datasheet for flax plants at the two Mana Island study sites.

Date: **Observer(s):**

Southern study site				
Plot	North	East	South	West
FW01				
FW02				
FW03				
FW04				
FW05				
FW06				
FW07				
FW08				
FW09				
FW10				
FW11				
FW12				
FW13				
FW14				
FW15				
FW16				
FW17				
FW18				
FW19				
FW20				
FW21				
FW22				
FW23				
FW24				
FW25				

Northern study site				
Plot	North	East	South	West
FW26				
FW27				
FW28				
FW29				
FW30				
FW31				
FW32				
FW33				
FW34				
FW35				
FW36				
FW37				
FW38				
FW39				
FW40				
FW41				
FW42				
FW43				
FW44				
FW45				
FW46				
FW47				
FW48				
FW49				
FW50				

Each plant should be scored as one of:

H/UnE	Healthy/Uneaten
H/E	Healthy/Eaten = weevil feeding sign apparent
UnH/UnE	Unhealthy/Uneaten
UnH/E	Unhealthy/Eaten
D/UnE	Dead/Uneaten
D/E	Dead/Eaten
Dead	(if it is not possible to determine whether the plant had been eaten or not)
Abs	Absent = no plant remains detectable

Please scan and email completed datasheets to colin.miskelly@tepapa.govt.nz