

Ecology and conservation of the rare moth *Asaphodes frivola* Meyrick

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Introduction

The geometrid *Asaphodes frivola* (Meyrick 1913) (Geometridae; Larentiinae) is a medium-sized species of moth with a wingspan of 22-26mm (Plates 1 and 2). The adults are sexually dimorphic with flighted males and much smaller short-winged females that are flightless (Plate 3).

It is ranked as Nationally Endangered by the Department of Conservation in its list of threatened New Zealand Lepidoptera (Stringer *et al.* 2012).

This report, commissioned by the Department of Conservation, Southland, provides an overview of the known status of the species, including the history of collection, and information on known populations. It also includes the results of a recent survey to establish whether the species still exists in previously known sites, and likely new sites that have been checked. The larval host plant has been ascertained and the implications are discussed. Finally, future work requirements to secure this species and its specialised habitat are outlined.

Relationships

The geometrid genus *Asaphodes* contains about 46 species of often attractively marked moths with a wingspan range of 22-40mm (Dugdale 1988 and the author's collections). They inhabit a wide range of ecosystems nationwide, from the coast to the high alpine zone. Many species are diurnal in behaviour while others are nocturnal. They mostly utilise damp habitats and their larvae feed on a range of herbaceous plants. As is the case with many other

endemic species-rich invertebrate genera, the genus defines New Zealand both geographically and topographically, with every area of the nation, including off-shore island groups having a different suite of species, often containing local endemics. The genus is especially species-rich in southern New Zealand with the alpine zone there being particularly diverse. Four of the eleven species recorded close to Invercargill have their Type Locality there (Table 1).

Asaphodes frivola is a member of a suite of similar-looking geometrid species that are found around the margins of upland wetlands in northern and western Southland, and Central Otago (Plate 2). These species include *Asaphodes sericodes*, *A. periphaea*, *A. ida*, *A. dionysias*, *A. recta*, *A. helias*, *A. oraria*, *A. exoriens*, and *A. aphelias* and all appear to be closely related to *A. frivola*, both morphologically and ecologically (Patrick 2012). Usually they are found in these upland wetlands between 800-1,100m but *A. dionysias* is found considerably higher to 1,600m on the alpine plateaux of the Central Otago ranges where extensive wetlands occur. Most have short and narrow-winged females that hold their tiny wings above their bodies and are not capable of flight (Plate 3) (Patrick 2012). Of this group of typically upland moths only *A. oraria* is found at sea-level close to Invercargill. This occurrence of typically upland species at sea-level in the vicinity of Invercargill is a special feature of the vegetation, flora, and fauna assemblages of the area, and has been discussed previously by Patrick (1994). *Asaphodes frivola* is endemic to the Invercargill area.

Seven *Asaphodes* species were found in open non-forest habitats around Invercargill until the 1930s (Patrick 1994) (Table 1). Since then two of these species- *Asaphodes prasinius* and *A. stinaria*- have become locally extinct (Patrick 2000). Nationally the former is still widespread but uncommon while the latter is rare and has a ranking of Nationally Vulnerable (Stringer *et al.* 2012). Forest species have fared even worse, with the local extinction of three other species, two of which (*Asaphodes imperfecta* and *A. obarata*) also have high national threat rankings (Table 1).



Plate 1: Adult male *Asaphodes frivola* on its probable larval host plant *Ranunculus glabrifolius*, Tiwai Spit, Southland, 17 April 2014.

Interestingly, two species- *Asaphodes aegrota* and *A. oraria*- appear to have benefited from human-induced ecological changes in the Invercargill area, as they have adapted to feeding as larvae on an introduced daisy (*Bellis perennis*) in suburban lawns. *Asaphodes oraria* is only found in this setting in the suburb of Otatara, southeast of Invercargill (Patrick 1981). Like *A. frivola*, *A. oraria* too has a short-winged flightless female.

Table 1: *Asaphodes* species recorded from the Invercargill area, and their habitat and the local status of each taxon.

| Species | Type Locality | Habitat | Local Status |
|------------------------------|--------------------------|------------------|---------------------|
| <i>Asaphodes abrogata</i> | Waikouaiti | Dry open areas | Common |
| <i>Asaphodes aegrota</i> | Wairarapa | Forest/edge | Common |
| <i>Asaphodes beata</i> | ?Castle Hill | Forest | Common |
| <i>Asaphodes frivola</i> | near Invercargill | Endemic; coastal | Rare |
| <i>Asaphodes imperfecta</i> | West Plains | Forest | Extinct |
| <i>Asaphodes oraria</i> | New River | Non-forest | Locally common |
| <i>Asaphodes obarata</i> | Nelson | Forest | Extinct |
| <i>Asaphodes philpotti</i> | Lake Wakatipu | Forest | Extinct |
| <i>Asaphodes prasinias</i> | Castle Hill | Forest/shrubland | Extinct |
| <i>Asaphodes stephanitis</i> | Invercargill, sand hills | Dunes/grassland | Rare |
| <i>Asaphodes stinaria</i> | Canterbury | wetlands | Extinct |



Plate 2: Adult male *Asaphodes frivola* from Tiwai Spit, 17 April 2014.



Plate 3: Brachypterous adult female of *Asaphodes frivola* at Tiwai Spit 14 April 2011. Note the small, thin wings that are held above the body.

Discovery

Alfred Philpott discovered the unassuming geometrid *Asaphodes frivola* near Invercargill just over one hundred years ago (Plate 1). He sent the solitary male specimen he found to Edward Meyrick in England for description and the latter subsequently described it as *Xanthorhoe frivola* in 1913 and recorded it from Invercargill. The Holotype specimen is stored in London's British Museum of Natural History (Plate 4).



Plate 4: The Holotype male of *Asaphodes frivola* that is stored in the British Museum of Natural History, London. Image is used courtesy of Landcare Research Ltd. Note the scale in millimetres across the top of the image.

Philpott never found or recognised the moth again and neither did other lepidopterists over the following 68 years. Because of this there were no specimens in New Zealand collections which George Hudson could borrow and illustrate for his monumental work (Hudson 1928) on New Zealand butterflies and moths, but he did describe the species and note that Philpott found it ‘near Invercargill’.

Based on Philpott's collections from habitats at the New River estuary, including his discovery of many new moth species there such as the closely related *Asaphodes oraria*, New River estuary is the most probable place where he discovered *A. frivola* (Patrick 1997, 1998). The New River Estuary is at the mouth of the Oreti River flanked by both Sandy Point and Otatara (Fig. 1). This is (or was) a complex ecological area of sandy soils and related vegetation including totara forest, sand dune and saltmarsh vegetation. Major reclamation works and ongoing degradation by a combination of direct human disturbance and invasion by human-assisted exotic plants has dramatically altered the natural habitats and processes of this system.

Dugdale (1988) in his catalogue of New Zealand Lepidoptera lists *Asaphodes frivola* under *Asaphodes* and notes the type locality and collector.

Following its initial discovery, no further records of *Asaphodes frivola* were made until it was rediscovered on 19 March 1981 at Sandy Point (Patrick 1981). In coastal grassland one male *Asaphodes* was disturbed and caught. Three nights later, one male was attracted to light at my home a few kilometres away at Grant Road, Otatara. On return to the Sandy Point site on the night of 6 April 1981, the short-winged and flightless female of this species was located sitting on low herbage about 8cm off the ground (Patrick 1983). While flightless, the agile female can run quite quickly as it has relatively long legs. I searched this site again on 14 April 1981 and found an additional male. It appeared from the records to date that *Asaphodes frivola* emerges as adults from mid-March to mid-April, and is active on the warmest nights during that period.

Through the 1980s, 1990s, and 2000s I explored by day and light-trapped by night, many other apparently suitable sites in the environs of Invercargill. Only one site close to the Tiwai Aluminium Smelter on the coastal fringe of Tiwai Spit south of Invercargill- yielded

further males and females (Table 3). At the time, this population appeared to be the only known one for the species although the Sandy Point population from 1981 had not been systematically searched for or relocated. Further survey in April 2011 at Tiwai Spit confirmed that the population was still present, with ten males and five females located over a small area of coastal fringe herbfield with knobby clubrush (*Ficinia nodosa*) and silver tussock (*Poa cita*) as the canopy species.

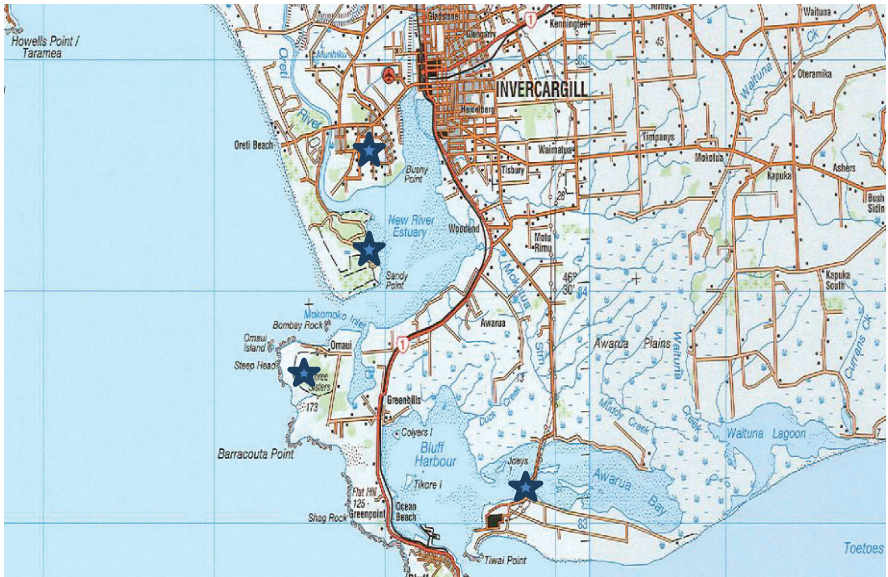


Figure 1: Invercargill area showing the four past and present sites for *Asaphodes frivola* highlighted with four blue stars. The top star is positioned at Otatara.

Between 16 and 18 April 2013, Department of Conservation entomologist Eric Edwards surveyed for *Asaphodes frivola* at Fortrose Spit (east of Tiwai Spit), along the southern coast of Tiwai Spit, at the known Tiwai Spit site, and at the Three Sisters Sand Dune (west of Tiwai between Bluff and Omahau). He located one

additional population at the Three Sisters Sand Dune (Figure 1) where he describes the moth as occurring in similar habitats as on Tiwai Spit, but noted that overall suitable habitat for the moth was uncommon and what remained was threatened by weed invasion. He also found two males close to the known Tiwai Spit site (Table 2).

Table 2: All known records of *Asaphodes frivola*.

| Date | Place | Sex | Person | Individuals |
|---------------|----------------------------|-----|---|-------------|
| 1912? | “nr Invercargill” | m | Alfred Philpott | 1 |
| 19 March 1981 | Sandy Point | m | Brian Patrick | 1 |
| 22 March 1981 | Otatara | m | Brian Patrick | 1 |
| 6 April 1981 | Sandy Point | m,f | Brian Patrick | 9 |
| 14 April 1981 | Sandy Point | m | Brian Patrick | 1 |
| 5 April 1984 | Tiwai Spit | m | Brian Patrick | 3 |
| 6 April 1990 | Tiwai Spit | m | Brian Patrick | 2 |
| 12 April 2002 | Tiwai Spit | m | Brian Patrick and Eric Edwards | 2 |
| 14 April 2011 | Tiwai Spit | m,f | Brian Patrick | 15 |
| 17 April 2013 | Tiwai Spit | m | Eric Edwards | 2 |
| 18 April 2013 | Three Sisters Sand Dune | m | Eric Edwards | 2 |
| 17 April 2014 | Tiwai Spit | m | Brian Patrick | 1 |

Table 3: Grid references of the known sites for *Asaphodes frivola* near Invercargill.

| Site Name | NZTM Grid Reference |
|-------------------------------|---------------------|
| Otatara | E1239950 N4846130 |
| Sandy Point | E1239540 N4841180 |
| Tiwai Spit - first site 1981 | E1248230 N4831830 |
| Tiwai Spit - second site 2013 | E1248540 N4831500 |
| Three Sisters Sand Dune | E1235080 N4835030 |

Table 2 summarises all the known records of the species with dates, while Table 3 provides accurate grid references of those sites.

Biology

Eggs were obtained from the flightless female discovered at Sandy Point in 1981 and the larvae were reared on two exotic herbs: daisy (*Bellis perennis*) and Buck's horn plantain (*Plantago coronopus*). Its natural host was not investigated further but was strongly suspected to be a low-growing herb in the coastal tussock grassland.

The yellow eggs were laid singly on 8 April 1981 and hatched in captivity 31 days later on 9 May 1981. At first the young larvae were a dull greyish colour with cuticle on the most posterior segment consisting of two plates, a black head and legs, darker grey posteriorly, with distinct dots on its lateral and dorsal areas. By the 20 June the larvae were 5-6mm long with a distinct dorsal herring-bone pattern surrounding a pale area. They had a white lateral line, a wide ventral pale area which was surrounded by a dark band on each side. The greenish-brown larvae were feeding and growing slowly, and by 29 August had only grown to 8mm in length.

By 11 December the largest had grown to 18.5mm in length and they were now a dull greenish-brown colour with a pinkish tinge. Laterally they were dull green and with paler ventral and dorsal areas. The dorsal herring-bone pattern was more distinct than before with broad black stripes and a dull green tinge. Ventrally the larvae were brown with a white stripe bordered by a thin black line followed by a broad black stripe. The body shape was flattened (Fig. 2).



Figure 2: The author's 1981 notebook sketch of the larva at 216 days old (11 December 1981) and 18.5mm in length. The larvae were reared from eggs from a Sandy Point female.

By 13 January the larvae were 19mm and generally fed from below on foliage that lies flat on the ground. They were a dull greenish colour with dull brown mottling and a black dorsal herring-bone pattern. There was a thin white lateral line and they were ventrally dull green with many darker lines. The prolegs were smaller than before. By 23 January 1982, all the larvae had died, of unknown causes. They were about 20mm in length. Based on my subsequent experience with rearing related species, the larvae may have been full-grown at this time and died because the right conditions for pupation were not provided.

In this captive situation, the total observed larval stage was 259 days in duration. This is likely to also reflect the situation in the wild because, if anything, rearing in captivity speeds up development

compared to in the wild, based on my personal experience. This data fits well with the observed annual life cycle for the species.

Field survey methods 2014

Visits were made to the following sites in southern Southland over the period 17-19 April 2014 to survey for *Asaphodes frivola*, deduce its possible larval host plant, and to gather information on the ecology of the moth species:

- Tiwai Spit - the key site first identified in 1984 was examined by day and night.
- Margins of Awarua Bay - 12 km of estuarine coastline was walked and examined for the larval host plant and adult moth by day.
- Coastal Tiwai Spit - the south side of the Spit was surveyed for potential habitat by day.
- Sandy Point - the original 1981 site was relocated and other possible sites on its New River margin were examined by day and night.
- The north end of Oreti Beach at the end of Ferry Road was examined by day where potential natural habitat exists for the moth.
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Field survey results 2014

At the sites surveyed in 2014, only one male *Asaphodes frivola* was found, and that was at the original 1981 Tiwai Spit site (Table 2). No adult moths were found at any of the other sites searched, despite the large search effort. Sadly the 1981 Sandy Point site appears no longer to support *A. frivola* as it was searched twice during this survey under apparently suitable conditions.

Measurement of the Tiwai Spit site where the moth and its potential host plant were found show that the area of occupancy is less than 25 m² spread along a short but continuous part of the coastline.

Larval host plants

Tiwai Spit is the key site for *Asaphodes frivola* with flightless females being found at the site in 2011, suggesting that eggs must be laid nearby and that larvae must be feeding on one of the plants available. The site is small and confined, narrowing the potential options for identification of the host plant.

The indigenous buttercup, *Ranunculus glabrifolius*¹ was found to be present at the site by Department of Conservation botanist Brian Rance. About 50m of almost continuous *R. glabrifolius* occurs along this coastal fringe. This fringe is only about 30cm wide, and is backed by a band of dense, often exotic, grasses and herbs. Subsequent searches found no more buttercup plants in the area.

Ranunculus glabrifolius is the most likely host plant and this is supported by the genus *Ranunculus* being the main host plant among the 46 species of *Asaphodes*, where the host plant is known with certainty.

Ranunculus glabrifolius appears to be rare in the coastal fringe vegetation of the Oreti River and Awarua Bay but more survey effort is required to confirm this (Bythell *et al.* in prep.). Typically it is found in damp areas within open or semi-open areas. Its rarity appears to have been caused by the invasion of a suite of aggressive exotic herbs and grasses, and probably ongoing damage by recreational vehicles, which have unhindered access to these sites (Plate 7). Bythell *et al.* (in prep.) note that *R. glabrifolius* occurs on the long spit that stretches out into Awarua Bay on the northern edge of Tiwai Spit, close to the bridge. The plant community they

¹*Ranunculus glabrifolius* is not threatened and is found throughout New Zealand, often partially submerged in shallow water, wet grassland and lake, pond or tarn marginal turf communities (NZPCN website: www.nzpcn.org.nz)

describe it in also appears to be suitable habitat for *Asaphodes frivola*.

Habitat

Based on the collection records, *Asaphodes frivola* inhabits sheltered coastal herbfield dominated by either knobby clubrush or silver tussock right on the coastal edge adjacent to either gravel or shell beaches (Plate 5). That this is the precise habitat of the larvae and therefore the species has been confirmed by the discovery of five females at the site in April 2011. These females were found a short way up (5-20cm) the stems of the knobby clubrush where they had climbed to release their pheromone to attract males. The female is flightless, and therefore where she is found is where she will lay eggs and the species breeds.

This plant community is classified by Singers and Rogers (2014) as *Ecosystem Unit Code SA4, Shore bindweed, knobby clubrush gravelfield/ stonefield*. This community is still relatively extensive around the more sheltered coastline of the Awarua Bay and nearby inshore islets, New River Estuary, and Bluff Harbour.

In reality, the moth's specialised habitat is a subset of this broad community type, and is not common in its intact form. This community is generally only 30-50cm wide but can extend for tens of metres along the coastal fringe. The canopy of knobby clubrush (*Ficinia nodosa*) and silver tussock (*Poa cita*) occurs above a range of indigenous herbs such as *Apium prostratum* variety *filiforme*, *Selliera radicans*, *Leptinella serrulata*, *Centella uniflora*, and *Ranunculus glabrifolius*.



Plate 5: Formerly suitable habitat for *Asaphodes frivola* on the inner (Awarua Bay) coastline of Tiwai Spit, April 2014. Invasion by aggressive exotic grasses and herbs has rendered the site unsuitable as few indigenous herbs now occur here.

Inland of this narrow ecosystem is a shrubland dominated by the shrub daisy *Olearia nummulariifolia*, prickly mingimingi (*Leptocophylla juniperina*), matagouri (*Discaria toumatou*), *Coprosma propinqua*, *C. tayloriae*, *Myrsine australis*, *Ozothamnus vauvilliersii*, *Hierochloe redolens*, copper tussock (*Chionochloa rubra cuprea*), *Muehlenbeckia complexa*, *M. australis*, bracken (*Pteridium esculentum*), and flax (*Phormium tenax*). Within this shrubland, open areas of quartz pea gravels support a species-rich herbfield dominated by *Raoulia glabra*, *Pimelea prostrata* variety *ventosa*, and *Muehlenbeckia axillaris*. The presence of an occasional shrub of saltmarsh ribbonwood (*Plagianthus divaricatus*) on this coast confirms the estuarine nature of the area. The rare moth

Asaphodes stephanitis, a close relative of *A. frivola*, is found in this grassland–shrubland community.

Conservation

Habitat for *Asaphodes frivola* is incrementally disappearing from the Invercargill area. Based on the results of the April 2014 survey, *A. frivola* appears to have gone from the 1981 Sandy Point site. This may be due to invasion by exotic herbs and grasses of the coastal fringe habitat and increased recreational vehicle use (Plate 7). At the end of Ferry Road, at the northern end of Oreti Beach, there is (or was) potential habitat for *A. frivola* in a seasonally-wet, dune slack habitat behind the foredune. This site also harbours other rare moth species (Patrick 1994), but has been badly damaged by off-road vehicles (Plate 6).

Its two known remaining habitats- on Tiwai Spit and at Three Sisters Sand Dune- are small and vulnerable to a range of threats, including uncontrolled recreation and fire. A large fire in 2009 swept across much of Tiwai Spit, destroying about 48% of the indigenous vegetation of the Tiwai Spit Conservation Area (Bythell *et al.* in prep.).

Remaining sites for *Asaphodes frivola* are now so small that they are vulnerable to extirpation by random events and also to incremental invasion of exotic plants that could overtop and kill the larval host plant.



Plates 6 and 7: At left, off-road vehicle damage is obvious to seasonally wet hind dune systems at the north end of Oreti Beach where other rare moths have been found in the 1980s. At right, damage to coastal saltmarsh from vehicles at the 1981 Sandy Point site where *Asaphodes frivola* appears to have disappeared.

Discussion

The moth genus *Asaphodes* is in decline with local extinction in the environs of Invercargill and elsewhere in New Zealand (Patrick 2000). Seven of the eleven species (64%) recorded from Invercargill are now either locally extinct or rare, with four of them having a high national threat ranking (Stringer *et al.* 2012). Where the life history is known, the larvae feed in damp areas on a range of herbaceous species particularly the genus *Ranunculus*, in the buttercup family.

The demise of many of these *Asaphodes* species and the genus generally can be linked to the drying out and disappearance of many of our natural ecosystems over the past approximately 160 years as various forms of land conversion have progressed. In the Invercargill area, significant areas of podocarp forest and larger areas of associated forest-edge communities are gone; lost to a spreading city and its nearby suburbs such as Otatara, intensification of farming and infrastructure such as roads and pylons. Huge areas of *Carex secta*-dominated wetlands, the *Donatia*-wiredrush-*Sphagnum*-manuka-*Dracophyllum* wetlands of Seaward Moss-Waituna, and dune slacks in the large swath of sand dune country behind Oreti Beach have contracted greatly or disappeared since Europeans arrived from the late 1850s onwards. In addition, the ecosystems that survived this spatial onslaught were forever changed in terms of quality, with lowered water tables, modification by ever-changing farming practices, ongoing invasion by pest plants and animals and indiscriminate recreational use. Natural non-forest habitats, many containing biota with alpine affinities, which were once widespread around Invercargill, are of high significance in terms of species-richness, biogeography and conservation of a unique suite of indigenous plants and fauna with many local endemic species (Patrick 1983; Patrick 1994).

The natural habitat of *Asaphodes frivola* is very specialised, being coastal or near-coastal wetland which has a canopy of knobby

clubrush or silver tussock with an under-storey of herbs, in particular, *Ranunculus glabrifolius*. It is possible that the moth occupied a larger range of coastal habitats prior to changes associated with European settlement but this is not borne out by early observations and records. *Asaphodes frivola* is a rare species, endemic to a narrow and confined part of the southern Southland coastline, immediately east and south of Invercargill. It has never been commonly recorded since European settlement, and may have been losing ground over a long period of global warming as non-forest communities at sea-level in southern Southland have contracted since the last ice ages. Only 34 males and six females have ever been found, despite intensive searching over the past 33 years.

The species is perilously close to extinction even at its best site on Tiwai Spit where its apparent area of occupancy is less than 25m². Although Tiwai Spit is managed by the Department of Conservation, there is still a very high risk that its habitat could disappear. There is a well-used gravel road and boat ramp nearby, either of which could be easily expanded, extinguishing the species almost overnight. Both sites are also threatened with fire. Exotic grasses and herbs may also be an issue in over-topping and smothering the larval host plant at both sites (although this was not investigated in this study). At its more remote site on Three Sisters Sand Dune, the population size and area of occupancy of *A. frivola* are unknown, but are likely to be similar to Tiwai Spit. Threats such as aggressive exotic weeds invading its habitat are also likely (Eric Edwards, Department of Conservation, pers. comm. April 2014).

Asaphodes frivola is not the only conservation casualty of land use changes; the local species of boulder copper butterfly (*Lycaena* new species) was once recorded from both Sandy Point and Otatara (Philpott 1917), but hasn't been seen in either place for many decades. Its host plant *Muehlenbeckia axillaris* and other ground-hugging herbs, such as the southern endemic *Gunnera hamiltonii*, are also gone from those places.

Based on the information above, the threat ranking of *Asaphodes frivola* has been increased to ‘**Nationally Critical**’². This was a result of only two known populations, much additional survey work that did not locate more populations, ongoing threats to the moth’s habitats and knowledge of the probable host plant that is itself rare and possibly threatened in the area. Without management, *A. frivola* is very likely to become extinct within the next 10-30 years, as even at its two known sites it has very small population numbers, has very small areas of occupancy and has a number of identified existing threats to its continued survival.

Future work

Asaphodes frivola is perilously close to extinction. Without active and effective management *Asaphodes frivola* will disappear within the next 10-30 years. Management is therefore urgent, but needs to be carefully considered and staged. This includes:

- Confirm species range
- Confirm larval host
- Define habitat
- Assess and possibly enhance habitat
- Establish monitoring

A prioritised and staged action plan has been supplied to the Department of Conservation, Southland based on this approach. It is envisaged that this plan will begin in November 2014 with a search for larvae on *Ranunculus glabrifolius* on Tiwai Spit.

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Polly Bulling, Sarah Thorne, and Julie Newell (Department of Conservation, Southland) are thanked for instigating this project,

The information above was presented at a meeting of the Department of Conservation’s specialist Lepidoptera Panel held in Auckland on 28-29 April 2014 where the threat ranking was subsequently increased.

their logistical help, and their enthusiasm with this project, particularly in the field.

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