BATHURST
RESOURCES LIMITED

Powelliphanta Snail Management Plan

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Contents

1.0 Introduction

1.1 Background

Powelliphanta snails are a genus of giant carnivorous land snails endemic to New Zealand. Two species of *Powelliphanta* snails are known to occur on Buller Plateaux - *Powelliphanta patrickensis* and *P. augusta*.

Populations of *P. patrickensis* on Stockton and Denniston Plateaux (together, "Buller Plateaux") are separate subspecies (*P. "patrickensis" patrickensis* and *P. "patrickensis* Denniston") restricted to the Buller Plateaux. Both subspecies are ranked as "Nationally Critical" (Walker et al., 2024) because of significant population declines (60%) over the last ten years (Lloyd, 2024a, 2024b). Damage patterns on snail shells indicate the decline was primarily a result of increased predation by weka (*Gallirallus australis*) but a significant proportion were preyed on by rats (Lloyd, 2024b).

[redacted] The species is ranked as "Nationally Critical" (Walker et al., 2024) with the remnant population actively managed both in the wild and in captivity by DOC as described in the *Powelliphanta augusta* Recovery Strategy (Gruner et al., 2021). Ongoing and proposed coal mining activity on Buller Plateaux will not affect *P. augusta* or habitat within its current distribution range.

There has been coal mining on the Buller Plateaux since the 1880's resulting in a significantly modified landscape with a cumulative legacy of underground workings, transport networks, and large-scale open-cast operations. Mining has had, and will continue to have, a negative impact on *Powelliphanta* snails on Buller Plateaux, destroying their habitat and killing snails. In recent years, a variety of strategies have been used to alleviate and compensate for mining's impact on *Powelliphanta* snails including relocating snails out of disturbance areas; relocating snail habitat out of disturbance areas; rehabilitating disturbed areas by planting; captive rearing and release of captive bred snails; mammalian pest control and funding conservation measures off the Plateaux.

1.2 Purpose

This *Powelliphanta* Snail Management Plan provides a programme to manage and monitor the effects on *Powelliphanta* snails of existing and proposed coalmines on Buller Plateaux. The plan outlines the objectives, risks, management controls, responsibilities, and training requirements to effectively manage impacts on *Powelliphanta* snails from the development, construction, operation, and closure of coal mines on Buller Plateau, including existing mining in Stockton and Cypress Mines and proposed new areas of mining for the Buller Plateaux Continuation Project (BPCP or the "Project") on Stockton and Denniston Plateaux (Figure 1).

[redacted]

1.3 Objectives

The objective of this Plan, as specified in the statutory approvals is to describe measures to avoid or minimise, and monitor adverse ecological effects on *Powelliphanta* during construction, mining and mining operations, and rehabilitation of the BPCP, including Cypress Mine, and to provide a framework for managing residual effects on *P. patrickensis*.

This *Powelliphanta* Management Plan has been prepared to detail proposed effects management and compensation for the impacts of coal mining on Buller Plateaux on *Powelliphanta* snails and their habitat. Best practice field methods for working with *Powelliphanta* snails are provided in the Appendices to this *Powelliphanta* Management Plan.

Proposed effects management strategies are:

- Using vegetation direct transfer (VDT) to relocate areas of snail habitat and snails from disturbance areas wherever possible, and
- Where VDT cannot be used:
    - Manual relocation of snails from areas before disturbance to proposed pest exclusion fenced areas or weka-free exclosures (i.e. snail salvage) as described in Appendix 5.

- Whenever practicable using Slash Direct Transfer (SDT) or jumble dumping with soil transferred directly from disturbance areas to rehabilitation areas and covered with vegetation slash from the disturbance areas.

- Where VDT or SDT cannot be used, manage soil stockpiles to retain soil ecosystems.
- When mining is completed, rehabilitate disturbed areas by creating habitat suitable for *Powelliphanta* snails.

Proposed compensation for the residual impacts of mining on *P. patrickensis* are:

- Construction of permanent pest exclusion fenced areas and removal of pests from the fenced areas to protect snails from predation by weka and predation or trampling by introduced mammals.
- Increasing the extent, intensity and effectiveness of control of mammalian pest species outside the pest exclusion fenced areas.

Although disturbance associated with the Project will not affect any of the historic or current distribution ranges of *P. augusta*, a 15-ha pest exclusion fenced area is being proposed as part of a compensation package for the Project's residual impacts on *P. patrickensis* and other indigenous fauna. The proposed fenced area, located approximately 1 km north of Mt Augustus on the north-west edge of Stockton Plateau, is designed to protect *P. augusta* from predation by rodents, weka and possums (BCP-ENV-PLN_022). Construction of the pest exclusion fenced area for *P. augusta* will be undertaken in coordination with DOC's *Powelliphanta augusta* Recovery Working Group.

1.4 Tasks for Achieving the Plan's Objectives

To achieve the Plan's objectives, Bathurst will undertake the following tasks.

1.4.1 *Powelliphanta* Snail Management in Areas Outside the Known Range of *Powelliphanta*

A large proportion of the Stockton Mining Consent area is outside of the known range of any *Powelliphanta* taxa (Figure 1). However, if live *Powelliphanta* snails, eggs or recent (not sub-fossil) shells are detected in areas outside the known range of *Powelliphanta* snails, the significance of the discovery will be established by assessing *Powelliphanta* snail distribution and abundance in the area surrounding the discovery and determining the taxonomic identity of the specimen(s). Distribution and abundance will be assessed by initial nocturnal searches of a 50 m square around the find's location and diurnal sub-surface searches of a 10 m square around the location. If more specimens are found during initial searches, the search area will be extended to establish the snail's distribution range. To determine the specimens' taxonomic identity, experts on *Powelliphanta* taxonomy will be provided with any shells found and, or close-up photographs and morphometric details of any live snails. The Department of Conservation will be informed of the findings and consulted with on future action to protect any *Powelliphanta* snails in the area.

1.4.2 *P. patrickensis* Snail Management on Buller Plateaux

Tasks for the management of *P. patrickensis* snails in areas within their known range on Buller Plateaux are:

- Undertake vegetation direct transfer (VDT) of snail habitat from disturbance areas wherever possible.
- Build weka-free exclosures within the footprints of proposed pest exclusion fenced areas for salvaged snails and maintain them until the surrounding pest exclusion fenced areas are completed and pest free.
- Establish pest exclusion fenced areas, free of weka and mammalian pest species and ensure that they remain pest-free for 50 years after construction of the last fenced area.
- Search disturbance areas not suitable for VDT to salvage snails before earthworks are undertaken and relocate the salvaged snails to pest exclusion fenced areas or, when suitable fenced areas are not yet available, relocate the salvaged snails to the footprint of a planned pest exclusion fenced area, where at least half of the snails will be placed in weka-free exclosures.
- During rehabilitation of disturbance areas, create snail habitat on engineered landforms (ELFs), using VDT or SDT of habitat from disturbance areas wherever possible.
- Relocate stored VDT from the Cypress Mine into a pest exclusion fenced area on the ELF in the rehabilitated Cypress Mine area.
- Research methods to improve the quality of snail habitat created by planting and, or seeding into previously stockpiled soil spread on ELF's during mine rehabilitation.
- Develop rehabilitation methods to provide sufficient snail habitat in the rehabilitated Cypress pit to satisfy consent condition for Cypress Mine.
- When rehabilitated snail habitat on ELF's appears suitable, undertake trial snail relocations into the rehabilitated snail habitat followed by large scale relocations when the relocation trials are successful as detailed in Section 2.4.5.

1.4.3 *P. patrickensis* Snail Monitoring on Buller Plateaux

Tasks for monitoring *P. patrickensis* snails on Buller Plateaux are:

- Monitor cause of death for snails inside and outside pest exclusion fenced areas and weka-free exclosures to identify methods to improve snail survival.
- Monitor snail population trends and population structure inside and outside pest exclusion fenced areas to ensure that the areas are an effective method to increase snail abundance.
- Monitor the survival of salvaged snails to establish whether snail salvage is a successful conservation strategy and identify methods to improve survival of salvaged snails.
- Monitor the fate of snails relocated by VDT.
- Monitor the fate of snails relocated into snail habitat rehabilitated by planting and, or seeding.
- Monitor earthworm communities in snail habitat rehabilitated by Slash Direct Transfer (SDT), jumble dumping or planting and, or seeding.

1.4.4 *P. augusta* Snail Management

Establishing and maintaining a pest exclusion fenced area for *P. augusta* snails will be undertaken in coordination with the Technical Advisory group and DOC's *P. augusta* Recovery Working Group.

1.5 Other Management Plans

Other management plans affecting management of *Powelliphanta* snails on Buller Plateaux are:

- Rehabilitation Management Plan: Buller Plateaux (BCP-ENV-PLN_002).
- Avifauna Management Plan (BCP-ENV-PLN_003).
- Pest Control and Elimination Plan (BCP-ENV-PLN_022),
- Cypress Mine Closure Plan (Bathurst Resources Limited, 2018a).
- Cypress Mine Rehabilitation Management Plan (Bathurst Resources Limited, 2018a)
- Cypress Mine Powelliphanta Patrickensis Management Plan (Bathurst Resources Limited, 2018)
- Cypress Mine Predator Control Management Plan (Bathurst Resources Limited, 2018)
- Conceptual Mine Closure Strategy (BCP-ENV-PLN_050).

1.6 Relevant Resource Consent Conditions

To be inserted up on issue of the final decision.

2.0 Management Approach

2.1 Scope of the *Powelliphanta* Snail Management Plan

The BPCP proposal entails reconsenting the existing Stockton Mine (STO) infrastructure and mining operations to allow mining at Stockton Mine to continue up to 2037, varying consents for the Cypress Mine, and obtaining new consents for the Upper Waimangaroa Haul Road (UWHR) and two new mining areas on Buller Plateaux: Mount Frederick South (MFS) and Escarpment Extended (ESE) where mining is planned for 16 years, from 2027 to 2042.

The *Powelliphanta* Snail Management Plan will apply to existing and proposed areas consented for coal mining activity on Buller Plateaux (Figure 1) including the existing Stockton and Cypress Mining Consent areas and three newly proposed consent areas for the Buller Plateaux Continuation Project (BPCP).

2.2 Environmental Setting and Distribution

2.2.1 Powelliphanta patrickensis

Powelliphanta patrickensis belongs to the endemic New Zealand genus *Powelliphanta,* a group of giant carnivorous land snails that includes 70 taxa with 13 recognised species and 10 undescribed species (Walker, 2018; Walker et al., 2024). Previously considered a single species restricted to Stockton and Denniston Plateaux, populations of *P. patrickensis* on the two plateaux are now thought to be separate subspecies (*P. "patrickensis" patrickensis* and *P. "patrickensis* Denniston") belonging to a species that includes three other subspecies found to the south of Buller Plateaux, on the Paparoa and Brunner ranges. *P. patrickensis* populations on Stockton and Denniston Plateaux are ranked by the Department of Conservation (DOC) as having a "Nationally Critical" conservation status (Walker et al., 2024).

On Buller Plateaux, *P. patrickensis* inhabit a variety of low growing vegetation types (Lloyd, 2012; Overmars & Lloyd, 2012), including: pākihi, tussock, manuka (*Leptospermum scoparium*) shrubland with wire rush (*Empodisma minus*), and low forest with mixtures of mountain beech (*Fuscospora cliffortioides*), yellow-silver pine (*Lepidothamnus intermedius*), pink pine (*Halocarpus biformis*) and southern rata (*Metrosideros umbellata*).

Results from monitoring programmes using sub-surface searches of more than one-hundred 10 m square plots (Lloyd, 2024b) and capture-recapture surveys in two 70 m square plots (Lloyd, 2024a) indicate there was a 60% decline in *P. patrickensis* populations on the two plateaux between 2012 and 2024. Damage patterns on shells found during plot searches indicate that the population decline was primarily caused by increased predation by weka (*Gallirallus australis*), a native rail, with 35% of 388 shells preyed on by weka and 16.5% by rats (Lloyd, 2024b). *P. patrickensis* population monitoring undertaken by DOC on Denniston Plateau documented a similar population decline between 2007 and 2024 (Papworth, 2024). However, Papworth (2024) concluded that rats were the primary cause of the decline, with 38% of 45 shells found during 2024 showing evidence of predation by rats and approximately 10% predation by weka. In the most recent conservation status ranking for *Powelliphanta* (Walker et al., 2024), 26 of 28 Nationally Critical *Powelliphanta* taxa are listed as being affected by weka predation, with 13 of the taxa affected severely.

2.2.2 *Powelliphanta augusta*

P. augusta was discovered in 1996 with a few shells collected near Mt Augustus on the western edge of the Stockton Plateau. However, it was not recognised as a unique species until 2003 (Trewick et al., 2008; Walker et al., 2008). The species' original range is unknown, but in 2004 *P. augusta* was restricted to about 10 ha of habitat along the Mt Augustus ridgeline on the western scarp of the Stockton Plateau with any former range to the east destroyed by opencast coal mining. *P. augusta* is commonest at high altitude (940–980 m asl) in very cool and extremely wet sites. The species is ranked as "Nationally Critical" (Walker et al., 2024) with the remnant population actively managed by DOC, both in the wild and in captivity as described in the *Powelliphanta augusta* Recovery Strategy (Gruner et al., 2021). [redacted]

Although *P. augusta* and *P. patrickensis* are geographic neighbours, [redacted] the two species are not closely related. There is a 7.8% genetic distance between the two species (Trewick et al., 2008). *P. augusta* is a sister species to *P. lignaria* (Buckley et al., 2014; Trewick et al., 2008; Walker, 2018), a lowland species with a distribution range 9 km northeast from Mt Augustus.

2.3 Effects of Mining on *Powelliphanta* Snails

Mining activity on Buller Plateaux has had, and will continue to have, a negative impact on *Powelliphanta* snails, destroying their habitat and killing snails directly. When an area is stripped for mining, most snails in the area will die directly as a result of injury from heavy machinery during excavations and, or earthworks. Snails in areas where soil is stockpiled after stripping are unlikely to survive the process. Snails not killed during excavation will die in the stockpiled soil, because it is compacted, lacks structure, has low organic matter content, unfavourable moisture conditions, very low pH and anaerobic interiors (Boyer et al., 2011). Mining activity will also fragment continuous areas of snail habitat into smaller isolated patches surrounded by barriers to snail dispersal. This fragmentation will likely have adverse effects leading to extinctions of isolated snail populations in small fragments (Lloyd's Ecological Consulting, 2026a).

2.3.1 *Powelliphanta patrickensis*

The original distribution range of *P. patrickensis* on Buller Plateaux (Figure 2), before the impact of mining related activity, extended over at least 58.5 km^2 along an 18 km long south-west to north-east axis along the two plateaux (Walker, 2012). In 2005, before construction of Cypress Mine began, approximately 4.5 km^2 (7.7%) of the species original distribution range on Buller Plateau had been affected by disturbance associated with previous mining activity including the Stockton Mine and no longer provided suitable habitat, leaving 54 km^2 of relatively undisturbed snail habitat, comprising 33.3km^2 on Stockton Plateau and 20.7 km^2 on Denniston Plateau (Table 1 and Figure 2). Cypress Mine will further reduce the species distribution range on Buller Plateaux to 90% of its original range and the Buller Plateaux Continuation Project will reduce the species distribution range further to 79% of its original range (Lloyd's Ecological Consulting, 2026a).

Table 1. Remaining areas (km²) and proportions (%) of the original distribution ranges of P. patrickensis on Buller Plateaux in 2005, when mining at Cypress ends and in 2042, at the time of BPCP closure.

Plateau	Distribution Range (km^2) and as a Percentage of Original Range						
	Original	2005		After Cypress		2042	
Stockton	37.32	33.27	*(89.1%)*	32.01	*(85.8%)*	29.65	*(79.5%)*
Denniston	21.16	20.70	*(97.8%)*	20.52	*(97.0%)*	15.94	*(75.3%)*
Both Plateau	58.48	53.97	*(92.3%)*	52.53	*(89.8%)*	46.00	*(78.7%)*

[redacted]

[redacted]

Extrapolating an estimate of 102 mature snails ha^{-1} from a capture-recapture survey undertaken in 2024 (Lloyd, 2024a) to the proposed disturbance areas for the BPCP gives estimates of approximately 20,000 and 47,000 snails with maximum diameters ≥20 mm present in proposed disturbance areas for the BPCP on Stockton and Denniston Plateaux respectively.

2.3.2 *Powelliphanta augusta*

The original distribution range of *P. augusta* is unknown as most of its distribution range on Mt Augustus was destroyed by mining in Stockton Mine between 2006 and 2008 soon after the species discovery, leaving 10 ha of its original range (Gruner et al., 2021). Only a small proportion of the *P. augusta* snail population occurs naturally in undisturbed habitat, the rest of the species' population is either in areas of VDT, relocated into remaining areas of suitable habitat or managed in captive breeding facility. None of the disturbance associated with the proposed Buller Continuation Project or ongoing activity in the Cypress and Stockton Consent areas, will affect *P. augusta* or any of its remaining range (Figure 1).

2.4 Effects Management Methods for *Powelliphanta* Snails

Manual relocation (snail salvage), vegetation direct transfer (VDT), slash direct transfer (SDT), the creation of snail habitat by planting and, or seeding and the construction of weka-free exclosures for salvaged snails are all effects management methods that target *Powelliphanta* snails directly and are described in this section. Other effects management methods that affect *Powelliphanta* snails but are not designed primarily for their benefit are: managing soil stockpiles, described in the Rehabilitation Management Plan (BCP-ENV-PLN_002), and the construction and maintenance of pest exclusion fenced areas and enhanced mammalian pest control, both described in the Pest Control and Elimination Plan (BCP-ENV-PLN_022).

2.4.1 Manual Relocation or Snail Salvage

Manual relocation, described as "search and collect" or "snail salvage", involves pre-stripping searches of areas of snail habitat scheduled for destruction and transfer of collected live snails and egg masses to previously selected destination sites. Ideally, destination sites should be in pest exclusion fenced areas or weka-free exclosures as close as possible to the source locations. Field methods for relocating *Powelliphanta* snails and eggs are described in Appendix 5.

Searches to find snails for relocation can be either nocturnal searches for snails active on the surface (Appendix 3) or daytime sub-surface searches (Appendix 4). Comparisons between results from the two search methods show that nocturnal searches are more effective than daytime sub-surface searches (Lloyd, 2024c), with considerably less search effort per hectare and much higher snail capture-rates per person hour. The average search effort was 12 person hours per hectare for nocturnal searches (based on 84 nocturnal searches of 70 m square plots) compared to 382 person hours per hectare for daytime sub-surface searches (based on 344 daytime searches of 10 m square plots). In a comparison of snail encounter rates for the two methods, 8.19 snail /person hr were found during nocturnal searches compared to 0.12 snails/person hr found during daytime sub-surface searches (Lloyd, 2024c). However, nocturnal searches for snail salvage have two disadvantages compared to daytime sub-surface searches: egg clusters aren't found and a lower proportion of small snails (<15 mm diameter) are found. Consequently, the best option for snail salvage searches is a mixed strategy combining the advantages of the two methods (Appendix 5). Initially there should be two nocturnal searches of the area of snail habitat to be stripped, with the two nocturnal searches spaced a few days apart to improve capture rates during the second search. Nocturnal searches should only be undertaken on warm moist nights when snail surface activity is high. The nocturnal searches should be followed by daytime sub-surface searches restricted to areas where high densities of snails are found during one of the nocturnal surveys.

2.4.1.1 Recommended Search Effort

Results from the numerous surveys for *P. patrickensis* snails on Buller Plateaux undertaken between 2012 and 2026 show that on average nocturnal searches take 12 person hours of searching per hectare, while daytime sub-surface searches take 382 person hours of searching per hectare.

However, search effort required per hectare with either method will vary greatly according to the nature of the habitat and snail abundance in the habitat. Although setting a fixed target for search effort (person hours) expended during snail salvage seems an attractive option, it is not practical because the search effort per ha will vary greatly according to the nature of the habitat and snail abundance in the habitat. The recommended search effort for snail salvaging from a disturbance area is a minimum of two nocturnal searches, each taking approximately 12 person hours of searching per hectare of potential snail habitat, which may be followed by daytime sub-surface searches of ¼ ha parcels of the nocturnal survey area where densities of snails found during one of the nocturnal searches reached a pre-determined threshold value initially set as ≥5 live snails in a ¼ parcel, as described in Appendix 5.

2.4.2 Vegetation Direct Transfer of Snails and their Habitat

Vegetation direct transfer (VDT) is a rehabilitation method that results in snails being relocated with their habitat from areas being stripped for mining. Details of the VDT method are provided in Rehabilitation Management Plan: Buller Plateaux (BCP-ENV-PLN_002).

VDT is an established mine rehabilitation technique used to restore native ecosystems at sites disturbed by mining (Rodgers et al., 2011; Simcock & Ross, 2014). During VDT, when overburden is being stripped from a site to be mined, slabs of topsoil with intact native vegetation are lifted by a digger and the habitat slabs transferred directly to a prepared site where they are reassembled. Ideally the recipient site is an engineered landform (ELF) on a nearby previously mined area but can be a temporary holding site where the stripped VDT material is kept until a suitable ELF is available for final relocation. The method is designed to retain ecosystem integrity throughout the rehabilitation process, establishing areas of transferred habitat that resemble the original, with minimal plant dieback, and including the original invertebrate populations (Rodgers et al., 2011; Simcock & Ross, 2014). DOC requires all VDT material be placed on a suitable rehabilitation surface as close as possible to its source location.

Results from monitoring VDT undertaken on the Stockton Plateau demonstrate that high proportions of *P. patrickensis* snails survive the transfer process and snail populations persist in the relocated habitat (Lloyd, 2021; MacKenzie, 2014), with healthy snail populations present in habitat relocated by VDT four years after relocation (MacKenzie, 2014). Although snail relocation by VDT has proven successful, there are limited opportunities for using the method as it can only be used to transfer low growing vegetation (< 1.5 m high) and depending on the stage of the mining cycle, there may be few suitable sources and or destination sites. Consequently, most snail relocations have been, and will be, undertaken using the manual relocation method.

2.4.3 Slash Direct Transfer (SDT) and Jumble Dumping

Slash direct transfer (SDT) and jumble dumping both entail transferring stripped material to its final destination immediately after stripping (BCP-ENV-PLN_002; BCP-ENV-PLN_050). In SDT the stripped surface material is spread evenly across the ELF, whereas in jumble dumping larger amounts of stripped material are deposited non-uniformly on the ELF. In both procedures surface material (leaf litter, vegetation and vegetation slash), topsoil and subsoil are stripped separately and spread onto previously prepared ELFs, with surface material layered over topsoil layered over subsoil. Although there have been no studies, it seems likely that some snails and their earthworm prey are likely to survive the SDT and jumble dumping procedures and overtime establish viable populations in the transferred material, but there are no studies to confirm this result.

2.4.4 Creating Snail Habitat by Planting and Seeding

General methods for the rehabilitation of habitats by planting and, or seeding are discussed in the Rehabilitation Management Plan (BCP-ENV-PLN_002), however creation of habitat that will sustain viable populations of *Powelliphanta* snails will require specially designed methods. Results from nocturnal transects through areas rehabilitated by planting and, or seeding show that most attempts at rehabilitation by planting, and or seeding have failed to provide suitable habitat for *P. patrickensis* snails, in some cases even 20 years after rehabilitation (Lloyd, 2024c). Live snails were only found clustered in a 45 m section of a 3 km long transect through rehabilitated habitat on the lower slopes of Mt Frederick in a small patch (64 m^2) rehabilitated during 2005–2006.

The presence of this cluster of live snails in a small patch of rehabilitated habitat indicates that with the right method it might be possible to create suitable habitat for *P. patrickensis* snails using planting and or seeding. Unfortunately, there is no information on the method used to rehabilitate the patch with snails, but vegetation in it was taller and more complex than in surrounding rehabilitated areas. The presence of tree slash indicates that fascining (i.e., placing tree branches with ripe seed capsules on rehabilitated surfaces) may have been used to provide seeds and shelter.

Despite the failure of past efforts at rehabilitation by planting and, or seeding to provide suitable habitat for *P. patrickensis* snails, by necessity, the method will be used to rehabilitate most areas disturbed by mining. It will therefore be important to develop rehabilitation methods with better outcomes for *Powelliphanta* snails.

2.4.4.1 Optimum Snail Habitat

P. patrickensis snails occur in a wide variety of habitats on Buller Plateaux ranging from low pakihi to forest. Results from a study of snail distribution found during sub-surface searches of 245 ten metre square plots during 2011–2012 show the influence of habitat factors on *P. patrickensis* snail densities (Lloyd, 2013). Average soil depth and proportions of ground rock had strong, but opposite influence on snail density. Expected snail numbers increase from no snails in plots with little, or no, soil to 5 snails in plots with deep soil, whereas expected snail numbers declined from 2 snails in plots with no ground rock to no snails in plots with 50% ground rock. Vegetation types also had a strong influence on snail density with highest snail densities in plots with medium height (1-2 m high) scrub with tussock and flax. Plots with the highest numbers of *P. patrickensis* snails, and presumably the optimum habitat for snails, had no ground rock, included deep soil, and were covered by medium height (1-2 m high) scrub with tussock and flax. Suitable plant species for planting to recreate snail's natural habitat are: manuka (*Leptospermum scoparium*), yellow-silver pine (*Lepidothamnus intermedius*), tussock (*Chionochloa juncea* and *C. rubra)*, gahnia (*Gahnia. Spp.*), flax (*Phormium cookianum*) and tangle fern (*Gleichenia dicarpa*).

2.4.4.2 Earthworm Communities in Rehabilitated Habitat

Earthworms are a key component of the diet of *P. patrickensis* (Waterhouse et al., 2014), consequently for *P. patrickensis* snail populations to survive in rehabilitated habitats healthy earthworm communities must be present. Earthworm diversity, species richness and biomass are low in areas rehabilitated by planting and or seeding into previously stockpiled soil, because soil stockpiling induces anaerobic conditions at, and below, a depth of 1 m, where earthworms don't survive (Boyer et al., 2011). If soil stripped from disturbance areas is spread immediately after stripping onto prepared surfaces without stockpiling, live earthworms remaining in the stripped soil are likely to survive. However, spreading stripped soil immediately after stripping without stockpiling is usually not practicable during mine operations. To improve rehabilitation outcomes for snails it will be important to develop methods for establishing healthy earthworm communities in areas rehabilitated by planting and, or seeding. Methods to be developed include:

- Methods to monitor earthworm communities in rehabilitated areas.
- Breeding endemic earthworms from Buller Plateaux in captivity and releasing them into rehabilitated areas.
- Relocating locally endemic earthworms from natural areas into rehabilitated areas (Boyer & Wratten, 2010).
- Fertilising and mulching rehabilitated areas to encourage development of earthworm communities.
- Including numerous small areas of VDT habitat within areas rehabilitated by planting or seeding as sources for earthworm recolonisation.

2.4.5 Relocating Snails into Rehabilitated Habitat

Even when areas rehabilitated by planting and, or seeding are suitable for *P. patrickensis* snails, natural recolonization from surrounding natural snail populations is likely to be extremely slow because of snails' sedentary behavior. To establish snail populations in rehabilitated mine areas, snails will be relocated into rehabilitated areas from nearby pest exclusion fenced areas, ideally, from destination sites for snails originally relocated out of the disturbance areas being rehabilitated.

Methods for handling snails and eggs during relocation operations are detailed in Appendix 5. In both stages of the relocation into the rehabilitated mine area, the snails will be relocated from nearby pest exclusion fenced areas.

Relocating *P. patrickensis* into the rehabilitated mine area will be a two-stage process, only undertaken when results from monitoring vegetation and earthworms in the rehabilitated areas indicate that rehabilitated areas will probably provide suitable habitat for *P. patrickensis*. The first stage will be trial relocations to determine whether the rehabilitated habitat is suitable and relocations into the rehabilitated area are successful. Once results from monitoring a trial relocation indicate that relocation was successful, the second stage, operational relocations, will be undertaken.

When results from monitoring vegetation and earthworms, indicate that rehabilitated areas will probably provide suitable habitat for *P. patrickensis*, an initial small scale trial relocation will be undertaken with relocated snails released into a prepared 70 m square capture-recapture plot in potential snail habitat in the rehabilitated mine site. Capture-recapture surveys (described in Section 2.5.2.1 and Appendix 7) will be undertaken in the plots biennially starting one year after the initial trial relocation. If necessary, trial relocations will be repeated as required until the results of monitoring indicate that the rehabilitated habitat is suitable and trial relocations into the rehabilitated area have been successful. Operational relocations will only be undertaken when, or if, trial relocations into the rehabilitated area have been successful. Monitoring snail population abundance, size structure and distribution in rehabilitated areas (Section 8.4) will begin four years after the operational relocation is undertaken using nocturnal searches along transects (Appendix 3) and time-based diurnal searches of 10 m square plots (Wildlife Surveys, 2005). Subsequent management will depend on the results of the monitoring programme.

2.4.6 Weka-free Exclosures

Weka-free exclosures are small areas (typically 0.5 ha) surrounded by temporary fences designed to exclude weka but allow snails and lizards access into the exclosures. Once the exclosures are complete, weka are removed from the exclosures and released outside the exclosures. Exclosures will be constructed within the footprint of pest exclusion fenced areas, and be maintained until the pest exclusion fenced area has been cleared of all pests. Weka-free exclosures are a low-cost method to protect small numbers of snails from predation by weka temporarily until larger and more expensive pest exclusion fenced areas can be created. A design for weka-free exclosures being trialled in Abel Tasman National Park is included in Appendix 8. Preliminary results from the exclosures in ATNP indicate that populations of snails and other invertebrates are increasing within the weka-free exclosures (pers. comm. R. Bolongino, Science Advisor & Director of Operations, Project Janszoon). In an e-mail to Charmain Petereit (Takaka Hill Biodiversity Group Project Manager) K. Walker (DOC) reported immediate doubling of a *Powelliphanta hochstetteri obscura* population in a small experimental plot on D'Urville Island with weka, pigs and hedgehogs excluded.

2.5 Monitoring Methods for *Powelliphanta* Snails

2.5.1 Monitoring Objectives

The monitoring programme described in this *Powelliphanta* Snail Management Plan is designed to provide statistically valid quantitative information on the outcomes of the proposed programme of effects management for snails. The information from monitoring will provide the basis for adaptive management of effects management for snails, identifying whether effects management methods are successful, or not, and where improvements to effects management methods are required, information from monitoring will assist development of better methods by providing feedback on the results of changes to management methods.

2.5.2 Monitoring Snail Population Trends and Population Structure

2.5.2.1 Capture-recapture Plot Surveys

Capture-recapture plot surveys are used for monitoring population trends. A single capture-recapture survey entails repeated nocturnal searches for *Powelliphanta* snails active on the surface of a permanently marked 70 m square plot during a period of three to five weeks (Hamilton, 2015b; Lloyd, 2015, 2017). Snails found in the plot are individually marked with numbered identification tags and then released at their capture locations. Estimates of the numbers of snails in a plot are then obtained from the capture histories of individually marked snails recaptured during successive searches of the plot using established analytic methods (Borcher et al., 2002; Cooch & White, 2018; Lukacs, 2018;

White et al., 1982; Williams et al., 2002). To get information on population trends in a plot capture-recapture surveys of the plot are repeated at annual or biennial intervals. Results from capture-recapture surveys include information on plot population size structure and recruitment. Details of the capture-recapture survey methods are presented in Appendix 7.

2.5.2.2 Day-time Sub-surface Plot Searches

Day-time sub-surface searches of 10 m square plots (Walker, 1997) is DOC's standard method for monitoring snail population trends. The sub-surface search method is described in Appendix 4. For population monitoring, samples of permanently marked 10 m square plots are searched at biennial or longer intervals. Daytime sub-surface plot searches provide indices of plot population size, not plot population estimates. The relationship between population indices and actual population sizes is unknown and likely to vary according to habitat and environmental conditions during the searches. The sub-surface plot search method is useful for providing information on predation and getting information on snail distribution and abundance over wide geographic areas, but conclusions about population trends or comparisons between snail populations in different areas are dubious without supporting information from capture-recapture monitoring.

2.5.3 Monitoring Cause of Snail Deaths

Powelliphanta shells or shell fragments found during snail salvage operations, surveys or monitoring programmes on Buller Plateaux will be collected and examined for evidence of predator damage using criteria from Meads et al. (1984). Details of the methods are presented in Appendix 2. After being assessed by Bathurst's snail experts, shells will be sent to DOC Buller District Office accompanied by identifying details, including plot name, location, search date, and the number and diameters of live snails found during each search.

2.5.4 Monitoring Snail Distribution and Abundance

Searches along transects can be used to assess snail distribution and abundance in an area. Searches along transects can be either nocturnal searches for live snails or snail shells visible on, or above, the ground surface (Appendix 3), or day-time sub-surface searches for live snails and snail shells on, or below the surface and hidden in vegetation (Appendix 4).

Another method that has been used previously for assessing snail distribution and abundance is time-based diurnal searches of 10 m square plots at 200 m spacing along transects spaced 250 m apart (Wildlife Surveys, 2005).

3.0 Recent and Ongoing Effects Management and Monitoring

3.1 Stockton Mine

3.1.1 P. patrickensis

Documentation on previous effects management for *P. patrickensis* snails in the Stockton Mine consent area is incomplete, presumably because information was mislaid during change of ownership from Solid Energy New Zealand (SENZ) to Bathurst in 2017. Effects management for the mine's effects on *P. patrickensis* snails include manual relocation out of areas before stripping, rehabilitation by planting and VDT of snail habitat.

Records show that between June 2007 and November 2011, a total of 1,553 live snails and 36 egg clusters were found in areas searched before stripping for mining and then released at 5 locations in nearby undisturbed habitat. There might have been more manual relocations but documentation for them is missing.

Progressive rehabilitation of the 284 ha of disturbance areas within *P. patrickensis* distribution range has been ongoing since 2003 with a total of 165 ha rehabilitated up to 2025 (Figure 3). Most rehabilitation has been by planting and, or seeding with no serious attempts to create habitat for *P. patrickensis* snails. However, 8.2 ha of snail habitat was rehabilitated by VDT, with 13 patches of VDT habitat ranging in size from 0.03 ha to 3.8 ha. Results from capture-recapture surveys of 2 plots (MF 7 and MF16) in areas of VDT near Mt Frederick demonstrated that populations of *P. patrickensis* were present in the plots immediately after VDT and remained relatively stable during the four-year and six-year monitoring periods after relocation by VDT (Lloyd, 2023; MacKenzie, 2014).

[redacted]

3.1.2 *P. augusta*

There has been an intensive programme of effects management and monitoring for *P. augusta* in the Stockton Mine consent area since 2006. Management of *P. augusta* snails is now the responsibility of DOC but is supported financially by BT mining and by habitat enhancement measures undertaken by BT Mining in collaboration with the DOC Technical Advisory Group. The programme, which is overseen by the *P. augusta* Recovery Working Group, is well documented (Gruner et al., 2021; Otley et al., 2016; *P. augusta* Recovery Working Group, 2007). Effects management for *P. augusta* has included manual translocation and relocation of snails, VDT of habitat containing *P. augusta,* habitat rehabilitation by planting, habitat enhancement using VDT from other areas, additional soiling of rocky areas and infill planting of appropriate plant species, captive breeding with release of captive bred progeny into the wild and mammalian pest control. Other habitat enhancement measures include increased weed control and rodent control in known *P. augusta* habitat. Previous translocations included an attempt to establish new populations of *P. augusta* near Mt Rochfort on Denniston Plateau, 15 km south-west of their distribution range. Monitoring includes monitoring the survival of translocated and relocated snails fitted with transponders (Wildland Consultants, 2009). Mean annual survival of *P.augusta* snails translocated to the two sites on Mt Rochfort were 79% & 76% during the period 2007 to 2009. Long-term population trend monitoring using both capture-recapture surveys (MacKenzie, 2020) and sub-surface plot searches has also been undertaken in areas along Mt Augustus ridge line (Gruner et al., 2021; Otley et al., 2016; P. augusta Recovery Working Group, 2007).

3.2 Cypress Mine

The Cypress Mine consent area extends over 247 ha of the distribution range of *P. patrickensis*. Mining activity began in 2012, and last coal mining should finish by 2032, with final rehabilitation works to follow. In early 2026 approximately 105 ha of vegetation had been stripped for the mine with approximately 20 ha remaining to be stripped. Because there were large areas of disturbed habitat in the consent area before mining began, there will be 122 ha of disturbed habitat in the Cypress consent area at the end of mine life. Effects management undertaken for the Cypress Mine's effects on *P. patrickensis* snails include manual relocation of snails, VDT of snail habitat and the control of mammalian predators in and around the Cypress Mine consent area.

During the period 2004 to 2025, a total of 1,462 live snails and 412 egg clusters were relocated out of the Cypress Mine area manually before stripping and relocated to nearby areas. VDT has been used to transfer snail habitat out of disturbance areas since stripping began in 2012. During 2012, VDT was used to relocate approximately 4 ha of snail habitat from Cypress Mine to a site 1.5 km west of Cypress Mine, close to the main ridge between Mt Frederick and Mt Augustus. Subsequently, VDT habitat from disturbance areas in Cypress Mine has been placed in storage at various sites in, and near, the Cypress consent area for return to the rehabilitated mine site. In 2026, there was 13.3 ha of VDT habitat in storage at various sites, including McCabe's laydown area (1.5 km north of Cypress Mine), along the side of Cypress Access Rd and on ELFs in the Cypress consent area. Approximately 0.56 hectares of VDT habitat has been placed in the final rehabilitated landform at Strip Zero, in the northern end of Cypress North Pit as of July 2024.

3.3 Recent and Ongoing Monitoring of *P. patrickensis* on Buller Plateaux

[redacted]

There have been several programmes to monitor *P. patrickensis* on Buller Plateaux. Capture-recapture methods and sub-surface plot searches have both been used to monitor snail population trends.

- During summer 2009–10, eight capture-recapture plots were established in the pest control area surrounding the Cypress Mine (Figure 4) to monitor the effects of mammalian predator control on *P. patrickensis* snails in accordance with the original *P. patrickensis* Management Plans for Cypress Mine (Solid Energy New Zealand, 2011). Results from repeated surveys between 2009 and 2021 showed there were declines in most plot populations and the expected increase in snail abundance in response to mammalian predator control required by the Cypress Mine consent conditions had not occurred (Lloyd, 2023).
- Monitoring population trends in two capture-recapture plots on Denniston Plateau (Figure 4) has been undertaken biennially since summer 2014–15 (Lloyd, 2015, 2024a). Results showed 60% and 64% declines in the plot populations between 2014 and 2024.
- Sub-surface searches of more than one-hundred 10 m square plots spread across the species distribution range on both plateaux were undertaken during 2012 and 2024 (Lloyd, 2024b) to monitor population changes. Results from the surveys indicated that there was a 59% decline in the snail population between 2012 and 2024.

Capture-recapture methods have been used to assess the outcomes of VDT for snails.

- Capture-recapture surveys were used to monitor *P. patrickensis* snail populations in two plots in patches of snail habitat rehabilitated by VDT close to Mt Frederick (Figure 4) with annual capture-recapture surveys undertaken between 2010 and 2015 (Lloyd, 2023; MacKenzie, 2014). Results showed populations of *P. patrickensis* in the plots remained relatively stable during the four- and six-year monitoring periods after relocation by VDT.

- Results from a capture-recapture study of the survival of snails during VDT of snail habitat from Cypress Mine to the storage site at McCabe's laydown area during 2021 showed most snails survived the transfer (Lloyd, 2021). Subsequently during 2024, capture-recapture surveys of two 70 m square plots in VDT habitat from Cypress Mine stored at McCabe's laydown area (Figure 4) showed that there were healthy populations of snails in both plots (Lloyd, 2024c).

Capture-recapture methods have been used to monitor the survival of relocated snails.

- One of the two capture-recapture plots on Mt Frederick established to monitor snail survival in VDT was in a destination area for manually relocated snails. Results from capture-recapture surveys showed no significant differences between survival of relocated snails and the survival of other snails in both plots (MacKenzie, 2014).
- During 2020, a monitoring programme was established using capture-recapture surveys to compare the survival of snails in areas on Whirlwind Rise with and without snails relocated from the Cypress Mine area (Bathurst Resources Limited, 2018b). Deficiencies in study design meant that results from the capture-recapture surveys were inconclusive (Lloyd, 2023).

Monitoring cause of snail death has been undertaken routinely.

- Information on cause of death has been collected since 2012 by identifying snail's predators from the damage patterns left on snail shells collected routinely during snail salvage operations, surveys and plot monitoring (Lloyd, 2012, 2015, 2021, 2023, 2024b).

Nocturnal searches along transects have been used to investigate snail distribution.

- During 2024, results from nocturnal searches for snails along transects through areas rehabilitated by planting showed that most areas rehabilitated by planting are not yet suitable for *P. patrickensis* snails (Lloyd, 2024c).

- During 2025, nocturnal searches along transects were used to confirm that snails were present in the areas of the proposed pest exclusion fenced areas in *P. patrickensis* snail's distribution range on Buller Plateaux during 2025 (Lloyd's Ecological Consulting, 2026a).

4.0 Pre-commencement Management and Monitoring for Newly Consented Areas of the Project

4.1 Snail Salvage

Before habitat stripping begins, areas of snail habitat scheduled for disturbance in the proposed Mt Frederick South, Upper Waimangaroa Haul Road and Escarpment Extended consent areas during the first year of the Project will be searched for *P. patrickensis* snails and any snails found will be relocated to areas of snail habitat (Table 2) in the footprint of a nearby proposed pest exclusion fenced area (Sections 2.4.1 & 5.4.4). Before suitable pest exclusion fenced areas have been completed, salvaged snails will be relocated into temporary fenced weka-free exclosures (Section 2.4.6 & Appendix 8) built within the footprints of the proposed pest exclusion fenced areas.

Searches for snail salvage will be undertaken using the mixed strategy described in Section 2.4.1 and Appendix 5, with 2 nocturnal searches, each with a search effort of 12 person hours per hectare, which may followed by a daytime sub-surface search of ¼ ha parcels of the nocturnal survey area where densities of snails found during one of the nocturnal searches reach an agreed threshold value, initially set as ≥5 live snails in a ¼ parcel, as described in Appendix 5. T

The maximum diameter of captured snails will be measured and snails with maximum diameter ≥20 mm diameter will be tagged with unique numbered tags (Appendix 1). All details of the salvage operation will be recorded (Appendix 5), including date and location for capture and release, and snail size and identity of tagged snails.

If earth works commence before suitable weather conditions for snail salvage occur (i.e. moist and warm overnight condition: RH > 90% and temperature > 8°C), attempts will be made to minimise disturbance of good snail habitat during the earthworks.

4.2 Monitoring *P. patrickensis* Snails

4.2.1 Establish a Before-After-Control-Impact Monitoring Programme to Compare Population Trends Inside and Outside Pest Exclusion Fenced Areas

A Before-After-Control-Impact (BACI) population monitoring programme will be established using capture-recapture plot surveys, with the methods described in Appendix 7, to compare snail population trends inside and outside the proposed pest exclusion fenced areas. The monitoring programme will entail matched 70 m square plots inside and outside proposed fenced areas with monitoring undertaken biennially beginning before the pest exclusion fenced areas are established.

Two capture-recapture plots will be established in the footprint of the planned 47-ha Denniston North fenced area, during the summer before construction of the fence begins. Two nearby existing capture-recapture plots on Denniston Plateau (Lloyd, 2024a) will be retained to serve as matching plots for plots inside the pest exclusion fenced areas. The locations of the two plots inside the fenced area will be selected to match habitats in the existing two plots outside the fence. Plots inside and outside the

Denniston North pest exclusion fenced areas will all be surveyed during summer one year after the Project commences and then biennially (Table 3).

4.2.2 Initiate a Programme to Monitor the Survival of Salvaged Snails

One third of the area of the Denniston North pest exclusion fenced area will be designated as an area for relocating salvaged snails. The snail relocation area should be at least 200 m away from the two capture-recapture plots used for monitoring snail plot population sizes biennially. A third 70 m square capture-recapture plot will be established within the designated snail release area and surveyed during the summer before the Project commences, before any salvaged snails are relocated into the release area (Table 3).

4.2.3 Monitor Cause of Death Inside and Outside Weka-free Exclosures

Cause of death monitoring (Appendix 2) will be undertaken inside and outside a sample of weka-free exclosures (Appendix 8) established during the first year of the Project, with sub-surface searches of matched samples of four 10 m square plots (Appendix 6) inside and outside each weka-free exclosures being monitored.

4.2.4 Monitor Cause of Death Inside and Outside Pest Exclusion Fenced Areas

Identifying the cause of death from damage patterns on snail shells found during survey and monitoring work (Appendix 2) will continue as previously during the pre-commencement phase but will be augmented by a formal BACI monitoring programme with sub-surface searches of matched samples of 10 m square plots (Appendix 6) inside and outside areas of the proposed pest exclusion fenced areas.

4.2.5 Related Pre-commencement Monitoring Described in Other Management Plans

In addition to the pre-commencement monitoring of *P. patrickensis* described in Section 4.2, complimentary monitoring undertaken in accordance with other plans will include:

- Establishing a programme to monitor mammalian pest abundance inside and outside of the proposed pest exclusion fenced areas in the Pest Control and Elimination Plan (BCP-ENV-PLN_022).
- Establishing a programme to monitor weka abundance inside and outside of the proposed pest exclusion fenced areas in the Avifauna Management Plan (BCP-ENV-PLN_003).

5.0 Management During Construction and Operational Phases

5.1 Objectives:

- Reverse ongoing *P. patrickensis* population decline on Buller Plateaux by construction of three pest exclusion fenced areas and removing weka and introduced mammals from the fenced areas. A fourth 14 ha pest exclusion fenced area will be established in the rehabilitated Cypress pit during Cypress Mine closure to accommodate red tussock VDT habitat returned from storage as required by Cypress Mine Consent Conditions. The four proposed fenced areas will have a total area of 910 ha and enclose approximately 14.5% (760 ha) of the currently remaining distribution range of *P. patrickensis* on the plateaux.
- Minimise snail mortality and habitat loss during mine stripping by using VDT wherever practicable, with a target of at least 15% of the area to be stripped using VDT.
- Wherever VDT cannot be used during mine stripping:
  - Salvage *P. patrickensis* snails from the areas to be stripped and relocate them into pest exclusion fenced areas or, when suitable fenced areas aren't yet available, the footprints of the proposed pest exclusion fenced areas.
  - When snails are relocated to areas within the footprints of pest exclusion fenced areas before the fenced areas are completed, at least half of the salvaged snails will be placed in weka-free exclosures.
  - After snail salvage has been completed use SDT and or jumble dumping for stripping the disturbance area.
- Where neither VDT nor SDT or jumble dumping can be used during mine stripping rehabilitate habitats with improved methods for creating snail habitat.

5.2 Stockton

Although Stockton Mine remains operational, stripping vegetation in the distribution range of *P. patrickensis* was completed in 2011, and there has not been any significant impact on *P. patrickensis* in the mine area since then. Progressive rehabilitation by planting, and or seeding in the Stockton Mine disturbance area of is ongoing with documented methods (Bathurst Resources Limited, 2022, 2025b).

5.2.1 Snail Salvage

However, there will be additional disturbance of 9.7 ha in the Peninsular Block (Figure 3), just inside the northern boundary of *P. patrickensis*'s distribution range, beginning in 2027 and lasting for 2 years. Before stripping begins in this area, searches for the snails and eggs will be undertaken using the mixed search strategy described above (Sections 2.4.1 and 4.1) and in Appendix 5, with nocturnal searches for snails active on the surface followed by daytime sub-surface searches of ¼ ha areas where densities of snails found during one of the nocturnal searches reaches a pre-determined threshold value. Snails and eggs found during the searches will be relocated into the Whirlwind Rise pest exclusion fenced area when it is completed or weka-free exclosures in the footprint of the proposed Whirlwind Rise pest exclusion fenced area before it is completed. Rodent control will be undertaken around the weka-free exclosures initially but will be terminated 2 years before construction of the Whirlwind Rise fenced area begins to avoid compromising pest eradication within the fenced area.

5.3 Cypress

Until the Project is approved and varied consent conditions are in place, effects management and monitoring for snails during operation of Cypress Mine will meet the requirements of existing consent conditions, with snail monitoring for the Cypress Mine continuing as described in Section 3.2.

5.3.1 Snail Salvage

Manual relocation will be used to relocate live snails and egg clusters out of the areas scheduled for stripping before habitat stripping occurs. The existing conditions for Cypress Mine (C 38a) required daytime search for snail salvage with an average of 50 person days of search effort per year. In the Cypress Mine *P. patrickensis* Management Plan (Solid Energy New Zealand, 2011) this requirement was converted to 40 person hours of daytime search effort per hectare of disturbance. We propose that searches for snails and eggs will be undertaken using the mixed search strategy described above (Section 2.4.1 and 4.1) and in Appendix 5, which has much higher snail capture rates (per person hour) than daytime searching. There will be 2 nocturnal searches for snails active on the surface of potential snail habitat, each taking 12 person hours of searching per hectare, followed by daytime sub-surface searches of ¼ ha areas where densities of snails found during one of the nocturnal searches reaches a pre-determined threshold value. The total amount of daytime searched time will vary according to snail densities observed during nocturnal searches. Snails and eggs found during the searches will be relocated into weka-free exclosures in the footprint of the proposed Whirlwind Rise pest exclusion fenced area. Rodent control will be undertaken around the destination sites initially but will be terminated 2 years before construction of the Whirlwind Rise fenced area begins to avoid compromising pest eradication within the fenced area.

In mid-2026, only 18 ha of habitat remained in the Cypress Consent area to be stripped for the Cypress mine (Figure 6), with habitat stripping to be completed by 2029. Most (9.7 ha) of the remaining area to be stripped is tall forest, which is unsuitable for VDT and is likely to contain few snails.

5.4 Newly Consented Areas of the Project (ESE, MFS & UWHR)

5.4.1 Construction Schedule for the BPCP

An indicative schedule of the areas of *P. patrickensis* snail habitat in their distribution range to be disturbed, rehabilitated by VDT, searched for snails (i.e. salvaged) and included in pest exclusion fenced areas during each year of the newly consented areas for Buller Continuation Project (Table 2) was obtained from the March 2025 Mine Plan for the Project (Bathurst Resources Limited, 2025a).

The schedule is subject to the approvals obtained for the Project, which will determine the starting date for the Project.

Table 2. Indicative schedule of areas (ha) of snail habitat to be disturbed, rehabilitated by VDT, salvaged and included in pest exclusion fenced areas during each year of the project[1] after commencement.

Project Year	Indicative Schedule for Denniston Plateau				Indicative Schedule for Stockton Plateau			
	Disturbed (ha)	VDT (ha)	Salvage Required (ha)	Fenced Area (ha)	Disturbed (ha)	VDT (ha)	Salvage Required (ha)	Fenced Area (ha)
0	0.0	0.0	0.0		0.0	0.0	41.7	
1	0.0	0.0	105.1		41.7	0.0	7.2	
2	109.7	4.6	62.8	47*	13.1	5.9	7.6	
3	77.4	14.6	111.5		11.2	3.7	6.3	
4	121.2	9.7	11.8		7.7	1.4	7.4	
5	18.4	6.6	18.6	154*	8.8	1.4	2.7	
6	33.0	14.4	0.0		3.5	0.8	9.2	
7	0.0	0.0	22.9		9.9	0.7	27.3	
8	25.6	2.7	0.0		29.9	2.6	5.1	
9	0.0	0.0	7.4		7.6	2.5	10.5	544*
10	12.9	5.5	17.8		14.7	4.3	14.7	
11	24.0	6.3	25.1		19.0	4.3	4.0	
12	28.7	3.6	3.9		4.6	0.6	18.5	
13	4.6	0.7	2.9		19.4	0.9	3.3	
14	2.9	0.0	0.0		3.5	0.2	0.3	
15	0.0	0.0	0.0		0.3	0.0	0.0	

* ~ Area (ha) of snail habitat inside pest exclusion fenced areas.

5.4.2 Establishing and Maintaining Pest Exclusion Fenced Areas for the BPCP

There are plans for four pest exclusion fenced areas as compensation for the residual impact of the BPCP (Figure 5). Three are to protect *P. patrickensis* and a fourth to protect *P. augusta*, as part of the compensation package for the Project's residuals effects on *P. patrickensis*. Two of the proposed fenced areas will be on Denniston Plateau, a 47-ha area at Denniston North and a 154-ha area at Coalbrookdale. A third 695-ha fenced area is proposed for the Whirlwind Rise area on Stockton Plateau, however only 544 ha of its area is undisturbed habitat in the known range of *P. patrickensis*. The pest exclusion fenced area proposed for *P. augusta* is a 15-ha area, approximately 1 km north of Mt. Augustus on the north-west edge of Stockton Plateau. Full details of the establishment and maintenance of pest exclusion fenced areas are in the Pest Control and Elimination Plan (BCP-ENV-PLN_022). Removal of weka from the fenced areas is described in the Pest Control and Elimination Plan and the Avifauna Management Plan (BCP-ENV-PLN_003).

[1] The schedule was obtained from the March 2025 Mine Plan for the Project and is subject to the approvals that are obtained for the Project.

[redacted]

Models of likely *P. patrickensis* population trends with the Project and the proposed pest exclusion fenced areas were compared to models of population trends without the Project assuming the current predation levels (Lloyd's Ecological Consulting, 2026b). The population models were developed using a range of likely demographic parameter estimates obtained from snail monitoring. In models with the Project and pest exclusion fenced areas, there were initial reductions in the size of the snail populations as a result of stripping snail habitat and continued predation outside the fenced areas, but as snail populations in the fenced areas begin to grow in the absence of predation, population declines on both plateaux slowed and snail populations in models with and without the Project were similar after between 9 & 11 years. Subsequently, in models with the Project, populations either levelled out or increased as they approached whichever carrying capacity for habitat in the pest-free exclosures was used in the model, usually within 30 years. By contrast, in models with current predation levels and without the Project the snail population declined by 89% (Range 68% – 96%) after 20 years and by 96% (Range 82% –99%) after 30 years.

5.4.3 Constructing Temporary Weka-free Exclosures

Before the pest exclusion fenced areas are completed, temporary weka-free exclosures (Appendix 8) will be built in designated snail release area within the footprints of the proposed pest exclusion fenced areas and half of all salvaged snails will be relocated into the weka-free exclosures to protect them from predation by weka.

5.4.4 Snail Salvage

Before an area of snail habitat is to be stripped for mine construction or operation, the area will be searched for snails and egg clusters. Any snails or egg clusters found will be relocated to the nearest existing or planned pest exclusion fenced area on the same plateau using the methods described in Appendix 5. Searches for snails and eggs to be salvage will use the mixed search strategy described above (Sections 2.4.1 and 4.1) and in Appendix 5, with two nocturnal searches for snails active on the surface followed by daytime sub-surface searches of ¼ ha areas where densities of snails found during one of the nocturnal searches reaches a pre-determined threshold value.

Snails captured during salvage operations will be relocated to a nearby pest exclusion fenced area if a suitable one is available. If not, the salvaged snails will be relocated to weka-free exclosures in the footprint of a proposed nearby pest exclusion fenced area,. Salvaged snails will be released at least 200 m away from capture-recapture plots for monitoring population changes. Snails ≥20 mm diameter will be tagged with unique identification tags (Appendix 1) to monitor their survival.

5.4.5 Snail Management in other Plans

Plans for Vegetation Direct Transfer (VDT) of snail habitat are described in the Rehabilitation Management Plan (BCP-ENV-PLN_002).

Planned research and adaptive management to improve rehabilitation by planting and, or seeding outcomes for snails is described in the Rehabilitation Management Plan (BCP-ENV-PLN_002).

Pest management for the Project includes:

- Creating temporary weka-free exclosures in the footprints of proposed permanent pest exclusion fenced areas.
- Building permanent pest exclusion fenced areas.
- Relocating weka out of pest exclusion fenced areas.
- Eradicating mammalian pest species in the pest exclusion fenced areas.
- Maintaining pest exclusion fenced areas to ensure they remain pest-free for 50 years after construction of the last fence (Whirlwind Rise) , and
- Controlling mammalian pests throughout the known range of *P. patrickensis* on Buller Plateaux.

The construction and maintenance of pest exclusion fenced areas and mammalian pest control are described in the Pest Control and Elimination Plan (BCP-ENV-PLN_022). Removal and relocation of weka is described in the Pest Control and Elimination Plan and the Avifauna Management Plan (BCP-ENV-PLN_003).

6.0 Management During Closure and Post-closure

6.1 Management Objectives

- Enhance survival of *P. patrickensis* and *P. augusta* snails by maintaining pest exclusion fenced areas for 50 years after completion of construction of the final pest exclusion fenced area.
- Develop methods to improve suitability of rehabilitated habitat for snails in areas rehabilitated by planting and, or seeding.
- In disturbed areas and on ELFs re-establish areas of habitat suitable for recolonisation by *P. patrickensis.*
- When areas of rehabilitated habitat are suitable for snails, relocate snails from nearby pest exclusion fenced areas into the rehabilitated habitat.

6.2 Stockton Mine

Effects management for *P. patrickensis* snails during closure of the Stockton Mine will entail completing the rehabilitation of areas within the snail's distribution range disturbed during construction and operation of Stockton Mine. Progressive rehabilitation during mine operation has rehabilitated approximately 165 ha of the disturbed areas by the end of 2025. Current plans are to rehabilitate the remaining 123 ha by planting and, or seeding progressively during 2029, 2036 & 2040.

6.3 Cypress Mine

Effects management for snails and their habitat required by the Cypress Mine Consent Conditions (RC03175/1-18) during closure and post-closure of the Cypress Mine are:

- Increasing the *P. patrickensis* snail population in the vicinity of Cypress Mine,
- Relocating stored red tussock VDT to the rehabilitated mine site,
- Establishing a population of >1,000 mature snails in the rehabilitated mine site, and
- Providing snail habitat over a similar proportion of the rehabilitated mine site as snails were present in during 2004.

6.3.1 Increasing the Local Snail Population

Previous consent conditions for Cypress Mine required the consent holder to undertake a programme of predator control to increase abundance of *P. patrickensis* in the vicinity of Cypress Mine and the wider Snail Enhancement Area as compensation for the impact of Cypress Mine on *P. patrickensis* snails. Recently observed declines in *P. patrickensis* populations on Buller Plateaux resulting from increased predation by weka (Lloyd, 2024a, 2024b) have prompted reconsideration of snail management for the Cypress Mine as controlling introduced mammalian predators has not proven an effective method for increasing the *P. patrickensis* snail population and may have contributed to the population's decline by increasing weka abundance.

Instead, to enhance the local snail population Bathurst is proposing establishing two pest exclusion fenced areas: a 14-ha pest exclusion fenced area on the rehabilitated Cypress Mine pit and a nearby 695-ha pest exclusion fenced area on Whirlwind Rise (Figure 6). The 14-ha pest exclusion fenced area will be built on an engineered landform in the rehabilitated Cypress Mine area, during mine closure, with expected completion in 2031. The proposed pest exclusion fenced area in the rehabilitated Cypress mine site will be contiguous with, but fenced separately from, the 695-ha Whirlwind Rise pest exclusion fenced area proposed as compensation for the Project. Completion of the Whirlwind Rise pest exclusion fenced area is planned for ten years after the Project commences, 5 or 6 years after the Cypress pest exclusion fenced area is built. When the Whirlwind Rise pest exclusion fenced area is built, the two areas together will create a 709-ha pest exclusion fenced area enclosing 558 ha of snail habitat.

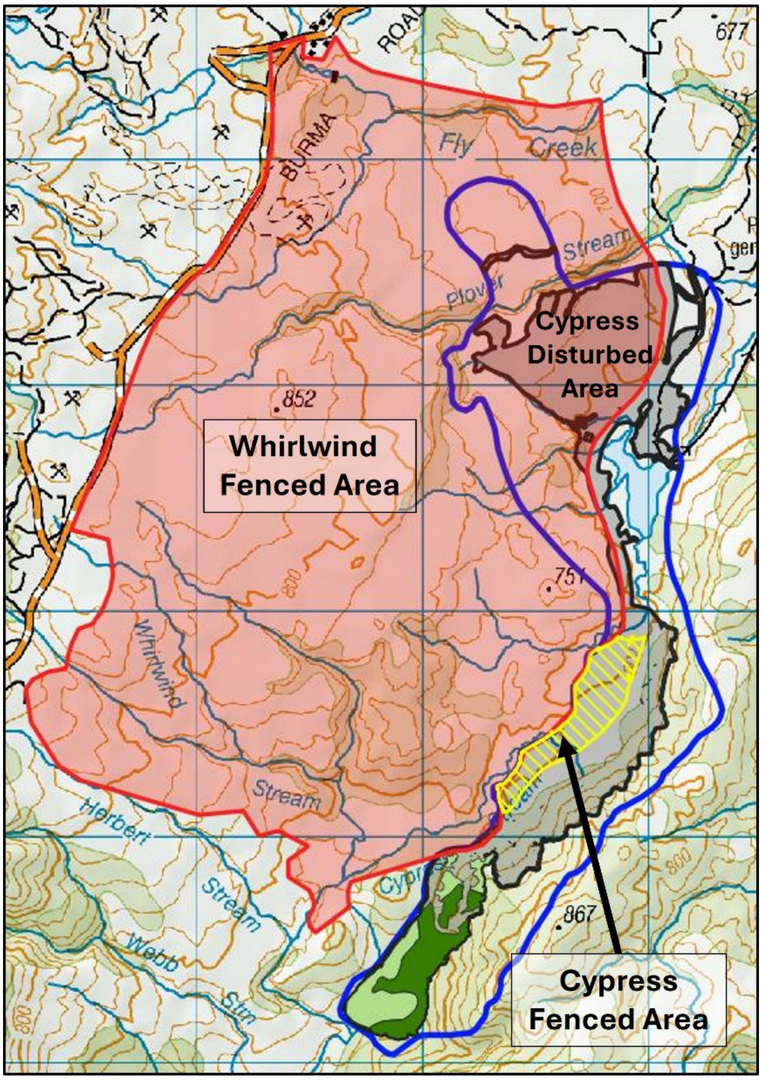

Figure 6. Proposed Whirlwind and Red Tussock pest exclusion fenced areas (red shading and yellow hatching respectively), the existing disturbance area for the Cypress Mine (grey shading) and areas of scrub (light green) and forest (dark green) remaining to be disturbed before closure of the Cypress Mine.

6.3.2 Relocating Stored Red Tussock Habitat to the Rehabilitated Mine Site

The 13.3-ha of red tussock snail habitat originally transferred by VDT from Cypress Mine area onto temporary laydown areas for storage during Cypress Mine operation will be relocated onto the ELF in the area where the 14-ha pest exclusion fenced area is to be established in the rehabilitated Cypress Mine area, as detailed in the Rehabilitation Monitoring Plan (BCP-ENV-PLN_002).

6.3.3 Establishing a Population of >1,000 Mature Snails in the Rehabilitated Mine Site

Consent conditions (RC03175 C35b) for the Cypress Mine required the consent holder to establish a *P. patrickensis* population of at least 1,000 mature snails in the rehabilitated mine site. It seems likely that more than 1,000 mature *P. patrickensis* snails will be present in the 13.3 ha of VDT returned to the rehabilitated pit as the estimated snail density from capture-recapture surveys in the red tussock VDT during 2024 (Lloyd, 2024c) was 188 snail/ha with 84% mature (≥32 mm maximum diameter) or 158 mature snails/ha, giving more than 2,000 mature snails in the 13.3 ha of VDT habitat. As the relocated red tussock habitat will be inside a pest exclusion fenced area the snail population within it will increase rapidly and provide a source for repopulating other areas in the rehabilitated mine site.

6.3.4 Provide Snail Habitat Over a Similar Proportion of the Rehabilitated Mine Site as Snails Were Present in During 2004

The consent conditions (C35b) for the Cypress Mine required the consent holder to establish a *P. patrickensis* population of snails over at least a similar proportion of the rehabilitated pit area to the proportion observed during snail surveys of the consent area undertaken in 2004 (Wildlife Surveys, 2005) before the mine area was disturbed for the Cypress Mine.

During the 2004 snail surveys, *P. patrickensis* snails or shells were found in 13 of 36 plots (i.e. 36%) in the Cypress Mine's footprint (Figure 7a). At the end of mine life disturbance for the Cypress Mine will extend over 122 ha. To fulfil consent conditions the rehabilitated mine site should provide at least 44 ha of the snail habitat (i.e. 36% of 121.5 ha). The capture locations of snails relocated out of the mine before stripping up until 2025 show a similar distribution pattern to the distribution pattern observed during the 2004 surveys with a 27-ha polygon enclosing all but 2 of the 1,301 locations where snails or eggs were found between 2009 and 2025 (Figure 7b), with most salvaged snails found near the ecotone between scrub and tussock. When added to the 13.3 ha of red tussock snail habitat relocated using VDT the total area with snails is 40.3 ha, which is only slightly smaller than the area with snails observed during the 2004 snail surveys.

[redacted]

After the 13.3-ha of red tussock snail habitat originally transferred by VDT from Cypress Mine area onto temporary laydown areas is returned to the rehabilitated mine site another 30.6 ha of snail habitat in the rehabilitated mine site will need to be created by planting and, or seeding to fulfil the consent conditions requiring 44 ha of snail habitat in the rehabilitated mine site. Results from searches for snails in areas rehabilitated by planting and seeding previously show that snails have not colonised rehabilitated areas even 20 years after rehabilitation despite snail populations being present in surrounding undisturbed areas (Lloyd, 2024c). Improvement in methods for creating snail habitat by planting and, or seeding as discussed in Section 2.4.4 above and in the Rehabilitation Management Plan (BCP-ENV-PLN_002) will be implemented in order to achieve the required additional 30.6 ha of snail habitat.

6.3.5 Relocating Snails into the Rehabilitated Mine Area

Relocating snails into the rehabilitated mine area will begin during 2031 when snails in red tussock habitat previously transferred by VDT from Cypress Mine onto temporary laydown areas for storage during mine construction will be relocated into the 14-ha pest exclusion fenced area built on ELF in the rehabilitated Cypress Mine area (Figure 6).

Relocation of snails into areas of Cypress Mine rehabilitated by planting and, or seeding will be a lengthier and uncertain process undertaken by manual relocation of snails. Relocating *P. patrickensis* into the rehabilitated mine area will only be undertaken when results from monitoring vegetation and earthworms indicate that rehabilitated areas will probably provide suitable snail habitat. Subsequently, relocations of *P. patrickensis* into the rehabilitated mine area will be a two-stage process accompanied by monitoring with operational relocations only undertaken when small scale trial relocations into the rehabilitated area have been successful as described in Section 2.4.5 above.

Snails for manual relocations will be sourced from one of the two nearby pest exclusion fenced areas. In these fenced areas absence of predation by weka and mammalian predators will mean that the snail populations will be increasing towards whatever carrying capacity the habitat has. Ideally snails relocated into areas of Cypress Mine rehabilitated by planting, or seeding, will be from either the destination sites for snails previously relocated manually out of the Cypress Mine into the footprint of the Whirlwind Rise fenced area or the relocated red tussock habitat in the Cypress pest exclusion fenced area.

6.4 Newly Consented Areas of the Project

Subject to approvals, all authorities for the BPCP are likely to commence in 2027 with development of the Upper Waimangaroa Haul Road and two new mining areas (Mount Frederick South and Escarpment Extended) likely to begin during 2027. Mine operations are predicted to last for 16 years, with final mining and closure of the newly consented areas likely to occur during 2042 (Bathurst Resources Limited, 2025a) and the predicted closure dates for the Project on Denniston and Stockton Plateaux likely to be 2042 (BCP-ENV-PLN_050).

6.4.1 Pest Exclusion Fenced Areas

At the time of BPCP closure, Bathurst will have completed construction and eliminated pests (weka and introduced mammals) from five pest exclusion fenced areas (Figures 5 & 6), four established to protect *P. patrickensis* snails from predation and a fifth 15-ha area to protect *P. augusta* (BCP-ENV-PLN_022). The Cypress fenced area is proposed as compensation for the impact of the Cypress mine on *P. patrickensis*. The other four fenced areas are proposed as compensation for the Project's impacts on *P. patrickensis.* The four fenced areas for protecting *P. patrickensis* will have a combined area of 910 ha and include 760 ha of the current distribution range of *P. patrickensis*. A programme of routine maintenance will be in place to maintain the integrity of the fences and ensure that the pest exclusion fenced areas remain pest-free for 50 years after construction of the last fenced area (BCP-ENV-PLN_022).

6.4.2 Rehabilitating Habitat

Detailed closure criteria for habitat rehabilitated by planting and, or seeding in the BPCP are provided in the Rehabilitation Management Plan (BCP-ENV-PLN_002).

6.4.3 Using Relocation to Establish Snail Populations in Rehabilitated Areas

When results from monitoring vegetation and earthworms in areas of the mine sites rehabilitated by planting indicate that habitat in rehabilitated areas will probably be suitable for *P. patrickensis*, relocations into potential snail habitat in the rehabilitated mine site will be undertaken as described in Section 2.4.5 above. Initial small scale trial relocations will only be followed by operational relocations when results from capture-recapture monitoring indicate trial relocations were successful. Snails relocated into the rehabilitated areas will be from nearby pest exclusion fenced areas, ideally, from destination sites for snails originally relocated out of the disturbance areas being rehabilitated.

7.0 Monitoring During Mine Life

7.1 Monitoring Objectives During Mine Life

Monitoring the effects on *P. patrickensis* snail populations of the fenced pest exclusion fenced areas and planned mammalian predator control outside the pest exclusion fenced areas will be undertaken to:

- Ensure snail populations increase in response to predator control and removal of pests from the pest exclusion fenced areas.
- Identify predation related problems affecting snail populations.
- Identify methods to improve outcomes for snail populations.

Monitoring the cause of death inside and outside weka-free exclosures will be undertaken to:

- To confirm that weka-free exclosures are effective in reducing predation of snails.

Monitoring the success of snail salvage operations will be undertaken to:

- Improve efficiency of snail salvage operations.
- Determine whether snail salvage is an effective mitigation method.
- Identify methods to improve survival of salvaged snails.

Monitoring snails in VDT relocated into the rehabilitated Cypress Mine site will be undertaken to:

- Determine whether snails in stored VDT survive second relocation of their habitat by VDT.

Outcome monitoring for *P. patrickensis* snails described in this plan links to outcome monitoring for fauna at ecological rehabilitation and residual effects management sites described in the Biodiversity Outcome Monitoring Plan (BCP-ENV-PLN_009) and the Avifauna Management Plan (BCP-ENV-PLN_003).

7.2 Summary of Proposed Monitoring During Mine Life

7.2.1 Monitoring Snail Population Trend Inside and Outside Pest Exclusion Fenced Areas

Monitoring *P. patrickensis* population trends in areas of undisturbed snail habitat inside and outside the pest exclusion fenced areas will be undertaken with a monitoring programme using biennial capture-recapture surveys of snail populations in matching samples of 70 m square plots inside and outside the pest exclusion fenced areas.

7.2.2 Monitoring Cause of Snail Deaths

Monitoring the cause of death for *P. patrickensis* snails will entail inspection of damage patterns on snail shells found during daytime sub-surface searches of matching samples of 10 m square plots

(Appendices 2 & 6). Information from shells found during sub-surface plot searches will be augmented by inspection of damage patterns on snail shells found during snail salvage operations, and other survey or monitoring work. There will be two programmes to monitor the causes of snail death. An initial programme to compare cause of death inside and outside the temporary weka-free exclosures, followed by a programme to compare cause of snail death inside and outside the permanent pest exclusion fenced areas.

7.2.3 Monitoring Snail Salvage Operations

The success of snail salvage operations will be assessed by:

- Routine review of snail capture-rates per person hour of searching and per hectare.
- Reviewing the results of snail salvage searches with mixed search strategy (Appendix 5 and Section 2.4.1) to determine the optimum threshold value for snails found during nocturnal searches to initiate daytime sub-surface searches.
- Monitoring the survival of salvaged snails by tagging them with unique identification tags before relocating them to designated, mapped release areas. Their survival in the release areas will be monitored by capture-recapture surveys of 70 m square plots in the release areas. (BCP-ENV-PLN_002).

7.2.4 Related Monitoring Described in Other Plans

- Monitoring mammalian pest abundance inside and outside pest exclusion fenced areas is described in the Pest Control and Elimination Plan (BCP-ENV-PLN_022).
- Monitoring weka abundance is described in the Avifauna Management Plan (BCP-ENV-PLN_003).
- Monitoring snail habitat quality in areas rehabilitated by either VDT or planting and, or seeding is described in the Rehabilitation Management Plan (BCP-ENV-PLN_002).

7.3 Monitoring Snail Population Trends Inside and Outside Pest Exclusion Fenced Areas

Monitoring and comparing trends in *P. patrickensis* snail populations inside and outside proposed pest exclusion fenced areas, will be undertaken using a Before-After-Control-Impact (BACI) monitoring programme with biennial capture-recapture surveys of matching samples of 70 m square plots inside and outside the fenced areas. Details of the capture-recapture methods are provided in Appendix 7. The BACI monitoring programme in each of the pest exclusion fenced areas will begin before the area is fenced and pests removed, with capture-recapture surveys of matching plots located inside and outside the footprints of the proposed pest exclusion fenced areas undertaken twice, ideally with a two-year interval between surveys. After an area is fenced and pests removed, surveys of the matching plots in the fenced area will initially be undertaken biennially. Results from each set of biennial surveys will be reviewed promptly after surveys are completed to identify whether any management responses are required and to decide on the schedule for future monitoring.

7.3.1 Denniston Plateau

Two permanently marked capture-recapture plots will be established in the area of the planned 47-ha Denniston North pest exclusion fenced area (Figure 5) and two existing nearby capture-recapture plots (Lloyd, 2024a) on Denniston Plateau (Figure 4) will be retained to serve as matching plots for plots in the fenced area. Capture-recapture plots should be established in the footprint of the proposed pest exclusion fenced area and surveyed during the first summer after the project commences, before the area is fenced and pests are removed. Capture-recapture surveys of the matching plots will be undertaken biennially until 7 years after the Project commences (Table 3), when results of the monitoring programme will be reviewed to determine whether continued monitoring is required.

7.3.2 Stockton Plateau

The existing long-term monitoring (LTM) capture-recapture plots on Stockton Plateau (Figure 4) will be incorporated into the BACI monitoring programme for the proposed Whirlwind Rise pest exclusion fenced area (Figure 5). Two existing long-term snail monitoring plots (LTM Plots 3 & 4) are within the area of the proposed Whirlwind Rise pest exclusion fenced area, while nearby LTM Plots 1 & 2 are nearby but outside of it and will serve as matching plots for LTM Plots 3 and 4. To achieve representative geographic sampling, another two capture-recapture plots will be established in snail habitat elsewhere in the footprint of the Whirlwind Rise pest exclusion fenced area with matching nearby plots outside of the footprint. Fencing and removal of pests from the Whirlwind Rise pest exclusion fenced area is scheduled to be completed ten years after the Project commences on Stockton Plateau. There should be biennial capture-recapture surveys of the matching plots beginning 7 years after the Project commences (Table 4) and continuing until the Project's mine closure on Stockton Plateau, which is predicted to be 16 years after commencement (Bathurst Resources Limited, 2025a; BCP-ENV-PLN_050).

7.4 Monitoring Cause of Snail Deaths

Monitoring cause of death for snails inside and outside of the proposed pest exclusion fenced areas will be undertaken with a BACI monitoring programme using inspection of shell damage patterns to identify cause of death for snail shells found during daytime sub-surface searches of matching samples of 10 m square plots, inside and outside of a pest exclusion fenced area. To reduce habitat damage in plots caused by repeated searches each sample of plots will be divided into two sets, with each set of plots searched at 4-year intervals. However, searches of the two sets will be offset by two years providing information on cause of death at biennial intervals. Surveys of matching sets of plots for each pest exclusion fenced area will begin before the area is fenced and pests removed. Results from inspecting shells found during sub-surface plot searches will be augmented by inspection of damage patterns on any snail shells found during other snail monitoring work. Results from each set of biennial surveys for shells will be reviewed promptly after surveys are completed to identify whether any management responses are required and whether the monitoring programme for cause of death should continue. Details of the method used to identify cause of death from shell damage patterns are provided in Appendix 2. Details of the daytime sub-surface plot search method are provided in Appendix 5.

7.4.1 Denniston Plateau

Matching samples of ten permanently marked 10 m square plots will be established inside and outside the 154-ha area of the proposed Coalbrookdale pest exclusion fenced area before it is fenced and pests removed. Fencing and pest removal from the Coalbrookdale pest exclusion fenced area is scheduled to be completed 4 years after mining commences on Denniston Plateau. Surveys using daytime sub-surface searches of the matching samples of 10 m square plots will begin two years after the Project commences before the pest exclusion fenced area is scheduled for completion to obtain information on cause of death before the area is fenced (Table 3). Results of the cause of death monitoring will be reviewed promptly after each of the biennial surveys is completed to identify whether any management responses are required and whether the monitoring programme should continue beyond seven years after Project commencement.

7.4.2 Stockton Plateau

Matching samples of 16 permanently marked 10 m square plots will be established inside and outside the proposed Whirlwind Rise pest exclusion fenced area before it is fenced and pests removed. Fencing and pest removal from the Whirlwind Rise pest exclusion fenced area is scheduled to be completed ten years after mining commences on Stockton Plateau. Surveys using daytime sub-surface searches of the matching samples of 10 m square plots will begin three years before the pest exclusion fenced area is scheduled for completion (Table 4) to obtain information on cause of death before the area is fenced. Results of the cause of death monitoring will be reviewed promptly after each of the biennial survey is completed to identify whether any management responses are required and whether the monitoring programme should continue beyond 13 years after Project commencement.

7.4.3 Comparing Cause of Snail Deaths Inside and Outside Weka-free Exclosures

To monitor cause of snail death in the temporary 0.5 ha weka-free exclosures after weka have been removed, two 10 m square plots will be established in each of a sample of the temporary weka-free exclosures and two matching plots will be established nearby, outside of the exclosures in similar habitat. Sub-surface searches will then be undertaken in all the plots to remove snail shells from the plots. Subsequently, each year one of the plots inside and one outside each of the weka-free exclosures will be searched for shells and snail's predators identified from the damage patterns left on snail shells (Appendix 2). Monitoring cause of snail death inside and outside weka-free enclosures will be continued until the effectiveness of the exclosures is confirmed.

7.5 Monitoring Snail Salvage Operations

The success of searches for salvaging snails from areas before they are stripped will be assessed by routine review of snail capture-rates per person hour of searching and per hectare searched. Analyses will be undertaken to identify factors affecting capture rates to identify ways to improve the effectiveness of snail salvage searches and to optimise the threshold value used for initiating sub-surface searches (Appendix 5).

All salvaged snails ≥20 mm diameter will be tagged with a unique identification tag before being relocated to a nearby pest exclusion fenced area or when there are none available a weka-free exclosure in the footprint of a nearby pest exclusion fenced area. The designated release areas will be at least 200 m from the capture-recapture plots being used to monitor population trends in the pest exclusion fenced areas. Capture-recapture methods will be used to monitor the survival of salvaged snails after their release and compare their survival with survival of snails already resident at the release sites.

To achieve this, a 70 m square capture-recapture plot will be established in the designated snail release areas in both the Denniston North and Whirlwind Rise pest exclusion fenced areas. Capture-recapture surveys will be undertaken in these two plots immediately after they are established and subsequently at biennial intervals to obtain survival estimates for salvaged and resident snails (Tables 3 & 4). Ideally capture-recapture plots in a pest exclusion fenced area for monitoring population trends and for monitoring salvaged snail survival should be surveyed during the same summer. Results of capture-recapture population monitoring will be reviewed promptly after each set of surveys is completed to identify whether any management responses are required and whether the monitoring programme should continue.

7.6 Monitoring Schedule for BPCP During Mine Life

Tables 3 and 4 summarise the areas of snail habitat searched for snails each year and the proposed monitoring schedules for snails on Denniston and Stockton Plateaux for the newly consented areas for the Buller Plateaux Continuation Project. The tables are based on information in the March 2025 Mine Plan for the Project and the Project Description (Bathurst Resources Limited, 2025a). Project Year is the number years since Project commencement.

Table 3. Proposed schedule of areas to be searched for snail salvage and schedules of snail monitoring in pest exclusion fenced areas on Denniston Plateau during years 0 to 16 following Project commencement.

Project Year	Area (ha) to be searched on Denniston	Denniston North			Project Year	Coalbrookdale	
		Plot Type:	Capture-recapture			Plot Type: (2 sets of 10):	10 m sq. plots
			Pop. Trend	Salvage			Cause of Death
			No. of Plots:				No. of Plots:
0				1	0		
1	105.1		4		1		
2	62.8	Fence Completed		1	2		
3	111.5		4		3		10
4	11.8			1	4	Fence Completed	
5	18.6		4		5		10
6					6		
7	22.9		4		7		10
8					8		
9	7.4				9		10
10	17.8				10		
11	25.1				11		
12	3.9				12		
13	2.9				13		
14					14		
15					15		
16		Closure	4		16	Closure	10

Table 4. Proposed schedule of areas to be searched for snail salvage and schedules of snail monitoring in the Whirlwind Rise pest exclusion fenced area on Stockton Plateau during years 0 to 16 following Project commencement.

Project Year	Area (ha) to be searched on MFS	Whirlwind Rise Pest Exclusion Fenced Area			
		Plot Type:	Capture-recapture (0.49ha)		10 m sq. plots
			Pop. Trend	Salvage	Cause of Death
		N. of Plots:			(2 sets of 16)
0	41.7				
1	7.2			1	
2	7.6				
3	6.3			1	
4	7.4				
5	2.7			1	
6	9.2				
7	27.3		8	1	16
8	5.1				
9	10.5		8	1	16
10	14.7	Pest Exclusion Fenced Area Completed			
11	4.0		8	1	16
12	18.5				
13	3.3		8		16
14	0.3				
15	0		8		
16		Closure			

8.0 Closure and Post-Closure Monitoring

Monitoring the effectiveness of snail management will be undertaken at closure using the monitoring methods used during mine life. At mine closure:

- Capture-recapture surveys will be used to estimate *P. patrickensis* snail population densities inside and outside two pest exclusion fenced areas, the Denniston North area on Denniston Plateau and Whirlwind Rise areas on Stockton Plateau.
- Inspection of shell damage patterns in shells collected from 10 m square plots will be used to monitor cause of death for snails inside and outside of the Coalbrookdale and Whirlwind Rise pest exclusion fenced areas.
- Capture-recapture surveys will be used to monitor the survival of snails in red tussock habitat relocated from temporary storage areas onto ELF in the rehabilitated Cypress Mine.
- Snail relocation into rehabilitated areas will be a staged process with progress determined by results from an accompanying monitoring programme.

8.1 Snail Population Trends Inside and Outside Fenced Areas

The schedule for post-closure monitoring of snail population trends will depend on the results of monitoring at closure. If results from population trend monitoring show that snail populations are increasing in the pest exclusion fenced areas and declining outside of them as expected, a schedule with 10-year intervals between successive capture-recapture surveys during 50-year period after closure should be adequate. However, if population trends are not as expected the consent holder and authorities should together decide on an appropriate monitoring schedule.

8.2 Cause of Death for Snails Inside and Outside Fenced Areas

Routine cause of death monitoring inside the Coalbrookdale and Whirlwind Rise pest exclusion fenced areas during the 50-year post-closure period will provide a sensitive method for detecting any pest populations that establish in the fenced areas. Cause of death monitoring outside the pest exclusion fenced areas will provide information on predation pressure in areas subject to mammalian pest control and the levels of rat and weka predation on snails relocated into rehabilitated mine areas.

Cause of death monitoring at and after closure will be undertaken using the methods used during mine life, described in Section 2.5.3 and Appendix 2. Cause of snail deaths will be determined from damage patterns on snail shells found during daytime sub-surface searches of matching samples of permanently marked 10 m square plot. There will be 10 plots inside the Coalbrookdale, 16 plots inside Whirlwind Rise fenced area and equal numbers of matching plots nearby but outside the two fenced areas. To reduce habitat damage caused by repeated searches of plots the sample of plots in each area will be divided into two sets, with each set of plots searched at 4-year intervals as described in Sections 7.4 & 7.6.

8.3 Monitoring the Survival of Snails in Relocated Red Tussock Habitat

At mine closure, the area of red tussock snail habitat previously transferred by VDT from Cypress Mine onto temporary storage areas during mine operation will be relocated into the 14-ha pest exclusion fenced area on the ELF of the rehabilitated Cypress Mine site. Capture-recapture methods (Appendix 7) will be used to monitor the effect of relocation on *P. patrickensis* snails in the red tussock habitat.

A 70 m square capture-recapture plot was established in red tussock habitat at the storage site and surveyed during summer 2023-2024, giving a plot population estimate of 92.4 (CI95%: 58 - 180) snails (Lloyd, 2024c). A capture-recapture survey of the same 70 m square plot will be undertaken during the summer before the red tussock habitat is relocated to the rehabilitated mine site to obtain a new plot population estimate. This likely to occur during summer 2030-2031.

When the red tussock habitat is relocated to the ELF of the rehabilitated Cypress Mine site, every attempt will be taken to reassemble material from the 70 m square capture-recapture plot at the storage site to recreate the plot. After the red tussock is relocated to the rehabilitated Cypress Mine site, a 70 m square capture-recapture plot will be established enclosing as much of the material from the original pre-transfer capture-recapture plot as possible. A capture- recapture survey of the plot will be undertaken during the summer after relocation and at least twice more at biennial interval to monitor the fate of the *P. patrickensis* populations in the relocated red tussock habitat.

Because of likely differences between the habitat areas and snails present in pre- and post-transfer plots, it will only be possible to compare plot population estimates before and after relocation, not snail survival during relocation. However, with three capture-recapture surveys at biennial intervals after the habitat is relocated robust capture-recapture analyses can be used to estimate survival and recruitment of snails in the habitat during the period after relocation. Results from capture-recapture surveys will also provide insights into population health before and after relocation, as they include the population's size structure, a surrogate of age-structure, at the time of the surveys.

8.4 Monitoring Snails Relocated into Rehabilitated Areas

It is likely to be more than 20 years after rehabilitation before areas rehabilitated by planting and, or seeding provide suitable habitat for *P. patrickensis* snails and snails can be relocated into them. When results from monitoring vegetation and earthworm communities in rehabilitated area indicate that there will probably be suitable habitat for *P. patrickensis*, trial relocations into the rehabilitated mine areas will be undertaken as described in Section 2.4.5 above. To monitor the results of trial relocation a 70 m square capture-recapture plot will be established in potential *P. patrickensis* habitat in the rehabilitated mine site before snails are relocated. A sample of 200 *P. patrickensis* snails with maximum diameters ≥ 20 mm will be relocated from previous relocation destination sites into the capture-recapture plot in the rehabilitated mine site. The relocated snails will be tagged with individually numbered tags and have their maximum diameter and weight recorded before release into the mark-recapture plot in the rehabilitated mine area. During the summer after the snails are relocated a standard capture-recapture survey will be undertaken in the plot. To identify migration out of the plot, there will be additional nocturnal searches throughout a 20 m buffer around the capture-recapture plot undertaken after the plot searches. Results from searches outside the plot are not used for obtaining plot population estimates, but will assist distinguishing between mortality and migration out of the plot.

Capture-recapture surveys of the plot will be repeated annually. If the plot population is stable, or increasing with successful recruitment of young snails, the trial relocation will be considered successful and a comprehensive programme of operational relocation into snail habitat throughout the rehabilitated mine site begun. If the plot population is declining, without evidence of recruitment, the trial relocation will be repeated with additional relocations to the capture-recapture plot undertaken at intervals as the rehabilitated habitat improves until the relocations are successful, and all parties are satisfied that operational relocations can take place successfully.

When a trial relocation into the rehabilitated mine site is judged successful, operational relocations will be undertaken with *P. patrickensis* snails relocated into suitable snail habitat in the rehabilitated mine site. Two years after operational relocation of snails to the rehabilitated mine site is undertaken, a second capture-recapture plot will be established in suitable *P. patrickensis* habitat in the rehabilitated mine site and capture-recapture surveys will be undertaken in the two plots in the rehabilitated mine site to estimate plot population sizes. Four years after operational relocations are undertaken snails' distribution and abundance in areas around the relocation released sites will be assessed using either nocturnal searches along transects or time-based diurnal searches of 10 m square plots at 200 m spacing along transects 250 m apart as described in Wildlife Surveys (2005). Capture-recapture surveys and distribution abundance surveys will then be undertaken biennially until results from the surveys demonstrate that snail habitat in the rehabilitated mine area supports a viable self-sustaining population of *P. patrickensis* snails.

9.0 Proposed Performance Targets

The following set of performance targets for management of *P. patrickensis* on Buller Plateaux are proposed using results from monitoring described in Sections 7 & 8 above. When any performance targets aren't met, a panel of appropriate experts, including both independent external experts and representatives for Bathurst, should be engaged to determine the best management responses based on all available information.

9.1 Cypress Mine: Red Tussock Relocation

Monitoring method: Capture-recapture surveys (Section 2.5.3, Appendix 7)
Location: Cypress Mine (Section: 8.3)

Population density before & after relocation

Target: Population density after relocation is ≥70% of the density before relocation
Sources for target estimate: (Gruner et al., 2021; Lloyd, 2024c; MacKenzie, 2014)

Population trend in red tussock relocated to the pest exclusion fenced area

Target: Snail population increases ≥11% & 22%, measured 2 and 4 years after relocation.
Source for target estimate: Lower CI95% in Figure 3, Lloyd's Ecological Consulting (2026).

9.2 VDT for the Project

Area transferred as a proportion of the stripped area

Monitoring method: Mine operational records
Target: ≥15% of area stripped relocated by VDT

9.3 Pest Exclusion Fenced Areas for the Project

Long-term snail population trend in pest exclusion fenced areas

Monitoring method: Capture-recapture surveys (Section 2.5.2, Appendix 7)
Locations: Denniston North & Whirlwind Rise fenced areas (Sections: 4.2.1, 7.2.1, 7.3, 7.6 & 8.1)
Target: Snail population increases ≥11% & 22%, measured 2 years and 4 years after elimination of pests
Source for target estimate: Lower CI95% in Figure 3, Lloyd's Ecological Consulting (2026).

Cause of death

Monitoring method: Shell damage patterns in shells found during subsurface searches of 10 m square plots (Section 2.5.3, Appendix 2)
Monitoring locations: Coalbrookdale &Whirlwind Rise fenced areas (Sections: 4.2.4, 7.2.2, 7.4, 7.6 & 8.2)
Target: 0% of fresh shells with evidence of predation by weka, rodents or possums.

9.4 Snail Salvage

Search effort

Monitoring method: Field survey records (Appendix 4)
Locations: All disturbance areas (Section 7.6)
Target: Search effort, 2 nocturnal searches of potential snail habitat, each with 12 person hours per hectare of searching
Source: Snail capture-recapture surveys, Buller Plateaux 2016-2026 (Lloyd, 2024a & c)

Salvaged snail's annual survival

Monitoring method: Capture-recapture surveys (Section 2.5.2, Appendix 7)
Locations: Denniston North & Whirlwind Rise fenced areas (Sections 7.2.3, 7.5)
Target: No significant difference between survival estimates for relocated and resident snails 2 and 4 years after relocation.

9.5 Weka Free Exclosures

Cause of death

Monitoring method: Shell damage patterns in shells found during subsurface searches of 10 m square plots (Section 2.5.3, Appendix 2)
Locations: Weka-free exclosures in footprints of fenced areas (Sections 7.4.3, 7.5)
Target: 0% of fresh shells found with evidence of predation by weka.

9.6 Relocation to Areas Rehabilitated by Planting

Population trends in rehabilitated areas

Monitoring method: Capture-recapture surveys (Section 2.5.2, Appendix 7)
Details: Trial relocations into followed by operational relocations (Section 8.4)
Target without pests: Snail annual survival ≥ 0.65
Target with pests: Snail annual survival ≥ 0.45
Source: Lloyd's Ecological Consulting (2026)

Distribution in rehabilitated areas of the Cypress Mine

Monitoring method: Nocturnal searches along transects (Section 8.4, Appendix 3)
Details: Sections 6.3 & 8.4
Target: Snails present in ≥36% of the rehabilitated area 30 years after Cypress mine closure

10.0 Data Management

Reporting on the impacts of mining activity on *Powelliphanta* snails and the results of effects management for the impact will require a long-term time-series datasets collected over decades. The datasets must include information on the location, extent and timing of habitat stripping and effects management for *Powelliphanta* snails as well as results from the programme for monitoring *Powelliphanta* snails. To ensure data is available and intelligible, the datasets will be curated to ensure all data is recorded accurately and consistently, without duplication. The curated datasets should include meta-data to make them comprehensible to future workers and be organised to allow easy access. Datasets should be stored safely with backup copies at offsite locations.

11.0 Reporting

11.1 Internal Reporting

Information on effects management undertaken for *Powelliphanta* snails and the results of *Powelliphanta* snail monitoring programmes will be compiled and reported to internal management on a 12-monthly basis within the Environmental Management System (EMS) Management Review Process. The Environmental Manager will be responsible for scheduling this review and presenting performance against objectives and Key Performance Indicators (KPIs).

11.2 Annual Reporting Requirements

All potential and actual non-compliance with this *Powelliphanta* Snail Management Plan identified by site personnel during site inspections or monitoring activities are to be rectified in accordance with the requirements of this management plan.

11.2.1 Annual *Powelliphanta* Monitoring Report

As appropriate, effects management activities and monitoring results for *Powelliphanta* snails will be documented and reported in the Annual *Powelliphanta* Monitoring Report. At the time of submitting the Annual *Powelliphanta* Monitoring Report, BRL shall advise of any material changes that it intends to initiate and the timeframe for such material change.

The Annual *Powelliphanta* Monitoring Report must include (but not be limited to):

- A summary of how *P. patrickensis* effects management measures were implemented during the reporting period;
- A description of all *P. patrickensis* monitoring undertaken during the reporting period, including:
  - The type of monitoring undertaken;
  - A map showing locations and areas monitored;
  - Timing and frequency; and
  - Methods used.
- Details of all salvage, relocation and habitat management activities undertaken, including:
  - A description of salvage methods and results (including numbers of individuals salvaged and relocated);
  - A description of relocation and release activities (including locations and receiving environment);
  - A summary of post-release monitoring results, including survival and condition of salvaged individuals; and
  - Maps illustrating where avoidance, minimisation and salvage activities were undertaken.
- A summary of the monitoring results and an interpretation of those results in relation to:
  - Population trends inside and outside of pest exclusion fenced areas and weka-free exclosures;

    - Survival of salvaged and relocated individuals;
    - Cause of death monitoring.
- A summary of any incidents, including:
    - Any unexpected mortality events;
    - Any non-compliances with the PMP or consent conditions; and
    - The corrective actions implemented in response.
- Recommendations for any changes to *Powelliphanta* management (including updates to the PMP or implementation methods), based on monitoring outcomes.

12.0 Expertise and Training

12.1 Authorised Personnel for Working with *P. patrickensis* Snails

All taxa of *Powelliphanta* snails are absolutely protected wildlife (Schedule 7, Wildlife Act 1953, inserted by section 3(3) of the Wildlife Amendment Act 1980). Section 53 of the Wildlife Act 1953 prohibits catching and handling live *Powelliphanta* snails or holding collections of their shells except with written Wildlife Act Authorisation. Management and monitoring *P. patrickensis* snails entails the following activities that require a Wildlife Act Authority:

- Catching and liberating live *P. patrickensis* snails for monitoring surveys, salvaging or relocation.
- Attaching numbered snail tags to live *P. patrickensis* snails for population monitoring.
- Collecting *P. patrickensis* shells for identifying the cause of death.

Only the Authority Holder of the appropriate Wildlife Act Authority and their Authorised Personnel are authorised to undertake these activities. Authorised Personnel are suitably qualified ecologists, employed by the Wildlife Act Authority Holder (Bathurst and BT Mining Ltd) approved of in writing by DOC's Western Southern Island (WSI) Statutory and Community Manager prior to commencement of the activity.

12.2 Experience and Training of Personnel Working with *P. patrickensis* Snails

Field work on *Powelliphanta* snails on Buller Plateaux undertaken for Bathurst Resources Ltd and BT Mining Ltd will be undertaken by an outside contractor, MBC Environmental Ltd (previously MBC Contracting Ltd.). Field staff from MBC Environmental Ltd have undertaken most of the field work on *Powelliphanta* snails on Buller Plateaux since 2006, initially for Solid Energy New Zealand (SENZ), but more recently for Bathurst. Their field work has included: snail salvage operations (Gruner, 2011; Hamilton, 2015c); destructive plot searches (Hamilton, 2015a); distribution and abundance surveys using daytime sub-surface searches of 10 m square plots (Lloyd, 2013, 2024b) and nocturnal transects (Lloyd, 2024c); and population trend monitoring with capture-recapture surveys (Lloyd, 2023, 2024a; MacKenzie, 2014). Throughout this time, the company has exhibited professionalism in their field work, data collection and data management. During field work on *Powelliphanta* snails, field staff from MBC adhere to the guidelines set out in the Appendices to the *Powelliphanta* Management Plan, March 2026: Methods for Working with *Powelliphanta* Snails. All new field staff working with *Powelliphanta* snails receive hands-on training and mentorship in the field on methods for working with *Powelliphanta* snails from experienced field-staff.

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Appendices of Methods for Working with *Powelliphanta* Snails

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- Attaching numbered snail tags to live *P. patrickensis* snails for population monitoring.
- Collecting *P. patrickensis* shells for identifying the cause of death.

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Appendix 1: Measuring and Tagging *Powelliphanta* Snails

Measuring Snails

To achieve consistent, repeatable snail maximum diameter measurements digital callipers are used with the snail placed in the callipers as described in Meads et al. (1984). The snail is then gently rotated until the jaws of the callipers are pushed out to a maximum dimension. Finally, the snail is moved up and down in the callipers to find the extreme point on the curved side of the shell where the maximum diameter is measured.

Tagging Snails

A numbered polyethylene tag is glued to the ventral surface of the snail's shell immediately behind the aperture with Selleys Supa Glue™ Quick Fix Non-Drip. The tags are attached ventrally to avoid attracting predators to the coloured tags and immediately behind the aperture to avoid tags being overgrown as the shells grow. Two different tag types should be used: four-digit and two-digit glue-on shellfish tags (Hallprint, www.hallprint.com). The four-digit tags are used on larger snails (> 30 mm diameter) and two-digit tags on smaller snails (20–30 mm). Before a tag is attached the snail is wiped dry with a paper towel, a small area on the shell is roughened with fine sandpaper, and the tag is glued to this spot using Selley's Quick Fix Supa Glue Non-Drip, which is recommended by Grüner (2007) and has been tested using double tagging trials. Snails are released once the glue is cured enough to hold the tag in place. Snails with a maximum diameter smaller than 20 mm will not be tagged, because their shells are too small to fit a tag to.

Appendix 2: Determining Causes of Death from Damage Patterns on Shells

Field Method

Any *Powelliphanta* shells or shell fragments found during snail salvage operations, surveys or monitoring programmes on Buller Plateaux should be collected with shells and large fragments (>50% of shell) placed in separate bags for each location. Bags should be labelled with date, observer and habitat details and full location details including geographic coordinates.

The shells and shell fragments should be examined for evidence of predator damage in the office. Before being examined they should be cleaned by washing in warm water. Soak shells briefly to soften accumulated soil and litter. Soil and litter can be removed from inside the shell with a wire hook, while the outside of the shell can be cleaned with a toothbrush and water. Shells should be handled carefully as they can be very fragile. Where possible smaller shells or live snails found inside shells should be identified to species.

Shells from different locations should be washed separately, to ensure that they are not mixed up. After washing, water can be removed from the shells by gently shaking and then wiping with a dry paper towel or cloth. The shells should then be laid out on a sheet of newspaper to dry, with the shells turned occasionally to ensure they dry evenly and to avoid water marks. Don’t place shells in direct sunlight or near a heat source because they will disintegrate if they are dried too quickly.

Damage Patterns

Once shells are dry, they should be examined for evidence of damage by predators using criteria based on Meads et al. (1984), modified to reflect more recent experience of damage patterns caused by different predators. Each of the shells examined should be allocated to one of the seven classifications described below (i.e., Intact, Weka, Rodents, Brush-tailed possum, *Turdus* sp., Trampled and Indeterminate).

Intact: No damage apparent, although older shells might be decayed with the apex and peristome collapsed and the shell having a crumpled look.

Weka: Shells preyed on by weka were characterised by puncture holes with sharp and fractured edge created when the snails were stabbed by the weka’s beak. Weka-inflicted puncture holes were usually on the side of the shell, close to the aperture, and often extended into the internal whorls of the shell.

Rodents: Shells preyed on by rodents have obvious rodent teeth-marks evident along the edges of holes. The width of the serrations can indicate rodent species as incisor width varies among species with rat incisors >2 mm and mice incisors <2 mm.

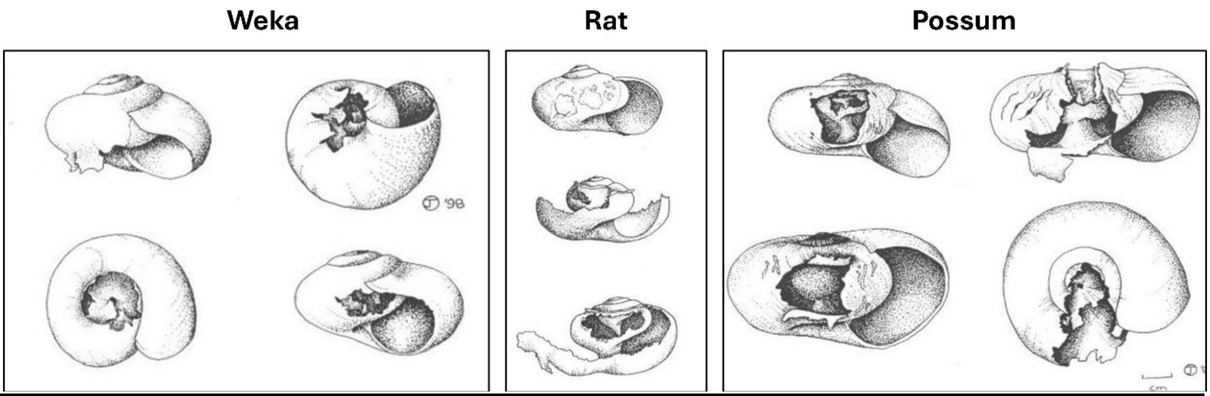
Brush-tailed possum: Walker (2003) noted that snail shells preyed on by possum have characteristic damage pattens but didn’t provide a description.

***Turdus* sp.:** Shells preyed on by song-thrushes or blackbirds generally have shatter holes on the opposite side to the aperture. Song-thrushes also use anvils for smashing snail shells leaving clusters of broken shells.

Trampled: Trampled shells are flattened, with numerous cracks, but no holes.

Indeterminate: Natural decay has broken the shell so that the cause of death was no longer evident or if the damage pattern was difficult to interpret.

Typical damage patterns left on snail shells by the three commonest predators of *P. patrickensis* on Buller Plateaux are shown in Figure 1.



[redacted]

Recording Data

Details of the shell assessments should be recorded in the Excel Spread sheet "Cumulative Snail Shell Predation" managed by the Stockton Environmental and Community Team for Bathurst. Details recorded should include:

- an individual reference number for each shell,
- snail species,
- identity of the person who assessed the damage pattern,
- date the shell was collected,
- type of search being undertaken when the shell was found,
- location where the shell was found, including the area's name and geographic coordinates (using NZTM 2000 projection) for the shell's location,
- the shell's damage pattern classification, and
- the age and condition of the shell.

Each of the assessed shells should be photographed, with clear images of any damage patterns on a shell and the shell's reference number included in the photograph. An archive of the shell photographs should be maintained by the Stockton Environmental and Community Team for Bathurst.

Forwarding Shells to DOC

After shells have been assessed, they will be sent to DOC Buller District Office accompanied by identifying details, including plot name, location, search date, and the number and diameters of any live snails found during each search. Differences between predator assessment by experts from Bathurst and DOC will be resolved promptly.

Appendix 3: Nocturnal Searches

Field Method

Nocturnal searches for live snails or snail shells visible on, or above, the ground surface can be used as either a distribution survey method or to find snail for relocation out of areas scheduled for disturbance, i.e. snail salvage. When used as a survey method, searches should be along transects, with transect routes designed in GIS (Geographic Information Software) and provided to field staff as GPX (i.e. GPS Exchange format) route files. For snail salvage searches, the perimeter of the search area should be designed in GIS and provided to field staff as GPX route file. Transect routes should be designed to avoid hazardous areas.

Searches should be undertaken on warm moist nights, with minimum overnight temperatures > 8°C and relative humidity remaining above 90%, ideally at, or close to, 100%, throughout the search. Typically, snail numbers are highest on damp nights following a long dry period. Searches should be undertaken during the hours of darkness, beginning 30 minutes after dusk and finishing no later than 30 minutes before dawn. Searchers should have a powerful waterproof (IP68) headlamp (e.g., Fenix HP25R v2 or Fenix HP16R) and a powerful hand torch. It helps searching if all team members have headlamps with a similar light output. The width of the strip that each person can search effectively will vary depending on the habitat types. In open areas such as low pakihi or sandstone pavement effective search width can be as much as 5 m, whereas in areas of dense tangled vegetation effective search width can be as little as 1 or 2 m. Searches should be undertaken with each searcher moving slowly and methodically along their designated search strip with an average search speed of about 5 metres per minute. Sections of transect routes that searchers consider hazardous should be avoided.

For distribution surveys, there should be two searchers working together, with one searching on each side of the transect. For area searches for snail salvage, a search team of 4 or 5 searchers should work 5 m apart along 5 m wide swathes in the designated search area. Continuous tracking on handheld GPS (i.e. Global Positioning System) should be used by searchers to ensure the entire search area is searched. Searcher's tracks and the locations of any snails or shells found should be recorded on a handheld GPS unit. The maximum diameter and condition of live snails should be recorded. Shells should be collected and placed in labelled bags to be examined to determine cause of death (Appendix 2). The bag labels should include the date and location of the search and the identity of the search team.

Record Keeping

Track-files and waypoints from searchers GPS units should be downloaded and saved. Other details of nocturnal searches that should be recorded are:

- name of the area being searched,
- identities of searchers,
- date and time at the start and finish of a search,
- environmental conditions during search,
- geographic coordinates (NZTM2000) of snail and shell locations,

- maximum diameter and condition of each snail found,
- label details for shell collection bags.

Appendix 4: Daytime Sub-surface Search

Field Method

Daytime searches for live snails and egg clutches on, or below the surface and hidden in vegetation can be used for pre-clearance searches for relocation out of areas scheduled for disturbance (i.e. snail salvage), for distribution and abundance surveys and to find shells for cause of death monitoring. Searching involves:

- Moving aside vegetation;
- Turning leaf litter;
- Checking the bases of flax, *Gahnia* and tussocks;
- Feeling for snails in root cavities and moss;
- Sorting through overhanging and ground-hugging vegetation.

Snails often shelter under large sedges (especially *Gahnia*), mountain flax, moss, tangle fern and wire rush, among other locations. Search methods will follow those generally suggested by Walker (1997), but searches will target the most likely habitat within search areas.

Record Keeping

During searches the field teams' hand-held GPS units are kept running continuously. The GPX track file of the designated search block is used to define area to be searched, while the current tracks on the GPS units provide a record of search effort. When live snails or egg masses are found, their locations are recorded on the GPS unit as waypoints. Other data collected on digital devices are:

- Search block identity;
- Search block area (ha);
- Total search effort (person-hours);
- Dates and times of searches;
- Number of live snails and egg masses found and collected;
- Vegetation type where snails or egg masses were found;
- Maximum diameter of each live snail;
- Number of snail shells found and collected;
- Weather conditions (humidity, rainfall and minimum temperature) during searches.

Appendix 5: Relocating *Powelliphanta* Snails and Eggs

Mixed Search Strategy

Searches to find snails for relocation can be either nocturnal searches for snails active on the surface (Appendix 3) or daytime sub-surface searches (Appendix 4). Comparisons between results from the two search methods show that nocturnal searches are much more effective than daytime sub-surface searches (Lloyd, 2024) with considerably less search effort per hectare (12 *v.* 382 person hrs/ha) and much higher snail capture-rates (e.g. 8.19 *v.* 0.12 snails/person hr). However, nocturnal searches for snail salvage have two disadvantages compared to daytime sub-surface searches: egg clusters aren't found and the proportion of small snails (<15 mm diameter) found is lower. Consequently, the best option for snail salvage searches is a mixed strategy combining the advantages of the two methods.

In the mixed search strategy, initially there should bemtwo nocturnal searches of the area of snail habitat to be stripped with search transects 5 m apart. The nocturnal searches should be spaced a few days apart to improve capture rates during the second search. The nocturnal searches may be followed by daytime sub-surface searches of areas where high densities of snails were found during nocturnal searches. To decide where daytime sub-surface searches should be undertaken using GIS to create a map of extent of the nocturnal search area and the locations of live snails found during nocturnal searches and divide the search area into quarter hectare parcels using a GIS tool for dividing polygons into equal-area parcels. Sub-surface searches may be undertaken throughout the area of any parcels where the number of snails encountered during one of the two nocturnal searches reaches or exceeds a set threshold. The threshold value for initiating sub-surface searches may need adjusting with experience, but initially should be set at ≥5 live snails in a quarter hectare parcel. This equates to an actual density of about 200 snails per ha, as typically 10% of snails ≥20 mm diameter present in an area are found during one nocturnal search.

Field Search Method

Before pre-clearance searches are undertaken, the boundaries of planned vegetation clearance areas to be searched are obtained from mine planning engineers as geospatial files. The files are entered into GIS where the boundaries of the planned clearance areas are overlaid onto high resolution aerial images of the areas. Each clearance area is divided into a number of conveniently sized and shaped search blocks. The boundaries of each of the search blocks is converted into GPX track files, which are then loaded into the field teams' hand-held GPS units. During searches, searchers should be carrying hand-held GPS units with tracking on throughout the searches and the locations of any live snails or eggs found recorded as waypoints. Searchers should avoid areas they consider hazardous.

Live *Powelliphanta* snails must be handled carefully, with hands free from contaminants such as fuel or pesticides. Handling should be minimised. To transport snails for relocation, the snails should be placed in plastic containers (e.g. plastic ice-cream containers) perforated to allow airflow, while preventing snails from escaping. The containers must be clean and contain damp leaf litter, *c.* 60 mm deep, collected from where the snails were found. There must not be more than eight snails in a two-litre container and snails must be placed in the container upright with the apex of their shells upwards. Containers with snails in them must be kept out of the sun and kept cool at all times. Each transport containers should have a unique identification label. Eggs must be collected using sterilised utensils, such as teaspoons. Each clutch of eggs should be placed in a separate container without snails, but containing damp leaf litter collected from the site where the eggs were found.

Relocation Procedure

Before release at a destination site, all snails should be weighed, their maximum diameter measured (Appendix 1), and their general condition recorded. Snails with maximum diameter ≥ 20 mm should be tagged with a numbered polyethylene tag using the method described in Appendix 1.

During snail salvage operations, destination sites for relocated snails and eggs should be as close as possible to the source locations, but be at least 50 m from any existing or planned future disturbance. Ideally salvaged snails should be released in the nearest existing or planned pest exclusion fenced area.

Snails and eggs must be released at destination sites as soon after capture as practicable, at most within 24 hours of capture. Snails should be released separately and placed with the apex of their shells upwards in likely snail resting places, such as under damp litter or moss. Egg clutches must be placed separately in likely egg laying sites, ideally resembling sites where they were found.

To facilitate subsequent monitoring of snail survival, all relocated snails should be measured and tagged with unique numbered tags (Appendix 1) before being released into designated, mapped release areas. The designated release areas should be at least 200 m away from capture-recapture plots being used to monitor snail population trends.

Record Keeping

Track-files and waypoints from searchers GPS units should be downloaded and saved. Other details of the relocation procedure that should be recorded are:

- identities of searchers,
- search method used,
- date and time at the start and finish of a search,
- date and time of captures and releases,
- environmental conditions during search,
- names of capture and release sites,
- geographic coordinates (NZTM2000) of both capture and release sites,
- identity of each transport container,
- number of snails in each container,
- weight maximum diameter and condition of each snail,
- identities of tagged snails, and
- number of eggs in a clutch.

Appendix 6: Daytime Sub-surface Plot Searches

Field Method

The sub-surface plot search method follows the standard DOC protocol for *Powelliphanta* surveys and monitoring (Walker, 2003) based on Walker (1997). Briefly, the surface and sub-surface of randomly located 10 m square plots are searched for live snails and snail shells during daytime. Sub-surface searching involves moving aside overhanging vegetation, sifting through loose leaf litter, and looking under easily moved objects, but should not cause significant damage to the habitat.

The following steps provide specific details of the sub-surface plot search protocol.

1. Plot locations are randomly selected using a spatial randomisation algorithm. This can be achieved using the R-function *spsurvey* to generate generalized random-tesselation survey (GRTS) designs (Stevens & Olsen, 2004a, 2004b). A GRTS sampling design provides random locations, while avoiding the spatial clustering characteristic of simple random sampling designs.
2. Randomisation with *spsurvey* produces a list of locations for primary plots as well as extra plots, or oversamples. These oversample plots are used to replace any primary plots that are deemed unsuitable in the field, e.g. due to access difficulties or safety issues.
3. The locations of both primary plots and oversample plots are loaded to a GPS unit.
4. The GPS unit is used to navigate to within approximately 20 m of each plot location. The exact plot location is then defined using a compass and measuring tape by following the bearing and distance given by the GPS unit when you first arrive within about 20 m of the survey point.
5. In areas where GPS reception is poor, and accuracy is >20 m, the plot location should be found by 'dead reckoning navigation' using a map, compass and tape from the last reliably known location.
6. If the survey point for a primary plot cannot be reached, or the plot site is found to be dangerous, the plot should be abandoned and be replaced by the nearest oversample plot. In this case, the surveyor should repeat steps 4–6.
7. A plot must be surveyed even if all or most of the plot area is unsuitable for snails (e.g. bare rock or water). However, the proportion of the plot unsuitable for snails should be recorded.
8. When a survey point has been located, it is pegged and measuring tapes are used to lay out the boundary of a square 10 m x 10 m plot starting at the survey point. The first side should run up the dominant slope in the area or, if there is no discernible slope, magnetic north. The second side should be to the right of the first side.
9. Corners should be at right angles and the tape in a straight line between corners as close to the ground as practical.
10. If the plot area defined in this way cannot be surveyed because it is too dangerous or inaccessible then try, in the following order, plots with:

    a) first side up-slope (or north), second side to the left;

b) first side down-slope (or south), second side to the left;

c) first side down-slope (or south), second side to the right;

11. If none of the alternative plots around a survey point are suitable, the plot should be abandoned and replaced by the nearest oversample plot (as per step 6 above).

12. Once a plot has been established, the location of the four corners of the plot should be recorded on a GPS unit together with the plot's identity.

13. For plots that will be resurveyed a permanent marker should be placed at the primary (i.e. first) corner of the plot before a plot is left.

14. Formal searches for live snails and shells are then undertaken using a ≥50% inclusion rule to decide what is counted in both the plot and subplots. With the ≥50% inclusion rule shells or live snails will only be counted if ≥50% of their bulk is within the middle of the boundary tape.

15. The number of live snails and empty shells found are recorded.

16. All empty shells and shell fragments found on the plot are collected and placed in separate bags for each plot. Each bag is labelled with full location, plot identity, date, and observer details.

17. Live snails should be weighed, their maximum diameter measured using digital callipers. Once processed the live snails are returned to where they were found, or a nearby shady place.

18. Presence and numbers of any *Powelliphanta* eggs found are recorded, but the eggs are not handled.

19. A brief description of habitat in the plot should be recorded with vegetation cover in the plot allocated to one the vegetation types described in (Ecological Solutions Ltd., 2024) and the environmental information including: altitude, slope, aspect, landform, ground cover, drainage and canopy height.

20. At least one photograph is taken at each plot to illustrate the habitat.

21. Soil and litter depth are recorded near the middle of each of four 5x5 m sub-plots.

22. Information recorded for each plot includes weather parameters (current and previous weather conditions, temperature and ground litter dampness), person-hour search times, the presence of patches of shell fragments at thrush anvils or in rat caches, and any other relevant observations.

23. All information from plot searches should be recorded in standard sub-surface plot search forms shown in the section below. These can be either digital or on weather-proof paper forms.

24. The collected shells and shell fragments are retained and examined for evidence of cause of death in the office as described in Appendix 2.

Sub-surface Plot Search Form

PLOT DETAILS

Plot_Name	Date	Team_Leader	East NZTM	South NZTM	Used	Replacement Plot	Altitude (m asl)	Slope (degrees)	Aspect (degrees magnetic)	Landform	Disturbance	Average Canopy Height (m)	Canopy Closure (%)
Plot_nnn	dd/m/yy	J. Doe	nnnnnnn	nnnnnnn	Surveyed	Plot_nnn	nnn	nn	nnn	Ridge	None	n	nn%
					Abandoned					Face	Burnt		
										Terrace	Cleared		
										Gully	Mined		
											Tracked		

Brian Lloyd:
Use plotnames in the gpx file. Ensure that plot number contains 3 numeric digits

Brian Lloyd:
NZ Transverse Mercator 2000, projection from GPS; No decimal places

Brian Lloyd:
Plot name of replacement plot

Plot Details Continued:	Ground Cover %					Litter Depth (cm)				Soil Depth (cm)			
	Vegetation	Non-vascular	Litter	Bare Soil	Rock	A_Lit	B_Lit	C_Lit	D_Lit	A_Soil	B_Soil	C_Soil	D_Soil
	nn%	nn%	nn%	nn%	nn%	nn	nn	nn	nn	nn	nn	nn	nn

SURVEY DETAILS

Plot_Name	Date	Start_Time	Finish Time	Team_Leader	Observer_1	Observer_2	Observer_3	Temp	RH	Previous_Weather	Current_Weather	GroundMoistu	Comments
Plot_nnn	dd/m/yy	hh:hh	hh:hh	J. Doe	K. Doe	L. Doe	M. Doe	n	nn%	Dry	Fine	Dry	
										Variable	Cloudy	Moist	
										Wet	Mist	Wet	
											Occ showers		
											Rain		

Brian Lloyd:
Use plotnames in the gpx file. Ensure that plot number contains 3 numeric digits (i.e.

Brian Lloyd:
24 hour clock

Brian Lloyd:
Degrees centigrade at start of survey

SNAIL & SHELL DETAILS

Plot_Name	Date	Snails	Max_Diam	Weight	Shell_Fate	Shell_Condition	Comments
Plot_nnn	dd/m/yy	Shell	nn.n	nn.n	Intact	Fresh	
		Live_Snail			Weka	Recent	
		Egg			Rat	Old	
					Mouse	Very Old	
					Possum		
					Thrush		
					Trampled		
					Unknown		

Brian Lloyd:
Use plotnames in the gpx file. Ensure that plot number contains 3 numeric digits

an Lloyd:
Maximum Diameter (mm), one decimal place. For missing values leave blank.

Brian Lloyd:
Weigh (gm), one decimal place. For missing values leave blank.

Brian Lloyd:
Use for any extra information

Appendix 7: Capture-recapture Methods for *Powelliphanta* snails

Capture-recapture, also known as mark-recapture, is a method for obtaining population estimates when counting the number of individuals in a population is impracticable (Williams et al., 2002b). The capture-recapture field method for long-term monitoring of population trends in *Powelliphanta* was developed by the Department of Conservation and Solid Energy New Zealand (Gruner et al., 2011; Hamilton, 2015b; Lloyd et al., 2014).

Briefly, capture-recapture monitoring of *Powelliphanta* snails entails repeated nocturnal searches for snails active on the surface of a permanently marked plot during a period of three to five weeks (Hamilton, 2015a; Lloyd, 2015, 2017a). Snails found in the plot are individually marked with numbered identification tags and then released at their capture locations. Estimates of the numbers of snails in a plot are obtained from the capture histories of individual marked snails recaptured during successive searches of the plot using established capture-recapture analytic methods (Borcher et al., 2002; Cooch & White, 2018; Lukacs, 2018; White et al., 1982; Williams et al., 2002a) undertaken using the R-package *RMark* (Laake, 2013) as an interface for the software *MARK* (Cooch & White, 2018; White & Burnham, 1999). Details of snails captured during surveys also provides information on the population's age structure.

Field Method

Plot Setup

Ideally capture-recapture plots for capture-recapture surveys of *Powelliphanta* are 70 m square. This size and shape reduces the probability cross-boundary movements by snails in and out of the plot. However, the shape and size of capture-recapture plots may be constrained by the available area of snail habitat.

Capture-recapture plot sites are selected by first defining areas known to have typical densities of *Powelliphanta* snails, include a range of snail habitats, and have safe terrain for field workers. The actual plot locations were selected randomly within these areas. The plot boundaries and seven 10 m wide lanes across the dominant slope of the plots are delineated with Gallagher Poly Wire (a long-lasting polyethylene farm fencing material) anchored on 300 mm metal standards.

Details of the plots that should be recorded include: accurate locations of the plot corner pegs obtained using a GPS unit; photographs of the plot; and a brief description of habitats in the plot using the vegetation types described in Ecological Solutions Ltd. (2024).

Capture-recapture Survey Method

A single capture-recapture survey (i.e., a primary session) entails five or more nocturnal plot searches undertaken within a 5-week period. Successive searches are spaced at least two nights apart to ensure independence, and ideally less than two weeks apart to minimise snail dispersal and mortality between searches. For best results, capture-recapture surveys should be repeated annually.

More searches are required to achieve good population estimates when nightly capture probabilities are low (i.e., < 0.10). To achieve high capture probabilities, searches are best undertaken on nights when weather conditions favour snail movement (i.e., ideally temperatures > 8°C and humidity at, or close to, 100%). Typically, snail numbers are highest on damp nights following a long dry period.

Each search entailed a complete search of the entire plot for live snails visible on the surface during the period of darkness. Completed plot searches are essential for fulfilling the assumption that capture probabilities during a search are the same for all individuals in the plot.

Searches are undertaken by a team of four people working side by side, along the 10 m wide lanes marked within the plot with the search speed averaging about 5 metres per minute. The starting lane and the direction of searches along the lanes are chosen randomly on each search night.

When a live snail is found during a search, its capture location is marked temporarily with a reflector, or flashing LED (Light Emitting Diodes), and a numbered label.

When snails previously tagged during the survey are recaptured, only their tag number and general condition are recorded, before release at their capture locations.

All other snails are transported to a nearby tent or vehicle outside the plot for processing. Snails should be transported in plastic containers partly filled with damp moss or leaf litter and sealed with a perforated lid. A label with the same number as the numbered label at the capture location is tied to the outside of the container, so that each snail could be released at its original capture site after processing.

- On first capture during each survey, all snails (both untagged snails and snails tagged during previous surveys) are weighed, their maximum diameter measured (Appendix 1), and their general condition recorded.
- Untagged snails with maximum diameter ≥ 20 mm should be tagged with a numbered polyethylene tag (Appendix 1).
- On first capture snails tagged during previous surveys are measured and weighed; their tags checked and replaced if the snail's shell was overgrowing the tag or the tag is damaged.

After processing, each snail is released at its original capture site.

Data Recording During Searches

Accurate reading and recording of tag identification information (ID number, colour and tag type) is crucial because incorrect identification of even one snail can have a major impact on population estimates. In early years, data were recorded on waterproof record cards, but more recently data have been recorded on digital devices, such as smart phones. The data should be input into prepared forms to ensure all data are collected. Digital input in the field avoids the errors that inevitably occur during transcription from hard-copy to digital format required for analyses.

Capture-recapture Analyses

Because not all captured snails < 20 mm are tagged, only records from snails with maximum diameter ≥ 20 mm are included in capture-recapture analyses. Consequently, population estimates, and demographic parameter estimates from capture-recapture analyses are only for snails with maximum diameter ≥ 20 mm.

Currently, analyses of capture-recapture data to obtain plot population size estimates is most commonly undertaken using the R-package *RMark* (Laake, 2013) as an interface for the software MARK (Cooch & White, 2018; White & Burnham, 1999). *RMark* provides a wide range of models for analysing capture-recapture data and will almost certainly be used for analysing data from the monitoring programme. However, recent developments in Bayesian analyses of capture-recapture data using the R-package *nimble (*Gimenez, 2023) make Bayesian analyses an attractive proposition for undertaking parallel analyse for comparisons with analyses using *RMark*. A list of other software available for analysing capture-recapture data can be found at: http://www.phidot.org/software/.

Closed Population Models

The plot population size at the time of each survey of a plot can be estimated using closed population capture-recapture models in *RMark* using the conditional likelihood model (Huggins, 1989), Huggins Closed Population Estimation (*Huggins*).

The conditional likelihood model has two encounter parameters: *p* the probability of first capture; and *c* the probability of recapturing an individual caught and marked during a previous search in the survey session. Although six models can be fitted to the capture-recapture data using the two encounter parameters, the only useful model for analyses of the snail data is time-only model with the probabilities of first capture and recapture the same on any search night but varying between nights. This is symbolised as $p_t = c_t$, where p_t is the probability of first capture at time *t*, and c_t is the probability of recapture at time *t*. Other models including snail diameter can be used, but our experience is that the time-only model provides the most reliable estimates with narrowest confidence intervals.

If more than one model is used model averaging using AIC weightings (Burnham et al., 1987) can be used to obtain single population estimates from the models. Confidence limits for model-averaged population estimates can be estimated manually using the method described in Section 14.10.1 of (Cooch & White, 2018).

Closed population capture-recapture models to obtain population estimates from repeated searches during a single survey are based on the assumption of population closure, with no emigration, immigration, births or deaths during the survey. The population closure assumptions seem reasonable for *Powelliphanta*. *Powelliphanta* are slow breeding and long-lived (Walker 2003), consequently there will be negligible recruitment or natural mortality during a survey, while the small home ranges (mean 5.6 m^2) of radio-tagged *P. patrickensis* snails (Lloyd, 2015) indicate that few, or no, snails will migrate into, or out of, a 70 m square plot during a 5-week survey period.

Robust Design Models

When three or more capture-recapture surveys (i.e., primary sessions) have been undertaken in a plot, robust design capture-recapture models (Kendall, 2001, 2018; Williams et al., 2002d) can be used to estimate both plot population sizes during each capture-recapture survey and demographic changes during the intervals between successive capture-recapture surveys. The robust design model combines a closed populations model (Lukacs, 2018; Otis et al., 1978; White, 2008; White et al., 1982; Williams et al., 2002b) using a Huggins' estimator (Huggins, 1989) with an open population Pradel model (Pradel, 1996; Williams et al., 2002c). Analyses are undertaken using *RMark* with the robust design model (Robust Design Pradel Recruitment Huggins' Closed Populations), implemented using the R-code *RDPdfHuggins*.

The closed population model in the robust design analyses provides estimates of population size N_t for each survey and capture rate p_{tn} for each search night. The Pradel model provides three demographic parameter estimates for intervals between surveys: apparent survival rate φ (phi); per-capita recruitment rate f; and population growth rate λ (lambda). Apparent survival rate φ_t is the proportion of individuals present on the plot at time *t-1* that remain alive and on the plot at time *t*. It is the product of the true survival rate (S_t) and study area fidelity (F_t), i.e. $\varphi_t = S_t \times F_t$. Per-capita recruitment rate f_t is the number of new individuals per-capita in the plot as a result of either breeding in the plot or immigration into the plot during the interval *t-1* to *t*. Population growth rate λ_t is the change in population size during the interval *t-1* to *t*, i.e. $\lambda_t = N_t/N_{t-1}$. Demographic parameter estimates for intervals are all annualized to allow comparisons between survey intervals of different lengths.

Analyses can be undertaken using four differently parameterized models for each plot:

1) $\varphi_t + f_c + p_{cc}$; 2) $\varphi_t + f_c + p_{nc}$; 3) $\varphi_t + f_c + p_{nt}$; 4) $\varphi_t + f_t + p_{nt}$

In models with φ_t and f_t, the parameter values vary between intervals, whereas with f_c is constant and the same for all intervals. In models with p_{nt}, nightly capture rates vary between night and session; with p_{nc} nightly capture rates vary between nights but are constant within a session; and with p_{cc} the nightly capture rate is constant. Akaike's Information Criterion (AIC_c) is used for model selection among the four differently parameterised, but nested, models (Burnham et al., 1987). Models with the smallest AIC*c* value are the most parsimonious, or best-fit, models. Model averaging using AIC weightings can be used to obtain single model averaged estimates for each of the three demographic parameters (*φ, f* & *l*).

Simulations

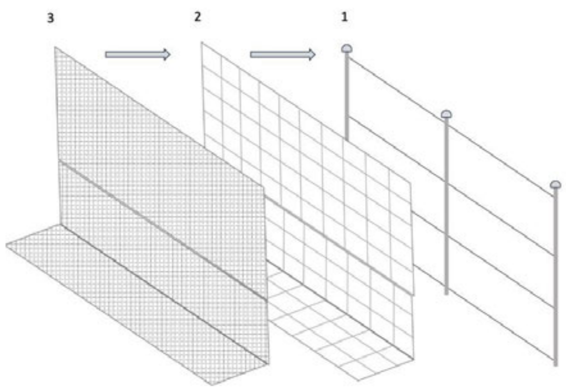
Simulations have been used to investigate the influence on accuracy and precision of capture-recapture population estimates for *P. hochstetteri* (Lloyd, 2019) and *P. patrickensis* (Lloyd, 2021, 2023) of three different factors: number of searches, capture probability and plot population size. Simulations were also used to investigate biases in population estimates resulting from the edge effect.

Simulations using a random-walk model provided a good fit to observed data. In the random-walk models, each simulation began with snails randomly distributed throughout a 200 m square region centred on the 70 m square plot, with snail starting location generated using the R-function *runif*. Successive locations of each simulated snail for each night of the simulated mark-recapture survey period were generated using a random-walk model. Nights when the simulated snails moved were selected randomly using the R-function *rbinom* with the probability of movement obtained from the radiotelemetry studies (Lloyd, 2015, 2017b). On nights when a simulated snails moved, the directions they moved in were random, with values of azimuth (α_k between 0 and 2p radians) generated using the R-function *runif*, and the distances moved (D_k) generated using the R-function *rgamma,* with shape and rate parameter estimates for the gamma distribution obtained using the R-function *fitdistr* in the R-library *MASS* to fit a gamma distribution to the distances radio-tagged snails moved overnight. The location of simulated snails at the end of night *k* (X_k, Y_k) was calculated from its location at the end of the previous night (X_{k-1}, Y_{k-1}): [Equation]; and [Equation]. A random sample of snails for a simulated survey night was drawn from snails located within 70 m square plot on the night using the R-function *sample* without replacement and sample size set as required for the simulations. Samples from survey nights for each simulated mark-recapture survey period were then compiled to provide capture histories for all snails sampled during the simulations for capture-recapture analyses using *RMark*.

All three factors (number of searches, capture probability and plot population size) affected the accuracy and precision of mark-recapture simulated population estimates. However nightly capture probability had the largest influence, typically, reliable population estimates could only be achieved with nightly capture probabilities >0.10. Interim analyses undertaken between sessions during a capture-recapture survey can be used in conjunction with results from simulations to adjust survey effort to improve the quality of population estimates from a survey.

Appendix 8: Weka-free Exclosures

A burgeoning weka population in Abel Tasman National Park (ATNP) constitute a major threat to populations of threatened *P. hochstetteri* and *Rhytida oconnori* snails in the park (Lloyd et al., 2021). To investigate if the exclusion of weka alone is adequate to facilitate the recovery of populations of the two snail species two 0.5 ha fenced enclosures were built with fences designed to exclude weka but allow rats access into the exclosures (Bollongino, 2024).



a)

b)

Figure 2: Weka-proof fence design used in Abel Tasman National Park, and b) the finished fence with logs used to hold down the skirt until it was naturally covered by leaf litter and soil, from Bollongino (2024)

Bollongino (2024) provide details of the weka-proof fence construction. The fence was constructed with three layers (Figure 2). Layer 1, the backbone of the fence, comprises Y-posts at 2 m spacings with 4 rows of high tensile wire. Layer 2 is made from 2 rows of 90 cm wide sheep netting stitched together to create a 1.2 m high fence with a 60 cm skirt on the ground surface. Layer 3 is two rows of 90 cm wide hex-netting, with 41 mm mesh, stitched together to create a 1.2 m high fence with a 60 cm skirt on the ground surface, initially held down by logs. Wooden strainer and stay posts were used at the corners of the exclosures. ?? muster weka??

Preliminary results from the exclosures in ATNP indicate that populations of snails and other invertebrates are increasing within the weka-free exclosures (pers. comm. R. Bolongino, Science Advisor & Director of Operations). K. Walker (DOC) in an e-mail to Charmain Petereit (Takaka Hill Biodiversity Group Project Manager) reported immediate doubling of a *Powelliphanta hochstetteri obscura* population in a small experimental plot on D'Urville Island with weka pigs and hedgehogs excluded.

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