An Assessment of the Impacts of the Buller Plateaux Continuation Project on *Powelliphanta patrickensis* Snails and Proposed Effects Management

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Table of Contents

EXECUTIVE SUMMARY

Bathurst Resources Limited and its subsidiary companies are proposing the Buller Plateaux Continuation Project (the "Project") to extend the life of Stockton Mine by reopening and extending the Escarpment opencast coal mine on Denniston Plateau and establishing a new opencast coal mine south of Mt. Frederick on Stockton Plateau. A new haul road will link the mine areas (Escarpment Extension and Mount Frederick South) with existing coal processing facilities on the north end of Stockton Plateau.

The Project will affect a considerable proportion of the current distribution ranges of the threatened terrestrial carnivorous land snail *Powelliphanta patrickensis* on Stockton and Denniston Plateaux. 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 south of Denniston Plateau, on the Paparoa and Brunner ranges. *P. patrickensis* populations on Stockton and Denniston Plateaux are ranked by the Department of Conservation as having a "Nationally Critical" conservation status.

In recent years, there have been large declines in populations of *P. patrickensis* on Denniston and Stockton Plateaux outside of areas impacted by mining disturbance. These declines correlate with increased predation by weka (*Gallirallus australis*), a native rail. The proportion of snail shells found with evidence of predation by weka increased from 6.2% of 658 shells in 2012 to 35% of 388 in 2024. Weka abundance has increased over the same period. Plot population estimates from two 70 x 70 m capture-recapture plots on Denniston Plateau declined by 62% between 2014 and 2024, and numbers of snails found during daytime subsurface searches of more than one hundred 10 x 10 m plots spread across both plateaux declined by 59% between 2012 and 2024. If the observed decline in *P. patrickensis* populations on Buller Plateaux continues unabated, there is a high probability that the populations will approach extinction within the next 30 years, without impacts from the proposed mine. Effective conservation management interventions will be required to ensure survival of *P. patrickensis* on Buller Plateaux.

Mine construction for the proposed Project will reduce the current distribution range of *P. patrickensis* by 1.95 km^2 or 6.1% of 32.01 km^2 on Stockton Plateau and by 4.58 km^2 or 22.3% of 20.52 km^2 on Dennison Plateau. In addition to removing significant areas of snail habitat and causing snail mortality during habitat stripping, the Project will convert a portion of previously continuous areas of snail habitat into isolated fragments of snail habitat. The viability of snail populations in the isolated fragments will depend on the size and configuration of the fragments and the permeability of barriers to snail dispersal between fragments. Without intervention, snail populations in small fragments surrounded by the main areas of mining disturbance will be at increased risk of extinction because of random fluctuations in their small population sizes (i.e., demographic stochasticity) and inbreeding depression. In addition, edge effects will degrade high proportions of habitat within small, ragged shaped fragments adjoining mine areas. There will be 6 larger habitat fragments, three on each Plateau, large

enough (>1 km^2) to hold viable snail populations. The sizes of the other 12 fragments created during mine construction range between 0.005 km^2 and 0.46 km^2, with a combined area of 1.4 km^2. Snail population in these smaller fragments are unlikely to be viable. Likely loss of snail populations in the small non-viable fragments will probably increase distribution range loss by 0.38 km^2 to 7.3% of the species current range on Stockton Plateau and by 1.015 km^2 to 27.3% of the species current range on Denniston Plateau. When the areas of proposed disturbance and habitat lost as a result of fragmentation are combined with previous range loss to mining activity, including ongoing and planned mining in the Cypress consent area, *P. patrickensis* will have lost 20.5% (7.64 km^2) of its original range on Stockton Plateau (37.32 km^2) and 29.5% (6.23 km^2) of its original range on Denniston Plateau (21.16 km^2).

The main barrier to snail dispersal among the larger fragments where snail populations could persist will be the proposed haul road. Currently there is no information on whether *P. patrickensis* will be able to disperse across the haul road to maintain connectivity between the fragmented populations but given the road's width and likely high traffic volume, the haul road is likely to create a significant barrier to snail dispersal. The proposed haul roads on Stockton Plateau also present a significant risk to the integrity of the relatively unmodified and intact snail habitat remaining after the proposed mining disturbance. Without careful management the haul roads on Stockton Plateau could provide conduits for pest and weed dispersal and enable unauthorized vehicular access into previously undisturbed parts of the plateau.

A programme for addressing adverse effects of the Project on *P. patrickensis* has been developed using the standard effects management hierarchy framework: avoid, minimise, remedy, and where necessary, offset or compensate for residual impacts. Avoiding impacts is the first step in the effects management hierarchy, but is not feasible as the snail's distribution range extends over all the remaining coal reserves on Buller Plateaux. The next step in the hierarchy is minimising effects.

Snail habitat loss will be minimised by avoiding disturbance to areas of snail habitat not essential for mine construction and operation. Remediation is the next option for managing the effects of snail habitat loss. Wherever possible, remediation of snail habitat loss resulting from stripping areas for mine construction will be achieved by using Vegetation Direct Transfer (VDT), which entails stripping overburden in disturbance areas as slabs of topsoil with intact native vegetation and transferring the slabs to a prepared site where they are reassembled. Recent investigations show that areas restored by VDT provide good snail habitat with viable snail populations persisting in areas of VDT 13 years after transfer. However, because of engineering and practical constraints, including scheduling and availability of suitable landforms at the time of vegetation stripping, only 15% of the area disturbed during the Project is likely to be rehabilitated by VDT. Where VDT cannot be used, the next best option for remedying snail habitat loss is transferring stripped soil directly from the disturbance area to a final laydown site and covering it with vegetation debris from the stripped site.

Where neither VDT nor direct transfer of stripped soil are possible and soil must be stockpiled, snail habitat loss will be remedied by planting native plants and seeding into the soil after the stockpiled soil is spread at its final destination on engineered landforms in previously mined areas. To enhance the viability of soil ecosystems in the stockpiled soil, stockpiles will be kept low, not compacted and be planted with appropriate native plant species. There will be ongoing research and adaptive management to improve the outcome of rehabilitating snail habitat by planting and or seeding.

Snail mortality will be minimised by avoiding disturbance to areas where snails occur that are not essential for mine construction or operation. Snail mortality will be further minimised by using VDT during excavations and earthworks whenever possible, as recent investigations show that most snails survive in habitat transferred by VDT. The next option for minimising snail mortality when snail habitat is disturbed is to transfer stripped soil directly to a final destination immediately after stripping, with stripped vegetation debris spread across the soil surface. Some snails will die directly as a result of injury during the process, but snails remaining in the stripped soil are likely to survive and establish viable populations. Where VDT is not possible and soil must be stockpiled, snails are unlikely to survive in the stockpiled soil. Snail mortality will be minimised in these areas by salvaging a proportion of snails from the disturbance area and translocating them to areas not scheduled for disturbance, ideally one of the pest exclusion fenced areas.

Minimising habitat degradation will be achieved by developing site plans that reduce edge effects at the periphery of disturbed areas by managing biosecurity, preventing contaminants from roads and other disturbed areas reaching undisturbed areas, and keeping haul roads closed to the public during mine life. To counter loss of genetic diversity resulting from population fragmentation, small numbers of snails may be routinely relocated between adjacent population fragments.

Despite the proposed programme of minimisation and remediation, the Project will have significant residual impacts on *P. patrickensis* snails and their habitat. Compensation, the final option in the effects management hierarchy, is recommended for addressing the Project's residual impacts on snails and their habitats. The proposed compensation is the construction and ongoing management of three pest exclusion fenced areas with a combined area of 896 ha of which 745.7 ha is in *P. patrickensis* habitat. The pest exclusion fenced areas are mainly designed to halt weka predation, the primary cause of recent declines in *P. patrickensis* populations on Buller Plateaux, but will also prevent predation by rodents and possums, which are predicted to increase in response to climate change.

Population models were used to compare *P. patrickensis* snail population trends on Buller Plateaux with and without the Project and associated proposed pest exclusion fenced areas. In models without the Project, snail populations declined as a result of predation to 11% (CI95%: 4%–32%) of current population levels within 20 years and declined to 3.7% (CI95%: 0.8%–18.5%) after 30 years. In models with the Project and pest exclusion fenced areas, there were initial reductions in snail populations as a result of the combined impacts of predation and stripping snail habitat, but as snail populations in pest exclusion fenced areas began to grow in the absence of predation by weka, rodents and possum, population decline slowed. In models for both plateaux using mean estimates of population growth, snail populations with and without the Project were similar within 9 – 11 years. After 11 years, snail population trends in models with the Project either leveled out or increased, until they approached the carrying capacity of the pest exclusion fenced areas, usually within 30 years.

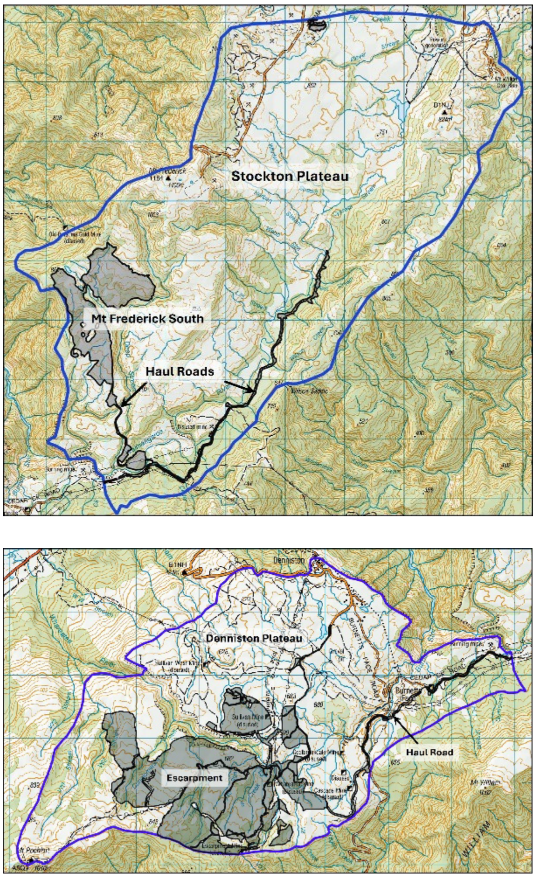
Without the proposed pest exclusion fenced areas, *P. patrickensis* populations on Buller Plateaux are likely to approach extinction within 30 years with or without the Project. Whereas the pest exclusion fenced areas, proposed as compensation for the Project's residual impacts on snails and their habitats, will ensure continued survival of *P. patrickensis* populations on Buller Plateaux.

Details of the Buller Plateaux Continuation Project

Bathurst Resources Limited and its subsidiary companies are proposing the Buller Plateaux Continuation Project (the "Project") to extend the life of Stockton Mine with the development of four key projects on Buller Plateaux (Figure 1):

- Stockton Reconsenting,
- Escarpment Extension,
- Mount Frederick South, and
- Upper Waimangaroa Haul Road.

All four key projects are required for a commercially viable export operation to extend the life of Stockton Mine. The Project proposal includes opencast mining in the existing Escarpment mine area, in Whareatea West, and in Sullivan areas on Denniston Plateau, north and west of the Escarpment Mine area. The Mt. Frederick South project is for an opencast mine in an area with a previous underground mine in the Upper Waimangaroa catchment, on Stockton Plateau, southwest of Mt. Frederick. The proposed Upper Waimangaroa Haul Road will link the proposed Escarpment Extended and Mt. Frederick mining areas with the existing Stockton and Cypress mine operations in the north of Stockton Plateau (Figure 1).



a)

b)

Figure 1. Details of the proposed Project (grey shading) within the distribution range of *Powelliphanta patrickensis* (blue boundary line) on (a) Stockton and (b) Denniston Plateaux.

The proposed Project will affect a considerable proportion of the distribution ranges of two taxa of the threatened terrestrial carnivorous land snail *Powelliphanta patrickensis*. The two taxa are confined to the Stockton and Denniston Plateaux and are ranked as having a Nationally Critical conservation status (Walker et al., 2024).

POWELLIPHANTA PATRICKENSIS

Taxonomy

Powelliphanta patrickensis belong to the endemic New Zealand genus *Powelliphanta,* a group of giant carnivorous land snails, which includes 70 taxa with 13 recognised species and 10 undescribed species (Walker, 2018; Walker et al., 2024). *P. patrickensis* is relatively small for a *Powelliphanta* snail, having a maximum diameter of 45 mm and reaching maturity at a maximum diameter of approximately 30 mm (Lloyd, 2015).

Although the taxon name *P. patrickensis* is used throughout this report to describe populations of *P. patrickensis* snails on Buller Plateaux, analyses of genetic and morphological differences among *Powelliphanta* taxa (Daly et al., 2019; Walker, 2018) indicate that *P. patrickensis* on Buller Plateaux is one of a group of closely related, thin-shelled, snail taxa belonging to a poorly resolved species complex[1] widespread in montane habitat in the north-west of South Island. Named the “Kawatiri” species complex, its distribution range extends over 120 km in a north-south direction, from Garabaldi Ridge in the north to Springs Junction in the south, and 80 km eastwards from the west coast. Populations belonging to the “Kawatiri” species complex are present in southern Kahurangi National Park on the Matiri and Mt. Arthur Ranges, on Braeburn Range in Nelson Lakes National Park, and the Mt. William (i.e., Stockton and Denniston Plateaux), Paparoa and Brunner Ranges.

Relationships within the "Kawatiri” species complex are not well resolved, probably because of geologically recent (2.58 million to 11,700 years b.p.) rapid fragmentation of a widespread ancestral species. Several alternative phylogenies[2] have been proposed for the "Kawatiri” species complex (Daly et al., 2019; Walker, 2018). The consensus is for geographic partitioning with two separate clusters, one containing western populations (Paparoa, Brunner and Mount William ranges) and the other the eastern populations. On the basis of this phylogeny Walker (2018) proposed that the “Kawatiri” species complex should be classified as two species: a western species (*P. patrickensis*) and an eastern species (*P. “calci”*), with a further subdivision into 5 subspecies proposed for each of these species. In the proposed taxonomy, populations of *P. patrickensis* on Stockton and Denniston Plateaux were classified as separate subspecies (*P. “patrickensis” patrickensis* and *P. “patrickensis* Denniston”), with three other subspecies of *P. patrickensis* to the south on Paparoa and Brunner ranges.

[1] A **species complex** is a group of closely related organisms that are so similar that the taxonomic boundaries between them are often unclear.
[2] **Phylogeny** is the evolutionary history of a group of related taxa.

Given the narrow strip of suitable habitat joining Stockton and Denniston plateaux, *P. patrickensis* snail's sedentary behaviour and restricted habitat requirements, populations of *P. patrickensis* on the two plateaux could well be separate subspecies. However, available morphological and genetic evidence (Daly et al., 2019; Trewick & Daly, 2012; Walker, 2003, 2018) is inadequate to confirm their subspecies status. If Denniston and Stockton populations of *P. patrickensis* are separate subspecies, they are parapatric subspecies, having adjacent distribution ranges without significant overlap except in a narrow contact zone. An abrupt change in characters across a narrow hybrid zone between adjacent populations is the key diagnostic for parapatric subspecies. Although there are genetic and morphological differences between snails on the two plateaux, no snails have been examined from the 5.3 km wide strip across the contact zone between the populations. Consequently, it is not possible to determine whether differences between snails on the two plateaux are a result of isolation-by-distance along a cline extending through the length of the two plateaux or an abrupt change in characters across a narrow hybrid zone between the two populations, which would justify separate subspecies status for the two populations. During most genetic analyses, snails from the Stockton Plateau population clustered separately (i.e., appeared to be a separate taxa), however this could be a sampling artefact resulting from the uneven sampling regime, which included a large sample of snails (n = 31) from Stockton Plateau and much smaller samples, in some cases single snails, from other locations.

P. patrickensis on Stockton and Denniston Plateaux

On Buller Plateaux *P. patrickensis* occurs between 550 and 1,100 m above sea level in a patchy distribution (Figure 2) that extends from Fly Creek, a tributary of St Patrick Stream, in the north to Mt. Rochfort in the south-west, Mt. Frederick in the west, and the crest of the Mt. William range in the east (Walker, 2003).

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The species inhabits a variety of low growing vegetation types on Buller Plateaux (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*). Previously, the species distribution range on Buller Plateaux extended over at least 58.5 km^2 along an 18 km long south-west to north-east axis (Figure 2) along the two plateaux, but approximately 6.0 km^2 has been affected by disturbance associated with historic or ongoing consented mining activity and no longer provides suitable habitat, leaving 52.5 km^2 of relatively undisturbed snail habitat, comprising 32.0 km^2 on Stockton Plateau and 20.5 km^2 on Denniston Plateau.

The wet and windy climate of the species' distribution range, together with the generally poorly drained infertile soils and underlying geology of Brunner Coal Measures on Buller Plateaux, and a history of burning have resulted in a distinctive coal measure habitat, characterised by a mosaic of sandstone-erosion pavement, "pakihi" wetland, manuka shrubland and low stature forest (Ecological Solutions Ltd., 2024b; Overmars & Lloyd, 2012). *P. patrickensis* on Buller Plateaux is thought to be adapted to, and dependent on, this distinctive coal measure habitat (Walker, 2003).

P. patrickensis'*s* distribution on Buller Plateaux is patchy, with considerable variation in density and occurrence over distances of only a few meters, probably in response to fine-scale variation in habitats. Densities are highest in areas with deep soils, manuka scrub of medium height (1–2 m), and a dense ground cover dominated by wire rush and tangle fern *Gleichenia dicarpa*, but including mountain flax *Phormium cookianum* and north Westland snow tussock *Chionochloa juncea* (Lloyd, 2012). Snails are especially abundant in microhabitats with deep soil or leaf litter and shelter from prevailing weather conditions, with shelter often provided by flax plants. The best microhabitats for *P. patrickensis* are typically close to the interface between different habitat types.

Demography

Density estimates for *P. patrickensis* snails with maximum diameter ≥20 mm have been obtained from biennial capture-recapture surveys in two 70 x 70 m plots in the Denniston Biodiversity Enhancement Area since summer 2014–15 (Lloyd, 2024b). During the 2024 capture-recapture survey 69% of the estimated 147 snails per ha were reproductively mature (>30 mm diameter) giving an estimated 102 mature snails per ha. Extrapolating this density estimate to the species current range on Stockton and Denniston Plateaux (32.0 km^2 & 20.5 km^2) gives estimates of 326,483 and 209,305 mature snails (>30 mm diameter) present on Stockton and Denniston Plateaux respectively at the time of the 2024 surveys.

Estimates of the *P. patrickensis* population size on the two plateaux have also been obtained from daytime sub-surface searches of 10 x 10 m plots with 100 plots searched during 2012 and 123 plots searched during 2024. Daytime sub-surface searches of 10 x 10 m plots is the Department of Conservation's (DOC) standard *Powelliphanta* survey method (Walker, 1997), but snail counts from the method are not the numbers of snails present in the plot, instead they are the numbers of snails that can be found during searches (i.e., the number of findable snails). Results from repeated destructive plot searches and capture-recapture surveys indicate that actual plot populations could be between three and five times higher than the numbers found during a sub-surface search of a plot (Hamilton, 2015a; Lloyd, 2015; Lloyd et al., 2021; McLennan, 2006).

During the 2024 plot surveys, the estimated average numbers of snails found in 10 x 10 m plots were 0.34 and 0.58 on Stockton and Denniston Plateaux respectively (Lloyd, 2024c). Extrapolating estimated average numbers of findable snails in plots on the two plateaux to the species range on the plateaux gives total population estimates of 108,828 and 119,017 findable snails on Stockton and Denniston Plateaux respectively. Adjusting estimates of the populations of findable snails by factors of 3 & 5 gives total population estimates of 326,483–544,138 and 357,050–595,083 snails of all sizes on Stockton and Denniston Plateaux respectively in 2024. These ranges of estimates for total population of all sized snails are consistent with the population estimates for mature snails obtained from capture-recapture surveys.

Plot population estimates from the two capture-recapture plots in the Denniston Biodiversity Enhancement Area show declines of 64% and 60% in the two plot populations over a 9-year monitoring period from 2014–15 to 2023–2024 (Lloyd, 2024b). The average number of snails found during surveys using daytime sub-surface searches of plots during 2012 and 2024 showed a similar decline, with results from general linear modelling (used to adjust for differences between sample designs of the 2012 and 2024 surveys) also indicating that there was a 59% decline in the snail population between 2012 and 2024 (Lloyd, 2024c).

Estimates of growth rates and a range of demographic parameters for *P. patrickensis* were obtained from monitoring snails in the two capture-recapture plots on Denniston Plateau over the period 2014–15 to 2023–24 (Lloyd, 2024b). Estimates of the age for reaching reproductive maturity using two criteria, 30 mm and 32 mm diameter, were respectively 2.47 and 2.97 years from hatching. The proportions of mature snails among the tagged snails ranged from 78% to 54% for the ≥30 mm maturation size criterion and 69% to 40% for the ≥32 mm maturation size criterion. Estimates of the generation time between successive generations of eggs being laid ranged from 5.78 to 7.45 years using the ≥30 mm maturity criterion and 6.60 to 8.15 years using the ≥32 mm maturity criterion.

Predation on *P. patrickensis*

The damage patterns left on shells preyed on by the three main predators of *P. patrickensis* are distinctive (Figure 3) allowing reliable identification of predators of medium and large snails. Smaller snails and snail eggs are likely to be consumed whole, leaving no evidence of predation.

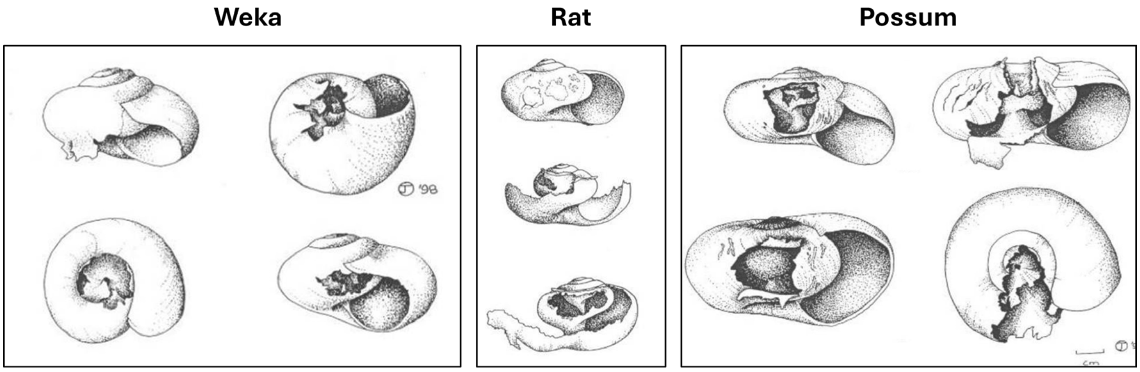

Figure 3. Illustrations of typical damage patterns left on *Powelliphanta* shells by the three commonest predators of *Powelliphanta.* (From DOC-5607936.)

The proportion of *P. patrickensis* shells found during plot surveys with evidence of predation by weka (*Gallirallus australis*), a native rail, increased from 6.2% of 658 shells in 2012 to 35% of 388 shells in 2024, while the proportion of intact shells declined from 75% to 35% (Lloyd, 2024c). The proportion of shells with evidence of predation by rats (*Rattus sp.*) increased from 6% to 16%, whereas the proportion with evidence of predation by brushtail possum (*Trichosurus vulpecula*) declined from 13% to 3%. In models investigating the effects of survey year and plot characteristics on shell damage predation rates, differences between years were significant for weka and possum but not for rats. The apparent increase in rat predation was a consequence of unbalanced sampling design with a higher proportion of plots favoured by rats surveyed during 2024. An even higher proportion (48%) of a sample of 440 snail shells collected on Stockton Plateau during the period 2019–2021 had evidence of predation by weka (Lloyd, 2023). Only 21.3% of the sample of 440 shells showed no evidence of predation. In another sample of shells collected on Stockton Plateau in 2021, 66% of 61 shells showed evidence of weka predation (Lloyd, 2021).

Given the observed increase in proportion of snail shells with damage patterns typical of weka predation, it seems likely that the observed decline in the *P. patrickensis* population on Buller Plateaux during the last ten years is a consequence of increased predation by weka. Weka abundance on Buller Plateaux has increased in recent years, with weka call rates on Denniston Plateau increasing by 89% between 2015 and 2019 (Nichol, 2019). Increased weka abundance, and concomitant increases in their predation of other *Powelliphanta* snail species, has also been observed in Abel Tasman National Park and Golden Bay, where increases in weka predation are usually associated with pest control operations in a phenomenon described as mesopredator release (Lloyd et al., 2021).

Threat Ranking

In the most recent assessment of the conservation status of *Powelliphanta* snails (Walker et al., 2024), *P. patrickensis* on Buller Plateaux, along with 31 other *Powelliphanta* taxa, was assessed as Nationally Critical, because they were judged to have '*ongoing or forecast declines in their populations of >70% over the next 10 years or three generations, whichever is longer'*. Although it was noted that *P. patrickensis* on Stockton and Denniston plateaux are separate subspecies, the two were assessed as a single taxon. The Nationally Critical ranking was based on observed declines in snail numbers in monitoring plots surveyed for DOC in undisturbed areas on Denniston Plateau between 2007 and 2021 and the prospect of additional opencast coal mining. Additional qualifiers added to the status assessment for *P. patrickensis* are that it only occurs at one location and is subject to the effects of both climate change and population fragmentation. The effects of climate change were explained as being a combination of increases in soil moisture deficits during summer, when snails are susceptible to desiccation, and warmer winters allowing expansion of ship rat's altitudinal range and resulting increases in rat predation of snails. Characteristic features of *P. patrickensis* biology including habitat specialisation, small, fragmented populations and limitations to dispersal have been identified as traits increasing invertebrate taxa's vulnerability to climate change (Brumby et al., 2025). Interestingly, there was no mention of weka predation affecting *P. patrickensis* in Walker et al. (2024), despite listing 26 of 28 other Nationally Critical *Powelliphanta* taxa as being affected by weka predation, 13 of them severely.

If the observed decline in the *P. patrickensis* on Buller Plateaux over the preceding decade (Lloyd, 2024b, 2024c) continues unabated, there is a high probability that the populations on both plateaux will approach extinction within the next 20 to 30 years without the impacts of the proposed mine (Lloyd, 2026). Effective conservation management interventions will be required to ensure survival of *P. patrickensis* on Buller Plateaux.

POWELLIPHANTA AUGUSTA

A second taxon of *Powelliphanta*, *P. augusta*, is present on Buller Plateaux. Most of its historic distribution range on the Mt. Augustus ridgeline, on the northwest edge of Stockton Plateau, was lost to opencast coal mining during the period 2004–2007 (Walker et al., 2008). Its current range includes relict portions of its historic range and areas with translocated snails both north of Mt. Augustus and near Mt. Rochfort, in the extreme southwest of Denniston Plateau (Gruner et al., 2021; Otley et al., 2016). The Project will not affect any of the historic or current distribution ranges of *P. augusta*.

IMPACT OF THE PROJECT ON *P. PATRICKENSIS* AND ITS HABITAT

Reductions in the Snail's Distribution Range

The proposed mine construction on Stockton Plateau (Figure 4a & Table 1a) will reduce the current distribution range of *P. patrickensis* on Stockton Plateau by 1.95 km^2 or 6.1% of 32.01 km^2. When the area of proposed disturbance is combined with previous range loss to mining activity, including recent, ongoing and planned mining at the already consented Cypress Mine, *P. patrickensis* will have lost 19.5% (7.26 km^2) of its original distribution range on Stockton Plateau (37.32 km^2) to opencast mining.

Proposed mine construction on Denniston Plateau (Figure 4b & Table 1b) will reduce the current distribution range of *P. patrickensis* on Dennison Plateau by 4.58 km^2 or 22.3% of 20.52 km^2. When the area of the proposed disturbance is combined with previous range loss to mining and roading disturbance the taxon will have lost 24.7% (5.23 km^2) of its original range on Denniston Plateau (21.16 km^2).

Table 1. Areas in the distribution ranges of *P. patrickensis* on Stockton (a) and Denniston (b) plateaux affected by proposed and previous opencast mining.

a) Stockton	Original	Current
P. patrickensis range	37.32 km^2	32.01 km^2

Disturbance	Area (km^2)	% of Range	
		Original	Current
Existing	5.31	14.2%	
Proposed	1.95	5.2%	6.1%
Cumulative	7.26	19.5%	

b) Denniston	Original	Current
P. patrickensis range	21.16 km^2	20.52 km^2

Disturbance	Area (km^2)	% of Range	
		Original	Current
Existing	0.64	3.0%	
Proposed	4.58	21.7%	22.3%
Cumulative	5.23	24.7%	

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Figure 4. The original distribution range of *P. patrickensis* (blue outline) on Stockton (a) and Denniston (b) plateaux with areas of existing or consented mining disturbance (red shading), areas to be disturbed by the Project (grey shading) and the extent of consent buffer around disturbance areas (magenta shading).

The proposed consent area for the Project extends beyond the area of the proposed disturbance to form a buffer (Figure 4 a & b). Although there are no plans to disturb snail habitat in this buffer area, minor adjustments to the disturbance areas during mine construction and operation could extend into the buffer areas. On Stockton Plateau, the consent buffer extends over 0.400 km^2 of snail habitat around the proposed Mt. Frederick South mine area and 0.125 km^2 along the proposed haul road. There is another 0.755 km2 of snail habitat within the consent buffer around areas of historic disturbance on and to the north of Mt. Frederick. On Denniston Plateau, the consent buffer extends over 0.993 km^2 of snail habitat, with 0.765 km^2 of the buffer around the Escarpment mine area and 0.227 km^2 along the haul road. Habitat disturbance in the buffer areas was not considered in the assessment of the Project's impact on snail habitat, because any disturbance in the buffer will be minor and likely offset by corresponding reductions in the area of the proposed disturbances.

Snail Mortality

Estimated Snail Populations in Disturbance Areas

Snail density estimates from the two capture-recapture plots on Denniston (Lloyd, 2024b) were used to estimate the likely number of reproductively mature snails present in the disturbance areas. During the 2024 capture-recapture survey 69% of the estimated 147 snails ha^{-1} were reproductively mature (>30 mm diameter) giving an estimated 102 mature snails ha^{-1}. Extrapolating the estimate of 102 mature snails ha^{-1} from the 2024 capture-recapture survey to the proposed disturbance areas gives estimates of 19,871 and 46,710 mature snails present in proposed disturbance areas on Stockton and Denniston Plateaux respectively.

During Habitat Stripping

Before habitat stripping is undertaken in an area scheduled for disturbance, areas suitable for Vegetation Direct Transfer (VDT) will be identified, the habitat in them stripped and relocated to suitable locations. Most, or all, snails in areas stripped using VDT will be transferred successfully in the VDT habitat and the snail's long-term survival after transfer is high.

Studies show similar results when VDT has been used to relocate areas of habitat with either *P. patrickensis* or *P. augusta*. Significant proportions of both *P. patrickensis* and *P. augusta* snails in habitat transferred by VDT survive the VDT process (Hamilton, 2015c; Lloyd, 2021, 2024d). Results from capture-recapture plot surveys undertaken in an area of *P. patrickensis* habitat relocated by VDT on Mt. Frederick during the five-year interval following relocation in 2009 show that annual survival estimates from capture-recapture plots in VDT habitat and undisturbed habitat were similar, with ranges of 72–76% and 71–74% respectively (MacKenzie, 2014). High snail encounter rates along a nocturnal transect through the area of VDT habitat on Mt. Frederick during 2024 (Lloyd, 2024d) indicate that a healthy population of snails remains in the area fifteen years after relocation by VDT. In another more recent capture-recapture study of snail habitat relocated by VDT from the Cypress mine, the estimated annual survival during the interval from pre-transfer to one-year after relocation by VDT during 2020 was 64%. The estimated annual survival during the subsequent 3-year interval was 76%, (Lloyd, 2024d), which is considerably higher than annual survival estimates 45% and 67% from two plots in an undisturbed area during a similar interval (Lloyd, 2024b). Results from capture-recapture surveys during 2024 show healthy populations of *P. patrickensis* remain in the area of VDT relocated during 2020 and a nearby area of red tussock relocated by VDT during 2012 (Lloyd, 2024d). Similar results have been obtained for *P. augusta* in an area of habitat relocated by VDT. Results from capture-recapture plot surveys show annual survival estimates for *P. augusta* in an area of VDT habitat on Mt. Augustus are similar to estimates from nearby undisturbed areas with ranges of 62–78% and 71–82% respectively (MacKenzie, 2020). Results from the most recent survey, undertaken during 2020, show a healthy population of *P. augusta* remains in the plot thirteen years after the habitat was relocated by VDT during 2006–2007 (Gruner et al., 2021; MacKenzie, 2020).

However, not all disturbance areas are suitable for VDT and its use is further constrained by mine planning because laydown areas are not always available. In current mine plans for the

Project, at least 15% of the area of snail habitat scheduled for disturbance will be rehabilitated using VDT.

The fate of snails in disturbance areas not suitable for VDT is more uncertain. Some snails 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). Additionally, the snail's earthworm prey will not survive in stockpiled soil. However, if soil stripped from disturbance areas can be spread immediately on prepared surfaces without stockpiling, the abiotic conditions in stockpiled soil described by (Boyer S, 2013) are unlikely to develop. Consequently, when the stripped soil is spread immediately some of the snails in it are likely to survive along with earthworms they prey on. Spreading stripped vegetation debris across the soil surface should enhance the survival of snails and earthworms as well as promoting vegetation growth.

Vehicle Impact

The daytime refuges of many snails are close to the surface and provide little protection from crushing by off-road vehicles. Thus, off-road operation of any vehicles, either associated with the mine project or recreational vehicle (4x4 vehicles, motor bikes or mountain bikes) present a risk to snails. At night when snails are active on the surface, snails are also vulnerable to vehicles travelling on roads or formed tracks. This type of mortality will be increased because of the higher number of vehicle movements brought about by mining.

Habitat Fragmentation

Habitat fragmentation is the process through which a species' habitat is 'broken apart' into patches surrounded by land cover types that are unsuitable for the species and are less permeable to the species' dispersal compared to intact species' habitat. Habitat fragmentation typically accompanies habitat loss, consequently effects of the two phenomena are often confounded, with negative effects from habitat loss attributed to habitat fragmentation. However, there is no consensus on the effects of habitat fragmentation *per se*, conditional on a given amount of habitat (Valente, 2023; Villard & Metzger, 2014). Two reviews of literature on the topic arrived at opposing and mutually exclusive conclusions. Haddad et al. (2015) concluded that habitat fragmentation reduces biodiversity by 13% to 75% and impairs key ecosystem functions, whereas Fahrig (2017) concluded that significant responses to habitat fragmentation independent of habitat loss are rare and mostly positive for both species richness and for single species.

Summary of the Negative Effects of Fragmentation

Negative effects associated with habitat fragmentation are well documented (Haddad et al., 2015; Hanski, 2015; Harrison, 1991; Harrison & Bruna, 1999; Pinto et al., 2024; Rogan & Lacher Jr., 2018; Saunders et al., 1991). Negative effects include habitat degradation along the edges of fragments, increased demographic stochasticity and reduced genetic variability.

Habitat Degradation Along Fragment Edges

Habitat characteristics at the edges of habitat patches are different to habitat characteristics away from the edge due to altered biophysical properties such as shade, shelter and drainage affecting light penetration, temperature, and moisture conditions. The edges of habitat fragments may also be affected by an influx of biota from disturbed areas (i.e., weed seed, pest animal species) replacing, or augmenting, the movement of local biota that occurs in continuous undisturbed habitats. The proportion of a fragment subject to edge effects will depend on its size and configuration. In small ragged shaped fragments, with a high edge-to-area ratio, the entire fragment can be degraded by the edge effect.

Increased Demographic Stochasticity

In small populations random fluctuations in population size can lead to extinction, a phenomenon called demographic stochasticity. Reduced dispersal among isolated fragments, especially of species with a low dispersal ability like snails, means recolonization following local extinction will be lower in isolated fragments than in patches of continuous habitat with the same area. Thus, habitat fragmentation results in increased rates of local extinction and decreased patch recolonization, which lead to larger population declines than expected from habitat loss alone.

Reduced Genetic Variation

In the absence of dispersal among populations, small, isolated populations lose genetic diversity over time. The resulting inbreeding and genetic drift may cause inbreeding depression, which increases the risk of local (patch) extinction. However, when populations become small enough for inbreeding depression to occur, demographic and environmental stochasticity are likely to cause extinction before inbreeding plays an important role.

Extent of Fragmentation

The extent of fragmentation can vary from largely intact habitat areas crisscrossed by roads that impede but do not halt dispersal, through to small, isolated fragments surrounded by extensive disturbed areas that completely prevent dispersal.

The Effects of Roads and Vehicle Tracks

For species with low dispersal ability, the negative effects of even relatively small-scale roads and vehicle tracks requires special consideration (Rytwinski & Fahrig, 2012; Villard & Metzger, 2014). Even though the total area disturbed by roads and vehicle tracks may be modest at a landscape scale, the amount of habitat alongside roads and vehicle tracks degraded by edge effect will be proportionally greater than for a similar area of disturbance with a compact configuration. Roads and vehicle tracks frequently degrade habitats further by providing conduits for pest and weed dispersal. Roads and vehicle tracks through an area also increase its susceptibly to habitat degradation by activities such as off-roading with 4x4 vehicles, trail bikes or mountain bikes, rubbish dumping and firewood, gravel or other resource extraction. For species such as snails, with limited dispersal abilities, roads and tracks may present barriers impeding dispersal between habitat fragments and isolating local populations (Clark et al., 2010). Roads and tracks may also increase mortality directly as a consequence of traffic mortality or increasing vulnerability to predation and desiccation in open areas on the roads and vehicle tracks (Gravel et al., 2012).

Positive Effects of Fragmentation

Positive effects of habitat fragmentation *per se* are not as well documented as negative effects, presumably because of the widespread assumption that habitat fragmentation effects are generally negative (Fahrig, 2017). However, many studies demonstrate positive effects of fragmentation on species occurrences (Fahrig, 2017). Also, modelling indicates that a positive relationship between fragmentation and species survival is a more realistic null hypothesis than a negative relationship (May et al., 2019). Two of the positive effects listed by Fahrig (2017) are relevant to *P. patrickensis*. Firstly, higher edge density in more fragmented landscapes is likely to have a positive effect on *P. patrickensis* because they are most abundant at natural habitat interfaces. Secondly, habitat fragmentation spreads the risk of extinction over a larger number of sites, thus reducing the risk of simultaneous extinction of all local populations. Results from modelling (May et al., 2019) demonstrate that for species with aggregated distributions, such as *P. patrickensis*, habitat fragmentation had positive effects on species survival probability. However, any positive effects of fragmentation are only possible in habitat fragments large enough to retain viable populations.

Current Fragmentation of *P. patrickensis* Range

Stockton Plateau

Historic, ongoing and planned mining activity and related infrastructure up to 2024 has resulted in the loss of 14.2% of *P. patrickensis* known range on Stockton Plateau (Table 1a), with almost all habitat loss due to mining restricted to the northwest and northeast of the snail's range on Stockton Plateau (Figure 2). Most of the snail's existing range on Stockton Plateau is a single almost continuous 32.0 km^2 area of undisturbed habitat, which comprises 85.87% of its original range. Exceptions are: a 2.4 km^2 area with extensive tracking and disturbance in the north-east of the snails range, two small areas of snail habitat isolated from the main area of habitat, between mining disturbance and the snail's range limit at the northwest edge of the plateau, and a small area of regenerated habitat from disturbance associated with historic underground mining and 3.8 km of tracks in the southeast of the plateau.

Snails are unlikely to persist long-term in the two habitat fragments northwest edge of the plateau. However, their proximity to translocated snail populations in areas rehabilitated by VDT (Lloyd, 2023; MacKenzie, 2014) might improve the viability of snail populations in both the two habitat fragments and the areas of VDT.

Denniston Plateau

Currently, habitat in *P. patrickensis* range on Denniston Plateau remains largely unaffected by opencast mining. However, approximately 3.0% of the species original range on the plateau has been degraded by roading and other disturbance associated with historic underground mining activity (Figures 2 & 5). Although roads and vehicle tracks cover a relatively small proportion of the Plateau, their impact on the snail population is likely to be proportionally greater, because roads and vehicle tracks degrade adjacent habitat (edge effects), give access to offroad vehicles, provide conduits for pest and weed dispersal and may impede snail dispersal, potentially fragmenting the Denniston snail population.

It is unknown whether roads and vehicle tracks impede dispersal of *P. patrickensis*. On warm moist nights, the author has observed snails crossing unvegetated areas, including sandstone pavement, bare earth and disturbed areas with gravel and coarse sand. These observations indicate that under suitable conditions tracks and roads do not necessarily present impermeable barriers to snail dispersal. However, it seems likely that dispersal across roads and tracks will be restricted compared to dispersal across similar distances of undisturbed snail habitat. Also, the magnitude of decreases in dispersal is likely to be affected by the nature of the road or track, influenced by factors such as width, surface composition and the presence of ditches or embankments. If roads and vehicle tracks do significantly impede dispersal of *P. patrickensis*, the extensive road and track network on Denniston Plateau (Figure 5) may have already created many partly or completely isolated sub-populations of *P. patrickensis*.

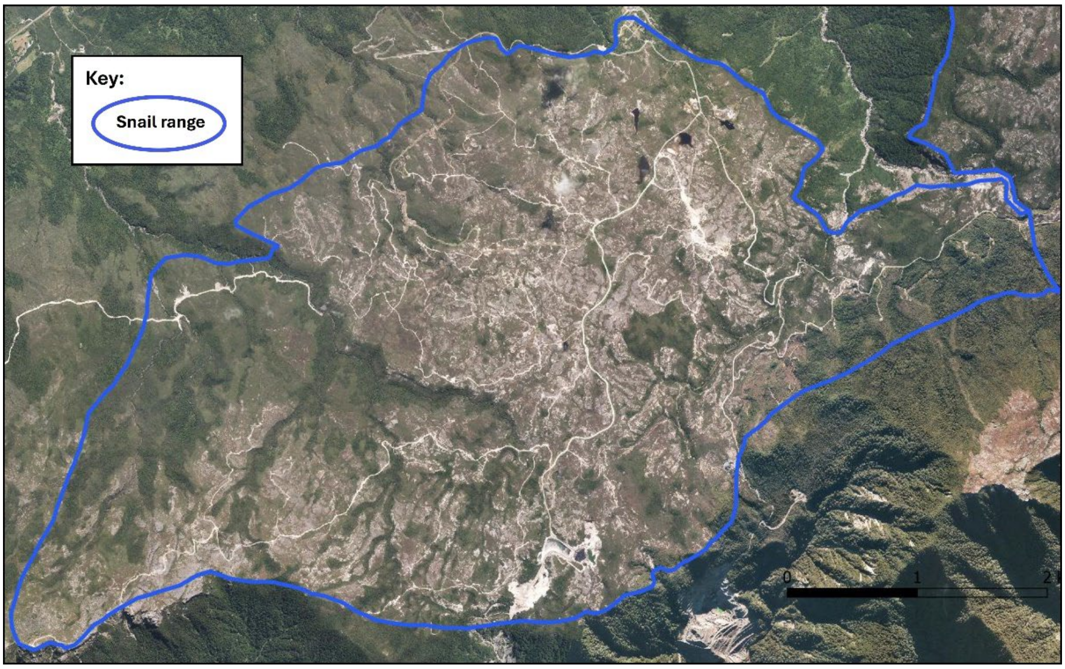


Figure 5. Aerial photos of Denniston Plateau taken during 2015–16 showing the existing network of roads, vehicle tracks and other disturbance on the plateau, overlayed by the original distribution range of *P. patrickensis* on the plateau (blue outline).

Additional Fragmentation Caused by the Project

Stockton Plateau

On Stockton Plateau, the proposed Project will result in three sizeable habitat fragments separated by haul roads and four small, isolated fragments of snail habitat (Table 2a & Figure 6a). Two of the small, isolated fragments (Northwest and North) are already isolated by previous mining. The other two isolated fragments (Deep Creek and Edge) are very small (0.028 km^2 & 0.005 km^2), almost completely isolated from other snail populations by the proposed disturbance and unlikely to remain viable, even over the short term (< 20 years).

Two of the three sizeable habitat fragments are large (Main 19.2 km^2 & Southeast 8.7 km^2), while the other is moderate sized (West 1.7 km^2). There will be degradation of habitat quality along the fragment edges caused by the edge effects. However, assuming edge effects degrade a 10 m wide strip of habitat around the fragment edges, the area of habitat degraded by edge effect in the three larger fragments is only 3.5% of the total area of the fragments (Table 2a). Given the width of mine haul roads and likely high traffic volume on them, it seems likely that the proposed haul roads will create significant barriers impeding snail dispersal between the three fragments, during mine life, but more information about *P. patrickensis* ability to disperse across roads is required to predict whether the haul roads would completely isolate snail populations in the fragments. Because of the relatively large size of the fragments and generally unmodified habitats remaining within them, it seems likely that even if the snail populations in the fragments are completely isolated by the haul roads, they should remain viable. Loss of snail populations in the four small non-viable fragments on Stockton Plateau will decrease their distribution range by 0.38 km^2, leaving 29.68 km^2, 92.7% of their current range and 79.5% of their original range.

Denniston Plateau

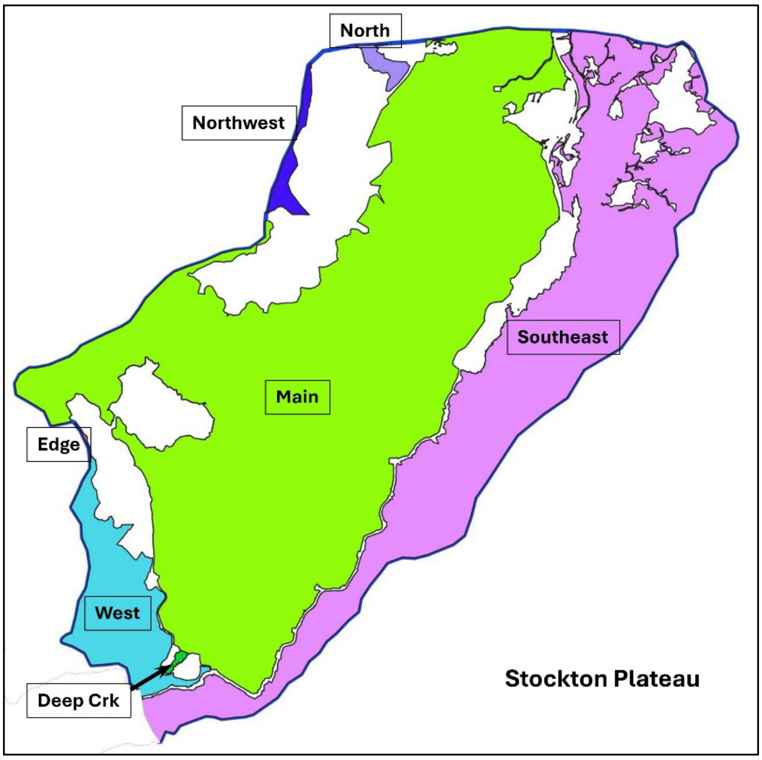
Areas of proposed opencast mining and associated disturbance on Denniston Plateau will almost completely isolate eleven areas of snail habitat (Table 2b & Figure 6b), with areas ranging from 0.014 km^2 to 12.2 km^2. It seems unlikely that snail populations in the eight smallest fragments (0.008 km^2 to 0.457 km^2) will remain viable even over the short term because of their small population sizes, lack of dispersal into the fragments from surrounding areas and edge effects degrading habitat within the fragments. Assuming edge effects degrade a 10 m wide strip of habitat around the fragment edges, the proportion of habitat degraded by edge effect in the eight smallest fragments is 20.7% (Range: 16%–83%) compared to 3.9% (Range 3.3%–7.1%) in the three largest fragments. It seems likely that snails are already absent from the fragment around the Denniston settlement (i.e., Denniston) because of the fragment's small size (0.125 km^2), isolation from other snail habitat and a long history of modifications around the settlement. Snail populations in the small fragments surrounded by proposed Escarpment Extension mine excavations are unlikely to be viable in the medium term because of small population sizes, habitat degradation from the surrounding activities and isolation from other snail populations. Persistence of snail populations in the Cascade fragment, which is isolated by the proposed haul road, is uncertain and will depend on whether existing roads and the proposed haul road create impermeable barriers to snail dispersal.

Post-mining, snail's remaining range on Denniston Plateau will include three large habitat fragments (Main, East & Burnetts Face) separated from one another by the proposed haul road (Table 2b & Figure 6b). There are no records of snails from the East fragment, but this probably reflects lack of search effort rather than absence of snails. The three fragments are already separated by existing roads, which may have already isolated populations of *P. patrickensis* in them. If vehicle tracks impede snail dispersal, snail populations in the three fragments might already be further subdivided by the extensive network of vehicle tracks on the plateau (Figure 5). Snail populations in the three largest fragments (Table 2b) are likely to remain viable in medium to long-term, with or without dispersal between them. Loss of snail populations in the eight small non-viable fragments on Denniston Plateau will decrease their distribution range by 1.015 km^2, leaving 14.9 km^2, 72.7% of their current range and 70.5% of their original range.

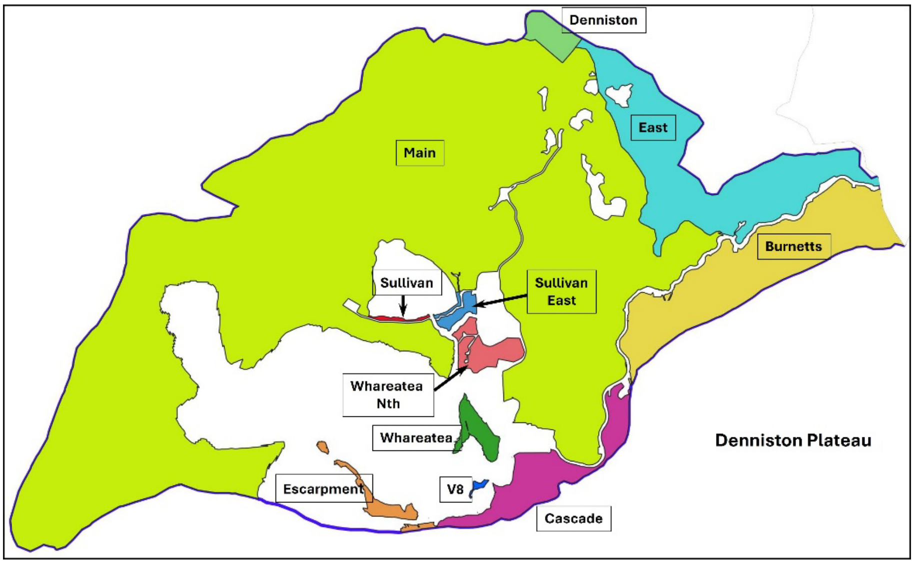
Table 2. The size of habitat fragments within the distribution range of *P. patrickensis* on a) Stockton and b) Dennison Plateau remaining after disturbance from the proposed opencast mining areas and the proportion of each of the fragments affected by a 10 m wide edge effect from disturbance (i.e. Edge Effect).

a) Stockton Plateau Habitat Fragments					
Viable	Area (km^2)	Edge Effect	Probably Not Viable	Area (km^2)	Edge Effect
Main	19.24	2.1%	Northwest	0.216	20.0%
Southeast	8.72	6.3%	North	0.132	15.8%
West	1.69	5.7%	Deep Creek	0.028	37.6%
			Edge	0.005	83.0%
Total Viable:	29.65 km^2	3.5%	Total Not Viable:	0.381 km^2	20.7%

b) Denniston Plateau Habitat Fragments					
Viable	Area (km^2)	Edge Effect	Probably Not Viable	Area (km^2)	Edge Effect
Main	12.13	3.3%	Cascade	0.457	12.7%
East	1.46	7.1%	Whareatea North	0.154	20.1%
Burnetts Face	1.33	5.8%	Denniston	0.125	11.8%
			Whareatea	0.105	22.0%
			Escarpment	0.097	36.1%
			Sullivan East	0.055	35.7%
			Sullivan	0.013	77.2%
			V8	0.008	60.6%
Total Viable:	14.92 km^2	3.9%	Total Not Viable:	1.015 km^2	19.4%



a)



b)

Figure 6. Isolated fragments of the distribution range of *P. patrickensis* on a) Stockton and b) Denniston plateaux remaining after disturbance for the proposed Project. Different colours distinguish the 18 isolated fragments from one another.

Habitat Degradation

Edge Effects
Undisturbed snail habitat along the sides of the proposed haul roads and around the periphery of excavations, earthworks and associated disturbance is likely to be degraded by edge effects. The proportion of a fragment's area affected by the edge effect will depend on the fragment's total area and configuration. The likely magnitude of edge effects on the different fragments was estimated by assuming edge effects extend 10 m into otherwise undisturbed habitat from the edges of proposed and previous disturbances (Table 2). On this basis, the proportions of large and medium sized habitat fragment's areas (>1 km^2) affected by edge effect ranged between 2.1% and 7.1%. For smaller fragments (<1.0 km^2), the proportions affected by 10 m wide edge effects ranged from 11.8% to 83%.

Effects of Haul Roads
Because there is already an extensive road and track network on Denniston Plateau (Figure 5) and most of the proposed haul road follows an existing road, the new haul road proposed for Denniston Plateau will have relatively little additional impact on habitat on the plateau other than a minor increase in the area of habitat lost. By contrast, the proposed haul roads on Stockton Plateau present a significant risk to the integrity of snail habitat remaining after the proposed mining disturbance. Currently, habitat in these areas is relatively unmodified and intact, with only a short section (3.8 km) of access track from Denniston Plateau. The proposed haul roads extend >12 km into Stockton Plateau, with bridges or culverts across several streams. Without careful management the haul roads could provide a conduit for pest and weed dispersal and unauthorized vehicular access into previously undisturbed parts of the plateau. If the roads remain intact post-mining, unauthorized vehicular access could make large areas of the snail's range susceptible to habitat degradation by activities such as off-roading with 4x4 vehicles, trail bikes or mountain bikes.

Rehabilitated Habitat
Plans for the proposed mine include rehabilitation of disturbed areas after mining. Wherever possible rehabilitation will be by VDT. However, in current mine plans only slightly more than 15% of the area of snail habitat scheduled for disturbance will be rehabilitated using VDT, and the rest will be rehabilitated by planting and or seeding. Habitat patches created by VDT provide good habitat for snails (Lloyd, 2021, 2024d) and recover their vegetation values relatively quickly (Ecological Solutions Ltd., 2024a). Personal observations of snails using slots between VDT habitat slabs as refugia indicate that with the current high incidence of weka predation habitat created by VDT might be better for snails than the original undisturbed habitat. This suggestion is supported by higher annual survival rates observed during capture-surveys of plots in areas of habitat relocated by VDT than during surveys of plots in undisturbed areas (Lloyd, 2024b, 2024d).

Over the last 20 years large areas have been rehabilitated by planting and or seeding following mining disturbance on Stockton Plateau. During repeated nocturnal searches along 8 km of transects through areas rehabilitated by planting or seeding, snails were only found along a short (45 m) section of transect, whereas on the same nights, large numbers of snails were found along nearby transects through undisturbed habitat (Lloyd, 2024d). These results indicate that most areas rehabilitated by planting and or seeding do not provide suitable habitat for *P. patrickensis* snails, even 20 years after rehabilitation. However, the presence of a cluster of live snails and shells in a small patch of rehabilitated habitat near Mt. Frederick on the western edge of Stockton Plateau indicates that an investigation into how to create suitable habitat for *P. patrickensis* snails by planting and or seeding is worthwhile.

PROPOSED EFFECTS MANAGEMENT FOR THE PROJECT

A programme for addressing adverse effects of the Project on *P. patrickensis* has been developed using the standard effects management hierarchy framework (MFE, 2024): avoid, minimise, remedy and, where necessary, offset or compensate for residual impacts. A summary of the likely impacts of the Project on *P. patrickensis* snails and their habitat, together with proposed effects management for the impacts, is presented in Table 3.

Effects Management of Snail Habitat Loss

Avoiding any loss of *P. patrickensis* habitat is not practicable as the snail's distribution range extends over all the remaining coal reserves on Buller Plateaux. Although the location of coal reserves largely determines the areas that will be mined, snail habitat loss was minimised during mine planning by avoiding placing infrastructure such as roads, buildings and overburden disposal sites disturbance on areas of snail habitat. Section 9.6.2 of the Project's EcIA (Ecological Solutions Ltd., 2024b) lists areas of good habitat avoided during the mine planning process. These include approx. 153 ha in and around the Whareatea Gorge, approx. 8.5 ha in the headwaters of Billo Stream and approx. 8.3 ha for a planned haul road from Mt. Frederick to the Mt. Frederick South disturbance area.

The next option in the effects management hierarchy is remedy. Two mitigation methods have been used to remedy snail habitat disturbed by mining, vegetation direct transfer (VDT) and rehabilitation by planting and or seeding. VDT entails stripping overburden as slabs of topsoil with intact native vegetation. The slabs are lifted by a digger and transferred directly to a prepared site where they are reassembled (Rodgers, Simcock, Bartlett, Wratten, & Boyer, 2011; Simcock & Ross, 2014). VDT is best suited to the rehabilitation of habitat areas with gentle slopes and low stature vegetation. Engineering and practical constraints, including scheduling and availability of suitable landforms to receive habitat at the time it is stripped, further reduce the proportion of disturbed areas that can be rehabilitated by VDT. In current mine plans for the Project, VDT will be used to rehabilitate at least 15% of the disturbance footprint. Other habitat disturbed during mine construction will be rehabilitated by planting and or seeding.

Rehabilitation by planting and or seeding on Stockton Plateau has entailed spreading stockpiled soil from excavated areas over engineered landforms (ELF) on previously mined areas before seeding or hydro-seeding the bare soil with pasture grasses and, or planting with locally sourced or nursery grown native plants. Artificial fertiliser or biosolid waste are sometimes spread on seeded areas to enhance short term vegetation growth and promote plant establishment. Planting can be into either previously seeded areas or into bare soil. Typically planted species include mānuka (*Leptospermum scoparium*), southern rātā (*Metrosideros robusta*), hebe (*Veronica* spp.), mountain flax (*Phormium cookianum*) and tussock (*Chionochloa sp.*) (Lloyd, 2024d; McLennan et al., 2024).

Table 3. The likely impacts of the Project on *P. patrickensis* snails and their habitat with proposed effects management.

<table>
<tr><th rowspan="2">Impact</th><th colspan="5">Effects Management Hierarchy</th></tr>
<tr><th>Avoid</th><th>Minimise</th><th>Remedy</th><th>Offset</th><th>Compensate</th></tr>
<tr><td></td><td></td><td></td><td></td><td rowspan="7"></td><td rowspan="7">Detailed below</td></tr>
<tr><td rowspan="4">Snail Habitat Loss</td><td rowspan="4">Not possible</td><td rowspan="4">Mine plans are designed to avoid disturbance to areas of snail habitat that are not essential for mine construction.</td><td>Use Vegetation Direct Transfer (VDT) during habitat stripping wherever possible.</td></tr>
<tr><td>When VDT cannot be used:
– Strip & transfer vegetation, topsoil, & subsoil separately.
– Transfer stripped soil directly to the final laydown site and cover with vegetation debris from the stripped site.</td></tr>
<tr><td>When VDT cannot be used and stripped soil must be stockpiled, habitat should be rehabilitated by planting & or seeding.</td></tr>
<tr><td>Ongoing research and adaptive management to improve the outcome of rehabilitation by planting & or seeding.</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Table 3 (continued). The likely impacts of the Project on *P. patrickensis* snails and their habitat with proposed effects management.

Impact	**Effects Management Hierarchy**				
	Avoid	**Minimise**	**Remedy**	**Offset**	**Compensate**
Snail Habitat Degradation	Not possible	Have site plans to: – minimise dust from vehicle traffic & excavation. – ensure pollutants don't contaminate undisturbed areas.	.		Detailed below
		Revegetation of disturbance areas around remaining undisturbed areas of snail habitat.			
		Have well designed drainage to avoid changing hydrology in undisturbed areas.			
		Prevent vehicular access to remote areas of Stockton Plateau along haul roads by closing them to public during mine life.			

Table 3 (continued). The likely impacts of the Project on *P. patrickensis* snails and their habitat with proposed effects management.

Impact	Effects Management Hierarchy				
	Avoid	**Minimise**	**Remedy**	**Offset**	**Compensate**
Snail Mortality	Not possible	Mine plans avoid disturbance to areas with snails unless the areas are essential for mine construction. Use Vegetation Direct Transfer (VDT) during habitat stripping wherever possible. Relocate VDT habitat to pest exclusion fenced areas wherever possible When VDT cannot be used: – Strip & transfer vegetation, topsoil, & subsoil separately. – Transfer stripped soil directly to the final laydown site and cover with vegetation debris from the stripped site. When neither VDT nor direct transfer of soil are possible, undertake snail salvage and relocate snails to nearby areas not scheduled for disturbance, ideally pest exclusion fenced areas.			Construct pest exclusion fenced areas to reduce predation by weka & rodents as well as reducing the indirect effects of climate change increasing mammalian predator populations (e.g. rodents & possums).
Snail Population Fragmentation	Not Possible	Undertake relocations of small numbers of snails between isolated populations.			

Vegetation Direct Transfer (VDT)

Although habitat patches created by VDT appear botanically and aesthetically degraded, they provide good habitat for *P. patrickensis* snails and *P. augusta* (Gruner et al., 2021; MacKenzie, 2020). The results of monitoring programmes using capture-recapture methods in 4 plots in habitat rehabilitated by VDT on Stockton Plateau show viable populations of *P. patrickensis* snails are present in rehabilitated habitat up to 13 years after rehabilitation by VDT (Lloyd, 2021, 2023, 2024d; MacKenzie, 2014). Results from capture-recapture monitoring of *P. augusta* snails in an area rehabilitated by VDT during 2006–7 are similar, with a viable snail population remaining in the area 13 years after rehabilitation (Gruner et al., 2021; MacKenzie, 2020).

Results from botanical surveys of rehabilitated areas (Ecological Solutions Ltd., 2024a) show that vegetation and microhabitats in areas of VDT remain intact following transfer and persist over time. Areas of short-stature vegetation such as red tussock (*Chionochloa rubra*), mānuka shrubland and low forest transferred using VDT resemble natural coal measures vegetation much more quickly than planted areas. Areas rehabilitated by VDT also had higher vascular plant ground cover and total vegetation cover than other rehabilitated areas. Slots between VDT habitat slabs provide refugia for snails, possibly making habitat created by VDT better for snails than the original undisturbed habitat.

Rehabilitation by Planting and or Seeding

Results from the nocturnal searches along transects show that most areas rehabilitated by planting and or seeding in the past do not provide suitable habitat for *P. patrickensis* snails, even 20 years after rehabilitation (Lloyd, 2024d). Despite finding high numbers of snails during nocturnal searches along transects through nearby areas of undisturbed habitat, the only live snails found along 8 km of transects through areas rehabilitated by planting were clustered in a 64 m^2 patch of rehabilitated habitat. Vegetation in the patch with snails was taller and more complex than in surrounding rehabilitated areas (Nichol, 2021) indicating a different rehabilitation method was used to create the small patch of snail habitat. It appears to be the result of direct transfer of stripped soil subsequently covered with vegetation debris from the stripped area.

In botanical surveys, native vegetation cover was significantly lower and species composition different in planted sites compared to undisturbed sites and areas of VDT (McLennan et al., 2024). The invasive exotic weed heath rush (*Juncus squarrosus*) was common in planted sites but rare in undisturbed sites or VDT.

Earthworms in Rehabilitated Areas

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 populations in areas of VDT and undisturbed areas of snail habitat were not significantly different, with similar biomass and species diversity (Boyer et al., 2011). By contrast, earthworm diversity, species richness and biomass were all much lower in areas rehabilitated by planting and or seeding into previously stockpiled soil than either undisturbed sites or sites rehabilitated by VDT (Boyer et al., 2011). Soil stockpiling induces anaerobic conditions at, and below, a depth of 1 m, where earthworms don't survive. Consequently, the use of stockpiled soil for vegetation replanting leads to low diversity and low abundance of earthworms (Boyer et al., 2011).

Recommendations for Restoring Snail Habitat by Planting and, or Seeding

Meaningful attempts to restore snail habitat lost to mining by planting and, or seeding will require significant changes to mine planning and rehabilitation procedures with major modifications to stripping and scheduling methods. In the past, rehabilitation by planting and or seeding was not designed to create snail habitat. Lloyd (2024d) and McLennan et al. (2024) both provide detailed discussions with recommendations on how to improve rehabilitation outcomes for snails in areas rehabilitated by planting or seeding. Recommendations for restoring snail habitat include:

1. Rehabilitation by planting or seeding should only be undertaken where VDT is impracticable because of engineering and practical constraints.
2. Stockpiling soil should be avoided wherever possible.
3. Where practicable stripped material (soil and vegetation/slash) should be transferred to its final destination and spread immediately after stripping.
4. Where practicable, surface material (leaf litter and vegetation debris) and topsoil should be kept separate from subsoil during the rehabilitation process. Achieving this will require staged mine planning with surface material and topsoil stripped separately from subsoil and immediately spread onto previously prepared ELFs, with surface material and topsoil layered over subsoil.
5. To preserve soil communities, especially earthworms, soil compaction by heavy machinery should be minimised throughout the stripping and transfer process by using tracked vehicle rather than wheeled vehicles wherever possible.
6. If soil must be stockpiled, where practicable surface material and topsoil should be stockpiled separately from the subsoil.
7. Soil stockpiles should not be compacted, as earthworms cannot survive in high, compacted soil stockpiles.
8. Stockpiles should be kept as low as possible, to reduce compaction, while avoiding disturbance to extra areas of habitat that would be required for storing lower stockpiles.
9. Where soil needs to be stockpiled for periods longer than one year, stockpiles should be planted or seeded to promote the development and survival of soil fauna.
10. Naturally occurring snail habitat is generally moist and not well drained. Consequently, to restore snail habitat, some areas of ELF should be designed to have relatively flat surface with poor drainage.
11. Slash (i.e. vegetation debris) from freshly stripped areas should be spread across surfaces rehabilitated from soil stockpiles to augment planting and seeding.
12. Species used for planting and seeding should be local coal measures species typically found in areas where *P. patrickensis* are most abundant (Lloyd, 2012), e.g., wire rush, tussocks, mountain flax, manuka, and the podocarps pink pine and yellow-silver pine.
13. Effective measures are required to prevent establishment of invasive weeds, especially heath rush, into planted areas.
14. There should be ongoing research and adaptive management to improve rehabilitation outcomes for snails, which could include:
    - Undertaking extensive nocturnal searches along transects in habitat rehabilitated by planting to find other areas rehabilitated by planting with snail populations.

- Investigating vegetation, soils, and earthworm fauna in areas rehabilitated by planting where snails are found.
- Undertake trials translocating locally endemic earthworms into areas rehabilitated by planting to determine whether it improves rehabilitation outcomes for snails (Boyer & Wratten, 2010).

Effects Management of Snail Mortality During Mine Construction

There are three methods for minimising snail mortality during mine construction: VDT, direct transfer of stripped soil and snail salvage.

Vegetation Direct Transfer

Most, or all, snails in habitat stripped using VDT will survive transfer and several studies show that viable populations of *P. patrickensis* and *P. augusta* snails remain in areas rehabilitated by VDT up to 15 and 13 years after transfer respectively (Gruner et al., 2021; Hamilton, 2015b; Lloyd, 2021, 2024d; MacKenzie, 2014; MacKenzie, 2020). Consequently, VDT of snail habitat should be the first choice for minimising snail mortality during mine construction.

Results of Monitoring Snails in Areas Rehabilitated by VDT

Capture-recapture surveys were undertaken in an area prior to stripping by VDT during 2020 and in the resulting area of VDT one year and four years after transfer (Lloyd, 2021, 2024d). Population estimates from the three surveys were 123 (CI95%: 93–183), 134 (CI95%: 62–374) and 85 (CI95%: 49–188). Difference among population estimates from the three surveys were not significant. However, a gap in size distribution of snails caught in the plot during 2024 is evidence of a 16-month gap in recruitment immediately after VDT. This could be because snail eggs and recently hatched snails did not survive the habitat transfer process.

During 2024, a capture-recapture plot was established in an area of red tussock created by VDT 6 years earlier, during 2018. The density estimate from capture-recapture survey in the plot during 2024 was 189 (CI95%: 119–367) snails ha^{-1}. This is higher than the average density estimate of 146.7 (CI95%: 79–215) snails ha^{-1} for two capture-recapture plots in undisturbed habitat on Denniston Plateau during 2024 (Lloyd, 2024b), and within the range of density estimates (164–314 snails ha^{-1}) from four plots in undisturbed habitat on Stockton Plateau surveyed during summer 2020–21 (Lloyd, 2023).

Annual capture recapture surveys were undertaken in two plots 450 m apart in an area rehabilitated by VDT near Mt. Frederick during 2009 and 2011. Results from the surveys show that during six-year (2009–10 to 2014–15) and four-year (2011–12 to 2014–15) monitoring periods, there were only minor fluctuations in plot population estimates (Lloyd, 2023; MacKenzie, 2014). Differences between plot population estimates from the first and last survey sessions were not statistically significant. More recently, results from nocturnal transects during 2024 in the area near Mt. Frederick rehabilitated by VDT show that good numbers of *P. patrickensis* snails remain in the areas rehabilitated using VDT more than 13 years after VDT (Lloyd, 2024d).

Comparable results have been reported for *P. augusta* snails in an area rehabilitated by VDT during 2006–7, with snails remaining in the area 13 years after rehabilitation. Results from routine capture-recapture monitoring show a decline in plot population estimates from 87 (CI95%:68–111) snails in 2011 to 52 (CI95%: 38–83) in 2020 (Gruner et al., 2021; MacKenzie, 2020). However, Gruner et al. (2021) noted that changes in the populations size structure over the course of the monitoring programme suggest that the *P. augusta* snail population in the VDT plot might be stable or recovering.

Direct Transfer of Stripped Soil

In current mine plans for the Project, at least 15% of the area of snail habitat scheduled for disturbance will be rehabilitated using VDT. The fate of snails in disturbance areas not rehabilitated using VDT is more uncertain. Some snails will die directly as a result of injury from heavy machinery during excavations and, or earthworks. If soil stripped from disturbance areas is spread immediately after stripping onto prepared surfaces without stockpiling, live snails remaining in the stripped soil are likely to survive along with earthworms they prey on. Spreading stripped vegetation debris across the soil surface should enhance the survival of snails along with their earthworm prey.

Snail Salvage

Snails in soil stockpiled after stripping are unlikely to survive in the stockpiled soil because the soil is compacted, lacks structure, has low organic matter content, unfavourable moisture conditions, very low pH and anaerobic interiors (Boyer et al., 2011). Snail salvage can be used to minimise snail mortality in areas where stripped soil must be stockpiled. Snail salvage entails intensive searches for live snails in areas before the habitat is stripped and translocating any live snails found to nearby areas not scheduled for disturbance (Bathurst Resources Limited, 2023).

Searches can be either nocturnal for live snails active on the surface or daytime sub-surface searches. Nocturnal searches are more effective than daytime searches, with much higher capture rates per person search hour than daytime searches, but can only be undertaken on warm moist nights when snails are active on the surface. However, egg masses can only be found during sub-surface searches. Before snail salvage is undertaken, there should be a decision on the amount of search effort to be expended (e.g., 100 person hours of searching per hectare).

There is relatively little information on the survival of *P. patrickensis* snails following salvage and translocation. However, estimates of the annual survival of tagged *P. patrickensis* snails from 2 years of capture-recapture monitoring during 2012 & 2013 were similar for snails translocated to a plot and for snails resident in the same plot and others resident in a nearby plot (MacKenzie, 2014). Annual survival estimates for translocated snails were 0 .75 (CI: 0.56–0.88) and 0.73 (0.48–0.89) for the two years, while estimates for resident snails ranged between 0.71 (CI: 0.56–0.82) and 0.74 (CI: 0.63–0.82). Estimates of mean annual survival from a study of the survival of translocated *P. augusta* snails fitted with transponders during the period 2006 to 2007 ranged between 0.55 and 0.79 (Gruner et al., 2021). By comparison, estimates of the annual survival of resident *P. patrickensis* in 2 capture-recapture plots during the period 2014 to 2024 were considerably lower, ranging between 0.31 and 0.67 (Lloyd, 2024b). Presumably the lower annual survival in recent years is a consequence of increased predation by weka (Lloyd, 2024c).

Salvaged snails translocated to suitable snail habitat in one of the proposed pest exclusion fenced areas should have relatively high annual survival rates (i.e. >0.7) because weka and rats, the main causes of snail mortality (Lloyd, 2024c), will be absent. Survival rates for salvaged snails released outside of pest exclusion fenced areas are likely to be lower (<0.7) due to high levels of predation by weka.

Concern previously raised by the Department of Conservation over the negative consequences of competition between translocated snails and existing snail populations at translocation release sites (Bathurst Resources Ltd., 2018) seems unwarranted, given the documented *c.* 60% declines in snail density estimates for Buller Plateaux between 2012 and 2024 as a result of weka predation (Lloyd, 2024b, 2024c).

All translocated snails large enough to be tagged (i.e. ≥20 mm diameter) should be tagged with unique tags before release at their destination site. To assess the success of snail translocations, the survival of translocated snails at their destination site should be monitored routinely for several years after translocation. Details of the monitoring programme will need to be developed, but ideally should be undertaken using capture-recapture methods. Results from the monitoring programme will provide the basis for adaptive management to improve the salvage and relocation process. Existing information, cited above, indicates that survival rates for snails translocated into an area and for snails already resident in the same area will not be significantly different. If survival rates of translocated snails are significantly lower than survival rates of resident snails, it will be necessary to reconsider how translocations are undertaken.

Effects Management for Habitat Fragmentation

Excavation, earthworks and roading for the proposed Project will fragment currently largely continuous areas of snail habitat into smaller isolated patches of varying size surrounded by barriers to snail dispersal. The extent of fragmentation will vary, from large (18.7 km^2) intact areas mostly isolated by haul roads, to small (<1 km^2), isolated fragments surrounded by extensive disturbed areas that completely prevent snail dispersal. It seems unlikely that snail populations in the smaller fragments will be viable, even over the short term. Because of the high edge to area ratio, edge effects will degrade a high proportion of snail habitat in small fragments.

Restoring Connectivity Between Isolated Populations

Where the barrier to snail dispersal between fragments is extensive, such as mine pits or large areas of infrastructure, there is no possibility of dispersal between snail populations in the fragments and the only option for restoring connectivity between isolated populations is routine relocations of snails between isolated populations to minimise demographic and genetic effects of population fragmentation. Although the total area disturbed by the proposed haul roads is relatively small, they will be the cause of most habitat fragmentation. Haul roads will almost certainly impede snail dispersal, but they might not be impermeable barriers as snails are frequently seen in unvegetated areas on warm moist nights. For mobile species safe road crossing, such as land bridges, culverts and extended stream crossing, have been used to reduce population fragmentation caused by roads. However, safe road crossings are unlikely to be effective for snails because snails will not be searching for crossing points. They only move short distances and their movements are random. Consequently, relocating snails between populations isolated by haul roads is likely to be the only method available to minimise demographic and genetic effects of population fragmentation.

Effects Management for Habitat Degradation Associated with Habitat Fragmentation

Intact snail habitat at the periphery of excavations, earthworks, and associated disturbance or along the sides of haul roads is likely to be degraded by edge effects caused by altered biophysical properties such as shade, shelter and drainage along the edges of disturbed areas, which affect light penetration, temperature, and moisture in the adjacent intact habitat. Intact habitat at the edges of disturbed areas will also be vulnerable to the effect of contaminants and influxes of biota (i.e., weed seed and pest animal species) from disturbed areas. Although the total area disturbed by the proposed haul roads is relatively small, the area of habitat alongside haul roads likely to be degraded by edge effect will be proportionally much greater than for a similar area of disturbance with a compact configuration. Roads also increase an area's susceptibly to habitat degradation by activities such as off-roading with 4x4 vehicles, trail bikes or mountain bikes, rubbish dumping and firewood or gravel extraction. Although these can be controlled during the life of the mining areas, after mining is completed, access will be much less restricted.

It's not practicable to completely avoid edge effects caused by structural differences between disturbed and undisturbed areas, but rehabilitation plans for the Project include various strategies for extending remaining fragments of snail habitat by rehabilitating surrounding disturbed areas to alleviate edge effects over time. Strategies for extending fragments of snail habitat include using VDT, creating bunds, placing logs and boulders, covering soil relocated from stripped areas with vegetation debris (i.e. jumble dumping) and the targeted use of fertiliser to promote fast growth and litter development in planted areas. To avoid changes to hydrology in the intact habitat, there should be well designed drainage system at disturbance boundaries with sediment retention ponds to settle suspended particles and slow runoff. Habitat degradation along the edges of undisturbed area can also be minimised by effective biosecurity measures, pest control and pollution control, which should be included in site management plans.

To prevent degradation of intact snail habitat on Stockton Plateau by activities such as off-roading with 4x4 vehicles, trail bikes or mountain bikes, rubbish dumping and firewood or gravel extraction, during mine life most of the haul roads on Stockton Plateau will be closed to the public, with public access managed and restricted to small sections. Ideally at the end of mine life, the haul roads should be removed. This will entail making the roads impassable to 4x4 vehicles by removing culverts and bridges as well as restoring snail habitat on the decommissioned roadways.

COMPENSATION FOR RESIDUAL IMPACTS

Despite all the proposed minimisation and remediation, there will be significant residual impacts on snails and their habitat from the proposed Project. Compensation, the final option in the effects management hierarchy, will be needed to address the Project's residual impacts on snails and their habitats.

If observed declines in *P. patrickensis* populations on Stockton and Denniston Plateaux (Lloyd, 2024a, 2024b) continue unabated, there is a high probability that both populations will approach extinction within the next 30 years, even without the impacts of proposed mining (Lloyd, 2026). Thus, the best option to compensate for residual impacts of the project on *P. patrickensis* populations is effective conservation management to ensure the populations' survival. The main cause of the declining populations is increased predation by weka, a native rail (Lloyd, 2024a). Climate change could be a secondary factor affecting the snails, either as a result of increases in soil moisture deficits during summer making snails vulnerable to desiccation or because climate change increases populations of snail's predators (Walker et al., 2024). The proposed compensation for the Project's residual impacts on *P. patrickensis* snails is constructing a number of pest exclusion fenced areas for the snails to reduce predation by weka and rats on snails and improving the snail population's resilience to the impacts of climate change.

Pest Exclusion Fenced Areas as Compensation for Residual Impacts

Declines in *P. patrickensis* Populations

In recent years, there have been large declines in populations of *P. patrickensis* on Denniston and Stockton Plateaux, with population declines of 62% between 2014 and 2024 in two capture-recapture plots on Denniston Plateau (Lloyd, 2024b), and a 59% decline between 2012 and 2024 in snail numbers found during searches of more than one hundred plots spread across both plateaux (Lloyd, 2024c). *P. patrickensis* populations on Stockton and Denniston Plateaux are ranked by the Department of Conservation (DOC) as Nationally Critical (Walker et al., 2024) on the basis of declines in snail numbers in DOC's monitoring plots in undisturbed areas on Denniston Plateau between 2007 and 2021 and the prospect of additional opencast coal mining.

Cause of the Decline

Mining disturbance is not implicated in the observed decline as none of the monitoring plots are in areas affected by mining. The main cause of the decline is increased predation by weka. The proportion of snail shells found with evidence of predation by weka increased from 6.2% in 2012 to 35% in 2024 (Lloyd, 2024c). This increases matches an 87% increase in weka call numbers on Denniston Plateau between 2015 and 2017 (Nichol, 2019). Increased weka predation has been implicated as the cause of declines in other *Powelliphanta* taxa. A burgeoning weka population in Abel Tasman National Park has been implicated in annual declines of between 30% and 77%s in plot populations of both *P. hochstetteri* and *Rhytida oconnori* snails (Lloyd et al., 2021). Between 2018 and 2020, weka predation of *P. hochstetteri* increased from 8% to 27% at one capture-recapture plot and reached 54% at a second capture-recapture plot. Results of DOC's snail monitoring programme show weka are now *Powelliphanta* snail's main predator in Golden Bay (Ogle, 2019), with 32% of shells found on plots during 2018 with evidence of predation by weka. Weka are listed as a significant threat to 21 of 29 threatened *Powelliphanta* taxa in monitoring plots between 2005 and 2021 (Walker et al., 2024).

Using Pest Exclusion Fenced Areas to Reduce Predation by Weka

Western weka (*G. a. australis*), the taxon present on Buller Plateau, is classified as Not Threatened (Robertson et al., 2021) and is relatively common in many parts of the top of the South Island, whereas *P. patrickensis* is classified as Nationally Critical (Walker et al., 2024) and is restricted to Buller Plateaux. Despite this disparity in the threat rankings and distribution ranges of the two taxa, there are no realistic options for managing weka at a landscape scale to avoid their impact on the *P. patrickensis* populations.

There is an ongoing trial of fenced weka exclusion plots to protect snails from weka predation in Abel Tasman National Park, with two half-hectare sized weka exclusion plots established during 2023 (Bollongino, 2024). Initial results from the trial are encouraging (Bollongino, pers. comm.). Although weka exclusion plots are not a realistic proposition for landscape wide conservation in many areas, they could provide a useful tool for managing *P. patrickensis* and *P. augusta* on Buller Plateaux. Relatively open habitats on much of the plateaux simplify construction and maintenance of weka-proof fences and mean that fenced weka exclusion areas larger than half-hectare are realistic propositions.

Several sizeable fenced weka exclusion areas spread across the two plateaux could provide an effective conservation management intervention to prevent extinction of *P. patrickensis* populations on Buller Plateaux (Lloyd, 2026). Fenced weka exclusion areas will also provide safe destination sites for snails salvaged from areas to be disturbed. In future, they could provide source populations for translocation into areas rehabilitated following mining disturbance.

Ideally, snail habitat rehabilitated by VDT should be relocated to the proposed pest exclusion fenced areas to avoid predation by weka after rehabilitation. However, most habitat inside the proposed pest exclusion fenced areas will be intact with only small areas cleared of vegetation available for habitat relocated by VDT. Consequently, there will be limited opportunities to relocate areas rehabilitated by VDT into pest exclusion fenced areas.

As an additional benefit, pest exclusion fenced areas will be designed to exclude other pest animals such as rodents, possums and mustelids with the aim of enhancing populations of other native species such as lizards and a range of ground dwelling invertebrates. Pest exclusion fenced areas will also protect snail populations from increased abundance of mammalian predators predicted to result from climate change.

Proposed Pest Exclusion Fenced Areas

Final decisions on the number, size and location of pest exclusion fenced areas depend on numerous factors, foremost being selecting sites where fence construction is practicable and avoiding habitat clearance by constructing fences along existing cleared areas. The following additional criteria are important for selecting pest exclusion fenced areas to provide compensation for the Project's impact on *P. patrickensis* snails and their habitats:

1. The presence of *P. patrickensis* snails.
2. Good snail habitat.
3. Proximity to Project disturbance areas.
4. Geographically representative locations.
5. No prospect of future disturbance.

Currently, there are plans for four pest exclusion fenced areas: three to protect *P. patrickensis* and a fourth to protect *P. augusta* (Figure 7). Two of the proposed areas will be on Denniston Plateau, a 47.3 ha area at North Denniston and a 154.3 ha area at Coalbrookdale. A third area of 694.5 ha is proposed for Whirlwind area on Stockton Plateau, but only 544 ha of the Whirlwind area is undisturbed habitat in the known range of *P. patrickensis*. The fenced area proposed for *P. augusta* is a 14.6 ha area approximately 1 km north of Mt. Augustus on the north-west edge of Stockton Plateau. Weka removed from pest exclusion fenced areas will be relocated into areas outside the distribution range of any *Powelliphanta* snail taxa, but within the wider pest control area for the Project (Bathurst Resources Limited, 2025a, 2025b).

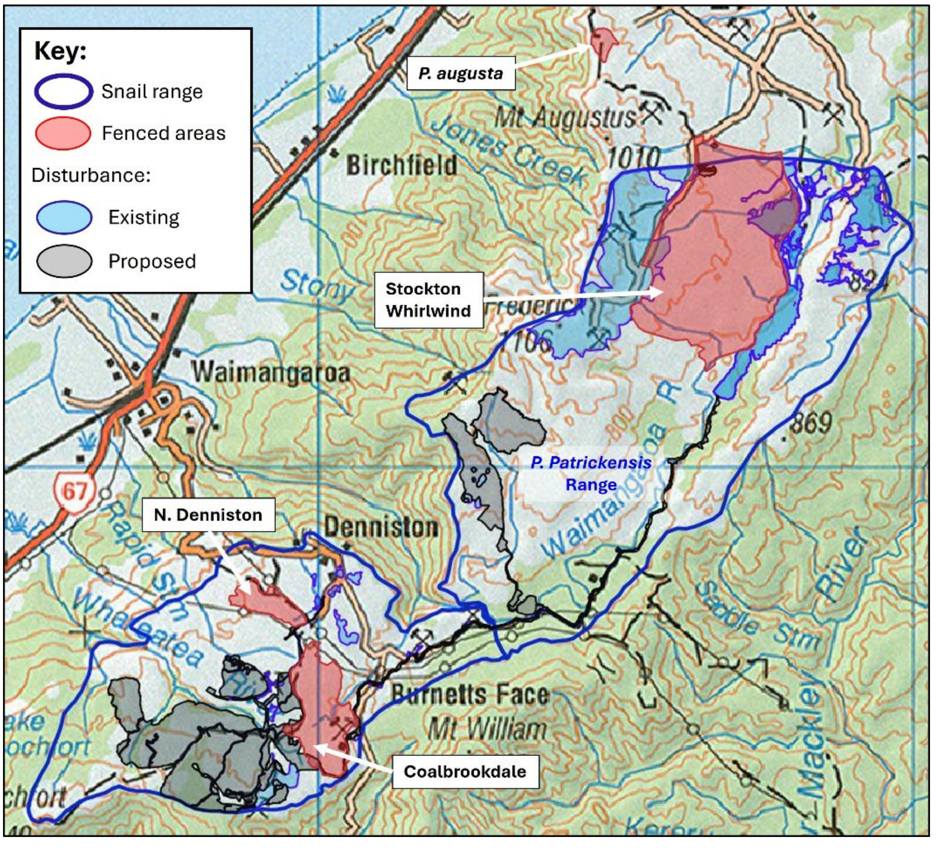


Figure 7. Proposed fenced pest exclusion fenced areas on Buller Plateaux.

To confirm that *P. patrickensis* are present in the three proposed pest exclusion fenced areas for *P. patrickensis*, snail surveys were undertaken along nocturnal transects in the proposed areas (Table 4 & Figure 8) on four warm moist nights during April and May 2025.

[redacted]

Table 4. Results of surveys for *P. patrickensis* snails along nocturnal transects in the footprints of proposed pest exclusion fenced areas.

Location	Transect	Snails		Shells	
	Length (km)	N.	Snail/ km	N.	Shells/km
North Denniston	[redacted]				
Coalbrookdale	[redacted]				
Stockton	[redacted]				

P. patrickensis snails and shells were found on all nocturnal transects in the footprints of the three proposed pest exclusion fenced areas for *P. patrickensis* (Table 4 & Figure 8). Evidence of predation by weka on a high proportion of shells found during the nocturnal transects indicates that predation by weka is the primary cause of snail mortality in the three areas, with evidence of predation by weka on 33% and 47% of the shells found on Denniston and Stockton Plateaux respectively.

Modelling Snail Population Trends With and Without the Project

A Biodiversity Offset Accounting Model (BOAM) was not used to assess likely nett effects of the Project and associated mitigation and compensation on *P. patrickensis* snail populations, because the model is inappropriate for declining populations. Biodiversity Offset Accounting Models are based on the assumption that in the absence of either the impact or offset, the state of biodiversity will remain stable (Denne & Bond-Smith, 2011; Maseyk et al., 2015). Consequently, final biodiversity values are compared to values before the impact, rather than what is likely to have occurred in the absence of the impact and offset. Maseyk et al. (2015) identifies this feature of BOAMs as a limitation to the model but justifies it with the argument that robust information on dynamic biodiversity baselines is generally unavailable. Denne and Bond-Smith (2011) justify the use of stable baselines and discounted future values in BOAMs because of uncertainty about future biodiversity wealth. However, there is robust information on *P. patrickensis* snail populations on Buller Plateaux (Lloyd, 2024b, 2024d; Walker et al., 2024). Monitoring studies show that over the last 12 years *P. patrickensis* snail populations on Buller Plateaux have declined by 10% per annum, primarily as a consequence of predation by weka (Lloyd, 2024b, 2024d). Without major conservation management intervention there is no reason to expect change in this population trajectory.

Instead of using BOAMs, demographic data from the monitoring studies was used to develop stochastic population models predicting the likely trajectories of snail populations on the plateaux with and without the Project and associated pest exclusion fenced areas (Lloyd, 2026). In snail population models without the Project snail populations declined as a result of predation to around 11.2% (CI95%: 4%–32%) of current population levels within 20 years and 3.7% (CI95%: 0.8%–18.5%) after 30 years. In models with the Project and the three proposed pest exclusion fenced areas, there were initial reductions in snail populations as a result of the combined impacts of predation and stripping snail habitat, but as snail populations in pest exclusion fenced areas began to grow in the absence of predation by weka and rodents, population declines slowed. Snail populations in models with and without the Project were similar after 9–11 years. In models with the Project and the pest exclusion fenced areas snail populations either leveled out or increased after 11 years and usually approached the carrying capacities of the pest exclusion fenced areas within 30 years. After 30 years, predicted snail populations in models without the project were 8,233 (CI95%: 1,669–40,608) and 13,766 (CI95%: 2,791–67,903) on Denniston and Stockton Plateaux respectively, whereas predicted snail populations in models with the Project and pest exclusion fenced areas were 71,471 (CI95%: 38,478–77,111) and 183,631 (CI95%: 85,317–201,194) on Denniston and Stockton Plateaux respectively (Table 11 in Lloyd 2025).

CONCLUSION

Over recent years there have been major declines in the *P. patrickensis* populations on Buller Plateaux. The declines have occurred in areas not affected by ongoing or historic mining and are primarily a result of increased predation by weka and ongoing predation by rodents. Population models show that if the population decline observed over the preceding decades continues unabated, there is a high probability that snail populations on Buller Plateaux will approach extinction within the next 30 years.

The proposed Project will have a significant impact on *P. patrickensis* snails on Buller Plateaux, reducing their current distribution range by 6.1% on Stockton Plateau and 22.3% on Dennison Plateau. Despite a comprehensive programme designed to avoid, minimise and remedy the projects negative effects, the Project will have significant residual impacts on snails and their habitat. However, construction of three pest exclusion fenced areas enclosing a total 746 ha of *P. patrickensis* habitat proposed as compensation for the Project's residual impacts on *P.*

patrickensis snails and their habitats will halt and reverse declines in the snail populations caused by weka and rodent predation and ensure the long-term survival of *P. patrickensis* on Buller Plateaux.

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APPENDIX: THE EFFECTS OF DUST ON *POWELLIPHANTA* SNAIL POPULATIONS

(A memo prepared in response to feedback from West Coast Regional Council on the Air Quality Assessments.)

From: Brian Lloyd, Lloyds Ecological Consulting

Date: 17 March 2026

Introduction

There have been no investigations on whether dust generated by mine related activities affects *Powelliphanta* snails, consequently it is not possible to make a definitive statement about the matter. However, there are ten capture-recapture snail population monitoring plots close to areas disturbed by mine related activities on Stockton Plateau (Figure 1). Six capture-recapture plots were established along the Mt. Augustus ridgeline during 2009 for monitoring plot populations of *P. augusta*. Four capture-recapture plots were established for monitoring plot populations of *P. patrickensis* in areas rehabilitated by VDT: two near Mt. Frederick established during 2009 and 2011 and another two at McCabe's laydown area near the Burma Road, Fly Creek crossing established during 2020 and 2024.

Figure 1. Locations of 10 capture-recapture plots for monitoring *Powelliphanta* snails on Stockton Plateau.

The 6 plots for monitoring *P. augusta* were surveyed periodically during the interval 2009–2019 (Gruner et al., 2021; MacKenzie, 2020). The 2 plots near Mt. Frederick for monitoring *P. patrickensis* were surveyed annually following establishment, with one surveyed during six summers 2009–10 to 2014–15, and the other surveyed during four summers 2011–2012 to 2014–2015 (MacKenzie, 2014). One of the plots for monitoring *P. patrickensis* at McCabe's laydown area was surveyed during 2020, both plots were surveyed during 2024.

All ten of the capture-recapture plots are within 200 m of areas of mine related disturbance likely to generate dust (Figures 2–4). The edges of 3 of the 6 plots monitoring *P. augusta* on

Mt. Augustus ridge line and all 4 plots monitoring *P. patrickensis* are within 10 m of disturbance areas.

Results from Capture-recapture Plots for P. augusta Snails

Gruner et al. (2021) concluded that size and weight data for *P. augusta* snails in the 6 capture-recapture plots on the Mt. Augusta ridgeline (Figure 2) indicate that snails in all plots are in good condition. Gruner et al. (2021) concluded that although results from capture-recapture monitoring are inconclusive, due to wide confidence intervals around population estimates, changes in the size structure in plot populations indicate that populations in 3 plots (Site A High, West 3 and R6 VDT) might be stable or recovering.

[redacted]

Figure 2. Locations of 6 capture-recapture plots for monitoring *P. augusta* snails on the Mt. Augusta ridgeline on a 2016 aerial image.

Results from Capture-recapture Plots for P. patrickensis Snails

Results from annual capture-recapture surveys in the two plots near Mt. Frederick (Figure 3) show that during 6-year (2009–10 to 2014–15) and 4-year (2011–12 to 2014–15) monitoring periods, there were only minor fluctuations in plot population estimates (Lloyd, 2023; MacKenzie, 2014) with plot population estimates from the first and last survey sessions not statistically significant.

[redacted]

Figure 3. Locations of 2 capture-recapture plots for monitoring *P. patrickensis* snails near Mt. Frederick on a 2016 aerial image.

The two capture-recapture plots at McCabe's laydown area are especially exposed to dust from mine related activities as they are surrounded by vehicle tracks and a wider disturbance area with vehicle activity within a few meters of the plots (Figure 4), but there is no indication that snail populations in the two plots are being affected by dust. Difference among population estimates from the Strip 7 plot one year and four years after transfer by VDT were not significant (Lloyd, 2024b). The density estimate from capture-recapture survey in the plot in red tussock during 2024 was higher than the average density estimate for two capture-recapture plots in undisturbed habitat on Denniston Plateau during 2024 (Lloyd, 2024a), and within the range of density estimates from four plots in undisturbed habitat on Stockton Plateau surveyed during summer 2020–21 (Lloyd, 2023).

[redacted]

Figure 4. Locations of 2 capture-recapture plots for monitoring *P. patrickensis* snails at Mcabe's laydown area on a 2021aerial image.

Conclusion

Although it is not possible to make a definitive statement about how dust from mine related activities affects *Powelliphanta* snails, results from long-term capture-recapture monitoring of *Powelliphanta* snail populations in 10 capture-recapture plots close to disturbed areas likely to be sources for dust show that snail populations persist in all 10 plots despite exposure to dust from mine related activities. Thus, despite the ten plots' proximity to disturbance areas, there is no evidence that snail populations in any of the plots have suffered adverse effects from dust originating in the disturbance areas.

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