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Environmental Consultants





August 2026

Buller Plateaux Continuation Project
Wildlife Act Authorisation Technical Report

Prepared for Bathurst Resources Limited

water fauna flora land

Quality Assurance

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1.0 Introduction

Bathurst Resources Limited (including its subsidiary companies BT Mining Ltd, Bathurst Coal Ltd, and Buller Coal Ltd) (collectively referred to here as 'Bathurst') are seeking Wildlife Act Authorisation (WAA) through the Fast-track Approvals Act 2024 ('FTAA') for the Buller Plateaux Continuation Project ('BPCP', or the 'Project'). A WAA is being sought for the following five Project sub-areas:

- Stockton (including the Ngakawau Coal Handling Facility and Aerial Ropeway, 'Stockton');
- Mount Frederick South ('MFS');
- Escarpment Extended ('ESE');
- Upper Waimangaroa Haul Road ('UWHR'); and
- Cypress Mining Area ('Cypress').

For the purpose of this technical report, these areas are collectively referred to as the 'Project sub-areas'.

A WAA as defined in Clause 1 of Schedule 7 can be applied for under Section 42(4)(h) of the FTAA. As part of the FTAA, a stand-alone report is required under Schedule 7 to seek authorisation to survey, capture, handle and translocate protected wildlife (i.e. bird, lizard and specified invertebrate species) under the Wildlife Act (1953).

Ecological Solutions Ltd have been asked to provide this technical report in support of the WAA application covering all fauna management activities proposed to occur within the footprint of the Project sub-areas, as well as incidental killing or disturbance of protected wildlife during works.

The following sections of this report have been arranged to address the specific requirements outlined in Schedule 7 Clause 2(1) of the FTAA as laid in Section 2.0 below.

2.0 Information Requirements

The following information is required for the application to obtain a 'wildlife approval' (where 'wildlife approval' means a lawful authority for an act or omission that would otherwise be an offence under the Wildlife Act 1953) as set out in Clause 2(1) of Schedule 7 of the FTAA:

(1) For the purposes of section 43(3)(h), application for a wildlife approval must—

> *(a) specify the purpose of the proposed activity:*
>
> *(b) identify the actions the applicant wishes to carry out involving protected wildlife and where they will be carried out (whether on or off public conservation land):*
>
> *(c) include an assessment of the activity and its impacts against the purpose of the Wildlife Act 1953:*
>
> *(d) list protected wildlife species known or predicted to be in the area and, where possible, the numbers of wildlife present and numbers likely to be impacted:*
>
> *(e) outline impacts on threatened, data deficient, and at-risk wildlife species (as defined in the New Zealand Threat Classification System):*
>
> *(f) state how the methods proposed to be used to conduct the actions specified*

under paragraph (b) will ensure that best practice standards are met:

(g) describe the methods to be used to safely, efficiently, and humanely catch, hold, or kill the animals and identify relevant animal ethics processes:

(h) state the location or locations in which the activity will be carried out, including a map (and GPS co-ordinates if available):

(i) state whether authorisation is sought to temporarily hold or relocate wildlife:

(j) list all actual and potential wildlife effects (adverse or positive) of the proposed activity, including effects on the target species, other indigenous species, and the ecosystems at the site:

(k) where adverse effects are identified, state what methods will be used to avoid and minimise those effects, and any offsetting or compensation proposed to address unmitigated adverse effects (including steps taken before the project begins, such as surveying, salvaging, and relocating protected wildlife):

(l) state whether the applicant or any company director, trustee, partner, or anyone else involved with the application has been convicted of any offence under the Wildlife Act 1953:

(m) state whether the applicant or any of the company director, trustee, partner, or anyone else involved with the application has any current criminal charges under the Wildlife Act 1953 pending before a court:

(n) provide proof and details of all consultation, including with hapū or iwi, on the application specific to wildlife impacts:

(o) provide any additional written expert views, advice, or opinions the applicant has obtained concerning their proposal.

3.0 Purpose of the Proposed Activity

(a) Specify the purpose of the proposed activity:

Bathurst proposes to continue mining operations on the Buller Plateaux for a further 25 years as part of the BPCP. The purpose of the BPCP is to obtain the necessary approvals to enable the ongoing use of the existing infrastructure and mining operations and provide access to additional coal mining areas across the Buller Plateaux. Management of wildlife forms part of the mitigation and remediation activities integral to the Project.

4.0 Actions to be Carried Out

(b) Identify the actions the applicant wishes to carry out involving protected wildlife and where they will be carried out (whether on or off public conservation land):

Mining is proposed to be by conventional drill and blast, load and haul open pit mining and would be a 24/7 operation using existing coal handling infrastructure. The actions to be carried out involving protected wildlife will include vegetation clearance and habitat removal within the Project sub-areas to access coal reserves. The Project sub-areas are located on a combination of Public Conservation, LINZ, Buller District Council, and private (BRL titled) lands as outlined in the BPCP Project description (Bathurst Resources Limited 2026f).

Each of the Project sub-areas and the activities involved at each location are set out in more detail in the Assessment of Environmental Effects accompanying the application (Mitchell Daysh Limited 2026). A brief summary of mining activities is also found in Section 1.1.2 of the Terrestrial Ecological Impact Assessment Report (Ecological Solutions Limited 2026a).

Specific species management measures to be implemented as mining proceeds are outlined in site- and species-specific management plans (Bathurst Resources Limited 2026) and have been designed to reduce the direct effects of mining on protected wildlife.

Specific actions relating to protected wildlife will include:

- Catch alive and liberate on site individuals of *Powelliphanta patrickensis*, *Powelliphanta augusta*, *Naultinus tuberculatus*, *Mokopirirakau granulatus* and *Oligosoma* aff. *newmanii* Buller for the purpose of salvage/relocation.
- Incidentally kill the species listed above that could not be salvaged or deterred/relocated.
- Collect *Powelliphanta* snail shells from monitoring plots for identification by the Department of Conservation (DOC) of the cause of mortality.
- Take somatic samples from the lizard species listed above for genetic testing
- Searching, capture and handling and permanent marking of the land snail *Powelliphanta patrickensis* for the purposes of snail salvage, relocation[1] (including relocation of salvaged snails and movement of snails as part of vegetation direct transfer (VDT)), and monitoring in accordance with the Powelliphanta Management Plan (BPCP-ENV-PLN-004).
- Surveying, capture, handling, banding and application of radio transmitters to roroa (great spotted kiwi, *Apteryx maxima*) for the purposes of monitoring, territory mapping and managing roroa in accordance with the Avifauna Management Plan (BPCP-ENV-PLN-003). This includes:
    - Capture and handling of roroa with the assistance of conservation dogs prior to disturbance due to mining activities and for the purposes of monitoring and/or health checks.
    - Disturbance of roroa when at risk of direct harm (‘shepherding’ out of harm’s way).
    - Translocate roroa when at risk of direct harm due to habitat loss.
    - Uplift eggs and chicks for Operation Nest Egg when at risk of direct harm.
    - Take pin feathers from roroa as samples for genetic testing.
- Disturbance of indigenous birds during the breeding season to encourage them to nest outside areas destined for vegetation clearance in accordance with the Avifauna Management Plan (BPCP-ENV-PLN-003)).
- Capture, handling and translocation of kakaruai (South Island robin, *Petroica australis australis*) and mātātā (South Island fernbird, *Poodytes punctatus punctatus*) in accordance with the Avifauna Management Plan (BPCP-ENV-PLN-003)).
- Capture, handling, banding, application of radio transmitters and translocation of western weka (*Gallirallus australis australis*) from inside pest exclusion fenced in accordance with the Avifauna Management Plan (BPCP-ENV-PLN-003)).

[1] In this context, relocation refers to moving an animal a short distance to nearby suitable habitat, for example relocation of snails via VDT or salvage and removal to nearby predator exclusion fenced areas. Translocation refers to a long-distance relocation of animals that have larger home ranges, for example translocation of weka from within the predator exclusion fenced areas to the Blackburn Pakihi or translocation of roroa that have a high proportion of their habitat removed to a suitable site elsewhere (to be determined in consultation with the Department of Conservation and Ngāti Waewae).

- Capture, handling, application of radio transmitters and translocation (including as part of VDT) of West Coast green gecko *(Naultinus tuberculatus),* forest gecko *(Mokopiriakau granulatus)* and Newman's speckled skink *(Oligosoma* aff. *newmanii* "Westland"*)* in accordance with the Lizard Management Plan (BPCP-ENV-PLN-005)).
- Handling, capture, and translocation (including via vegetation direct transfer (VDT)) of any Helms's stag beetle *(Geodorcus helmsi)* incidentally encountered during the works. Note that no Helm's stag beetle have been detected in the Project sub-areas, but the area is within their known distribution and there are historic records.
- Incidental killing or disturbance of protected wildlife where the protected wildlife cannot be removed in advance of works .

More details relating to species management actions are set out in the species-specific management plans (Bathurst Resources Limited 2026)

The removal and translocation of western weka from the predator exclusion fenced areas, as set out in the Avifauna Management Plan (BPCP-ENV-PLN-003), is intended to protect *Powelliphanta* snails within the predator exclusion fenced areas from weka predation and assist in enabling an increase in snail abundance within the predator exclusion fenced areas. A sample of relocated weka will be monitored using radio-tracking in order to determine their fate.

All of the above actions as well as the incidental killing of protected wildlife which cannot be removed in advance of vegetation clearance or as part of VDT, will require WAA.

The specific habitats to be removed within the Project Sub-areas are set out in Table 1 below.

Table 1: Extent of vegetation types (i.e. habitats) removed within Disturbance Areas[2] at each Fast Track Project Sub-area.

	Extent of Disturbance (ha)			
	Stockton	**Mount Frederick South**	**Escarpment Extended**	**Upper Waimangaroa Haul Road**
Forest				
Mixed beech-podocarp-broadleaved forest	0.0	0.0	0.4	5.1
Southern rātā-mountain beech-podocarp forest	10.3	25.5	128.8	12.6
Silver beech-mountain beech forest	0.0	5.5	0.0	0.0
Shrubland				
Mānuka-mountain beech-podocarp shrubland	7.8	34	39.5	3.4
Mānuka/Gahnia-wire rush shrubland	0.5	0	8.7	0.0
Shrubland with exotic component	1.1	0	10.5	1.0
Mānuka-tussock-wire rush shrubland	6.0	3.2	88.3	6.7
Mānuka-mountain flax/wire rush shrubland	0.2	2.0	1.5	0.0
Low vegetation				
Low pākihi	2.4	83.4	122.1	5.9
Tussock-mountain flax shrubland	0.0	0.9	0.2	0.5
Exotic grassland	0.0	0.0	0.8	0.0
Non-vegetated land cover				

[2] The disturbance area is based on shapefiles released by Bathurst Resources Limited on 15 October 2025 and excludes the Waimangaroa Storage Area.

Bare Rock	2.1	19.3	41.8	0.4	
Vegetation cleared	1.1	1.6	58.0	9.2	
Water	0.0	0.0	2.1	0.0	
Total	**31.3**	**175.4**	**502.8**	**44.8**	**754.2**

5.0 Impact Assessment

(c) *Include an assessment of the activity and its impacts against the purpose of the Wildlife Act 1953:*

The Wildlife Act 1953 does not have a dedicated purpose statement. However, the Supreme Court has concluded that 'The purpose of the Act is to protect Wildlife' [3].

The actions proposed and described in Section 4.0 of this report are intended to protect wildlife from mortality or physical injury associated with vegetation clearance and other mining activities. Approximately 755 ha of vegetated and non-vegetated habitats are proposed to be cleared in the Project sub-areas. If actions are not taken to avoid and minimise the effects, this vegetation clearance will result in loss of habitat, injury, or death to a range of protected wildlife.

Proposed methods to capture roroa, weka, kakaruai, mātāta, lizards, and *Powelliphanta* are detailed in Section 9.0 of this report and the avifauna, Powelliphanta and lizard management plans for the Project (BPCP-ENV-PLN-003, BPCP-ENV-PLN-004 and BPCP-ENV-PLN-005 respectively). The actual and potential effects of the activity are detailed in Section 12.0 and measures to manage the identified effects are detailed in Section 13.0.

Wildlife will also be affected by activities associated with rehabilitation and residual effects management. This includes incidental translocation during VDT of any snails, Helms's stag beetles or lizards and capture and handling of weka to remove them from the pest proof exclosures. The capture and handling of weka will be done in accordance with the measures outlined in the Avifauna Management Plan (BPCP-ENV-PLN-003) in order to minimise adverse effects. This will also improve the survival and productivity of *Powelliphanta patrickensis* within these exclosures by releasing them from weka predation.

With Bathurst's implementation of the management measures detailed below, adverse effects on protected wildlife will be avoided to the extent practicable. Any temporary effects of capture and translocation of individuals will be minimal, but would include social disruption and increased competition for individuals that are relocated and individuals already resident in translocation areas.

6.0 Protected Wildlife

(d) *list protected wildlife species known or predicted to be in the area and, where possible, the numbers of wildlife present and numbers likely to be impacted:*

6.1 Species Known or Predicted in the Area

In total 28 species of birds, three species of lizard and two invertebrates that are specified within Schedules 1 – 5 of the Wildlife Act 1953, and are therefore either partially or absolutely protected, are known or predicted to be present in the project area. These species are set out

[3] Shark Experience Limited v Pauamac5 Incorporated [2019] NZSC 111 [11 October 2019] at paragraph 66

in the Terrestrial Ecological Impact Assessment (Ecological Solutions Limited 2026a).

It is impractical to manage specific effects on all bird species confirmed, known or predicted to be present within the BPCP during mining. Methods to reduce effects of vegetation clearance on birds are set out in the Avifauna Management Plan (BPCP-ENV-PLN-003) and include timing of vegetation clearance and use of deterrents to discourage birds from nesting in vegetation about to be cleared.

There are 16 protected wildlife species of conservation concern that are known or predicted to be within the Buller Plateaux as shown in Table 2.

Table 2: 'Threatened' and 'At Risk' wildlife species that are known or predicted to be present within the Project Sub-areas.

Species	Conservation Status	Conservation status qualifiers	Presence
Avifauna	**Robertson et al. 2021**		
Apteryx maxima (Great spotted kiwi/roroa)	Threatened – Nationally Vulnerable	Conservation Dependent Recruitment Failure	Known resident
Poodytes punctatus (South Island fernbird/mātātā)	At Risk – Declining	Climate Impact Data Poor Size Data Poor Trend	Known resident
Anthus novaeseelandiae (New Zealand pipit)	At Risk – Declining	Climate Impact Conservation Research Needed	Known resident
Petroica australis (South Island robin)	At Risk – Declining	Conservation Dependent Climate Impact Data Poor Trend	Known resident
Cyanoramphus auriceps (Yellow-crowned parakeet/Kakariki)	At Risk – Declining	Climate Impact Conservation Research Needed Data Poor Size Data Poor Trend Extreme Fluctuations	Known resident
Nestor notabilis (Kea)	Threatened – Nationally Endangered	Conservation Dependent Climate Impact Conservation research Needed	Known visitor
Falco novaeseelandiae ferox (New Zealand bush falcon)	Threatened – Nationally Increasing	Conservation Research Needed Increasing	Known resident
Phalacrocorax carbo novaehollandiae (Black shag)	At Risk - Relict	Biologically Sparse Conservation Research Needed Data Poor: Size Data Poor: Trend Secure Overseas	Known resident
Microcarbo melanoleucos brevirostris (Little shag)	At Risk – Relict	Conservation Research Needed Data Poor: Trend	Predicted

Eudynamys taitensis (Long-tailed cuckoo)	Threatened – Nationally Vulnerable	Climate Impact Conservation Research Needed Data Poor: Trend	Known seasonal resident
Charadrius bicinctus bicinctus (Banded Dotterel)	At Risk - Declining	Climate Impact Conservation Dependent Conservation Research Needed Data Poor: Size Partial Decline	Known visitor
Lizards	**Hitchmough et al. 2026**		
Oligosoma aff. *newmani* "Westland" (Newman's speckled skink)	Threatened – Nationally Vulnerable	Climate Impact Conservation Dependent Partial Decline Sparse	Known resident
Naultinus tuberculatus (West Coast green gecko)	Threatened – Nationally Vulnerable	Climate Impact Data Poor Size Data Poor Trend Sparse	Known resident
Mokopirirakau granulatus (Forest gecko)	At Risk – Declining	Climate Impact Conservation Research Needed Data Poor Trend Partial Decline Population Fragmentation	Known resident
Terrestrial Invertebrates			
Powelliphanta patrickensis	Threatened – Nationally Critical Walker et al. 2024	Conservation Dependent Climate Impact One Location	Known resident
Powelliphanta augusta	Threatened – Nationally Critical Walker et al. 2024	Conservation Dependent Climate Impact One Location	Known resident
Geodorcus helmsi (Helms's Stag beetle)	No status recorded in Leschen et al. 2012		Predicted

Of the birds listed in Table 2, New Zealand pipit, New Zealand falcon, kea, black shag, little shag and banded dotterel would not be substantially affected by the proposal. Specific management of roroa, South Island fernbird and South Island robin is proposed. Specific management of the three lizard species and *Powelliphanta* snails is also proposed, along with management of any Helms's stag beetles incidentally discovered or inadvertently transferred with VDT. No species-specific management of yellow crowned kakariki or long-tailed cuckoo is proposed and protection of those species would rely on the methods set out in the Avifauna Management Plan (BPCP-ENV-PLN-003)). In addition to the species set out in Table 2, specific management of western weka is proposed in relation to their removal from the predator exclusion fenced areas to reduce predation on *P. patrickensis*. More detail in relation to the management actions proposed is set out below.

6.2 Avifauna

Great spotted kiwi / roroa

Roroa are present in low densities across the Buller Plateaux and the population has been stable for several decades (McLennan 2020, Toy et al. 2021). Monitoring of roroa at the Buller Plateaux began in 1993 and has used call count monitoring, radio tracking, call mapping and use of trained conservation dogs. The results of these surveys are summarised by McLennan (2020).

More recently, a 2022 survey of roroa calls at the ESE sub-area recorded low-moderate numbers of calls. The survey area also included the western extent of the UWHR Sub-area (Nichol 2022). In the absence of survey data along the full UWHR route, roroa are expected to be present throughout that sub-area. A 2024 survey using acoustic recorders at the MFS sub-area recorded roroa on all 12 recorders deployed. These results also confirmed the presence of roroa near the current boundary of Stockton Mine, in previously rehabilitated areas (Stewart 2024). The population of roroa at the Cypress sub-area has been monitored using trained kiwi dog surveys, night listening surveys and capture and monitoring since 1997 (McLennan 1998). The pre-mining survey in 1997 identified ten birds (four pairs and two males) in or near the proposed disturbance areas of the Cypress North and South Pits. Surveys and telemetry-based monitoring undertaken in April and May 2010, identified and tracked ten birds (five pairs) whose territories overlapped the Cypress Mine footprint (McLennan 2010, McLennan 2011). Mining commenced in the Cypress mining area in 2014, by which time little change in territory distribution and size had been detected, with one pair's range partially overlapping the planned clearance areas. Monitoring and transmitter replacement then focused on this pair (2015–16). By 2022, monitoring (including by telemetry) showed five individual rōroa had home ranges within or near the Cypress South Pit. As at summer 2025, there were at least 11 individual rōroa (seven males and four females) within the Cypress sub-area indicating that numbers have been relatively stable since 1997. This suggests residents can adapt to habitat removal due to mining.

Further details on roroa distribution can be found in the relevant Project Sub-area reports (appendices of Ecological Solutions Limited 2026a) and Ecological Solutions Limited (2026b).

Other avifauna

‘Threatened’ and ‘At Risk’ avifauna species that are confirmed to be or possibly occur within the Project sub-areas are detailed in Table 2. Apart from roroa (discussed above), there are ten other ‘Threatened’ or ‘At Risk’ species. Five-minute bird counts (5MBC) performed by Ecological Solutions Limited (2026a) recorded long-tailed cuckoo, New Zealand bush falcon, South Island fernbird, South Island robin and yellow crowned parakeet within ESE. South Island robin was also detected at MFS and Cypress in 5MBC by Nichol (2020). New Zealand pipit has been detected at all the Project sub-areas (Ecological Solutions Limited 2026a, Nichol 2020). As well as ESE, South Island fernbird has been detected at Stockton, UWHR and Cypress sub-areas. Kea was detected by acoustic recorders within the MFS sub-area (see Ecological Solutions Limited 2026a Appendix D). Further details with respect to these avifauna detections can be found in the relevant Project sub-area baseline surveys provided as appendices to Ecological Solutions Limited 2026a.

Black shag and little shag have been sporadically recorded across the Buller Plateaux (Buckingham 1998, Overmars et al., 1998, Thomas & Toft 1997, Thomas et al. 1997, G. Bramley pers. obs. 2011), including black shags using constructed tarns at Stockton Mine (M Lambert unpubl. data 2024). Banded dotterel have been observed on the Denniston Plateau (Buckingham, 2011) and at Stockton Mine including near the Bathhouse and at Mt Frederick (M Lambert pers. comm., G Bramley pers. obs.). Given their mobility and use of rehabilitated sites and constructed water features, it is considered unlikely these species will require active management.

Seventeen species of native birds which are considered 'Not Threatened' and have been recorded within the Project sub-areas include: western weka, grey warbler/riroriro (*Gerygone igata*), New Zealand bellbird (*Anthornis melanura*), silvereye (*Zosterops lateralis*), tomtit (*Petroica macrocephala*), tui (*Prosthemadera novaeseelandiae*), New Zealand fantail (*Rhipidura fuliginosa*), Swamp harrier (*Circus approximans*), morepork/ruru (*Ninox novaeseelandiae*), mallard x grey duck hybrid (*Anas platyrhynchos* x *superciliosa*), spur-winged plover (*Vanellus miles*), pied stilt (*Himantopus leucocephalus*), welcome swallow (*Hirundo neoxena*), kererū (*Hemiphaga novaeseelandiae*), pīpipi (*Mohoua novaeseelandiae*), Southern black-backed gull/karoro (*Larus dominicanus*), and paradise shelduck/pūtangitangi (*Tadorna variegata*).

Other 'Threatened' and 'At Risk' species recorded include South Island pied oystercatcher (*Haematopus finschi*) (At Risk – Declining), kākā (Nestor *meridionalis*) (At Risk – Recovering) and New Zealand grey duck/pārera (*Anas superciliosa*) (Threatened – Nationally Vulnerable). However, these are considered to be occasional visitors to the Buller Plateaux and are unlikely to be affected by the proposed activities.

6.3 Lizards

Three species of native lizards have been recorded within the Project sub-areas: West Coast green gecko (*Naultinus tuberculatus*) (Threatened – Nationally Vulnerable), Forest gecko (*Mokopirirakau granulatus*) (At Risk – Declining) and Newman's speckled skink (*Oligosoma* aff. n*ewmani* "Westland") (Threatened – Nationally Vulnerable). Surveys within and immediately around the ESE sub-area and Cypress sub-area have confirmed the presence of West Coast green gecko and forest gecko at those locations with Newman's speckled skinks also present at ESE. All three species are almost certainly present in all the Project sub-areas. The highest value lizard habitats in the Project sub-areas were those with high topographical diversity such as forested gullies surrounded by sandstone pavement and pākihi (Alliance Ecology 2024).

6.4 Terrestrial Invertebrates

The 'Threatened – Nationally Critical' *Powelliphanta patrickensis* snail occupies a range of between 3,500ha and 5,000ha, on or near the Buller Plateaux, including habitats within all the Project sub-areas.

The 'Threatened – Nationally Critical' *Powelliphanta augusta* snail occupies a range immediately near the former peak of Mt Augustus. The Project includes building a predator exclusion fenced area around this habitat to protect resident *P. augusta*. On that basis, salvage and relocation, as well as incidental killing of snails that cannot be salvaged, may be required during fence construction.

Helms's stag beetle have also been recorded on the Buller Plateaux (Sherley et al. 1994) and would also be affected by vegetation clearance if present. No Helms's stag beetles have been collected in pit fall trap surveys throughout the Project sub-areas, and we could find no other recent records, but their presence cannot be ruled out.

7.0 Impacts on Threatened, Data Deficient and At-Risk Species

(e) outline impacts on threatened, data deficient, and at-risk wildlife species (as defined in

the New Zealand Threat Classification System):

7.1 Threatened Wildlife Species

Impacts on protected wildlife are set out in Section 5.0. There are five 'Threatened' species which would be affected:

- *Powelliphanta patrickensis*;
- *Powelliphanta augusta*
- Roroa
- West Coast green gecko

Powelliphanta patrickensis ('Threatened – Nationally Critical') are known to be present across the Buller Plateaux. The range of this species is restricted to coal measures vegetation which includes the Denniston and Stockton Plateaux and immediate surrounds.

Powelliphanta augusta ('Threatened – Nationally Critical') were known to occur naturally across c. 8.5ha along the Mount Augustus ridgeline of the Stockton Plateau. The remaining natural habitat comprises c. 3ha near the former peak of Mt Augustus. Individuals of *P. augusta* have also been relocated to a small number of sites nearby (e.g. Mt Rochfort). The Project would construct a predator exclusion fenced area which would include all the remaining natural habitat of *P. augusta*.

Roroa ('Threatened – Nationally Vulnerable') are known to be present in low densities across the Buller Plateaux including all the Project sub-areas. Vegetation clearance within the Project sub-areas will affect roroa with territories that overlap the disturbance areas and at least their immediate neighbours. Radio tracking within Cypress sub-area has confirmed that residents with part of their home range removed by mining naturally adjust and reconfigure their home range in response. Whilst this likely carries a cost, such birds have gone on to successfully breed despite mining removing part of their home range (Bathurst Resources Limited 2023).

West Coast green gecko ('Threatened – Nationally Vulnerable') are present across the Buller Plateaux, occupying a range of habitats. They have been recorded in the ESE sub-area and near the Cypress sub-area and are possibly present in other sub-areas given the range of forest and shrubland habitats.

Impacts on Threatened species (excluding *P. augusta*) include:

- Habitat loss, fragmentation, degradation and general disturbance through vegetation clearance and earthworks including the deposition of overburden.
- Habitat fragmentation for the range-restricted and poorly mobile *P. patrickensis* could result in increased demographic stochasticity and reduced genetic variation.
- Direct mortality or injury that may be caused during vegetation clearance or earthworks activities.
- The creation of habitat edge effects, altering the composition and health of adjacent vegetation (i.e. habitat degradation), which may affect habitat suitability.
- Disturbance associated with noise, dust, lighting, and vibration from mining activities.

Effects on *P. augusta* include:

- Potential for mortality due to construction of the predator exclusion fenced area.
- Overall, the effects of the predator exclusion fenced area is expected to be positive for the *P. augusta* population due to the decrease in predation by rats and weka.

7.2 At Risk Wildlife Species

Impacts on protected wildlife are set out in Section 5.0. Four bird species and two lizard species which inhabit the Project Sub-areas where vegetation clearance will occur to enable mining are considered to be 'At Risk – Declining' including:

- Fernbird;
- South Island Robin;
- New Zealand pipit;
- Yellow-crowned parakeet;
- Forest gecko;
- Newman's speckled skink.

The impacts on these 'At Risk' species are similar to the effects on 'Threatened' species and include:

- Habitat loss, fragmentation, degradation and general disturbance through vegetation clearance and earthworks including the deposition of overburden.
- Direct mortality or injury that may be caused during vegetation clearance or earthworks activities.
- The creation of habitat edge effects, altering the composition and health of adjacent vegetation (i.e. habitat degradation), which may affect habitat suitability.
- Disturbance associated with noise, dust, lighting, and vibration from mining activities.

7.3 Data Deficient Species

There are no Data Deficient species (that are protected under the Wildlife Act 1953) known to be present within the Project sub-areas.

8.0 Meeting Best Practice Standards

(f) state how the methods proposed to be used to conduct the actions specified under paragraph (b) will ensure that best practice standards are met:

The management plans which accompany the Project application have been prepared in accordance with available best practice guidance as well as consultation with the Department of Conservation and local iwi. The plans will be updated as required, for example if new best practice standards are developed or new information with respect to the managed species becomes available.

Species management in accordance with site- and species-specific management plans intended to reduce the effects of mining on wildlife will be implemented. The best practice standards listed below will be adhered to, are incorporated within the relevant species management plans where relevant and will be updated as required:

- Key principles for lizard salvage and transfer in New Zealand (Department of Conservation 2019);
- Kiwi Best Practice Manual (Robertson et al. 2020);
- DOCCM-5597576 Birds: kiwi territory mapping v1.0 (Robertson 2018)
- Best practice techniques for the translocation of North Island robins (*Petroica longipes*),

South Island robins (*P. australis australis*) and Stewart Island robins (*P. a. rakiura*) (Collen et al. 2014); and

- Techniques used to translocate North Island fernbirds to Tiritiri Matangi island described by Parker (2002).

There are no current best practice standards for handling or otherwise managing *P. patrickensis*. The methods proposed here are informed by the Powelliphanta Management Plan (BPCP-ENV-PLN-004) which draws on experience and expertise in snail management across the Buller Plateaux.

Similarly, no best practice standards exist for weka handling and translocation. The methods specified here are informed by experience in capturing and relocating North Island weka, methods used for the transfer of fernbird to Tiritiri Matangi described by Parker (2002) and best practice methods described for North Island robins (Collen et al. 2014) and roroa (Robertson et al. 2020).

9.0 Methods to Catch, Hold or Kill

(g) describe the methods to be used to safely, efficiently, and humanely catch, hold, or kill the animals and identify relevant animal ethics processes:

9.1 Summary

Methods to catch, hold or kill (via humane euthanasia) animals for the Project are detailed in the respective management plans for each species as set out in Section 4.0. Summaries of the methods and protocols for each protected species are provided below. When handling wildlife, the animal welfare provisions of the Animal Welfare Act 1999 and its welfare codes (e.g., transport within New Zealand, frequency of trap checking) will be met.

9.2 Great spotted kiwi / roroa

BT Mining, which operates Stockton Mine has been implementing management of roroa since prior to mining commencing at Cypress Mining Area in c. 2016.

The capture, handling and radio tagging of roroa to monitor their habitat use, map territories and determine which birds, if any, will need to be 'shepherded' on prior to vegetation clearance or translocated for their own protection, will be undertaken following the Kiwi Best Practice Manual (Robertson et al. 2020) as detailed in the Avifauna Management Plan (BPCP-ENV-PLN-003). Birds will be marked with bands and/or transponders as well as radio transmitters in order to enable individual identification and minimise future handling. A sample of at least 50% of the adult birds able to be captured (at least one individual in each pair) and a sample of juvenile birds will be fitted with radio-transmitters in order to follow their movements. The capture and handling process aims to minimise stress and ensure the welfare of the birds throughout capture, handling, tagging, and release. Cultural practices, such as karakia, are also integrated into the process to respect Māori values and bird welfare.

While health screening is only mandatory for translocations beyond local ecological districts, birds showing signs of illness will be recorded and tracked, both for their welfare and to monitor any potential disease transmission.

Capture and handling are restricted to accredited handlers and trained personnel. Strict hygiene protocols are enforced, including equipment sterilization and single-use bird bags. Detailed data will be recorded for each bird, including physical morphometrics and photographs.

9.3 Weka

There is no specific guidance for the translocation of weka; consequently, the translocation process will adopt methods set out in the Kiwi Best Practice Manual (Robertson et al. 2020) as detailed in the Avifauna Management Plan (BPCP-ENV-PLN-003). The process aims to minimise stress and ensure the welfare of the birds throughout capture, handling, transport, and release. Prior to the completion of weka-proof fences and establishment of trapping, as many weka as possible will be shepherded out to minimise the amount of weka left to trap. Shepherding will be done using a systematic grid search method, where a line of people move from the farthest area of the fenced area towards the gate with the aim of moving any weka out and towards the gate. After this, trapping can commence using methods outlined in the below sections. If trapping fails to remove all weka from the weka-proof fenced areas, removal via poisoning may have to occur. Birds to be translocated from the predator exclusion fenced areas will be caught prior to any toxin operation to remove rodents and prior to any translocation of lizards and *P. patrickensis* into the predator exclusion fenced areas. Although it is proposed to relocate pairs together where possible in order to reduce disruption, they often do not maintain bonds after release.

Health screening is only mandatory for translocations beyond local ecological districts since local movements mimic natural dispersal patterns. However, birds showing signs of illness will not be moved, both for their welfare and to avoid disease transmission. Birds will be marked with bands to enable individual identification and minimize future handling and will not be held more than 24 hours following capture without feeding. A sample of at least 30 and no more than 50 weka, including adults and juveniles, will be fitted with radio-transmitters at any one time in order to follow their movements post release. Cultural practices, such as karakia, are also integrated into the process to respect Māori values and bird welfare.

Weka will be captured using live capture cage traps, which have been selected for their ability to safely capture an animal without causing harm. Once traps are armed, they will be checked at least twice daily or at a minimum within 12 hours from sunrise (as necessitated under the Animal Welfare Act 1999). Capture and handling are restricted to accredited handlers and trained personnel. Strict hygiene protocols will be enforced, including equipment sterilization and single-use bird bags. Detailed data will be recorded for each bird, including physical measurements and photographs. Transport boxes must comply with Department of Conservation standards, and only one bird will be housed per compartment to avoid injury or heat stress. Canvas bags may be used in rugged terrain, with regular ventilation.

Release locations will be within habitats undergoing pest control that are not at carrying capacity for weka, and that are not strongholds for *Powelliphanta* snails. Transport will typically be by vehicle or helicopter, with birds kept cool and secure to avoid stress or injury. Vehicles must be well-ventilated and enclosed car boots will not be used for transport. Driving should balance safety and efficiency, with gentle handling on rough roads. Finally, birds will be released near areas with shelter/cover. Known pairs can be released near each other, although pair bonds often dissolve.

9.4 South Island robin/South Island fernbird

Any capture and translocation programme for kakaruwai /South Island robin and/or mātatā/South Island fernbird will be undertaken in accordance with the best practice techniques for the translocation of kakaruwai/robins (Collen et al. 2014) and the methods detailed in Parker (2002) as detailed in the Avifauna Management Plan (BPCP-ENV-PLN-003). The process aims to minimise stress and ensure the welfare of the birds throughout capture, handling, transport, and release.

Translocation sites will be within the proposed Buller Plateaux predator exclusion fenced areas in the first instance. There are four separate predator exclusion fenced areas to be built in a staged manner to coincide with mine disturbance and construction activities. Details of each predator exclusion fenced area are outlined in the Pest Control Plan (BPCP-ENV-PLN-022).

The team of ecologists undertaking the capture and relocation will be led by the Project Ornithologist(s) and supported by ecologists that are suitably qualified and experienced in the capture, handling, holding and release techniques to be used.

9.5 Lizards

The lizard search and capture methodology, translocation and monitoring process is detailed in the Lizard Management Plan (BPCP-ENV-PLN-005) which follows the key principles for lizard salvage and transfer in New Zealand (Department of Conservation 2019). Lizards will be captured and handled only by trained personnel under the supervision of the Project Herpetologist or suitably trained ecologists, using sterilised equipment and proper hygiene practices between each capture. Key data such as species, sex, age class, measurements, reproductive status, and photographs will be recorded. For transport, lizards will be placed in ventilated containers with natural materials from the capture site and kept at ambient temperature for no longer than four hours.

Lizards will be released within the pest exclusion fenced areas in the first instance into suitable habitat at least 20 metres apart, unless found together. Radio tags will be applied to up to 100 lizards to assist in monitoring translocation success and habitat use. Details of the release, including species, time, GPS location, and habitat type, will be documented.

9.6 *Powelliphanta patrickensis*

9.6.1 Information Requirements

Snails will be released into the predator exclusion fenced areas to maximise the likelihood of survival and ensure that no area which has received snails will be mined or disturbed in the future. In order to minimise unnatural genetic mixing, release sites will be located as close as possible to the source location. The location of the destination areas and numbers of *Powelliphanta* to be transferred to each destination area will be agreed in advance with the Department of Conservation based on the following information:

- Habitat quality at proposed destination areas.
- Abundance and genetic composition of the snail population already at proposed destination areas.
- Genetic composition of the snail populations at the various source areas.

This information will be available before any *Powelliphanta* are collected. Searching and monitoring techniques will follow those generally suggested in Walker (1997) but will preferentially target the most likely snail habitats within search areas and occur under favourable searching conditions, even if those occur up to three months before vegetation clearance is to occur.

9.6.2 Search method

Searches will involve moving aside vegetation, shifting leaf litter, checking the bases of flax, Gahnia and tussocks, feeling for *Powelliphanta* in logs, and root cavities (anything bigger than about 15 cm diameter) and amongst moss, and sorting through overhanging and ground-hugging vegetation. Previous searches have adopted a diurnal search method at 40 person hours per hectare during any time of year. Investigation of survey results across the Buller Plateaux has revealed that it is more effective to target favourable conditions (i.e., nocturnal searches in warm and wet summer conditions) rather than use previous diurnal search methods (Lloyd 2024). Limited diurnal searching may be used in areas known to have a dense population of snails for the purposes of collecting and salvaging eggs. Nocturnal searches during optimal effective survey conditions of >6˚C air temperature and >75% humidity will be prioritised.

Where *Powelliphanta* are being felt for through and under vegetation, bare hands shall be used in preference. Where conditions dictate, e.g. ground is frozen, rubber gloves or a small stick may be used for brushing aside vegetation and wet litter. All searching shall minimise damage to the vegetation cover. At the completion of the search all the litter and vegetation that has been pushed aside shall be carefully returned to its origin. Travel through search areas shall minimise trampling by such means as avoiding standing on sensitive vegetation and where the option exists, walking on bare rock surfaces.

9.6.3 Handling method

All *Powelliphanta* will be handled carefully by experienced snail staff with hands free from contaminants (e.g. fuel). Handling shall be kept to an absolute minimum. Two litre containers with perforated lids that allow airflow, but do not let the animal escape, will be used to transport *Powelliphanta*. The containers shall be clean and contain damp litter 60mm deep (collected from where the snail was located) or wet paper. A maximum of five *Powelliphanta* shall be placed in an upright position (i.e. apex skyward) in each container. The container shall be kept cool at all times. If *Powelliphanta* eggs are found during search efforts, these shall be collected so as to minimise damage, such as using a sterilized teaspoon, and placed in a container as described above. Only one clutch of eggs will be stored in any container.

All live *Powelliphanta* and eggs found will be released as soon as practical following capture, and always on the same day as they were captured, at areas of comparable habitat within the nearest fenced exclosure. The location of the destination sites and numbers of *Powelliphanta* to be transferred to each destination site shall be agreed in advance with the Department of Conservation based on the following information, as available:

- Availability of appropriate snail habitat.
- Abundance and genetic composition of the snail population already at proposed destination sites.
- Genetic composition of the snail populations at the various source areas.

Powelliphanta shall be released individually (i.e. not in clumps) and in an upright position (i.e. apex skyward).

9.6.4 Relocation

As soon as practicable after capture, and in any case within 24 hours of capture, *Powelliphanta* will be moved to the destination site within predator exclusion fenced areas and placed into favourable habitat. Snails will be permanently marked to enable mark – recapture population estimates and monitoring. Searching and handling methods for *Powelliphanta* will follow those outlined in the current Powelliphanta Management Plan (BPCP-ENV-PLN-004) for all Project sub-areas.

9.7 Powelliphanta augusta

9.7.1 Information Requirements

Any snails salvaged from the footprint of the predator exclusion fenced area in advance of fence construction will be released into the predator exclusion fenced area in similar habitat to that where they were found. Snail search and salvage will be undertaken no more than 72 hours prior to vegetation clearance for fence construction.

9.7.2 Search method

Searches will involve moving aside vegetation, shifting leaf litter, checking the bases of flax, Gahnia and tussocks, feeling for *Powelliphanta* in logs, and root cavities (anything bigger than about 15 cm diameter) and amongst moss, and sorting through overhanging and ground-hugging vegetation. Previous searches have adopted a diurnal search method at 40 person hours per hectare during any time of year. Investigation of survey results across the Buller Plateaux has revealed that it is more effective to target favourable conditions (i.e., nocturnal searches in warm and wet summer conditions) rather than use previous diurnal search methods (Lloyd 2024). Diurnal searching may be used immediately (<24 hours) in advance of fence construction. Nocturnal searches during optimal effective survey conditions of >6˚C air temperature and >75% humidity will be prioritised.

Where *Powelliphanta* are being felt for through and under vegetation, bare hands shall be used in preference. Where conditions dictate, e.g. ground is frozen, rubber gloves or a small stick may be used for brushing aside vegetation and wet litter. All searching shall minimise damage to the vegetation cover. At the completion of the search all the litter and vegetation that has been pushed aside shall be carefully returned to its origin. Travel through search areas shall minimise trampling by such means as avoiding standing on sensitive vegetation and where the option exists, walking on bare rock surfaces.

9.7.3 Handling method

All *Powelliphanta* will be handled carefully by experienced snail staff with hands free from contaminants (e.g. fuel). Handling shall be kept to an absolute minimum. Two litre containers with perforated lids that allow airflow, but do not let the animal escape, will be used to transport *Powelliphanta*. The containers shall be clean and contain damp litter 60mm deep (collected from where the snail was located) or wet paper. A maximum of five *Powelliphanta* shall be placed in an upright position (i.e. apex skyward) in each container. The container shall be kept cool at all times. If *Powelliphanta* eggs are found during search efforts, these shall be collected so as to minimise damage, such as using a sterilized teaspoon, and placed in a container as described above. Only one clutch of eggs will be stored in any container.

All live *Powelliphanta* and eggs found will be released as soon as practical following capture, and always on the same day as they were captured, at areas of comparable habitat within the predator fenced exclusion area.

Powelliphanta shall be released individually (i.e. not in clumps) and in an upright position (i.e. apex skyward).

9.8 Personnel to undertake authorised activities

All field staff undertaking authorised activities must be trained and directed by experienced fauna surveyors and handlers approved by the office of the Buller District Operations Manager for the Department of Conservation, located in Westport.

10.0 Proposed Activity Locations

(h) *state the location or locations in which the activity will be carried out, including a map (and GPS co-ordinates if available):*

The five Project sub-areas are situated on the Buller Plateaux, an area which includes the Stockton and Denniston Plateaux and is within the Ngakawau Ecological District and North Westland Ecological Region (McEwen 1984). The consent areas and coordinates are shown below in Figure 1. The total disturbance area within the Project Sub-areas is proposed to cover approximately 754.2 ha[4].

Figure 2 shows the specific location of the predator exclusion fenced areas (where weka would be captured and snails, lizards and potentially mātātā and kakaruai would be relocated to) and the proposed locations of weka releases which are at the edge of the landscape scale pest control proposed as part of the Project and located on public conservation land within the Ngakawau and Orikaka Ecological Areas and the intensive ground control management area at Blackburn Pākihi. The release locations are within the adjoining Ngakawau and Buller Ecological Districts.

[4] The Project area boundary is based on shapefiles released by Bathurst on 4 December 2025.

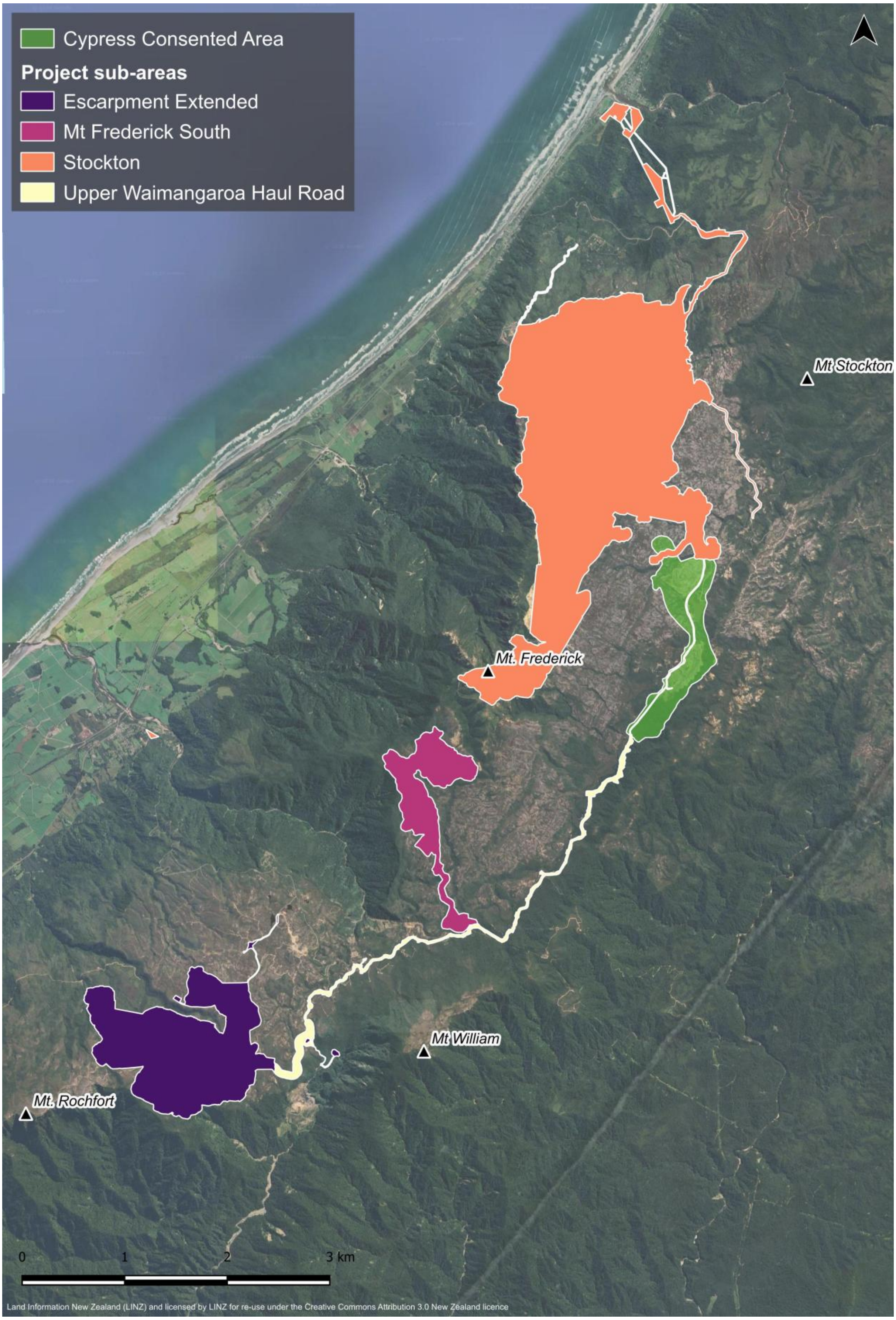

Figure 1: Proposed Activity Locations – Fast Track Sub-areas

[redacted]

Figure 2: Location of pest proof exclosures and weka release locations associated with the Buller Plateau Continuation Project

11.0 Holding or Relocating Wildlife

(i) state whether authorisation is sought to temporarily hold or relocate wildlife:

A Wildlife Act Authorisation will be required to:

- capture, handle and radio tag roroa;
- translocate any roroa that are significantly affected by habitat removal;
- capture, handle, radio tag and translocate weka;
- capture, handle and relocate mātātā (fernbird) and kakaruwai (South Island robins);
- capture, handle, radio tag and relocate (including via VDT) lizards;
- capture, handle, permanently mark and relocate (including via VDT) *Powelliphanta* snails; and
- capture, handle and relocate (including via VDT) any Helms's stag beetles.

The proposed relocation/translocation sites include:

- Rehabilitated sites within the same Project sub-area (with respect to VDT).
- Predator exclusion fenced areas – within the Buller Plateaux.
- Pest Management Area – predator and weed controlled area surrounding and including the Blackburn Pākihi and Buller Plateaux.

A Wildlife Act Authorisation will also be required to disturb wildlife (birds) for the purpose of discouraging nesting in vegetation to be cleared.

A Wildlife Act Authorisation will also be required for incidental killing of individuals of all the above named species which cannot be relocated in advance of works.

12.0 Actual and Potential Effects

(j) list all actual and potential wildlife effects (adverse or positive) of the proposed activity, including effects on the target species, other indigenous species, and the ecosystems at the site:

Potential adverse effects of mining activities may include:

- Loss, fragmentation and degradation of habitat.
- Direct mortality or injury to individuals that may be harmed during vegetation clearance or earthworks activities.
- Temporary effects of capture and relocation/translocation of individuals may include social disruption and increased competition in translocation areas.
- The creation of habitat edge effects, altering the composition and health of adjacent vegetation (i.e. habitat degradation), which may affect habitat suitability for flora and fauna and promote invasion by pest species.
- Disturbance associated with noise, dust, lighting, and vibration from mining activities.

The activities for which these authorisations are sought will protect individuals, reduce the adverse effects of mining and assist in maintaining populations of the 'Threatened' and 'At Risk' species present in the vicinity of the works for the life of mining.

13.0 Methods to Avoid/Minimise Adverse Effects

(k) where adverse effects are identified, state what methods will be used to avoid and minimise those effects, and any offsetting or compensation proposed to address unmitigated adverse effects (including steps taken before the project begins, such as surveying, salvaging, and relocating protected wildlife):

Potential adverse effects have been identified in Section 5.0, Section 7.0 and Section 12.0 of this report. Measures to avoid and minimise these effects are outlined in the relevant management plans as identified in Table 3:

- Powelliphanta Management Plan (BPCP-ENV-PLN-004).
- Avifauna Management Plan (BPCP-ENV-PLN-003).
- Lizard Management Plan (BPCP-ENV-PLN-005).

Other directly relevant management plans intended to reduce or avoid effects on indigenous species and minimise or remediate effects of mining include:

- Weed Management Plan (BPCP-ENV-PLN-008).
- Biosecurity Management Plan (BPCP-ENV-PLN-007).
- Pest Control Plan (BPCP-ENV-PLN-022).
- Rehabilitation Management Plan (BPCP-ENV-PLN-002).

There is no specific management plan for salvage of *P. augusta* but methods will follow the relevant parts of the Powelliphanta Management Plan (BPCP-ENV-PLN-004).

Table 3: Management methods to avoid or minimise effects on 'Threatened' and 'At Risk' protected wildlife.

Species	Methods	Management plan
Roroa	Pre-clearance monitoring, capture and tracking to inform management. Monitoring for the life of mining. Translocation of individuals with a substantial proportion of their home range removed by mining. Salvage of eggs and chicks directly affected by vegetation removal for hand rearing as part of Operation Nest Egg. Handling and management undertaken by suitably qualified and experienced personnel.	BPCP-ENV-PLN-003
South Island robin	Pre-clearance survey, capture and relocation. Handling and management undertaken by suitably qualified and experienced personnel.	BPCP-ENV-PLN-003
Fernbird	Pre-clearance survey, capture and relocation. Handling and management undertaken by suitably qualified and experienced personnel.	BPCP-ENV-PLN-003
Powelliphanta patrickensis / P. augusta	Pre-clearance surveys to salvage snails within affected area. Handling kept to a minimum and carried out by suitably qualified and experienced	BPCP-ENV-PLN-004

	personnel. Snails kept in containers protected from elements and released into favourable habitat within predator exclusion fenced areas as soon practicable after capture, and in any case within 24 hours of capture. Released populations will be monitored by suitably qualified and experienced personnel.	
Lizards	Pre-clearance survey, capture and relocation to suitable habitat within predator exclusion fenced areas outside affected area. Handling and management undertaken by suitably qualified and experienced personnel.	BPCP-ENV-PLN-005

Where residual adverse effects have been identified, a separate assessment and proposal for managing these effects has been prepared by Alliance Ecology (2026).

14.0 Offences and Current Charges

(l) *state whether the applicant or any company director, trustee, partner, or anyone else involved with the application has been convicted of any offence under the Wildlife Act 1953:*

No such convictions have been recorded.

(m) *state whether the applicant or any of the company director, trustee, partner, or anyone else involved with the application has any current criminal charges under the Wildlife Act 1953 pending before a court:*

No such charges are pending.

15.0 Proof of Consultation

(n) *provide proof and details of all consultation, including with hapū or iwi, on the application specific to wildlife impacts:*

A Community and Stakeholder Engagement Report is included with the BPCP FTA application which outlines specific details of iwi engagement on the Project. This includes Bathurst's ongoing engagement with Te Rūnanga o Ngāti Waewae to support the preparation of a Cultural Impact Assessment (CIA), review effects assessments, and guide long-term involvement.

Written notifications of Bathurst's intention to lodge the application, together with an invitation for consultation was provided to Ngāti Apa ki te Rā Tō, Ngāti Tama ki Te Waipounamu Trust, Te Ātiawa o Te Waka-a-Māui Trust, Te Pātaka a Ngāti Kōata, Te Pātaka a Ngāti Kōata, Te Rūnanga o Ngāti Kuia Trust, Te Rūnanga o Ngāti Rārua, Te Rūnanga o Toa Rangatira.Te Rūnanga o Ngāi Tahu (Ngāi Tahu) advised the Fast Track Advisory Group on 24 June 2024 that it supports Ngāti Waewae exercising its rangatiratanga and rights as mana whenua for the BPCP area. Ngāti Waewae has prepared a Cultural Impact Assessment (CIA) to support the application. In the CIA, Ngāti Waewae outlined that as they were representing the interests of iwi with ancestral connections, mana whenua interests, or other cultural interests that may be affected by the proposed project as it is located within the Ngāi Tahu Kāwatiri takiwā.

The CIA outlines that Ngāti Waewae supports the Buller Plateaux Continuation Project provided that the proposed mitigation, rehabilitation and compensation measures are fully implemented and that meaningful engagement with the rūnanga continues throughout the life of the project. Ngati Waewae have made a request for continued engagement throughout the BPCP project assessment.

Overall, the CIA seeks long-term protection of mana whenua values through active partnership, environmental restoration, cultural monitoring, and Ngāti Waewae participation in project decision-making and implementation.

The FTAA requires consultation to occur with iwi authorities and groups that represent hapū that are parties to Mana Whakahono ā Rohe. The West Coast Regional Council Mana Whakahono ā Rohe, signed in 2020 has representatives from Te Rūnanga o Ngāi Tahu, Te Rūnanga o Ngāti Waewae, and Te Rūnanga o Makaawhio. Of the three iwi authorities that are signatories, only Te Rūnanga o Makaawhio (Makaawhio) was the only relevant iwi authority whose interests had not already been addressed through other consultation processes.

In response to consultation, Makaawhio acknowledges that Buller sits within the Ngāti Waewae takiwā. Makaawhio expressed their support for the BPCP as a means to safeguard employment as well as acknowledging the broader contribution to the regional and national economy. Makaawhio also stated that the area is a valuable environmental asset and mining is to be undertaken in a responsible manner in order to benefit future generations.

16.0 Additional Supporting Documentation

(o) *provide any additional written expert views, advice, or opinions the applicant has obtained concerning their proposal.*

The management plans accompanying the application have been peer reviewed by appropriate experts and their comments are provided with the application.

17.0 References

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Environmental Consultants





April 2026

Assessment of Rehabilitation Outcomes

Submitted to:

Bathurst Resources Limited

Quality Assurance

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Executive Summary

BT Mining Limited ('BT Mining'), a subsidiary company of Bathurst Resources Limited ('Bathurst') operate Stockton Mine (which for the purposes of this report includes the adjacent Cypress mining area), which is New Zealand's largest open-cast coal mine located approximately 35km north-east of Westport. In 2024 the active mine site comprised 787ha, including 474ha of rehabilitated area. Rehabilitation at Stockton has been an evolving practice for over 30 years, informed by extensive field trials and refining of various techniques, which have included hydroseeding, planting and vegetation direct transfer (VDT).

Bathurst's current overall objectives with respect to rehabilitation are to create safe and geotechnically stable sites, incorporate landforms that are sympathetic to the surrounding landscape and encourage an indigenous, self-sustaining and diverse vegetation cover and ecosystem. Other specific objectives are required by current Stockton Mine Licences, by resource consent conditions for Cypress Mine, and by access agreements with Land Information New Zealand.

This report sets out the findings of vegetation (including bryophyte) and fauna surveys at planted and VDT rehabilitated sites where the rehabilitation approach and history are known, as well as a sample of non-remediated (historic) sites where no effort was made to rehabilitate them following disturbance. Outcomes for vegetation and terrestrial invertebrate fauna at constructed and natural tarns are also reported. In addition, historic drill sites where the drilling date and access method was known were surveyed to determine the long-term effects of drilling on local vegetation.

The purpose of this work was to assist in understanding how rehabilitated sites are performing with respect to variables relevant to mine closure such as species richness, indigenous dominance, canopy cover, growth rates, colonisation rates, weed presence and native species occupancy. A secondary purpose was to develop recommendations for future rehabilitation of the site based on outcomes at sites with a known history. This information is required to inform future applications for resource consents where the ability to remediate the site effectively for both vegetation and fauna, and a high degree of certainty with respect to outcome, will be important considerations for decision-makers.

The most successful rehabilitation method in terms of vegetation and fauna outcomes was VDT. VDT minimises structural damage to both vegetation and soils, and is able to support a range of animals with reduced mobility such as land snails, lizards and soil invertebrates. VDT results in higher vegetation cover, higher native species cover and provides favourable habitat for fauna and bryophytes when compared to other rehabilitation methods. Non-remediated sites had lower vegetation cover and retained fewer 'Threatened' and 'At Risk' plants than VDT sites. Bryophyte communities within VDT plots contained >25% of indicator taxa, as well as 'Threatened' and 'At Risk' species, confirming that this rehabilitation approach can retain and support mature bryophyte communities and species of conservation concern.

Population densities of *Powelliphanta patrickensis* snails in areas rehabilitated by VDT were similar to densities in undisturbed habitats, however planted sites supported very few snails.

Mean species richness of invertebrate samples was comparable at non-remediated, planted, and VDT sites, though there was larger range at VDT sites. Several non-remediated sites were located adjacent to forest and included forest and shrubland vegetation, therefore establishment of invertebrates was not unexpected. There were also several exotic species collected at rehabilitated sites which contrasts with natural sites sampled previously where indigenous species dominated. Native and exotic money spiders

(Linyphiidae), which are typical invaders of disturbed New Zealand ecosystems, were collected from all habitats.

Five-minute bird counts undertaken across areas rehabilitated by planting and VDT showed that the conspicuousness of New Zealand pipit ('At Risk – Naturally Uncommon') and fernbird ('At Risk – Declining') was similar in both of these rehabilitated vegetation types.

Natural tarns had significantly higher native vegetation cover than either constructed tarns with VDT or constructed and planted tarns, although overall vegetation cover and number of 'Threatened' and 'At Risk' species was not significantly different between treatments. Aquatic invertebrate surveys demonstrated that constructed tarns provided new and important habitat that was statistically indistinguishable from natural tarns.

Results from 32 drill sites across the Buller Plateaux indicate that drilling activities generally do not promote weed invasion. Most (78%) plots had no exotic species recorded.

Strategic planning of rehabilitation with final vegetation communities in mind would enhance future rehabilitation outcomes. Other recommendations to improve rehabilitation outcomes include site-wide considerations, recommendations with respect to VDT, creation of habitats for fauna, recommendations for planted sites, post-rehabilitation site management, creation of tarns, maintenance of bryophytes and monitoring as follows:

Site-wide considerations

i) Site-wide planning which takes into account and provides for local variation in soil depth, topography, exposure, slope angle, aspect, surface roughness and drainage to incorporate ecological gradients and local habitat variation would improve future rehabilitation outcomes across the site.

ii) Planting sites should be prepared using appropriate soil, ideally minimally handled soils of sufficient depth to allow for root establishment of target plants. Minimising structural breakdown of soils by using methods of stripping and placement that minimise handling (i.e., 'jumble dump') is preferred over using stockpiled soil.

iii) Notwithstanding the constraints of mine planning, soil stockpiles for subsequent plant establishment should ideally be minimally handled so as to maintain live vegetation and ideally be low (i.e. < 3m) and short term (< 5 years). Use of fresh soils should be prioritised over stockpiled soils, and dilution of organic soil layers with acidic overburden should be minimised.

iv) If soil stockpiles are to be maintained for more than three years, planting with local species or the transfer of sods containing local vegetation should be used to assist in promoting and retaining soil fauna, reducing sediment mobilisation and providing established plant material for transfer. Where stockpiles are vegetated, a target of 70% vegetation cover is proposed in order to assist in reducing erosion and mobilisation of sediment.

v) The pool of planting species should be expanded beyond that used historically or the standard nursery stock. Appropriate coal measures species that are amenable to nursery propagation, either as seedlings, cuttings or divisions, should be prioritised (e.g., wire rush (*Empodisma minus*), *Chionochloa juncea*). Methods for large-scale propagation of wire rush should be investigated and incorporated into applied research to support site rehabilitation.

vi) Rehabilitation planning should identify and consider the final ecosystem type achievable taking into account elements such as altitude, slope, drainage and aspect. Planting should be done in a way to facilitate succession towards the appropriate vegetation community (forest, shrubland, tussockland etc). This may involve staged planting with key ecosystem engineer species (e.g., wire rush, mānuka) used initially to set the trajectory for the intended ecosystem type followed by supplementary planting (e.g., of podocarps) in following years once appropriate microhabitats are established.

vii) Storage of VDT and soils on existing high value vegetation should be avoided or minimised so as to optimise outcomes for the highest-value vegetation. Use of stockpiles of mixed soil and lower value vegetation (jumble dumping) may assist in maximising resources for use in rehabilitation.

viii) Where achievable, vegetation types typical of natural local measures vegetation should be the goal. Propagation and use of wire rush should be prioritised due to its ability to spread and establish ground cover, protect soils and create favourable growing conditions for other species. Mānuka should be similarly prioritised because of its relative abundance in most pre-mining vegetation communities. In order to achieve adequate, rapid vegetation cover of rehabilitated sites cost effectively, techniques such as germination of forest duff and litter from other vegetation types to provide a large number of seedlings, use of smaller plant grades, planting at higher density, greater use of jumble dumping and seeding/fascining as well as the strategic/targeted use of fertiliser will assist in meeting vegetation cover targets at planted sites.

ix) Some of the existing plantings contain species which are not local or not appropriate at the density at which they are used. For some species, this may be due to misidentification and/or contamination in the nursery. The use of species not typical of the local coal measures ecosystem should be avoided, or at least minimised. This includes bush and snow tussocks (*Chionochloa conspicua*, *C. flavescens*), koromiko (*Veronica salicifolia*, *V. stricta*), broadleaf (*Griselinia littoralis*), mountain akeake (*Olearia aviceniifolia*), Northern rātā (*Metrosideros robusta*), harakeke (*Phormium tenax* and hybrids) and kānuka (*Kunzea* spp.).

x) Attention to both nursery and site biosecurity will be required to prevent future invasions of 'new' weeds, invertebrate taxa and establishment of other unsuitable species.

xi) Specific attention to rehabilitation of bryophyte habitats would assist in maintaining the 'Threatened' and 'At Risk' species throughout their natural range. This includes steep, damp rock faces, boulder fields with sheltered cavities and a range of suitable vegetation types (pākihi, low forest, red tussock grassland).

xii) Development of specific methods for transitioning recent (rather than historic) rehabilitated sites dominated by exotic or non-local species towards an ecological state which better meets rehabilitation goals would improve ecological outcomes, e.g., for sites dominated by *Agrostis capillaris*, toetoe or *Chionochloa conspicua*, a method to transition them to a more diverse and appropriate habitat.

xiii) Formalising a diversity of approaches to short-term site stabilisation and *Juncus squarrosus* treatments would assist in enhancing establishment of native nursery plants and regeneration of native species.

In relation to VDT:

i) VDT should be used to the maximum extent practicable, especially for low-growing vegetation communities.

ii) Transfer of sods from forested areas, either as VDT or DT of slash provides habitat for fauna and assists in maintaining the existing seed bank and encouraging the area to regenerate faster than by replanting alone. It is important to ensure there are minimal gaps between sods.

iii) The location of final VDT placement should be planned to provide for ecological connections with surrounding habitats as well as to provide ‘islands’ of habitat to act as a source of seeds/propagules for surrounding planted areas.

In relation to habitats for fauna:

i) Provision of habitat for fauna within or adjoining VDT could improve its value for fauna more quickly than allowing natural establishment of these features.

ii) Provision of fauna habitat should include creation of microhabitat features (e.g., individual logs/root plates, wood stacks, boulders as stacks and clusters), and macrohabitat features (e.g., logs with holes/root plates). This is particularly important for planted areas which would not otherwise have these features for decades. Creation of variable depth, stable and dry refuges would assist in providing habitat for fauna.

iii) To improve habitats for lizards, this should include excavation of dry (not water-filled) cavities below the surface to provide stable refugia which are protected from cold temperatures during winter.

iv) Topsoil and subsoil should be kept separate during the rehabilitation process and soil structural disturbance and compaction by heavy machinery should be avoided to provide favourable conditions for maintaining earthworms and therefore Powelliphanta snails.

v) Further investigation into the use of fascining, either alone or in combination with planting and seeding, to determine how the outcome of plantings can be improved for snails.

vi) Ensuring that VDT sites are ecologically connected to natural habitats and in proximity to gully habitat complexes to support lizard survival.

vii) Using optimally sized buckets to minimise loss of individual lizards during the VDT process.

viii) The development and implementation of scientifically robust research and monitoring programme(s) are recommended to confirm the benefits of VDT for lizards including radio-tracking lizards before and after VDT and long-term monitoring of lizard populations at VDT sites.

In relation to areas to be planted:

i) Boulders, rocks, logs, root plates and other biological resources should be used to create microhabitats and contribute relief to planted areas.

ii) Fertiliser such as blood and bone, worm castings and pelleted manures which are free of weed seeds should be used strategically to support vegetation establishment at targeted locations and using targeted methods (e.g., placed under the root ball rather than broadcast). Widespread application of fertiliser at high rates is not recommended.

iii) Hydroseeding of steep batters with locally sourced species may assist in reducing the potential for exotic species establishment.

In relation to site management:

i) Weeds have the potential to prevent closure criteria being achieved. Priority should be given to avoiding weed incursions and managing known weed sources, particularly those that occur at the top of a catchment, are adjacent to vulnerable ecosystems, and are along access tracks (foot or vehicle).

ii) Weed control needs to be addressed on a site wide basis and prioritised to prevent the establishment and spread of heath rush and other exotic species into natural communities. Biosecurity measures such as boot washes at the entrances to all new rehabilitated areas would assist in reducing weed invasion, particularly for *Juncus* which is more likely to be spread on footwear and other equipment than by wind or animals.

iii) Soils known to contain *J. squarrosus* should be used for rehabilitating areas destined to become taller shrublands and forest only since these communities are likely to eventually shade out and supress this weed (Simcock 2011).

iv) Soils known to contain *J. squarrosus* should be used at locations separated from riparian areas to prevent seeds being spread down the catchment.

In relation to tarns:

i) Constructed tarns provide useful habitat for aquatic invertebrates almost immediately and when combined with VDT also have value for vegetation and terrestrial invertebrates.

ii) Tarns should be constructed on gently sloping banks, semi-natural hydrologic regimes and suitable substrates to support diverse plant communities.

iii) Constructed tarns should provide for soft, moist substrates and emergent vegetation.

iv) Large woody debris and/or root wads, as well as additional edge planting in the constructed tarns is recommended.

v) Tarns should ideally be constructed over a sediment base of rock/gravel floor.

vi) VDT should be used around tarns where achievable.

In relation to bryophytes:

i) Consideration should be given to habitat specificity – recognising unique habitat requirements for different species.

ii) Habitat design should create humid microsites, and a variety of hydrological conditions and substrates.

In relation to monitoring:

i) Permanent plots should be established to assess rehabilitation outcomes and should include the plots used in this report. In addition, control sites should be setup to compare succession in ‘natural’ vegetation types to rehabilitation sites.

ii) Recording of baseline information for all rehabilitation sites should be undertaken at the commencement of rehabilitation at each site. This includes recording slope angles, soils, drainage, erosion control and vegetation establishment (method, planting densities and the like). Additional information for vegetated sites can include whether additional native seed was applied, the use of wilding transplants (including number and species) and the degree to which live plants regenerated from stripped/replaced soils at the time of planting.

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Appendices

1.0 Introduction

1.1 Background

Stockton Mine is the largest opencast coal mine in New Zealand and is comprised of multiple pits, engineered landforms and rehabilitated areas. Stockton Mine (including Cypress mining area) currently comprises approximately 1,261ha with approximately 787ha disturbed and rehabilitated areas forming approximately 474ha as shown in Figure 1.

Stockton Mine encompasses mining within the Stockton Coal Mining Licence ('CML') (with associated conditions) which was granted in 1990 and backdated to 1987. Cypress mining area operates under a separate mining permit with associated resource consent conditions. Note that while there were no special conditions set out in associated Wildlife Act Authorities at Stockton and Cypress which would apply to provision of post-mining fauna habitat, the Powelliphanta Technical Advisory Group has provided advice with respect to planting and site rehabilitation, particularly at Mt Augustus.

The conditions of the Stockton CML require that the licence holder implements such rehabilitation research as may be necessary for effective rehabilitation of the disturbance areas. In addition, the licence holder is required to undertake a research programme to determine an effective method of revegetating the Webb and Stockton No 2 overburden dumps and to establish a vegetative cover of endemic species that conforms to locally occurring ecological patterns. Initially the focus was on creating stable landforms and treating historic acidic metalliferous drainage (also known as acid mine drainage) discharges to streams draining to the Ngakawau River.

Rehabilitation at Stockton is challenging: rainfall is high, soils are shallow, naturally acidic and infertile, temperatures are cold and there is low solar radiation. As a result, many species are slow to grow and disperse naturally. Natural vegetation and disturbed areas are also prone to invasion and displacement of native species by exotic plants, particularly gorse (*Ulex europaeus*) and heath rush (*Juncus squarrosus*).

Rehabilitation trials began at Stockton Mine in the early 1990s. Progressive Rehabilitation of disturbed sites remains a fundamental goal of the Stockton rehabilitation strategy with a view that the earlier sites are rehabilitated, the sooner a self-sustaining ecosystem can become established, and ongoing maintenance costs are reduced. In the past, under a previous mine operator, significant areas of vegetation, soils and overburden were removed to expose the coal seam, however the coal was not removed because suitable markets were not available. Rehabilitation of these sites was then undertaken, but the area was later "re-mined" when market conditions shifted, meaning that some locations have been rehabilitated more than once.

One of the most successful techniques used to date is vegetation direct transfer ('VDT') (Rodgers et al. 2011). Vegetation direct transfer is the process by which intact mats of vegetation and attached soils are removed and relocated to sites to be rehabilitated. This type of rehabilitation technique minimises structural damage to both vegetation and soils, and enables the relocation of short vegetation, as well as any associated fauna which survives or is moved in advance of works, in its entirety.

Resource consent A14.1d of the Cypress mining resource consents requires that rehabilitation develop a 'self-sustaining ecosystem' and this approach has also been applied more generally at Stockton. Self-sustaining ecosystem here refers to indigenous plant and animal communities that establish, grow, reproduce, and persist indefinitely in response to the ecological gradients present and are underpinned by natural ecological succession without human intervention, management or protection. These ecosystems maintain their own biodiversity, nutrient cycles, and resilience against natural disturbances (including weeds) and function as self-regulating, low-maintenance, or wild, environments.

A range of stabilisation and rehabilitation techniques have been developed to conserve soils and native ecosystems at Stockton. Current practice is fairly consistent at planted sites with 400mm granite capping overlain by 200mm soil. Locations with VDT are more variable, depending on the VDT resource (including soil).

Other methods of rehabilitation have included seeding (primarily with pasture grasses and legumes), planting into established exotic grasses or bare soil, and hydroseeding ahead of planting (usually of slopes or steep batters prone to erosion). Fertiliser or biosolid waste has been used in the past to enhance growth rates. Hydromossing has been investigated in a series of trials that included developing methods to grow and harvest mosses (e.g. Ross & Simcock 2004). There are also previously disturbed areas where there has been no remediation attempted. These sites include historic mines and settlements which pre-date rehabilitation efforts or which are outside the direct authority of Bathurst. These previously disturbed sites are referred to here as ‘non-remediated sites’.

As at June 2024, approximately 474ha has been rehabilitated to varying degrees at Stockton Mine, including by the previous operator. VDT comprises approximately 17.4% of the revegetated rehabilitation completed. Only a small amount of rehabilitation (including planting and some VDT) has taken place within the Cypress mining area to date.

This report measures rehabilitation outcomes for vegetation and fauna at sites located on both Stockton and Denniston plateaux for three different rehabilitation approaches, including VDT, planting and non-remediated sites. Vegetation and fauna outcomes for natural tarns and constructed tarns were also measured. Lastly, vegetation outcomes at historic drill sites where access date and method are known were surveyed to determine long-term effects of drilling and associated disturbance on vegetation.

In addition, we remeasured three plots within the VDT portion of Strip 7 of the Cypress Mining Area, where the vegetation was measured before transfer and the sods for the plots relocated together. Long term monitoring of red tussock grassland and associated herbfield vegetation directly transferred from Cypress Mining Area is described in a separate report (Ecological Solutions Limited 2025b).

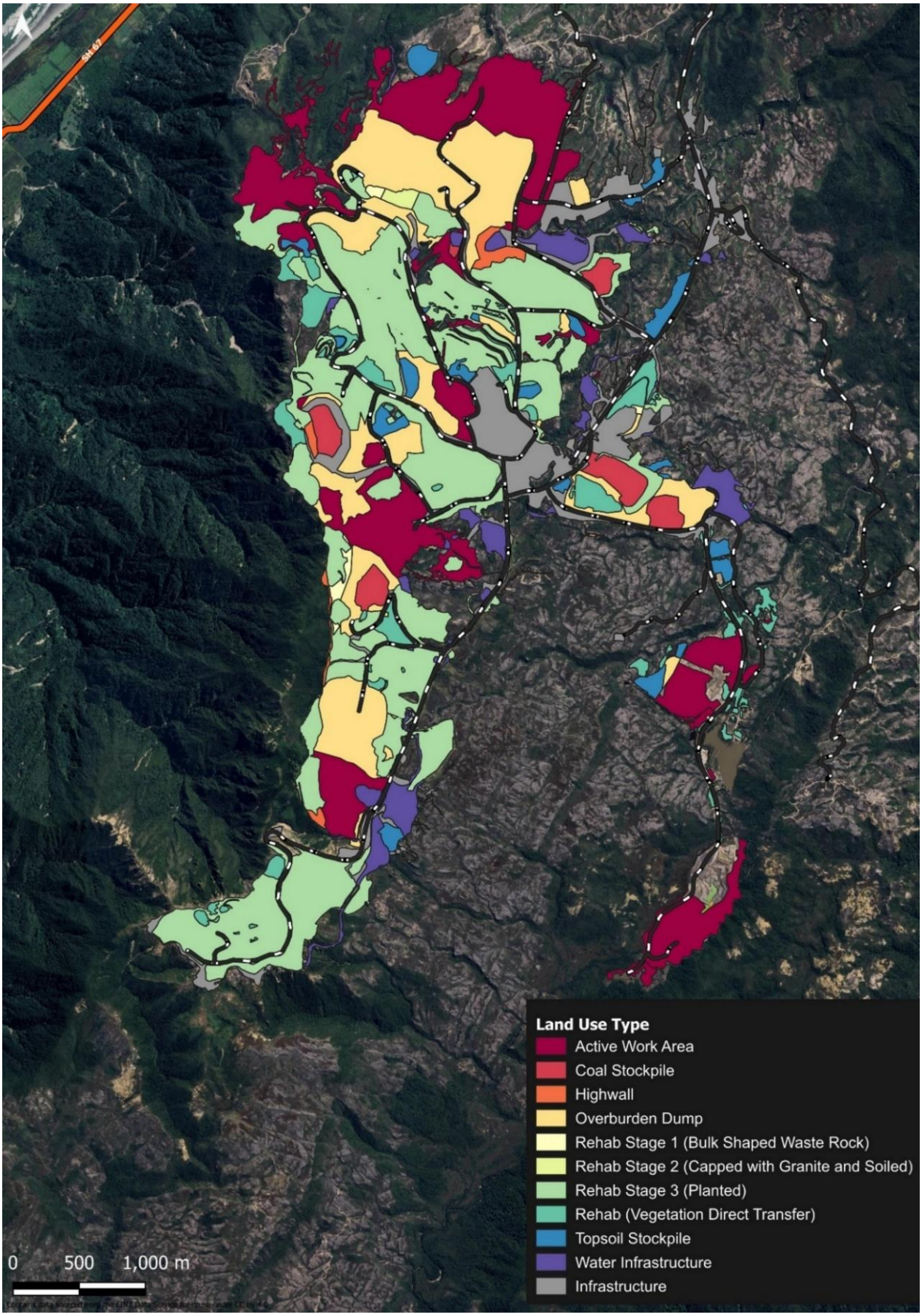

Figure 1: Land use at Stockton Mine and Cypress Mining Area as at May 2024.

1.2 Relevant Coal Mining Licence and Resource Consent Conditions

Rehabilitation outcomes in the CML 37-150 (Stockton Mine) consent which runs from1 April 1987 to 31 March 2027 include conditions A1(1), A1(2), A3(1)(a), (b), and (e), A5 and A13 (3) which are reproduced in Table 1.

Table 1: Conditions relevant to rehabilitation from the Stockton Mine CML 37-150.

Condition	
A1(1), (2)	Notwithstanding condition 1, the licensee shall prepare and forward reports and plans as follows: (1) The licensee shall forward for the approval of the Inspector in consultation with local authorities, including the local territorial authority, catchment authority, and Department of Conservation as the Inspector deems appropriate, annual working plans compiled in accordance with Section 57 of the Coal Mines (Opencast Coal Mines) Regulations 1986 for opencast mining or in accordance with Section 136 of the Coal Mines Act 1979 for underground mining: (a) A detailed plan for the proposed rehabilitation work to be undertaken in the next 12 months; (b) A progress report for the rehabilitation work carried out over the previous 12 months; and, (c) A detailed report indicating the likely extent, magnitude, and impact of surface subsidence predicted to occur as a result of mining in the next 12 months, and where appropriate, plans for monitoring and remedial work; (d) A progress report of the extent, magnitude, and impact of surface subsidence, and remedial measures carried out over the previous 12 months and; (e) An outline of the projected mining, subsidence, and rehabilitation areas for the next 6 years. (2) The plan and report required under subsection (1)(a) and (1)(b) above shall include: (a) Soil salvage including details of area, depth, volume and disposition; (b) Soil replacement including details of area, volume, depth, and source of replaced soil materials; (c) Soil stockpiles, disposition, salvage and consumption (d) Contouring and grading of earthworks (e) Surface pre-treatment and vegetation; (f) Fertilisation strategy and procedures; (g) Post-rehabilitation management; (h) Variations from the approved plans, the reasons for the variations, and their impact on the rehabilitation plan; (i) Results from any rehabilitation research carried out and any further work proposed; and, (j) Details of any proposed roads, access tracks, and exploratory drill sites.
A3(1)(a), (b), (e)	Notwithstanding condition 3; (1) The licensee shall: (a) Keep disturbance of the environment to a minimum and, in particular seek to minimise injury or damage to native plants and trees: (b) As far as possible prevent injury or damage to wildlife and native bird life: … (e) Control noxious weed species within the license area.
A5	Notwithstanding condition 5; (1) In planning and carrying out rehabilitation the licensee shall observe the following goals:

(a) To minimise hazardous conditions.

(b) To ensure short- and long-term stability of the site.

(c) To protect the land surface against wind or water erosion.

(d) To provide for adequate surface drainage.

(e) To minimise post-operational maintenance.

(f) To conduct rehabilitation progressively.

(g) To return land to an equivalent land capability to that which existed prior to disturbance, or to a state suitable for recreation, wildlife habitats or other use as specified in the detailed rehabilitation plan(A1(1a)).

(h) To preserve and restore landscape values in consultation with interested local agencies including the local territorial authority, catchment authority and Department of Conservation.

(2) Where soil or overburden materials to be disturbed are capable of sustaining plant growth, sufficient suitable soil or overburden materials must be salvaged for the purpose of soil replacement.

(3) Soil replacement in the disturbance areas must consist of sufficient suitable topsoil, subsoil or spoil materials to support a productive, erosion controlling vegetative cover that mees the intended post-development land capability.

(4) All excavations must be graded to contours that are compatible with the post-development land capability. All disturbed areas must be contoured to conform to the surrounding topography.

(5) When final pit walls are proposed to be left in the rehabilitated landscape, they must be geotechnically stable and at a slope angle that is compatible with the post-development land capability.

(6) As soon as possible after soil (or spoil) replacement a vegetative cover must be established that is compatible with the post-development land capability.

(7) The licensee shall undertake such rehabilitation research as may be necessary for effective rehabilitation of the disturbance areas.

A13(3) The licensee shall take such measures as are necessary (including the removal of waste coal stockpiles) to progressively rehabilitate the Webb and Stockton No. 2 overburden dumps and establish a vegetative cover of endemic species that conforms to locally occurring ecological patterns, sufficient to:

(a) Minimise the visual impact of overburden dumps

(b) Seek to minimise impact of overburden rehabilitation work on surrounding undisturbed areas.

(c) Minimise impact on the water quality of surrounding catchments.

Rehabilitation at the Cypress Mining Area only recently commenced, but the relevant general conditions are set out in Table 2.

Table 2: General conditions relevant to rehabilitation that apply to Cypress Mine Mine Permit MP41515 Consents Cypress BDC 030164.

Condition	
A14.1	The Consent Holder shall undertake rehabilitation and re-vegetation, to achieve an outcome generally in accordance with Figure 3.16 of the AEE (Refer Attachment 2 of these conditions) and in accordance with the following objectives: (a) In the short-term to create stable landforms by establishing a native vegetation cover and erosion-resistant surfaces that have physical and chemical characteristics that favour growth of sustainable plant communities and manage runoff and sediment generation; and (b) In the medium to long-term, to establish ecosystems similar in plant and animal species diversity and functioning to undisturbed ecosystems adjacent to the site that help the constructed landforms blend into the adjacent landscape and prevent erosion and sediment generation. In relation to stream function, the rehabilitation objective is for stream channel width to match the expected flow and for stream channels to be constructed so as to reflect existing channel complexity, including sinuosity and the removal of culverts where practicable. (c) To prevent weeds and pests invading the site so far as is reasonably possible, and otherwise to eradicate or control weeds and pests on the site. (d) To develop a self-sustaining ecosystem. (e) Red tussock communities (including red tussock wetland communities) are to be established in the western part of the rehabilitated valley floor in the north pit, including the western slope of the toe embankment, and the floor of the south pit.
A14.5	The Consent Holder shall, as far as practicable and to the satisfaction of the Peer Review Panel, ensure that rehabilitation is carried out such that the performance of any modified landform, watercourse, or any permanent structures and facilities under a Probable Maximum Flood or Maximum Credible Earthquake do not result in damage to landforms or structure greater than those that would have occurred under natural slope and landform conditions.
A14.6	The Consent Holder shall undertake progressive rehabilitation of all disturbed areas including highwall benches as areas of practical working size become available, in accordance with the Annual Work Plan and the Rehabilitation Management Plan.
A14.7	The Consent Holder shall, as far as practicable, salvage topsoil and forest duff from areas to be disturbed. All salvaged material shall be used for rehabilitation purposes in accordance with the principle of achieving a minimum of 100mm of topsoil on forest and shrubland rehabilitation and 300mm of topsoil on tussock rehabilitation over subsoils and/or 1.5-3m of non-acid generating overburden.
A14.8	The Consent Holder shall utilise, wherever practical given the characteristics of the land, direct transfer methods of rehabilitation.
A14.9	The Consent Holder shall translocate, as far as practicable, existing vegetation to the banks of new stream channels.
A14.10	Seed and plant resources shall be genetically sourced from the locality or Ngakawau Ecological District from at least 500m above sea level.
A14.11	Tussock that has been removed from the mine areas in accordance with the Rehabilitation Management Plan shall not be buried or destroyed, but shall be utilised as soon as possible in rehabilitation, and if surfaces for rehabilitation are unavailable, shall be stockpiled for re-use either within the mining permit area or at Stockton Mine, as far as possible.
A14.12	Any machinery utilised for any rehabilitation activities, including excavation of topsoil, that is brought onto or moved from the Cypress site must be cleaned before and after use in order to minimise the potential for weed species to be introduced onto or off the site.
A14.13	The Consent Holder shall translocate representative samples of the wetland vegetation other than red tussock for storage and later 'seeding' or nucleus establishment within the rehabilitated red tussock vegetation in the area identified in condition A14.1e.

1.3 Scope of Report

Ecological Solutions Limited was engaged to carry out ecological surveys at rehabilitated sites, including drill sites, tarns and previously disturbed (i.e., from mining, settlements or mining infrastructure), and then non-remediated sites where the rehabilitation approach and history is known. The purpose of these surveys was to assist in understanding how the sites are performing with respect to variables relevant to mine closure such as species diversity, indigenous dominance, percentage cover, growth rates, colonisation rates, weed presence and indigenous species occupancy. This suite of information will be used to inform future rehabilitation efforts, as well as applications for resource consents where the ability to remediate the site effectively for both vegetation and fauna, and a high degree of certainty with respect to outcome, will be important considerations for decision makers.

This report includes 10 sections as follows:

- Section 1.0 sets out the background to the Stockton CML and Cypress mining area and the consent conditions relating to rehabilitation there.
- Section 2.0 describes the ecological setting of Stockton Mine.
- Section 3.0 describes the rehabilitation undertaken to date at Stockton Mine.
- Section 4.0 describes the methods used to survey the rehabilitated sites.
- Section 5.0 sets out the results of the surveys.
- Section 6.0 describes the use of rehabilitated areas by fauna.
- Section 7.0 discusses the relative effectiveness of the rehabilitation methods and any other relevant observations.
- Section 8.0 makes recommendations for future rehabilitation based on the findings.
- Section 9.0 provides a summary.
- Section 10.0 lists the references used in preparing this report.

2.0 Ecological Setting

2.1 Ngakawau Ecological District

Stockton Mine (including the Cypress mining area) is located within the Ngakawau Ecological District and North Westland Ecological Region (McEwen, 1987). The boundaries of the Ngakawau Ecological District are defined by a line connecting Te Kuha to Mount Rochfort, Mount William and a peak west of Mt Lyall in the south, the Glasgow Range in the east and the Mokihinui River in the North. The coastal escarpment marks the boundary of the district to the west, with the coastal plain forming part of the adjacent Foulwind Ecological District. The district covers approximately 48,710ha and the boundaries were defined on the basis of geology, topography and vegetation (McEwen 1987, F. Overmars pers. comm. 2012).

The Ngakawau Ecological District is characterised by elevated coal plateaux (Stockton and Denniston, collectively the Buller Plateaux), southwest and west trending coastal hills and low mountains up to 1,400m asl in the north and southeast (McEwen 1987, F Overmars pers. comm. to G Bramley 2011). The area is characterised by a mild, wet climate and low annual water deficits (Leathwick et al. 2002). The district includes large areas of Eocene (40–50 million years old) quartzose sandstone, grit and conglomerate with Brunner coal seams forming dissected plateaux with highly distinctive vegetation. There are also smaller areas of gneiss, granite, greywacke and argillite (McEwen 1987, Rattenbury et al. 1998, Nathan et al. 2002). Soils overlying granitic geologies are typically deeper and more fertile and occur most commonly in the southeast of the district (in the headwaters of the Mackley (Orikaka) River), with occasional instances elsewhere. The area experiences mild – cold temperatures and high annual rainfall and most of the district remains in indigenous vegetation (McEwen 1987). There is a strong altitudinal gradient in rainfall across the Buller Plateaux, with the annual average ranging from 3,799mm at Millerton (569m asl) to 7,490mm at Mt Frederick (1,056m asl). On average, rainfall exceeds evapotranspiration in all months on the Buller Plateaux, which is critical to the success of VDT and also influences the timing of planting. Short periods (hours) of high intensity rainfall are also a feature of the Buller Plateaux which affects rehabilitation, particularly the mobilisation of sediment and flashiness of streams draining the plateaux.

The Ngakawau Ecological District includes the distinctive coal measures vegetation and exposed sandstone erosion pavement which characterise the Buller Plateaux as well as large areas of wetland, including pākihi, shrubland and forest and much smaller areas of tussockland, herbfield and boulderfield. The Ngakawau Ecological District is the only ecological district in New Zealand defined by the presence of extensive elevated coal measure geology with its associated landforms, vegetation and flora. The Ngakawau Ecological District includes endemic species such as coal measures tussock (*Chionochloa juncea*) and *Celmisia morganii* (McEwen 1987, Overmars et al. 1998). It also includes naturally uncommon ecosystems including sandstone pavement, boulderfields of acidic rock, pākihi wetlands, seepages and flushes, and tarns (Ecological Solutions Limited 2026a). Some of these naturally uncommon ecosystems are considered threatened (Holdaway et al. 2012).

High-resolution drone photographs collected between 2021 and 2024 and a RECCE-plot based vegetation survey have been used to describe, discriminate and map the vegetation across the Buller Plateaux resulting in the identification of thirteen separate vegetation types (Ecological Solutions Limited, 2026b). Plant species of conservation concern present within the Buller Plateaux and surrounds includes 31 species of vascular plant, 41 species of terrestrial non-vascular plant (bryophyte), four species of aquatic bryophyte and eight species of lichen. Given that not all areas have been fully surveyed, new records of bryophytes (and invertebrates) are likely when new or additional areas are surveyed.

Principal Components Analysis has confirmed that altitude and slope are key ecological drivers of vegetation communities on the Buller Plateaux, along with aspect and the amount of bare rock (Ecological Solutions Limited 2026b). In terms of vegetation, sandstone erosion pavement provides habitat for a vegetation mosaic comprising stunted and prostrate mānuka (*Leptospermum scoparium* agg.) shrub-tussock–wire rush (*Empodisma minus*) and tussock (*Chionochloa juncea, C. rubra* and hybrids of these species) communities. Altitudinal sequences of lowland to subalpine vegetation occur on steep coastal hillslopes comprising mixed beech-kāmahi (*Pterophylla racemosa*)-podocarp (often rimu (*Dacrydium cupressinum*)) forest grading into beech (mountain beech (*Fuscospora cliffortioides*), silver beech (*Lophozonia menziesii*)) and Southern rātā (*Metrosideros umbellata*) forest which becomes more stunted with increasing altitude. Mānuka, pink pine (*Halocarpus biformis*), yellow-silver pine *(Lepidothamnus intermedius*) and *Gahnia* spp. are a significant component of the dense shrubland and low stature forest on the high elevation slopes of the Buller Plateaux (Newell 1990, Overmars et al. 1998). Forested gullies dissecting the sandstone pavement are typically dominated by stunted mountain beech, silver beech and Southern rātā in the canopy, with other common species including pink pine, yellow-silver pine, mānuka, mountain toatoa (*Phyllocladus alpinus*) and kamahi. On the peaks of Mt Augustus and Mt Frederick, subalpine herbs, grasses and cushion plants were common (*Celmisia* spp., wire rush, *Chionochloa* spp., and *Donatia novae-zelandiae*).

Birds present within the district include species adapted to forests, shrublands and open areas, although numbers on the Buller Plateaux are generally lower than in the surrounding habitats which are mostly forests and are typically more fertile, have more structural complexity and higher food availability (including more fruiting species, Overmars et al., 1998). Pākihi shrubland provides habitat for South Island fernbird (*Poodytes punctatus punctatus*) which are also locally common throughout parts of the Tiger and Blackburn pākihi and at Te Kuha (within the Ngakawau Ecological District, Ecological Solutions Limited unpubl. data (2026), R Buckingham pers. comm. 2013, G Bramley pers. obs. 2013) and at the German and Caledonian terraces (immediately outside the Ngakawau Ecological District). Black shag (*Phalacrocorax carbo*) and little shag (*P. melanoleucos*) are characteristic of major rivers and other waterways. Long-tailed cuckoo (*Eudynamys taitensis*) are also seasonally present throughout the Ngakawau Ecological District and likely use densely forested areas around the Buller Plateaux, where one of their host species, brown creeper (*Mohoua novaeseelandiae*) is also present. Western weka (*Gallirallus australis australis*) are common across the Buller Plateaux using a range of habitats, including shrubland, pākihi and forest.

Tall forest vegetation on fertile sites within the ecological district provides habitat for other threatened bird species such as South Island kākā (*Nestor meridionalis meridionalis*), rōroa (great spotted kiwi, *Apteryx maxima*) and New Zealand falcon (*Falco novaeseelandiae*). Kea (*Nestor notabilis*) are also known from the district and have been observed occasionally at Stockton (McEwen, 1987, G. Bramley pers. obs., 2012).

The threatened land snails *Powelliphanta patrickensis*, *P. augusta* and sub-species of *P. lignaria* are also endemic to the district. *P. lignaria* occurs north of the Buller Plateaux, but the former species both occur on the Buller Plateaux with *P. augusta* formerly limited to the area surrounding Mt Augustus. Five species of terrestrial invertebrate with a threat status ranking are known from the Buller Plateaux, although there are number of species which have not been assessed (Ecological Solutions Limited 2026a).

The Ngakawau Ecological District hosts six species of lizards. This includes three species of skink; northern grass skink (*Oligosoma polychroma*), Newman's speckled skink (*O.* aff. *newmani* "Westland") and brown skink (*O. zelandicum*), and three species of gecko; West Coast green gecko (*Naultinus tuberculatus*), Nelson green (starred) gecko (*N. stellatus*) and forest gecko (*Mokopirirakau granulatus*) (Ecological Solutions Limited 2026a). Of these species, five are of conservation concern (Hitchmough et al. 2026), but only three are known to occupy the Buller Plateaux (Newman's speckled skink, West Coast green gecko, both listed as 'Threatened – Nationally Vulnerable'; and forest gecko considered 'Not Threatened').

3.0 Rehabilitation at Stockton Mine (including Cypress Mine)

3.1 History

Stockton No. 2 Mine opened in the mid-1970s following a long history of principally underground mining on the Stockton Plateau and at Millerton from the 1880s. Initially the key focus under the Stockton CML was to rehabilitate landforms for the purpose of reducing sediment runoff to waterways and ponds used for onsite water management. Soils were disposed of within overburden dumps as they were difficult to transport, generated sediment and initial rehabilitation trials considered them poor quality for plant growth. It was later recognised that mixed soils could be managed and be suitable for plant growth. A vegetated soil cap became integral to (and was more practical to deliver) on overburden dumps recontoured to reduce generation of acid mine drainage (AMD) resulting from the predominance of acid generating overburden. Over time there has been an increased drive to establish a variety of ecosystems similar in structure, diversity and function to that of nearby undisturbed ecosystems.

In 1990 and 1991 the first rehabilitation trials were established at Stockton by R.D. Keating and Associates and the Fertiliser and Lime Research Centre (Massey University). Initially, they tested the suitability of diverse overburdens as surrogate soils for plant growth (Simcock et al. 2004). Initial failure of direct-transfer shrubland in early 1990s (it was placed on an acid seep) and the cost of VDT in trials in the late 1990s delayed development of this method. Direct seeding of red tussock (*Chionochloa rubra*) and fascining of mānuka (*Leptospermum scoparium*) was also considered unsuitable because both exhibited slow growth rates and produced limited overall cover so the substrate remained vulnerable to erosion (Simcock et al. 2004). Early rehabilitation efforts aimed to build up organic matter and nitrogen to boost plant growth and achieve stabilisation of sediments in the high rainfall environment at Stockton, thereby assisting in preventing sediment discharge to streams. Attempts to establish legumes to build soil organic matter and nitrogen were successful in the short term, but required applications of both lime and fertiliser. The most successful method developed was hand-salvage and planting of tussocks and rushes. An exotic rush (*Juncus squarrosus*), initially thought to be a native *Carpha*, was particularly easy to establish on waste rock surfaces (Simcock et al. 2004).

The coal mined from the Buller Plateaux generally sits within one mineable seam that is 4m to 15m thick beneath up to 35m of quartzose sandstones, grits and topsoil (collectively called 'overburden') (Wright 2009). Generation of AMD remains an issue at Stockton and is effectively managed via minimising oxygen and water ingress in engineered landforms through soil compaction and use of non-acid forming overburden as capping material.

By the mid-1990s, greywacke/sandstone surfacing was used where possible to overcome the acidity of mudstones (Simcock et al. 2004). Hand transplants of wilding red tussocks provided 'instant' large plants at some locations on rehabilitated areas. Nursery-raised plants were also trialled with high survival rates attributed to thorough hardening off at Stockton and a planting technique that ensured plant root balls were protected from erosion using rock mulching (Simcock et al. 2004). Planting density trials using native nursery-grown plants sourced from the Buller Plateaux were also established. Unsuccessful establishment of planted seedlings on angle of repose (35º to 37º) dump slopes due to erosion around the root ball led to research on alternative rehabilitation techniques which included short-term soil stabilisation using non-native grasses, manuka fascining, and in 1999, hydroseeding (Simcock et al. 2004). Some of these techniques were not progressed when overburden dump construction methods changed, reducing slopes to ~20 degrees and allowing placement of a root zone of mixed soils nominally 300mm deep. Success was also associated with delaying planting of nursery-species until slopes had naturally 'armoured' with rock. Between 2001 and 2004, hydroseeding and 'dry seeding' trials were carried out at Stockton Mine using mosses, lichens and colonising vascular plants (e.g., *Epilobium* sp.). These trials demonstrated that the moss hydroseeding technique sped up natural plant colonising processes, stabilised slopes and provided a green cover on areas difficult to rehabilitate (e.g., embankments and rock dump slopes) (Simcock et al. 2004).

Research over this period emphasised the importance of identifying low-acid generating root zones (avoiding the need for lime application) and of surface roughness to create sheltered microhabitats. The practice of 'jumble dumping' developed in which 1-3 m high windrows of stripped mixed soils and attached plants were dumped on the flat tops of overburden dumps. The technique meant soils were minimally disturbed (the trucks used a spreading run and mounds were not smoothed), and erosion risk was low. The technique allowed natural regeneration of plants in some areas, and water was trapped between some windrows, forming permanent ponds. Trials on some of these areas confirmed shelter was a critical factor promoting growth of native nursery-grown plants, but that some species and soil-less substrates also required fertilisers to establish and persist.

By the late 1990s, natural regeneration of native species on soil stockpiles had achieved nearly 100% cover at some locations (Simcock et al. 2004). Previous VDT, where sods of intact plants and soils (and any associated poorly mobile fauna) are moved intact from stripped areas, was also regenerating. VDT is described in more detail in Section 3.3.3 below. The value of soil with attached vegetation was recognised and minimal-disturbance techniques were developed to enable handling soils of varying competency and composition, such as pākihi. Direct transfer trials in 1998 quantified both cost and benefit of increased invertebrate and plant diversity compared with conventionally treated areas (Simcock et al. 1999). Creation of other small areas of VDT helped refine the technique, which initially used large machinery (3m wide buckets) that was able to remove shrublands up to 5m tall which were being stripped at the time.

In 1998, the first thorough assessment of rehabilitation costs was undertaken as part of assessing the Crown's liability, and as the State-Owned Enterprise Solid Energy New Zealand Limited (the then owner and operator of the Stockton mine) was indemnified against rehabilitation costs associated with previous operations. This added impetus to develop effective rehabilitation techniques for the site.

The use of 'large scale' VDT began at Stockton Mine in approximately 2005 – 2006 (B Walker, pers. comm.) and continued at Stockton until about 2012. Since that time only small areas of VDT have been completed annually.

The resource consent conditions, which were granted in 2005, for the Cypress Mining Area include a requirement to complete 12.5ha of VDT of red tussock grassland and herbfield vegetation, a requirement for different root zones and slopes for areas rehabilitated to tussock and shrubland and closure criteria (standards) with respect to species cover, diversity and weed presence. They also included the requirements to restrict propagation materials to sites above 500m ASL, create accessible habitat for kiwi and to re-establish a minimum number of *Powelliphanta patrickensis* in rehabilitated areas. These closure criteria were the first of their type applied at the Buller Plateaux and were developed further in the resource consent conditions applied at the existing Escarpment Mine (partially completed – currently on care and maintenance) and the Mt William North Mining Area (consented, but not yet developed).

3.2 Modern Rehabilitation Processes

Prior to removal of vegetation in preparation for opencast mining, edge protection is established, which includes constructing clean water diversions, bunds and erosion and sediment control measures. Large wood is then removed or felled, then vegetation, boulders and soils are removed and either placed in overburden storage areas or directly at specific rehabilitation sites, depending on the availability of sites ready to receive them. The underlying 'soft' overburdens (e.g. colluvial layers in valleys) are then removed, and sandstone is then fractured using explosives, removed by excavator and truck, and stored, ready for use in rehabilitation.

Once the coal has been removed, rehabilitation normally follows a three-stage process:

i) Backfilling the void with overburden material, which is managed to reduce the potential for AMD, followed by reshaping of material overburden areas. Overburden placement is also used to create geotechnically stable engineered landforms (ELFs).

   Weathered granite is a commonly used growth medium when available, since it does not generate acid. The fundamentals of the engineered cover construction from the base up are as follows:

   a. A base of coarse material is provided which acts as a "capillary" break to resist drying of the cap by capillary "suction" from areas that are dry and have some suction capacity.

b. A graded zone is used to cover the capillary zone to support the core of the cap.

c. The core of the cap is a low permeability zone approximately 0.5m thick.

d. The provision of a layer of coarse material to prevent drying from the surface.

e. A subsoil and topsoil zone is established to protect the engineered cover from erosion and support rehabilitation.

f. Any drainage systems established on the engineered cover are constructed in enlarged compacted zones and lined with coarse sandstone, granite and/or mixed geologies (depending on availability) to resist erosion.

ii) Adding roughness to ELFs so as to promote vegetation growth, spreading root zones (generally soils), adding habitat materials (boulders, coarse wood) and then choosing and applying the combination of revegetation methods that deliver a) short term stabilisation, and b) native vegetation (i.e., planting, VDT, hydroseeding), followed by maintenance (primarily weed control and predator control).

iii) Civil works and construction of roads and water channels

The short-term goal of rehabilitation is to minimise erosion by establishing vegetation cover or erosion-resistant surfaces (e.g., rock mulch, flatter or rougher sites). Initial hydroseeding of soiled slopes remains a key measure to minimise erosion on sites vulnerable to erosion whilst native vegetation becomes established. Ideally, the desired long-term outcome is establishing a mosaic of ecosystems similar to those in the affected area prior to disturbance (Simcock et al. 1999). The ELF does not typically replicate the original detailed topography of the site, but is intended to create a landscape that is generally consistent with that present before mining began (Wright 2009).

3.3 Rehabilitation Methods

3.3.1 Landform and Erosion Control

Large-scale recontouring of overburden placement areas down to 20° slopes with irregular benching enables access for planting, controlled water flows and creating a more natural landform (Simcock et al. 2004). Erosion control methods vary according to slope angle and may include using rough surfaces with no seeding on flatter surfaces and rock mulching on shorter, steeper slopes. Typically, the only post-mining slopes exceeding 20º are highwalls, which are cut into the bedrock. Highwalls are terraced, featuring batter slopes and flat benches.

Wetland and tarn complexes are constructed by creating impeded drainage in flat areas. Impeded drainage is achieved via compaction of suitable substrate close to the surface. Poorly draining subsoil, low gradient and high rainfall contributes to surface saturation and ponding in small depressions which maintain wetland/tarn conditions and in particular, surface water.

3.3.2 Planting

Planting of locally sourced nursery raised specimens has been the dominant (conventional) rehabilitation technique used at Stockton Mine since the early 1990s. It has been used in conjunction with hand-transplanting individual plants, hydroseeding and straw-mulching to achieve vegetation cover on mixed soils and overburden.

Species planted

Up to 25 indigenous species have been used in rehabilitation plantings to date, with plants grown from seed, divisions and cuttings sourced from the Stockton Plateau (Kingsbury 2007, Simcock 2011). In the search for fast-growing nurse species that were readily available from suppliers, some species not local to the Buller Plateaux were also used in early years, e.g. *Carex comans* 'Frosted curls'.

Planting densities at Stockton have typically ranged from 7,500 to 10,000 plants per hectare with a proportion of this being individual 'wild' transplants. The most common species used have been those that have demonstrated consistently high survival and growth rates, including mānuka (*Leptospermum scoparium*), Southern rātā (*Metrosideros umbellata*), hebes (*Veronica* spp.), mountain flax (*Phormium cookianum*), red tussock (*Chionochloa rubra*) and *C. conspicua* (Simcock 2011). These species are typically planted together in varying proportions and spatial arrangements as shown in Figure 2. Dominant species have changed over time, depending in part on plant availability. Kingsbury (2007) developed different planting mixes for higher altitude/exposed areas and lower altitude/protected areas, although the extent to which these guidelines were applied remains unknown. Since 2011, dominant species have included *Ozothamnus vauvilliersii*, broadleaf (*Griselinia littoralis*), broad-leaved tussock (*Chionochloa conspicua*), hebe (*Veronica odora*, *V. mooreae*), and toetoe (*Austroderia richardii*).

Figure 2: Planted area (foreground) and native planting into seeded exotic pasture (background) near Hope Dump, Stockton Mine.

Propagation trials of 'species of significance', including 'Threatened', 'At Risk' and range-restricted species, have been undertaken as part of the existing Escarpment Mine activities (Ecological Solutions Limited 2024d). Seed and cuttings from species such as Parkinson's rātā, and *Pseudowintera traversii* and divisions from *Sticherus urceolatus* and *S. tener* have been collected from the existing Escarpment Mine footprint and surrounds, propagated in Bathurst's nursery, and transplanted into rehabilitated and natural areas at Stockton Mine and elsewhere. High survival has been observed for *Sticherus* and woody species such as pahautea (*Libocedrus bidwillii*), *Lepidothamnus intermedius* (yellow-silver pine), *Halocarpus biformis* (pink pine), *Dracophyllum densum* and *Dracophyllum rosmarinifolium*. Survival of small monocots and herbs has been more variable. Monitoring of selected individuals of *Metrosideros parkinsonii* and *Pseudowintera traversii* in 2021 revealed that 16 out of 23 individuals did not survive and the remaining seven could not be found, although survival and expansion of other species, including beech trees and herbs such as *Celmisia dallii* was better. (Ecological Solutions Limited 2024d).

Transplanting of individual ‘wild’ plants by hand has also been undertaken at many locations historically, targeting species of significance and species known to be tolerant of shifting such as red tussock (Ross 2008) and flax, (Kingsbury 2007). Transplants were routinely used (e.g. at Downers Dump) to provide ‘instant’ visible revegetation and supplement the nursery seedlings which were supplied as root trainers. In addition, Solid Energy staff (led by Paul Comeskey) and Drs Ruth Bartlett and Robyn Simcock intensively hand transplanted species from the Mt Augustus ridgeline to areas at Hood’s Dump known as “the Mt Augustus gardens” beginning in 2008.

Earthworms

A 2024 survey of earthworms from 58 sampling sites located within planted areas undertaken by MBC Contracting found “most” sites were categorised as ‘Low abundance and low diversity’, with “some” sites (those with more than 16 worms per sample) being ‘Good abundance, low diversity’ (MBC Environmental 2024). No sites met the threshold for ‘High abundance, high diversity’ or ‘Low abundance, high diversity’, because worms representing the ‘Deep burrowing’ ecological grouping were absent from all sites. These rehabilitation sites dated from 2004 - 2023, but the majority of samples were from pre-2017 sites. This report should be used to establish locations for repeat surveys to better understand changes in earthworm communities at rehabilitated sites over time.

Of the 221 worms found, 25 were adults and the remaining 185 were juveniles. All were exotic, which is perhaps surprising given the isolation of Stockton, although only planted sites were sampled, and nursery plants are a likely source of exotic earthworms. No deep burrowing worms were found, with all worms being either ‘dung’ or ‘topsoil’ types. More worms were found at sites with higher leaf litter availability and generally higher fertility, e.g. biosolid treated sites with predominantly grass cover and healthy planted vegetation (B Walker, pers. comm.).

3.3.3 Vegetation Direct Transfer

Vegetation Direct Transfer, also known as “habitat translocation” or “community translocation”, involves the removal and relocation of intact mats or sods of vegetation and attached soil (Rogers et al. 2011). The technique was first used at Stockton in the mid-1990s, although the practice has been refined since those initial attempts. Early VDT attempts had large gaps between sods; however, the current VDT process aims to minimise these gaps to ensure consistent vegetation cover. Providing an immediate ground cover of naturally-occurring vegetation via VDT is ecologically favourable compared with planting or seeding, as the latter may take 20–50 years to reach a dense cover of vegetation on mixed soils/overburden, whilst also being vulnerable to erosion and weed invasion for a prolonged period (Ross 2008). An example of VDT is shown in Figure 3.

Figure 3: Vegetation Direct Transfer on the batter below the Augustus Gardens at Stockton Mine. This vegetation was placed in 2007 and photographed in 2024 (approximately 17 years post placement).

Having sufficient area to place VDT sods immediately after they have been extracted can be a challenge in an active mining environment. For the Cypress mining area, 'storage pads' were created as an interim solution to store VDT material prior to backfilling. Monitoring of red tussock vegetation placed within the storage pads has confirmed that native species survival is generally high including for the 'At Risk' herb *Euphrasia wettsteiniana*, and average species richness in monitoring plots has increased as shown in Figure 4. Native dominance and cover have also remained high (generally >90% except in 2019 and 2020 as shown in Figure 5) and the percentage of bare ground has steadily declined since placement as shown in Figure 6.

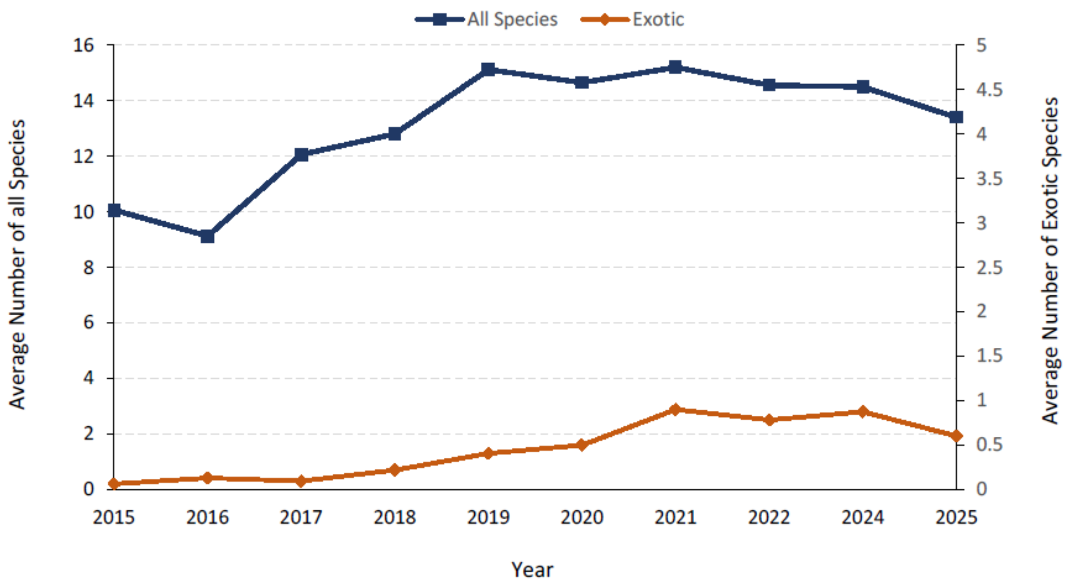

Figure 4: Average number of species per plot (n=32) along transects in stored vegetation from Cypress Mining Area (from Ecological Solutions Limited 2025).

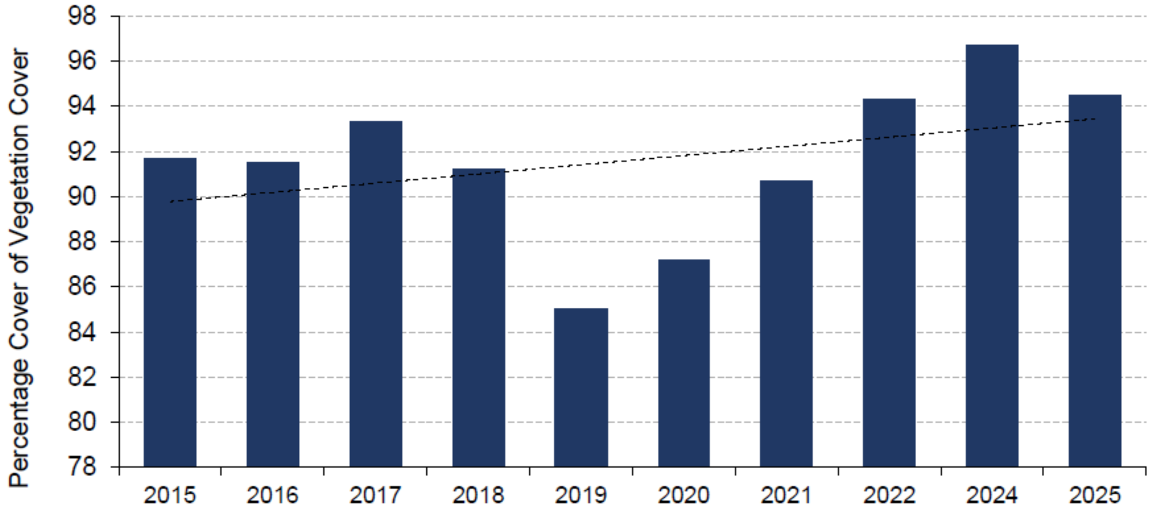

Figure 5: **Average percentage cover of live vegetation in plots (n = 32) in stored vegetation from Cypress Mining Area (from Ecological Solutions Limited 2025).**

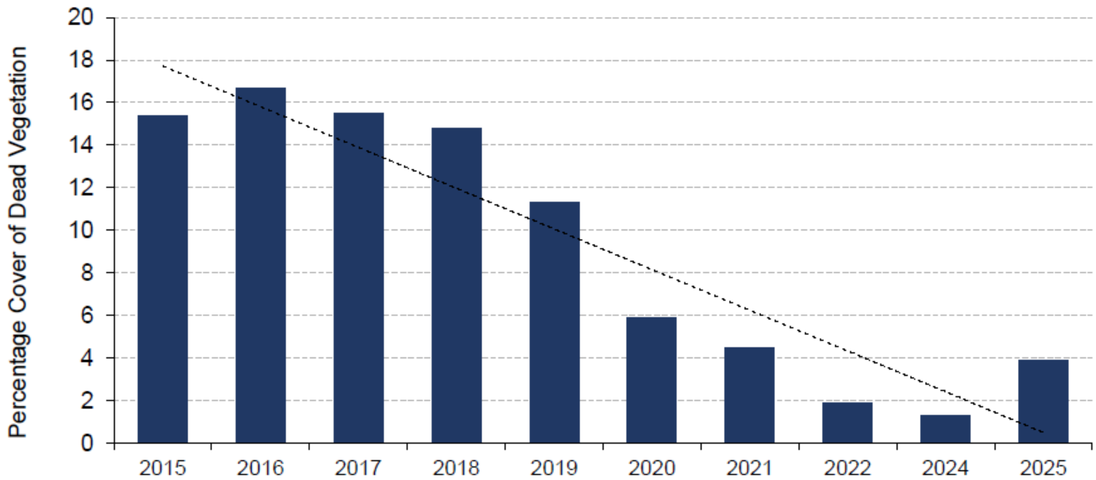

Figure 6: **Average percentage cover of bare ground in plots (n = 32) in stored vegetation from Cypress Mining Area (from Ecological Solutions Limited 2025).**

The invasion of weeds and presence of native shrubs (mostly mānuka) not normally found in red tussock ecosystems will both require careful management to meet stringent closure conditions of ≤ 5% exotic plant cover and ≤1% mean *Juncus squarrosus* cover) in post-mining vegetation (Ecological Solutions Limited 2025). Frequent monitoring also has the potential to damage vegetation (through trampling) and introduce and maintain weed populations, so limiting the frequency of monitoring and ensuring regular weed control are critical for meeting weed targets, particularly in VDT (Ecological Solutions Limited 2025).

VDT is an effective way to conserve plants which are not propagated by nurseries, to maintain large/old individual plants, and to translocate poorly mobile species of fauna such as snails and lizards (Rogers et al. 2011). VDT soils contain an earthworm biomass and diversity slightly lower and more variable than undisturbed soils, but significantly higher than stripped and stored soils (Boyer et al. 2011). Not all vegetation types are suitable for VDT, with taller vegetation (> 1.5m in height) and rocky soils being less suitable than shorter vegetation on more consistent soils. Red tussock/wire rush-mānuka vegetation responds particularly well to direct transfer because of its short stature and shallow rooting depth (Simcock et al. 2011), meaning that whole root zones can be transferred with minimal disturbance. Although significant dieback and deaths of shrubs and trees (particularly podocarps) typically occur when transferring forest vegetation, regenerative capacity can still be retained in root plates, understorey vegetation and the seed bank retained in the soil (Ross 2008). In addition, some tree species are resilient to shifting and regrow from their base or trunk (notably rātā, but also some beech species).

3.3.4 Seeding and Hydroseeding

Seeding and hydroseeding have been trialled as methods to revegetate sites that are not suitable for planting or VDT such as road batters, embankments and overburden placement slopes.

A method of seeding called 'fascining' was first trialled in 1990 by placing branches with ripe seed capsules on various substrates, with most successful establishment on soil or finely weathered greywacke/granitic materials as opposed to overburden containing acid-forming rock (Solid Energy 2004). The branches provided shelter and a light mulch of dead leaves which facilitated seed germination, along with controlling soil erosion (Solid Energy 2010). Mānuka is the preferred species for fascining since it produces plentiful seed which is held for a long time on the plant (providing flexibility in harvesting) and ready germination, but this method is labour-intensive. Simcock et al. (2004a) considered that fascining produced slow, limited results compared to other methods of rehabilitation such as planting or direct transfer, but Lloyd (2024) considered that the benefits of fascining had not fully been evaluated in terms of its utility in creating suitable snail habitat. An example of such vegetation is shown in Figure 7.

Figure 7: Area rehabilitated in 2005-2006 using a combination of methods, which included planting and most likely fascining (from Lloyd 2024).

Hydroseeding is the application of a water-based slurry of seeds, adhesive, wood fibre, straw mulch or newspaper and fertilisers using machine-operated high-pressure hoses (Solid Energy 2010). Large-scale hydroseeding trials were implemented in 2002 on an overburden dump and along road sides/cut faces (Ross & Simcock 2004). The two methods used at the overburden dump (dry and wet application of moss mix with fragments of herbs) produced successful germination, particularly for *Epilobium* species. For the trials along road sides and cut faces, eight treatments were trialled with varying amounts of mulch, fertiliser, moss, exotic grasses and seeds of native species (mānuka, koromiko, mountain flax). Successful germination of all species occurred at these sites, with flax being the most successful in terms of growth. Native species responded well where exotic grasses were excluded from the hydroseeding treatment. Trials using fragments of non-vascular plants and small colonising herbs (*Nertera depressa*, *Epilobium* species, and *Anaphalioides bellidioides*) have also been successful as part of specialised hydroseeding mixes containing adhesive, soil amendment and fertiliser.

Hydroseeding can establish vegetation cover quickly (i.e., within 3–6 months) compared to other methods such as planting (Ross 2008). Hydroseeding trials using native species indicated that areas that are south-facing (shady and retain moisture), have protected, stable microsites (e.g., logs and boulders) and are veneered with granitic overburden produce the best hydroseeding results (Ross & Simcock 2004, Solid Energy 2004). Adding soil and some fertiliser to hydroseeding treatments increased moss cover, which is desirable because moss helps to stabilise slopes, retain moisture and build soil and also speeds up natural plant colonising processes. The use of mosses within hydroseeding treatments also increased native plant cover. These trials also developed methods of propagating moss in tunnel houses (to reduce establishment of weeds and increase growth rates) as well as harvesting and processing methods.

Seeding and hydroseeding have not been used to create shrubland or forest vegetation types because it is expensive (particularly the collection of sufficient volumes of seed from commercially unavailable species) and trials have not yet demonstrated a high level of feasibility for this approach. Aerial sowing of native species was undertaken by Michael Kingsbury (Solid Energy), and more recently (at Cypress mining area) using drones, but is also limited by the effort required to collect adequate volumes of suitable seeds, although mānuka is commercially available. Hydroseeding and seeding are effective treatments for achieving erosion control on steeper slopes with limited accessibility for planting and VDT (Simcock et al. 1999, Solid Energy 2010).

3.3.5 Use of Fertiliser and Biosolids

The generally limited amount of soils available at Stockton poses a challenge for planting. Furthermore, soils across the Buller Plateaux are naturally infertile and therefore support plants adapted to those conditions. Despite this adaptation, the use of fertiliser and biosolids can be beneficial at sites where nitrogen and phosphorus are severely lacking, including planting into overburdens, indicate that plant establishment and survival is better when fertiliser is used (Solid Energy Limited 2004). Fertilisers may be applied:

- Directly to the root ball of each plant at planting;
- Via slits after planting;
- Mixed through the soil profile when spreading the root zone; or
- As broadcast fertiliser.

Where fertiliser is located, the underlying soil condition and the target species are all important factors to be considered in fertiliser application. Broadcast fertiliser at the soil surface is generally the least preferred option because whilst it facilitates growth of erosion control seeding, it also facilitates growth of *Juncus squarrosus* and other weeds and can contribute to the formation of a thick cover of exotic grass which is hard for native species to colonise/establish in.

The quantum and efficacy of fertiliser application is species and root zone dependant. Currently fertiliser and biosolids are strategically used in plantings depending on location and substrate. Plantings on mixed substrates including waste rocks, boulders, rock fines, and soil or soil-like plant media where fertilisers have been applied have seen an improvement in growth and survival compared to older plantings situated on compacted overburden sandstone, also likely due in part to the provision of microhabitats (Ross 2008, Theinhardt 2003).

Theinhardt (2003) found that the addition of fertiliser on sites with soil had no significant effect on plant growth, however when fertiliser was added to sandstone or quarry rock substrates, plant growth was enhanced. In Theinhardt's trials toetoe and mountain flax responded most strongly to fertiliser, whereas the response of silver beech and koromiko depended on the substrate and level of exposure (Theinhardt 2003).

A 1997 fertiliser trial with nursery-raised plants showed an increase in height and ground cover of red tussock, Southern rātā and koromiko after addition of an NPK fertiliser tablet. Mountain flax has been commonly used in plantings for its fast growth and suitability as a nurse crop and as snail habitat; however, at infertile sites it requires repeated fertiliser applications to sustain growth and set seed (Simcock & Ross 2014).

The use of biosolids (dried and sterilised municipal sewage waste) to overcome high acidity and infertility of soils has resulted in some success in terms of increasing plant growth and improving the availability of nutrients (Waterhouse et al., 2014); however, the establishment of native plants at some biosolid sites has proven difficult. A more recent biosolids application field trial area using only native plantings is shown in Figure 8a. High mortality of nursery seedlings has occurred in some application trial areas where exotic grasses smother native plants as shown in Figure 8b. A pot trial adding biosolids into the propagation medium for red tussock (*Chionochloa rubra*) at the rate of one-part biosolids to four parts soil stockpile composite increased plant biomass, but also increased earthworm mortality (Waterhouse et al. 2014). The use of biosolids at the Stockton mine will cease when the current contract with Christchurch City Council expires later this year.

Figure 8a: Biosolids application trial area using only native plantings at Rockies South, Stockton Mine. Planted 2019, photographed 2024 (approximately 5 years old).

Figure 8b: Biosolids application trial area near Mt Frederick, Stockon Mine (established 2012, photographed 2015).

3.3.6 Tarns

Tarns are subalpine and alpine ponds, and in the context of the Buller Plateaux are ephemeral and permanent features of the sandstone pavement landscape, occurring in areas of impeded drainage (Simcock et al. 2011). Since the early 2000s there has been both deliberate and inadvertent rehabilitation of tarns on impermeable coal floor, in areas rehabilitated with VDT, and on flat compacted overburden areas, either as individual features isolated by landforms or bunds or as part of a tarn complex. At some locations. tarns have been used to help manage sediment in the short term. The substrate of constructed tarn floors is typically sediment, and margins and adjacent areas are generally either planted or receive VDT. An example of an inadvertently constructed tarn with planted and hand transferred vegetation is shown in Figure 9.

Figure 9: Tarn constructed approximately 2008 with planting and hand transfer vegetation at Mt Augustus Gardens, Stockton Mine, photographed 2024 (approximately 16 years after construction).

3.4 Bryophytes

VDT and rock transfer have both been undertaken at Stockton Mine, but the survival of bryophytes has typically not been monitored. Glenny (2012) found bryophytes recolonise VDT areas more effectively than hand-planted areas without soil. Glenny's comparison between bryophytes present in 'natural pākihi' and at sites rehabilitated by planting, showed that the two bryophyte communities shared only two common moss species, *Campylopus clavatus* and *C. introflexus*. Glenny (2012) noted that naturally uncommon bryophyte species typically have narrow and uncommon niches, and restored sites likely have fewer such niches unless they are intentionally created.

Terry (2017) surveyed rehabilitated sites at Stockton for bryophytes and lichens, noting that liverwort diversity had noticeably increased (43 liverworts, 20 mosses, and 17 lichens) since Glenny's 2012 survey. This increasing diversity suggests that there was sufficient shade and moisture present at older sites to support a wider range of bryophytes, particularly liverworts, preventing them from drying out. Terry (2017) also found that VDT supported more mature bryophyte communities, and contained more 'At Risk' and 'Data Deficient' lichens (e.g., *Cladia inflata*, 'At Risk – Declining', and *Parasiphula elixii,* 'Data Deficient', de Lange et al. 2018) than planted sites.

Glenny (2012) considered that a mature bryophyte and lichen community would be established when 25% of the indicator species for a particular vegetation type were present. The indicator species and vegetation types are set out in Table 3. Since 2012, taxonomic revisions have placed some species formerly in the genus *Telaranea* (Lepidoziaceae) in *Ceramanus*, *Kurzea*, *Neolepidozia* and *Tricholepidozia*. For simplicity we have included the latter genera as 'indicator taxa' in Table 3. Furthermore, because some bryophyte genera such as *Acromastigum* and *Pulchrinodus,* which were not listed as 'indicator species' in Glenny (2012), but do occur in 'mature bryophyte communities' (e.g., Glenny 1999, Glenny and Fife 2001, Glenny 2003), we have expanded Glenny's (2012) list to include the 'indicator taxa' set out in Table 3. Given that the indicator species identified by Glenny also occur in other habitats, we have grouped the habitat types.

For the purposes of assessing rehabilitation outcomes, we consider that if at least 25% of the indicator taxa listed in Table 3 have established, then the bryophyte community can be considered successionally advanced.

Note that no rehabilitated sites at Stockton comprise tall forest and are not expected to for some decades. Glenny (2012) considered that up to 50 years might be required for a mature bryophyte community to establish, but the outcome is likely to depend on a variety of factors including rehabilitation method and plant growth rates. There is currently no data available to confirm the length of time required.

Table 3: Indicator species for mature bryophyte communities proposed by Glenny (2012), and a modified indicator list adapted for this project.

<table>
<tr><th>Habitat type</th><th>Indicator species of mature communities</th><th>Habitat type</th><th>Indicator taxa of successionally advanced communities</th></tr>
<tr><td>Forest</td><td>Bazzania adnexa
Bazzania monilinervis
Bazzania nitida
Bazzania novae-zelandiae
Gottschea pinnatifolia
Kurzia hippuroides
Lepidozia digitata
Lepidozia kirkii
Lepidozia pendulina
Neolepidozia tetrapila
Psiloclada clandestina
Schistochila glaucescens
Zoopsis argentea
Zoopsis nitida
Zoopsis setulosa</td><td rowspan="3">Forest, Shrubland, Pākihi / Tarns, open sandstone pavement</td><td rowspan="3">Acromastigum
Bazzania
Ceramanus
Gottschea
Kurzia
Lepidozia
Neolepidozia
Pallavicinia
Pleurophascum ovalifolium
Psiloclada clandestina
Pulchrinodus inflatus
Rhacocarpus purpurascens
Riccardia
Schistochila
Syzygiella colorata
Telaranea
Tricholepidozia
Zoopsis</td></tr>
<tr><td>Pākihi</td><td>Kurzia hippuroides
Pallavicinia rubristipa
Pleurophascum ovalifolium
Riccardia asperulata
Riccardia cochleata
Riccardia crassa</td></tr>
<tr><td>Open sandstone pavement</td><td>Rhacocarpus purpurascens
Syzygiella colorata</td></tr>
</table>

4.0 Methods

4.1 Vegetation Survey

4.1.1 Rehabilitated Sites

Twenty-one 10m x 10m vegetation plots at rehabilitated sites were surveyed in October and November 2023[1] including eight which had been subject to vegetation direct transfer (VDT sites), seven which were planted (PL sites) and six which were previously disturbed but not remediated (i.e., 'non-remediated' DS sites). Sites were chosen so as to sample a range of ages of rehabilitation, a range of vegetation types and a range of accessible locations across Stockton Mine to include higher and lower altitude sites.

The non-remediated sites were subject to disturbance from mining, associated infrastructure or settlements up to approximately 54 years ago and have since been left to naturally regenerate for varying amounts of time with no rehabilitation methods applied.

[1] 31st October 2023; 1st, 2nd, 15th, 18th, 20th, 21st and 22nd November 2023.

The approximate length of time since disturbance is provided in Appendix A.

To provide a comparison of the three rehabilitation methods to structurally similar, but undisturbed vegetation, data from a subset of plots (n = 10) collected using the same method as part of a wider Buller Plateaux mapping project (Ecological Solutions Limited 2026b) were used in statistical analyses. The locations of these plots are shown in Figure 10, Figure 11 and Figure 12 and are also provided in Appendix A. Vegetation within the plot was recorded using a modified RECCE method (Hurst et al. 2022). Each 10m x 10m plot was divided into four 5m x 5m quadrats and each quadrat was recorded separately. The north eastern quadrat of each plot was surveyed for bryophytes and lichens.

In addition, vegetation surrounding 12 natural tarns (TN sites) and six constructed tarns (TM sites) was also surveyed. The location of these tarns is shown in Figure 10. To define the survey area a tape measure was laid around the perimeter of each tarn, maintaining a 2m separation from the water. The area between the perimeter of the tarn and the tape measure was divided into two or four quadrats (depending on the perimeter length) and the same data was recorded as at the rehabilitated sites. Locations and descriptions of the rehabilitated sites and tarn sites are presented in Appendix A

Plant species were recorded within each quadrat along with their percentage cover and height classes. The physiography, slope, aspect and soil drainage were recorded for each plot, and soil depth was recorded for each quadrat. Physiography was assigned using the classes defined by Bell (2005). Slope angle and aspect were estimated using a compass. Soil depth was recorded using a 70cm steel soil probe near the centre of each quadrat.

Soil drainage class was assigned for each plot by digging an approximately 20cm deep hole, either adjoining or within the plot, and using soil features to assign one of five soil drainage classes (Taylor and Pohlen 1979). Other features such as surface water, soil saturation and vegetation type were also considered when determining drainage class. With respect to vegetation, the wetland indicator status of species assigned by Clarkson et al. (2021) was considered. Where the dominant ground cover species was obligate (e.g., wire rush) or facultative wetland (e.g. *Machaerina teretifolia*), soils were considered poorly drained.

The percentage of ground cover vascular vegetation, non-vascular vegetation (i.e., bryophytes), litter, bare ground and rock was estimated for each quadrat. The estimated average top height (m) and percentage canopy cover was also recorded for each quadrat. Any vegetation browse, invertebrates or birds encountered within the plot or nearby were also recorded, along with the rehabilitation method applied.

From the information collected, the following metrics were calculated for each plot:

- Number of species.
- Number of indigenous and exotic species.
- Proportion of indigenous species.
- Total percentage vegetation cover.
- Number of ‘Threatened’ and ‘At Risk’ species.
- Percentage cover of ‘Threatened’ and ‘At Risk’ species.

The number and type of colonising species (i.e., those not planted) were also recorded at planted sites.

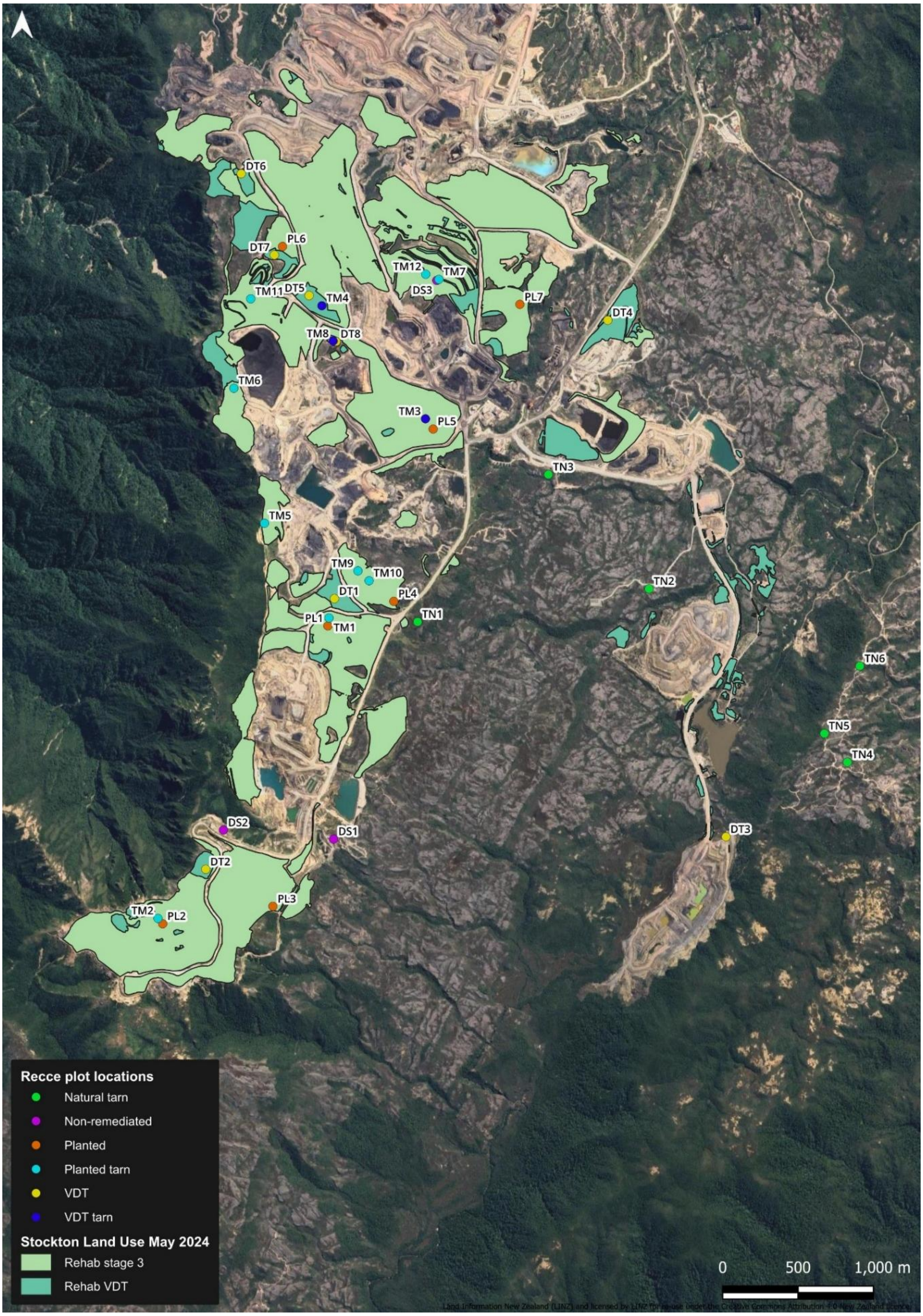

Figure 10: **Location of direct transfer, planted, and tarn plots at Stockton Mine[2].**

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[2] Note Rehab Stage 3 are areas that have been planted.

[redacted]

Figure 11: Location of plots at drill sites and non-remediated sites at the Buller Plateaux.

Figure 12: Location of plots at natural sites at the Buller Plateaux.

4.1.2 Drill Sites

Thirty-two drill sites across the Buller Plateaux were surveyed to determine whether prospecting and drilling activities promoted the establishment or persistence of weedy vegetation. Six sites were surveyed south of Mt Frederick (DC sites), six near the Cypress mining area (STK sites) and twenty throughout the Denniston Plateau (DEN sites), as shown in Figure 11. The locations and descriptions of these drill sites are set out in Appendix A.

Access for drill rigs included helicopter (n=20), ground-based vehicle (n=3) and track-mounted drill rig (n=4). Access at five sites (one at Denniston, four at Stockton) was unrecorded, but it is likely these were helicopter access given the distance from roads and the lack of tracks to those sites. The sites were active between 1997 (Stockton) and 2023 (Mt Frederick South) with Stockton sites being drilled from 1997–2023 and Denniston sites drilled from 2011–2015. Due to the relatively small extent of their footprint (typically 10m x 10m or less) and comparatively minimal disturbance, none of the drill sites had been subject to any rehabilitation management. Vegetation at drill sites was surveyed using 5m x 5m RECCE plots as described in Section 4.1.1, with the drill hole located at the centre of each plot.

4.1.3 Statistical Analysis

To simplify the dataset used for statistical analyses, species cover and ground cover values and soil depths were averaged across the two sub-plots (for tarns) or four quadrats (for RECCE plots) of the plot so that each of these variables had only one metric per plot.

It was expected that there would be higher mean total vegetation cover, higher cover of native species and a higher proportion (in terms of cover) of plants of conservation interest (‘PCI’ i.e., plants considered to be ‘Threatened’ or ‘At Risk’ by de Lange et al. 2024) at natural plots compared to the other plot types, and that VDT sites would have higher mean total vegetation cover, higher cover of native species and a higher proportion of PCI than either non-remediated sites or planted sites. We also expected that vegetation surrounding natural tarns would have higher percentage cover, a higher proportion of native species and more PCI than vegetation surrounding constructed tarns.

Mean total vegetation cover, cover of native vegetation, and proportion of PCI were also compared between natural plots and VDT plots of the same vegetation type (beech forest, shrubland, tussockland). Due to small sample sizes (n: 2–4), no statistical tests were applied to these data.

High variation relative to the mean (overdispersion) is a common feature of count data, so to avoid some of the constraints of traditional ANOVA models, the generalised linear model (GLM) function in R (R Core Team 2022) was used with a quasi-Poisson error distribution and log-link function to determine whether the number of PCI varied between treatments (planted, direct transfer, non-remediated and natural (control)). Because the percentage cover (i.e., total cover and total native cover) exceeded 100%, a normal (“gaussian”) distribution was used in the GLM models.

4.2 Bryophytes

The north-eastern quadrat of each vegetation and tarn plot was surveyed for bryophytes at the same time as the vascular plant survey described above. Terrestrial and epiphytic microhabitats sampled included ground cover vegetation, leaf litter and detritus, decomposing wood, soil, rock, bedrock and fissures, substrate overhangs, bark, and areas where moisture accumulated.

Specific efforts were made to detect adventive bryophytes such as weasel moss

(*Sphagnum subnitens*). Metrics reported here include species richness per plot, percentage cover, presence of 'Threatened' or 'At Risk' species (de Lange et al. 2020, Michel et al. 2026) and the proportion of 'indicator taxa' described above (Table 3).

In addition, bryophytes were surveyed along Monitoring Transect 4 at McCabe's tussock storage pad which consisted of red tussock (*Chionochloa rubra*) grassland. Red tussock grassland is particularly high value habitat for bryophytes. The vegetation was originally relocated from Cypress mining area to the McCabe's tussock storage pad in 2008. The vegetation had not been surveyed for bryophytes previously, but the presence of any bryophytes would indicate that they had either survived the VDT process or colonised the vegetation after placement.

4.3 Avifauna

4.3.1 Incidental Observations

All bird species encountered during the vegetation surveys were recorded.

4.3.2 Five-minute Bird Counts

Five-minute bird counts were collected using the standard method of Dawson and Bull (1975), modified for distance sampling. Only birds within 200m were recorded (i.e., a bounded survey) to try and limit the inclusion of birds heard outside the rehabilitated areas, particularly from adjacent unmodified areas.

A total of 46 permanent five-minute bird count stations were established at rehabilitated sites at Stockton at the locations shown in Figure 13 including:

- Between four and seven stations established within each of R6, Ross Dump, Campbells Dump and the Tussock Storage Pad in 2021.
- 24 stations at an additional 12 rehabilitated areas (eight planted sites and four VDT sites) in 2024.

Each station was sampled once by two observers on 18th February 2021 and again 6th or 7th March 2024. Each of the 46 stations was surveyed once by each observer. Stations were separated by at least 100m to provide representative coverage of each rehabilitated area. Data from five-minute bird counts undertaken at natural habitats on the Denniston Plateau was used to compare differences in species composition and numbers between rehabilitated and natural sites. Surveys were undertaken on two consecutive days, with fine weather, little wind, and only a light shower during some periods on the second day of each survey. Noise from heavy machinery introduced moderate to loud interference, which was particularly noticeable at the Tussock Storage Pad, Campbell's Dump, and the Mt Augustus Gardens area. It is recommended that additional bird surveys be undertaken during site shut-downs where possible.

A paired sample t-test was used to compare the average number of birds per five-minute bird count between planted and VDT rehab sites.

4.3.3 Kiwi Dog Survey

Nine sites were surveyed in February and March 2021 including R6, Plover, MF16, Mt Fred Tarn Trial, Mt Fred Quarry, A Drive, SN13, Hook Dump and SN05. Surveys used approximate transect lines within each site walked by Lynne Maguire (MBC Environmental Ltd) and a certified protected species conservation dog, Mica.

Three sites were surveyed in 2024, including R6, Mt Fred Quarry and Tyler Road, using the same method as the 2021 survey by Lynne Maguire (MBC Environmental Ltd) and a certified protected species conservation dog, Petra. In addition, two trail cameras and two acoustic recorders were set at Mt Fred Quarry to record for three nights from 24 June 2024 to 27 June 2024.

4.4 Herpetofauna

To assist in determining whether VDT sites can support lizard populations, 100 Artificial Cover Objects (ACOs) were deployed in March 2019 at five VDT sites. Each ACO consisted of two stacked onduline sheets, each measuring approximately 500mm x 450mm. ACOs within the VDT sites were surveyed on the 14 January 2020 and again on 12 and 13 February 2024 to determine whether any lizards were using them.

Surveys included the checking of ACOs in conjunction with manual searching which included visual scans for West Coast Green gecko and turning over rocks or coarse wood for forest gecko or Newman's speckled skink. One of the five sites (Mt Frederick) was inaccessible due to programmed blasting activity and not surveyed. The 2020 survey involved 16.75 person hours of searching by four people and the 2024 survey involved 43.75 person hours also by four people.

The focus of these later surveys was to confirm the presence of West Coast green gecko in the VDT sites. To that end, surveys were undertaken in Hope Dump and Campbells as these were considered the most likely to have West Coast Green gecko due to the habitat type and quality there.

In accordance with standard protocols set out in Lettink & Monks (2016), information recorded for each lizard included:

- Location detected (GPS).
- Species.
- Snout Vent Length (SVL).
- Sex and reproductive status (gravid or non-gravid).
- Tail regeneration status (original or regenerating tail).
- Dorsal, ventral and lateral photos.
- ACO or CFC number (reptile shelters) or height above ground and tree species detected in (nocturnal surveys).

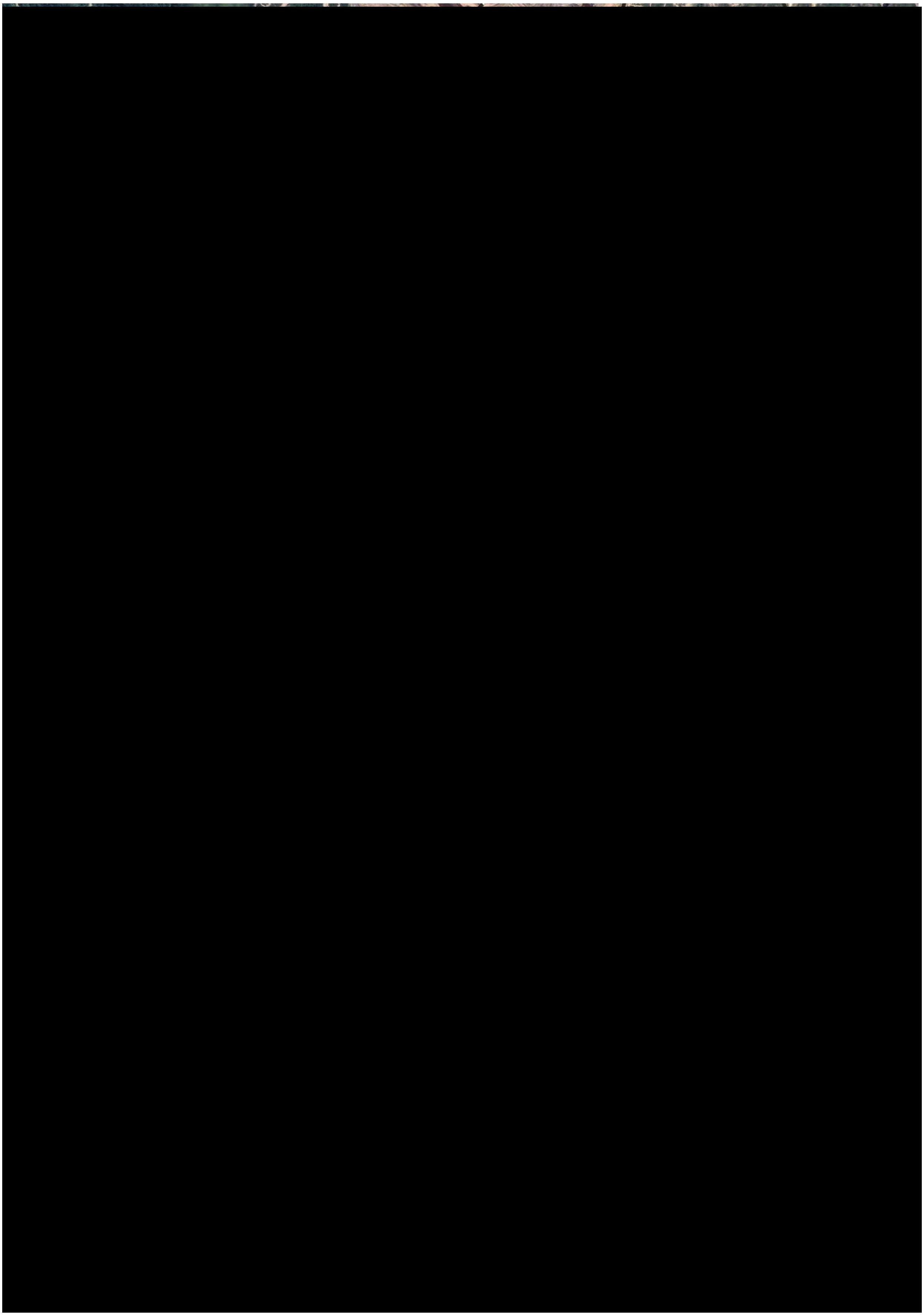

Figure 13: Locations of five-minute bird count stations at Stockton.

4.5 Terrestrial Invertebrates

4.5.1 Soil Dwelling Invertebrates

Twenty-eight soil samples with a volume of approximately 800cm^3 (8 litres, 20cm deep x 20cm wide) were collected, including seven from VDT sites, five from planted sites, ten from near constructed tarns and six from near natural tarns. The litter layer was included in the samples. Soil was bagged into large snap-lock bags and sent to Lincoln University for extraction and identification of soil fauna.

Soil samples were checked by hand for macrofauna (i.e., 0.5–50mm in size) before being placed into a Berlese funnel for extraction of microfauna. Berlese funnels are devices used to extract desiccation-intolerant invertebrates (e.g. earthworms) from samples of soil or leaf litter. They work by providing a heat source at the top of the device, gradually drying the soil from top to bottom. This encourages desiccation-intolerant invertebrates to move further down into the soil to stay moist, eventually falling into a sampling container or pottle placed underneath the device.

Soil samples were placed into Berlese funnel trays and left to dry for approximately seven days or until completely dry. A pottle filled with 100mL of 70% ethanol was placed under each Berlese funnel to catch any invertebrates from the sample. The light used to provide a heat source were Phillips 75W Bayonet light bulbs. Following collection, microfauna (i.e., organisms with a body size of <0.1mm, e.g. mites (Acari)) were identified using a stereo microscope.

4.5.2 *Powelliphanta* Snails

Field surveys for *Powelliphanta patrickensis*, a 'Threatened – Nationally Critical' terrestrial carnivorous land snail restricted to the Buller Plateaux, were undertaken by MBC Environmental during summer 2023–24 in rehabilitated areas on the Stockton Plateau (Lloyd, 2024, Walker et al. 2024). The purpose of these surveys was to assess whether different rehabilitation techniques are effective in supporting healthy populations of snails. Nocturnal surveys were undertaken along 8km of transects through planted areas and nearby undisturbed habitat, while nocturnal capture-recapture surveys were undertaken in two 70m x 70m plots in red tussock VDT at McCabe's Tussock Storage Pad. Nocturnal surveys were undertaken by two observers, working during the hours of darkness on warm moist nights, with overnight temperatures > 8°C and relative humidity remaining above 90%.

Data from snails ≥ 20mm in diameter were used in capture-recapture analyses to estimate plot population sizes and demographic changes (apparent survival rate, per-capita recruitment rate and population growth rate) between surveys (Lloyd 2024). Analyses were undertaken to determine snail age based on diameter and the proportion of reproductively mature snails in samples.

4.5.3 Surface Dwelling Invertebrates

4.5.3.1 Introduction

Five different methods were used to sample terrestrial invertebrates including malaise trapping, pitfall trapping, sweep netting, beat sampling and hand searching. Different methods were used in order to sample a range of microhabitat types which are utilised by different invertebrate species. A total of 39 sites were sampled in this survey, at the same locations as the vegetation plots.

At each sampling site, one malaise trap was set and three pitfall traps were installed. Pitfall traps were placed within 5m of malaise traps. Additionally, suitable vegetation surrounding the site was sweep-netted and beat-sampled for at least ten minutes on the day the traps were installed. Traps were set between 31 October and 2 November 2023 and retrieved on 20 November and 22 November 2023. During the three weeks the traps were deployed, 349mm of rain fell and an average wind speed of 14km/h (range 9–25km/h) was recorded at Stockton (Bathurst Resources Limited unpubl. data). Specific methods are described for each sampling method in more detail below.

4.5.3.2 Malaise Trapping

Malaise traps are 'tent-like' passive intercept traps that primarily catch flying insects, particularly wasps (Hymenoptera) and flies (Diptera), but also moths (Lepidoptera, particularly if combined with an ultraviolet light). They are usually set in contact with the ground to collect low flying species, but can also be set in the forest canopy to sample high flying insects. Each malaise trap was nestled among short vegetation where possible so as to minimise damage and movement of the trap due to wind. One malaise trap was set at each site and an example of a malaise trap is shown in Figure 14. Deployment period was approximately four weeks. Traps were not emptied and reset during the deployment period.

Figure 14: A malaise trap erected at site DT8.

4.5.3.3 Pitfall Trapping

Pitfall traps were placed in a triangular formation around the malaise trap, spaced approximately 2–3m apart. The container was buried so that the lip was flush with the surface of the ground, so as to allow any invertebrates to crawl under and fall into the trap. Traps were approximately one-third filled with monopropylene glycol. A small piece of corrugated polypropylene (corflute) measuring approximately 20 x 20cm was placed over top of the container and held in place by weed mat staples to reduce rainfall directly entering the trap. An example of a pitfall trap set up is shown in Figure 15.

Figure 15: A pitfall trap with a corflute cover raised approximately 5cm off the ground.

4.5.3.4 Sweep Netting

Sweep netting involves use of a net (similar to a butterfly net, but often with a canvas bag) to sweep across vegetation to collect insects and other invertebrates living there. Sweep netting allows the collector to cover a large area relatively quickly, but does not typically capture ground dwelling invertebrates. A sweep net was used to sample suitable vegetation within 5m of the malaise trap for at least 10 minutes per site.

4.5.3.5 Beat Sampling

Beat sampling involves using a 'beating tray' which typically consists of a pale coloured cloth that is stretched out over a frame. The frame is then held under the plant and the plant is knocked firmly with a 'beating stick', causing any invertebrates on the plant to fall onto the tray where they can be retrieved and transferred to a sample jar. Beat sampling was used to sample suitable vegetation within 5m of the malaise trap for at least 10 minutes per site. Suitable vegetation included dense shrubs and trees over approximately 1m in height.

4.5.3.6 Hand Searching

Hand searching was used to search *Gahnia procera* (if present), which is the host plant of the forest ringlet butterfly (*Dodonidia helmsii*), and other plants (for example mountain flax, *Astelia* spp.) likely to house large, relatively immobile species such as leaf-veined slugs or stick insects for signs of these species. Up to 30 minutes was spent hand-searching suitable vegetation at each sampling site on the day when the traps were set.

4.5.4 Tarns

At each tarn, one malaise trap was set and sweep-netting and beat-sampling was undertaken. No pitfalls were used at tarns due to the likelihood of water flooding the traps and compromising the samples. Sampling protocols followed those outlined in Sections 4.5.3.2 and 4.5.3.4 to 4.5.3.6.

Malaise traps were deployed at tarns on 19 and 20 March 2024. They were left for four weeks and retrieved on 16 and 17 April 2024. During the four weeks the traps were deployed, 415mm of rain and an average wind speed of 14km/h (range 6–31km/h) was recorded at Stockton (Bathurst Resources Limited unpubl. data).

4.5.5 Identification and Statistical Analysis

Specimens were trapped in monopropylene glycol, and later transferred to 70% ethanol for storage and identification. Identification was performed under a dissecting microscope. For each sample a count of the number of taxa present as recognisable taxonomic units ('RTU') and identified species was recorded, with each taxon being marked as native, exotic or unknown (e.g., for a taxon identified at family level where the family is known to contain both introduced and native species).

A two-way ANOVA model was used to measure the effect of rehabilitation type and native/exotic status of the invertebrates on taxa diversity. Taxa diversity was transformed using square root to meet model assumptions of normality. A second ANOVA model was used to analyse the effect of tarn type and native/exotic status of the invertebrates collected.

4.6 Aquatic Fauna

Field surveys were undertaken by NIWA (now Earth Sciences New Zealand) in January and April 2024 at the tarns shown in Figure 10 in order to assess the success of tarn rehabilitation with respect to aquatic values (Watson et al. 2024). The field surveys focused on comparing water quality and physical variables as well as macroinvertebrate metrics between tarn types.

Water quality variables measured included pH, conductivity and dissolved metal concentrations. Physical parameters measured included tarn surface area, bank slope and altitude. Macroinvertebrates were collected using a D-frame kick net (250µm mesh) sampling a total area of $1m^2$ around different habitat types within each tarn. Macroinvertebrate metrics calculated included taxa richness, abundance and the percentage (%) of Chironomidae. Chironomidae are low-scoring taxa that typically dominate soft-bottomed habitats, prefer living in algal mats, are widespread haphazard dispersers and are often the most abundant invertebrate in aquatic ecosystems, especially degraded ones (Stark and Maxted 2007, Watson et al. 2024).

5.0 Results

5.1 Vascular Vegetation

5.1.1 Rehabilitated Sites

Cover data is summarised in Table 4. Natural (i.e., undisturbed) plots had the highest average total vegetation cover (182%, whereby vegetation cover exceeds 100% due to the layering and overlap of vegetation tiers). Of the three rehabilitation treatments, VDT plots had the highest total vegetation cover, highest canopy cover and the highest mean number of species per plot, followed by non-remediated sites and then planted sites (8 – 20 years post planting).

The number of species per plot (shown in Table 5) and the mean top height did not vary according to rehabilitation type. Soils were deepest at VDT sites (mean = 409 mm, ± 37 (SE)), followed by natural sites (mean = 366 mm ± 31 (SE)), non-remediated sites (mean = 235 ± 77 SE)) and planted sites (mean = 229 mm ± 31 SE)). Drainage was typically 'imperfect' at natural, VDT and disturbed sites, and 'well drained' at planted sites, however VDT sites showed the most variation in drainage.

Table 4: Plot cover summary data for rehabilitated and natural sites across Stockton Mine.

Site	n	Total vegetation cover*	Non-vascular cover	Litter cover	Rock cover	Bare ground	Top height	Canopy cover
VDT	8	136.7 ± 27.8 (109-165)	5.8 ± 5.4 (0.4-11)	6.9 ± 6.9 (0-14)	1.5 ± 3.1 (0-5)	3.4 ± 5.9 (0-9.3)	1.0 ± 0.3 (0.6-1.3)	38.5 ± 15.5 (23-54)
Planted	7	90.9 ± 38.2 (53-129)	15.8 ±15.6 (0.2-32)	5.4 ± 4.4 (2-9)	19.5 ± 15.9 (4-35)	4.9 ± 8.8 (0-13.7)	0.6 ± 0.2 (0.4-0.9)	19.6 ± 12.2 (8-32)
Non-remediated	6	111.5 ± 57.5 (54-169)	21.6 ± 17.2 (4-39)	7.7 ± 5.2 (2-13)	5.9 ±5.9 (0-12)	3.0 ± 3.0 (0-6)	0.9 ± 0.6 (0.3-1.5)	12.6 ± 11.4 (1-24)
Natural	10	181.7 ± 65.1 (117-247)	14.6 ±16.4 (0-31)	11.1 ± 7.3 (4-18)	2.0 ± 5.0 (0-7)	0.75 ± 1.1 (0-1.9)	2.2 ± 1.8 (0.4-4)	29.3 ± 15.2 (14-45)

*Data are shown as mean ± standard deviation (range)

Vegetation at VDT sites was variable and included low forest consisting of silver beech, mountain beech and *Archeria traversii*, shrubland dominated by mānuka, yellow-silver pine and Southern rātā, and low tussock-shrubland with red tussock, stunted mānuka, mountain flax and wire rush. Ground cover vegetation appeared to survive the direct transfer process well, however there was evidence of dieback on the taller trees such as beech and Southern rātā. This may be attributed to root damage during transfer or a change in environmental conditions compared to its original location (e.g., soil depth, drainage, aspect or exposure).

Planted sites contained a mix of forest, shrubland and tussockland species as well as a range of exotic species. Eighty-two vascular plant species including 19 planted and 63 colonist (naturalised, unplanted native) species were recorded at planted sites as set out in Appendix B. The four different treatments were similar in terms of species richness as shown in Table 5. Planted sites had more bare rock and bare ground than VDT and natural sites as shown in Table 4. However, rock cover in VDT is generally manipulated through deliberate additions of boulders as habitat features, rather than exposure of smaller rocks which is more typical of planted sites.

Non-remediated sites had variable vegetation type and structure. Low-growing grassland and shrubland with exotic grasses and rushes were present where large areas had been disturbed (e.g., Stockton Mine, Sullivan Mine), and taller shrubland with gorse was present in non-remediated sites adjoining undisturbed areas (e.g., Cedar Creek Road).

There was a low level of browse detected across all plots.

Table 5: Species richness for rehabilitated and natural sites at Stockton Mine.

Site	n	Species per plot		
		Mean ± SD	Min	Max
VDT	8	37.8 ± 4.8	27	45
Planted	7	32 ± 8.2	15	43
Non-remediated	6	21.8 ± 4.5	14	27
Natural	10	28.4 ± 7.3	13	46

Total vegetation cover

The total vegetation cover includes the cover of each species in each height tier, and is therefore a reflection of vegetation density. Mean total vegetation cover ranged between

91% in planted areas to 182% in the natural plots as shown in Figure 16. The mean total cover in the VDT plots was 137%. Total cover was statistically different between plot types ($F_{3,45}$ = 3.54, P = 0.02). Tukey's post-hoc testing revealed that natural plots had higher cover than planted (P_{adj} = 0.01). Adjusted p-values were not significantly different at the 0.05 level between natural and VDT plots (P_{adj} = 0.07), planted and VDT plots (P_{adj} = 0.33) or non-remediated and VDT plots (P_{adj} = 0.39).

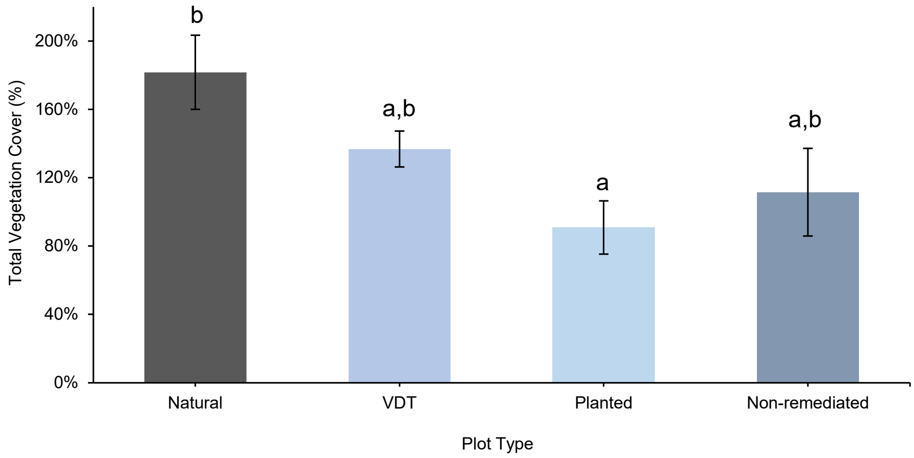

Figure 16: Mean (± SE) percentage total vascular vegetation cover among plot types.

Percentage cover of Native Vegetation

No exotic species were detected at plots in natural vegetation. The mean percentage cover of native vegetation was lowest at planted and non-remediated sites (80% and 72% respectively), i.e., non-remediated sites were the weediest (Figure 17). Overall, natural and VDT sites were statistically indistinguishable, but there was a significant difference between the percentage of native vegetation cover between plot types ($F_{3,45}$ = 7.34, P<0.001), with higher native vegetation cover at natural sites than at both planted sites (P_{adj} = <0.01) and non-remediated sites (P_{adj} = <0.01). There was no statistical difference in the percentage of native vegetation cover between VDT and planted sites (P_{adj} = 0.29) or between VDT and non-remediated sites.

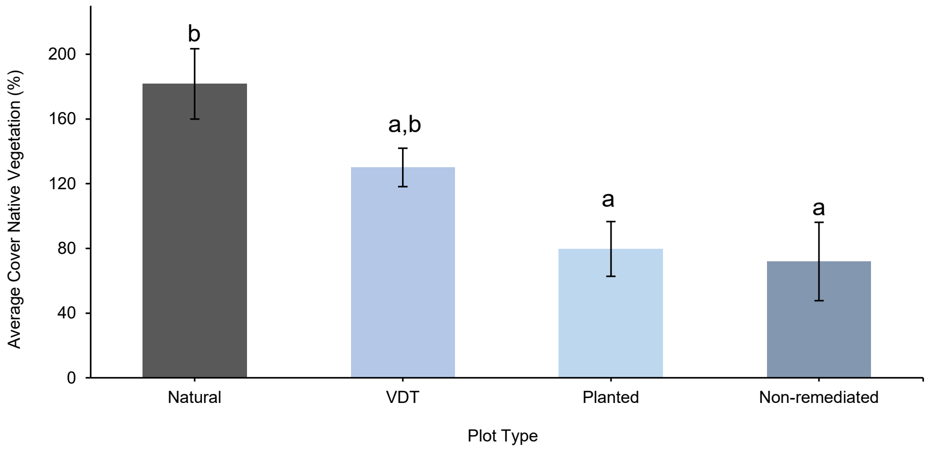

Figure 17: Mean (± SE) percentage cover of native vegetation at rehabilitated and natural sites at Stockton Mine.

Plants of Conservation Interest (PCI)

There was a significant difference in the frequency of PCI within each plot type ($c_{3,27} = 10.1$; *P* 0.017). Plants of conservation interest occurred in 81% of natural plots, 57% of planted plots, 25% of the VDT plots and 16% of the non-remediated plots.

Logistic regression showed that PCI plants were more common in natural plots than either non-remediated (β= 2.99; SE = 1.35; *P*=0.02) or VDT plots (β= -2.48; SE = 1.13; *P*=0.02), but natural plots were not significantly different from planted plots (β= -0.47; SE = 1.55; *P*=0.68). Frequency of PCI in plots VDT and non-remediated plots was not significantly different either (β= 0.51; SE = 1.36; *P*=0.71).

The number of PCI was similar in beech forest plots (50%), tussockland plots (57%) and shrubland plots (57%).

Differences between natural and VDT plots of the same vegetation type

Natural and VDT plots were similar with respect to total percentage vegetation cover, percentage native vegetation cover and presence of PCI species as shown in Figure 18 and Figure 19. Total vegetation cover was higher at natural plots than VDT plots, irrespective of vegetation type ($F_{1,12} = 5.11$, $P = 0.03$). Beech forest had higher vegetation cover than shrubland and tussockland, regardless of rehabilitation approach ($F_{2,12} = 6.33$, $P = 0.01$).

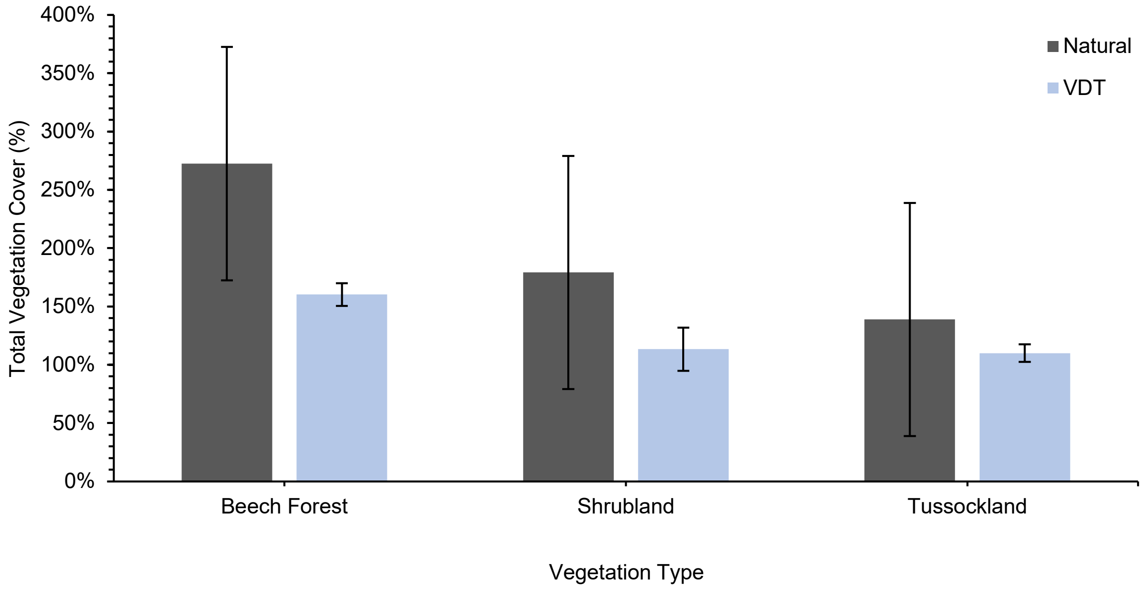

Figure 18: Mean (± SE) percentage vegetation cover at natural and VDT plots by vegetation type.

Indigenous vegetation cover was higher at natural plots than VDT plots, irrespective of vegetation type ($F_{1,12} = 6.29$, $P < 0.05$). Beech forest had higher indigenous vegetation cover than shrubland and tussockland regardless of rehabilitation approach ($F_{2,12} = 6.02$, $P < 0.05$). This is unsurprising since forest vegetation was taller and included more tiers.

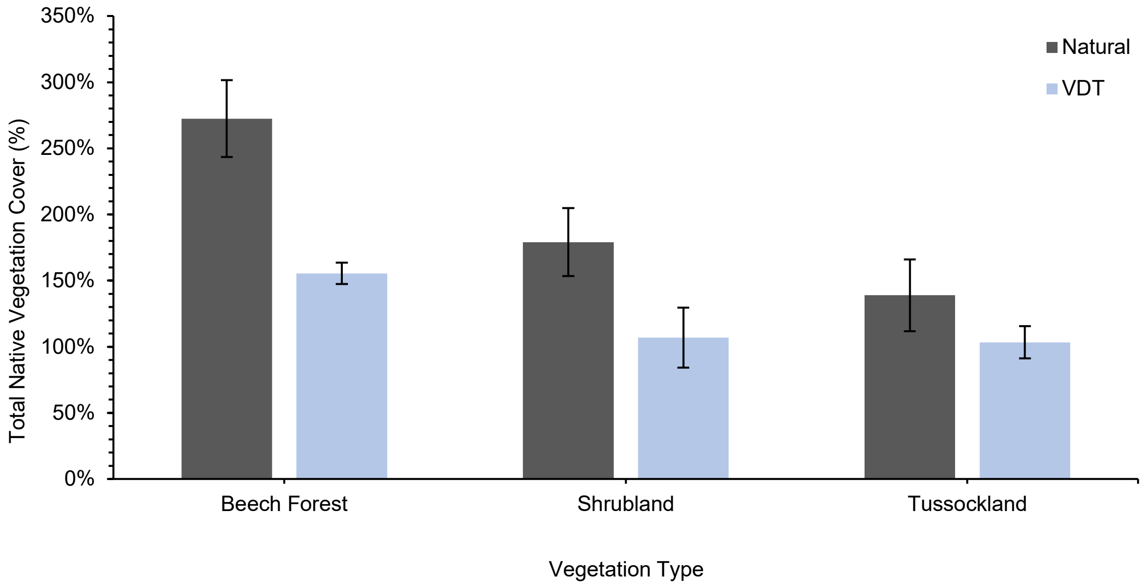

Figure 19: Mean (± SE) percentage cover of native species at natural and VDT sites by vegetation type.

5.1.2 Tarns

Natural tarns were similar to constructed tarns rehabilitated with VDT in terms of ground cover and vegetation parameters, although constructed and planted tarns had higher rock cover than natural tarns or constructed tarns with VDT and were more variable in terms of the number of species present (Table 6).

Table 6: Plot descriptors for natural tarns and constructed tarns rehabilitated by VDT and planting.

Site	n	Total vegetation cover*	Non-vascular cover*	Litter cover*	Rock cover*	Top height (m)	Canopy cover*	no. of species per plot	
								min	max
Constructed Tarn (Planted)	9	89.5 ± 53.9	10.4 ± 7.1	2 ± 0.6	27.3 ± 20.2	0.5 ± 0.3	10.4 ± 12	13	36
Constructed Tarn (VDT)	3	121 ± 13	8 ± 5.5	1.3 ± 1.9	3.8 ± 2.9	0.7 ± 0.2	25.8 ± 9.5	32	46
Natural Tarn	6	104.4 ± 45.9	6.7 ± 6.9	3.1 ± 5.3	3.7 ± 7.3	0.6 ± 0.4	23.5 ±11	22	34

*Data are shown as mean percentage cover ± standard deviation

There was no statistically significant difference in total vegetation cover or number of PCI between the different tarn types (Figure 20, Figure 21). However, native vegetation cover was significantly higher at natural tarns than at planted constructed tarns ($F_{1,16} = 8.46$, $P < 0.05$) as shown in Figure 22. Average soil depth was similar across all three tarn types (374 mm ± 63 (SE) for natural tarns, 357 mm ± 35 (SE) for VDT constructed tarns and 254 mm ± 45 (SE) for planted constructed tarns).

Although the total vegetation cover was similar across tarn types, the species composition of the vegetation varied. Vegetation at constructed VDT tarns was typically [mānuka]/red tussock-snow tussock shrubland (e.g., TM03), mānuka-square sedge-pākihi rush shrub-rushland (e.g., TM04) and mānuka-mountain beech shrubland (e.g., TM08). Mānuka-tussock/wire rush shrubland was the dominant vegetation type at natural tarns, except

TN05 which included a range of species from forest and shrubland vegetation types.

Constructed tarns where the surrounding vegetation had been planted were not typically representative of natural (i.e., undisturbed) tarn vegetation in terms of species composition, instead including species from a range of different habitat types (e.g., forest, low pākihi, shrubland) as well as upland species not typical of poorly-drained tarn ecosystems such as Southern rātā and *Ozothamnus vauvilliersii* as well as exotic grasses (including browntop and Yorkshire fog (*Holcus lanatus*)) and rushes (including heath rush and toad rush (*Juncus bufonius*)).

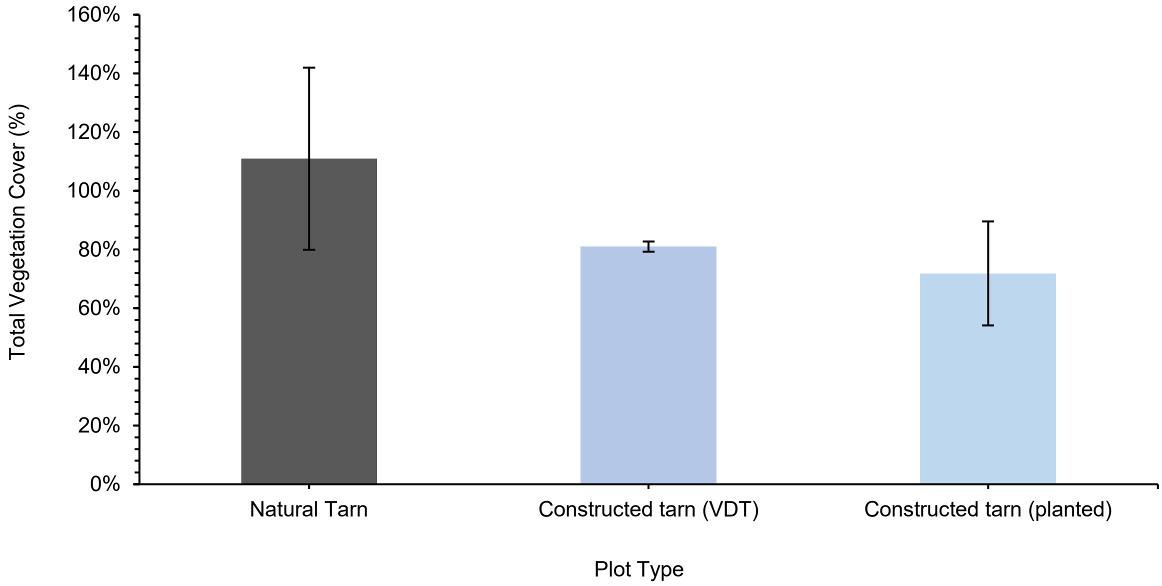

Figure 20: Mean (± SE) vegetation cover for natural and constructed tarns.

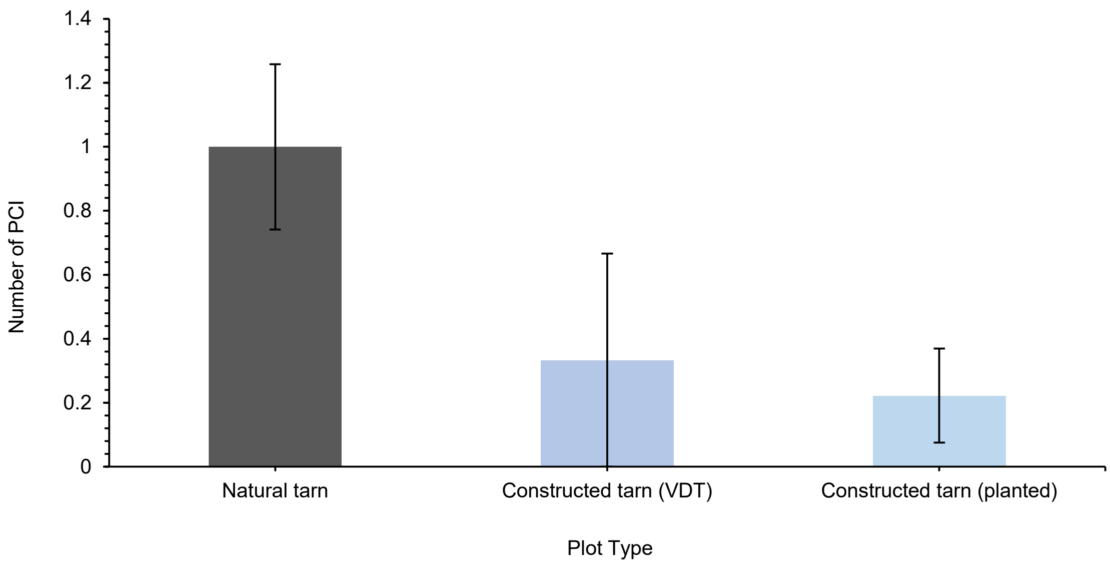

Figure 21: Mean (± SE) number of PCI species for natural and constructed tarns.

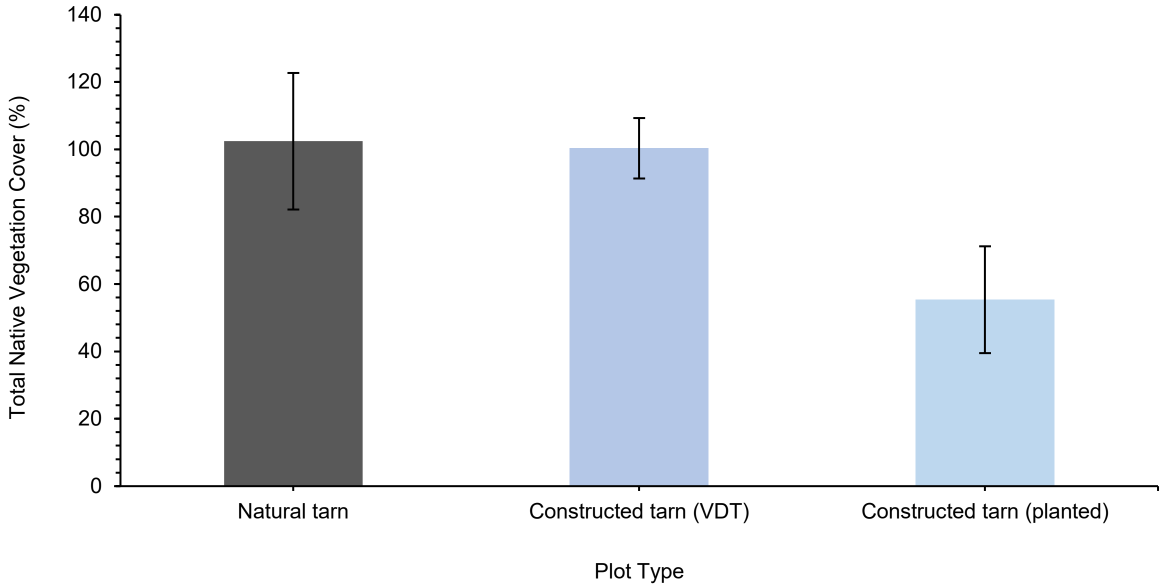

Figure 22: Mean (± SE) cover of native species present at natural and constructed tarns.

5.1.3 Drill Sites

5.1.3.1 Vegetation

Drill site locations are selected to target specific geological locations, but final placement of drill rigs considers potential for disturbance to vegetation and easy establishment and access of the rig. For that reason, areas of exposed rock or low pākihi are preferred as drill sites and forests are generally avoided. Vegetation at 17 of the 32 drill sites comprised low pākihi characterised by stunted mānuka (0.3–1m in height), coal measures tussock and wire rush with a variety of small shrubs, herbs and cushion-forming species. Eight drill sites were located within sandstone erosion pavement where ground cover of rock was between 45% and 90%. Two sites at Stockton and two at Denniston were within low forest dominated by mānuka, beech (mountain beech and silver beech and native conifers (mountain toatoa and yellow-silver pine). The two low forest sites at Stockton (drilled in 1997 and 2009) featured exotic grasses and rushes in the ground layer, but the species composition of the canopy and understorey layers were similar to surrounding undisturbed vegetation. No exotic species were recorded at the two low forest sites at Denniston.

The vegetation at the drill sites was mostly intact, and generally comprised similar vegetation to that of the surrounding undisturbed vegetation. This was particularly apparent for drill sites located within low pākihi and sandstone pavement communities at Denniston.

Overall, the presence of exotic species at drill sites was low, with only seven (22%) of the plots containing exotic species, five of which were at Stockton Mine. The most common exotic species was heath rush. PCI present at drill sites included the locally endemic species coal measures tussock (‘At Risk – Declining’) and *Dracophyllum densum* (‘At Risk – Declining’) (de Lange et al. 2024).

The percentage vegetation cover in the ground layer at drill sites ranged from 2% to 90%, depending on the vegetation type, but did not vary with access type as shown in Table 7. Total vegetation cover also varied with vegetation type, ranging from 6% at plots located within sandstone erosion pavement where vegetation was short and sparse to 231% in low forest where vegetation consisted of trees and shrubs present in multiple tiers.

5.1.3.2 Access

The four Mt Frederick South sites that were drilled in 2023 and accessed by helicopter had no exotic species present, and species composition was equivalent to natural sandstone pavement communities. Only one of the remaining 16 helicopter access sites which were older (drilled 2007–2013), and mainly on the Denniston Plateau, had an exotic species present (heath rush). Of the three ground-based access sites on the Denniston Plateau (2011–2013), one exotic species (heath rush) was recorded at one (33%) of the sites. None of the plots at the four track-mounted drill rig sites on the Denniston Plateau (drilled 2013–2015) contained exotic species.

Exotic species were most prevalent in the Cypress mining area of Stockton, which was drilled between 1997–2011. Two of those sites were accessed by helicopter and the remaining four did not have the access method recorded, but were likely to have been via helicopter since there were no vehicle tracks and only one walking track to Cypress mining area at that time. Five sites contained exotic species, ranging from one to five exotic species per plot, including browntop (*Agrostis capillaris*), castear (*Hypochaeris radicata*), gorse (*Ulex europaeus*), heath rush, soft rush (*Juncus effusus*) and sweet vernal (*Anthoxanthum odoratum*).

Table 7: Vegetation descriptors for drill sites according to access method.

	Helicopter	Ground-based	Track-mounted drill rig	Unknown
No. plots	20	3	4	5
Years active	1982; 2007; 2009; 2011–2013; 2023	2011; 2013	2013 - 2015	1997; 1998; 2011
Mean number of species	18	13	17	15
Mean proportion native species	0.99	0.98	1	0.91
Mean vegetation cover (%)	93	164	111	107
Mean ground cover (%)	54	64	49	48
Mean bare ground (%)	6	24	23	6
Mean non-vascular (%)	9	8	6	28
Mean rock (%)	26	3	21	13
Mean canopy cover (%)	11	2	25	7
Average top height (m)	0.65	1.00	0.43	1.80

5.1.3.3 Physical characteristics

Drill sites typically had a low slope angle (between 0 and 10°), poor soil drainage and low vegetation top height (between 0.2m and 1.7m), a result of being situated mainly on exposed sandstone pavement and low pākihi vegetation communities. Soil depth ranged from 0mm on bare sandstone pavement sites to c. 740mm under beech forest in the Cypress mining area of Stockton Mine. Physical characteristics of the drill site plots are summarised in Table 8.

Table 8: Soil and physiography descriptors for drill sites by access type.

Access	Mean soil depth (mm)	Typical drainage	Mean slope angle
Helicopter	180	poor	5
Ground-based	267	poor	2
Track-mounted drill rig	243	poor	3
Unknown	220	poor	3

5.2 Bryophytes

A total of 183 species of bryophytes (96 mosses and 87 liverworts) were recorded at rehabilitated (VDT and planted) sites, non-remediated sites, constructed tarns (planted & VDT) and natural tarn sites, including three species regarded as 'At Risk – Naturally Uncommon' (the liverworts *Cryptolophocolea tuberculata* and *Riccardia furtiva* and the moss *Pleurophascum ovalifolium* (de Lange et al. 2020, Michel et al. 2026)). In addition, the botanically interesting moss species *Pulchrinodus inflatus* ('Not Threatened') was recorded. A list of bryophyte species recorded is provided in Appendix D.

Six bryophytes associated with anthropogenetic and disturbed habitats were also recorded from five constructed tarns, one VDT site and one non-remediated site as follows:

- *Ceratodon purpureus* (native) was recorded from square sedge-mānuka shrubland (TM-04) and mixed shrubland (TM-06) around two constructed tarns on the Stockton Plateau;
- *Funaria hygrometrica* (native) was recorded from a planted mixed shrubland around a constructed tarn (TM-09) on the Stockton Plateau;
- *Leptobryum pyriforme* (adventive) was recorded from heath rush rushland from a non-remediated site (DS-01) on the Stockton Plateau;
- *Marchantia polymorpha* subsp. *polymorpha* (adventive) was recorded from planted mixed shrubland around a constructed tarn (TM-09) on the Stockton Plateau;
- *Tortula muralis* (native) was recorded from mānuka–red tussock/wire rush shrubland from a VDT site (DT-08) on the Stockton Plateau; and
- Weasel moss (adventive) was recorded from planted mixed shrubland around a constructed tarn (TM-03) on the Stockton Plateau.

These species are common greenhouse weeds, typically found on soil attached to nursery-raised plants and reported to be spreading in the wild in New Zealand. It is most likely that they arrived via nursery-raised plants during rehabilitation planting. There have been previous records of them on the Buller Plateaux and they may also be spreading there. Terry (2017) recorded *M. polymorpha* in high-quality VDT comprised of mānuka shrubland/ heathland on the Stockton Plateau. *M. polymorpha* was also recently recorded from riparian habitat associated with Pit Lake on the Denniston Plateau (S Gorinski, unpubl. data June 2025). Weasel moss was first recorded from red tussock grassland in Cypress valley near the Stockton Plateau by Glenny (1999). There appears to be no records of weasel moss on the Denniston Plateau. Weasel moss is known to outcompete the native *Sphagnum cristatum* where they co-occur after disturbance (Glenny 1999).

5.2.1 Rehabilitated Sites

Non-remediated sites, planted sites and VDT sites had similar bryophyte species composition, and were not significantly different from each other ($p>0.05$), as shown in Table 9, Table 10 and Figure 23.

Table 9: Plot species richness at non-remediated sites and sites rehabilitated by VDT and planting at Stockton Mine.

Plot type	Mean	Standard Error	Range
Non-remediated	22.1	3.51	11-36
Planted	19.8	2.83	11-32
VDT	17.1	2.19	9-25

Table 10: Species richness and the proportion of indicator taxa at non-remediated sites and sites rehabilitated by VDT and planting at Stockton Mine.

Plot type	Species (total)	Liverwort species	Moss species	Indicator taxa	Proportion of indicator taxa	'At Risk' taxa
Non-remediated	84	44	40	18	21%	1[a, ^]
Planted	75	35	40	19	25%	1[b]
VDT	78	40	38	21	27%	1

Notes:

[a]*Riccardia furtiva* (TN-01; DS-04), [b]*Cryptolophocolea tuberculata* (PL-04).

^Species of interest *Pulchrinodus inflatus* (TN-02, 03, DS-01).

The bryophyte community at planted sites typically comprised common and widespread pioneer and early seral species such as *Campylopus* species (*C. clavatus*, *C. introflexus, C. purpureocaulis*), *Cryptolophocolea mitteniana*, *Cuspidatula monodon*, *Dicranoloma* species (*D. billardierei*, *D. dicarpum*, *D. fasciatum*, *D. menziesii*), *Ditrichum* species, *Isotachis montana*, *Kurzia hippuroides*, *Lepidozia* species (*L. concinna, L. laevifolia*), *Macromitrium* species, *Polytrichadelphus magellanicus*, *Ptychomnion aciculare*, *Telaranea* spp., and *Wijkia extenuata*. One 'At Risk' liverwort, *Cryptolophocolea tuberculata* was recorded at a planted site (PL-04), as shown below in Figure 24. This species was found growing amongst indicator taxa including *Bazzania involuta, Gottschea pinnatifolia*, *Kurzia hippuroides, Lepidozia* species (*L. concinna, L. laevifolia, L. ulothrix*), *Riccardia* species (incl. *R. aequicellularis*, *R. bipinnatifida*, *R. cochleata*), *Rhacocarpus purpurascens, Syzygiella colorata, Telaranea* species and *Tricholepidozia lindenbergii*.

In total, 75 bryophyte species were recorded at planted sites (40 mosses and 35 liverworts). The highest diversity of bryophytes at a planted site was recorded under mānuka-tussock shrubland (PL-04, 32 species including 18 liverworts and 14 mosses).

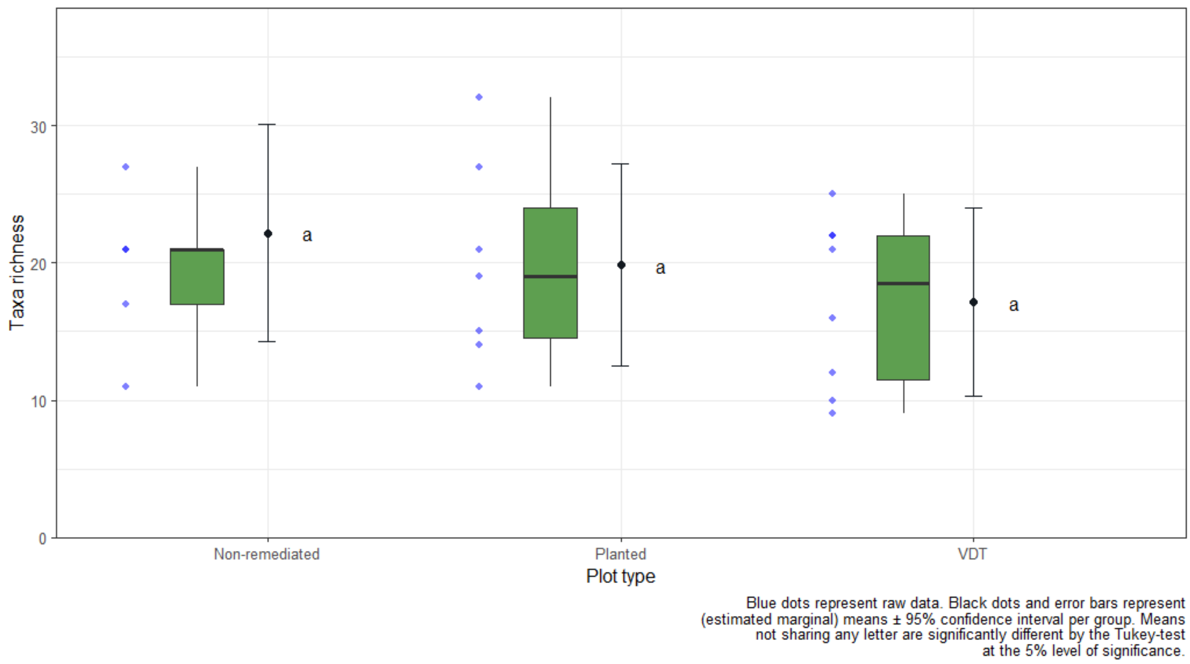

Figure 23: Bryophyte species richness at non-remediated and planted and VDT sites.

Figure 24: Planted vegetation where *C. tuberculata* was recorded (PL-04), Stockton Plateau.

The bryophyte community at VDT sites commonly comprised widespread species such as *Campylopus clavatus*, *C. introflexus*, *Dicranoloma billardierei*, *Distichophyllum pulchellum*, *Isotachis montana*, *Kurzia hippuroides*, *Lepidozia* sp., *Ptychomnion aciculare*, *Riccardia* sp., *Sphagnum* species (*S. falcatulum*, *S. squarrosum*) and *Wijkia extenuata*.

In addition, one 'At Risk' moss, *Pleurophascum ovalifolium* was recorded at two VDT sites (DT-02, 04). Indicator taxa at VDT sites were commonly present and included *Acromastigum* species (*A. anisostomum, A. marginatum*), *Bazzania* species (*B. adnexa*, *B. involuta*, *B. novae-zelandiae*), *Gottschea pinnatifolia*, *Kurzia* species (*K. hippuroides, K. helophila*), *Lepidozia* species (*L. concinna*, *L. laevifolia*, *L. ulothrix*), *Neolepidozia patentissima, P. connivens, Pallavicinia* sp., *Rhacocarpus purpurascens, Riccardia* species (incl. *R. crassa*), *Telaranea species* (incl. *T. herzogii*) and *Zoopsis setulosa*.

In total, 84 bryophyte species were recorded at VDT sites (44 liverworts and 40 mosses). The highest diversity of bryophytes (25 species, 12 liverworts and 13 mosses) was recorded under Archeria/mountain beech forest (DT-02).

The bryophyte community at non-remediated sites also commonly comprised *Campylopus* species (*C. bicolor*, *C. clavatus*, *C. introflexus*, *C. purpureocaulis*), *Brachytheciastrum paradoxum*, *D. billardierei*, *Heteroscyphus* species (*H. cuneistipulus*, *H. deceptifrons, H. fissistipus*), *Kurzia* species, *Isotachis montana*, *Macromitrium* species (incl. *M. longipes, M. microstomum*)., *Polytrichadelphus magellanicus*, *Ptychomnion aciculare*, *Riccardia* species (incl. *R. bipinnatifida, R. crassa*), *Solenostoma* species (*S. inundatum*, *S. totipapillosum*) and *Wijkia extenuata*. One 'At Risk' liverwort, *Riccardia furtiva*, was recorded growing on *Lepidolaena palpebrifolia* (DS-04). The botanically interesting moss *Pulchrinodus inflatus* was also recorded at a non-remediated site (DS-01). The exotic moss *Leptobryum pyriforme,* which as noted above, probably arrived via nursery-raised plants during planting, was also recorded from heath rush rushland (DS-01). Indicator taxa were common at non-remediated sites and included species such as *Kurzia* (*K. helophila, K. hippuroides, K. quinquespina*), *Lepidozia* sp., *Neolepidozia* (*N. patentissima*, *N. praenitens*), *Pallavicinia tenuinervis*, *Schistochila glaucescens, Telaranea herzogii, Tricholepidozia lindenbergii.*

5.2.1.1 Presence of Indicator Taxa

The number of indicator taxa was not statistically different across the three rehabilitation approaches (VDT, planting, non-remediation) (P = 0.11).

VDT plots met the criterion of ≥ 25% of the indicator taxa set out in Table 3 present typical of mature bryophyte communities (mean indicator taxa = 27% ± 4.4 SE). VDT plots averaged 21 indicator taxa dominated by liverworts, particularly from the family Lepidoziaceae (62%). The two moss species (*Pleurophascum ovalifolium* ('At Risk'), and *Rhacocarpus purpurascens*) were also present. *Gottschea pinnatifolia* (Schistochilaceae), usually associated with forest, was also recorded.

Non-remediated and planted sites did not meet the threshold to be considered a mature bryophyte community (mean indicator taxa = 15.5% ± 3.5 SE and mean = 20.7% ± 2.8 SE respectively) (see Figure 25 and Table 10).

Non-remediated sites contained 18 indicator taxa, with the community similarly dominated by liverworts from the family Lepidoziaceae (61%). The moss species present included *Pulchrinodus inflatus*. *Schistochila glaucescens* (Schistochilaceae), another species usually associated with forest habitats, was also recorded.

Planted sites contained 19 indicator taxa, again dominated by liverworts from the family Lepidoziaceae (63%). In addition, two species typically associated with forest were recorded, *Cryptolophocolea tuberculata* ('At Risk') (Lophocoleaceae) and *G. pinnatifolia.*

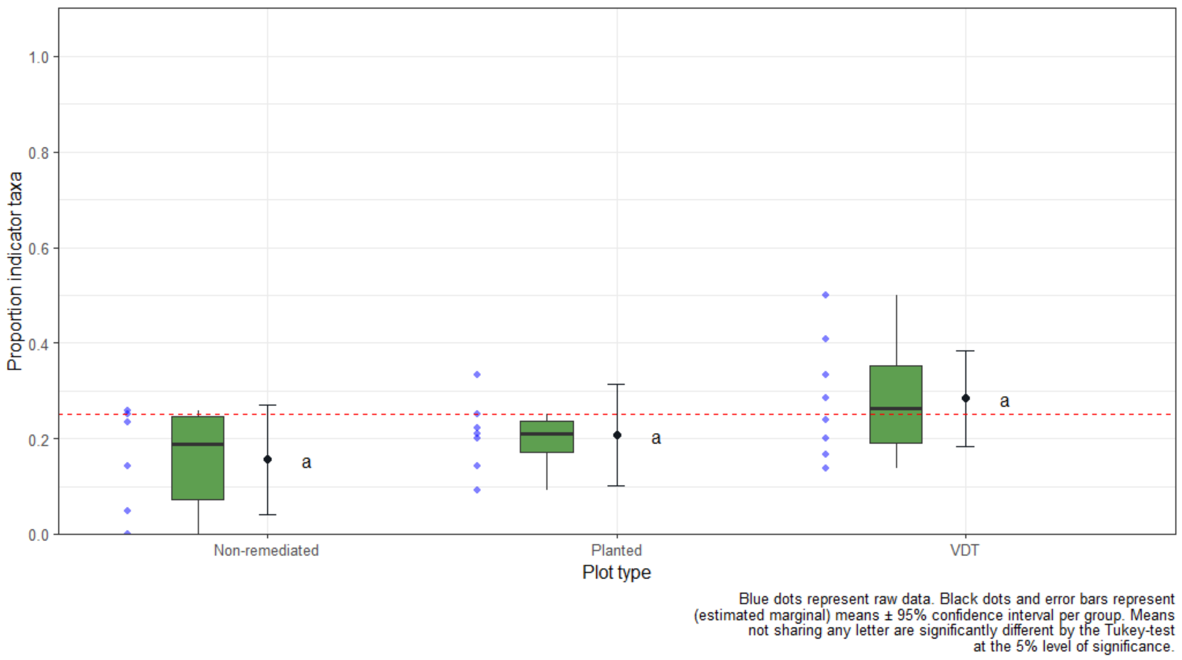

Figure 25: Proportion of indicator taxa present at non-remediated sites and sites rehabilitated by VDT and planting.

5.2.2 Tarns

Bryophyte communities at constructed tarns with VDT, constructed tarns with planting and natural tarns had similar species composition and were not significantly different from one another in terms of species richness ($p>0.05$) as shown in Table 11, Table 12 and Figure 26.

Table 11: Species richness at natural and constructed tarns rehabilitated by VDT and planting at Stockton Mine.

Plot type	Mean number of species	Standard Error	Range
Natural Tarn	12.5	1.81	4-16
Constructed Tarn (planted)	10.3	1.21	6-17
Constructed Tarn (VDT)	15.0	2.08	11-18

Table 12: Bryophyte community descriptors at natural and constructed tarns rehabilitated by VDT and planting at Stockton Mine.

Plot type	Species (total)	Liverwort species	Moss species	Indicator taxa	Proportion of indicator taxa	'At Risk' taxa
Natural Tarn	44	25	19	20	45%	2[a, b, ^]
Constructed Tarn (planted)	47	21	26	7	15%	-
Constructed Tarn (VDT)	38	16	22	11	29%	-

Notes: [a]*Riccardia furtiva* (TN-01; DS-04), and [b]*Pleurophascum ovalifolium* (TN-04-06; DT-02, 04). ^Species of interest *Pulchrinodus inflatus* (TN-02, 03, DS-01).

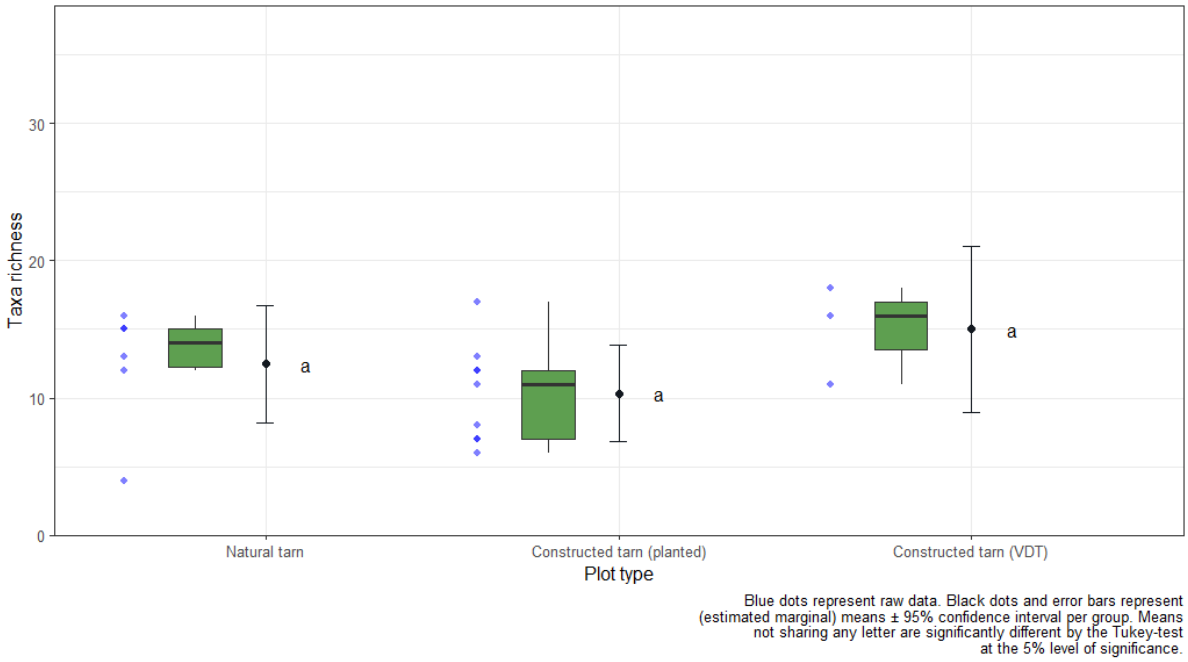

Figure 26: Species richness at natural and constructed tarns at Stockton Mine.

The bryophyte community at natural tarns typically comprised widespread species such as *Campylopus clavatus*, *C. introflexus*, *Dicranoloma billardierei*, *Kurzia hippuroides*, *Lepidozia* species (incl. *L. attenuata*, *L. concinna*), *Ptychomnion aciculare*, *Riccardia* species and *Wijkia extenuata.* Two 'At Risk' taxa were recorded near natural tarns, the liverwort *Riccardia furtiva* (TN-01) and the moss *Pleurophascum ovalifolium* (TN-04-6), as well as the moss *Pulchrinodus inflatus* (TN-02-3). These distinctive species were found growing amongst various indicator taxa including *Acromastigum anisostomum, Kurzia* species (incl. *K. compacta*, *K. hippuroides*, *K. quinquespina*), *Neolepidozia patentissima, Pallavicinia* sp., *Riccardia* species (incl. *R. aequicellularis*, *R. cochleata, R. crassa*), *Syzygiella colorata*, *Telaranea herzogii* and *Zoopsis setulosa*.

The liverwort *Lepidolaena novae-zelandiae* ('At Risk – Naturally Uncommon'), was also present as an epiphyte on a mountain beech branch adjacent to a natural tarn (TN-06).

In total, 44 bryophyte species were recorded at natural tarn sites (25 liverworts and 19 mosses). The highest diversity of bryophytes (16 species) was recorded under mānuka–tussock / wire rush shrubland (TN-06), including nine liverworts and seven mosses.

The bryophyte community at constructed tarns with planting typically comprised widespread species such as *Andreaea* sp., *Bartramia* sp., *Campylopus clavatus*, *C. introflexus*, *Dicranoloma billardierei, Isotachis* species (incl. *I. lyallii*, *I. montana*), *Kurzia hippuroides*, *Lobatiriccardia alterniloba*, *Marchantia berteroana, Polytrichadelphus magellanicus, Polytrichum* species (incl. *P. commune*, *P. juniperinum*), *Ptychomnion aciculare*, *Racomitrium* species, *Riccardia* species, *Solenostoma inundatum, Sphagnum falcatulum* and *Wijkia extenuata*.

Indicator taxa at planted tarns were limited to *Bazzania involuta, Kurzia hippuroides*, *Lepidozia* species (incl. *L. ulothrix*), *Neolepidozia praenitens* and *Riccardia aequicellularis.* No species of interest were recorded. Both the adventive weasel moss (at TM-03), and the liverwort *Marchantia polymorpha* (at TM-09) were recorded. Both these species probably arrived via nursery-raised plants during planting.

In total, 47 bryophytes (26 mosses and 21 liverworts) were recorded at natural tarns. The highest diversity of bryophytes (16 species, nine liverworts and seven mosses) was recorded under mānuka–tussock / wire rush shrubland (TN-06).

The bryophyte community at constructed tarns with VDT commonly comprised widespread species such as *Bartramia* sp., *Campylopus clavatus*, *C. introflexus*, *Ceratodon purpureus*, *Conostomum* sp., *Cryptolophocolea mitteniana*, *Isotachis* species (*I. montana I. lyallii*), *Lepidozia* species, *Macromitrium longipes*, *Neolepidozia* species, *Polytrichadelphus magellanicus*, *Racomitrium* sp., *Riccardia* species and *Sphagnum* species.

Indicator taxa included *Kurzia hippuroides*, *Lepidozia* species (incl. *L. hirta*, *L. laevifolia*), *Neolepidozia* species (*N. patentissima, N. tetrapila*), *Rhacocarpus purpurascens*, *Riccardia* species (*R. aequicellularis, R. crassa*), *Telaranea* sp., and *Tricholepidozia lindenbergii*. No species of interest were recorded. The adventive weasel moss was recorded from a mixed shrubland (TM-03).

In total, 38 bryophyte species were recorded at constructed tarns with VDT (22 mosses and 16 liverworts). The highest diversity of bryophytes (19 species, 11 mosses and eight liverworts) was recorded under Mānuka–tussock / wire rush shrubland (TN-06).

5.2.2.1 Presence of Indicator Taxa

Based on the presence of ≥ 25% of the indicator taxa set out in Table 3, natural tarns and constructed tarns with VDT met the criterion to be considered mature bryophyte communities (mean indicator taxa = 47.5% ± 4.6 SE; mean = 25.5% ± 5.5 SE, respectively) (see Figure 27). Although constructed tarns with planting had the highest species diversity (n = 47) of the approaches sampled, they did not meet the threshold for a mature bryophyte community (mean proportion of indicator taxa = 12.2% ± 3.4 SE).

Overall, natural tarns included 20 indicator taxa (45%), which was the highest proportion across all sites. The bryophyte communities at natural tarns was dominated by liverworts, particularly from the family Lepidoziaceae (55%). The two moss species *Pleurophascum ovalifolium* ('At Risk') and *Pulchrinodus inflatus*, and the 'At Risk' liverwort *Riccardia furtiva* were also recorded at natural tarns. Constructed tarns with VDT had a greater proportion of indicator taxa (29%) than tarns with planting (15%). Species of conservation interest were only recorded at natural tarns.

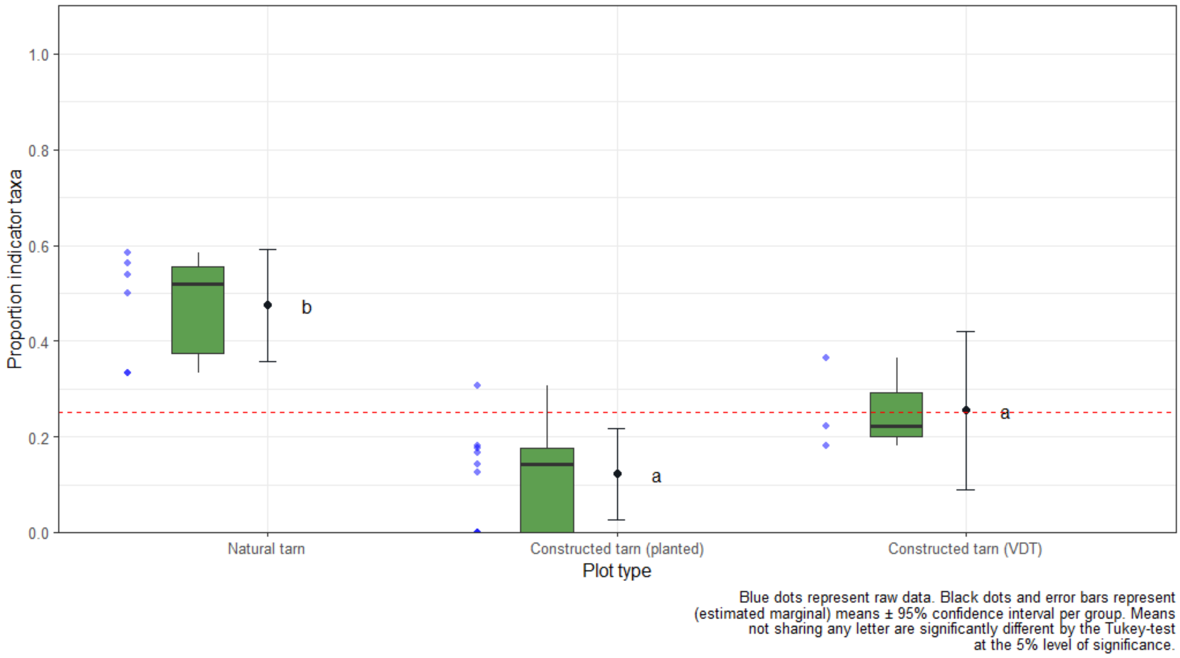

Figure 27: Percentage of indicator taxa present at natural and constructed tarns.

5.2.3 Bryophytes of Conservation Interest

Three 'At Risk – Naturally Uncommon' species were recorded at six locations, including:

- *Cryptolophocolea tuberculata* growing under mānuka-tussock shrubland at a planted site (PL-04).
- *Pleurophascum ovalifolium*. Sterile specimens were found in VDT habitat at site DT-02 (Archeria/mountain beech forest, 1,004m asl) and DT-04 (yellow-silver pine–mānuka shrubland, 726m asl), and surrounding natural tarns in mānuka–tussock shrubland types (TN-04–06).
- *Riccardia furtiva* growing under red tussock / wire rush shrubland (pākihi) surrounding a natural tarn (TN-01), and within a gorse dominated shrubland at the non-remediated site DS-04.

Cryptolophocolea tuberculata is an endemic liverwort primarily confined to the very rainy western sector of the South Island (22 records) mainly in dense mountain and silver beech forests, often on moist cliff faces (Engel and Glenny 2019, Schuster 2021). Two records are from Southland (c. 720m asl). Surveys of natural areas on Stockton Plateau have recorded *Cryptolophocolea tuberculata* growing on soil under stunted silver beech forest on Mt. Frederick (1,050m asl) (Glenny 2007), and within an underground cavity with a stream flowing beneath sandstone boulders, under sparse Southern rātā forest on Mt. William Range (688m asl) (Glenny and Dawson 2011).

Riccardia furtiva is an endemic epiphytic liverwort with a scattered population known from five records in the North Island (Coromandel, Tongariro and Tararua Ecological Districts) and 15 records from the South Island (Western Nelson, Westland and Stewart Island), including both Denniston and Stockton Plateaux. Surveys of natural areas on coal measure vegetation have recorded *Riccardia furtiva* in mountain beech–Southern rātā–silver pine forest (c. 700m asl) (Glenny 1999), yellow-silver pine scrub/forest (630m asl) (Glenny and Fife 2001), mountain beech-silver pine forest (740m asl), mountain beech–pink pine–*Dracophyllum townsonii* scrub (867m asl) (Glenny 2002), and on twigs of mountain toatoa; among mixed riparian scrub including gorse, Southern rātā and yellow-silver pine (Glenny 2008). We have recently recorded this species growing under Southern rātā/podocarp–beech–broadleaf forest at Conglomerate Stream on the Denniston Plateau.

A sterile specimen of the moss *Pulchrinodus inflatus,* which has never been observed with reproductive capsules (Fife 2017, Glenny 1999), was also found within heath rush rushland at the non-remediated site DS-01 (799m asl), and at two natural tarns TN-02 and TN-03 (c. 740 m asl.).

The liverwort *Lepidolaena novae-zelandiae* ('At Risk – Naturally Uncommon') recorded adjacent to a natural tarn (TN-06), has a sparse distribution, but can be relatively common at certain locations within the Buller Plateaux (D Glenny, pers. comm. August 2024). Typically epiphytic on myrtaceous species, frequently on mānuka, it also grows on beech (as observed in April 2025 and described here), and *Dracophyllum* (Glenny 1999).

One 'Threatened' and two 'At Risk' liverwort species and one 'At Risk' moss were recorded along Transect 4 including:

- *Neogrollea notabilis* ('Threatened – Nationally Critical').
- *Saccogynidium decurvum* ('At Risk – Declining').
- *Acromastigum mooreanum* ('At Risk – Naturally Uncommon').
- *Pleurophascum ovalifolium* ('At Risk – Naturally Uncommon').

Given that the affected vegetation had never been surveyed, but had been relocated, these records demonstrate that these species can either successfully survive relocation and persist for at least 16 years or colonise VDT sites. On that basis, VDT facilitates the best outcomes for retention and maintenance of bryophytes.

5.3 Fauna

5.3.1 Avifauna

5.3.1.1 Incidental Observations

Several birds of conservation interest were observed incidentally at Stockton Mine during our survey of rehabilitated vegetation and tarns, including New Zealand pipit (*Anthus novaeseelandiae novaeseelandiae,* 'At Risk – Declining'), New Zealand bush falcon (*Falco novaeseelandiae ferox,* 'Threatened – Nationally Increasing'), and banded dotterel (*Charadrius bicinctus bicinctus*, 'At Risk – Declining').

New Zealand pipit were observed frequently throughout the mine site. Pipit were often seen foraging in open habitats and have been observed at other mine sites on the West Coast.

New Zealand bush falcon were observed on one occasion just south of Mt Augustus chasing after a smaller bird along the ridgeline. Falcon are regular visitors to the mine and are often seen hunting smaller passerines (L. Maguire, pers. obs. MBC Environmental, 2024). Suitable breeding habitat, such as tall forest with podocarps, is present immediately outside the mine site.

A single banded dotterel was observed near the Bathhouse where it was foraging amongst the short stature shrubs present, including mānuka, toetoe (*Austroderia richardii*) and koromiko (*Veronica salicifolia*). Banded dotterel have been observed breeding at the mine before and have been seen on more than one occasion using rehabilitated sites at Mt Frederick (L Maguire, pers. comms., G Bramley pers. obs.).

5.3.1.2 Five-minute bird counts

Although call counts from rehabilitated sites were low, there was an almost two-fold increase (88%) in the number of bird species recorded between the 2021 survey and 2024 survey. This may be, at least in part, due to the smaller number of sites surveyed in 2021 (n=4) compared to 2024 (n=16). Most species present were common indigenous or exotic species. Three bird species of conservation interest recorded were recorded using rehabilitated areas (New Zealand pipit, South Island fernbird and South Island robin (*Petroica australis australis*)).

There was no significant difference in the average number of birds per five-minute bird count between planted (mean = 0.22, SD = 0.10) and VDT sites (mean = 0.14, SD = 0.03, t_{30}, p = 0.35).

Several species were more commonly recorded at planted sites, including the introduced blackbird (*Turdus merula*), common redpoll (*Acanthis flammea*), dunnock (*Prunella modularis*) and European goldfinch (*Carduelis carduelis*). The presence of these species may reflect the availability of grass seed in planted areas. New Zealand pipit, Western weka (*Gallirallus australis australis*) and welcome swallow (*Hirundo neoxena*) were also common in planted areas as shown in Figure 28. Indigenous species including South Island fernbird, South Island robin, South Island tomtit, Southern black-backed gull and swamp harrier were more commonly recorded at VDT sites. Paradise shelduck (*Tadorna variegata*) were only found in disturbed habitats, being associated with rehabilitated sites with open water and short vegetation dominated by grasses (such as around sediment ponds and water storage areas).

South Island fernbird were most often recorded within VDT sites, but were also recorded at two planted sites (N2 and W6, approximately 18 years and 16 years old respectively) in low numbers (mean number of birds per count = 0.25). Both planted sites comprised suitable habitat for South Island fernbird with small pockets of mānuka and tussock (*Chionochloa rubra, C. juncea*).

South Island robin were only recorded at two VDT sites; MF16 and R5, and in low numbers (average no. of birds per count = 0.25). Both sites were immediately next to the extensive mixed beech forest of the Mt Augustus ridgeline (within approximately 100m and 300m respectively). Five-minute bird counts are not the best method for detecting robin and this may underestimate their occupancy of rehabilitated sites. Robin home ranges are typically up to c. 5ha, so these birds may have been using both rehabilitated sites and adjacent forest habitat.

New Zealand pipit were encountered at all sites. New Zealand pipit were relatively common in areas that have been subject to disturbance, so it is unsurprising to have encountered them so frequently. The lowest densities were recorded at R6 (average birds per count < 0.25), where the vegetation was shrubland approximately 20 years post-placement. This observation is consistent with New Zealand pipit occupying rough, open areas rather than forest or shrubland.

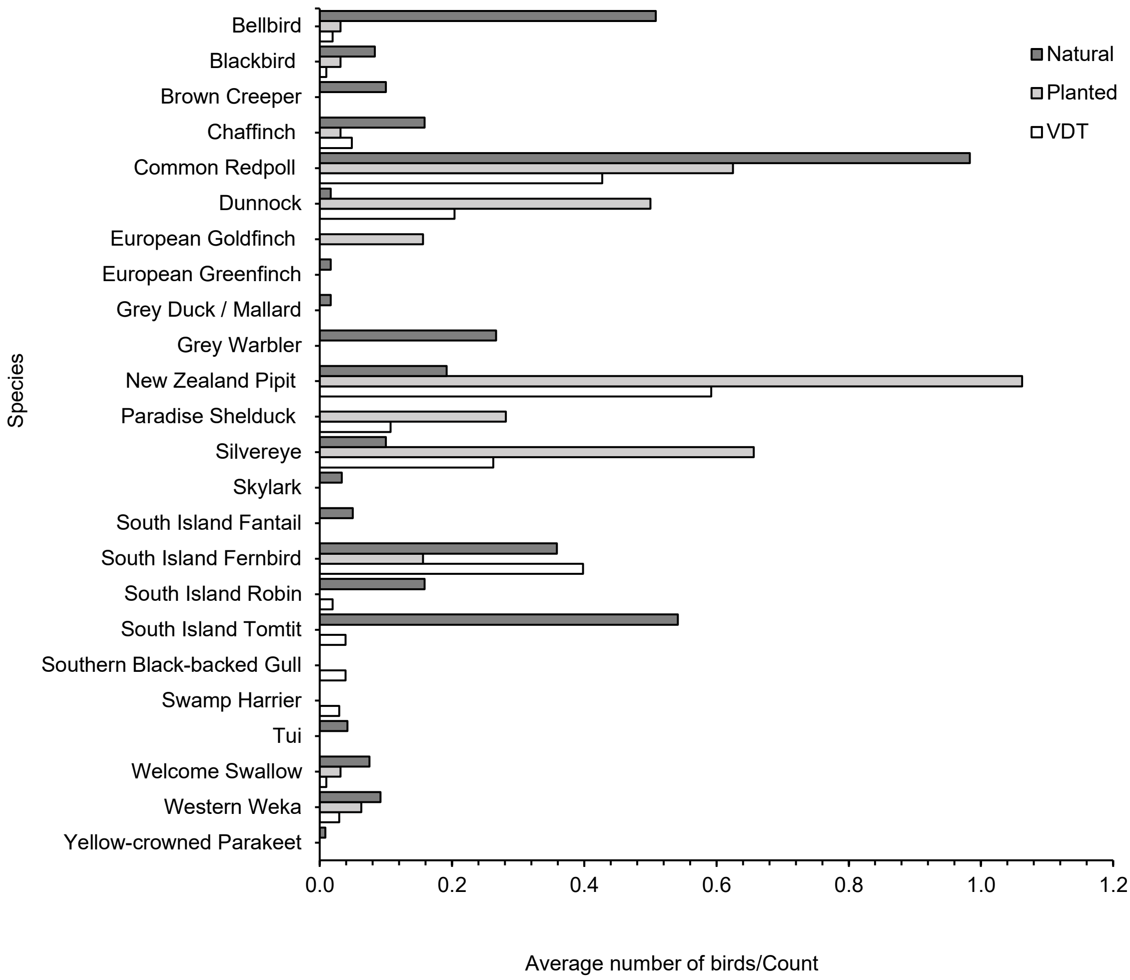

Figure 28: **Average number of birds per five-minute bird count at planted, VDT and natural sites.**

Table 13: Average number of birds per five-minute bird count at rehabilitated sites.

Status	Species	2021 n = 43	2024 n = 92
Endemic	Bellbird (*Anthornis melanura*)	0.000	0.033
	New Zealand Pipit (*Anthus novaeseelandiae novaeseelandiae*)	0.488	0.804
	Paradise Shelduck (*Tadorna variegata*)	0.000	0.217
	South Island Fernbird (*Poodytes punctatus punctatus*)	0.093	0.457
	South Island Robin (*Petroica australis australis*)	0.000	0.022
	South Island Tomtit (*Petroica macrocephala macrocephala*)	0.000	0.043
	Western Weka (*Gallirallus australis australis*)	0.000	0.054
	Total Endemic	**0.581**	**1.630**
Native	Silvereye (*Zosterops lateralis*)	0.256	0.402
	Southern Black-backed Gull (*Larus dominicanus dominicanus*)	0.143	0.000
	Swamp Harrier (*Circus approximans*)	0.047	0.011
	Welcome Swallow (*Hirundo neoxena*)	0.023	0.011
	Total Native	**0.469**	**0.424**
Exotic	Blackbird (*Turdus merula*)	0.000	0.022
	Common Redpoll (*Acanthis flammea*)	0.814	0.315
	Chaffinch (*Fringilla coelebs*)	0.070	0.033
	Dunnock (*Prunella modularis*)	0.000	0.402
	European Goldfinch (*Carduelis carduelis*)	0.000	0.054
	Total Exotic	**0.884**	**0.826**
	Overall Total	**1.934**	**2.880**

5.3.1.3 Great Spotted Kiwi/Rōroa

2021 Survey

The locations of rōroa sign within rehabilitated areas are shown in Figure 29. Of the nine sites surveyed in 2021, four may have been used to some degree by rōroa/great spotted kiwi.

Signs of rōroa were seen at several locations within R6 including two burrows, one roost, and seven scents as indicated by kiwi dog Mica. Additionally, there was a kiwi feather found in one of the burrows, providing positive confirmation of use. Vegetation in the R6 survey area included tall mānuka and flax, rehabilitated by a mix of VDT (approximately 9.1ha) and contiguous planting (approximately 4.6ha). The R6 site is bound by undisturbed beech forest to the west and an access road to the east. At Hook Dump one old burrow, three probe holes and two scents, as indicated by Mica, were recorded. At MF16 two probe holes were recorded and one probe hole was recorded at the Mt Frederick Tarn Trial.

Other areas near the surveyed sites had scents detected by Mica, however great spotted kiwi are known to use the areas surrounding the mine and it is possible that these scents were from outside the mine itself.

2024 Survey

The 2024 survey of three rehabilitated sites detected rōroa sign at R6 and Mt Frederick (MF16, MF7 and MF11). Three probe holes were found within R6 at the locations shown in Figure 29. These areas were rehabilitated by VDT and are located to the east of undisturbed beech forest.

Acoustic recorders deployed at Mt Frederick Quarry recorded ten kiwi calls over three nights, but trail cameras did not record any great spotted kiwi. These calls may have been from natural habitats nearby.

[redacted]

Figure 29: Signs of great spotted kiwi in rehabilitated areas.

5.3.2 Herpetofauna

Five forest geckos and one speckled skink were recorded at three of the four VDT sites surveyed in 2020 during ACO checks coupled with 16.75 person hours of searching by four searchers as set out in Table 14. The VDT sites appeared to provide high quality habitat for these species. These were the first records of forest gecko and speckled skink within VDT.

Table 14: Lizards recorded 14 January 2020 within VDT vegetation at Stockton Mine.

Species	Capture method	Habitat	Snout-Vent Length	Sex	Reproductive status
Hope Dump (2.64ha)					
Forest gecko	Manual searching	Under log (planted area)	75	Female	Not Gravid
Forest gecko	ACO check	Under ACO	85	Female	Gravid
Forest gecko	ACO check	Under ACO	88	Female	Not Gravid
Pavement trial / Rock cache (0.6ha)					
No lizards found					
Campbells (6.8ha)					
Newman's speckled skink	ACO check	Under ACO	Escaped		
Forest gecko	Manual searching	Under rock	88	Male	Not Applicable
Ross dump (4.15ha)					
Forest gecko	Manual searching	In rock crevice	Adult but could not determine SVL or sex		
Forest gecko	Manual searching	In rock crevice (different one)	Adult but could not determine SVL or sex		
Mt Fred (2.62ha)					
Not able to access site due to blasting activities					

Surveys undertaken on 12 and 13 February, 2024 recorded two forest gecko and one Newman's speckled skink during incidental searching of old ACOs. However, no West Coast Green gecko were observed during 43.75 person hours by four searchers. West Coast Green gecko were not detected in either survey and it remains unknown whether the VDT habitats are able to support West Coast green gecko.

5.3.3 Soil Dwelling Invertebrates

5.3.3.1 Rehabilitated Sites

In general, the soil fauna of rehabilitated sites was not particularly diverse (min = 1 species, max = 13 species, n=12) as shown in Figure 30. The most commonly collected invertebrates were beetles (Coleoptera, n = 10 species), followed by roundworms (Nematoda, n = 7) and terrestrial worms (Opisthopora, n = 6). Species diversity was highest at DT1 and lowest at DT8 and PL4.

Up to 15 individual soil dwelling invertebrates were collected per site (median = 3) as shown in Figure 30. Abundance was highest at DT1 and lowest at sites DT8 and PL4.

In general, both abundance and diversity of soil dwelling invertebrates were higher at direct transfer sites than at planted sites as shown in Figure 30.

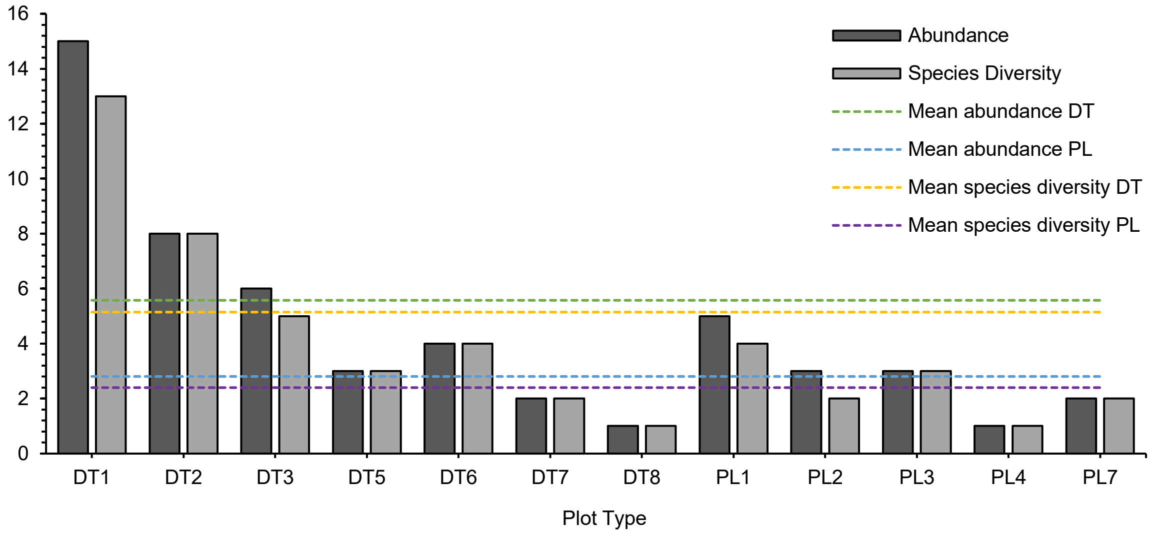

Figure 30: Soil-dwelling invertebrate abundance and species diversity at VDT (DT) and planted sites (PL).

5.3.3.2 Tarns

The diversity of terrestrial invertebrate species collected from around natural tarns (TN) ranged from 1–7 species (median = 5) as shown in Figure 31. The most commonly collected invertebrates were beetles and roundworms (Coleoptera and Nematoda, n = 12), followed by mites (Acari (n = 9).

Invertebrate abundance ranged from 1–8 individuals per sample (median = 5) and was highest at TN4 and TM4 (n = 8) and lowest at TM9 (n = 1) as shown in Figure 31.

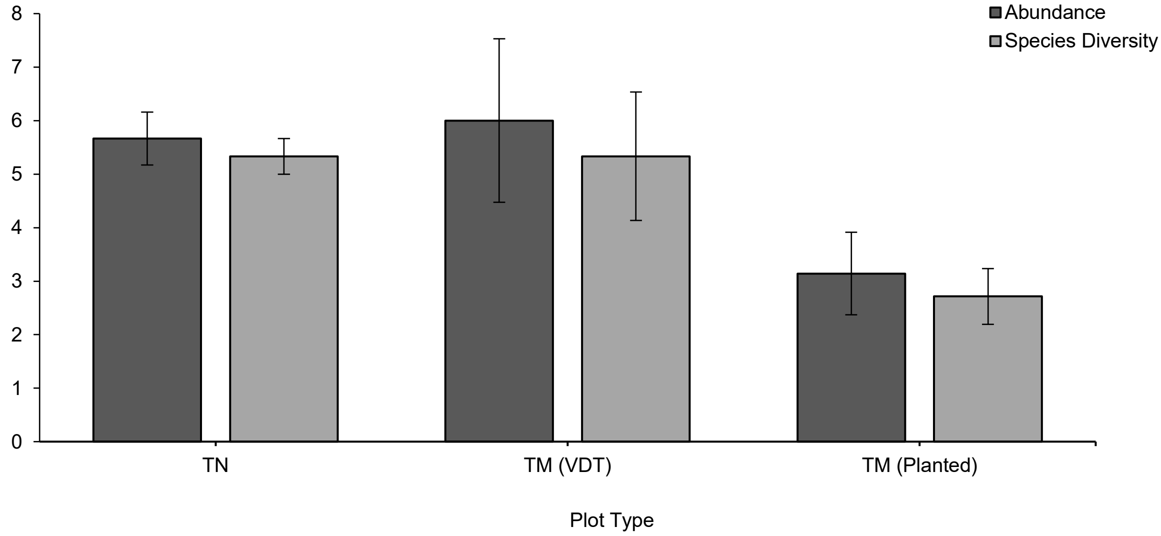

Figure 31: Average soil-dwelling invertebrate abundance and species diversity (± SE) at natural (TN) and constructed tarns (TM).

5.3.4 *Powelliphanta* Snails

Lloyd (2024) confirmed that *Powelliphanta patrickensis* snails survive and maintain viable populations in areas rehabilitated using VDT. Snail density estimates from the two capture-recapture plots in VDT habitat at McCabe's (established in 2020) were within the range of those in undisturbed habitat using the same capture-recapture plot survey method. Comparisons of the size distributions of snails before and 12 months after transfer at the two VDT plots showed the proportion of larger snails had increased after transfer. Snail condition indices were also higher in the population after transfer. However, the lack of snail recruitment in the 16-month period following establishment of the VDT indicates that eggs or recently hatched snails may not have survived the habitat translocation process. Survey data from two capture-recapture plots established in 2009 and 2011 at Mt Frederick indicate that the population of snails has remained stable there, with only minor fluctuations between the first and second surveys (Lloyd 2023). More recent results from nocturnal transects have found similar encounter rates for snails in VDT and nearby undisturbed habitat at Mt Fredrick (Lloyd 2024).

Capture-recapture monitoring of *Powelliphanta augusta* has confirmed survival of snails in one VDT plot 13 years after placement (Grunner et al. 2021 in Lloyd 2024). Although Grunner (2021) suggested that the snail population in the VDT plot may be stable or recovering, population estimate results were not statistically significant (Lloyd 2024).

Nocturnal transect surveys in areas rehabilitated by planting and seeding have indicated that these habitats have failed to support snail populations, in some cases even 20 years after rehabilitation (Lloyd, 2024). However, there has been a lack of survey effort in planted and seeded areas relative to VDT areas, with the 2024 survey being the first to provide such data. The only live snails found in these rehabilitated areas were clustered along a short (45m) section of transect, even though nearby undisturbed areas contained relatively high numbers of snails. Previous rehabilitation records indicated that this location was rehabilitated using transfer of stripped overburden with fresh slash (i.e., 'jumble dumping' of fresh soils, woody debris and associated vegetation) and/or mānuka fascining, so snails found at this location may have been present in the material transferred there and the survivors have persisted since then (Lloyd 2024).

5.3.5 Surface Dwelling Invertebrates

5.3.5.1 Invertebrate Taxa

Overall, 194 distinct invertebrate taxa were identified. Over 80% of specimens could not be identified to species level for a variety of reasons, including damage to specimens, lack of adults for identification, being undescribed or poorly described species and a lack of available taxonomic expertise. Many taxa were only identified to the genus, family or even order levels. In cases where taxa could not be identified to a high enough level to assume they were native or exotic (i.e., a family that contains both exotic and native species) these were recorded as 'unknown'.

There were also issues with sample preservation and trapping which degraded the condition and availability of several specimens. In particular, specimens from several malaise traps were damaged. For these reasons, the number and diversity of terrestrial invertebrate species present will be much higher, and diversity of flying insects in particular will have been underestimated here.

There were high numbers of native taxa compared with exotic, with most of these being consistent with the biota of the north-western South Island. Spiders (Aranae), beetles (Coleoptera), true bugs (Hempitera), and bees, wasps and ants (Hymenoptera) were well represented in their diversity, which is typical for most invertebrate sampling in New Zealand.

5.3.5.2 Rehabilitated vegetation

Across all rehabilitation treatments (planted, non-remediated, VDT), there were more native terrestrial invertebrate taxa captured than exotic taxa ($F = 87.440$, $p < 0.0001$) as shown in Figure 32. VDT sites had the highest overall native invertebrate taxa richness, with 51 taxa recorded at one site. However, the two-way ANOVA showed no evidence of a significant interaction between native/exotic invertebrate presence and rehabilitation method ($F = 1.473$, $p = 0.223$) or a significant overall effect of rehabilitation method itself ($F=1.294$, $p=0.282$). This may indicate recolonising by native invertebrates (rather than exotic invertebrates) following disturbance, or alternatively that certain terrestrial invertebrate biodiversity "hotspots" are maintained by VDT that would be lost by other methods of rehabilitation, even if the average levels of taxa richness is similar. By comparison, invertebrate taxa richness in planted sites had relatively low variation, possibly indicating homogenisation of invertebrate taxa at planted sites, as opposed to the higher variation in diversity seen on VDT sites. This may reflect the variation in vegetation types and more complex structural architecture of VDT plots, as well as the lack of leaf litter layers, soil humus layers, and ponded water typical at planted plots.

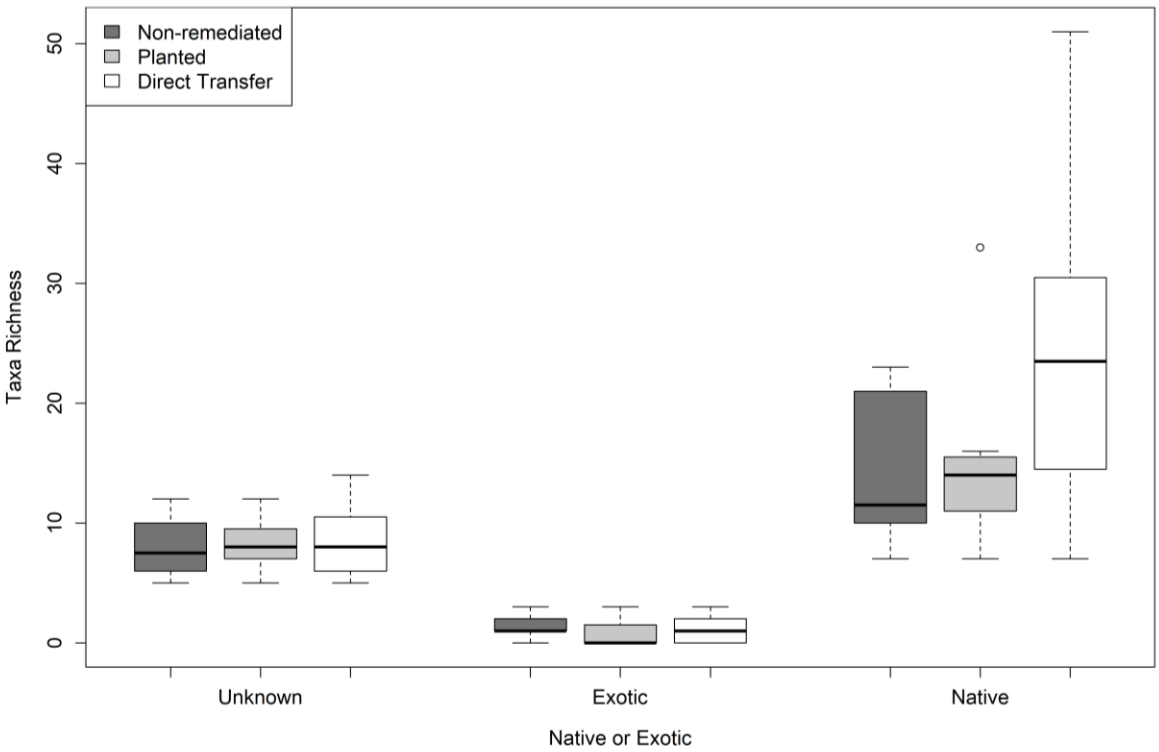

Figure 32: Number of distinct taxa at native, exotic and unknown terrestrial invertebrates across rehabilitated vegetation.

Of particular note is the presence of the invasive Australian copper-bellied ant (*Ochetellus glaber*), which was found in one planted site and several direct transfer sites. Whilst this species has become more common in the Nelson region recently, it is typically associated with warm and dry urban habitats, making its presence at Stockton surprising. In rural habitats *O. glaber* seems to show a strong preference for exploiting the margin between forest and shrubland[3]. It's impact in native habitats remains unknown, although since it is an arboreal species, it will likely occupy very different habitats from native ant species, none of which nest above the ground.

Common money spiders (*Diplocephalus cristatus*) were also found at planted sites and non-remediated sites, though none were found in VDT sites. These spiders are a threat to native ecosystems, due to their invasive ability in native habitats and apparent ability to displace similar native species (Paquin et al. 2010). This makes their presence at Stockton concerning, despite their current absence from direct transfer sites. In general, money spiders (Linyphiidae) were abundant in the samples across most habitat types and included invasive *D. cristatus*, at least one unidentified species with a distinctive horn and what were most likely native *Haplinis* sp. Malumbres-Olarte (2010) observed that *Haplinis* are difficult to identify and whilst a definitive identification could not be reached for this/these species, it is unlikely to be any of the 'At Risk' species. Linyphiidae are known to perform well in disturbed habitats in New Zealand due to their high dispersal ability (Malumbres-Olarte 2010, Topping and Lovei 1997, Vink et al. 2004).

Three gorse seed weevils (*Exapion ulicis*) were found at a non-remediated site where gorse was present. These are a deliberately introduced biocontrol agent for gorse.

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3 https://www.landcareresearch.co.nz/discover-our-research/biodiversity-biosecurity/plants-invertebrates-fungi-and-bacteria/invertebrate-systematics/ants-wasps-and-bees/ants-of-new-zealand/ochetellus-glaber/ Accessed 12 March 2025.

Notable native fauna included a ground beetle (Carabidae) that is a member of the tribe Zolini, but could not be assigned to any of the known species, and may therefore represent a new species (Ian Millar pers.comm.). Two beetle species, *Mecodema ducale* and *Heterotyles argentatus* typically associated with forest were recorded in a planted and direct transfer site respectively. The presence of *Mecodema ducale* is particularly notable, given members of this genus are flightless. This species has been collected from the Buller Plateaux before, however, only from tall forest areas near Stockton. *Heterotyles argentatus* has been previously recorded near Mount Rochfort, and is typically associated with podocarp forests.

Ground beetle richness and diversity was highest at VDT plots. Only four specimens were found at non-remediated sites, and only two were found at planted sites. This is compared to 40 specimens across nine taxa in VDT plots. Cave wētā (Rhaphidophoridae) were also more common at VDT plots. This is consistent with the identified benefits of direct transfer for species with large bodied species with limited dispersal ability (Rogers et al. 2011). A smaller wētā species, *Anderus maculifrons*, was more common in planted plots.

5.3.5.3 Tarns

The number of native invertebrate taxa collected near tarns was significantly higher than the number of exotic species collected ($F = 31.773$, $p < 0.0001$). There was no effect of tarn-type on overall diversity ($F = 0.209$, $p = 0.650$) or the diversity of native vs exotic species ($F = 0.892$, $p = 0.417$). Constructed tarns appeared to emulate natural tarns well in terms of terrestrial invertebrate diversity, with the species diversity at each tarn type being very similar as shown in Figure 33.

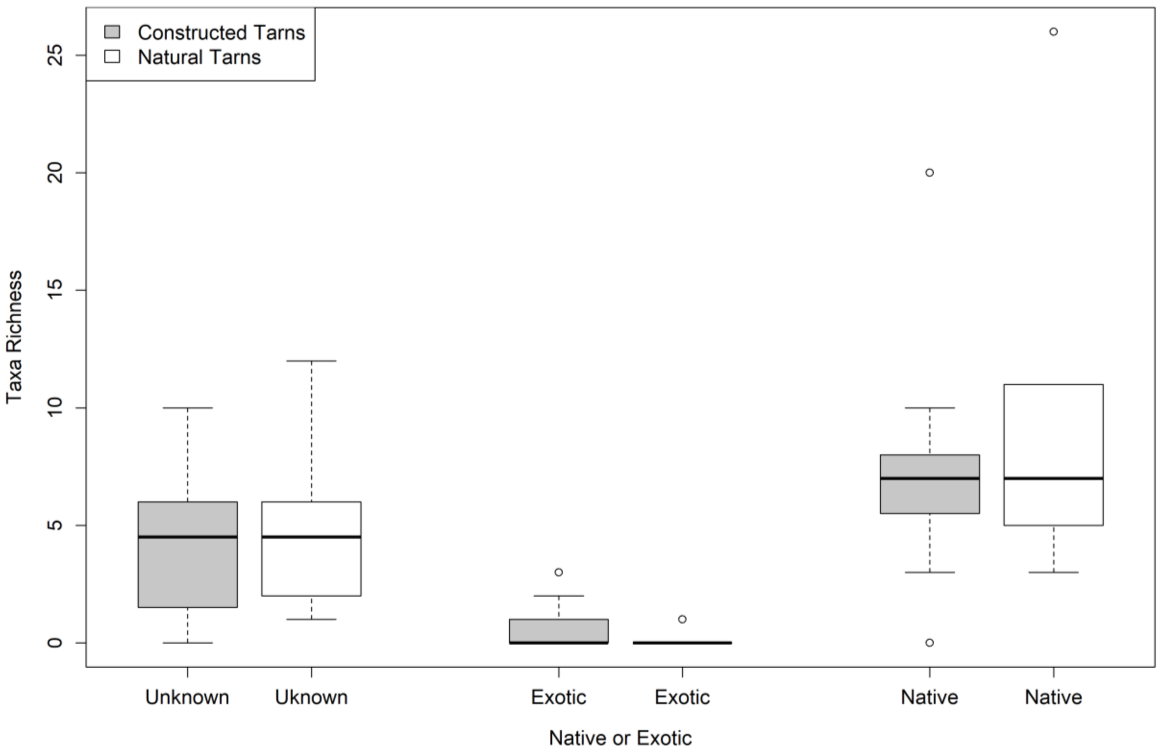

Figure 33: Number of distinct taxa of native, exotic and ‘unknown’ terrestrial invertebrates at natural and constructed tarns.

Several exotic terrestrial invertebrate species were collected in association with constructed tarns. Australian cognate sweat bee (*Lasioglossum cognatum*) was found at constructed tarn TM10 and may be new to the region. This species is similar to native *Lasioglossum* spp. also found on the plateaux, making discriminating between the species difficult. Two giant willow aphids (*Tuberolachnus salignus*) were also collected from vegetation surrounding constructed tarns. Given that these aphids were collected in their adult, winged, form, these were likely individuals on dispersal flights from other habitats that were coincidentally intercepted by our sampling. Other exotic species collected near constructed tarns were potato mirid bug (*Closterotomus norvegicus*), European meadow spittle bug (*Philaenus spumarius*), and small grass fly (*Lonchoptera bifurcata*). These exotic species may have blown up from lowland areas or be resident in areas of exotic grassland nearby, such as biosolid treated areas.

The constructed tarns also had high numbers of Dolomedidae spiders (likely *Dolomedes minor*). Whilst native, this common species thrives in human-modified shrubby habitats (Vink and Dupérré 2010). Their relative abundance at constructed tarns, as well as the presence of several other exotic species there, may indicate that the constructed tarns (1 – 20 years post construction) do not fully emulate the habitat structure of the natural tarns. This is consistent with our observations on plant community composition around tarn edges.

5.3.6 Aquatic Fauna

Watson et al (2024) surveyed the same tarns described here and concluded that many of the constructed tarns provide new and important habitat that was statistically indistinguishable from natural tarns in terms of aquatic invertebrate communities. The year in which tarns were constructed was not a significant determinant of community structure, which suggests that manmade tarns can provide suitable habitat and be colonised quickly by aquatic species (Watson et al, 2024).

A total of 36 different macroinvertebrate genera were collected across all of the tarn sites. Total richness ranged between six at site TM6 and 19 at site TN2. Macroinvertebrate abundance ranged between 222 and 7,955 at TM6 and TM3 respectively. None of the macroinvertebrate community metrics for constructed and natural tarns were statistically different, based on Kruskal-Wallis tests ($p > 0.05$).

Dominant taxa included chironomid (*Tanytarsus funebris*), *Chironomus zealandicus, Polypedilum* spp., *Tanypodinae* sp.,) and Ceratopogonidae midges. Other common taxa included damselflies (*Austrolestes* sp. and *Xanthocnemis* sp.), nematodes, mites, and hemipterans (e.g., water boatman—*Sigara* sp., and the semi-aquatic hemipteran *Microvelia macgregori*. Oligochaete worms were the only taxa found at all sites.

Watson et al. (2024) did not find any species of conservation interest during their survey, but two taxa were collected that had insufficient data to be evaluated. These taxa were *Dasyhelea,* a genus of biting midge (Ceratopogonidae) which was discovered in an artificial pond in Northland in 2019, and Syncarida, which is a group of freshwater crustaceans, which can occur in open water, but the majority are found in groundwaters and have been identified as potential indicators of water quality (Gordon 2013).

Watson et al. (2024) recorded one kōura (*Paranephrops planifrons*) in a natural tarn (TN1) and a claw in another natural tarn (TN2), but none were detected in constructed tarns. NIWA also noted that there were signs birds, frogs, deer, and terrestrial invertebrates were using the tarns, except TM6 and TM10.

6.0 Use of Rehabilitated Areas by Fauna

6.1 Avifauna

6.1.1 Five-minute Bird Counts

Rehabilitation of mining sites at Stockton has provided habitat for species, such as New Zealand pipit and Paradise shelduck (the latter only recorded in rehabilitated areas). Pipit and non-native passerines were most often encountered in planted areas and least often in natural areas. This is likely due to the openness of the planted areas since pipit are not forest-dwelling species, and food sources provided for passerines (e.g., seeds of exotic grasses and weeds).

Several species were only recorded at natural sites, including tūī (*Prosthemadera novaeseelandiae*), brown creeper, grey warbler (*Gerygone igata*) and South Island fantail (*Rhipidura fuliginosa fuliginosa*). This is likely due to the mature vegetation at natural sites providing a dense canopy with multiple ecological niches available for different species to fill relative to the simpler planted communities. The rehabilitated areas at Stockton are expected to provide an increasing range of niches over time as the plant communities develop. Mountain flax, which provides nectar sources for tui and bellbird when flowering, is a common component of the vegetation at planted sites and maybe providing seasonal habitat which was not detected due to the timing of our surveys.

6.1.2 Great Spotted Kiwi

Great spotted kiwi are known to inhabit the mature beech forest surrounding Stockton Mine. Signs of great spotted kiwi were found in several rehabilitated areas, including R5, R6, Ross dump, MF16 and Mt Frederick Tarn Trial as shown in Figure 29. Of these, the Mt Frederick Tarn Trial comprises only planted vegetation, whilst the other areas include VDT. All are contiguous with natural habitats outside the mine footprint. Signs of kiwi activity included probe holes and scent indications from the certified conservation dog(s). Burrows and roosts were evident in the older, more established VDT areas (R5 and R6).

Within R6 there was a mixture of established vegetation and newly planted or VDT areas. Whilst it is likely that kiwi use the R6 area for foraging and roosting, it is unlikely they would be resident solely within the R6 area. The close proximity of the R6 area to undisturbed forest habitat likely plays a factor in supporting kiwi activity.

It is highly likely that great spotted kiwi travel into Mt Frederick Quarry and MF16 to forage given the close proximity to mature forest, however burrows are probably not present in the Quarry area. Rehabilitated areas could be improved for fauna, including great spotted kiwi, more quickly if attention was given to providing suitable roosting/retreat habitats for them, e.g. designing dry burrows when VDT is placed or including cavities prior to planting using boulders, stumps and logs with strategic planting. Even if roosts are provided, development of leaf litter and communities of soil dwelling invertebrates will still be required to provide food sources for kiwi using rehabilitated areas. It is expected that over time as the leaf litter develops, rehabilitated areas will be able to support kiwi for more of the time.

6.2 Herpetofauna

VDT provides suitable habitat for forest gecko and Newman's speckled skink as confirmed by their presence. However, it remains unknown whether lizards were present in VDT habitats because they had survived transfer or because they had colonised from surrounding areas or both.

It remains unknown whether VDT provides suitable habitat for West Coast Green gecko.

6.3 *Powelliphanta* Snails

Populations of *Powelliphanta patrickensis* snails can survive and remain viable in areas rehabilitated by VDT at similar densities to populations in undisturbed habitats (Lloyd 2024). Earthworms are a key component in the diet of snails and VDT habitats are likely to have earthworm biomass and species richness comparable to that of undisturbed habitats (Lloyd 2024; Boyer et al. 2011). Both snails and earthworms have poor dispersal abilities, so the ability for VDT to retain existing populations likely makes it the best rehabilitation method for maintaining these species. Although non-native earthworms are present in planted areas, their value as food for rōroa and snails remains unknown.

Snails have not been detected in areas rehabilitated by planting or seeding, suggesting that they either fail to colonise or survive in these areas (Lloyd 2024). Earthworm survival is also known to often be low in planted areas because of the unfavourable conditions created in lower parts of soil stockpiles (Boyer et al. 2011), however earthworm numbers in the surface of soil stockpiles were similar to the lower range of VDT as shown in Figure 34.

In addition, the number of exotic worms in planted areas may reach relatively high numbers relatively quickly (within 10–15 years at fertile sites, B. Walker, BT Mining, pers. comm. 2024). Although captive *Powelliphanta* snails eat non-native earthworms. it remains unknown if free living *Powelliphanta* snails will eat exotic worms, but the lack of deep leaf litter and other retreats is likely a limiting factor for snails using rehabilitated sites, at least initially. The only live snails found in planted areas were clustered along a short (45m) section of transect, where vegetation was taller, more complex than in surrounding areas, and had evidence of slash (Lloyd 2024). This observation of snails at one planted location suggests that planting or seeding methods could be improved to provide habitat for snails (Lloyd 2024). Planted habitats may also become suitable over time, but the available data suggests that quite a long time is required at ‘typical’ sites and recolonisation rates by snails are likely to be very slow.

6.4 Soil-dwelling Invertebrates

Very few of the specimens collected could be identified to species level, with the majority being identified to order or class. It is therefore unlikely that the results reported here accurately reflect the level of soil fauna diversity at rehabilitated sites.

The soil used as substrate in planted areas is typically from soil stockpiles of varying age. The surface layers of soil stockpiles contain earthworms, but the deeper layers contain few, if any, earthworms (Boyer et al. 2011). Spreading of soils onto rehabilitated areas further reduces earthworms in newly spread soils (due to physical damage), particularly soils that are conventionally spread rather than back-dumped without spreading. Natural colonisation to conventionally spread soils therefore relies almost exclusively on fauna dispersing from adjacent areas (Boyer et al. 2011). Many sample sites were located in isolated patches away from natural ecosystems, likely preventing rapid recolonisation from adjacent areas. Such isolation may explain the lack of abundance and diversity encountered in the samples collected. It can take up to 30 years for soil macrofauna, particularly earthworm, communities to return to their pre-disturbance biomass in the United Kingdom and Europe (Scullion et al. 1988, Hüttl & Weber 2001). The age of rehabilitated areas sampled at Stockton Mine ranged from pre-2005 (e.g., PL1) to as recently as 2023 (e.g., VDT3) so few sites are likely to have been regenerating long enough to develop a mature soil macrofauna.

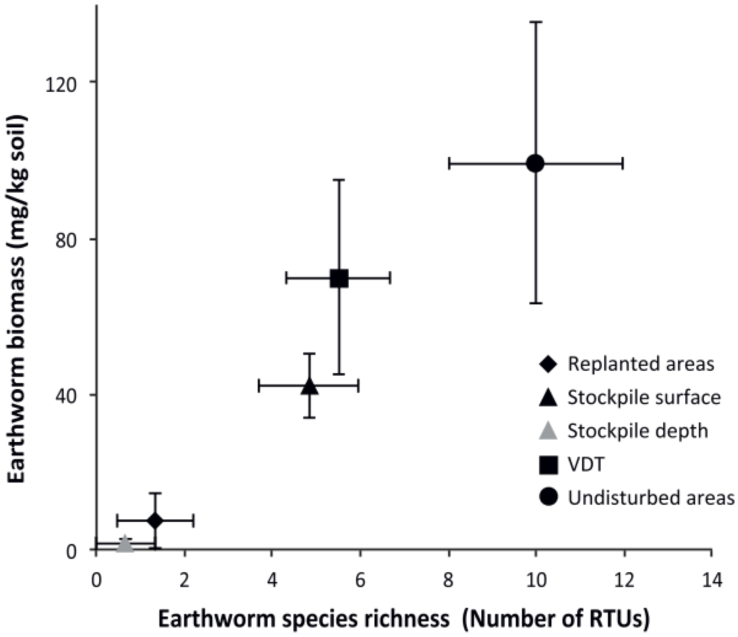

Figure 34: Relationship between earthworm diversity and earthworm biomass at different rehabilitation sites (means ± SE) (from Boyer et al. 2011).

6.5 Other Terrestrial Invertebrates

On average, VDT plots were comparable with planted and non-remediated plots in terms of their terrestrial invertebrate diversity, however some VDT samples had very high diversity. Common money spiders (*Diplocephalus cristatus*) were also absent from VDT plots, indicating that these habitats are less disturbed and potentially more resilient to invasion than planted sites. Whilst now well established in New Zealand, *D. cristatus* is a new detection on the Buller Plateaux (Malumbres-Olarte 2010, R Toft, Entecol Consulting Entomologists, pers. comm. 2024).

Simcock et al. (1999) surveyed terrestrial invertebrates at W6C following a trial to compare conventional rehabilitation (i.e., planting into mixed soil) with VDT. Surveys were undertaken between three and eight months post-rehabilitation. Two control areas were also surveyed and included an area of bare, flat top overburden dump ('bare control'), and an area of undisturbed vegetation and soil ('vegetated control'). Invertebrates were sampled using malaise and pitfall traps. Moths (Lepidoptera), beetles (Coleoptera), wētā (Orthoptera), bristle flies (Tachnidiae) and crane flies (Tipulidae) were of particular interest.

In general, Simcock et al. (1999) found invertebrates were most diverse and abundant in the vegetated control plots. However, VDT plots were not significantly different from the vegetated control plots in six of the eight parameters measured. VDT plots had significantly more species of beetles, moths, crane flies and bristle flies than mixed soil planted plots, and a greater abundance of moths and crane flies. The bare control plots had significantly fewer individuals and species than the VDT plots.

Of particular interest was the presence of wētā, which were found in all of Simcock et al's (recent) VDT plots and two vegetated control plots. Additionally, ground beetles (Carabidae) were numerous in vegetated control plots and less common in VDT plots, but completely absent from bare control plots. Large, flightless invertebrates are likely to have difficulty colonising sites revegetated by conventional methods, particularly isolated sites, unless some form of ecological corridor is provided (Simcock et al. 1999a). We found wētā to be most common in VDT plots, followed by planted plots. *Anderus maculifrons* (a small, nocturnal wētā) was present in planted plots surveyed here. This is consistent with Simcock's (1999) finding that flightless invertebrates are favoured by VDT.

6.6 Aquatic Fauna

Macroinvertebrate communities were similar in richness, abundance and structure at both constructed and natural tarns, indicating that the distance to similar habitats is not a barrier to their dispersal (Watson et al. 2024). It appears that constructed tarns can be colonised relatively quickly since the year of construction was not a determinant of macroinvertebrate community composition. A total of 36 different macroinvertebrate genera were collected across all of the tarn sites, with Oligochaete worms the most common taxa and midges the dominant taxa. Some of the most abundant taxa in tarns are characterised as widespread common dispersers (e.g., *Liodessus*) or widespread haphazard dispersers (i.e., no spatiotemporal patterns of aerial dispersal), such as *Chironomus*. Kōura, a poorly-dispersing species, were only rarely observed, even at natural tarns suggesting that these spatially isolated habitats are not easily colonisable by kōura. Brown tree frog (*Rawlinsonia ewingii*) tadpoles, an Australian species, were observed in almost all surveyed tarns. In general, the presence of frogs in an ecosystem is an indicator of environmental health and clean water, because they possess highly permeable skin that absorbs water and contaminants directly from their surroundings. Brown tree frog tadpoles are omnivorous, feeding on algae, detritus and bacteria, whilst adults are insectivorous eating small freshwater invertebrates, and terrestrial insects, spiders, and other small invertebrates. Their presence in constructed tarns suggests that the aquatic and terrestrial communities are sufficient to sustain them there. There are no extant native frogs in the South Island.

7.0 Discussion

7.1 General Considerations

This survey is limited by the small sample sizes which reduce statistical power, increasing the risk of both Type II errors (missing real effects) and Type I errors (false positives due to noise). Small sample sizes also increase the margin of error, making results less reliable, harder to generalize, and often unable to detect small, meaningful effects. Sample sizes were necessarily small for this study because of the continuous improvement applied to rehabilitation techniques at Stockton Mine (limiting the number of sites which have received similar treatment), the tendency of previous mine operators to "re-mine" rehabilitated sites when economic conditions change and the difficulty in recording and maintaining data about a particular site's history. Monitoring and inclusion of additional sites as rehabilitation proceeds would assist in increasing sample sizes, but there is also value in repeated monitoring at the sites identified here to assist in understanding longer term rehabilitation outcomes, despite the small number of sites.

7.2 Landscape Considerations

The topography and slopes of rehabilitated landforms are more regular and less variable than natural landforms at both the macro- (individual ridges and slopes) and micro- (within slope) scale. Providing as much variation in slope, exposure, topography and drainage as possible is required to underpin variation in habitats which will enable a diversity of species to establish and persist at rehabilitated sites. Inclusion of gullies, as occurs naturally at Stockton, would contribute sheltered, humid microsites with deeper soils and good drainage and assist in increasing the variety and type of microsites present in post rehabilitation landscapes. In natural vegetation, gullies act as corridors across the plateaux and the ecotones between gullies and adjoining plateaux habitats provide important habitats for fauna, including lizards.

As shown in Figure 1, VDT has historically often been located near the edge of mined areas. This is helpful for buffering adjoining vegetation, but is a lost opportunity for providing corridors of more intact vegetation throughout rehabilitated areas and therefore sources of propagules to assist in facilitating revegetation from VDT into adjoining planted areas. Distributing VDT more strategically across any future mined areas would assist in decreasing the distance between planted areas and natural seed sources available in VDT vegetation, as well as reducing the travel distance for animals moving between patches of suitable habitat. Incorporating VDT in this way could speed up native species dispersal and improve ecological function of rehabilitated sites.

7.3 Vegetation Direct Transfer

7.3.1 Vegetation

VDT allows some vegetation and its respective microhabitats and elements of the fauna to remain intact immediately following transfer and persist over time. Short-stature vegetation including red tussock, mānuka shrubland and low forest communities have been successfully transferred using VDT and resemble natural communities of flora and fauna much more quickly than planted communities. These relocated communities have now been shown to persist for more than 10 years (Ecological Solutions Limited 2025, this study). Taller-stature vegetation is more challenging to transfer and involves felling of larger trees prior to transfer. VDT sites had higher vegetation cover, including native vegetation cover, than planted sites. Vegetation direct transfer sites also better reflect natural coal measures communities than planted or non-remediated sites. VDT sites had higher vascular plant ground cover and total vegetation cover compared to other rehabilitation types. There was no significant difference in the proportion of PCI species between natural and rehabilitated sites using VDT.

Within VDT sites, poorly-dispersing species such as beeches (*Fuscospora* spp., *Lophozonia menziesii*), podocarps (*Lepidothamnus* spp., *Halocarpus* spp.) and herbaceous species (*Astelia* spp., cushion plants) persisted through the VDT process. In contrast, there is little evidence of regeneration of these species within 10 years from seed bank or via natural dispersal at planted sites.

With respect to exotic species, heath rush (*Juncus squarrosus*) was the most prevalent in terms of cover at all VDT sites. One site (DT06) had 20% cover of heath rush, with the remaining sites having 6% or less. This species colonises open, disturbed areas and forms tight, low-growing mats that prevent establishment of small native herbs (except some orchids which can germinate and grow within the centre of large patches) and smother a range of species, including wire-rush (Simcock 2011). At fertile sites it can also smother shorter plants and exclude tussocks (Simcock 2011). The presence of heath rush may indicate either poor VDT technique at that particular location (e.g., gaps between sods, damage to sods), dispersal of seeds via machinery or people (i.e., insufficient biosecurity either during or after placement of sods) or existing heath rush plants and/or seed bank in stockpiled soil beneath the VDT or within the VDT itself. Other exotic species present at VDT sites included wind dispersed grasses (*Agrostis capillaris* and *Holcus lanatus*) and catsear (*Hypochaeris radicata*) and other species dispersed by wind, water or animals (the rushes *Juncus bufonius* and *J. effusus*), or via explosive propulsion (gorse). These exotic species comprised less than 1% of the total vegetation cover at VDT sites. Compared to the other rehabilitation methods, VDT was the most effective at creating vegetation that is likely to be self-sustaining (as defined in Section 1.1) particularly with respect to resisting weed invasion. Non-remediated sites were the weediest (i.e., contained the highest cover of exotic species).

7.3.2 Bryophytes

A total of 40 liverworts and 38 mosses were recorded from VDT plots, similar to the number of species recorded by Terry (2017). VDT plots contained the highest proportion of mean indicator taxa (27% ± 4.4 SE). The presence of >25% of the indicator taxa at VDT sites and constructed tarns with VDT confirms that VDT is the best method to maintain bryophyte communities as well as vascular vegetation as part of site rehabilitation, including near tarns.

7.3.3 Fauna

Terrestrial invertebrate diversity at VDT and non-VDT sites was comparable, although VDT sites had a much higher maximum diversity. This likely reflects the ability of VDT to preserve microhabitats which are important for a diverse invertebrate ecosystem and the creation of new microhabitats via disturbance. Orthoptera, including wētā, and poorly mobile beetles were maintained by VDT. This is advantageous due to their flightlessness and slow natural dispersal to new habitats within mine sites. VDT sites may have also resisted invasion by the money spider *Diplocephalus cristatus*, possibly indicating a more resilient invertebrate community in VDT sites. Invasive copper bellied ants were present at VDT sites.

The typically small size of VDT sites (up to a few hectares) and low, open structure typical of pākihi and tussockland vegetation most commonly transferred, probably makes these habitats less attractive to forest birds, particularly where they are surrounded by open planted rehabilitation, rather than adjacent to intact forest or shrubland. South Island fernbird, South Island robin and South Island tomtit were more commonly recorded at VDT sites and bird numbers may be increasing at rehabilitated sites over time. This increase over time could be due to the specialist habitat requirements of some species, which takes time to develop. By way of example, South Island fernbird prefer dense (often mānuka) shrubland and South Island robin and tomtit prefer forested areas, both of these habitat types are likely to become denser and more complex following placement of VDT, particularly if the initial placement was not ideal. South Island robin might venture into the VDT sites near forest edges to forage or as part of a range that includes intact forests nearby. Recent 1080 operations in the surrounding forested areas may also contribute to the apparent increases in bird numbers.

Given that VDT is successful in maintaining vegetation cover and retaining soil fauna, it is unsurprising that this rehabilitation type is able to support and maintain viable populations of *Powelliphanta patrickensis* snails comparable to that of undisturbed habitat. Snails and their eggs require moist soil and a humid environment, in addition to deep and moist leaf litter to support their key prey item, earthworms (Walker et al. 2024).

7.4 Planted Sites

7.4.1 Vegetation

Vegetation cover has been established at planted sites, and microhabitat conditions have been created which favour the colonisation of other native plant species typical of the area, for example *Celmisia* spp. and *Drosera* spp. Despite there being more rock, bare ground and non-vascular vegetation cover at planted sites than at either VDT or natural sites, native species diversity was comparable to VDT and natural sites. This may reflect historic use of wilding transplants in some planted areas. However, native vegetation cover was significantly lower at planted sites than natural sites. The higher proportion of rock cover is not necessarily an undesirable outcome, provided that it contributes to the vegetation being resistant to weed invasion. The typology of rock is also important – rock in recent VDT areas is added as large 'habitat enrichment boulders' (at least 0.5m diameter), whereas most rock in planted areas is small.

In general, species composition of planted sites was typical of shrubland and low forest vegetation types appropriate for the better-drained, higher slope angle landforms, but was not representative of, or similar to, natural vegetation. Plantings were dominated by tussock species (particularly *Chionochloa conspicua*), flax (*Phormium* spp.), mānuka, mountain tauhinu (*Ozothamnus vauvilliersii*), toetoe, hebes (*Veronica* spp.) and Southern rātā. This combination of species does not occur in natural communities at Stockton. Colonisation by non-vascular vegetation and species with a good dispersal ability (particularly small herbs such as *Celmisia*, *Forstera*, orchids) was evident across planted sites, although seeds of these species may have been introduced during transplants of wild native plants. Six of the seven planted sites contained wire rush, an important component of coal measures vegetation which was planted at some sites as 'hitchhikers' with wilding transplants, but has not been grown and deliberately planted to date. It is also able to survive in clumps through soil stripping and spreading processes (and was present on the surface of some stockpiles). It is unknown whether wire rush seed can survive stockpiling as a seed bank, or how far seed can spread in wind or water. Although present at low densities, this species can be expected to spread and facilitate colonisation of other coal measures species. Wire rush is an 'ecosystem engineer' which directly or indirectly modulates the availability of resources (other than themselves) to other species, by causing physical state changes in biotic and abiotic materials (including soil formation and water retention) thereby influencing community development and succession (Hodges and Rapson 2010).

Planted sites had the highest average number of PCI compared to the other two rehabilitation methods, but the average was lower than natural sites. This may be explained by the use in plantings of 'At Risk' species including coal measures tussock and *Dracophyllum densum*. Again, both were also introduced as wilding transplants, with coal measures tussock deliberately targeted given its high survival rates

Propagation and repatriation, or individual hand transfer, of some species of significance ('SOS') plants such as the two *Sticherus* spp. identified as priorities for protection at Escarpment Mine, is achievable and is a viable method of maintaining some species of conservation interest or increasing their populations beyond the pre-mining level. Other SOS plants, for example Parkinson's rātā (*Metrosideros parkinsonii*), have been able to be propagated, but have had high mortality when small numbers have been reintroduced suggesting that additional effort in establishing these species is required (Ecological Solutions Limited 2024).

By their very nature, planted areas will take longer to reach a self-sustaining ecosystem compared to VDT. One of the planted sites (PL02) was approximately eight years old and had less than 50% vegetation cover in the ground layer, of which 80% was native species. The majority of the ground cover in that plot was rock and bare ground. In contrast, PL04 was 20 years old and had > 140% vegetation cover, and 137% native vegetation cover, demonstrating that planting can be effective at achieving canopy cover in the medium term.

A high proportion of rock and bare ground is not an undesirable rehabilitation outcome per se, as long as the community is resistant to weeds and the bare soil does not lead to sediment mobilisation, however the relatively high cover of bare ground at planted sites, at least initially, can make them susceptible to weed invasion, particularly by heath rush which was present at all planted sites. At one site (PL06), heath rush comprised more than half of the vegetation cover. Plants are typically slow growing at Stockton, so most planted areas are not expected to produce a high proportion of vegetation cover quickly. Native plant cover is best achieved where native plants don't have to compete with exotic grasses and herbs, long-lived precocious species (i.e., those which reproduce early e.g., mānuka) are used and 'hitchhiker' plants are common.

Boulderfields of acidic rock are one of the naturally uncommon ecosystems found across the Buller Plateaux. If this ecosystem were to be replicated for rehabilitation purposes, planting may be the most suitable option to establish a natural vegetation community due to boulderfields having naturally sparse vegetation.

7.4.2 Bryophytes

Planted sites had low proportion of mean indicator taxa (20.7% ± 2.8 SE) with a higher moss to liverwort ratio than the other rehabilitated sites surveyed. The presence of one 'At Risk' liverwort, *Cryptolophocolea tuberculata* and multiple 'indicator taxa' at PL-04, suggests that bryophyte communities can establish a trajectory towards establishing 'mature' communities typical of the area in the short-medium term where conditions are suitable. PL-04 was approximately 18 years old, with the oldest remediated site sampled being approximately 20-years old (PL-01).

PL-04 supported high vascular vegetation cover (80%), a relatively open-canopy (20% cover) and the second highest vascular species richness (39 native species) among the planted plots, surpassed only by PL-07 (42 native vascular species). The vegetation at PL-04 comprised mānuka-tussock-mountain flax shrubland and was situated on a southeast-facing hillside with a gentle 3°slope at an evaluation of 874m asl. The substrate consisted of shallow soils c. (252.5mm) with moderate drainage, and low levels of bedrock, broken rock, and surface rock.

While liverworts such as *Schistochila* (Schistochilaceae) which mostly occur in forests were absent from all the remediated sites we surveyed, PL-04 did support another species associated with forest habitats, *Gottschea pinnatifolia* (Schistochilaceae), which was growing amongst *C. tuberculata*. This suggests that some forest liverworts may begin to re-establish before forest vegetation is present if conditions are suitable.

Specific methods to enhance/preserve 'Threatened' and 'At Risk' bryophytes such as ex situ propagation and repatriation to terrestrial rehabilitated habitats have not been attempted at Stockton before, but could assist in maintaining bryophyte species of particular conservation concern. Habitat enrichment by adding boulders and wood to planted areas may also assist in creating humid microsites and allowing bryophytes to establish and persist.

7.4.3 Fauna

Indigenous birds, including New Zealand pipit and Western weka use planted areas. Planted sites where fernbirds were detected were close (c. < 50 m) to VDT sites which are likely to provide more suitable habitat (mānuka-dominant low stature shrubland). The presence of dense coal measures vegetation within the home range of fernbird may be a key influence on their presence in rehabilitated sites, as for some forest birds. As planted areas develop, the increase in the extent of suitable habitats across the site is expected to encourage species, including forest-dwellers such as South Island robin and pākihi specialists such as fernbird, to expand their home range to include adjoining planted areas more frequently and encourage dispersal of juveniles.

No planted areas are considered able support *Powelliphanta* snails or soil fauna comparable to that of VDT and undisturbed habitats. Key limitations are the absence of a deep, moist leaf litter, lower soil organic matter and lower vegetation cover which together reduce humidity. Over time, as the plantings grow and organic matter builds up, features such as a deep litter layer develop and plants such as flax and Astelia mature and provide suitable retreats/refugia for snails. Over time earthworm numbers also increase in the soil and these factors together create more favourable conditions for *Powelliphanta* snails to recolonise and persist. This process is likely to take many decades without either direct management to improve outcomes or a change in rehabilitation stripping and placement practices. Snail recolonisation is dependent on snails persisting in the habitats nearby and their productivity in those habitats being such that snails are available to colonise the adjoining rehabilitated areas. Given the ongoing decline of snails reported by Lloyd (2024) neither of these prerequisites are likely to be operating at present.

Planted sites had high numbers of money spiders (*D. cristatus*), indicating a more disturbed state than the VDT sites. Copper-bellied ants (*O. glaber*) were also present at planted sites. The most likely source of these invaders is nursery-raised plants. Whilst average invertebrate species richness at planted sites was comparable to VDT sites, VDT sites demonstrated the most diverse invertebrate communities. A reliance on planted sites alone is likely to lead to homogenisation of terrestrial invertebrate biodiversity. The potential invertebrate diversity in planted sites is most likely lower due to the absence of leaf litter layers, lower plant species diversity and the absence of microhabitats that are found in more structurally complex VDT associated with mature plants.

7.5 Tarns

7.5.1 Vegetation

Natural tarns had significantly higher native vegetation cover than both constructed tarn types, although overall vegetation cover and number of PCI were not significantly different.

Natural tarns were surrounded by low pākihi communities typical of sandstone pavement, whereas the constructed planted tarns included species typical of shrubland or forest communities. Heath rush was present at all constructed tarns, but only at two of six natural tarns. Some constructed tarns had soil conditions supporting natural tarn vegetation, evidenced by the presence of wire rush, red tussock and coal measures tussock. The use of wire rush in plantings is required to enable constructed and planted tarns to support more natural coal measures vegetation in future.

7.5.2 Bryophytes

Natural tarns (TN) and constructed tarns (TM) with VDT had the most mature bryophyte communities, with the proportion of indicator taxa exceeding 25%. Species richness at constructed tarns with VDT (38 species) and constructed tarns with planting (47 species) were higher than at natural tarns (44 species), but natural tarns had the highest proportion of indicator taxa (45%).

Tarns typically have a lower bryophyte diversity than forested habitats within the Buller Plateaux (Glenny 2012). Liverworts dominated the bryophyte communities at natural tarns, while mosses were more prevalent at constructed VDT and planted tarns. This suggests that VDT and planted constructed sites may not yet provide sufficient shade and moisture to support a wider range of liverworts, preventing them from drying out.

7.5.3 Fauna

Constructed tarns supported aquatic macroinvertebrate communities similar to those found in natural tarns, and are able to be colonised relatively quickly due to the good dispersal ability of many of the macroinvertebrate species (Watson et al. 2024). Additionally, the presence of sediments provides habitat for zooplankton resting eggs or live individuals to provide a food source for colonising species.

Diversity of terrestrial invertebrates at constructed and natural tarns was similar. An abundance of common species (particularly Dolomedidae) and several exotics at both types of rehabilitated tarns, but not at natural tarns, suggests the habitat structure differs between tarn types. Constructed tarns were typically surrounded by rehabilitated areas (either planted or VDT or both) and the influence of this surrounding vegetation may also be important in determining the local fauna community at each particular tarn.

7.6 Non-Remediated sites

7.6.1 Vegetation

Disturbed and subsequently non-remediated sites had lower total vegetation cover than natural and VDT sites, but were similar to planted sites. Non-remediated sites adjoining forested areas had higher percentage vegetation cover and taller vegetation than non-remediated sites within an active mining environment. Exotic species were a common component of the vegetation at all non-remediated sites despite, in most cases, being several decades post-disturbance.

Gorse (*Ulex europaeus*) dominated the vegetation at the older non-remediated sites (i.e., Escarpment Mine, Cedar Creek Road, Sullivan Mine). Exotic grasses and exotic rushes dominated the vegetation at more recently non-remediated sites at Stockton. Heath rush was present at all non-remediated sites, and exotic grasses such as browntop (*Agrostis capillaris*) were also abundant.

In general, gorse is expected to be shaded out and replaced by native forest over time at the Escarpment mine and Cedar Creek Road areas.

7.6.2 Bryophytes

Bryophyte communities at non-remediated sites were highly diverse (84 species), but included a low proportion of mean indicator taxa (15.5 % ± 3.5 SE), so the communities were not yet mature. The non-remediated site DS-04, a kāmahi-mānuka-red beech/flax shrubland left to regenerate naturally for approximately 42 years, supported the richest liverwort assemblage of the non-remediated sites (36 species), including *Schistochila glaucescens,* and *Riccardia furtiva* (‘At Risk – Naturally Uncommon’).

7.6.3 Fauna

Terrestrial invertebrate diversity and general community structure at non-remediated sites was comparable to planted sites, and similar to VDT sites. These sites also had high numbers of native wolf spiders (*Anoteropsis adumbrata*) which are often common in alpine habitats (Vink 2002). Wolf spiders in New Zealand primarily disperse as spiderlings (young spiders) through a passive aerial mechanism known as ballooning, which allows them to cover distances ranging from a few metres to several kilometres or more. Adult wolf spiders are also active hunters and are highly nomadic, moving on the ground to find new hunting grounds, mates, or shelter. The presence of wolf spiders, which are a predator, indicates that there are sufficient lower trophic order species available to sustain them at non-remediated sites.

7.7 Drill sites

There is no evidence that exploration drilling sites are generally prone to developing weedy vegetation over either the short or long term. Results from 32 drill sites across the Buller Plateaux indicate that drilling activities generally do not promote weed invasion, with most (78%) plots having no exotic species recorded. Because drill sites are not generally weedy, they are not expected to be a source of weed spread into adjacent undisturbed habitats.

The most common exotic species was heath rush, and sites with the highest number of exotic species (i.e., >2 per plot) were associated with drill sites that were established between 1997–2009, mainly in the Cypress area. Vegetation communities at drill sites were generally indistinguishable from surrounding natural vegetation communities in terms of vegetation composition, particularly where those communities were low stature or naturally sparsely vegetated. Weeds are likely to persist in four out of the seven drill sites that contained weeds due to their location in open areas with low vegetation, whereas the remaining three may have weeds gradually outcompeted due to growth of forest vegetation. Drill sites close to mining areas and tracks are more at risk to due to higher traffic and proximity to wind-dispersed weeds, particularly exotic grasses and rushes.

8.0 Recommendations

8.1 Introduction

Recommendations to improve rehabilitation outcomes for future mining areas on the Buller Plateaux based on the findings set out above are summarised below.

8.2 Landscape-scale Considerations

- Development of a strategy to vary future rehabilitation outcomes across the site as appropriate based on VDT and planting methods is recommended.
- Site-wide rehabilitation planning to create and account for ecological gradients and local habitat variation would improve overall outcomes. Vegetation types are naturally limited by altitude, drainage, aspect, slope angle and soil depth, so using plants or VDT sods that are suited to local site conditions on more variable engineered landforms will be more likely to maintain indigenous species replicating a natural ecosystem in the longer term. To achieve and maintain the most similarity to undisturbed habitats, rehabilitation planning should identify and consider the final ecosystem type achievable taking into account these elements. For example, a reasonable soil depth, good drainage and steeper slope angle will likely produce a forest ecosystem, whereas shallow soil on flat areas will likely produce rushland wetland ecosystems. Mimicking undisturbed vegetation types (e.g., forests) by using species both typical of and distinctive to these types should be prioritised.
- The location of final VDT placement should be planned to provide for ecological connections with surrounding habitats as well as to provide ecological connection across sites (e.g., via gullies or similar) and 'islands' of habitat to act as a source of seeds/propagules for surrounding planted areas.
- Creation of small areas of variable habitat with a large amount of edge should be prioritised over creation of large areas of homogenous vegetation where achievable.

8.3 VDT

- Vegetation Direct Transfer should be used to the maximum extent practicable, especially for low-growing vegetation communities. To date approximately 17% of rehabilitated sites have been achieved via VDT. Key determinants of a good outcome with VDT are competent substrate with even depth (particularly managing water and underlying soils), good biosecurity and minimising the extent and duration of bare soil. The best VDT outcomes have been achieved where particular operators have been dedicated to this task, allowed to specialise in this role and improve their skills over time, using specialised VDT cutting and transportation machines (buckets and truck decks).
- Provision of habitat for specific fauna and for bryophytes within or adjoining VDT. These include:
    - Boulder 'outcrops'.
    - Rubble piles.

  - Replaced wood (vertical and part buried) including root plates.
  - Tarns.
  - Burrows.
  - 'Roost' plants (e.g., for *Powelliphanta*).
  - 'Habitat' plants (e.g., *Gahnia*, for forest ringlet butterfly, *Liparophyllum* for the avatar moth).
- VDT of forested areas still has value, because even if large trees and shrubs are felled and removed, sods contain tree stumps with attached root plates and woody debris that provide habitat for fauna together with some minimally-disturbed soils containing seedlings and seed bank, mycorrhizae and soil microbiome retained in sods. These accelerate rehabilitation and can be supplemented with planting nursery-raised seedlings if required.
- Storage of VDT on existing vegetation should be avoided unless the VDT is an irreplaceable vegetation community and the storage area is very low value vegetation which does not support threatened species or naturally uncommon ecosystems.

8.4 Soils and Root Zones

- Planting sites should be prepared using appropriate soil, ideally minimally handled soils of sufficient depth to allow for root establishment of target plants. Minimising structural breakdown of soils by using methods of stripping and placement that minimise handling (i.e., 'jumble dump') is preferred over using stockpiled soil. The use of excavators rather than bulldozers, and avoiding excessive smoothing of landforms is recommended.
- Topsoil separation at stripping should be prioritised to prevent contamination of topsoil with acidic overburden material.
- Soil stockpiles for subsequent plant establishment should ideally be low (i.e. < 3 m), short term and created using minimal disturbance techniques that maintain soil structure and living attached plants, not compacted or smoothed. These practices assist wire-rush and soil invertebrate communities survive the stockpiling process and colonise rehabilitated areas when topsoil is spread. Use of fresh soils should be prioritised.
- Soil stockpiles should be managed to firstly stabilise soils against erosion, and secondly to maintain soil fauna via maximising native plant regrowth and introducing additional native plants if necessary to promote soil fauna. This approach could also provide established plant material for transfer. This may require development of specific methods for short-term erosion control that provide for native regrowth and weed management.
- Methods to manage short-term erosion control so as to deliver the primary goal while also facilitating establishment of native species should be developed.
- Soils known to contain *J. squarrosus* should be used for rehabilitating taller shrublands and forest only, since these communities will eventually shade out and supress this weed.
- Fertiliser should be used strategically to support vegetation establishment at targeted locations. Widespread application of fertiliser or biosolids at high rates is not recommended.

8.5 Surface Micro-habitats

Creation of a range of microhabitats helps underpin diversity of outcome at rehabilitated sites. Methods to create microhabitats include:

- Jumble dumping to retain surface roughness and create sheltered microsites. Jumble dumping also retains some elements of the vegetation and much of the soil vitality.
- The addition of microhabitat features such as logs and boulders to assist in providing microhabitats for plants and, if properly designed and implemented, habitat for fauna as well.
- Variability in soil depth and slope and the provision of sub-surface crevices and cavities (e.g. armoured by boulders).

8.6 Planting

- The pool of planting species should be expanded to include other local species typical of the Buller Plateaux. Coal measures species that are amenable to nursery propagation, either as seedlings, cuttings or divisions should be prioritised for use in plantings.
- Identify methods to propagate, introduce and accelerate growth of wire rush in planted areas. This should be included as part of the applied research program.
- Review the potential for individual wilding transplants, particularly for species that are not amenable to nursery production or are difficult to establish using potted plants. Retention of species' microbiome may be required for success of wilding transplants.
- Planting should be done in a way to facilitate succession towards the appropriate vegetation community (forest, shrubland, tussockland etc). This may involve staged planting with key ecosystem engineer species (e.g., wire rush, mānuka) used initially to set the trajectory for the intended ecosystem type followed by supplementary planting in following years once microhabitats are established.
- Vegetation types should be able to transition towards natural local coal measures vegetation. Wire rush should be prioritised due to its ability to spread and establish ground cover, protect soils and create favourable growing conditions for other species – this will require control of species that are able to smother it, notably *Juncus squarrosus*. Mānuka should be similarly prioritised because of its relative abundance in most pre-mining vegetation communities. Mānuka can be used strategically as a 'nusery crop' to develop favourable conditions over time for sensitive, later-successional forest species.
- The use of species not typical of the local coal measures ecosystem should be reduced to discrete areas. This includes bush and snow tussocks (*Chionochloa conspicua*, *C. flavescens*), koromiko (*Veronica salicifolia, V. stricta*), broadleaf (*Griselinia littoralis*), mountain akeake (*Olearia aviceniifolia*), toetoe. Broadleaf species such as koromiko and broadleaf should be restricted to lower altitude sites transitioning to forest, and bush and snow tussocks restricted to higher elevation rocky sites such as the upper slopes of Mt Frederick.
- Post-planting surveys should remove harekeke (*Phormium tenax*), kānuka (*Kunzea robusta*) *V. stricta* and northern rātā (*Metrosideros robusta*) where appropriate since they are are likely to have been introduced as inadvertent contaminants within nursery plantings.

- Develop methods to transition newly rehabilitated areas dominated by non-native species (pasture grasses) and non-coal measures species to coal measures vegetation.

8.7 Weed Management

- Weeds have the potential to smother native plants, reduce habitat quality for invertebrates, and prevent closure criteria being achieved. Within rehabilitated areas, priority should be given to preventing weed incursions into new areas and supressing weeds in VDT and managing known weed sources, particularly those that occur at the top of a catchment.
- Weed control needs to be addressed on a site wide basis and prioritised to prevent the establishment and spread of heath rush and other weed species into natural communities. Biosecurity measures such as boot washes at the entrances to sensitive rehabilitated areas would assist in reducing weed invasion, particularly for *Juncus* which is more likely to be spread on footwear and other equipment than by wind or animals.

8.8 Fauna

- Microhabitat and macrohabitat features provide important refuges for native fauna such as lizards and kiwi. Provision of fauna habitat should be planned as part of rehabilitation through the creation of microhabitat features (e.g., wood stacks, boulders), and macrohabitat features (e.g., logs with holes). This is particularly important for planted areas where it takes a long time (decades – centuries) for natural refuges to develop. The provision of fauna habitat will also have the added benefit of reducing the area of bare ground available for weed colonisation, providing microsites to enable plant establishment, assisting with erosion control and providing nutrients for plants through decomposition.
- Lloyd (2024) suggested that where possible, topsoil and subsoil be kept separate during the rehabilitation process and soil compaction by heavy machinery be avoided to provide favourable conditions for earthworms and *Powelliphanta* snails.
- The use of fascining/slash in addition to planting and seeding should be explored further to determine how the outcome of non-VDT rehabilitation can be improved for snails (Lloyd 2024).
- Ensuring that VDT sites are ecologically connected to natural habitats and in proximity to gully habitat complexes to support lizard survival.
- Using optimally sized buckets to minimise loss of individual lizards and snails during the VDT process.
- Attention to both nursery and site biosecurity will be required to prevent future invasions of ‘new’ invertebrate taxa.

8.9 Tarns

Constructed tarns provide habitat for aquatic invertebrates almost immediately and when combined with VDT also have value for vegetation and terrestrial invertebrates. Watson et al. (2024) recommended the following actions to improve rehabilitation outcomes:

- Tarns should be constructed on gently sloping banks and create semi-natural hydrologic regimes to support diverse plant communities.

- Soft substrates and emergent vegetation are important for the colonisation of many invertebrates, particularly for oviposition and emergence locations.
- Large woody debris and/or root wads and enrichment edge planting of constructed tarns is likely to enhance the cover / refuge that is required for species such as kōura.
- Constructed tarns with a sediment base over rock/gravel floor more closely resemble natural tarns. Minimise areas with a sand, gravel, or coal floor sediment base as these are associated with low macrophyte cover and poorer water quality. Therefore, constructed tarns should seek to be over a sediment base of rock/gravel
- VDT be used around tarns where achievable.

8.10 Bryophytes

The most successful rehabilitation method for retaining ecological values is VDT. VDT supports a wide range of in situ biodiversity, including 'Threatened' and 'At Risk' bryophytes and lichens. The following should be included in the design for bryophyte rehabilitation:

- Use VDT across a range of vegetation communities.
- Create humid microsites, and a variety of hydrological conditions, including tarns.
- Vary geological substrates –salvaged sandstone boulders, low fertility soils and an organic soil layer. Include wood.
- Exclude and control heath rush.

Specific attention to rehabilitation of bryophyte habitats would assist in maintaining the 'Threatened' and 'At Risk' species throughout their natural range. This includes steep, damp rock faces, boulder fields with sheltered cavities and a range of suitable vegetation types (pākihi, red tussock grassland, low forest).

8.11 Applied research

The development and implementation of scientifically robust research and monitoring programme(s) would assist in developing methods before they are required to be implemented at scale, including (but not limited to):

- Investigation of methods of propagation (e.g., particularly for wire rush, bryophytes, podocarps).
- Confirm the benefits of VDT for lizards via radio-tracking lizards.
- Methods to minimise the use of exotic species (e.g., for soil stabilisation).
- Methods to accelerate habitat suitability for snails.
- Use of artificial habitat by great spotted kiwi.

9.0 Summary

Rehabilitation across the Buller Plateaux, and particularly at Stockton Mine, has developed a range of rehabilitation methods since the early 1990s. The most successful of these in terms of retaining ecological values is VDT, which achieves habitat which closely mimics natural ecosystems in the shortest possible time. This type of rehabilitation minimises structural damage to both vegetation and soils and maintains an unknown proportion of animals with reduced mobility (i.e., snails, lizards, soil invertebrates). VDT produces a higher vegetation cover with a higher proportion of native species (including bryophytes), retains PCI and provides better fauna habitat, particularly for invertebrates, when compared to other rehabilitation methods. VDT should be maximised to the extent practicable so as to minimise and remediate adverse ecological effects.

The value of VDT for fauna can be enhanced by including microhabitat features such as logs and boulders to provide roosts/refugia and by effective biosecurity and weed management. Planted sites had more exotic species than VDT sites which is likely attributable to the higher proportion of bare ground present and in some cases the use of erosion stabilising methods that facilitate exotic species colonisation. Weed presence, and in some cases dominance, is a feature of rehabilitated sites which has the potential to prevent mine closure and reduce ecological values in the long term.

Low numbers of indigenous birds, including kiwi, use rehabilitated habitats at Stockton where they are available and suitable. Bird diversity and abundance were similar at VDT and planted sites, although sample sizes were small. Species with specific habitat requirements were only found at rehabilitated sites that were similar to their natural habitat, e.g. South Island fernbird were recorded at pākihi sites, whilst pipit and non-native passerines were recorded in planted areas. South Island robins were recorded near tall forest and weka were recorded throughout. The survey methods used were not appropriate to discriminate seasonal use of rehabilitated areas by birds, but it is likely that the presence of seasonal resources would attract birds to rehabilitated areas e.g, flax nectar for tūī and korimako. Attention to creation of specific habitats for fauna including lizards, kiwi and snails, would likely improve outcomes for fauna, particularly at planted sites, where development of natural habitats could be expected to take decades – centuries.

Terrestrial invertebrate diversity was comparable at non-remediated, planted, and VDT sites, as well as natural and man-made tarns, though there was larger range of diversity at VDT sites. There were also several invasive/exotic species recorded for the first time, although the risk these pose remains mostly unknown. Native and exotic money spiders (Linyphiidae) were present in all rehabilitated habitats, and these are typical invaders of disturbed New Zealand ecosystems. Future management of the site and other sites should include planning and biosecurity to prevent invasion of exotic species (where practicable).

Constructed tarns are statistically similar to natural tarns with respect to macroinvertebrate richness, abundance and structure. However, vegetated margins of planted constructed tarns had lower percentage cover than natural tarns, and percentage of bare ground was higher. It is likely that, much like planted sites, bare ground influences exotic species colonisation. Soil fauna diversity was highest at natural tarns and VDT tarns and lowest at planted tarns.

VDT, including in association with constructed tarns, is the most effective rehabilitation approach for sustaining bryophyte communities, supporting mature bryophyte communities (≥ 25% indicator taxa), as well as species of conservation concern. In contrast, planted sites had a lower proportion of indicator taxa (20.7% ± 2.8 SE). Where conditions and habitat are suitable, bryophyte communities in planted habitats may develop a mature bryophyte community within the medium term (approximately 18–20 years).

Drill sites were mostly free of weeds and are not prone to weed invasion over the short or long term, regardless of access type. The composition of vegetation communities at drill sites was indistinguishable from surrounding natural vegetation communities. Exotic species, especially heath rush, pose a threat to all rehabilitated vegetation types except taller shrubland and forest. Exotic invertebrates may also pose a threat, although the nature and extent of any threat remain largely unknown.

To improve rehabilitation outcomes at Stockton and other sites, it is recommended that a range of methods, at a range of scales from microhabitat to landscape be adopted. Consideration of rehabilitation at the landscape-scale, including creation of variation in the landform, extent and location of VDT and planted sites, proximity to undisturbed habitat, ecological connectivity and a target final ecosystem type will help in creating rehabilitation that retains key local elements, including 'Threatened' and 'At Risk' and locally important species and is contiguous with the surrounding landscape. Maximising the use of VDT, combined with specific topsoil and soil stockpile management and soil spreading methods to minimise physical damage as well as maintaining separate topsoil and subsoils and increasing soil fertility at targeted locations, will assist in creating conditions which deliver high organic matter inputs (leaves and roots) and enable the more rapid build-up of leaf litter and humus, which will improve outcomes for fauna dependent on soil invertebrates and will contribute to the long-term viability of vegetation placed on such soils.

Planting mixes should prioritise local coal measures species which are appropriate to the target ecosystem. Adding microhabitat features to rehabilitated sites, especially planted sites, will improve rehabilitation outcomes for a range of fauna. Finally, it is recommended effective biosecurity practices be developed and a strategy to improve rehabilitation outcomes be devised and implemented via a site-wide Rehabilitation Management Plan.

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APPENDIX A

Sampling Sites

Non-remediated Sites

Site	NZTM Easting	NZTM Northing	Rehab type	Location	Time since disturbance
DS1	[redacted]		Non-remediated	[redacted]	Disturbed sometime between 1988 and 2003, so at least 21 years. Possibly associated with water infrastructure before becoming a topsoil stockpile area (Sam Taylor pers. comm).
DS2	[redacted]		Non-remediated	[redacted]	At least 21 years. An area of side-cast material from widening of the Mt Fred haul road prior to 2003 (Sam Taylor pers. comm).
DS3	[redacted]		Non-remediated	[redacted]	Approximately 18 years. Area is a soil dump formed in 2006 (Sam Taylor pers. comm).
DS4	[redacted]		Non-remediated	[redacted]	Approximately 42 years. Work in Escarpment Mine ceased around 1982 (Watson, 2009).
DS5	[redacted]		Non-remediated	[redacted]	Approximately 54 years. This area was managed by State Coal (Campbell Robertson pers. comm.)
DS6	[redacted]		Non-remediated	[redacted]	Approximately 40 years. This area likely closed when Sullivan West Mine developed in 1984 (Campbell Robertson pers. comm.)

Vegetation Direct Transfer Sites

Site	NZTM Easting	NZTM Northing	Rehab type	Location	Age of rehab
DT1	[redacted]	[redacted]	VDT	[redacted]	FY12
DT2	[redacted]	[redacted]	VDT	[redacted]	FY11
DT3	[redacted]	[redacted]	VDT	[redacted]	July 2023
DT4	[redacted]	[redacted]	VDT	[redacted]	FY12
DT5	[redacted]	[redacted]	VDT	[redacted]	FY11
DT6	[redacted]	[redacted]	VDT	[redacted]	RY06/07
DT7	[redacted]	[redacted]	VDT	[redacted]	RY07/08

DT8	[redacted]	[redacted]	VDT	[redacted]	RY07/08

Planted Sites

Site	NZTM Easting	NZTM Northing	Rehab type	Location	Age of rehab
PL1	[redacted]	[redacted]	Planted	[redacted]	Pre RY04/05
PL2	[redacted]	[redacted]	Planted	[redacted]	FY16
PL3	[redacted]	[redacted]	Planted	[redacted]	RY05/06
PL4	[redacted]	[redacted]	Planted	[redacted]	RY04/05
PL5	[redacted]	[redacted]	Planted	[redacted]	RY07/08
PL6	[redacted]	[redacted]	Planted	[redacted], [redacted]	RY07/08?
PL7	[redacted]	[redacted]	Planted	[redacted]	RY05/06

Constructed Tarn Sites

Site	NZTM Easting	NZTM Northing	Rehab type	Location	Age of rehab	Notes
TM1	[redacted]	[redacted]	Planted tarn	[redacted], [redacted]	Pre RY04/05	NIWA report states constructed 2005
TM2	[redacted]	[redacted]	Planted tarn	[redacted]	FY16	NIWA report states constructed 2013
TM3	[redacted]	[redacted]	VDT tarn	[redacted] A [redacted]	RY07/08	NIWA report states constructed 2002
TM4	[redacted]	[redacted]	VDT tarn	[redacted]	FY11	NIWA report states constructed 2007
TM5	[redacted]	[redacted]	Planted tarn	[redacted]	FY18	Not mentioned in NIWA report

TM6	[redacted]	[redacted]	Planted tarn	[redacted]	FY21	NIWA report states constructed 2006
TM7	[redacted]	[redacted]	Planted tarn	[redacted]	RY05/06	NIWA report states constructed 1997-98
TM8	[redacted]	[redacted]	VDT tarn	[redacted]	RY07/08	NIWA report states constructed 1998
TM9	[redacted]	[redacted]	Planted tarn	[redacted]	FY23	Not mentioned in NIWA report
TM10	[redacted]	[redacted]	Planted tarn	[redacted]	RY04/05	NIWA report states constructed 1998-99
TM11	[redacted]	[redacted]	Planted tarn	[redacted]	FY17	NIWA report states constructed 1997-98
TM12	[redacted]	[redacted]	Planted tarn	[redacted]	RY05/06	Not mentioned in NIWA report

Natural Tarn Sites

Site	NZTM Easting	NZTM Northing	Rehab type	Location	Age of rehab	Notes
TN1	[redacted]	[redacted]	Natural	[redacted]	Natural	-
TN2	[redacted]	[redacted]	Natural	[redacted]	Natural	[redacted]
TN3	[redacted]	[redacted]	Natural	[redacted]	Natural	-
TN4	[redacted]	[redacted]	Natural	[redacted]	Natural	-
TN5	[redacted]	[redacted]	Natural	[redacted]	Natural	-
TN6	[redacted]	[redacted]	Natural	[redacted]	Natural	-

Natural Sites

Site	NZTM Easting	NZTM Northing	Location
[redacted]			

Drill Sites

Site	NZTM Easting	NZTM Northing	Rehab type	Location	Date of establishment
[redacted]					

[redacted]

APPENDIX B

Vascular species list for planted sites

Rehabilitation Type	Species	Common Name	Naturally occurring on the Buller Plateaux
Planted	*Austroderia richardii*	Toetoe	yes
	Chionochloa conspicua	Broad leaved bush tussock	no
	Chionochloa juncea	Coal measures tussock	yes
	Chionochloa rubra	Red tussock	yes
	Dracophyllum densum		yes
	Dracophyllum longifolium	Inaka	yes
	Dracophyllum rosmarinifolium	Inaka	yes
	Fuscospora cliffortioides	Mountain beech	yes
	Griselinia littoralis	Broadleaf; kāpuka	yes
	Lepidothamnus intermedius	Yellow-silver pine	yes
	Leptospermum scoparium	Mānuka	yes
	Metrosideros robusta	Northern rātā	no
	Metrosideros umbellata	Southern rātā	yes
	Olearia avicenniifolia	Mountain akeake	yes
	Ozothamnus vauvilliersii	Mountain tauhinu	yes
	Phormium cookianum	Mountain flax; wharariki	yes
	Phormium tenax	Flax; lowland flax	no
	Veronica mooreae		yes
	Veronica salicifolia	Koromiko	no
Naturalised	*Agrostis capillaris**	Browntop; browntop bent	no
	Anaphalioides bellidioides	Hells bells	yes
	Androstoma empetrifolium	Bog mingimingi	yes
	Aporostylis bifolia	Odd-leaved orchid	yes
	Brachyglottis bellidioides		yes
	Bulbinella species	Bulbinella; Māori onion	yes
	Carex gaudichaudiana	Gaudichaud's sedge	yes
	Celmisia dallii	Dall's mountain daisy	yes
	Celmisia dubia	Mountain daisy	yes
	Celmisia lateralis		yes
	Centella uniflora	Centella	yes
	Centrolepis ciliata		yes
	Chionochloa australis	Carpet grass	yes
	Coprosma cuneata		yes
	Coprosma dumosa		yes
	Coprosma linariifolia	Mikimiki; Yellow wood;	yes
	Corybas species	Spider orchid;	yes
	Cyathea colensoi	Mountain tree fern	yes
	Diphasium scariosum	Creeping clubmoss	yes
	Donatia novae-zelandiae	Cushion plant	yes
	Drosera spatulata	Sundew	yes
	Drosera stenopetala	Sundew	yes
	Elaeocarpus hookerianus	Pōkākā	yes
	Empodisma minus	Wire rush	yes
	Epacris alpina	Nehenehe	yes
	Epilobium brunnescens subsp. brunnescens		yes
	Epilobium melanocaulon		yes
	Epilobium pernitens		yes
	Forstera mackayi		yes
	Gahnia procera	Mountain gahnia; giant sedge	yes
	Gaultheria antipoda	Bush snowberry; fools beech	yes
	Gaultheria macrostigma	Prostrate snowberry	yes

	Gunnera monoica		yes
	Histiopteris incisa	Water fern; mātātā	yes
	Hydrocotyle moschata	Hairy pennywort	yes
	*Hypochaeris radicata**	Castear	no
	Isolepis aucklandica		yes
	*Juncus squarrosus**	Heath rush	no
	Kelleria dieffenbachii		yes
	*Leontodon saxatilis**	Hawkbit	no
	Leptecophylla juniperina	Prickly mingimingi	yes
	Leucopogon fasciculatus	Soft mingimingi; tall mingimingi	yes
	Liparophyllum gunnii		yes
	Lobelia angulata	Pratia	yes
	Lomaria discolor	Crown fern	yes
	Luzula rufa	Red woodrush	yes
Naturalised contd.	*Luzula species*	Woodrush	-
	Neomyrtus pedunculata	Rōhutu	yes
	Nertera balfouriana		yes
	Nertera depressa	Bead plant; fruiting duckweed	yes
	Paesia scaberula	Ring fern; hard fern	yes
	Parablechnum montanum	Mountain kiokio	yes
	Parablechnum novae-zelandiae	Kiokio	yes
	Parablechnum procerum	Small kiokio	yes
	Pentachondra pumila		yes
	Phyllocladus alpinus	Mountain toatoa; mountain celery pine	yes
	Polystichum vestitum	Prickly shield fern	yes
	Prasophyllum colensoi	Leek orchid	yes
	Pterophylla racemosa	Kāmahi	yes
	Pterostylis species	Greenhood orchid	yes
	Quintinia serrata	Quintinia	yes
	Rytidosperma gracile		yes
	Rytidosperma nigricans		yes

APPENDIX C

Vegetation types for natural, VDT and drill site plots

Plot type	Plot ID	Vegetation description
VDT	DT01	Silver-mountain beech forest
	DT02	Archeria/mountain beech forest
	DT03	Red tussock/wire rush shrubland
	DT04	Yellow-silver pine-mānuka shrubland
	DT05	Mānuka-flax rushland
	DT06	Southern rātā/mānuka-flax-Gahnia shrubland
	DT07	Mānuka-tussock/wire rush shrubland
	DT08	Mānuka-red tussock/wire rush shrubland
Natural (NT)	N01	Mānuka-tussock/wire rush shrubland
	N02	Southern rātā-mountain beech forest
	N03	Mānuka-mountain beech forest
	N04	Mānuka-*Chionochloa juncea*/wire rush shrubland
	N05	Mānuka-mountain beech forest
	N06	Silver beech/leatherwood shrubland
	N07	Red tussock-tangle fern shrub-rushland
	N08	Mountain flax-red tussock/tangle fern-wire rush shrubland
	N09	Silver beech-mountain beech/Archeria-podocarp forest
	N10	Mānuka-mountain flax/wire rush shrubland
Non-remediated	DS01	Heath rush grassland
	DS02	Toetoe/heath rush tussock-shrubland
	DS03	Southern rata/heath rush-wire rush shrubland
	DS04	Kāmahi-manuka-red beech/flax shrubland
	DS05	Manuka-kamahi shrubland
	DS06	Toetoe/mānuka-heath rush shrubland
Drill Sites (DS)	DC007	Mānuka-wire rush-tussock shrubland
	DC1187	Mānuka/herbfield shrubland (sandstone pavement)
	DC16	Mānuka-tussock/wire rush shrubland
	DC17	Mānuka/wire rush shrubland
	DC18	Mānuka/tussock shrub-rushland
	DC19	Southern rātā/mānuka-tussock shrubland (sandstone pavement)
	DEN120	Mānuka/podocarp-beech low forest
	DEN153	Mānuka-tussock/wire rush shrubland
	DEN156	Tussock/mānuka-wire rush shrubland
	DEN187	Tussock/mānuka-wire rush shrubland
	DEN188	Mānuka-tussock/wire rush shrubland
	DEN190	Tussock-wire rush/mānuka shrubland
	DEN191	Gahnia/mānuka-tussock shrubland
	DEN200	Square sedge-tussock shrub-rushland
	DEN202	Mānuka-tussock/wire rush shrubland
	DEN204	Square sedge/mānuka-wire rush rushland
	DEN206	Mānuka-square sedge shrub-rushland
	DEN209	Mānuka-tussock/wire rush shrubland
	DEN211	Square sedge-pakihi rush/mānuka rushland
	DEN246	Red tussock-tanglefern shrub-rushland
	DEN256	Mānuka/tussock-wire rush shrubland
	DEN257	Mānuka/tussock-wire rush shrubland
	DEN34	Mānuka-tussock/wire rush shrubland
	DEN49	Mānuka-Dracophyllum/wire rush shrubland
	DEN65	Mānuka/podocarp-beech low forest
	DEN99	Mānuka-tussock/square sedge rushland
	STK1520	Silver beech-mountain toatoa/sedge-rushland
	STK1523	Mānuka/tussock-wire rush shrubland
	STK1526	Mānuka/tangle fern-wire rush shrubland

STK3058	Mānuka/tussock-wire rush shrubland
STK3792	Mixed beech-mountain toatoa/Gahnia shrubland
STK5592	Mānuka-tussock grassland

APPENDIX D

Bryophyte species recorded

Species of conservation concern are marked in bold (de Lange et al. 2020, Michel et al. 2026).
Species of conservation interest are marked by an asterisk (*).

Location: [redacted]

Plot ID: **DT-01**

Cultural: VDT (Vegetation Direct Transfer)

Grid reference (NZTM): [redacted]

Date measured: 31/10/2023

Altitude: 915 m asl

Area: 5 x 5 m

Plot description: Silver-mountain beech forest

Bryophytes:

Acrobolbus epiphytus
Acromastigum anisostomum
Acromastigum marginatum
Bazzania adnexa
Cuspidatula monodon
Dicranoloma billardierei
Dicranoloma sp.
Dicranoweisia sp.
Dinckleria fruticella
Distichophyllum pulchellum
Frullania rostrata
Herbertus oldfieldianus
Heteroscyphus sp.
Kurzia hippuroides
Lepidogyna hodgsoniae
Lepicolea attenuata
Mniodendron colensoi
Neolepidozia patentissima
Ptychomnion aciculare
Riccardia crassa
Sphagnum falcatulum
Sphagnum squarrosum.

Location: [redacted]

Plot ID: **DT-02**

Cultural: VDT (Vegetation Direct Transfer)

Grid reference (NZTM): [redacted]

Date measured: 2/11/2023

Altitude: 1,004 m asl

Area: 5 x 5 m

Plot description: Archeria/mountain beech forest

Bryophytes:

Acrobolbus concinnus
Acrobolbus epiphytus
Acromastigum anisostomum
Bazzania adnexa
Bazzania involuta
Calomnion brownseyi
Campylopus clavatus
Campylopus introflexus
Dicranoloma billardierei
Dicranoloma sp.

Distichophyllum pulchellum
Gottschea pinnatifolia
Herbertus oldfieldianus
Heteroscyphus sp.
Lepicolea attenuata
Lepicolea scolopendra
Lepidogyna hodgsoniae
Lepidozia ulothrix
Macromitrium longipes
Plagiothecium sp.
Pleurophascum ovalifolium – ***'At Risk – Naturally Uncommon'***
Polytrichadelphus magellanicus
Ptychomnion aciculare
Sphagnum falcatulum
Wijkia extenuata.

Location: [redacted]
Plot ID: **DT-03**
Cultural: VDT (Vegetation Direct Transfer)
Grid reference (NZTM): [redacted]
Date measured: 2/11/2023
Altitude: 710 m asl
Area: 5 x 5 m
Plot description: Red tussock/wire rush shrubland

Bryophytes:

Camptochaete sp.
Campylopus clavatus
Campylopus introflexus
Campylopus sp.
Dicranella sp.
Isotachis montana
Kurzia hippuroides
Pallavicinia connivens
Philonotis sp.
Wijkia extenuata.

Location: [redacted]
Plot ID: **DT-04**
Cultural: VDT (Vegetation Direct Transfer)
Grid reference (NZTM): [redacted]
Date measured: 2/11/2023
Altitude: 726 m asl
Area: 5 x 5 m
Plot description: Yellow-silver pine–mānuka shrubland

Bryophytes:

Bazzania involuta
Campylopus introflexus
Campylopus sp.
Conostomum sp.
Dicranoloma billardierei
Distichophyllum pulchellum
Isotachis montana
Kurzia hippuroides

Lembidium nutans
Lepidozia concinna
Lepidozia sp.
Leucobryum javense
Pallavicinia sp.
Pleurophascum ovalifolium – ***'At Risk – Naturally Uncommon'***
Riccardia sp.
Telaranea herzogii.

Location: [redacted]
Plot ID: **DT-05**
Cultural: VDT (Vegetation Direct Transfer)
Grid reference (NZTM): [redacted]
Date measured: 2/11/2023
Altitude: 888 m asl
Area: 5 x 5 m
Plot description: Mānuka-flax rushland

Bryophytes:

Bazzania novae-zelandiae
Campylopus clavatus
Campylopus introflexus
Dicranoloma ?fasciatum
Dicranoloma sp.
Kurzia hippuroides
Lembidium nutans
Riccardia spp.
Wijkia extenuata.

Location: [redacted]
Plot ID: **DT-06**
Cultural: VDT (Vegetation Direct Transfer)
Grid reference (NZTM): [redacted]
Date measured: 16/11/2023
Altitude: 818 m asl
Area: 5 x 5 m
Plot description: Southern rātā/mānuka-flax-Gahnia shrubland

Bryophytes:

Adelanthus occlusus
Bazzania adnexa
Brachythecium paradoxum
Breutelia elongata
Campylopus introflexus
Cuspidatula monodon
Dicranoloma billardierei
Isotachis montana
Kurzia ?helophila
Kurzia hippuroides
Lepidozia laevifolia
Lepidozia sp.
Lepidozia ulothrix
Lobatiriccardia alterniloba
Polytrichadelphus magellanicus
Ptychomnion aciculare
Radula sp.

Riccardia sp.
Sphagnum squarrosum
Telaranea herzogii
Telaranea sp.
Wijkia extenuata.

Location: [redacted]
Plot ID: **DT-07**
Cultural: VDT (Vegetation Direct Transfer)
Grid reference (NZTM): [redacted]
Date measured: 16/11/2023
Altitude: 865 m asl
Area: 5 x 5 m
Plot description: Mānuka-tussock/wire rush shrubland

Bryophytes:

Brachythecium allisonii
Breutelia elongata
Campylopus clavatus
Campylopus purpureocaulis
Dicranoloma billardierei
Heteroscyphus allodontus
Kurzia hippuroides
Lepidozia sp.
Oligotrichum sp.
Riccardia spp.
Solenostoma inundatum
Wijkia extenuata.

Location: [redacted]
Plot ID: **DT-08**
Cultural: VDT (Vegetation Direct Transfer)
Grid reference (NZTM): [redacted]
Date measured: 21/11/2023
Altitude: 879 m asl
Area: 5 x 5 m
Plot description: Mānuka-red tussock/wire rush shrubland

Bryophytes:

Bazzania adnexa
Calyptrochaeta apiculata
Campylopus clavatus
Dicranoloma dicarpum
Drepanolejeunea sp.
Frullania ptychantha
Frullania rostrata
Isotachis montana
Kurzia hippuroides
Leucobryum javense
Macromitrium sp.
Meesia uliginosa
Neolepidozia patentissima
Philonotis tenuis
Pseudotaxiphyllum falcifolium
Racomitrium sp.

Rhacocarpus purpurascens
Riccardia spp.
Telaranea sp.
Tortula muralis
Zoopsis setulosa.

Location: [redacted]

Plot ID: **TN-01**

Cultural: Tarn Natural

Grid reference (NZTM): [redacted]

Date measured: 1/11/2023

Altitude: 843 m asl

Area: 5 x 5 m

Plot description: Red tussock / wire rush shrubland

Bryophytes:

Acromastigum anisostomum
Breutelia pendula
Campylopus introflexus
Campylopus sp.
Cryptochila nigrescens
Dicranoloma billardierei
Isotachis lyallii
Kurzia hippuroides
Ptychomnion aciculare
Riccardia aequicellularis
Riccardia furtiva – ***'At Risk – Naturally Uncommon'***
Syzygiella colorata
Telaranea herzogii
Wijkia extenuata
Zoopsis setulosa.

Location: [redacted]

Plot ID: **TN-02**

Cultural: Tarn Natural

Grid reference (NZTM): [redacted]

Date measured: 1/11/2023

Altitude: 740 m asl

Area: 5 x 5 m

Plot description: Mānuka–tussock / tangle fern-wire rush shrubland

Bryophytes:

Campylopus clavatus
Campylopus purpureocaulis
*Pulchrinodus inflatus**
Riccardia spp.

Location: [redacted]

Plot ID: **TN-03**

Cultural: Tarn Natural

Grid reference (NZTM): [redacted]

Date measured: 15/11/2023

Altitude: 747 m asl

Area: 5 x 5 m

Plot description: Podocarp / tussock-wire rush shrubland

<u>Bryophytes</u>:

Campylopus clavatus
Campylopus introflexus
Cuspidatula monodon
Dicranoloma sp.
Dicranoweisia antarctica
Goebeliella cornigera
Kurzia hippuroides
Lepidozia concinna
*Pulchrinodus inflatus**
Riccardia cochleata
Riccardia crassa
Riccardia sp.
Wijkia extenuata.

Location: [redacted]

Plot ID: **TN-04**

Cultural: Tarn Natural

Grid reference (NZTM): [redacted]

Date measured: 18/11/2023

Altitude: 805 m asl

Area: 5 x 5 m

Plot description: Mānuka–tussock / wire rush shrubland

<u>Bryophytes</u>:

Acromastigum anisostomum
Campylopus clavatus
Cladomnion ericoides
Kurzia hippuroides
Neolepidozia patentissima
Pallavicinia sp.
Pleurophascum ovalifolium – ***'At Risk – Naturally Uncommon'***
Polytrichum commune
Ptychomnion aciculare
Riccardia crassa
Telaranea sp.
Wijkia extenuata.

Location:[redacted]

Plot ID: **TN-05**

Cultural: Tarn Natural

Grid reference (NZTM): [redacted]

Date measured: 18/11/2023

Altitude: 812 m asl

Area: 5 x 5 m

Plot description: Mānuka–tussock / tangle fern-wire rush shrubland

Bryophytes:

Campylopus clavatus
Dicranoloma sp.
Fallaciella robusta
Frullania rostrata
Kurzia hippuroides
Lejeunea sp.
Lepidozia sp.
Leucobryum javense
Pleurophascum ovalifolium – ***'At Risk – Naturally Uncommon'***
Polytrichadelphus magellanicus
Ptychomnion aciculare
Radula sp.
Telaranea herzogii
Telaranea sp.
Wijkia extenuata.

Location: [redacted]
Plot ID: TN-06
Cultural: Tarn Natural
Grid reference (NZTM): [redacted]
Date measured: 18/11/2023
Altitude: 770 m asl
Area: 5 x 5 m
Plot description: Mānuka–tussock / wire rush shrubland

Bryophytes:

Campylopus introflexus
Dicranoloma billardierei
Dicranoloma sp.
Frullania rostrata
Kurzia ?compacta
Kurzia hippuroides
Kurzia quinquespina
Lepidozia attenuata
Neolepidozia patentissima
Pleurophascum ovalifolium – ***'At Risk – Naturally Uncommon'***
Radula sp.
Riccardia spp.
Sphagnum sp.
Telaranea herzogii
Weymouthia cochlearifolia
Wijkia extenuata.

Location: [redacted]
Plot ID: **PL-01**
Cultural: Planted
Grid reference (NZTM): [redacted]
Date measured: 31/10/2023
Altitude: 928 m asl
Area: 5 x 5 m
Plot description: Mānuka–mountain flax–broadleaf / tussock open-shrubland

Bryophytes:

Andreaea ?amblyophylla
Campylopus clavatus
Campylopus introflexus
Cryphaea tenella
Cryptolophocolea mitteniana
Dicranoloma billardierei
Dicranoloma sp.
Isotachis montana
Kurzia hippuroides
Macromitrium longirostre
Pohlia ?tenuifolia
Polytrichadelphus magellanicus
Riccardia cochleata.

Location: [redacted]
Plot ID: **PL-02**
Cultural: Planted
Grid reference (NZTM): [redacted]
Date measured: 1/11/2023
Altitude: 1,107 m asl
Area: 5 x 5 m
Plot description: Tussock mixed-shrubland

Bryophytes:

Andreaea sp.
Campylopus clavatus
Campylopus introflexus
Campylopus sp.
Conostomum sp.
Ditrichum sp.
Heteroscyphus ?cuneistipulus
Isotachis montana
Polytrichadelphus magellanicus
Ptychomnion aciculare
Telaranea sp.

Location: [redacted]
Plot ID: **PL-03**
Cultural: Planted
Grid reference (NZTM): [redacted]
Date measured: 2/11/2023
Altitude: 893 m asl
Area: 5 x 5 m
Plot description: Mixed-mānuka shrubland

Bryophytes:

?Plagiothecium sp.
Adelanthus occlusus
Bazzania involuta
Campylopus clavatus
Campylopus sp.
Dicranoloma dicarpum

Dicranoloma menziesii
Gackstroemia alpina
Isotachis montana
Lepidozia concinna
Lepidozia ?novae-zelandiae
Macromitrium sp.
Philonotis tenuis
Polytrichadelphus magellanicus
Racomitrium sp.
Rhacocarpus purpurascens
Riccardia aequicellularis
Riccardia bipinnatifida
Riccardia sp.
Sphagnum squarrosum
Wijkia extenuata.

Location: [redacted]

Plot ID: **PL-04**

Cultural: Planted

Grid reference (NZTM): [redacted]

Date measured: 15/11/2023

Altitude: 874 m asl

Area: 5 x 5 m

Plot description: Mānuka-tussock shrubland

<u>Bryophytes</u>:

Adelanthus falcatus
Adelanthus occlusus
Bartramia sp.
Bazzania involuta
Brachythecium sp.
Campylopus clavatus
Campylopus purpureocaulis
Campylopus sp.
Cryptolophocolea mitteniana
Cryptolophocolea tuberculata – ***'At Risk – Naturally Uncommon'***
Cuspidatula monodon
Dicranoloma menziesii
Dicranoloma sp.
Gottschea pinnatifolia
Heteroscyphus billardierei
Isotachis lyallii
Isotachis montana
Kurzia hippuroides
Lepidozia concinna
Lepidozia laevifolia
Lepidozia sp.
Lepidozia ulothrix
Lobatiriccardia alterniloba
Pohlia sp.
Polytrichum commune
Ptychomnion aciculare
Racomitrium crispulum
Racomitrium sp.
Rhacocarpus purpurascens
Syzygiella colorata
Telaranea sp.

Wijkia extenuata.

Location: [redacted]
Plot ID: **PL-05**
Cultural: Planted
Grid reference (NZTM): [redacted]
Date measured: 15/11/2023
Altitude: 836 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

<u>Bryophytes</u>:

Andreaea ?mutabilis
Bryum sp.
Campylopus clavatus
Campylopus sp.
Cryptolophocolea mitteniana
Cuspidatula monodon
Cyrtopus setosus
Dicranoloma sp.
Dicranoloma fasciatum
Distichophyllum pulchellum
Fossombronia ?australis
Heteroscyphus ?cuneistipulus
Heteroscyphus deceptifrons
Isotachis montana
Kurzia hippuroides
Lepidozia concinna
Lepidozia sp.
Macromitrium sp.
Neolepidozia patentissima
Philonotis ?scabrifolia
Pleuridium nervosum
Ptychomnion aciculare
Riccardia sp.
Syzygiella colorata
Telaranea herzogii
Tortella fragilis
Wijkia extenuata.

Location: [redacted]
Plot ID: **PL-06**
Cultural: Planted
Grid reference (NZTM): [redacted]
Date measured: 16/11/2023
Altitude: 861 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

<u>Bryophytes</u>:

Campylopus clavatus
Campylopus introflexus

Campylopus sp.
Ditrichum ?buchananii
Ditrichum sp.
Isotachis montana
Kurzia hippuroides
Macromitrium sp.
Metzgeria leptoneura
Ptychomnion aciculare
Racomitrium pruinosum
Riccardia aequicellularis
Riccardia bipinnatifida
Telaranea sp.
Tricholepidozia lindenbergii.

Location: [redacted]
Plot ID: **PL-07**
Cultural: Planted
Grid reference (NZTM): [redacted]
Date measured: 16/11/2023
Altitude: 770 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

Bryophytes:

Bazzania adnexa
Brachythecium sp.
Campylopus sp.
Campylopus clavatus
Cheilolejeunea sp.
Dicranoloma billardierei
Kurzia hippuroides
Lepidozia concinna
Lobatiriccardia alterniloba
Metzgeria leptoneura
Pohlia annotina
Polytrichum commune
Ptychomnion aciculare
Wijkia extenuata
Isotachis montana
Drepanolejeunea sp.
Cuspidatula monodon
Lepidozia sp.
Radula sp.

Location: [redacted]
Plot ID: **TM-01**
Cultural: Constructed tarn (planted)
Grid reference (NZTM): [redacted]
Date measured: 31/10/2023
Altitude: 908 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

Bryophytes:

Campylopus clavatus
Dicranoloma billardierei
Isotachis montana
Isotachis sp.
Kurzia hippuroides
Lepidozia sp.
Macromitrium sp.
Neolepidozia praenitens
Polytrichadelphus magellanicus
Ptychomnion aciculare
Sphagnum falcatulum.

Location: [redacted]
Plot ID: **TM-02**
Cultural: Constructed tarn (planted)
Grid reference (NZTM): [redacted]
Date measured: 1/11/2023
Altitude: 1,077 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

Bryophytes:

Racomitrium sp.
Isotachis montana
?Scorpidium cossonii
Polytrichum juniperinum
Racomitrium ?crumianum
Riccardia sp.
Campylopus sp.

Location: [redacted]
Plot ID: **TM-03**
Cultural: Constructed tarn (VDT)
Grid reference (NZTM): [redacted]
Date measured: 21/11/2023
Altitude: 849 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

Bryophytes:

Adelanthus occlusus
Andreaea mutabilis
Brachythecium sp.
Breutelia ?pendula
Breutelia elongata
Campylopus clavatus
Campylopus introflexus
Cryptolophocolea mitteniana
Isotachis montana
Lobatiriccardia alterniloba
Macromitrium longipes
Metzgeria leptoneura

Neolepidozia patentissima
Neolepidozia tetrapila
Polytrichadelphus magellanicus
Ptychomnion aciculare
Rhacocarpus purpurascens
Sphagnum subnitens
Tricholepidozia lindenbergii.

Location: [redacted]
Plot ID: **TM-04**
Cultural: Constructed tarn (VDT)
Grid reference (NZTM): [redacted]
Date measured: 15/11/2023
Altitude: 886 m asl
Area: 5 x 5 m
Plot description: Square sedge-mānuka shrubland

Bryophytes:

?Bartramia sp.
?Conostomum sp.
Campylopus clavatus
Campylopus introflexus
Ceratodon purpureus
Isotachis montana
Kurzia hippuroides
Lepidozia hirta
Racomitrium sp.
Riccardia aequicellularis
Riccardia crassa.

Location: [redacted]
Plot ID: **TM-05**
Cultural: Constructed tarn (planted)
Grid reference (NZTM): [redacted]
Date measured: 20/11/2023
Altitude: 943 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

Bryophytes:

Campylopus clavatus
Fossombronia ?australis
Heteroscyphus sp.
Lobatiriccardia alterniloba
Metzgeria leptoneura
Ptychomnion aciculare
Riccardia aequicellularis
Solenostoma inundatum.

Location: [redacted]
Plot ID: **TM-06**

Cultural: Constructed tarn (planted)

Grid reference (NZTM): [redacted]

Date measured: 20/11/2023

Altitude: 943 m asl

Area: 5 x 5 m

Plot description: Mixed shrubland

Bryophytes:

Bartramia sp.
Campylopus clavatus
Campylopus introflexus
Ceratodon purpureus
Chiloscyphus lentus
Dicranoloma billardierei
Ditrichum sp.
Isotachis montana
Marchantia berteroana
Polytrichadelphus magellanicus
Polytrichum commune
Polytrichum juniperinum.

Location: [redacted]

Plot ID: **TM-07**

Cultural: Constructed tarn (planted)

Grid reference (NZTM): [redacted]

Date measured: 21/11/2023

Altitude: 816 m asl

Area: 5 x 5 m

Plot description: Mānuka shrubland

Bryophytes:

Bazzania involuta
Campylopus clavatus
Campylopus introflexus
Dicranoloma billardierei
Drepanolejeunea aucklandica
Isotachis montana
Kurzia hippuroides
Lepidozia ulothrix
Macromitrium sp.
Metzgeria leptoneura
Polytrichadelphus magellanicus
Ptychomnion aciculare
Riccardia aequicellularis.

Location: [redacted]

Plot ID: **TM-08**

Cultural: Constructed tarn (VDT)

Grid reference (NZTM): [redacted]

Date measured: 21/11/2023

Altitude: 882 m asl

Area: 5 x 5 m

Plot description: Mānuka shrubland

Bryophytes:

?Cryphaea sp.
Campylopus clavatus
Campylopus sp.
Cryptolophocolea mitteniana
Dicranoloma menziesii
Dicranoloma sp.
Isotachis lyallii
Isotachis montana
Lepidozia laevifolia
Lepidozia sp.
Macromitrium longipes
Polytrichadelphus magellanicus
Racopilum sp.
Sphagnum falcatulum
Sphagnum squarrosum
Telaranea sp.

Location: [redacted]
Plot ID: **TM-09**
Cultural: Constructed tarn (planted)
Grid reference (NZTM): [redacted]
Date measured: 21/11/2023
Altitude: 866 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

Bryophytes:

Bryum laevigatum
Campylopus clavatus
Funaria hygrometrica
Marchantia polymorpha
Philonotis pyriformis
Polytrichastrum alpinum
Wijkia extenuata.

Location: [redacted]
Plot ID: **TM-10**
Cultural: Constructed tarn (planted)
Grid reference (NZTM): [redacted]
Date measured: 22/11/2023
Altitude: 900 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

Bryophytes:

Andreaea sp.
Bazzania involuta
Campylopus clavatus
Campylopus introflexus
Campylopus sp.
Cryptochila grandiflora
Dicranoloma billardierei

Dicranoloma sp.
Ditrichum sp.
Isotachis montana
Kurzia hippuroides
Neolepidozia praenitens
Oligotrichum tenuirostre
Polytrichadelphus magellanicus
Ptychomnion aciculare
Sphagnum falcatulum
Wijkia extenuata.

Location: [redacted]
Plot ID: **TM-11**
Cultural: Constructed tarn (planted)
Grid reference (NZTM): [redacted]
Date measured: 22/11/2023
Altitude: 901 m asl
Area: 5 x 5 m
Plot description: Heath rush grassland

Bryophytes:

Bartramia sp.
Campylopus clavatus
Campylopus sp.
Isotachis lyallii
Isotachis montana
Lobatiriccardia alterniloba
Macromitrium sp.
Meesia uliginosa
Polytrichum juniperinum
Racomitrium sp.
Solenostoma inundatum
Thuidiopsis furfurosa.

Location: [redacted]
Plot ID: **TM-12**
Cultural: Constructed tarn (planted)
Grid reference (NZTM): [redacted]
Date measured: 22/11/2023
Altitude: 821 m asl
Area: 5 x 5 m
Plot description: Mixed shrubland

Bryophytes:

Andreaea sp.
Bartramia sp.
Campylopus clavatus
Heteroscyphus fissistipus
Isotachis montana
Polytrichadelphus magellanicus.

Location: [redacted]
Plot ID: **DS-01**
Cultural: Non-remediated
Grid reference (NZTM): [redacted]
Date measured: 20/11/2023
Altitude: 799 m asl
Area: 5 x 5 m
Plot description: Heath rush grassland

Bryophytes:

Bartramia sp.
Brachythecium paradoxum
Campylopus clavatus
Campylopus purpureocaulis
Campylopus sp.
Isotachis lyallii
Isotachis montana
Leptobryum pyriforme
Polytrichum commune
Polytrichum juniperinum
*Pulchrinodus inflatus**

Location: [redacted]
Plot ID: **DS-02**
Cultural: Non-remediated
Grid reference (NZTM): [redacted]
Date measured: 20/11/2023
Altitude: 917 m asl
Area: 5 x 5 m
Plot description: Toetoe/heath rush tussock-shrubland

Bryophytes:

Andreaea sp.
Campylopus ?bicolor
Campylopus clavatus
Campylopus introflexus
Campylopus sp.
Dicranoloma sp.
Distichophyllum pulchellum
Ditrichum sp.
Heteroscyphus ?cuneistipulus
Isotachis montana
Lobatiriccardia alterniloba
Lophozia sp.
Macromitrium microstomum
Philonotis tenuis
Polytrichadelphus magellanicus
Ptychomnion aciculare
Rhizogonium novae-hollandiae
Riccardia sp.
Solenostoma inundatum
Solenostoma totipapillosum
Wijkia extenuata.

Location: [redacted]

Plot ID: **DS-03**

Cultural: Non-remediated

Grid reference (NZTM): [redacted]

Date measured: 21/11/2023

Altitude: 788 m asl

Area: 5 x 5 m

Plot description: Southern rātā/heath rush-wire rush shrubland

Bryophytes:

Bartramia sp.
Brachythecium paradoxum
Campylopus introflexus
Campylopus sp.
Chiloscyphus sp.
Cryptochila grandiflora
Cryptolophocolea mitteniana
Dicranoloma billardierei
Dicranoloma sp.
Ditrichum cylindricarpum
Grimmia sp.
Heteroscyphus ?cuneistipulus
Isotachis montana
Kurzia hippuroides
Macromitrium sp.
Metzgeria leptoneura
Pohlia sp.
Polytrichadelphus magellanicus
Riccardia bipinnatifida
Saccogynidium australe
Neolepidozia praenitens.

Location: [redacted]

Plot ID: **DS-04**

Cultural: Non-remediated

Grid reference (NZTM): [redacted]

Date measured: 23/11/2023

Altitude: 688 m asl

Area: 5 x 5 m

Plot description: Kāmahi-mānuka-red beech/flax shrubland

Bryophytes:

Achrophyllum quadrifarium
Acrobolbus sp.
Bazzania adnexa
Campylopus introflexus
Dicranoloma billardierei
Dicranoloma sp.
Frullania rostrata
Frullania sp.
Heteroscyphus deceptifrons

Heteroscyphus fissistipus
Kurzia ?helophila
Kurzia hippuroides
Kurzia quinquespina
Lembidium nutans
Lepidolaena palpebrifolia
Lepidolaena sp.
Lepidozia sp.
Lobatiriccardia alterniloba
Macromitrium microstomum
Macromitrium sp.
Neolepidozia patentissima
Pohlia cruda / nutans
Pohlia sp.
Radula physoloba
Radula sp.
Riccardia crassa
Riccardia furtiva – ***'At Risk – Naturally Uncommon'***
Rosulabryum billardierei
Saccogynidium australe
Schistochila glaucescens
Sphagnum cristatum
Syntrichia rubra
Telaranea herzogii
Tricholepidozia lindenbergii
Wijkia extenuata
Zoopsis setulosa.

Location: [redacted]

Plot ID: **DS-05**

Cultural: Non-remediated

Grid reference [redacted]

Date measured: 23/11/2023

Altitude: 535 m asl

Area: 5 x 5 m

Plot description: Mānuka-kāmahi shrubland

<u>Bryophytes</u>:

Bazzania adnexa
Brachythecium paradoxum
Brachythecium sp.
Campylopus introflexus
Cuspidatula monodon
Cyathophorum bulbosum
Dicranoloma billardierei
Dicranoloma sp.
Frullania rostrata
Lepidolaena taylorii
Lepidozia sp.
Leucobryum javense
Macromitrium longipes
Pallavicinia tenuinervis
Polytrichadelphus magellanicus
Porella elegantula
Ptychomnion aciculare
Rhizogonium distichum
Riccardia sp.

Solenostoma inundatum
Sphagnum cristatum
Symphyogyna / Pallavicinia
Telaranea herzogii
Neolepidozia praenitens
Kurzia quinquespina
Telaranea sp.
Wijkia extenuata.

Location: Sullivan [redacted]

Plot ID: **DS-06**

Cultural: Non-remediated

Grid reference (NZTM): [redacted]

Date measured: 23/11/2023

Altitude: 675 m asl

Area: 5 x 5 m

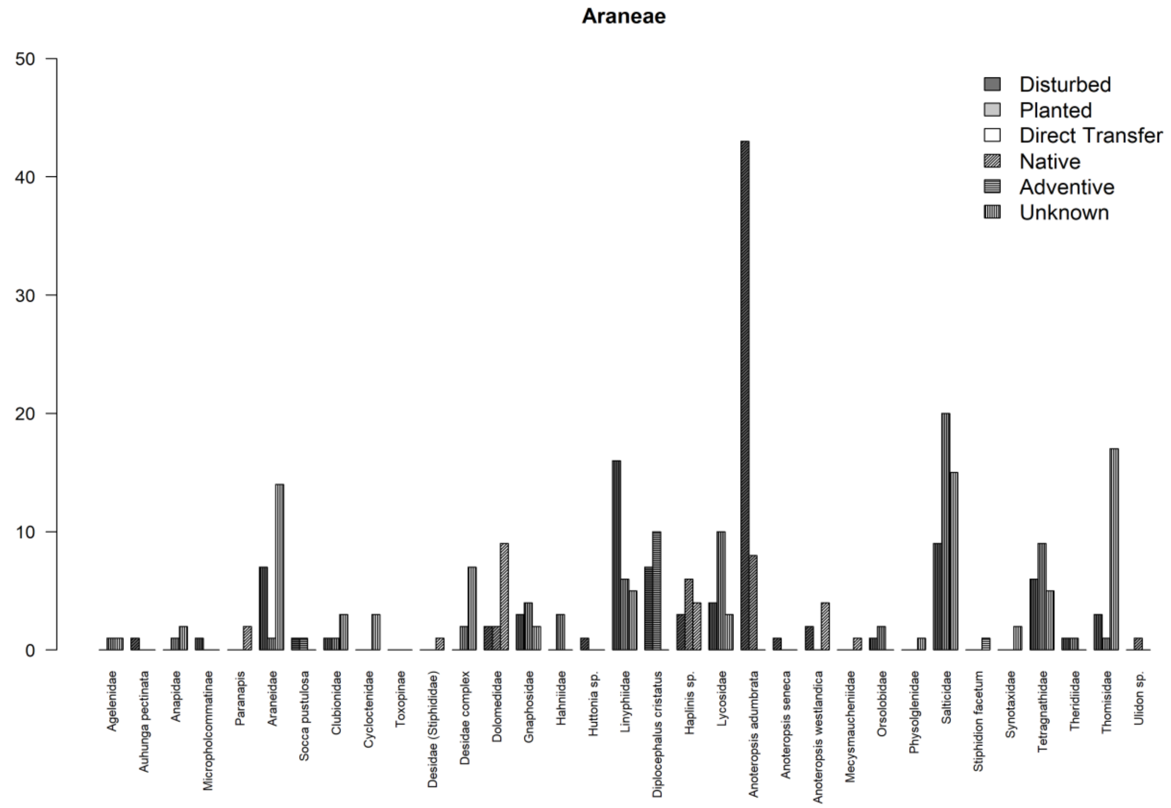
Plot description: Toetoe/mānuka-heath rush shrubland

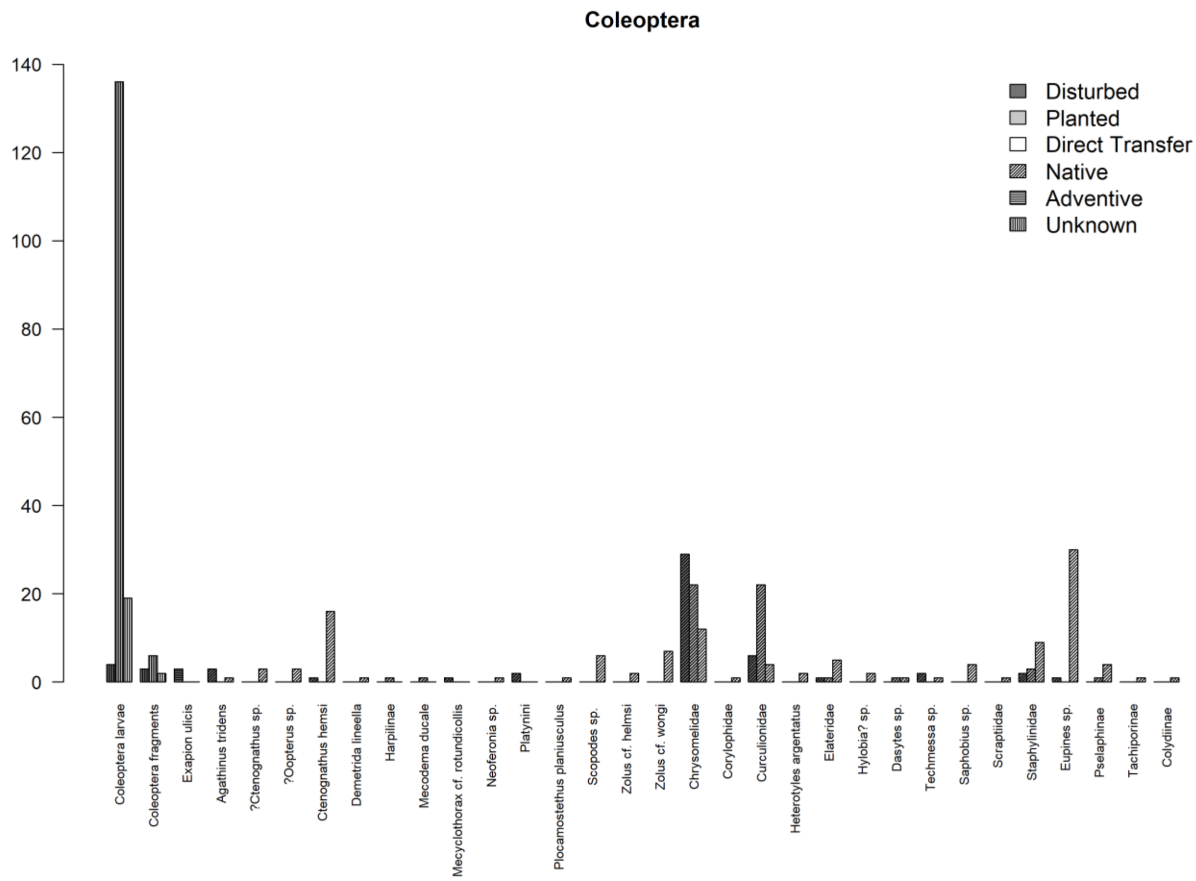
Bryophytes:

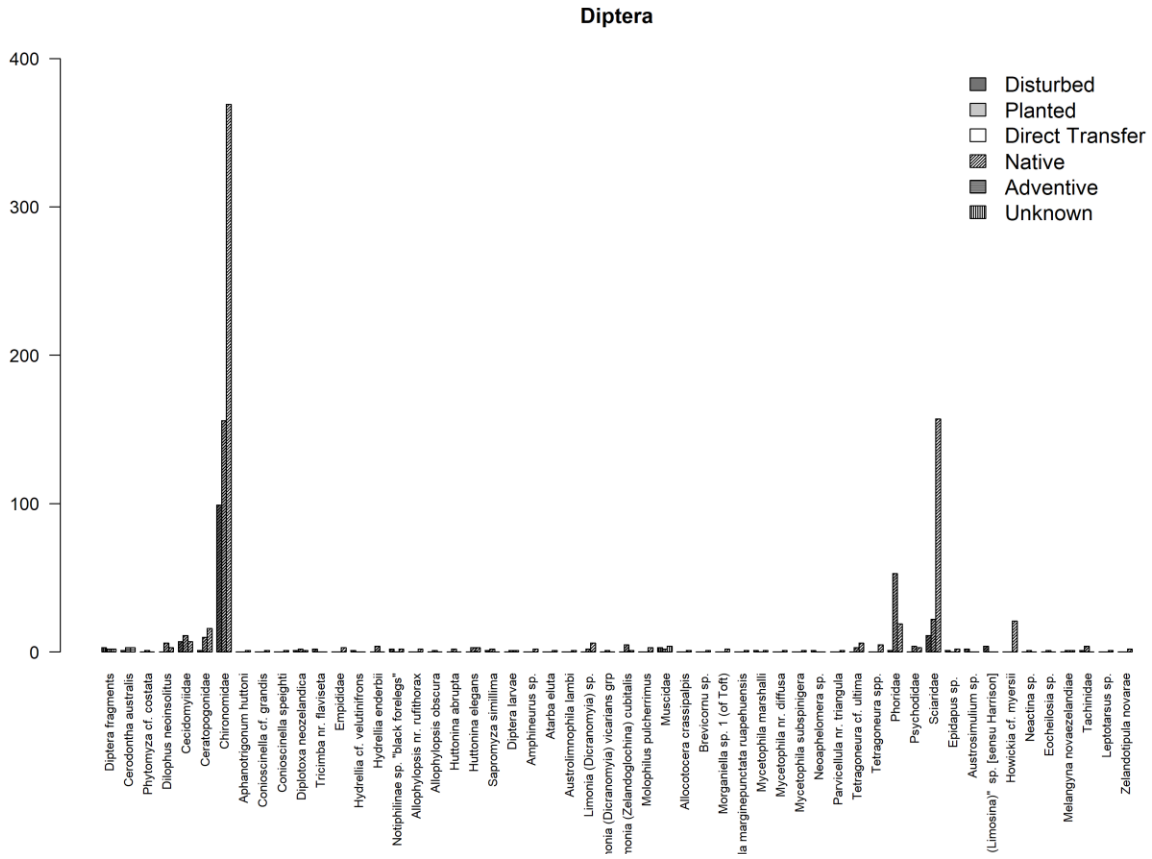
Brachythecium paradoxum
Breutelia pendula
Campylopus clavatus
Campylopus introflexus
Cryptolophocolea mitteniana
Dicranoloma dicarpum
Heteroscyphus sp.
Isotachis montana
Metzgeria leptoneura
Philonotis tenuis
Polytrichadelphus magellanicus
Ptychomnion aciculare
Riccardia sp.
Sphagnum sp.
Telaranea herzogii
Neolepidozia patentissima
Telaranea sp.

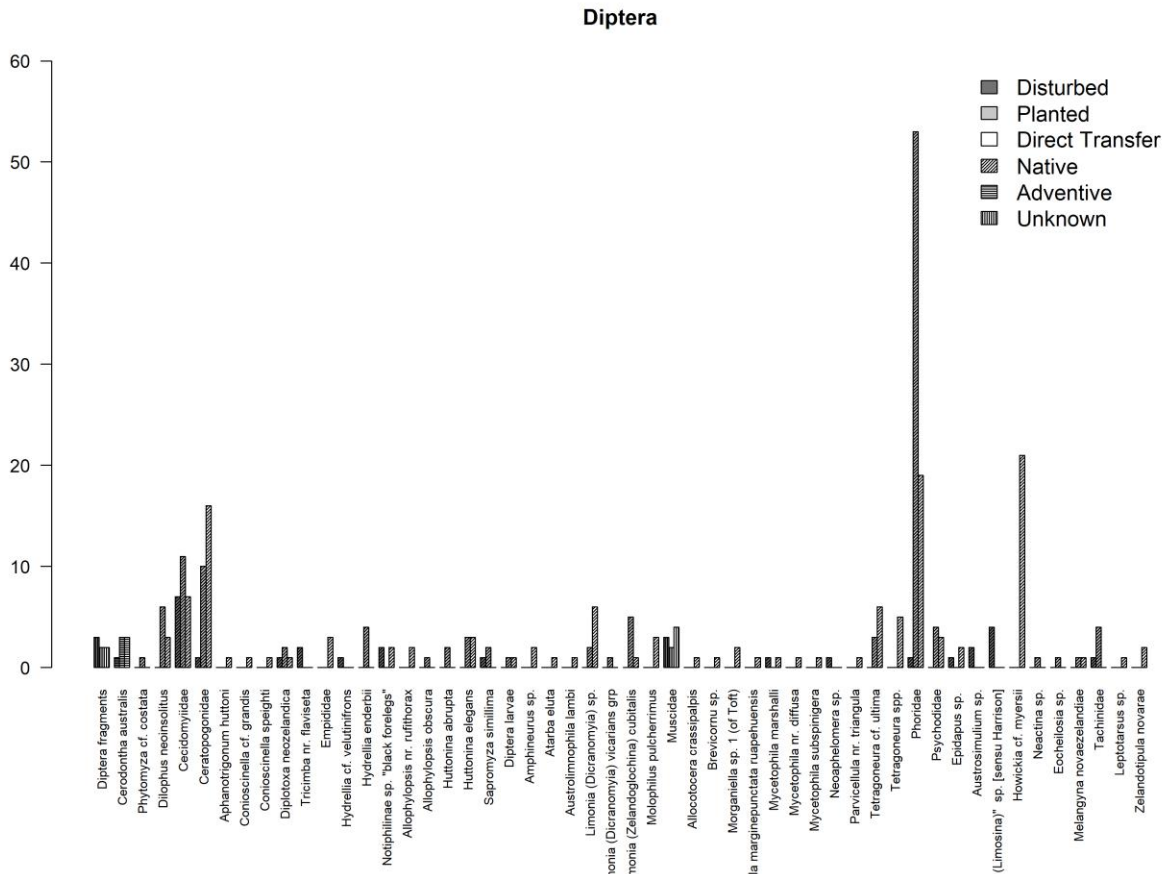
APPENDIX E

Summary of invertebrate communities


Araneae
50
40
30
20
10
0
Disturbed
Planted
Direct Transfer
Native
Adventive
Unknown
Agelenidae
Auhunga pectinata
Anapidae
Micropholcommatinae
Paranapis
Araneidae
Socca pustulosa
Clubionidae
Cycloctenidae
Toxopinae
Desidae (Stiphididae)
Desidae complex
Dolomedidae
Gnaphosidae
Hahniidae
Huttonia sp.
Linyphiidae
Diplocephalus cristatus
Haplinis sp.
Lycosidae
Anoteropsis adumbrata
Anoteropsis seneca
Anoteropsis westlandica
Mecysmaucheniidae
Orsolobidae
Physoglenidae
Salticidae
Stiphidion facetum
Synotaxidae
Tetragnathidae
Theridiidae
Thomisidae
Ulidon sp.


Coleoptera
140
120
100
80
60
40
20
0
Disturbed
Planted
Direct Transfer
Native
Adventive
Unknown
Coleoptera larvae
Coleoptera fragments
Exapion ulicis
Agathinus tridens
?Ctenognathus sp.
?Oopterus sp.
Ctenognathus hemsi
Demetrida lineella
Harpilinae
Mecodema ducale
Mecyclothorax cf. rotundicollis
Neoferonia sp.
Platynini
Plocamostethus planiusculus
Scopodes sp.
Zolus cf. helmsi
Zolus cf. wongi
Chrysomelidae
Corylophidae
Curculionidae
Heterotyles argentatus
Elateridae
Hylobia? sp.
Dasytes sp.
Techmessa sp.
Saphobius sp.
Scraptiidae
Staphylinidae
Eupines sp.
Pselaphinae
Tachiporinae
Colydiinae


Diptera
400
300
200
100
0
Disturbed
Planted
Direct Transfer
Native
Adventive
Unknown
Diptera fragments
Cerodontha australis
Phytomyza cf. costata
Dilophus neoinsolitus
Cecidomyiidae
Ceratopogonidae
Chironomidae
Aphanotrigonum huttoni
Conioscinella cf. grandis
Conioscinella speighti
Diplotoxa neozelandica
Tricimba nr. flaviseta
Empididae
Hydrellia cf. velutinifrons
Hydrellia enderbii
Notiphilinae sp. "black forelegs"
Allophylopsis nr. rufithorax
Allophylopsis obscura
Huttonina abrupta
Huttonina elegans
Sapromyza simillima
Diptera larvae
Amphineurus sp.
Atarba eluta
Austrolimnophila lambi
Limonia (Dicranomyia) sp.
ıonia (Dicranomyia) vicarians grp
ıonia (Zelandoglochina) cubitalis
Molophilus pulcherrimus
Muscidae
Allocotocera crassipalpis
Brevicornu sp.
Morganiella sp. 1 (of Toft)
la marginepunctata ruapehuensis
Mycetophila marshalli
Mycetophila nr. diffusa
Mycetophila subspinigera
Neoaphelomera sp.
Parvicellula nr. triangula
Tetragoneura cf. ultima
Tetragoneura spp.
Phoridae
Psychodidae
Sciaridae
Epidapus sp.
Austrosimulium sp.
(Limosina)" sp. [sensu Harrison]
Howickia cf. myersii
Neactina sp.
Eocheilosia sp.
Melangyna novaezelandiae
Tachinidae
Leptotarsus sp.
Zelandotipula novarae


Diptera
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40
30
20
10
0
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Planted
Direct Transfer
Native
Adventive
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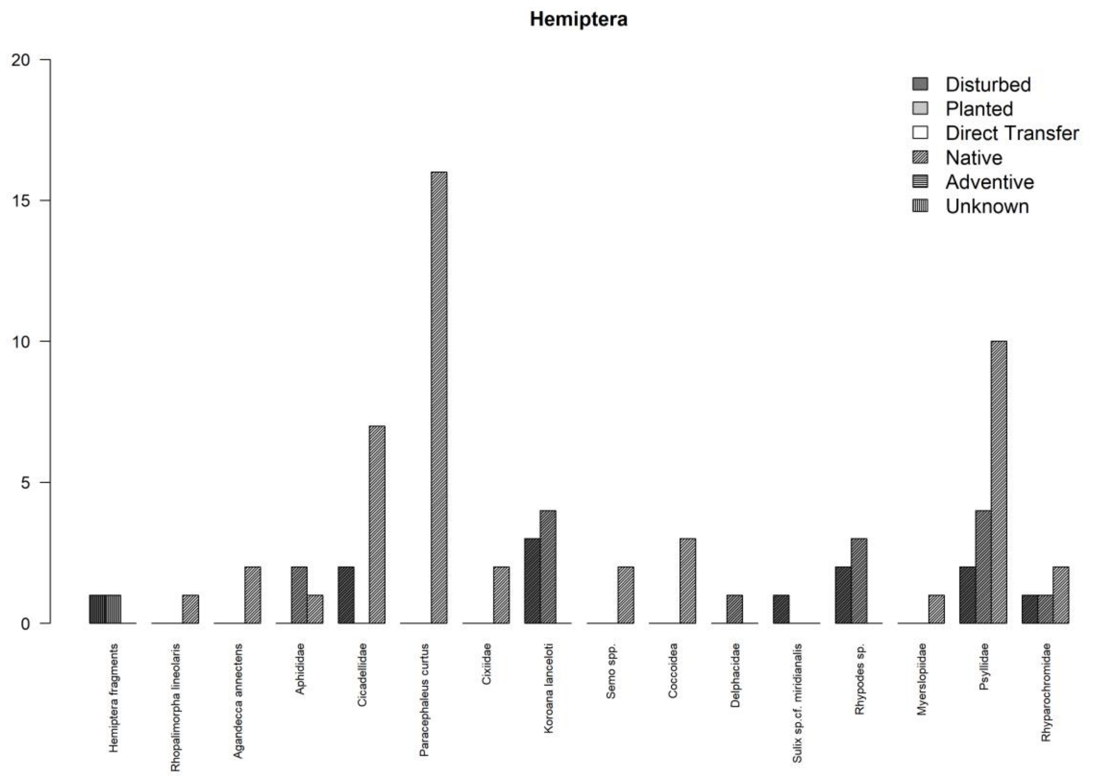
Phytomyza cf. costata
Dilophus neoinsolitus
Cecidomyiidae
Ceratopogonidae
Aphanotrigonum huttoni
Conioscinella cf. grandis
Conioscinella speighti
Diplotoxa neozelandica
Tricimba nr. flaviseta
Empididae
Hydrellia cf. velutinifrons
Hydrellia enderbii
Notiphilinae sp. "black forelegs"
Allophylopsis nr. rufithorax
Allophylopsis obscura
Huttonina abrupta
Huttonina elegans
Sapromyza simillima
Diptera larvae
Amphineurus sp.
Atarba eluta
Austrolimnophila lambi
Limonia (Dicranomyia) sp.
ıonia (Dicranomyia) vicarians grp
ıonia (Zelandoglochina) cubitalis
Molophilus pulcherrimus
Muscidae
Allocotocera crassipalpis
Brevicornu sp.
Morganiella sp. 1 (of Toft)
la marginepunctata ruapehuensis
Mycetophila marshalli
Mycetophila nr. diffusa
Mycetophila subspinigera
Neoaphelomera sp.
Parvicellula nr. triangula
Tetragoneura cf. ultima
Tetragoneura spp.
Phoridae
Psychodidae
Epidapus sp.
Austrosimulium sp.
(Limosina)" sp. [sensu Harrison]
Howickia cf. myersii
Neactina sp.
Eocheilosia sp.
Melangyna novaezelandiae
Tachinidae
Leptotarsus sp.
Zelandotipula novarae



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20
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10
5
0
Disturbed
Planted
Direct Transfer
Native
Adventive
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Hemiptera fragments
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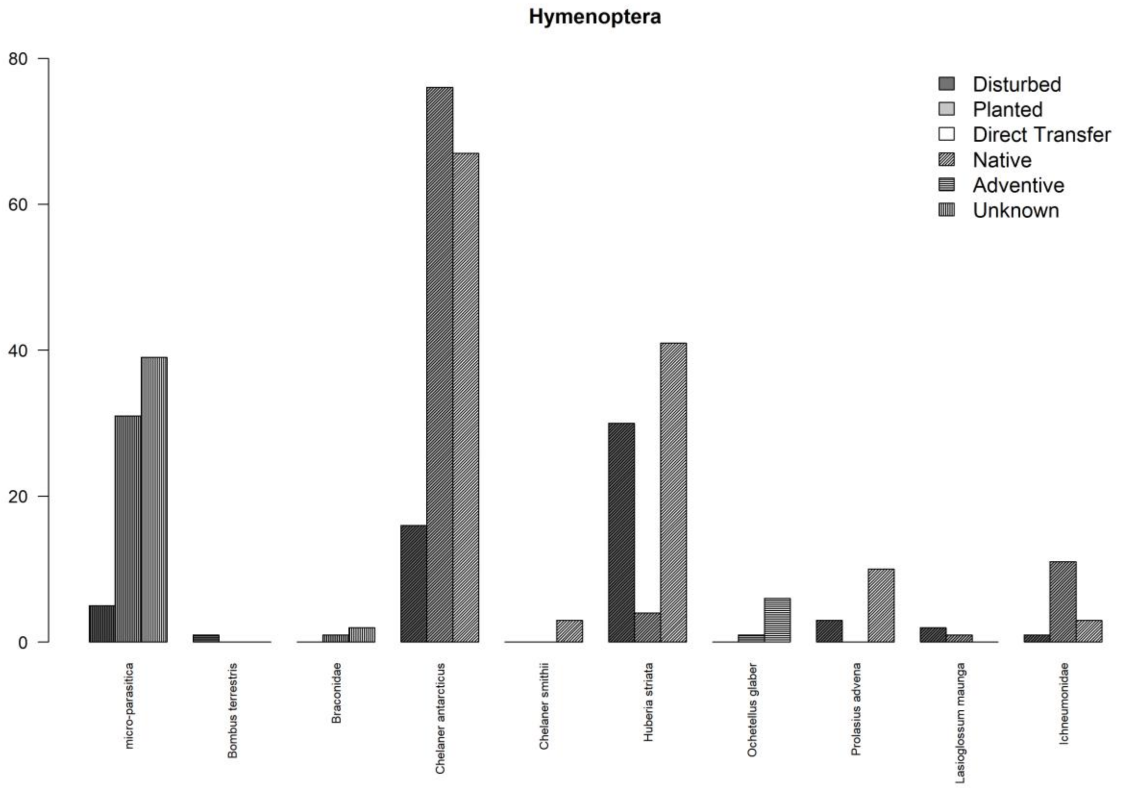
Agandecca annectens
Aphididae
Cicadellidae
Paracephaleus curtus
Cixiidae
Koroana lanceloti
Semo spp.
Coccoidea
Delphacidae
Sulix sp.cf. miridianalis
Rhypodes sp.
Myerslopiidae
Psyllidae
Rhyparochromidae



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20
0
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Planted
Direct Transfer
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Adventive
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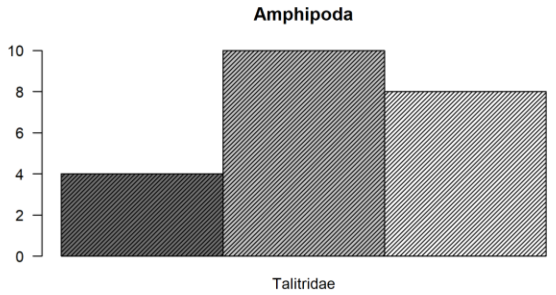
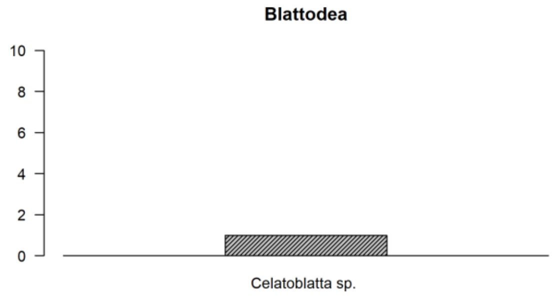
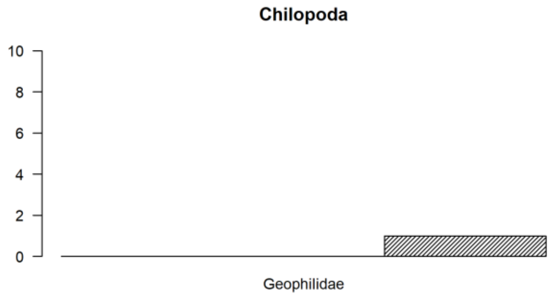
Bombus terrestris
Braconidae
Chelaner antarcticus
Chelaner smithii
Huberia striata
Ochetellus glaber
Prolasius advena
Lasioglossum maunga
Ichneumonidae







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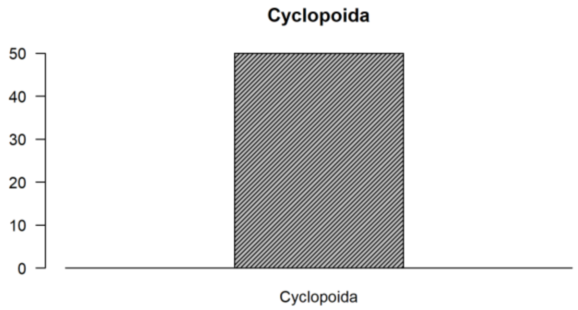

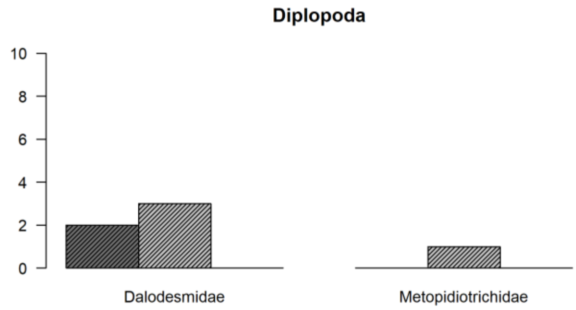

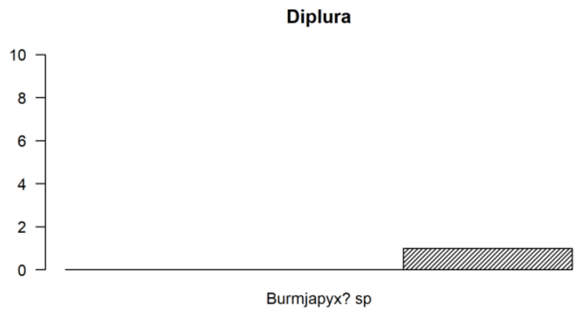

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Direct Transfer
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Adventive
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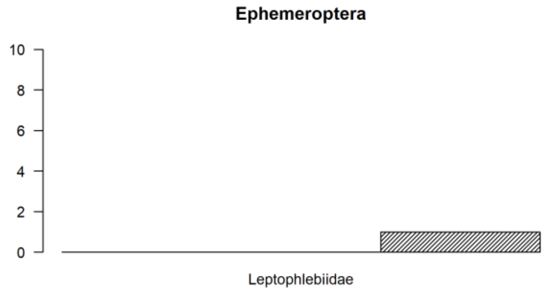
Ephemeroptera
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6
4
2
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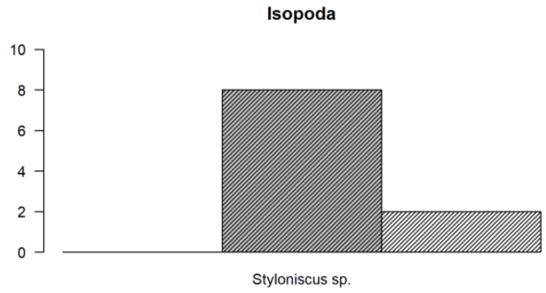
Leptophlebiidae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8
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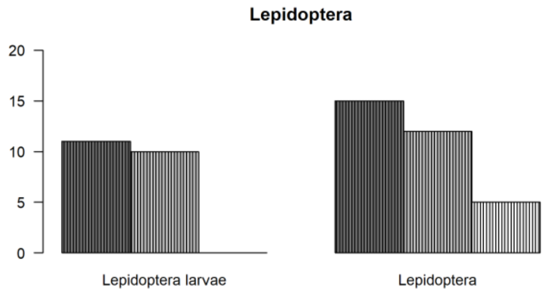
4
2
0
Styloniscus sp.


Lepidoptera
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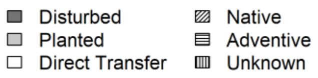
10
5
0
Lepidoptera larvae
Lepidoptera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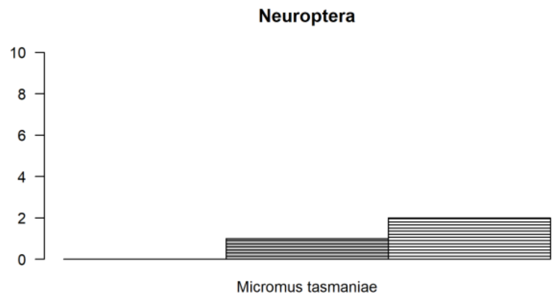
Planted
Direct Transfer
Native
Adventive
Unknown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8
6
4
2
0
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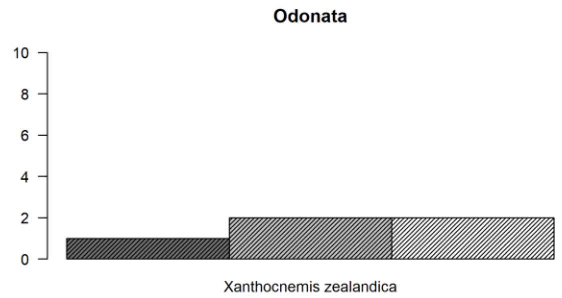
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6
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2
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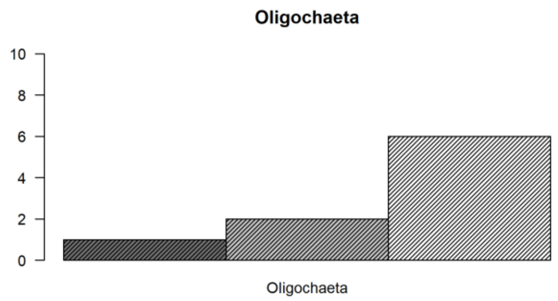
Xanthocnemis zealandica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6
4
2
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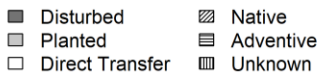
Oligochaeta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Planted
Direct Transfer
Native
Adventive
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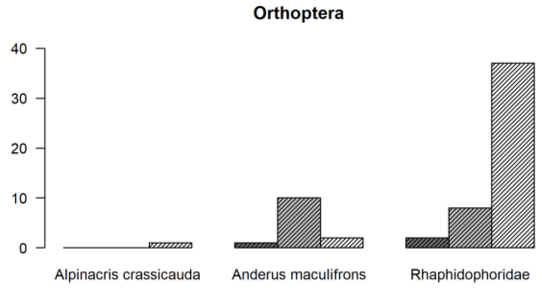
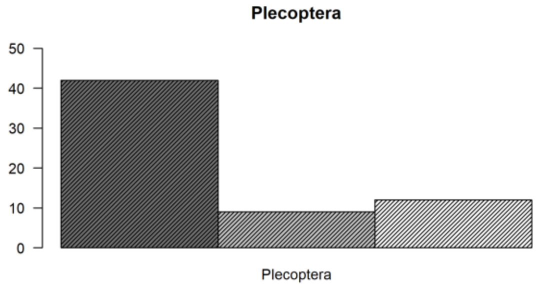
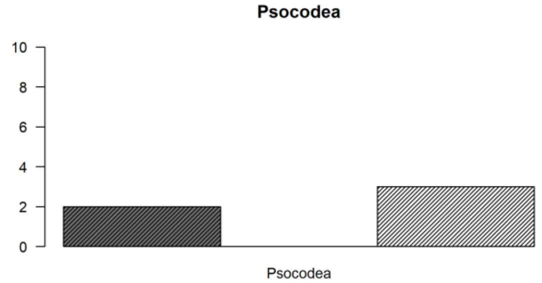
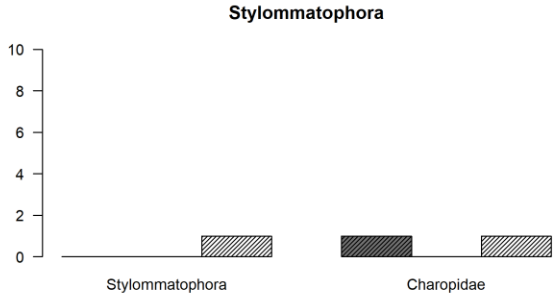
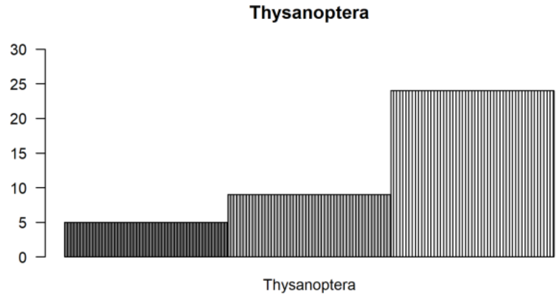


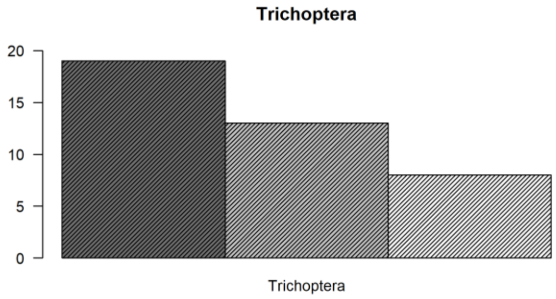




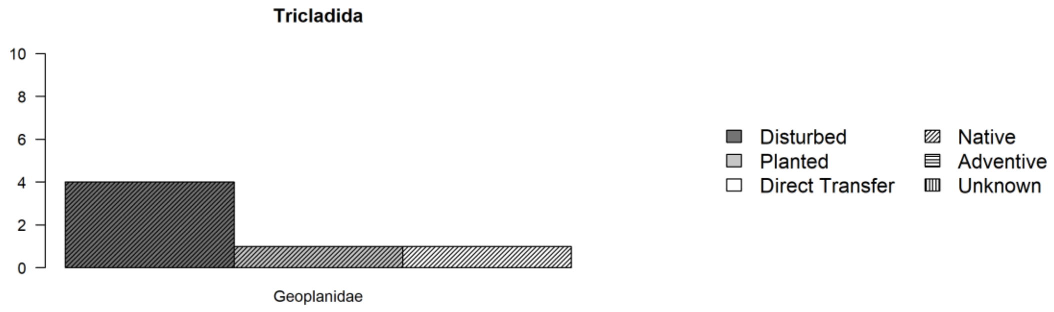
Disturbed
Planted
Direct Transfer
Native
Adventive
Unknown







Disturbed
Planted
Direct Transfer
Native
Adventive
Unknown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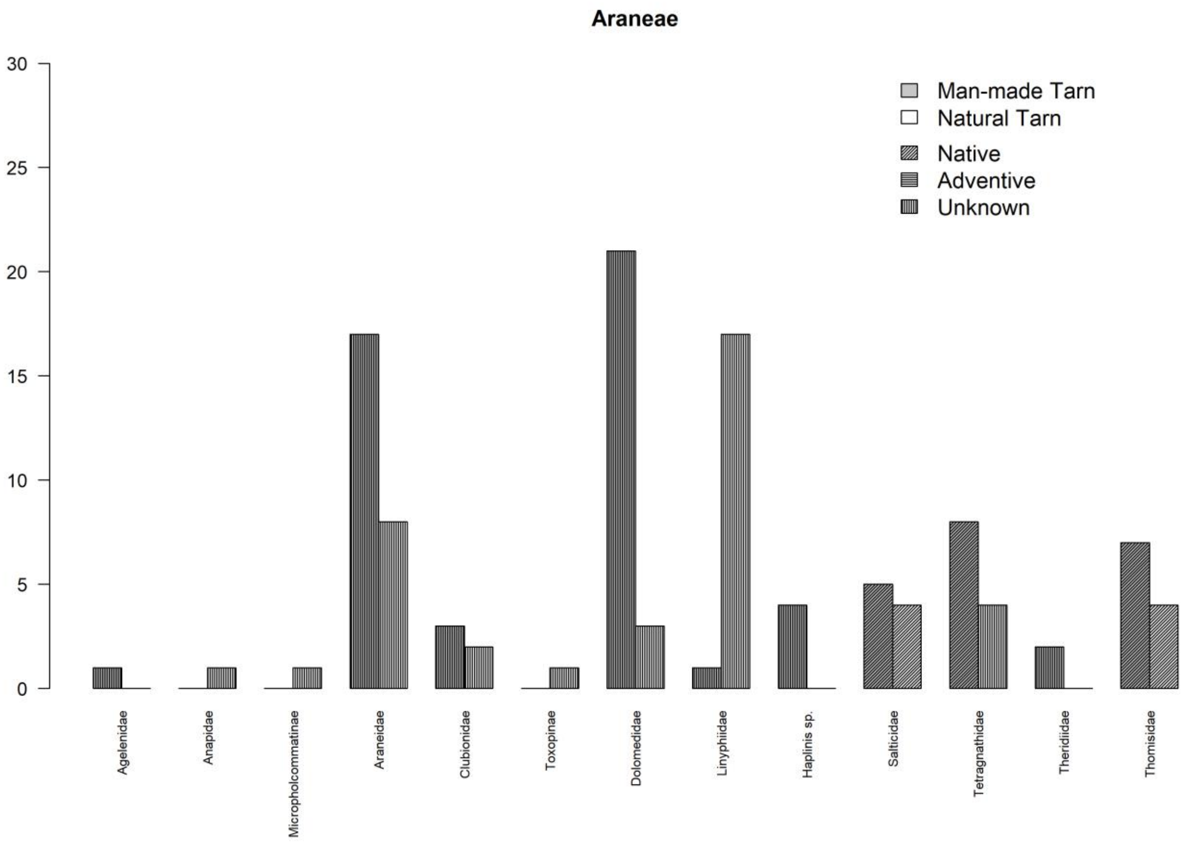
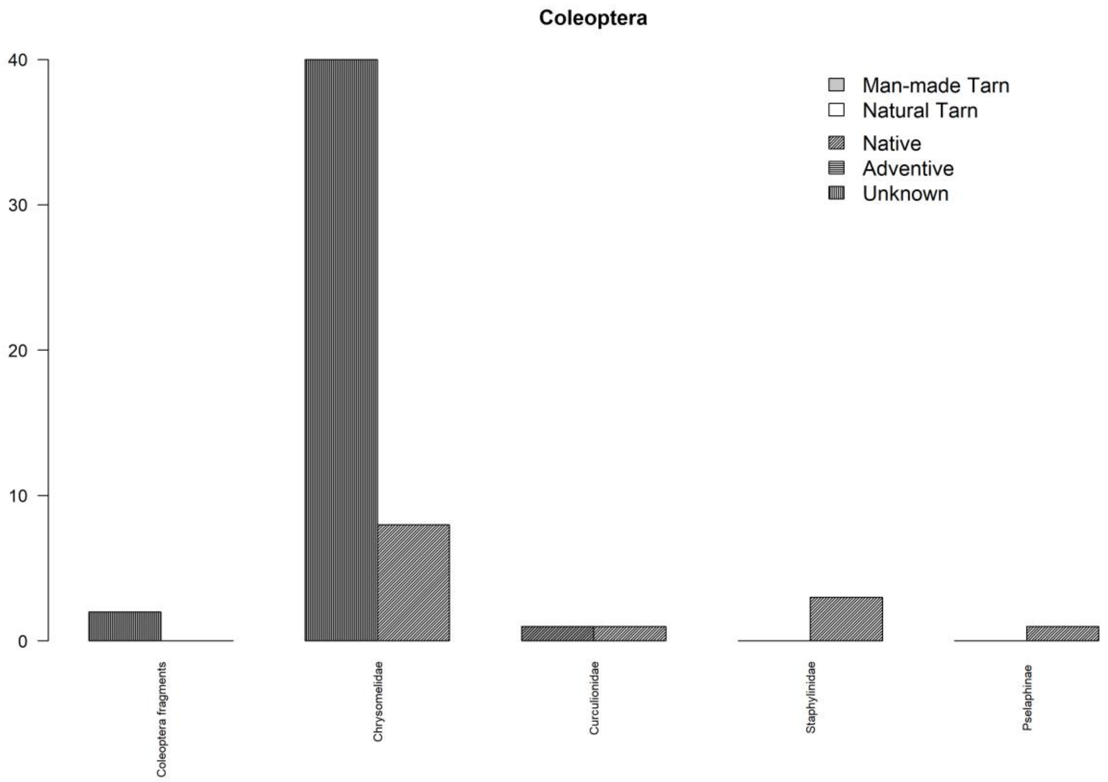
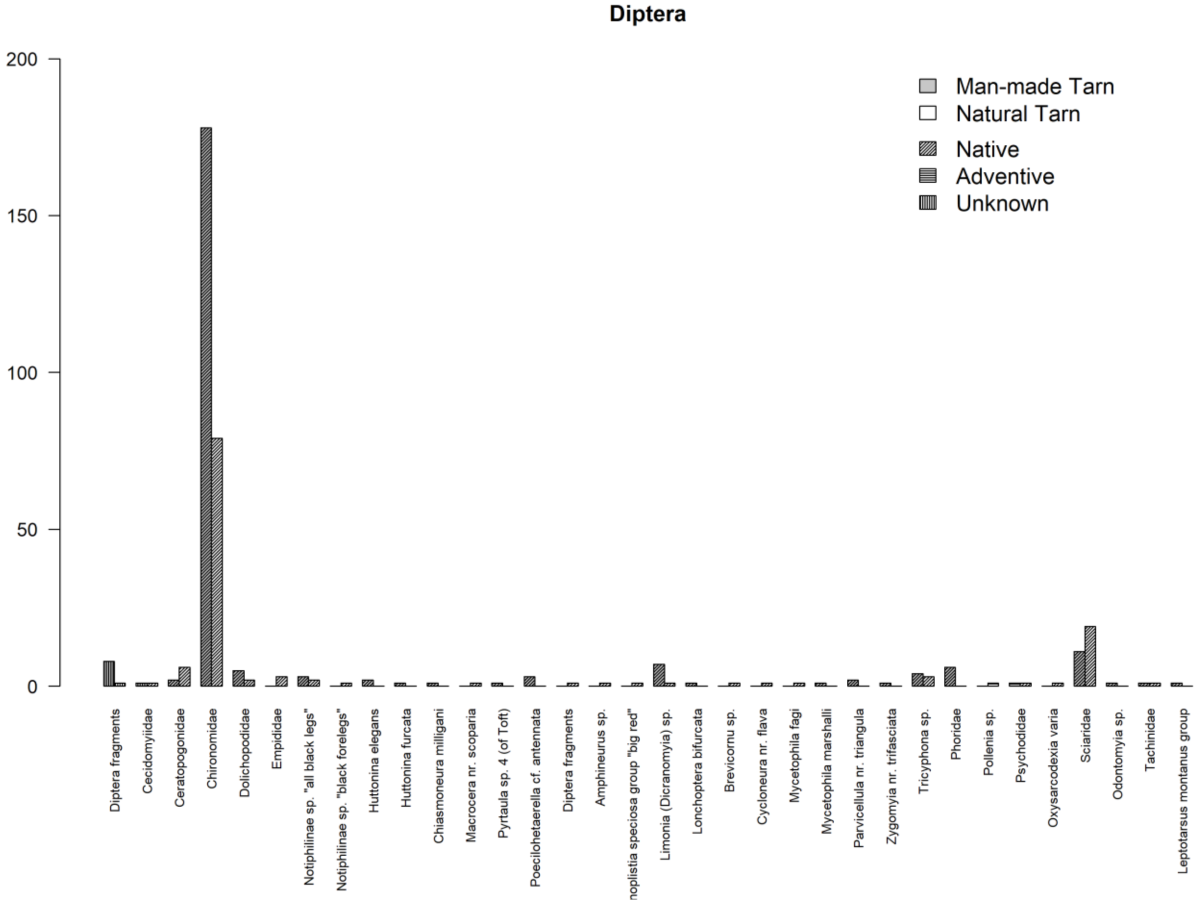
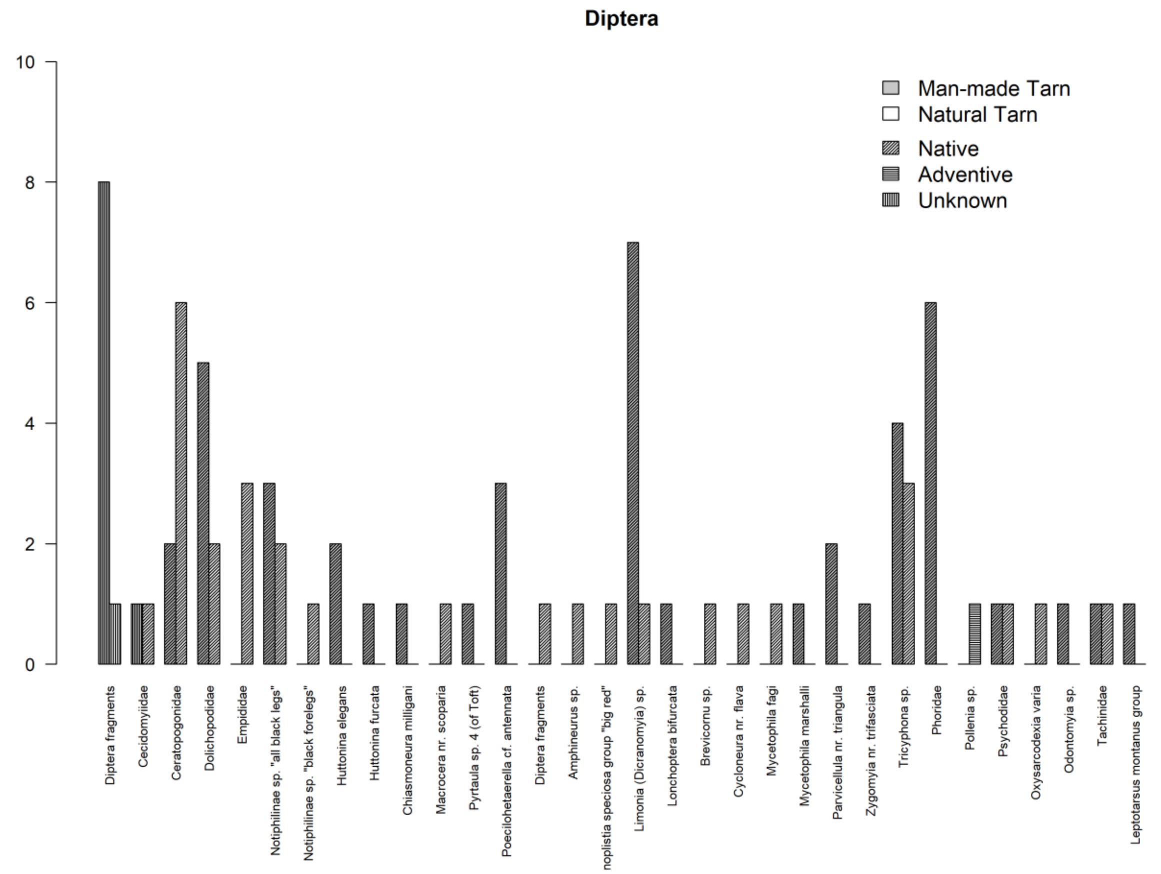
10
8
6
4
2
0
Geoplanidae
Disturbed
Planted
Direct Transfer
Native
Adventive
Unknown

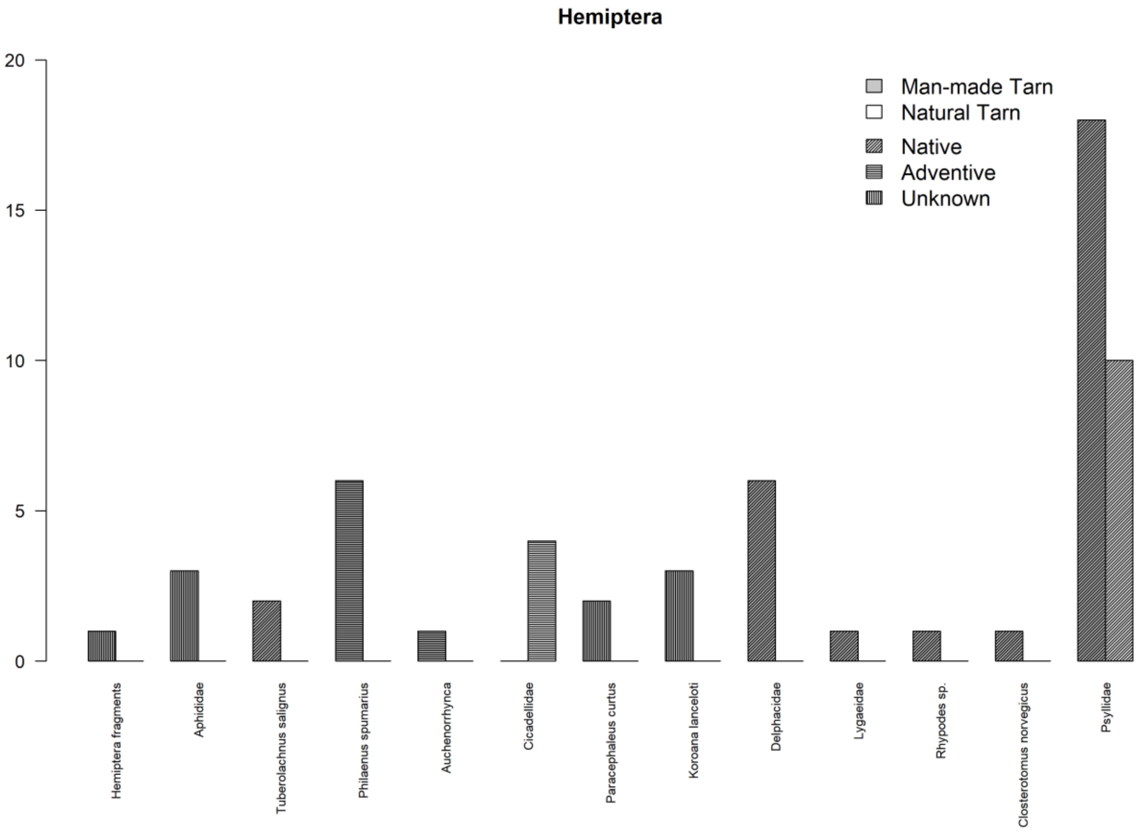

Araneae
Man-made Tarn
Natural Tarn
Native
Adventive
Unknown
30
25
20
15
10
5
0
Agelenidae
Anapidae
Micropholcommatinae
Araneidae
Clubionidae
Toxopinae
Dolomedidae
Linyphiidae
Haplinis sp.
Salticidae
Tetragnathidae
Theridiidae
Thomisidae

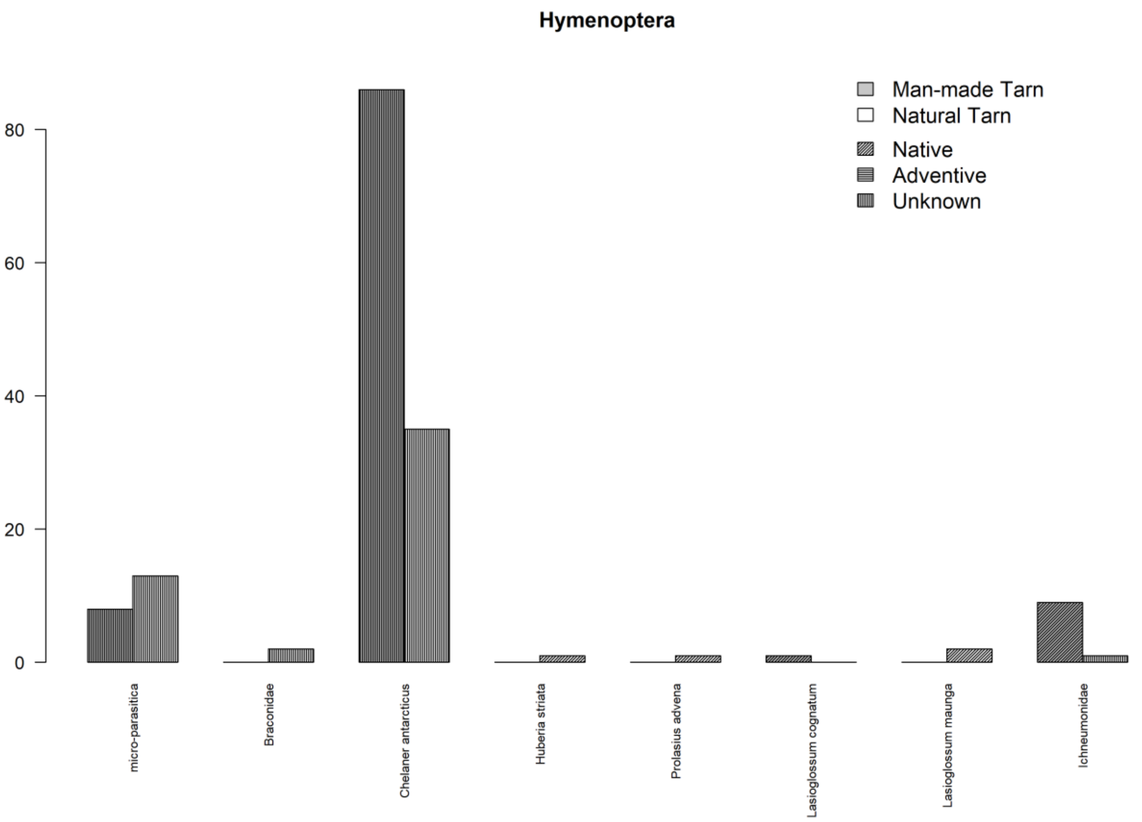

Coleoptera
Man-made Tarn
Natural Tarn
Native
Adventive
Unknown
40
30
20
10
0
Coleoptera fragments
Chrysomelidae
Curculionidae
Staphylinidae
Pselaphinae

Diptera


Diptera
200
150
100
50
0
Man-made Tarn
Natural Tarn
Native
Adventive
Unknown
Diptera fragments
Cecidomyiidae
Ceratopogonidae
Chironomidae
Dolichopodidae
Empididae
Notiphilinae sp. "all black legs"
Notiphilinae sp. "black forelegs"
Huttonina elegans
Huttonina furcata
Chiasmoneura milligani
Macrocera nr. scoparia
Pyrtaula sp. 4 (of Toft)
Poecilohetaerella cf. antennata
Diptera fragments
Amphineurus sp.
noplistia speciosa group "big red"
Limonia (Dicranomyia) sp.
Lonchoptera bifurcata
Brevicornu sp.
Cycloneura nr. flava
Mycetophila fagi
Mycetophila marshalli
Parvicellula nr. triangula
Zygomyia nr. trifasciata
Tricyphona sp.
Phoridae
Pollenia sp.
Psychodidae
Oxysarcodexia varia
Sciaridae
Odontomyia sp.
Tachinidae
Leptotarsus montanus group


Diptera
10
8
6
4
2
0
Man-made Tarn
Natural Tarn
Native
Adventive
Unknown
Diptera fragments
Cecidomyiidae
Ceratopogonidae
Dolichopodidae
Empididae
Notiphilinae sp. "all black legs"
Notiphilinae sp. "black forelegs"
Huttonina elegans
Huttonina furcata
Chiasmoneura milligani
Macrocera nr. scoparia
Pyrtaula sp. 4 (of Toft)
Poecilohetaerella cf. antennata
Diptera fragments
Amphineurus sp.
noplistia speciosa group "big red"
Limonia (Dicranomyia) sp.
Lonchoptera bifurcata
Brevicornu sp.
Cycloneura nr. flava
Mycetophila fagi
Mycetophila marshalli
Parvicellula nr. triangula
Zygomyia nr. trifasciata
Tricyphona sp.
Phoridae
Pollenia sp.
Psychodidae
Oxysarcodexia varia
Odontomyia sp.
Tachinidae
Leptotarsus montanus group


Hemiptera
20
15
10
5
0
Man-made Tarn
Natural Tarn
Native
Adventive
Unknown
Hemiptera fragments
Aphididae
Tuberolachnus salignus
Philaenus spumarius
Auchenorrhynca
Cicadellidae
Paracephaleus curtus
Koroana lanceloti
Delphacidae
Lygaeidae
Rhypodes sp.
Closterotomus norvegicus
Psyllidae


Hymenoptera
80
60
40
20
0
Man-made Tarn
Natural Tarn
Native
Adventive
Unknown
micro-parasitica
Braconidae
Chelaner antarcticus
Huberia striata
Prolasius advena
Lasioglossum cognatum
Lasioglossum maunga
Ichneumonidae

ecoLogical Solutions
Environmental Consultants





December 2025

Upper Waimangaroa Haul Road Wildlife Mitigation – Literature Review

Submitted to:

Bathurst Resources Limited

water fauna flora land

Quality Assurance

This report has been prepared and reviewed by the following:

Prepared by:	[redacted] Ecologist	[redacted]
Technical Review	[redacted] Senior Ecologist	[redacted]
Final Review and Signoff:	[redacted] Terrestrial Team Leader	[redacted]

Status: Finalv2 **Issued:** 17 December 2025

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1.0 Introduction

1.1 Background

Bathurst Resources Limited (including its subsidiary companies BT Mining Ltd, Bathurst Coal Ltd, and Buller Coal Ltd) (collectively referred to here as 'Bathurst') are seeking approvals through the Fast-track Approvals Act 2024 ('FTAA') for the Buller Plateaux Continuation Project ('BPCP', or the 'Project'). One component of the Project is the Upper Waimangaroa Haul Road ('UWHR'), which would be used to enable transportation of coal from the Extended Escarpment mining area ('ESE') on the Denniston Plateau to the Coal Handling and Processing Plant ('CHPP') at Stockton Mine as well as movement of plant and personnel between sites. During design of the UWHR, Bathurst commissioned this report to understand methods and measures which are most effective at reducing wildlife impacts from roads, based on existing research. This report also identifies potential impacts of the construction and operation of this road on wildlife, and recommends potential effects management actions that could be incorporated into the design in order to reduce effects.

The UWHR would be a gravel road used for mining activities only and would therefore carry a relatively low volume of vehicles at low speed when compared with public roads. The vehicles would be predominantly heavy, with long stopping distances. Post mine closure, parts of the road may be left in situ for recreational users. It is anticipated that post-mining traffic would be limited to low volumes of light vehicles similar to other areas on the Denniston Plateau.

1.2 Proposed Route

The UWHR road footprint would be 16.7m wide (including bunds on either side of the 8.6m wide road) and approximately 19km long. Construction would involve upgrading and extending existing low-use tracks in the Upper Waimangaroa Valley as well as approximately 7km of greenfield construction. The greenfield habitats include a mix of tall forest, shrubland, low pākihi, and bare rock. The majority of the UWHR footprint is crown owned land administered by Land Information New Zealand, with the remaining portion administered by the Department of Conservation.

The relative effects of two potential route options for the greenfield construction segment were considered in detail in Ecological Solutions Limited (2025a). The location of the proposed UWHR, including both options considered, in relation to the Waimangaroa River is shown in Figure 1.

1.3 Scope

Ecological Solutions Limited was engaged by Bathurst to review international and domestic literature about the effects of roads on wildlife and the effectiveness of mitigation measures designed to address these impacts. On the basis of that review, we were asked to recommend which, if any, methods might be appropriate to include in the design and construction of the UWHR and assess the expected effectiveness as management of potential effects on wildlife.

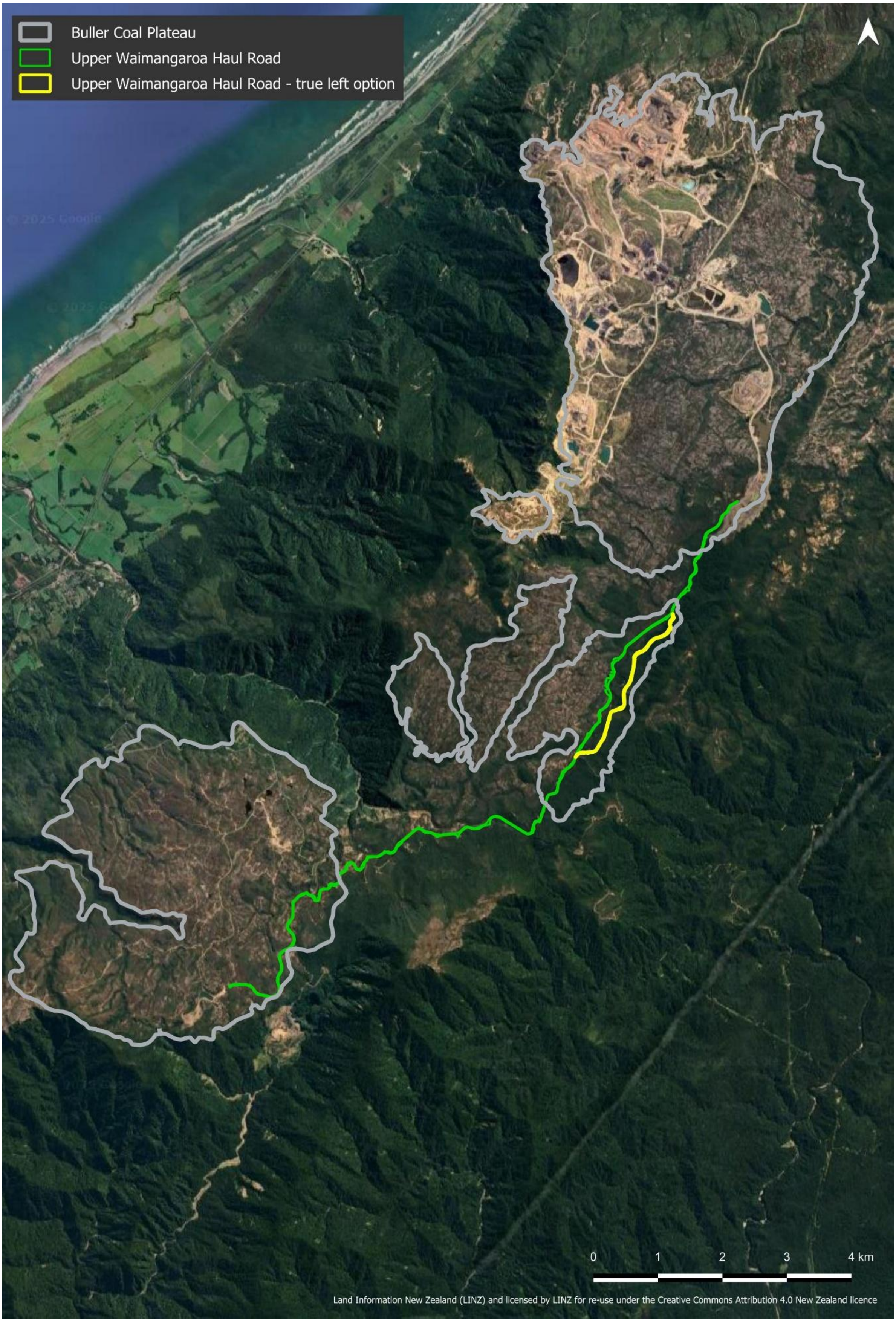

Figure 1: Proposed Upper Waimangaroa Haul Road including alternative route options.

1.4 Ecological Context

The Buller Plateaux comprises the Denniston and Stockton plateaux which are separated by the Waimangaroa Gorge. The Denniston Plateau, located south of the Waimangaroa River, covers approximately 1,700ha, forming a roughly circular area about 4.5km across. Most of the Denniston Plateau lies between 600–700m above sea level (‘asl’), but it includes c. 280ha which is up-warped to the south (near Mt Rochfort) and a down-warped part covering c. 200ha in the northwest (Mabin 2012). The Stockton Plateau covers approximately 3,120ha north of the Waimangaroa River, forming an oval shape between Mt Augustus, the Mt William Range and Mt Stockton and comprising five separate areas (Templeton & McMorran 2020). Stockton Plateau includes a large triangular shaped area of outcropping Brunner coal measures geology within which Stockton Coal Mine is located and smaller areas (sub-plateau) of outcropping Brunner coal measures further south, between the Waimangaroa River and the existing mine. The Stockton Plateau slopes towards the northeast at elevations mostly varying between 610m and 860m asl. One of the southern sub-plateaux rises to 1,105m asl at the peak of Mt Frederick. The division of the smaller sub-plateau is predominately due to faulting and incision of watercourses into the plateau forming valleys and gorges (Templeton & McMorran 2020).

More than 50 terrestrial and aquatic ecological surveys have been undertaken in various parts of the Ngakawau Ecological District (‘ED’) including the Upper Waimangaroa valley and the Buller Plateaux (Ecological Solutions 2025b). Altitudinal sequences of lowland to subalpine vegetation occur on steep coastal hillslopes such as Mt Frederick (1,105m asl), which overlays fertile gneiss and granite parent material, Mt Rochfort (1,040m asl), which overlies infertile Brunner Coal Measures and Mt William (1,062m asl), which includes both granite and coal measures geology (Rattenbury et al. 1998, Nathan et al. 2002). At these locations lowland mixed beech-kāmahi-podocarp (often rimu) forest grades into beech (including both mountain beech and silver beech and Southern rātā forest which becomes more stunted with increasing altitude (Overmars et al. 1998).

The Buller Plateaux has high conservation values in the form of ‘threatened’ and ‘at risk’ species, indigenous habitats, and naturally uncommon ecosystems (Ecological Solutions Limited 2025c). Ecological Solutions Limited (2025b) reported at least 542 species of terrestrial plant, 56 species of bird (including 28 native species), 458 species of bryophyte species (345 liverworts, 123 mosses, 5 hornworts), three species of lizards, more than 300 species of terrestrial invertebrates and 186 taxa of aquatic invertebrates from within the Ngakawau ED. There are also at least five naturally uncommon ecosystems present within the Ngakawau ED, all of which occur on the Buller Plateaux including boulderfields of acidic rock, sandstone erosion pavement, tarns, seepages and flushes and pākihi wetlands (Ecological Solutions Limited 2025b).

Vegetation on the Buller Plateaux includes stunted forest, shrubland with a high component of mānuka (*Leptospermum scoparium* agg.), pākihi, and various rushland and tussockland vegetation types (Ecological Solutions Limited 2025d). Mānuka, pink pine (*Halocarpus biformis*), yellow-silver pine *(Lepidothamnus intermedius*) and *Gahnia* spp. are a significant component of the dense shrubland and low stature forest on the high elevation slopes.

Vegetation on the gently sloping sandstone pavements is dominated by stunted tussock-shrublands (Ecological Solutions Limited 2025d). *Chionochloa* spp. (tussock), *Gleichenia dicarpa* (tangle fern), *Dracophyllym* spp., wire rush (*Empodisma minus*) and prostrate mānuka are common and widespread. Based on the vegetation alone, large parts of the Buller Plateaux meet the criteria for natural inland wetlands (Ministry for the Environment 2020, Ecological Solutions Limited 2025d).

Approximately 94% of the 5,272ha Buller Plateaux receives ecosystem management funded by Bathurst as part of the Denniston Permanent Protection Area (‘DPPA’, 718ha); Denniston Biodiversity Enhancement Area (‘DBEA’, 1,742 ha); Snail Enhancement Area

('SEA', 893ha) or Wider Habitat Enhancement Area ('WHEA', 1,588ha) which extend beyond the Plateaux to adjoining habitats (Ecological Solutions Limited 2025b). Together the DPPA and the WHEA comprise 12,700ha which covers c. 26% of the Ngakawau ED (Ecological Solutions Limited 2025b).

The types of wildlife known to occupy the UWHR Project sub-area and which could be expected to be affected by the UWHR include flightless birds such as rōroa (*Apteryx maxima*) and western weka (*Gallirallus australis australis*) and poorly mobile species such as lizards (West Coast green gecko (*Naultinus tuberculatus*), forest gecko (*Mokopirirakau granulatus*) speckled skinks (*Oligosoma infrapunctatum*)) and land snails (*Powelliphanta patrickensis*).

2.0 Effects of Roads on Wildlife

2.1 Overview

The effects of roads on wildlife include mortality of large and small animals and a range of indirect effects on ecosystems. Benítez-López et al. (2010) concluded that, globally, road networks contribute significantly to terrestrial biodiversity loss because they remove and fragment habitats, facilitate land use change and infrastructure development (leading to further habitat loss), increase pollution, increase access for weeds and pests and can reduce animal populations directly due to vehicle collision. The effects of roads on wildlife can be summarised as follows:

Direct effects:

- Construction effects (mortality and habitat loss during construction); and
- Collision mortality during operation.

Indirect effects:

- Fragmentation of habitats;
- Habitat loss; and
- Habitat degradation due to weeds, pests, edge effects and pollution (including noise, lighting and chemical pollution).

These effects are generally well documented, although there is a geographic bias in published studies to Western Europe and North America and an over-representation in published material of the direct effects on large mammals.

Evidence of effects or effective mitigations in the New Zealand context is scarce. The exception is a comprehensive literature review of the indirect effects of roads in New Zealand undertaken by Manaaki Whenua – Landcare Research for Waka Kotahi – New Zealand Transport Agency (Simcock et al. 2022). Indirect effects explicitly considered by Simcock et al. (2022) were fragmentation and edge effects.

Efforts to mitigate the impacts of roads on wildlife are now common internationally with a wide range of strategies employed, although evidence for their effectiveness is often lacking (Rytwinski et al. 2016). There is no 'catch-all' approach to mitigation of effects either, since effective management must be tailored to the particulars of the road, each potentially vulnerable species present and the relevant ecological context.

Mitigation measures vary in suitability depending on the animal groups affected and the relative importance of each roading effect. In addition, there is likely to be multiple simultaneous impacts, with mitigations that vary in suitability between the different impacts and between species and locations. Mitigations for one type of effect may exacerbate another, e.g., physical barriers may effectively reduce roadkill of some species, while increasing fragmentation effects for animals that were previously able to cross the road successfully (Olsson & Widen 2008).

The effects of roads on wildlife, as well as the range of mitigation measures aimed at reducing them, are summarised in Sections 2.2 and 2.3. These sections also identify and discuss the effects relevant to the UWHR. Species that could be expected to be affected by the UWHR are identified and discussed in Section 3. Mitigation measures specific to the UWHR are discussed in Section 4 and the findings of this literature review in relation to the UWHR are summarised in Section 5.

Where residual effects of the BPCP and UWHR cannot be avoided, minimised or remedied, offsetting and/or compensation will be applied. The extent and nature of the proposed offset and compensation activities is set out in Alliance Ecology Limited (2025a in prep).

2.2 Direct Effects

2.2.1 Construction Effects

Mortality during construction poses a risk to a range of fauna present within the footprint of a new road. Other disturbance effects, such as heavy machinery noise or lighting, can extend some distance beyond the physical works (Weller 2015). The construction effects of roads are generally similar to mining and urban development and involve vegetation clearance, heavy machinery and earth moving. These activities can cause mortality and/or disturbance of native fauna and temporarily increase background noise, dust, lighting and mobilisation of sediment if not properly managed.

These effects are generally managed to acceptable levels via a suite of site environmental management plans ('SEMPs') which may place limits on hours of operation, noise and/or lighting and also include measures to reduce dust (e.g., use of water trucks) and mobilisation of sediment into watercourses (e.g., decanting bunds, filter cloth, sediment ponds).

Poorly mobile species such as lizards, snails, and nesting birds within the road footprint itself would be at highest risk of mortality during construction. Individuals which move too slowly, or too short a distance, to avoid effects can be killed when vegetation and earthworks commence.

The primary means of reducing mortality of poorly mobile species during construction is pre-surveys combined with salvage, trapping and relocation of fauna from the construction footprint as set out in a species management plan. Exclusion fencing during construction has also been used to reduce risk to fauna, once pre-survey, salvage and relocation have occurred. Specific fauna management plans for lizards, snails, kiwi and the like are developed according to best practice (e.g., Department of Conservation Lizard Technical Advisory Group 2019). Although widely implemented, and expected to reduce mortality, the relative effectiveness of this approach remains unknown.

2.2.2 Collision Mortality

Summary of relevant Literature

Wildlife vehicle collision ('WVC') usually results in mortality and is the most commonly reported direct effect on wildlife due to roads, although it often goes undetected (Taylor & Goldingay 2010). WVC can affect large proportions of animal populations and has been implicated in declines in populations of a wide range of taxa (Rytwinski & Fahrig 2015).

WVC is often noticeable since animals, large mammals in particular, are highly visible when killed near roads. Total mortality is higher, possibly much higher, than reported, since a large proportion of animals hit by vehicles die out of sight and small animal carcasses are quickly scavenged (Romin 1994).

WVC can be the biggest cause of mortality for some animals where dense, high speed and high traffic road networks are present. In the United Kingdom approximately one million wild animals each year are thought to be killed in traffic collisions (Underhill & Angold 2000), including as much as 50% of the total red fox population (White & Harris 1994) and 49% of the badger population (Clarke et al. 1998).

Collision mortality has been implicated in the decline in a range of animals, including in amphibians (Fahrig et al. 1995), marsupials (Jones 2000), reptiles (Gibbs & Shriver 2002) birds (Summers et al. 2011) and carnivorous mammals (Rytwinski & Fahrig 2015). In some cases, collision mortality has been found to be high enough to reduce genetic diversity and subsequent reproductive fitness and resilience of the population through depletion of the gene pool (Jackson & Fahrig 2011).

Effects of WVC are not always negative – a review found that effects at the population level varied, being typically negative for most carnivores and amphibians, neutral or negative for snakes and lizards, often neutral for perching birds and often positive for rodents and hoofed mammals (Rytwinski & Fahrig 2015). The positive effects may represent predation release from carnivores, which are more strongly affected by road mortality than some other groups.

In New Zealand, Beauchamp (2009) considered that the birds he found dead along an arterial road near Whangārei were a subset of those that used the road margins and neighbouring habitats. He recorded 116 bird deaths of 17 species over three years, with increasing mortality associated with increasing vehicle speed limits and the presence of important habitats (a bridge which connected estuarine and riparian habitats). No dead birds were collected from the stretch of road with a 50km/h speed limit, 8 deaths per km per year in the 70km/h zone and 15.6 deaths per kilometer per year in the 80km/h zone (Beauchamp 2009).

Brockie et al. (2009) compared the number of medium-sized animals (between rat- and dog-size) killed on roads using repeated counts along the same 1,660km of North Island highways in 1984, 1994 and 2005 with other counts going back to 1949. They recorded 11 mammal and 14 bird species with possums (*Trichosurus vulpecula*), hedgehogs (*Erinaceus europaeus*) and rabbits (*Oryctolagus cuniculus*) predominating. For birds, pūkeko (*Porphyrio porphyrio*), mynas (*Acridotheres tristis*), and Australian magpies (*Gymnorhina tibicen*) were most common. The relationship between road-kill and traffic volume indicated that roads carrying more than 3,000 vehicles per day act as barriers to larger mammals, while vehicles on less busy roads were most dangerous for crossing animals.

Not all roads, or stretches of roads, affect animals equally. Some stretches of road cause unusually high mortality and are considered 'blackspots' while others have minimal effects (Brockie 2007). Road attributes which contribute to the risk of WVC include:

- Vehicle speed and driver behaviour;
- Traffic volume;
- Road width;
- Habitats present on the road margin and species using them;
- Disconnection of habitat/populations;
- The presence of bridges.

Evidence from a wide range of sources, including in New Zealand, indicates that mortality is strongly influenced by both traffic intensity and speed (Seiler & Helldin 2006, Beauchamp 2009). This risk increases sharply above speeds at which detection and avoidance are possible for either the animal or the driver. Detection is particularly influenced by the visibility of the animal to the driver (e.g. size) and the animal's mobility/speed (Hobday 2010).

Mortality increases with traffic volume (Sadleir & Linklater 2016), although total mortality may level off at very high traffic volumes (Taylor & Goldingay 2010) which can become a barrier and reduce mortality as animals avoid crossing at higher traffic densities (Denneboom at al. 2024). Seiler and Heldin (2006) proposed a conceptual model in which moderate traffic roads presented the greatest risk to wildlife, as traffic intensity lowers the chance of animals successfully crossing and decreases crossing attempts. Blackspots occur where animal densities or crossings are concentrated or where animals are locally more vulnerable (Rea et al. 2014). Bridges were found to be blackspots for pest mammals, but also for shags and gulls in New Zealand (Brockie 2007, Beauchamp 2009).

Research by Rytwinski & Fahrig (2015), Andrews et al. (2015) and others summarised by Simcock et al. (2022), identified wildlife attributes associated with greater road mortality as:

- Speed of animal movement (i.e., time spent crossing the road);
- Size and location of home range relative to the road (for example: a kiwi occupying several hectares would likely need to cross roads, but a lizard occupying several square metres would be less likely to need to cross a road);
- Types and frequency of movements (for example, breeding, migration or foraging movements);
- Attraction to road or road edge (e.g. by lighting, habitat type or food abundance);
- Lack of road avoidance behaviour.

Species with naturally low population densities and low reproductive rates are particularly vulnerable to decline as a result of this type of mortality which is usually additional to background levels (Rytwinski & Fahrig 2015).

Wildlife Vehicle Collision in New Zealand

New Zealand lacks the large mammalian ground fauna which are both vulnerable and conspicuous when killed near roads. Research into collision mortality for native fauna has been limited in New Zealand, though there have been a small number of studies (see Beauchamp (2009), Brockie et al. (2009) and Sadleir and Linklater (2016) for New Zealand case studies). Sadleir & Linklater (2016) considered that in New Zealand, exotic pest mammals are most frequently killed by WVC, although Beauchamp (2009) recorded nine exotic and eight indigenous species collected dead near Whangārei, suggesting indigenous animals are also susceptible to WVC. Indications are that a number of native species are vulnerable to WVC, particularly nocturnal, flightless or walking birds or those which are attracted to roadside habitats, live in proximity to roads or use features that cross them (such as rivers or estuaries) as habitat (Beauchamp 2009, Simcock et al. 2022).

Previous research has highlighted WVC associated mortality for weka (*Gallirallus australis*) and kororā/little blue penguins (*Eudyptula minor*), whilst general collection of animal carcasses has indicated a range of species are affected. Road kill was responsible for 43% of deaths of radio-tracked adult North Island weka at Rakauroa, inland from Gisborne, where stoat predation also accounted for 43% of deaths (Bramley & Veltman 2000). Both weka and stoats were likely to be preferentially using habitats adjoining the road, although no dead stoats were ever collected (G. Bramley, unpublished data). Road kill of western weka was found to be approximately 6 birds per kilometre per year around Cape Foulwind (near Westport), which was considered to be 2–4% of the local population (Freeman 2010).

Hocken (2000) examined carcasses of kororā in North Otago and determined road collision was responsible for 10.4% of deaths. Sadleir & Linklater (2016) found the most commonly killed animals on a stretch of lower North Island highway were pest mammals and common native birds such as such as swamp harrier (*Circus approximans*) and pūkeko.

Simcock et al. (2022) summarised the available literature, and concluded that roadkill may affect populations of threatened native birds including kiwi, pāteke (*Anas chlorotis*), kererū (*Hemiphaga novaeseelandiae*), and kea (*Nestor notabilis*), noting that mortality estimates vary substantially. For example, a management plan for North Island brown kiwi on Kerikeri Peninsula estimated 0.3 road kill deaths per month, while local newspapers estimated roadkill deaths at a rate of 0.75-0.8 per month (Simcock et al. 2022).

Five kea were killed on SH 24 (Te Anau - Milford) in only a few months in 2024 (Department of Conservation 2024). The West Coast Penguin Trust recorded over 100 fatalities of kororā at a roadkill blackspot on State Highway 6 (West Coast Penguin Trust 2023). Between 17% (in Auckland) and 27% (in the lower North Island) of dead and injured kererū delivered to Auckland Museum and the Department of Conservation were affected by WVC (Gill 2006; Cousins 2010).

A citizen science project recording roadkill of native and introduced animals in New Zealand on iNaturalist began in 2020 (iNaturalist 2020) and currently contains 1,805 observations from 123 species, 66 of which are native. This is a valuable dataset due to its breadth, though its lack of consistent survey methodology means that biases are highly likely. The direction of those biases is hard to predict, for example there may be an overrepresentation of uncommon or threatened species, because of a greater interest in those species, or a bias towards larger, more common species which are more noticeable. Similarly, there may be more reports from highly used roads, because there are more potential observers, or from less busy roads, where observations may be safer to collect. Currently, the most frequently recorded species are pūkeko with 289 observations (16%), followed by six introduced species and the swamp harrier with 44 observations (2.5%), silver eye (*Zosterops lateralis*) (35, 1.9%), weka with 30 observations (1.7%) three of which were North Island weka (*Galliralus australis greyi*) and one buff weka (*Galliralus australis hectori*), fantail/pīwaiwaka (*Rhipidura fuliginosa*), ruru (*Ninox novaeseelandiae*) and kererū. These findings are consistent with the observation that species which use roadside habitats, are attracted to roads, or cross them frequently when travelling between habitats, are most at risk. A high proportion (28 of 66, 42%) of species of conservation concern have been recorded in this dataset to date as set out in Table 1. Seabirds (10 species), lizards (eight species), lake or wetland birds (four species) and snails (one species) are all represented. Whilst the most frequently recorded species are common and/or known to associate with roads, the diversity of rare species recorded to date demonstrates the broad impacts roads can have.

Table 1: Species of conservation concern recorded in iNaturalist Roadkill Project (accessed 11 November 2024).

Species	Threat status	Number of records (percentage)
Little blue penguin (*Eudyptula minor*)	At Risk – Declining	9 (0.5)
Australasian bittern (*Botaurus poiciloptilus*)	Threatened – Nationally Critical	6 (0.3)
Brown teal *(Anas chlorotis*)	Threatened – Nationally Increasing	4 (0.2)
North Island weka (*Gallirallus australis greyi*)	At Risk – Relict	3 (0.17)
Spotted shag (*Stictocarbo punctatus*)	Threatened – Nationally Vulnerable	3 (0.17)
Forest gecko (*Mokopirirakau granulatus*)	At Risk - Declining	3 (0.17)
North Island brown kiwi (*Apteryx mantelli*)	Not Threatened	2 (0.1)
Black shag (*Phalacrocorax carbo novaehollandiae)*	At Risk – Relict	2 (0.1)
Bush falcon (*Falco novaeseelandiae ferox*)	Threatened – Nationally Increasing	2 (0.1)
Fairy prion (*Pachyptila turtur*)	At Risk – Relict	2 (0.1)
Little shag (*Phalacrocorax melanoleucos brevirostris*)	At Risk – Relict	2 (0.1)
Banded rail (*Gallirallus philippensis assimilis)*	At Risk - Declining	1 (0.06)
Barking gecko (*Naultinus punctatus*)	At Risk – Declining	1 (0.06)
Black-billed gull (*Chroicocephalus bulleri*)	At Risk – Declining	1 (0.06)
Buff weka (*Galliralus australis hectori*)	Ati Risk - Relict	1 (0.06)
Elegant gecko (*Naultinus elegans*)	At Risk - Declining	1 (0.06)
Fernbird (*Poodytes punctatus*)	At Risk - Declining	1 (0.06)
Fluttering shearwater (*Puffinus gavia*)	At Risk – Relict	1 (0.06)
Hutton's shearwater (*Puffinus huttoni*)	Threatened – Nationally Vulnerable	1 (0.06)
Kauri snail (*Paryphanta busbyi*)	At Risk – Declining	1 (0.06)
Marlborough green gecko (*Naultinus manukanus*)	At Risk - Declining	1 (0.06)
Mottled petrel (*Pterodroma inexpectata*)	At risk – Relict	1 (0.06)
Northland green gecko (*Naultinus grayii*)	At Risk - Declining	1 (0.06)
North Island rifleman (*Acanthisitta chloris granti*)	At Risk - Declining	1 (0.06)
Northern striped gecko (*Toropuku inexpectatus*)	Threatened – Nationally Vulnerable	1 (0.06)
Ornate skink (*Oligosoma ornatum*)	At Risk - Declining	1 (0.06)
Southern Alps gecko (*Woodworthia "Southern Alps"*)	At Risk - Declining	1 (0.06)
South Island pied oystercatcher (*Haematopus finschi*)	At Risk - Declining	1 (0.06)
White-fronted tern (*Sterna striata*)	At risk – Declining	1 (0.06)

Native Species Vulnerability

Impacts of WVC and factors which increase the risk of roads for birds were summarised by Simcock et al. (2022). Traits which increase vulnerability of native species were:

- Nocturnality;
- Fright freeze response;
- Flightlessness;
- Fly along rivers;
- Roost over water;
- Attracted to roads for food;
- Attracted to roads by lighting and;
- Roost at high tide.

Some of these traits are exhibited by species present in the Upper Waimangaroa Valley, specifically great spotted kiwi/ rōroa, ruru, weka and shag species. Risk factors associated with WVC and indirect effects for species present in The Upper Waimangaroa valley are discussed in Section 3.2.

Reducing Wildlife Vehicle Collision

Measures to reduce the direct effects of roads on wildlife range from wildlife crossing signs to alert drivers, which have low cost, but also little evidence of effectiveness, to infrastructure such as fences and crossings, which can be expensive to install, maintain and monitor, but provide the best evidence of reducing effects (Bramley & Veltman 2000, Glista et al. 2008). Other potential mitigations include planning of road placement to avoid important locations or habitats, reduction in speed limits, education to increase driver awareness, and monitoring and management of vulnerable species.

Driver Behaviour and Speed

Driver behaviour is one of the primary factors influencing collision mortality, particularly vehicle speed and awareness since both fauna and driver are afforded longer to avoid collisions at lower speeds, particularly if the driver understands that wildlife are present (Seiler & Helldin 2006). Speeds that would allow safe stopping distances ranged from 38km/h to 83km/h and was highest for brightly coloured animals and when drivers used high beams at night (Hobday 2010).

Modifying driver behaviour can be achieved by lowering maximum speed limits, constructing speed bumps or placing signage (Rytwinski et al. 2016). These mitigations have often proved ineffective however (Glista et al. 2008) likely due to poor compliance. Bramley & Veltman (2000) considered signage warning of weka crossing would be highly unlikely to be effective on State Highway 2 since drivers would become habituated to the signs and not alter their behaviour.

The existing speed limit within Stockton Mine is 60km/h and this is strictly enforced. As such, this limit is expected to significantly reduce the risk to rōroa and weka compared with typical open road speeds of 80 - 100km/h, despite the larger vehicles requiring longer stopping distances than smaller vehicles at equivalent speeds. A speed limit of 80km/h is proposed for the UWHR, with the average speed expected to be 40km/hr.

Ecopassages

Ecopassages such land bridges, pole or rope bridges, dry bridges or empty pipes/culverts and extended stream crossings can provide safe passage for animals and thereby reduce mortality and fragmentation effects for some species (Taylor & Goldingay 2010, Lesbarreres & Fahrig 2012). The effectiveness of ecopassages relies on the affected animals first detecting and then using the passages provided. This requires an intermediate level of road avoidance behaviour as very high or low road avoidance can both prevent detection of the ecopassages. Animals with low road avoidance may use the road at any point without searching for a safe crossing, while strong road avoidance can mean animals will avoid the area surrounding the road and have a low probability of detecting the ecopassage (Underhill & Angold 2000).

Ecopassages would be most effective with species which occupy large home ranges or travel large distances and can be directed towards the artificial crossings (e.g. via fencing or road avoidance behaviours). For species with small home ranges, or which make small daily or seasonal movements, locating and then using a passage across a c. 17m wide road would be unlikely.

Ecopassages have generally low effectiveness except when used in conjunction with fences to direct wildlife towards them (Rytwinski 2016) or when bridges are extended to allow passage alongside waterways beneath roads (Lesbarreres & Fahrig 2012). This ‘extended stream crossing’ method has been found to be the most effective type of ecopassage. Using this approach, road bridges must allow room for animal passage either side of the stream bank, leaving at least 5 m of clear bank above the waterline (Lesbarreres & Fahrig 2012). The likely reason why extended stream crossings are more successful than dry bridges is that streams themselves are natural crossing points for wildlife i.e., a linear feature in the landscape which animals use for navigation or as a range boundary (Brockie 2007). The addition of extended stream crossings may therefore, under the right conditions, convert what could be a WVC blackspot into a highly used ecopassage (Niemi et al. 2014).

Use of crossings by road avoidant species can be increased by incorporating cover near, at, and within the crossing, while non-avoidant species can be funnelled to the crossing with fencing (Taylor & Goldingay 2010). Use of crossings varies between species or animal groups according to their requirements or preferences for passage types or features. Crossings could act as prey traps for some species by creating bottlenecks of prey that could be exploited by predators, though there is scant evidence for this occurring (Little et al. 2002).

Barriers

Barriers such as fences have been found to be the most effective way of reducing WVC (Rytwinski et al. 2016). However, fences are not completely effective for all species, are generally expensive, and can exacerbate fragmentation effects. A meta-analysis found that barriers reduced roadkill by 40%, and that effectiveness increased to 83% for large mammals when crossings and barriers were combined (Rytwinski et al. 2016).

The selection of fence design and materials would depend on the target species. A 2.4m high wire mesh fence reduced WVC by 80% on a four lane, high traffic volume highway in Alberta, Canada, although the data collection relied on incidents reported to park wardens and would therefore be biased towards large mammals (Clevenger et al. 2001). Fences aimed at preventing small vertebrates such as lizards accessing roads are usually low height (15-120cm) and made from a variety of materials such including metal, soft plastics and tarpaper (Dodd 1991). Retrofit silt fences using wire and soft plastic have often been used to prevent lizard movement, including locally at the Westland Mineral Sands site at Nine Mile near Westport, although these have low durability, which compromises effectiveness and can have negative impacts such as entanglement (Kapfer & Paloski 2011). Recent developments of dedicated fence materials and designs for mitigation of effects on small to medium sized fauna have resulted in best practice guidelines and methods to reduce attempted crossings overseas (Aburrow et al. 2023).

The construction of an exclusion fence to reduce mortality of kororā/little blue penguin crossing roads at Punakaiki, is a rare national example of this approach and appears to have significantly reduced penguin mortality associated with State Highway 6 (West Coast Penguin Trust 2023). Fencing is likely to be effective in this instance because the risk is highly concentrated at a single crossing point between nesting and feeding habitat and the birds all make that journey twice a day (going to feed and returning to roost/nest). This contrasts with roads which bisect the normal home range of birds such as a kiwi where the risk is diffuse and crossing points are much less predictable.

2.3 Indirect Effects of Roads on Wildlife

2.3.1 Habitat loss

Construction of new roads results in habitat loss which is both cumulative and permanent and can account for a large area in intensively modified landscapes (Underhill & Angold 2000). New Zealand has an overall moderate density of roads by international standards, similar to much of Europe and North America (Simcock et al. 2022). Construction of the UWHR would result in the loss of approximately 37.6ha of habitat and edge effects in a further 51.6ha. The specific type of habitat would vary depending on the route selected and amount of cut and fill required.

Habitat loss is an unavoidable consequence of road construction, however, consideration of road placement to avoid high value habitats can mitigate this effect, as can appropriate treatment of road edges and disturbed areas which are no longer required for road maintenance (Forman 2005). In addition, restoration and enhancement of habitats in the surrounding landscape can offset a reduction in habitat for some species (Cuperus et al. 1999).

2.3.2 Fragmentation

Roads can form partial or complete barriers to animal movement, particularly for poorly mobile species or those susceptible to WVC. If not managed, this can result in disconnection from previously available habitats and the separation of populations into smaller units. Fragmentation effects can be divided into;

- Habitat fragmentation,
- Population fragmentation.

Fragmentation is most severe when roads become impassable, either due to strong avoidance behaviour (Seigle-Ferrand et al. 2022), high collision mortality preventing successful crossing (Underhill & Angold 2000) or due to the road surface and associated infrastructure, including fences, preventing animals reaching the other side (Eftestøl et al. 2014). A habitat broken into smaller patches by roading could result in a reduction in accessible habitat, with particularly strong effects when the road constrains home ranges and reduces connectivity between habitats or resources e.g. food sources and nesting habitat (Eigenbrod et al. 2008). Species with large home ranges and multiple resource requirements are particularly vulnerable to this type of effect.

Fragmenting populations would reduce the size of each isolated sub-population, which can have reproductive (fitness) and genetic effects if prolonged. Multiple disconnected sub-populations are much more vulnerable to local extinction than a single connected large population. Genetic effects resulting from population fragmentation can include reduced genetic diversity and inbreeding depression and if prolonged, this separation can result in reduced productivity and local population extinction (Jackson & Fahrig 2011).

Ecopassages, as described in Section 2.2.2, are an attempt to address habitat and population fragmentation effects, however in order to be effective, animals would have to use them in sufficient numbers to overcome the fragmentation and maintain natural (or similar) levels of gene flow. Evidence for the effectiveness of ecopassages is limited to confirmation of use by animals. We could find no evidence of ecopassages confirming the maintenance of genetic diversity or population viability. There is a general lack of connectivity measures pre- and post-construction, or in the absence of any road, upon which to base any definitive conclusions with respect to fragmentation (Lesbarreres & Fahrig 2012).

Population fragmentation or disconnection could be an issue for snails and lizards at the UWHR because the known distribution of *Powelliphanta patrickensis* generally includes some areas to the east of both proposed routes, although we note that the Waimangaroa River itself would provide a significant barrier throughout parts of its length (particularly further downstream) and the true left route is outside the best snail habitats and the majority of snail and shell records as shown in Figure 2. Both of these features would tend to mitigate fragmentation effects for snails, but could lead to an overall reduction in the known range. Note that snails do occur on both sides of the Waimangaroa River, with records from near Burnett's Face in the south and at Cypress Mine in the north.

If habitat disconnection was identified as a significant effect, it could be addressed, at least in theory, via assisted dispersal (i.e., relocation). There are few examples of the success of this approach. The popular novel Braiding Sweetgrass by Kimmerer (2013) described informal work where the author assisted a nocturnal migration of salamanders across a rural road, though whether this was successful remains unknown. While carrying out this self-directed assistance of salamanders, Kimmerer unintentionally interrupted a study of population effects of the road mortality (Gibbs & Shriver 2005) which concluded that annual mortality exceeding 10% could lead to extirpation of the salamander population.

[redacted]

Figure 2: Records of live snails and snail shells in relation to the UWHR route.

2.4 Habitat Degradation

2.4.1 Overview

Roads remove habitat from within the footprint of the road itself and its immediate margin and can also degrade surrounding habitats to varying degrees via edge effects which can extend up to 1000m depending on the vegetation type (Forman & Deblinger 2000). These effects include alterations to microclimate and vegetation and road specific effects such as sediment runoff, pollution, noise and artificial light (Simcock et al. 2022).

Effects which extend beyond the footprint of the road itself include:

- Noise and vibration;
- Pollution from vehicle exhausts, brakes and tyres;
- Artificial light at night;
- Invasion by exotic plants and predators;
- Edge effects on vegetation, animals and microclimate;
- Erosion, sediment mobilisation and altered hydrology.

Each of these is considered in more detail below.

2.4.2 Noise and Vibration

The UWHR will be a low-speed gravel road, used predominantly by large vehicles (trucks), at least during mine life. Gravel roads can be subject to wash boarding (corrugation), which can create additional noise/vibration beyond 'normal' roads if not constructed/maintained appropriately.

Road noise is identified internationally as a major cause of far-reaching effects of roads (Forman et al. 2003) although there has been little research with respect to effects of noise on wildlife generally in New Zealand. Road noise can degrade habitats by triggering stress response and avoidance behaviours, reducing foraging effectiveness or masking vocalizations (Bennett 2017). There has been no New Zealand research identifying thresholds or distances at which road noise adversely affects native bird, lizard or invertebrate species, however the 55–59 decibels (dB) contour (designed for humans) is commonly used as an upper limit above which noise effects are considered likely to be negative (Simcock et al. 2022).

In New Zealand, the general approach to managing noise and vibrational disturbance for avifauna has been for consenting authorities to specify a setback distance from works, most often 50m. Such an approach is not site or species specific, nor is there a scientific rationale for that particular setback distance.

Species vary in their response to noise. A review of overseas literature from 1999 to 2013 found that animals respond to road noise at levels lower than 50dB (Shannon et al. 2016). With respect to birds, noise levels as low as 45db affected song frequency, abundance, stress levels and reproductive metrics (Shannon et al. 2016). Little blue penguins/kororā at Waiheke Island were found to be tolerant of construction noise up to 80dB close to their burrows (Lawrence et al 2023), whilst at an Australian site average noise levels of 67dB resulted in no grey shrikethrush (*Colluricincla harmonica*) being detected and at 72.3dB no grey fantails (*Rhipidura albiscapa*) were detected (Ortega 2012). This lack of detection could have been due to the difficulty of detecting birds in the presence of loud noise, rather than an absence of birds per se (Ortega 2012). The frequency of grey shrikethrush calls also increased with increasing traffic noise, with the trend beginning at 30dB, possibly to overcome the masking effect of traffic noise. The birds were unable to fully compensate for the masking effect, and the alteration to their song may have made them less desirable as mates (Parris & Schneider 2009). Internationally, some bird species, such as black-chinned hummingbirds (*Archilochus alexandri*) and house finches (*Haemorhous mexicanus*) appear to prefer noisier nesting sites (up to 85dB), perhaps because their predators avoid noisier sites (Ortega 2012).

Traffic also causes localised ground vibrations and the nature and magnitude of the effects of these vibrations on wildlife are not well understood. Effects could be similar to noise, i.e., including inducing stress, masking calls, disrupting prey detection, or mimicking environmental signals such as initiating reproductive activity in giant wētā (Wu & Elias 2014, Simcock 2022). Vibration effects are likely to operate over shorter distances than noise effects.

Noise and vibration can be reduced by adopting lower speed limits, deploying low noise road surfaces, planning of road placement, and incision of roads to avoid steep gradients. Reduction in speed corresponds with a reduction of noise, especially from 80-50 km/hr. Road noise is 75% lower at 40km/hr compared with 110 km/hr (Den Boer & Schroten 2007). Use of low road noise surfaces can be effective although these are generally types of porous asphalt (Wareing et al. 2022). Reduction in slope through planning and hillslope incision can also significantly reduce noise (Hosseini et al. 2016).

2.4.3 Discharges

Discharges from roads includes hydrocarbons, particulates and gasses from exhausts, and through wear from tyres and brake pads. These can accumulate in soils and have been found internationally to cause plant stress for road edge vegetation, invertebrates and aquatic biota (Bignal et al. 2007, Reck & van der Ree 2015, Sager 2020). These pollutants can degrade local receiving environments, including waterbodies such as streams and wetlands and reduce the health of aquatic organisms (Hwang et al. 2016). Spills can also be an acute source of pollution for roadside soils or waterbodies (Siqueira et al. 2017). Apart from accidental spills and the like, the effects of discharges would increase with increasing traffic density.

Reduction of discharges from engine exhausts and wear on brakes and tyres is difficult, although containment of these pollutants may reduce their overall impact and low traffic volumes reduce the risk. Treatment of roadside run off at retention ponds can reduce the acute loads of these pollutants entering nearby waterways and maintaining or planting roadside vegetation can help to settle suspended particles (Mrowiec 2016, Baldauf 2017).

Dust nuisance is a common effect of unmanaged gravel roads and this can also affect roadside vegetation. Dust control sprays, which keep unsealed roadside surfaces from becoming suspended as dust are effective in reducing dust, but some additives can themselves become pollutants and should be avoided (Kunz et al. 2021). Dust suppression using water carts occurs on existing roads at Stockton Mine and is generally effective at suppressing dust.

2.4.4 Artificial Lighting

The UWHR will not have any fixed street lighting, however, there would be vehicle movements along the UWHR at night.

Artificial lighting can disorient night-active birds, particularly seabirds and migratory birds, and kiwi and other animals crossing roads, causing them to collide with infrastructure or vehicles, which can cause mortality (Longcore et al. 2018). Lights from towns, vehicles, boats at sea and the like all have similar disorienting effects on wildlife. The brightness of light is also known to affect species' vision and behaviour (e.g., 'possum in the headlights'). Lighting also affects other nocturnal species and can disrupt food webs by, for example, concentrating insects such as moths around lights, which in turn attracts their predators.

Unmanaged artificial lighting produced by streetlights or vehicle headlights, can influence animal behaviour by, for example, disrupting bird migration and feeding patterns, and attracting flying invertebrates and their predators (Simcock et al. 2022). Artificial lighting can have particularly severe effects on seabirds which can be attracted to lights, resulting in groundings (Rodríguez et al. 2017) and bird strike with vessels (Goad et al. 2023). The effects of artificial light at night have not been well studied on New Zealand land birds, reptiles or insects (Simcock et al. 2022), although grounding of Westland petrels (tāiko, *Procellaria westlandica*) between Westport and south of Hokitika and grounding of Hutton's shearwater (*Puffinus huttoni*) near Kaikoura are both thought to be a result of artificial lighting and to contribute significantly to population mortality for those species (Wilson 2016).

Management of artificial light to reduce effects from roading can be achieved by avoiding or limiting stationary lighting in high value areas, restricting lighting duration, shielding to direct light more precisely, lowering intensity of lights, and changing the spectral composition (Gaston et al. 2012). Specific lighting guidelines have been developed to reduce effects on wildlife (Department of Climate Change, Energy, the Environment and Water 2023) and where lighting effects are considered important, lighting can be managed via a specific lighting management plan.

2.4.5 Invasion by Exotic Plants, Pathogens and Animal Pests

Roads can facilitate exotic plant invasions via transportation of seeds, spores or fragments, and by creating corridors of disturbance which are vulnerable to invasion (Christen & Matlack 2009). This effect is particularly severe where weeds using roadside margins were previously absent and are capable of invading surrounding habitats and outcompeting existing native vegetation, thus lowering the quality of habitat available for native fauna and increasing competition/reducing space for native plants (Simcock et al. 2022). Roads can also create corridors used by pests and pathogens into otherwise less accessible habitat (Murphy and Dowding 1994; Delgado et al. 2017).

Invasion into disturbed areas and via roads has already occurred on the Buller Plateaux where heath rush (*Juncus squarrosus*) and gorse (*Ulex europaeus*) are widespread on road margins and in disturbed habitats. Weed invasion can be reduced by:

- Use of already disturbed areas;
- Location of roads away from areas most vulnerable to weed invasion (low growing or sparse vegetation);
- Monitoring of weeds, including for new incursions, and prompt attention to weed control; and
- Revegetation with native species at disturbed sites along margins to reduce opportunities for weed invasion.

Appropriate biosecurity measures can avoid introducing pests and pathogens, particularly cleaning of large vehicles and earth moving machinery coming from offsite. Increased pest access can be mitigated by undertaking pest control along road margins.

2.4.6 Edge Effects

Roads modify habitats by creating new edges, which can alter the existing edges, add to the extent of edge habitats and create zones with increased light and wind, which in turn affects temperature and humidity. These effects can extend for some distance into the surrounding habitats (Davies-Colley et al 2000). The extent and magnitude of edge effects depends on the original vegetation type and the species present. Norton (2002) found microclimate edge effects extended up to 20m from the edge of forest fragments, although effects extended to 70m for sensitive flora such as ferns and bryophytes and up to 100m for pest predators.

Roadside plantings, particularly of hardy and 'bushy' species where ecologically appropriate can help to protect or 'seal' the edge of newly exposed forested areas (Denyer et al. 2006).

2.4.7 Mobilisation of Sediment and Water Runoff

Roads increase surface run off by decreasing infiltration of rainfall, altering hydrological regimes and increasing sedimentation and erosion (Gudino-Elizondo et al. 2018). This can pollute and degrade receiving waters and negatively affect aquatic life (Waters 1995). The placement of roads, can also alter catchments and divert water, adversely affecting freshwater habitats such as wetlands and streams. Use of sediment retention ponds and planting and maintenance of roadside vegetation can help to settle suspended particles and slow runoff (Mrowiec 2016, Baldauf 2017).

3.0 Species that might be affected by the Upper Waimangaroa Haul Road

3.1 Context

The proposed UWHR is described in Section 1.2, and the effects of roading and approaches to mitigation are summarised in Section 2. This section identifies the species present and considers how the expected effects would manifest along the UWHR and how the species present might be affected. Due to a lack of specific evidence of the effects of roads on the particular suite of species present, we have based this assessment on traits which are known to be risk factors and species known to be affected by roads elsewhere.

In terms of assessing likely effects, the Project Description sets out that coal haulage is based on c. 70-minute return cycle time per load (average speed of 40 kmph). There will be variable speed restrictions across the road length, determined by road design, operating conditions, other users and the types of vehicles. There will be an overall maximum limit of 80 km/h for some vehicles in some sections. Average speeds will likely be much lower than this due to the meandering nature of the road and associated sightlines and stopping distances. We have assumed that the current road management at Stockton Mine would apply with respect to dust management.

We have also factored into our consideration the presence of the Waimangaroa River as a natural barrier to small, poorly mobile fauna. We have focussed here specifically on operational effects rather than construction effects.

3.2 Potentially Vulnerable Species

3.2.1 Introduction

Fauna known or considered likely to occur within the UWHR route and considered vulnerable to the effects of roads are listed in Table 2. Each species has been assessed against the attributes which contribute to WVC listed in Section 2.2.2.

Table 2: Species known or likely to be present within the UWHR footprint and considered likely to be vulnerable to roading impacts.

	WVC		Direct Effects	Indirect Effects
	Risk factor for WVC	WVC Risk[1]		
Birds				
Threatened – Nationally Endangered				
Kea (*Nestor notabilis*)	Behaviour, road attraction.	Low	Risk of collision	Increased pests, pollution
Threatened – Nationally Vulnerable				
Great spotted kiwi/rōroa (*Apteryx haastii*)	Nocturnal, flightless, freeze response, large home range.	Moderate	Habitat loss, risk of collision, possibly fragmentation	Lighting, noise, increased pests
At Risk – Declining				
New Zealand pipit/pīhoihoi (*Anthus novaeseelandiae novaeseelandiae*)	Road attraction, habitat preference.	Low	Risk of collision	Noise, increased pests
Not Threatened				
Kererū (*Hemiphaga novaeseelandiae*)	Low flight paths	Low	Habitat loss, risk of collision	Noise, increased pests
Weka (*Gallirallus australis*)	Flightless, habitat preference, crepuscular (predominantly dawn and dusk active)	Moderate	Habitat loss, risk of collision, possibly fragmentation	Lighting, noise, increased pests

[1] All species are likely to be subject to the direct effect of construction mortality, depending on the specific habitats affected and the timing of habitat clearance. Therefore, construction effects are not included as a line item for each species individually here.

	WVC		Direct Effects	Indirect Effects
	Risk factor for WVC	WVC Risk[2]		
Lizards				
Threatened – Nationally Vulnerable				
West Coast green gecko *(Naultinus tuberculatus)*	Low mobility, cathemeral (irregularly active at any time of day), potentially attracted to road for basking (heliothermic).	Moderate	Habitat loss, risk of collision, fragmentation	Lighting, noise, increased pests, pollution
At Risk – Declining				
Forest gecko (*Mokopirirakau granulatus*)	Low mobility, nocturnal, potentially attracted to road for basking (heliothermic). Fragmentation.	Moderate	Habitat loss, risk of collision, fragmentation	Lighting, noise, increased pests, pollution
Speckled skink (*Oligosoma newmani*)	Low mobility, potentially attracted to road for basking (heliothermic). Fragmentation.	Moderate	Habitat loss, fragmentation, risk of collision	Lighting, noise, increased pests, pollution
Snails				
Threatened – Nationally Critical	**Risk factor**			
Powelliphanta patrickensis	Low mobility, nocturnal. Fragmentation.	High	Habitat loss, Fragmentation, risk of collision	Noise, increased pests, pollution

[2] All species are likely to be subject to the direct effect of construction mortality, depending on the specific habitats affected and the timing of habitat clearance. Therefore, construction effects are not included as a line item for each species individually here.

3.2.2 Birds

Three species of birds of conservation concern occur in and around the UWHR footprint, as well as two species which are not threatened, but are also considered vulnerable to road effects. The species known or likely to be present and are considered vulnerable to roading effects are listed in Table 2.

Kiwi are vulnerable to roadkill and habitat fragmentation (Simcock et al. 2022). Their vulnerability is increased by their behavioural traits, since they are nocturnal, flightless, have large home ranges (c. 60 – 80ha) and can exhibit a freeze response. Great spotted kiwi/rōroa are known to occur in and around the UWHR route. Rōroa have a population of c. 14,000 birds spread across approximately 850,000ha (approximately one bird per c. 61ha) (Toy et al. 2021, Roroa Practitioner Group 2021). Rōroa are classified as 'Threatened – Nationally Vulnerable', and are declining primarily due to stoat predation (Robertson et al. 2021). Territories on and near the Buller Plateaux are exceptionally large (≥ 80ha) and typically include a range of habitat types (McLennan 2020).

Instances of WVC with rōroa have been rare over the recent history of mining activity on the Buller Plateaux with two fatalities recorded at Stockton Mine in the last approximately 20 years (L. Maguire, MBC Environmental, pers. comm.). This number is relatively low, despite home ranges of multiple birds overlapping existing road networks and mining areas and regular reports of drivers seeing rōroa using or near the road. This indicates that despite the risk factors for rōroa, the overall risk is likely to be low. Compared to roads that have caused high kiwi mortality elsewhere, roads on the Buller Plateaux have low traffic volumes and are travelling at low speed which greatly reduces their risk to rōroa.

Other bird species present include those adapted to forests, shrublands and open areas, although numbers on the Buller Plateaux are generally lower than in the surrounding habitats which are typically more fertile (Overmars et al. 1998, Ecological Solutions Limited 2025b). Forest birds are considered to be of low risk of collision mortality because they are highly mobile and generally avoid roads, furthermore the UWHR does not bisect tall forest habitats at any point.

Pākihi shrubland provides habitat for South Island fernbird. Black shag (*Phalacrocorax carbo*) and little shag (*Phalacrocorax melanoleucos*) are characteristic of major rivers in the ED and may be present at low densities in the Upper Waimangaroa Valley. Long-tailed cuckoo (*Eudynamys taitensis*) are also seasonally present and likely use densely forested areas nearby, where one of their host species, brown creeper (*Mohoua novaeseelandiae*) are present.

Species of low or open habitat such as fernbird and pipit are potentially vulnerable to the impacts of roads, due to the potential creation of favourable habitats at roadside margins. The behaviour of pipit increases their risk, as they show low avoidance behaviours and preferentially select recently disturbed habitats around earthworks and road edges (Beauchamp 2019). The behaviour of fernbird, flying close to the vegetation, often from plant to plant, would reduce their risk because they would likely not cross the road. The low speed of vehicles using the UWHR would reduce the risk to pipit.

3.2.3 Long-tailed Bats

Bats are potentially vulnerable to a wide range of road effects. However, bats are unlikely to be exposed to risk of effects from UWHR because they are not known to be present. Bats (presumed long-tailed bats) were recorded in the Happy Valley area (Upper Waimangaroa River) on the Buller Coal Plateau in 1997 (Thomas et al. 1997), but have not been detected since in the plateau or surrounding areas since, despite survey effort to detect them (Buckingham 1999; Thomas & Toft 2002; Waybacks & Wildlife Solutions 2008).

3.2.4 Lizards

The Buller Plateaux and Waimangaroa Valley provide habitat for forest gecko ('At Risk – Declining') West Coast green gecko ('Threatened – Nationally Vulnerable') and speckled skink ('At Risk – Declining') (Hitchmough et al. 2021).

Though there is a lack of evidence about the effect of roads on lizard populations in New Zealand, lizards have been recorded in the iNaturalist Roadkill Project and are considered at risk of WVC and fragmentation of habitats at the UWHR. Lizards have poor ability to avoid collision due to low mobility and fright freeze behaviour. In addition, they may be thermally attracted to some road surfaces, and particularly sensitive to chemical pollutants (Andrews et al. 2006). The iNaturalist Roadkill Project contains perhaps the best evidence of WVC of lizards in a New Zealand context (see Table 1). Though reported in low numbers there is a high diversity of lizard species collected. They are very likely under-represented compared with larger animals due to the likely low detection rate of small animals (Underhill & Angold 2000). That database includes mortality of species within the same genera (*Naultinus* and *Oligosoma*) as those found near the UWHR, although none of the three species present have been recorded. Lizards are also at risk of population fragmentation, because the low probability of successfully crossing the road means that the population could become disconnected. The chance of lizards successfully crossing the road is reduced by the width and open nature of the road, relative to lizard home ranges, and by the fact lizards would be too small for drivers to see and too slow moving to avoid WVC. The low number of vehicles would reduce the risk for lizards somewhat.

3.2.5 Snails

Powelliphanta are a group of large carnivorous land snails with at least 20 species and 59 sub-species (Walker 2018). Predation by pests, especially possums, predation by native animals such as weka, habitat degradation and climate change are thought to be causing population declines of *Powelliphanta* (Walker 2003, Walker et al. 2024). The conservation status of 28 taxa worsened to 'Threatened – Nationally Critical' in the most recent assessment, including the two present on the Buller Plateaux (Walker et al. 2024).

The frequency with which snails use roads is currently uncertain and would be the main determinant of their risk of WVC. Road construction may pose a threat to *Powelliphanta patrickensis*, principally due to loss and degradation of habitat. Predation by thrushes (*Turdus philomelos*) and loss of habitat due to the upgrading of the narrow road to the Oparara Arch in Kahurangi National Park are thought to have contributed to the decline of *P. annectens* which occur from the Oparara River near Karamea, to Gunner Downs south of the Heaphy River (Walker et al. 2024). Road mortality was also considered an important factor in population decline of *Powelliphanta lignaria lusca,* due to locally high mortality on the new Karamea Highway through prime snail habitat at Happy Valley Saddle (Walker et al. 2024). There is one record of WVC of snail from the related genus *Paryphanta* (kauri snails) in the iNaturalist Roadkill Project (Table 1).

Powelliphanta patrickensis (Threatened – Nationally Critical, Walker et al. 2024) is the only species present near the UWHR. This species is confined to the infertile, poorly drained Brunner coal measures of the Buller Plateaux and occurs patchily from the headwaters of St Patrick Stream south to Mt Rochfort. Previous surveys have found a high density of *P. patrickensis* on the east (true left) side of the Waimangaroa River (Buckingham 1998), although this is close to the edge of the species distribution as noted above and set out in Walker (2003).

P. patrickensis may lose habitat within the road footprint, and have habitat degraded at the road margin and a short distance beyond. It is clear that any snails using the road would be at high risk of mortality due to their slow mobility and small size which would make them undetectable to drivers. However, the road routes do not provide, nor bisect, ideal snail habitat, since *P. patrickensis* require low vegetation for overhead cover and as a substrate. The UWHR is located near the distribution edge. Together these factors would make crossings less likely, and the effect is likely to be a reduction in the known range, rather than fragmentation per se, although the distribution does extend further east near Cypress Mining Area and Burnett's Face as discussed above, so fragmentation may be an issue.

4.0 Recommendations

4.1 Introduction

Based on our review, the key drivers of effects on wildlife due to roading include road design, road location, vehicle speed, driver behaviour, life history characteristics of particular species, habitat quality adjoining the road and the presence of bridges or other pre-existing wildlife routes. The level of effects can be influenced by good road design, appropriate construction management and ongoing operational management practices. Each of these factors is considered in more detail below.

4.2 Road Design

The best time to reduce overall effects is when considering and planning road placement and construction, since this can mitigate or amplify other effects once construction and operation proceed. Placement of the UWHR should avoid or minimise features which can create roadkill blackspots as described in Section 2.2.2. This includes consideration of road width, road location, gradient, habitats adjoining the road and their relative value, the species present, and the location and nature of bridges.

A major landscape feature in relation to the UWHR and its potential effects on wildlife, is the Waimangaroa River. The river likely represents an existing barrier to rōroa, lizards and snails to varying, but unknown, degrees. This was considered in Ecological Solutions Limited (2025a) and contributed to selection of the true left route.

For lizards and snails for which the road would be an impermeable barrier, road placement close to the river would remove and/or bisect the smallest amount of habitat. Placement near the river might also reduce the risk of WVC by reducing the likelihood of crossing attempts. For any animals 'orphaned' between the road and the river however, fragmentation and WVC effects are likely to be severe and the best outcome for those individuals and species might be to salvage and relocate them to suitable habitats nearby. Ecopassages to connect any areas of large or important habitat remaining between the river and road would be unlikely to assist the species most affected by the road (lizards and snails), because of their poor mobility.

For rōroa, habitat loss and fragmentation would depend on the specific home ranges of the resident individuals. This could be informed by a radio-tracking study and decisions made with respect to the degree to which individual birds would be affected. Provision of ecopassages (in the form of extended stream crossings and/or dry crossings) might assist juvenile rōroa dispersing across the landscape to cross the road, but in the absence of an understanding of the cues rōroa use for moving across the landscape, these would need to be relatively frequent to ensure they were located by birds wanting to cross the road. Given that rōroa are regularly reported crossing mine roads at Stockton, the presence of ecopassages is unlikely to provide significantly greater protection.

Assessment of the relative value of the habitats within and adjoining the footprint contributed to the selection of the true left route and therefore avoidance of the higher value habitats on the true right of the Waimangaroa River (Ecological Solutions Limited 2025a). This approach will have avoided direct habitat loss for those habitats on the true right. In addition, the route on the true left of the Waimangaroa River which was selected will not require multiple bridges over the Waimangaroa River which could create WVC blackspots for species travelling up and down the river such as shags.

The UWHR route generally closely follows the Waimangaroa River, reducing the amount habitat fragmentation, although potentially increasing its impact on animals or populations existing between the river and road. At some locations the Waimangaroa River meanders away from the road creating fragments up to 40ha in extent. Other management approaches discussed below are of particular importance where habitat exists between the road and river.

4.3 Construction Management

4.3.1 Species Management

Species and habitat management techniques already deployed at Stockton Mine for vegetation removal including direct transfer of vegetation, search and salvage for lizards and snails and radio tracking of rōroa combined with pre-clearance surveys would reduce the risk of direct effects on fauna species due to construction.

4.3.2 Construction Elements

Ecopassages

Ecopassages in the form of dry/empty culverts spaced along the UWHR could theoretically reduce fragmentation and WVC effects, allow safe passage of rōroa and weka and enable movements of snail and lizards, though use by these species is uncertain, particularly for lizards and snails which are poorly mobile. Due to the low effectiveness of ecopassages without funnelling (Taylor & Goldingay 2010) (such as by fencing), use of ecopassages alone is not recommended.

Extended Crossings

Although ecopassages are most effective when combined with barriers, the extended crossing style passage uses natural animal behaviour to partially address the lack of funnelling without fencing (Taylor & Goldingay 2010). In addition, extended crossings could possibly be added to existing crossings at relatively low cost.

The available literature suggests that extended crossings are more effective than ecopassages alone, due to the funnelling effect for animals which tend to follow streams and other linear landscape features. The UWHR will cross a number of watercourses of various sizes and extended stream crossings or similar could assist in reducing the risk of WVC for species such as rōroa and weka, and for flighted species such as shags which would move along the waterways. Extended crossings also mitigate the increased risk of WVC which can occur at bridges (Lesbarreres & Fahrig 2012).

Since neither weka nor rōroa are likely to move preferentially along streams, and given that use of mine roads has not been shown to be a significant cause of mortality for either species to date, extended crossings are not considered necessary.

Barriers

Barriers serve to either prevent animals from entering the road or divert and focus them to cross at particular (safe) locations. Safe crossings are most effective with highly mobile species, whilst barriers could prevent even poorly mobile species from entering roads, but would also effectively create separate subpopulations bisected by the barrier, unless managed. Barriers are not recommended for the UWHR.

Exclusion fencing would prevent rōroa, lizards and snails from using the road however it would exacerbate fragmentation impacts for those species. Given the risk of WVC for rōroa and weka can be reduced by other means, including speed limitation, barriers are not justified.

Determining the magnitude of WVC on lizards and snails in this context would require detailed monitoring via regular and frequent searches for carcasses and live individuals. We are only aware of one West Coast green gecko ever being recorded dead on Fly Creek Road at Stockton Mine, although the cause of death was unknown. It would depend on the frequency of crossing attempts and/or mortality whether construction of a barrier would mitigate these effects. It seems unlikely that WVC is significant for lizards or snails, and more likely that they are affected by habitat fragmentation and loss.

Snails and lizards have small home ranges and are poorly mobile. The width of the UWHR (16.7m) may mean that lizards and snails attempting to cross the UWHR via an ecopassage devoid of food or habitat would not be successful, even if such passages were present. The appropriateness of barriers for lizards and snails is difficult to assess, but given they could adversely affect other species, barriers are not recommended for the UWHR.

4.4 Operational Management

4.4.1 Vehicle speed

While the success of speed restrictions on public roads can be limited, this is generally due to poor driver adherence to posted limits (Glista et al. 2008). Since the UWHR would be used by mine employees or contractors, vehicle speeds can be reliably controlled. An average speed of 40km/hr on Stockton Mine roads would significantly reduce the risk of WVC for rōroa and other birds compared to higher speeds. Data from Beauchamp (2009) suggests each 10km/hr increase in the speed of vehicles would approximately double the wildlife mortality. Limiting the use of the road at night would reduce this risk further.

The low mobility and detectability of snails and lizards means speed limitation would not reduce the risk of WVC for these species.

4.4.2 Noise

Road noise can be mitigated by limiting vehicle speeds. Den Boer & Schroten (2007) considered that the optimal speed for reducing road noise was 40-50 km/hr, however there is no reliable evidence with respect to the noise level above which wildlife living within the UWHR route would be affected.

4.4.3 Dust

The existing dust management at Stockton Mine in general and specifically Cypress Mining Area is sufficient to avoid visible build-up of dust and therefore any likely effects on vegetation or fauna (Ecological Solutions Limited 2025e).

4.4.4 Lighting

Lighting effects can be minimized via management of light usage via a lighting management plan. This would include eliminating stationary lights wherever possible, shielding and directing lights where they are required, using fewer lights at less attractive wavelengths to wildlife.

4.4.5 Increased access for weeds and pests

Weed invasion can be reduced by placement of roads away from areas most vulnerable to weed invasion and this has been considered in route selection (Ecological Solutions Limited 2025a). Monitoring for new weed invasions and prompt control of new weed infestations is also required. Weed management for the wider Buller Plateaux, including the UWHR Project sub-area is set out in the Weed Management Plan for the BCPCP. Revegetation with native species, either via planting or VDT, along margins which are not to be intensively managed can reduce opportunities for weed invasion.

Control of pest mammal species along the UWHR would reduce the effects of these predators and pests and this is proposed as part of site management (Alliance Ecology Limited 2025b).

4.4.6 Species Relocation

Wildlife movements across the UWHR are expected to be low, and mostly consist of movements by mobile animals which have low to moderate vulnerability to WVC such as forest birds, or rōroa and weka. Management of vehicle speed is expected to address the risk to these animals. The placement of the UWHR alongside the Waimangaroa River has the potential to disconnect small areas of habitat from each other, creating isolated habitat fragments.

For more sedentary, or poorly mobile, species, fragmentation effects are expected to be high or very high, depending on their distribution in relation to the road. Although ecopassages might address this habitat fragmentation, it remains unknown whether they would be effective. Alternatively, if sub-populations of lizards or snails were confirmed to be isolated by the road, episodic relocations of small numbers of individuals from one side of the road to the other could reduce fragmentation effects (particularly on the population genetics). The value of this approach has not been confirmed anywhere, but at least in theory, this could restore connectivity and prevent loss of genetic diversity by enabling flow of individuals (and genes) across the road. Research would be required to determine the level of relocation required (i.e., number of individuals, frequency of relocation, direction of relocation and the like) and measure the effectiveness of this approach.

4.5 Monitoring

Monitoring of rōroa in the vicinity of the proposed road is likely to be required prior to construction in order to mitigate construction effects. Given the low risk to rōroa due to low traffic volume and speed, ongoing monitoring of rōroa surrounding the UWHR is unlikely to be required.

Survey of existing mine or other roads (e.g., at Denniston) for either live snails and lizards or carcasses in advance of UWHR construction could provide evidence about the risks to these species posed by the UWHR, which is currently uncertain. Such survey would need to be sufficiently frequent to represent a real chance of detecting WVC before they are removed by predators or natural decay. Given that these animals are not expected to frequently attempt to use or cross roads, since they prefer vegetation cover, the chances of detecting WVC and accurately attributing the cause of mortality is very low. On the basis of current evidence, WVC for lizards and snails seems unlikely, with much greater effects due to habitat loss and/or fragmentation/isolation of habitats. On that basis, management of effects should focus on addressing habitat removal and fragmentation.

5.0 Summary

The proposed Upper Waimangaroa Haul Road could negatively affect fauna directly, through mortality during construction and WVC during operation, as well as indirectly through loss, fragmentation and/or degradation of habitat via habitat removal, discharges of contaminants and edge effects. Planning of road placement can reduce, but not eliminate, these effects. Monitoring of wildlife mortality associated with roads (particularly WVC) both within New Zealand and internationally has identified that a range of species are affected to varying (usually unknown) degrees. Mitigations which have been attempted internationally in order address effects on wildlife include:

- Reducing vehicle speed;
- Barrier fencing;
- Including ecopassages in road construction (sometimes with barrier fencing);
- Providing extended stream ecopassages; and
- Lighting, noise and dust management.

The efficacy of these approaches has generally not been measured, and although intuitively sensible, it remains unknown whether they are effective at reducing effects or not. The strongest evidence, including that collected in New Zealand, relates to limiting vehicle speeds to reduce WVC. Monitoring of individual home ranges of rōroa around the footprint, as occurs elsewhere during mine development, would inform efforts to reduce effects during construction.

With respect to speed, limiting vehicle speed to 80km/hr (with an average speed of 40km/hr due to road conditions and vehicle type), and providing for dust suppression and lighting management would substantially reduce associated effects at the UWHR.

The use of extended stream passages and/or dry culverts as ecopassages at construction would be relatively low cost and might afford some species, such as weka and rōroa, protection from WVC in particular, but is unlikely to reduce effects on poorly mobile species such as lizards and snails, which would be unlikely to come in contact with an ecopassage, and if they did, would take substantial time to use it to cross the road. Given effects on weka and rōroa are expected to be negligible, the use of ecopassages is not recommended.

The degree to which populations of poorly mobile species such as lizards and snails might become fragmented remains unknown, but could be high. This effect would be reduced to some extent via the placement of the road near the Waimangaroa River, and the use of ecopassages where habitat exists on both sides of the road is unlikely to assist these poorly mobile species in moving across the road to any meaningful degree. Episodic relocation of individuals or, alternatively, salvage and relocation of as many individuals as possible to suitable habitat elsewhere prior to or soon after construction could reduce the population level effects (particularly genetic effects) on those species, although this remains untested as well and would require research to inform the effort required.

Avoiding high weed risk areas as part of route planning, combined with effective weed and pest control and replanting of any areas not required to be kept cleared would reduce any adverse effects due to weeds and is proposed within the site environmental management plans for the BCPCP.

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20 December 2024

(Revised 6 August 2025)

Bathurst Resources Limited

[redacted]

Attention: [redacted]

Upper Waimangaroa Haul Road (UWHR) Options Assessment

Introduction

Bathurst Resources Limited (including its subsidiary companies BT Mining Ltd, Bathurst Coal Ltd, and Buller Coal Ltd) (collectively referred to here as 'Bathurst') are seeking approvals through the Fast-track Approvals Act 2024 ('FTAA') for the Buller Plateaux Continuation Project ('BPCP', or the Project'). A component of the Project is the Upper Waimangaroa Haul Road ('UWHR'), which would be used to enable transportation of coal from the Extended Escarpment mining area on the Denniston Plateau to the Coal Handling and Processing Plant ('CHPP') at Stockton Mine, as well as for movement of plant and personnel between sites.

Two potential haul road routes through the Upper Waimangaroa Valley were considered by Bathurst, one on the true left and one on the true right of the Waimangaroa River. The haul road would be c. 19km long, but only c. 7km would affect greenfield sites, the balance being an upgrade of an existing 4WD track. The vegetation types within the greenfield sections of the two options provided to Ecological Solutions Limited in August 2024 are shown in Figure 1. The true right option occupies 22.71ha, while the true left option has a slightly smaller footprint, covering 21.63ha.

Ecological Solutions Limited were commissioned in late 2024 to assess the ecological values of habitat and fauna within the greenfield section of each potential route, in order to assist in determining the likely level of relative effects for each alternative routes and inform project planning. This assessment was completed in December 2024 using information available at that time and this letter was updated in August 2025 to accompany the application for resource consent.

[redacted]

Figure 1: Vegetation types with the greenfield sections of the alternative proposed Upper Waimangaroa Haul Road routes.

Methodology

Introduction

A generally accepted approach to assessing ecological values and determining ecological effects in New Zealand is the application of the Ecological Impact Assessment (EcIA) guidelines (Roper-Lindsay et al. 2018), which assists with assessing values and effects in a consistent and transparent way. The method involves assigning both ecological value and a magnitude of effect on a 5-point scale ('very low' to 'very high'), which feeds into a matrix to provide an overall level of effect (also on a five-point scale). The difficulty in using this approach for this particular assessment is that the ecological values present within each haul road option, and the magnitude of effect for each option, are very similar and the resulting overall level of effect would be unlikely to reflect the relative difference in the effects of the route options at the fine scale required.

In the absence of a model or template in the literature, for this assessment we developed a scoring system using four different attributes in order to provide a quantitative score for each option which could then be compared.

The four attributes scored for each route option were:

- The likelihood that each vegetation type within the route supported a species of conservation concern.
- The extent of naturally uncommon ecosystems.
- The extent of wetlands.
- The vulnerability of each vegetation type to weed invasion.

The details of our approach are set out in Appendix A and Appendix B. To summarise:

- Existing information about the actual and potential vegetation, habitats and fauna present within the potential greenfield construction sections each of the alternative proposed haul road options was compiled from relevant previous surveys, reports and databases.
- The vegetation and habitat types within each route option were identified and mapped using our recent Buller Plateaux-wide vegetation map (Ecological Solutions Limited, 2025). We included an additional 25m either side of each footprint to account for edge effects.
- For the purposes of this assessment, we have estimated a riparian zone to be approximately 2m either side of the Waimangaroa river and other smaller watercourses. This area is intended to capture the area of shaded rocky stream banks and additional associated rock in these locations which provide habitat for some species of interest, particularly bryophytes.
- Once the extent of each vegetation type present along each alternative route had been calculated, it was then scored for each of the four factors outlined in Table 1 and described below.

Table 1. Factors considered for each alternative route.

Description of factor considered	Score
Likelihood of the presence of 'threatened' or 'at risk' species of flora and fauna. 'Species of conservation concern score'	Expressed as the combined average score (per fauna group) of species of conservation concern within each habitat type (refer to detailed methodology) **multiplied by** the total extent of that habitat type within each route (including a 25m buffer).
Naturally uncommon ecosystems present.	Expressed as the total extent (ha) of naturally uncommon ecosystems within each route (including a 25m buffer).
Wetlands present.	Expressed as the total extent (ha) of wetlands within each route (including a 25m buffer).
Weed invasion risk score	Expressed as the weed vulnerability score of each habitat type (refer to detailed methodology) **multiplied by** the total extent of that habitat type within the 25m wide buffer each road route (excluding the haul road footprint).

Species of Conservation Concern

Species of conservation concern may occur throughout any of the vegetation types present. For that reason, we scored each vegetation type according to the number of species of conservation concern that are known to use that particular vegetation type as habitat. Habitat value was assigned for 'Threatened' and 'At Risk' species of vascular plant, bryophytes, lichens, avifauna, lizards, *Powelliphanta* snails and other terrestrial invertebrates. Aquatic flora, fish and freshwater invertebrates were not included.

For each 'threatened' and 'at-risk' species, a value from 0 - 1 was derived for the vegetation type, based on the likelihood of occupancy and the suitability of that habitat for each species being considered. Appendix B provides the completed table setting out the scores used. Once each species was assigned a score, the scores were averaged for each fauna or flora group and then combined (i.e., added) to give an overall habitat score for each vegetation type. The higher the score, the more species of conservation concern the vegetation type is likely to support. The maximum score of 7 would indicate that all species of conservation concern known to occur within the Stockton and the Denniston Plateaux (together referred to as the Buller Plateaux) would use that particular vegetation type as core habitat.

A score of 3.5 was considered high, and indicates that around half of the species of conservation concern known to inhabit the area would occur within that vegetation type.

The final habitat score was multiplied by the extent of that vegetation type within each respective route in order to provide a route specific 'species of conservation concern score'. A higher score indicates that construction of that route would remove more important habitat for species of conservation concern than a route with a lower score.

Naturally Uncommon Ecosystems

The extent of naturally uncommon ecosystems present within each alternative route was calculated using the Buller Plateaux vegetation map completed by Ecological Solutions Limited (2025). All the 'bare rock' mapped was considered to be sandstone erosion pavement for the purposes of this assessment. This is likely to overstate the amount of sandstone pavement present slightly, since this land cover type also included minor elements of talus, boulderfields and rocky margins of watercourses.

Tarns, seepages and flushes are also naturally uncommon ecosystems known to occur on the Buller Plateaux, and may be present within each haul road option, but were not separately mapped.

Tarns are small lakes, which in the context of the Buller Plateaux, are embedded amongst the sandstone erosion pavement landscape. The extent of tarns is likely to be captured within the extent of habitat classed as sandstone pavement and/or within the low pākihi vegetation type.

Seepages and flushes have a limited extent across the Buller Plateaux, being present on hillslopes, gullies and among red tussock vegetation in Happy Valley. Due to the difficulty in mapping small, sometimes ephemeral features like seepages these have not been considered here; however, they may exist within the alternative routes.

The score for naturally uncommon ecosystems was expressed as the total extent (hectares) of sandstone pavement and pākihi within each option plus a 25m buffer.

Wetlands

With respect to wetlands, the following vegetation types were defined as wetlands for the purposes of this assessment:

- Mānuka-mountain beech-podocarp shrubland;
- Mānuka-tussock-wire rush shrubland;
- Tussock-flax shrubland; and
- Low pākihi.

These vegetation types had vegetation, hydrology and/or soil features characteristic of wetlands (Ecological Solutions Limited 2025). The two pākihi groups met all the criteria to be considered a 'natural inland wetland' in terms of the National Policy Statement for Freshwater Management (2020 and subsequent amendments). Although the vegetation tests for the mānuka-mountain beech-podocarp shrubland were ambiguous, they were considered to meet the hydrology and soil tests. The red tussock fen sub-type of the tussock-flax shrubland exists on the flat terraces along the Waimangaroa River.

The score for wetlands was expressed as the total area (hectares) of wetlands within each option plus a 25m buffer.

Weed Invasion Risk

The risk of weed invasion was assessed for vegetation adjoining the road footprint (between the footprint and the outer edge of the 25m wide buffer) and scored on a scale from 0 - 1. A low score indicated a vegetation/ habitat type that was highly resistant to invasion, while a high score indicated low resistance to invasion. The weed invasion score for each vegetation type was then multiplied by the total area of that vegetation type within each footprint to give a weed risk score.

Scores for weed risk for the vegetation types present adjacent to the road footprint were as follows;

- Mixed beech-podocarp-broadleaved forest: **0** (low vulnerability)
- Southern rātā-mountain beech-podocarp forest: **0.25**
- Mānuka-mountain beech-podocarp shrubland: **0.5**
- Weed Shrubland: **0.5**
- Moderate height mānuka-tussock-wire rush shrubland: **0.5**

- Low pākihi: **1** (high vulnerability)
- Tussock-flax shrubland: **1**
- Sandstone pavement: **0.75**
- Riparian: **0.5**
- Open water: **0**
- Cleared vegetation: **1**

Habitat within the Proposed Haul Road Routes

The extent of each vegetation/habitat type within the alternative haul road routes is summarised in Table 2 and shown in Figure 1 (in Introduction). Each vegetation type is described in more detail in 'Buller Plateaux Vegetation Mapping' (Ecological Solutions Limited 2025).

Vegetation accounts for over 99% (22ha) of the extent of the true left haul road route and buffer, with open water and cleared vegetation accounting for <1%. Both forest types and pākihi were the most widespread vegetation types, since this route intersects the colluvial toe slopes of the Mt William range and gently sloping terraces along the Waimangaroa River as shown in Figure 1.

Vegetation accounts for 90% (21ha) of the extent of the true right haul road route with bare rock (sandstone erosion pavement), cleared vegetation and open water accounting for the remaining 10%. Short forest (i.e., Southern rātā-mountain beech-podocarp forest) and pākihi were the most common vegetation type within this route as shown in Figure 1.

The true left route was dominated by mixed beech-podocarp-broadleaved forest in the northern section. The true right route featured red tussock wetlands in the northern part. These wetlands appear to be fed by small watercourses originating in sandstone pavement to the west.

Table 2: Extent of each vegetation type within the alternative Upper Waimangaroa Haul Road routes.

Vegetation type	True left		True right	
	Total (ha)	25m buffer only (ha)	Total (ha)	25m buffer only (ha)
Mixed beech-podocarp-broadleaved forest	5.52	3.88	0.85	0.69
Southern rātā-mountain beech-podocarp forest	6.54	4.84	7.23	4.76
Mānuka-mountain beech-podocarp shrubland	2.46	1.82	0.35	0.34
Weedy shrubland	-	-	0.53	0.32
Mānuka-tussock-wire rush shrubland	6.40	4.48	7.65	5.26
Low pākihi	0.11	0.11	1.06	0.80
Tussock-flax shrubland	0.12	0.09	2.29	1.78
Sandstone pavement	-	-	0.31	0.27
Cleared vegetation	0.18	0.06	1.23	0.69
Water	0.09	0.09	0.65	0.56
Riparian	0.23	0.19	0.57	0.45
Total	**21.63**	**15.57**	**22.71**	**15.93**

Species of Conservation Concern

Species of conservation concern may be present within any of the vegetation types present. A summary of the vegetation types and their respective habitat scores for species of conservation concern is provided in Table 3.

Vegetation types that scored the highest included both pākihi types and tussockland (all of which were also considered to be wetlands). These habitats had scores ranging between 3.53 and 3.62. The high scores could be attributed to the likelihood of these habitats providing primary or core habitat for the majority of vascular plants of conservation concern and for lizards and snails, with known records. These habitats were also important for terrestrial invertebrates, birds (particularly fernbird*, Poodytes punctatus*), bryophytes and lichens.

Southern rata-mountain beech-podocarp forest and mānuka-mountain beech-podocarp shrubland also scored highly with scores of 2.84 and 2.71 respectively. Both habitat types were considered important for lizards and bryophytes, the former also provides important habitat for birds such as South Island robin (*Petroica australis*) and rōroa (*Apteryx maxima*).

The removal of these vegetation types is likely to have a greater impact on species of conservation concern (and therefore, greater overall level of effect) than the removal of the other habitat types within the proposed footprints.

The average species score per vegetation type multiplied by the extent of each vegetation type within the different route options is presented in Table 4. The true right alignment has a higher score, indicating it would affect more habitat that is important for species of conservation concern than the true left option.

Naturally Uncommon Ecosystems

There are at least five naturally uncommon ecosystems present within the Ngakawau Ecological District, two of which (sandstone erosion pavement and pākihi wetlands) occur within the footprint of the true right UWHR alignment. The true left alignment route of the UWHR contains 6.51ha of naturally uncommon ecosystems, all of which is pākihi. The true right alignment route contains 9.02ha of naturally uncommon ecosystems (0.31ha of sandstone erosion pavement and 8.71ha of pakihi) as shown in Figure 2.

It is possible that tarns exist within the proposed routes, but these would be captured within the sandstone erosion pavement category or low pākihi as stated above. Both of these habitat types are also considered naturally uncommon ecosystems in their own right. Seepages and flushes may also be present, but are not considered here.

Part of the reason these habitats are important, is their irreplaceability, and there are limits to what can practically be achieved to mitigate or offset effects on these environments. The loss of naturally uncommon ecosystems would have a greater overall level of effect than the loss of other more common or more easily replaceable habitat types within the proposed haul road footprints.

Table 3: Average habitat score by species group for the habitats present within the alternative UWHR routes.

	Tall forest	Short forest	Shrubland		Pākihi		Tussockland				
	Mixed beech-podocarp-broadleaved forest	Southern rātā-mountain beech-podocarp forest	Mānuka-mountain beech-podocarp shrubland	Weedy Shrubland	Mānuka-tussock-wire rush shrubland	Low pākihi	Tussock-flax shrubland	Sandstone pavement	Riparian	Open water	Cleared vegetation
Vascular plants	0.13	0.23	0.20	0.11	0.27	0.44	0.44	0.16	0.17	0.00	0.07
Lizards	0.75	0.75	0.83	0.50	1.00	1.00	1.00	0.83	0.00	0.00	0.08
Snails	0.00	0.25	0.50	0.25	1.00	1.00	1.00	0.00	0.25	0.00	0.00
Birds	0.47	0.53	0.25	0.14	0.36	0.28	0.39	0.28	0.17	0.11	0.08
Terrestrial invertebrates	0.25	0.33	0.33	0.00	0.46	0.46	0.42	0.21	0.08	0.25	0.00
Bryophytes	0.25	0.75	0.59	0.06	0.47	0.44	0.28	0.16	0.66	0.00	0.00
Lichens	0.00	0.00	0.10	0.00	0.55	0.30	0.45	0.65	0.00	0.00	0.00
Total Score (Max 7)	**1.85**	**2.84**	**2.71**	**1.07**	**3.56**	**3.62**	**3.53**	**1.63**	**1.33**	**0.36**	**0.25**

Table 4: Average habitat score multiplied by area of habitat type.

	Tall forest	Short forest	Shrubland		Pākihi		Tussock land					
	Mixed beech-podocarp-broadleaved forest	Southern rātā-mountain beech-podocarp forest	Mānuka-mountain beech-podocarp shrubland	Weedy Shrubland	Mānuka-tussock-wire rush shrubland	Low pākihi	Tussock-flax shrubland	Sandstone pavement	Riparian	Open water	Cleared vegetation	Total
True Left	10.20	18.56	6.68	0.00	22.79	0.40	0.42	0.00	0.31	0.03	0.04	**59.39**
True Right	1.57	20.52	0.95	0.56	27.24	3.83	8.08	0.51	0.76	0.23	0.29	**64.26**

[redacted]

Figure 2: Location of naturally uncommon ecosystems within the proposed alternative routes.

Wetlands

Wetlands are present within both proposed routes, but are more common in the true right alignment as shown in Figure 3. There is approximately 9.1ha of wetland in the true left route and 11.4ha of wetland in the true right route. Pākihi vegetation and tussockland accounts for 85% of wetland extent in the true left route and 97% of wetland extent in the true right route.

Wetlands are a habitat type that has been severely reduced in extent. By 2008, wetlands were estimated to have declined to 10.1% (about 250,000ha) of the estimated pre-human extent of 2,471,080ha – with swamps[1] particularly affected. Policy 6 of the National Policy Statement for Freshwater Management 2020 (and subsequent amendments) promotes the protection and enhancement of natural inland wetlands and the avoidance of further loss of extent.

Weed Invasion Risk

Vulnerability to weed invasion can vary between vegetation types depending on the relative competitiveness of existing native plants and communities against potential invaders (Hulme 2020). This is an important consideration because roads can provide pathways for invasion, which can potentially spread from road margins into surrounding habitats. Vulnerability depends on weed species traits and tolerances and relative competitiveness of existing native vegetation in that context.

The weed invasion risk scores, multiplied by the total extent of each vegetation type within the buffer area are shown in Table 5.

The true right route has a higher combined weed invasion risk score than the true left alignment (7.28 vs. 4.59). Adopting the true right route would likely expose more vulnerable habitats to weed infestation than the true left route.

[1] https://www.stats.govt.nz/indicators/wetland-extent/ Accessed 19/12/2024.

[redacted]

Figure 3: Wetlands by vegetation type within the 25m buffer adjoining the proposed alternative road routes.

Table 5: Weed invasion risk scores.

	Tall forest	Short forest	Shrubland		Pākihi		Tussockland					
	Mixed beech-podocarp-broadleaved forest	Southern rātā-mountain beech-podocarp forest	Mānuka-mountain beech-podocarp shrubland	Weedy Shrubland	Mānuka-tussock-wire rush shrubland	Low pākihi	Tussock-flax shrubland	Sandstone pavement	Riparian	Open water	Cleared vegetation	Total Score
True Left	0.00	1.21	0.91	0.00	2.24	0.11	0.09	0.00	0.03	0.00	0.19	**4.58**
True Right	0.00	1.19	0.17	0.16	2.63	0.80	1.78	0.20	0.35	0.00	0.45	**7.28**

Conclusions

Based on our assessment set out above, the true right scores higher in all of the factors considered. The footprint of this route occupies a larger area, provides more valuable habitat for species of conservation concern, contains a greater extent of naturally uncommon ecosystems and wetlands, and the vegetation surrounding it is more vulnerable to weed invasion. This is primarily attributable to the larger areas of low and open vegetation and habitat types present within and adjoining the true right route which are less common within and adjoining the true left route, which is predominantly forested.

Table 6 below provides a summary of scores with commentary.

Table 6: Summary of scoring for alternative road routes.

	True Left	True Right	Outcome	Commentary
Total area (ha)	21.65	22.72	True Right + 1.07	The true left alignment is marginally smaller in terms of overall area based on the shape files provided in August 2024.
Species score	59.39	64.26	True Right + 4.88	True left alignment has a lower overall species score. This indicates using this route would affect less of the highest priority habitats (i.e., those which are home to threatened and at-risk species).
Naturally uncommon ecosystems (ha)	6.51	9.02	True Right + 2.51	The true left alignment would remove a smaller amount of naturally uncommon ecosystems.
Wetlands (ha)	9.09	11.35	True Right + 2.26	The true left alignment would remove less wetland habitat.
Weed invasion risk score	4.59	7.28	True Right + 2.69	The true left alignment has a lower weed vulnerability score, meaning the habitats exposed by the creation of the haul road are less vulnerable to weed invasion than those that would be exposed if the haul road was constructed on the true right alignment.

To summarise, we consider the true left route would have a lower overall level of effects on the ecological values of the area than the true right route. If you have any questions, please contact the author.

Sincerely

[redacted]

Senior Ecologist

[redacted]

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Vegetation and Landcover Within the Haul Road Footprint

The vegetation within the proposed UWHR route options was mapped following a recent survey of the Buller Plateaux and surrounds which used data from 152 RECCE plots (Hurst et al. 2022) and high-resolution drone images to map and describe 13 vegetation types derived from non-metric multidimensional scaling ordinations (Ecological Solutions Limited, 2025a). The 13 vegetation types were mapped using training samples that informed the classification of segmented polygons. These mapped vegetation types were overlayed onto the proposed UWHR route options to inform this survey.

Scoring

Introduction and Overview

Our assessment of the proposed UWHR routes involved assigning four scores to each option for comparison. The four scores generated captured:

- Species of conservation concern,
- Weed invasion risk,
- Naturally uncommon ecosystems present,
- Wetlands.

The methods used to develop the species of conservation concern and weed vulnerability scores are described in greater detail below.

Species of Conservation Concern Score

The species of conservation concern included in scoring were those listed as either 'threatened' or 'at-risk in the applicable Department of Conservation New Zealand Threat Classification Series (de Lange et al. 2024, de Lange et al. 2020, de Lange et al. 2018, Grainger et al. 2018, Hitchmough et al. 2021, Hoare et al. 2017, Robertson et al. 2021, Trewick et al. 2022, Walker at al. 2024).

The habitat value of each vegetation and land cover type was assigned a score from 0 – 1 for each individual species of conservation concern based on the suitability for, and likelihood of occupancy by, that species. Each individual species score is presented in Appendix B.

The score for each individual species was then averaged within the following groups:

- Vascular plants,
- Bryophytes,
- Lichens,
- Avifauna,
- Lizards,
- *Powelliphanta* snails,
- Other terrestrial invertebrates.

Each average group score was then combined (i.e., added) to give a species of conservation score for each vegetation or landcover type.

The species of conservation score per vegetation or landcover type was then multiplied by the extent of the corresponding vegetation or land cover type within each haul road option, and combined (i.e., added) to give an overall value score for each option.

The sources of information and method of scoring each species of conservation concern were as follows:

Source of Species Distribution and Habitat Preference Information

The information used to derive species scores was sourced from the Buller Plateaux Contextual study (Ecological Solutions Limited 2025b) which synthesised the available ecological surveys from the Ngakawau Ecological District and Buller Plateaux to describe the ecological values of the Buller Plateaux and the context in which they are located. The study summarised the available literature and survey information on flora, bryophytes, lichens, terrestrial invertebrates, avifauna and lizards.

Species scores for vascular and non-vascular plant species of conservation concern were supplemented by information from the New Zealand Plant Conservation Network (NZPCN).

Species scores for lizards were workshopped by the authors and Dr Matt Baber (Alliance Ecology Limited).

Flora

A scoring system was used to assess habitat/vegetation type suitability and the likelihood of occurrence of each species for each vegetation type. The scoring system is set out in Table 7.

Table 7. Flora species scoring system.

Score	Description
0	Unsuitable habitat.
0.25	Marginal habitat. No evidence of vegetation type being suitable for said species, but possibility of occurrence based on structure, composition, hydrology or other environmental variables associated with the vegetation type.
0.5	Likely suitable habitat, but lacking occurrence records within that vegetation type, A broad description of vegetation type was provided in surveys. Habitat preference was derived from NZPCN or other sources not specific to the Buller Plateaux.
0.75	Preferred habitat as evidenced from descriptions in surveys/studies undertaken within the Buller Plateaux and surrounds, but lacking location data
1	Preferred habitat with confirmed record of species within that vegetation type on the Buller Plateaux and surrounds (e.g. herbarium records, survey data or georeferenced photographs).

Fauna

The habitat value of each vegetation type for fauna was assessed using a scoring system on the same scale as flora, with slight modification of criteria as shown in Table 8, to capture the temporal and spatial use of habitats as fauna move across the Buller Plateaux.

This mobility varies between fauna groups and to a lesser extent between species, though the high heterogeneity of the habitats at the Buller Plateaux means that even less mobile species may travel between multiple vegetation types. Detectability of fauna also varies and increases the degree of uncertainty.

Table 8. Fauna species scoring system.

Score	Description
0	Unsuitable habitat. Records may exist, although occupancy is expected to be limited to movements between other habitat types.
0.25	Marginal or occasional habitat. Near the edge of habitat requirements, may be used infrequently and is of minor importance to species requirements.
0.5	Suitable secondary habitat. Provides habitat of value, though occupancy is not permanent or at lower densities than primary habitat.
0.75	Suitable primary habitat. Likely to support permanent populations, though preferred habitat exists elsewhere.
1	Preferred primary or obligate habitat.

Weed Risk

The risk of weed invasion was considered for vegetation surrounding the road footprint (between the footprint and 25m from the edge of the footprint) on a 5-point scale from 0 – 1 as set out in Table 9. A low score indicated a vegetation/habitat type that was highly resistant to an uncontrolled invasion of the main light demanding weed species present on the Buller Plateaux (for example gorse, health rush), while a high score indicated low resistance to invasion. The weed invasion score for each vegetation/ habitat type was then multiplied by the total extent of that habitat type within each footprint, to give a final score.

There are shade tolerant weed species present throughout the Buller Plateaux, although they are not as commonly encountered as the light demanding species noted above and they are not currently considered to pose as high a risk to indigenous communities. The consideration of invasion of shade tolerant species would likely result in different scores to those included here.

Table 9. Weed risk scoring system.

Score	Description
0	Highly resistant to invasion due to deep shade, leaf litter layer, root competition and soil conditions.
0.25	Resistant to invasion, with local opportunities for invasion that recede with time.
0.5	Minor displacement of natives, weeds may be persistent.
0.75	Partial dominance and displacement of native vegetation with persistent weeds.
1	Low resistance to invasion, displacement of natives and exotic dominance is likely without control.

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Appendix B: Species Scoring

Vascular Plants

Species of Conservation Concern (de Lange et al. 2023)	Tall forest	Short forest	Shrubland		Pākihi		Tussockland	Sandstone pavement	Riparian	Open Water	Cleared vegetation
	Mixed beech-podocarp-broadleaved forest	Southern rātā-mountain beech-podocarp forest	Mānuka-mountain beech-podocarp shrubland	Weedy shrubland	Mānuka-tussock-wire rush shrubland	J: low pākihi	M: tussock-flax shrubland				
Threatened – Nationally Vulnerable											
Bearded orchid (*Calochilus paludosus*)	0	0	0	0	0.25	0.5	0.5	0	0	0	0
At Risk – Declining											
Bulbinella modesta	0	0	0	0	0.75	0.5	0.5	0	0	0	0
Coal measures tussock (*Chionochloa juncea*)	0	0	0.25	0.25	1	1	1	1	0	0	0.5
Dracophyllum densum	0	0	0	0	0.25	1	0	1	0	0	0.5
Euphrasia wettsteiniana	0	0	0	0	0.25	1	1	0	0	0	0
Long-leaved pimelea (*Pimelea longifolia*)	0	0.25	0.5	0.5	0.5	0.25	0.75	0	0	0	0
Red mistletoe (*Peraxilla tetrapetala*)	0.5	1	0.5	0.25	0	0	0	0	0	0	0
At Risk – Naturally Uncommon											
Astelia subulata	0	0	0	0	0	1	0.5	0	0	0	0
Brachyglottis traversii	0	0	0	0	0.25	1	0.5	1	0.5	0	0.25
Carse's sedge (*Carex carsei*)	0	0	0.25	0.25	0.25	0.5	1	0	0	0	0
Dall's sedge (*Carex dallii*)	0	0	0.25	0.25	1	0.5	1	0	0	0	0
Euphrasia disperma	0	0	0	0	0.25	1	1	0	0	0	0
Hymenophyllum australe	0	0	0	0	0	0	0	0	0.75	0	0
Hymenophyllum pluviatile	0.5	0.5	0.5	0	0	0	0	0	0	0	0
Dwarf rush (*Juncus pusillus*)	0	0	0	0	0.75	0.5	0.5	0	0	0	0
Lobelia fatiscens	0	0	0	0	0	0.25	0.5	0	0.5	0	0.25
Pterostylis humilis	0.5	0.5	0.25	0.25	0.25	0	0	0	0	0	0
Travers horopito (*Pseudowintera traversii*)	0.5	1	0.5	0	0	0	0	0	0	0	0
Schizacme helmsii	0	0	0	0	0.25	0.75	1	0.5	0	0	0
Townsonia deflexa	0.75	0.75	0.5	0.25	0	0	0	0	0	0	0
Sticherus tener	0	0.5	0.5	0.25	0	0	0	0	1	0	0
Sticherus urceolatus	0	0.5	0.5	0.25	0	0	0	0	1	0	0
Total	2.75	5	4.5	2.5	6	9.75	9.75	3.5	3.75	0	1.5
Mean	**0.13**	**0.23**	**0.20**	**0.11**	**0.27**	**0.44**	**0.44**	**0.16**	**0.17**	**0.00**	**0.07**

Lizards

Species of Conservation Concern (Hitchmough et al. 2021	Tall forest: Mixed beech-podocarp-broadleaved forest	Short forest: Southern rātā-mountain beech-podocarp forest	Shrubland: Mānuka-mountain beech-podocarp shrubland	Shrubland: Weedy shrubland	Pākihi: Mānuka-tussock-wire rush shrubland	Pākihi: Low pākihi	Tussockland: Tussock-flax shrubland	Sandstone pavement	Riparian	Open water	Cleared vegetation
Threatened - Nationally Vulnerable											
West Coast green gecko *(Naultinus tuberculatus)*	1	1	1	0.5	1	1	1	0.75	0	0	0
At Risk - Declining											
Forest gecko *(Mokopirirakau granulatus)*	1	1	1	0.5	1	1	1	0.75	0	0	0
Speckled skink *(Oligosoma newmani)*	0.25	0.25	0.5	0.5	1	1	1	1	0	0	0.25
Total	2.25	2.25	2.5	1.5	3	3	3	2.5	0	0	0.25
Mean	**0.75**	**0.75**	**0.83**	**0.50**	**1.00**	**1.00**	**1.00**	**0.83**	**0.00**	**0.00**	**0.08**

Snails

Species of Conservation Concern (Walker et al. 2022)	Tall forest: Mixed beech-podocarp-broadleaved forest	Short forest: Southern rātā-mountain beech-podocarp forest	Shrubland: Mānuka-mountain beech-podocarp shrubland	Shrubland: Weedy shrubland	Pākihi: Mānuka-tussock-wire rush shrubland	Pākihi: Low pākihi	Tussockland: Tussock-flax shrubland	Sandstone pavement	Riparian	Open water	Cleared vegetation
Threatened – Nationally Critical											
Powelliphanta patrickensis	0	0.25	0.5	0.25	1	1	1	0	0.25	0	0
Total	0	0.25	0.5	0.25	1	1	1	0	0.25	0	0
Mean	**0**	**0.25**	**0.5**	**0.25**	**1**	**1**	**1**	**0**	**0.25**	**0**	**0**

Birds

Species of Conservation Concern (Robertson et al. 2021)	Tall forest	Short forest	Shrubland		Pākihi		Tussockland	Sandstone pavement	Riparian	Open water	Cleared vegetation
	Mixed beech-podocarp-broadleaved forest	Southern rātā-mountain beech-podocarp forest	Mānuka-mountain beech-podocarp shrubland	Weedy shrubland	Mānuka-tussock-wire rush shrubland	Low pākihi	Tussock-flax shrubland				
Threatened – Nationally Endangered											
Kea (*Nestor notabilis*)	0.25	0.25	0	0	0.25	0.25	0.5	0.5	0	0	0
Threatened – Nationally Vulnerable											
Great spotted kiwi *(Apteryx haastii)*	1	1	0.5	0.25	0.25	0.25	1	0.25	0	0	0
Long tailed cuckoo *(Eudynamys taitensis)*	1	1	0.5	0	0.5	0	0	0	0	0	0
South Island kaka *(Nestor meridionalis meridionalis)*	1	0.5	0	0	0	0	0	0	0	0	0
At Risk – Declining											
South Island fernbird *(Bowdleria punctata punctata)*	0	0.5	0.5	0.25	1	0.5	1	0.25	0	0	0
South Island robin *(Petroica australis)*	1	1	0.5	0	0.25	0	0	0	0	0	0
New Zealand pipit *(Anthus novaeseelandiae novaeseelandiae)*	0	0	0.25	0.75	1	1	1	1	0	0	0.75
At Risk – Relict											
Black shag (*Phalacrocorax carbo novaehollandiae*)	0	0.25	0	0	0	0.25	0	0.25	0.75	0.5	0
Little shag (*Phalacrocorax melanoleucos brevirostris*)	0	0.25	0	0	0	0.25	0	0.25	0.75	0.5	0
Total	4.25	4.75	2.25	1.25	3.25	2.5	3.5	2.5	1.5	1	0.75
Mean	**0.47**	**0.53**	**0.25**	**0.14**	**0.36**	**0.28**	**0.39**	**0.28**	**0.17**	**0.11**	**0.08**

Invertebrates

Species of Conservation Concern (Hoare et al. 2017, Grainger et al. 2018, Trewick et al. 2022)	Tall forest	Short forest	Shrubland		Pākihi		Tussockland				
	Mixed beech-podocarp-broadleaved forest	Southern rātā-mountain beech-podocarp forest	Mānuka-mountain beech-podocarp shrubland	Weedy shrubland	Mānuka-tussock-wire rush shrubland	Low pākihi	Tussock-flax shrubland	Sandstone pavement	Riparian	Open water	Cleared vegetation
Threatened – Nationally Critical											
Avatar moth (*Arctesthes avatar*)	0	0	0	0	0.5	1	0.75	0.5	0	0	0
Spathula neara (Aquatic flatworm)	0	0	0	0	0.25	0.25	0.75	0.25	0	0.5	0
Threatened – Nationally Endangered											
White-faced cave weta (*Occultastella morgana*)	1	1	1	0	0.5	0	0	0	0	0	0
Threatened – Nationally Vulnerable											
Kokira miharo (aquatic caddisfly)	0	0	0	0	0	0	0	0	0	0.5	0
Rygmodus alienus (water scavenger beetle)	0	0	0	0	0.5	0.75	0.5	0.5	0	0.5	0
At Risk - Relict											
Forest ringlet (*Dodonidia helmsii)*	0.5	1	1	0	1	0.75	0.5	0	0.5	0	0
Total	1.5	2	2	0	2.75	2.75	2.5	1.25	0.5	1.5	0
Mean	**0.25**	**0.33**	**0.33**	**0.00**	**0.46**	**0.46**	**0.42**	**0.21**	**0.08**	**0.25**	**0.00**

Bryophytes

Species of Conservation Concern (de Lange et al. 2020)	Tall forest	Short forest	Shrubland		Pākihi		Tussockland				
	Mixed beech-podocarp-broadleaved forest	Southern rātā-mountain beech-podocarp forest	Mānuka-mountain beech-podocarp shrubland	Weedy shrubland	Mānuka-tussock-wire rush shrubland	Low pākihi	Tussock-flax shrubland	Sandstone pavement	Riparian	Open water	Cleared vegetation
Threatened – Nationally Critical											
Allisoniella scottii	0	0	0	0	0.25	0.25	0	0	1	0	0
Isolembidium anomalum var. anomalum	0.25	1	1	0.25	0.75	1	0.25	0.5	1	0	0
Neogrollea notabilis	0	0	0	0.25	1	1	1	0.5	0	0	0
Pseudolophocolea denticulata	0.25	1	0.5	0	0.5	0	0	0	0	0	0
Threatened Nationally – Vulnerable											
Acromastigum verticale	0	1	1	0	0	0	0	0	1	0	0
Telaranea inaequalis	0.25	1	0.25	0	0.25	0.25	0	0	1	0	0
At Risk - Declining											
Acromastigum interstisiale	1	1	1	0	0	0	0	0	1	0	0
Saccogynidium decurvum	0.25	1	1	0	1	1	1	0.25	0.25	0	0
Total	2	6	4.75	0.5	3.75	3.5	2.25	1.25	5.25	0	0
Mean	**0.25**	**0.75**	**0.59**	**0.06**	**0.47**	**0.44**	**0.28**	**0.16**	**0.66**	**0.00**	**0.00**

Lichen

Species of Conservation Concern (de Lange et al. 2018)	Tall forest	Short forest	Shrubland		Pākihi		Tussockland				
	Mixed beech-podocarp-broadleaved forest	Southern rātā-mountain beech-podocarp forest	Mānuka-mountain beech-podocarp shrubland	Weedy shrubland	Mānuka-tussock-wire rush shrubland	Low pākihi	Tussock-flax shrubland	Sandstone pavement	Riparian	Open water	Cleared vegetation
Threatened Nationally Endangered											
Pycnothelia caliginosa	0	0	0	0	0	0	0	1	0	0	0
Threatened Nationally Vulnerable											
Austropeltum glareosum	0	0	0	0	0.25	0.25	0	1	0	0	0
Knightiella splachnirima	0	0	0	0	1	1	1	0.25	0	0	0
Cladia fuliginosa	0	0	0	0	0.5	0.25	0.25	1	0	0	0
At Risk - Declining											
Cladia inflata	0	0	0.5	0	1	0	1	0	0	0	0
Total	0	0	0.5	0	2.75	1.5	2.25	3.25	0	0	0
Mean	**0.00**	**0.00**	**0.10**	**0.00**	**0.55**	**0.30**	**0.45**	**0.65**	**0.00**	**0.00**	**0.00**

Weed Vulnerability Score

	Tall forest	Short forest	Shrubland		Pākihi		Tussockland				
	Mixed beech-podocarp-broadleaved forest	Southern rātā-mountain beech-podocarp forest	Mānuka-mountain beech-podocarp shrubland	Weedy shrubland	Mānuka-tussock-wire rush shrubland	Low pākihi	Tussock-flax shrubland	Sandstone pavement	Riparian	Open water	Cleared vegetation
Weed risk score	0	0.25	0.5	0.5	0.5	1	1	0.75	0.5	0	1
Total	0	0.25	0.5	0.5	0.5	1	1	0.75	0.5	0	1
Mean	**0.00**	**0.25**	**0.50**	**0.50**	**0.50**	**1.00**	**1.00**	**0.75**	**0.50**	**0.00**	**1.00**

ecoLogical Solutions
Environmental Consultants

December 2025

Conservation Prioritisation at the Buller Plateaux

Submitted to:
Bathurst Resources Limited

water fauna flora land

Quality Assurance

This report has been prepared and reviewed by the following:

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1.0 Introduction

1.1 Background and Purpose

Bathurst Resources Limited ('Bathurst') is seeking authorisation through the Fast-track Approvals Act 2024 ('FTAA') for the Buller Plateaux Continuation Project ('the BPCP'). The BPCP area includes parts of both the Denniston and Stockton Plateaux, collectively referred to here as the 'Buller Plateaux' and is located approximately 15km northeast of Westport as shown in Figure 1. The BPCP is a complex proposal which seeks to enable a mix of ongoing and new mining activities.

The BPCP has been divided into five project areas as follows and shown in Figure 1:

- Stockton (including the Ngakawau Coal Handling Facility and Aerial Ropeway);
- Cypress Mining Area ('Cypress');
- Mount Fred South ('MFS');
- Escarpment Extended ('ESE');
- Upper Waimangaroa Haul Road ('UWHR').

Disturbance areas (identified in Figure 1) show the extent of 'new' habitat removal within each of the project areas above.

Despite its long history of mining and human occupation, the Buller Plateaux is home to a large number of species of non-vascular flora (mosses, liverworts, hornworts, and lichens), vascular plants, terrestrial invertebrates (including land snails and wētā), lizards and birds which are considered 'Threatened' or 'At Risk' as well as naturally uncommon ecosystems and distinctive assemblages of species. The communities are predominantly indigenous and there are also a number of species with unusual or disjunct distributions which include the Buller Plateaux. Most of the Denniston Plateau comprises public conservation land administered by the Department of Conservation and conservation values are high or very high. Due to the competing interests of coal mining and ecosystem, habitat and species protection, the identification of any areas of particularly high conservation value is critical to inform planning for the BPCP by:

- Enabling avoidance of high value areas where achievable;
- Identifying suitable locations for minimisation and remediation activities where relevant; and
- Locating priority areas for ecological offsetting and compensation activities.

Conservation mapping of the Buller Plateaux was previously undertaken using Zonation software by the Department of Conservation in 2013 (Gruner 2013). Gruner (2013) used 24 biodiversity features and explored six scenarios, resulting in six maps with different conservation priority areas depending on the assumptions and constraints applied to each scenario. The Gruner (2013) assessment concluded that the use of potentially out of date and inaccurate data was a limitation, and noted that her approach provided a proof of concept to expand upon as new data came to hand. Another limitation of the Gruner (2013) approach was that survey effort was not comprehensive across the plateaux, and most information was collected from areas proposed for development, which may or may not have proceeded. A recent addition to the data available for inclusion to inform the assessment is a high-resolution vegetation map for the area. The vegetation within the area outlined in black in Figure 1 was recently mapped and described using plot-based surveys, high resolution drone photography, machine learning, local knowledge, and multivariate analysis to discriminate, describe and map the different vegetation types present (Ecological Solutions Limited 2025a). A low-resolution version of the vegetation map is provided as Figure 2.

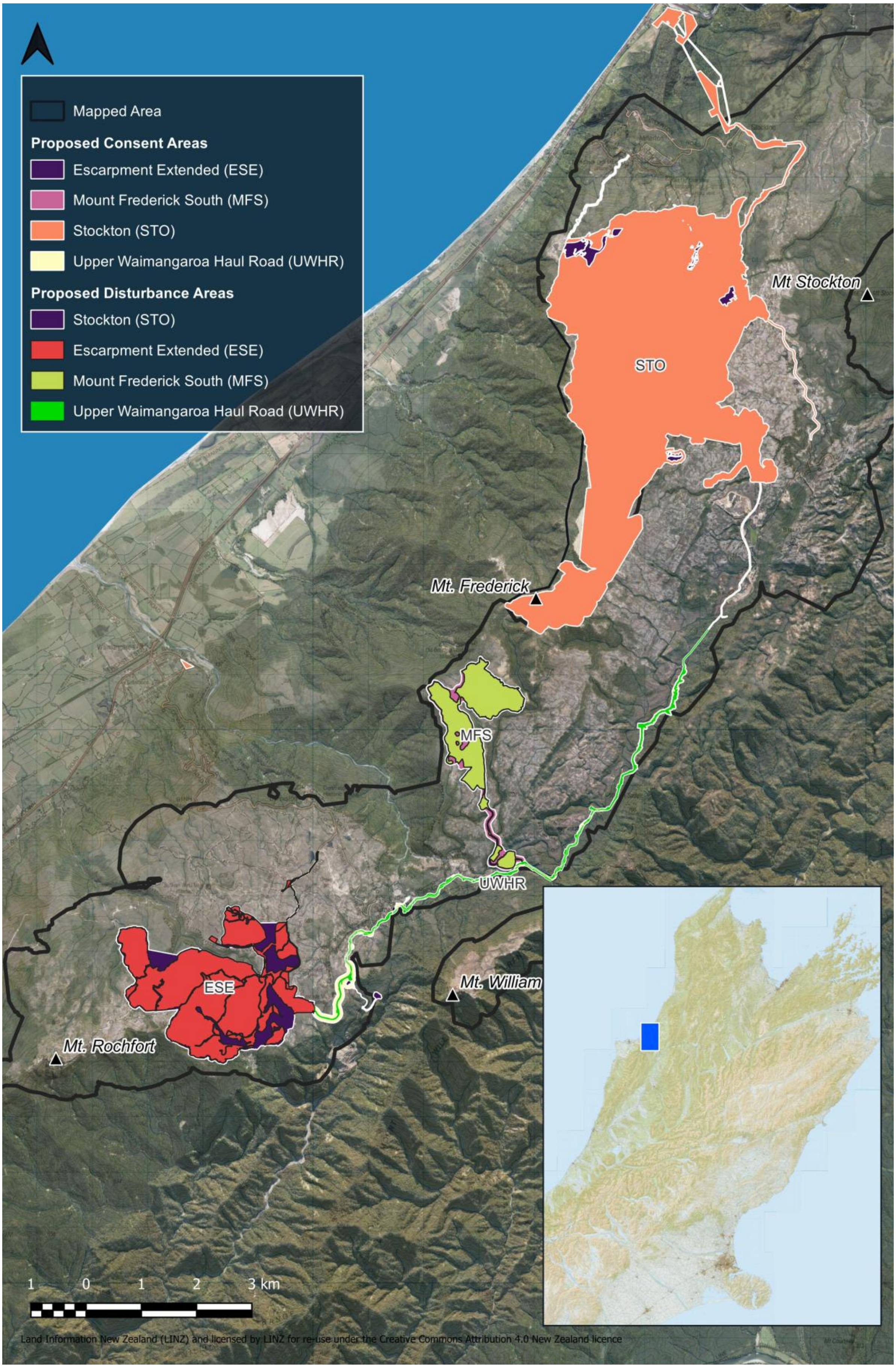

Figure 1: Mapped Area in relation to the Proposed Consent and Disturbance areas.

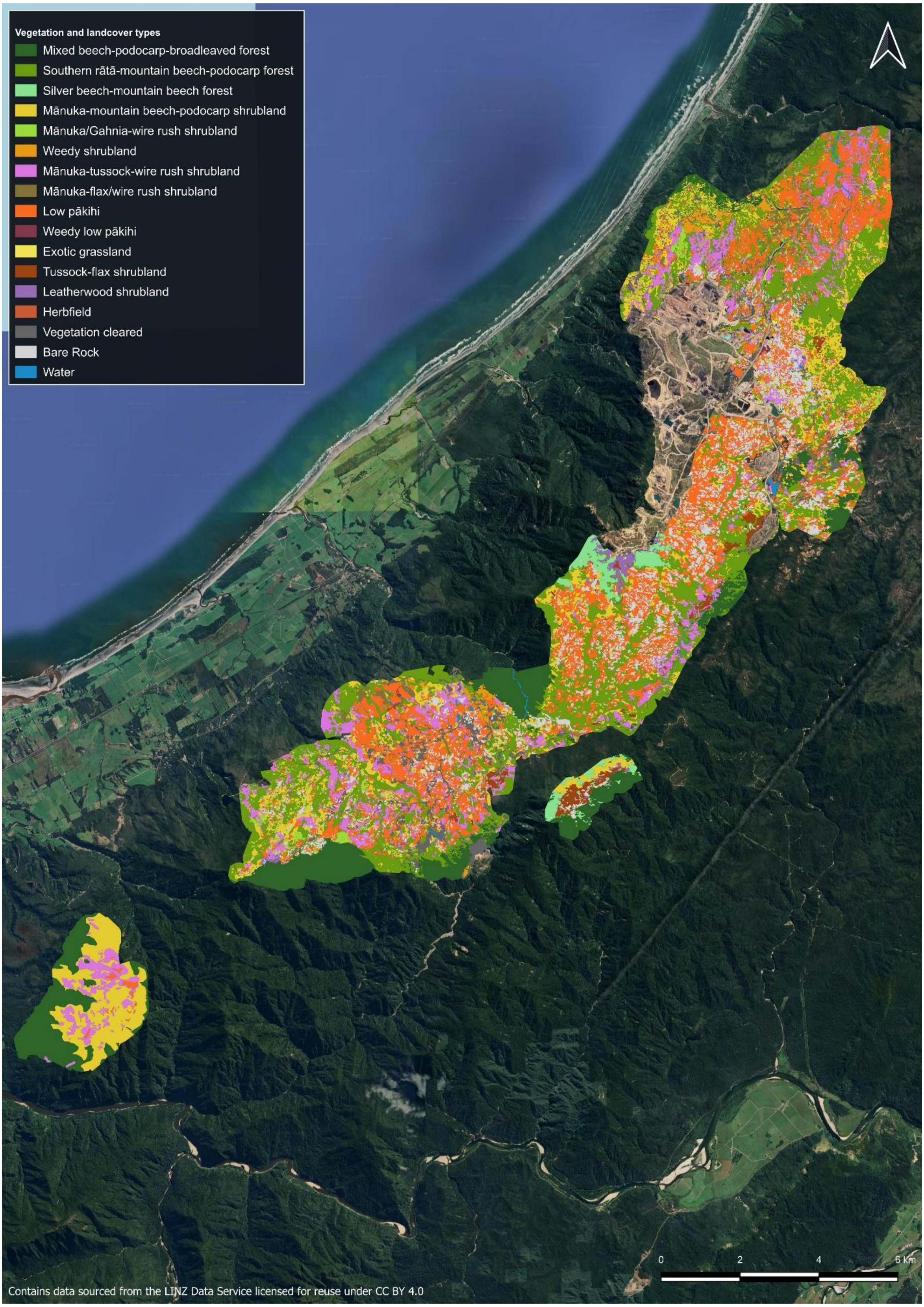

Figure 2: Buller Plateaux vegetation and land cover types (from Ecological Solutions Limited 2025a).

The vegetation types present are discussed further in Section 2.3.1 and described in detail in Ecological Solutions Limited (2025a). The mapped area was used as the boundary for this analysis.

This study used two approaches, firstly expanding on the analysis in Gruner (2013) by compiling recent species and feature location data collected up to 2024. Since this method was heavily reliant on survey effort, and the location of previous surveys, we attempted to reduce the sampling bias resulting from the previous unequal survey effort across the plateaux by using vegetation type as the primary input, rather than species locations, and scoring each vegetation type according to its value as habitat for the species of interest.

This report sets out the data and methods used to identify and map the areas of relative conservation value within the mapped area shown in Figure 2. The relative conservation value was identified using Zonation 5 software ('Zonation') (Moilanen et al. 2024) and data collected between approximately 1997 and 2024 and sourced from the ecological reports summarised in Ecological Solutions Limited (2025a, 2025b). Those reports, along with this one, are part of a suite of baseline ecological reports prepared to inform the BPCP Assessment of Environmental Effects ('AEE') (Mitchell Daysh 2025, in prep.).

2.0 Methods

2.1 Background and Rationale

Systematic Conservation Planning ('SCP') is a field of conservation biology concerned with the effective allocation of conservation efforts and the implementation of management actions. Zonation is a decision support tool used in spatial conservation and land use planning to identify priority areas and provide quantitative methods for enhancing species persistence.

Zonation has been used globally, although the tool has had limited application in New Zealand (Ribeiro and Atadeu 2019). Recent examples of the use of Zonation include spatial conservation over entire river basins (Yaun et al. 2025), conservation management of small mammals considering land use and climate change (da Costa-Pinto et al. 2023), amphibian conservation (Fuentes-de la Rosa et al. 2024) and restoration planning for land birds (Frand et al. 2024). As mentioned above, an earlier version of Zonation was used to identify and map high priority locations for conservation of biodiversity on the Buller Plateaux by Gruner (2013).

Zonation uses spatial raster input layers of the distribution of individual biodiversity features (species, habitats, ecosystem services and the like) to build a conservation prioritisation map which can be used to identify both 'high value' and 'low value' areas for conservation action. The Zonation software implements a set of interrelated techniques in one package and can account for many factors, including multiple costs, habitat condition and ecological connectivity. In this study, Zonation mapping was undertaken using two methods which are described in detail in Sections 2.4 and 2.5. The main differences in approach were:

Approach 1 - The first approach replicated and updated Gruner (2013), whereby historical survey data and current conservation status were used to give a score to individual species based on their vulnerability and threat status. In this approach the resulting conservation prioritisation map is based on known distributions of species within the Buller Plateaux and is necessarily dependent on known survey locations and distribution data. The species scores were derived during a workshop by Ecological Solutions and Dr. Matt Baber of Alliance Ecology Limited (a herpetologist) on 19 December 2024 (see Section 2.4.2 for detail). This approach favours areas which have been surveyed and found to contain 'Threatened' or 'At Risk' species, but does not take account of those species where they are present in areas that have not been surveyed.

Approach 2 - The second approach employed the 16 vegetation and land cover types that were identified as part of vegetation mapping of the Buller Plateaux as the input layers. Each vegetation and landcover type was scored based on its suitability for each of 54 species of conservation concern (either 'Threatened' or 'At-Risk') informed by the previous records from NZPCN, eBird, NZ Birds online of those species within the relevant vegetation/landcover. Using this approach the resulting conservation priority rank map is based on the known and potential distribution of the species of conservation concern within each vegetation type, independent of species records at particular locations. This approach was used in an attempt to reduce the sampling bias inherent in the first approach.

2.2 Zonation Outputs

2.2.1 Priority Rank Map (Heatmap)

The first output from the Zonation analysis is a priority rank map, otherwise known as a 'heatmap'. The heatmap is a raster layer containing a conservation priority value for each one-hectare cell. Values range between 0 (no value) and 1 (highest priority for conservation) indicating their priority rank. The heatmap is colour coded with a simple-to-interpret gradient from deep blue (low priority) to green (moderate priority) to orange and red indicating the highest priority areas. The priority is based on the input layers applied.

2.2.2 Performance Curves

The second output of Zonation are 'performance curves' that quantify the proportion of a feature that would be conserved if cells at a given rank were protected. In the example below (Figure 3), the top 20% of cells (i.e., ranks 0.8–1.0) hold roughly 85% of the distribution of that biodiversity feature. Conversely, the bottom 80% of cells contain 15% of that feature. Performance curves are generated for each input layer, and mean curves are also available in the output (Lehtomäki et al. 2016). The curves are helpful for understanding the overall performance of a zonation analysis, but can also be produced for individual features of interest (e.g., species or vegetation type).

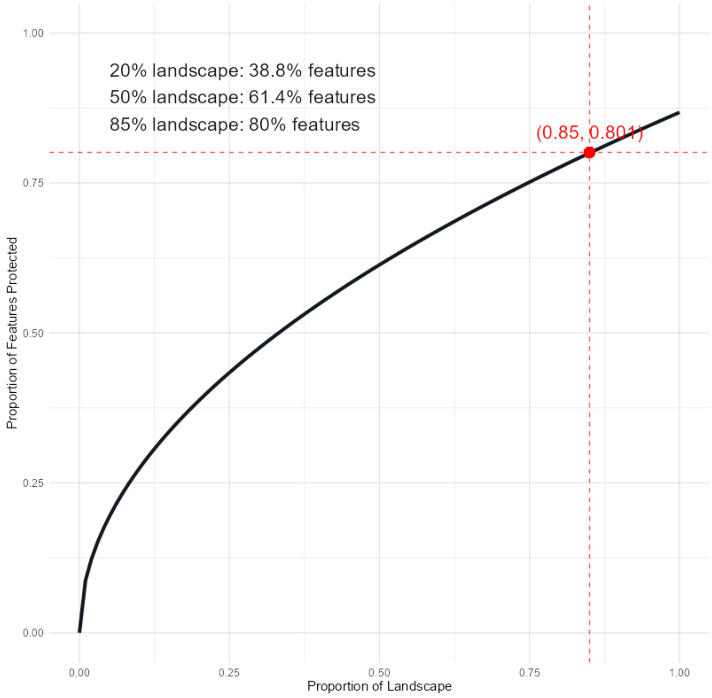

Figure 3: Hypothetical example of a performance curve produced by Zonation software illustrating the relationship between the proportion of landscape protected and the proportion of features protected.

2.3 Data Sources

2.3.1 Vegetation and Land Cover Types (Approach 1 and 2)

Vegetation and land cover types used were as defined and mapped in Ecological Solutions Limited (2025a). Ecological Solutions Limited (2025a) analysed compositional variation in 152 vegetation plots using data collected between 2008 and 2025 across the Buller Plateaux using multivariate analysis to discriminate classes.

By training a machine learning algorithm on the aerial images of plots of known vegetation class, 45,690 aerial photographs collected between July 2019 and January 2024 were then classified into vegetation classes and these were then used to create the overall vegetation map. The vegetation and land cover types identified and mapped within the mapped area covered c. 11,438ha within and surrounding the Buller Plateaux and this area also defined the boundary for this analysis.

2.3.2 Species Distribution Layers (Approach 1 and 2)

Approach 1

Each of the 24 species distribution layers used in Approach 1 was generated by collating data from existing reports where it was possible to identify and subsequently map an exact or approximate location for records of a species. The references used to derive the species distribution layers are listed by taxonomic group in Section 5.0. By way of example, we were able to use:

- GPS co-ordinates supplied within reports;
- Ecological Solutions Limited photographs of ‘Threatened’ and ‘At-Risk’ species with geolocation tags; and
- Geo-referenced maps from within reports.

QGIS version 3.34 was then used to generate a shapefile layer for each species with specific location information.

Approach 2

The information used to assign a value to each vegetation and land cover type dependent on either occupancy by or potential suitability for ‘Threatened and At-Risk’ species was informed by both existing records and known habitat preferences for these species described in existing reports (including those listed by group in Section 5.0), the Buller Plateaux Contextual study (Ecological Solutions Limited 2025b) and other sources such as the New Zealand Plant Conservation Network (NZPCN) website[1] and New Zealand Birds Online website[2]. Details with respect to assigning those values are set out in Section 2.4.3.

Species used in Each Approach

There were differences in the number of flora and fauna species used for Approaches 1 and 2 because the species used in Approach 1 were derived from existing location records whilst species used in Approach 2 were derived from both existing records as well as the presence of the preferred habitat for that species.

For example, some ‘Threatened’ and ‘At Risk’ species known to occur within habitats at the Buller Plateaux (e.g., avatar moth (*Arctesthes avatar*) and Denniston white-faced wētā (*Occultastella morgana*)) were excluded in Approach 1 because there were few or no specific location records for them. However, these species were included in Approach 2 because suitable habitat for them is present.

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[1] https://www.nzpcn.org.nz/
[2] https://www.nzbirdsonline.org.nz/

The list of plant species used in Approach 2 was more extensive than that used in Approach 1 (i.e., 26 versus 9 species) because a combination of confirmed species records and species known to occur in the Ngakawau Ecological District, but not confirmed from the Buller Plateaux, were used in Approach 2, but not in Approach 1. Species of conservation interest that have the potential to occur within the area were added and scored against the vegetation and land use types in Approach 2 but not in Approach 1. Details of both methods are discussed in Sections 2.4 and 2.5.

2.3.3 Streams (Approach 1)

Hogsden and Watson (2024) ranked stream quality within the Buller Plateaux based on data collected by various organisations between 1986 and 2024 including water quality information, sampling location coordinates and acidic metalliferous drainage ('AMD') categories. Data from Hogsden and Watson (2024) was provided in an excel spreadsheet to Ecological Solutions Limited and their categories were adopted here. Specifically in relation to AMD:

- High = mine affected.
- Low = not affected.
- Moderate = mixture of moderately mine affected and naturally acidic.

The classification of the streams was based on the following criteria:

1. pH – where pH >6 = low AMD, pH 4–6 = moderate AMD, and pH <4 = high AMD.
2. Conductivity – where conductivity <90µS/cm = low AMD, conductivity >90µS/cm = high AMD.
3. Metalloids – AMD were high where aluminium, nickel and/or zinc exceeded the ANZECC (ANZG 2018) and Canadian Council of Ministers of the Environment guidelines, or were an order of magnitude higher than the 'low' sites.

2.4 Zonation - Approach 1

2.4.1 Overview

The 45 data layers used for conservation mapping using Approach 1 are set out in Table 1. They include 26 species layers for 'Threatened' and 'At Risk' plant and animal species known to occur on the Buller Plateaux, three stream layers (low AMD, moderate AMD and high AMD) and 16 vegetation and land cover classes identified in Ecological Solutions Limited (2025a). The sources used to generate each layer are set out in Section 2.3.

2.4.2 Data Processing and Setup

The conservation priority maps were developed using the following workflow:

1. Vegetation types, species distribution and other relevant data were collated from various sources as set out in Section 2.3. The specific data used is set out in Table 1.
2. Each data layer was processed so that species presence / absence was recorded within each 1ha cell.
3. Presence data was converted to a raster layer for input into Zonation for analysis.
4. Zonation configuration files (i.e., the settings files) included settings for the features and rules are shown in Table 2.

This pre-processing of species data (i.e., steps 1–4) was automated in QGIS version 3.34.

The features and rules of the model are detailed in Table 2.

Table 1: Input data used in the preparation of conservation priority maps – Approach 1.

Group	Species / features	Conservation status	Scoring Criteria A Irreplaceability	Scoring Criteria B Vulnerability (threat) status	Score (A x B)
Avifauna	Kea (*Nestor notabilis*)	Threatened – Nationally Endangered	0.10	0.70	0.07
	Kākā/South Island kākā (*Nestor meridionalis meridionalis*)	Threatened – Nationally Vulnerable	0.20	0.70	0.14
	Rōroa/Great spotted kiwi (*Apteryx maxima*)	Threatened – Nationally Vulnerable	0.50	0.70	0.35
	Koekoeā/long-tailed cuckoo (*Eudynamys taitensis*)	Threatened – Nationally Vulnerable	0.20	0.70	0.14
	Kakaruai/South Island robin (*Petroica australis australis*)	At Risk – Declining	0.20	0.50	0.10
	Mātātā/South Island fernbird (*Bowdleria punctata punctata*)	At Risk – Declining	0.70	0.50	0.35
	Pīhoihoi/New Zealand pipit (*Anthus novaeseelandiae novaeseelandiae*)	At Risk – Declining	0.60	0.50	0.30
	Yellow-crowned parakeet (*Cyanoramphus auriceps)*	At Risk – Declining	0.20	0.50	0.10
Non-vascular flora (bryophytes and lichens)	Four species of liverwort*	Threatened – Nationally Critical	1.00	1.00	1.00
	Two species of liverwort	Threatened – Nationally Vulnerable	0.50	0.70	0.35
	Two species of liverwort	At Risk – Declining	0.50	0.50	0.25
	32 species of liverwort, two species of moss and one hornwort	At Risk – Naturally Uncommon	0.50	0.30	0.15
	Three species of lichen	Threatened – Nationally Endangered Threatened – Nationally Vulnerable	0.50	0.70	0.35
	Four species of lichen	At Risk – Declining At Risk – Naturally Uncommon	0.50	0.50	0.25
Herpetofauna	Forest gecko *(Mokopirirakau granulatus)*	At Risk – Declining	0.80	0.50	0.40
	West coast green gecko *(Naultinus tuberculatus)*	Threatened – Nationally Vulnerable	0.90	0.70	0.63
	Newman's speckled skink (*Oligosoma newmani)*	At Risk – Declining	0.50	0.50	0.25
Invertebrates	*Powelliphanta patrickensis*[#]	Threatened – Nationally Critical	1.00	1.00	1.00
Streams	High AMD	-	0.20	0.10	0.02
	Moderate AMD	-	0.20	0.20	0.04
	Low AMD	-	0.20	0.60	0.12
Vascular Plants	*Astelia subulata*	At Risk – Naturally Uncommon	0.20	0.30	0.06

	Brachyglottis traversii	At Risk – Naturally Uncommon	0.50	0.30	0.15
	Coal measures tussock (*Chionochloa juncea*)	At Risk – Declining	1.00	0.50	0.50
	Dracophyllum densum	At Risk – Declining	0.30	0.50	0.15
	Euphrasia wettstieniana	At Risk – Declining	0.50	0.50	0.25
	Red mistletoe (*Peraxilla tetrapetela*)	At Risk – Declining	0.20	0.50	0.10
	Pseudowintera traversii	At Risk – Declining	0.50	0.50	0.25
	Sticherus (*S. tener, S. urceolatus*)	At Risk – Naturally Uncommon	0.50	0.30	0.15
Vegetation Types	Silver beech-mountain beech forest	-	0.70	0.25	0.17
	Mānuka-mountain beech-podocarp shrubland	-	0.80	0.25	0.20
	Mānuka/Gahnia-wire rush shrubland	-	0.70	0.50	0.35
	Weedy shrubland	-	0.30	0.20	0.06
	Mānuka-tussock-wire rush shrubland	-	0.70	0.50	0.35
	Mānuka-flax/wire rush shrubland	-	0.70	0.50	0.17
	Exotic grassland and herbfield	-	1.00	0.75	0.75
	Low pākihi	-	1.00	0.25	0.25
	Weedy low pākihi	-	0.80	0.20	0.16
	Exotic grassland	-	0.10	0.10	0.01
	Tussock-flax shrubland and herbfield merged	-	1.00	0.75	0.75
	Leatherwood shrubland	-	0.50	0.75	0.37
	Cleared vegetation	-	0.10	0.10	0.01
	Mixed beech-podocarp-broadleaved forest	-	0.50	0.50	0.25
	Southern rātā-mountain beech-podocarp forest	-	0.80	0.25	0.20
	Bare rock	-	1.00	0.25	0.25

Note: * Nationally critical liverwort species: *Allisoniella scottii, Isolembidium anomalum* var. *anomalum, Neogrollea notabilis* and *Pseudolophocolea denticulata*.

Powelliphanta augusta also occurs within the Buller Plateaux, but it's known natural distribution is mostly within the active Stockton Mine so it was not included in this analysis.

Table 2: Zonation Setup – Approach 1.

Features and rules	Comment
Input layers	45 input layers listed in Table 1 reflecting known distributions of native flora and fauna of conservation concern and other relevant information including vegetation types and stream classifications.
Weighting	Weights were applied based on endemism, threat status and conservation values as shown in Table 1. Streams were scored according to their acidic metalliferous mine drainage (AMD) status (Hogsden and Watson 2024), vegetation classes were scored equally. Bryophytes were weighted according to their conservation status (de Lange et al. 2020; Rolfe et al. 2016) as were vascular plants (de Lange et al. 2024) and lichens (de Lange et al. 2024). Land snails (*Powelliphanta patrickensis*) are 'Threatened – Nationally Critical' (Walker et al. 2022) and were given a weight of '1' given they are endemic to the Buller Plateaux and have the highest possible threat status. Birds were also weighted according to conservation status (Robertson et al. 2021).
Cost	No cost layer was applied. Cost layers can be used when the costs of rehabilitation land acquisition and maintenance are known or have been estimated for areas of interest.
Hierarchical masks	A hierarchical mask in Zonation is a GIS layer that captures information about the hierarchy of land uses in the landscape. Zonation ensures that highest priority ranks are assigned to protected areas. Masks were not applied at this stage of the project because this would have elevated the ranks of legally protected conservation areas, as opposed to identifying the highest value conservation areas.
Cell removal rule	The core area zonation (CAZ2) cell removal value was applied in this analysis. This is the default rule in Zonation 5. The CAZ2 emphasises high average coverage, even at the cost of reduced coverage for some features. Adopting this rule comes with the trade-off of lower coverage for the lower-weighted features.

2.4.3 Assigning Scores

Alliance Ecology Limited and Ecological Solutions Limited held a workshop (19 December 2024) to assign scores for each input layer used in Approach 1. Weights were assigned for each species or feature on a scale between 0 and 1. Scores were assigned according to irreplaceability and vulnerability which were multipliers for the final overall weighting as set out in Table 1.

The irreplaceability score for a feature or species was based on their uniqueness (endemism), their dependence upon the Buller Plateaux habitat types for their persistence and the relative importance of the Buller Plateaux for that species. For example, the snail *Powelliphanta patrickensis* is endemic, is dependent on vegetation at the Buller Plateaux and is only found there. It was accordingly scored '1' for irreplaceability.

The vulnerability score is a proxy for threat status, with 'Nationally Critical' species being assigned a 1, 'Nationally Endangered' or 'Nationally Vulnerable' species assigned 0.7, 'Declining' species assigned 0.5 and 'Naturally Uncommon' species assigned 0.3.

An example of how irreplaceability differs from vulnerability for kea (*Nestor notabilis*) using the plateau is as follows: kea are highly vulnerable with a threat status of 'Threatened – Nationally Endangered' – they were assigned a vulnerability score of 0.7. Kea using the plateaux were assigned a low irreplaceability score (0.1) because they only occasionally visit the plateaux, and it is not regarded as 'core habitat' for kea. The loss of the Buller Plateaux habitats used by kea would be unlikely to significantly affect kea persistence.

With respect to vulnerability of streams, there is no conservation status classification system for watercourses that we are aware of. High AMD streams were given a score of 0.2 for irreplaceability and a score of 0.1 for vulnerability based on their current poor state and the limited potential for further effects in an already affected stream. Moderate AMD streams were given weights of 0.2 for irreplaceability and vulnerability.

Low AMD streams were also given a weight of 0.2 for irreplaceability and a moderately high weight of 0.6 for vulnerability as they are more susceptible to change than the high and moderate AMD streams.

Ecological Solutions Limited (2025a) identified 16 vegetation and land types which were used as input layers for zonation. Vegetation types: mānuka/Gahnia-wire rush shrubland, mānuka-tussock-wire rush shrubland, mānuka-flax/wire rush shrubland, low pākihi and weedy low pākihi are considered 'Naturally Uncommon' (Wiser et al. 2007). Bare rock (sandstone erosion pavement is 'Endangered' (Holdaway 2012) and other wetland types not assigned threat status but referred to as 'Naturally Uncommon' (MfE 2007) are mānuka-mountain beech-podocarp shrubland and tussock-flax shrubland.

The irreplaceability scores for vegetation classes were based on rarity, uniqueness, and value as habitat for 'Threatened' plant species. Consideration of vulnerability was largely based on the extent remaining within the Buller Plateaux for each vegetation class with those which have already been substantially reduced scoring higher than those which have not (Ecological Solutions Limited 2025a).

2.5 Zonation – Approach 2

2.5.1 Overview

The 16 vegetation and land cover types identified in Section 2.3 were used as input layers for Approach 2. The features and rules of the model are detailed in Table 3. Approach 2 relied on an estimated habitat value for each of the species known or likely to occur on the Buller Plateaux identified in Table 3. To estimate this value, each vegetation type was assigned a habitat value on a 5-point scale (0–1) for each species. This value was then summed for each of the seven taxa groups (vascular plants, bryophytes, lichen, snails, other terrestrial invertebrates, lizards and birds) to give a habitat value for each group and then across all groups to give an overall habitat value score.

2.5.2 Data Processing and Setup

The conservation priority maps were developed using the following workflow:

1. A list of 'Threatened' and 'At Risk' species known or predicted to occur, vegetation types, species distribution and other relevant data were collated from various sources as set out in Section 2.3. The specific data used is set out in Table 3.
2. Each species was assigned a habitat suitability score between 0 and 1 for each vegetation and land cover type as set out in Sections 2.5.3 and 2.5.4.
3. Each of the 16 vegetation type layers were converted to raster layers based on the presence or absence of each feature in each 1ha. grid cell across the mapped area.
4. Zonation configuration files (i.e., the settings files) included settings for the features and rules are shown in Table 4.

This pre-processing of species data (i.e. steps 1–4) was automated in QGIS version 3.34. The features and rules of the model are detailed in Table 4.

Table 4: Zonation Setup – Approach 2.

Features and rules	Comment
Input layers	16 vegetation and land cover layers (Table 3) which were assigned scores for their suitability and known occupancy for each of the 54 species identified.
Scores	Scores were assigned to each vegetation class using the scoring system described below and in Table 5 and Table 6. Stockton Mine was included in the analysis and given a negative score indicating that it is not available or suitable habitat. This is a conservative approach because 'Threatened' and 'At Risk' species are known to occur in rehabilitated sites within the mine, including *Powelliphanta patrickensis*.
Cost	No cost layer was applied. Cost layers can be used when the costs of rehabilitation land acquisition and maintenance are known or have been estimated for areas of interest.
Cell removal rule	The core area zonation (CAZ2) cell removal value was applied in this analysis. This is the default rule in Zonation. The CAZ2 emphasises high average coverage, even at the cost of reduced coverage for some features. Comes with the trade-off of lower coverage for the lower-weighted features.

2.5.3 Flora Scoring System

A scoring system was used to assign each vegetation type a habitat suitability score considering the likelihood of occurrence for each species within each vegetation and landcover type. The scoring system for flora species is presented in Table 5.

Table 5: Habitat scoring system used to assign habitat value to vegetation types for vascular and non-vascular plants for input into Zonation.

Score	Description
0	Unsuitable habitat. No known records within the vegetation type and/or completely different vegetation from the usual habitat for the species under consideration.
0.25	Marginal habitat. No evidence of the vegetation type being suitable for species under consideration, but may be present based on the structure, composition, hydrology or other environmental variables associated with the vegetation type.
0.5	Likely suitable habitat, but the species under consideration within that vegetation type is unconfirmed (i.e., based on a broad description of the vegetation type from surveys, habitat preference derived from NZPCN or other sources not specific to the Buller Plateaux).
0.75	Preferred habitat as described in surveys/studies undertaken within the Buller Plateaux and surrounds, but lacking specific location data.
1	Preferred habitat with confirmed record of species under consideration within the vegetation type within the Buller Plateaux and surrounds (e.g., herbarium records, survey data or photographs).

2.5.4 Fauna Scoring System

The habitat value of each vegetation type for particular fauna was assigned using a similar scoring system to that used for flora as set out in Table 6. An assessment of the likelihood of occupancy by fauna must also consider the temporal and spatial use of habitats since fauna move across the Buller Plateaux and wider landscape using a variety of vegetation classes at different times with varying frequency. This mobility varies between fauna groups and to a lesser extent among species, although the high heterogeneity of the habitats within the Buller Plateaux means that even poorly mobile species may travel between several vegetation types regularly. Detectability of fauna also varies, including across different habitat types, which increases the degree of uncertainty associated with estimating habitat value.

Some species with ranges extending beyond the Buller Plateaux have declined in abundance or range, or both, to the point that the likelihood or frequency of habitat use on the plateaux has been affected and this is reflected in the scores shown in Table 6. A summary of habitat descriptions provided in previous surveys was used to separate habitat value for fauna into the five levels set out in Table 6 which consider both likelihood and frequency of occupancy.

Table 6. Fauna species scoring system applied to different vegetation classes.

Score	Description
0	Vegetation type comprises mostly unsuitable habitat. Records may exist, although occupancy is expected to be limited to movements between other habitat types.
0.25	Vegetation type includes marginal or occasional habitat. Near the edge of habitat requirements, may be used infrequently and is of minor importance to the species being considered.
0.5	Vegetation type includes suitable secondary habitat. Occupancy may not be permanent or densities are lower than primary habitats.
0.75	Vegetation type includes suitable primary habitat. Supports permanent populations, at higher densities than secondary habitat, although preferred habitat may exist elsewhere.
1	Vegetation type includes referred primary or obligate habitat. Supports permanent populations at the highest densities known.

3.0 Results

3.1 Approach 1

3.1.1 Performance Curves

Performance curves for streams, flora (all vegetation types and species listed in Table 1) and fauna (all fauna groups listed in Table 1) are shown in Figure 4. The proportion of land potentially protected is shown on the x-axis and the shading along the x axis also shows the priority cell ranks (i.e., priority ranks 0.7–1.0 cover ~ 30% of the landscape). The y-axis represents the mean proportion of a species or feature that would be protected given the proportion of land protected.

On average, if 10% of the Buller Plateaux was protected (i.e., protection of areas with priority rank of 90 or above), approximately 70% of species / features would be present within those areas. For fauna, this area would include approximately 90% of the species distribution and for flora, this number is 60%. Increasing protected areas to 20% would increase flora species presence to approximately 80% of species. On average, protection of approximately 30% of the area would include around 90% of species.

Approximately 90% of the Buller Plateaux stream extent would be included if 25% of the land was protected. The number of streams that were categorised for the zonation analysis under-represented the diversity of the plateaux stream network, which is why distribution cover of 100% is achieved with less land protection than shown by the flora, fauna and feature average curves.

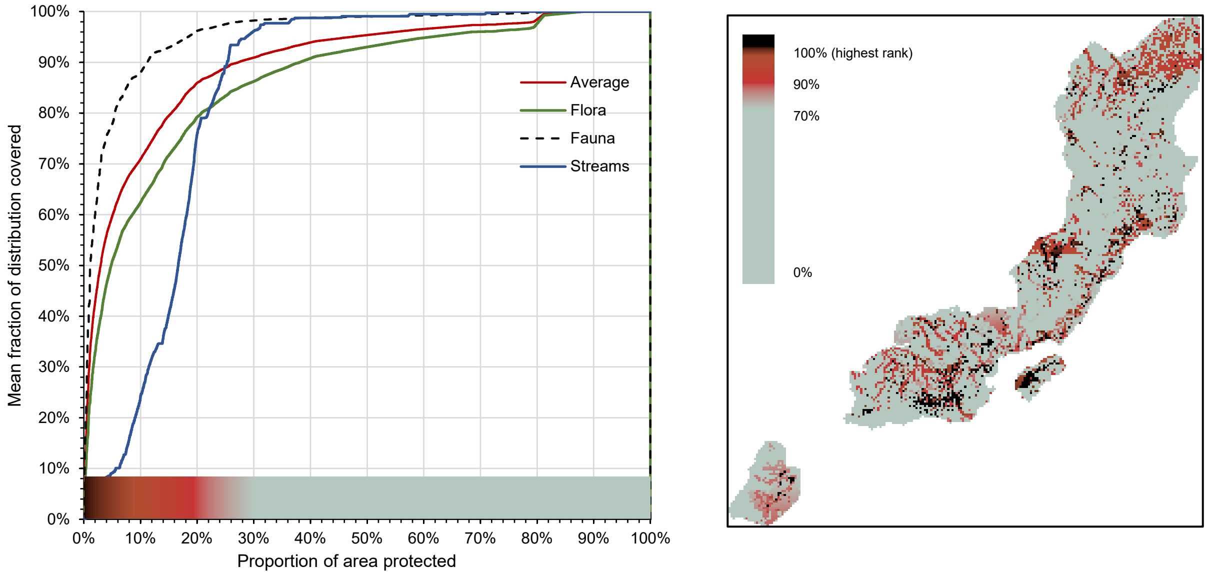

Figure 4: Zonation performance curves for each input group at the Buller Plateaux.

Performance curves for individual species present are useful to identify specific areas and/or habitat classes for management. For example, if the top 20% of areas (i.e., priority areas with ranks 0.8–1.0) were protected, 73% of the forest gecko and 100% of West Coast green gecko distribution would be retained as shown in Figure 5A.

Similarly, if the top 20% of areas for bryophytes were protected, all bryophytes would be captured as shown in Figure 5B. This also applies to snails (Figure 5C), coal measures tussock (Figure 5D), great spotted kiwi (rōroa) (Figure 5E) and South Island fernbird (Figure 5F).

3.1.2 Feature Richness

Locations with the highest number of features (i.e., species and feature richness) are identified in Figure 6. The scale 0–20 in Figure 6 represents the number of species and features in each 1ha cell. Red areas contain the greatest number of species and/or features, while the darker blue areas contain the fewest.

As shown in Figure 6, the highest number of species and/or features are located in three general areas:

1. to the north and east of the Stockton project area;
2. to the north and east of the Mount Frederick South project area (south of Mt Frederick itself); and
3. within and north of the Escarpment Extended project area.

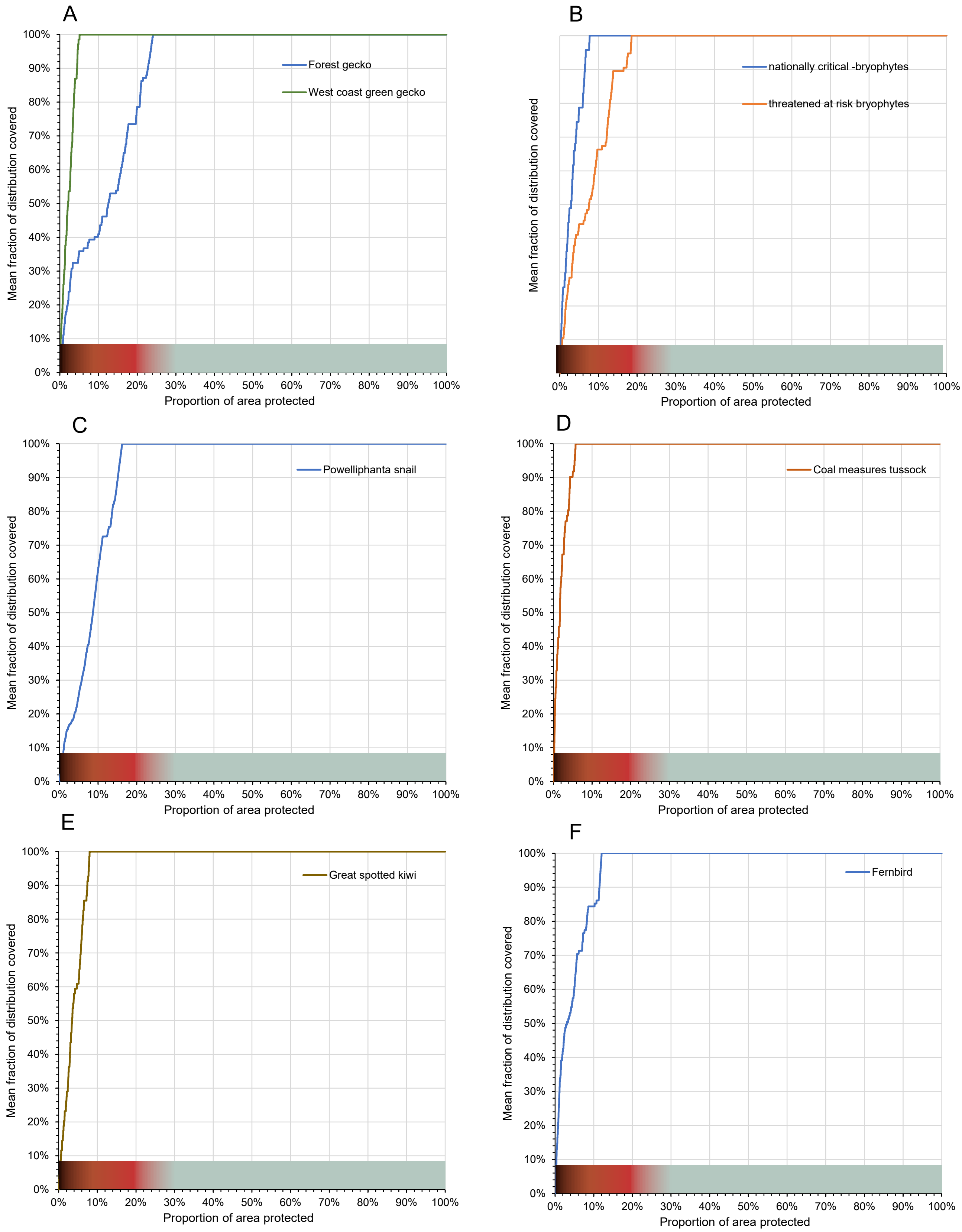

Figure 5: Individual Zonation performance curves for A) Lizards, B) Bryophytes, C) snails, D) coal measures tussock, E) rōroa, and F) Fernbird at the Buller Plateau.

3.1.3 Priority Rank Heatmap

Selected species distribution maps are provided in Appendix A, which show the locations of highly weighted features in relation to the priority rankings.

The areas identified as having high feature richness (i.e., species and land types) in Figure 6 show that feature richness is not the key driver in determining the conservation priority ranks on the Buller Plateaux. For example, the Mount Frederick and Te Kuha areas have low diversity compared to Mount Stockton and the Escarpment Mine areas, but have high conservation priority ranks as shown in Figure 7.

In the case of Mount Frederick, the high ranks are a result of several 'Threatened' and/or 'At Risk' plant species being present, whilst at Deep Creek the low AMD stream, and presence of snails and vegetation types with moderate habitat scores have led to the high overall scores.

The zonation analysis using Approach 1 identified eight main locations at the Buller Plateaux with high priority rankings (i.e., >0.7) as shown in Figure 7.

The highest priority areas were:

- South of Mt Frederick;
- Within the Extended Escarpment Project Area;
- North of Mount Stockton including Weka Creek, Mangatini Stream;
- The summit and upper slopes of Mt William;
- Te Kuha;
- West of Cypress Mining area;
- The summit of Mount Rochfort; and
- West of the UWHR Project sub-area.

Together these eight areas cover c. 3,453ha within the mapped area (30% of total area). The majority of these high priority areas would not be affected by the BPCP. Of the high priority areas identified, 361ha (10.5%) would be removed by the BPCP, with the worst affected areas being the Escarpment Extended and Mount Frederick South Project areas as set out in Table 7. The location of these high priority areas in relation to the Project Area is shown in Figure 7.

Table 7: High conservation priority cells (score >0.7) comprising each proposed disturbance area for the Buller Plateaux Continuation Project.

Project Area	Total area (approx.)	Disturbance within Project Area (loss)	High priority land within Project area (a)	High priority land within Disturbance area (loss) (b)	Proportion of high priority land in disturbance area lost (b/a)
Mount Frederick South	215ha	153ha	34ha	22ha	0.65
Escarpment Extended	574ha	459ha	338ha	279ha	0.83
Stockton	1,892ha	93ha	522ha	42ha	0.08
UWHR	283ha	38ha	132ha	18ha	0.14
Mapped Area	11,582ha	743ha	1,026ha	361ha	0.35

[redacted]

Figure 6: Species and vegetation class richness heatmap derived using Zonation. Red areas have high species richness; blue areas have low species richness.

[redacted]

Figure 7: Conservation priority areas ranked from low (blue) to high (red) and project disturbance areas.

A comparison of Figure 7 and Figure 8 highlights the similarities and some differences between this assessment and that by Gruner (2013). The two analyses were conducted 12 years apart. Note that the colour scale in Figure 8 is the reverse of the scale used here (red is low value, blue is highest value in Figure 8) and that the two studies have a different boundary and extent. There have been additional surveys in all the Project sub-areas since Gruner's analysis.

The priority heatmap generated using the first approach is generally consistent with Gruner's (2013) assessment. The unconstrained map (Scenario 1 in Gruner 2013, reproduced as Figure 8, showed the highest value areas in that scenario were located along the Mt Augustus/Mt Frederick ridgeline, from the slopes of Mt Stockton south into the St Patricks Stream and the upper Waimangaroa River catchments, in the Whareatea River catchment, around Myers Stream and along the Te Kuha ridgeline. The same area ranked highly (between 0.7 and 1.0) in this study due to the presence of 'Threatened' and 'At Risk' bryophytes, high value indigenous vascular flora and high stream values.

The areas immediately north and west of the Escarpment Extended project area also scored highly in the conservation priority/heat maps derived here and shown in Figure 7 and 8.

The high priority area along the UWHR includes a 100m buffer (50m either side) allowing for edge effects and general access during the construction works. More recent surveys have identified a large number of new records for bryophytes, snails, geckos and kiwis along the UWHR (including Ecological Solutions Limited, 2025a, Baber, 2024 and Nichol, 2020). Whilst Figure 6 shows that the UWHR has low species richness, it has high priority cell ranks, which is driven by the scores given to the species occurring there and their relative vulnerability and irreplaceability.

Low conservation priority areas identified using the first approach were also similar to those identified by Gruner (2013). Gruner (2013) also identified low value areas around the Coal Creek catchment at Denniston and around the Millerton and Stockton settlements, on the western slopes below Mt Augustus and Mt Frederick, and in the lower Orowaiti, Ballarat Creek and Coal Creek catchments which were outside the area considered here.

The location of the high priority areas just north of Mount Stockton were similar in both studies, although the present study extended further in that area as well.

The main difference between Gruner (2013) and this study is the identification of high priority areas in the southern part of the proposed UWHR and higher priority ranks associated with the Te Kuha area in this study. Interestingly, the high priority area along the UWHR was identified as high priority in both analyses.

[redacted]

Figure 8: Conservation priority areas (Gruner 2013). Ranked from low (red) to high (blue) and disturbance areas.

3.1.4 Area Statistics

The individual project areas on the Buller Plateaux range between 213–1,845 ha at Mount Frederick South and Stockton, respectively (shown in Table 7, Section 3.1.3), although the actual area of new disturbance would be less (also shown in Table 7).

Highly ranked (i.e., priority) areas covered 338ha in the Extended Escarpment project area, 132ha along the UWHR, 522ha within the Stockton Project Area and a total of 3,453ha within the mapped area. The proportion of each Project Area occupied by high conservation priority cells (i.e., >70%) is set out in Table 7. Within the Project Area the new disturbance comprises c. 35% of the high priority areas.

3.2 Approach 2

3.2.1 Performance Curves

The average performance curve for the 16 vegetation and land cover layers, as well as the priority rank map for cells with ranks 0.7–1.0 are shown in Figure 9A and 9B respectively.

The proportion of land required to be protected is shown on the x-axis and the y-axis is the mean proportion of vegetation or land cover classes that would be retained given the proportion of land protected. As shown in Figure 9A, if 10% of the Buller Plateaux (i.e., areas with priority rank of 90 or above) was protected, approximately 40% of vegetation types and associated values would be retained within these areas. Increasing the extent of protected areas to include 60% of the priority areas would increase the retention of ecological values to approximately 80%. Protection of approximately 80% of the priority areas is required to retain 90% of the features.

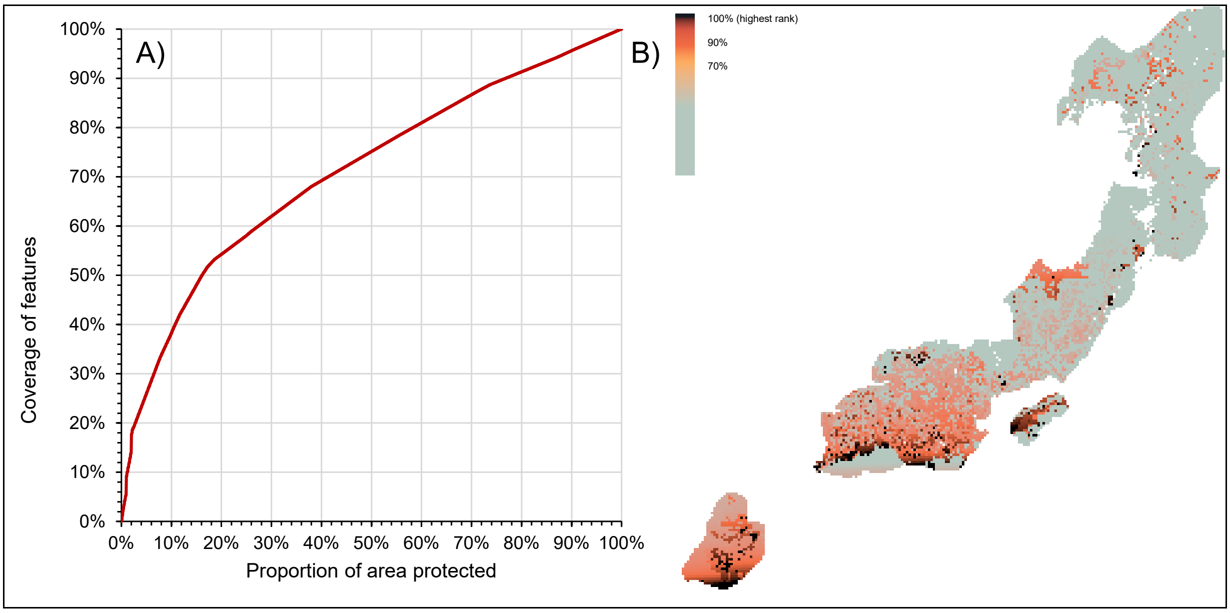

Figure 9: A) Mean performance curve for input layers into Zonation using Approach 2 B) High priority areas (rank 0.7–1.0) identified.

3.2.2 Priority Rank Heatmap

The priority conservation rank heat map for all species is shown in Figure 10. Conservation rank maps for each species group are shown in Appendix B. The overall map presents the results from all species scores (out of a possible 54) while the individual maps provide conservation priority ranks for each individual species group within each vegetation type.

Approach 2 identified four main areas with priority rankings above 0.7 (i.e., high priority areas) as shown in Figure 10. These areas are:

- Denniston Plateaux including and surrounding the Extended Escarpment Project area;
- The headwaters of Deep Creek (north of the proposed Mt Fred South Project area and south of Mt Frederick);
- The summit of Mt William; and
- Te Kuha.

The vegetation types identified as high priority occupy large areas at both Te Kuha and within the Extended Escarpment Project Area and surrounds as shown in Table 8. The large amount of priority habitat partly explains why the extent of high priority areas required to protect all the features in Approach 2 is larger than the area identified using Approach 1 – the priority rank heatmap is based on species and features being present within those vegetation types, rather than at specific locations. The high priority locations (i.e., those with ranks above 0.7) are shown in Figure 10.

Figure 7 and Figure 10 have some similarities, including that the highest priority areas (i.e., ranks >0.7) are located within the Extended Escarpment Project area, at Mt William and at Te Kuha.

Vegetation within the priority area identified at the Deep Creek headwaters is dominated by mixed silver and mountain beech forest, which provides important habitat for birds (see Appendix B). The priority area also includes approximately 11ha of low pākihi habitat, which scores highly for vascular plants, snails, invertebrates and lichens of conservation concern.

Vegetation at the summit of Mt William mostly comprised two main vegetation types: mixed silver and mountain beech forest and tussock / flax shrubland. The former provides habitat for significant bird species and the latter provides habitat for significant vascular plants and lizard species. Snails are not known to occur at Mt William. A third vegetation type (mānuka-mountain beech-podocarp shrubland) occupies approximately 36ha at Mt William and provides habitat for two lizard species and bryophytes of conservation interest (see Appendix B).

At Te Kuha there were three common vegetation types including: beech-podocarp-broadleaved forest, mānuka-mountain beech-podocarp shrubland and mānuka-tussock-wire rush shrubland, which provides habitat for significant bird species, lizards and bryophytes, invertebrates and lichens. No *Powelliphanta* snails have been recorded at Te Kuha.

Table 8: Extent of vegetation and land cover types in High Priority areas using Approach 2 and the species that each type supports.

Vegetation and land cover types	Extent (ha.)				Key species groups from Table 6 associated with vegetation and landcover types.
	Deep Creek Headwaters	Escarpment	Mt. William	Te Kuha	
Forest					
Mixed beech-podocarp-broadleaved forest	0.00	104.28	19.03	293.74	Birds
Southern rātā-mountain beech-podocarp forest	12.83	641.93	1.79	0.00	Birds
Silver beech-mountain beech forest	81.23	0.00	40.34	0.00	Birds
Shrubland					
Mānuka-mountain beech-podocarp shrubland	3.11	270.02	36.75	369.04	Lizards, bryophytes
Mānuka/Gahnia-wire rush shrubland	0.00	62.00	0.00	0.00	Lizards, bryophytes
Weedy shrubland	0.00	56.56	0.00	0.00	-
Mānuka-tussock-wire rush shrubland	0.00	326.76	0.00	129.33	Snails, other terrestrial invertebrates, lichens
Mānuka-flax/wire rush shrubland	0.50	25.11	0.00	0.00	Snails, bryophytes
Leatherwood shrubland	32.59	4.68	4.53	0.00	-
Low vegetation					
Low pākihi	11.17	545.52	0.71	14.22	Vascular plants, snails, other terrestrial invertebrates, lichens
Weedy pākihi	0.00	2.28	0.00	0.00	-
Tussock-flax shrubland	2.33	14.26	45.39	0.00	Vascular plants, snails
Exotic grassland	0.00	1.09	0.00	0.00	-
Herbfield	0.00	0.00	0.00	0.25	-
Non-vegetated land cover					-
Bare Rock	6.30	176.22	14.58	0.00	Vascular plants, lizards
Vegetation cleared	0.00	173.84	0.00	0.00	-
Water	0.00	5.47	0.00	0.06	-

[redacted]

Figure 10: Conservation priority rank heat map created using Approach 2 in Zonation.

[redacted]

Figure 11: Conservation priority rank heatmap for all species showing high rank (0.7–1.0) locations only created using Approach 2 in Zonation.

4.0 Discussion

4.1 Limitations and opportunities

The application of Zonation to biodiversity data has resulted in simple ranking maps based on feature weights (assigned using professional judgement and relevant local experience) and distribution (confirmed via previous surveys, many of which were for proposed developments and focused primarily on the affected areas). As such, the priority rank maps do not include condition layers, retention layers, costs or hierarchical masks.

The Zonation results presented in this report are unconstrained rankings, meaning that they ignore a number of attributes of the landscape including variations in habitat condition, land that has already been, or cannot be, legally protected, costs associated with acquiring or protecting land and any costs associated with any rehabilitation or active management (e.g., pest control) required.

Condition layers, or quality of habitat information, could be incorporated relatively easily into the existing model to account for the loss of, or potential improvement in, specific areas of concern (e.g., the remaining *Powelliphanta augusta* habitat), or could be included to predict or reflect the ecological condition of an area after rehabilitation (e.g., following vegetation direct transfer or planting).

Retention layers could also be added to the existing model to reflect, to what extent, a species or other ecological value can be retained in the landscape in the absence of conservation action (Moilanen et al. 2024).

Hierarchical masks could be applied so that land available for conservation is given a certain value, land unavailable for conservation given another value, and areas already protected a third value. Since most of the land affected on the Buller Plateaux is either administered by Land Information New Zealand or the Department of Conservation and the protected areas are not necessarily guaranteed management, a hierarchical mask was not considered helpful in the present study.

Costs can be added to account for land acquisition, risk costs, restoration costs and other financial, ecosystem management or biodiversity costs. Defining the costs of particular biodiversity protection varies according to method, frequency, target species (to control or to protect), monitoring required and other variables, and was considered beyond the scope of this analysis.

Gruner (2013) applied some of these tools resulting in six different scenarios, each accounting for public conservation land, coal measures as values and coal bearing rock removal. Gruner (2013) analysed the performance of different scenarios calculated by Zonation, and found with regard to biodiversity conservation, that her Scenario 1 was the most favourable since it retained the highest average proportion of biodiversity features throughout the removal process.

4.2 Conservation Priority Areas

Because Approach 2 used vegetation layers as a proxy for habitat value for species of conservation concern, the mapped high priority areas are more aggregated than in Approach 1 due to the location and distribution of the high scoring vegetation types. This has resulted in a much larger area being identified as required to retain the majority of the species and features using Approach 2 than in Approach 1.

Both approaches identified the western slope and summit of Mt. William and the headwaters of Deep Creek immediately south of Mt Frederick as important areas for conservation prioritisation. Approach 2 identified four key areas as high priority for conservation including:

- The headwaters of Deep Creek;
- Areas within and surrounding the Extended Escarpment Project sub-area;
- The summit and upper slopes of Mt. William; and
- Te Kuha.

Approach 1 yielded a similar result except:

- Approach 1 identified eight priority areas in total, the others being north of Mount Stockton, west of Cypress Mining area, west of the UWHR and the summit of Mt Rochfort.
- Approach 2 identified a larger extent of high priority areas at Te Kuha due to the extent of contiguous vegetation.
- The priority areas identified along the UWHR and north of the Stockton Project areas using Approach 1 were valued lower (and were smaller in extent) in Approach 2 because Approach 2 did not rely on specific location data.
- The priority area at the headwaters of Burnett Creek identified in Approach 1 was not ranked as highly using Approach 2.

4.3 Effects Management

This analysis has identified approximately 3,453ha of 'high priority for conservation' land within the mapped area. Of that 361ha would be removed by the BPCP leaving 3,092ha of high priority areas which would be retained in indigenous vegetation. Depending on the values present, either alone or in conjunction with other areas, these high priority locations may be suitable for management to offset the ecological values lost as part of the BPCP. The location and extent of the remaining high conservation priority land is set out in Table 8.

The current disturbance areas would result in a loss of approximately 361ha of high priority ranked land across the proposed project sites. Reducing the magnitude of the loss of high priority areas could realistically be achieved through the effective application of the effects management hierarchy by remediation including vegetation direct transfer and other mitigation actions within these areas, including, but not limited to, actions such as salvage and relocation of snails and management of threatened and at risk vascular and non-vascular plant species.

Realigning the disturbance footprints to avoid high ranking areas would be the most certain option to reduce the potential loss. In areas that cannot be avoided, the remediation of areas using vegetation direct transfer as described in Ecological Solutions Limited (2025c) would provide the best outcome in terms of maintaining ecological values in the medium-long term. Mitigation measures including landscape scale pest mammal control form part of the proposal and are intended to assist in minimising the risk of losing species and habitats from high priority areas which are being removed by maintaining them in the surrounding areas. These mitigation measures are set out in the relevant management plans.

4.4 Conclusion

The output maps provided in this report are a decision tool to provide guidance in relation to what high conservation priority areas would be lost due to the BPCP and where the remaining conservation opportunities exist. These remaining high priority areas are proposed to be used to maximise the value of offsetting and compensation proposals, including the location of predator proof exclosures.

Both Approach 1 and Approach 2 identify high priority areas within and surrounding the Escarpment Extended Project area. In our view, the survey effort bias inherent in Approach 1 and indicated by the location of high priority areas associated with areas subjected to extensive survey (e.g., along the UWHR, at Cypress mine and to the north of Stockton Mine), is removed using Approach 2.

Approach 2 results in those areas (i.e., UWHR, Cypress Mine, north of Stockton Mine) not being identified as a high conservation priority. The priority areas identified using Approach 2 are associated with five widespread vegetation types that provide important habitat for birds, lizards, bryophytes, snails and other terrestrial invertebrates. Approach 2 is less biased towards previous survey effort, but is reliant on professional judgement of habitat quality and may overestimate the value of certain habitats where high value species (e.g., snails or 'Threatened' bryophytes) are not found. Approach 2 produced heatmaps which covered a wider area and were less 'patchy' than the heatmaps produced using Approach 1 because they were not reliant on specific locations.

Additional input feature layers and constraints analysis could provide more nuanced solutions and may identify alternative options not identified here.

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APPENDIX A

Species distribution maps – Approach 1

[redacted]

Confirmed Snail (*Powelliphanta patrickensis*) locations on the Buller Plateaux.

[redacted]

Confirmed west Coast green (*Naultinus elegans*) and forest gecko (*Mokopirirakau granulatus* locations on the Buller Plateaux.

[redacted]

Confirmed coal measures tussock (*Chionochloa juncea*) records on the Buller Plateaux.

[redacted]

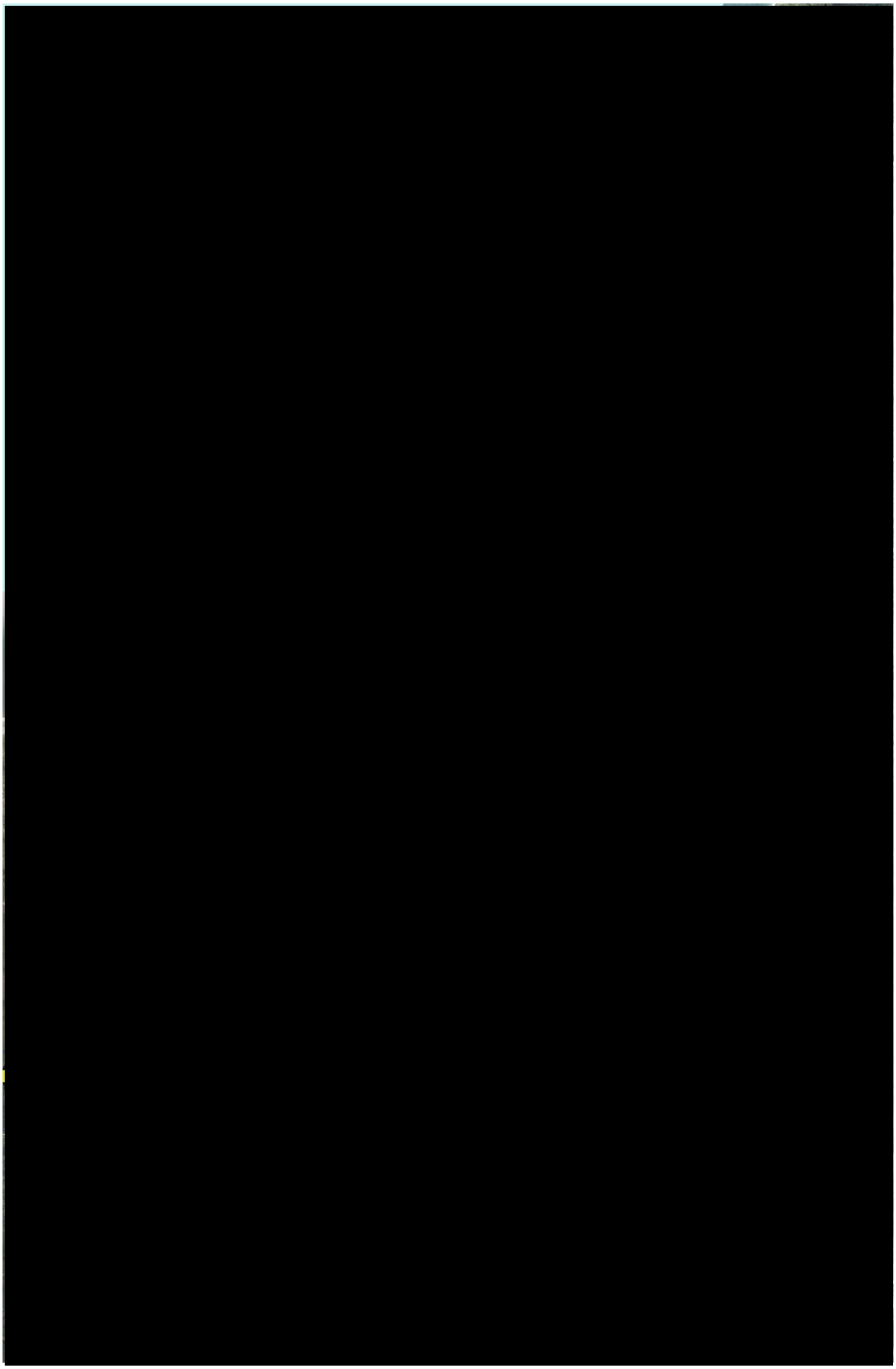
Confirmed bryophyte locations on the Buller Plateaux.

[redacted]

Confirmed great spotted kiwi (*Apteryx maxima*) distribution on the Buller Plateaux (based on call counts and limited radio tracking data).

[redacted]

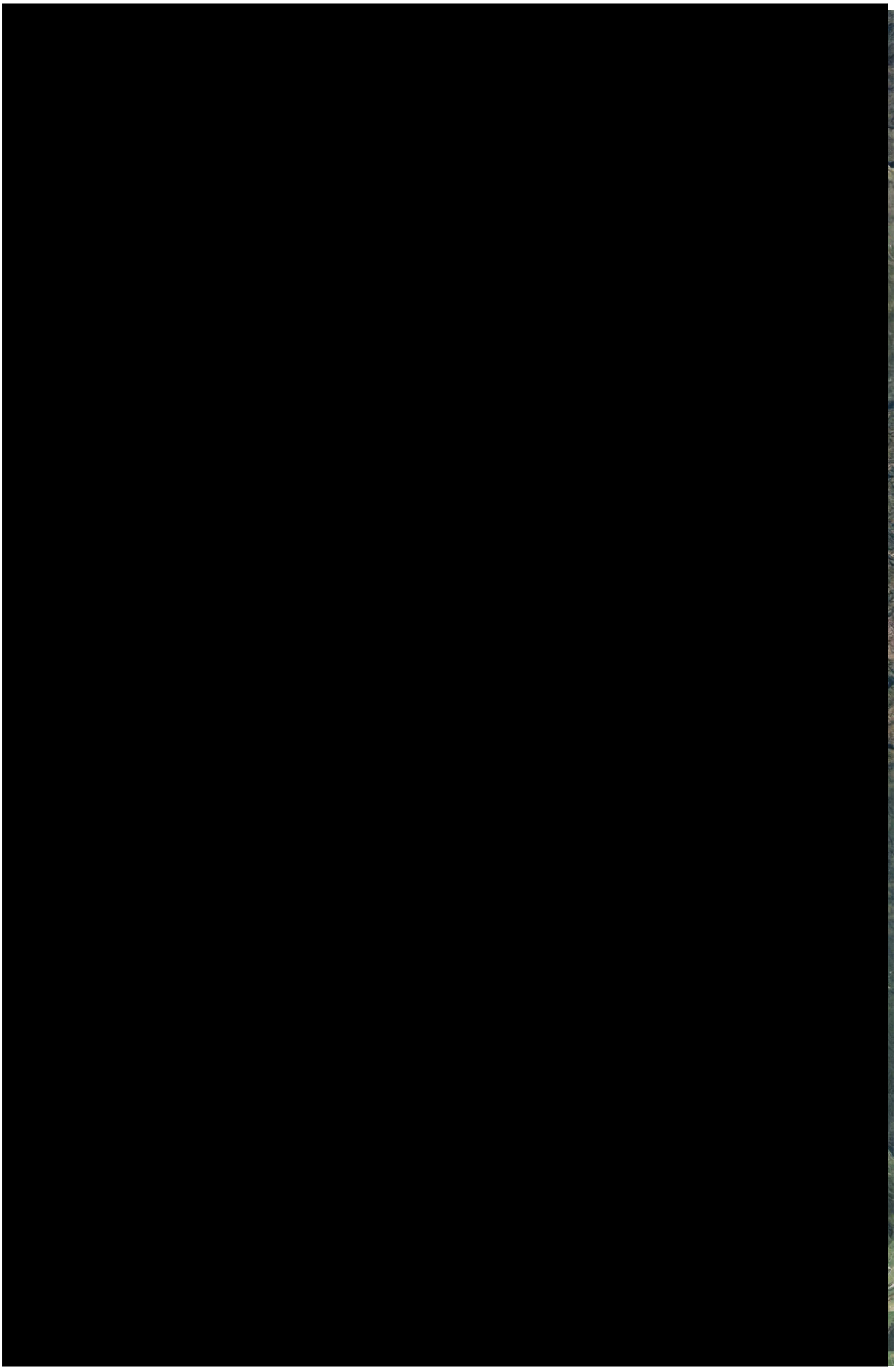
Confirmed fernbird (*Bowdleria punctatus*) distribution on the Buller Plateaux.



Stream classification on the Buller Plateaux (from NIWA).

APPENDIX B

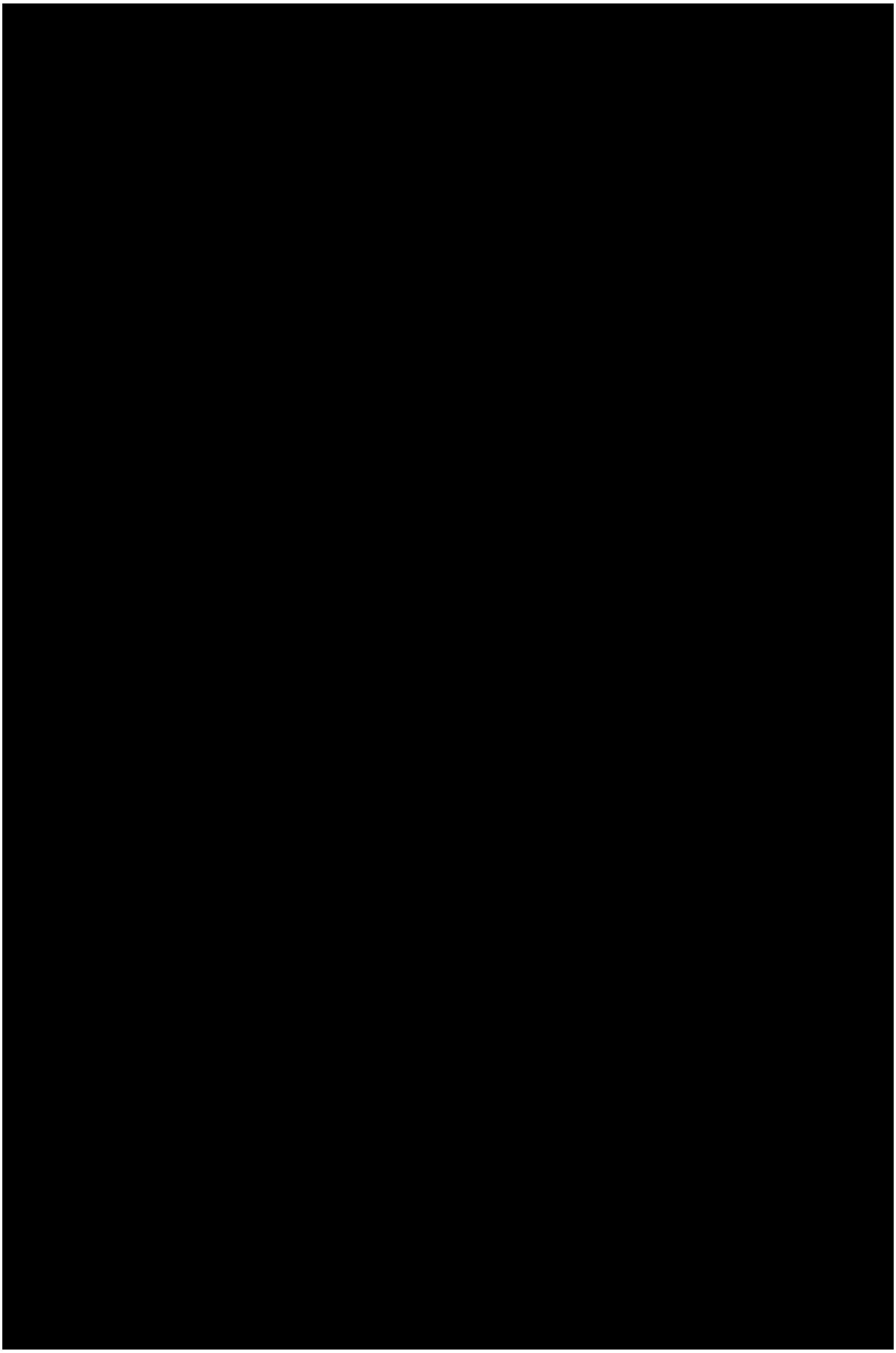
Conservation priority maps – Approach 2 (taxonomic groups)



Conservation rank map for vascular plants at the Buller Plateaux.

[redacted]

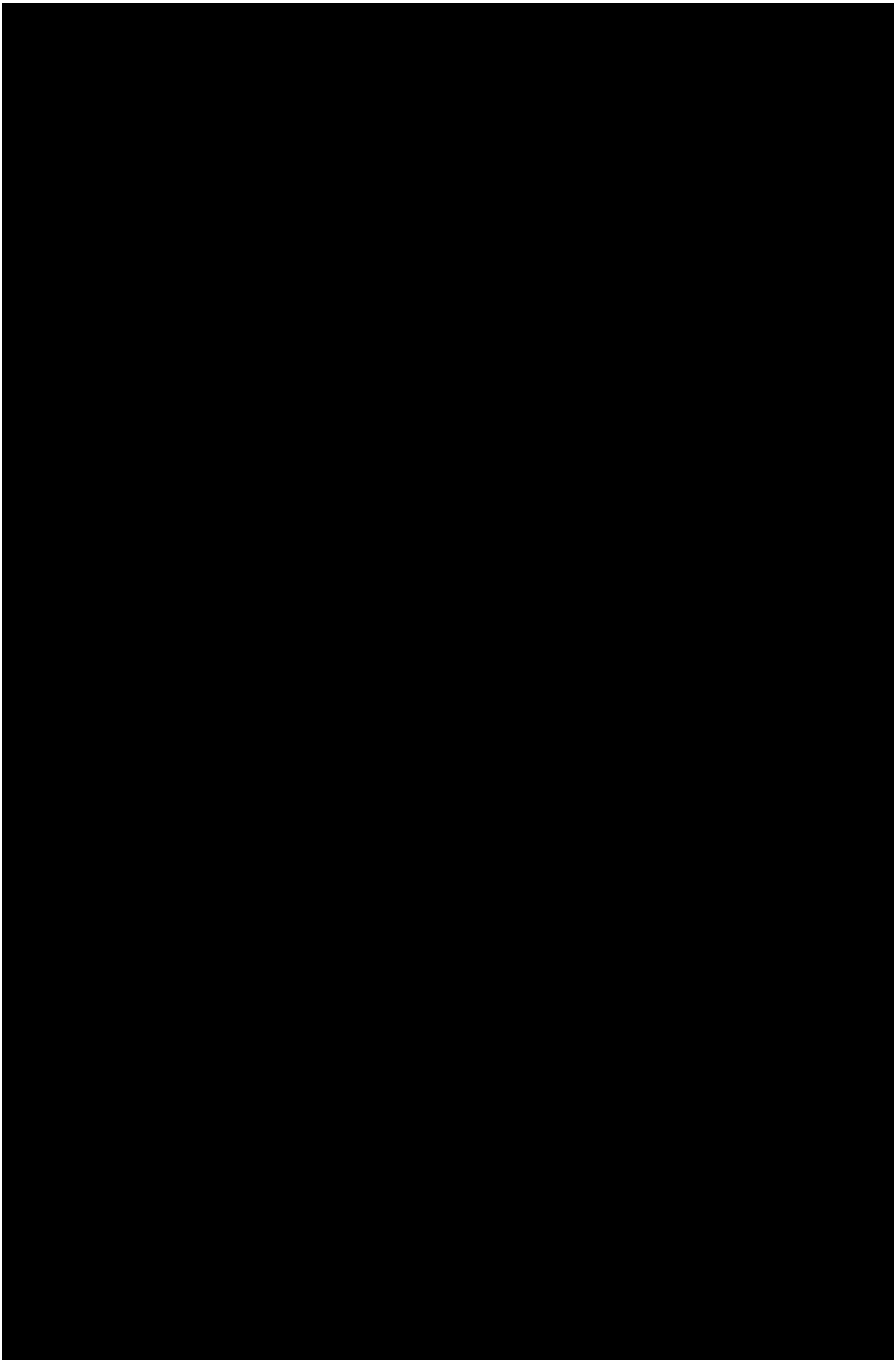
Conservation rank map for birds at the Buller Plateaux.



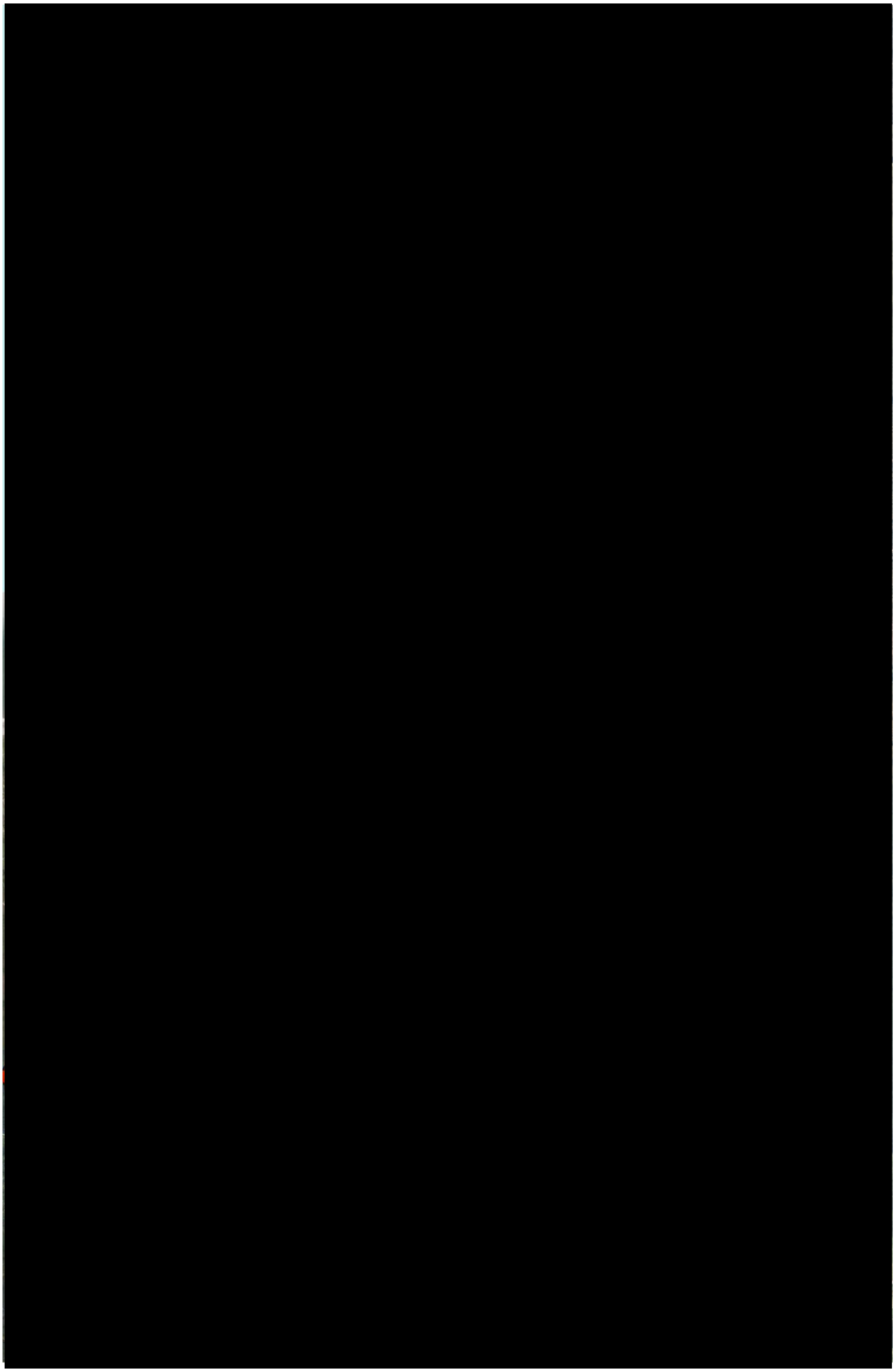
Conservation rank map for lizards at the Buller Plateaux.

[redacted]

Conservation rank map for *P. patrickensis* at the Buller Plateaux.



Conservation rank map for bryophytes and lichens at the Buller Plateaux.



Conservation rank map for terrestrial invertebrates at the Buller Plateaux.