Biodiversity treasures of the Flora

A stocktake of the ecological values of the Salisbury Ecological Management Unit and the threats they face

Photo: Ruedi Mossiman

A report for Friends of Flora and the Department of Conservation, August 2016

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Summary

The Salisbury Ecological Management EMU (EMU) covers 14,520 ha centred on Mt Arthur (Wharepapa) and the Tableland, in the north east corner of Kahurangi National Park. The community group, Friends of Flora (FOF) has been working in partnership with the Department of Conservation (DOC) since 2001 to restore the biodiversity values of this area. The area has a wealth of ecological treasures:

- 24 different ecosystems
- at least 88 species categorised as threatened or at risk
- at least 4 plant and 3 invertebrate species that occur only in the EMU – nowhere else in the world
- some of the best examples of marble ecosystems in the country
- the two deepest caves in New Zealand, both of international significance
- and is one of the best places to experience beech forest birdlife

Despite these riches, the sub-fossil remains preserved in the caves are testament to the amount of wildlife lost from the EMU. Many of the remaining specialities persist in precariously small populations. The main threats are non-native predators particularly rodents and mustelids; introduced herbivores particularly hares and deer and other non-native species that disrupt ecosystem functioning such as weeds, pigs and wasps. The subterranean systems are particularly vulnerable to human activities.

Management of all these threats is critical to restoring the biodiversity of the Salisbury EMU. In particular, without management, the critically endangered plants in the EMU will become extinct.

The EMU has been identified by DOC as a priority for ecosystem restoration and a comprehensive long term management plan is to be prepared. This stocktake summarises available information on the ecological values of the EMU and their associated threats. It will underpin the management plan.

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1 Introduction

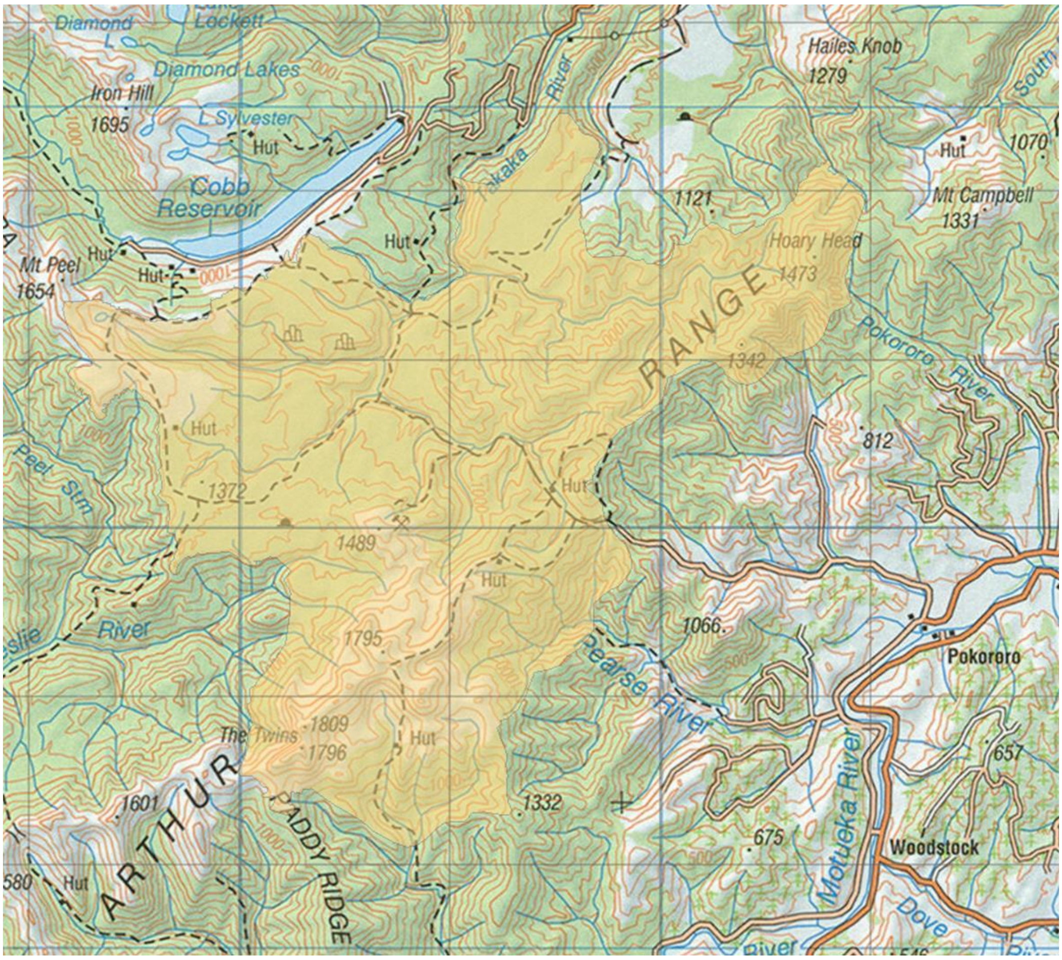
The Salisbury Ecological Management Unit (EMU) at the north eastern corner of Kahurangi National Park is centred on the Flora Stream project area. Friends of Flora (FOF) has been working in partnership with the Department of Conservation (DOC) since 2001 to restore the biodiversity values of this area. Restoration has focused on landscape scale predator control (more than 8,000 ha) which has enabled the re-establishment of blue duck, *Hymenolaimus malacorhynchos* and great spotted kiwi, *Apteryx haastii*. The EMU has been identified by DOC as a priority for ecosystem restoration due to the outstanding range of ecosystems and threatened species it supports. It contains nationally representative mid altitude beech forest, but what makes it special is the range of communities that reflect the geological diversity of the site and the associated extraordinarily high number (89) of threatened and at risk species.

This document summarises available information from the scientific and grey literature on the ecological values of the EMU and their associated threats. It is intended to inform a comprehensive management plan.

2 History and current management

The Salisbury EMU extends over 14,520 ha of Kahurangi National Park (Figure 1).

Figure 1 Location and extent of the Salisbury EMU



In the 150 years prior to the declaration of the National Park in 1996, the EMU had been periodically used for livestock grazing and gold mining as well as recreational tramping and hunting. In 1863, Thomas Salisbury blazed a trail over Gordon's Pyramid to the Tableland. This access route was used until the current track along the Flora Stream was made in 1878 to facilitate gold digging. Edward's Store was set up in tents in the clearing where Flora Hut now stands, to provide services to the 'diggers'. Sheep were led from the Graham Valley for slaughter at 'Butcher Town' just west of Salisbury Lodge on the Tableland to feed the diggers. In the depression of the 1930s, diggers again appeared for a short period and log and shingle huts were built in the Flora, Takaka and Leslie Valleys (Bereton 1974). Cattle and sheep were driven in and grazed from Mt Arthur to the Cobb until the last mob of cattle was brought out in 1949 and the sheep a few years later. Fires associated with the mining and grazing activities have affected the vegetation of the Tableland (Hayward 1980).

Red deer were released in Nelson in 1861, spread into the Arthur Range and reached high numbers in the 1930s. By the 1950s populations had levelled out at lower densities (Clarke 1976). Fallow deer were released in the upper Takaka Valley in 1908 and near Mt Arthur in 1910. They built up to peak numbers in the 1940s and have also declined since (Hayward 1980).

North West Nelson Forest Park was formed in 1970 under the management of the New Zealand Forest Service. Management policy aimed for the conservation of the indigenous forest for perpetual timber production, for soil protection, and for recreation. In 1981 a recreational hunting area of 49,000 ha was gazetted within the Forest Park, including part of the EMU. In this area, commercial hunting was prohibited.

Kahurangi National Park was gazetted in 1996 with the primary objective of preserving in their natural state in perpetuity the landscape, natural ecological systems, wilderness and natural and historic features of the area and as far as possible eradicating introduced plants and animals. Two Key Biodiversity Areas in the park (Hoary Head/Crusader and Tableland/Flora/northern Arthur Range) which contain biological organisms or associations of particular importance and vulnerability, make up the EMU(DOC 2010).

Founded in 2001, Friends of Flora (FoF) is a community group working to restore the biodiversity values of the Flora Catchment and its environs in Kahurangi National Park. To this end, in partnership with DOC, FOF has installed a mustelid and possum control network covering more than 8,000 ha at the core of the EMU. The successful predator control has enabled FOF to re-establish populations of blue duck and great spotted kiwi.

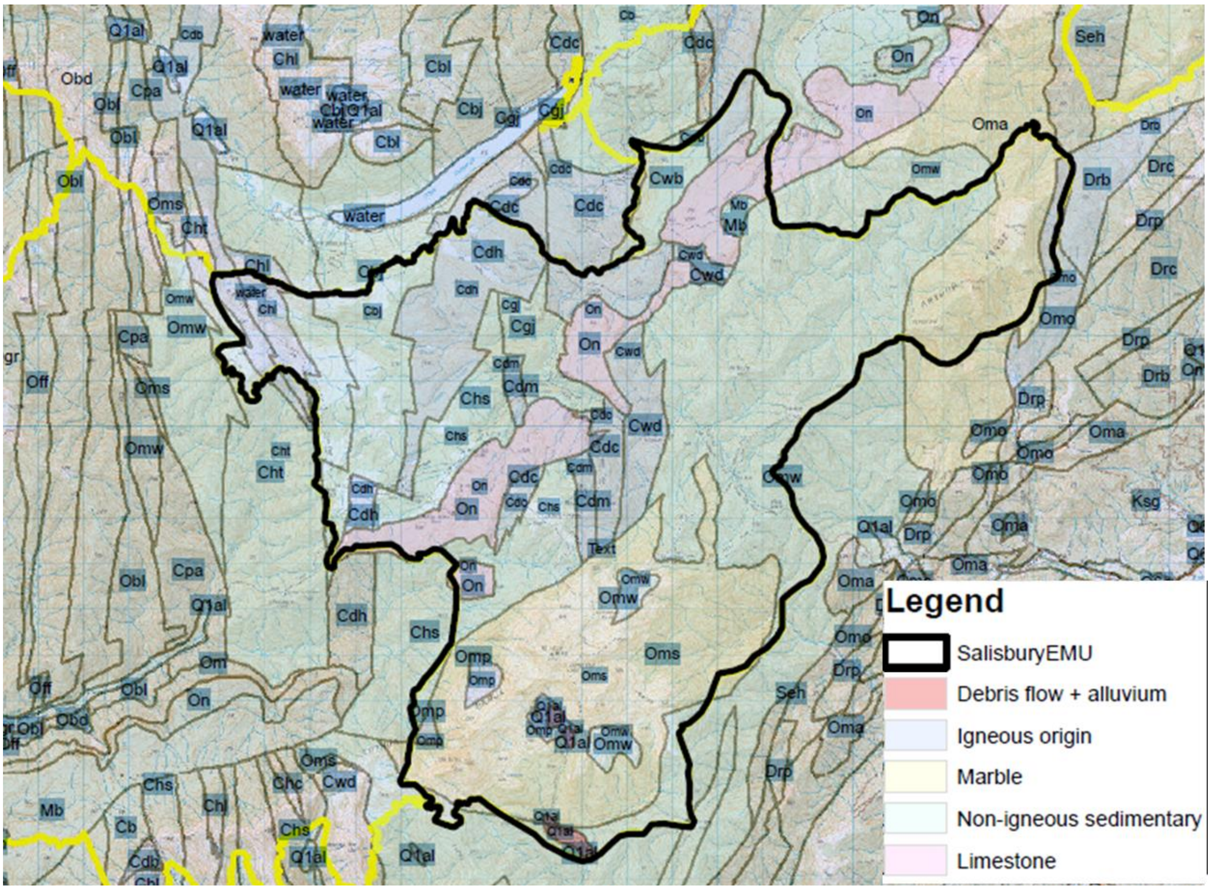
3 Ecological context

The EMU is almost entirely within the Arthur Ecological District. The western part falls within the Wangapeka Ecological District. It ranges from about 700 m altitude in the upper Takaka valley to 1795 m at Mt. Arthur (Wharepapa). Drainage is mainly to the Takaka River in the northwest, but the limestone area around the Mt Arthur range drains east to the Motueka River. Summers are warm and sunny. Winters are cold with heavy frosts and snow at high altitudes. The climate is relatively dry with 1500-4000 mm p.a., wetter in the western part of the EMU (McEwan 1987).

3.1 Geology and physiography

The distinctive landscapes of the EMU reflect its diverse geology (Figure 2) which includes some of the oldest in New Zealand. The oldest rocks are the Devil River Volcanics Group composed of andesite, basalt and associated volcaniclastic sedimentary deposits along with, in lower Ghost Creek, mafic and ultramafic igneous rocks. In the west of the EMU are slightly younger rocks of the Haupiri Group, which is dominantly of sedimentary origin. These groups formed 510 to 490 million years ago during the Cambrian period.

Figure 2 Geology of the EMU



The Arthur Range, in the east, comprises hard, crystalline Arthur Marble, metamorphosed from limestone, and grey sandstone and siltstone of the Wangapeka Formation. The area to the north of the Flora track between the marble blocks comprises siltstones, quartz sandstone and limestone bands. These rocks, belonging to the Mount Arthur Group, were deposited during the Ordovician period, which ended 445 million years ago (Rattenbury *et al*. 1998). Unlike the Cambrian rocks they tend to lack igneous material and were deposited in a quiet marine environment. Fossils are rare in all of these old rocks partly because they would have been destroyed by the heat and pressure of the metamorphic processes during uplift and folding in the middle of the Devonian period (417 to 354 million years ago)(Thornton 1985).

A large amount of subsequent geological time is missing from the EMU but by about 70 million years ago, during the Late Cretaceous, a long period of terrestrial weathering commenced resulting in the land being reduced to a low-lying landscape, the Waepounamu Erosion Surface, locally known as the Northwest Nelson Peneplain. This is a remnant of a once extensive sea-level plain which over 45 million years ago stretched across New Zealand. Tertiary sedimentary rocks were deposited on the erosion surface in the EMU beginning about 30 million years ago, with sand and gravel then, as the sea transgressed onto the land, limestone. In the EMU the terrestrial coal measure deposits are largely absent but their former presence has given rise to the alluvial gold that was mined on the Tableland. In the last 14 million years the peneplain has been uplifted by block faulting and tilting. One prominent fault, the Karamea, trends northeast through the EMU and uplift on its southeast side has formed the Arthur Range whose concordant summit heights are all that is left of the peneplain. On the opposite side of the fault the peneplain rises to Mt Peel, forming the Tableland, and mountain summits beyond the Cobb valley. As uplift progressed, the Tertiary cover rocks were eroded leaving only a strip in the fault angle depression northwest of the Karamea Fault (Rattenbury *et al*. 1998).

Much of the uplands of northwest Nelson were subject to successive glaciations. During the Last Glacial Maximum a substantial valley glacier system existed in the Cobb valley to the north-west of the EMU. Tributaries of the Cobb glacier over-rode saddles on the southern side of the Cobb Reservoir, as evidenced by lines of terminal moraines blocking the Peat and Bullock creeks in the EMU, but did not extend down the Takaka valley (Schulmeister *et al*. 2001). Peat swamps formed in the valleys impounded by terminal moraines (Schulmeister *et al*. 2003). Ice flowing from Mt Peel into the headwaters of the Deep Creek formed glacial escarpments, terminal moraines and a cirque, the latter now occupied by Lake Peel (Schulmeister *et al*. 2001). Small glaciers also eroded the heads of the small creeks radiating out from Mt Arthur and The Twins.

By about 17,000 radiocarbon years before present (BP) ice had retreated some distance up the Cobb River valley and a podocarp heath and tussockland vegetation covered non-glaciated areas. By 14,000 radiocarbon years BP, the valley floor and adjacent lower ridges were occupied by montane podocarp forest dominated by celery pine and bog pine. Beech forest expanded into some sites as early as 13,000 years BP but the modern beech cover was not established until the Holocene (11,700 years BP onwards)(Schulmeister *et al* .2003). During the Last Glacial Maximum, global sea level was about 120 m lower. The west coast shore line was tens of kilometres further into the Tasman Sea than at present and a low plain extended from northwest Nelson towards Taranaki. The floral diversity of northwest Nelson suggests that these plains may have been a glacial refugium (Wardle 1963) and it is likely that they, and adjacent lowland areas, contained at least remnant stands of podocarp/broadleaf forest. There is no evidence from the fossil record for interchange of vertebrate species of the North and South Islands via a land bridge during the glaciation (Worthy & Holdaway 1994). Pollen records suggest that the Tableland was poorly vegetated during the deglaciation and forest refugia were limited or absent in the Arthur area, and confined to the lower valleys (Schulmeister *et al*. 2003).

Karst features are widespread within the marble of the Arthur Range with numerous tomos, or sinkholes, and deep underground drainage systems flowing towards the Motueka valley. Sub-horizontal caves are also present in the gently southeast dipping Tertiary limestone preserved northwest of the Karamea Fault.

3.2 Ecosystems

An ecosystem is a biological community of interacting organisms and their physical environment. Singers & Rogers (2014) produced a comprehensive terrestrial ecosystem classification, combining an abiotic framework with biotic communities drawn from the various pre-existing classifications. An earlier unpublished version of this ecosystem classification (Singers & Rogers 2011) was used in DOC's national prioritisation programme and consequent management planning process. Table 1 summarises the ecosystems present in the EMU. Appendix 1 cross-references the published (Singers & Rogers 2014) and unpublished classifications for ecosystems present in the EMU. Appendix 1 also lists which of these ecosystems are equivalent to ecosystems identified by Williams *et al.* (2007) as naturally rare and the subset of these, Holdaway *et al*. (2012) identified as nationally threatened.

The ecological significance of the Salisbury EMU is that it contains representative examples of widespread ecosystems as well as nationally rare ecosystems and those that are threatened. Rare ecosystems are defined as those having a total extent less than 0.5% (i.e. < 134 000 ha) of New Zealand's total area (268,680 km^2) (Williams *et al*. 2007). Threatened ecosystems are those that are rare **and** suffering decline (Holdaway *et al.* 2012). These are national rankings. Within the EMU, caves are extensive and since their water sources and the land surface above the cave are within the National Park these caves are unlikely to be critically endangered, as are caves elsewhere.

To facilitate consideration of ecosystem management, the ecosystems in the EMU have been grouped by DOC, on the basis of similarity of pressures into Alpine, Tussockland, Forest, Rivers and lakes and Subterranean (Table 1). Macroclimatic variables of temperature and moisture availability are considered to be the primary drivers of ecosystem differences in New Zealand (Singers & Rogers 2014). However, in some areas the vegetation is more influenced by extremes of rock and soil chemistry. Such ecosystems, for instance cliffs and wetlands, often occur at a small scale. They are important components of the ecosystem mosaic in the Salisbury EMU, particularly as habitat for threatened species, and may occur in more than one ecosystem grouping.

Table 1 Ecosystems present in the EMU and their national threat status

Ecosystem	Alpine	Tussockland	Forest	Rivers & Lakes	Subterranean
Snow tussock	2386 ha				
Frost flat scrub		11ha Endangered			
Frost flat red tussock		94 ha Endangered			
Riparian turf		Too small to measure			
Peat bog		14 ha Vulnerable?			
Red tussock		83 ha			
Shrublands on non-calcareous talus			12 ha		
Silver-mountain beech forest			1736 ha		
Silver beech forest			891 ha		

Ecosystem	Alpine	Tussockland	Forest	Rivers & Lakes	Subterranean
Mountain, silver beech podocarp forest			1128 ha		
Red-silver beech forest			7649 ha		
River				unmeasured	
Lake				5 ha	
Caves					3897 ha * critically endangered
Ultramafic			Too small to measure Vulnerable		
Marble cliffs	Too small to measure Vulnerable		Too small to measure Vulnerable		
Limestone bluffs and outcrops			Too small to measure Vulnerable		
Cliffs, scarps and tors of non- calcareous rock			Too small to measure		
Marble pavements	177 ha Endangered		Too small to measure Endangered		
Marble Scree	355 ha Vulnerable				
Cliffs, scarps and tors of non- calcareous rock			Too small to measure		
Sinkholes	Too small to measure Endangered	Too small to measure Endangered	Too small to measure Endangered		
Seepages and flushes in Forests			Too small to measure Endangered		
Alpine seeps and flushes	Too small to 14 ha Endangered				

*the cave ecosystem underlies other ecosystems

3.3 Species

Kahurangi National Park and the EMU in particular is an acknowledged biodiversity hotspot. Some species like the kakapo, have been lost, others like great spotted kiwi have been re-established by Friends of Flora, but many more remain threatened and at risk. Endemic species, those that occur only in New Zealand, are of particular concern. The species threat classification system (Townsend *et al*. 2008) provides a framework for establishing the risk of extinction faced by species. There are three threatened categories and four categories of 'at risk' species (Appendix 2). For an organism to be included in the threat classification it must be identified as a distinct taxon. Taxonomic knowledge of New Zealand's non vascular flora and invertebrate fauna is patchy and some groups such as millipedes, centipedes and earthworms are very poorly known. For instance, about 170 species of native earthworms have been described but these may represent less than 20% of the actual number of species (I. Millar pers. comm.). These groups are therefore under-represented in the threat classification lists (McGuinness 2001). Even groups for which the taxonomy has been clarified, specific life histories, and therefore threats and management requirements are known for only a tiny fraction of species.

Biological recording is also patchy and historical records are not always accessible. The EMU has long been of interest to naturalists. Entomological recording was boosted with the establishment of the Cawthron Institute in Nelson in the 1920s and Mt Arthur, the Flora Valley and the Tableland are type localities for a large number of endemic invertebrate species. However, the taxonomic and distribution information on the many species collected from this area is held in a vast range of journals and publications many of which have not been accessed.

Despite these limitations, an extraordinary number (86) of threatened and at risk species, many of which are endemic, have been recorded from the EMU. They are considered in this document, under the ecosystem group with which they are primarily associated. There are likely to be more threatened and at risk organisms in the EMU for which there are no known records or insufficient information available for them to be classified.

4 Alpine biodiversity and threats

The alpine zone occurs above the bush line. Here the karst landscape with bare marble rockland and bluff vegetation, doline turfland, and snowgrass tussock characterises the EMU and provides habitat for numerous threatened species. Tussockland (chapter 6) ecosystems are largely a subset of alpine ecosystems. In practice there is considerable overlap in the threats affecting the two zones.

4.1 High alpine stonefield/cushionfield

The high alpine zone extends above the mean summer 5°C isotherm and roughly equates to the limit of tall tussock vegetation (Mark & Dickinson 1997 in Singers & Rogers 2014). It contains complex mosaics of plant communities reflecting sharp changes in physiographic gradients such as those of wind exposure, snow accumulation and duration, snow and rock avalanching, storm water and frost-heave erosion, and soil and substrate type. Wet fellfield predominates with areas of rock pavement, talus, boulderfield and bluffs and locally cushionfield and snow banks. Characteristic herbs and sub-shrubs include *Aciphylla, Brachyscome, Brachyglottis, Celmisia, Epilobium, Gaultheria, Gentianella, Hebe, Ourisia, Poa, Ranunculus,* and cushion genera with snow banks of *Chionochloa oreophila, Poa colensoi* with *Celmisia hectorii* (Singers & Rogers 2014).

4.2 Low alpine snow tussock

The low alpine zone occurs between the treeline and the upper limit of tall tussock vegetation. The combination of raw and thin soils, steep slopes, northern aspect, high solar radiation, and wind exposure can result in site-specific periodic drought events, despite generally high precipitation and low evapotranspiration (Mark & Dickinson 1997 in Singers & Rogers 2014). The vegetation is mainly tall tussock grassland and shrubland of *Chionochloa pallens* and *C. flavescens*, and locally *C. rubra* and *C. australis*, and species of *Hebe* and *Dracophyllum*, with areas of talus, boulderfield and bluffs (Singers & Rogers 2014).

4.3 Marble cliffs

Cliffs occur throughout the EMU including in the forested ecosystems but are most obvious in the alpine zone, particularly to the east of Hoary Head, Crusader and McMahon. Cliffs can host lichen, bryophyte, herb, grass, fern, shrub and small tree species on the limited microhabitats where soil forms or where their roots are able to penetrate bedding and jointing fractures. Small seeps on cliff faces can support a distinct flora. The talus accumulations that occur immediately beneath cliffs are an important component of this ecosystem type (Singers & Rogers 2014). These ecosystems are considered rare (Williams *et al*. 2007) and vulnerable (Holdaway *et al*. 2012).The EMU is thought to contain one of the best examples of upland marble cliff ecosystems in the country (Moore 2016).

4.4 Marble scree and boulderfields

Screes are an accumulation of broken rock fragments ranging from gravel to boulders on slopes greater than about 35° (Singers & Rogers 2014). As the calcium carbonate of the interstitial fines tends to dissolve (solution weathering), stabilized boulderfields have few or no fines between the boulders, making it difficult for plants to establish. For many years, lichens and mosses may be the only colonists. With time, calcareous boulderfields may be invaded from the margins by mat-forming plants or those spreading vegetatively (see Figure 3). Calcareous screes are considered a rare (Williams *et al*. 2007) and vulnerable (Holdaway *et al*. 2012) ecosystem. They are associated with marble geology on steeper gradients within the EMU and are thought to be excellent examples of western South Island upland marble scree ecosystems (Moore 2016).

Figure 3 Marble scree on Hoary Head. Photo: S. Toy

4.5 Marble pavements

Bare rockland erosion pavements (Figure 4) with a sparse cover of lichens and bryophytes, and infrequent prostrate vascular plants occur in the alpine zone particularly around Winter Peak. They are considered a nationally rare (Williams *et al*. 2007) and endangered (Holdaway *et al*. 2012) ecosystem. The EMU is considered a national stronghold for upland marble pavement ecosystems (Moore 2016).

Figure 4 Marble pavement on Mt Arthur Ridge. Photo: S. Toy

4.6 Cave entrances and sink holes

There are superb solution features around the Mt Arthur massif occurring in the alpine as well as tussock and forest zones. Sinkholes and cave entrances are considered rare (Williams *et al*. 2007) and endangered or critically endangered (Holdaway *et al*. 2012) ecosystems. The EMU supports nationally significant examples of upland marble sinkholes and western South Island upland marble cave entrances (Moore 2016).

4.7 Alpine seepages and flushes

Low stature sedgeland, mossfield and herbfield occurs in seepages and flushes in the alpine zone, with abundant mosses, liverworts and sedges, and a wide range of herbs, including *Schoenus pauciflorus* and *Carpha alpina*, and locally species of *Epilobium, Montia, Ranunculus, Schizeilema, Hydrocotyle* and *Gentianella* (Singers & Rogers 2014). Seepages and flushes are considered rare (Williams *et al.* 2007) and endangered (Holdaway *et al*. 2012) ecosystems. No information has been identified on the invertebrate fauna of alpine flushes within the EMU but work by Collier & Smith (2006) suggests that they may be an important invertebrate habitat.

4.8 Threatened and at risk species associated with the alpine zone

Table 2 summarises the status of threatened and at risk species recorded from the alpine zone of the EMU.

Table 2 The status of threatened and at risk species recorded from the alpine zone of the EMU.

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU
bird	2Nationally Endangered	*Nestor notabilis*	kea	Yes	Widely distributed
bird	2Nationally Endangered	*Xenicus gilviventris*	rock wren	Yes	Lake Peel, Mt Arthur
plant	1Nationally Critical	*Botrychium aff. lunaria*	marble moonwort	No	Hoary Head
plant	1Nationally Critical	*Melicytus obovatus "Mount Owen"*	marble mahoe	Yes	Mt Arthur
plant	1Nationally Critical	*Montia drucei*		Yes	Mt Arthur, Twins, Cundy Creek, Heath Creek
plant	1Nationally Critical	*Myosotis angustata*	marble forget-me-not	Yes	Mt Arthur, Twins
plant	2Nationally Endangered	*Melicytus aff. alpinus"Matiri"*	limestone porcupine shrub	Yes	Mt Arthur
plant	3Nationally Vulnerable	*Clematis marmoraria*	marble clematis	Yes	Hoary Head, Crusader
plant	3Nationally Vulnerable	*Senecio aff. glaucophyllus "Burnett"*	marble groundsel	Yes	Mt Arthur, Twins, Hoary Head
plant	4Declining	*Myosotis pygmaea*		Yes	Hoary Head, Mt Arthur, Balloon
plant	4Declining	*Pimelea longifolia*		Yes	Hoary Head, Crusader
plant	4Declining	*Pterostylis tanypoda*		Yes	Mt Arthur
plant	4Declining	*Traversia baccharoides*		Yes	Mt Arthur, Twins, Tableland
plant	7Naturally Uncommon	*Anemone tenuicaulis*	native anemone	Yes	Mt Arthur
plant	7Naturally Uncommon	*Carex cremnicola*	marble carex	Yes	Mt Arthur, Twins, Hoary Head
plant	7Naturally Uncommon	*Carex enysii*		Yes	Mt Arthur, Twins, Hoary Head
plant	7Naturally Uncommon	*Carex impexa*		Yes	Hoary Head
plant	7Naturally Uncommon	*Carex trachycarpa*		Yes	Mt Arthur, Twins
plant	7Naturally Uncommon	*Dracophyllum marmoricola*	marble inaka	Yes	Mt Arthur, Twins, Hoary Head, Crusader
plant	7Naturally Uncommon	*Epilobium "pink"*		Yes	Mt Arthur
plant	7Naturally Uncommon	*Epilobium margaretiae*		Yes	Mt Arthur, Mt Peel
plant	7Naturally Uncommon	*Epilobium vernicosum*	varnished willowherb	Yes	Mt Arthur, Twins, Hoary Head
plant	7Naturally Uncommon	*Gentianella angustifolia*	marble gentian	Yes	Hoary Head, Mt Arthur, Gordons Pyramid

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU
plant	7Naturally Uncommon	*Gentianella filipes*	limestone gentian	Yes	Mt Arthur, Twins, Hoary Head, Crusader, Heath Creek
plant	7Naturally Uncommon	*Gentianella decumbens*		Yes	Mt Peel
plant	7Naturally Uncommon	*Hebe calcicola*		Yes	Mt Arthur, Tableland limestone
plant	7Naturally Uncommon	*Hebe ochracea*	golden whipcord	Yes	Mt Arthur, Twins, Lake Peel
plant	7Naturally Uncommon	*Myosotis* "australis" small white"		Yes	Mt Arthur, Hoary Head, Tableland limestone
plant	7Naturally Uncommon	*Myosotis arnoldii*		Yes	Hoary Head, Crusader
plant	7Naturally Uncommon	*Poranthera alpina*	marble poranthera	Yes	Mt Arthur, Twins, Hoary Head, Crusader
plant	7Naturally Uncommon	*Pterostylis humilis*		Yes	Hoary Head, Mt Arthur
plant	7Naturally Uncommon	*Senecio glaucophyllus s.s.*	limestone groundsel	Yes	Tableland limestone
plant	7Naturally Uncommon	*Trisetum drucei*		Yes	Mt Arthur, Twins, Hoary Head
plant	Not assessed data deficient	*Pimelea nitens* subsp. *nitens*		Yes	Hoary Head
reptile	3Nationally Vulnerable	*Mokopirirakau kahutarae*	black-eyed gecko	Yes	Mt Arthur
reptile	7Naturally Uncommon	*Woodworthia* 'Mount Arthur'	Mount Arthur gecko	Yes	Mt Arthur
reptile	4Declining	*Oligosoma infrapunctatum*	speckled skink	Yes	Winter Peak
insect	7Naturally Uncommon	*Deinacrida tibiospina*	Mt Arthur giant wētā	Yes	Mt Arthur
mollusc	Not assessed data deficient	Powelliphanta "Lodestone"	large land snail	Yes	NE Mt Arthur tops & Lodestone; Heath Creek

4.8.1 Birds

The rock wren, *Xenicus gilviventris* is a diminutive, ground-feeding bird found only in alpine areas of the South Island. The Acanthisittidae (New Zealand wrens) is an ancient lineage that until 1000 years ago included at least seven species in five genera. As a result of predation by introduced mammals, only the rock wren and the rifleman, *Acanthisitta chloris* remain. The New Zealand wrens have no extant close relatives and are one of the most significant groups in the New Zealand avifauna as well as being one of the most genetically isolated bird assemblages in the world. Rock wrens generally occur in alpine basins close to the bush line, especially where scree and rockfalls are interspersed with stable areas of scrub, fellfield and cushion vegetation (Heather & Robertson 1996). Within the

EMU there have been casual records of recent sightings from Mt Arthur and Mt Peel, but no confirmed population.

Kea, *Nestor notabilis* is the world's only mountain parrot. They occur most often in high altitude forest, high alpine basins and steep valleys, but they also descend to low levels. They breed in holes in the ground, in logs or cavities in jumbled rock generally in the upper forest (Heather & Robertson 2015). Kea have an omnivorous diet and have been reported to hunt and kill vertebrates e.g. Hutton's shearwater chicks and mice (reviewed in Greer *et al*. 2015). In alpine areas, kea feed mainly on fruit during summer and autumn, changing primarily to leaves during winter and spring and increasing invertebrate consumption in springtime (Greer *et al*. 2015). They are highly mobile and have home ranges of up to 4 km^2 (cited in Orr-Walker 2010)

4.8.2 Plants

Many of the threatened and at risk plant species in the EMU occur in the alpine zone.

Species associated with bluffs, pavements and scree include:

- *Myosotis angustata*, a forget-me knot endemic to the Mt Arthur area. It has a very limited distribution on shaded marble outcrops and associated talus (De Lange 2008).
- North-west Nelson is a stronghold for *Myosotis* "*australis* small white". It occurs under overhangs in both low alpine areas and forested areas, notably the Heath Creek limestone within the EMU (Gaskell *et al.* 2016).
- *Myosotis arnoldii,* which has a disjunct distribution. It is known from Crusader and Hoary head within the EMU and from the Chalk Range in the Kaikouras. It grows on sparsely vegetated marble and limestone cliff faces, ledges and associated rubble slopes (Brandon 2001, De Lange 2008). Hoary head is its stronghold in the EMU (Gaskell *et al*. 2016).
- *Montia drucei,* a dimunitive, mat forming herb previously known as *Neopaxia drucei*, grows on shallow, skeletal soils where vegetation is short, on rock outcrops, the edges of sinkholes, and at the margin of scree and herbfield. It favours sites where competition with other vegetation is limited (Heenan 1999). It is only known from Mt Arthur, Twins and Cundy Creek and Heath Creek limestone, the latter occurring well below the bush-line (Gaskell *et al*. 2016).
- Marble mahoe, *Melicytus* aff. *obovatus* "Mount Owen" is restricted to limestone cliffs on the Mt Owen and Mt. Arthur massifs (Eagle 2006). It occurs in both forest and alpine zones.
- *Clematis marmoraria* is a suckering sub-shrub, known only from Crusader and Hoary Head, where it grows in crevices in massive marble or amongst semi-fixed rocks in open herbfield (Sneddon 1974).
- *Pimelea longifolia* is a shrub, usually fund in open sites in forest, on forest margins and in scrub, on or near rock outcrops, especially base-rich rock from coastal to montane areas. Its range has contracted significantly due to habitat loss and it is now threatened by hybridisation with *P. gnidia* (Burrows 2008).
- *Pimelea nitens* subsp. *nitens* is a small sprawling shrub occurring in tall tussock grassland and on rock outcrops and cliffs, especially marble, limestone and sandstone, sometimes on ultramafics from 770 to 1550m. It is thought to be relatively common in western Nelson but

not enough information is available on its status (Burrows 2011). Within the EMU it has been reported from Hoary Head on stable marble with gravel filled cracks and on fractured talus (Gaskell *et al.* 2016).

- *Epilobium vernicosum,* a willowherb of montane to subalpine screes and rock outcrops of limestone and marble. Its exact status throughout its range is uncertain, because it was, until recently treated as part of the range of variation exhibited by the common *E. glabellum* (NZPCN 2014b). Occasional plants occur on marble talus on south west aspect slopes near the summit of Hoary Head (Gaskell *et al*. 2016).
- *Hebe calcicola* is endemic to Kahurangi and the Arthur and Peel ranges are a stronghold. It is confined to limestone and marble outcrops, talus and bluffs in the montane to subalpine zones, where it grows in low scrub of which it is often the dominant species. Within the EMU it has been reported from limestone outcrops on the Tableland in the Sphinx Valley and Cundy Creek (Bayly 2001; Gaskell *et al*. 2016).
- *Gentianella filipes*, a tiny annual gentian, confined to Kahurangi National Park where it is mostly on calcareous substrates. On Hoary Head it is sparsely scattered in stable marble talus, crevices and thin soils. It also occurs in Horseshoe basin (Glenny 2004) and on limestone pavement in Heath Creek (Gaskell *et al*. 2016).
- *Gentianella decumbens* is also restricted to Kahurangi National Park. Within the EMU it has been recorded from scree on Mt. Peel.
- *Poranthera alpina,* a low-growing creeping herb with a tightly curled leaf, giving the appearance of succulence. It is a North-West Nelson marble endemic, and is locally common on stable marble talus on Hoary Head (Gaskell *et al*. 2016).
- *Senecio glaucophyllus* s.s. , a North-West Nelson endemic associated with limestone and marble rock outcrops and boulderfalls from 300 – 1300 m. It is very local, known from very few places, and common at none (De Lange 2008). It has been recorded on a vegetated ledge on limestone on the Tableland limestone (Gaskell *et al*. 2016).

Short turf species include:

- *Botrychium* aff. *lunaria*, moonwort, a tiny fern occurring in *Coprosma atropurpurea* turfs often associated with dolines in limestone and marble karst systems (Gaskell *et al*. 2016). After fruiting in November – January the above-ground foliage browns off and withers back to underground root stock. Although a cosmopolitan species, in New Zealand it is now known only from Hoary Head within the EMU and from Billies Knob and Mt Bell on Mt Owen Range. At neither location is it common. New Zealand and Australian plants appear to be distinct from the northern hemisphere form of *B. lunaria* (De Lange 2005).
- *Epilobium margaretiae,* a high alpine willowherb, endemic to Kahurangi National Park. Within the EMU it has been recorded from Mt Arthur and Mt Peel. It is confined to steep ridge lines and crests where it grows in open rock rubble on frost flats and fell field, but is thought to be common in the few places it has been found (Mark & Adams 1973).
- *Gentianella angustifolia,* endemic to Kahurangi National Park. It occurs in alpine herbfields and short shrublands on limestone and marble karst usually on shallow soils that limit the development of taller competing vegetation. Within the EMU *G. angustifolia* has been recorded from Hoary Head, Gordons Pyramid and Mt Arthur (Glenny 2004).

- *Hebe ochracea ,* a distinctive ochre coloured endemic hebe found at 1500 m on Mt Peel in damp snow tussock herbfields (Mark & Adams 1973).

Species associated with tussock or alpine seepages include:

- *Pterostylis tanypoda ,*an orchid endemic to montane to subalpine areas in the South Island amongst tussock grasses, in grey scrub or in shingle (NZPCN 2015).
- *Anemone tenuicaulis ,* a naturally sparse herb, occurring from 900-1300m in herbfield and short to tall tussock grassland, usually in damp sites, flushes or seepages (de Lange 2004).
- *Carex enysii,* a small, naturally sparse sedge of open, moist, stony ground, particularly on or near limestone. It is usually found within tussock grassland or associated subalpine scrub but is sometimes present in montane forest (NZPCN 2014c).
- *Carex trachycarpa* occurs in marble and limestone subalpine to alpine habits where it is found within tussock grassland, herbfield, fellfield, gravel and rock pavements, usually in and around small ponds, seepages or flushes. It occurs on Mt. Arthur and Mt. Peel (De Lange 2006).
- *Trisetum drucei,* a grass growing in seepages on cliff faces, preferably calcareous (Edgar 1998).

Species associated with rock shrubland include

- *Carex cremnicola ,* a sedge that occurs only in northwest Nelson on marble substrates. It is commonly found in open forest and shrubland growing in cracks, clefts, and hollows in karst terrain, at the bases of cliffs, on ledges, and in cracks of sinkhole walls (Ford 2007). On Hoary Head it is sparsely scattered in stable rock shrubland (Gaskell *et al*. 2016).
- *Carex impexa,* a naturally uncommon sedge endemic to northwest Nelson found in tussock grassland or scrub overlying weakly weathered limestone, marble and calcareous mudstone/siltstone. It occurs beneath cliffs, on ledges, debris slopes, boulder field and around sinkholes or on forest edges in sites from 630 - 1400 m (Ford 1998) Small clumps occur on stable rock shrubland on the north face of Hoary Head (Gaskell *et al*. 2016).
- *Dracophyllum marmoricola*, endemic to mountain slopes and peaks in Kahurangi. It grows on dark sandy loam in open and exposed sites or in marble rock crevices in low cliffs in alpine tussock-herbfield. Populations of *D. marmoricola* are extensive numbering more than 1000 plants and can form carpets of up to a metre diameter covering rock rubble (Venter 2002). It is a common Hoary Head shrubland component (Gaskell *et al*. 2016).
- *Myosotis pygmaea,* a tiny ground-hugging forget-me-knot that occurs on well drained open sites from coastal to alpine areas across New Zealand (De Lange 2003). On Hoary Head it occurs sparsely in shrubland on gravelly soils between stable rock (Gaskell *et al*. 2016).
- *Pterostylis humilis*, the endemic mountain greenhood orchid occurs in montane to subalpine habitats in beech forest and subalpine scrub, often in deep drifts of leaf litter, or amongst mosses and under bushes. It has also been recorded from bare mountain tracksides (De Lange 2007). It has been recorded from Hoary Head (Druce 1980), Mt Arthur ridge and Peel Ridge (Nelson Botanical Society).

- *Senecio* aff. *glaucophyllus* "Burnett" is endemic to Kahurangi. It is a calicole confined to rock outcrops and boulderfalls. It usually occurs in open sites or in sparsely vegetated situations but sometimes in shrubland, often around cave entrances and tomos (De Lange 2008). A population of more than 100 plants of this distinctively glaucous *Senecio* occur on steep rockland with loose talus on Hoary Head. Most were short statured plants without flowers and were embedded in crevices or tucked under shrubs indicating goat browse pressure. Larger statured flowering plants were uncommon (Gaskell *et al*. 2016).
- *Traversia baccharoides*, a montane to sub-alpine, bushy spreading shrub. It often occurs at forest margins on cliff faces, on steep rubble-strewn slopes, amongst boulders or at the bottom of talus slopes in and amongst other low shrubs (NZPCN 2014a). It is a widely scattered component of a diverse shrubland community on boulder fields below the Deep Creek cirque bluffs (Gaskell *et al*. 2016).

4.8.3 Reptiles

Black-eyed gecko, *Mokopirirakau kahutarae* is a nocturnal mountain species typically occupying alpine bluffs and cliffs. There have been no definitive sightings since 1998 (Whitaker *et al*. 1999) despite night time surveys on Mt Arthur Ridge and Hoary Head, although geckos that evaded capture were sighted in February 2016. G-minnow traps deployed in February 2016 also failed to capture geckos. Definitive foot prints were however found in foot print tracking tunnels baited with tinned pear, placed off the Mt Arthur ridge by Friends of Flora in 2016 (Rogers 2009, Rogers 2016).

Kahurangi gecko, *Woodworthia* "Kahurangi", previously called *Hoplodactylus* sp. 'Mt Arthur' (Hitchmough *et al*. 2013) is another nocturnal species found on the Mt Arthur massif ranging from 1280 to 1500 m in altitude. It occurs in two habitats: screes of small angular stones of argillite, and exposed marble surfaces occurring as a mosaic with sub-alpine shrubland in which the dominant plants are tussock (*Chionochloa* spp.) and various species of *Dracophyllum, Coprosma, Hebe* and *Cassinia* shrubs to about a metre in height. The relative density of 'Mt Arthur' geckos is higher in the screes (up to 5 at one site) than beneath marble slabs (where only single geckos were found) (Whitaker *et al*. 1999). It also occurs on Mt. Owen, Mt. Mytton and the Anatoki Range. Night searching and foot print tracking tunnels on Hoary Head in 2016 found no sign (Rogers 2016). Friends of Flora placed 20 foot print tracking tunnels in Horseshoe basin (random spacing) baited with pear for lizards, and 50 unbaited at 15m spacing along Mt Arthur ridge for wētā. Cards were replaced weekly and bait renewed for the lizard-specific tunnels over a six week period in summer 2016. *Woodworthia "*Kahurangi*"* tracks were found each week, the majority in unbaited tunnels set for wētā (Rogers 2016).

The speckled skink, *Oligosoma infrapunctatum* has been recorded from Winter Peak and Mt Arthur ridge in March 2009 and February 2016. Other skinks found on Lodestone and the Tableland have yet to be identified (Rogers 2009, Rogers 2016).

4.8.4 Invertebrates

No comprehensive invertebrate surveys have been undertaken in the EMU, although there has been more recording here than in many alpine areas.

Mt Arthur giant wētā, *Deinacrida tibiospina* are small in comparison with other species of giant wētā, measuring around 40 mm in length. They inhabit sub-alpine tussock and herbfields. They are nocturnal and during the day they hide in or under the bases of tussock, thick clumps of *Astelia*, or other plants, generally between 1300-1500 m. They are restricted to Kahurangi National Park and are rarely encountered, with fewer than 30 sightings reported from 1980 to 2012 (I. Millar pers. comm.). They have been reported from Mt Arthur ridge, the Twins and Mt Peel within the EMU, which is a stronghold for the species. Friends of Flora initiated a monitoring programme for these wētā in the summer of 2016 (see section 4.8.3). *D. tibiospina* footprints occurred regularly in the tunnels. However, there were a large number of prints which could not be definitively identified. It is likely that they were made by *D. tibiospina* on the basis of size and habitat (I. Millar pers. comm.). Efforts will be made to identify the tracks using trail cameras and pit fall traps, but until definitive identification is possible, the size of the population cannot be determined.

The giant scree wētā, *Deinacrida connectens* (not listed as threatened or at risk) has also been recorded from Mt Arthur and Mt. Peel areas. Although it is the most widespread of the giant wētā species, it shows genetic differentiation as a result of the glaciations which separated populations in the past. The NW Nelson population, best known from Mt Arthur, is now permanently separated from the other populations along the main South Island ranges, and forms a genetic clade which is distinct from other populations (Trewick 2001). This genetic variation is worthy of protection (I. Millar pers. comm.). Wētā prints assumed to be from *D. connectens* (I. Millar pers. comm.) were also found in Friends of Flora's 2016 tracking tunnels. As for *D. tibiospina,* definitive identification is necessary before conclusions on population size can be drawn.

A large flightless weevil, *Anagotus oconnori* which is host specific to *Astelia nivicola* is not listed as threatened or at risk but is a dramatic species that was reportedly common on Mt Arthur, but is susceptible to rat predation (Meads 1989).

Powelliphanta "Lodestone" is a relatively small carnivorous snail (maximum diameter 41 mm; height 18 mm) with a very low spire and flattened appearance. It has not been formally described but is considered to either be a strongly genetically divergent subspecies or full species. It is known only from the EMU and is found at 1100–1400 m just below, at, and just above the bush line. It lives under litter and under the skirts of *Astelia nervosa*, prickly shield fern and red tussock just above the bush line, and under litter and bush tussock in silver and mountain beech forest on limestone substrates. It has been recorded from Mt Arthur and Mt Lodestone with doubtful records from Hoary Head and the Gordon's Pyramid – Arthur ridge (Walker 2003). Twelve shells were found at about 1000m in Heath Creek in February 2016. A single shell was also found well above the bushline on Mt Arthur ridge (Rogers 2016).

4.9 Threats to alpine biodiversity

4.9.1 Competition

The hawkweeds, *Pilosella officinarum* and *Pilosella caespitosum , Pilosella praealta* (formerly in the *Heiracium* genus) are considered to be the greatest weed threat in the alpine zone in general (Mark & Adams 1973) and within the EMU (Gaskell *et al*. 2016). Small infestations of *P. caespitosum* were found on Hoary Head in 2016 (Gaskell et al 2016) and King devil hawkweed (*Pilosella praealta*) was noted at sites in the Lake Peel basin, and beside the Gordon's Pyramid and Mount Arthur tracks (Whiting 2016). Low growing plant species with restricted distributions such as moonwort and *Myosotis pygmaea* are particularly vulnerable to competition for space, water and nutrients from weeds. In addition to its ground covering properties, *Pilosella* invasion can have implications for litter breakdown and below ground processes because of its high foliar nutrient concentrations (Wiser & Allen 2000). Montane calcareous boulder fields may be invaded by other herbaceous weeds such as thistles and non-native grasses on the margins and small pockets of fines (Buxton undated). Movement of seed by trampers or in gravel for track maintenance is likely to be the main pathway for spread of weeds to the more vulnerable alpine areas. The upgrade of the Mount Arthur track from the saddle to the hut has brought many weeds in with the imported gravel (Whiting 2016). Ungulates are another pathway for spread of weeds. *P.officinarum* is widespread and control is probably unrealistic except at localised locations where it threatens particular species.

The tussock hawkweed (*Pilosella lepidulum)* is scattered extensively through tussock, herbfield and shrubland in the EMU. It also occurs all along the main Flora track. Catsear (*Hypochaeris radicata*) is similarly widespread but less common. *Carex ovalis* is scattered in damp areas along tracks and beside tarns and seeps in the subalpine and alpine zones such as the Tableland and around Lake Peel. The rushes *Juncus effusus* and *J. articulatus* are both common in wet areas. There are also areas dominated by exotic pasture species – mainly grasses such as sweet vernal (*Anthoxanthum odoratum)* and browntop (*Agrostis capillaris*) with some clover (*Trifolium repens*) and occasional selfheal (*Prunella vulgaris*), mouse ear chickweed (*Cerastium fontanum*) and ragwort (*Jacobaea vulgaris*). They are found mainly beside tracks, around huts, and on historically disturbed ground on the Tableland and adjacent to Balloon Creek. Sheep's sorrel is patchily distributed on disturbed sites on the Tableland and on Hoary Head. Wall lettuce (*Mycelis muralis*) occurs above the bushline but is more common within forest mainly on bluffs and steep slopes. All these weeds are considered too widespread to be effectively controllable (Whiting 2016).

4.9.2 Herbivory

Until European settlement, New Zealand's alpine grasslands were browsed only by flightless indigenous birds and invertebrates. Now, most high altitude grasslands are subject to grazing and browsing by various combinations of feral herbivores. Browsing can influence species richness, the relative abundance of species, and the physical structure of the community.

Within the EMU, goats, *Capra hircus* and hares, *Lepus europaeus* have the greatest impact in the alpine zone. Taller growing shrubby plants are particularly at risk from goats, which are controlled by DOC through contract hunters. Hares are likely to adversely affect most of the threatened and at risk species (S. Courtney pers. comm.). They may travel 15 km while feeding in one night although most are relatively sedentary. Home ranges varying from 30 ha (for a female) to 70 ha (for a male) have been reported. Hares clip vegetation with a characteristic 45° cut and often eat only the more nutritious bottoms of tussocks. Numerous herbs, other grasses, shrubs, mosses and seeds make up their diet. Hares may adversely impact individual threatened species, for instance, herbivory by hares drastically reduced seed production and subsequent seedling establishment of New Zealand native broom species in in Fiordland (Grüner & Norton 2006).

The foliage and flowers of *Clematis marmoraria* are very vulnerable to browse by hares, goats and deer. A steel mesh cage set up on Hoary Head in about 2003 to observe browse effects dramatically illustrates this pressure. Under the cage, foliage extended beyond crevices and flowers were numerous (figure 5). Very few flowers were encountered anywhere outside the cage (Gaskell *et al*.

2016). Since this clematis occurs only on Hoary Head and nearby Crusader, this lack of seed set is particularly serious.

Figure 5 *Clematis marmoraria* flowers maturing into wind-dispersed seed under protective cage on Hoary Head. Photo: R. Gaskell

There is currently no reliable and effective method for estimating and monitoring hare densities and no effective control mechanism in the alpine zone where hare populations are relatively low and access and terrain is difficult. One intensive control study found that although hare numbers could be reduced by 60% through a combination of shooting and poisoning, there was substantial recovery in hare numbers during the subsequent breeding season. Hare control programs therefore need to be large scale and sustained if conservation benefits are to be achieved (Wong & Hickling 1999).

4.9.3 Predation

Predation, particularly by rodents is considered the greatest threat facing New Zealand's unique endemic invertebrates which evolved without mammalian predators and often lack the behavioural adaptations to successfully counteract the prey-seeking behaviour of mammals. New Zealand has a high proportion of large, flightless, ground-dwelling invertebrates, some of which produce a strong odour, and whose main defence mechanism is to remain still (e.g. giant wētā). Whilst this behaviour may be a successful survival strategy to cope with endemic predators such as tuatara it is often fatal when dealing with introduced mammalian predators that utilise both sight and smell to locate their prey (e.g. rats). A number of species may have safe daytime refuges, but their nocturnal activity makes them vulnerable to introduced predators that hunt at night (McGuinness 2001). The small range and number of large weevil species in New Zealand in comparison with that evident from Holocene fossils suggests that predation by rodents has driven the decline (Kuschel & Worthy 1996). Every few years, the dominant tussock grasses (*Chionochloa* spp.) of the alpine zone experience a mast year and produce large numbers of flowers and later set seeds. This may result in pulses in the abundance of rodents in alpine habitats.

The diet of mice is dominated by invertebrates, especially wētā (Orthoptera), spiders (Araneae), caterpillars (Lepidoptera) and grasshoppers (Orthoptera). Wilson *et al*. (2006) report an inverse correlation between capture rates of mice and ground wētā (*Hemiandrus* spp.) in snap traps at alpine sites, suggesting that predation by mice may reduce the abundance of these insects. Burrowing species are probably vulnerable to mouse predation at all life stages, and, because such burrowing species mature slowly, predators may have a considerable impact on their abundance (Wilson *et al*. 2006). *D. tibiospinosa* were monitored using tracking tunnels during and after a mouse irruption on Mt Arthur in 2010. Mice appeared to strongly influence wētā activity (probably by predation) during the irruption but the wētā appeared to bounce back the following season. The population revival was likely to be partly from eggs laid the previous year before wētā were predated and/or from small nymphs of the previous year that escaped predation. However, since monitoring did not occur before the mouse irruption, it is not known whether wētā activity recovered to the level it had been prior to the irruption. The effects of mice on wētā are likely to be an indicator of their likely effects on other large invertebrates in the subalpine (I. Millar pers.comm.).

Rock wrens' weak flight, persistent home ranges, and ground-feeding habit promote a disjunct distribution and hence a vulnerability to local extinction. In addition there is evidence of eggs, nestlings, and adult rock wrens being preyed on by mice and stoats (Michelsen-Heath & Gaze 2007) and they are likely to be particularly vulnerable after a mast flowering event such as occurred in the EMU in spring 2014 with subsequent rodent and stoat irruptions. It is difficult to quantify changes in rock wren abundance because of the low and variable detection rates even when they are present (Michelsen-Heath & Gaze 2007).

Kea are vulnerable to a range of introduced mammalian predators due to their ground-nesting habit and extended nesting cycle (it takes four months to fledge young). Kemp *et al*. (2014) cited in DOC (2014) identified the key predators of kea using a combination of nest cameras, corpse necropsy and inference from predator density fluctuations during nest survival monitoring. Nest cameras recorded visits by stoats, possums, ship rats, house mice and weka. Stoats were identified as the predator in three of 16 nest failures while no positive identification was possible for the other cases. Statistical modelling of the effect of predator visitation on nest survival suggests that visits by stoats, possums and rats were predictors of nest failure, with the strongest support for stoat visits. Predator control needs to take place on a landscape scale to protect kea nests from predation by stoats for two reasons: kea breeding pairs and nests are found at a low density so broad scale control is needed to cover even a small number of nests; stoats have high productivity and a large home range and dispersing young are capable of long distance travel. Localised small scale control measures are quickly undone by immigration. Surveys by the Kea Conservation Trust in Kahurangi National Park have documented a decline in kea populations (Kea Conservation Trust 2014).

All New Zealand geckos are vulnerable to mammalian predation. Predators include mice, rats, hedgehogs, weasels and stoats. Since most of these predators are active at night and hunt on the ground, species that are large, terrestrial and/or nocturnal are more at risk than species that are smaller, arboreal (tree-dwelling) and/or diurnal. Small predators can follow the larger species but not the smaller ones into the crevices where they shelter and sleep. Long term monitoring of skink populations in Rotoiti mainland island using pitfall traps found that the level of mammalian predator control currently occurring there is insufficient to protect or allow recovery of the skink populations.

Populations have declined significantly and the proportion of females to males and the body size of females caught since the 1970s have decreased (Dumont, Briskie & Monks in Nelson & Keall 2015). *Powelliphanta* 'Lodestone' snails are vulnerable to predation by rats, thrushes and hedgehogs (Walker 2003).

Rodent populations in the forest zone of the EMU are monitored using Footprint Tracking Tunnels, but there is currently no monitoring above the bushline.

A home range study of radio tagged stoats found that stoats spent significantly more time in alpine grassland than in adjacent beech forest. Alpine grasslands are therefore unlikely to be barriers to stoat immigration; rather they may be a source of dispersing stoats (Smith *et al*. 2007). This has implications for predation impacts throughout the EMU and FOF's stoat trapping network extends into the alpine zone.

The results of current research being undertaken by DOC should provide a better understanding of the predator dynamics and their impact on threatened species in the alpine zone.

The alpine fauna is likely to suffer increased predation by rodents if their range expands as result of climate change. However, areas (such as the EMU) with diverse micro-topography offer a diversity of microclimates where species might find at least temporary refuge from changes in climate (Mark *et al*. 2013).

4.9.4 Physical habitat disturbance

Deer, hare, pigs and goats can damage the moist, deep litter layer which protects *Powelliphanta* 'Lodestone' snails from desiccation and predation (Walker 2003). They also impact on regeneration and create gaps in alpine turf which are vulnerable to weed invasion.

4.9.5 Habitat loss

Climate change can have a significant impact in the alpine zone. A 0.6°C rise could threaten 40–70 indigenous alpine species nationally through loss of habitat to both native flora and exotic weeds. Over millennia, fragmentation of alpine areas might favour speciation, but in the shorter term the loss of up to 80% of existing alpine islands would substantially shrink species ranges and significantly increase the risks of extinction (McGlone *et al*. 2010).

4.9.6 Poaching

New Zealand geckos are rare, unique and desirable on the international pet trade market. There have been instances of geckos being poached in the wild, albeit not in the EMU. Orchids are also vulnerable to theft.

4.9.7 Other human activities

Karst surface landscapes are vulnerable to recreational activities, such as trampling of vegetation, especially where people congregate (e.g. climbers around ledges); scrubbing rocks and cleaning crevices for improved climbing holds; and the smothering of vegetation by dumped rubbish. In addition, bolts put into the rocks to aid climbing can degrade the attractiveness of karst, as can graffiti (Department of Conservation 1999).

There is evidence that lead exposure from flashing and nails on hut roofs may be an important contributing factor in kea mortality (Youl 2009).

5 Tussockland biodiversity and threats

The extensive tussock grasslands of the Tableland peneplain and adjoining slopes are a characteristic feature of the EMU. They occur above the treeline in the low alpine zone as well as below the treeline in frost flat areas. The Tussockland zone overlaps with the alpine zone (Section 4) with which it shares many threats.

5.1 Red tussock tussockland

These ecosystem which is extensive on the Tableland and Peel Ridge (Figure 6) dominated by red tussock, and *Schoenus pauciflorus*, with cushionfield, sedgeland, sphagnum, wire rush and scattered shrubs (e.g. *Hebe odora* and bog pine) and shallow pools (Singers & Rogers 2014). Non-native grasses and clover have displaced the small tussocks and other native grasses in large patches which are maintained by deer. Bogs are sporadic across the Tableland such as on flat ground below directly below the cirque at the head of Deep Creek. *Shoenus pauciflorus* is dominant in these areas with bulbinella fringed with red tussock. The wettest areas contain *Sphagnum* and patches of the exotic rushes, *Juncus effusus* and *Juncus articulatus* (Gaskell *et al*. 2016).

Figure 6 Tussockland on Cobb Ridge looking towards the Arthur Range. Photo: S. Toy

5.2 Frost flat scrub

Coprosma - Olearia dominated scrub, sometimes called grey scrub occurs in frost hollows or alluvial terraces (Singers & Rogers 2014). Frost hollows are considered a rare (Williams *et al.* 2007) and endangered (Holdaway *et al*. 12) ecosystem. The upper Balloon Creek/Cundy Creek area has good examples of this ecosystem.

5.3 Frost flat red tussock

Tall tussock grassland of abundant red tussock with inter-tussock herbfield/short tussockland and prostrate shrub species with wire rush is dominant in frost flat areas of Balloon and Deep Creeks. While intense frost (probably temperatures of below -9°C) is likely to be a critical factor in excluding tall trees from this low-lying topography, other physical stressors are also likely to be at play, including summer drought on stony or pumice substrates, soil nutrient impoverishment, and high water tables (Singers & Rogers 2014).

5.4 Riparian turf

Ephemeral wetlands occur as very small areas adjacent to watercourses amongst montane frost flats. Herbfield and/or low sedgeland is dominated by a range of predominantly montane, short-statured herbs, grasses and sedges(Singers & Rogers 2014). Within the EMU, this ecosystem occurs on flood zone gravel and cobble beds associated with concave bends in the upper reaches of creeks such as Balloon Creek (Figure 7), and extends intermittently over several hundred meters. Species associated with this habitat are: *Coriaria plumosa, Lobelia macrodon, Lobelia angulata, Linum catharticum*, Rytidosperma sp. with Leptinella, *Acaena profundeincisa, Oreomyrrhis colensoi* and *Raoulia glabra* (Gaskell *et al*. 2016).

Figure 7 Riparian turf in frost flat tussock at Balloon Creek. Photo: R. Gaskell

5.5 Peat bog

Low alpine bogs on gentle hillslopes, plateaus and depressions with organic soils are dominated by tall tussockland and restiad rushland, with tangle fern and scattered shrubland (Singers & Rogers 2014). Within the EMU, bog systems occur on peat over a podzol at the Tableland between Balloon Creek and the Mataki Stream (Figure 8), and at Peat flat. They are nutrient poor with acidic pools, edged with the exotic rush *Juncus effusus,* separated by wire rush, *Empodisma minus* on peat with *Dracophyllum filifolium* and *Dracophyllum rosmarinafolium*, pygmy pine, *Lepidothamnus laxifolius*, bog pine *Halocarpus bidwilii*, *Coprosma decurva*, and red tussock (Gaskell *et al*. 2016).

Figure 8 Peat bog with Gordon's Pyramid behind. Photo: S. Toy

5.6 Threatened, at risk and extinct species associated with the tussock zone

Since tussockland ecosystems are a subset of alpine ecosystems some species such as the giant wētā, *Deinacrida tibiospinosa*, included in chapter 4, also occur in tussock ecosystems.

Table 3 summarises the status of threatened and at risk species recorded primarily from the tussock zone of the EMU.

Table 3. The status of threatened and at risk species recorded primarily from the tussock zone of the EMU.

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU
bird	4Declining	*Bowdleria punctata*	fernbird	Yes	Peat Flat, Cobb Ridge, Pyramid
plant	4Declining	*Mentha cunninghamii*	native mint	Yes	Widespread
plant	7Naturally Uncommon	*Euchiton paludosus*	bog cloak daisy	Yes	Tableland
plant	7Naturally Uncommon	*Euchiton polylepis*	river cloak daisy	Yes	Tableland, forested wetlands
plant	7Naturally Uncommon	*Kelleria tessellata*		Yes	Tableland
plant	7Naturally Uncommon	*Olearia quinquevulnera*		Yes	Tableland
invertebrate	4Declining	*Stigmella sp. "traversia"*	Moth (leaf miner)	Yes	Mt Arthur
invertebrate	7Naturally Uncommon	*Deinacrida rugosa*	NW Nelson giant weta	Yes	Tableland
invertebrate	Not assessed data deficient	*Hakaharpalus maddisoni*	beetle	Yes	Mt Arthur

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU
invertebrate	Not assessed data deficient	*Kiwimiris bipunctatus*	bug	Yes	Mt Arthur
invertebrate	7Naturally Uncommon	*Rhypodes brachypterus*	flightless bug	Yes	Mt Arthur

5.6.1 Birds

The endemic fernbird is widespread and locally common west of the Southern Alps. It declined about the time of European settlement with the loss of much wetland and fernland through agricultural development, introduction of mammalian predators and periodic burning of wetland and scrub habitats. It occurs in low, dense ground vegetation interspersed with emergent shrubs in swamps and rush and tussock covered frost flats as well as scrub (Heather & Robertson 2015).

5.6.2 Plants

Mentha cunninghamii or native mint is a common component of grassland and other open places such as cliffs, river banks, lakesides, grey scrub, occasionally in swampy ground. It is widespread within the EMU occurring from wetlands in the Grecian right through to the Tableland (Gaskell *et al*. 2016).

Euchiton paludosus is an endemic daisy that occurs mainly in bogs, or occasionally along stream and tarn margins, seepages and flushes within forest, shrubland, tussock grassland or herbfield. It is a naturally uncommon, biologically sparse species that is widely distributed but never common at any particular place (NZPCN 2011).

Euchiton polylepis is also endemic, and occurs from lowland to subalpine in damp places, especially stream sides and damp hollows in grassland, cliffs and rocky places. It is easily overlooked and little is known about its distribution. Within the EMU It has been recorded from the Flora Stream (1975) and broken Bridge on the Takaka River(1969) as well as in riparian flat turf in the upper Balloon and in forested wetlands on limestone (Gaskell *et al.* 2016).

Kelleria tessellata is a trailing shrub in the Daphne family. It occurs on fine debris and gravel fields in snow tussock grassland and herb fields (Mark & Adams 1973).

Olearia quinquevulnera, previously known as Olearia capillaris, is an endemic bushy shrub with zig-zagging tangled branches growing up to 2 m in the montane to subalpine zones on valley floors, on forest margins, clearings, amongst rocks, below cliffs and in subalpine scrub, often in poorly drained or permanently wet soils (Heenan 2005). Its stronghold in the EMU is at Balloon creek where it forms a dense monoculture on the ecotone between silver/mountain beech forest and red tussock flats. Here a shrubland of Astelia nervosa, Coprosma decurva, Coprosma propinqua, Olearia lacunosa , Olearia virgata, Hebe topiaria, Melicytus spp. mountain flax and exotic grassland merge into an almost pure stand of Olearia quinquivuelnera. Individuals and clumps of plants occur up to 500 m upslope from the main population in silver beech forest light gaps. Occasional hybrids with Olearia lacunosa occur outlying the main population (Gaskell et al. 2016). Despite abundant flowering no young plants were found in 2016. The only other stronghold for this species in Kahurangi, is on Mt Xenicus in the Cobb valley.

5.6.3 Invertebrates

While not listed as threatened, a number of notable invertebrate species occur in the tussocklands. The large speargrass weevils, *Lyperobius clarkei* and *L. fallax* are endemic to the upper part of the South Island including the Arthur Range (Craw 1999). Many *L. clarkei* were recorded feeding at night on the Mt Arthur ridge in 1998, along with large numbers of stick insects, many of them mating. These were most likely to be an undescribed species of *Micrarchus*, known also from Lockett Range, Cobb and Mt Murchison (Thomas Buckley, pers. comm. to I. Millar). The bugs *Kiwimiris bipunctatus* and *Rhypodes brachypterus* are known only from Mt Arthur (Eyles 1990; Eyles & Carvalho 1995), and the moth, *Stigmella* sp. "traversia" and the beetle, *Hakaharpalus maddisoni* are known only from Mt Arthur and Berts Creek (Molesworth) (I.Millar pers. comm.).

5.6.4 Extinct species

See discussion in Section 6.9.6 on evidence from cave fossils.

5.7 Threats to tussockland biodiversity

5.7.1 Competition

. New Zealand's tussock grasslands are particularly vulnerable to weed invasion, perhaps because they are easily overgrazed, which creates bare ground which in turn can be readily colonised by aggressive, often relatively unpalatable weeds (Mark *et al.* 2013).

Introduced grasses and legumes are abundant in many areas of the Tableland and Deep Creek, probably dating back to when the Tableland were grazed (Hayward 1980). Much of the damp valley floor of upper Balloon creek and Deep Creek has a sward of exotic grasses including sweet vernal, browntop, Yorkshire fog and *Carex ovalis* with white clover. Slender St Johns wort, *Hypericum pulchrum* is a weed capable of invading damp tussock land. Numerous plants occur in *Schoenus*, red tussock in Upper Deep Creek and a localised patch in red tussock on the trackside on the tableland. It is also widespread at Peat Flat and spreading along the track to Cobb ridge. Control is likely to be problematic as seed is very fine. Weed threats to the temperature inversion and river gravel communities within the EMU include *Pilosella officinarum*, *Prunella vulgaris* and *Hypochoeris radicata*. These are low level and problematic to manage effectively (Gaskell *et al*. 2016). The wetland ecosystems are vulnerable to the spreading weed *Juncus squarrosus* which has not yet been detected in the EMU.

5.7.2 Predation

See Section 4.9.3 on predation threats to alpine biodiversity which also apply to the tussock zone. Populations of the speargrass weevil *Lyperobius huttoni* are known to be preyed on by mice, amongst other predators (in Wellington) and all the tussockland weevil species are likely to be vulnerable to mouse predation, especially during mouse irruptions resulting from tussock masting (I. Millar pers. Comm.).

5.7.3 Herbivory

Wilson *et al.* (2006) reviewed the diet and impact of hares in tussock grassland. In Nelson Lakes National Park, hares fed primarily on snow tussock in winter and the grass *Poa colensoi* in summer. Hares also ate herbs, including *Celmisia* spp., and, to a smaller degree, shrubs such as *Aristotelia fruticosa* and *Coprosma* spp., especially in winter. Hares may affect the condition (basal area, height and density) of *Chionochloa* tussocks, and intensive browsing by hares may be enough to prevent the recovery or re-establishment of tussocks even many years after the removal of sheep.

Less is known about the impacts of deer in grasslands compared with impacts in forests. Red deer generally made intensive use of alpine grasslands and subalpine shrublands prior to the advent of helicopter-based hunting. They preferred well-drained and fertile sites containing the highest diversity and biomass of preferred food plants (principally the grasses *Chionochloa pallens* and *C. flavescens* and the herbs *Anisotome haastii and Celmisia verbascifolia*). The effects of deer on individual grassland plants may persist for decades (Forsyth *et a*l. 2010).

There is considerable evidence of impact from hares on the Tableland. Deer impacts are evident particularly in the forests adjoining the valley bottoms (Gaskell *et al.* 2016).

5.7.4 Habitat modification

The tussock ecosystems are vulnerable to accidental fires which would likely result in further spread of non-native grasses and weeds. Fires are theoretically only permitted in designated sites at huts and shelters within the National Park, but the increasing numbers of casual visitors to the area, increases the risk of accidental fire.

5.7.5 Hybridisation

The shrub *Olearia quinquevulnera* is known to hybridise with other species (Heenan 2005). At Balloon Creek occasional hybrids with *Olearia lacunosa* occur outlying the main population (Gaskell *et al*. 2016).

6 Forest biodiversity and threats

Forests are the most abundant ecosystems in the EMU. Sub-alpine scrub occurs at higher altitude with beech forests dominating the lower altitudes but the boundaries between ecosystem types are often indistinct. Rare and threatened forest ecosystems are associated with localised features including limestone bluffs and pavements, wetlands and ultramafic rocks.

6.1 Shrublands on non-calcareous talus

Olearia, Psuedopanax and *Dracophyllum* dominate with a range of other shrubs such as *Brachyglotis, Hebe, Coprosma, Hoheria,* montane podocarp trees*, Mānuka* and *Phormium cookianum* (Singers & Rogers 2014). Within the EMU, shrublands occur on acidic rock in the upper part of Deep Creek (figure 9). Only a minor element of tussock, *Chinocloa flavescens* is present among a diverse shrubland including *Olearia colensoii, O. numularifolia, Hebe topiaria, H. albicans, Traversia baccaroidies, Acephylla glaucescans, Pseudopanax colensoi*, *Dracophylum filifolium,* snow totara, *Totara nivalis* and mountain flax, *Phormium cookianum*. The threatened *Traversia baccharoides* is frequent here and the lack of browsing of the palatable mountain ribbonwood (*Hoheria glabrata*) indicates a low deer presence in this ecosystem (Gaskell *et al*. 2016).

Figure 9 Deep Creek headwaters bluff supporting *Traversia baccharoides* shrubland. Photo: R. Gaskell

6.2 Silver and mountain beech forest

Forest of abundant silver beech, *Lophozonia menziesii* and mountain beech, *Fuscospora cliffortioides*, occurs on upper mountain slopes, locally with mountain celery pine, *Phyllocladus alpinus*; three-finger, *Psuedopanax* colensoi; *Olearia* spp., broadleaf, *Griselinia littoralis* and small-leaved shrubs (Singers & Rogers 2014). This is a widespread ecosystem in the EMU.

6.3 Mountain, silver beech podocarp forest

This is a more diverse ecosystem with mountain and silver beech with yellow-silver pine, *Lepidothamnus intermedius*; Southern rata, *Metrosideros umbellata;* and mountain neinei, *Dracophyllum traversii*. At lower altitudes silver pine, *Manoao colensoi*; rimu, *Dacrydium cupressinum*; miro, *Prumnopitys ferruginea*; mountain cedar, *Libocedrus bidwillii*; Hall's tōtara, *Podocarpus cunninghamii* and pōkākā, *Elaeocarpus hookerianus* occur (Singers & Rogers 2014). *Dracophyllum traversii* is a characteristic species of the EMU with prominent stands notably on the Mt. Arthur track. Good examples of this ecosystem occur around Heath and Deep Creek on gentle slopes with poor drainage and poor fertility on soils of volcanic origin. Mountain cedar, *Libocedrus bidwillii* is an important associate species here. This ecosystem also occurs on limestone and sedimentary substrates on low gradient landforms to the north of the Flora. This shows on aerial photos as having a smooth texture indicating a typically tighter canopy, whereas red-silver beech forest shows as more dappled, with a more open canopy of mixed aged trees (Moore 2016).

6.4 Silver beech forest

Silver beech dominated forest generally occurs on upper mountain slopes, locally with mountain celery pine, three-finger, *Olearia* spp., kōtukutuku, broadleaf and small-leaved shrubs (Singers & Rogers 2014). Within the EMU, it occurs on the marble of the Arthur Range, where the mountain beech component of upland forest drops out, leaving pure silver beech forest to form the treeline (Moore 2016).

6.5 Red-silver beech forest

At lower altitudes red beech, *Fuscospora fusca* and silver beech forest dominates locally with podocarp/ broadleaved species. Mountain beech; Hall's totara; mountain cedar; kamah*i, Weinmannia racemosa*; hard beech*, Fuscospora truncate*; rimu; miro and matai, *Prumnopitys taxifolia* may occur (Singers & Rogers 2014). This is the most widespread ecosystem in the EMU. There is an old massive debris flow likely to date back to the Quaternary on the true left of the Ellis. The forest cover here is now no different to that of the surrounding beech forest (Moore 2016).

6.6 Ultramafic forest and mānuka/kanuka scrub

This nationally rare and threatened ecosystem associated with Cambrian ultramafic rocks supports many rare plant species. It comprises a mosaic of short forest, scrub and rockland with a wide variety of podocarp trees, beech, southern rātā and kāmahi, interspersed with areas of low mānuka scrub and bare ground/rock (Singers & Rogers 2014). Although it is a significant feature of the adjoining Cobb EMU only a small ultramafic outcrop occurs within the Salisbury EMU at the bottom of Ghost Creek. The area appears to have been burnt and opportunities for colonisation by shrubs, herbs and grasses may have been limited by the short time since fires exposed the ultramafic surfaces. Only a few of the endemic plants restricted to ultramafic habitats occur here, many other plant species common on this geology on the other side of the Takaka river are absent from the EMU(Walls 2005).

6.7 Seepages and flushes in Forests

A range of localised wetlands occur within the forest systems. Red tussock - *Schoenus pauciflorus* grassland occurs in patches particularly in the Deep Creek /Heath Creek area (see also Section 5.1). Elsewhere, mossfield, herbfield, sedgeland with S*phagnum* and other mosses, short-statured sedges and a range of herbs such as *Epilobium*, *Euphrasia* and *Gentianella* also occurs with cushionfield, typically with species of *Oreobolus*, *Donatia, Gaimardia, Centrolepis, Carpha alpina* and *Phyllachne*, and often *Androstoma empetrifolia, Pentachondra pumila* and *Lepidothamnus laxifolius* occurs Scattered mānuka*, Leptospermum scoparium*; pink pine*, Halocarpus biformis*; mountain beech and yellow silver pine are characteristic of these wetlands (Singers & Rogers 2014). These wetlands are nationally endangered. The forest wetlands on limestone to the north of the Flora are particularly noteworthy (Druce 1992, Druce 1992a, Walls 2005). They are small, support high numbers of threatened and at risk plants and are vulnerable to weed invasion and pugging by deer and pigs.

6.8 Marble and limestone cliffs, screes and pavements and sinkholes

These localised ecosystems occur in the forest as well as the alpine zone (Section 4.3 – 4.6)(Figure 10)and often support threatened and at risk species. Dramatic clint and grike topography, forming giant corridors of tertiary limestone occurs on the Barron Flat, either side of the Flora stream and south Tableland parts of the EMU. The ecosystem associated with the limestone bluffs is not well defined by the Singers & Rogers classification (2014) but approximates to a mosaic of scrub, shrub, fern and grass species. They are frequently associated with local endemics (see section 6.9.5). There are large sinkholes/poljes in the Grange and Sphinx areas of the Tableland which have impeded drainage.

Cliffs, scarps and tors of non- calcareous rock are a scarce ecosystem type within the EMU which are thought to be the habitat of the critically endangered *Simplicia buchananii* (Moore 2016).

Figure 10 Limestone bluffs in forest ecosystems with the alpine zone of Hoary Head and Crusader in the background. Photo: S. Toy

6.9 Threatened, at risk and extinct species associated with the Forest zone

Table 4 summarises the status of threatened and at risk species recorded from the forest zone of the EMU.

Table. 4 The status of threatened and at risk species recorded from the forest zone of the EMU

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU
mammal	1Nationally Critical	*Chalinolobus tuberculatus*	long-tailed bat	Yes	Unknown
bird	3Nationally Vulnerable	*Apteryx haastii*	great spotted kiwi	Yes	Widespread
bird	3Nationally Vulnerable	*Nestor meridionalis meridionalis*	kaka	Yes	Widespread
bird	3Nationally Vulnerable	*Falco novaeseelandiae*	New Zealand falcon	Yes	Widespread
mollusc	4Declining	*Powelliphanta hochstetteri hochstetteri* (brown based	large land snail	Yes	Widespread
plant	1Nationally Critical	*Montia drucei*		Yes	Mt Arthur, Twins, Cundy Creek, Heath Creek
plant	1Nationally Critical	*Myosotis chaffeyorum*	overhang forget-me-not	Yes	Tableland limestone
plant	1Nationally Critical	*Ourisia modesta*	shy foxglove	Yes	Ghost creek
plant	1Nationally Critical	*Simplicia buchananii*		Yes	Mt Arthur, Cundy Creek

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU
plant	2Nationally Endangered	*Pittosporum patulum*	pitpat	Yes	Tableland
plant	4Declining	*Alepis flavida*	yellow mistletoe	Yes	Mt Arthur, Tableland
plant	4Declining	*Peraxilla colensoi*	scarlet mistletoe	Yes	
plant	4Declining	*Peraxilla tetrapetala*	red mistletoe	Yes	Mt Arthur, Tableland
plant	Not assessed Data Deficient	*Notogrammitis gunnii*	ginga strapfern	No	not confirmed, possibly at Cundy Creek
plant	Not assessed Data Deficient	*Ranunculus simulans*		Yes	Tableland
plant	7Naturally Uncommon	*Carex cremnicola*	marble carex	Yes	Mt Arthur, Twins, Hoary Head
plant	7Naturally Uncommon	*Libertia "peregrinans NW Nelson"*		Yes	Mt Arthur, Tableland
plant	7Naturally Uncommon	*Melicytus obovatus*	limestone mahoe	Yes	Hoary Head, Ghost Creek
plant	7Naturally Uncommon	*Myosotis "australis small white"*		Yes	Mt Arthur, Hoary Head, Tableland
plant	7Naturally Uncommon	*Myosotis brockiei*		Yes	Tableland & Heath Creek limestone
plant	7Naturally Uncommon	*Myosotis spathulata*		Yes	Ghost Creek
plant	7Naturally Uncommon	*Myosotis venosa*		Yes	Tableland, Peat Creek
plant	7Naturally Uncommon	*Pseudopanax macintyrei*	limestone five finger	Yes	Tableland, Ghost Creek
plant	7Naturally Uncommon	*Acianthus viridis (Townsonia deflexa)*		Yes	Flora Saddle
plant	7Naturally Uncommon	*Uncinia longifructus*		Yes	not confirmed but likely to occur
plant	7Naturally Uncommon	*Dracophyllum ophioliticum*		Yes	Ghost Creek ultramafic
plant	7Naturally Uncommon	*Trisetum serpentarium*		Yes	Ghost Creek ultramafic
plant	7Naturally Uncommon	*Carex devia*		Yes	Ghost Creek ultramafic
reptile	4Declining	*Mokopirirakau granulatus*	forest gecko	Yes	Unknown
reptile	4Declining	*Naultinus stellatus*	Nelson green gecko	Yes	Unkown
invertebrate	7Naturally Uncommon	*Priasilpha carinata*	ground beetle	Yes	Mt Arthur

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU
invertebrate	7Naturally Uncommon	*Mecodema angustulum*	ground beetle	Yes	Mt Arthur area, including Tableland & Flora track

6.9.1 Mammals

Long tailed bats, *Chalinolobus tuberculatus* were commonly observed in the Sphinx Cave area of the Tableland until the 1970s (M. Poleglase pers. comm.to I. Rogers). Rates of decline of 5-9% per annum have been reported elsewhere in long-tailed bats (Pryde *et al*. 2006). They live more than 20 years and require large, old trees for maternity colonies. They forage for aerial insects mainly along the edges and above canopies of trees rather than in the forest interior. Home range requirements, based on radio-tracking studies, of up to 1500 ha have been recorded with individuals flying straight line distances of up to 19 km between roosting and foraging areas (O'Donnell 2001). Bats frequently change roost sites and there may be several kilometres between roost sites (O Donnell & Sedgely 1999). In February 2014 a bat recording box placed near Sphinx cave recorded a long tailed bat. It is not known whether this bat was roosting in the EMU, or merely feeding in the area. Ten bat recorders deployed across the EMU in February 2016 in sites close to water, close to historic sightings and in favourable habitat failed to detect any bats (Rogers 2016). It appears that bats are at best scarce within the EMU.

6.9.2 Birds

Kea, *Nestor notabilis* are discussed in Section 4.8.1, although they nest principally in the forest zone.

Great spotted kiwi, *Apteryx haastii* (roroa) disappeared from the EMU in the 1970s. FOF has been working with DOC to re-establish them. Forty four kiwi have been translocated into the area from four different source sites over the period 2010-2016 (Toy & Toy 2014). The translocated kiwi were fitted with radio transmitters and have been intensively monitored to determine the success of the translocation and to contribute to an understanding of the ecology of this poorly studied species. Roroa live for about fifty years with very low productivity and are declining over most of their range. Although listed as at nationally vulnerable (Robertson *et al*. 2013) there is growing evidence that they meet the criteria for critically endangered status (H. Robertson pers. comm.).

Whio, *Hymenolaimus malacorhynchos* occur primarily in the riverine and lake zone and are discussed in Section 7.3.1. They nest in forested areas near streams.

South Island kaka, *Nestor meridionalis meridionalis* occur at low levels through the EMU, but the population size and trend is unknown. Kaka nest in cavities mainly in the trunks of live canopy and emergent trees with a minimum trunk diameter at breast height of c. 600 mm. Kaka are episodic breeders and breeding is strongly linked to mast seeding of beech trees (Powlesland *et al*. 2009).

New Zealand falcon, *Falco novaeseelandiae* also occurs in small numbers through the EMU. It has been recorded nesting on bluffs in at least three locations. It is territorial with territories of up to 15 km^2 in native bush. The nest is a simple scrape on a cliff ledge, under an overhang, in a log or up to 40 m up a tree in a clump of *Astelia* (Heather & Robertson 1996).

Western weka, *Gallirallus australis australis* is not listed as threatened (Robertson *et al*. 2013)but is a characteristic and currently abundant species in the EMU. Populations such as that in the Flora undergo major fluctuations and some become locally extinct for several years before reinvasion and rapid breeding and they become common again. For instance Butler (2008) reports that 'weka are scattered across the ranges of Kahurangi but usually only as isolated individuals. The reasons for the overall decline are poorly understood but predators are likely to be a factor, perhaps combined with reduced food supplies due to climate fluctuations, and disease.'

In addition to these species the EMU is a stronghold for forest bird species which are monitored by annual five minute bird counts along the Flora track. Results since 2005 show no significant changes in relative abundance of the typical forest bird species such as robin, tom tit and rifleman which are abundant in the EMU (R.Toy pers. comm.).

6.9.3 Reptiles

Nelson green gecko*, Naultinus stellatus* is arboreal, inhabiting forests and shrublands to the subalpine zone and rarely subalpine herbfields. *N. stellatus* and the forest gecko *Mokopirirakau granulatus* are thinly distributed through Kahurangi and are likely to be present in the EMU in low and probably undetectable numbers.

6.9.4 Invertebrates

The giant *Powelliphanta hochstetteri hochstetteri* snail occurs in high altitude (750 – 1200 m) beech forest with occasional southern rata and mountain cedar, under leaf litter and logs. Shell colour varies and the EMU is a stronghold for the 'brown-based' form (Walker 2003). The population has been monitored approximately every three years since 1993 in eight 400 m^2 permanent plots in the Flora. Numbers rose after ground based control of possums was instigated in 1994, but have fallen steadily since 2006. The 2016 monitoring survey revealed rats and weka as the main identifiable predators. However, there were a large number of shells with no obvious predator. Desiccation is a possible cause of death, with the dryness of the forest floor exacerbated by the paucity of understory and ground cover as a consequence of long-term ungulate browse (K. Walker pers. comm.).

The forest invertebrate fauna of the EMU is diverse but poorly known. For example, in only four nights during the summer of 2001-2002, 163 moth species representing about 9% of the total New Zealand moth fauna were identified from light traps placed between the Flora carpark and Flora hut (Dugdale & Millar 2002). Three species of giant endemic *Holacanthella* collembola (springtails) were collected between Flora Hut and Flora Saddle, with a potential fourth species found at Balloon. *Holacanthella* species are decomposers and contribute to nutrient cycling of coarse woody debris. They are among the largest collembola known, with some individuals reaching 17 mm in length. They have strict habitat requirements and low mobility and require unmodified old growth forests (Steens *et al*. 2007).

The Carabid family of beetles include some that are large and flightless. About 92% of the carabid fauna are endemic. Approximately 8% of New Zealand carabids are listed as threatened and about 31% of species in the *Mecodema* genus. *Mecodema angustulum* was only known from the EMU, but in recent years this species has been recorded from the Gouland area (I. Townsend pers. comm. to I.

Millar) and it may prove to be more widely distributed in the mountainous parts of Kahurangi. It is cryptic and difficult to find and was last recorded in the EMU in 1998 (Landcare Research 2007).

The ground beetle *Priasilpha carinata* is a small (c. 4mm long) beech forest litter dweller, known from a handful of specimens from Mt Arthur, Mt Domett, Cobb Valley and the Haupiri Range (I. Millar pers. comm.).

6.9.5 Plants

Many of the threatened and at risk plant species are associated with karst habitats in the forest zone, as they are in the alpine zone. Species associated with bluffs, pavements and scree include:

- *Simplicia buchananii*, a critically endangered grass, which occurs below overhanging rock outcrops with a southerly aspect, overhead forest canopy and sometimes dry substrate in a narrow zone where other competitive grasses, herbs and shrubs find conditions difficult. It was recorded in 1967 at the headwaters of Balloon Creek and in 1975 in Cundy Creek, but a moderate search of suitable limestone outcrop habitat in 2011 and again in 2016 failed to find the species on the Tableland (Walls 2011, Gaskell *et a*l. 2016).
- *Myosotis brockiei*, with a distribution centred on the Cobb Valley where there are several small populations on either ultramafic and limestone outcrops. It is associated with cliff faces, talus and rubble within the forest zone. Within the EMU it has been reported from Gridiron, Dry Rock, Salisbury area and limestone near Lower Junction (Brandon 2001). It also occurs in turf under limestone outcrops in Heath Creek (Gaskell *et al*. 2016). It is naturally uncommon and vulnerable to loss from plant collectors, habitat destruction and competition from weeds (De Lange 2008).
- *Myosotis chaffeyorum*, a critically endangered forget-me-not occurs in closed red beech forest in dry loose fine soil under limestone overhangs. There are five known populations, all very small. Within the EMU it occurs near the Ghost Creek saddle and in the upper Takaka valley (Lehnebach 2012).
- *Myosotis mooreana*, another critically endangered forget-me-not is known only from the Cobb where it grows among the twigs and leaf-litter accumulated among large boulders under red beech (Lehnebach 2012). It could potentially occur within the EMU (S. Courtney pers. comm.).
- The forget-me- not, *Myosotis spathulata*, limestone five finger, *Pseudopanax macintyre*i and limestone mahoe, *Melicytus obovatus* are all associated with limestone outcrops, but only occur on the sides of bluffs out of reach of browsing animals (S. Courtney pers. comm.).

Threatened species associated with wetlands in the forests:

- *Ourisia modesta* , the critically endangered shy foxglove (figure 11) grows in beech forest alongside rivers, usually in seepages or on poorly drained terraces amongst leaf litter or in muddy hollows or sometimes associated with stream and river banks, or in flushes within subalpine scrub (De Lange 2009). The wetlands in the northern part of the EMU are considered significant for this species (S. Courtney pers.comm.).

Figure 11The critically threatened shy foxglove. Photo: S. Courtney

- *Ranunculus simulans*, a diminutive buttercup that occurs from lowland to alpine (0-1200 m), in damp seepages and pools within forest, along stream banks and in seepages and flushes in subalpine scrub and herbfield. It is believed to be a very uncommon, widely distributed and biologically sparse species. It is easily overlooked (De Lange 2003).
- *Myosotis venosa* which occurs from the central North Island to the Nelson region. It requires damp mossy conditions and occurs at stream sides, damp cave entrances and track sides within the forest. Within the EMU it has been recorded from Peat Creek and south of Gordon's Pyramid (Brandon 2001).

Threatened species associated with ultramafic habitats:

- *Dracophyllum ophioliticum, Trisetum serpentarium* and *Carex devia* are all naturally uncommon being restricted to habitat on ultramafic substrate. *D. ophioliticum* is known only from the Cobb and upper Takaka valleys. Within the EMU they are occur only on the Ghost Creek outcrop (Walls 2005).

Threatened and at risk species associated with miscellaneous forest habitats:

- *Peraxilla tetrapetala*, *P.colensoi* and *Alepis flavida* are all mistletoe species parasitic on beech trees. They are easily overlooked, especially when they occur high in the canopy, but carpets of fallen petals were conspicuous during the spring 2014 mast flowering event. They are now rare compared with reports from Dorrien-Smith who traversed the Mt Arthur area in 1908 and wrote: "At about 3000 feet I noticed scarlet patches on the beech trees and these turned out to be the scarlet-flowered mistletoe, a lovely sight, which as we got higher became more frequent and perfectly gorgeous". Returning via Mt Peel over the Tableland he reported : "The scarlet mistletoe was more gorgeous than ever..." (in Ogle 1995). *P. tetrapetala* plants occurring relatively close to the ground on starvation ridge were in good condition in 2016 with numerous seed capsules, attesting to the low possum and deer pressure at that time. In contrast, plants in the Deep Creek area were in poor condition with dieback (Gaskell *et al*. 2016).

- *Pittosporum patulum*, a small tree of subalpine scrub, and canopy gaps in mountain beech forest. It often occurs in sites that have undergone disturbance such as avalanche chutes, fire induced scrub, and river margins. Strongholds of adults occur in subalpine scrub where recruitment can occur without disturbance, and bluffs in beech forest that are similarly little disturbed (De Lange 2006). A survey of the Tableland in 2016, revealed only one sub adult plant although it is a notoriously cryptic species and others may have been missed. It is highly attractive to deer and possums and seedlings are eaten by hares. The plant found, showed signs of a series of terminating browse events (Gaskell *et al*. 2016).
- *Notogrammitis gunnii*, a fern with strap shaped fronds that grows in granite, marble, greywacke and schist outcrops or in soil lodged amongst boulders derived from these substrates. It has been reported from Kahurangi National Park but virtually nothing is known about this species (NZCPN 2014), and surveys for it to date within the EMU have been unsuccessful see Walls (2011).
- *Townsonia deflexa*, a small, easily overlooked endemic orchid favouring mossy logs and deep moss patches especially in beech forests from lowland to the sub-alpine. It forms small diffuse colonies (De Lange 2007). In the EMU it has been reported from the Flora Saddle area.
- *Libertia* “peregrinans NW Nelson”. Little information could be found on this species in the EMU.

6.9.6 Extinct species

Sub-fossil remains in the caves of the EMU provide evidence of the historic fauna of the area. Worthy (1997) describes the glacial fauna derived from the Hodge Cave system. Remains of birds that fell into tomos include the following species that are now extinct nationally: large bush moa, slender moa, little bush moa, upland moa, giant moa, crested moa, heavy-footed moa, stout legged moa, Finsch’s duck, owlet nightjar, Haast's eagle, adzebill and an extinct coot. Species that were previously widespread but are no longer present in the EMU include: kakapo, takahe, saddleback, a frog, brown teal and kokako. In addition, there are bones of great spotted kiwi, which has recently been re-established in the EMU. The plateau in which the cave developed is presently about 900-950 m above sea level and during the later parts of the last glacial period, glaciers would have extended down to about 1200 m on the flanks of Mt Arthur, two kilometres to the south. The Late Glacial faunas were probably living in a subalpine grassland/shrubland close to permanent snow and ice. Additional species found of probable Holocene age (post ice age) include parakeet, robin, bellbird, saddleback, wrens (*Xenicus* spp.), rifleman, owlet-nightjar, little bush moa and large bush moa. The deposits of kakapo coprolites (faeces of fibrous vegetable matter with the form of a tube which is coiled upon itself to make a structure 2.5-3 cm wide and up to about 7 cm long) are considered particularly important. Their presence is related to dry preservation conditions and they are probably not of great age since kakapo lived in the Mt Arthur area up to the 1960s.

Other species that have been lost from the EMU in more recent times include:

- Red-crowned kākāriki, *Cyanoramphus novaezelandiae* has not been reported in the EMU for many years. They are more vulnerable than yellow-crowned kākāriki (which are still abundant in the EMU)to predation by stoats and rats because they tend to use cavities close to the ground or in rocks or burrows in densely matted vegetation for breeding (Heather &

Robertson 1996). The majority of parakeet fossils found in caves on nearby Takaka hill are thought to be red-crowned parakeet (Worthy & Holdaway 2014).

- Yellowhead (mohua)*Mohua ochrocephaala* disappeared from the area in the 1980s (G. Elliot pers.comm.) probably due to stoat and rat predation. They often feed noisily on or close to the ground and females incubate or oversee nestlings for long periods in their nest holes, making them vulnerable to predation especially during mast seeding events when there is an explosion of predators.
- Little spotted kiwi, *Apteryx owenii* was last recorded in North-west Nelson near Westhaven Inlet in 1978 (Worthy & Holdaway 1994). Adults may weigh less than 1 kg, and are vulnerable to stoat predation. Little spotted kiwi are now restricted to offshore islands or fenced sanctuaries (Heather & Robertson 1996). Numerous little spotted kiwi bones have been found in caves to the north of the EMU (Worthy & Holdaway 2014).
- The original reptile fauna of the district would have been more diverse than is found today. Sub-fossil remains show that tuatara were once widespread but they are now confined to predator-free islands in other districts(Worthy & Holdaway 1994).

6.10 Threats to forest biodiversity

6.10.1 Predation

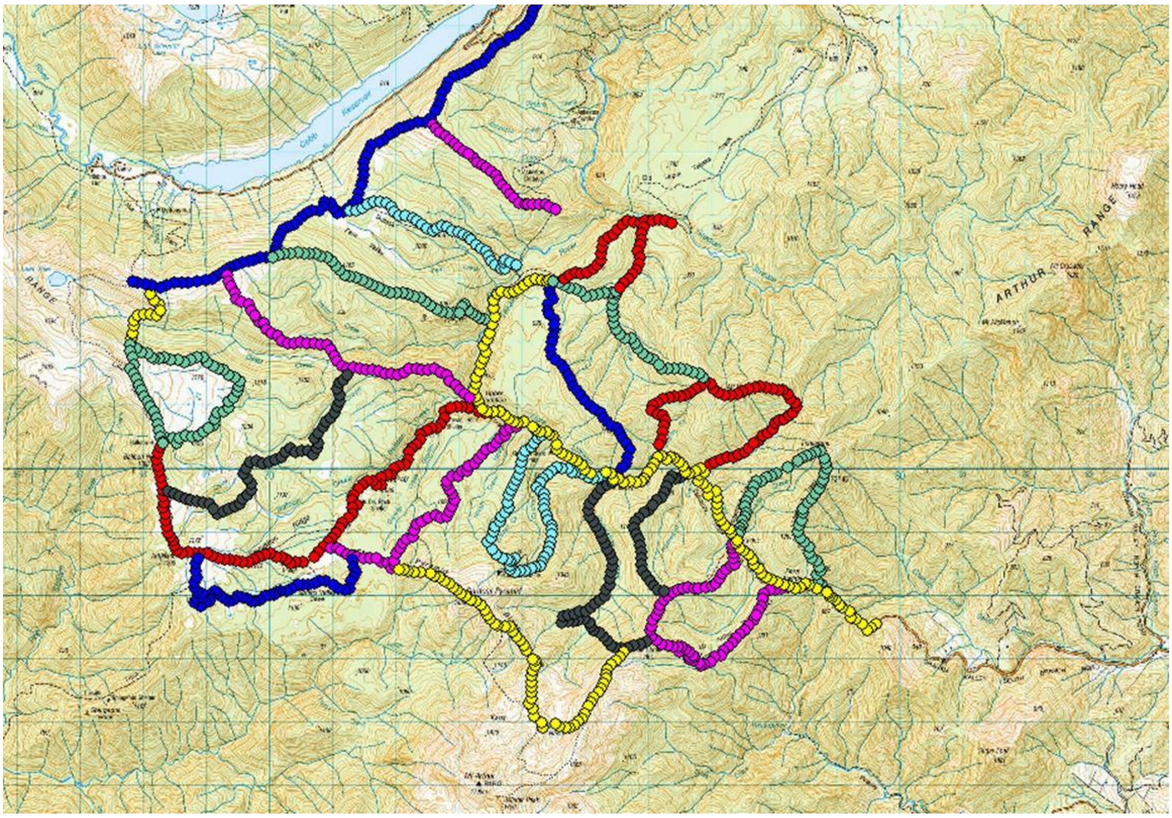
Stoats, rats and possums have all been implicated in the decline of long tailed bats along with threats such as habitat loss (Pryde *et al*. 2006) that are less relevant in the EMU. Bats are vulnerable to predation while in torpor in their roosts during the day. It can take several minutes for bats to raise their body temperature to 39-40°C before they can fly and escape predation. Large roosts are noisy sites at dusk when bats leave *en masse*, and this, in addition, to the strong ammonia smell of roosts may act as an attractant to predators (Molloy 1995).

Non-native mammals are also the main predators of kaka. Stoats and possums predate female kaka on the nest as well as eggs and nestlings, and newly fledged birds on the ground are also vulnerable to predation. Breeding success is dependent on predator control (Powlesland *et al*. 2009). Native avian predators, such as New Zealand falcon, *Falco novaeseelandiae* and the Australasian harrier, *Circus approximans*, have both been observed hunting and feeding on kaka fledglings, but given the current scale of predation by introduced mammals, natural predation events are likely to be of relatively minor importance (Powlesland *et al.* 2009). Similarly, weka, kea and falcon may cause nest failure in whio and roroa, but such events are rare compared with predation by stoats.

The main threat to New Zealand falcon is nest predation by introduced mammals (Seaton 2007).

Many of the species that are threatened by stoats and possums occur in low densities and/or have large territories. Large scale, sustained predator control is therefore essential for their survival. Friends of Flora's landscape scale stoat control programme achieves this in the core of the EMU, but there is no sustained predator control programme in the Grecian, southern Barron Flat, the upper Pearse catchment, or the Ellis catchment (figure 12).

Figure 12 FOF/DOC stoat trapping network



Both possums and stoats have a high frequency of invertebrates in their diet and although total intake by volume is low relative to other prey items, these predators may have local impacts on particular invertebrate populations. Invertebrates most at risk are likely to be large-bodied relatively sluggish nocturnal species with high detectability (Cowan & Moeed 1987).

Weasels have not traditionally been considered a major threat to forest biodiversity. However, following the beech mast event of 2014 large numbers of weasels have been caught in stoat traps within the EMU and elsewhere. This may be due in part to a higher proportion of mice than rats in their diet. Mice numbers are not controlled by 1080 applications as effectively as rat numbers. In addition, weasels breed three times a year compared with once in stoats. Therefore unless 1080 poisoning kills a very high proportion of weasels through secondary poisoning, their numbers can build up unimpeded. Similar spikes in weasel numbers have been reported elsewhere (G. Elliot pers. comm.). Given their smaller size, the impact of weasels on forest biodiversity might be considered to be lower than that of stoats, but little evidence is available.

Rodents are an important predator of the smaller threatened species, including *Powelliphanta* snails. FOF and DOC monitor rodent population trends through a network of 12 footprint tracking tunnel lines in the forest zone.

Much experimental and circumstantial evidence suggests or demonstrates that predation by introduced mammals is the primary cause of declines of native forest birds (Innes *et al*. 2010). However, predator dynamics are complex and not fully understood. For instance, gut contents of 554 stoats in beech forest in Nelson Lakes National Park reveal that they ate mostly mice (53%) and invertebrates (37%). Bird remains were less common (20%) than in stoat diet in other New Zealand beech forests. Rats were eaten by 9% of the stoats. The peak mouse and rat abundance that followed the heavy seeding of beech and tussock in 2000 resulted in high rodent consumption (81%). Conversely, bird consumption was low that year, but the variation in bird consumption from year to year was not statistically significant (Clapperton *et al.* 2011). In mast beech seeding years, rodents feed on the abundant seed, breed rapidly through the winter and fuel a spike of mustelid predators the following spring and summer. The devastating consequences of such events for biodiversity are summarised in the Parliamentary Commissioner for the Environment's report (2011). Figure 13 shows mast flowering of the beech forest on the slopes of Lodestone in 2013.

Figure 13 mast beech flowering at Flora Hut November 2013. Photos: Ingrid Hutzler

Hedgehogs (which are periodically caught in stoat traps within the EMU) are insectivorous and mice are omnivorous, with invertebrates constituting a large proportion of both species' diets. Studies have shown that mice can have very large impacts on local invertebrate abundances and biomass. Hedgehog impacts in New Zealand may be similar, but this has never been formally investigated (Jones & Toft 2006). Predation is believed to be the most significant threat to large, flightless invertebrates such as the carabid beetle, *Mecodema angustulum* (McGuinness 2007).

Feral pigs are omnivorous opportunistic feeders and differ markedly from other introduced ungulate species in their feeding habits. In podocarp-hardwood forest, Thomson & Challies (1988) found that 62% of the feral pigs' food was obtained by foraging on the ground, 31% by rooting, and the balance by browsing and grazing. Approximately 70% of the diet comprised plant material, with animal carrion, earthworms, and insects making up the remainder. Similar proportions of plant versus animal derived material were reported from pigs on Auckland Island, although in that case, birds were consumed in addition to invertebrates (Challies 1975). It is assumed that diet would be similar in beech forest systems. Rats, hedgehogs, thrushes, weka, feral pigs and possums all predate *Powelliphanta* snails (Walker 2003).

Adult kiwi are vulnerable to predation by dogs (eg. Pierce & Sporle 1997).The EMU is wholly contained within Kahurangi National Park and only permitted dogs should be present. Nonetheless, there are repeated instances of unpermitted dogs (both pets and hunting dogs) in the EMU. Permits are issued for recreational hunting dogs in the front country part of the EMU on Barron Flat. There is no requirement for kiwi aversion training. Feral cats are serious predators, but are not currently known to be a problem in the EMU.

Non-native mammals are a threat to forest geckos, which may also be at risk from predation by wasps (Whitaker & Lyall 2004). Wasps are a significant seasonal predator of invertebrates throughout the forest zone, with the effect of vastly altering invertebrate communities from the likely pre-wasp norm. There are no data on the invertebrate fauna prior to the introduction of wasps, so their impact cannot be quantified. However, wasps have been observed attacking and killing insects up to the size of large tree wētā (I. Millar pers. comm.). The beautiful and rare forest ringlet butterfly *Dodonidia helmsii* historically occurred in the Flora valley (Hudson, 1889) but is now thought to be restricted to the Lewis Pass area and a few sites in Northland. The causes of this range contraction are not known, but wasps are a likely contributor (Watts *et al*. 2012).

6.10.2 Competition

Although predation is the primary threat to forest birds, food shortage may contribute to population declines. Brushtail possums are the most cause of food limitation because they are large, arboreal, and can consume large quantities of flowers and fruits.

Hedgehogs consume most invertebrates compared with other mammals, and could compete with insectivorous birds (Innes *et al*. 2010) as well as reptiles and bats. Pigs are omnivorous and earthworms, form a major part of their diet. For example, 26% by dried weight of pig diet on Auckland Island and about 10% by dried weight in the Urewera National Park were annelids (Coleman *et al*. 2001). They are likely competitors with ground feeders such as kiwi.

Introduced *Vespula* wasps are important consumers of honeydew (produced by an endemic scale insect in beech forest) and invertebrates previously eaten by native forest birds (Innes *et al*. 2010). Competition with vespid wasps since the 1940s may have contributed to the dramatic decline in mohua in the northern half of the South Island (Heather & Robertson 1996). High densities of wasps may also impact the viability of ground based management work in beech forests during the late summer and early autumn due to the risk of allergic reactions to stings. There is currently no effective landscape scale management tool available for wasps.

Competition by weeds is not currently considered a major threat to forest ecosystems in the EMU, although there is concern that rare species such as *Ourisia modesta* and *Myosotis brockiei* are vulnerable to the spread of weeds when their habitat is disturbed for instance through pig rooting. The invasive rush, *Juncus squarrosus* occurs outside the EMU on Barron Flat and could easily be brought into the EMU.

6.10.3 Herbivory

Non-native herbivores including deer, goats, pigs, possums and hares are all abundant in the EMU.

Hughey & Hickling (2006) and Forsyth *et al.* (2010) review the impact of deer on forest ecosystems. The impacts at a site vary according to the deer taxa present, how long the population has been established, and the effect of hunting on the population, but in general, the most preferred plant species are greatly reduced in abundance and the number of seedlings and saplings is reduced. In addition there are indirect impacts which are more poorly understood: deer can modify the composition and quantity of the litter layer and hence the rate of litter decomposition, but the flow-on effects for biomass production and resource allocation have not been investigated. Litter-dwelling invertebrate groups are consistently reduced in abundance by browsing mammals which may be due to trampling rather than changes in above-ground vegetation composition and density. Deer alter the quality of resource inputs to decomposers through the return of faeces and urine. They can move organic material from more fertile to less fertile parts of the landscape but the consequences of plant materials being returned to the soil as faeces and urine, rather than litterfall, has not been investigated in New Zealand. In addition to deer modifying food availability, reduced vegetation density in the browse tier may change nesting opportunities and/or success for forest birds for instance, by increasing nest predation rates by introduced rodents and brushtail possums. There has been speculation that non-native ungulates have merely replaced the browsing undertaken by moa before they went extinct. Having reviewed available evidence, Forsyth *et al.* (2010) conclude that the impacts of introduced deer on ecosystems have been markedly different from those of moa, primarily because of differences in their abundance. Although collectively the various taxa of deer in New Zealand use all of the habitats utilised by moa, and there is partial overlap in the diets of deer and moa, deer can attain densities and biomasses 100- fold greater than reasonably surmised for moa.

Vegetation dynamics and the response of herbivores to control measures is complex. Other environmental factors that affect vegetation dynamics also influence vegetation processes and it is difficult to partition impact between different herbivores (Hughey & Hickling 2006). Nonetheless, once a forest understorey has been depleted, only a small number of deer are needed to prevent its recovery. This may be because in New Zealand forests the biomass of seedling foliage produced annually by deer-preferred species is relatively small. Litterfall provides a large part of the forage requirements for deer populations, maintaining deer numbers that are sufficient to exert browsing pressure on the seedlings of preferred species, that is essentially independent of deer density. For more browse-resistant or less palatable species the relationship is more linear, and the least preferred species are affected only at high deer densities or not at all. Protection of the most highly preferred species requires the almost total removal of deer (Fraser 2000). Based on experimental evidence, Forsyth *et al*. (2013) conclude that the substantial uncertainty about the relationships between deer control effort and changes in deer abundance mean that it cannot be assumed that the problems caused by deer can be alleviated by either ground or helicopter based control or aerial 1080 applications (although not registered for deer control, baits containing 1080 can kill deer with by-kill of deer ranging from 0 to > 90%).Within the EMU, there have been historically high densities of ungulates have been in the Grecian (Hayward 1983)but there has been considerable modification of the composition of the understory and sub-canopy throughout (e.g. figure 14).

Figure 14 Heavily browsed forest in Deep Creek. Photo: R. Gaskell

Feral goats are browsers of shrubs and trees and switch their diets as the more palatable food species are eliminated from their habitat. They can reach places on cliffs and bluffs that are inaccessible to deer and have high birth rates. The specialised flora associated with limestone bluffs is affected by goats and is now confined to the most inaccessible faces (Walls 2005). The mountain cabbage tree, *Cordyline indivisa*, while not listed as threatened is a characteristic montane species that is notably scarce in the EMU, being restricted to only five known plants. It is likely the victim of grazing by goats and red deer (S. Courtney pers. comm. to I. Rogers).

Goats have been greatly reduced, temporarily removed, or eradicated from many forests using ground hunters. Aerial hunting from helicopters has been effective in controlling low density populations in forested habitats (by targeting goat-favoured slips and clearings) and high-density populations in grassland/scrub habitats. The use of radio-telemetered Judas goats to locate remnant groups has also proved successful. As with all pest control, sustained, targeted effort is required (Parkes 1993).

In general, possums eat much the same range of plant species as deer, although their preferences differ markedly. The most important difference between deer and possums is the latter's arboreal habit, which means that they have access to and can potentially impact upon all the vegetation in an area. Deer and other ungulate species only affect the vegetation up to a height of c. 2 m. The sustained selective browsing of possums has led to considerable dieback of a number of species e.g. tree fuchsia, rata, five-finger, as well as threatened species such as mistletoes (Fraser 2000; De Lange 1995).

Often a whole suite of non-native herbivores may impact threatened species. For example, *Pittosporum patulum* is palatable and threatened by ungulates eating juvenile foliage, possums eating both the juvenile and adult foliage and flowers, rodents eating seed in litter beneath adult trees, and insect browse that can deform new growth (De Lange 2006).

6.10.4 Habitat modification

Pigs, deer, goats and cattle open up the forest understory exposing it to more wind and desiccation and reduce the litter layer causing it to dry out so moisture-loving invertebrates such as *Powelliphanta* snails cannot survive. The forest ground cover is also reduced making it easier for predators to find large invertebrates (Walker 2003). There is a proposal to fence a large area at nearby Canaan to exclude pigs, deer and goats to determine their impact on snails (K. Walker pers. comm.).

Predators such as rats also eat seeds and seedlings, thereby affecting the forest structure. The true extent of loss to the invertebrate fauna from habitat modification is not known but is likely to be significant and ongoing (McGuinness 2007). Carabid beetles suffer from modification of forest habitat for instance by loss of refugia such as fallen logs (Landcare Research 2007).

Feral pigs have large home ranges (1- 17 km^2). They breed throughout the year in the northern part of the South Island and can reach high densities. Their home ranges vary with habitat but can be up to several km^2 (McIlroy 2001). There has not been any official control of pigs within the EMU, although there are anecdotal reports of recreational pig hunting in the Barron Flat area. There is considerable ground disturbance by pigs throughout the northern part of the EMU which has recently extended to the south of the Flora. Deer and goats also cause significant localised ground disturbance of sensitive wetlands (Figure 15) and bluff overhangs. Habitat damage is a concern for the critically endangered shy foxglove *Ourisia modesta* (Walls 2005).

Figure 15 Wetland sward pugged by deer and pigs 2016. Photo: S. Toy

The forest ecosystems, like tussock ecosystems (section 5.7.4), are vulnerable to the effects of fire. The increasing numbers of casual visitors to the EMU, increases the risk of accidental fire.

7 Riverine and lake biodiversity and threats

Singers & Rogers (2014) ecosystem classification covers only terrestrial ecosystems. Freshwater ecosystems within the EMU occur in the numerous streams and rivers and the glacial Lake Peel.

7.1 Rivers

The Takaka river catchment (which includes all the west draining steams in the EMU) is considered a potential water body of national importance for its biodiversity values (MFE 2004).

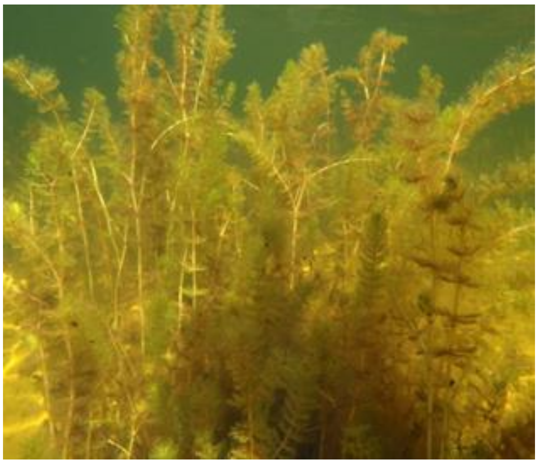
Waikoropupu springs near Takaka are of considerable cultural as well as biodiversity significance. Although outside the EMU, they rely, in part, on water derived from the EMU. The largest single water source for this system, estimated at c.60% of the springs' outflow, is the Takaka River, which loses flow into its bed along a stretch some 13 km from the springs. This is the largest known phreatic (saturated) karst aquifer in New Zealand and it is likely to be the most complex, with many different microhabitats of biodiversity significance. Although the springs are well outside the EMU, activities within the EMU have the potential to impact the quality of the whole system (Millar 2003). See also section 8.

The upper catchments of the Pearse and the Ellis streams are within the EMU and included in the Motueka Water Conservation Order in recognition of their outstanding wild and scenic values and their karst (scientific and recreational values). The Conservation Order requires the quality, quantity, level and rate of flow of the waters to be retained in their natural state (Water conservation order 2004).

7.2 Lakes

The high alpine Lake Peel is the dominant freshwater body in the EMU. It has a highly intact native flora and fauna. The aquatic plant community is heavily dominated by *Myriophyllum triphyllum,* with a mosaic of other species in the shallows including *Potamogeton cheesmanii*, the small aquatic fern *Pilularia novae hollandiae*, *Lilaeopsis novae- zealandiae* and the introduced toad rush *Juncus bufonius* in scattered patches (figure 16). In deeper water occasional *Potamogeton* grows through the *Myriophyllum*. The invertebrate fauna on lake aquatic plants and lakeshore substrates include the leech *Glossiphonia*, the pea mussel *Sphaerium novaezelandiae*, the mollusc *Physastra*?, the water boatmen *Sigara*, unidentified water beetles family Hydrophilidae?, unidentified worms (Oligochaeta), larvae of the midge *Chironomus* zealandicus and unidentified orthocladiine and tanypodinid midges. Larvae of the damselfly *Xanthocnemis* are very common on aquatic plants with a few found on rocky substrates. Taxa recorded from rocky substrates but not plants included stony cased caddis (*Pycnocentrodes sp* ?) and free living rhyacophilid caddis (*Neurochorema sp?)*, present in low- moderate numbers. The macroinvertebrates of the outlet stream differ to that found in the lake notably in the large numbers of the net spinning caddis *Aoteapsyche*. The outlet stream supports significant algal growths in places including thick blankets of a species of *Cymbella* and a green filamentous algae identified as *Zygnema.* No koura or fish are found in the lake or outlet stream. Since there are no significant human created barriers that would interfere with fish passage upstream into the Deep Stream catchment, this absence is an uncommon natural feature which provides the opportunity for research into the food-web structure of fish - free lakes (Rutledge 2016).

Figure 16 *Myriophyllum triphyllum* (at 2 m depth) and *Pilularia novae hollandiae* (at 0.5m depth) in Lake Peel. Photo: M. Rutledge



7.3 Threatened and at risk species associated with the riverine and lake zone

Table 5 summarises the status of threatened and at risk species recorded from the rivers and lake zone of the EMU.

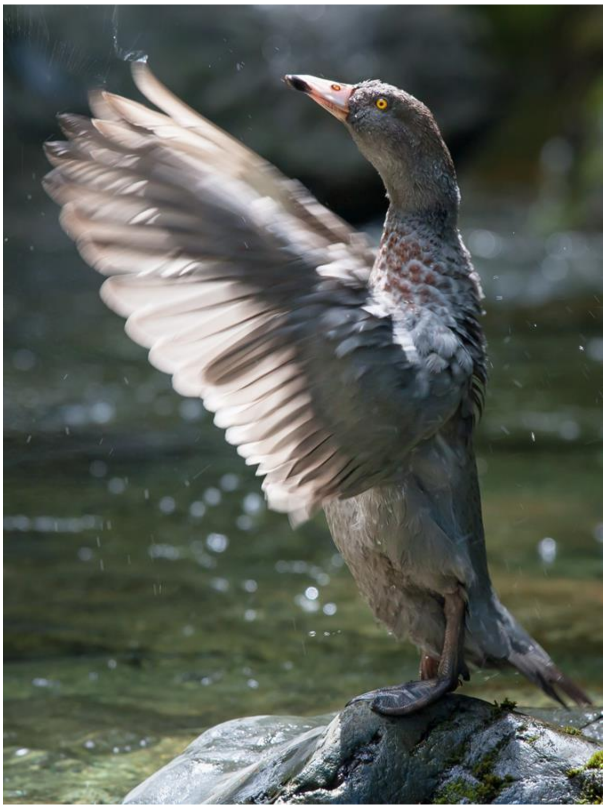
Table 5. The status of threatened and at risk species recorded from the rivers and lake zone of the EMU

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU
bird	3Nationally Vulnerable	*Hymenolaimus malachorhynchos*	whio	Yes	Flora stream, Deep Creek, Takaka River, Grecian Stream
fish	4Declining	*Galaxias brevipinnis*	koaro	Yes	Flora stream
fish	4Declining	*Anguilla dieffenbachii*	longfinned eel	Yes	Upper Takaka, Pearse,
crustacean	4Declining	*Paranephrops planifrons*	northern koura	Yes	Widespread?

7.3.1 Birds

The EMU is now a stronghold for whio or blue duck, *Hymenolaimus malacorhynchos* (Figure 17), a dramatic turnaround on the single male present in the Flora in 2001. In 2014 the Friends of Flora annual December walkthrough survey from Flora hut to the confluence with Balloon Creek recorded three family groups with 14 ducklings between them. In February 2015, five pairs and eight juveniles were recorded with a further eight pairs in the Grecian and lower Ghost Creek. In addition, a pair with ducklings has been recorded in lower Deep Creek and single birds have been recorded in the upper Takaka and Balloon creek. It appears that the Flora is now acting as a source for re-colonisation of surrounding waterways. At least 5 pairs breed in the Pearse immediately to the east of the EMU. DOC has harvested eggs from this population over the last few years for the Whio Operation Nest Egg programme to supplement the population in the Wangapeka, which is being managed as a nationally 'secure' site for Whio. Both the Pearse and the Flora are identified as 'Recovery' sites in the Whio Recovery Plan (Glaser *et al*. 2010)

Figure 17 Whio in the Flora. Photo: Ruedi Mossiman).



7.3.2 Fish

Few surveys have been undertaken of the fish fauna of the EMU. The New Zealand long finned eel, *Anguilla dieffenbachii* and, koaro have been reported from the upper Takaka and rivers draining to the east (M. Rutledge pers. comm.). Upland Bully, *Gobiomorphus breviceps*, which is not listed as threatened, has been recorded from the lower reaches of Eyles Creek near the Pearse resurgence (I. Rogers pers. comm.).

A single large koaro, *Galaxias brevipinnis* was detected in an electrofishing survey of the Flora in January 2014. The habitat seemed ideal with plenty of invertebrate food so the paucity of fish may be due to migration barriers between the sea and Flora Stream – natural or man-made areas where the water flows too swiftly or falls freely with nothing for the fish to climb or the high-flow events in the area are too large or frequent for a decent population to build up (S. McQueen pers. comm.). The steep nature of the catchments and impact of floods are also likely to be important (M. Rutledge pers. comm.). Koaro is the second most common, and the most widespread, of the five diadromous (migrate between the sea and freshwater) galaxiids which comprise the New Zealand whitebait runs. Its habitat is generally rapidly flowing, tumbling, rocky streams in native forest and its climbing abilities are legendary (Hayes 1995).

7.3.3 Invertebrates

The only known threatened freshwater invertebrate in the EMU is the northern native freshwater crayfish, koura, *Paranephrops planifrons*, which has been reported from the upper Takaka and the rivers draining to the east (M. Rutledge pers.comm.). However, given the limited collecting and the number of freshwater habitats in the EMU, this may be merely a reflection of our limited knowledge.

The uncommon tipulid fly *Dicranomyia nelsoniana* whose adults are associated with freshwater margins has been recorded from the Tableland. The caddisfly *Xenobwsella motueka* has been recorded from the Pearse River but its larvae are not known. These species were considered of potential conservation interest (Collier 1992). The caddis fly fauna of the EMU is diverse with 56 species, around 24% of the known New Zealand fauna collected from the upper Flora stream area in just four nights (Dugdale & Millar 2002). Stream properties (size, substrate, flow rate, temperature, water condition/quality, shading, etc.) influence their distribution in the EMU.

Macroinvertebrates recorded from lower altitude sections of the Baton, Pearse, Graham and Pokororo rivers (downstream of the EMU) are typical of high water quality sites with lots of mayfly, caddis and stonefly species (M. Rutledge pers. comm.).

7.4 Threats to aquatic biodiversity

7.4.1 Water quality

The invasive alga Didymo, *Didymosphenia geminata* has been reported from the Motueka River and mid reaches of the Takaka River (Wells *et al*. 2007) but not from the EMU. Its impact on threatened species such as whio is not known but since it smothers the substrate, changes in the proportions of invertebrate communities in affected rivers are likely to adversely affect aquatic species with restricted distributions such as whio (Glaser *et al*. 2010).

As with subterranean ecosystems (Section 8), the key to the conservation of the special aquatic ecosystems in the EMU is maintaining the catchments in a natural condition including sediment, hydrological and nutrient regimes. There is an active slip and deposition zone at the western end of Lake Peel, resulting in highly mobile fine sediment in the lake. Browsing, trampling and defecation in the wider catchment and lakeshore margins by feral ungulates needs to be addressed in order to minimise erosion, sediment and nutrient inputs (Rutledge 2016).

7.4.2 Predation

Stoats have been identified as the main agent of decline of whio in many areas with nesting females, eggs, young broods and juveniles all vulnerable. Native predators such as weka also prey on whio nests but such predation would not be problematic for the species in the absence of predation by mustelids (Glaser *et al*. 2010). Friends of Flora's landscape-scale stoat control programme addresses this major threat in the core of the EMU, but there is no sustained predator control programme in the Grecian, the upper Pearse catchment, or the Ellis catchment (Figure 12).

Preventing the spread of trout or other fish into Lake Peel is vital to preserve the lakes natural functioning (Rutledge 2016). Maintaining the rivers free of such predators is also important.

7.4.3 Downstream impacts

Factors operating outside the EMU can have an impact on freshwater biodiversity values within it. Several common agents of decline have been implicated in the possible range contraction and decrease in abundance of large galaxiids generally. They include: overharvesting of the juvenile whitebait stage; impediments to migration and recruitment; habitat destruction; pollution of waterways; changes in catchment landuse, and the impacts of introduced species such as salmonid fish (Department of Conservation 2005).

The downstream section of the Takaka River from Lindsays Bridge to Spring Brook (outside the EMU) regularly dries out in summer. This effects the distribution and size of native fish found throughout the Takaka River catchment. Migration by fish through this zone is impossible when dry and potentially lethal as flow declines. Torrentfish, *Cheimarrichthys fosteri* ; redfin bully, *Gobiomorphus huttoni* ; common bully*, Gobiomorphus cotidianus;* inanga, *Galaxias maculatus* and lamprey, *Geotria australis* populations appear to be restricted to reaches of the river downstream of the drying zone (Young *et al*. 2001).

8 Subterranean ecosystems biodiversity and threats

Caves are considered a nationally rare ecosystem type (Williams *et al.* 2007) and are a defining feature of the EMU. They predominantly form within subterranean calcareous rocks (e.g. limestone and marble) in combination with subterranean water-flow that facilitates both chemical weathering and physical erosion. The biotic component is dominated by invertebrate and microbial species and communities (Singers & Rogers 2014).

Caves are the subterranean component of the karst landscape of the EMU that is seen above ground in the marble bluffs, screes and pavements and sink holes in the alpine and forested zones. The EMU supports nationally significant examples of western South Island upland marble cave systems (Moore 2016). The subsurface cave drainage systems can be very complex, varying from single rooms, passages, and open shafts to intricate three-dimensional interconnected cavities. Some caves are completely dry and inactive, others totally filled with water; some are periodically flooded, and others permanently contain streams or lakes (Department of Conservation 1999). The surface and underground catchments bear little relationship to the other. For instance the Nettlebed Cave system starts in the Horseshoe catchment of the Flora, which feeds into the Takaka River to the north-west, but emerges at the Pearse resurgence which is part of the Motueka River catchment in the south-east. Similarly, limestone bands deposited in sandy and silty sediments of the Wangapeka Formation form significant isolated outcrops of karst in the area between Mt Arthur and Hailes Knob. One or more of these bands captures the entire low to moderate flow of the Grecian Stream, a physiographic tributary of Takaka River. The position of the limestone in relation to local topography and geology suggests that the captured water probably flows underground into one of the larger blocks of Arthur marble to the east, and thence to the Motueka River (Millar 2003).

Cave habitats are characterised by a distinctive range of physical features: a total lack of light, greatly reduced climatic fluctuations (e.g. temperature fluctuation) and usually constantly high humidity in the cave atmosphere. Without light there is no photosynthesis to generate energy within the subterranean environment. The energy that powers caves enters from the surface, as sediments, plant detritus and occasional live or dead animals which fall or are washed into the cave.

Caves are a subset of a wider group of subterranean habitats that share these physical features. Other such habitats include deep, consolidated screes with soil and plant cover; superficial cracks and crevices in bedrock beneath deep soil; and deep alluvial gravels beneath river plains, which are known to harbour both terrestrial and aquatic faunas. Some cave-dwelling species are known to occur in some of these other subterranean habitats also but others appear not to.

Caves have a specialist fauna. Troglophiles such as glowworms, *Arachnocampa luminosa,* live in underground environments because these suit their behaviours and they may have a physiological predisposition to caves, but they do not rely on caves. Troglobites however, are permanent, obligatory occupants of the subterranean environment and cannot live outside of it. These species typically have little or much reduced eye and cutaneous pigments, and have slow growth and development (Urich 2002). Within caves, much of the fauna probably prefers the smaller cracks and crevices, where there is less exposure to air movements. This may include the spaces within rockfalls in cave passages. The caves accessible to humans are only a small part of the subterranean ecosystem and, while caver impacts may affect fauna habitat, much of the habitat will likely be out of reach and therefore not impacted (I. Millar pers. comm.).

Caves are generally not subject to the deteriorative effects of climate and erosion and, in combination with their cool, relatively stable temperatures this has enabled evidence of New Zealand's environmental history to be preserved within them. The structure, form and age of these sites and the nature of their contents (such as sediments, bone deposits etc.) can be related to such phenomena as past sea levels, land uplift, glaciations and erosional cycles. These "time vaults" are important sites for geological, geomorphological, palaeontological and climatological studies. Caves contain many types of secondary mineral deposits, known as speleothems (for example stalactites and stalagmites). Speleothems are one of the major sources of palaeoclimate information (Department of Conservation 1999).

The Mount Arthur karst to Pearse resurgence has been identified as a water dependent geodiversity feature of national importance (MFE 2004). Nettlebed cave and the Pearse resurgence have been considered geo-heritage features of international importance, with the Ellis and Horseshoe Basin karst features of national importance (Basher 2003). The main cave systems in the EMU are:

Mt Arthur system which has a large marble catchment almost all of which debouches at a single site, the Pearse resurgence on the eastern edge of the EMU. Accessible parts of this underground network include many kilometres of cave streamways ranging from ephemeral trickles to large volumes and a major phreatic zone just behind the rising which extends to depths of over 100 m. This network of streamways is accessed by two major cave systems: the Ellis Basin system and Nettlebed Cave as well as numerous others eg. HH Cave, Windrift, Misty Pot, etc. What makes this system important is its size, the fact that it comprises an entire headwater catchment system with a range of stream sizes, the variety of habitats and the relative isolation of this system from other karst systems, making it possible that it will hold some distinctive faunal elements. The accessibility of many parts of this system via explored cave passages adds to its value (Millar 2003). The Nettlebed/Stormy Pot system at 1174 m and the Ellis Basin System at 1026 m, are New Zealand's two deepest known caves. They are also the second and third longest caves in New Zealand at 38 km and 33 km respectively (NZ Speological Society 2014).

Hodge Creek/Gridiron Creek system. The upper section of Hodge Creek falls into a stream sink in its bed, one of several entrances to Cheops Cave. Around 2 km of stream passage is accessible within this cave, including autogenic inputs (rainfall which has fallen directly onto the karst and thence underground without travelling along a surface streambed). A second, separate system captures karst waters to the west of Hodge Creek and drains into lower Hodge Creek. The water eventually enters a phreatic zone to re-emerge in Gridiron Creek to the east. Hodge and Gridiron Creeks are tributaries of Flora Stream in the Takaka River catchment (Millar 2003).

Moonsilver Cave is the main drainage system for the large area of karst forming Barron Flat, between the Grecian Stream and Barron Stream. The system is almost entirely vadose (not flooded), and probably receives large amounts of both allogenic (rainfall which falls on non-karst surfaces, gathers in a surface stream, and eventually flows underground via a sink) and autogenic recharge. Over 3 km of streamway has been explored in this cave. Although entirely within the National Park, the downstream quarter or so of the cave underlies former farmland which is now reverting to scrubland and is located outside the EMU. The cave drains to Barron Stream in the Takaka River catchment (Millar 2003).

Tableland caves. Caves in the large areas of limestone on the Tableland and continuations of this to the south above the Leslie and Karamea Rivers are currently being explored with new discoveries such as Te Mana Nui. The Tableland limestone is continuous with that of Hodge Creek: it is a single karst unit, with several drainages. At the Tableland end, the caves drain into the Leslie, which ultimately drains to the West Coast via Karamea River; the Hodge/Gridiron end drains to the Takaka River catchment. At present the location of the catchment boundaries within the karst are unknown (I. Millar pers. comm.).

The least known of the karst areas within the proposed EMU is that in which Crusader and Hoary Head are located. There is a karst spring in a major tributary of the Graham River North Branch, 2.5 km south of Mt McMahon, outside the EMU. This is presumably a major rising from this karst system (I. Millar pers.comm.).

8.1 Threatened and at risk species associated with the subterranean zone

Table 6 summarises the status of threatened and at risk species recorded from the subterranean zone of the EMU.

Table 6. The status of threatened and at risk species recorded from the subterranean zone of the EMU.

Life Form	Threat Status	Species	Common name	Endemic	Distribution in EMU
invertebrate	7Naturally Uncommon	*Scototrechus hardingi worthyi*	cave beetle	Yes	Tableland limestone
invertebrate	7Naturally Uncommon	*Scototrechus morti*	cave beetle	Yes	Mt Arthur marble
invertebrate	7Naturally Uncommon	*Syllectus magnus*	ground beetle	Yes	Mt Arthur marble

8.1.1 Invertebrates

Little is known about the New Zealand cave fauna in general and that of the EMU in particular, and consequently threat lists are not a useful conservation tool for this group (See reviews by Johns 1991; Hunt 2004, Pugseley *et al*.undated). Of the described troglobitic species from NZ caves, the majority are carabid beetles (trechines and harpalines), opiliones and aquatic snails. Some troglobitic collembola have been described from the Waitomo area, but none of the species known from other regions are described. For other groups, such as the millipedes, spiders, pseudoscorpions, mites, Crustacea etc., few, if any, species have been described. The aquatic fauna is especially poorly known. However, the northwest Nelson region appears to have the greatest diversity of cave fauna in New Zealand (Pugsley *et al.* undated).

Invertebrates were collected from the Hodge Creek cave system in 2000. Only a few were able to be identified but most were from groups with very little up-to-date taxonomy. Finds included up to four species of undescribed millipedes, unidentified carabid beetle larvae, harvestmen (including a possible new species from the Synthetonychiidae, a small family of minute harvestmen apparently endemic to NZ), two species of freshwater planarian worms (considered to be from genera *Neppia* and *Prorhynchus*) and two hydrobiid snails. At the time, the snails were identified as *Opacuincola kuscheli* and *Potamopyrgus cresswelli*, both considered to be quite widespread in caves and aquifers. However, a major revision of the New Zealand Hydrobiidae (Haase, 2008) saw these two species defined much more narrowly, with neither occurring in caves in the EMU. Unfortunately the specimens from Hodge Creek Cave were not included in the review so we have no idea of which species they might now belong to. In addition, an undescribed species of cave-dwelling aquatic amphipod was collected (I. Millar pers. comm.). This species has a distribution that includes a number of sites in Golden Bay and one near the Heaphy River, West Coast (Fenwick, 2000). Amphipods, copepods and another planarian were collected in another small cave in this limestone. A pair of tiny, apparently flightless flies from the family Sciaridae, were collected. The flies were winged, but lacked sufficient musculature to allow them to fly. It is uncertain whether they were bait contaminant from outside the cave, but regardless of whether this is a cave species or surface species it occurs in the EMU and is of some significance. Unfortunately the specimens were passed to an overseas researcher, and no formal identification was made (I. Millar pers. comm.).

The Mt Arthur cave fauna is poorly known and much of what has been collected has not resulted in published information to date. Undescribed species include a handful of aquatic Crustacea, an aquatic hydrobiid snail, a theridiid spider, one or more millipede species and potentially at least one undescribed cave beetle species. NIWA cave divers recently discovered three new-to-science species in the Pearse Resurgence: a transparent amphipod, a worm, and a small snail (Fenwick 2012). The published information that is available and the lack, to date, of finds of certain other species indicates that Mt Arthur is likely to have a terrestrial fauna at least partly different from any other karst area (I. Millar pers. comm.). The cave beetles *Syllectus magnus* (troglophile) and *Scototrechus morti* (troglobite) have been recorded from the caves of Ellis basin and Mt Arthur. The Trechini are small (<10mm) ground beetles that live in habitats with high humidity. Many of the species such as *S. morti* are adapted for living in caves and have reduced eyes, or have lost their eyes altogether. The true cave dwellers are pale brown in colour, having lost the characteristic dark pigmentation of most other ground beetles. They are endemic to New Zealand with a high concentration in northwest Nelson (Townsend 2010).

The situation with Tableland karst is less clear in that the one described cave beetle species known from this area (*Scototrechus hardingi worthy*) also occurs in the Takaka Hill karst to the north. It is likely that this species will also be found to occur in the northern Arthur Range karst of the EMU. No cave fauna collections are known from this northern area. Although this karst is ultimately continuous with that of the extensive band of marble which drains to both branches of the Riwaka

River, it shouldn't be assumed that the fauna will necessarily be fully shared with these more northern areas (I. Millar pers. comm.). There is a second, undescribed, troglophilic carabid found rarely in Tableland caves and around Flora Stream which is not known from anywhere else. This belongs in the genus *Oopterus*, Zolini group (I. Millar pers. comm.).

Springs occur at the interface of groundwater, surface water and terrestrial ecosystems. Their defining characteristics (thermal and hydrological stability) are controlled by the hydrogeological context of their parent aquifer. Springs have a significant fauna, with high levels of endemism in hydrobiid snails and amphipods. At the regional level, north-west Nelson is a hotspot for spring biodiversity (Scarsbrook *et al*. 2008). Of the 64 known hydrobiid snails species, 30 are currently only known from their type localities and 70% (21 species) of these local endemics are found in the north-west Nelson region (Scarsbrook *et al*. 2008). Information on the spring fauna of the EMU has not been found.

8.2 Threats to cave biodiversity

8.2.1 Land disturbance in cave catchments

Due to the interconnectedness of karst systems, activities outside of the limestone environment but within the watershed may have important impacts when the water derived from the other geologies enters the limestone zones. The major, large-scale threats to cave systems come from land disturbance activities within cave stream catchments, such as deforestation, some farm activities, forestry, quarrying and mining, and subdivision/urbanization. These activities can send accelerated amounts of sediments into cave systems, choking habitats, raising stream levels and destroying features that may have survived for millenia. They also increase the likelihood of pollutants entering cave systems. The key influences on the natural development of karst features is the quality of water they receive from the surface, either as direct rainwater inputs or as surface streams flowing into the karst. Therefore the major requirement for good management is maintaining karst catchments in a natural condition, not subject to significant human- or pest-induced perturbations (I. Millar pers. comm.). Significant human-induced land disturbance effects are not likely to be an issue in the EMU due to its National Park status.

8.2.2 Habitat modification

Subsurface features are especially vulnerable to careless recreational use, some of which may lead to irreversible impacts, particularly in areas that had previously been relatively undisturbed. Potential impacts include: disturbance of cave passageways by trampling and erosion, the effects of which could stay in place for hundreds of years in a dry passage; damage to or removal of speleothems, which may take thousands of years to re-form; damage to or removal of fossils, particularly of extinct species; and the disturbance of sediment and its subsequent spread over speleothems and floor deposits. Waste left in caves may permanently alter the cave's microbial flora. Changes to airflows and humidity in cave systems from, e.g. digging through sediment-filled passages for recreational access or development of a cave for public viewing, can have major effects. Cave-dwelling species and growing speleothems are often dependent on temperature-stable, humid microclimates (Department of Conservation 1999). There is a strong relationship between entrance ways, climate and air movement and impacts on the near-entrance cave environment. Hence changes in the vegetation in dolines or sinkholes (tomo) that often form around the entrances to caves can lead to substantial and potentially irreversible impacts on the processes operating in that area (Clarke, 1997; Urich 2002).

Cave species are particularly vulnerable to human-induced environmental change because they have become adapted to a very limited, predictable range of climate variation, and to limited energy inputs into their habitat. Some cave species also have limited distributions, confined to one or two very small karst areas, e.g. the cave bug *Confuga persephone* which is found in two small caves in small karst areas in the Takaka Valley, Golden Bay. Most of the New Zealand troglobite fauna is unknown and hence a precautionary approach to habitat protection is warranted (Hunt 2004). Many troglobitic species make use of sediment banks along cave streams because these are places that receive periodic input of water-borne nutrients. Both detritus feeders and predators are found in this type of habitat. This is habitat which may seem of a temporary nature and therefore of little consequence to cavers. Sediment compaction due to trampling is one of the most direct impacts cavers may have on troglobitic species. A key freshwater environment in caves is small, low-energy streams with sufficient silt and detritus to provide a food source. These streams have low flow variability and their waters are seldom silted up and they consistently have the most diverse populations of aquatic troglobites. Some species groups in particular, e.g. freshwater isopods, are extremely weak swimmers and simply cannot survive in a water current. They normally live interstitially in gravels and only when the conditions are favorable will they be present visibly on the streambed. These streams are also prone to impacts from trampling.

Impacts to cave habitats from recreational cavers can be reduced by taping or cording routes of minimal impact through such areas, as is commonly undertaken in areas with important or aesthetic mineral deposits. The New Zealand Speleological Society has a set of ethical guidelines for caving practice which it promotes to its members, aimed at minimizing recreational impacts in caves. While cave fauna is included in the guidelines, they tend to concentrate on the preservation of speleothems and cave aesthetics (Hunt 2004).

8.2.3 Climate change

Acidification of rainwater since the Industrial Revolution and the effects of increased carbon dioxide in the atmosphere may increase rates of limestone erosion with consequent impacts on cave systems (Urich 2002).

9 Knowledge gaps and priorities for surveys and research

The main knowledge gaps relating to biodiversity in the EMU are:

1. Status of threatened species with no confirmed records in the last ten years including the sedge, *Uncinia longifructus;* the strapfern, *Notogrammitis gunnii*; the buttercup, *Ranunculus simulans*; the grass, *Simplicia buchananii* and the forget-me-not, *Myosotis mooreana* and the carabid beetle, *Mecodema angustulum* .

2. The invertebrate fauna of all zones is relatively poorly understood.

3. A good understanding of predator dynamics: monitoring rodent populations in the alpine zone using foot print tracking tunnels, would help understand the role of mice and the interaction between predators in the tussock and the forest zones.

4. Monitoring damage to the small-scale threatened ecosystems, particularly the forest wetlands.

5. Effective landscape scale management options for some threats, especially hares, pigs, deer and wasps.

6. Monitoring programmes for indicator species, which can be used to identify new threats or changes in threats to the biodiversity values of the EMU. For instance the giant wētā, *Deinacrida tibiospina* might serve as an indicator species for other large-bodied, flightless invertebrates inhabiting the alpine zone.

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Appendix 1 Ecosystem types

Summary ecosystem description	**Ecosystem Type Singers & Rogers unpublished (2013)**	**Ecosystem Type Singers & Rogers Published (014)**	**Naturally Rare Terrestrial Ecosystem (Williams *et al*, 2007)**	**Terrestrial Ecosystem Threat Status (Holdaway *et al*, 2012)**
Stonefield/ cushionfield	AH3 Gravelfield/ stonefield, cushionfield	AH3 Gravelfield/ stonefield, mixed species cushionfield		
Snow tussock	AL5 Mid-ribbed, broad-leaved, red and carpet tussockland/ shrubland	AL5 Mid-ribbed, broad-leaved, red and carpet grass tussockland/shrubland		
Frost flat scrub	T14 *Coprosma, Olearia* scrub	TI4: Coprosma, Olearia scrub (Grey scrub)	Frost hollows	Endangered
Frost flat red tussock	TI6 Red tussockland	TI6: Red tussock tussockland	Frost hollows	Endangered
Silver-mountain beech forest	CF19 Silver-mountain beech forest	CLF11 Silver beech forest CLF12 Silver beech, mountain beech forest		
Mountain, silver beech - podocarp forest	CF17 Mountain, silver beech podocarp forest	CDF7: Mountain beech, silver beech, montane podocarp forest		
Silver beech forest	CF18 Silver beech forest	CLF 11: Silver beech forest		
Red-silver beech forest	CF16 Red silver beech forest	CLF10: Red beech, silver beech forest		
Shrubland	CF13 *Olearia, Pseudopanax, Dracophyllum* scrub	CDF6: *Olearia, Pseudopanax, Dracophyllum* scrub		
Mānuka or kanuka scrub	Mānuka or kanuka scrub	VS3: Mānuka, kānuka scrub		
River	RV River	None because classification is terrestrial only		
Lake	LK3.7 Glacial-G Lake (Cool, moderately shallow, small)??	None because classification is terrestrial only		
Subterranean	CV1 "Caves", Subterranean rockland, stonefield	CV1: Subterranean rockland, stonefield	Cave entrances	Critically endangered
Ultramafic	UM2 Podocarp, beech, mānuka forest/ scrub/ rockland	UM2: Conifer, beech, mānuka forest/scrub/rockland	Ultrabasic screes, boulderfields and hills	Vulnerable
Marble cliffs	CL11 Mountain tutu, Hebe, wharariki, Chionochloa shrubland/tussockland/rockland	CL11: Mountain tutu, Hebe, wharariki, Chionochloa shrubland/tussockland/rockland	Cliffs, scarps and tors of calcareous rock	Vulnerable

Summary ecosystem description	**Ecosystem Type Singers & Rogers unpublished (2013)**	**Ecosystem Type Singers & Rogers Published (014)**	**Naturally Rare Terrestrial Ecosystem (Williams *et al*, 2007)**	**Terrestrial Ecosystem Threat Status (Holdaway *et al*, 2012)**
Marble pavements	Amalgamation of AL5 (tussock grassland), BR4 (bare rock incl. sandstone pavement) & SC1 (Screes, gravelfield)	EP1: Rockland (Bare rockland (erosion pavements) with a sparse cover of lichens and bryophytes, and infrequent prostrate vascular plants generally restricted to crevices. Limestone variant)	Sandstone ersosion pavements	Endangered
Marble Scree	SC1 "Screes" gravelfield	SC1: Gravelfield	Screes of calcareous rock	Vulnerable
Sinkholes	none	none	Sinkhole	Endangered
Seepages and flushes in Forests	WL8 Herbfield/ mossfield/ sedgeland	WL8: Herbfield/mossfield/sedgeland	Seepages and flushes	Endangered
Seepages and flushes in Forests	WL9 *Oreobolus* cushionfield	WL9: Cushionfield	Seepages and flushes	Endangered
Alpine seeps and flushes	WL 17 *Schoenus pauciflorus* sedgeland	WL17: *Schoenus pauciflorus* sedgeland	Seepages and flushes	Endangered
Red tussockland	WL 16 Red tussock, Schoenus tussockland	WL16: Red tussock, Schoenus pauciflorus tussockland		
Riparian turf	WL14 Ephemeral wetland	WL14 Ephemeral wetland		
Peat bog	WL7 *Chionochloa* tussockland	WL7 *Chionochloa* tussockland	? part of blanket mire group?	Vulnerable? (blanket bog?)

Appendix 2 New Zealand threatened species classification system

After Townsend *et al*. (2008)