The Dietary Impacts of Sambar Deer (*Rusa unicolor*) in Native Ecosystems of South-Eastern Australia

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ABSTRACT

The introduction and establishment of non-native species into novel ecosystems can cause significant ecological and economic harm. Native to the tropical environments of India, southern China and south-eastern Asia, sambar deer (*Rusa unicolor*) have become well established following their introductions into Australia in the late nineteenth century. Land managers, community groups and researchers are increasingly concerned by the presence of these large-bodied ungulates across a variety of contrasting habitats in the state of Victoria, and their impacts on biodiversity.

The aim of this thesis was to investigate the impacts of sambar deer through browsing and seed-dispersal in native alpine and wet forest ecosystems of south-eastern Australia. A variety of methods were utilised to understand sambar deer dietary impacts, the results of which will provide land managers with information on the plant species and communities most vulnerable to sambar deer presence.

In Chapter 2, I examine both the feeding and dispersal impacts of sambar deer on plant species in two contrasting environments: the wet forests of the Yarra Ranges National Park, and the high-elevation communities of the Alpine National Park. This was achieved through the collection of faecal pellet samples, which were analysed using DNA metabarcoding techniques to detail the full dietary profile and subjected to one year of glasshouse germination trials to examine the potential for species to be spread. The results of this chapter revealed contrasting patterns, where a large proportion of the species detected in the sambar deer diet were of native origin, yet a higher number of exotic seedlings were observed during germination trials. I discuss the implications of these findings for native ecosystems inhabited by sambar deer.

In Chapter 3, I further investigated spatial and temporal variation in the diet of sambar deer in the Alpine National Park over a three-month flowering period. The results of this study show that sambar deer diet is dominated by forb species in the Alpine National Park, which are the

most abundant plant growth form in the landscape and highlight a feeding behaviour driven by forage availability. Most interestingly, spatial variation in the diet was evident over relatively small scales. This suggests that the management of sambar deer in the Alpine National Park requires site-specific approaches, as the varying composition of plant species within sites may result in very different impacts exerted by sambar deer.

STATEMENT OF AUTHORSHIP

Except where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis accepted for the award of any other degree or diploma. No other person's work has been used without due acknowledgement in the main text of the thesis. This thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

The following authors contributed to the work undertaken as part of this thesis:

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Chapter 2 and 3 are co-authored manuscripts in preparation for publication. As such, I use the term 'we' to refer to my co-authors collectively within these two chapters. All authors contributed intellectually to the design of Chapter 2 and 3. Nicholas Murphy and John Morgan acted as supervisors. Matthew Quin organised collection of samples. Matthew Quin performed all laboratory work and statistical analyses. Matthew Quin wrote the manuscript, and Nicholas Murphy and John Morgan provided feedback and revisions of the manuscript.

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CHAPTER 1

GENERAL INTRODUCTION

Invasion ecology

The deliberate or accidental introduction of non-native species into new ecosystems can cause significant ecological and economic harm in cases where the invading species becomes established (Sakai *et al.* 2001; Chornesky & Randall 2003; Doody *et al*. 2009). As a result of the increasing influence of humans, many species have invaded new continents and subsequently impacted novel ecosystems (Pimentel *et al*. 2005; Van Kleunen *et al*. 2010). Invasive species are of significant concern, as their establishment can modify ecosystem processes and functions, and negatively impact biodiversity (Mack *et al*. 2000; Chornesky & Randall 2003; Phillips & Shine 2006; Doody *et al*. 2009; Powell *et al*. 2011). Alongside habitat loss and climate change, invasive species are a leading cause in the extinction of endemic species and further endangerment to local biodiversity (Phillips & Shine 2006; Moon *et al*. 2015; Duenas *et al*. 2018), through predation, competition, parasitism, and disease (Sakai *et al*. 2001; Chornesky & Randall, 2003; Doody *et al*. 2009).

Following introduction into a new environment, a species is generally considered invasive once it establishes a self-sustaining population size that also allows for an increase in distribution (Kolar & Lodge 2001; Blackburn *et al*. 2011). Although not all introductions result in a species becoming invasive, a variety of traits have been attributed to successful invasive species (Capellini *et al*. 2015). In plants, rapid growth and high seed output have been viewed as key characteristics of 'ideal weeds' (Baker 1965). Extended flowering duration, small seeds, and high leaf area have also been regarded as predictors of invasiveness (Rejmanek & Richardson 1996; Reich *et al*. 1997; Lloret *et al*. 2005; Hodgins *et al.* 2018). In animals, the size of the founding population plays an important role in establishment success (Lockwood *et al*. 2005; Zayed *et al*. 2007; Garnier *et al*. 2012), as problems arising from inbreeding depression and genetic bottlenecks are less likely in larger populations (Pimm 1991; Simberloff 2009; Forsman 2015). However, once established, fast growth, early maturity, and high rates of reproduction are considered key predictors of invasiveness (Pimm 1991; Capellini *et al*. 2015).

Australia has the highest rate of species extinction in the world and invasive species are considered one of the key contributing factors (Woinarski *et al*. 2015; Hoffmann & Broadhurst 2016; Davies *et al*. 2018; Ward *et al*. 2019). More than 80 species of non-native vertebrates have successfully established wild populations in Australia, including hard-hoofed ungulates (Bomford & Hart 2002; Hoffmann & Broadhurst 2016). In a review of ungulate impacts globally, Spear and Chown (2009) advised that ungulate species should not be introduced into areas with rare or endemic plants that are not adapted to ungulate herbivory, nor should they be introduced into ecosystems alongside indigenous species that are functionally different. Considering the evolution of native ecosystems in Australia have occurred in the absence of hard-hoofed ungulates, invasive ungulate populations are of significant environmental concern (Newsome *et al*. 2002; Pickering *et al*. 2010). Therefore, to respond to the threats posed by non-native ungulates in native ecosystems, an improved understanding of their impacts on native species and vegetation communities is essential.

Sambar deer as an invasive species

Sambar deer (*Rusa unicolor*) are a large bodied ungulate species native to the tropical environments of India, southern China and south-eastern Asia (Bennett 2008; Leslie 2011). Considered the largest and most widespread species of deer in Asia (Corbet & Hill 1992; Semiadi *et al*. 1993), seven subspecies are currently recognised and are observed across a variety of habitats and elevations (Groves & Grubb 1987; Grubb 2005; Leslie 2011).

Sambar deer are often described as timid and secretive and tend to exhibit crepuscular activity patterns (Bennett 2008; Davies *et al*. 2020). Adult males can reach a body mass of 225 – 320 kg, and females are observed at the lower end of this range (Sankar & Acharya 2004; Leslie

2011). Although males are typically solitary, females often dominate small groups comprising offspring (Leslie 2011).

The diet of sambar deer is varied, with season, location, habitat variety, competition, and human activities all playing a role in dietary selection (Kushwaha *et al*. 2004), although forage availability appears to be the key driver (Schaller 1967; Geist 1998). In most cases, sambar deer display intermediate feeder behaviour, with the capacity to adapt to diets comprised heavily of browse or graze material (Leslie 2011). However, shrubs and trees comprise most of their diet (Khan *et al*. 1994; Srivastava *et al*. 1996; Forsyth & Davis 2011). Sambar deer habitat selection is closely tied with forested landscapes, with preference for forest edges where tall grasses connect dense forests with grasslands (Ngampongsai 1977). Although the species tends to avoid areas disturbed by humans, they can adapt to a wide range of environments (O'Brien *et al*. 2003; Kushwaha *et al*. 2004).

Breeding of sambar deer can occur throughout the year (Bennett 2008). Female sambar deer reach sexual maturity between 18 – 24 months, with a gestation period of eight months (Leslie 2011). This suggests that an adult female may potentially have up to three offspring in a two-year period (Hayssen *et al*. 1993; Bentley 1998), although Forsyth *et al*. (2004) suggests one offspring per year as more plausible.

Sambar deer in Australia

Since European colonisation, eighteen species of deer have been deliberately introduced into the Australian landscape by acclimatisation societies (Bentley 1998; Moriarty 2004). Only six of the eighteen introduced species have become naturalised (Strahan 1995); chital deer (*Axis axis*), fallow deer (*Dama dama*), hog deer (*Axis porcinus*), red deer (*Cervus elaphus*), rusa deer (*Rusa timorensis*) and sambar deer. In many cases, exact species introduction locations and abundance records are either vague or unavailable (Bentley 1957), however, below presents the current understanding of sambar deer establishment and distribution in Australia, with a particular focus on the state of Victoria.

Several different subspecies of sambar were introduced into Australia, including the subspecies *unicolor*; native to India, *equinus*; native to western Indonesia, *brookei*; native to the Indomalayan island of Borneo, and *phillipinus*; of the Philippines (Moriarty 2004; Leslie 2011; Ali *et al*. 2021). In the state of Victoria, sambar deer numbers continue to rise even though recent estimates for yearly harvesting rates by hunters have approached close to 90,000 individuals (Moloney & Powell 2019; Watter *et al*. 2020). Forsyth *et al*. (2015) estimated that the total breeding distribution of sambar deer in Victoria was 66,915 km^2, approximately 29% of the land area, and is comprised of four distinct populations: Eastern Victoria, French Island, Mount Cole and Timboon. Eastern Victoria populations stem from sambar deer releases into the Kinglake National Park, Snake Island, Gembrook and Tooradin localities between 1863 and 1873 (Bentley 1998; Forsyth *et al*. 2015). During the same period, individuals were also released on French Island (Bentley 1998) and around Mount Cole (Gilbert 1888; Bentley 1998).

The Eastern Victoria population of sambar deer slowly grew in the first half of the twentieth century, and by the early 1950s sambar deer were present across the broader alpine bioregion. Over the following two decades the distribution of sambar continued to spread east, and by 1968 the species had moved into New South Wales via the Thredbo River area (Forsyth *et al*. 2015). In the 1970s, a small captive group of sambar deer either escaped or were deliberately released, resulting in the formation of a small, distinct population around Timboon (Forsyth *et al*. 2015), and currently, sambar deer likely occupy most of the eastern portion of Victoria (Parkes *et al*. 2011; Forsyth *et al*. 2015; Figure 1).

Figure 1. Current distribution of sambar deer populations in Australia, shaded in grey. Adapted from Bennett (2008) and Forsyth *et al*. (2015).

Outside of Victoria, a small, isolated population of sambar deer is currently distributed in the Cobourg Peninsula area of the Northern Territory, stemming from their introduction into the area alongside fallow deer in 1916 (Bentley 1957; Moriarty 2004). It is likely that this sambar deer population remains limited in size and range due to predation by dingoes and wild dogs (Frith 1973). Sambar deer are distributed across south-eastern New South Wales, largely because of the movement of eastern Victorian populations into the Thredbo River area in approximately 1968, and subsequent colonisation of the southern portion of Kosciuszko National Park by 1980 (Dunn 1985; Bentley 1998; Forsyth *et al*. 2015). Around this same time, sambar deer were first observed in the Australian Capital Territory and are now considered to be distributed within southern parts of the territory (Moriarty 2004; Forsyth *et al.* 2015).

Impacts of sambar deer herbivory on vegetation and seed-dispersal

Each species of deer introduced into Australia has the potential to impact the environment in different ways, due to distinct differences in habitat and dietary requirements (Hall & Gill 2005). Sambar deer are known to forage on a wide variety of plant species (Forsyth & Davis 2011), and thus when deer density is high, the species has the potential to alter the composition and function of plant communities through differential consumption of leaves, stems, flowers, and fruits (Augustine & Jordan 1998; Côté *et al*. 2004). A reduction in plant fitness owing to limited opportunity for reproduction, future recruitment, and growth may place plant populations at risk (Marquis 1992; Augustine & Frelich 1998; Côté *et al*. 2004; Peel *et al*. 2005). This is of particular concern for native plant species which may lack adaptations to withstand the browsing pressure of novel, invading herbivores (Parker *et al*. 2006; Orrock *et al*. 2015). The impacts of sambar deer herbivory on vegetation may also be driven by the palatability and preference for plant species, resulting in less preferred or more browse-tolerant species persisting whilst preferred species are targeted and reduced (Augustine & McNaughton 1998; Gill & Beardall 2001). This has been observed in the East Gippsland region, where sambar deer have been implicated in the reduction of native plant species of differing growth forms including trees, shrubs, forbs, vines, and ferns (Peel *et al*. 2005).

Due to their large size, sambar deer require a large amount of plant material to meet daily energy requirements. In the Yarra Ranges National Park, Bennett (2008) estimated that sambar deer consumed approximately 3 – 4 kg of dry plant material per individual per day, eclipsing the levels of consumption by other coexisting native herbivores in the study areas. Considering that sambar deer are likely to have overlapping diets with many native herbivores across their current range in Australia (Forsyth & Davis 2011), the high level of plant biomass consumption by sambar deer has the potential to impact coexisting herbivores through competition, as well as impede the growth of plant species that are preferred dietary items, and/or of limited availability (Côté *et al*. 2004; Dorrough *et al*. 2007; Davis *et al.* 2016).

Sambar deer may also play a role in altering plant communities through the dispersal of both native and exotic plant seeds via ingestion and defecation, a process referred to as endozoochory. Currently, an understanding of the role of sambar deer as vectors for seed-dispersal in south-eastern Australia remains limited, although the potential of the species to facilitate the spread of an environmental weed, Himalayan Honeysuckle (*Leycesteria formosa),* has been demonstrated in Mount Buffalo National Park (Eyles 2002). Considering the large body size of sambar deer, large quantities of forage required, and large home ranges, the species may move plant seeds long distances and aid in the future dispersal and establishment of environmental weeds (Gill & Beardall 2001, Forsyth & Davis 2011).

Methods for estimating herbivory

In south-eastern Australia, very little research has been published on the diet of sambar deer in native ecosystems. Previously, microhistological and macroscopic techniques were used to study dietary diversity, with identification based on morphological traits and cell structural properties of plant matter collected from the stomach of a species of interest (Gill *et al*. 1983; Nugent 1983; Norbury & Sanson 1992; Forsyth & Davis 2011). These techniques are, however, difficult, and often lead to species being underestimated or missed entirely (McCaffery *et al*. 1974; Kessler *et al*. 1981; Gill *et al.* 1983; Wheeler *et al.* 2004; Stribling *et al.* 2008). DNA metabarcoding provides a suitable alternative for investigation of diet composition (Lopes *et al.* 2015). First described by Hebert *et al*. (2003), the process of DNA metabarcoding is a fast and efficient method for surveying multiple species within a sample (Creer *et al*. 2016), allowing for large amounts of sequencing data to be generated, and greater taxonomic resolution to identify plant species within a diet (Valentini *et al*. 2009; Pompanon *et al*. 2012; Ando *et al*. 2013; Nichols *et al.* 2016). The metabarcoding approach can be used to infer the relative abundance of various items in a species diet, provided potential sources of bias are recognised and accounted for in the preliminary stages of a metabarcoding study (Deagle *et al*. 2019).

The use of faecal pellet sequencing for dietary analysis is developing rapidly (e.g. Erickson *et al*. 2017; Rytkönen *et al*. 2018; Goldberg *et al*. 2020; Lopes *et al*. 2020), and when compared to traditional microhistological and macroscopic techniques for assessing herbivore diet has been shown to identify more taxa, provide finer taxonomic resolution and remove observer biases (Soininen *et al*. 2009; Valentini *et al*. 2009; Soininen *et al*. 2015; Khanam *et al*. 2016; Goldberg *et al*. 2020). However, the results obtained from DNA sequence-based methodologies can be hindered by the inappropriate choice of one or more gene regions for analysis (Wilkinson *et al*. 2017; Mallot *et al*. 2018). Gene region selection is dependent on a variety of factors surrounding the study species of interest (Pompanon *et al*. 2011; Deagle *et al*. 2019) and for herbivores in particular, several barcoding regions (*matK*, *rbcL*, ITS and *trnL*) have been recommended as ideal candidates for detailing the plant species within faecal samples (Taberlet *et al*. 2007; Hollingsworth *et al*. 2009; Deagle *et al*. 2018). Nevertheless, finding the balance between gene region choice, resolution and amplification success is important for any study utilising DNA metabarcoding methods for dietary analysis (Iwanowicz *et al*. 2016, Erickson *et al*. 2017, Mallot *et al*. 2018).

THESIS RATIONALE AND OBJECTIVES

Land managers, community groups and researchers are increasingly concerned by the presence of sambar deer across a variety of contrasting habitats in the state of Victoria, and the impacts of the species on biodiversity. In the Yarra Ranges National Park, the Central Highlands Eden project group, which is overseen by the Department of Environment, Water, Land and Planning, undertakes routine monitoring and removal of weed species to restore areas within the broader Central Highlands landscape. However, high numbers of sambar deer in the area and the presence of several unexpected weed species in sites where human-mediated dispersal is considered unlikely, has prompted the group to suspect that sambar deer may be dispersing weeds within the area. Additionally, researchers and land managers have raised concerns about the presence and dietary behaviour of sambar deer in high-elevation sites within the Alpine National Park, which has previously been negatively impacted by other introduced, grazing ungulates such as cattle (*Bos taurus*), and feral horses (*Equus caballus*) (Wahren *et al.* 1994; Driscoll *et al*. 2019; Good & Johnston 2019; Robertson *et al*. 2019).

In this thesis, DNA-based methodologies are used to examine questions surrounding the diet of sambar deer in different ecosystems, with the aim to adequately assess dietary diversity and composition. Additionally, the potential for sambar deer to act as seed dispersers through the process of endozoochory is explored through germination trials.

Chapter 2 is titled "Assessing the diet and seed-dispersal ability of non-native sambar deer (*Rusa unicolor*) in native ecosystems of south-eastern Australia". In this chapter, the focus was to detail the dietary items ingested and potentially dispersed by sambar deer in two contrasting environments: the wet forests of the Yarra Ranges National Park, and the high-elevation vegetation communities of the Alpine National Park. This was achieved through the collection of faecal pellet samples, which were analysed using DNA metabarcoding techniques and subjected to glasshouse germination trials.

Chapter 3 is titled "Spatial and temporal variation in the diet of sambar deer (*Rusa unicolor*) in an alpine landscape". This chapter concentrated on spatial and temporal variation in the diet of sambar deer in the Alpine National Park over a three-month flowering period, whilst also exploring potential dietary preferencing of plant species.

Lastly, Chapter 4 assesses the findings from both chapters and presents recommendations for future research and management of landscapes inhabited by sambar deer.

The two experimental chapters that are presented in Chapter 2 and 3 are written as manuscripts for publication in a scientific journal. Chapter 2 has been prepared for submission to the *Journal of Applied Ecology* and Chapter 3 has been prepared for submission to *Wildlife Research*.

Because of this, there is some unavoidable repetition of the study species and areas, DNA methodologies, and concepts surrounding the impacts of herbivory in the thesis.

CHAPTER 2

Assessing the diet and seed dispersal ability of non-native sambar deer (*Rusa unicolor*) in native ecosystems of south-eastern Australia.

This chapter is prepared for submission to the *Journal of Applied Ecology*.

ABSTRACT

1. Understanding the influence of non-native herbivores on ecosystems through dietary foraging and seed dispersal requires multiple methodologies. In south-eastern Australia, sambar deer (*Rusa unicolor*) are rapidly expanding in range and are potentially placing native ecosystems at risk through browsing and as vectors for seed dispersal.

2. We estimated the dietary composition of sambar deer in Alpine and Wet Forest ecosystems by DNA sequencing 40 groups of sambar deer faecal pellets using the *trnL*, ITS2, and *rbcL* gene regions. We also simultaneously performed seed germination trials to investigate the plant species that germinate from faecal pellets.

3. DNA sequencing of the three gene regions resulted in a total of 1003 plant Operational Taxonomic Units (OTUs) being detected, with a diverse species composition. A large proportion of plant OTUs were considered 'likely native', however, the proportion of 'likely exotic' species in the diet was greater than would be expected based on their proportion in the landscape. Sambar deer exhibited intermediate feeder behaviours dominated by forbs in Alpine and shrubs in Wet Forest ecosystems.

4. Seed germination trials indicated that sambar deer can disperse a substantial number of native and exotic species in both Alpine and Wet Forest ecosystems. In Alpine ecosystems, an individual sambar deer was estimated to disperse on average 847 (±201) seeds per day during the study period, of which 676 (±182) were exotic.

5. *Synthesis and applications*. Our results suggest that native plant species comprise a large proportion of sambar deer diets in Australian ecosystems, and that the species is dispersing both native and exotic plant species via endozoochory. However, exotic species seedling germination numbers were significantly higher in Alpine ecosystems. Management of native plant species and vegetation communities of conservation significance or at-risk to sambar deer browsing is

of high priority, through either the removal of sambar deer or implementation of exclusion-based methods for vulnerable plant species at a local scale.

Keywords: Alpine, DNA sequencing, endozoochory, faecal DNA, germination, invasive plant species, native plant species, wet forest.

INTRODUCTION

The introduction and colonisation of non-native species into new environments can have direct negative impacts on native species and pose serious threats to native ecosystem function (Atkinson 1989; Mack *et al*. 2000; Mahon 2009; Spear & Chown 2009). In Australia, plant species evolved in the absence of hard-hoofed mammals (Newsome *et al*. 2002; Pickering *et al*. 2010), however, many non-native ungulates have colonised successfully since European settlement, including six species of deer (Moriarty 2004; Davis *et al*. 2016). Currently, evidence suggests that three species, fallow deer (*Dama dama*), red deer (*Cervus elaphus*), and sambar deer (*Rusa unicolor*) are increasing both their population size and distribution in the south-eastern area of the continent (Moriarty 2004; Forsyth *et al*. 2015; Davis *et al*. 2016).

Deer can alter the structure and function of ecosystems through browsing, grazing, and trampling (Rooney & Waller 2003), which can lead to soil erosion and sedimentation as well as affecting nutrient cycling, primary production, light levels, and moisture dynamics (Williamson 1996; Rooney & Waller 2003; Davis *et al*. 2016). In areas where native herbivores share habitat and resources with deer, competition for foraging material and territory is high (Forsyth & Davis 2011), and where deer are at high densities, competition may threaten the persistence of some native fauna (Côté *et al*. 2004). As levels of deer browsing and grazing increase, the growth and reproduction of plant species is reduced (Côté *et al*. 2004). In some ecosystems, deer have shown selective feeding strategies, browsing certain plants more heavily than others, and in forested ecosystems, cascade effects on biodiversity have been observed following reductions in both canopy and herb layers through deer foraging activity (Gill 1992; Dolman & Wäber 2008). However, the diet of deer in Australian ecosystems is poorly understood (Davis *et al*. 2016), and a detailed investigation is necessary to understand deer dietary selection and the potential impacts on native plant species.

Many studies for estimating herbivore diet have relied on microhistological and macroscopic techniques (Norbury & Sanson 1992; Suter *et al*. 2004; Shrestha *et al*. 2005; Forsyth & Davis 2011), which involve sampling the stomach contents and identifying the plant material contained based on morphological and cell structural properties (Nugent 1983; Gill *et al*. 1983). However, these methods can be problematic due to the invasive techniques required for collecting samples, the taxonomic expertise required for distinguishing plant species, and potential over- and under-estimation of dietary items due to differences in digestion rates (McCaffery *et al*. 1974; Kessler *et al*. 1981; Gill *et al*. 1983; Wheeler *et al*. 2004; Stribling *et al*. 2008). Recent advances in genetic techniques have enabled the analysis of trace DNA in environmental samples and hence, DNA metabarcoding provides a fast and efficient alternative for the investigation of herbivore diets, through sampling of faecal pellets within an ecosystem of interest (Creer *et al*. 2016; Erickson *et al*. 2017; Goldberg *et al*. 2020; Lopes *et al*. 2020).

Browsing of plant species by deer is also likely to influence seed dispersal (Bartuszevige & Endress 2008). In Australia, hog deer (*Axis porcinus*) have been shown to disperse >133,000 viable seeds per day via defecation of faecal pellets, of which a majority were native (Davis *et al*. 2010). Claridge *et al*. (2016) compared the viable seed from faecal pellets of fallow deer and the native eastern grey kangaroo (*Macropus giganteus*) and determined that a greater number of plant species germinated from the faecal pellets of fallow deer, as well as a higher number of non-native species. Considering the longer stomach passage times attributed to deer, in combination with high levels of daily movement and ability to forage on a wide range of plant materials, endozoochory by deer has the potential to transport plant-seeds long distances (Gill & Beardall 2001). An exploration of which plant seeds can survive the digestive system of deer, in conjunction with overall dietary composition of deer through germination trials and DNA analysis would provide valuable knowledge surrounding the most abundantly and frequently consumed and dispersed plant species by deer.

In this study, we focus on sambar deer which are native to India, southern China and south-eastern Asia, and have been successfully released in the United States, New Zealand and

Australia (Wodzicki 1950; Lewis *et al*. 1990; Bentley 1998; Leslie 2011). Since their introduction into Australia in the 1860s, sambar deer have become well-established in south-eastern Australia in a variety of habitats ranging from coastal to alpine summits (Peel *et al*. 2005; Forsyth *et al*. 2015). We assessed sambar deer herbivory and the capacity for endozoochoric seed dispersal in two contrasting habitats; Alpine and Wet Forests, both of which support varying densities of sambar deer (Bennett 2008; Brown *et al*. 2016). We used sambar deer faecal pellets to explore diet through DNA analyses and performed germination trials to determine which plant species are capable of germinating from faecal pellets. From this, we aimed to determine the diversity of plant species and growth forms eaten and spread by sambar deer, and the dietary behaviour of the species in two different ecosystems.

METHODS

Study area

Alpine

The Bogong High Plains are situated in the Alpine National Park (36° 53' S, 147° 18' E) in north-east Victoria, Australia and are the most extensive areas of high mountain vegetation in the state (Wahren *et al*. 1999). Located on a series of undulating alpine and subalpine plateaus (1660–1880 m above sea level; Van Rees 1982; Williams 1992; McDougall 2003), the study area comprised a mixture of tussock grasslands, snowpatch herbfields, open heathlands and Snow Gum (*Eucalyptus pauciflora*) heathy woodlands. Mean annual precipitation in this study area is 2430 mm (much of which falls as snow in winter), with mean annual minimum and maximum temperatures of 2.7 °C and 9.5 °C, respectively.

Wet Forest

The Central Highlands study area comprised both the western and bordering portions of the Yarra Ranges National Park, approximately 90 km east of Melbourne, Victoria (37° 41' S, 145° 34' E). The study area consisted of densely vegetated wet, damp, and riparian forests dominated by Mountain Ash (*Eucalyptus regnans*) with shrubs, grasses, and ferns comprising the understorey. The topography was varied with elevations from 200 m to 1200 m, and the mean annual rainfall in the study area is 1081 mm, with mean annual minimum and maximum temperatures of 7.5 °C and 20.5 °C, respectively.

Sample collection

Sambar deer faecal pellets were collected from both study areas for DNA analysis and germination trials during Autumn 2019, after most seed had set but before autumn seed germination (Appendix Figure 1, Tables 1-4). As sambar deer expel many faecal pellets in one defecation, we define a faecal pellet group as a collection of pellets which varies in the total number of individual units yet are produced by only one sambar deer. A total of 160 sambar deer faecal pellet groups were collected across the two study areas (Alpine; $n = 81$, Wet Forest; $n = 79$). Sambar deer faecal pellets were easily distinguished from other native and exotic herbivores, however, a deer-specific field guide (Claridge 2016) was used to ensure only pellets from sambar deer were collected, particularly in the Wet Forest study area where other species of deer are known to occur. Only fresh samples were collected, described as those that were still brown and exhibited a wet shine with no outer decay (Mayze & Moore 1990). Pellet groups that exhibited clear signs of contamination from non-food items such as leaf or plant tissue were ignored.

Wet Forest faecal pellet groups were randomly subdivided such that all pellet groups were subjected to both DNA and germination analysis. However, due to issues during sample collection, Alpine faecal pellet groups were randomly allocated to either DNA or germination treatments.

Faecal pellets for DNA analysis were stored in individual plastic zip-lock bags (18 × 16.5 cm) with silica gel sachets to limit moisture accumulation. For seed germination trials, faecal pellets were collected and stored in individual paper bags (26 × 20 cm). All faecal samples for DNA analysis were stored at -30 °C, and germination trial samples were stored in a dark environment at room temperature.

DNA extraction

A total of 40 faecal pellet samples (Alpine; n = 20, Wet Forest; n = 20) were selected for DNA extraction. Each sample comprised 8–12 faecal pellets collected in the field, which were homogenised into a single sample. Three subsamples of ~200 mg of each homogenised sample were then placed into separate 2 mL microcentrifuge tubes for DNA extractions.

DNA extractions were undertaken in a Polymerase Chain Reaction (PCR) free room following protocols in the QIAamp Fast DNA Stool Mini Kit (Qiagen), with negative controls run throughout. Alpine and Wet Forest samples were extracted in different sessions to minimise contamination. DNA concentrations were quantified with a Thermo Fisher NanoDrop Lite Spectrophotometer and stored at 4 °C.

PCR amplification and library preparation

Established primer sets were used to amplify segments of the *rbcL*, ITS2, and *trnL* intron P6 loop gene regions, following custom PCR protocols (Appendix Table 5 & 6). Each PCR mixture included 15.5 µL of H_2O, 5 µL of MyTaq™ Red Reaction Buffer (Bioline), 0.5 µL of each forward and reverse primer (10 µM), 0.5 µL of MyTaq™ DNA polymerase (Bioline), and 3 µL of DNA template (ranging in concentration from 4.3–158.5 ng μL^{-1}) for a 25 µL reaction. In cases where samples failed to amplify, DNA samples were diluted at 1/10 and 1/100 rates with H_2O until amplification was successful. PCRs included both negative extraction and H_2O controls to test for sample contamination.

Illumina adaptors and index primers were attached following the first round of PCRs and these reactions comprised 9.45 µL of H_2O, 3 µL of MyTaq™ Red Reaction Buffer (Bioline), 0.75 µL of the index primer pair (Illumina), 0.3 µL of MyTaq™ DNA polymerase (Bioline), and 1.5 µL of DNA PCR template for a 15 µL reaction. Conditions for this PCR consisted of an initial denaturation period of 95 °C for 3 min, followed by 10 cycles of denaturation at 95 °C for 20 s, annealing at 60 °C for 15 s, and elongation at 72 °C for 30 s, with a final extension step at 72 °C for 3 min. PCR products were cleaned to remove non-specific DNA fragments, in accordance with an AmpureXP protocol, using an SPRI magnetic bead mix.

The concentrations of the PCR products were quantified using a Thermo Fisher NanoDrop Lite Spectrophotometer, and samples were normalised using H_2O. A final library comprising Alpine and Wet Forest samples was prepared as per Illumina MiSeq protocol. Sequencing was performed using MiSeq Reagent v2 (2 × 250bp) sequencing kit.

Data filtering and bioinformatics

For ITS2 and *trnL* sequences, forward and reverse sequences for each sample were merged using the fastq_mergepairs function in the sequence analysis tool USEARCH v11.0.667 (Edgar 2010). All *rbcL* sequences were analysed separately as forward and reverse sequences, as the length of these sequences prevented merging. However, to ensure the number of *rbcL* OTUs was not artificially inflated, sequences from both forward and reverse reads that were identified to the same species were only counted as one species in later analysis. The fastx_truncate function was used to remove the primers attached in the first round of PCR for each gene region, and sequences were then filtered based on length using the fastq_filter function, which removed sequences <200 bp in length for *rbcL* and ITS2 sequences, and <30 bp in length for *trnL* sequences. Contaminants and singleton sequences were removed using the fastx_uniques function, with remaining sequences then grouped into Operational Taxonomic Units (OTUs) based on ≥97% similarity, following the convention that ≥97% similarity corresponds to species level (Schloss & Handelsman 2005). Any OTUs present in negative extractions or H_2O controls were removed from the entire dataset, as were any OTUs with a read depth <5. After the completion of filtering, OTUs from each of the three extraction sub-samples were merged into a single sample.

The taxonomic assignment of OTUs was determined by comparison with the National Centre for Biotechnology Information (NCBI) GenBank nucleotide database. BLAST (Basic Local Alignment Search Tool; Altschul *et al*. 1990) was used to search each OTU against NCBI GenBank with default parameters.

An OTU was assigned to species level when a ≥97% match of a reference sequence to the full length of the consensus OTU sequence was observed. Matches that were not able to be made to species level were assigned to the lowest taxonomic level possible. The Atlas of Living Australia (www.ala.org.au) and Royal Botanic Gardens Victoria VicFlora (www.vicflora.rbg.vic.gov.au) were used to ensure that the identification of taxa was plausible, by ensuring taxonomic matches to species, genus or family were within or surrounding the study areas.

Seed germination trials

For many Alpine plant species, a period of snow cover is required to break seed dormancy and promote germination (Hoyle *et al.* 2014). To simulate these conditions, the use of a cold-wet stratification technique was applied to the Alpine samples (Iravani *et al*. 2011). Samples were halved by weight, with half placed at room temperature in a dark environment, while the other half were sprayed with 5 mL of water and placed in a cool room to undergo a cold-wet stratification. All samples were stored for 35 days in the dark, and the temperature of the cool room was recorded regularly, with a minimum of 0.8 °C and maximum of 5.2 °C observed during the stratification phase. During this period, the Wet Forest samples were stored at room temperature in a dark environment.

Following the completion of the cold-wet stratification procedure, 256 punnets (85 × 135 × 50 mm) were prepared with a 4:1 mixture of sterilised seed raising mix (Osmocote) to vermiculite. Pellet samples were crushed within individual paper bags and evenly spread over the seed raising mix (layer of approximately 5 mm). The 81 Alpine pellet group samples were divided to create matched pairs of cold-wet stratified and non-stratified samples (n = 162 in total). In addition to these samples, 79 Wet Forest samples and 15 control punnets containing only seed raising mix and vermiculite were distributed on the centre bench of an unheated glasshouse. Trays were illuminated with natural light during the day and were watered *ad libitum*. All trays were randomly redistributed once a week to avoid within-glasshouse microclimatic differences, and 'control' punnets were randomly distributed within trays to record potential contamination by wind-blown seed. After germination, seedlings were identified, counted, and removed from punnets. Unknown species were transferred to individual pots and grown further until they could be identified. The germination study was run for 365 days.

Statistical Analysis

Genetic data

For DNA sequence data, the frequency of OTUs across samples from each gene region was examined and compared between the study areas. The proportional richness of sambar deer diet comprising native and exotic species was assessed with a two-proportion z-test in R (Chayes & Kruskal 1966; R Development Core Team 2010), comparing the observed proportions of native and exotic OTUs with the expected proportions of native and exotic species within each study area generated with the Royal Botanic Gardens Victoria VicFlora Checklist feature (https://vicflora.rbg.vic.gov.au/flora/checklist). The VicFlora checklist feature provides a comprehensive list of all available plant species within each study area, and hence the many species that could be consumed by sambar deer. For Alpine samples, the Alpine National Park dataset available within the VicFlora Checklist was used to determine the proportion of native and exotic species in this study area, whilst the Yarra Ranges National Park dataset was used for Wet Forest samples. To determine the proportion on native and exotic species within the sambar deer diet, the datasets for each gene region were combined and duplicate species were removed. OTUs were labelled as 'Likely Native', 'Likely Exotic' or 'Unknown' by comparison to the 'Establishment Means' information on the online Royal Botanic Gardens Victoria VicFlora database. The status of OTUs classified only to genus was based on the proportion of native to exotic species contained within the genus, and their relative distribution in comparison to each study area. Therefore, only the plant species from any detected genera that were listed as present within each individual study area were considered for 'Likely Native' or 'Likely Exotic' classifications. A genus was labelled 'Likely Native' if more than 50% of the species within the genus were native and 'Likely Exotic' if more than 50% of the species within the genus were exotic. The 'Unknown' characterization was used for OTUs that were named to family, as well as for genera that were split with 50% native and 50% exotic species. An identical test was used to compare whether the proportional foraging of sambar deer on native and exotic species was similar between the Alpine and Wet Forest ecosystems.

To assess the feeding behaviour of sambar deer in both ecosystems, we labelled each of the OTUs as one of five plant growth forms (Fern, Forb, Grass, Other Graminoid, Shrub or Tree). The growth form of OTUs classified to genus level were based on the proportion of species of a particular growth form within the genus, and their relative distribution in comparison to each study area. We then compared the OTU richness for each growth form using a Kruskall-Wallis H test with post-hoc Dunn's test in R (Kruskal 1952; Dunn 1964).

Germination data

To determine whether the two Alpine datasets should be analysed independently, a Spearman's Rank Correlation Coefficient test (Spearman 1904) was used to determine whether Alpine non-stratified and cold-wet stratified samples were correlated for number of germinants per punnet, number of different species per punnet and number of germinants for each different species. A non-parametric Wilcoxon Rank Sum Test (Wilcoxon *et al.* 1970) was used to compare the number of native and exotic seedlings that emerged from sambar deer faecal pellets in both study regions, and the same test was used to compare the mean plant species richness per punnet between the Alpine and Wet Forest samples. To test for differences in the plant growth form of emerging seedlings (Forb, Grass, Other Graminoid, Shrub or Tree), a Kruskal-Wallis H test with post-hoc Dunn's test was performed.

The mean number of viable seeds dispersed daily during the study period by an individual sambar deer within each study area was estimated following previous methodologies (Williams *et al*. 2008; Davis *et al*. 2010). The mean number of germinants for a complete sambar deer defecation was determined by multiplying the mean number of native, exotic and total germinants from the maximum of 12 collected pellets in this study by 3.1, based on an estimated average of 37 pellets comprising a full sambar deer pellet group (Pacioni, Department of Environment, Land, Water, and Planning, 2021, unpublished data). This figure was estimated from 91 observations within the broader Wet Forest study area and is on the conservative side of the estimated 40–60 pellets per pellet group for most deer species (Mayle *et al*. 1999). We then multiplied the mean number of germinants from a complete sambar deer defecation by an estimated sambar deer defecation rate of 12 pellet groups per day (Srikosamatara 1993) to determine the mean number of viable seeds dispersed daily by an individual sambar deer during the study period.

RESULTS

DNA Sequencing

A total of 5,988,518 filtered reads were generated, comprising 2,949,158 from Alpine samples and 3,039,630 from Wet Forest samples. Further data filtering and bioinformatic processes resulted in a total of 138 Alpine and 227 Wet Forest plant OTUs for analysis using the *trnL* gene region, 123 Alpine and 221 Wet Forest plant OTUs using the ITS2 gene region and 79 Alpine and 215 Wet Forest plant OTUs using the *rbcL* gene region (Appendix Table 7 & 8).

For the combined OTU data set, 110 genera from 56 families were represented in the Alpine samples, the most common OTUs being from the Myrtaceae (12.8%), Asteraceae (12.5%), Rubiaceae (9.3%), Rosaceae (7.7%), Poaceae (5.1%), and Fabaceae (4.8%). Sequences from the Myrtaceae contributed to the highest proportion of reads (34.3%), followed by Rubiaceae (12.3%), and Rosaceae (12.2%). A greater diversity of genera and families were observed in Wet Forest samples, with a total of 168 genera from 78 families detected. The most common OTUs from the Wet Forest study area were Rubiaceae (18.6%), Poaceae (10.3%), Fabaceae (7.1%), Asteraceae (6.4%), Rosaceae (4.8%), and Myrtaceae (3.9%). Sequences from the Winteraceae contributed to the highest proportion of reads (33.9%), followed by Poaceae (15.3%), and Rosaceae (14.6%).

In the Alpine samples, the most frequently occurring OTUs across each of the samples (appearing in >75% of pellet samples for any of the three gene regions studied) were *Acaena* sp., **Acetosella vulgaris*, *Asperula* sp., *Celmisia costiniana*, *Eucalyptus* sp., *Galium* sp., *Poa* sp., **Sonchus* sp., and *Tasmannia* sp. (* denotes non-native species). The most frequently occurring species across the Wet Forest samples were *Acaena* sp., **Anthoxanthum odoratum*, **Ehrharta erecta*, *Eucalyptus* sp., *Geranium* sp., *Microlaena stipoides*, *Poa* sp., *Rubus* sp., and *Tasmannia* sp.

In both study areas, a higher proportion of 'likely native' species comprised the diet of sambar deer (Alpine; 77%, Wet Forest; 75%). However, the proportion of 'likely native' species detected in the diet compared to the proportion of native species in the environment (Alpine; 85% native species in the environment, Wet Forest; 86% native species in the environment) resulted in a significant difference in proportions in both the Alpine ($z = -4.038$, $P < 0.001$) and Wet Forest ($z = -6.117$, $P < 0.001$) study areas favouring exotic species. However, no difference was observed between the detected proportion of plant species considered 'likely native' across the two study areas ($z = -0.762$, $P = 0.447$), suggesting similar feeding patterns of 'likely native' species in Alpine and Wet Forest ecosystems.

There was a significant difference in mean number of detected OTUs from different plant growth forms in Alpine areas ($\chi^2(4) = 81.51$, df = 4, $P < 0.001$; Figure 1), and all pairwise comparisons were significantly different, except for Forb & Shrub or Tree ($z = -1.53$, $P = 0.125$), Other Graminoid & Grass ($z = -2.44$, $P = 0.147$) and Fern & Other Graminoid ($z = 0.499$, $P = 0.618$). A similar result was observed in Wet Forest samples ($\chi^2(4) = 66.77$, df = 4, $P < 0.001$), with pairwise comparisons resulting in a significant difference in mean number of OTUs from different plant growth forms for all comparisons, except for Forb & Shrub or Tree ($z = 0.445$, $P = 0.657$), Forb & Grass ($z = -2.33$, $P = 0.2$), Fern & Grass ($z = 2.04$, $P = 0.416$), Fern & Other Graminoid ($z = -2.00$, $P = 0.45$), and Grass & Shrub or Tree ($z = 2.77$, $P = 0.06$).

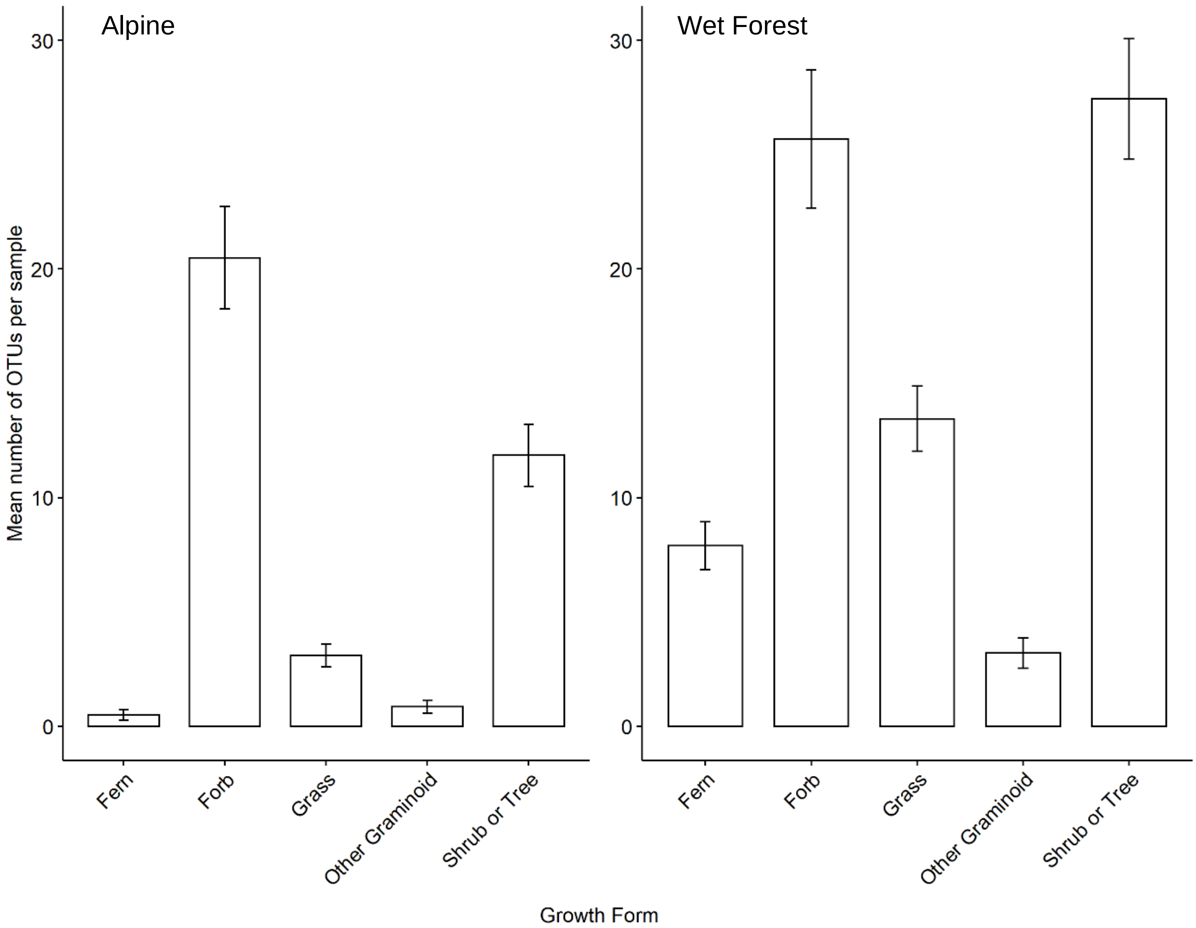

Figure 1. Mean (±1 SE) number of detected Operational Taxonomic Units (OTUs) classified by growth form from sambar deer faecal pellets collected in Alpine and Wet Forest ecosystems.

Germination

A total of 2,087 seedlings emerged during the germination trials, consisting of 1,849 from Alpine samples (89%) and 238 from Wet Forest samples (11%). This was comprised of 68 plant species, 39 of which were native (58%), 26 exotic (38%) and 3 were of uncertain origin (3%; Table 1). Alpine samples contained 32 plant species (20 native, 12 exotic) and Wet Forest samples contained 50 plant species (24 native, 23 exotic and 3 uncertain). Fourteen species were recorded in both ecosystems (5 native, 9 exotic).

Table 1. List of plant species that germinated from sambar deer faecal pellets collected from the two study areas. For Alpine samples (*n* = 81) and Wet Forest samples (*n* = 79), the plant families, growth form, origin, total germinants and percentage of pellet groups that each species emerged from (Frequency) are shown.

				Alpine		**Wet Forest**	
Family	**Species**	**Growth Form**	**Origin**	**Total**	**Frequency %**	**Total**	**Frequency %**
Apiaceae	*Oreomyrrhis eriopoda*	Forb	Native	1	1	0	0
Araliaceae	*Hydrocotyle laxiflora*	Forb	Native	0	0	2	3
Asteraceae	*Argyrotegium fordianum*	Forb	Native	1	1	0	0
Asteraceae	*Cassinia aculeata*	Shrub	Native	0	0	3	3
Asteraceae	*Cassinia* sp.	Shrub	Native	3	4	0	0
Asteraceae	*Coronidium monticola*	Forb	Native	2	1	0	0
Asteraceae	*Cotula alpina*	Forb	Native	83	22	0	0
Asteraceae	*Erigeron bonariensis*	Forb	Exotic	1	1	1	1
Asteraceae	*Euchiton involucratus*	Forb	Native	0	0	1	1
Asteraceae	*Gamochaeta purpurea*	Forb	Exotic	0	0	4	5
Asteraceae	*Hypochaeris radicata*	Forb	Exotic	3	4	1	1
Asteraceae	*Lagenophora stipitata*	Forb	Native	2	1	0	0
Asteraceae	*Leptinella filicula*	Forb	Native	0	0	1	1
Asteraceae	*Sonchus oleraceus*	Forb	Exotic	8	9	1	1
Asteraceae	*Symphyotrichum subulatum*	Forb	Exotic	2	1	0	0
Asteraceae	*Taraxacum sect. taraxacum*	Forb	Exotic	0	0	5	6
Brassicaceae	*Cardamine lilacina*	Forb	Native	1	1	0	0
Campanulaceae	*Lobelia anceps*	Forb	Native	0	0	1	1
Campanulaceae	*Wahlenbergia gracilis*	Forb	Native	0	0	4	3
Caryophyllaceae	*Cerastium glomeratum*	Forb	Exotic	129	36	13	9
Caryophyllaceae	*Scleranthus biflorus*	Forb	Native	179	47	0	0
Cyperaceae	*Carex appressa*	Other Graminoid	Native	0	0	2	3
Cyperaceae	*Carex breviculmis*	Other Graminoid	Native	7	4	0	0
Cyperaceae	*Carex gaudichaudiana*	Other Graminoid	Native	0	0	3	1
Cyperaceae	*Carex inversa*	Other Graminoid	Native	0	0	5	5
Fabaceae	*Lotus corniculatus*	Forb	Exotic	0	0	2	3
Fabaceae	*Trifolium glomeratum*	Forb	Exotic	11	5	1	1
Fabaceae	*Trifolium repens* var. *repens*	Forb	Exotic	32	7	4	5
Gentianaceae	*Centaurium erythraea*	Forb	Exotic	0	0	6	6
Haloragaceae	*Gonocarpus tetragynus*	Forb	Native	0	0	1	1
Iridaceae	*Romulea rosea* var. *australis*	Forb	Exotic	0	0	1	1
Juncaceae	*Juncus bufonius*	Other Graminoid	Uncertain	0	0	10	11

Juncaceae	*Juncus holoschoenus*	Other Graminoid	Native	0	0	28	22
Juncaceae	*Juncus planifolius*	Other Graminoid	Native	0	0	6	6
Juncaceae	*Luzula modesta*	Other Graminoid	Native	19	16	1	1
Lamiaceae	*Mentha laxiflora*	Forb	Native	0	0	3	3
Lamiaceae	*Prunella vulgaris*	Forb	Exotic	0	0	1	1
Myrtaceae	*Eucalyptus* sp.	Tree	Native	0	0	1	1
Myrtaceae	*Leptospermum* sp.	Shrub	Native	4	5	2	3
Onagraceae	*Epilobium ciliatum*	Forb	Exotic	17	2	0	0
Onagraceae	*Epilobium billardiereanum*	Forb	Native	3	4	15	5
Plantaginaceae	*Callitriche muelleri*	Forb	Native	0	0	1	1
Plantaginaceae	*Gratiola peruviana*	Forb	Native	0	0	6	8
Plantaginaceae	*Plantago euryphylla*	Forb	Native	2	1	0	0
Plantaginaceae	*Plantago major*	Forb	Exotic	0	0	2	3
Plantaginaceae	*Veronica arvensis*	Forb	Exotic	5	2	3	3
Poaceae	*Agrostis capillaris*	Grass	Exotic	193	14	7	6
Poaceae	*Axonopus fissifolius*	Grass	Exotic	0	0	1	1
Poaceae	*Ehrharta erecta*	Grass	Exotic	0	0	3	4
Poaceae	*Eragrostis brownii*	Grass	Native	0	0	3	4
Poaceae	*Holcus lanatus*	Grass	Exotic	0	0	1	1
Poaceae	*Phleum pratense*	Grass	Exotic	4	1	0	0
Poaceae	*Poa hothamensis*	Grass	Native	7	7	0	0
Poaceae	Unidentified Poaceae sp. 1	Grass	Uncertain	0	0	1	1
Poaceae	Unidentified Poaceae sp. 2	Grass	Uncertain	0	0	1	1
Poaceae	*Vulpia bromoides*	Grass	Exotic	0	0	3	3
Polygonaceae	*Acetosella vulgaris*	Forb	Exotic	1066	65	46	5
Polygonaceae	*Persicaria decipiens*	Forb	Native	0	0	1	1
Ranunculaceae	*Ranunculus victoriensis*	Forb	Native	2	2	0	0
Rosaceae	*Aphanes arvensis*	Forb	Exotic	0	0	3	4
Rosaceae	*Rubus parvifolius*	Shrub	Native	1	1	0	0
Rosaceae	*Rubus ulmifolius*	Shrub	Exotic	0	0	4	1
Rubiaceae	*Asperula conferta*	Forb	Native	55	32	10	9
Rubiaceae	*Galium leiocarpum*	Forb	Native	0	0	7	4
Rutaceae	*Asterolasia trymalioides*	Shrub	Native	1	1	0	0
Solanaceae	*Solanum nigrum*	Forb	Exotic	0	0	1	1
Urticaceae	*Australina pusilla* subsp. *muelleri*	Forb	Native	1	1	0	0
Urticaceae	*Urtica incisa*	Forb	Native	4	2	5	3

The mean (±1SE) species richness per punnet in the Alpine samples (3.05 ± 0.26) was significantly higher than observed in the Wet Forest samples (1.78 ± 0.19, W = 4334, P < 0.001). Germination from non-stratified and cold-wet stratified Alpine faecal samples were highly correlated for number of germinants per punnet (r = 0.85, P < 0.001), number of different species per punnet (r = 0.73, P < 0.001) and number of germinants for each different species (r = 0.72, P < 0.001), resulting in these two Alpine datasets being pooled for further analysis.

A total of 1849 seedlings emerged in the Alpine samples, comprising 378 native (20% of total seedlings) and 1471 exotic seedlings (80%), with a significantly higher mean number of exotic seedings per punnet (18.2 ± 4.91) than native species (4.67 ± 1.15; W = 4033, P = 0.011). In the Wet Forest samples, a total of 238 seedlings emerged comprising 112 native (47% of total seedlings), 114 exotic (48%) and 12 seedlings of uncertain origin (5%). However, no significant difference between the mean number of exotic seedlings (1.44 ± 0.498) and natives per pellet group (1.42 ± 0.196, W = 234, P = 0.076) was observed in Wet Forest samples.

The most frequently germinating species in the Alpine samples (from >10% of pellet samples) were the exotic forbs *Acetosella vulgaris* and *Cerastium glomeratum*, and the exotic grass *Agrostis capillaris*, which together comprised approximately 75% of all Alpine seedlings. The most frequently germinating native species were the forbs *Cotula alpina*, *Scleranthus biflorus* and *Asperula conferta*, and the native rush *Luzula modesta*. Only two species were observed in >10% of Wet Forest samples, the rushes *Juncus holoschoenus* and *Juncus bufonius*.

Forb seedlings were higher in mean abundance per punnet in Alpine samples than all other growth forms ($\chi^2(3)$ = 154.65, df = 3, P < 0.001; Figure 2), which did not differ from one another. There was a significant difference in mean number of seedlings to emerge from different plant growth forms in the Wet Forest samples ($\chi^2(3)$ = 50.933, df = 3, P < 0.001), with pairwise comparisons resulting in a significant difference between Forb and Grass (z = -4.98, P < 0.001), Forb and Shrub or Tree (z = -6.38, P < 0.001), Grass and Other Graminoid (z = 3.19, P = 0.008) and Other Graminoid and Shrub or Tree (z = -4.59, P < 0.001).

The mean (±1SE) number of seeds dispersed daily by an individual sambar deer within the Alpine study area was estimated as 847 (±201), which includes 676 (±182) exotic seeds and 173 (±43) native seeds. Estimated seed load dispersed daily by sambar deer in the Wet Forest study area was lower, comprising of 53 (±7) native and 54 (±18) exotic seeds, with an estimated mean daily dispersal of 106 (±21) seeds by individual sambar deer in this ecosystem (Appendix Table 9).

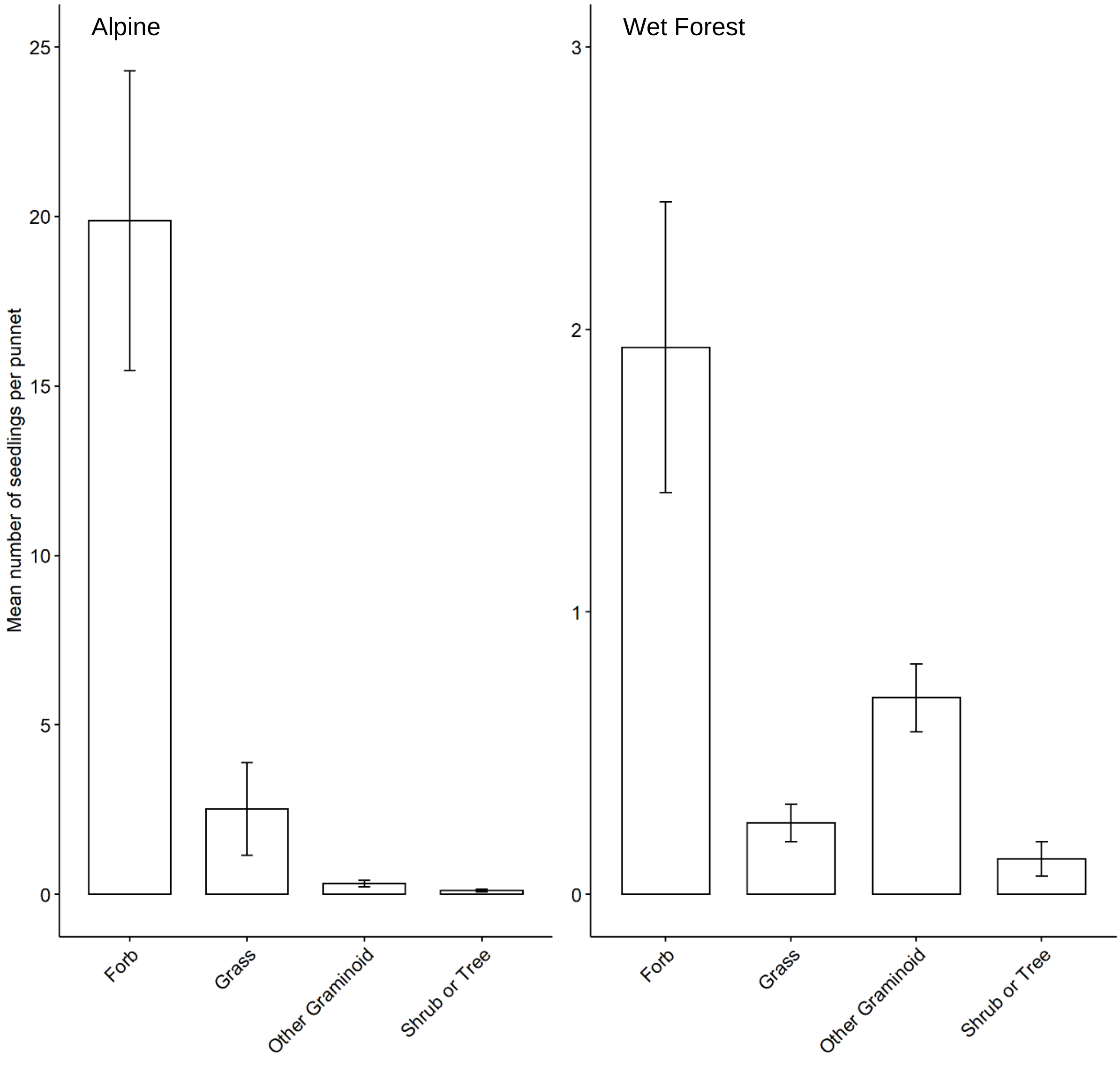

Figure 2. Mean (±1 SE) number of seedlings per punnet for each growth form that emerged from sambar deer faecal pellets collected in Alpine and Wet Forest ecosystems.

DISCUSSION

We assessed the dietary foraging characteristics of a non-native herbivore whilst simultaneously estimating seed-dispersal ability. Here we have shown that the dietary composition of sambar deer across two ecologically distinct landscapes comprised a higher proportion of 'likely native' plant species. However, this contrasted with observations from germination trials where a higher number of exotic seedlings emerged from faecal pellets in both study areas.

Diet composition

The use of three gene regions for dietary analysis allowed us to highlight the number of plant species foraged by sambar deer and unsurprisingly, the plant species richness of the diet was much higher than detected through germination trials. Previous dietary studies of herbivores in Australia have been undertaken with microhistological and macroscopic techniques that involve complex sieving and fine-scale plant fragment identification (Storr 1961; Norbury 1988; Carron *et al*. 1990; Bice & Moseby 2008; Davis *et al*. 2008). With a smaller number of samples and a technique capable of faster results (Khanam *et al*. 2016), we were able to detect a total of 168 genera from 78 families, which increased the number of previously known species eaten by sambar deer in Wet Forest habitats of south-eastern Australia (Forsyth & Davis 2011). The metabarcoding technique also allowed us to detect several rare species in the diet of sambar deer (i.e. relatively few individuals and/or populations), including *Leptostigma breviflorum*, *Ozothamnus stirlingii* and *Wittsteinia vacciniacea*, each of which are restricted in distribution to Wet Forest ecosystems, and less likely to be detected with other methods due to their rare occurrence in the environment (Garnick *et al*. 2018). However, while the DNA metabarcoding approach is clearly a powerful tool for assessing herbivore diet and impacts (Berry *et al*. 2017, Moorhouse-Gann *et al*. 2018), the lack of a DNA reference library for plant species within the two study areas meant that we were only able to resolve a small percentage to species level.

Future research should aim to collect reference plant species samples in the landscape to create a comprehensive reference library, as increasing the taxonomic accuracy would clearly be more informative to land managers and would ensure the diet is appropriately evaluated.

In both Alpine and Wet Forest ecosystems, the diet of sambar deer was comprised of a higher proportion of species that are 'likely native', which is not unexpected given these areas are natural areas conserved as National Parks. However, the proportion of 'likely exotic' species in the diet was significantly higher than expected, suggesting that sambar deer may be targeting exotic species. The enemy release hypothesis proposes that in novel ecosystems, exotic plants may benefit from a lack of co-evolved predators (Williamson 1996; Keane & Crawley 2002). However, in some cases, exotic plant species may in fact be advantaged by the presence of these co-evolved predators, as suggested by the enemy of my enemy hypothesis (Colautti *et al*. 2004). Parker *et al*. (2006) performed a meta-analysis to investigate the impacts of native and exotic species on native and exotic vegetation and revealed that grazing by exotic herbivores caused an increase in exotic species richness and abundance whilst reducing the species richness and abundance of native species. In Alpine and Wet Forest ecosystems, native plant species have not evolved in the presence of novel consumers such as sambar deer, and as such are likely more vulnerable to herbivory due to a lack of adequate defences (Hokkanen & Pimentel 1989; Parker & Hay 2005). Equally, deer have many indigenous species in all continents except Antarctica and Australia, and it is possible that many exotic plant species established in Australia have co-evolved alongside deer species in their native ranges. Therefore, our results suggesting that deer may be targeting exotic plant species is problematic, because if these exotic plant species have similar home origins and adaptations to deer herbivory, then sambar deer may promote the relative abundance and species richness of coadapted exotic plants in Alpine and Wet Forest habitats, at the detriment of native species (Crawley *et al*. 1996; Parker & Hay 2005; Parker *et al*. 2006).

Forbs were well-represented in deer diets in Alpine ecosystems, while Forbs and Shrubs or Trees were equally well-represented in Wet Forests. Dietary selection of a species depends upon many factors including nutritional requirements, digestion ability, and competition (Stewart *et al*. 2003; Kushwaha *et al*. 2004), however, sambar deer diet heavily depends on forage availability (Geist 1998; Leslie 2011). Previous research on the diet of sambar deer have suggested they are browsers (Semiadi *et al*. 1995), intermediate feeders (Varman & Sukumar 1993; Forsyth & Davis 2011) or grazers (Padmalal *et al*. 2003), depending on the environment they inhabit, and it is unsurprising that in forb-dominated Alpine ecosystems the diet of the sambar deer heavily comprises forb species (McDougall 1982). Equally, in shrub-dominated Wet Forest ecosystems the diet was dominated by browse material, and these results are in line with previous studies (Forsyth & Davis 2011). However, we observed a higher contribution of forbs to the diet relative to the study performed by Forsyth and Davis (2011). This may be due to DNA analysis providing better resolution of the readily digested and often underestimated forb growth form in microhistological and macroscopic analysis (Kessler *et al.* 1981), or due to sambar deer diet changing throughout the year (Bennett 2008). If the latter, further research on temporal variation in sambar deer diet would resolve a significant knowledge gap in south-eastern Australia.

Deer as vectors for seed dispersal

Our results suggest that in both Alpine and Wet Forest ecosystems, sambar deer can disperse a wide range of both native and exotic plant species through endozoochory. However, more exotic than native seedlings emerged from faecal pellets collected in both ecosystems.

Deer species have been shown to act as a dispersal mechanism for exotic plant seed, which may result in successful recruitment of exotic plant species (Vellend 2002; Myers *et al.* 2004; Williams *et al.* 2008). Many of the exotic species that emerged during this study have native origins in countries coinciding with deer presence, and therefore may be better adapted to dispersal by ungulates (Vavra *et al.* 2007; Davis *et al.* 2010). Considering this, it is likely that the direct effects of deer presence play a substantial role in exotic species invasion, as hoof action can degrade and disrupt the soil surface, forming disturbed sites that are optimal for exotic species establishment (Vavra *et al*. 2007). However, native species were also observed to germinate from sambar deer faecal pellets, a trend which has also been observed in south-eastern Australia studies on fallow and hog deer (Davis *et al*. 2010; Claridge *et al*. 2016). Our results are therefore viewed as challenging for the management of ecosystems with sambar deer, as although the species may aid native recruitment through endozoochory, the facilitation of exotic species and potential spread into newer areas may reduce the viability of the native species that emerge (Gosper *et al.* 2005).

In Wet Forests, and to a lesser extent the Alpine ecosystems of south-eastern Australia, sambar deer coexist with numerous herbivores and omnivores including the native swamp wallaby (*Wallabia bicolor)* and common wombat (*Vombatus ursinus)*, and the introduced European rabbit (*Oryctolagus cuniculus)*, red fox (*Vulpes vulpes*), and feral pig (*Sus scofra*). The role of each species as seed-dispersers has been investigated in a variety of ecosystems worldwide (Bourgeois *et al*. 2005; Evans *et al.* 2006; Auld *et al.* 2007; Matías *et al*. 2010; O'Connor & Kelly 2012), and factors such as size, diet, movement patterns, and digestive system differences vary the number of plant species seeds potentially dispersed by each (Eycott *et al.* 2007; Davis *et al*. 2010; Calvino-Cancela 2011). However, deer have been demonstrated to deposit a larger number of seeds (Eycott *et al*. 2007; Claridge *et al*. 2016). Therefore, it is likely that in Alpine and Wet Forest ecosystems, sambar deer are drastically increasing the potential for native and exotic plant species recruitment through an increase in seed dispersal (Masters & Sheley 2001). However, this is of concern in Alpine ecosystems, as the native, low-growing forb species observed at high elevation have typically relied on gravity and/or wind as main dispersal mechanisms, and may have limited capacity for long-distance seed dispersal via the process of endozoochory (Morgan & Venn 2017). Consequently, browsing by sambar deer, now a dominant herbivore in Alpine ecosystems, may prevent these typical methods of seedling establishment and subsequently limit the recruitment of native plant species (Côté *et al.* 2004).

As demonstrated in other studies of ungulate endozoochory, forb species were abundant and diverse in the germination trials (Gill & Beardall 2001; Shiponeni & Milton 2006). The high number of forb seedlings is likely a function of the seed traits of these species as they typically contain small, hard seeds that are inconspicuously positioned and unavoidable for foraging herbivores (Gill & Beardall 2001; Pakeman *et al.* 2002; Shiponeni & Milton 2006; Iravani *et al.* 2011). Furthermore, the seed-traits of individual plant species explain why only a limited number of species emerged from faecal pellets when DNA results suggest that sambar deer are foraging a wide variety of species. It is likely that only a small portion of foraged material have seeds attached for dispersal, and only a small portion of these seeds ingested would be able to survive the ruminant digestive system of deer species (Iravani *et al.* 2011).

Faecal samples contained viable seeds of the exotic variety of blackberry (*Rubus ulmifolius*) one of the most significant environmental and agricultural weeds in the state of Victoria (Deehan *et al*. 2007). Although the invasive weed typically has low germination rates (Evans *et al*. 1998; McGregor 1998), the frequent detection of the genus in the diet of sambar deer suggests that with increased seed supply through high rates of foraging, sambar deer may increase the likelihood of seedling recruitment for the species. Moreover, *Acetosella vulgaris* seedlings in faecal pellets were clearly the most abundant. A pasture weed in Australia and overseas (Korpelainen 1993), *Acetosella vulgaris* is one of the more common invasive species in the Australian Alps (McDougall *et al*. 2005) and has high seed production (Pickering *et al*. 2003). Similarly, the high numbers of seedlings observed for the exotic species *Agrostis capillaris* and *Cerastium glomeratum,* which were introduced into Alpine areas for soil stabilisation and rehabilitation in the mid twentieth century, is likely due to their availability in Alpine areas, as they have since become more established in the landscape (Johnston & Pickering 2001; McDougall & Walsh 2007; Morgan & Carnegie 2009). However, the ability for each of these species to invade disturbed habitats (Houssard & Escarré 1991; Morgan & Carnegie 2009), implies that the trampling, trail creation, and disturbance associated with sambar deer presence may provide optimal establishment potential for these exotic species in the broader landscape and more remote areas (Bentley 1998). In the case of *Agrostis capillaris* and *Cerastium glomeratum,* these two species were clearly dominant in the germination trials yet were infrequently observed in the dietary analysis. This highlights the disconnect between plant species that only need to be a minor proportion of the diet yet are capable of being abundantly dispersed.

We estimated that sambar deer dispersed 847 (±201) seeds per day in Alpine ecosystems, and that approximately 80% of the seeds were exotic. However, the potential role played by sambar deer as seed-dispersers also depends heavily on their movement within the landscape (Gill & Beardall 2001; Davis *et al*. 2010). Previous research of sambar deer movement using radio-telemetric techniques have observed mean annual home ranges of between 10–13.3 km^2 for stags and 3–6.46 km^2 for hinds (Sankar 1994; Chundawat *et al*. 2007). Differences in home range size are normally attributed to the exploration of larger areas by sambar deer males during the rutting season (Sankar 1994). Home range movements of sambar deer would constitute long-distance dispersal of plants (Cain *et al*. 2000), and for some plant species, this method may be advantageous over other dispersal mechanisms (Tackenberg *et al*. 2003; Davis *et al*. 2010). Considering the predicted range expansions of deer species in south-eastern Australia, further research into the geographical barriers for movement, and the ecological and physiological limits of sambar deer in both study regions will further detail potential paths for invasion by exotic species through endozoochory (Webley *et al*. 2007; Davis *et al*. 2016).

Management Implications

Mitigating the impacts of non-native herbivores in native ecosystems is imperative for protecting plant species and vegetation communities (Augustine & Jordan 1998). Our results demonstrate that sambar deer are browsing native species and dispersing weeds, which can clearly have detrimental impacts on native ecosystems.

The sheer number of plant species and seedlings that germinated from faecal pellets collected at a single time point emphasises that endozoochory by sambar deer has the capacity to alter the composition of ecosystems, and in the Alpine and Wet Forest ecosystems of south-eastern Australia, sambar deer may be one of the most important vectors for long-distance seed dispersal. Clearly, a major concern is the ability of deer to access remote areas, which may successfully move seeds between isolated patches of similar habitats (Poschlod & Bonn 1998). Further research of sambar deer movement patterns and home ranges in south-eastern Australia should be undertaken, as this will determine the extent to which the species can act as long-distance dispersal mechanisms of native and exotic plant seed and may additionally lead to more focussed management actions.

Density and grazing intensity are two critical factors in determining the degree to which species affect broader ecosystems and should be considered when managing areas inhabited by non-native herbivores (Alverson *et al*. 1988; Anderson 1994). Sambar deer populations continue to increase in south-eastern Australia (Davies *et al.* 2020; Watter *et al*. 2020), and previous research has highlighted the high levels of plant biomass consumed by sambar deer, eclipsing the consumption by other coexisting native herbivores (Bennett 2008). Therefore, in areas where deer density is high, and/or rare plant species and communities are established, sambar deer should be recognised as a serious threat, and either the removal of individuals or implementation of exclusion-based methods should be explored.

As this study was conducted at a single time point, future research should assess temporal variation in the diet and seed dispersal ability of sambar deer, to further understand the potential impacts of the species long-term. Also, considering the increasing distribution of sambar deer in south-eastern Australia, extending this study to incorporate other contrasting habitat types would further tease apart the implications of sambar deer presence in multiple environments.

CHAPTER 3

Spatial and temporal variation in the diet of sambar deer (*Rusa unicolor*) in an alpine landscape.

This chapter is prepared for submission to *Wildlife Research.*

ABSTRACT

Context. In south-eastern Australia, the abundance and distribution of non-native sambar deer (*Rusa unicolor*) has increased over recent decades in alpine environments. Sambar deer have been shown to exhibit a variety of feeding behaviours depending on the environment they inhabit, and hence significant concern surrounds the potential for the species to impact rare plant species and vegetation communities through browsing.

Aims. We aimed to detail the diversity of the plant species that comprise the diet of sambar deer in the Alpine National Park, and to compare any spatial and temporal variation in the abundance and composition of dietary items.

Methods. We collected 90 groups of sambar deer faecal pellets over a three-month flowering period in two contrasting study sites. We performed DNA sequencing using the ITS2 gene region and assigned dietary items to the lowest taxonomic level possible. The frequency of occurrence and sequencing read depth of each dietary item was calculated to investigate the diet of sambar deer at spatial and temporal scales, and dietary preferencing was assessed by comparing the frequency of occurrence of dietary items to the observation records for each item in the study area.

***Key results*.** We detected a total of 369 unique plant zero-radius Operational Taxonomic Units (zOTUs) from sambar deer faecal samples, representing 35 families and 80 genera, although only 59 dietary items could be identified to species level. Considerable variation in the diet was observed over small spatial scales, and evidence of temporal variation was noted in one of the two study sites. We detected Silky Snow-daisy (*Celmisia sericophylla),* which is currently listed as threatened under the *Flora and Fauna Guarantee Act 1988,* and Hawkweed (*Pilosella spp.*), a highly invasive, non-native taxon which is sparingly established in Alpine ecosystems, in the diet.

Conclusions. We consider sambar deer to be displaying an intermediate feeder behaviour in alpine environments, foraging on a variety of forbs and shrubs, however forbs were the dominant dietary items. Additionally, the spatial variation observed in the diet of sambar deer suggests that individual deer are unlikely to be dispersing widely while foraging.

Implications. Our results highlight the requirement for the impacts of sambar deer to be carefully evaluated within individual sites and at small spatial scales. The detection of several conservation significant species in the diet indicates that the presence of sambar deer should be considered a significant risk to biodiversity in areas of high conservation value.

Additional keywords: Alpine, DNA sequencing, faecal DNA, invasive species, native species, preference, sambar deer, spatial variation, temporal variation.

INTRODUCTION

Globally, non-native species present significant conservation concerns due to their potentially negative impacts on native biodiversity (Wilcove *et al*. 1998; Chapin *et al*. 2000; Ricciardi 2007; Spear and Chown 2009; Nuñez *et al*. 2010). Non-native ungulate species have been introduced globally for a variety of purposes including sport, hunting, and food provision for humans (Griffith *et al*. 1989; Forsyth and Duncan 2001). In some cases, these species have established invasive populations, affecting native ecosystems through both direct and indirect pathways (Forsyth and Duncan 2001; Moriarty 2004; Pavel 2004; Suominen and Danell 2006; Foster and Scheele 2019).

Introduced deer (family Cervidae) have undergone significant global expansion over the last century (Côté *et al.* 2004), and in many countries have become regarded as agricultural and environmental pests (Moriarty 2004), due to their detrimental impacts on native ecosystems, and the ensuing costs associated with ongoing management (Figgins and Holland 2012). Consumption of vegetation by deer can affect the growth, reproduction, and long-term survival of plant species (Watson 1983; Côté *et al*. 2004), and preferential selection by deer is likely to cause changes to the composition of plant communities, with less preferred or more browse-tolerant species becoming dominant, which may subsequently alter overall ecosystem function (Augustine and McNaughton 1998; Putman and Moore 1998; Gill and Beardall 2001; Rooney and Waller 2003; Côté *et al*. 2004).

In south-eastern Australia, the impact of deer in alpine environments is of significant concern, as these rare ecosystems occupy only 0.15% of the continent and contain species and ecological communities of national and international significance (Good 1989; Williams and Costin 1994; Venn *et al*. 2017). For over a century, alpine areas were used for grazing by many introduced species including cattle (*Bos taurus*), sheep (*Ovis aries*) and horses (*Equus caballus*) (McDougall and Walsh 2007; Williams 2019). However, grazing and trampling by these hard-hoofed animals resulted in considerable damage to vegetation and soils (Good and Johnston 2019; Williams 2019), leading to the practices being discontinued from high-elevation sites in Victoria in the mid-to-late 1990s, and from the Alpine National Park entirely in 2005 (Williams *et al*. 2006; McDougall and Walsh 2007). Currently, grazing practices and the use of these landscapes by introduced herbivores remains a divisive issue (Driscoll *et al*. 2019).

Over the last decade, there has been a significant increase in the range and abundance of sambar deer (*Rusa unicolor*) within the Alpine National Park, with potential for the species to impact vegetation by preferential browsing, trampling, and wallowing (Brown *et al*. 2016; Davies *et al*. 2020; Watter *et al*. 2020). The effects of browsing by sambar deer remains poorly understood within this landscape, however the past impacts of other introduced ungulates in alpine landscapes offers clear insight into the potential consequences of inaction (Wahren *et al.* 1994; Driscoll *et al*. 2019; Robertson *et al*. 2019; Williams 2019). Therefore, an investigation of the dietary components and feeding behaviour of sambar deer in high-elevation ecosystems is considered critical for effective future management of alpine landscapes in south-eastern Australia.

We analysed sambar deer faecal pellets using DNA metabarcoding techniques to assess the dietary composition of the species in the alpine landscape. Faecal samples were collected across multiple months and within several different vegetation communities at two contrasting sites to detail the taxonomic and trait diversity of the plant species that comprise the diet of sambar deer in the Alpine National Park. We pursued the following aims:

1. Determine whether some plant genera are preferred by sambar deer, testing the hypothesis that sambar deer will consume all plant genera relative to their availability in the landscape.

2. Determine whether the diet of sambar deer varies across the main alpine growth period, testing the hypothesis that sambar deer will consume different plant species at different times during the study.

3. Determine whether the composition of faecal pellets varies across alpine sites and vegetation communities, testing the hypothesis that due to broad movement by sambar deer, the plant species composition of faecal pellets will not be dependent on the site and vegetation community that samples are collected from.

MATERIALS AND METHODS

Study species

Sambar deer are a large-bodied ungulate species native to the tropical and temperate ecosystems of India, southern China and south-eastern Asia (Bennett 2008; Leslie 2011) and were first introduced into south-eastern Australia in the mid-to-late 1800s (Forsyth *et al*. 2015). A cautious and secretive species, sambar deer are generally solitary (Harrison 1998), and prefer densely forested ecosystems, with a tendency to emerge from these areas at night for foraging (Eisenberg and Lockhart 1972; Bennett 2008). In 1941, the first reports of sambar deer in the alpine bioregion were documented at Mount Howitt, and as of 2015, sambar deer were estimated to have established wild, self-sustaining breeding populations covering approximately 29% of Victoria's land area (Forsyth *et al*. 2015). Sambar deer are listed under the *Flora and Fauna Guarantee Act 1988* as a 'potentially threatening process' to biodiversity in the state of Victoria yet are also protected as wildlife under the *Wildlife Act 1975*, due to their value as game species (Davis *et al*. 2016).

Study area

The study was conducted on the Bogong High Plains (BHP), within the Alpine National Park, approximately 240 km north-east of Melbourne, Victoria, Australia (36° 50' S, 147° 20' E). The

BHP occupy an area of approximately 120 km^2 and comprises vegetation communities ranging from woodlands, open and closed-heathlands, tussock grasslands, wetlands and snowpatch herbfields (McDougall 1982). The area experiences mean annual minimum and maximum temperatures of 2.7 °C and 9.5 °C respectively, and a mean annual precipitation of 2430 mm, much of which falls as snow in winter (Lawrence 1995, Giljohann *et al*. 2011). The BHP is snow-covered from June to September, and the potential for ground frost is highest during the months of April, May and October. Sambar deer are the only species of deer observed on the BHP, inhabiting the area following snowmelt in late spring and remaining until the beginning of winter when they descend to lower elevations (Downes 1983; Watter *et al*. 2020).

Two ecologically distinct sites on the BHP were selected for sampling and are separated by <10 km. The alpine Mt Nelse study site (36° 50' 06" S, 147° 20' 21" E) is 1884 m above sea level (a.s.l), and because of its high-altitude experiences long periods of late-lying snow following winter (Wahren *et al*. 2001). The sub-alpine Basalt Hill study site (36° 53' 24" S, 147° 18' 42" E) is 1640 m a.s.l and has been described as discordant with the rest of the BHP due to differing underlying geomorphology and plant species diversity (McDougall 1982; Wahren *et al*. 2001). At each of the study sites, collection area for faecal pellet samples was <5 km^2.

Within each site, we concentrated on collecting samples from three different vegetation types: snowpatch herbfields, grasslands and wetlands. Snowpatch herbfields are one of the rarest vegetation types in Australia (Wahren *et al*. 2001; Williams *et al*. 2015), and are typically dominated by low growing forbs, sedges, and grasses due to the shortened growing season at high elevation (Burrows 1977; Wahren *et al*. 2001; Venn and Morgan 2007; Williams *et al*. 2015). Wetland ecosystems include the Alpine Sphagnum Bogs and Associated Fens ecological community, currently listed as endangered under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. These communities are of high importance hydrologically and are particularly sensitive to grazing and trampling by ungulate species (McDougall 1982; Williams and Costin 1994). Grasslands are widespread and diverse across the alpine landscape, however, high levels of deterioration within these communities has been observed due to previous grazing practices, which has resulted in the establishment of a range of invasive plants (Carr and Turner 1959; McDougall *et al*. 2005).

Sample collection

To assess spatial and temporal variation in sambar deer diet, faecal pellets were collected monthly (January to March), from within each of the selected vegetation types at the two study sites. As sambar deer expel many faecal pellets in one defecation, we define a faecal pellet group as a collection of pellets which varies in the total number of individual units yet is produced by only one sambar deer. A total of 90 faecal pellet group samples were collected (n = 45 at each of the study sites; comprising 15 samples from each month across the three vegetation communities; Appendix Figure 2, Table 10). Only fresh samples were collected, described as those that were still brown and exhibited a wet shine with no outer decay (Mayze and Moore 1990). Pellet groups that exhibited clear signs of contamination from non-food items such as leaf or plant tissue were ignored. Each faecal pellet group sample consisted of approximately 10–12 faecal pellets, which were stored in a plastic zip-lock bag and placed in -30 °C freezers until processing.

Plant reference library

We collected tissue samples of plant species that could be consumed by sambar deer in each of the study sites yet lacked available reference sequences on the National Centre for Biotechnology Information (NCBI) GenBank nucleotide database. We used these tissue samples to generate a plant DNA reference library. Approximately 100 mg of tissue was collected from each of the selected plant species (n = 63), and a DNeasy Plant Mini Kit (Qiagen) was used to perform DNA extractions. Plant DNA extractions were undertaken in a separate

Polymerase Chain Reaction (PCR) free laboratory to the faecal pellet extractions to prevent contamination.

Faecal DNA extraction and PCR amplification

Each faecal pellet group sample was homogenised and subsampled three times, resulting in a total of 270 samples for DNA extraction. DNA extractions were performed with ~100 mg of faecal sample using a QIAmp Fast DNA Stool Mini Kit (Qiagen) following manufacturers protocols and were eluted in a final volume of 200 µL. Throughout the process, negative extractions containing no faecal material were performed to monitor potential contamination.

Each DNA extraction (faecal and plant) was amplified using the ITS2 gene region of nuclear ribosomal DNA, using the established primer set ITS2-S2F and ITS4 (White *et al.* 1990; Chen *et al.* 2010). In Chapter 2, the use of the ITS2 gene region resulted in the detection of a larger number of unique plant OTUs in the diet of sambar deer than the *trnL* and *rbcL* gene regions, and hence was chosen to use singularly in this study. The robustness of the ITS2 gene region for analysing plant material that has undergone digestion and excretion has also been highlighted by Moorhouse-Gann (2018). Amplification of the ITS2 region was carried out in a final volume of 15 µL, using 2 µL of DNA extract as a template, 6.25 µL of MyTaq™ Red Mix (Bioline), 0.5 µL of each forward and reverse primer, and 5.75 µL of H_2O. The mixture was denatured at 94 ˚C for 5 min, followed by 35 cycles of 30 s at 94 ˚C, 30 s at 50 ˚C and 45 s at 72 ˚C. A final extension of 72 ˚C for 10 min completed the PCR amplification stage. In cases where samples failed to amplify, DNA samples were diluted at 1/10 and 1/100 rates with H_2O until amplification was successful. PCRs included both negative extraction and H_2O controls to test for sample contamination.

Illumina adaptors and indexing primers were attached following the first round of PCRs and these reactions comprised 6 µL of H_2O, 6.25 µL of MyTaq™ Red Mix (Bioline), 0.75 µL of the index primer pair (Illumina), and 2 µL of DNA PCR template for a 15 µL reaction. Conditions for this PCR consisted of an initial denaturation period of 95 °C for 3 min, followed by 10 cycles of denaturation at 95 °C for 20 s, annealing at 60 °C for 15 s, and elongation at 72 °C for 30 s, with a final extension step at 72 °C for 3 min. PCR products were cleaned using an SPRI magnetic bead mix to remove non-specific DNA fragments. Preparation for sequencing was undertaken following the Illumina MiSeq protocol, using a MiSeq Reagent v2 (2 × 250bp) sequencing kit.

Sequence analysis

The sequence analysis tool USEARCH v11.0.667 (Edgar 2010) was used to generate a sequence list of zero-radius Operational Taxonomic Units (zOTUs), which were then analysed to investigate the diet of sambar deer. The fastx_truncate function was used to remove the primers, and sequences were then filtered based on length using the fastq_filter function, to remove sequences <200 bp. Contaminants and singleton sequences were removed using the fastx_uniques function, and the -unoise3 function was used to generate zOTUs. Any zOTUs with fewer than three reads in a sample were removed from the dataset for analysis, and any zOTU present in negative extractions and H_2O controls were also discarded. After the completion of filtering, zOTUs that were derived from each of three extraction sub-samples were merged back into one single sample.

The final list of zOTUs were first compared to our plant species reference sequence database, and if no match was found, compared to the National Centre for Biotechnology Information (NCBI) GenBank nucleotide database, using BLAST (Basic Local Alignment Search Tool; Altschul *et al*. 1990) with default parameters. We assigned all sequences to the lowest taxonomic level possible and considered correct assignment to species when a ≥97% match of a reference sequence to the full length of the zOTU sequence was observed, following the convention that ≥97% similarity corresponds to species level (Schloss and Handelsman 2005). Likewise, ≥95% similarity was required for assignment to genus level and ≥90% for family level (Elbrecht *et al*. 2017). The Atlas of Living Australia (www.ala.org.au) and Royal Botanic Gardens Victoria VicFlora (www.vicflora.rbg.vic.gov.au) databases were used to ensure that plant species, genera or families identified from the zOTUs had been previously recorded within or surrounding the study sites.

Statistical analysis

To determine whether the diet of sambar deer on the BHP had been sufficiently sampled, the cumulative diversity of all detected zOTUs, genera and families across both study sites were plotted against the number of faecal samples using the 'vegan' package in R (R Development Core Team 2010; Oksanen *et al*. 2013). Differences in the number of zOTUs sequenced each month were compared using a non-parametric Kruskall Wallis H Test (Kruskal 1952).

The lowest taxonomic resolution observed for a majority of the detected zOTUs was at the genus level (≥95% similarity), and therefore much of the dietary preferencing analysis was performed at this taxonomic rank. All identified zOTUs were grouped at the genus level and the frequency of occurrence was plotted for each detected genus. In accordance with Nawaz *et al*. (2019), we considered any genera that were present in ≥50% of all samples overall to be preferred plant dietary items for sambar deer, and furthermore, any genera that were observed in ≥10% of samples were regular dietary items, and those with <10% occurrence were rare dietary items. To investigate dietary preferences, we determined if the genera detected across all samples occurred in sambar diet more or less frequently relative to their presence in the BHP plant records. Observation data was obtained from the online Atlas of Living Australia database by extracting all observation records within a 10 km radius of each of the two study sites. A genus was judged as 'preferred' if its proportional representation across faecal samples within the study site was greater than its proportional representation in the environment as judged by ALA records (total records for target genera/total records for all genera).

To assess the feeding behaviour of sambar deer, we labelled each identified plant zOTU as one of three plant growth forms (Forb, Woody, Graminoid), using information from the online Royal Botanic Gardens Victoria VicFlora database. The combined sequencing read depth of each growth form across the three months and within each site was compared using a multivariate analysis of variance (MANOVA; O'Brien and Kaiser 1985), calculated using a Pillai trace statistic in the 'car' package in R (Olson 1976; Fox *et al*. 2007). The number of sequence reads for multiple dietary items can indicate the relative amounts of each of these items contained within a sample, and therefore sequence read depth data is used here to provide a proxy measure of overall plant biomass from each of the three plant growth forms consumed by sambar deer (Kowalczyk *et al*. 2011; Elbrecht and Leese 2015; Thomas *et al*. 2016; Deagle *et al*. 2019). Although the use of sequence read depth data for dietary analysis can be considered controversial due to a number of potential biases (Deagle *et al*. 2019), we justify the use of this analysis by cross validating the results with the same analysis using cumulative zOTU richness in addition to sequence read depth.

An ordination plot comparing the plant species composition of faecal samples within each site and vegetation community during the three-month sampling period was generated using the 'phyloseq' package in R (McMurdie and Holmes 2013), and ANOSIM analysis using the 'vegan' package was performed to test for significance between faecal pellet composition for site (Mt Nelse or Basalt Hill), month (January, February or March), and vegetation community (Snowpatch herbfield, grassland or wetland) treatments. Exploration and comparison of faecal pellet composition between different treatments in this case was considered to provide a more concentrated approach assessing the relationship between pellet composition and collection location. The 'indicspecies' package in R was used to identify plant genera that were differently distributed among treatments (De Cáceres 2013).

RESULTS

A total of 369 unique zOTUs were detected in 90 faecal samples, representing 35 families and 80 genera, although only 59 dietary items could be identified to species level (Appendix Table 11). The cumulative zOTU diversity reached an asymptote at a sample size of approximately 80–90 faecal samples, suggesting that a representative sample of the diet across the two study sites had been obtained (Figure 1).

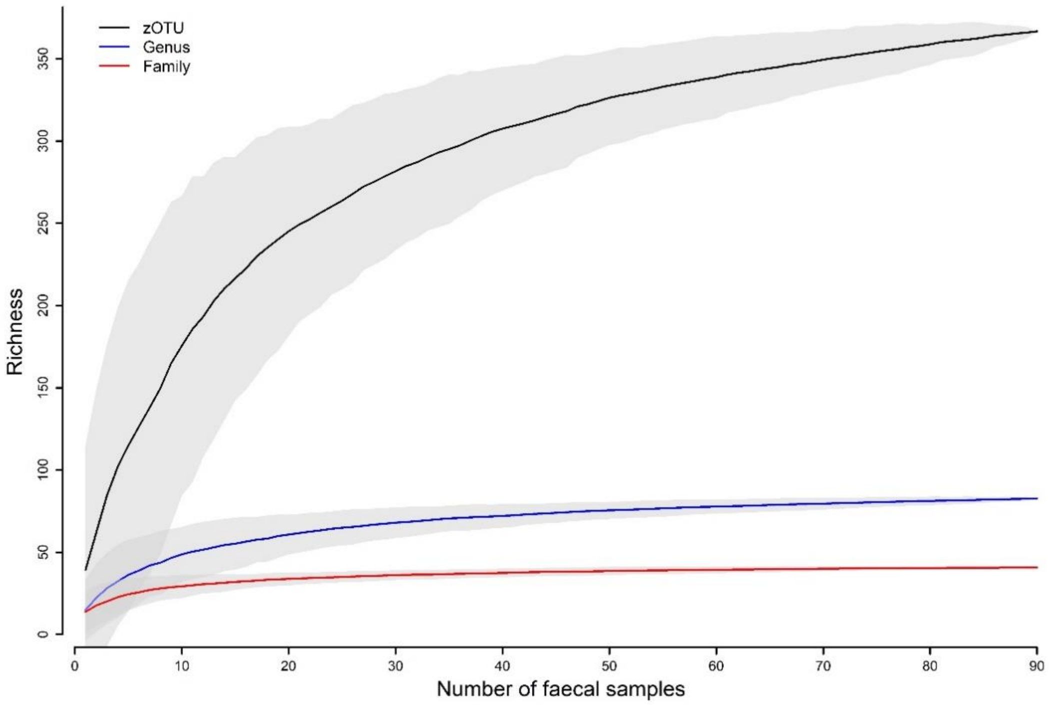

Figure 1. Cumulative diversity of sambar deer dietary items at zOTU, genus and family levels with increasing number of faecal pellet samples.

Diet and dietary preferences

The plant genera detected in the diet of sambar deer were not evenly represented; frequency of occurrence within faecal samples ranged from 1 – 81%. Eleven plant genera were represented in only one faecal sample, and approximately 60% of all genera were found in 10 or fewer samples. The combined regular and preferred plant diet (≥10% occurrence) of sambar deer was comprised of 34 genera, 20 of which were forbs, 11 shrubs and three graminoids (Figure 2). Forbs dominated the diet, both in terms of number of taxa detected and frequency of occurrence across faecal samples. Only three genera were noted as comprising the preferred diet (≥50% occurrence): *Acaena*, *Eucalyptus* and **Acetosella*. [* denotes non-native genera]

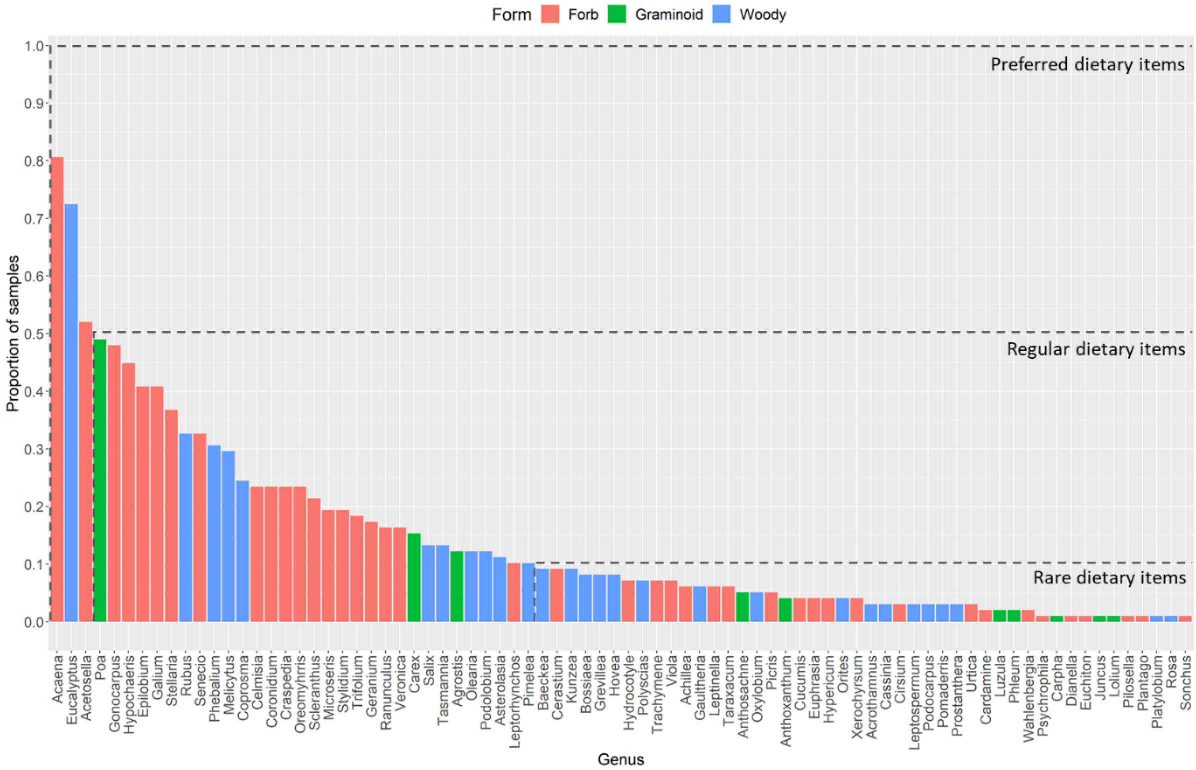

Figure 2. Frequency of occurrence for each genus detected in the diet of sambar deer across the two study sites on the BHP. The growth form for each genus is represented by one of three different colours. Dashed lines separate preferred, regular and rare dietary items.

A number of genera were detected more frequently from faecal samples than would be expected based on plant species observation records. These genera are therefore considered to be over-represented in the diet, and include the forbs *Acaena*, **Acetosella*, *Gonocarpus*, **Hypochaeris*, *Galium*, *Epilobium* and the woody genus *Eucalyptus* (Figure 3). Conversely, several genera were under-represented in the diet, in comparison to their presence in plant observation records, including the most commonly observed plant genus within the entire study area (*Poa*), and two other graminoids (*Carex*, *Luzula)*.

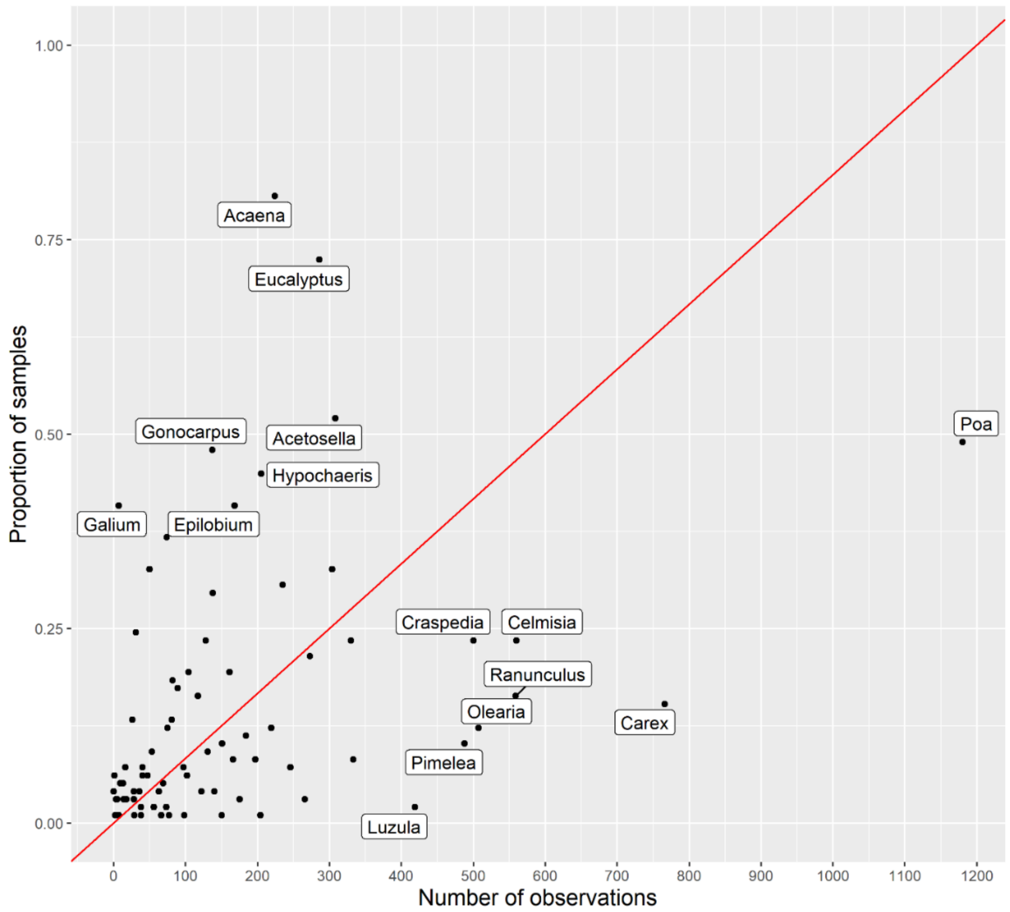

Figure 3. Relative occurrence of plant genera in 90 faecal samples and number of observations within the study area based on observations from the Atlas of Living Australia online database. The red line indicates the equal detection of plants in faecal samples relative to observation counts in the landscape. Points above the line indicate higher occurrence of genera in the faecal samples than in the landscape and points below the line indicate lower occurrence in the samples than would be predicted from recorded observations. Labels are included for the genera with more than 400 recorded observations, and/or detected in ≥37.5% of samples.

Of the zOTUs that were identified to species level, the most frequently detected across all faecal samples were *Acaena novae-zelandiae*, *Eucalyptus pauciflora*, **Acetosella vulgaris*, *Poa costiniana*, **Hypochaeris radicata* and *Gonocarpus montanus*. These species, as well as *Coprosma hirtella*, *Oreomyhrris eriopoda*, *Scleranthus biflorus*, *Phebalium squamulosum subsp. ozothamnoides* and **Salix cinerea* were also abundant in terms of overall sequencing read depth (each with a total read depth >5000).

Nine species were detected that are currently considered rare (i.e. relatively few individuals and/or populations in the state of Victoria). Four of these species were either detected in few samples, or had low sequence read depths, suggesting that they comprise a minor component of the diet. These species were *Tasmannia vickeriana* (5 samples, average read depth <70), *Carpha nivicola* (1 sample, average read depth <40), *Psychrophila introloba* (1 sample, average read depth <10), and *Celmisia sericophylla* (1 samples, average read depth <5), which is currently listed as threatened under the *Flora and Fauna Guarantee Act 1988*.

Alternatively, five rare species were detected in either an increased number of samples or had high sequence read depths, suggesting that these species appear more regularly in the diet than would be expected. These species were *Phebalium squamulosum subsp. ozothamnoides* (29 samples, average read depth <300), *Carex canescens* (15 samples, average read depth <15), *Ranunculus eichlerianus* (10 samples, average read depth <15), *Bossiaea foliosa* (7 samples, average read depth <350), and *Pimelea axiflora subsp. alpina*, (4 samples, average read depth <200).

Temporal variation

There was no difference in the mean number of detected zOTUs across the two study areas in each of the three months ($\chi^2(2) = 0.828$, df = 2, $P = 0.661$), suggesting that the number of dietary items detected in the diet of sambar deer was similar throughout the study period. However, distinct monthly variation was observed in the sequence read depth of plant growth forms in Basalt Hill samples (Pillai's = 0.411, F = 3.54, df = 6, 82, $P < 0.01$), but not in Mt Nelse (Pillai's = 0.226, F = 1.743, df = 6, 82, P = 0.121; Figure 4). These results were supported by similar analysis using cumulative zOTU richness in addition to sequence read depth (Basalt Hill samples; Pillai's = 0.541, F = 5.064, df = 6, 82, $P < 0.01$, and Mt Nelse samples; Pillai's = 0.254, F = 1.993, df = 6, 82, P = 0.076). The sequence read depth of woody dietary items increased significantly in Basalt Hill samples in February (F = 5.62, df = 2, 42, $P < 0.01$), however the contribution of forbs remained high across all months in the Mt Nelse samples.

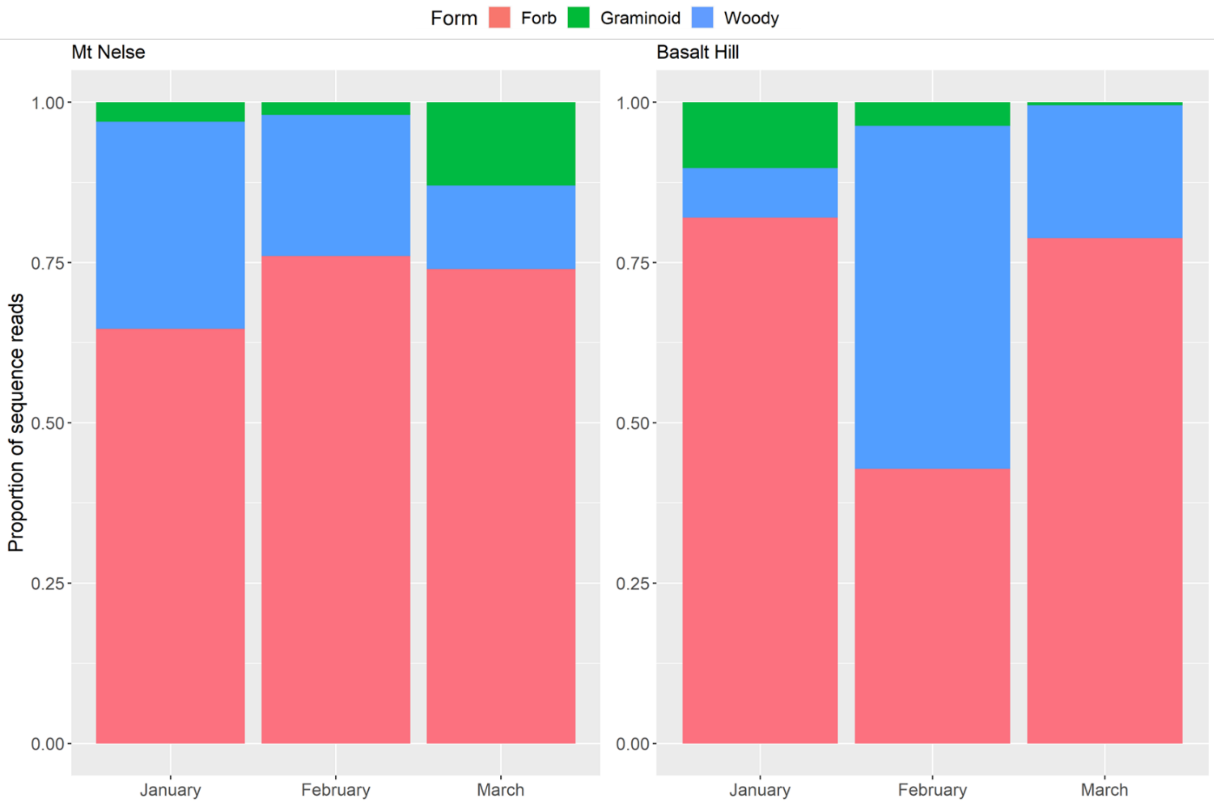

Figure 4. Monthly variation in the diet of sambar deer in terms of sequence read depth of respective growth forms.

ANOSIM analysis comparing the plant species composition of faecal pellets across the three-month sampling period resulted in no significant differences amongst the Mt Nelse samples ($R = -0.015$, $P = 0.636$), however, there was significant variation observed in Basalt Hill samples ($R = 0.249$, $P = 0.001$; Appendix Table 12). In Basalt Hill samples, the woody genus *Asterolasia* was more associated with February samples ($P = 0.033$) and the forb genus *Leptinella* was more associated with March samples ($P = 0.035$). Additionally, the genera *Eucalyptus*, *Gonocarpus*, *Phebalium*, and *Veronica* were significantly associated with the February and March samples, but not January ($P < 0.01$).

Spatial variation

A significant difference was observed between the plant species composition of samples from Mt Nelse and Basalt Hill ($R = 0.242$, $P = 0.01$; Figure 5), suggesting differences in sambar deer diet between the two sites. Twelve genera were significantly more associated with samples collected from Basalt Hill ($P < 0.01$), including *Rubus*, *Poa*, *Phebalium*, *Galium*, *Stellaria*, *Coprosma*, **Trifolium*, *Veronica*, *Agrostis*, *Geranium*, *Tasmannia*, and **Cerastium*. However, none of the detected genera were unique to only Mt Nelse samples.

Differences were also observed between sites for direct comparisons of snowpatch herbfields ($R = 0.33$, $P = 0.001$), grasslands ($R = 0.237$, $P = 0.001$), and wetlands ($R = 0.212$, $P = 0.011$). However, comparisons between vegetation communities within individual study sites resulted in non-significant results for Mt Nelse ($R = -0.015$, $P = 0.619$) and Basalt Hill ($R = 0.052$, $P = 0.124$), suggesting that within each study site, sambar deer diet contains a mixture of items from multiple vegetation communities.

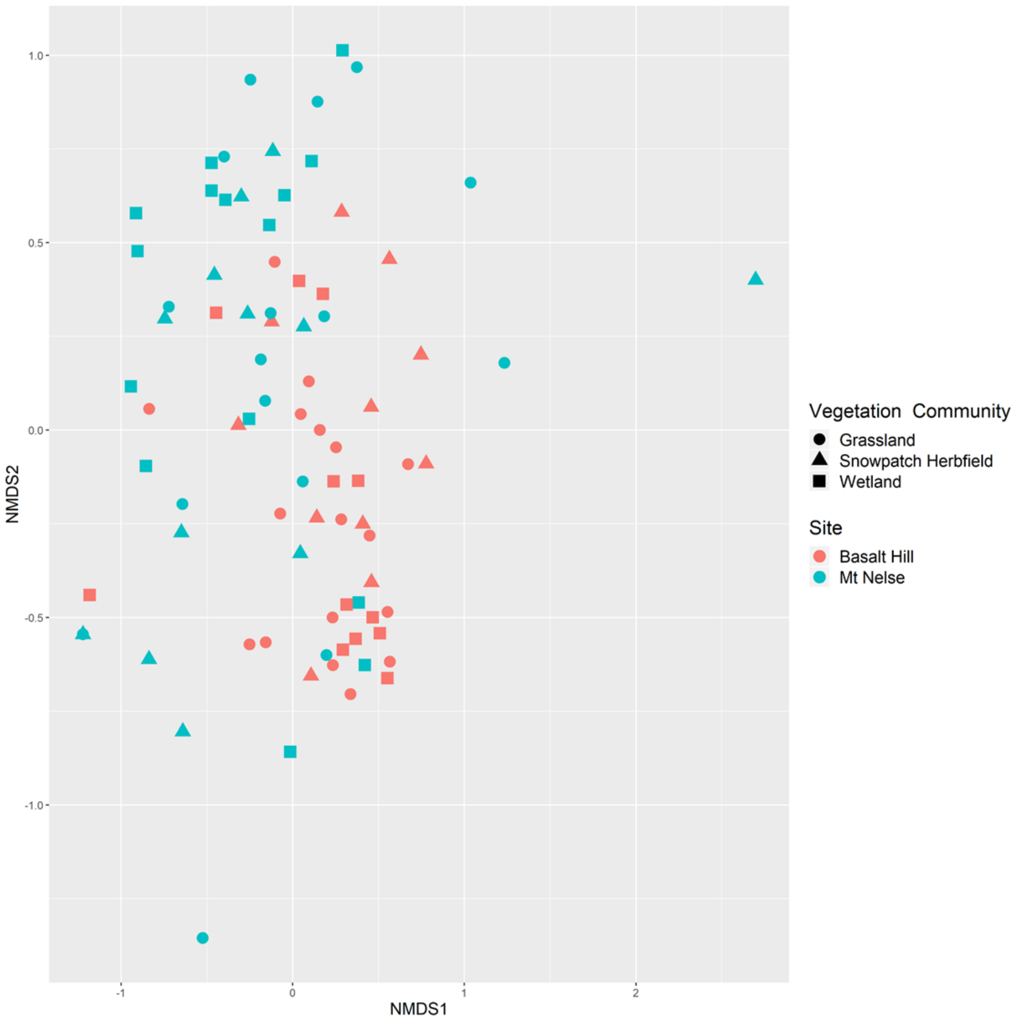

Figure 5. Non-metric multi-dimensional scaling (nMDS) comparison of plant species composition of sambar deer faecal pellet samples collected from Basalt Hill and Mt Nelse. Bray–Curtis dissimilarity, presence/absence transformation (Stress = 0.19).

DISCUSSION

We investigated the diet of sambar deer within high-elevation sites in the Alpine National Park, where the foraging behaviours and subsequent impacts of the species remain poorly understood. Using DNA metabarcoding, the diet of sambar deer showed considerable diversity, with a total of 369 zOTUs from 80 genera and 35 families identified over the three-month sampling period. Forbs were most frequently observed in the sambar deer diet, although their importance appeared to fluctuate at one study site throughout the study period. A variety of plant species of conservation significance and invasive potential were detected, and preferencing of several dietary items was inferred. Notably, our results demonstrated significant spatial variation in the diet of sambar deer over a relatively small scale, which despite the large home ranges suggested for sambar deer elsewhere, may highlight a localised feeding behaviour of the species on the BHP.

Overall diet

Although sambar deer can be observed as grazers, browsers or intermediate feeders across their range (Varman and Sukumar 1993; Semiadi *et al*. 1995; Padmalal *et al*. 2003; Forsyth and Davis 2011), our study demonstrates that in alpine environments, sambar deer exhibit an intermediate feeder diet mostly comprised of forbs and shrubs and appear to adjust the composition of dietary items to adapt to food quality, quantity, and availability. Forbs were the dominant dietary items, and several genera were preferred by sambar deer (i.e., *Acaena*, *Eucalyptus*, and *Acetosella*). Other dietary studies of introduced deer in south-eastern Australia have reported similar dominance of forbs and shrubs in the diet of hog deer (*Axis porcinus*), red deer (*Cervus elaphus*), and sambar deer, in a variety of environments ranging from coastal grassy woodlands to wet forests (Davis *et al.* 2008; Forsyth and Davis 2011; Roberts *et al.* 2015). In alpine environments, it is hypothesised that ungulates display opportunistic feeding behaviours due to the shortened growing season (Schaller and Gu 1994). Our results support this, as the high contribution of forbs to the overall diet of sambar deer is likely a function of their abundance in the alpine landscape (McDougall 1982) and suggests that sambar deer are exhibiting feeding behaviours adapted to the environments they inhabit (Hofmann and Stewart 1972). However, equally plausible is that the high contribution of forbs in the diet is also explained from a nutritional perspective, as forbs are of high nutritional quality (high metabolizable energy) and have the additional benefit of retaining their quality throughout the summer period, whilst the quality of other plant growth forms decline (Holechek 1984; Shrestha *et al*. 2005; Goldberg *et al*. 2020).

Surprisingly, graminoids were not a main dietary item of sambar deer at either study site, or across the summer season. However, in Mt Nelse samples, graminoid abundance did increase towards the end of the summer season as the abundance of shrubs in diets declined. Stafford (1997) noted a dominance of grasses in the diet of sambar deer in New Zealand, a result which has been observed in other study systems (Kelton and Skipworth 1987; Padmalal *et al*. 2003). Although grasses, sedges and rushes represent an easily palatable and accessible supply of energy, (Jones and Wilson 1987; Frase and Armitage 1989), on the BHP, the intake of graminoids may be observed as only a minor component in the diet of sambar deer due to the availability of other, more nutritious growth forms (Goldberg *et al*. 2020). Therefore, it is likely that graminoids are only utilised by sambar deer to maintain energy intake and nutrient requirements when other growth forms are limited (Belovsky 1986; Frase and Armitage 1989).

We detected several genera more frequently in faecal samples than would be expected based on their presence in the study area, including *Acaena*, *Eucalyptus*, **Acetosella*, *Gonocarpus*, *Galium*, *Epilobium* and **Hypochaeris*. The targeting of these particular plant genera suggests that sambar deer are not strictly opportunistic feeders in the Alpine National Park, and are possibly exhibiting some selective feeding behaviours towards certain species. Selective feeding has the potential to alter the abundance of favoured dietary items, and is of particular concern when these items are rare or vulnerable (Kirby 2001; Keith and Pellow 2005).

Currently, none of the genera detected as over-represented in the diet are considered threatened on the BHP, however their representation may hint at possible movement patterns of sambar deer in alpine environments. The habitat of sambar deer in Australia is heavily associated with densely forested ecosystems, a preference which aids in the species avoidance of high winds and increased temperatures (Moore 1994; Bennett 2008; Forsyth *et al*. 2009). In sub-alpine environments, sambar deer display strong crepuscular activity patterns, and on the BHP, snow-gum woodland and closed-heathland environments at lower elevations likely provide ideal habitat for the species during daylight hours (Leslie 2011; Davies *et al*. 2020). Considering these environments accommodate a majority of the genera observed as over-represented in the diet (McDougall 1982; Williams and Ashton 1987), it is probable that the high frequency of these genera highlights the feeding patterns of sambar within their predicted habitat, and the movement between alpine and subalpine vegetation zones during active hours.

Spatial and temporal changes in diet

Considering the diverse range of plant material eaten by sambar deer in this study, the composition of individual faecal samples would be heavily dependent on the movement, gut passage retention times and foraging patterns of sambar deer prior to defecation (Mautz and Petrides 1971; Milne *et al*. 1978; Holand 1994; Gill and Beardall 2001; Pellerin *et al*. 2016). Therefore, it seems unlikely that the composition of faecal samples would be a direct reflection of the specific vegetation community from where it was collected, and this was supported by the results of this study. Combined with the evidence of sambar deer moving between alpine and subalpine areas, these results further highlight that within individual sites sambar deer are using multiple vegetation communities for foraging and defecating, and could have negative impacts through seed-dispersal of plant species into new communities and trampling of sensitive communities while browsing (Pakeman *et al*. 2002; Ismail and Jiwan 2015).

We did however observe differences between the plant species composition of faecal pellets collected from Mt Nelse and Basalt Hill, which not only suggests differences in the dietary items consumed by sambar deer between these two sites, but also infers that sambar deer individuals are unlikely to be moving between these two areas. Mt Nelse and Basalt Hill are less than 10km apart, which is well within home range estimates of sambar deer males, and on the upper limit for females (Sankar 1994; Chundawat *et al*. 2007). The clear separation in dietary composition between sites highlights localised feeding and movement behaviours, and possibly limited dispersal of sambar deer individuals within the broader study area. With the exception of sambar deer at high elevations descending to lower environments during winter, the species is typically considered non-migratory across much of its range and has a tendency to remain sedentary within locations (Schaller 1967; Leslie 2011). Further investigation utilising population level genetic techniques would provide better assessment of the movement and dispersal patterns of sambar deer within alpine landscapes, and most importantly would aid in more effective management of current populations.

Species of conservation importance

Although many of the species detected in the diet of sambar deer are considered widespread in the environment, we detected several species of conservation significance. Rare wetland species (i.e. relatively few individuals and/or populations) such as Broad-leaf Flower rush (*Carpha nivicola)* and Alpine Marsh-marigold (*Psychrophila introloba)*, and the Silky Snow-daisy (*Celmisia sericophylla)*, which is currently listed as threatened under the *Flora and Fauna Guarantee Act 1988*, were each observed in a small number of samples. While it appears that sambar deer are not selectively targeting these particular dietary items, the extent of browsing may only need to be minimal to have detrimental impacts on rare species (Davis *et al*. 2011). Therefore, it is recommended that routine monitoring of the abundance and distribution of rare plant species on the BHP is undertaken to ensure any negative impacts from sambar deer habitation is managed promptly.

We also detected Hawkweed (*Pilosella spp*.) and Grey Sallow Willow (*Salix cinerea*), both of which are invasive and pose serious threats to native vegetation, particularly snowpatch herbfields and wetlands (Morgan 2000; Karrenberg *et al*. 2002; Williams *et al*. 2008; Giljohann *et al*. 2011; Moore and Thomas 2011; Primrose *et al*. 2016). Although control programs exist to restrict and eradicate both species, the presence of each within the diet highlights that these species are still available in the landscape for consumption by sambar deer. It is possible that the Hawkweed genus, which contains species that are sparingly established in the landscape, could be more widespread in the diet of sambar deer, however the DNA metabarcoding approach applied in this study may have failed to detect these rare items due to low amounts of DNA compared to more common plant dietary item DNA (Deagle *et al*. 2019). Therefore, to better understand the extent of rare items in the diet, whether of conservation significance or invasive potential, a more refined method may be required. A targeted approach using species-specific primers in conjunction with real time quantitative PCR (qPCR) would be feasible for determining the presence a single genus or species of interest in the diet of sambar deer (Harper *et al*. 2017), and most importantly could aid in tracking the distribution of rare dietary items through sambar deer faecal pellets.

Management Implications

In the Alpine National Park, a long history of cattle grazing practices were discontinued in 2005 after the detrimental impacts by the species on native vegetation, soils and water quality were highlighted (Carr 1977; Costin 1977; Van Rees 1982; Wahren *et al*. 1994; Williams *et al*. 2006). Since this time, the recovery of impacted plant species and communities has been slow (Wahren *et al*. 1994). Since cattle removal, sambar deer have become the primary large herbivore observed on the BHP, and although the density of sambar deer is likely different to cattle during past periods of grazing, our results highlight clear concerns for the management of the alpine plant species and vegetation communities in the presence of sambar deer.

Sambar deer displayed largely opportunistic feeding behaviours in this study, however the preferencing of several genera highlights the ability of the species at times to be more selective with their dietary choices (Hanley 1982). The detection of rare, threatened native species and exotic weeds in the diet is problematic and should be carefully evaluated, with careful monitoring recommended where sambar deer coexist alongside plant species or communities of conservation significance.

The detection of distinct spatial and temporal variation in the diet of sambar deer within high elevation sites of the Alpine National Park, also emphasises the need for land managers to evaluate the presence of sambar deer within individual sites. Our detection of spatial variation in the diet of sambar deer provides evidence that individual deer are localised, and are therefore unlikely to be moving large distances. However, further research into the population genetics of sambar deer individuals on the BHP is of importance, as the utilisation of advancing DNA analysis techniques for estimating population structure and dispersal characteristics would better detail the movement patterns of sambar deer within each of the study sites, and possibly the broader Alpine National Park (Hampton *et al*. 2004; Brinkman and Hundertmark 2009; Davies *et al*. 2020).

CHAPTER 4

GENERAL DISCUSSION AND CONCLUSIONS

Sambar deer are now abundantly distributed across south-eastern Australia, particularly in the densely vegetated habitats of eastern Victoria, and forage on a wide variety of plant species and plant parts (Forsyth & Davis 2011). Exotic ungulates and their associated impacts on vegetation in native ecosystems is a significant and increasing concern for land managers, as native ecosystems have evolved in the absence of large, hard-hoofed species. As a result, native ecosystems may be susceptible to the impacts of herbivory and trampling, due to a lack of adequate adaptations to persist in the presence of novel ungulate species (Newsome *et al*. 2002; Pickering *et al*. 2010).

In this thesis, dietary diversity, spatial and temporal variation, preference, and seed dispersal were examined to better understand the potential impacts of sambar deer in native ecosystems. The results of this study provide valuable information regarding the plant species and communities most vulnerable to sambar deer.

In Chapter 2, sambar deer faecal pellets were used to explore diet and seed dispersal through a combination of DNA metabarcoding and germination trials. I aimed to determine the diversity of plant species and growth forms eaten and spread by sambar deer, as well as the dietary behaviour of the species in two contrasting habitat types. Despite wide variation in individual sambar deer diets, much of the diet was comprised of native species in both alpine and wet forest study areas. However, the proportion of exotic plant species in the diet was higher than would be expected based on availability in the landscape, suggesting that sambar deer are targeting exotic plant species.

In both study areas, sambar deer were not considered to strictly browse or graze and were therefore regarded as intermediate feeders. These results corroborate other studies on the species in forest ecosystems (Varman & Sukumar 1993; Forsyth & Davis 2011). However, the diet of sambar deer was heavily comprised of forbs in alpine samples, and shrubs in wet forest samples, suggesting an opportunistic feeding behaviour largely dictated by forage availability in each of these landscapes (Geist 1998; Leslie 2011).

Germination trials resulted in a wide variety of native and exotic species emerging in samples collected from both ecosystems, however forb seedlings were the most common growth form observed. The prevalence of forb species is common in studies of endozoochory by ungulate species (Gill & Beardall 2001; Shiponeni & Milton 2006). Alpine samples comprised a large number of seedlings for three exotic species (*Acetosella vulgaris*, *Agrostis capillaris* and *Cerastium glomeratum*) which are currently well-established within the study area (Johnston & Pickering 2001; McDougall & Walsh 2007; Morgan & Carnegie 2009). In wet forest samples, the emergence of exotic blackberry (*Rubus ulmifolius*) seedlings were recorded in multiple samples, suggesting that sambar deer may be involved in the dispersal of this significant invasive weed (Deehan *et al*. 2007).

In Chapter 3, I further investigated the impacts of sambar deer in alpine ecosystems. I aimed to assess the spatial and temporal variation in the sambar deer diet over the main flowering period on the Bogong High Plains, as well as explore any evidence of plant species preferencing in this study area.

The plant species composition of sambar deer diet showed distinct spatial variation across two study sites, which were relatively close in terms of spatial scale (<10 km apart). This suggests that sambar deer individuals are unlikely to be dispersing widely whilst foraging. Furthermore, this result implies that the management of sambar deer requires carefully evaluated site-specific approaches, as the contrasting composition of plant species within different sites highlights that sambar deer may exert very different impacts in different areas.

Temporal variation in diet was only observed in samples from one of the study sites, which is likely explained by this study site containing a greater variety of forage available at different times during the study period (McDougall 1982). The diet of sambar deer was once again considered to be heavily based on forage availability, as forbs are abundant in the landscape and were the dominant dietary items (McDougall 1982; Geist 1998; Leslie 2011).

Plant species of conservation concern, as well as highly invasive plant species were detected in the diet of sambar deer, further emphasizing the need for monitoring and assessment of vegetation communities in the presence of sambar deer to mitigate potential reductions of rare species and prevent the establishment of invasive weeds.

MANAGEMENT IMPLICATIONS AND SUGGESTIONS

In the state of Victoria, sambar deer are protected as wildlife under the *Wildlife Act 1975,* yet are also managed as game under the Wildlife (Game) Regulations 2012. As such, sambar deer can be legally hunted all year (stalking only), with no limits on the individual harvest by recreational hunters. However, barring a few exceptions, hunting within National Parks is not permitted. Thus, the study areas in Chapter 2 and 3 are within regions where sambar deer hunting cannot legally take place, unless by professional wildlife management contractors in collaboration with land managers.

Removing introduced herbivores from ecosystems for the purpose of protecting and repairing habitats is generally considered a logical first step in ecosystem restoration, especially in cases where native vegetation is still abundant (Zavaleta *et al*. 2001; Gosse *et al*. 2011). Studies have emphasised positive outcomes for native vegetation following the removal of exotic herbivores, including increases in diversity and abundance (Cole & Litton 2014). Currently, recurrent periods of culling are undertaken in both the Yarra Ranges National Park and Alpine National Park and should be continued to reduce deer densities in these areas. However, it is possible that the removal of herbivores can result in unfavourable outcomes where changes in plant composition and abundance favour exotic species, or previously suppressed species through browsing are advantaged due to a sudden lack of herbivory (Abbott *et al*. 2000; Bullock *et al*. 2002; Donlan *et al*. 2002). Therefore, it is recommended that assessments of the plant species composition and abundance of vegetation communities closely associated with sambar deer herbivory is undertaken before, during, and after periods of culling, to adequately evaluate ecosystem changes following sambar deer removal, and allow prompt response by land managers to any negative changes in native species composition or abundance. The measure of success should not be determined by the number of removed sambar deer, but more importantly the recovery and ongoing persistence of native vegetation.

Culling programs often have non-shooting periods, and during these times it is also important to explore non-lethal methods to not only protect areas from damage, but to also influence the land used by sambar deer. This is especially important considering the findings of this thesis which highlighted the potential for sambar deer to consume threatened plant species and disperse native and exotic seeds in a variety of vegetation communities. Exclusion based approaches such as fencing have been shown to reduce small-scale damage and aid in the protection of vegetation from browsing (Nolte 1999; Davis & Coulson 2010; Bennett & Coulson 2011). However, fencing is often costly and only feasible at smaller spatial scales (Walter *et al*. 2010; Davis *et al.* 2016). Additionally, the use of fencing in either of the study areas in this thesis might be unfavourable, as fencing is likely to impact the aesthetic of natural landscapes in National Parks, and may also unintentionally exclude native fauna (Bennett & Coulson 2008; Walter *et al*. 2010). Clearly, balancing the costs and benefits of non-lethal approaches is important for maintaining positive benefits within ecosystems (DeNicola *et al*. 2000), and as such, methods for deterring sambar deer from areas as opposed to complete exclusion may prove more feasible. Scare devices rely on delivering a stimulus to startle and disperse individuals away from an area and may present a viable option when strategically placed in sites of high conservation value such as significant/rare vegetation communities (Davis *et al*. 2016). Generally, these devices incorporate audio and visual components such as sirens and lights to deter problematic species (Nolte 1999; Walter *et al*. 2010). Scare device effectiveness may decrease over prolonged periods (Bomford & O'Brien 1990; Gilsdorf *et al*. 2002), however, during short periods when culling is ceased, or in high elevation sites where deer inhabit for short periods of the year, short periods of scare device deployment is likely to deter sambar deer activity and ensure that vegetation and communities are protected when culling is not feasible.

FUTURE RESEARCH

There has been an increase in published literature focussing on sambar deer within Australian ecosystems. These studies have concentrated on reproductive rates (Watter *et al*. 2020), activity and detectability patterns (Davies *et al*. 2020), disease transmission (Huaman *et al*. 2020), and interactions with apex predators and mesopredators (Forsyth *et al*. 2018). However, the continuing expansion of sambar deer populations and distribution in south-eastern Australia suggests that further research on sambar deer ecology and impacts is required. In this section, I present a series of future research directions which are considered valuable for further understanding the impacts of sambar deer and will assist in developing effective management approaches.

1. *Further DNA metabarcoding approaches*

Using faecal samples alone, this thesis has detailed the plant species comprising the sambar deer diet in two contrasting ecosystems, and further demonstrated the value of the DNA metabarcoding technique. However, the results obtained in this thesis are by no means considered exhaustive. Further collection of samples, across all seasons and within additional ecosystems inhabited by sambar deer would greatly expand on the current knowledge of sambar deer dietary impacts in south-eastern Australia.

Considering that some deer species can exhibit distinct seasonal variation in diet (Storms *et al*. 2008; Azorit *et al*. 2012; Zweifel-Schielly *et al*. 2012), further understanding of dietary shifts by sambar deer, particularly as they migrate from high alpine to low elevations during winter is of high importance, as during this period the species is likely to coexist with a number of native herbivores (Davis *et al*. 2016). Collection of faecal samples from not only sambar deer, but also other co-occurring herbivores would provide better insight into the extent of competition between sambar deer and native herbivores.

Lastly, the use of the DNA metabarcoding approach on both stomach and faecal samples from the same individual would aid in further developing methods for sufficiently detailing the diet of a species, and would provide insight into digestion rate differences and potential sources of bias in future metabarcoding studies.

2. *Plant specific detection*

The focus of the DNA metabarcoding approach used in this thesis was to describe the many plant species comprising the diet of sambar deer. However, a plant species-specific method may be justified in cases where the presence of a particular dietary item is of concern and requires monitoring (Williams *et al*. 2019). In Chapter 3, I highlighted the presence of the invasive hawkweed genus (*Pilosella* spp.) in one of the 90 faecal samples that were analysed. Three species of hawkweed are currently present in the Victorian Alps, and the genus poses a serious threat to native vegetation due to its ability to spread aggressively and exclude other native species (Morgan 2000; Williams *et al*. 2008; Primrose *et al*. 2016). The current small infestations of hawkweed in Victoria, New South Wales and Tasmania have the potential to occupy large areas of south-eastern Australia if left unmanaged, with potential losses to agricultural areas in the order of $68 million AUD per annum (Brinkley & Bomford 2002, Hamilton *et al*. 2018). Each summer, Parks Victoria oversee a volunteer program designed to search for and eradicate any potential hawkweed infestations on the Bogong High Plains.

A targeted approach using species-specific primers in conjunction with real time quantitative Polymerase Chain Reaction (qPCR) would be more feasible for determining the presence of the hawkweed genus in the diet of sambar deer (Harper *et al*. 2017). This method would ensure that any potential amplification bias resulting in less common DNA sequences being undetected would be prevented, as the species-specific approach is more capable of identifying rare species (Kelly *et al*. 2014; Evans *et al*. 2016; Harper *et al*. 2017). Through species-specific PCR, the extent of hawkweed in the sambar deer diet would be better evaluated, and the environments where the genus is detected in faecal pellets would inform land managers of current distribution of the invasive genus. If samples were routinely collected at regular time intervals, the results would also allow land managers to track potential changes in the distribution of hawkweed over time, ensuring any potential establishment into new areas is promptly dealt with.

3. *Differences in diet between sexes*

Numerous studies have shown composition and quality differences between diets of male and female deer species occupying the same range (Beier 1987; Putman *et al*. 1993; Roberts *et al*. 2015), likely due to varying body size, nutrient requirements, and postures adopted when feeding (Ruckstuhl & Neuhaus 2002). Where culling programs are implemented, a variety of considerations may lead to programs focussing on removal of male or female deer. For example, removing males may be the focus in vulnerable areas due to their destructive patterns including thrashing and wallowing (Leslie 2011), alternatively, female removal may be the focus if the overall goal is density reduction (McCullough 1979). Nonetheless, linking dietary information to sex would be valuable for assessing the dietary impacts of male and female sambar deer in native ecosystems. Using markers within the amelogenin locus, sex determination in bovids and cervids is possible through a relatively straightforward PCR procedure (Brinkman &

Hundertmark 2009). More specifically, when using faecal pellet samples, the use of the primer pair SE47 and SE48 to produce X-linked and Y-linked amplicons to assign sex to ungulate DNA has been demonstrated (Ennis & Gallagher 1994; Davies *et al*. 2020). Culling programs could then be modified to remove deer of a particular sex if results suggest that one of the sexes is more likely to exert detrimental impacts in certain areas.

4. Natural predator research

In the absence of natural predators, sambar deer abundance is only likely to decrease through lethal control or fire (Forsyth *et al*. 2018). However, one regularly suggested solution to reduce the abundance of sambar deer in south-eastern Australia is to restore dingo (*Canis lupus dingo*) populations in areas where control programs have reduced the abundance of this apex predator (Dickman *et al*. 2009; Ritchie *et al*. 2012; Forsyth *et al*. 2018). Present in Australia for >4000 years (Savolainen *et al.* 2004), trophic regulation of introduced predators and herbivores by dingoes could provide positive flow-on effects to other small native animals and vegetation (Dickman *et al*. 2009). Sambar deer calves are predated by dingoes (Bentley 1998), yet little knowledge exists regarding whether the species kills adult sambar deer (Forsyth *et al*. 2018). Forsyth *et al*. (2018) observed no reduction or suppression of sambar deer abundance in the presence of dingoes. However, this may be due to a long history of lethal control measures reducing dingo populations, which likely impact the ability of the species to form packs and hunt cooperatively to kill sambar deer (Wallach *et al*. 2010; Dickman *et al*. 2014). Clearly, the proposal for dingoes to be explored as a method for control is controversial (Allen & Fleming 2012; Newsome *et al*. 2015). However, further study evaluating the hunting pressure exerted on sambar deer by dingoes, and the resulting ecological change in areas of varying dingo density, would fill this important research gap. As a starting point, the DNA metabarcoding technique and methods utilised in this study could be modified to analyse the contents of carnivorous faecal samples, which would highlight the extent of sambar deer in the dingo diet.

5. Genetics studies

Once established, invasive species are difficult to eradicate and expensive to control and therefore land managers require cost-effective strategies for managing their presence (Byers *et al*. 2002; Le Roux & Wieczorek 2009). Advancing DNA analysis techniques using non-invasive methods have made it feasible to assess many aspects of invasive species biology and ecology, which is important for ongoing management (Hampton *et al*. 2004; Brinkman & Hundertmark 2009; Davies *et al*. 2020). Evaluation of population structure, hybridisation, dispersal characteristics, abundance estimates, and sex ratios is not only feasible using genetic methods, but also highly likely to improve current management of sambar deer in native ecosystems. Valuable information is to be gained from placing the results from this thesis in context of future genetics-based research. For example, abundance estimates, and evaluation of dispersal characteristics are likely to provide better information on density and movement patterns, which can place the endozoochory results obtained in this thesis in context of seed-dispersal extent in the environment. It is suggested that future research explore the use of these techniques to better inform the management of sambar deer in south-eastern Australia.

CONCLUSION

The application of a variety of methods in this thesis have provided another important step in understanding the dietary diversity and potential impacts of sambar deer herbivory in south-eastern Australia. Using only faecal pellets, which are plentiful in inhabited ecosystems and easily sampled, the use of DNA metabarcoding techniques offered information on the many dietary items consumed by sambar deer, including detection of plant species that are considered rare, common and invasive. The opportunistic, intermediate feeder behaviours adopted by sambar deer in contrasting habitat types emphasise the ability of the species to adapt to new environments. This is of significant concern for habitats not yet reached by sambar deer. An expansion of the DNA metabarcoding methods used in this thesis are likely to further detail the dietary impacts of sambar deer in native ecosystems, however, considering the rapid development of additional genetic techniques, it is important for future study to also focus on dispersal and population genetics of sambar deer, as this research is also integral for informing future culling procedures and management of areas inhabited by sambar deer.

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APPENDIX

Figure 1. Map of Australia, with inset showing south-eastern Australia sampling regions for sambar deer faecal pellet collections for germination trials and DNA analysis (number of sites within each region is shown in brackets). Shading represents the current distribution of sambar deer.

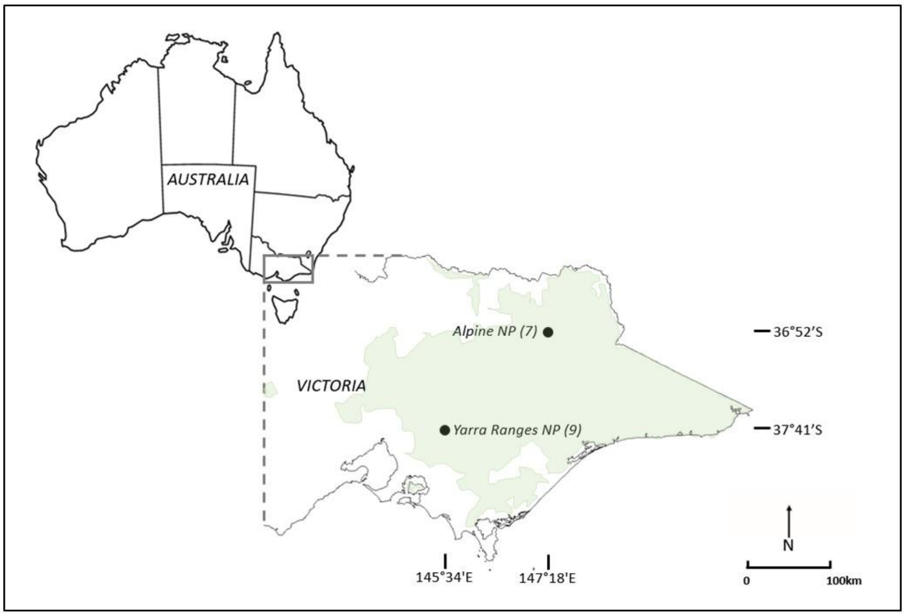

Table 1. Alpine: Sambar deer faecal pellet collection locations for germination trials.

Sample	Latitude	Longitude
1	-36.8286	147.3327
2	-36.8285	147.3327
3	-36.8282	147.3325
4	-36.8279	147.3325
5	-36.8279	147.3323
6	-36.8278	147.3325
7	-36.8279	147.3326
8	-36.8279	147.3322
9	-36.828	147.3323
10	-36.8278	147.3328
11	-36.8287	147.3332
12	-36.829	147.333
13	-36.8289	147.3332
14	-36.8272	147.3401
15	-36.8273	147.3413
16	-36.8274	147.3411
17	-36.8269	147.3413
18	-36.8267	147.341
19	-36.8267	147.3414
20	-36.8267	147.3417
21	-36.8261	147.3437
22	-36.826	147.3437
23	-36.8263	147.3438
24	-36.8262	147.3443
25	-36.8264	147.3443
26	-36.8263	147.3444
27	-36.8265	147.3444
28	-36.8265	147.3447
29	-36.8268	147.3449
30	-36.8272	147.3451
31	-36.8269	147.3445
32	-36.827	147.3452
33	-36.8404	147.3403
34	-36.8412	147.3415
35	-36.8413	147.3419
36	-36.8419	147.3429
37	-36.8421	147.3431
38	-36.8267	147.3407
39	-36.8417	147.3454
40	-36.8416	147.3471
41	-36.8415	147.3467
42	-36.8416	147.3473
43	-36.8418	147.3482
44	-36.8424	147.3484
45	-36.8424	147.3486

46	-36.8424	147.3493
47	-36.843	147.3487
48	-36.8418	147.3491
49	-36.8417	147.347
50	-36.841	147.3417
51	-36.842	147.3391
52	-36.9134	147.2942
53	-36.9133	147.2945
54	-36.9138	147.2946
55	-36.9145	147.2946
56	-36.9146	147.2946
57	-36.9144	147.2947
58	-36.9146	147.2946
59	-36.9152	147.2957
60	-36.9151	147.2958
61	-36.915	147.2961
62	-36.9144	147.2963
63	-36.915	147.296
64	-36.9144	147.2958
65	-36.892	147.3107
66	-36.8922	147.3108
67	-36.892	147.3112
68	-36.8921	147.3114
69	-36.8907	147.3178
70	-36.8906	147.3177
71	-36.8905	147.3182
72	-36.8905	147.3184
73	-36.8901	147.3189
74	-36.8907	147.3189
75	-36.8908	147.3179
76	-36.8917	147.3158
77	-36.892	147.3155
78	-36.8922	147.3147
79	-36.8922	147.3139
80	-36.8925	147.3136
81	-36.8919	147.3135

Table 2. Alpine: Sambar deer faecal pellet collection locations for DNA analysis.

Sample	Latitude	Longitude
3	-36.843	147.3434
4	-36.8433	147.3431
7	-36.8447	147.3445
17	-36.8286	147.3334
21	-36.8282	147.333
26	-36.8277	147.3384
27	-36.8262	147.3438
31	-36.8262	147.3446
35	-36.8264	147.3448
39	-36.8429	147.3486
46	-36.8664	147.3084
50	-36.867	147.3094
51	-36.8678	147.3074
54	-36.8909	147.3169
57	-36.8906	147.317
60	-36.8917	147.3154
63	-36.8914	147.309
64	-36.9137	147.2934
67	-36.9146	147.2959
75	-36.9055	147.2943

Table 3. Wet Forest: Sambar deer faecal pellet collection locations for germination trials.

Sample	Latitude	Longitude
1	-37.55574	145.88811
2	-37.55579	145.88759
3	-37.55518	145.88815
4	-37.55553	145.88868
5	-37.55531	145.88894
6	-37.55591	145.8888
7	-37.55661	145.88862
8	-37.55729	145.8887
9	-37.55706	145.88918
10	-37.55702	145.88915
11	-37.55827	145.88884
12	-37.5586	145.88902
13	-37.55892	145.8885
14	-37.54039	145.8419
15	-37.54014	145.84166
16	-37.53983	145.84157
17	-37.54039	145.84236
18	-37.5296	145.87053
19	-37.52936	145.87159
20	-37.52964	145.87107
21	-37.5302	145.87095
22	-37.53028	145.8706
23	-37.53031	145.87015
24	-37.68617	145.56767
25	-37.68585	145.5676
26	-37.6863	145.56759
27	-37.68623	145.56777
28	-37.68617	145.56815
29	-37.68623	145.56792
30	-37.68594	145.56797
31	-37.68585	145.56798
32	-37.68605	145.56837
33	-37.6859	145.56845
34	-37.71312	145.74734
35	-37.71321	145.74724
36	-37.71332	145.74731
37	-37.71329	145.74744
38	-37.71338	145.74751
39	-37.71346	145.74736
40	-37.71364	145.74749
41	-37.71357	145.74726
42	-37.71369	145.74732
43	-37.71379	145.74742
44	-37.67234	145.8497
45	-37.67203	145.8497

46	-37.67235	145.84982
47	-37.67233	145.84998
48	-37.67251	145.84986
49	-37.67241	145.8501
50	-37.67261	145.85002
51	-37.67256	145.85015
52	-37.67247	145.85023
53	-37.6723	145.84995
54	-37.68453	145.84444
55	-37.68437	145.84476
56	-37.6846	145.84454
57	-37.68441	145.8444
58	-37.68465	145.84433
59	-37.68471	145.8441
60	-37.6847	145.84449
61	-37.68465	145.84421
62	-37.68483	145.84458
63	-37.68489	145.84517
64	-37.68508	145.84491
65	-37.68754	145.8298
66	-37.68769	145.82985
67	-37.68772	145.82997
68	-37.68754	145.83011
69	-37.68746	145.83014
70	-37.68737	145.83034
71	-37.68763	145.8302
72	-37.68751	145.83022
73	-37.68751	145.83035
74	-37.68737	145.83033
75	-37.68719	145.83046
76	-37.68719	145.83046
77	-37.53	145.87063
78	-37.5913	145.64372
79	-37.59136	145.64366

Table 4. Wet Forest: Sambar deer faecal pellet collection locations for DNA analysis.

Sample	Latitude	Longitude
1	-37.55574	145.88811
7	-37.55661	145.88862
10	-37.55702	145.88915
12	-37.5586	145.88902
16	-37.53983	145.84157
18	-37.5296	145.87053
21	-37.5302	145.87095
22	-37.53028	145.8706
27	-37.68623	145.56777
29	-37.68623	145.56792
33	-37.6859	145.56845
35	-37.71321	145.74724
38	-37.71338	145.74751
48	-37.67251	145.84986
56	-37.6846	145.84454
62	-37.68483	145.84458
65	-37.68754	145.8298
71	-37.68763	145.8302
76	-37.68719	145.83046
79	-37.59136	145.64366

Table 5. Primer names, sequences and expected size for *rbcL*, ITS2 and *trnL* gene regions.

Locus	Size	Primer Name	Primer Sequence 5'-3'	Reference
rbcL	550bp	rbcLa-F	ATGTCACCACAAACAGAGACTAAAGC	Levin *et al*. 2003
		rbcLa-R	GTAAAATCAAGTCCACCRCG	Kress & Erickson 2007
ITS2	300-460bp	ITS2-S2F	ATGCGATACTTGGTGTGAAT	Chen *et al*. 2010
		ITS4	TCCTCCGCTTATTGATATGC	White *et al*. 1990
trnL intron P6 loop	10-143bp	g	GGGCAATCCTGAGCCAA	Taberlet *et al*. 2007
		h	CCATTGAGTCTCTGCACCTATC	Taberlet *et al*. 2007

Table 6. PCR programs used for each gene region during first rounds of amplification.

PCR Protocols	***rbcL***		***ITS2***		***trnL intron P6 loop***	
	Temp	**Time**	**Temp**	**Time**	**Temp**	**Time**
Initial	94°C	4min	94°C	5min	95°C	10min
Denaturation	94°C	30s	94°C	30s	95°C	30s
Annealing	55°C	30s	50°C	30s	50°C	30s
Extension	72°C	1min	72°C	45s	72°C	10s
Number of Cycles	35		35		35	
Final Extension	72°C	10min	72°C	10min	72°C	2min
Hold	**4°C**		**4°C**		**4°C**	

Table 7. Taxonomic table displaying the assignment of OTUs in the Alpine samples in Chapter 2. Sum refers to total number of sequence reads for each OTU. Count refers to the number of samples an OTU was detected in, and average read depth highlights the total reads on average for OTUs across detected samples.

OTU ID	Locus	Class	Order	Family	Genus	Species	Growth Form	Origin	Sum	Count	Average Read Depth
Otu1	trnL	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	139875	18	7771
Otu2	trnL	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	94094	19	4952
Otu4	trnL	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	Likely Exotic	72271	20	3614
Otu5	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	59486	19	3131
Otu6	trnL	Magnoliopsida	Gentianales	Rubiaceae	Asperula		Forb	Likely Native	52957	19	2787
Otu7	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	27934	6	4656
Otu8	trnL	Pinopsida	Pinales	Podocarpaceae	Podocarpus	lawrencei	Shrub or Tree	Likely Native	15838	8	1980
Otu11	trnL	Magnoliopsida	Poales	Poaceae	Poa		Grass	Likely Native	14016	18	779
Otu13	trnL	Magnoliopsida	Asterales	Asteraceae			Forb	Unknown	10253	3	3418
Otu14	trnL	Magnoliopsida	Proteales	Proteaceae	Grevillea		Shrub or Tree	Likely Native	7903	11	718
Otu15	trnL	Magnoliopsida	Sapindales	Rutaceae			Shrub or Tree	Unknown	7234	17	426
Otu16	trnL	Magnoliopsida	Asterales	Asteraceae	Sonchus		Forb	Likely Exotic	9513	17	560
Otu17	trnL	Magnoliopsida	Fabales	Fabaceae	Pultenaea		Shrub or Tree	Likely Native	6046	10	605
Otu18	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	4777	5	955
Otu20	trnL	Magnoliopsida	Malpighiales	Salicaceae	Salix	cinerea	Shrub or Tree	Likely Exotic	2650	7	379
Otu22	trnL	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Shrub or Tree	Likely Native	2266	12	189
Otu24	trnL	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	Likely Native	2151	12	179
Otu25	trnL	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	1874	16	117
Otu30	trnL	Magnoliopsida	Rosales	Urticaceae			Forb	Unknown	1444	3	481

Otu31	trnL	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	Likely Native	1149	3	383
Otu32	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	1101	10	110
Otu35	trnL	Magnoliopsida	Malvales	Thymelaeaeae	Pimelea		Shrub or Tree	Likely Native	770	5	154
Otu36	trnL	Magnoliopsida	Lamiales	Lamiaceae	Prostanthera		Shrub or Tree	Likely Native	1157	1	1157
Otu40	trnL	Magnoliopsida	Ranunculales	Ranunculaceae	Ranunculus	repens	Forb	Likely Exotic	496	11	45
Otu47	trnL	Magnoliopsida	Lamiales	Plantaginaceae	Plantago	lanceolata	Forb	Likely Exotic	386	2	193
Otu48	trnL	Magnoliopsida	Geraniales	Geraniaceae	Geranium		Forb	Likely Native	461	8	58
Otu50	trnL	Polypodiopsida	Polypodiales	Dryopteridaceae	Polystichum	proliferum	Fern	Likely Native	339	5	68
Otu52	trnL	Magnoliopsida	Poales	Juncaceae	Luzula	modesta	Grass-like Plants	Likely Native	491	6	82
Otu54	trnL	Magnoliopsida	Poales	Poaceae			Grass	Unknown	363	5	73
Otu71	trnL	Magnoliopsida	Myrtales	Myrtaceae	Kunzea		Shrub or Tree	Likely Native	251	3	84
Otu72	trnL	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	380	4	95
Otu74	trnL	Magnoliopsida	Poales	Poaceae	Anthoxanthum	odoratum	Grass	Likely Exotic	189	3	63
Otu81	trnL	Magnoliopsida	Lamiales	Orobanchaceae	Euphrasia		Forb	Likely Native	153	1	153
Otu84	trnL	Pinopsida	Pinales	Cupressaceae			Shrub or Tree	Unknown	150	1	150
Otu85	trnL	Pinopsida	Pinales	Cupressaceae			Shrub or Tree	Unknown	178	3	59
Otu86	trnL	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle	sibthorpioides	Forb	Likely Native	139	2	70
Otu88	trnL	Magnoliopsida	Fabales	Fabaceae	Templetonia	egena	Shrub or Tree	Likely Exotic	114	4	29
Otu95	trnL	Magnoliopsida	Solanales	Solanaceae	Solanum		Shrub or Tree	Likely Exotic	109	1	109
Otu99	trnL	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	35	2	18
Otu107	trnL	Magnoliopsida	Fabales	Fabaceae	Bossiaea		Shrub or Tree	Likely Native	45	1	45
Otu109	trnL	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	209	7	30
Otu113	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	12	1	12
Otu114	trnL	Magnoliopsida	Asterales	Goodeniaceae	Goodenia		Shrub or Tree	Likely Native	67	2	34
Otu116	trnL	Magnoliopsida	Poales	Cyperaceae	Carex	breviculmis	Grass-like Plants	Likely Native	92	2	46
Otu117	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	52	2	26

Otu118	trnL	Magnoliopsida	Oxalidales	Oxalidaceae	Oxalis	corniculata	Forb	Likely Exotic	69	1	69
Otu119	trnL	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum	fluviatile	Fern	Likely Native	66	1	66
Otu121	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	14	1	14
Otu122	trnL	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Shrub or Tree	Likely Native	51	1	51
Otu124	trnL	Magnoliopsida	Asterales	Campanulaceae	Wahlenbergia	multicaulis	Forb	Likely Native	65	2	33
Otu125	trnL	Magnoliopsida	Fabales	Fabaceae	Daviesia		Shrub or Tree	Likely Native	65	1	65
Otu132	trnL	Magnoliopsida	Asterales	Asteraceae	Cirsium	vulgare	Forb	Likely Exotic	43	2	22
Otu133	trnL	Magnoliopsida	Gentianales	Rubiaceae	Asperula		Forb	Likely Native	22	1	22
Otu134	trnL	Magnoliopsida	Poales	Poaceae	Rytidosperma		Grass	Likely Native	36	2	18
Otu139	trnL	Magnoliopsida	Ericales	Theaceae	Camelia		Shrub or Tree	Likely Exotic	66	1	66
Otu145	trnL	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Native	16	1	16
Otu150	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	28	1	28
Otu155	trnL	Magnoliopsida	Brassicales	Brassicaceae	Cardamine		Forb	Likely Native	24	1	24
Otu163	trnL	Magnoliopsida	Myrtales	Myrtaceae			Forb	Unknown	20	2	10
Otu173	trnL	Magnoliopsida	Solanales	Convulvulaceae	Dichondra		Forb	Likely Native	47	1	47
Otu174	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	609	7	87
Otu175	trnL	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	924	12	77
Otu190	trnL	Magnoliopsida	Malpighiales	Violaceae	Viola		Forb	Likely Native	44	1	44
Otu193	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	57	2	29
Otu194	trnL	Magnoliopsida	Apiales	Araliaceae	Polyscias	sambucifolia	Shrub or Tree	Likely Native	27	2	14
Otu195	trnL	Magnoliopsida	Rosales	Rosaceae			Forb	Unknown	36	2	18
Otu201	trnL	Magnoliopsida	Fabales	Fabaceae	Mirbelia	oxylobioides	Shrub or Tree	Likely Native	19	1	19
Otu205	trnL	Magnoliopsida	Poales	Cyperaceae	Carex		Grass-like Plants	Likely Native	51	2	26
Otu209	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	14	1	14
Otu217	trnL	Magnoliopsida	Proteales	Proteaceae	Orites	lancifolius	Shrub or Tree	Likely Native	11	1	11
Otu218	trnL	Magnoliopsida	Rosales	Ulmaceae	Ulmus		Shrub or Tree	Likely Exotic	33	1	33

Otu221	trnL	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	23	1	23
Otu222	trnL	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	Likely Native	2278	15	152
Otu231	trnL	Magnoliopsida	Brassicales	Brassicaceae	Cardamine		Forb	Likely Native	29	1	29
Otu235	trnL	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum	penna-marina	Fern	Likely Native	10	1	10
Otu236	trnL	Magnoliopsida	Poales	Cyperaceae	Carex		Grass-like Plants	Likely Native	17	1	17
Otu243	trnL	Magnoliopsida	Poales	Restionaceae			Grass-like Plants	Unknown	27	2	14
Otu250	trnL	Magnoliopsida	Brassicales	Brassicaceae			Forb	Unknown	27	1	27
Otu259	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	13	1	13
Otu262	trnL	Magnoliopsida	Asterales	Asteraceae	Erigeron		Forb	Likely Exotic	22	1	22
Otu263	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	10	1	10
Otu277	trnL	Magnoliopsida	Poales	Poaceae	Trisetum	spicatum	Grass	Likely Native	17	1	17
Otu283	trnL	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	23	1	23
Otu284	trnL	Magnoliopsida	Saxifragales	Haloragaceae	Myriophyllum		Forb	Likely Native	14	1	14
Otu285	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	34	2	17
Otu304	trnL	Magnoliopsida	Poales	Poaceae	Cenchrus	clandestinus	Grass	Likely Exotic	16	1	16
Otu331	trnL	Magnoliopsida	Asterales	Asteraceae			Forb	Unknown	1075	9	119
Otu338	trnL	Magnoliopsida	Asterales	Asteraceae	Gazania		Forb	Likely Exotic	13	1	13
Otu348	trnL	Magnoliopsida	Asterales	Asteraceae	Lactuca	serriola	Forb	Likely Exotic	18	1	18
Otu360	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	211	8	26
Otu364	trnL	Magnoliopsida	Rosales	Rosaceae	Sanguisorba		Forb	Likely Exotic	21	2	11
Otu370	trnL	Magnoliopsida	Malpighiales	Violaceae	Melicytus		Shrub or Tree	Likely Native	10	1	10
Otu373	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	169	6	28
Otu376	trnL	Magnoliopsida	Asterales	Asteraceae	Celmisia		Forb	Likely Native	13	1	13
Otu387	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	378	9	42
Otu395	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	563	11	51
Otu400	trnL	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	12	1	12

Otu409	trnL	Magnoliopsida	Lamiales	Lamiaceae	Prostanthera		Shrub or Tree	Likely Native	27	1	27
Otu410	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	12	1	12
Otu418	trnL	Pinopsida	Pinales	Cupressaceae	Callitris	glaucophylla	Shrub or Tree	Likely Exotic	15	1	15
Otu419	trnL	Magnoliopsida	Rosales	Rosaceae	Potentilla	recta	Forb	Likely Exotic	54	2	27
Otu430	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	583	11	53
Otu457	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	541	10	54
Otu482	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	347	10	35
Otu484	trnL	Magnoliopsida	Poales	Cyperaceae	Carex		Grass-like Plants	Likely Native	71	1	71
Otu501	trnL	Magnoliopsida	Apiales	Apiaceae			Forb	Unknown	283	1	283
Otu507	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	937	12	78
Otu514	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	192	4	48
Otu521	trnL	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	183	4	46
Otu546	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	396	10	40
Otu569	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	378	10	38
Otu582	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	336	8	42
Otu596	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	23	2	12
Otu620	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	571	11	52
Otu624	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	359	8	45
Otu631	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	24	1	24
Otu644	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	247	7	35
Otu648	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	621	7	89
Otu667	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	460	11	42
Otu677	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	61	3	20
Otu721	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	310	10	31
Otu731	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	320	10	32
Otu747	trnL	Magnoliopsida	Asterales	Asteraceae	Erigeron		Forb	Likely Exotic	10	1	10

Otu802	trnL	Magnoliopsida	Rosales	Rosaceae	Sanguisorba		Forb	Likely Exotic	123	4	31
Otu816	trnL	Magnoliopsida	Lamiales	Lamiaceae	Prostanthera		Shrub or Tree	Likely Native	217	1	217
Otu909	trnL	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	525	6	88
Otu970	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	66	2	33
Otu990	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	256	7	37
Otu1036	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	193	6	32
Otu1107	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	341	10	34
Otu1118	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	82	1	82
Otu1135	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	42	4	11
Otu1153	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	21	2	11
Otu1300	trnL	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	Likely Native	44	1	44
Otu1331	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	125	7	18
Otu1371	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	33	3	11
Otu1815	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	11	1	11
Otu2258	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	10	1	10
Otu9	ITS2	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	43406	16	2713
Otu11	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	20298	15	1353
Otu12	ITS2	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus		Forb	Likely Native	24513	13	1886
Otu13	ITS2	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	Likely Native	11900	5	2380
Otu14	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	Likely Exotic	28813	16	1801
Otu15	ITS2	Magnoliopsida	Asterales	Asteraceae	Cotula		Forb	Likely Native	6711	1	6711
Otu17	ITS2	Magnoliopsida	Asterales	Asteraceae	Hypochaeris	radicata	Forb	Likely Exotic	2326	6	388
Otu19	ITS2	Magnoliopsida	Sapindales	Rutaceae	Phebalium	Squamulosum	Shrub or Tree	Likely Native	2577	9	286
Otu29	ITS2	Magnoliopsida	Sapindales	Rutaceae	Asterolasia		Shrub or Tree	Likely Native	1133	2	567
Otu31	ITS2	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	2512	2	1256
Otu36	ITS2	Magnoliopsida	Poales	Poaceae	Poa		Grass	Likely Native	1066	13	82

Otu41	ITS2	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	Likely Native	1950	6	325
Otu45	ITS2	Magnoliopsida	Malpighiales	Salicaceae	Salix	cinerea	Shrub or Tree	Likely Exotic	1050	2	525
Otu47	ITS2	Pinopsida	Pinales	Podocarpaceae	Podocarpus	lawrencei	Shrub or Tree	Likely Native	567	1	567
Otu50	ITS2	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle		Forb	Likely Native	529	1	529
Otu52	ITS2	Magnoliopsida	Fabales	Fabaceae	Bossiaea	foliosa	Shrub or Tree	Likely Native	618	6	103
Otu54	ITS2	Magnoliopsida	Asterales	Asteraceae	Celmisia		Forb	Likely Native	957	4	239
Otu56	ITS2	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Shrub or Tree	Likely Native	757	6	126
Otu58	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	26	2	13
Otu61	ITS2	Magnoliopsida	Apiales	Apiaceae	Oreomyrrhis		Forb	Likely Native	338	4	85
Otu63	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Shrub or Tree	Likely Native	2260	2	1130
Otu68	ITS2	Magnoliopsida	Asterales	Asteraceae	Lagenophora		Forb	Likely Native	173	1	173
Otu70	ITS2	Magnoliopsida	Asterales	Asteraceae	Craspedia		Forb	Likely Native	277	2	139
Otu72	ITS2	Magnoliopsida	Asterales	Asteraceae	Olearia		Forb	Likely Native	305	5	61
Otu73	ITS2	Magnoliopsida	Lamiales	Lamiaceae	Prostanthera		Shrub or Tree	Likely Native	275	2	138
Otu75	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	377	6	63
Otu82	ITS2	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	Likely Native	198	4	50
Otu87	ITS2	Magnoliopsida	Brassicales	Brassicaceae	Brassica	oleracea	Forb	Likely Exotic	186	3	62
Otu89	ITS2	Magnoliopsida	Caryophyllales	Caryophyllaceae	Scleranthus	biflorus	Forb	Likely Native	175	3	58
Otu90	ITS2	Magnoliopsida	Rosales	Urticaceae	Urtica	incisa	Forb	Likely Native	138	1	138
Otu91	ITS2	Magnoliopsida	Asterales	Asteraceae	Coronidium	monticola	Forb	Likely Native	169	4	42
Otu101	ITS2	Magnoliopsida	Fabales	Fabaceae	Oxylobium	ellipticum	Shrub or Tree	Likely Native	142	2	71
Otu105	ITS2	Magnoliopsida	Geraniales	Geraniaceae	Geranium		Forb	Likely Native	129	1	129
Otu109	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	307	4	77
Otu111	ITS2	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus		Forb	Likely Native	96	3	32
Otu122	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Baeckea		Shrub or Tree	Likely Native	92	3	31
Otu125	ITS2	Magnoliopsida	Malpighiales	Violaceae	Viola		Forb	Likely Native	184	4	46

Otu133	ITS2	Magnoliopsida	Asterales	Asteraceae	Leptinella		Forb	Likely Native	83	1	83
Otu144	ITS2	Magnoliopsida	Fabales	Fabaceae	Hovea		Shrub or Tree	Likely Native	32	1	32
Otu149	ITS2	Magnoliopsida	Asparagales	Asphodelaceae	Dianella	tasmanica	Grass-like Plants	Likely Native	34	2	17
Otu153	ITS2	Magnoliopsida	Malvales	Thymelaeaeae	Pimelea	axiflora subsp. alpina	Shrub or Tree	Likely Native	58	1	58
Otu157	ITS2	Magnoliopsida	Malvales	Thymelaeaeae	Pimelea	alpina	Shrub or Tree	Likely Native	51	3	17
Otu158	ITS2	Magnoliopsida	Fabales	Fabaceae	Podolobium	alpestre	Shrub or Tree	Likely Native	49	2	25
Otu166	ITS2	Magnoliopsida	Asterales	Stylidiaceae	Stylidium		Forb	Likely Native	33	1	33
Otu168	ITS2	Magnoliopsida	Proteales	Proteaceae	Grevillea		Shrub or Tree	Likely Native	36	3	12
Otu173	ITS2	Magnoliopsida	Ranunculales	Ranunculaceae	Ranunculus		Forb	Likely Native	58	2	29
Otu180	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	9	1	9
Otu185	ITS2	Magnoliopsida	Ericales	Ericaceae	Acrothamnus		Shrub or Tree	Likely Native	36	1	36
Otu186	ITS2	Magnoliopsida	Asterales	Asteraceae	Senecio	pinnatifolius	Forb	Likely Native	43	1	43
Otu188	ITS2	Pinopsida	Pinales	Podocarpaceae	Podocarpus	lawrencei	Shrub or Tree	Likely Native	33	1	33
Otu190	ITS2	Magnoliopsida	Asterales	Asteraceae	Leptorhynchos	squamatus	Forb	Likely Native	20	1	20
Otu191	ITS2	Magnoliopsida	Caryophyllales	Montiaceae	Montia	australasica	Forb	Likely Native	71	1	71
Otu200	ITS2	Magnoliopsida	Malpighiales	Salicaceae	Salix	cinerea	Shrub or Tree	Likely Exotic	9	1	9
Otu202	ITS2	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	45	2	23
Otu205	ITS2	Magnoliopsida	Asterales	Asteraceae	Leptinella		Forb	Likely Native	44	1	44
Otu216	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	14	1	14
Otu217	ITS2	Magnoliopsida	Asterales	Stylidiaceae	Stylidium		Forb	Likely Native	47	1	47
Otu223	ITS2	Magnoliopsida	Asterales	Asteraceae	Leptinella		Forb	Likely Native	26	1	26
Otu225	ITS2	Magnoliopsida	Asterales	Asteraceae	Microseris	lanceolata	Forb	Likely Native	58	3	19
Otu231	ITS2	Magnoliopsida	Caryophyllales	Caryophyllaceae	Cerastium		Forb	Likely Exotic	25	1	25
Otu241	ITS2	Magnoliopsida	Asparagales	Amarylidaceae	Allium		Forb	Likely Exotic	14	1	14
Otu248	ITS2	Magnoliopsida	Poales	Juncaceae	Luzula		Grass-like Plants	Likely Native	8	1	8
Otu250	ITS2	Magnoliopsida	Solanales	Convulvulaceae	Dichondra	repens	Forb	Likely Native	19	1	19

Otu252	ITS2	Bryopsida	Dicranales	Ditrichaceae	Ceratodon	purpureus	Mosses	Unknown	78	2	39
Otu253	ITS2	Bryopsida	Pottiales	Pottiaceae	Oncophorus	elongatus	Mosses	Unknown	14	1	14
Otu258	ITS2	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus		Forb	Likely Native	12	1	12
Otu270	ITS2	Bryopsida	Bryales	Mniaceae	Pohlia	nutans	Mosses	Unknown	22	1	22
Otu272	ITS2	Magnoliopsida	Asterales	Stylidiaceae	Stylidium		Forb	Likely Native	18	1	18
Otu277	ITS2	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	19	2	10
Otu280	ITS2	Magnoliopsida	Asterales	Asteraceae	Leptinella	filicula	Forb	Likely Native	12	1	12
Otu284	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	21	1	21
Otu291	ITS2	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus		Forb	Likely Native	54	2	27
Otu293	ITS2	Magnoliopsida	Asterales	Asteraceae	Brachyscome	decipiens	Forb	Likely Native	10	1	10
Otu295	ITS2	Magnoliopsida	Poales	Cyperaceae	Carex		Grass-like Plants	Likely Native	21	2	11
Otu300	ITS2	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle		Forb	Likely Native	19	1	19
Otu301	ITS2	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	14	1	14
Otu308	ITS2	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	teucrioides	Forb	Likely Native	9	1	9
Otu317	ITS2	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	5	1	5
Otu320	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	10	1	10
Otu321	ITS2	Magnoliopsida	Asterales	Stylidiaceae			Forb	Unknown	16	1	16
Otu325	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae			Forb	Unknown	17	1	17
Otu330	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	8	1	8
Otu333	ITS2	Magnoliopsida	Asterales	Asteraceae			Forb	Unknown	37	1	37
Otu341	ITS2	Magnoliopsida	Asterales	Stylidiaceae	Stylidium		Forb	Likely Native	12	1	12
Otu351	ITS2	Magnoliopsida	Asterales	Asteraceae			Forb	Unknown	9	1	9
Otu353	ITS2	Magnoliopsida	Asterales	Asteraceae	Ozothamnus		Shrub or Tree	Likely Native	10	1	10
Otu355	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	7	1	7
Otu361	ITS2	Bryopsida	Hypnales	Brachytheciaceae	Brachytheciastrum		Mosses	Unknown	6	1	6
Otu364	ITS2	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	35	1	35

Otu381	ITS2	Magnoliopsida	Asterales	Asteraceae	Celmisia		Forb	Likely Native	361	4	90
Otu384	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	25	1	25
Otu386	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	9	1	9
Otu387	ITS2	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus		Forb	Likely Native	6	1	6
Otu399	ITS2	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	82	1	82
Otu401	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Lophostemon	confertus	Shrub or Tree	Likely Exotic	7	1	7
Otu402	ITS2	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	13	1	13
Otu406	ITS2	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	12	1	12
Otu408	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	5	1	5
Otu419	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	7	1	7
Otu427	ITS2	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	6	1	6
Otu432	ITS2	Pinopsida	Pinales	Podocarpaceae	Podocarpus		Shrub or Tree	Likely Native	7	1	7
Otu439	ITS2	Magnoliopsida	Rosales	Rosaceae			Forb	Unknown	10	1	10
Otu444	ITS2	Magnoliopsida	Asterales	Goodeniaceae	Goodenia		Shrub or Tree	Likely Native	10	1	10
Otu450	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	9	1	9
Otu452	ITS2	Magnoliopsida	Lamiales	Lamiaceae	Mentha		Forb	Likely Exotic	6	1	6
Otu460	ITS2	Magnoliopsida	Asterales	Asteraceae	Cirsium	vulgare	Forb	Likely Exotic	8	1	8
Otu464	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	11	1	11
Otu466	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	9	1	9
Otu470	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	9	1	9
Otu476	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	178	4	45
Otu479	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	24	3	8
Otu481	ITS2	Magnoliopsida	Laurales	Monimiaceae			Shrub or Tree	Unknown	5	1	5
Otu484	ITS2	Pinopsida	Pinales	Podocarpaceae	Podocarpus		Shrub or Tree	Likely Native	6	1	6
Otu491	ITS2	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	13	1	13
Otu504	ITS2	Magnoliopsida	Asterales	Stylidiaceae	Stylidium		Forb	Likely Native	9	1	9

Otu507	ITS2	Magnoliopsida	Asterales	Stylidiaceae	Stylidium		Forb	Likely Native	5	1	5
Otu519	ITS2	Magnoliopsida	Asterales	Asteraceae	Olearia		Forb	Likely Native	62	1	62
Otu536	ITS2	Jungermanniopsida	Jungermanniales	Lophocoleaceae	Chiloscyphus		Liverworts	Unknown	5	1	5
Otu544	ITS2	Magnoliopsida	Apiales	Apiaceae			Forb	Unknown	13	1	13
Otu550	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	38	1	38
Otu552	ITS2	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	34	1	34
Otu570	ITS2	Pinopsida	Pinales	Podocarpaceae			Shrub or Tree	Unknown	24	1	24
Otu597	ITS2	Magnoliopsida	Poales	Poaceae	Anthosachne		Grass	Likely Native	5	1	5
Otu1	rbcLFWD	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	178331	12	14861
Otu1	rbcLREV	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	143612	12	11968
Otu2	rbcLFWD	Magnoliopsida	Saxifragales	Haloragaceae	Myriophyllum		Forb	Likely Native	71891	9	7988
Otu2	rbcLREV	Magnoliopsida	Saxifragales	Haloragaceae	Myriophyllum		Forb	Likely Native	64354	9	7150
Otu3	rbcLREV	Magnoliopsida	Malpighiales	Violaceae	Viola		Forb	Likely Native	33158	1	33158
Otu3	rbcLFWD	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	Likely Native	27120	6	4520
Otu4	rbcLFWD	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	Likely Exotic	31290	10	3129
Otu4	rbcLREV	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	Likely Native	22876	6	3813
Otu5	rbcLFWD	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	Likely Native	32726	2	16363
Otu5	rbcLREV	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	Likely Native	15487	2	7744
Otu6	rbcLFWD	Magnoliopsida	Malpighiales	Violaceae	Viola		Forb	Likely Native	36690	1	36690
Otu6	rbcLREV	Jungermanniopsida	Jungermanniales	Cephaloziellaceae	Cephaloziella	spinicaulis	Mosses and Liverworts	Unknown	12249	1	12249
Otu7	rbcLREV	Magnoliopsida	Fabales	Fabaceae	Trifolium	repens	Forb	Likely Exotic	17455	2	8728
Otu7	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	15962	4	3991
Otu8	rbcLFWD	Magnoliopsida	Poales	Poaceae	Poa		Grass	Likely Native	14699	6	2450
Otu9	rbcLREV	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	13290	4	3323
Otu9	rbcLFWD	Jungermanniopsida	Jungermanniales	Cephaloziellaceae	Cephaloziella	spinicaulis	Mosses and Liverworts	Unknown	13352	1	13352
Otu10	rbcLFWD	Magnoliopsida	Asterales	Asteraceae	Cotula	australis	Forb	Unknown	11175	5	2235

Otu10	rbcLREV	Magnoliopsida	Asterales	Asteraceae	Cotula	australis	Forb	Unknown	9071	2	4536
Otu11	rbcLFWD	Magnoliopsida	Fabales	Fabaceae	Trifolium	repens	Forb	Likely Exotic	10092	1	10092
Otu12	rbcLREV	Bryopsida	Dicranidales	Ditrichaceae	Ceratodon	purpureus	Mosses and Liverworts	Unknown	6166	3	2055
Otu12	rbcLFWD	Bryopsida	Fissidentales	Fissidentaceae	Ditrichum	flexicaule	Mosses and Liverworts	Unknown	6789	2	3395
Otu13	rbcLREV	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	Likely Exotic	19009	10	1901
Otu13	rbcLFWD	Magnoliopsida	Solanales	Solanaceae	Solanum		Shrub or Tree	Likely Exotic	8144	1	8144
Otu14	rbcLREV	Magnoliopsida	Poales	Poaceae	Cenchrus		Grass	Likely Exotic	9466	1	9466
Otu15	rbcLREV	Magnoliopsida	Poales	Poaceae	Poa		Grass	Likely Native	11057	6	1843
Otu15	rbcLFWD	Magnoliopsida	Poales	Poaceae			Grass	Unknown	10924	1	10924
Otu16	rbcLFWD	Magnoliopsida	Fagales	Casuarinaceae	Allocasuarina	verticillata	Shrub or Tree	Likely Exotic	5320	1	5320
Otu16	rbcLREV	Magnoliopsida	Solanales	Solanaceae	Solanum		Shrub or Tree	Likely Exotic	7011	1	7011
Otu17	rbcLREV	Magnoliopsida	Fagales	Casuarinaceae	Allocasuarina	verticillata	Shrub or Tree	Likely Exotic	4483	1	4483
Otu18	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Shrub or Tree	Likely Native	3823	1	3823
Otu18	rbcLREV	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Shrub or Tree	Likely Native	3357	1	3357
Otu19	rbcLREV	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Shrub or Tree	Likely Native	2076	2	1038
Otu19	rbcLFWD	Magnoliopsida	Rosales	Urticaceae	Australina	pusilla	Forb	Likely Native	2992	1	2992
Otu20	rbcLFWD	Magnoliopsida	Caryophyllales	Caryophyllaceae	Scleranthus		Forb	Likely Native	3413	1	3413
Otu21	rbcLREV	Magnoliopsida	Sapindales	Rutaceae	Asterolasia	asteriscophora	Shrub or Tree	Likely Native	1551	1	1551
Otu22	rbcLFWD	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Shrub or Tree	Likely Native	2349	2	1175
Otu24	rbcLREV	Magnoliopsida	Caryophyllales	Caryophyllaceae	Scleranthus		Forb	Likely Native	2815	1	2815
Otu25	rbcLFWD	Magnoliopsida	Fabales	Fabaceae	Medicago		Forb	Likely Exotic	10901	1	10901
Otu25	rbcLREV	Bryopsida	Bryales	Bryaceae			Mosses and Liverworts	Unknown	1794	3	598
Otu27	rbcLFWD	Magnoliopsida	Sapindales	Rutaceae	Boronia		Shrub or Tree	Likely Native	1702	2	851
Otu27	rbcLREV	Magnoliopsida	Rosales	Urticaceae	Australina	pusilla	Forb	Likely Native	2455	1	2455
Otu29	rbcLREV	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	520	2	260
Otu34	rbcLFWD	Magnoliopsida	Asterales	Asteraceae	Hypochaeris	radicata	Forb	Likely Exotic	299	1	299

Otu34	rbcLREV	Pinopsida	Pinales	Cupressaceae	Cupressus		Shrub or Tree	Likely Exotic	458	1	458
Otu35	rbcLREV	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	825	1	825
Otu35	rbcLFWD	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	552	2	276
Otu36	rbcLFWD	Bryopsida	Bryales	Mniaceae	Pohlia	nutans	Mosses and Liverworts	Unknown	550	1	550
Otu38	rbcLREV	Magnoliopsida	Laurales	Atherospermataceae	Atherosperma	moschatum	Shrub or Tree	Likely Native	219	1	219
Otu39	rbcLREV	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria	media	Forb	Likely Exotic	212	1	212
Otu39	rbcLFWD	Pinopsida	Pinales	Cupressaceae	Cupressus		Shrub or Tree	Likely Exotic	475	1	475
Otu41	rbcLFWD	Polypodiopsida	Polypodiales	Dryopteridaceae	Polystichum		Fern	Likely Native	349	1	349
Otu41	rbcLREV	Polypodiopsida	Polypodiales	Dryopteridaceae	Polystichum		Fern	Likely Native	284	1	284
Otu42	rbcLFWD	Magnoliopsida	Poales	Poaceae	Anthosachne		Grass	Likely Native	232	1	232
Otu44	rbcLFWD	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria	angustifolia	Forb	Likely Native	235	1	235
Otu45	rbcLFWD	Magnoliopsida	Laurales	Atherospermataceae	Atherosperma	moschatum	Shrub or Tree	Likely Native	235	1	235
Otu45	rbcLREV	Magnoliopsida	Poales	Poaceae	Rytidosperma		Grass	Likely Native	98	1	98
Otu46	rbcLREV	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	Likely Native	183	2	92
Otu47	rbcLFWD	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	Likely Native	207	2	104
Otu47	rbcLREV	Bryopsida	Bryales	Bryaceae			Mosses and Liverworts	Unknown	355	1	355
Otu48	rbcLFWD	Magnoliopsida	Apiales	Apiaceae	Daucus	glochidiatus	Forb	Likely Native	138	1	138
Otu49	rbcLFWD	Magnoliopsida	Poales	Restionaceae	Empodisma	minus	Forb	Likely Native	80	1	80
Otu49	rbcLREV	Magnoliopsida	Poales	Restionaceae	Empodisma	minus	Forb	Likely Native	71	1	71
Otu51	rbcLREV	Magnoliopsida	Apiales	Apiaceae			Forb	Unknown	113	1	113
Otu54	rbcLREV	Magnoliopsida	Poales	Poaceae	Anthosachne		Grass	Likely Native	169	1	169
Otu54	rbcLFWD	Magnoliopsida	Poales	Poaceae	Rytidosperma	pallidum	Grass	Likely Native	90	1	90
Otu58	rbcLFWD	Magnoliopsida	Geraniales	Geraniaceae	Geranium		Forb	Likely Native	43	1	43
Otu58	rbcLREV	Magnoliopsida	Geraniales	Geraniaceae	Geranium		Forb	Likely Native	40	1	40
Otu59	rbcLFWD	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	936	1	936
Otu61	rbcLFWD	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	3104	1	3104

Otu65	rbcLREV	Magnoliopsida	Asterales	Asteraceae			Forb	Unknown	1048	4	262
Otu67	rbcLFWD	Bryopsida	Bryales	Bryaceae			Mosses and Liverworts	Unknown	1404	2	702
Otu68	rbcLFWD	Bryopsida	Dicranales	Ditrichaceae			Mosses and Liverworts	Unknown	344	1	344
Otu73	rbcLFWD	Bryopsida	Bryales	Bryaceae			Mosses and Liverworts	Unknown	529	1	529
Otu82	rbcLREV	Magnoliopsida	Fabales	Fabaceae	Medicago		Forb	Likely Exotic	111	1	111
Otu84	rbcLREV	Magnoliopsida	Fabales	Fabaceae	Medicago		Forb	Likely Exotic	44	1	44
Otu87	rbcLREV	Magnoliopsida	Fabales	Fabaceae	Medicago		Forb	Likely Exotic	273	1	273
Otu92	rbcLFWD	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	267	4	67
Otu125	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	39	1	39

Table 8. Taxonomic table displaying the assignment of OTUs in the Wet Forest samples in Chapter 2. Sum refers to total number of sequence reads for each OTU. Count refers to the number of samples an OTU was detected in, and average read depth highlights the total reads on average for OTUs across detected samples.

OTU ID	Locus	Class	Order	Family	Genus	Species	Growth Form	Origin	Sum	Count	Average Read Depth
Otu1	trnL	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	192048	16	12003
Otu2	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	71870	19	3783
Otu3	trnL	Magnoliopsida	Poales	Poaceae	Microlaena	stipoides	Grass	Likely Native	46700	17	2747
Otu4	trnL	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum	cartilagineum	Fern	Likely Native	27129	7	3876
Otu5	trnL	Magnoliopsida	Poales	Juncaceae	Juncus		Grass-like Plants	Likely Native	27417	3	9139
Otu7	trnL	Polypodiopsida	Polypodiales	Dennstaedtiaceae	Pteridium	esculentum	Fern	Likely Native	16117	13	1240
Otu8	trnL	Magnoliopsida	Poales	Poaceae	Anthoxanthum	odoratum	Grass	Likely Exotic	21164	15	1411
Otu9	trnL	Magnoliopsida	Poales	Poaceae	Poa		Grass	Likely Native	23188	17	1364
Otu10	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	16695	12	1391
Otu11	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	35122	19	1849
Otu12	trnL	Magnoliopsida	Asterales	Asteraceae			Forb	Unknown	14096	15	940
Otu13	trnL	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	12737	18	708
Otu14	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	15971	13	1229
Otu15	trnL	Polypodiopsida	Cyatheales	Cyatheaceae	Cyathea		Fern	Likely Native	8900	12	742
Otu17	trnL	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	Likely Exotic	7147	9	794
Otu18	trnL	Magnoliopsida	Fabales	Fabaceae	Lotus		Forb	Likely Exotic	7055	13	543
Otu19	trnL	Magnoliopsida	Fabales	Fabaceae	Pultenaea		Shrub or Tree	Likely Native	6256	6	1043
Otu20	trnL	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	5304	11	482
Otu21	trnL	Magnoliopsida	Gentianales	Rubiaceae	Asperula		Forb	Likely Native	8274	7	1182
Otu22	trnL	Magnoliopsida	Fagales	Fagaceae	Quercus	robur	Shrub or Tree	Likely Exotic	4808	1	4808
Otu23	trnL	Magnoliopsida	Lamiales	Lamiaceae	Prostanthera		Shrub or Tree	Likely Native	4720	12	393

Otu24	trnL	Magnoliopsida	Fabales	Fabaceae	Desmodium	gunnii	Forb	Likely Native	3597	4	899
Otu26	trnL	Magnoliopsida	Lamiales	Plantaginaceae	Plantago	lanceolata	Forb	Likely Exotic	4079	10	408
Otu27	trnL	Magnoliopsida	Oxalidales	Elaeocarpaceae	Tetratheca		Shrub or Tree	Likely Native	3829	6	638
Otu28	trnL	Magnoliopsida	Poales	Poaceae	Ehrharta	erecta	Grass	Likely Exotic	3050	2	1525
Otu30	trnL	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle		Forb	Likely Native	2797	3	932
Otu31	trnL	Magnoliopsida	Lamiales	Plantaginaceae	Gratiola		Forb	Likely Native	2834	1	2834
Otu32	trnL	Magnoliopsida	Rosales	Rhamnaceae	Spyridium	parvifolium	Shrub or Tree	Likely Native	2589	9	288
Otu33	trnL	Magnoliopsida	Geraniales	Geraniaceae	Geranium		Forb	Likely Native	2797	17	165
Otu34	trnL	Magnoliopsida	Poales	Poaceae	Dactylis	glomerata	Grass	Likely Exotic	2425	9	269
Otu35	trnL	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	3142	11	286
Otu36	trnL	Magnoliopsida	Poales	Cyperaceae	Carex		Grass-like Plants	Likely Native	2855	2	1428
Otu37	trnL	Magnoliopsida	Poales	Poaceae	Rytidosperma		Grass	Likely Native	2023	7	289
Otu38	trnL	Polypodiopsida	Cyatheales	Dicksoniaceae	Dicksonia	antarctica	Fern	Likely Native	1479	14	106
Otu39	trnL	Magnoliopsida	Poales	Poaceae	Holcus	lanatus	Grass	Likely Exotic	1149	9	128
Otu40	trnL	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	1295	7	185
Otu41	trnL	Magnoliopsida	Proteales	Proteaceae	Persoonia		Shrub or Tree	Likely Native	1345	7	192
Otu42	trnL	Magnoliopsida	Oxalidales	Cunoniaceae	Bauera	rubioides	Shrub or Tree	Likely Native	1728	4	432
Otu43	trnL	Pinopsida	Pinales	Pinaceae			Shrub or Tree	Unknown	1204	3	401
Otu46	trnL	Magnoliopsida	Caryophyllales	Polygonaceae	Persicaria		Forb	Likely Native	977	4	244
Otu47	trnL	Magnoliopsida	Rosales	Urticaceae	Urtica		Forb	Likely Native	923	8	115
Otu48	trnL	Pinopsida	Pinales	Pinaceae	Pinus	radiata	Shrub or Tree	Likely Exotic	1044	5	209
Otu49	trnL	Magnoliopsida	Poales	Cyperaceae	Lepidosperma	tortuosum	Grass-like Plants	Likely Native	874	7	125
Otu50	trnL	Magnoliopsida	Caryophyllales	Polygonaceae	Persicaria		Forb	Likely Native	264	3	88
Otu51	trnL	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	Likely Native	424	4	106
Otu52	trnL	Magnoliopsida	Poales	Poaceae			Grass	Unknown	972	7	139
Otu53	trnL	Magnoliopsida	Sapindales	Rutaceae	Zieria		Shrub or Tree	Likely Native	788	2	394
Otu54	trnL	Magnoliopsida	Fagales	Nothofagaceae	Nothofagus	cunninghamii	Shrub or Tree	Likely Native	858	1	858
Otu55	trnL	Magnoliopsida	Sapindales	Rutaceae			Shrub or Tree	Unknown	815	1	815

Otu56	trnL	Magnoliopsida	Fabales	Fabaceae	Glycine		Shrub or Tree	Likely Native	606	3	202
Otu58	trnL	Magnoliopsida	Laurales	Lauraceae			Shrub or Tree	Unknown	776	7	111
Otu60	trnL	Magnoliopsida	Poales	Poaceae	Phragmites	australis	Grass	Likely Native	620	1	620
Otu61	trnL	Magnoliopsida	Asterales	Asteraceae	Cirsium		Forb	Likely Exotic	410	5	82
Otu62	trnL	Magnoliopsida	Myrtales	Myrtaceae	Kunzea		Shrub or Tree	Likely Native	501	3	167
Otu63	trnL	Magnoliopsida	Rosales	Rosaceae	Cotoneaster		Shrub or Tree	Likely Exotic	293	3	98
Otu65	trnL	Polypodiopsida	Cyatheales	Dicksoniaceae	Calochlaena	dubia	Fern	Likely Native	279	8	35
Otu66	trnL	Magnoliopsida	Ericales	Ericaceae			Shrub or Tree	Unknown	449	3	150
Otu67	trnL	Magnoliopsida	Solanales	Solanaceae	Solanum	nigrum	Shrub or Tree	Likely Exotic	144	2	72
Otu68	trnL	Magnoliopsida	Oxalidales	Oxalidaceae	Oxalis	corniculata	Forb	Likely Exotic	407	6	68
Otu69	trnL	Magnoliopsida	Rosales	Rosaceae	Aphanes	arvensis	Forb	Likely Exotic	10	1	10
Otu70	trnL	Magnoliopsida	Lamiales	Plantaginaceae	Plantago		Forb	Unknown	48	2	24
Otu75	trnL	Magnoliopsida	Malpighiales	Salicaceae	Populus		Shrub or Tree	Likely Exotic	408	3	136
Otu78	trnL	Magnoliopsida	Asterales	Goodeniaceae	Goodenia		Shrub or Tree	Likely Native	349	4	87
Otu83	trnL	Magnoliopsida	Ranunculales	Ranunculaceae	Clematis		Forb	Likely Native	287	4	72
Otu88	trnL	Magnoliopsida	Asterales	Campanulaceae	Wahlenbergia		Forb	Likely Native	10	1	10
Otu89	trnL	Magnoliopsida	Poales	Cyperaceae	Lepidosperma		Grass-like Plants	Likely Native	262	4	66
Otu90	trnL	Magnoliopsida	Ranunculales	Ranunculaceae	Ranunculus	repens	Forb	Likely Exotic	238	2	119
Otu91	trnL	Magnoliopsida	Lamiales	Bignoniaceae	Pandorea	pandorana	Shrub or Tree	Likely Native	275	3	92
Otu93	trnL	Polypodiopsida	Polypodiales	Dryopteridaceae	Polystichum	proliferum	Fern	Likely Native	130	6	22
Otu95	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	171	4	43
Otu96	trnL	Magnoliopsida	Ericales	Primulaceae			Forb	Unknown	208	1	208
Otu98	trnL	Magnoliopsida	Myrtales	Lythraceae	Lythrum	salicaria	Forb	Unknown	211	1	211
Otu99	trnL	Magnoliopsida	Laurales	Lauraceae	Cassytha		Shrub or Tree	Likely Native	99	2	50
Otu100	trnL	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	180	1	180
Otu106	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	110	5	22
Otu108	trnL	Magnoliopsida	Malpighiales	Hypericaceae	Hypericum		Forb	Likely Exotic	133	3	44
Otu109	trnL	Magnoliopsida	Malpighiales	Euphorbiaceae	Amperea	xiphoclada	Shrub or Tree	Likely Native	142	1	142

Otu110	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	143	3	48
Otu112	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	135	3	45
Otu114	trnL	Magnoliopsida	Poales	Poaceae	Festuca		Grass	Likely Native	125	4	31
Otu117	trnL	Magnoliopsida	Ericales	Ericaceae	Rhododendron		Shrub or Tree	Unknown	121	1	121
Otu118	trnL	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	467	4	117
Otu119	trnL	Magnoliopsida	Fabales	Fabaceae	Acacia	melanoxyolon	Shrub or Tree	Likely Native	141	3	47
Otu120	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	15503	9	1723
Otu121	trnL	Magnoliopsida	Poales	Poaceae	Axonopus	fissifolius	Grass	Likely Exotic	110	3	37
Otu122	trnL	Magnoliopsida	Apiales	Araliaceae	Polyscias	sambucifolia	Shrub or Tree	Likely Native	90	2	45
Otu123	trnL	Magnoliopsida	Sapindales	Rutaceae	Correa		Shrub or Tree	Likely Native	481	5	96
Otu124	trnL	Pinopsida	Pinales	Cupressaceae	Callitris		Shrub or Tree	Likely Native	95	1	95
Otu126	trnL	Magnoliopsida	Santales	Loranthaceae	Muellerina	eucalyptoides	Shrub or Tree	Likely Native	67	3	22
Otu129	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	80	1	80
Otu130	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	114	1	114
Otu131	trnL	Magnoliopsida	Lamiales	Plantaginaceae	Plantago		Forb	Unknown	89	2	45
Otu134	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	152	5	30
Otu135	trnL	Magnoliopsida	Poales	Cyperaceae	Gahnia	sieberiana	Grass-like Plants	Likely Native	66	2	33
Otu136	trnL	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	111	2	56
Otu137	trnL	Polypodiopsida	Polypodiales	Pteridiaceae	Adiantum	aethiopicum	Creeper	Likely Native	88	1	88
Otu141	trnL	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	Likely Native	56	2	28
Otu142	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	85	1	85
Otu143	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	144	2	72
Otu147	trnL	Magnoliopsida	Malpighiales	Hypericaceae	Hypericum	androsaemum	Forb	Likely Exotic	64	2	32
Otu150	trnL	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	36	2	18
Otu151	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	65	1	65
Otu152	trnL	Magnoliopsida	Poales	Poaceae	Bromus	catharticus	Grass	Likely Exotic	65	1	65
Otu153	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	64	1	64
Otu156	trnL	Magnoliopsida	Fabales	Fabaceae	Goodia	lotifolia	Shrub or Tree	Likely Native	136	2	68

Otu159	trnL	Magnoliopsida	Ericales	Theaceae	Camelia		Shrub or Tree	Likely Exotic	62	1	62
Otu160	trnL	Magnoliopsida	Poales	Poaceae	Eragrostis	brownii	Grass	Likely Native	61	1	61
Otu161	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	66	1	66
Otu162	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	67	1	67
Otu163	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	64	1	64
Otu167	trnL	Magnoliopsida	Gentianales	Apocynaceae			Shrub or Tree	Unknown	42	1	42
Otu168	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	67	1	67
Otu176	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	231	2	116
Otu177	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	49	2	25
Otu178	trnL	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Native	57	3	19
Otu181	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	97	3	32
Otu184	trnL	Magnoliopsida	Poales	Juncaceae	Juncus		Grass-like Plants	Likely Native	56	1	56
Otu185	trnL	Magnoliopsida	Solanales	Convolvulaceae			Forb	Unknown	49	3	16
Otu186	trnL	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	45	1	45
Otu187	trnL	Magnoliopsida	Myrtales	Myrtaceae	Leptospermum		Shrub or Tree	Likely Native	153	2	77
Otu193	trnL	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	1122	10	112
Otu195	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	51	1	51
Otu196	trnL	Magnoliopsida	Brassicales	Brassicaceae	Brassica	oleracea	Forb	Likely Exotic	46	1	46
Otu197	trnL	Magnoliopsida	Asterales	Asteraceae	Helichrysum		Shrub or Tree	Likely Native	34	1	34
Otu198	trnL	Magnoliopsida	Myrtales	Myrtaceae	Leptospermum		Shrub or Tree	Likely Native	39	2	20
Otu205	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	27	2	14
Otu210	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	28	2	14
Otu212	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	24	1	24
Otu213	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	41	2	21
Otu216	trnL	Magnoliopsida	Fabales	Fabaceae	Indigofera	australis	Shrub or Tree	Likely Native	41	1	41
Otu217	trnL	Magnoliopsida	Poales	Juncaceae	Juncus		Grass-like Plants	Likely Native	41	1	41
Otu218	trnL	Magnoliopsida	Poales	Poaceae	Phleum	pratense	Grass	Likely Exotic	216	2	108
Otu222	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	38	1	38

Otu223	trnL	Magnoliopsida	Apiales	Pittosporaceae			Shrub or Tree	Unknown	33	2	17
Otu235	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	10	1	10
Otu238	trnL	Pinopsida	Pinales	Cupressaceae			Shrub or Tree	Unknown	30	1	30
Otu240	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	32	1	32
Otu241	trnL	Polypodiopsida	Polypodiales	Dennstaedtiaceae	Histiopteris	incisa	Fern	Likely Native	28	1	28
Otu245	trnL	Magnoliopsida	Poales	Poaceae			Grass	Unknown	35	1	35
Otu257	trnL	Magnoliopsida	Malpighiales	Euphorbiaceae	Ricinus	communis	Shrub or Tree	Likely Exotic	46	1	46
Otu261	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	33	1	33
Otu269	trnL	Magnoliopsida	Apiales	Pittosporaceae			Shrub or Tree	Unknown	28	1	28
Otu271	trnL	Pinopsida	Pinales	Pinaceae			Shrub or Tree	Unknown	32	1	32
Otu272	trnL	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	Likely Native	31	1	31
Otu275	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	27	1	27
Otu280	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	78	2	39
Otu282	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	53	2	27
Otu285	trnL	Magnoliopsida	Laurales	Lauraceae	Cassytha		Shrub or Tree	Likely Native	39	1	39
Otu288	trnL	Magnoliopsida	Rosales	Rosaceae	Potentilla	recta	Shrub or Tree	Likely Exotic	15	1	15
Otu295	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	13	1	13
Otu300	trnL	Magnoliopsida	Poales	Poaceae			Grass	Unknown	29	2	15
Otu301	trnL	Magnoliopsida	Fabales	Fabaceae			Shrub or Tree	Unknown	15	1	15
Otu312	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	30	1	30
Otu314	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	23	1	23
Otu315	trnL	Magnoliopsida	Poales	Poaceae			Grass	Unknown	11	1	11
Otu318	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	22	1	22
Otu320	trnL	Magnoliopsida	Poales	Cyperaceae	Lepidosperma		Grass-like Plants	Likely Native	15	1	15
Otu330	trnL	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	331	4	83
Otu331	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	10	1	10
Otu335	trnL	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	14	1	14
Otu339	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	20	1	20

Otu341	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	10	1	10
Otu343	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	24	1	24
Otu346	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	18	1	18
Otu347	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	24	1	24
Otu348	trnL	Magnoliopsida	Apiales	Apiaceae	Centella	cordifolia	Forb	Likely Native	17	1	17
Otu351	trnL	Magnoliopsida	Fabales	Fabaceae			Shrub or Tree	Unknown	33	1	33
Otu358	trnL	Pinopsida	Pinales	Cuppressaceae			Shrub or Tree	Unknown	20	1	20
Otu394	trnL	Pinopsida	Pinales	Podocarpaceae	Podocarpus	lawrencei	Shrub or Tree	Likely Native	15	1	15
Otu396	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	17	1	17
Otu403	trnL	Magnoliopsida	Poales	Cyperaceae	Gahnia		Grass-like Plants	Likely Native	15	1	15
Otu409	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	10	1	10
Otu411	trnL	Polypodiopsida	Osmundales	Osmundaceae	Todea	barbara	Fern	Likely Native	13	1	13
Otu416	trnL	Magnoliopsida	Asparagales	Iridaceae	Sisyrinchium	micranthum	Forb	Likely Exotic	11	1	11
Otu418	trnL	Magnoliopsida	Poales	Poaceae	Agrostis		Grass	Likely Native	22	1	22
Otu424	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	10	1	10
Otu426	trnL	Magnoliopsida	Asterales	Asteraceae	Helichrysum		Shrub or Tree	Likely Native	11	1	11
Otu427	trnL	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	11	1	11
Otu428	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	13	1	13
Otu436	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	16	1	16
Otu438	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	13	1	13
Otu442	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	11	1	11
Otu448	trnL	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	1678	11	153
Otu451	trnL	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	10	1	10
Otu456	trnL	Magnoliopsida	Rosales	Rhamnaceae			Shrub or Tree	Unknown	11	1	11
Otu466	trnL	Magnoliopsida	Poales	Poaceae	Poa		Grass	Likely Native	10	1	10
Otu484	trnL	Magnoliopsida	Lamiales	Lamiaceae	Prostanthera		Shrub or Tree	Likely Native	10	1	10
Otu504	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	17	1	17
Otu509	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	13	1	13

Otu516	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	16	1	16
Otu528	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	10	1	10
Otu533	trnL	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	126	1	126
Otu549	trnL	Magnoliopsida	Fagales	Fagaceae	Quercus	robur	Shrub or Tree	Likely Exotic	13	1	13
Otu558	trnL	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	10	1	10
Otu559	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	14	1	14
Otu575	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	32	2	16
Otu577	trnL	Magnoliopsida	Poales	Poaceae			Grass	Unknown	10	1	10
Otu586	trnL	Magnoliopsida	Poales	Poaceae	Dichelachne	crinita	Grass	Likely Native	1054	7	151
Otu588	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	357	4	89
Otu598	trnL	Magnoliopsida	Asterales	Asteraceae	Erigeron		Forb	Likely Exotic	352	8	44
Otu602	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	11	1	11
Otu627	trnL	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	10	1	10
Otu718	trnL	Magnoliopsida	Oxalidales	Cunoniaceae	Bauera	rubioides	Shrub or Tree	Likely Native	10	1	10
Otu819	trnL	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	488	7	70
Otu825	trnL	Magnoliopsida	Poales	Poaceae			Grass	Unknown	10	1	10
Otu859	trnL	Magnoliopsida	Asterales	Asteraceae	Helichrysum		Shrub or Tree	Likely Native	224	2	112
Otu891	trnL	Magnoliopsida	Ranunculales	Ranunculaceae	Clematis		Forb	Likely Native	120	3	40
Otu893	trnL	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle		Forb	Likely Native	88	3	29
Otu904	trnL	Magnoliopsida	Poales	Poaceae			Grass	Unknown	10	1	10
Otu1072	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	130	4	33
Otu1118	trnL	Magnoliopsida	Rosales	Rhamnaceae	Spyridium		Shrub or Tree	Likely Native	433	2	217
Otu1123	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	175	6	29
Otu1143	trnL	Magnoliopsida	Poales	Juncaceae	Juncus		Grass-like Plants	Likely Native	81	1	81
Otu1173	trnL	Magnoliopsida	Laurales	Lauraceae			Shrub or Tree	Unknown	234	2	117
Otu1181	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	11	1	11
Otu1231	trnL	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	89	3	30
Otu1253	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	41	2	21

Otu1313	trnL	Magnoliopsida	Fabales	Fabaceae			Shrub or Tree	Unknown	321	3	107
Otu1351	trnL	Magnoliopsida	Fabales	Fabaceae			Shrub or Tree	Unknown	243	3	81
Otu1360	trnL	Magnoliopsida	Ranunculales	Ranunculaceae	Clematis		Forb	Likely Native	50	3	17
Otu1375	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	155	6	26
Otu1380	trnL	Magnoliopsida	Poales	Poaceae			Grass	Unknown	25	1	25
Otu1433	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	211	7	30
Otu1785	trnL	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	68	2	34
Otu1898	trnL	Magnoliopsida	Poales	Juncaceae	Juncus		Grass-like Plants	Likely Native	26	1	26
Otu2411	trnL	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	29	1	29
Otu2465	trnL	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	22	1	22
Otu5	ITS2	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	83788	18	4655
Otu6	ITS2	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	31666	9	3518
Otu7	ITS2	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus		Forb	Likely Native	55548	14	3968
Otu10	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	32354	13	2489
Otu11	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	15848	9	1761
Otu15	ITS2	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	Likely Native	21031	17	1237
Otu16	ITS2	Magnoliopsida	Poales	Poaceae	Microlaena		Grass	Likely Native	9044	16	565
Otu18	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Leptostigma	breviflorum	Forb	Likely Native	4177	3	1392
Otu19	ITS2	Magnoliopsida	Lamiales	Plantaginaceae	Plantago	lanceolata	Forb	Likely Exotic	4305	13	331
Otu22	ITS2	Magnoliopsida	Lamiales	Lamiaceae			Shrub or Tree	Unknown	4187	11	381
Otu30	ITS2	Magnoliopsida	Fabales	Fabaceae	Pultenaea	muelleri	Shrub or Tree	Likely Native	4829	7	690
Otu31	ITS2	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle		Forb	Likely Native	2363	3	788
Otu32	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	3743	14	267
Otu34	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	3874	13	298
Otu38	ITS2	Magnoliopsida	Poales	Poaceae	Poa		Grass	Likely Native	1877	9	209
Otu40	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	4816	9	535
Otu41	ITS2	Magnoliopsida	Asterales	Asteraceae	Cassinia	aculeata	Shrub or Tree	Likely Native	2739	9	304
Otu42	ITS2	Magnoliopsida	Fagales	Fagaceae	Quercus	robur	Shrub or Tree	Likely Exotic	1363	1	1363

Otu43	ITS2	Magnoliopsida	Asterales	Asteraceae	Hypochaeris	radicata	Forb	Likely Exotic	626	9	70
Otu46	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Leptospermum	scoparium	Shrub or Tree	Likely Native	2643	4	661
Otu47	ITS2	Magnoliopsida	Oxalidales	Elaeocarpaceae	Tetratheca	cilata	Shrub or Tree	Likely Native	1500	4	375
Otu50	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus	regnans	Shrub or Tree	Likely Native	2165	8	271
Otu51	ITS2	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	Likely Native	1033	9	115
Otu55	ITS2	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle		Forb	Likely Native	21	2	11
Otu56	ITS2	Magnoliopsida	Rosales	Rosaceae	Aphanes	arvensis	Forb	Likely Exotic	14	1	14
Otu58	ITS2	Magnoliopsida	Fagales	Nothofagaceae	Nothofagus	cunninghamii	Shrub or Tree	Likely Native	1322	2	661
Otu59	ITS2	Magnoliopsida	Fabales	Fabaceae	Trifolium	repens	Forb	Likely Exotic	1969	3	656
Otu66	ITS2	Magnoliopsida	Myrtales	Lythraceae	Lythrum	hyssopifolia	Forb	Unknown	765	1	765
Otu69	ITS2	Magnoliopsida	Caryophyllales	Caryophyllaceae	Cerastium		Forb	Likely Exotic	12	1	12
Otu70	ITS2	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	1502	9	167
Otu73	ITS2	Magnoliopsida	Poales	Cyperaceae	Isolepis	inundata	Grass-like Plants	Likely Native	620	3	207
Otu76	ITS2	Magnoliopsida	Sapindales	Rutaceae	Correa	lawrenceana	Shrub or Tree	Likely Native	833	2	417
Otu79	ITS2	Magnoliopsida	Fabales	Fabaceae	Lotus	uliginosus	Forb	Likely Exotic	1273	11	116
Otu80	ITS2	Magnoliopsida	Fabales	Fabaceae	Platylobium		Shrub or Tree	Likely Native	669	1	669
Otu81	ITS2	Magnoliopsida	Lamiales	Plantaginaceae	Plantago	major	Forb	Likely Exotic	33	1	33
Otu82	ITS2	Magnoliopsida	Sapindales	Rutaceae	Zieria	arborescens	Shrub or Tree	Likely Native	580	2	290
Otu86	ITS2	Magnoliopsida	Poales	Poaceae	Holcus	lanatus	Grass	Likely Exotic	42	4	11
Otu87	ITS2	Magnoliopsida	Rosales	Urticaceae	Urtica	incisa	Forb	Likely Native	47	1	47
Otu93	ITS2	Magnoliopsida	Poales	Poaceae	Anthoxanthum	aristatum	Grass	Likely Exotic	565	13	43
Otu94	ITS2	Magnoliopsida	Poales	Juncaceae	Juncus	bulbosus	Grass-like Plants	Likely Exotic	358	2	179
Otu98	ITS2	Magnoliopsida	Asparagales	Amaryllidaceae	Allium	triquetrum	Forb	Likely Exotic	646	1	646
Otu101	ITS2	Magnoliopsida	Poales	Poaceae	Microlaena	stipoides	Grass	Likely Native	699	13	54
Otu102	ITS2	Magnoliopsida	Asterales	Asteraceae	Sonchus	oleraceus	Forb	Likely Exotic	5	1	5
Otu105	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Leptospermum	lanigerum	Shrub or Tree	Likely Native	455	5	91
Otu107	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Shrub or Tree	Likely Native	2221	4	555
Otu111	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	Likely Exotic	1530	6	255

Otu114	ITS2	Magnoliopsida	Lamiales	Plantaginaceae	Callitriche	stagnalis	Forb	Likely Exotic	174	1	174
Otu117	ITS2	Magnoliopsida	Cyatheales	Cyatheaceae	Cyathea		Fern	Likely Native	519	5	104
Otu118	ITS2	Magnoliopsida	Malpighiales	Salicaceae	Populus		Shrub or Tree	Likely Exotic	239	2	120
Otu125	ITS2	Magnoliopsida	Laurales	Monimiaceae	Hedycarya	angustifolia	Shrub or Tree	Likely Native	136	3	45
Otu126	ITS2	Magnoliopsida	Geraniales	Geraniaceae	Geranium		Forb	Likely Native	349	9	39
Otu131	ITS2	Magnoliopsida	Fagales	Fagaceae	Quercus		Shrub or Tree	Likely Exotic	226	1	226
Otu132	ITS2	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	128	3	43
Otu135	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Kunzea		Shrub or Tree	Likely Native	117	2	59
Otu136	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Persicaria		Forb	Likely Native	123	1	123
Otu138	ITS2	Magnoliopsida	Ericales	Ericaceae	Epacris		Shrub or Tree	Likely Native	110	2	55
Otu142	ITS2	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	Likely Native	135	5	27
Otu144	ITS2	Magnoliopsida	Proteales	Proteaceae	Lomatia		Shrub or Tree	Likely Native	197	5	39
Otu146	ITS2	Magnoliopsida	Asterales	Asteraceae	Argyrotegium	fordianum	Forb	Likely Native	124	2	62
Otu150	ITS2	Magnoliopsida	Poales	Poaceae	Agrostis	capillaris	Grass	Likely Exotic	188	9	21
Otu152	ITS2	Magnoliopsida	Fabales	Fabaceae	Acacia	verticillata	Shrub or Tree	Likely Native	83	4	21
Otu153	ITS2	Magnoliopsida	Poales	Poaceae	Anthoxanthum	odoratum	Grass	Likely Exotic	467	14	33
Otu156	ITS2	Magnoliopsida	Poales	Cyperaceae	Lepidosperma	laterale	Grass-like Plants	Likely Native	159	4	40
Otu159	ITS2	Magnoliopsida	Fabales	Fabaceae	Glycine	microphylla	Climber	Likely Native	101	3	34
Otu161	ITS2	Magnoliopsida	Fagales	Fagaceae	Quercus		Shrub or Tree	Likely Exotic	793	1	793
Otu162	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	57	1	57
Otu165	ITS2	Magnoliopsida	Asterales	Asteraceae	Olearia		Forb	Likely Native	116	4	29
Otu166	ITS2	Magnoliopsida	Asterales	Asteraceae	Cirsium	vulgare	Forb	Likely Exotic	103	4	26
Otu167	ITS2	Magnoliopsida	Santales	Loranthaceae	Muellerina	eucalyptoides	Shrub or Tree	Likely Native	83	2	42
Otu171	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	46	1	46
Otu172	ITS2	Magnoliopsida	Ericales	Ericaceae	Leucopogon		Shrub or Tree	Likely Native	112	1	112
Otu173	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Opercularia	varia	Forb	Likely Native	78	1	78
Otu174	ITS2	Magnoliopsida	Ericales	Primulaceae	Myrsine	howittiana	Shrub or Tree	Likely Native	64	1	64
Otu178	ITS2	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	59	2	30

Otu183	ITS2	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	Likely Native	209	5	42
Otu187	ITS2	Magnoliopsida	Poales	Poaceae	Dactylis	glomerata	Grass	Likely Exotic	67	3	22
Otu191	ITS2	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	56	3	19
Otu192	ITS2	Magnoliopsida	Malpighiales	Euphorbiaceae			Shrub or Tree	Unknown	40	1	40
Otu198	ITS2	Magnoliopsida	Fagales	Fagaceae	Quercus	robur	Shrub or Tree	Likely Exotic	31	1	31
Otu206	ITS2	Magnoliopsida	Lamiales	Lamiaceae	Prunella	vulgaris	Forb	Likely Exotic	55	3	18
Otu210	ITS2	Magnoliopsida	Oxalidales	Oxalidaceae	Oxalis	corniculata	Forb	Likely Exotic	46	1	46
Otu212	ITS2	Magnoliopsida	Apiales	Pittospiraceae	Billardiera	macrantha	Shrub or Tree	Likely Native	80	2	40
Otu213	ITS2	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	31	1	31
Otu220	ITS2	Magnoliopsida	Fabales	Fabaceae	Platylobium		Shrub or Tree	Likely Native	44	1	44
Otu221	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Spyridium	parvifolium	Shrub or Tree	Likely Native	54	2	27
Otu222	ITS2	Magnoliopsida	Ranunculales	Ranunculaceae	Ranunculus	repens	Forb	Likely Exotic	34	2	17
Otu225	ITS2	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	32	3	11
Otu227	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	20	1	20
Otu236	ITS2	Magnoliopsida	Poales	Poaceae	Dryopoa	dives	Grass	Likely Native	35	2	18
Otu237	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	19	1	19
Otu239	ITS2	Magnoliopsida	Fagales	Fagaceae	Quercus		Shrub or Tree	Likely Exotic	35	1	35
Otu246	ITS2	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	37	3	12
Otu248	ITS2	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	29	2	15
Otu251	ITS2	Magnoliopsida	Apiales	Apiaceae	Oreomyrrhis		Forb	Likely Native	21	2	11
Otu252	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	9	1	9
Otu255	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	25	1	25
Otu256	ITS2	Magnoliopsida	Asterales	Asteraceae	Leontodon	saxatilis	Forb	Likely Exotic	48	4	12
Otu257	ITS2	Magnoliopsida	Rosales	Rosaceae	Malus	pumila	Shrub or Tree	Likely Exotic	39	1	39
Otu258	ITS2	Magnoliopsida	Asparagales	Asphodelaceae	Dianella	tasmanica	Grass-like Plants	Likely Native	48	1	48
Otu259	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	193	4	48
Otu260	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	13	1	13
Otu261	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	64	1	64

Otu262	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	24	3	8
Otu263	ITS2	Magnoliopsida	Lamiales	Lamiaceae			Forb	Unknown	60	3	20
Otu265	ITS2	Magnoliopsida	Rosales	Rosaceae	Eriobotrya	japonica	Shrub or Tree	Likely Exotic	20	1	20
Otu266	ITS2	Magnoliopsida	Malvales	Thymelaeaeae	Pimelea	axiflora	Shrub or Tree	Likely Native	19	1	19
Otu267	ITS2	Magnoliopsida	Poales	Cyperaceae	Carex		Grass-like Plants	Likely Native	62	2	31
Otu279	ITS2	Magnoliopsida	Poales	Cyperaceae	Cyperus	eragrostis	Grass-like Plants	Likely Exotic	17	1	17
Otu281	ITS2	Magnoliopsida	Asterales	Asteraceae	Gamochaeta	americana	Forb	Likely Exotic	14	2	7
Otu286	ITS2	Magnoliopsida	Malpighiales	Hypericaceae	Hypericum	japonicum	Forb	Likely Native	18	2	9
Otu293	ITS2	Magnoliopsida	Apiales	Araliaceae	Polyscias	sambucifolia	Shrub or Tree	Likely Native	13	1	13
Otu299	ITS2	Magnoliopsida	Poales	Poaceae	Bromus	hordeaceus	Grass	Likely Exotic	11	1	11
Otu301	ITS2	Magnoliopsida	Ranunculales	Ranunculaceae	Clematis		Climber	Likely Native	13	1	13
Otu302	ITS2	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus		Forb	Likely Native	28	1	28
Otu306	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	35	2	18
Otu307	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	14	2	7
Otu312	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	9	1	9
Otu316	ITS2	Jungermanniopsida	Metzgeriales	Metzgeriaceae	Metzgeria	furcata	Liverwort	Unknown	16	1	16
Otu317	ITS2	Magnoliopsida	Sapindales	Rutaceae	Correa	reflexa	Shrub or Tree	Likely Native	46	2	23
Otu318	ITS2	Magnoliopsida	Malpighiales	Hypericaceae	Hypericum		Forb	Likely Exotic	23	1	23
Otu319	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	12	1	12
Otu320	ITS2	Magnoliopsida	Asterales	Asteraceae	Helianthus	annuus	Forb	Likely Exotic	20	1	20
Otu322	ITS2	Magnoliopsida	Poales	Poaceae	Dichelachne		Grass	Likely Native	17	1	17
Otu323	ITS2	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	8	1	8
Otu325	ITS2	Magnoliopsida	Poales	Poaceae	Setaria		Grass	Likely Exotic	20	2	10
Otu327	ITS2	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	15	1	15
Otu330	ITS2	Magnoliopsida	Lamiales	Plantaginaceae	Gratiola		Forb	Likely Native	37	1	37
Otu331	ITS2	Magnoliopsida	Poales	Poaceae	Lolium	multiflorum	Grass	Likely Exotic	31	2	16
Otu332	ITS2	Magnoliopsida	Rosales	Rosaceae	Malus	pumila	Shrub or Tree	Likely Exotic	103	2	52
Otu333	ITS2	Magnoliopsida	Fabales	Fabaceae	Lotus	subbiflorus	Forb	Likely Exotic	19	1	19

Otu334	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	13	1	13
Otu338	ITS2	Magnoliopsida	Asterales	Asteraceae	Olearia	argophylla	Forb	Likely Native	24	1	24
Otu340	ITS2	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	Likely Native	27	1	27
Otu345	ITS2	Magnoliopsida	Poales	Poaceae	Glyceria		Grass	Likely Exotic	6	1	6
Otu353	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	124	1	124
Otu354	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	10	1	10
Otu357	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	12	1	12
Otu364	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	15	1	15
Otu370	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	6	1	6
Otu371	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Nertera	granadensis	Forb	Likely Native	5	1	5
Otu372	ITS2	Magnoliopsida	Asterales	Asteraceae	Ozothamnus	stirlingii	Shrub or Tree	Likely Native	60	1	60
Otu377	ITS2	Magnoliopsida	Poales	Poaceae	Rytidosperma		Grass	Likely Native	5	1	5
Otu379	ITS2	Magnoliopsida	Rosales	Rosaceae	Potentilla	indica	Forb	Likely Exotic	5	1	5
Otu380	ITS2	Magnoliopsida	Asterales	Asteraceae	Senecio	phelleus	Forb	Likely Native	11	1	11
Otu381	ITS2	Magnoliopsida	Brassicales	Brassicaceae	Brassica	oleracea	Forb	Likely Exotic	9	1	9
Otu385	ITS2	Magnoliopsida	Asterales	Asteraceae	Cassinia	longifolia	Shrub or Tree	Likely Native	773	8	97
Otu387	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	34	1	34
Otu391	ITS2	Magnoliopsida	Saxifragales	Crassulaceae			Forb	Unknown	5	1	5
Otu401	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	19	1	19
Otu405	ITS2	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	Likely Native	67	1	67
Otu406	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	10	1	10
Otu409	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	10	1	10
Otu413	ITS2	Magnoliopsida	Asparagales	Asphodelaceae	Dianella		Grass-like Plants	Likely Native	6	1	6
Otu414	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	6	1	6
Otu416	ITS2	Magnoliopsida	Poales	Juncaceae	Juncus		Grass-like Plants	Likely Native	5	1	5
Otu417	ITS2	Magnoliopsida	Rosales	Rosaceae	Acaena		Shrub or Tree	Likely Native	5	1	5
Otu418	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Persicaria		Forb	Likely Native	14	1	14
Otu421	ITS2	Magnoliopsida	Ericales	Ericaceae	Rhododendron		Shrub or Tree	Unknown	10	1	10

Otu422	ITS2	Magnoliopsida	Asterales	Goodeniaceae	Goodenia	ovata	Shrub or Tree	Likely Native	10	2	5
Otu425	ITS2	Magnoliopsida	Lamiales	Plantaginaceae	Veronica	serpyllifolia	Forb	Unknown	7	1	7
Otu426	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	6	1	6
Otu432	ITS2	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	Likely Native	19	1	19
Otu450	ITS2	Magnoliopsida	Lamiales	Plantaginaceae	Plantago		Forb	Likely Native	7	1	7
Otu452	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	5	1	5
Otu453	ITS2	Magnoliopsida	Myrtales	Myrtaceae	Leptospermum		Shrub or Tree	Likely Native	7	1	7
Otu454	ITS2	Magnoliopsida	Poales	Poaceae	Phragmites	australis	Grass	Likely Native	9	1	9
Otu459	ITS2	Magnoliopsida	Rosales	Rosaceae	Malus	pumila	Shrub or Tree	Likely Exotic	18	1	18
Otu460	ITS2	Magnoliopsida	Asterales	Asteraceae	Cassinia		Shrub or Tree	Likely Native	7	1	7
Otu462	ITS2	Magnoliopsida	Gentianales	Apocynaceae	Parsonsia	brownii	Climber	Likely Native	9	1	9
Otu470	ITS2	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	7	1	7
Otu474	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	8	1	8
Otu478	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	6	1	6
Otu480	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	6	1	6
Otu482	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	44	2	22
Otu485	ITS2	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	5	1	5
Otu488	ITS2	Magnoliopsida	Asterales	Alseuosmiaceae	Wittsteinia	vacciniacea	Shrub or Tree	Likely Native	19	2	10
Otu492	ITS2	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	Likely Native	49	3	16
Otu503	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	12	1	12
Otu508	ITS2	Magnoliopsida	Rosales	Ulmaceae	Ulmus	procera	Shrub or Tree	Likely Exotic	12	2	6
Otu511	ITS2	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	12	2	6
Otu516	ITS2	Magnoliopsida	Caryophyllales	Polygonaceae	Rumex		Forb	Likely Exotic	57	3	19
Otu518	ITS2	Magnoliopsida	Asterales	Asteraceae	Euchiton		Forb	Likely Native	64	1	64
Otu520	ITS2	Magnoliopsida	Fabales	Fabaceae	Goodia	lotifolia	Shrub or Tree	Likely Native	17	1	17
Otu530	ITS2	Magnoliopsida	Poales	Poaceae	Paspalum	dilatatum	Grass	Likely Exotic	26	2	13
Otu547	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	5	1	5
Otu567	ITS2	Magnoliopsida	Ericales	Ericaceae	Rhododendron		Shrub or Tree	Unknown	5	1	5

Otu569	ITS2	Magnoliopsida	Poales	Poaceae			Grass	Unknown	6	1	6
Otu572	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	7	1	7
Otu575	ITS2	Magnoliopsida	Poales	Poaceae	Bromus	catharticus	Grass	Likely Exotic	14	1	14
Otu585	ITS2	Magnoliopsida	Fabales	Fabaceae	Trifolium		Forb	Likely Exotic	8	1	8
Otu595	ITS2	Magnoliopsida	Poales	Poaceae			Grass	Unknown	22	1	22
Otu598	ITS2	Magnoliopsida	Rosales	Rosaceae	Acaena		Forb	Likely Native	5	1	5
Otu605	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Shrub or Tree	Unknown	6	1	6
Otu616	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Shrub or Tree	Unknown	7	1	7
Otu635	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Shrub or Tree	Unknown	10	1	10
Otu639	ITS2	Magnoliopsida	Fabales	Fabaceae	Lotus		Forb	Likely Exotic	36	4	9
Otu643	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Shrub or Tree	Unknown	5	1	5
Otu668	ITS2	Magnoliopsida	Fabales	Fabaceae	Glycine		Climber	Likely Native	9	1	9
Otu670	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Shrub or Tree	Unknown	9	1	9
Otu680	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Shrub or Tree	Unknown	7	1	7
Otu683	ITS2	Magnoliopsida	Fagales	Fagaceae	Quercus		Shrub or Tree	Likely Exotic	497	1	497
Otu695	ITS2	Magnoliopsida	Apiales	Araliaceae			Shrub or Tree	Unknown	17	1	17
Otu715	ITS2	Magnoliopsida	Poales	Poaceae	Eragrostis	brownii	Grass	Likely Native	6	1	6
Otu722	ITS2	Magnoliopsida	Ericales	Ericaceae	Epacris		Shrub or Tree	Likely Native	6	1	6
Otu738	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	353	4	88
Otu763	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	12	1	12
Otu776	ITS2	Magnoliopsida	Rosales	Rosaceae			Shrub or Tree	Unknown	5	1	5
Otu787	ITS2	Magnoliopsida	Lamiales	Lamiaceae	Mentha		Forb	Likely Native	6	1	6
Otu799	ITS2	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	7	1	7
Otu802	ITS2	Magnoliopsida	Geraniales	Geraniaceae	Geranium		Forb	Likely Native	68	3	23
Otu805	ITS2	Magnoliopsida	Fagales	Fagaceae	Quercus		Shrub or Tree	Likely Exotic	9	1	9
Otu810	ITS2	Magnoliopsida	Solanales	Convulvulaceae	Ipomoea	indica	Forb	Likely Exotic	6	1	6
Otu854	ITS2	Magnoliopsida	Saxifragales	Haloragaceae			Forb	Unknown	5	1	5
Otu857	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Shrub or Tree	Unknown	5	1	5

Otu865	ITS2	Magnoliopsida	Gentianales	Rubiaceae			Shrub or Tree	Unknown	5	1	5
Otu868	ITS2	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	Likely Native	7	1	7
Otu874	ITS2	Magnoliopsida	Poales	Poaceae	Microlaena		Grass	Likely Native	7	1	7
Otu877	ITS2	Magnoliopsida	Ericales	Primulaceae	Lysimachia	arvensis	Forb	Likely Exotic	5	1	5
Otu887	ITS2	Magnoliopsida	Dipsacales	Caprifoliaceae	Sambucus	gaudichaudiana	Shrub or Tree	Likely Native	6	1	6
Otu912	ITS2	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Shrub or Tree	Likely Native	37	1	37
Otu917	ITS2	Magnoliopsida	Poales	Cyperaceae	Carex	fascicularis	Grass-like Plants	Likely Native	17	1	17
Otu1	rbcLFWD	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	204630	12	17053
Otu1	rbcLREV	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Shrub or Tree	Likely Native	193814	12	16151
Otu2	rbcLFWD	Magnoliopsida	Poales	Poaceae	Ehrharta	erecta	Grass	Likely Exotic	61033	17	3590
Otu2	rbcLREV	Magnoliopsida	Poales	Poaceae			Grass	Unknown	51912	17	3054
Otu3	rbcLFWD	Magnoliopsida	Poales	Poaceae	Anthoxanthum	odoratum	Grass	Likely Exotic	64389	18	3577
Otu3	rbcLREV	Magnoliopsida	Poales	Poaceae	Anthoxanthum	odoratum	Grass	Likely Exotic	48657	17	2862
Otu4	rbcLFWD	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	41524	16	2595
Otu4	rbcLREV	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	34154	16	2135
Otu5	rbcLFWD	Magnoliopsida	Poales	Juncaceae	Juncus	bulbosus	Grass-like Plants	Likely Exotic	24896	3	8299
Otu5	rbcLREV	Polypodiopsida	Polypodiales	Dennstaedtiaceae	Pteridium	esculentum	Fern	Likely Native	15881	12	1323
Otu6	rbcLFWD	Polypodiopsida	Polypodiales	Dennstaedtiaceae	Pteridium	esculentum	Fern	Likely Native	17075	12	1423
Otu6	rbcLREV	Magnoliopsida	Poales	Juncaceae	Juncus	bulbosus	Grass-like Plants	Likely Exotic	22692	3	7564
Otu7	rbcLFWD	Magnoliopsida	Saxifragales	Haloragaceae	Myriophyllum		Forb	Likely Native	20365	11	1851
Otu7	rbcLREV	Magnoliopsida	Saxifragales	Haloragaceae	Myriophyllum		Forb	Likely Native	17813	11	1619
Otu8	rbcLFWD	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	14007	7	2001
Otu8	rbcLREV	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Shrub or Tree	Likely Native	9532	11	867
Otu9	rbcLFWD	Polypodiopsida	Cyatheales	Cyatheaceae	Cyathea		Fern	Likely Native	9413	10	941
Otu9	rbcLREV	Polypodiopsida	Cyatheales	Cyatheaceae	Cyathea	australis	Fern	Likely Native	7842	10	784
Otu10	rbcLFWD	Magnoliopsida	Santalales	Santalaceae	Santalum		Forb	Likely Exotic	1137	6	190
Otu11	rbcLFWD	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	17218	15	1148
Otu12	rbcLREV	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Shrub or Tree	Likely Native	13303	14	950

Otu13	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae	Nertera	granadensis	Forb	Likely Native	10507	10	1051
Otu13	rbcLREV	Magnoliopsida	Poales	Cyperaceae	Isolepis		Grass-like Plants	Likely Native	6241	8	780
Otu14	rbcLFWD	Magnoliopsida	Geraniales	Geraniaceae	Geranium		Forb	Likely Native	5911	10	591
Otu14	rbcLREV	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum	cartilagineum	Fern	Likely Native	10729	8	1341
Otu15	rbcLFWD	Magnoliopsida	Oxalidales	Elaeocarpaceae	Elaeocarpus	reticulatus	Shrub or Tree	Likely Native	5527	5	1105
Otu15	rbcLREV	Magnoliopsida	Oxalidales	Elaeocarpaceae			Shrub or Tree	Unknown	4853	5	971
Otu16	rbcLFWD	Magnoliopsida	Poales	Cyperaceae	Isolepis		Grass-like Plants	Likely Native	5818	3	1939
Otu16	rbcLREV	Pinopsida	Pinales	Pinaceae			Shrub or Tree	Unknown	2676	4	669
Otu17	rbcLFWD	Magnoliopsida	Poales	Poaceae	Rytidosperma	pallidum	Grass	Likely Native	3553	4	888
Otu17	rbcLREV	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	5236	8	655
Otu18	rbcLREV	Magnoliopsida	Geraniales	Geraniaceae	Geranium		Forb	Likely Native	4858	9	540
Otu19	rbcLFWD	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	Likely Native	3110	12	259
Otu19	rbcLREV	Magnoliopsida	Poales	Poaceae	Rytidosperma		Grass	Likely Native	3102	4	776
Otu20	rbcLFWD	Magnoliopsida	Malpighiales	Violaceae	Viola		Forb	Likely Native	2636	4	659
Otu21	rbcLREV	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	Likely Native	3033	12	253
Otu22	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	2872	5	574
Otu22	rbcLREV	Magnoliopsida	Malpighiales	Violaceae	Viola		Forb	Likely Native	2310	4	578
Otu23	rbcLFWD	Magnoliopsida	Asterales	Asteraceae	Hypochaeris		Forb	Likely Exotic	1501	12	125
Otu24	rbcLFWD	Magnoliopsida	Lamiales	Plantaginaceae	Gratiola		Forb	Likely Native	2222	5	444
Otu24	rbcLREV	Magnoliopsida	Solanales	Convolvulaceae	Cuscuta		Forb	Likely Exotic	1252	1	1252
Otu25	rbcLFWD	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	Likely Exotic	1401	3	467
Otu26	rbcLFWD	Polypodiopsida	Cyatheales	Dicksoniaceae	Dicksonia	antarctica	Fern	Likely Native	1410	9	157
Otu26	rbcLREV	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	2465	5	493
Otu27	rbcLFWD	Magnoliopsida	Rosales	Rhamnaceae	Spyridium	parvifolium	Shrub or Tree	Likely Native	1412	5	282
Otu28	rbcLREV	Magnoliopsida	Lamiales	Plantaginaceae	Gratiola		Forb	Likely Native	1633	1	1633
Otu31	rbcLREV	Polypodiopsida	Cyatheales	Dicksoniaceae	Dicksonia	antarctica	Fern	Likely Native	1242	9	138
Otu32	rbcLFWD	Magnoliopsida	Fabales	Fabaceae	Desmodium		Forb	Likely Native	581	3	194
Otu32	rbcLREV	Magnoliopsida	Poales	Poaceae			Grass	Unknown	933	3	311

Otu33	rbcLREV	Magnoliopsida	Rosales	Rhamnaceae	Spyridium	parvifolium	Shrub or Tree	Likely Native	1234	5	247
Otu34	rbcLREV	Magnoliopsida	Fabales	Fabaceae	Desmodium		Forb	Likely Native	581	3	194
Otu35	rbcLREV	Magnoliopsida	Fagales	Fagaceae	Quercus	robur	Shrub or Tree	Likely Exotic	661	1	661
Otu36	rbcLREV	Magnoliopsida	Malpighiales	Hypericaceae	Hypericum		Forb	Likely Exotic	678	1	678
Otu37	rbcLFWD	Magnoliopsida	Fabales	Fabaceae	Trifolium	repens	Forb	Likely Exotic	739	1	739
Otu38	rbcLFWD	Magnoliopsida	Ericales	Ericaceae	Rhododendron		Shrub or Tree	Likely Exotic	599	2	300
Otu39	rbcLREV	Magnoliopsida	Lamiales	Plantaginaceae	Plantago	lanceolata	Forb	Likely Exotic	729	5	146
Otu40	rbcLFWD	Magnoliopsida	Oxalidales	Cunoniaceae			Shrub or Tree	Likely Native	945	3	315
Otu41	rbcLFWD	Magnoliopsida	Fagales	Fagaceae	Quercus	robur	Shrub or Tree	Likely Exotic	661	1	661
Otu44	rbcLFWD	Magnoliopsida	Lamiales	Plantaginaceae	Plantago	lanceolata	Forb	Likely Exotic	757	5	151
Otu45	rbcLFWD	Magnoliopsida	Fagales	Nothofagaceae	Nothofagus	cunninghamii	Shrub or Tree	Likely Native	712	2	356
Otu45	rbcLREV	Magnoliopsida	Fagales	Nothofagaceae	Nothofagus	cunninghamii	Shrub or Tree	Likely Native	633	2	317
Otu46	rbcLREV	Magnoliopsida	Ericales	Ericaceae	Epacris		Shrub or Tree	Likely Native	553	2	277
Otu47	rbcLREV	Magnoliopsida	Fabales	Fabaceae	Trifolium	repens	Forb	Likely Exotic	673	1	673
Otu56	rbcLREV	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	Likely Exotic	1036	3	345
Otu57	rbcLFWD	Magnoliopsida	Poales	Poaceae			Grass	Unknown	419	2	210
Otu57	rbcLREV	Bryopsida	Bryales	Bryaceae	Rosulabryum	capillare	Mosses and Liverworts	Unknown	315	3	105
Otu58	rbcLREV	Bryopsida	Hypnales	Hypnaceae	Hypnum	cupressiforme	Mosses and Liverworts	Unknown	380	1	380
Otu61	rbcLFWD	Bryopsida	Hypnales	Hypnaceae	Hypnum	curvifolium	Mosses and Liverworts	Unknown	422	2	211
Otu62	rbcLREV	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle		Forb	Likely Native	569	2	285
Otu70	rbcLFWD	Magnoliopsida	Laurales	Monimiaceae	Hedycarya	angustifolia	Shrub or Tree	Likely Native	341	4	85
Otu70	rbcLREV	Magnoliopsida	Oxalidales	Cunoniaceae	Bauera	rubioides	Shrub or Tree	Likely Native	641	3	214
Otu71	rbcLFWD	Magnoliopsida	Fabales	Fabaceae	Acacia		Shrub or Tree	Likely Native	6530	8	816
Otu71	rbcLREV	Magnoliopsida	Lamiales	Lamiaceae	Prostanthera		Shrub or Tree	Likely Native	257	3	86
Otu73	rbcLFWD	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	Likely Native	155	2	78
Otu80	rbcLFWD	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	541	9	60
Otu81	rbcLREV	Magnoliopsida	Lamiales	Plantaginaceae	Callitriche	stagnalis	Forb	Likely Exotic	226	1	226
Otu86	rbcLFWD	Magnoliopsida	Rosales	Urticaceae	Australina	pusilla	Forb	Likely Native	431	4	108

Otu86	rbcLREV	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	Likely Native	151	2	76
Otu88	rbcLREV	Magnoliopsida	Santales	Loranthaceae	Muellerina	eucalyptoides	Shrub or Tree	Likely Native	138	1	138
Otu92	rbcLREV	Magnoliopsida	Solanales	Convolvulaceae	Cuscuta	tasmanica	Forb	Likely Native	142	1	142
Otu94	rbcLFWD	Magnoliopsida	Ericales	Primulaceae	Myrsine	howittiana	Forb	Likely Native	179	1	179
Otu96	rbcLREV	Magnoliopsida	Ranunculales	Ranunculaceae	Clematis		Forb	Likely Native	116	1	116
Otu97	rbcLREV	Magnoliopsida	Asterales	Campanulaceae	Wahlenbergia	gloriosa	Forb	Likely Native	29	2	15
Otu100	rbcLREV	Magnoliopsida	Geraniales	Geraniaceae	Erodium		Forb	Likely Exotic	157	1	157
Otu101	rbcLREV	Magnoliopsida	Rosales	Urticaceae	Urtica	incisa	Forb	Likely Native	45	1	45
Otu103	rbcLFWD	Magnoliopsida	Caryophyllales	Caryophyllaceae	Cerastium	glomeratum	Forb	Likely Exotic	16	1	16
Otu103	rbcLREV	Polypodiopsida	Polypodiales	Dennstaedtiaceae	Histiopteris	incisa	Fern	Likely Native	147	2	74
Otu104	rbcLFWD	Magnoliopsida	Asterales	Campanulaceae	Wahlenbergia	gloriosa	Forb	Likely Native	28	2	14
Otu108	rbcLFWD	Magnoliopsida	Poales	Cyperaceae	Lepidosperma	tortuosum	Grass-like Plants	Likely Native	1188	6	198
Otu108	rbcLREV	Magnoliopsida	Rosales	Urticaceae	Australina	pusilla	Forb	Likely Native	273	3	91
Otu110	rbcLFWD	Magnoliopsida	Ranunculales	Ranunculaceae	Clematis	aristata	Forb	Likely Native	109	1	109
Otu112	rbcLFWD	Magnoliopsida	Solanales	Solanaceae	Solanum		Shrub or Tree	Likely Exotic	332	2	166
Otu112	rbcLREV	Magnoliopsida	Fabales	Fabaceae			Shrub or Tree	Unknown	147	3	49
Otu113	rbcLFWD	Polypodiopsida	Polypodiales	Dennstaedtiaceae	Histiopteris	incisa	Fern	Likely Native	174	2	87
Otu113	rbcLREV	Magnoliopsida	Apiales	Pittosporaceae	Pittosporum	undulatum	Shrub or Tree	Likely Native	205	2	103
Otu114	rbcLFWD	Magnoliopsida	Santales	Loranthaceae	Muellerina	eucalyptoides	Shrub or Tree	Likely Native	143	1	143
Otu115	rbcLREV	Magnoliopsida	Myrtales	Lythraceae	Lythrum		Forb	Likely Native	94	1	94
Otu117	rbcLFWD	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum	minus	Fern	Likely Native	111	2	56
Otu117	rbcLREV	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	104	1	104
Otu119	rbcLFWD	Magnoliopsida	Rosales	Rosaceae	Aphanes	arvensis	Forb	Likely Exotic	15	1	15
Otu120	rbcLREV	Magnoliopsida	Ericales	Ericaceae			Shrub or Tree	Unknown	61	1	61
Otu121	rbcLFWD	Magnoliopsida	Poales	Poaceae	Anthosachne		Grass	Likely Native	126	2	63
Otu124	rbcLREV	Bryopsida	Funariales	Funariaceae	Funaria	hygrometrica	Mosses and Liverworts	Unknown	59	1	59
Otu127	rbcLREV	Magnoliopsida	Fabales	Fabaceae			Shrub or Tree	Unknown	150	1	150
Otu130	rbcLFWD	Pinopsida	Pinales	Cupressaceae	Callitris	glaucophylla	Shrub or Tree	Likely Exotic	76	1	76

Otu134	rbcLFWD	Magnoliopsida	Sapindales	Rutaceae	Zieria		Shrub or Tree	Likely Native	133	2	67
Otu135	rbcLREV	Magnoliopsida	Solanales	Convolvulaceae			Forb	Unknown	52	1	52
Otu136	rbcLREV	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	2270	7	324
Otu137	rbcLREV	Pinopsida	Pinales	Cupressaceae	Callitris		Shrub or Tree	Likely Exotic	69	1	69
Otu141	rbcLREV	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	65	1	65
Otu142	rbcLFWD	Magnoliopsida	Fabales	Fabaceae	Mirbelia	oxylobioides	Shrub or Tree	Likely Native	134	3	45
Otu146	rbcLREV	Magnoliopsida	Fabales	Fabaceae	Lotus		Forb	Likely Exotic	56	2	28
Otu147	rbcLFWD	Magnoliopsida	Asparagales	Asphodelaceae	Dianella	tasmanica	Forb	Likely Native	47	1	47
Otu147	rbcLREV	Magnoliopsida	Solanales	Convolvulaceae	Cuscuta		Forb	Likely Exotic	40	1	40
Otu148	rbcLFWD	Magnoliopsida	Cucurbitales	Cucurbitaceae			Forb	Unknown	44	1	44
Otu149	rbcLFWD	Magnoliopsida	Proteales	Proteaceae	Lomatia		Shrub or Tree	Likely Native	43	1	43
Otu152	rbcLREV	Magnoliopsida	Malpighiales	Euphorbiaceae	Amperea	xiphoclada	Shrub or Tree	Likely Native	64	1	64
Otu154	rbcLREV	Magnoliopsida	Caryophyllales	Caryophyllaceae	Cerastium	glomeratum	Forb	Likely Exotic	10	1	10
Otu157	rbcLFWD	Polypodiopsida	Polypodiales	Dennstaedtiaceae	Hypolepis		Fern	Likely Native	94	3	31
Otu159	rbcLFWD	Magnoliopsida	Malpighiales	Euphorbiaceae	Amperea	xiphoclada	Shrub or Tree	Likely Native	61	1	61
Otu160	rbcLREV	Bryopsida	Dicranales	Ditrichaceae	Ditrichum		Mosses and Liverworts	Unknown	84	1	84
Otu161	rbcLREV	Magnoliopsida	Solanales	Convovulaceae			Forb	Unknown	44	1	44
Otu163	rbcLREV	Magnoliopsida	Poales	Poaceae			Grass	Unknown	39	1	39
Otu164	rbcLREV	Magnoliopsida	Poales	Poaceae			Grass	Unknown	78	1	78
Otu165	rbcLREV	Magnoliopsida	Solanales	Solanaceae	Solanum		Shrub or Tree	Likely Exotic	1871	13	144
Otu166	rbcLFWD	Magnoliopsida	Myrtales	Lythraceae	Lythrum		Forb	Likely Native	70	1	70
Otu167	rbcLREV	Magnoliopsida	Asparagales	Asphodelaceae	Dianella	tasmanica	Forb	Likely Native	37	1	37
Otu168	rbcLREV	Magnoliopsida	Sapindales	Rutaceae	Zieria	arborescens	Shrub or Tree	Likely Native	130	2	65
Otu176	rbcLREV	Magnoliopsida	Ericales	Primulaceae	Myrsine	howittiana	Shrub or Tree	Likely Native	112	1	112
Otu181	rbcLREV	Magnoliopsida	Proteales	Proteaceae	Persoonia		Shrub or Tree	Likely Native	37	1	37
Otu182	rbcLFWD	Bryopsida	Dicranales	Leucobryaceae	Campylopus		Mosses and Liverworts	Unknown	13	1	13
Otu187	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	38	1	38
Otu188	rbcLREV	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	31	1	31

Otu189	rbcLREV	Magnoliopsida	Fabales	Fabaceae	Glycine	tabacina	Forb	Likely Native	32	1	32
Otu191	rbcLREV	Magnoliopsida	Solanales	Convovulaceae			Forb	Unknown	22	1	22
Otu196	rbcLREV	Magnoliopsida	Poales	Poaceae	Phragmites	australis	Grass	Likely Native	54	1	54
Otu199	rbcLREV	Magnoliopsida	Malpighiales	Salicaceae	Populus	alba	Shrub or Tree	Likely Exotic	22	1	22
Otu202	rbcLREV	Magnoliopsida	Asparagales	Asteliaceae	Astelia		Forb	Likely Native	76	1	76
Otu208	rbcLREV	Magnoliopsida	Lamiales	Lamiaceae	Prunella	vulgaris	Forb	Likely Exotic	31	1	31
Otu209	rbcLFWD	Jungermanniopsida	Metzgeriales	Metzgeriaceae	Metzgeria		Mosses and Liverworts	Unknown	47	1	47
Otu212	rbcLREV	Jungermanniopsida	Metzgeriales	Metzgeriaceae	Metzgeria		Mosses and Liverworts	Unknown	40	1	40
Otu213	rbcLFWD	Magnoliopsida	Malpighiales	Salicaceae	Populus	alba	Shrub or Tree	Likely Exotic	21	1	21
Otu214	rbcLFWD	Magnoliopsida	Cucurbitales	Cucurbitaceae			Forb	Unknown	15	1	15
Otu217	rbcLFWD	Bryopsida	Funariales	Funariaceae	Funaria	hygrometrica	Mosses and Liverworts	Unknown	65	1	65
Otu218	rbcLREV	Pinopsida	Pinales	Pinaceae	Pinus		Shrub or Tree	Likely Exotic	18	1	18
Otu219	rbcLREV	Magnoliopsida	Poales	Juncaceae	Juncus		Grass-like Plants	Likely Native	45	1	45
Otu228	rbcLFWD	Pinopsida	Pinales	Cupressaceae	Cupressus	sempervirens	Shrub or Tree	Likely Exotic	17	1	17
Otu228	rbcLREV	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum	cartilagineum	Fern	Likely Native	20	1	20
Otu230	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae	Coprosma		Forb	Likely Native	34	1	34
Otu231	rbcLREV	Magnoliopsida	Gentianales	Rubiaceae			Shrub or Tree	Unknown	33	1	33
Otu233	rbcLFWD	Magnoliopsida	Poales	Poaceae	Phragmites	australis	Grass	Likely Native	144	2	72
Otu240	rbcLREV	Magnoliopsida	Cucurbitales	Cucurbitaceae			Forb	Unknown	34	1	34
Otu243	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	26	2	13
Otu243	rbcLREV	Magnoliopsida	Poales	Cyperaceae	Carex		Grass-like Plants	Likely Native	1921	4	480
Otu245	rbcLREV	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	Likely Native	15	1	15
Otu246	rbcLREV	Magnoliopsida	Solanales	Convovulaceae			Forb	Unknown	15	1	15
Otu248	rbcLREV	Magnoliopsida	Gentianales	Rubiaceae			Forb	Unknown	26	2	13
Otu250	rbcLFWD	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum	fluviatile	Fern	Likely Native	17	1	17
Otu260	rbcLREV	Magnoliopsida	Poales	Poaceae			Grass	Unknown	65	1	65
Otu263	rbcLFWD	Magnoliopsida	Gentianales	Gentianaceae	Centaurium	erythraea	Forb	Likely Exotic	12	1	12
Otu265	rbcLREV	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	21	1	21

Otu270	rbcLREV	Magnoliopsida	Poales	Poaceae	Paspalum	dilatatum	Grass	Likely Exotic	67	1	67
Otu274	rbcLREV	Magnoliopsida	Solanales	Convolvulaceae	Cuscuta		Forb	Likely Exotic	28	1	28
Otu279	rbcLFWD	Magnoliopsida	Apiales	Apiaceae	Oreomyrrhis	eriopoda	Forb	Likely Native	13	1	13
Otu283	rbcLREV	Magnoliopsida	Proteales	Proteaceae	Lomatia		Shrub or Tree	Likely Native	24	1	24
Otu288	rbcLFWD	Magnoliopsida	Poales	Poaceae	Holcus	lanatus	Grass	Likely Exotic	390	8	49
Otu289	rbcLFWD	Polypodiopsida	Gleicheniales	Gleicheniaceae	Gleichenia	dicarpa	Fern	Likely Native	12	1	12
Otu291	rbcLFWD	Magnoliopsida	Poales	Cyperaceae	Carex	buxbaumii	Grass-like Plants	Likely Exotic	2261	5	452
Otu294	rbcLFWD	Polypodiopsida	Polypodiales	Dryopteridaceae	Polystichum		Fern	Likely Native	14	1	14
Otu296	rbcLREV	Bryopsida	Dicranales	Leucobryaceae	Campylopus		Mosses and Liverworts	Unknown	28	1	28
Otu299	rbcLREV	Magnoliopsida	Laurales	Monimiaceae	Hedycarya	angustifolia	Shrub or Tree	Likely Native	249	3	83
Otu300	rbcLFWD	Magnoliopsida	Poales	Poaceae	Phleum	pratense	Grass	Likely Exotic	15	1	15
Otu301	rbcLREV	Pinopsida	Pinales	Cupressaceae			Shrub or Tree	Unknown	15	1	15
Otu305	rbcLFWD	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	216	1	216
Otu310	rbcLREV	Magnoliopsida	Ericales	Ericaceae	Leucopogon		Shrub or Tree	Likely Native	11	1	11
Otu313	rbcLREV	Magnoliopsida	Poales	Poaceae	Ehrharta	erecta	Grass	Likely Exotic	2525	2	1263
Otu316	rbcLFWD	Magnoliopsida	Poales	Poaceae			Grass	Unknown	2313	12	193
Otu317	rbcLFWD	Bryopsida	Bryales	Bryaceae	Bryum		Mosses and Liverworts	Unknown	304	3	101
Otu319	rbcLFWD	Magnoliopsida	Poales	Poaceae	Festuca	arundinacea	Grass	Likely Exotic	261	7	37
Otu322	rbcLFWD	Magnoliopsida	Poales	Juncaceae	Juncus		Grass-like Plants	Likely Native	32	1	32
Otu328	rbcLFWD	Magnoliopsida	Myrtales	Myrtaceae			Shrub or Tree	Unknown	237	3	79
Otu336	rbcLFWD	Magnoliopsida	Poales	Poaceae			Grass	Unknown	17	1	17
Otu344	rbcLREV	Magnoliopsida	Poales	Poaceae			Grass	Unknown	25	2	13
Otu348	rbcLREV	Magnoliopsida	Poales	Poaceae			Grass	Unknown	26	1	26
Otu349	rbcLREV	Magnoliopsida	Poales	Poaceae	Holcus	lanatus	Grass	Likely Exotic	2508	14	179
Otu353	rbcLFWD	Magnoliopsida	Poales	Poaceae	Agrostis	capillaris	Grass	Likely Exotic	358	7	51
Otu359	rbcLREV	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum	nudum	Fern	Likely Native	496	6	83
Otu364	rbcLREV	Magnoliopsida	Rosales	Urticaceae			Forb	Unknown	94	1	94
Otu365	rbcLREV	Magnoliopsida	Poales	Poaceae			Grass	Unknown	93	2	47

Otu367	rbcLFWD	Bryopsida	Dicranales	Ditrichaceae	Ditrichum		Mosses and Liverworts	Unknown	98	1	98
Otu374	rbcLREV	Magnoliopsida	Poales	Poaceae	Ehrharta		Grass	Likely Exotic	50	1	50
Otu379	rbcLFWD	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	2400	6	400
Otu386	rbcLFWD	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	584	1	584
Otu389	rbcLFWD	Magnoliopsida	Fabales	Fabaceae	Glycine	tabacina	Forb	Likely Native	34	1	34
Otu390	rbcLFWD	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	271	1	271
Otu391	rbcLFWD	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	Likely Native	10	1	10
Otu392	rbcLFWD	Magnoliopsida	Poales	Poaceae	Polypogon		Grass	Likely Exotic	84	3	28
Otu407	rbcLFWD	Magnoliopsida	Saxifragales	Haloragaceae	Myriophyllum		Forb	Likely Native	12	1	12
Otu416	rbcLFWD	Magnoliopsida	Poales	Poaceae	Agrostis		Grass	Likely Native	72	1	72
Otu419	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	568	1	568
Otu434	rbcLFWD	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum	nudum	Fern	Likely Native	837	7	120
Otu442	rbcLFWD	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	74	3	25
Otu449	rbcLFWD	Magnoliopsida	Fabales	Fabaceae			Shrub or Tree	Unknown	42	1	42
Otu452	rbcLFWD	Magnoliopsida	Poales	Poaceae			Grass	Unknown	210	4	53
Otu453	rbcLFWD	Magnoliopsida	Rosales	Rosaceae	Rubus		Shrub or Tree	Likely Exotic	14	1	14
Otu466	rbcLFWD	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	Likely Native	13	1	13
Otu477	rbcLFWD	Magnoliopsida	Poales	Poaceae	Avena		Grass	Likely Exotic	14	1	14
Otu490	rbcLFWD	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	294	1	294
Otu503	rbcLFWD	Magnoliopsida	Fabales	Fabaceae	Lotus		Forb	Likely Exotic	60	2	30
Otu518	rbcLFWD	Bryopsida	Grimmiales	Grimmiaceae	Schistidium		Mosses and Liverworts	Unknown	27	1	27
Otu523	rbcLFWD	Magnoliopsida	Poales	Juncaceae	Juncus		Grass-like Plants	Likely Native	432	1	432
Otu526	rbcLFWD	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	113	1	113
Otu537	rbcLFWD	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	12	1	12
Otu546	rbcLFWD	Magnoliopsida	Asterales	Asteraceae			Shrub or Tree	Unknown	56	1	56
Otu553	rbcLFWD	Polypodiopsida	Polypodiales	Blechnaceae	Blechnum		Fern	Likely Native	431	5	86

Table 9. Estimated mean number of seeds dispersed by sambar deer in both the Alpine National Park and Yarra Ranges National Park, based on vegetation communities that faecal samples were collected from.

		Germination Trial		**Number of viable seeds dispersed per day by individual sambar deer**	
Alpine	**Vegetation Community**	**Mean**	**SE**	**Mean**	**SE**
Native Seeds	Snowpatch Herbland	7.65	4.38	284.20	162.72
	Snow Gum Closed Heathland	3.29	0.766	122.22	28.46
	Heathland	4.15	0.882	154.17	32.77
	Grassland	2.91	0.694	108.11	25.78
Exotic Seeds	Snowpatch Herbland	10.8	5.46	401.22	202.84
	Snow Gum Closed Heathland	12	2.66	445.80	98.82
	Heathland	20.9	9.65	776.44	358.50
	Grassland	32.9	19.1	1222.24	709.57
Total Seeds	Snowpatch Herbland	18.4	9.7	683.56	360.36
	Snow Gum Closed Heathland	15.3	2.92	568.40	108.48
	Heathland	25.1	10.1	932.47	375.22
	Grassland	35.8	19	1329.97	705.85
	Native Seeds	4.67	1.15	173.49	42.72
	Exotic Seeds	18.2	4.91	676.13	182.41
	TOTAL Seeds	22.8	5.4	847.02	200.61
Yarra Ranges	**Vegetation Community**				
Native Seeds	Damp Forest	2.33	0.466	86.56	17.31
	Wet Forest	1.23	0.568	45.69	21.10
	Montane Wet Forest	2.82	0.772	104.76	28.68
	Riparian Forest	0.86	0.162	31.95	6.02
Exotic Seeds	Damp Forest	1.08	0.733	40.12	27.23
	Wet Forest	0.308	0.133	11.44	4.94
	Montane Wet Forest	6.18	3.19	229.59	118.51
	Riparian Forest	0.674	0.151	25.04	5.61
Total Seeds	Damp Forest	3.42	0.908	127.05	33.73
	Wet Forest	1.54	0.647	57.21	24.04
	Montane Wet Forest	9	3.3	334.35	122.60
	Riparian Forest	1.54	0.241	57.21	8.95
	Native Seeds	1.42	0.196	52.75	7.28
	Exotic Seeds	1.44	0.498	53.50	18.50
	TOTAL Seeds	2.86	0.568	106.25	21.10

Figure 2. Sambar deer faecal pellet collection locations for DNA analysis in Chapter 3. The Falls Creek Resort separates the Mt Nelse study area in the north from the Basalt Hill study area in the south. Each of the three different colours represent a different monthly collection period.

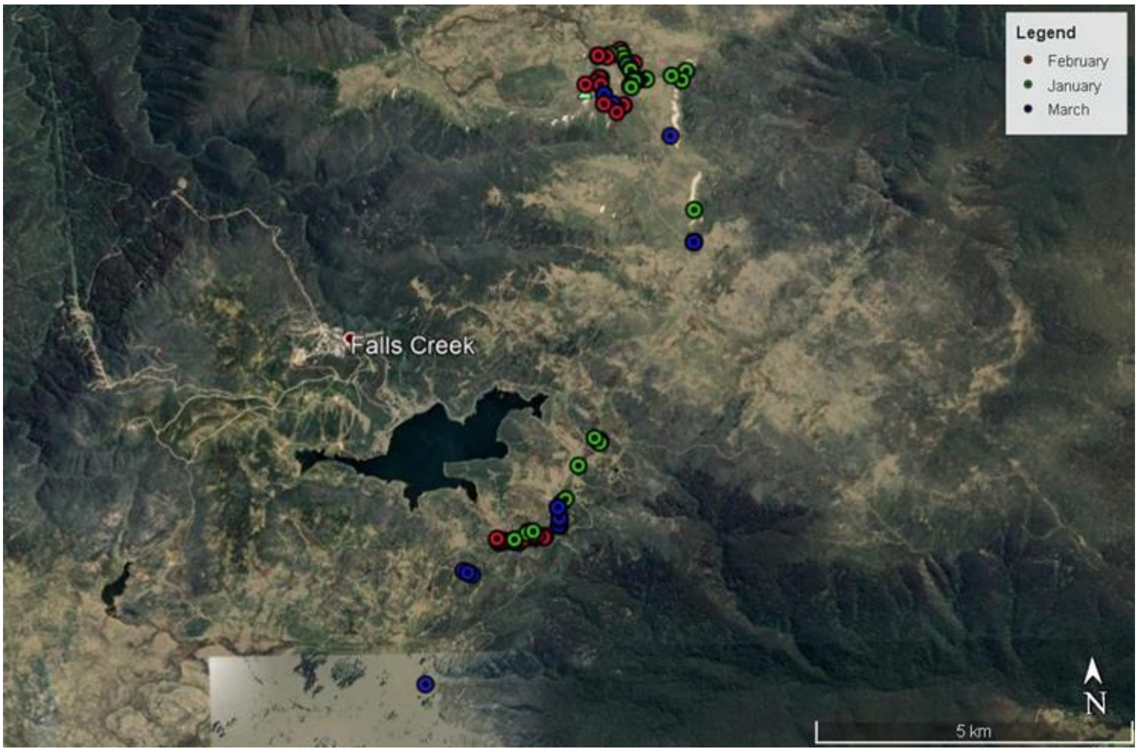

Table 10. Sambar deer faecal pellet collection locations for DNA analysis in Chapter 3. Samples collected in January begin with AJ, February with AF, and March with AM.

Sample	Easting	Northing	Vegetation Community	Site
AJ5	529265	5923964	Grassland	Mt Nelse
AJ6	529265	5923964	Grassland	Mt Nelse
AJ7	529265	5923964	Grassland	Mt Nelse
AJ8	529398	5923808	Snowpatch herbfield	Mt Nelse
AJ9	529398	5923808	Snowpatch herbfield	Mt Nelse
AJ10	529398	5923808	Snowpatch herbfield	Mt Nelse
AJ11	529792	5924174	Wetland	Mt Nelse
AJ12	529792	5924174	Wetland	Mt Nelse
AJ14	529792	5924174	Wetland	Mt Nelse
AJ15	529792	5924174	Wetland	Mt Nelse
AJ16	529741	5924190	Wetland	Mt Nelse
AJ19	530288	5923279	Snowpatch herbfield	Mt Nelse
AJ20	530598	5921602	Grassland	Mt Nelse
AJ21	530598	5921602	Grassland	Mt Nelse
AJ22	530598	5921602	Grassland	Mt Nelse
AJ23	526135	5914811	Wetland	Basalt Hill
AJ26	526792	5916571	Grassland	Basalt Hill
AJ28	526854	5916543	Wetland	Basalt Hill
AJ29	526860	5916538	Wetland	Basalt Hill
AJ30	526924	5916507	Wetland	Basalt Hill
AJ31	528317	5917515	Grassland	Basalt Hill
AJ34	528333	5917313	Grassland	Basalt Hill
AJ35	528333	5917353	Grassland	Basalt Hill
AJ36	528334	5917241	Snowpatch herbfield	Basalt Hill
AJ37	528334	5917241	Snowpatch herbfield	Basalt Hill
AJ39	528336	5917364	Grassland	Basalt Hill
AJ40	528336	5917218	Snowpatch herbfield	Basalt Hill
AJ42	528317	5917515	Grassland	Basalt Hill
AJ43	528317	5917240	Snowpatch herbfield	Basalt Hill
AJ45	528317	5917515	Grassland	Basalt Hill
AF2	529385	5924592	Grassland	Mt Nelse
AF4	529572	5924598	Wetland	Mt Nelse
AF5	529599	5924520	Wetland	Mt Nelse
AF6	529640	5924439	Grassland	Mt Nelse
AF7	529654	5924411	Grassland	Mt Nelse
AF8	529677	5924400	Grassland	Mt Nelse
AF9	529699	5924334	Grassland	Mt Nelse
AF11	529698	5924063	Wetland	Mt Nelse
AF12	529677	5924086	Wetland	Mt Nelse
AF13	528660	5918157	Wetland	Basalt Hill
AF14	528931	5918584	Wetland	Basalt Hill
AF15	528972	5918546	Wetland	Basalt Hill
AF17	529009	5918504	Grassland	Basalt Hill
AF18	529002	5918520	Grassland	Basalt Hill

AF19	529024	5918535	Grassland	Basalt Hill
AF20	527613	5917035	Wetland	Basalt Hill
AF21	527579	5917002	Wetland	Basalt Hill
AF22	527611	5917019	Grassland	Basalt Hill
AF23	527912	5917151	Snowpatch herbfield	Basalt Hill
AF24	527898	5917100	Snowpatch herbfield	Basalt Hill
AF25	527840	5917151	Snowpatch herbfield	Basalt Hill
AF26	527816	5917125	Snowpatch herbfield	Basalt Hill
AF27	530338	5924224	Snowpatch herbfield	Mt Nelse
AF28	530570	5924291	Snowpatch herbfield	Mt Nelse
AF34	530499	5924144	Snowpatch herbfield	Mt Nelse
AF35	529938	5924181	Grassland	Mt Nelse
AF39	529748	5924162	Wetland	Mt Nelse
AF41	530621	5922106	Snowpatch herbfield	Mt Nelse
AF43	528440	5917639	Grassland	Basalt Hill
AF47	528381	5917595	Grassland	Basalt Hill
AM1	527338	5917058	Grassland	Basalt Hill
AM2	527351	5917029	Grassland	Basalt Hill
AM3	527450	5917013	Wetland	Basalt Hill
AM4	527444	5917024	Wetland	Basalt Hill
AM5	527368	5916987	Grassland	Basalt Hill
AM8	527681	5916981	Wetland	Basalt Hill
AM9	527764	5917043	Snowpatch herbfield	Basalt Hill
AM11	527923	5917083	Snowpatch herbfield	Basalt Hill
AM13	527930	5917044	Snowpatch herbfield	Basalt Hill
AM14	528081	5917067	Grassland	Basalt Hill
AM16	528072	5917052	Grassland	Basalt Hill
AM18	528094	5917073	Grassland	Basalt Hill
AM22	527965	5917084	Snowpatch herbfield	Basalt Hill
AM27	529565	5923780	Snowpatch herbfield	Mt Nelse
AM28	529565	5923789	Snowpatch herbfield	Mt Nelse
AM29	529454	5923682	Snowpatch herbfield	Mt Nelse
AM30	529259	5923819	Snowpatch herbfield	Mt Nelse
AM32	528978	5924131	Grassland	Mt Nelse
AM34	529145	5924162	Grassland	Mt Nelse
AM35	529218	5924120	Grassland	Mt Nelse
AM36	529200	5924224	Wetland	Mt Nelse
AM38	529225	5924223	Wetland	Mt Nelse
AM40	529691	5924353	Wetland	Mt Nelse
AM41	529751	5924438	Wetland	Mt Nelse
AM42	529548	5924656	Grassland	Mt Nelse
AM44	529196	5924580	Grassland	Mt Nelse
AM45	529190	5924574	Grassland	Mt Nelse
AM47	527629	5917000	Wetland	Basalt Hill
AM48	527644	5917023	Wetland	Basalt Hill
AM49	529333	5924555	Wetland	Mt Nelse

Table 11. Taxonomic table displaying the assignment of zOTUs in the Alpine samples in Chapter 3. Sum refers to total number of sequence reads for each zOTU. Count refers to the number of samples a zOTU was detected in, and average read depth highlights the total reads on average for zOTUs across detected samples.

zOTU ID	Order	Class	Family	Genus	Species	Growth Form	Sum	Count	Average Read Depth
Zotu4	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Woody	89181	67	1331.06
Zotu6	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	132241	70	1889.16
Zotu8	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	81968	68	1205.41
Zotu11	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	42087	61	689.95
Zotu13	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus	pauciflora	Woody	24441	39	626.69
Zotu14	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Woody	19976	42	475.62
Zotu22	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Woody	10463	42	249.12
Zotu23	Magnoliopsida	Asterales	Asteraceae	Leptinella	filicula	Forb	4511	6	751.83
Zotu24	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	3298	31	106.39
Zotu25	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	7907	33	239.61
Zotu26	Magnoliopsida	Asterales	Asteraceae	Hypochaeris	radicata	Forb	9419	44	214.07
Zotu29	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	15522	22	705.55
Zotu30	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	1650	17	97.06
Zotu31	Magnoliopsida	Caryophyllales	Caryophyllaceae	Scleranthus	biflorus	Forb	8629	16	539.31
Zotu32	Magnoliopsida	Malpighiales	Salicaceae	Salix	cinerea	Woody	7562	12	630.17
Zotu35	Magnoliopsida	Sapindales	Rutaceae	Phebalium	squamulosum subsp. ozothamnoides	Woody	8052	29	277.66
Zotu37	Magnoliopsida	Apiales	Apiaceae	Oreomyrrhis	eriopoda	Forb	11857	23	515.52
Zotu39	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	6704	19	352.84
Zotu40	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	7014	51	137.53
Zotu43	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	5801	32	181.28
Zotu48	Magnoliopsida	Caryophyllales	Caryophyllaceae	Scleranthus	biflorus	Forb	5602	13	430.92

Zotu49	Magnoliopsida	Poales	Poaceae	Poa	costiniana	Graminoid	5523	45	122.73
Zotu53	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	4447	19	234.05
Zotu54	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Woody	2627	3	875.67
Zotu55	Magnoliopsida	Malpighiales	Salicaceae	Salix		Woody	2907	11	264.27
Zotu56	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	110	9	12.22
Zotu58	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	245	16	15.31
Zotu59	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	1525	14	108.93
Zotu60	Magnoliopsida	Fabales	Fabaceae	Bossiaea	foliosa	Woody	2348	7	335.43
Zotu66	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	165	14	11.79
Zotu73	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	2166	25	86.64
Zotu74	Magnoliopsida	Fabales	Fabaceae	Podolobium	alpestre	Woody	1624	12	135.33
Zotu75	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	1604	21	76.38
Zotu76	Magnoliopsida	Asterales	Asteraceae	Microseris	lanceolata	Forb	3483	18	193.50
Zotu78	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	1182	32	36.94
Zotu79	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	1847	14	131.93
Zotu80	Magnoliopsida	Fabales	Fabaceae	Bossiaea	foliosa	Woody	1656	7	236.57
Zotu81	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	2552	11	232.00
Zotu82	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	4047	20	202.35
Zotu83	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	138	6	23.00
Zotu86	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	364	10	36.40
Zotu87	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	1775	8	221.88
Zotu88	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	1462	16	91.38
Zotu89	Magnoliopsida	Sapindales	Rutaceae	Asterolasia	asteriscophora	Woody	360	11	32.73
Zotu90	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	786	25	31.44
Zotu91	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	891	17	52.41
Zotu92	Magnoliopsida	Caryophyllales	Caryophyllaceae	Scleranthus	biflorus	Forb	281	3	93.67
Zotu93	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	1812	14	129.43
Zotu95	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Woody	1183	7	169.00

Zotu97	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	4429	18	246.06
Zotu98	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	396	14	28.29
Zotu99	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle	sibthorpioides	Forb	207	5	41.40
Zotu103	Magnoliopsida	Asterales	Asteraceae	Craspedia	gracilis	Forb	2236	14	159.71
Zotu104	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	602	12	50.17
Zotu105	Magnoliopsida	Brassicales	Brassicaceae	Cardamine		Forb	36	2	18.00
Zotu107	Magnoliopsida	Fabales	Fabaceae	Podolobium	alpestre	Woody	780	1	780.00
Zotu108	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	1955	18	108.61
Zotu113	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	673	13	51.77
Zotu116	Magnoliopsida	Fabales	Fabaceae	Trifolium	repens	Forb	2196	12	183.00
Zotu117	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	911	12	75.92
Zotu119	Magnoliopsida	Fabales	Fabaceae	Trifolium	repens	Forb	7	1	7.00
Zotu120	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Woody	1202	24	50.08
Zotu126	Magnoliopsida	Caryophyllales	Caryophyllaceae	Cerastium	glomeratum	Forb	408	6	68.00
Zotu127	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	147	11	13.36
Zotu128	Magnoliopsida	Asterales	Asteraceae	Coronidium	monticola	Forb	1417	22	64.41
Zotu129	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	27	5	5.40
Zotu130	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	609	13	46.85
Zotu131	Magnoliopsida	Fabales	Fabaceae	Trifolium	repens	Forb	1557	13	119.77
Zotu133	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	185	20	9.25
Zotu134	Magnoliopsida	Malpighiales	Salicaceae	Salix	cinerea	Woody	757	5	151.40
Zotu140	Magnoliopsida	Poales	Poaceae	Phleum	pratense	Graminoid	27	2	13.50
Zotu141	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	251	10	25.10
Zotu143	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	30	5	6.00
Zotu144	Magnoliopsida	Asterales	Asteraceae	Cassinia	aculeata	Woody	6	2	3.00
Zotu147	Magnoliopsida	Geraniales	Geraniaceae	Geranium	solanderi	Forb	723	5	144.60
Zotu148	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	1674	15	111.60
Zotu149	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	363	27	13.44

Zotu151	Pinopsida	Pinales	Podocarpaceae	Podocarpus	lawrencei	Woody	21	3	7.00
Zotu155	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	1047	12	87.25
Zotu156	Magnoliopsida	Poales	Poaceae	Poa	costiniana	Graminoid	1269	27	47.00
Zotu160	Magnoliopsida	Sapindales	Rutaceae	Phebalium	squamulosum subsp. ozothamnoides	Woody	712	15	47.47
Zotu166	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	13	2	6.50
Zotu168	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	114	12	9.50
Zotu169	Magnoliopsida	Asterales	Asteraceae	Microseris	lanceolata	Forb	962	9	106.89
Zotu170	Magnoliopsida	Apiales	Araliaceae	Hydrocotyle	sibthorpioides	Forb	25	4	6.25
Zotu173	Magnoliopsida	Fabales	Fabaceae	Bossiaea	foliosa	Woody	562	2	281.00
Zotu175	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Woody	463	1	463.00
Zotu178	Magnoliopsida	Proteales	Proteaceae	Orites	lancifolius	Woody	587	3	195.67
Zotu179	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	478	4	119.50
Zotu180	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	1260	21	60.00
Zotu182	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Woody	556	16	34.75
Zotu184	Magnoliopsida	Rosales	Urticaceae	Urtica		Forb	3	1	3.00
Zotu185	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	11	1	11.00
Zotu193	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	582	21	27.71
Zotu194	Magnoliopsida	Asterales	Asteraceae	Craspedia		Forb	804	15	53.60
Zotu195	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	714	30	23.80
Zotu198	Magnoliopsida	Poales	Poaceae	Poa	pratensis	Graminoid	569	12	47.42
Zotu200	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	680	7	97.14
Zotu203	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	473	9	52.56
Zotu205	Magnoliopsida	Asparagales	Asphodelaceae	Dianella	tasmanica	Graminoid	1009	1	1009.00
Zotu209	Magnoliopsida	Poales	Poaceae	Agrostis		Graminoid	762	11	69.27
Zotu210	Magnoliopsida	Malvales	Thymelaeaeae	Pimelea	axiflora subsp. alpina	Woody	751	4	187.75
Zotu212	Magnoliopsida	Asterales	Asteraceae	Cassinia	aculeata	Woody	71	2	35.50
Zotu214	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	300	7	42.86
Zotu217	Magnoliopsida	Malvales	Thymelaeaeae	Pimelea	alpina	Woody	586	6	97.67

Zotu219	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	431	3	143.67
Zotu220	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	773	25	30.92
Zotu223	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	525	6	87.50
Zotu224	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	412	24	17.17
Zotu226	Magnoliopsida	Sapindales	Rutaceae	Phebalium	squamulosum	Woody	456	14	32.57
Zotu231	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	415	22	18.86
Zotu232	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	96	6	16.00
Zotu234	Magnoliopsida	Asterales	Asteraceae	Hypochaeris	glabra	Forb	14	1	14.00
Zotu235	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	565	26	21.73
Zotu240	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	838	31	27.03
Zotu241	Magnoliopsida	Asterales	Asteraceae	Craspedia		Forb	420	11	38.18
Zotu242	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	108	11	9.82
Zotu243	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	849	14	60.64
Zotu245	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	379	4	94.75
Zotu246	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	384	4	96.00
Zotu248	Magnoliopsida	Asterales	Asteraceae	Achillea	millefolium	Forb	431	6	71.83
Zotu249	Magnliopsida	Asterales	Asteraceae	Taraxacum		Forb	324	4	81.00
Zotu250	Magnoliopsida	Poales	Poaceae	Poa		Graminoid	381	11	34.64
Zotu251	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	395	14	28.21
Zotu252	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	820	27	30.37
Zotu256	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	539	23	23.43
Zotu257	Magnoliopsida	Asterales	Asteraceae	Coronidium	monticola	Forb	366	6	61.00
Zotu263	Magnoliopsida	Lamiales	Plantaginaceae	Plantago		Forb	55	1	55.00
Zotu267	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	295	12	24.58
Zotu268	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	305	2	152.50
Zotu270	Magnoliopsida	Caryophyllales	Caryophyllaceae	Cerastium		Forb	109	8	13.63
Zotu271	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	84	8	10.50
Zotu272	Magnoliopsida	Ranunculales	Ranunculaceae	Ranunculus	repens	Forb	135	9	15.00

Zotu274	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	402	2	201.00
Zotu275	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	310	14	22.14
Zotu280	Magnoliopsida	Fabales	Fabaceae	Bossiaea	foliosa	Woody	208	2	104.00
Zotu281	Magnoliopsida	Ranunculales	Ranunculaceae	Ranunculus	eichlerianus	Forb	134	10	13.40
Zotu282	Magnoliopsida	Asterales	Asteraceae	Coronidium	monticola	Forb	320	7	45.71
Zotu283	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	58	7	8.29
Zotu287	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	265	8	33.13
Zotu288	Magnoliopsida	Asterales	Asteraceae	Olearia	phlogopappa	Woody	244	11	22.18
Zotu289	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Woody	258	1	258.00
Zotu292	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	3	1	3.00
Zotu293	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	232	2	116.00
Zotu295	Magnoliopsida	Asterales	Asteraceae	Leptorhynchos	squamatus	Forb	316	10	31.60
Zotu297	Magnoliopsida	Canellales	Winteraceae	Tasmannia	vickeriana	Woody	208	5	41.60
Zotu298	Magnoliopsida	Asterales	Asteraceae	Euchiton	japonicus	Forb	13	1	13.00
Zotu299	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	259	4	64.75
Zotu300	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	323	7	46.14
Zotu303	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	390	8	48.75
Zotu304	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Woody	324	6	54.00
Zotu306	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Woody	243	9	27.00
Zotu307	Magnoliopsida	Lamiales	Lamiaceae	Prostanthera		Woody	12	3	4.00
Zotu309	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	153	12	12.75
Zotu310	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	343	15	22.87
Zotu311	Magnoliopsida	Poales	Poaceae	Lolium	perenne	Graminoid	186	1	186.00
Zotu312	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	91	1	91.00
Zotu318	Magnoliopsida	Poales	Poaceae	Poa		Graminoid	221	7	31.57
Zotu319	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	181	6	30.17
Zotu320	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	243	12	20.25
Zotu321	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	325	9	36.11

Zotu327	Magnoliopsida	Sapindales	Rutaceae	Phebalium	squamulosum subsp. ozothamnoides	Woody	301	12	25.08
Zotu331	Magnoliopsida	Ranunculales	Ranunculaceae	Ranunculus		Forb	27	3	9.00
Zotu334	Magnoliopsida	Myrtales	Myrtaceae	Leptospermum	lanigerum	Woody	223	3	74.33
Zotu335	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	365	1	365.00
Zotu337	Magnoliopsida	Myrtales	Myrtaceae	Baeckea		Woody	201	9	22.33
Zotu340	Magnoliopsida	Asterales	Asteraceae	Pilosella		Forb	26	1	26.00
Zotu342	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	312	7	44.57
Zotu345	Magnoliopsida	Asterales	Asteraceae	Craspedia	gracilis	Forb	263	6	43.83
Zotu346	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Woody	232	10	23.20
Zotu347	Magnoliopsida	Canellales	Winteraceae	Tasmannia	vickeriana	Woody	334	5	66.80
Zotu350	Magnoliopsida	Ericales	Ericaceae	Gaultheria	appressa	Woody	262	6	43.67
Zotu352	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	209	11	19.00
Zotu353	Magnoliopsida	Poales	Cyperaceae	Carex	canescens	Graminoid	166	15	11.07
Zotu354	Magnoliopsida	Rosales	Urticaceae	Urtica		Forb	14	3	4.67
Zotu358	Magnoliopsida	Asterales	Asteraceae	Coronidium	monticola	Forb	24	3	8.00
Zotu359	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	48	4	12.00
Zotu360	Magnoliopsida	Geraniales	Geraniaceae	Geranium	homeanum	Forb	210	16	13.13
Zotu362	Magnoliopsida	Poales	Poaceae	Poa		Graminoid	170	5	34.00
Zotu366	Magnoliopsida	Fabales	Fabaceae	Platylobium		Woody	126	1	126.00
Zotu369	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	306	5	61.20
Zotu375	Magnoliopsida	Malpighiales	Salicaceae	Salix		Woody	134	2	67.00
Zotu379	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	310	12	25.83
Zotu381	Magnoliopsida	Myrtales	Myrtaceae	Kunzea		Woody	134	5	26.80
Zotu385	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Woody	157	9	17.44
Zotu386	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	236	8	29.50
Zotu387	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	190	6	31.67
Zotu389	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	180	3	60.00
Zotu390	Magnoliopsida	Fabales	Fabaceae	Bossiaea	foliosa	Woody	218	2	109.00

Zotu391	Magnoliopsida	Caryophyllales	Caryophyllaceae	Scleranthus	biflorus	Forb	121	2	60.50
Zotu392	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	126	5	25.20
Zotu395	Magnoliopsida	Myrtales	Onagraceae	Epilobium		Forb	263	2	131.50
Zotu396	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	241	2	120.50
Zotu399	Magnoliopsida	Poales	Juncaceae	Luzula	modesta	Graminoid	7	2	3.50
Zotu402	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	412	19	21.68
Zotu404	Magnoliopsida	Poales	Poaceae	Agrostis		Graminoid	223	9	24.78
Zotu408	Magnoliopsida	Ericales	Ericaceae	Acrothamnus	maccrei	Woody	108	3	36.00
Zotu409	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	157	12	13.08
Zotu411	Magnoliopsida	Fabales	Fabaceae	Oxylobium	ellipticum	Woody	39	5	7.80
Zotu416	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	340	20	17.00
Zotu417	Magnoliopsida	Asterales	Asteraceae	Achillea	millefolium	Forb	243	4	60.75
Zotu418	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	134	10	13.40
Zotu419	Magnoliopsida	Asterales	Asteraceae	Olearia	phlogopappa	Woody	123	2	61.50
Zotu420	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	145	9	16.11
Zotu421	Magnliopsida	Asterales	Asteraceae	Taraxacum		Forb	52	5	10.40
Zotu423	Magnoliopsida	Sapindales	Rutaceae	Phebalium	Squamulosum	Woody	124	4	31.00
Zotu428	Magnoliopsida	Fabales	Fabaceae	Trifolium	repens	Forb	264	1	264.00
Zotu429	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	292	17	17.18
Zotu431	Magnoliopsida	Asterales	Asteraceae	Craspedia		Forb	99	4	24.75
Zotu435	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	49	8	6.13
Zotu438	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	257	19	13.53
Zotu439	Magnoliopsida	Myrtales	Myrtaceae	Kunzea	muelleri	Woody	125	8	15.63
Zotu440	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	87	1	87.00
Zotu441	Magnoliopsida	Proteales	Proteaceae	Grevillea		Woody	273	8	34.13
Zotu444	Magnoliopsida	Poales	Poaceae	Poa		Graminoid	108	3	36.00
Zotu445	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	148	1	148.00
Zotu446	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	107	12	8.92

Zotu447	Magnoliopsida	Proteales	Proteaceae	Orites	lancifolius	Woody	133	2	66.50
Zotu448	Magnoliopsida	Poales	Cyperaceae	Carpha	nivicola	Graminoid	38	1	38.00
Zotu449	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	184	10	18.40
Zotu450	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	209	5	41.80
Zotu451	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	110	10	11.00
Zotu455	Magnoliopsida	Asterales	Asteraceae	Olearia	phlogopappa	Woody	32	4	8.00
Zotu457	Magnoliopsida	Ranunculales	Ranunculaceae	Ranunculus		Forb	97	5	19.40
Zotu464	Magnoliopsida	Fabales	Fabaceae	Hovea		Woody	129	8	16.13
Zotu467	Magnoliopsida	Asterales	Asteraceae	Sonchus		Forb	6	1	6.00
Zotu469	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	59	1	59.00
Zotu473	Magnoliopsida	Caryophyllales	Caryophyllaceae	Cerastium		Forb	50	1	50.00
Zotu474	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	96	1	96.00
Zotu476	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	304	19	16.00
Zotu484	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Woody	217	1	217.00
Zotu485	Magnoliopsida	Asterales	Asteraceae	Picris		Forb	77	5	15.40
Zotu486	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	9	2	4.50
Zotu490	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	142	2	71.00
Zotu491	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	71	1	71.00
Zotu493	Magnoliopsida	Asterales	Asteraceae	Xerochrysum	subundulatum	Forb	30	4	7.50
Zotu494	Magnoliopsida	Asterales	Asteraceae	Achillea	millefolium	Forb	127	5	25.40
Zotu495	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	149	6	24.83
Zotu497	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	19	1	19.00
Zotu500	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	89	1	89.00
Zotu501	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	159	1	159.00
Zotu502	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	82	4	20.50
Zotu503	Magnoliopsida	Proteales	Proteaceae	Grevillea		Woody	226	4	56.50
Zotu506	Magnoliopsida	Asterales	Asteraceae	Celmisia	sericophylla	Forb	3	1	3.00
Zotu509	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	149	10	14.90

Zotu510	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	107	2	53.50
Zotu511	Magnoliopsida	Myrtales	Myrtaceae	Baeckea		Woody	84	4	21.00
Zotu512	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	210	1	210.00
Zotu518	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	66	3	22.00
Zotu519	Magnoliopsida	Cucurbitales	Cucurbitaceae	Cucumis		Forb	173	4	43.25
Zotu523	Magnoliopsida	Apiales	Araliaceae	Trachymene		Forb	123	7	17.57
Zotu524	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	70	9	7.78
Zotu525	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	76	7	10.86
Zotu526	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	137	2	68.50
Zotu542	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	203	11	18.45
Zotu544	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	66	7	9.43
Zotu545	Magnoliopsida	Proteales	Proteaceae	Orites	lancifolius	Woody	112	2	56.00
Zotu548	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	69	1	69.00
Zotu550	Magnoliopsida	Fabales	Fabaceae	Oxylobium	ellipticum	Woody	3	1	3.00
Zotu553	Magnoliopsida	Myrtales	Myrtaceae	Baeckea		Woody	46	2	23.00
Zotu558	Magnoliopsida	Poales	Poaceae	Agrostis		Graminoid	80	3	26.67
Zotu559	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	101	12	8.42
Zotu561	Magnoliopsida	Asterales	Asteraceae	Olearia	phlogopappa	Woody	88	2	44.00
Zotu582	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	30	1	30.00
Zotu583	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	21	3	7.00
Zotu586	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	146	1	146.00
Zotu588	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	39	5	7.80
Zotu589	Magnoliopsida	Asterales	Asteraceae	Achillea	millefolium	Forb	80	3	26.67
Zotu592	Magnoliopsida	Malpighiales	Violaceae	Viola		Forb	27	5	5.40
Zotu596	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	109	13	8.38
Zotu601	Magnoliopsida	Poales	Poaceae	Poa		Graminoid	111	5	22.20
Zotu602	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Woody	103	6	17.17
Zotu604	Magnoliopsida	Asterales	Asteraceae	Achillea	millefolium	Forb	31	1	31.00

Zotu605	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	59	2	29.50
Zotu608	Magnoliopsida	Sapindales	Rutaceae	Asterolasia	asteriscophora	Woody	32	5	6.40
Zotu615	Magnoliopsida	Lamiales	Orobanchaceae	Euphrasia	crassiuscula	Forb	60	4	15.00
Zotu619	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	122	9	13.56
Zotu626	Magnoliopsida	Apiales	Araliaceae	Polyscias	sambucifolia	Woody	90	7	12.86
Zotu630	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	34	4	8.50
Zotu632	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	192	12	16.00
Zotu639	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	47	2	23.50
Zotu640	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	41	6	6.83
Zotu642	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	113	11	10.27
Zotu643	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	38	3	12.67
Zotu645	Magnoliopsida	Asterales	Asteraceae	Coronidium	monticola	Forb	43	5	8.60
Zotu647	Magnoliopsida	Canellales	Winteraceae	Tasmannia	vickeriana	Woody	25	1	25.00
Zotu648	Magnoliopsida	Myrtales	Myrtaceae	Kunzea	muelleri	Woody	99	4	24.75
Zotu649	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	353	14	25.21
Zotu656	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	70	9	7.78
Zotu658	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Woody	79	9	8.78
Zotu663	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	65	5	13.00
Zotu665	Magnoliopsida	Myrtales	Myrtaceae	Baeckea		Woody	34	4	8.50
Zotu672	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	23	1	23.00
Zotu673	Magnoliopsida	Malpighiales	Salicaceae	Salix		Woody	38	1	38.00
Zotu674	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	76	2	38.00
Zotu675	Magnoliopsida	Asterales	Asteraceae	Olearia	phlogopappa	Woody	49	5	9.80
Zotu678	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	113	7	16.14
Zotu684	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	55	6	9.17
Zotu689	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	14	1	14.00
Zotu703	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	150	1	150.00
Zotu704	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	33	2	16.50

Zotu705	Magnoliopsida	Proteales	Proteaceae	Grevillea		Woody	52	3	17.33
Zotu706	Magnoliopsida	Rosales	Rhamnaceae	Pomaderris		Woody	71	1	71.00
Zotu708	Magnoliopsida	Malpighiales	Hypericaceae	Hypericum	japonicum	Forb	63	4	15.75
Zotu714	Magnoliopsida	Asterales	Asteraceae	Leptinella		Forb	16	1	16.00
Zotu715	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	91	9	10.11
Zotu716	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	60	5	12.00
Zotu719	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	113	9	12.56
Zotu720	Magnoliopsida	Sapindales	Rutaceae	Asterolasia	asteriscophora	Woody	63	6	10.50
Zotu730	Magnoliopsida	Asterales	Asteraceae	Cirsium	vulgare	Forb	85	3	28.33
Zotu731	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	9	3	3.00
Zotu734	Magnoliopsida	Ranunculales	Ranunculaceae	Psychrophila	introloba	Forb	7	1	7.00
Zotu735	Magnoliopsida	Poales	Poaceae	Poa		Graminoid	55	5	11.00
Zotu736	Magnoliopsida	Asterales	Asteraceae	Achillea	millefolium	Forb	60	3	20.00
Zotu737	Magnoliopsida	Malpighiales	Violaceae	Viola		Forb	44	2	22.00
Zotu738	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	90	7	12.86
Zotu739	Magnoliopsida	Fabales	Fabaceae	Bossiaea	foliosa	Woody	45	1	45.00
Zotu740	Magnoliopsida	Asterales	Asteraceae	Leptorhynchos	squamatus	Forb	18	1	18.00
Zotu741	Magnoliopsida	Poales	Juncaceae	Juncus	subsecundus	Graminoid	3	1	3.00
Zotu742	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	66	1	66.00
Zotu743	Magnliopsida	Asterales	Asteraceae	Taraxacum		Forb	42	1	42.00
Zotu770	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	18	1	18.00
Zotu772	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	38	1	38.00
Zotu775	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	153	13	11.77
Zotu776	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	72	1	72.00
Zotu777	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	31	1	31.00
Zotu778	Magnoliopsida	Ericales	Ericaceae	Acrothamnus	maccrei	Woody	11	1	11.00
Zotu791	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	55	1	55.00
Zotu792	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	19	1	19.00

Zotu794	Magnoliopsida	Fabales	Fabaceae	Bossiaea	foliosa	Woody	26	2	13.00
Zotu795	Magnoliopsida	Poales	Poaceae	Anthoxanthum	odoratum	Graminoid	49	4	12.25
Zotu800	Magnoliopsida	Asterales	Asteraceae	Leptorhynchos	squamatus	Forb	70	3	23.33
Zotu802	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	176	15	11.73
Zotu803	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	59	9	6.56
Zotu805	Magnoliopsida	Asterales	Asteraceae	Craspedia		Forb	38	1	38.00
Zotu807	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	35	4	8.75
Zotu808	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	27	2	13.50
Zotu809	Magnoliopsida	Poales	Poaceae	Agrostis		Graminoid	34	1	34.00
Zotu810	Magnoliopsida	Asterales	Asteraceae	Craspedia		Forb	24	1	24.00
Zotu811	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Woody	51	6	8.50
Zotu813	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	408	24	17.00
Zotu816	Magnoliopsida	Asterales	Asteraceae	Leptorhynchos	squamatus	Forb	77	3	25.67
Zotu821	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	15	1	15.00
Zotu822	Magnoliopsida	Asterales	Asteraceae	Celmisia	costiniana	Forb	9	2	4.50
Zotu823	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Woody	33	2	16.50
Zotu831	Magnoliopsida	Caryophyllales	Caryophyllaceae	Stellaria		Forb	26	1	26.00
Zotu838	Magnoliopsida	Malpighiales	Violaceae	Melicytus	dentatus	Woody	19	3	6.33
Zotu839	Magnoliopsida	Myrtales	Myrtaceae	Eucalyptus		Woody	576	18	32.00
Zotu842	Magnoliopsida	Asterales	Asteraceae	Achillea	millefolium	Forb	55	1	55.00
Zotu844	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	40	5	8.00
Zotu846	Magnoliopsida	Asterales	Asteraceae	Leptorhynchos	squamatus	Forb	33	3	11.00
Zotu847	Magnoliopsida	Geraniales	Geraniaceae	Geranium	homeanum	Forb	51	1	51.00
Zotu849	Magnoliopsida	Rosales	Rosaceae	Rosa		Woody	76	1	76.00
Zotu850	Magnoliopsida	Ranunculales	Ranunculaceae	Ranunculus		Forb	22	3	7.33
Zotu851	Magnoliopsida	Myrtales	Myrtaceae	Baeckea		Woody	20	2	10.00
Zotu852	Magnoliopsida	Rosales	Rosaceae	Acaena	novae-zelandiae	Forb	44	7	6.29
Zotu857	Magnoliopsida	Proteales	Proteaceae	Orites	lancifolius	Woody	45	1	45.00

Zotu858	Magnoliopsida	Asterales	Campanulaceae	Wahlenbergia	multicaulis	Forb	89	2	44.50
Zotu860	Magnoliopsida	Canellales	Winteraceae	Tasmannia		Woody	74	2	37.00
Zotu861	Magnoliopsida	Poales	Poaceae	Anthosachne		Graminoid	37	5	7.40
Zotu862	Magnoliopsida	Saxifragales	Haloragaceae	Gonocarpus	montanus	Forb	30	2	15.00
Zotu863	Magnoliopsida	Asterales	Stylidiaceae	Stylidium	graminifolium	Forb	17	1	17.00
Zotu864	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	30	4	7.50
Zotu867	Magnoliopsida	Rosales	Rosaceae	Rubus		Woody	114	3	38.00
Zotu868	Magnoliopsida	Lamiales	Plantaginaceae	Veronica		Forb	26	4	6.50
Zotu870	Magnoliopsida	Caryophyllales	Polygonaceae	Acetosella	vulgaris	Forb	52	2	26.00
Zotu871	Magnoliopsida	Gentianales	Rubiaceae	Coprosma	hirtella	Woody	43	1	43.00
Zotu872	Magnoliopsida	Gentianales	Rubiaceae	Galium		Forb	32	5	6.40
Zotu882	Magnoliopsida	Asterales	Asteraceae	Senecio		Forb	179	5	35.80

Table 12. Analysis of similarity (ANOSIM) results testing whether plant species composition of faecal pellet samples is significantly different between two or more groups. Each pairwise comparison was performed using 9999 permutations. Abbreviations refer to Mt Nelse (MtN), Basalt Hill (Bas), January (Jan), February (Feb), March (Mar), Wetlands (Wet), Grasslands (Gra), and Snowpatch herbfields (Sno). P-values in bold highlight faecal pellet group sample comparisons that are significantly different.

	Comparison between Groups	R-Statistic	P-value
All samples	MtN vs Bas	0.242	**0.011**
	Jan vs Feb vs Mar	0.119	**0.001**
	Jan vs Feb	0.189	**0.001**
	Jan vs Mar	0.191	**0.001**
	Feb vs Mar	0.004	0.337
	Wet vs Gra vs Sno	0.009	0.294
Snowpatch samples	MtN vs Bas	0.331	**0.001**
	Jan vs Feb vs Mar	0.114	0.081
Grassland samples	MtN vs Bas	0.237	**0.001**
	Jan vs Feb vs Mar	0.046	0.144
Wetland samples	MtN vs Bas	0.212	**0.011**
	Jan vs Feb vs Mar	0.109	0.057
Mt Nelse samples	Jan vs Feb vs Mar	-0.015	0.636
	Wet vs Gra vs Sno	-0.015	0.619
Mt Nelse Snowpatch samples	Jan vs Feb vs Mar	0.192	0.133
Mt Nelse Grassland samples	Jan vs Feb vs Mar	-0.022	0.562
Mt Nelse Wetland samples	Jan vs Feb vs Mar	0.264	**0.022**
	Jan vs Feb	0.451	**0.021**
	Jan vs Mar	0.398	**0.034**
	Feb vs Mar	-0.034	0.512
Basalt Hill samples	Jan vs Feb vs Mar	0.249	**0.001**
	Jan vs Feb	0.309	**0.001**
	Jan vs Mar	0.345	**0.001**
	Feb vs Mar	0.152	**0.013**
	Wet vs Gra vs Sno	0.053	0.124
Basalt Hill Snowpatch samples	Jan vs Feb vs Mar	0.233	0.079
Basalt Hill Grassland samples	Jan vs Feb vs Mar	0.259	**0.012**
	Jan vs Feb	0.287	**0.026**
	Jan vs Mar	0.421	**0.006**
	Feb vs Mar	0.118	0.157
Basalt Hill Wetland samples	Jan vs Feb vs Mar	0.194	0.092