Wild animal recovery operations Problem statement

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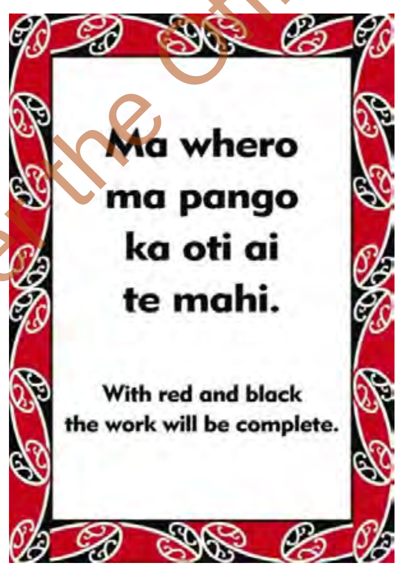

This whakatauki refers to co-operation where if everyone does their part, the work will be complete. The colours refer to the traditional kowhaiwhai patterns on the inside of the meeting house.

1 CONTENTS

Hughes 500 D helicopter recovering Red Deer shot in Fiordland National Park in the South Island of New Zealand. https://www.nzlandscapes.co.nz/product/434/14941/

PREFACE

Uncontrolled, wild animal populations in Aotearoa New Zealand cause unacceptable impacts on native forests, shrublands and alpine ecosystems.

Māori were historically expert hunters and fishers. Before colonisation Te Ao Māori perceived an environment where people were integral and related to all te taiao through whakapapa and wise use of resources was governed through kaitiakitanga. This world view expanded with the addition of introduced wild animals such as goats, pigs, and deer, and the role people took in these new arrivals, recognising both their value and their capacity to disturb the balance of nature.

When Europeans arrived this land was seen as depauperate of the food basket of plants and animals that underpinned the wellbeing of western civilisation. Once colonisation began in earnest this world view extended to wild animals – first goats and pigs (still called Captain Cookers) and then deer, tahr and chamois as game. However, no predators and few of diseases that contribute to controlling wild animal populations in their native ranges were introduced. Population growth was therefore limited only by the per-capita food supply (which decreases as population size increases) unless there was significant human hunting pressure as well.

With the coming of European settlers, introduced species, land sales and confiscation, the clearing of land and colonisation, Māori lost valuable traditional hunting and mahinga kai skills and the ability to continue their cultural practices and their connection to te Taiao. Many whanau and hapū are actively working on reviving these important whakapapa values. In pre-European times there was an abundance of native biodiversity that enabled Māori to respectfully manage their responsibility of kaitiakitanga. Today, with the changed landscape and practices, this inherent duty to care for native flora and fauna for future generations, has at times been nearly impossible and the weight and responsibility of this has been devastating to many whanau. Māori values and knowledge are needed in today's Wild Animal Recovery Operations[1] (WARO space). Upholding traditional values, providing kai, and sustaining kaitiakitanga values is a duty for many.

Up until the 1960's human induced mortality of the many species of introduced wild mammal populations was insufficient to control their population growth and the carrying capacity of the environments they inhabited were exceeded. Ecologically, the abundance of palatable indigenous plants in these areas was significantly reduced and, in some places, palatable species were extirpated. Continued wild animal browse in these areas results in unpalatable species gradually replacing palatable species. Thus, wild animals influence the vegetative composition of many uncultivated areas of Aotearoa New Zealand [2].

Aotearoa New Zealand has a long tradition of hunting for recreation, wild game meat, and trophies with estimated 30,000 - 80,000 active hunters and families in some cases with several generations engaged in pursuing a range of outcomes – sporting, food security, fitness, and conservation. Recreational hunting has become a significant component of New Zealand backcountry experience and enjoyment for both rural and urban enthusiasts and an enduring

[1] WARO is the term used by Government agencies for the recovery of wild animals as defined by the Wild Animal Control Act 1977 as live capture or for utilisation of carcasses. In this report we examine those taken from public conservation land while recognising that the practice also occurs on private land.
[2] Nugent, G., W. Fraser, and P. Sweetapple. 2001. Top down or bottom up? Comparing the impacts of introduced arboreal possums and 'terrestrial' ruminants on native forests in New Zealand. Biological Conservation **99**:65-79.

part of the Kiwi bloke mythology. As such it also supports a significant, predominantly rural small-town economy with a network of mainly small businesses providing clothing, equipment, and game estate and guiding services to both local and visiting recreational hunters. Based on Woods (2010)[3] conservative estimate of 30,000 hunters, Kerr (2014) estimated that recreational hunting removes around 125,000 deer each year[4].[5]

Helicopter-based commercial recovery of wild game is not unique to Aotearoa New Zealand, but it has been a significant tool for wild animal population control tool here since the establishment of an international market for wild venison in the 1950's[67]. For example, red deer abundance was estimated to have been reduced by 75% between 1960 and 1980[8]. Since its peak, WARO harvest has reduced significantly[9] and wild animal populations have increased in abundance[10].

In this report, we explore the history that has led to this situation and the system dynamics that are preventing or limiting progress.

Red deer PHOTO: Gordon Roberts ©

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[3] Woods, A., and G. Kerr. 2010. Recreational game hunting: motivations, satisfactions and participation. Lincoln University, Canterbury, New Zealand.
[4] Kerr, G. N., and W. Abell. 2014. Big game hunting in New Zealand: per capita effort, harvest and expenditure in 2011–2012. New Zealand Journal of Zoology **41**:124-138.
[5]Nugent *pers comm* suggests that the estimate may be substantially high as a result reporting bias (which was large in the Nugent 1992 study): i.e., the hunters who are most active and engaged are more likely to respond than those who are less interested.
[6] Figgins, G., and P. Holland. 2012. Red deer in New Zealand: game animal, economic resource or environmental pest? New Zealand Geographer **68**:36-48.
[7] Challies CN. 1989 Status and future management of the wild animal recovery industry "The New Zealand game packing industry originated about 1958-59 with a series of trial export shipments of red deer venison, which was obtained from ground-based hunters. Helicopters were first used to service hunters on foot, lifting them into shooting areas and returning later to ferry their kill from the hillside to the nearest road or depot. About 1964, attempts were made to shoot and recover deer from airborne helicopters. This method proved practical and economic and quickly became common practice."
[8] Nugent, G., and K. W. Fraser. 1993. Pests or valued resources - conflicts in management of deer. New Zealand Journal of Zoology **20**:361-366.
[9] Parkes, J., G. Nugent, and B. Warburton. 1996. Commercial exploitation as a pest control tool for introduced mammals in New Zealand. Wildlife Biology **2**:171-177.
[10] Moloney, P. D., D. M. Forsyth, D. S. L. Ramsey, M. Perry, M. McKay, A. M. Gormley, B. Kappers, and E. F. Wright. 2021. Occupancy and relative abundances of introduced ungulates on New Zealand's public conservation land 2012-2018. New Zealand Journal of Ecology **45**.

2 EXECUTIVE SUMMARY

1. In this report we conclude that Wild Animal Recovery Operations (WARO) have the potential to contribute far more to controlling and managing wild animals[11] than is currently being realised. Current harvest of wild red deer for commercial purposes fluctuates around 20,000 per annum. WARO has not significantly contributed to control of other deer, tahr, chamois, pigs or goats in the last decade or more.
2. The underlying causes of why WARO is not currently contributing at its potential are complex and layered. WARO under-performance in contributing to wild animal control is compounded of underlying factors, notably:
    a. Stunting of WARO as costs rise faster than prices and both fluctuate.
    b. Very limited support from Government for industry development.
    c. The industry lacks the collaboration seen in farmed deer and other primary production sectors required to resolve the issues it faces.
    d. Competition from farmed deer which produce higher quantity quality cuts at lower cost than can be achieved from recovering wild animals.
3. From a WARO operator point of view, it is "death by a thousand cuts". All those interviewed referenced food safety requirements, e.g., poison standdowns and land boundary buffer zones, as limiting the areas they can operate. Some also referenced restrictions on areas and times that they can operate. The higher price of fuel and equipment (helicopters, guns, ammunitions), and low value of wild caught export venison (compared to farmed venison) and low carcass weights was also viewed as limiting by many.
4. At the time of writing thirty-one companies or individuals held WARO concessions for the South Island and nine for the North Island some of whom also had concessions for the South Island. Most WARO concession holders do little or no carcass recovery from PCL each year. Concessions and other relevant licences are held in the hope for a window of higher prices while they use their infrastructure (principally helicopters and their pilots) on other, more profitable enterprises. A dedicated few keep operating even at a loss in times of lower prices and higher operating costs and thus sustain continuity in operational capability and in market confidence.
5. WARO operators are resourceful, highly skilled individuals, requiring a substantial economic base to establish and maintain capability. There is little incentive and costs are prohibitive for younger people entering the industry as operators.
6. There is no incorporated body to speak for the industry, and over recent decades, no strong voice for its development within central Government, e.g., for developing national level promotion to support international and domestic market stability and growth.
7. Apart from general under-resourcing, the limiting factor associated with the Department of Conservation is that WARO is not properly embedded as a key contributor in the wild animal management system.

[11] Wild animals are those defined in the Wild Animal Control Act – all species of deer, tahr, chamois, and feral pigs and goats.

8. Statutory policy and legal settings associated with DOC have been stable for many decades in the way they govern WARO and its associated permissions systems. The major change impacting WARO over the last two decades has been increasingly stringent food safety requirements.
9. Much of the thinking that went into operationalising that policy framework was established at a time when wild animal populations, particularly deer, were at lower abundancies in many parts of New Zealand, largely due to the impact of WARO. In the 1970s and early 1980s there were strong concerns from recreational hunters about effects of WARO in reducing herds in places favoured by recreational hunters. The concerns by recreational hunters around reducing population densities by WARO are not widely held today. Instead, the concerns now are around WARO being applied in a way that devalues herds valued by recreational hunters, e.g., targeting trophy or trophy potential males, impacting hunting experiences, and the risk this poses for increasing conflict.
10. While both WARO and recreational hunting have provided downward pressure on ungulate population numbers on PCL. Their collective impact has not reduced ungulate populations to levels compatible with conservation goals in many areas.
11. The most recent data show that ungulates occur at 82% of sites on public conservation land, an increase from 63% of sites in 2013[12].
12. Trust was found to be low across the portions of the WARO system we examined. WARO operators perceive undue influence from recreational hunting advocates. Recreational hunting spokespeople perceive undue influence from WARO and environmental advocates. Environmental advocates perceive undue influence from hunting interests of all sorts. Nobody expressed strong trust in DOC or MPI. However, all agreed that WARO was a valued part of wild animal management in New Zealand.
13. Underlying tensions fuelling that lack of trust related to a social divide in values. For some wild animals are a valued commercial, recreational, or aesthetic resource. For others they are conservation and/or agricultural pests. Within wider society many people view deer as of value, while also being concerned about adverse effects on natural environments[13]. Advocacy groups trying to shift the policy settings in favour of their values largely balance each other out.
14. Statutory agencies must manage to the requirements of the law. This means that DOC's primary role lies in maximising desired conservation outcomes, using wild animal control where necessary, with secondary roles in encouraging recreation and allowing tourism where these are compatible with its primary role. The Game Animal Council legislation can allow the status of some animals at some places to be changed from being conserved wild animals to be controlled. If game animals are managed as part of herd of special interest they are no longer seemed to be "wild animals" under the Wild Animal Control Act., but with constraints related to DOC's primary role.
15. These same tensions were expressed by iwi representatives that participated. There was deep concern about the damage caused by high densities of wild animals at places, including

[12] Abundance and distribution of ungulates 2021-2022 (doc.govt.nz)

[13] Russell, J. C. 2014. A comparison of attitudes towards introduced wildlife in New Zealand in 1994 and 2012. Journal of the Royal Society of New Zealand **44**:136-151.

on Māori land. At the same time deer and pigs have become cultural assets and form part of contemporary mahinga kai.

16. However, while the principal values of each group varied, core values were found to be largely shared. Both WARO operators and recreational hunters highly referenced their role in wild animal management and therefore in conservation. Neither wanted to conflict with the other, and both saw opportunities for practical accommodation at place. DOC and environmental advocates value the contribution of both hunting groups to protecting native ecosystems.
17. Some cited successful accommodation of interests at places. They referenced fostering local relationships and having each party able to see an outcome that they valued. These successful experiences integrated WARO components at a local, landscape scale.
18. Those that manage parts of the system (mostly DOC and MPI food safety) suggested causes for problems in WARO performance that differed depending on where they were placed. There is therefore no established dialogue between parties that allow issues to be resolved where more than one part of the system is involved. The inter-agency and industry group established by DOC and MPI ceased to meet during the COVID pandemic, and no one has taken responsibility for re-establishing it.
19. Within DOC, interactions with the WARO system, and the wider wild animal management system, seem to fall between silos with resulting mixed messages to a wide range of parties and a lack of coordination for achieving desirable outcomes. For MPI, WARO appears to be too small to attract the attention received by farming, fishing, and forestry.
20. Overall, there is more to be gained by creating culture of collaboration and working together on the practical issues than by conducting a full-scale review of WARO. The industry needs stability and support, and much can be achieved without changing the underlying policies.
21. A fundamental review would inevitably involve changing policy and legislation that have much wider implications. The resulting complexity would lead parties into unproductive conflict, rather than making real progress on restoring WARO as an important tool in wild animal management. The conservation law reform process has commenced and will reach the Wild Animal Control Act at some point after 2025[14].
22. Productive lines of work will involve:
    a. Reviving working together at a national level and at place.
    b. Supporting refinement in food safety requirements.
    c. Engaging WARO as a targeted tool for wild animal management.
    d. Supporting marketing of the product.

[14] https://www.doc.govt.nz/globalassets/documents/about-doc/role/legislation/conservation-law-reform-roadmap.pdf

3 Purpose of this Report

To advise the Department of Conservation on systemic problems with Wild Animal Recovery Operations (WARO). Our starting hypothesis was that wild animal recovery operations could contribute more to wild animal control in New Zealand if system constraints were reduced.

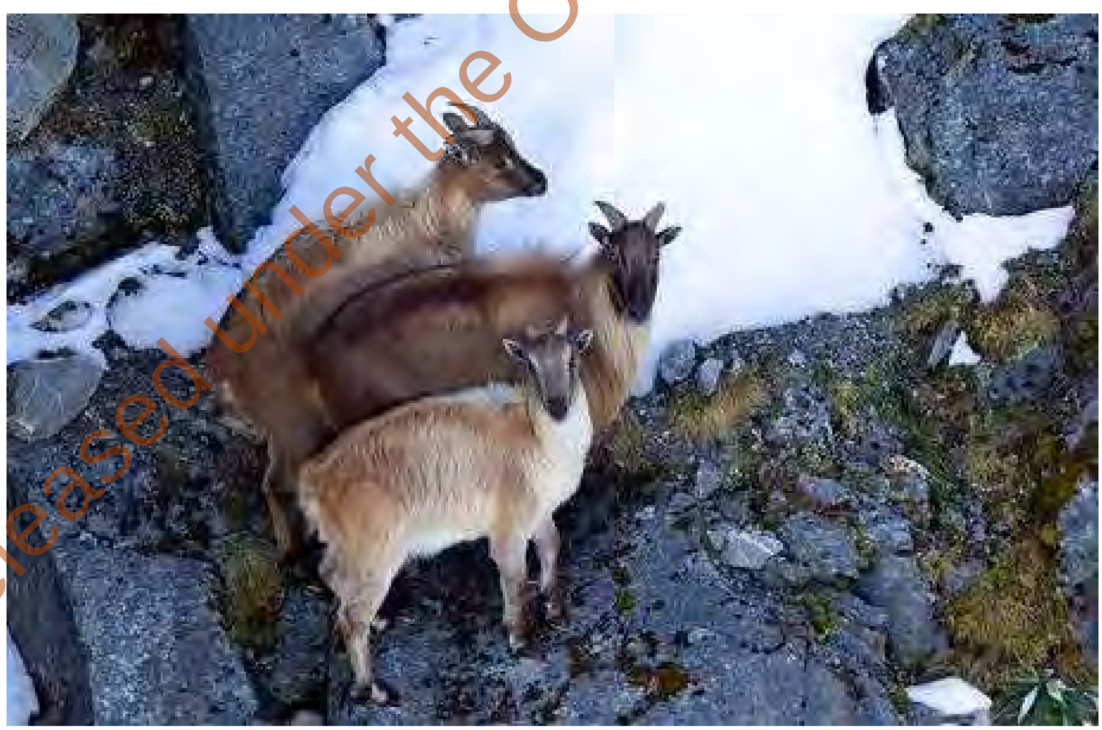
4 Scope

WARO is a commercial hunting activity within the wider systems of meat production and indigenous biodiversity conservation. Here we use the term to apply to commercial recovery of wild animals from public conservation land for any purpose. Wild animals are those so defined under the Wild Animal Control Act, all species of deer, feral goats, tahr, chamois, and feral pigs.

Within scope are the effects of commercial recovery on recreational, trophy, and subsistence hunting, but where meat or animal products are recovered for non-commercial purposes are out of scope.

This report examines the inter-connection of WARO with commercial recovery of wild animals from private land and recreational hunting of wild animals to the extent that they are relevant to understanding the issues involved in WARO *per se*.

Note that deer, goats, tahr, chamois, and pigs held securely behind fences are not deemed wild animals to be controlled except through ensuring that they do not escape. Similarly, any animals that in the future are classified as part of a herd of special interest under the Game Animal Council Act would not be deemed to be a wild animal. Conversely, wild deer that stray onto farms, but are not contained there for farming purposes, remain wild animals.



Himalayan Tahr Photo source DOC

5 SYSTEM DESCRIPTION

5.1 INTRODUCTION

Wild animals in New Zealand are grazers or browsers, or in the case of pigs, omnivores, that were introduced as a new food source (pigs and goats) or for game purposes (deer, tahr, and chamois).

No predators were introduced with these animals that might control their numbers, and care was taken to avoid introducing diseases. High rates of population increase are inevitable unless steps are taken to increase mortality or until environmental carrying capacity begins to decline.

Natural environments in New Zealand evolved in the absence of toothed browsers. Plant associations are quite different to those seen where plants and browsers evolved together. This makes forested, shrubland and alpine grassland ecosystems all vulnerable to browsing impacts. For some favoured plant species, impacts may be significant at relatively low deer densities. Conversely, many species are unpalatable to wild animals and can benefit from their presence through reduced competition for light and space.

5.2 A POTTED HISTORY

"The New Zealand game-packing industry originated about 1958-59 with a series of trial export shipments of red deer venison, which was obtained from ground-based hunters. Helicopters were first used to service hunters on foot, lifting them into shooting areas and returning later to ferry their kill from the hillside to the nearest road or depot. About 1964, attempts were made to shoot and recover deer from airborne helicopters. This method proved practical and economic and quickly became common practice."[15]

Historically, commercial recovery of some species of wild animals in some places has reduced populations to levels where adverse effects of browsing were noticeably reduced. This was most evident for deer and tahr in unforested alpine systems when export meat prices were high.

Live capture was a significant part of the system for a few years as these deer were used to found farmed deer populations. Today, live capture is a minor part of the system and most of the deer commercially recovered are processed for meat. In addition to red deer a small number of Himalayan tahr are taken for WARO in some years. Other deer species, chamois, feral goats and pigs are not significantly targeted for a range of reasons, but mainly because small size and/or low returns make hunting them unprofitable.

As can be seen from the graph below, the number of deer taken commercially from land of all tenure has declined from a peak of almost 140,000 per annum to a level that fluctuates at around 20,000 per annum at present. Over the period 2011 to 2021 DOC estimated the take from recreational hunters to be about six times the magnitude of the WARO take. Over the same decade deer farms were producing 350,000 to 450,000 animals each year. Note the dip around 2004 reflects contamination issues in exports that were later resolved. A smaller dip in 2019 occurred with the outbreak of the COVID-19 pandemic with a recovery toward pre-COVID numbers in following years.

[15] Nugent *pers com*

Data held by Department of Conservation derived from MPI processing figures for all feral venison activity across all land types. The figures exclude deer processed for pet food.

Going back 100 years saw the start of Government control and the fundamental source of the issue we face today. Perham's 1922 report; 'Deer in NZ'[16] to Parliament describes growing concern about the impacts of deer being realised at this time. It was from the period of the early 1900's to late 1920's's, culminating in a 1930 "Deer Menace" conference held in Christchurch, that led to Government action.

Initially the Department of Internal Affairs (led in a military style fashion by Captain Yerex – "The Skipper") took responsibility for the deer issue and field operations. The Crown had permitted importation of these animals, so it made sense that the Crown needed to step up and sort the situation out. Many of the politicians of the day were big farmers and had seen the impacts of deer for themselves. Early operations were criticised as ineffectual except in reducing competition with livestock as the hunters were under orders to retrieve deer skins from animals shot. This was a Government directive to offset control costs and establish a skin export market. Recovering skins and focussing on tallies proved a hindrance to effective early ground control methods.

New Zealand Forest Service (NZFS) took over deer control functions from the Department of Internal Affairs in 1956. Ground control effort shifted to a focus on erosion prone or high conservation value lands. NZFS operations were accompanied by extensive field surveys.

The shift in operational focus from the mid 1950's coincided with new thinking around forestry and soil erosion and conservation science. Much of this science was transplanted from Europe, USA, and Canada.

In the national context, by the late 1920's the country had stripped many of its useable native forests bare. Towns had experienced devastating floods through this period, alongside loss of

[16] DEER IN NEW ZEALAND. REPORT ON THE DAMAGE DONE BY DEER IN THE FORESTS AND PLANTATIONS IN NEW ZEALAND.APPENDIX TO THE JOURNALS OF THE HOUSE OF REPRESENTATIVES, 1922 SESSION I, C-03A https://paperspast.natlib.govt.nz/parliamentary/AJHR1922-I.2.1.4.7

productive farmland. People blamed loss of forests on indiscriminate land clearance together with a growing impact from introduced wild animals.

Early conservation organisations such as the Native Bird Protection Society (or Royal Forest and Bird Society as the organisation became)[17] trace their roots back to this period. The advocacy of these groups proved instrumental in prompting Government into action over conservation and wildlife issues

Catchment boards, developed from early local and urban based water boards (the forerunner of today's Regional Councils) formed under the Water and Soil Conservation Act 1941. Forestry, allied with soil erosion science, became a critical influence on both catchment board and NZFS thinking. For example, decisions around the planting of conifers for erosion control (the now problematic wilding conifers) can be traced back to this time. All this thinking also influenced decisions taken around wild animal management.

It is useful to note that Government subsidies (or incentivisation) to stimulate wild animal control are nothing new. Along with the earlier efforts to establish a venison meat and skin market there were free ammunition and tail bounty schemes operating through to the latter half of the 20th century.

The advent of helicopters in New Zealand from the mid-1960s proved a game changer for wild animal control and management. The innovative and effective use of helicopters for wild animal control and harvesting made ground hunting efforts by agencies such as NZFS less relevant.

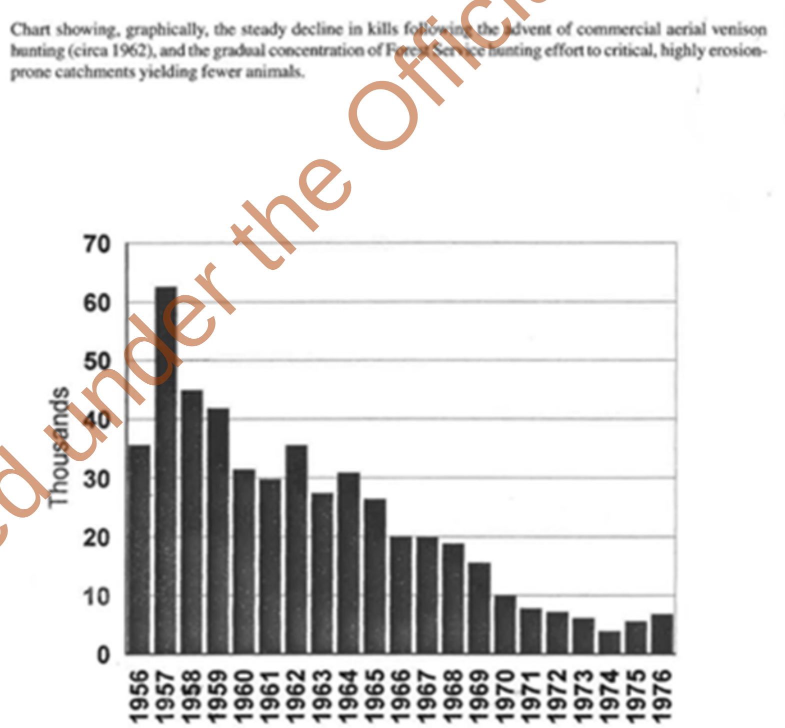


Chart showing, graphically, the steady decline in kills following the advent of commercial aerial venison hunting (circa 1962), and the gradual concentration of Forest Service hunting effort to critical, highly erosion-prone catchments yielding fewer animals.

Graph source: The Deer Menace. A History of Government Pest Control Operations 1930-1987. Written and compiled by Lynn Harris

[17] https://www.forestandbird.org.nz/about-us/our-history

Barry Crump was able to retire and write his books to create the mythology which lingers today.

All this created a big dive in deer numbers in the period before the Department of Conservation was formed on 1 April 1987.

Recreational hunters had not been happy with such low deer numbers. This created tension and blame still felt by helicopter WARO operators today and led, under the Forest Service (under the 1977 WAC act), to the creation of Recreational Hunting Areas[18] to try to keep recreational hunting groups happy by excluding commercial hunting. Ten RHAs were established in areas with smaller or rare deer (fallow, sika, white-tailed) of low commercial value. Some, but not all, RHAs attempted to manage hunting in ways that benefitted hunters, but such management effectively ceased when DOC was established. A substantial proportion of the track and hut network in forest parks and back country areas were leftovers from wild animal control operations established in earlier decades.

After 1987 the term 'noxious animal' disappeared from the lexicon in reports to Government and the term 'wild animal management' came to be used much more commonly.

To understand what happened to WARO administration between 1987 and 2023 the focus needs to widen to consider what happened to DOC as part of the wider public service system, and what happened to DOC as leadership and focus changed over time.

In 1987 the Department took on responsibility for one third of New Zealand, 13 Acts of Parliament, wildlife, marine mammals, coastal management, marine reserves, what turned out to be 16,000km of tracks and around 1,000 huts, a slew of other responsibilities and, wild animal management.

The Department has never been adequately resourced to meet expectations about its performance. Each time an area of responsibility was examined the answer was the same – not enough money, not enough people. This happened for visitor assets, possums, predators, some threatened species and so on. At the same time Government policy of not funding agencies to compensate for inflation fell heavily on the Department. Inflation is felt most strongly by distributed operational parts of the public system, such the police, health, education, and DOC. It is little felt by the policy agencies that help Government create the rules. This means that every year each part of the operation must find efficiencies or reduce output. Operating budgets are much less painful to reduce than staff budgets. Most wild animal management has historically been done through contracts. Deer lost the limited funding remaining from Forest Service operations first. DOC's priorities shifted from the NZFS focus on forest and land to prioritising protection of the native fauna from predators given the immediacy of the threat of extinction of many bird species. Goat control budgets have been gradually whittled away in real terms. Pigs and chamois have struggled for attention, with pigs getting some when they destroy threatened species or act as vectors for disease such as kauri dieback.

[18] Areas where recreational hunting would be the principal form of wild animal management were selected on the basis that soil, water, and indigenous vegetation values were not likely to be threatened by wild animal populations and that recreational hunters were likely to maintain these populations at acceptable levels (Miers 1985) from : K. Wayne Fraser & Peter J. Sweetapple (1992) Hunters and hunting patterns in part of the Kaimanawa Recreational Hunting Area, New Zealand Journal of Zoology, 19:3-4, 91-98, DOI: 10.1080/03014223.1992.10422313

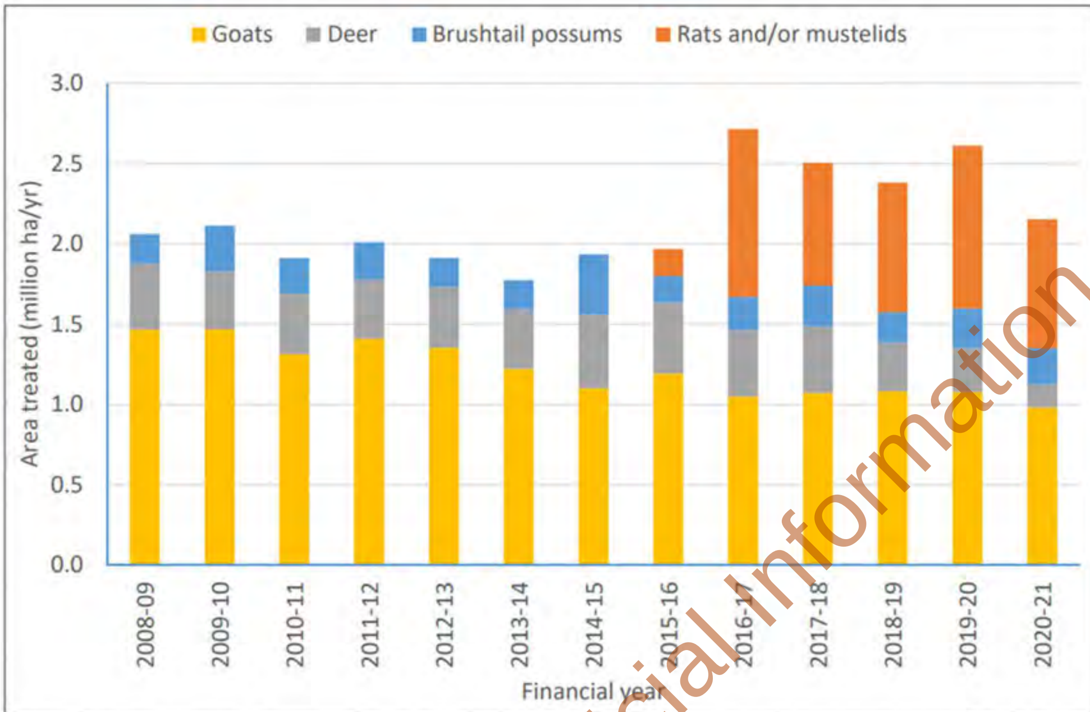


Figure 1. Geographic extent of areas receiving management by DOC for brushtail possums, rats and/or mustelids, deer and goats over thirteen financial years, based on data contained in DOC annual reports (DOC 2013; 2015; 2021).

Illustrating the declining emphasis on deer & goat control. Source: Leathwick, Byrom: Predator control: panacea or distraction? New Zealand Journal of Ecology (2023) 47(1): 3515 © 2023 [19]

Leathwick, Byrom: Predator control: panacea or distraction? 5

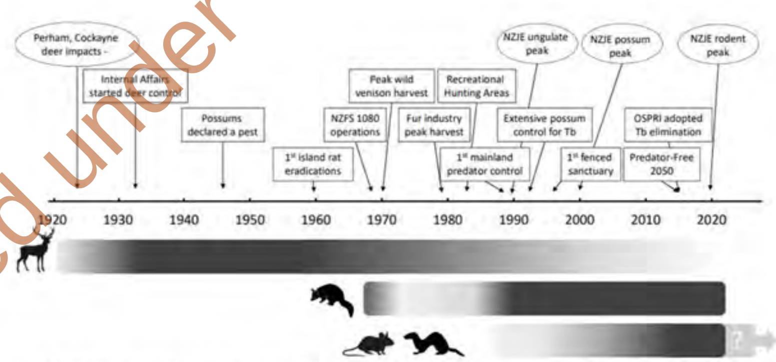


Figure 2. Timeline summarising temporal changes in management of ungulates, brushtail possums and predators by Crown agencies in Aotearoa. Darker shading indicates greater intensity of control operations; key events are listed in text boxes (top bar for deer, middle bar for possums, bottom bar for all predators). Peaks in the number of publications relevant to each group of invasive mammals in NZJE are shown in ellipses.

Graph source: Leathwick, Byrom: Predator control: panacea or distraction? New Zealand Journal of Ecology (2023) 47(1): 3515 © 2023

[19] https://newzealandecology.org/nzje/3515

However, key staff were also lost and not replaced at all levels, but critically at senior management levels. This was offset when the Department still had executives who had worked on the front lines, including wild animal control. That is no longer the case. This has accelerated in recent years as the aging workforce has incrementally lost institutional memory with each retirement. Multiple restructuring, sometimes called other things for the optics, have also tended to replace empowerment of the distributed ranger structure with a managerial approach. It has also created silos, with parts of wild animal management having to spend effort to connect, if they do at all.

As the wild animal management system within DOC degraded under these forces, WARO no longer had a functional system to fit into. This is now being rectified and a Level Three National operations director has been given responsibility for wild animal management but does not have direct authority over WARO concessions.

The Game Animal Council came into existence in 2013. This is its brief to the incoming Minister of Conservation in January 2023:

Wild Animal Recovery Operations (WARO) typically account for around 15-20 percent of the estimated annual deer harvest with recreational hunting accounting for almost all the rest. Because WARO is not adequately targeted it does not realise the potential benefits it could have for game animal management and conservation, and creates substantial conflict with the recreational hunting sector. The Department of Conservation has commissioned a partial review of WARO, which is currently underway. This is limited in scope and substantially fails to address the core issues that have existed with the WARO system for many years. The GAC strongly recommends that a comprehensive 'review' of the WARO system takes place in the 2023-24 year. The conservation and deer management challenge demands an integrated and modern approach and a comprehensive review is an essential step to maximising WARO's conservation potential and meeting the goals of the ANZBS and Te Ara ki Mua. The way WARO currently operates also provides for a high level of frustration for both operators and recreational hunters. Concerns relate to the number of deer being harvested in certain places, stags being harvested in accessible and popular recreational hunting locations and the boom-or-bust nature of the industry. The Department has signalled to the hunting sector for well over a decade that a comprehensive WARO review is required and although it is a substantial piece of work the GAC believes prioritising it in 2023-24 is critical.

The Department of Conservation brief to the same incoming Minister does not mention WARO as such. It does say "*We're struggling to supress predators and pests. Deer and other browsers are destroying our forests and we are only holding the line in areas with sustained predator control.* "*Effective browser control" (e.g., goats, deer, tahr)* was listed for the Minister as a priority work programme.

5.3 CURRENT SYSTEM

Wild animals for WARO are generally shot by skilled hunters operating in helicopters which are then used to recover the carcasses after the animal has been gutted. GPS tracks are recorded and submitted to meat processors for food safety purposes (primarily related to whether the deer was shot in or near a recently poisoned area).

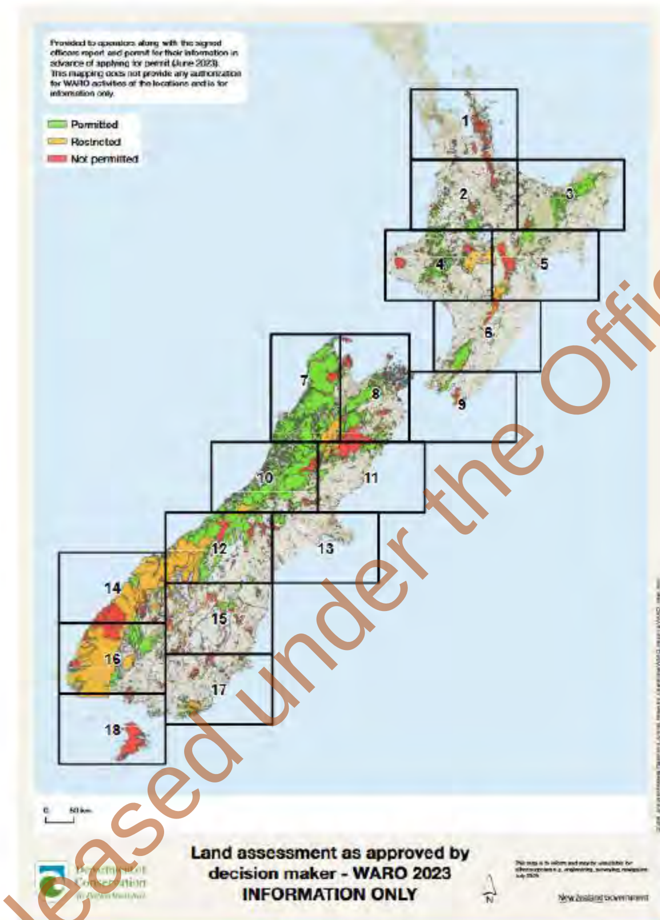
WARO can operate on public conservation land (PCL) under a concessions system and on private or leasehold land with the approval of the owner or occupier. The areas of PCL and the times they are available for WARO are defined in the concession documentation. They are determined by DOC staff based on current law and policy plus advice from operations staff. There are separate processes for

North and South Island concessions for deer, for tahr within their feral range in the South Island, as well as special permissions for things such as live recovery for game estates.

As of July 2023, there were 34 current WARO concessions comprising seven current in the North Island and 27 in in South Island. There was a total of 41 concessions being processed for the new WARO permit comprising nine concession applications for the North Island and 32 for the South Island[20].

At the time of writing on the total area 8,378,221ha of public conservation land WARO was:

- Permitted on 4,012,238ha.
- Restricted on 2,380,542ha.
- Not Permitted 1,985,441ha[21].



Source: https://www.doc.govt.nz/globalassets/documents/about-doc/concessions-and-permits/waro/waro-maps-2023/waro-2023-map-index.pdf

[20] A few operators have concessions for both the North and South Islands.
[21] https://www.doc.govt.nz/get-involved/apply-for-permits/business-or-activity/national-wild-animal-recovery-operations/national-waro-permit-renewal-process/

DOC reported the key outcomes of the WARO land schedule review as:

There are 8.7 million hectares of public conservation land. 8.4 million hectares (96.6%) of this is included in the new schedule but not all was under review. Of this, 6.4 million hectares is accessible to WARO at some time annually (76.2%). This is 0.1% higher than the total accessible to WARO since the last change in 2015.

The conservation land within the schedule is designated either:

- *Permitted (accessible to WARO all year except for Christmas and the roar exclusion periods, or*
- *Restricted (accessible to WARO only during certain seasons or periods), or*
- *Not Permitted (national WARO isn't allowed at any time during the year).*

Within the 6.4 million hectares accessible to WARO, just over 4 million hectares is Permitted all year (but for Christmas and the roar). This is a 2.3% reduction since 2015. 2.4 million hectares is Restricted to part of a year (a 4.2% increase). This reflects our desire to facilitate appropriate WARO access whilst considering the role of recreational hunters.[22]

The area available for WARO on any given date is reduced by pesticide food safety requirements. In general, any area that cannot be certified as pesticide free is unavailable. The regime appears to be more stringent for wild animals than farmed animals. For wild animals, none can be retrieved within 2km of any area not certified as pesticide free. However, there is no compulsory system for a centralised register of pesticide use. Therefore, all farmland is assumed to have pesticide use unless the landowner makes a declaration to the contrary. This means that most public land within 2km of its boundary with private land cannot be accessed for WARO. The same applies to private land where neighbours within 2km have not completed a declaration.

Recovered carcasses either go directly to the meat processor in a chiller truck or can be held in an approved and audited chiller if they subsequently arrive at the processing plant within 72 hours.

Meat processors generally take wild animals alongside farmed animals. In most cases the volume of farmed deer is far higher with the wild animals filling in gaps in the annual supply cycle. In 2017, there were 840,000 farmed deer, of which 290,000 were slaughtered, whereas commercial harvesters recovered 16,000-29,000 wild deer in 2015-2020.

Processed venison and tahr from WARO goes to both human and pet consumption on local and export markets.

In relation to human consumption or export the minimum standards are set by MPI and adjusted where higher standards are demanded by overseas markets. A template for approving new micro-abattoirs that are being proposed for WARO has been prepared. These can be mobile or stationary.

MPI also administers the food safety regulations for both human and pet consumption for both domestic and export. In this system vets are employed by MPI full-time in processing plant for antemortem inspection oversee general food safety, hygiene, plant operations, and animal welfare.

[22] https://www.doc.govt.nz/get-involved/apply-for-permits/business-or-activity/national-wild-animal-recovery-operations/national-waro-permit-renewal-process/

Assure Quality is responsible for post-mortem meat inspection, paid for by the processor. Whole carcasses in doubt are rejected or downgraded for pet food or rendering. MPI vets and food safety inspectors undertake auditing inspections, typically quarterly (depends on how compliant processor is). MPI and Assure Quality coordinate at plant and national level to address any issues that arise.

Overseas market access requirements limit where wild deer products can go. The wild venison can fit into times when farmed deer are scarce both in an annual cycle and to take up period when the farmed herd is smaller. Some WARO operators are now vertically integrated from shooting to the marketing while others contract with processors who contract with marketers. Most processors process all deer to the export standard even when the product goes to the domestic market. Other products such as pet food are produced as by-products when the markets for these are favourable. New operators wanting to enter the industry when returns become attractive are checked with known established operators to screen out “cowboys”.

6 METHOD

6.1 GENERAL APPROACH

The system was iteratively analysed using semi-structured interviews with knowledge holders and interested parties. Interviewees were offered the opportunity to review notes from their interview and most took advantage of this to correct details. Their responses were grouped by sector and theme. The project team recorded any perceptions of a “problem” whether or not any contrary views were raised by others. We then combined this with available published and unpublished information to understand underlying system dynamics. From this, meta-level statements were developed to create a coherent narrative. The findings of the team were presented to stakeholder groups for comment in June 2023 and this informed the final analysis. Our conclusions are presented in the systems analysis section below.

6.2 TE AO MĀORI – MĀORI WORLD VIEW

We also looked at the system through the lens of Te Ao Māori, the Māori world view. To do this we engaged an experienced tangata whenua knowledge holder and listened to other knowledge holders at the intersection of wild animal management and care for te Taiao[23].

They said that the Te Ao Māori view pays homage to our parents Ranginui (Rangi), the Sky Father, and Papatūānuku (Papa), the Earth Mother. This is an overarching korowai (cloak) that protects us, the teina (children) and provides sustenance for the survival of humanity. Acknowledgment of these tūpuna (ancestors) ensures that whatever we do is made accountable to them. We have a responsibility to ensure that we are respectful and look after our brothers and sisters and their children. This philosophy is the personification of Rangi and Papa and all the atua of te Taiao. It enables us to guide our behaviour as a society through a structure that ensures both our survival and the sustainability of te Taiao. It also captures the view that we are connected to te Taiao through whakapapa and we have an intrinsic relationship with natural ecosystems and species within those ecosystems.

[23] The number of informants was small and drew on work in the top South Island (see https://www.tasman.govt.nz/assets/Tasman-Biodiversity-Strategy-final.pdf) with further insights from the central North Island and South Island West Coast)

PHOENIX FACILITATION

Tangata whenua say that if we do things according to tikanga and kawa (the customary way of correct action) we will heal our relationship with te Taiao (the natural world). Tikanga and kawa are rooted in long experience with te Taiao. It is founded on whakapapa connections. Te Taiao contains us, which means that living in the world must be based on reciprocal restoration and care as we meet our needs. Placing tikanga/kawa at the centre of our interactions with the world offers the whole community an approach that leads to sustainable outcomes for the environment and for people.

7 POLICY CONTEXT

7.1 INTRODUCTION

Management of wild animals in New Zealand occurs in a complex legal and policy framework. WARO is a part of that framework and spans food safety and civil aviation requirements which are not covered here but whose functioning is critical to the future of WARO.

Understanding the framework requires reference to some constitutional conventions:

a. Agencies of State can only do what the law specifies;
b. Where more than one legal instrument applies the decision maker must try to reconcile all requirements, noting that where there is apparent conflict: the higher-level instrument takes precedence over the lower, the more specific over the more general, and the more recent over the earlier;
c. Statutory decisions can be changed using the process specified in law or policy. Where the law is silent the general approach is that the same process used to reach the decision is used to make a new decision about the same subject matter.

The sections below are structured to bring together statutes and policy instruments created under them. The statutes are ordered from those that provide overarching requirements, such as the Conservation Act, those that are specific to wild animals, such as the Wild Animal Control Act.

Note that these elements should be read together and that there are other factors that might influence legal and policy decisions that are not covered here. Each decision or legal determination relates to the facts of a specific case at a specific time. Of relevance will be policy responses to WAI262 and the Ngāi Tai ki Tāmaki Tribal Trust Supreme Court decision on the responsibilities of DOC in processing concessions.

7.2 CONSERVATION ACT 1987

The Conservation Act 1987 is the overarching statute establishing the Department of Conservation and case law shows that its higher-level provisions are applicable in interpreting Acts listed in its first schedule. Of relevance to the management of wild animals and therefore WARO are sections 4, 6 and 6B and Part 3B which governs the granting of WARO concessions.

Section 4 of the Conservation Act states that the Act shall be administered to give effect to the principles of the Treaty of Waitangi. Legal judgements have shown that this provision applies also to the Acts listed in the first schedule of the Conservation Act, and this includes the Wild Animal Control Act. The Settlement Acts cover many locations where wild animals are to be controlled. Read together these Acts mean that the Crown, and its Department of Conservation, have responsibilities to partner with tangata whenua in the management of public conservation land and in controlling wild animals.

Section 6 details the functions of the Department of Conservation. Within section 6 subsections (a) and (e) are important in understanding management of wild animals noting that specific reference is also made to the first schedule Acts and to the directions (if any) of the Minister. The relevant sections read:

> *(a) to manage for **conservation purposes**, all land, and all other natural and historic resources, for the time being held under this Act, and all other land and natural and historic resources whose owner agrees with the Minister that they should be managed by the Department*
>
> *(e) to the extent that the use of any natural or historic resource for recreation or tourism is **not inconsistent** with its conservation, to foster the use of natural and historic resources for recreation, and to allow their use for tourism*
>
> Interpretation of these sections is strongly influenced by the definitions in section 2, particularly the definition of conservation: *conservation means the preservation and protection of natural and historic resources for the purpose of maintaining their intrinsic values, providing for their appreciation and recreational enjoyment by the public, and safeguarding the options of future generations*

Preserve and protect are further defined as:

- ***preservation**, in relation to a resource, means the maintenance, so far as is practicable, of its intrinsic values;*
- ***protection**, in relation to a resource, means its maintenance, so far as is practicable, in its current state; but includes— its restoration to some former state; and its augmentation, enhancement, or expansion.*

The *resource* in this case refers to the natural environment. These provisions apply directly to all land held under the Conservation Act, and in an overarching way to land held under the Reserves and National Parks Act and these are further interpreted below.

Section 6B establishes functions of the NZ Conservation Authority and some of these are of relevance to the management of wild animals. These include advising the Minister on statements of general policy prepared under the Wild Animal Control Act and the Conservation Act, and approving conservation management strategies and conservation management plans for particular areas including those where wild animals are managed. General policies have been established for both the public conservation land on which wild animals occur and for the management of wild animals specifically. These are detailed below. These policies are relevant to the management of wild animal populations and the issuing of concessions for commercial activity on land administered by the Department.

7.2.1 Conservation General Policy

Conservation General Policy applies to everything in the first schedule Conservation Act statutes except national parks which have their own general policies formed through a process under the National Parks Act (see below).

The currently applicable Conservation General Policy was established in 2005. It contains provisions relevant to the management of wild animals *inter alia* (among other things):

- Policy 2 requires partnerships with tangata whenua and active avoidance of creating Treaty breaches;
- Policy 3 requires consultation with people and organisations interested in public conservation lands when statutory planning documents are developed and on specific proposals that have significance for them;
- Policy 4 says that pest management programmes[24] should give priority to: eradicating, containing, or reducing the range of pests that are established but not widespread, where practicable; and controlling widespread pests where this is required to protect indigenous species, habitats, and ecosystems, where eradication or containment of them is not practicable. It also specifies that recreational and commercial hunting of wild animals and animal pests should be encouraged to maximise the effective control of them, while minimising any adverse effects of hunting on planned outcomes at places.

7.3 Wild Animal Control Act 1977

The Wild Animal Control Act 1977 is the primary Act for wild animals. It is a first schedule Act in the Conservation Act, and therefore its implementation is subject to the provisions of that Act including General Policies and Conservation Management Strategies and Plans formed under the Act.

Wild animals are defined to include any deer, pig, feral goat, chamois or tahr excluding those that are held behind effective fences or otherwise constrained. The definition will not include an animal that is part of a herd of special interest under section 16 of the Game Animal Council Act 2013 once such herds have been designated.

Section 4 states that wild animals are to be controlled and that the purpose of the Act is to be *for the purposes of controlling wild animals generally, and of eradicating wild animals locally where necessary and practicable, as dictated by proper land use… so as to ensure concerted action against the damaging effects of wild animals on vegetation, soils, waters, and wildlife; and achieve co-ordination of hunting measures; and provide for the regulation of recreational hunting, commercial hunting, wild animal recovery operations, and the training and employment of staff.*

The Wild Animal Control Act applies to lands of all tenure, and its operation is affected by the status of the land on which the wild animals occur. In particular, the Department of Conservation has a much freer hand in managing wild animals on public conservation land than on land of other tenures. Even within public conservation lands legal requirements can differ depending on the status of the land.

Section 5 gives the Minister wide ranging powers to control wild animals including *inter alia*:

- Preparing and carrying out wild animal surveys, assessments of hunting and hunter influences, and any other matters concerning the incidence of wild animals and the means of controlling them.

[24] Wild animals are not explicitly included within the definition of pests but reading the definition in the glossary in conjunction with 4.2(d) implies that they are considered within the purview of 'pest management programmes' within the Policy.

- Co-ordinating the policies and activities of departments of State, local authorities, landowners and occupiers, boards, and public bodies in relation to the control, and (where necessary) eradication, of any species of wild animals.
- Conducting wild animal research work, co-ordinate such research work, and arrange for other departments or organisations to do such work or to collaborate in such work.
- Approving statements of general policy for the implementation of this Act, and approving amendments to such statements in the light of changing circumstances or increased knowledge.
- Preparing and issuing wild animal control plans and publications relating to wild animals and their control and collecting and disseminating information relating to wild animals.
- Making provision for the setting up of such technical, scientific, advisory, and other kinds of committees as she thinks fit.
- Making provision for the licensing of persons commercially hunting, capturing, transporting, holding, selling, or exporting wild animals, and persons who aid, assist, or guide other hunters in the hunting, capturing, transporting, holding, selling, or exporting of wild animals.
- Specifying conditions under which wild animals may be hunted, and periods and times at which they may be hunted, including making such charges and setting such fees as she considers necessary for any permit, service, and other matter consistent with the Act.

Of relevance are the Himalayan Thar Control Policy 1991 and the Himalayan Tahr Control Plan 1993. There is also a Deer Control Policy, but this does not seem to have been through the statutory procedures to give it more status than an internal DOC policy.

7.4 Game Animal Council Act 2013

The Game Animal Council Act 2013 establishes the Game Animal Council and makes provision for herds of special interest

The Game Animal Council also has functions in relation to game animals that *inter alia* include to:

- Advise and make recommendations to the Minister.
- Provide information and education to the hunting sector.
- Advise private landowners on hunting.
- Raise awareness of the views of the hunting sector.
- Liaise with hunters, hunting organisations, representatives of tangata whenua, local authorities, landowners, the New Zealand Conservation Authority, conservation boards, and the Department of Conservation to improve hunting opportunities.
- Conduct research, including research on the hunting of game animals.
- Operate voluntary certification schemes for professional hunting guides and game estates.

- Promote minimum standards and codes of conduct for certified hunting guides and game estates.
- Investigate complaints and take disciplinary action in relation to certified hunting guides and game estates.

As noted under the Wild Animal Control Act, deeming some wild animals to be herds of special interest would remove their status as “wild animals”. It should be noted that the Game Animal Council Act specifies “overriding considerations” that will constitute a stiff test for creating herds of special interest once specific proposals have been formulated.

7.5 Wildlife Act 1953

The Wildlife Act 1953 consolidated and amended the law relating to the protection and control of wild animals. It is an earlier and less specific Act than the Wild Animal Control Act.

Tahr, chamois, pigs, deer and feral goats are included in the definition of “animals” under the Wildlife Act but are not “wildlife”. This Act therefore does not deal directly with the management of wild animals but may have implications where wild animals or their management adversely affect wildlife protected under the Act.

The 1991 Thar Policy says that tahr are declared to be noxious animals under the Wildlife Act. This is not accurate. Schedule 6 of the Wildlife Act simply declares them to be wild animals subject to the Wild Animal Control Act.

7.6 National Parks Act 1980

The National Parks Act has specific requirements for the management of introduced animals, and these must be considered in operational decisions including establishing the land schedule for WARO. Section 4(2) directs that "introduced wild animals shall as far as possible be exterminated.

Operations in National Parks are also governed by a specific General Policies and Plans approved by the NZ Conservation Authority.

The **General Policy for National Parks** made in 2005 includes several provisions of relevance to management of wild animals:

- Policy 2 directs partnership with tangata whenua in the management of National Parks.
- Policy 3 directs consultation with people and organisations on policies and proposals that have significance for them.
- Policy 4 directs the identification and protection of the full range of indigenous species, habitats and ecosystems and specifies eradicating, where practicable, and containing and reducing the range of established introduced plants and animals and that decisions not to exterminate introduced species should only be made through the processes of the Authority. Policy 4 makes specific provision for concerted action including encouraging hunting where this aids rather than hinders the principal aim of controlling the introduced animals.

National Parks also have their own management plans while Conservation Management Strategies cover these and other public conservation land and wild animal management.

7.7 Reserves Act 1977

Some of land with wild animals is held under the Reserves Act 1977 and the classification of the reserves under that Act governs aspects of operational management. The Act includes as a general direction relevant to wild animals: *ensuring, as far as possible, the survival of all indigenous species of flora and fauna, both rare and commonplace, in their natural communities and habitats, and the preservation of representative samples of all classes of natural ecosystems and landscape which in the aggregate originally gave New Zealand its own recognisable character*.

7.8 Biosecurity Act 1993

The Biosecurity Act 1993 is an enabling act that creates powers to deal with harmful organisms. It applies to wild animals only if to the extent that wild animals have been defined as "pests" in a Plan made under the Act. This is currently not generally the case for wild animals subject to WARO. but could become so in the future.

Robert Wilson and Wattie Cameron load a deer carcass onto the side rack of a helicopter piloted by Milt Sills (right), in 1964. This was the very first venison recovery flight.
https://teara.govt.nz/en/photograph/15801/the-first-venison-recovery-by-helicopter

8 PERCEPTIONS

In this section we summarise and integrate what we heard through interviews and workshop. The statements reflect individuals understanding and opinion at a point in time. This material includes assertions that may not be factually correct. Our interview and workshop records were provided to those involved for comment and corrections made where appropriate reflecting the understanding of those involved.

8.1 LAW AND POLICY

The law and policy governing WARO concessions are complex.

Those in DOC processing concession applications for decisions by the Minister or by senior DOC officials have established a two-step process. The first step is to establish a "land schedule" that defines the places and times that WARO might operate. The second step is to offer the opportunity to apply for concessions for the North or South Island (the "bulk offer") so that these can all be considered together. Operators may apply for both the North and South Is and areas in the land schedule or just for those on one island. Concessions staff then form a "decisions document" in which they carefully analyse the legal requirements and scope for discretion in matters such as the term for the concessions. All concessionaires are granted matching permits.

The differing ages of the key pieces of legislation such as the Wild Animal Control Act 1977 and Conservation Act 1987 and policies such as the Himalayan Thar Control Policy 1991 and Deer Control Policy 2001 result in potential conflicts of interpretation. These then must be integrated into a whole with the two General Policies and places based legally binding strategies and plans. All these preceded broader policy and case law on Treaty and climate issues.

Overall, the legal direction to DOC is to control wild animals rather than give priority for a commercially viable industry (WARO) except to the extent it supports control.

DOC does have obligations to foster recreation, including recreational hunting, where this is compatible with its primary conservation directives. For wild animals this can include establishing recreational hunting areas (RHAs) where commercial hunting is excluded. The current areas were inherited from the NZ Forest Service and DOC has not made further use of this provision.

Herds of special interest, while proving challenging to establish, could alter commercial hunting authorisations where designated.

Regulatory requirements operated by the Ministry for Primary Industries were seen by WARO operators as a barrier to WARO access and to establishing small processing plants for wild animals.

8.2 SYSTEMS AND PROCESSES

Systems include processes, people, power, infrastructure, and the relationships between them. Processes define the ways things flow through the system. Formal processes are often the way the system is intended to work while informal processes often define how it works in practice.

Many commented that there appears to be no up to date overall strategy for wild animal management under the Wild Animal Control Act, and no clear role for wild animal recovery operations within that. The Department does not appear have any comprehensive way of identifying, quantifying, and prioritising the adverse impacts of wild animals on conservation values, and consequently cannot identify why, where, when, and how deer control should be implemented.

This then made it difficult for others to engage constructively either nationally or regionally those interviewed all would like ongoing involvement.

Consultation on the land access schedule is a long and involved process leading to a bulk WARO permit offer that operators do not have to accept. Some in the Department said that if lands are excluded from or added to the WARO schedule, DOC would likely face challenges from one or other of WARO, recreational hunting, or environmental interests. DOC staff said that the current process aims to ensure that effects on stakeholders, and the role of recreational hunting, are understood generally and at place and are managed.

Overall, DOC staff agreed that there was a lack of clear direction on wild animal management and where WARO fits and what role it should play and how they are to be 'co-ordinated'. They experienced:

- A lack of guidance on consultation and managing differing user objectives.
- Lack of data collection and analysis alignment with WAC Act.
- Difficulty in integrating WARO with the local context.
- Lack of clarity around the WARO system within the wider DOC context.

They commented that:

- WARO does not address other wild animals such as goats or pigs.
- WARO is tied to market price/commercial market so not a stable or consistent tool.
- DOC relies on MPI for detailed flight and catch data when it needs this information.

Iwi members said that iwi need to be at the table and that it is a Crown responsibility to ensure that this happens.

The Ministry for Primary Industries system for defining exclusions for harvesting wild animals from areas where pesticides **may** have been used was cited as an issue by all WARO operators and several others. These exclude areas that may have been treated with pesticides until either declarations from landowners can be obtained for 2km around the harvest area have been obtained, and/or until a withholding period is completed that differs for each toxin type and application method.

The wider WARO industry includes helicopter operators with concessions, meat processors, marketers, distributors, and retailers. These roles are integrated in some companies and there are a wide range of other arrangements around the country. The WARO operators include concession holders and their staff and contractors, with some concession holders not currently undertaking WARO activities, but intended to re-enter the industry when conditions are favourable. WARO operators say that the overall system does not work well for WARO and there are many obstacles to a successful operation to PCL. They say that most wild animals are taken from private land.

WARO operators suggested that bureaucracy creates bottlenecks for them. In their experience systems were cumbersome and centralised. They felt that they were being managed by people who did not understand the industry, both in permissions and in policymaking. They specifically cited policies around non-lead ammunition, Robinson helicopters, and use of thermal technology. They found internal DOC processes (such as procurement) often awkward and difficult to navigate. They felt that it stifled work on ground and ability to innovate with wild animal management and utilise WARO for specific DOC aims.

Meat processors said that they preferred to work with a small number of known operators to ensure confidence in quality and information. Processors can therefore control the entry of WARO operators to the system. Overseas market access requirements limit where wild deer products can go. WARO is a much smaller scale operation than farmed venison and has different requirements. Most wild animals are processed in short time blocks in plant otherwise committed to farmed animals which are a higher priority for these operations. They said that traceability was important for both farmed and wild. No cost was passed onto operators for covering MPI and Assure Quality checking, farmed only partially covers costs. Some process all deer to the export standard even when the product goes to the domestic market. Other products such as pet food are produced as by-products when the markets for these were favourable.

Recreational hunting representatives thought WARO systems did not adequately include or reflect the importance and drivers of recreational hunting, creating conflict and overlaps of effort in certain places at certain times, meanwhile, not effectively utilising some places and times without overlap. They said that recreational hunters support WARO as a population reduction and maintenance and resource quality improvement tool. Recreational hunters need a reporting system that allows them to make decisions on when and where to hunt to reduce the potential for conflict with WARO activities. They said that the WARO land schedule changes often miss important local, on-the-ground, considerations. They would like to have WARO focus on female deer, not on stags. Better communication processes could make it clear how recreational hunter values have been considered within decision making and whether these are accepted or rejected.

A game estate operator said that private land WARO supplements the system when PCL was not providing product. He said that WARO can be highly selective and targeted to species, sex and by trophy potential. In his view it was not worth game estates being certified suppliers to processors.

Environmental advocates said that WARO concessions seems to lack conservation purpose and that WARO concessions are not clearly managed for conservation purposes or benefit. They also said that WARO concessions were not adequately directing effort at local scale.

In the past the MPI Wild Game Industry Group drew together representatives of all major government and private sector WARO stakeholders and this was valued by participants. It could be integrated with the GAC function for 'conflict resolution' in relation to game management.

A venison recovery operation in Northern Southland. Doug Maxwell is at the controls of a Cabri helicopter as John Schmelz loads carcasses into a chiller truck. Photo: Hutton Collection. https://www.newsroom.co.nz/deer-devils-of-the-deep-south

8.3 Values And Culture

Values define why people do what they do. Culture determines the way things get done, often to a greater extent than formal system requirements.

Te Taiao is highly valued, and iwi wanted to be involved in caring for it. For iwi there was no separation of their roles in wild animal management and hence WARO from their connection to place and to the seen and the unseen aspects of Te Ao Māori. They said that kaitiakitanga is often translated as stewardship. This is the stewardship of wise use and protection in the same action. Rangatiratanga is translated as chiefly authority, but this misses the responsibility that goes with that authority. WARO fitted well in this frame in that the wild animal resource is utilised while the environment is protected. Shared use of resources and simultaneously caring for the environment resonates better than shooting without recovery.

DOC staff perception of its own (their) values were diverse. Some cited a lack of shared values unifying the Department's work. Those toward the centre were concerned about regional staff locally managing relationships over achieving conservation outcomes. Conversely, those in other parts of DOC thought that concessions staff valued conformity with due process rather than being helpful or customer focussed. It seemed easier for staff in the centre to value correct application of the law and statutory frameworks to decisions than for staff located at the edge. The regional staff who were directly exposed to the effects of events such as "Tahrmageddon" when there were widespread protests by recreational hunters about increases in tahr control. This was reported to lead to differing internal views on how the Wild Animal Control Act should be interpreted and applied due to different relationships and roles.

The horizontal disconnections were exemplified in the perception that a culture of silos with DOC mitigated against integration of wild animal management and therefore WARO improvement opportunities. It also reinforced hierarchical and disconnected activities, contrary to the intentions of Te Ara Ki Mua, and mitigated against inclusive and district-level inputs to WARO decision-making that could better include local knowledge and perspectives, especially from iwi. The vertical issue was seen in a perception that the Department had become very hierarchical limiting the effectiveness of knowledge holders to appropriately influence decisions.

Different parts of the Department agreed that processes were valued over results. Some saw this as a correct focus on due process while others perceived a culture of risk aversion and control rather than results oriented and innovative. Conversely others said that the legislation and policy are clear; 2001 deer policy statement is still current and the WAC Act and part 3B of the Conservation Act gave no wriggle room to be creative. These staff said that DOC's core mandate from 1987 remained biodiversity protection and enhancement. Game management, inherited from multi-purpose estate manager NZFS was not seen to fit well in this context.

A loss of key personnel with deep experience in wild animal control with consequent effects on overall culture and capability were also cited. This was linked to organisational change that was seen as having diminished DOC's ability to maintain wild animal management over time by attrition of in-house expertise, and de-prioritising it as a departmental function.

This loss of experienced personnel was cited to have had effects at all levels. They commented on staff turnover and loss of institutional knowledge. They said that new DOC staff at operations level often don't have a good understanding of WARO process or wild animal management, hence they start making poorly informed local decisions. They commented that DOC was losing connections to the rural hunting community because of past issues and loss of engaged staff.

This divided culture was said to lead to different internal views on how to consider WARO access, especially land schedule changes. Some said that the future of WARO as wild animal management tool was in doubt. These staff felt that, while WARO had in past been an effective wild animal management tool, it was generally in decline and losing effectiveness, especially in the North Island. In the South Island they said that WARO remained useful in open country.

Staff of MPI cited a wide range of values for WARO but did not see it as a high priority for the Ministry. Their core focus was on food safety in products destined for human consumption.

WARO operators strongly referenced their role in sustaining the health of the bush and biodiversity generally. While they needed to run a viable business, they did not present this as their prime motivator. Many safer, more profitable opportunities were available, and all operators participated in these. Some said that they were prepared to subsidise WARO operations from other business interests. They expressed a preference, wherever possible, to retrieving animals and while often engaged in control operations for DOC and private landowners reported that they dislike seeing the venison resource wasted. WARO operators' perception of own culture was consistent. Those operating these businesses are businesspeople and value their capacity to compete successfully in the marketplace. They valued their independence and their contribution to community and environmental well-being. While they did not cite this, their culture clearly embraced risk taking and self-reliance. Most operators were strongly attached to places (though these could be as big as the lower South Island). They valued their multi-functional role in their communities and could be patch protective. Some mentioned valuing fairness and appropriate use of public funds.

Federated Mountain Clubs advocated for a focus on protecting intangible values and natural quiet.

NZ Deerstalkers Association said that the values of their members were diverse and included: recreation, food gathering, safety, outcomes, action opportunity for a trophy from key heritage herds and high value herds and in attributing a high value to males (bucks, bulls, and stags), primarily targeted in the roar or rut. NZDA perceived their members to have a passion for hunting. They were said to be activity-driven with a family based intergenerational connection to this activity. They would like to be recognised as the largest recreational user group of PCL and as the largest group of active conservation workers in the field (combination of harvest and active initiatives).

Forest and Bird staff said that the core drivers of WARO should be protection and preservation of NZ's native plants and animals as a matter of national and international importance. They wanted the focus to be control of introduced wild animals as noxious pests, particularly on PCL.

The game estates representative mentioned animal welfare and game management objectives such as operations avoiding fawning and mismothering to maintain value of the residual population.

Those meat processors that handled wild animals in multi-species plants valued sustaining the financial viability of WARO within the context of also producing higher valued farm products.

The core of Game Animal Council culture was said to be seen in its legislative functions for game animals, deer, tahr, chamois and pigs, which are 'valued introduced species' as per the Aotearoa New Zealand Biodiversity Strategy 2020. The GAC vision was to be a national body working to improve the management of hunting and game animals for the benefit of all stakeholders. They reported wanting to see all hunting activity coordinated for sustainable wild animal management for recreation, commerce, communities, and conservation. For WARO, GAC said that this meant supporting WARO to be viable, effective, efficient and an enduring activity and coordinating WARO activities to benefit wider game animal management and to reduce conflict as far as possible. Fiordland Wapiti Foundation reported that the program's success was due to DOC's acceptance of the wild animals based on game animal management principles and taking a strong customer-based approach, where relationships were seen as key.

8.4 INFRASTRUCTURE

Infrastructure here refers to both human and capital resources. The issues with these were well understood within the industry and by MPI that works directly ensuring quality at the processing stage. Understanding of infrastructure issues was not reported by DOC staff, other than at the front line, or by the Game Animal Council. Overall, no one suggested that helicopters and meat processing capacity are likely to be limiting were harvest rates are to be increased.

Those that commented said that the policy environment had become less supportive – e.g., prohibited firearms (semi-automatic rifles, purchase and maintenance/parts supply, ammunition, auto monitoring). They suggested that the industry needed rejuvenation but that this was limited by expensive equipment both capital and operational (e.g., chillers, helicopters), limited operators due to cost and low revenue, aging operators and none coming through to replace them, lack of communications around concession rules at place and how to report misadventure.

Gaining and retaining skilled staff was an issue throughout the system. Staff in most parts of the system, both industry and regulatory, are aging and replacements take time to train. One larger WARO operator had a cadet scheme, but this was an exception. Meat processors were using immigrant labour but competition for skilled staff is high. How to ensure there were enough people in industry to ensure ongoing viability was an issue for processors and WARO operators. They said that WARO operators and shooters were critical for population management on game estates and, when prices become too low, they are the same operators undertaking culling instead. They said that trophy and meat recovery work together to create a financially viable system for managing game parks. New technologies are being adopted slowly in the industry. Some younger, new operators are using them.

Abattoirs were said by some to be generally old, inefficient and at capacity. The transport costs involved mean that WARO operators needed an abattoir nearby to make it work. Conversely, meat processors reported that processing plants were being kept up to date through re-investment. Plant and equipment were constantly maintained and replaced to keep effective and efficient (reconditioned every 3 months). Keeping equipment and plant such as chillers up to standard was costly and currently not covered by returns from WARO but were maintained in anticipation of potential being realised. Abattoirs struggled to get qualified technical staff as well as regular workers. This was said to be particularly challenging in regions where abattoirs are located. There were reported to be low incentives to upgrade or expand abattoirs for wild game processing due to lower value, lower percentage intake, and international trade restrictions. They said that micro-abattoirs were increasing but had high set-up costs ($200K plus), so they were more for human consumption than for pet food. They were also limited by the ante and post-mortem qualifications required.

WARO operators said that a Hughes 500 needed to be able to extract 7 deer/hr at a schedule of $5-6/kg to just cover costs. Using smaller machines was way more profitable for operators. They said that DOC restrictions on the use of Robinson helicopters was leading to increased costs in wild animal control. In terms of capital, an H500 costs $1.5M while an R44 is $O.5M and there is an equivalent difference in operating costs. One said that none of the Robinson helicopters deaths were on commercial operations. Conversely another operator said that they stopped using Robinson helicopters in 2018. They said that the chances of things going wrong were low but the consequences high.

8.5 Problems and Opportunities

Iwi informants said that:

Problems included:

1. There are now too many deer adversely affecting private, public, and Māori lands.

Opportunities included:

2. They would like to be able to provide kai for whanau while training iwi members in the safe handling of wild game. This could relate to employment opportunities.
3. They would like to see commercial markets re-established to make WARO viable again and to be enabled to participate in the industry. Exercising kaitiaki responsibilities in each rohe would imply roles in both decision making and active participation in the industry.

DOC staff said:

Problems included:

1. The core common problem was lack of clear direction on wild animal management and where WARO fitted in and how they were to be 'co-ordinated'.
2. Collectively they saw a legislative focus for DOC on animal control but said there was no budget for this.
3. Assessment of land access schedules was seen as limited by staff turnover for a highly complex piece of work integrating the relevant factors about each place with the legislation and policy framework.
4. They commented on lack of internal al gnment on how to manage hunting and its role creating problems between parts of the Department.
5. WARO was unable to reflect local context and it was not seen as a stable or consistent tool for wild animal management.
6. Some said that DOC systems and procedures made innovation difficult.
7. DOC was not supportive of WARO.
8. There was a lack of monitoring of WARO concessions and conditions and no enforcement of non-compliance.
9. Financial factors cause variability in WARO as a useful tool for wild animal management.
10. Regional Council possum operations using brodifacoum was adversely impacting WARO.
11. Some staff agreed with the WARO operators that said that a critical problem was DOC restrict on on Robinson helicopter use. DOC staff had views about WARO as a sector. They saw lack of coordination of WARO where all were doing their own thing.
12. For some the positive contribution of WARO in wild animal control was not reflected in support from DOC for the sector.
13. Others did not agree that WARO was a main wild animal management tool. They saw WARO as one 'tool in the box' with impact in certain areas at certain times in certain ways. More comprehensive data was required to determine best places for WARO in wild animal management.

Opportunities included:

14. There is opportunity to work with MPI to resolve the 2km pesticide buffer limitation.
15. It was critical to take opportunities to build on iwi partnerships.
16. Integrating wild animal management, HVU, permissions, legal, policy, GIS, website teams.

17. Improving internal structure and process breaking down silos and establishing more unifying values.
18. Building succession and capacity and knowledge around wild animal management and WARO.
19. Creating greater inclusion of district perspectives of realities on the ground.
20. Creating new permit conditions to allow for improved data capture for DOC directly from WARO to support WARO and wild animal management.
21. Establishing a database of landowners to resolve pesticide declaration issues and the 2km exclusion buffer for WARO.
22. Improving associated systems such as firearm purchase, enabling restricted parts availability by bulk purchasing and ensuring policy decisions are practical by including field staff in policy development.
23. Ensuring effectiveness in the new wild animal management team including internal staff education and communication programmes on wild animal management and WARO, so staff better understand the value of WARO to wild animal control.
24. Marketing opportunities were seen in low carbon (potentially carbon positive), organic, high-protein, free range, wild caught, low-fat product, and it's protecting our ecosystems.
25. Establishing a central database for pesticide recording.
26. Bringing industry players together for their common interests creating a body to lead WARO in a NZ Inc approach.
27. Te Ara ki Mua bringing well needed funding to wild animal management was seen as an opportunity. Te Ara ki Mua provides potential for a collaborative approach to wild animal management, incorporating WARO.
28. Improving relationships with recreational hunters and better realise the potential for GAC and the MPI Wild Game Industry Group to improve wild animal management.
29. Growing trust in the system. They said that trust issues had centred around data capture and commercial sensitivities.
30. The Emissions Trading Scheme could be a game changer if the role of wild animal control was recognised.
31. Looking for innovative ways to enable deer control through ground based commercial extraction.
32. Building Tier 2 monitoring methodology to measure short-medium term ecological impacts.

The MPI staff member interviewed said that:

Problems included:

1. Problems with poor communications around safety and systems leading to a 'grey zone' about who can eat game and what good process and standards would look like. This was linked to public perception of wasted resource at a time of economic hardship and food security concerns.
2. Issues in getting appropriate micro abattoirs accepted and established, a shortage of vets and postmortem inspectors, and local shortages of skilled abattoir staff. There is opportunity to realise the potential of micro abattoirs to meet small-scale local demand and increasing the ability of public access to local game meat products.
3. Barriers due to high traceability requirements due to risks for markets, especially export, competition from higher value, farm-raised game, and regulatory barriers.
4. Limited rejuvenation and innovation in processing industry.
5. A lack of trust in DOC by operators to protect commercially sensitive information.

Opportunities included:

6. Better inter-agency communication including Iwi engagement.
7. Increase capacity through training for vets and meat inspectors.
8. Improvements in monitoring disease and toxicity using common scientific practices (e.g., PCR monitoring for TB, hunter training).

In the view of Game Animal Council:

Problems included:

1. WARO is undertaken, permitted, and socially accepted for different reasons. This either is not well understood or not considered when regulating WARO activities.
2. There is a conflict between the reason WARO is undertaken and its benefit to conservation and its integration with other population management tools and recreational activities.
3. Lack of data to show the contribution of WARO in the wider system and on PCL versus private land.
4. There is a lack of an integrated, overall strategy for wild animal management and process to manage and consult with stakeholders.
5. There is a maturing positive relationship between DOC and GAC and a lack of trust between WARO operators and GAC.
6. Lack of DOC devolution or divesting of responsibilities to those more focused or capable in given areas.
7. The two kilometre and six-month to three-year pesticide buffer was a major problem for WARO and its contribution to deer management on PCL and private land.
8. Landing rights of WARO in areas where recreational hunters are not permitted to land, and the exclusion of WARO from certain recreational areas, creates a state of unfairness that results in conflict and poorer game animal management and conservation outcomes.

Opportunities included:

9. Undertaking a first principles review to achieve sustainable management of game animals and hunting for recreation, communities, commerce, and conservation.
10. Better targeting WARO for achieving biodiversity outcomes, by targeting and incentivising it to specific areas, focusing on females, as this is the demographic that determines population size and growth over the long term, and leaving males in areas where they are the key driver for incentivising recreational hunter activity.
11. Embracing the value of the GAC involvement in establishing a sustainable system with enduring solutions to conservation but reduced conflicts between management tools, commercial enterprise, and recreational activities.
12. Finding a "balance" of wild animal management practices to affordably achieve conservation outcomes over the long term.
13. Using herds of special interest to resolve issues of conflict between recreational hunters and WARO.
14. Allowing WARO within Recreational Hunting Areas (RHAs) with a females only policy at conflict reducing times of the year, thereby increasing the land available to WARO but not negatively impacting recreational interests.

WARO operators said that:

Problems included:

1. WARO was not currently viable on North Island PCL.

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2. Regional council use of brodifacoum for possum control it made many areas including private land unavailable. Most said that revising pesticide rules would produce the biggest improvement for them by freeing up areas where in fact there is no pesticide issue.
3. There was poor communication from agencies especially around pesticide operations.
4. Getting appropriate and energetic marketing was an issue for WARO operators as this happens further down the value chain.
5. That there were issues with firearms restrictions saying that police did not understand commercial hunting requirements.
6. Funding and regulatory support for establishing small abattoirs was lacking.
7. Landowners are sometimes overly protective of deer numbers.
8. Cyclic reviews of WARO make confidence in investment difficult.

Opportunities included:

9. Using incentives to encourage WARO to take deer. This could be specific to areas where DOC wanted more deer removed.
10. Continuity of supply could stabilise the system.
11. For the domestic market providing co-payment recognising the public good in removing the animals.
12. Using farm traps for multi-use pest control (slaughter in trap, leave offal and trap for rats, mustelids, and possums).
13. Supporting innovation for realising the dollar value from deer and to commercialise the whole deer recovery operations, not just for DOC PCL.
14. Reducing the number of concessionaires that do little with the concession and encourage larger operators to contribute more to control of deer and to achieving economies of scale and providing for succession in skilled roles
15. Sitting down as an industry with DOC and work out solutions to problems.
16. Better utilising technology such as thermal technology as a game changer for wild animal management and WARO.
17. Using Fiordland Wapiti Foundation as a model for other areas.
18. Give 10-year concessions with no significant change to conditions over this period to create stability and encourage longer term investment.
19. Recognising the WARO contribution to wild animal management through financial incentives such as associated remission on landing permits or providing carbon credits.
20. Support getting more people into recreational hunting and allow them to be flown into closed areas such as wilderness areas.
21. Building a strong wild game brand and foster suppliers that consistently meet high standards.

Processors said that:

Problems included:

1. Resolve problems with poisons, food safety, and staffing.
2. Labour and staff had been a challenge and they have been tapping into the overseas workers' market.
3. There were low levels of automation, but that plants were kept up to scratch with maintenance.
4. A lot of knowledge rested with a few older operators.

5. WARO had been restricted by international market returns for both wild and farmed venison, operator issues, processors issues, and costs of maintaining helicopters, staff, and equipment, plus inflation.
6. There were problems with brodifacoum including the stand down period and inequity re wild animals vs farm stock.
7. Poison statements give power to individuals without a stake, thus fuelling local politics and creating a 'massive handbrake' on operations.
8. There was a clash of competing values saying that DOC saw no value in deer while all WARO participants are dependent on value.
9. Ineffectiveness of WARO created greater need for control on PCL (i.e., shoot to waste) which is bad for public perception of industry.
10. There was a risk to operations in low value domestic product marketing.
11. USA markets think that WARO is cowboy supply so avoid wild venison.
12. Lack of a forum to connect to improve the system or fix problem or solve challenges.
13. Breakdown in the markets and in labour supply due to COVID. As processors didn't pay enough for wild supply, operators halted operations. This led to processors switching to just farmed deer.

Opportunities included:

14. Better availability of up-to-the-minute poison records for non-DOC and for PCL areas.
15. If commercial data security were respected, then far more data on operations could be provided to DOC.
16. Leveraging the experience and skills of stakeholders to a common solution.
17. Using micro-abattoirs in the local, domestic context, but not in relation to international markets.
18. Incorporating local realities in WARO permitting.
19. Applying lessons and elements from wapiti, tahr and sika.
20. Growing the social licence for wild animal management and WARO through market links to voluntary corporate social responsibility (First Light support to the Kete initiative).
21. Socialising the value of wild animal management to recreational hunters.

Forest and Bird said that:

Problems included:

1. Undue Game Animal Council and hunting lobby influence over DOC in wild animal control processes.
2. The DOC budget for wild animal control falls far short of need.
3. A lack of ability of WARO process to focus on place, especially for areas of ecological value.
4. Low trust across the system.
5. Negative impacts of DOC restructuring lost connections, sensitivity, and understanding of WAC/capacity to interact with (locally operating) WARO players.

Opportunities included:

6. Dealing with longstanding tensions between parties by finding fora to bring them.
7. Applying WARO in more places and provide the industry with greater continuity and security.
8. Using Jobs for Nature potential for training new WARO personnel to help rejuvenate the industry.

9. Establishing a 'formal' representative focal point or advocate for WARO, with increased funding for DOC for WAC, (re-) establishment of a Government focus on WARO, and exploration of options for funding WARO.
10. Using spatial planning to manage WARO and WAC at place.

NZDA said that:

Problems included:

1. DOC lacked care, knowledge, understanding, acknowledgement, and support for recreational hunters who provided significant conservation outcomes and major economic returns.
2. There was a lack of transparency on WARO harvest across time and space to support improved management and assist reducing conflicts.
3. WARO was currently in competition with recreational hunting.
4. There was a DOC focus on biodiversity management to the exclusion of wild animal management generally and recreational hunting.
5. WARO was a sunset industry with no rejuvenation.
6. WARO was not focused appropriately as a wild animal management tool.
7. Iwi interests were making access more difficult.
8. There was an overload of consultation and battles to defend recreational interests. This, they said, created an unfair advantage for commercial enterprises over recreational hunters.
9. Lack of a forum to bring stakeholders together in a neutral/'safe' environment to discuss problems and find solutions.
10. Extremist beliefs by minority groups with apparent undue influence (RF&B).

Opportunities included:

11. Providing meaningful participation in a collaborative participatory design of the wild animal management system including WARO.
12. Managing WARO to enable market certainty, and support other population management tools, including recreational hunting.
13. Recognising the benefits to conservation management of recreational hunting and WARO collectively.
14. Increasing DOC employment of wild animal and recreational use expertise and better communication internally and externally to rebuild relationships and re-establish mutually supportive wild animal management for conservation and social purposes.
15. Establishing a non-DOC-chaired or managed forum for stakeholder discussion and input to wild animal management.
16. Considering delegation and co-management of WARO and wild animal management to the GAC.

Fiordland Wapiti Foundation said that:

Problems included:

1. Marketing of WARO was not value additive and that the parties needed to collaborate to tell one big story.
2. There was too much competition in the market and that this could be rectified by set prices.
3. Processing plants had small markets so took easy deer when prices were right leading to a boom-and-bust scenario.
4. The focus of wild animal management was too stuck on eradication.
5. DOC was not regulating WARO to remove crossover.
6. WARO was too volume based and needed to be quality based.
7. Spend more time building relationships with community groups.

Opportunities included:

8. Managing deer in NZ rather than get rid of them enabling money obtained from the value of deer being put back into conservation creating a positive messaging opportunity.
9. Using a Fonterra model of branding.
10. Using of Herds of Special Interest provisions to deal with legis ation issues.
11. Professionalising the community management of herds at place and linking this with WARO.
12. Using WARO block systems, quota, or targeting by time and deer demographics to meet the need for sustainability.

The games estates informant said that:

Problems included:

1. Variability in the market was creating boom and bust cycles that compromised operator viability.
2. Not all WARO concession holders were operating and too many only start when prices are high which impacts the long-term operators and markets.
3. The times for best product from wild deer did not match times when processors had capacity.

Opportunities included:

4. Diversifying meat sales and distribution so farmed and wild are complementary, not competing.
5. Using a quota system for creating market certainty and operator certainty.
6. Regulating the pricing to stabilise the system and thus perhaps offset the years that are low priced with years that are well priced to create constant income.
7. Better communications around what, why, when, and how of population management in a way that is tailored to the target audience.
8. Developing better overarching management of wild animals across space and time for all land tenures.
9. Comparing what works overseas to what is happening here and thus building ideas of how the system can be improved.

8.6 CONCERNS

Concerns of interviewees often related to current and potential future problems.

Iwi members said:

1. That DOC needed to use its internal resources and knowledge before coming to overloaded iwi for more help.
2. Cowboy operators might re-enter the industry if markets are established.

DOC staff were concerned about:

1. The lack of a national plan or strategy for wild animal management within the contexts of Te Mana o te Taiao and Te Ara ki Mua to guide regional and district operational plans resulting in siloed systems and a competitive rather than collaborative internal culture.
2. Systems could become even more overwhelmed if WARO applicants to walk away from the national bulk permit offer process and ask that permit applications be considered anytime on their own merits (35-40 current WARO permit holders).
3. A lack of locally focussed national monitoring of wild animal numbers to help determine where wild animal management occurs or where WARO can assist with DOC objectives.
4. Searching for a perfect system that reconciled both commercial and recreational interests probably was not realistic, particularly without changing the WAC Act.
5. Loss of institutional knowledge and leadership for wild animal management at an executive level. Loss at operational levels of institutional knowledge, loss of staff connections to, and interest in, back-country, bush, and hunting.
6. Focus of the Department on managing stakeholders, especially around iwi ambitions was blocking decisions on concessions.
7. That if were DOC managing wild animals as game this would be outside the legal constraints.
8. Deer numbers were a problem in places where WARO had been restricted (and have increased elsewhere). Staff were concerned about the increase in deer numbers impacting adversely on DOC areas and values and said that deer populations were at the highest since 1940's and potentially could double every 3 years.
9. Issuing short term permits would lead to a lack of certainty for industry to invest.
10. Paralysis of organisational systems and procedures was impacting ability to get work done and created a lack of ability to innovate.
11. A perceived imbalance between WACA and Conservation Act.
12. Decisions made that did not reflect practical, safety and efficiency considerations with wild animal management.
13. Lack of compliance on WARO and cited a DOC loss of capacity and resources to do this.
14. Loss of collaborative relationships and common ambition with external stakeholders.
15. Lack of comprehensive monitoring to base decisions on.
16. That the WARO role for wild animal management was overestimated or underestimated.
17. That WARO was a permit for commercial activity on public conservation land and needed to be kept within that space.
18. A reset of populations was required, and that DOC needed to work out how to articulate that in the public arena.
19. That DOC saw iwi through a S4 Conservation Act lens leading to tick boxing rather than more fundamental recognition of iwi economy and Te Ao Māori which would imply co-management and co-design of wild animal management.

20. If Deer Policy Statement was revised there would be a real risk for recreational hunters and WARO that they may be disadvantaged.
21. Managing WARO based on population numbers or modelling was a failed model.
22. It would be dangerous to allocate property rights to WARO operators.
23. Competition from private land sources of both feral and farmed game both favoured by processors and markets were a significant threat to PCL WARO economics.
24. Over-regulation was likely to add cost and collapse the remaining WARO opportunity.
25. Use of helicopters for wild animal management should be led by CAA not DOC policy.

The MPI staff member interviewed was concerned that there was a systemic lack flexibility for small-scale operations to operationalise micro abattoirs and consequently to meet growing iwi interests.

The Game Animal Council was concerned:

1. That DOC rolled the concessions over year on year, ignoring requests for a review from the hunting sector.
2. About a perceived lack of overarching objectives in wild animal management to support improved targeting by place.
3. Lack of connection between WARO activity and high value conservation areas and thought that a reliance on cost and revenue incentives in WARO limited applicability into the wider system. Activity was purely driven by operator profitability not biodiversity outcomes, leading to targeting close animals and stags creating conflict.

Federated Mountain Clubs were concerned about sacrifice of intangible values in favour of commercial interests or even perceived biodiversity gains.

Forest and Bird were concerned about:

1. The systems analysis team composition (inclusion of GAC representation and neither WARO nor conservation interests) and said that gave perception of potential bias.
2. A trend in language and operational focus of DOC from wild animal control to wild animal management, from noxious pest to game animal.
3. Disproportionate influence by GAC over DOC.
4. An explosion of wild animals on PCL meaning that control measures were inadequate.
5. That wild animal management on PCL via WARO might become a form of farming for commercial objectives.
6. Use of wild animal management as a term by DOC rather than wild animal control as required by the statute.

WARO operators were concerned:

1. That further tenure review would lead to tensions between WARO and recreational hunter.
2. Lack of an overall plan for wild animal management with a realistic understanding of the role for WARO within this.
3. Resources were being targeted away from wild animal management and connections to wild animal management not being recognised or integrated. This, they said, led to a lack of monitoring and enforcement of concessions. Some WARO operators were said to be using concessions for private access to PCL, not WARO.
4. That it is the accumulation of many small barriers rather than one large issue that sucks the profitability out of the industry and keeps WARO small.
5. That CAA should make the call about appropriate helicopter use, not DOC.
6. New and inexperienced operators would jump in when the venison schedule lifts.

7. There was a lack of succession for skilled roles.
8. The whole industry could become untenable with policy changes.

NZDA was concerned that:

1. The role of recreational hunters in conservation management and economic activity was not appreciated or supported by DOC while the largely historic and declining role of WARO was given prominence.
2. WARO operators were a small group compared to recreational hunters but were provided disproportionate influence on decision making. Conservation advocacy groups had disproportionate influence that did not contribute meaningfully to the wild animal management system in decision making.
3. The poisons issue challenged the ability of recreational hunters to provide food for the table and for WARO to be an effective tool.
4. Budget cuts would lead to DOC reducing its focus on fixing its systemic problems.
5. There was unwillingness of DOC to delegate, devolve power and control even when it would be of benefit to conservation and wild animal management to do so.

Meat processors were concerned that:

1. WARO not a major priority for improvement.
2. Some operators were not keeping account of where they had sourced deer risking tarnishing of reputation of all NZ venison when product had issues in the export market.
3. There were risks of chronic wasting disease coming through the border with trophy hunter visitors.
4. The area accessible for the operators might further reduce.
5. Solutions would be too hard to find.

The Fiordland Wapiti Foundation said that going down a HOSI pathway risks what has been built should an application be rejected.

The game estates operator was concerned that blanket deregulation and self-focused decisions by hunters and operators was negatively impacting the whole system.

Helicopter on deer recovery. Lake Adelaide area. Fiordland National Park.
https://www.nzlandscapes.co.nz/product/2583/33928/

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8.7 Connections and Disconnections

We looked for which parts of the system were connected, the strength of the connections and effects these had on outcomes. Such connections can be within entities such as DOC and MPI, between entities such as between WARO operators and meat processors, and between people and elements in the wider environment. The common connection was to the natural environment both on public and private lands. This is, where the wild animals live. It is also where their adverse effects are felt. Disconnections lead to problems and connections can be a source of solutions.

Iwi spoke of a connection to:

1. Deer as kai for families and for the marae.
2. Local rural communities in diverse ways.
3. WARO operations and meat processing.
4. The land and te Taiao, whether it was on Māori land blocks or on private or public land within their rohe. Some of the land they were responsible for has become land-locked which makes connection difficult. They spoke of being kept away from places that were a natural part of life in the old days.
5. DOC and appreciated the efforts of the Department to understand their viewpoint. The constant changing of staff at a local level, however, made it difficult to keep relationships and continuity. The regional council and DOC were not seen to be collaborating.

The Department of Conservation staff referenced:

Connection in:

1. They provided to central Government policy processes through strong connection to what is happening on the ground.
2. Between concessions staff with the WARO industry and stakeholders that helps shape consideration of a new approved land schedule, which then leads into a national 'bulk offer' WARO permit.
3. Being built by the new wild animal management team in national operations with external stakeholders and with frontline staff who described the connections at place.

Disconnection in:

4. Concessions work operating in its own silo not connected to staff responsible for wild animal management.
5. That wild animal management data was not available directly from MPI or processors was not helpful.
6. Trust issues, noting that these were improving with WARO operators as they have more confidence that the 'Panel' are acting in accordance with the WACA (potentially delivering an inverse relationship with recreational hunters).
7. A problem was that commercially sensitive information supplied by operators in the past being mishandled by DOC.
8. They thought there was incomplete policy and operating framework to guide permissions at place. This involved an inability to recognise that there is a link between permit term and confidence to invest, train and increase effectiveness.
9. They said that recreational hunters want as short a term for WARO as possible (up to 3 years) to keep under review and allow a full 'system' review whilst WARO operators seek 10

years. Somewhere in between would enable DOC to react to changing wild animal pressures whilst avoiding resource capacity issues to undertake a review in a timely manner.

10. National wild animal management team members reported a loss of connection with hunting interest groups, particularly through the tahr protests and associated security concerns, followed by COVID.
11. They said that most Districts used to have some form of hunter liaison meetings, but this seems to no longer be a thing. This may be exacerbated by loss of staff with interests and history in wild animal management.
12. They had uncertainty around permissions process and were unsure if the land schedule review was complete. This may be indicative of a wider internal lack of knowledge on processes. They had not seen proposed new WARO concessions and were therefore unable to say what changes had been made to influence WARO, only the land schedule that determines where WARO is permitted or restricted or not allowed across PCL.
13. They reported disconnection:
    a. Between district or regional operations and national 'hubs' such as permissions.
    b. Between DOC permissions and WARO operators and interest groups.
    c. Discontinuity in institutional knowledge from loss of experienced wild animal management-focused staff.
    d. Due to there being insufficient data to inform decision making around WARO and its impact on PCL.
    e. In perception that WARO is a more significant wild animal management tool than it is (both internally in DOC, and in advocacy of operators).
    f. With Landcorp (lands bounding PCL) – access and pesticide information issues.
    g. Regional councils as their use of pesticides was not available to externals.
14. Historically between recreation staff working at a national level and WARO management, DOC recreation staff reported disconnection in:
    a. No connection with WARO in current role and no DOC commercial focus in structure.
    b. Districts need support to be holders of relationships with recreational hunters.
    c. Project management a weakness – Department asking too much of senior rangers and District Managers, who lack commercial expertise.
    d. Tensions between local interests or desires around WARO, which sometimes is at odds w th the national concession (bulk offer) process. Local interests often centre around wild animal populations deemed 'of special interest', or through direct hunting interests that they wish protected.
    e. Local staff cannot make local decisions because WARO is a national process.
    f. Parts of DOC are seen to be interacting with hunter group interests, while Permissions have relationships with WARO operators. There is a disconnect between working with hunter interests (improving stakeholder relationships) and the process of WARO authorisation.
15. Frontline staff reported loss of connection with WARO and hunter community through DOC organisational change. They said that organisational change had amplified disconnections between parts of DOC relating to wild animal management and WARO. The 2012 restructure was noted as a pivotal time for these disconnections with the following impacts noted:
    a. Removed programme managers from Districts responsible for managing wild animal management relationships and the links between DOC, operators, recreational hunters, and iwi.

b. Past spirit of cooperation and support among stakeholders, including WARO operators lost by new staff often lacking background, expertise, and special interest in wild animal management.
c. Resulted in overloaded senior rangers and district managers.
d. Recruited staff with less outdoors, back-country and bush, hunting, experience, and interests.
e. Wild animal management marginalised within DOC.
f. Greater pigeon-holing in silos across DOC resulted in loss of wider, cross-agency engagement in deer control.
g. Observed uncoordinated aspects of WARO industry.
h. Few districts in DOC have information on animal browse impacts.
i. Disconnect between Tier 1 and Tier 2 monitoring.
j. Lack of understanding at district operational level of WARO.

MPI Food Safety links the WARO industry to the standards required for domestic and external market and this facilitates connections throughout the system. MPI Food Safety reported disconnections:

1. Public misunderstandings of food safety requirements and associated regulations.
2. System's inability to accommodate public aspirations for gifting and donating game meat.
3. Lack of small micro-processors.
4. System's inability to bring together WARO operators and recreational hunters to achieve overall wild animal management goals.
5. Communications issues between DOC and MPI and more recently also GAC. Communications issues between formal WARO system (DOC, MPI, Assure Quality) and public stakeholders (operators, hunters, iwi, public generally).
6. Commercial data collection and limitation on sharing this versus recreational hunter 'patch' sensitivities.

The Game Animal Council reported connection with hunters, DOC, policy, legislation, and strategy development for hunter and wild animal management systems including acting as a link between the tools of wild animal management, the value of wild animals to NZ and conservation management. A general system disconnection between national and regional management was reported - WARO is not site specific and is not integrated with variable values, interests, and available tools. Lack of connection between the various statutory bodies mitigates against realising common outcomes. GAC noted that there are disconnections within the hunting sector and with various parts of the hunting sector and external stakeholders. The Game Animal Council reported disconnections between them with:

1. Some WARO operators as they can talk directly with DOC — a small few are swaying decision-making that impacts many.
2. Conservation NGOs.
3. Processors and markets.
4. Some parts of MPI.
5. DOC with conflicts and confusion in roles and responsibilities for improving wild animal and hunter management.

Federated Mountain Clubs said that they were loosely connected to WARO but had high-level connections to conservation policy making.

NZ Deerstalkers Association reported connection at the national and local levels representing the interests of recreational hunters and shooters. NZDA reported disconnection with:

1. Commercial WARO operators.
2. Limited acceptance of NZDA submissions under DOC permissions criteria.
3. DOC outside formal processes saying that DOC is a partisan decision-maker for wild animal management and has:
   a. Major land manager stakeholder role.
   b. A primary purpose of biodiversity conservation with limited focus/interest in user groups interests in other PCL resources.

Forest and Bird reported connection to DOC staff via legislative and policy processes and via the tahr policy and planning process and actions of local branches at places. Forest and Bird reported disconnection through:

1. Not being included in Te Ara ki Mua development.
2. WARO operators not being represented in system analysis team
3. GAC and WARO not being productively connected within the system.
4. Ongoing negative connection between RF&B and GAC.

WARO concession operators reported connection:

1. With one another through the South Island Wild Animal Recovery Operators Association (includes North Island).
2. Through the wild animal industry group formerly run by MPI
3. DOC and landowners wanting pest control.
4. Local community economies including iwi, farmers, hunters, processors, and local DOC offices.
5. Wider heli-operations.

WARO concession operators reported disconnection through:

6. A lack of communication from DOC updating concession holders.
7. A negative connection with Game Animal Council which is seen to want to change the WARO system to the detriment of operators.
8. Limited contact with DOC.
9. Operators who are not currently active assuming spokesperson status for the industry.
10. Negatively connected to regional council due to its use of brodifacoum.
11. Negatively connected with MPI due the impracticality of the 2km pesticide rules.
12. No unified industry voice for WARO and no champion for it within Government disconnecting operators from policy processes.
13. Lack of connection with OSPRI or DOC led pesticide operations.

Processors, procurement, and exporters reported connection to:

1. DOC via website to check location shot relative to poisons and MPI confirming that regulations are met by operators and themselves and previously through the WARO Government Industry Group (WGIG).
1. WARO operators as suppliers and companies that take wholesale product as customers. Brokered an industry survival arrangement during recent tough times with operators. Foodstuffs NZ for local marketing.
2. Sheep and beef farmers when crop damage from wild animals occurs.
3. Deer farming through Deer Industry NZ and the NZ Deer Farmers Association.

The game estate operator reported connection across WARO, game managers, deer farmer, and agencies. The game estate operator reported disconnection through lack of communication on where, when, and why WARO is being undertaken.

The wapiti system was connected with DOC and GAC through a community agreement and with WARO as service providers and recreational hunters as stakeholders. Stated disconnections of regulation of WARO by DOC to remove competition between operators at place.

8.8 FINANCIAL

Within the system money plays an important role in determining what gets done and what does not. WARO is a commercial activity and needs to be profitable to operate. The various parties saw this from differing perspectives.

Iwi members said that lack of resources had limited the capacity of iwi members to be involved in WARO. Early WARO was taking deer from Māori land, and they got involved to secure those connections as much as to make a living. This then led some into deer farming. There are many Government processes requiring the time of skilled iwi members and they are not recompensed for this. Where iwi priorities are different contributions will not be made.

DOC staff observed that:

1. WARO can save DOC money by controlling wild animals, but that MPI controls can affect financial viability of operators. They thought that markets and costs drive WARO but fluctuate. They said that the feral venison schedule needs to be at $8-$10/kg to make WARO attractive and profitable. WARO would still happen at lower price, but WARO would just be meeting costs. They observed that WARO businesses utilised the best economic and efficient tools.
2. Incentivising WARO operators was not favoured by some staff but supported by others. Those opposing said that the Beef and Lamb levy system might be a possibility (i.e., levy processors per animal or kg when schedule high, then determine subsidy to pay back when schedule falls below certain point, to support continuation of WARO and level the peaks and troughs of the market).
3. Some thought that it might be possible to work offsets (as done with tahr) see above into national concession but extremely labour intensive (costly) to manage system across whole country and with deer.

The MPI staff member observed that:

1. WARO product had low market value so there was low investment in the industry.
2. There were market challenges (greater returns from farmed game, competition from other producing countries, international markets setting higher processing and traceability standards).
3. There was limited scope for cost recovery in low value and declining industry segment and believe abattoirs need significant re-investment.

GAC said that there was reliance on commercial enterprise to foot the bill for an incidental benefit to conservation-based outcomes without supporting the sector to do so.

Federated Mountain Clubs did not want commercial interests to lead to erosion of conservation values.

Forest and Bird saw potential options for incentivising WARO on PCL that needed exploring.

WARO operators said that:

1. $7kg to $10kg is the schedule price to make the industry properly viable and the general price schedule was currently on the increase across venison.
2. They faced high and increasing costs, including maintaining gear. Their reported costs were like those reported by DOC staff:
    a. R44 costs per hour = $1,400 main WARO platform.
    b. B2 costs per hour = $2,200 ferry animals.
    c. Helicopter operating costs H500 v R44 as example.
    d. Search and destroy costs to DOC $100-$140 an animal (H500)- compared to $70 for R44.
    e. WARO business utilise best economic and efficient tools, i.e., deer are shot with mainly R44 helicopter – so they can separate out the cost of harvesting (control) vs. the cost of recovery (commercial).
3. There were potential local markets, but they were not being supported by the government agencies. Cost of recovering meat for the domestic market makes the product more expensive than fillet beef.
4. WARO operators observed that the farm kill was down to 260,000, the lowest since late 1980s with a peak of 760,000. They said markets were hard to establish, and farmed venison has promoted farmed over wild.
5. Carcass weights have changed a lot with deer density, fallow too light, so red deer in moderate densities are the mainstay.
6. Cannot use the term "subsidy" as it not allowed by the Public Finance Act or free trade agreements. Rather, incentives could be provided when prices are down to reflect the value to wild animal management.
7. Government funding could be applied to marketing, but it is best to leave the actual marketing to the experts.

Processors observed that overall, the returns must stack up for processors and operators for a viable industry. They said:

1. Remote monitoring tools replacing greater levels of staff engagement and liaison has increased costs to operators.
2. The estimated threshold for economic viability of the industry was $5.00/kg which would meet core operating costs only, not including profit, reinvestment, and rejuvenation costs.
3. Farmers need incentives to engage helpfully e.g., with pesticides declarations.
4. Rebuild district-level ability in DOC to manage stakeholder relationships in support of WARO

NZDA observed that:

1. The equipment to undertake WARO activities was expensive to acquire and maintain.
2. The ability of recreational hunters to meaningful contribute to consultation and wild animal management was limited by non-profit financial resources. In their view, DOC should consider providing financial support to non-profit organisations to attend meetings etc. They said that there were so many, and attendance comes at such a personal cost to participants that the potential value of recreational contributions was not being realised.
3. They thought that WARO operators had more money than non-profit organisations to pursue their interests, although likely funded by other parts of their enterprises. Conversely, they said that the limited revenue of WARO made it not a worthwhile industry to get into.

The Wapiti Foundation said that management needed to be self-funded to be sustained. Their system involved collecting data on vegetation to inform the number to take and then contracting to take that number. This, they said, provided security and a constant effort.

The games estates informant noted:

1. The cost of administration.
2. Need for stabilising markets and suggested targeted subsidies.

The processors and marketers said:

1. That the price schedule was on the increase across venison generally with wild venison historically following the farmed upwards.
2. Wild game was competing against higher value farmed deer (export market requirements, and wider range of products from whole carcass, especially velvet).
3. If the price continued to increase, then further operators would decide they were deer hunters again in addition to those who stayed in the business riding out the lows even when the return was negligible.
4. The cost of trucking had been moved to operators away from processing plant and this had led to efficiencies.
5. Vertical integration of WARO and processing could aid profitability.
6. The costs of helicopter operating citing comparison of H500 v R22/44 costs.

9 SYSTEMS ANALYSIS

WARO is not so much as a system as a definable part of wider systems of commerce, food production and safety, biodiversity conservation, public land management, and wild animal control on public and private land. Its functioning has implications for the success of biodiversity conservation, wild animal management and recreation including recreational hunting.

The main drivers in the system are the market prices versus costs in recovery of wild animals together with security of access to a sufficient resource over time.

Within the system we identified social forces by considering connections and disconnections and culture and values.

9.1 SHARED VALUES

All agreed that, inadequately controlled, wild animals could have adverse environmental impacts and that WARO should be a part of that control.

9.2 POLARISED VALUES

However, some values were polarised where some emphasised deer being a valued species and others wanting to reinstate their classification as a pest. WARO operators and processors identified with both sides of this divide. Most were recreational hunters as well as having commercial interest in deer as a resource. At the same time, they wanted to be valued for their role in controlling the numbers of wild animals and thus protecting the natural environment and/or reducing competition with livestock or crop damage on farmland.

Social research has shown this same division within wider society concluding that *New Zealanders generally accept that large mammals are both a resource and a pest requiring management and* *control*.[25] Our analysis supported this author's conclusion that: *Balancing the commercial and recreational benefits of introduced species with their negative ecological impacts can be difficult. Some people may take opposing attitudes on whether a species is a resource or pest and be unwilling to accept alternative attitudes, whereas others may be able to accept and reconcile both views, as part of an individual's 'wildlife acceptance capacity' (the maximum wildlife population level in an area that is acceptable to people sensu Carpenter et al. 2000). Generally, people accepted that some introduced animals had both resource and pest values, and should be managed as such. In particular for game animals, respondents generally considered they were a resource, and derived enjoyment from seeing (or potentially seeing) them. It is difficult to determine if this attitude is because respondents do not acknowledge the negative ecological impact, or is despite it, but people are more inclined to accept trade-offs for economic gain such as farming, rather than for recreational gains such as hunting.*

Polarised values create tensions that make collaboration difficult across the wild animal management system including WARO. It also makes it difficult for DOC to develop a better relationship with either side as any step in either direction is perceived negatively by the other.

9.3 CONNECTIONS

We found that hunting and environmental advocates were strongly connected to policy processes at multiple levels. Hunting advocates were promoting the idea that wild animals should be managed while environmental advocates were promoting the same species being regarded as pests. For officials this meant the easiest/safest option was to avoid opening the policy process to the divide and bringing the wrath of both sides down on their heads. Conversely, we found that WARO operators had little capacity or appetite to engage at the policy level and mostly wanted to be left alone to get on with business.

Iwi were connected collectively through higher level processes such as WA262 and representation on the NZ Conservation Authority and Conservation Boards. At the individual iwi level, they connected through regional and operational processes to DOC, as employees in WARO operations and as recreational hunters. They both valued deer as a resource and felt responsibility for the environment as kaitiaki. They wanted to be recognised for their role as kaitiaki in relation to their whole rohe, whether they retained the lands or not.

Some WARO operators and Forest and Bird distrust the Game Animal Council and this creates a tension between them and the Council. The Council itself has said that it would like a better connection with Forest and Bird and more a positive connection with all WARO operators. Disagreement with the values, role and mandate of the GAC seems to be the base of distrust and tension.

The GAC was well respected by recreational hunting interviewees and some WARO operators. Being highly respected means that the GAC has capacity to reduce conflicts for these groups.

Regional Council brodifacoum operations for possum control were negatively viewed by all involved in recovering wild animals. These operations limited the effectiveness of both commercial and recreational hunting. The social force that drives regional councils to this practice is the demonising

[25] JC Russell (2014) A comparison of attitudes towards introduced wildlife in New Zealand in 1994 and 2012, Journal of the Royal Society of New Zealand, 44:4, 136-151, DOI:10.1080/03036758.2014.944192

of 1080 which is an environmentally preferable toxin with a much shorter life in the environment and does not bio-accumulate up food chains. Note that WARO was almost banned in 2002 because of fears of 1080 contamination.

Those involved in WARO as an industry are not strongly connected to one another and are also quite isolated at a national level. Operators and processors are strongly connected to one another and to marketing. Operators and processors are strongly connected locally and marketers nationally and internationally. This pattern makes the WARO industry ineffective at cooperating to mutual advantage or influencing policy settings to their collective good.

DOC has become isolated from both the hunting community and from environmental advocates. It connects strongly at place, but values conflict at the national level that erupt into social media wars cause the parties to remain at arm's length or engage in formal ways that minimise risk of conflict.

9.4 Social tensions

WARO is managed in a context of social tensions around wild animals on public conservation land. Commercial activity on public conservation land is permitted only where it does not adversely affect the values for which the land is held. WARO constitutes a special case where in some instances it can positively benefit those values.

The policy settings in law generally direct wild animals to be eradicated or at least controlled, where necessary and practicable, and enables, but does not usefully direct hunting for this purpose. The exception to this is the GAC Act 2013 HOSI designation which potentially could enable a game animal herd to be managed for hunting purposes, subject to overriding considerations, including the conservation status of land. Hunting advocates expressly want to change the status quo settings to favour game management objectives and methods. Forest and Bird advocates for the current policy settings to be retained and better operationalised to protect native ecosystems. This creates social tensions that are expressed in media, lobbying, and in litigation.

Administrators must work within legal requirements in permitting WARO on public land while also being cognisant of the complexities of the social environment that can spill over into the political sphere. The net result of this for wild animal management is a zero-sum game as the balancing forces on the policy process dynamically preserve the status quo.

WARO is only commercially viable when wild animal densities are low enough to support enough larger individuals and high enough to enable cost efficient recovery. WARO is perceived to have beneficial environmental outcomes in reducing densities of wild animals in some places. It is perceived to have negative social outcomes for recreational hunters when it reduces the number deer to very low levels or targets trophy animals but mixed outcomes when it reduces densities just below carrying capacity as this improves the condition of animals but lowers the success rate for recreational hunters.

This adds a layer of complexity for those administering the WARO permissions system. The threat of litigation and social media storms makes them hypervigilant about doing things correctly. This in turn makes it difficult for WARO to be used in flexible and innovative ways as part of wild animal management.

The low level of trust mentioned by many of those interviewed is a key problem in the system we examined. When trust levels are low collaboration is disabled. People are naturally trusting, and low levels of trust reflect adverse experiences in the past. rust can be enhanced by increasing connection between people and encouraging parties to be open with one another. Encouraging recognition of shared values is also helpful.

10 CONCLUSIONS

We were given a broad brief – find out what the problems are in WARO and report back. WARO is a jargon term within DOC for the commercial recovery of wild animals recovered from public conservation land under concessions granted under the Conservation Act. However, the commercial deer hunting industry in this country includes wild animals taken from private land as well. It also includes the whole value chain to the retail customer. So, to understand how WARO on PCL in DOC terms works we had to look at the whole value chain.

Sustained commercial hunting of wild animals sometimes has positive effects in removing animals that can have adverse impacts on native forest or farmland by reducing densities, although it only influences population growth rates when females are targeted. It also has modest positive effects on communities generating economic activity and employment. The activity can also have adverse effects on other interests. To make sense of what the problems might be we had to gain an understanding of all these factors. It is generally systemic failure, rather than human incompetence or ill will, that leads to less than satisfactory outcomes.

The term "wild animal" here refers to all those covered by the Wild Animal Control Act. We were open to finding that feral pigs and goats might be commercially taken for human consumption – but in practice found that we were only hearing about red deer, tahr, chamois, wapiti and possibly fallow in the future. We focused on red deer in the limited time we had available for this work and more work will be required to see if our conclusions apply to other species.

We noted that uncontrolled wild animal populations in Aotearoa New Zealand cause unacceptable impacts on native forests, shrublands and alpine ecosystems. Over time, we have often been inadequate predators for controlling the wild animals we introduced.

In conducting this systems analysis, we were conscious that since their arrival in Aotearoa, iwi Māori have depended on hunting for survival and as an essential, intimate connection to te Taiao within te Ao. Following the introduction of exotic game animals, Aotearoa New Zealand has developed a multi-generational tradition of hunting for recreation, wild game meat, and trophies that is shared by tangata whenua and later arrivals.

What is clear is that WARO harvest has reduced significantly over recent decades, and over this time, wild animal populations have increased in abundance in many places, with WARO operators and recreational hunters alike reporting diminished carcass weights from these areas. Looking at the whole situation we concluded that WARO is a commercial activity that has incidentally provided major reductions in deer density in some places, but it has arguably never been deliberately managed to achieve a specific desired population reduction. If actively managed it has potential to contribute far more than is currently being realised.

The question for us was what was limiting WARO as a useful tool in wild animal control? We discovered that the underlying reasons for WARO not currently contributing to its potential are complex, layered, and compounded by underlying factors, notably:

- WARO being a market-driven mechanism dependent on business bottom lines, not central government direction.

- The reduced availability of WARO as a contribution to wild animal control as costs rise faster than prices and both fluctuate.
- Very limited support from Government for development of an industry that has remained tiny while overlapping with the much larger deer farming sector.
- The industry lacks the collaboration seen in farmed deer and other primary production sectors required to resolve the issues it faces.

From a WARO operator point of view, it looked to be "death by a thousand cuts". All those interviewed referenced food safety requirements as a limiting factor. These included poison standdowns, and land boundary buffer zones, as well as areas closed permanently or seasonally for a range of other reasons. These were limiting where WARO can operate and continuity of business through the year. The higher price of fuel and equipment (helicopters, guns, ammunitions) and low value of wild caught export venison (compared to farmed venison) was also viewed as limiting by many.

Many WARO concession holders do little or no carcass recovery from PCL each year. In 2016 nine out of 28 South Island operators submitted nil returns or no returns to DOC. Only one North Island operators reported any take.

At the same time many are operating on private land as higher numbers of deer build up on farm and forestry lands. For some, concessions and other relevant licences are held in the hope for a window of higher prices while they use their infrastructure (principally helicopters and their pilots) on other, more profitable enterprises. A dedicated few we talked with keep operating even at a loss in times of lower prices and higher operating costs and thus sustain continuity in operational capability and in market confidence.

WARO operators struck us as resourceful, very individualistic, and highly skilled individuals, committed to their work for a mix of commercial, social, and environmental reasons. They told us that getting into the industry requires a substantial economic base to establish and maintain capability. They said that there is little incentive, and costs are prohibitive for younger people wanting to enter the industry as operators. We also found no strong voice for WARO industry development within central Government.

We were told that those in the industry would value support for developing national level promotion to support international and domestic market stability and growth and grappling with issues in food safety and access. The details of actual marketing and business development they say should be left to the industry.

Apart from general under-resourcing, the limiting factor we felt was associated with the Department of Conservation was that WARO did not seem properly embedded as a key contributor in the wild animal management system. Statutory policy and legal settings associated with DOC have been stable for many decades in the way they govern WARO and its associated permissions systems, while the DOC restructuring and Government funding policies have together severely constrained the Department's focus and internal operational capacity to deliver on its wild animal management responsibilities. The major changes impacting WARO since C2,000 that are of concern to operators have been changes in food safety requirements.

Looking back, much of the thinking that went into operationalising the policy framework came from a time when wild animal populations, particularly red deer, were much lower in most parts of New Zealand. At this time there were strong concerns from recreational hunters about effects of WARO in reducing herds in places favoured by recreational hunters. We heard that the concerns by recreational hunters around reducing population densities by WARO were not widely held today rather the concerns centred around reducing the value of the recreational resource through WARO harvest selection.

While there are insufficient data to be definitive, what is clear is that, while both WARO and recreational hunting have provided downward pressure on ungulate population numbers on PCL, their collective efforts, as currently managed, are insufficient to manage current populations without additional official control, which has been lacking for decades in most places.

We looked at culture and values and found trust to be low across the portions of the WARO system we examined. This was from all the stakeholders. WARO operators perceived undue influence from recreational hunting advocates. Recreational hunting spokespeople perceived undue influence from WARO and environmental advocates. Environmental advocates perceived undue influence from hunting interests of all sorts. Nobody expressed strong trust in DOC or MPI to make things better.

However, while the principal values of each group varied, some core values were found to be shared. Both WARO operators and recreational hunters highly referenced their role in wild animal management and conservation while their primary motivations were to make money and hunt game respectively. Neither wanted to conflict with the other, and both saw some opportunities for practical accommodation at place. DOC and environmental advocates value the contribution of both hunting groups to protecting native ecosystems.

All parties interviewed believed in the potential for WARO to be a key, on-going, component of wild animal management, provided certain constraining factors can be resolved. Key among these are:

- Sorting issues of poisons declarations and management.
- Establishing effective dialogue between the main WARO interest groups both nationally and at place focusing on a shared overall goal for wild animal management.
- Consideration of options to limit the impacts of market volatility.
- Better managing wild animal control generally.

We found general optimism that with a will by all concerned, these are potentially solvable issues.

Where values differed was around the importance of controlling wild animals for conservation purposes versus their value as game for both recreational and commercial purposes.

Some cited successful accommodation of interests at places and we think this is an important clue for the future. These successful experiences integrated WARO components at a local, landscape scale, fostering local relationships and having each party able to see an outcome that they valued.

Those that manage parts of the system (mostly DOC and MPI food safety) suggested causes for problems in WARO performance that differed depending on where they were placed. We found no established dialogue between parties that allow issues to be resolved where more than one part of the system is involved. Such dialogue is required at the national level for issues involving the industry as a whole and at the local level to deal with issues at places. Some referred to the value of past hunter liaison engagement by DOC at district offices. The inter-agency and industry group established by DOC and MPI ceased to meet during the COVID pandemic, and no one has taken responsibility for re-establishing it.

Within DOC, interactions with the WARO system, and the wider wild animal management system, seemed to fall between organisational silos. This seems to result in mixed messages to a wide range of parties and a lack of coordination for achieving desirable outcomes. For MPI, WARO appears to be too small to attract the attention received by farming, fishing, and forestry. WARO is not so much as a system, but is a definable part of wider systems, primarily those of market-driven commerce, but impinging on food safety, biodiversity conservation, public land management, and wild animal control. Its functioning has implications for the success of wild animal management, recreation including most notably recreational hunting, biodiversity conservation, and deer farming.

The main drivers of success for the industry are the market prices versus costs in recovery of wild animals together with security of access to the resource over time. However, there will be no one magical fix if WARO is to play a strong role in wild animal control in the future. Any initiatives must consider the inherent complexity in the system.

Within the overall system we recognised dynamics limiting performance.

With the benefit of hindsight, the accidental adversaries of recreational hunters and WARO operators taking action to increase their own success disabled processes potentially beneficial to both. However, currently more abundant deer populations and reduced WARO industry now makes collaboration between these stakeholders a more achievable proposition.

More significant were the time delays in policy approaches that effectively reinforced historical perspectives rather than reflecting current realities and creating settings aligned to evolving market and political signals. The application of pesticide rules falling more strongly on wild than farmed animals is a case in point.

Overall, we concluded that there is more to be gained by creating culture of collaboration and working together on practical issues than by conducting a full scale review of WARO. What policy makers and decision makers can do is work with the industry to remove barriers and find win-win solutions. The process of doing so must remain connected with a wider halo of stakeholders to ensure that changes are understood, and unintended adverse effects are avoided.

However, all those involved need to consider how to resolve the low level of trust mentioned by the majority of those interviewed. When trust levels are low, collaboration is disabled. People are naturally trusting, and low levels of trust reflect adverse experiences in the past. Trust can be enhanced by increasing connection between people and encouraging parties to be open with one another. Encouraging recognition of shared values is also helpful. Above all, those involved need to act with integrity and be seen to be acting with integrity. That means embracing transparency and forgoing back-room politicking.

We heard that the industry needs stability and support, policy changes are only required if the underlying policies prevent or hinder WARO from being successfully embedded in the wild animal management system. A fundamental WARO review would inevitably involve changing policy and legislation bringing much wider implications.

We think that the resulting complexity would lead parties into unproductive conflict, rather than making real progress on restoring WARO as an important tool in wild animal management.

11 RECOMMENDATIONS

We recommend that DOC:

1. Revives working together with the industry, MPI and stakeholders at a national level including working together to revive the Wild Animal Industry Coordination Group.
2. Enhances capacity for regional staff to integrate WARO with wild animal management at place working with iwi, the industry, and stakeholders.
3. Reviews its operational strategy and associated internal policy settings for wild animal management to better support the Department's mandate both nationally and at place.
4. Engages WARO as a targeted tool for wild animal management rather than just as a set of concessions.[26]
5. Works with MPI and a revitalised Wild Animal Industry Coordination Group to support refinement in food safety requirements for WARO so that wild and farmed animals face similar pesticide restrictions and exclusion boundaries reflect actual risk.
6. Works with MPI, MBIE, the WARO industry, iwi, and stakeholders to investigate ways, including financial incentives where these match conservation priorities, of supporting the industry to expand markets and increase schedule prices to levels that allow ongoing industry renewal and development as part of wild animal control for conservation purposes.
7. Supports the Game Animal Council to better connect with WARO operators to enable it to be more effective in helping resolve conflict between recreational and commercial hunters at place.

[26] Targeting requires assessing where deer control is most needed - effectively DOC needs to identify where it wants deer to be controlled, and where it would implement control if WARO ceased.

12 GLOSSARY OF TERMS AND ABBREVIATIONS

CMS is an abbreviation for Conservation Management Strategy the binding statutory policies applying to specific parcels of Public Conservation Land.

DOC is the Department of Conservation.

FWF is the Fiordland Wapiti Foundation.

GAC is the Game Animal Council.

Hapū is a subtribe of an iwi.

Kaitiaki is a role of attending to care, protection, and wise use of te Taiao. Kaitiakitanga is the activity of attending to kaitiaki responsibilities which now also have formal legal implications through inclusion in statutes.

MPI is the Ministry for Primary Industries.

Ngai Tai ki Tamaki a legal decision that affected the understanding of applying section 4 of the Conservation Act to concessions - https://www.beehive.govt.nz/sites/default/files/2019-08/cabinet-paper-ngai-tai-ki-tamaki-supreme-court-decision-response.pdf.

PCL is Public Conservation Land that encompasses all land administered by DOC on behalf of the Crown.

RF&B is the Royal Forest and Bird Protection Society

Rangatira are chiefs and rangatiratanga is the exercise of chiefly authority.

Rohe is the area of an iwi.

Tangata whenua are the people of the land.

Te Ao Māori is the Māori worldview.

Te Ara ki Mua refers to Te Ara ki Mua Framework for adaptive management of wild animals (doc.govt.nz) which is an operational policy of DOC to implement Te Mana o te Taiao – the Aoteroa New Zealand Biodiversity Strategy.

Te Taiao is the natural world.

WAC is the Wild Animal Control Act 1971.

WAI262 is the claim for the flora and fauna and intellectual property of the tāngata whenua. See https://www.wai262.nz/.

wild animal management refers to Wild Animal Management.

WARO refers to Wild Animal Recovery Operations.

WICG refers to Wild Animal Industry Coordination Group which was a body convened by the Ministry of Primary Industries.

Whanau means extended family.

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Fiordland National Park Seedling Ratio Index

2010-2021

Internal Report: Methods and Results

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October 2024

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CONTENTS

1. Methods

1.1 Field methods

1.1.1 Study area

The study encompassed three areas in Fiordland National Park operating under different deer management regimes:

- Wapiti (managed under a hunter-led control plan)
- Central Fiordland (not actively managed, open to recreational hunters and Wild Animal Recovery Operations/WARO), and
- Murchison Mountains (managed to low density by the Department of Conservation).

1.1.2 Survey design

This study followed the method described by Knightbridge (2003) based on the work of Sweetapple and Burns (2002).

Within each management unit, catchments were subjectively selected to evaluate the effects of different deer management regimes on Seedling Ratio Index (SRI). The catchments cover a range of deer abundance levels (Ewans 2009).

Three catchments were selected for Wapiti and Central Fiordland, and one catchment for the Murchison Mountains (as less variability was expected). Local knowledge/expert opinion of deer abundance at these sites are shown in Table 1.

Data were collected over the austral summer field seasons.

Table 1: Summary of Fiordland National Park Seedling Ratio Index study sites. Based on Ewans (2009).

Management unit	*Catchment*	*Estimated deer abundance*	*Seasons measured (year monitoring season ended)*
Wapiti managed under a specific wild animal control plan; see DOC 2009	Wapiti River	Low	2010, 2015, 2021 Note: pellets not counted 2010
	Glaisnock River	Medium	2010, 2015, 2021
	Catseye Bay river	High	2010, 2015, 2021
Central Fiordland managed under normal WARO conditions	Delta Burn	Low	2011, 2016, 2021
	Cozette Burn	Medium	2011, 2016, 2021
	Namu River	High	2011, 2016, 2021
Murchison Mountains deer numbers are managed to low levels by DOC	Ettrick Burn	Low	2011, 2019

Ten transects were measured within each catchment. The transects were 400 m in length and started at a random point within a 2-hour walk of a pre-identified base camp. Of 20 start points, 10 were chosen to allow for sites to be dropped based on operational constraints such as impassable terrain

(Figure 1). Transect bearings were restricted to a random selection of compass bearings. If a bearing was impractical on site, the next random bearing was used. Transect start points were permanently marked and repeated measurements followed the original bearing.

Figure 1: Location of Seedling Ratio Index transects within Fiordland National Park. Points are coloured by management unit.

Transects were comprised of circular plots placed at equal intervals. Most transects had 20 plots, 20 m apart (Figure 2). However, two transects in Namu catchment in 2021 had 40 plots. This was likely due to the transects having little understorey and hence a need for more data to reduce inter-transect variability (following Knightbridge 2003).

1.1.3 Measurements

At each plot, presence of tall and short seedlings of target plant species were recorded for calculating SRI, as well as deer browse and deer pellet presence.

Species selection

Target species for SRI were those that can grow more than 30 cm tall unaided (which excludes climbers and short, ground-cover species).

Target species for the browse measures included additional species to the SRI list, for example, species which cannot grow over 30 cm.

Seedling Ratio Index

Plots had a radius of 1.41 m. In this plot, presence of tall seedlings (30 – 200 cm natural standing height) was recorded by species

In the centre of the tall seedling plot was a 0.49 m subplot (Figure 2) for measuring short seedlings (less than 30 cm tall).

Figure 2: Seedling Ratio Index plot layout

Browse

A browse score (0 – 5) was assigned to all target species present in the 1.41 m plot with live foliage between 15 – 200 cm above ground level (Table 2).

Table 2: Definition of browse scores. Source: Knightbridge (2003).

Browse score	Description
0	No ungulate browse observed
1	1-10% of stems with some browse observed
2	11-25% of stems with some browse observed
3	26-50% of stems with some browse observed
4	51-75% of stems with some browse observed
5	76-100% of stems with some browse observed

Deer pellets

Presence or absence of deer pellets in each plot was recorded.

1.2 Data methods

Data preparation and analysis were completed in R (version 4.4.0) with RStudio (version 2024.04.2 build 764) (R Core Team, 2004) based on Ingrid Gruner's analysis for Secretary Island (2022 unpublished).

1.2.1 Preparation

Data from all measurement years were combined into one table with standard, column names and types . For SRI calculation, NA values in tall and short seedling columns were replaced with zeros. A unique identifier for each transect was created in a column called "transect.ID": a combination of catchment and transect names.

One transect was excluded from analysis (C11) as it was only measured once, so had little relevance for looking at changes across time. Transects where not all plots were measured each survey were included in the analysis, as SRI values are transect means

Data were collected over two summers, so I added a "measure" column where 2010/11, for example, means a plot was either measured in the 2010 or the 2011 season. I also added a scaled "time" variable (time = years since 2009).

Species observed on the plots were classed according to their palatability to deer (P = preferred, NS = not selected, A = avoided) based on Forsyth et al. (2002) and local DOC staff knowledge. For species that didn't have a local palatability class, I applied National Vegetation Survey (NVS) palatability classes.

NVS data were also used to update species names to standard six letter codes (as of 17/6/23). Some ambiguous entries in the SRI data were manually corrected George Ledgard (pers. comm.). Only SRI target species with palatability classes were used in analysis. I excluded two species that did not have a palatability class, grasses, vines, and other non-target species. The list of target species for the SRI method was taken from the Wapiti master data (see Appendix 5.2 for data source information).

Indices for analysis were calculated as follows:

Seedling Ratio Index

SRI was calculated as:

(Species richness of tall seedlings - species richness of short seedlings)/ (Species richness of tall seedlings + species richness of short seedlings)

SRI was calculated for each palatability class, on a transect, per survey.

Browse

For consistency, browse was calculated for the same dataset as SRI but without rows where browse was not scored. This was because it was unclear if there had been other target species identified for the browse method. The same approach was used for a recent analysis of data from Secretary Island (I. Gruner, pers. comm.).

Mean browse was calculated for each palatability class, within a transect, per survey.

Browse Index

Browse Index (BI) was calculated based on Sweetapple and Nugent (2004). Whereas Sweetapple and Nugent used a scale of 0 – 4 for browse severity, this study used 0 – 5.

Therefore, the calculation was updated to:

(BI = - log (1 – mean browse per transect / 5)

A Browse Index was calculated for preferred and not selected species combined, on each transect, per survey.

Deer pellets

The proportion of plots per transect with pellets was calculated as:

(proportion = sum (deer pellets = present) / sum (rows where deer pellets = present or absent)

For each transect, per survey. I used proportion rather than count of plots with pellets per transect because some transects had 40 plots, which could unduly inflate their pellet value.

One outlier was removed because its proportion was 1 because only one plot was measured for that transect, that year

1.2.2 Analysis

We report the relationship between management unit and SRI because of its relevance to management. However, there should be some caution taken in interpreting the results, because catchments were not objectively selected to represent the management unit.

I fitted a linear mixed effects model on the transect-level SRI using the *lme4* package and assuming a normal distribution

Management unit, palatability class and time since 2009 were included as fixed effects with potential interaction between these terms. A random term of (catchment/transect.ID/palatability.class) was included to account for the location specific variance within each management unit (and transect variance nested within that). Palatability class was nested within transect.ID to avoid possible rank deficiency.

Model assumptions were checked using the *DHARMa* package (see Appendix). Quantile deviations were detected, however based on the results of other assumption tests and expert advice, the analysis proceeded.

While the model selection process indicated a two-way interaction had lower AIC, the r squared values were similar indicating the models explained a similar amount of variance in the data. We retained the three-way interaction to show trends over time which may be of interest to managers (Table 3). The three-way model output (Table 4) can be compared to the two-way model output (Appendix).

Table 3: Models considered for SRI analysis

Model formula	AIC	R squared (fixed terms only / fixed and random terms)
Three-way interaction: lmer(SRI.transect ~ time * management.unit * palatability.class + (1|catchment/transect.ID/palatability.class)	332.4268	0.453 / 0.719
Two-way interaction: lmer(SRI.transect ~ time + management.unit + palatability.class + (1 | catchment/transect.ID) + time:palatability.class + management.unit:palatability.class, data = f.sri.time)	328.4172	0.447 / 0.613

Data analysis exploration

A fixed effect of browse was not included in case it violated the assumption of independence as it could be correlated with other predictors such as management unit or palatability class. I fitted a separate model with Browse Index and browse as response variables, but residual plots were too skewed to proceed. This report only shows results for SRI. Exploratory plots for deer pellets, mean browse, and Browse Index (along with some scatterplots looking at multiple variables) are in the Appendix. The plots in the Appendix are purely exploratory, they aren't modelled to include the nested structure of the data and covariates, so they are not suitable for making inferences from.

Post hoc analysis

I used the *emmeans* package to show how different levels of predictors affect SRI and to show confidence intervals on management unit means.

To assess the differences in **state** of SRI for each of the management units, contrasts were made between the estimated marginal means (emmeans) of palatability classes within management units (e.g. Wapiti P vs. Wapiti NS), and between management units (e.g. Wapiti P vs. Central Fiordland P) when time since 2009 was at its mean (6.6 years). Adjustments were made for each set of comparisons.

Additionally, the *emtrends* function was used to evaluate differences in the **trend** of SRI for each palatability class, at each of the management units, over time. The *ggplot2* package was used to plot interaction effects.

Random effects were assessed using the *lattice* package.

2. Results

SRI

2.1 Summary

- Averaged across sites and years, plants' palatability to deer has a significant effect on seedling ratios ($p \leq 0.05$). Preferred and not selected species had fewer tall seedlings compared to avoided species.
- The effect of palatability class varied by management unit. Specifically, Murchison Mountains had no significant difference in SRI scores between palatability classes.
- Preferred species at Central Fiordland had significantly lower predicted SRI than preferred species at Murchison Mountains.
- Wapiti showed a significant difference in SRI between palatability classes through time. The positive SRI trend for Wapiti preferred species was significantly different from the other palatability classes (which were relatively stable over time). The trend for preferred species in Wapiti was also significantly different to that in Central Fiordland (comparing the positive trend in Wapiti to the slightly negative trend in Central Fiordland).

2.2 Model output

Preferred and not selected species had a lower SRI than those classed as avoided. Coefficient estimates were -0.79 for preferred species and -0.23 for not selected (Table 4), meaning that the SRI for preferred species was estimated to be 0.79 lower than for avoided species. The SRI scale is -1 to 1 so this degree of difference is reasonable. The effect of palatability class varied by management unit.

Table 4: Linear mixed effects model summary. Significant p values (≤ 0.05) are shown in bold.

Management Unit Seedling Ratio Index

Predictors	*Estimate*	*std. Error*	*z*	*p*
(Intercept)	0.30	0.10	3.07	**0.002**
time	-0.01	0.01	-1.25	0.210
management unit [Murchison Mountains]	-0.17	0.20	-0.85	0.394
management unit [Wapiti]	0.15	0.14	1.09	0.275
palatability class [NS]	-0.23	0.08	-2.83	**0.005**
palatability class [P]	-0.79	0.08	-9.65	**<0.001**
time × management unit [Murchison Mountains]	0.01	0.01	0.80	0.423
time × management unit [Wapiti]	0.00	0.01	0.04	0.967
time × palatability class [NS]	-0.01	0.01	-1.20	0.230
time × palatability class [P]	0.00	0.01	0.43	0.664
management unit [Murchison Mountains] × palatability class [NS]	0.59	0.17	3.37	**0.001**
management unit [Wapiti] × palatability class [NS]	-0.02	0.11	-0.22	0.823
management unit [Murchison Mountains] × palatability class [P]	0.93	0.18	5.32	**<0.001**
management unit [Wapiti] × palatability class [P]	0.05	0.11	0.45	0.656
(time × management unit [Murchison Mountains]) × palatability class [NS]	-0.02	0.02	-1.18	0.238
(time × management unit [Wapiti]) × palatability class [NS]	0.02	0.01	1.37	0.170
(time × management unit [Murchison Mountains]) × palatability class [P]	-0.02	0.02	-0.77	0.442
(time × management unit [Wapiti]) × palatability class [P]	0.02	0.01	2.00	**0.046**
Random Effects				
σ^2	0.06			
$\tau_{00\ palatability.class:(transect.ID:catchment)}$	0.03			
$\tau_{00\ transect.ID:catchment}$	0.01			
$\tau_{00\ catchment}$	0.02			
ICC	0.49			
$N_{palatability.class}$	3			
$N_{transect.ID}$	70			
$N_{catchment}$	7			
Observations	596			
Marginal R^2 / Conditional R^2	0.453 / 0.719			

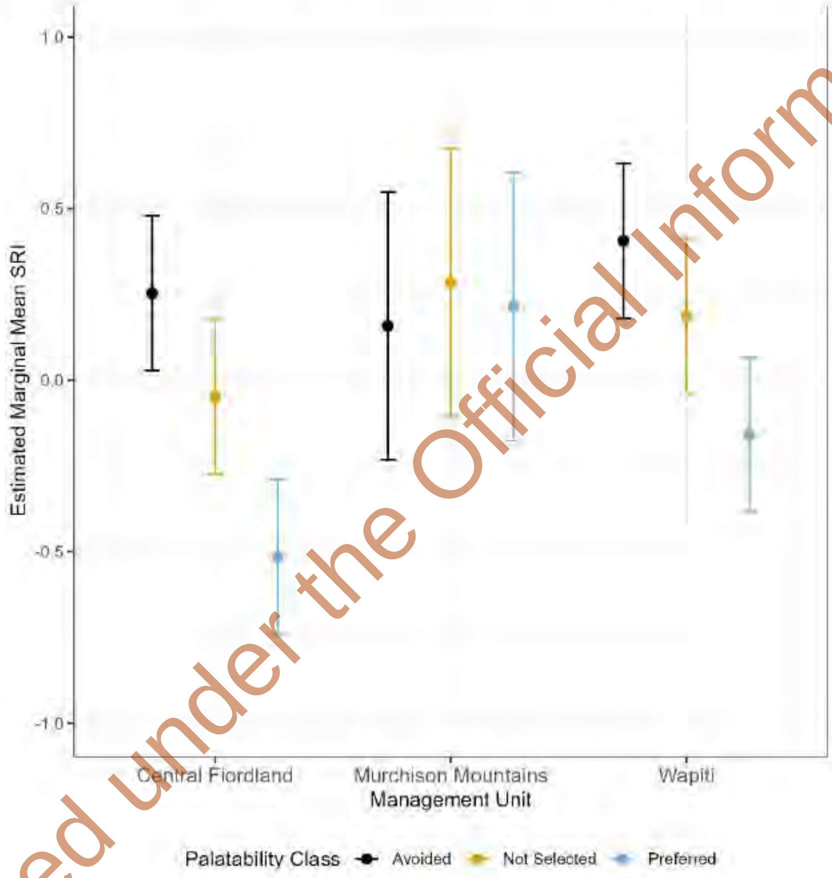
2.3 Post hoc analysis

Effect of management units and palatability classes, on SRI state and trend were visualised in pairwise contrast tables and plots.

2.3.1 SRI state: effect of palatability and management unit

Figure 3 shows the two-way effect of management unit and palatability class on SRI at the mean time since 2009 (6.6 years).

Figure 3: Estimated marginal mean Seedling Ratio Index for each palatability class within management unit. Error bars represent 95% confidence intervals.



Within management unit:

Predicted SRI varied significantly between palatability classes in the Wapiti and Central Fiordland management areas. The biggest effect was in Central Fiordland (where predicted SRI was -0.52 vs. 0.25 for preferred and avoided species respectively). However, at Murchison Mountains there were no significant differences in emmean SRI between palatability classes (Table 5)

Table 5: Contrasts of estimated marginal mean Seedling Ratio Index between palatability classes within each management unit. A = Avoided, NS = Not Selected, P = Preferred.

contrast	management.unit	time	estimate	SE	df	t.ratio	p.value
A - NS	Central Fiordland	6.5973	0.3019	0.0554	128.4907	5.4450	0.0000
A - P	Central Fiordland	6.5973	0.7689	0.0554	128.4907	13.8683	0.0000
NS - P	Central Fiordland	6.5973	0.4670	0.0554	128.4907	8.4233	0.0000
A - NS	Murchison Mountains	6.5973	-0.1266	0.1059	187.2341	-1.1965	0.4568
A - P	Murchison Mountains	6.5973	-0.0562	0.1072	193.9684	-0.5244	0.8595
NS - P	Murchison Mountains	6.5973	0.0704	0.1072	193.9684	0.6570	0.7886
A - NS	Wapiti	6.5973	0.2203	0.0555	129.0423	3.9675	0.0004
A - P	Wapiti	6.5973	0.5643	0.0555	129.0423	10.1617	0.0000
NS - P	Wapiti	6.5973	0.3440	0.0555	129.0423	6.1942	0.0000

Between management units:

There was only one significant difference in emmeans comparing palatability classes across management units: preferred species at Central Fiordland had much lower emmean SRI than preferred species at Murchison Mountains (Table 6) (-0.52 vs. 0.21 respectively).

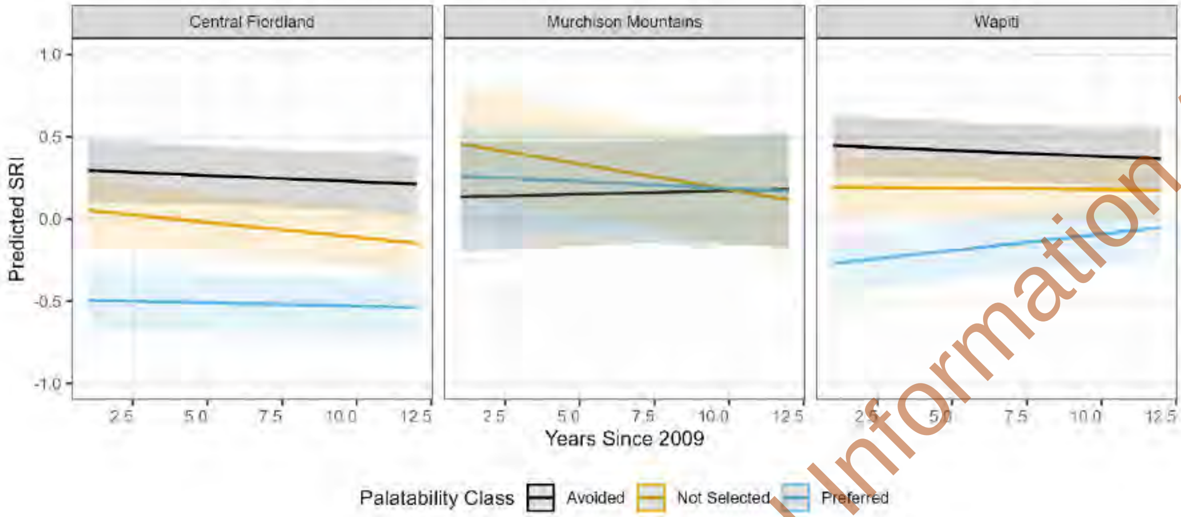
Table 6: Contrasts of estimated marginal mean Seedling Ratio Index for each palatability class between management units. A = Avoided, NS = Not Selected, P = Preferred.

contrast	palatability.class	time	estimate	SE	df	t.ratio	p.value
Central Fiordland - Murchison Mountains	A	6.5973	0.0949	0.1811	5.6011	0.5241	0.8629
Central Fiordland - Wapiti	A	6.5973	-0.1528	0.1261	5.2711	-1.2114	0.4948
Murchison Mountains - Wapiti	A	6.5973	-0.2477	0.1811	5.6028	-1.3677	0.4167
Central Fiordland - Murchison Mountains	NS	6.5973	-0.3336	0.1811	5.6011	-1.8420	0.2402
Central Fiordland - Wapiti	NS	6.5973	-0.2344	0.1261	5.2711	-1.8581	0.2401
Murchison Mountains - Wapiti	NS	6.5973	0.0992	0.1811	5.6028	0.5478	0.8516
Central Fiordland - Murchison Mountains	P	6.5973	-0.7302	0.1819	5.6989	-4.0141	0.0181
Central Fiordland - Wapiti	P	6.5973	-0.3574	0.1261	5.2711	-2.8337	0.0754
Murchison Mountains - Wapiti	P	6.5973	0.3728	0.1819	5.7006	2.0490	0.1852

2.3.1 SRI trend over time

Figure 4 shows the three-way interaction effect of management unit, palatability class, and time, on SRI.

Figure 4: Predicted Seedling Ratio Index (SRI) trends by palatability class and management unit. Ribbons represent 95% confidence envelopes.



Within management unit:

Trends were only significantly different for palatability groups in the Wapiti management area, where SRI for preferred species increased from approximately -0.25 to -0.1 over the twelve years of our study, whereas the means for not selected and avoided species remained relatively stable (Figure 4, Table 7). The increase in preferred species SRI is not large, 7.5% of the possible SRI range (although plausible range may be smaller, as mean SRI for preferred species across management units ranges from -0.5 to approximately 0.25) (Figure 4).

Table 7: Contrasts of Seedling Ratio Index estimated marginal trends between palatability classes within each management unit. A = Avoided, NS = Not Selected, P = Preferred.

contrast	management.unit	estimate	SE	df	t.ratio	p.value
A - NS	Central Fiordland	0.0105	0.0087	377.7852	1.2017	0.4529
A - P	Central Fiordland	-0.0038	0.0087	377.7852	-0.4346	0.9012
NS - P	Central Fiordland	-0.0142	0.0087	377.7852	-1.6363	0.2317
A - NS	Murchison Mountains	0.0350	0.0188	377.7852	1.8563	0.1530
A - P	Murchison Mountains	0.0124	0.0192	385.3301	0.6471	0.7941
NS - P	Murchison Mountains	-0.0225	0.0192	385.3301	-1.1745	0.4691
A - NS	Wapiti	-0.0057	0.0079	377.7950	-0.7190	0.7524
A - P	Wapiti	-0.0273	0.0079	377.7950	-3.4560	0.0018
NS - P	Wapiti	-0.0216	0.0079	377.7950	-2.7370	0.0178

Between management unit:
The only significant difference in palatability class trend between management units was for preferred species at Central Fiordland compared to Wapiti (Table 8). Preferred species SRI in Central Fiordland was stable over the 12 years of our study (decreasing from -0.5 to -0.6), whereas preferred species SRI in Wapiti increased from approximately -0.24 to -0.1 (Figure 4).

Table 8: Contrasts of Seedling Ratio Index estimated marginal trends for each palatability class between management units. A = Avoided, NS = Not Selected, P = Preferred.

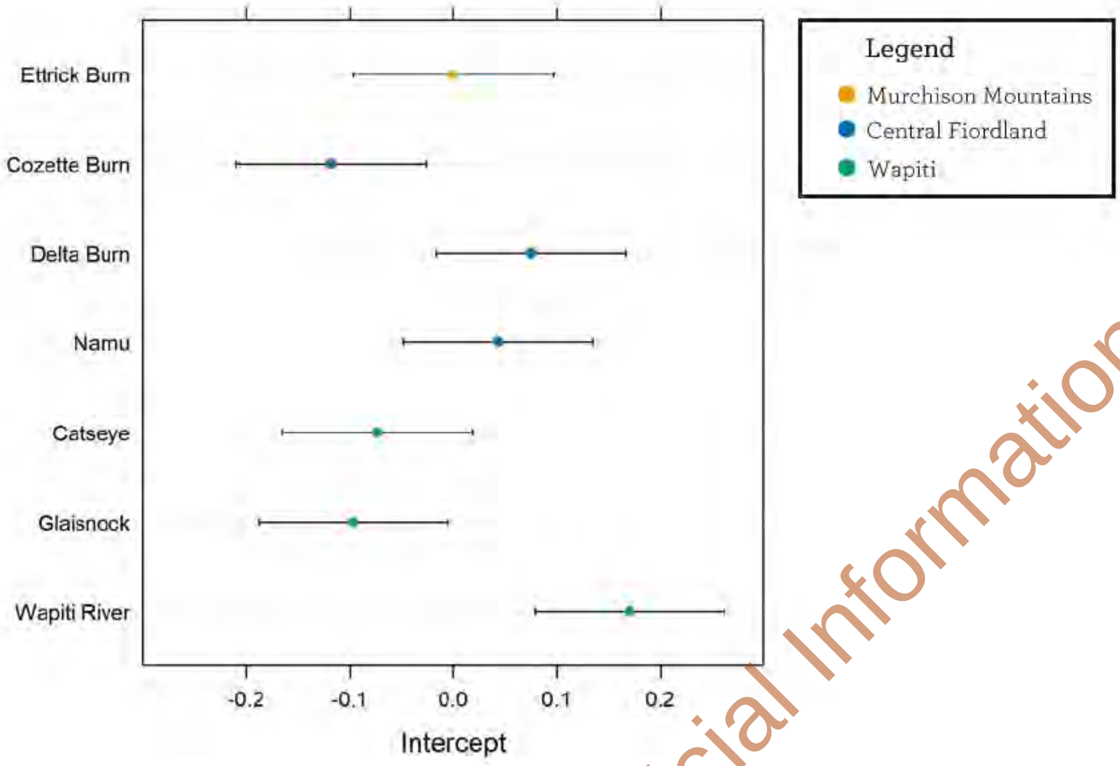
contrast	palatability.class	estimate	SE	df	t.ratio	p.value
Central Fiordland - Murchison Mountains	A	-0.0118	0.0147	377.7852	-0.8025	0.7017
Central Fiordland - Wapiti	A	-0.0003	0.0083	377.7892	-0.0415	0.9991
Murchison Mountains - Wapiti	A	0.0114	0.0144	377.7865	0.7913	0.7086
Central Fiordland - Murchison Mountains	NS	0.0127	0.0147	377.7852	0.8681	0.6608
Central Fiordland - Wapiti	NS	-0.0165	0.0083	377.7892	-1.9832	0.1177
Murchison Mountains - Wapiti	NS	-0.0292	0.0144	377.7865	-2.0228	0.1081
Central Fiordland - Murchison Mountains	P	0.0044	0.0151	389.9675	0.2927	0.9539
Central Fiordland - Wapiti	P	-0.0239	0.0083	377.7892	-2.8717	0.0120
Murchison Mountains - Wapiti	P	-0.0283	0.0149	390.3364	-1.8976	0.1407

Note: we fit a linear trend over time, which smooths some of the actual variation between years at the management units; confidence ribbons show some of this variability. Also, the time scale is standardised.

2.3.2 Random effects

Random effect intercepts show the effect of catchment on SRI (Figure 5). The plot suggested that there was some inter-catchment variation within management units. For example, in the Wapiti management unit, average SRI for Wapiti River was higher (by approximately 0.26) than other catchments. In Central Fiordland, Cozette Burn had a lower SRI intercept (-0.1) than the overall estimate for the management unit (zero on the x axis). Note the scale of these differences. As an example, the overall Wapiti SRI intercept was 0.15. Whereas the modelled SRI for Wapiti River catchment may have been approximately 0.3 (0.16 higher than the management unit average). The intercepts are averaged across palatability classes and time.

Figure 5: Visualisation of the model intercepts for the random effect of "catchment" on Seedling Ratio Index (SRI). Coloured by management unit. Error bars show 95% confidence intervals. Response variable (SRI) range is -1 to 1. Zero on the x axis represents the estimated intercept for the management unit.



You can also see how transects varied within catchments in the Appendix. Of the transects, Wapiti River 31 deviated the most from its catchment average.

3. Acknowledgements

We acknowledge the use of data drawn from the National Vegetation Survey Databank (NVS) on 17 June 2023.

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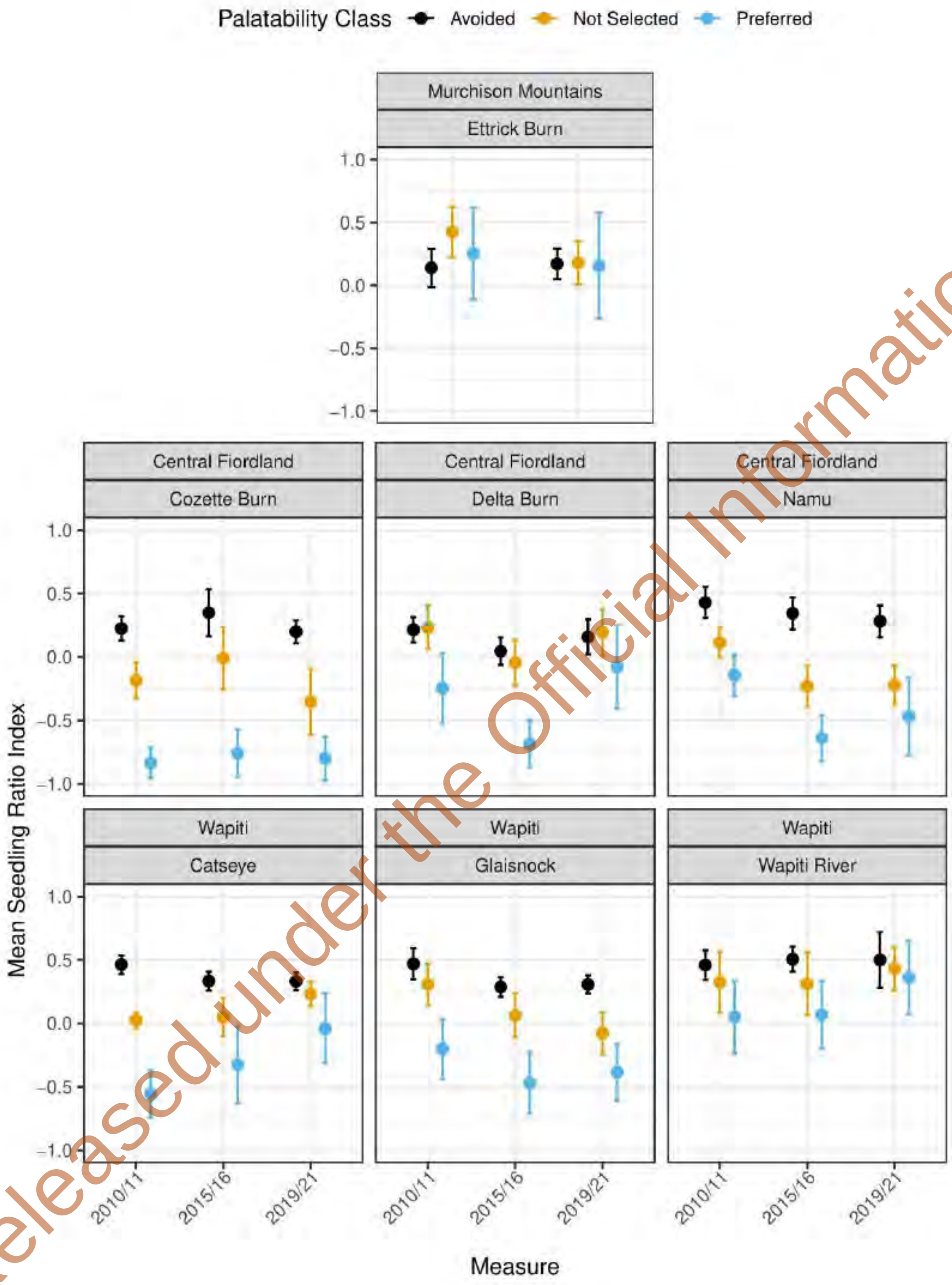
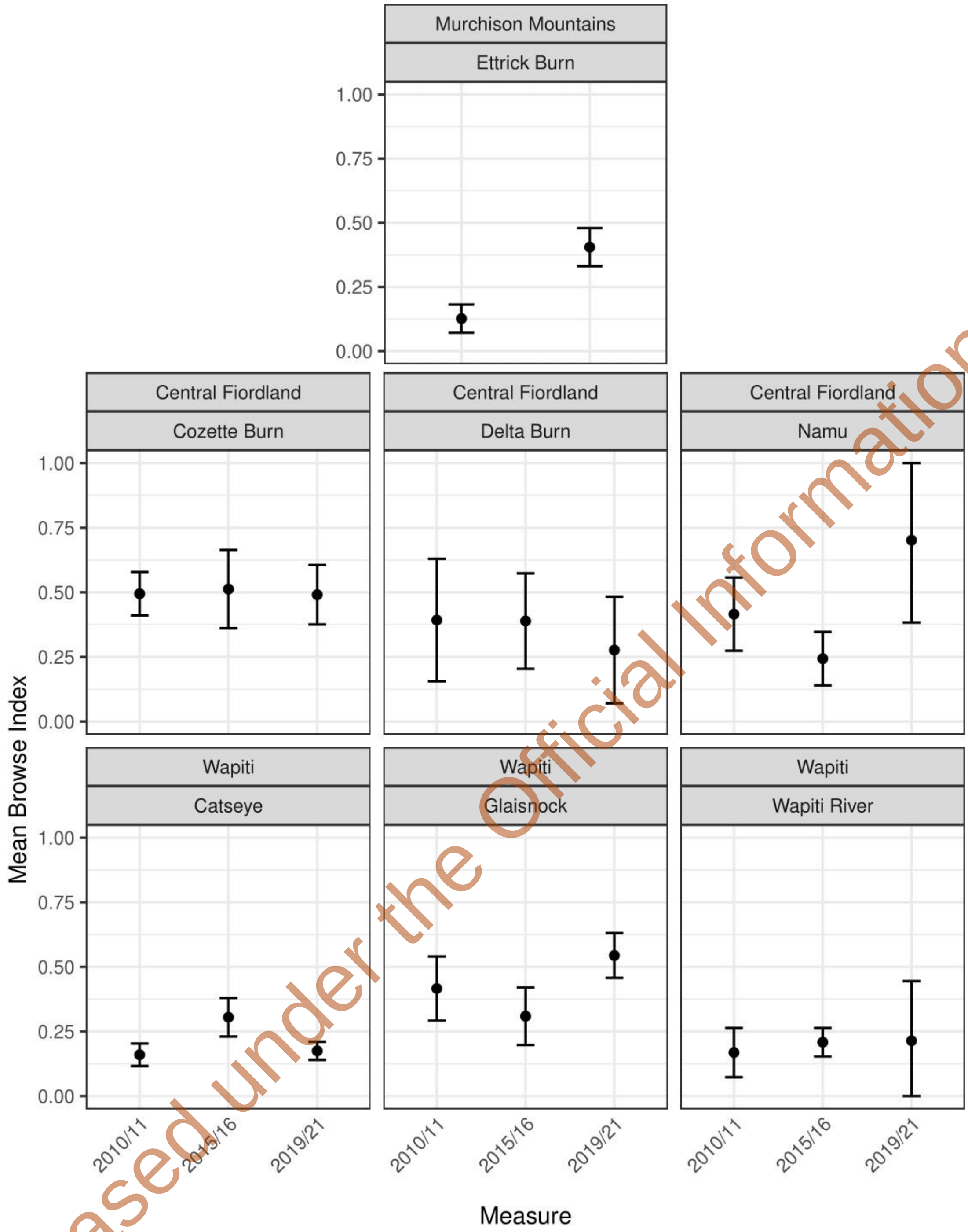
5. Appendix

5.1 Additional plots

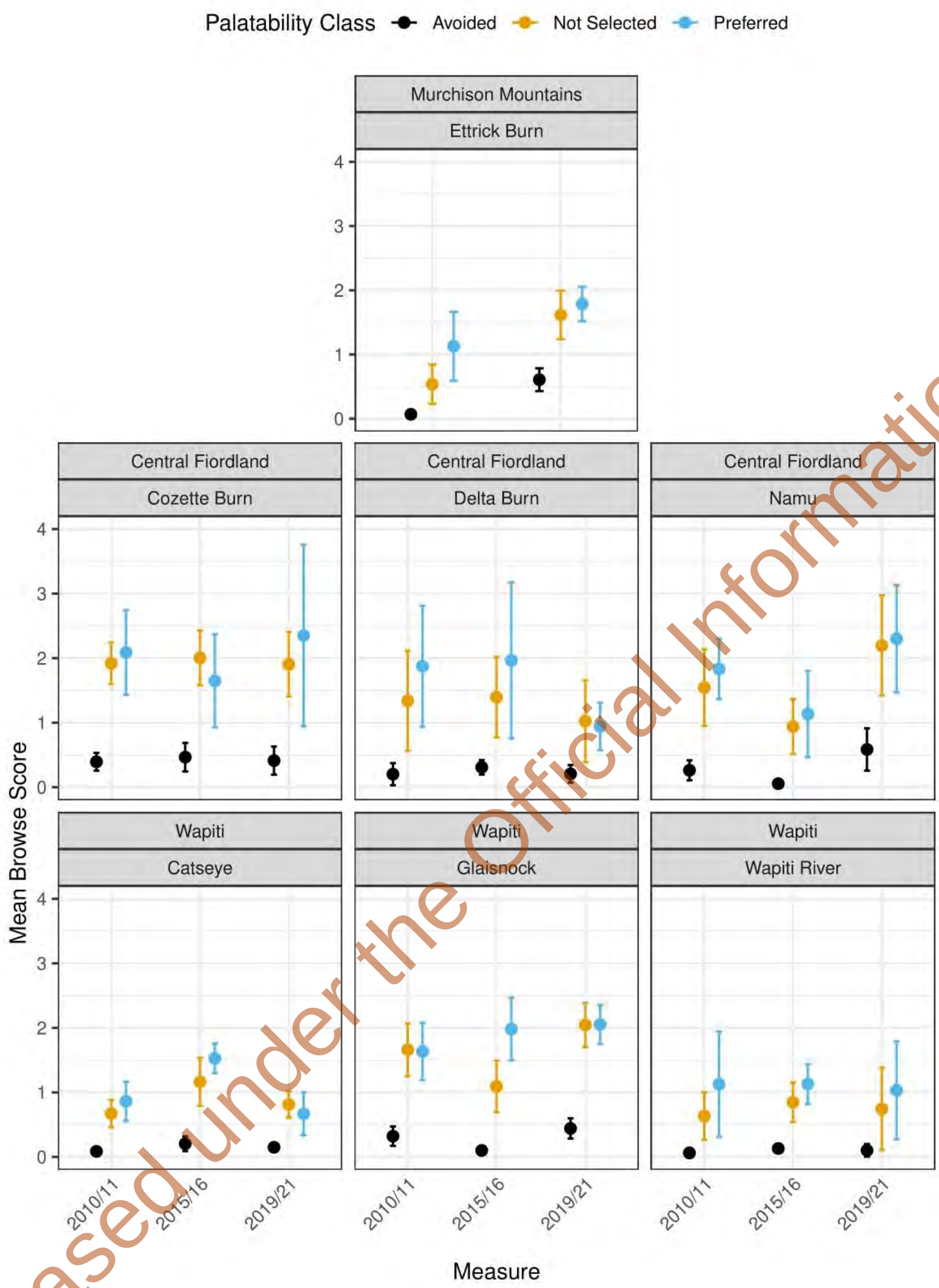
5.1.1 Exploratory plots

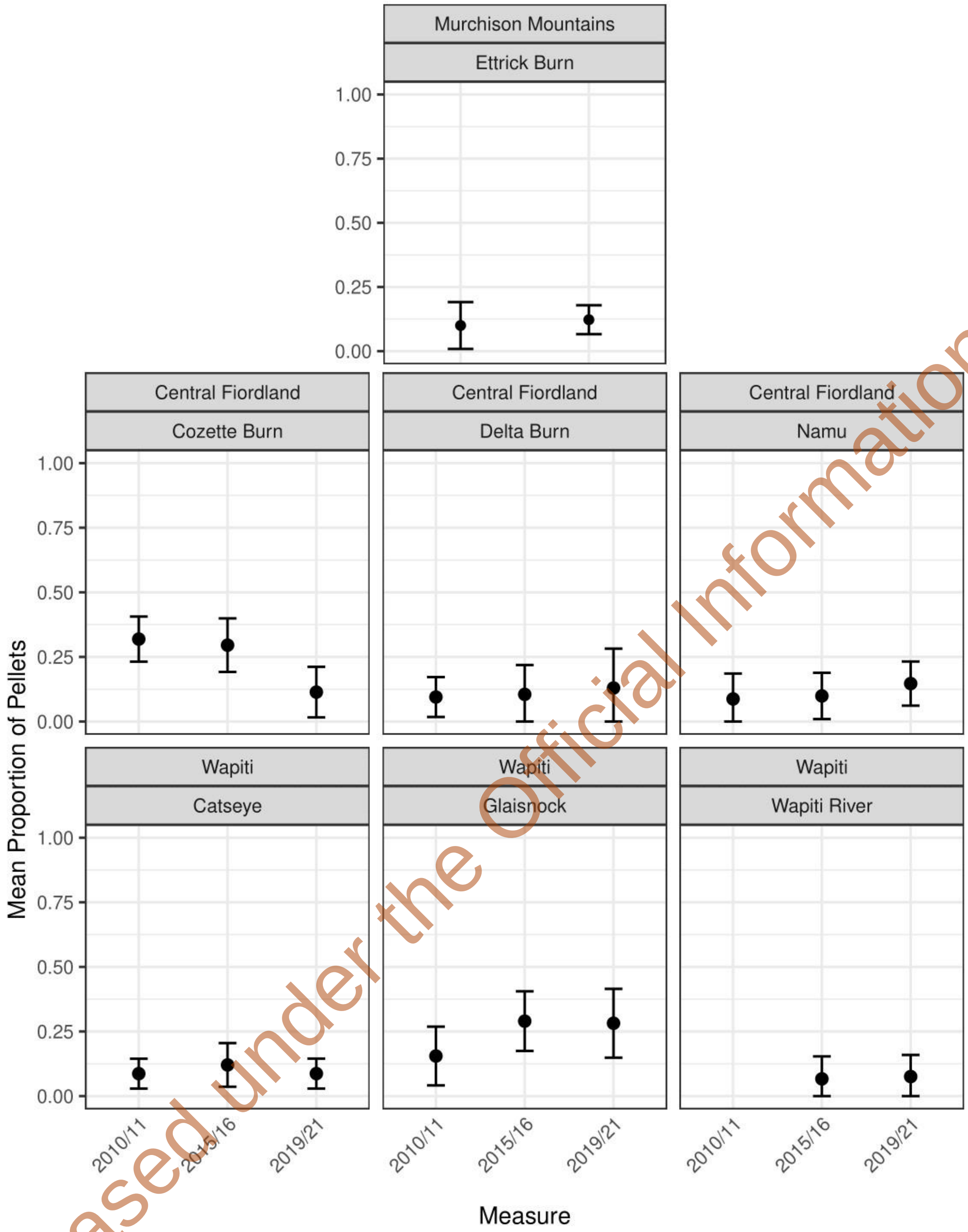
(in order: SRI, Browse Index, browse score, proportion of pellets, correlation of SRI and browse). Error bars represent 95% confidence intervals.

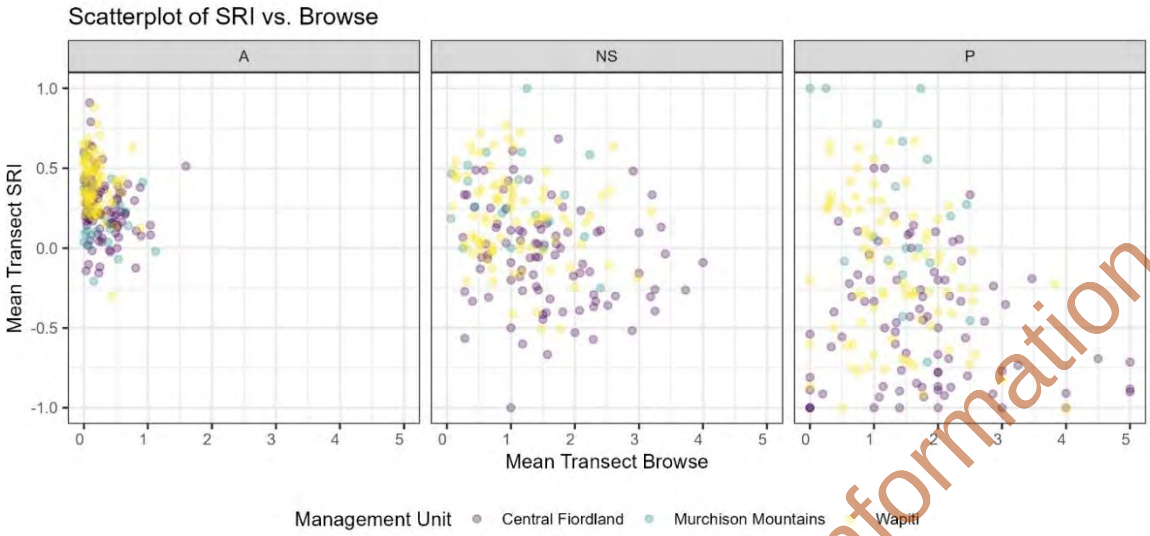




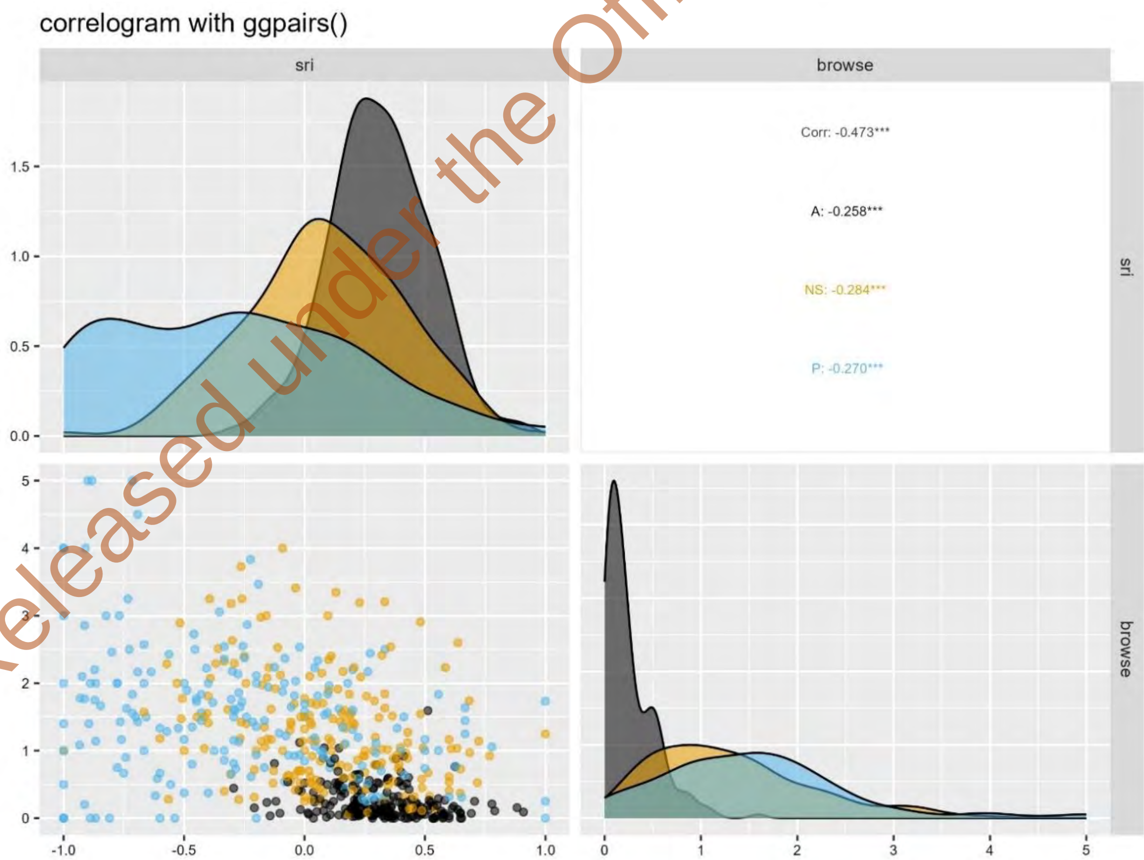
Murchison Mountains
Ettrick Burn
Central Fiordland
Cozette Burn
Central Fiordland
Delta Burn
Central Fiordland
Namu
Wapiti
Catseye
Wapiti
Glaisnock
Wapiti
Wapiti River
Mean Browse Index
1.00
0.75
0.50
0.25
0.00
2010/11
2015/16
2019/21
Measure


Palatability Class
Avoided
Not Selected
Preferred
Murchison Mountains
Ettrick Burn
Central Fiordland
Cozette Burn
Central Fiordland
Delta Burn
Central Fiordland
Namu
Wapiti
Catseye
Wapiti
Glaisnock
Wapiti
Wapiti River
Mean Browse Score
0
1
2
3
4
2010/11
2015/16
2019/21
Measure


Murchison Mountains
Ettrick Burn
Central Fiordland
Cozette Burn
Central Fiordland
Delta Burn
Central Fiordland
Namu
Wapiti
Catseye
Wapiti
Glaisnock
Wapiti
Wapiti River
Mean Proportion of Pellets
1.00
0.75
0.50
0.25
0.00
2010/11
2015/16
2019/21
Measure

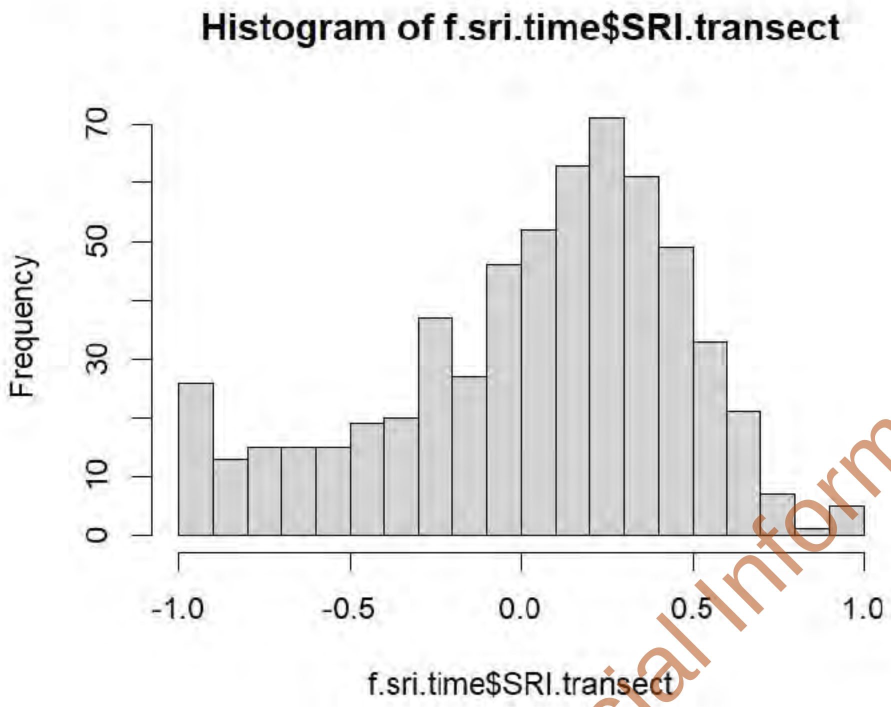


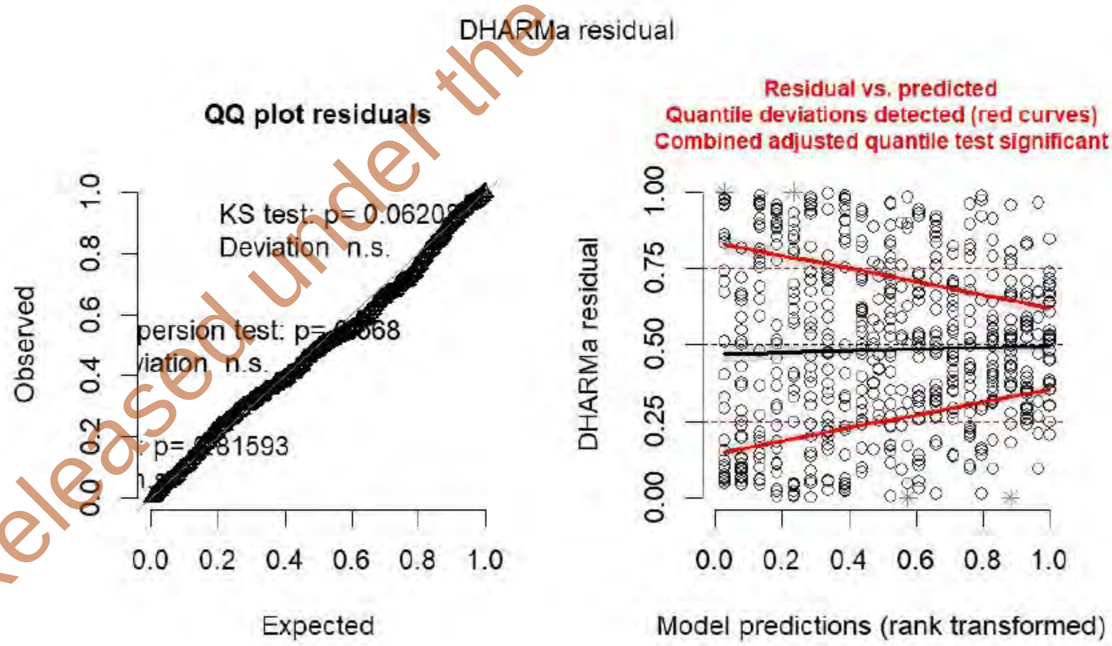
Scatterplot of SRI vs. Browse
A
NS
P
Mean Transect SRI
Mean Transect Browse
Management Unit
Central Fiordland
Murchison Mountains
Wapiti



correlogram with ggpairs()
sri
browse
Corr: -0.473***
A: -0.258***
NS: -0.284***
P: -0.270***

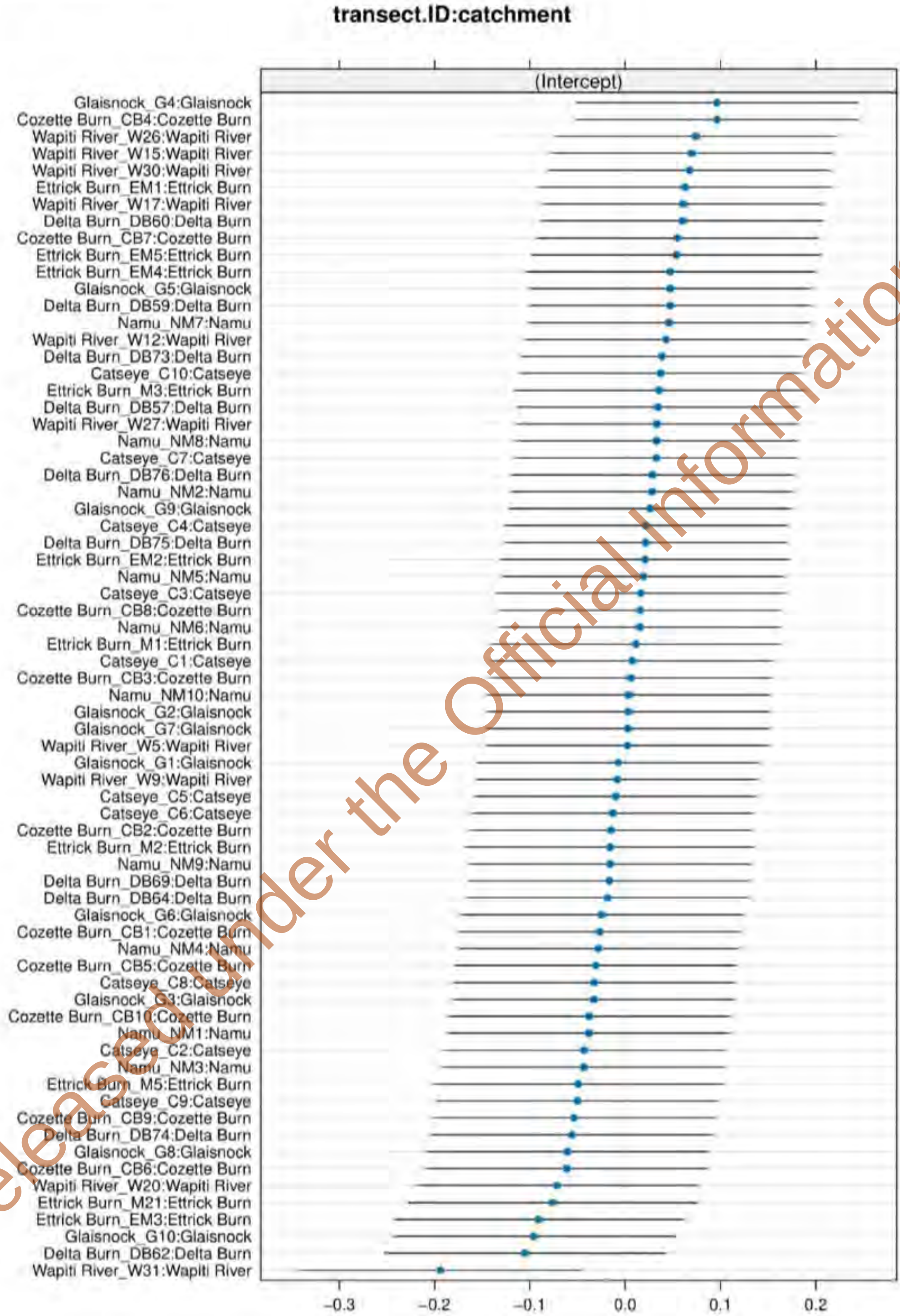
5.1.2 Data distribution and model assumptions





5.1.3 Random effects

Error bars represent 95% confidence intervals.



5.2 Data sources

Data	Contents	Title/s	Source	Scale
Plot measure data	• Catchment (location), transect, plot • Species name • Year measured • SRI: presence of tall and short seedlings • Browse scores • Palatability class • SRI target species (Y/N) • Presence/absence of deer pellets on plots	• Central Fiordland SRI 2021 - Freya Copy.csv • Wapiti Area SRI 2021 - Freya Copy.csv • Murchison Mountains SRI masterdata - DOC-5997479 (1).csv • Central Fiordland SRI previous data - Freya Copy.csv • Wapiti Area SRI previous data - Freya Copy.csv	DOC Te Anau (George Ledgard)	Each row is a species at a plot at a given time point

Plot measure metadata	• Includes lookup tables for
	  - species palatability (local list of classifications)
	  - species included/excluded from SRI method
	• Information sheet briefly summarising data and study methods
		Wapiti Area SRI master data - Freya Copy.xls	DOC Te Anau (George Ledgard)	Varies by sheet

Palatability and SRI target species	List taken from Wapiti metadata of local deer palatability classifications and target species for SRI. CSV version for data analysis	palatability.fiordland.csv	This is the "pala" sheet from Wapiti metadata (source: DOC Te Anau)	Each row is a species
NVS data (17/6/23)	Regularly reviewed national database of native plant species including current and old species names, species type (e.g. grass, vine), and palatability class	CurrentNVSNames.csv	https://nvs.landcareresearch.co.nz/	Each row is a species

5.3 Alternative model summary

Management Unit Seedling Ratio Index

Predictors	*Estimate*	*std. Error*	*z*	*p*
(Intercept)	0.30	0.09	3.19	**0.001**
time	-0.01	0.00	-1.41	0.159
management unit [Murchison Mountains]	-0.10	0.18	-0.57	0.569
management unit [Wapiti]	0.15	0.12	1.25	0.212
palatability class [NS]	-0.27	0.06	-4.44	**<0.001**
palatability class [P]	-0.87	0.06	-14.00	**<0.001**
time × palatability class [NS]	-0.00	0.01	-0.70	0.486
time × palatability class [P]	0.01	0.01	2.14	**0.033**
management unit [Murchison Mountains] × palatability class [NS]	0.45	0.10	4.60	**<0.001**
management unit [Wapiti] × palatability class [NS]	0.08	0.06	1.39	0.165
management unit [Murchison Mountains] × palatability class [P]	0.84	0.10	8.49	**<0.001**
management unit [Wapiti] × palatability class [P]	0.21	0.06	3.48	**0.001**
Random Effects				
σ^2	0.08			
$\tau_{00\ \mathrm{transect.ID:catchment}}$	0.01			
$\tau_{00\ \mathrm{catchment}}$	0.02			
ICC	0.30			
$N_{\mathrm{transect.ID}}$	70			
$N_{\mathrm{catchment}}$	7			
Observations	596			
Marginal R^2 / Conditional R^2	0.447 / 0.613			

5.4 R Code

(as of 19/07/24):

BEGINS

```
# Fiordland Seedling Ratio Index & Browse Index #
# Data prep, analysis, and visualisation #

# drafted by Freya Clarke as directed by George Ledgard
# substantial parts of code based on Ingrid Gruner's Secretary Island SRI analysis
# support from Amy Hawcroft
#-------------------------------------------------#
citation()
sessionInfo()

## PREPARE RAW DATA ##
# check working directory before starting
# clear workspace

rm(list=ls()) #clear R workspace

# load packages
# install any you don't already have
library(DHARMa)
library(lattice)
library(broom.mixed)
library(sjPlot)
library(emmeans)
library(patchwork)
library(GGally)
library(knitr)
library(kableExtra)
library(tidyverse)
library(lmerTest)

# read in data for each management unit's surveys in 2021 season and past years
# management units = Central Fiordland, Wapiti, & Murchison Mts
CF2021<-read_csv("Data_Raw/Central Fiordland SRI 2021 - Freya Copy.csv")
problems(CF2021) #row 846 has "P" in numerical browse col, allow R to change to NA
W2021<-read_csv("Data_Raw/Wapiti Area SRI 2021 - Freya Copy.csv")
# all other years for Murch Mts
MM<-read_csv("Data_Raw/Murchison Mountains SRI masterdata - DOC-5997479 (1).csv")
problems(MM) #relates to notes, which will be excluded anyway
# all other years for Central Fiordland
CF<-read_csv("Data_Raw/Central Fiordland SRI previous data - Freya Copy.csv")
# all other years for Wapiti
W<-read_csv("Data_Raw/Wapiti Area SRI previous data - Freya Copy.csv")
# Current NVS plant species names, downloaded 17 June 2023
NVS<-read_csv("Data_Raw/CurrentNVSNames.csv")

# Note: the 2021 data has extra column "true_year" to reflect the calendar year measured as field
        sheets had dates
# for the previous data "year" meant season;
```

```
# i.e. the year measuring ended for the season (generally runs over summer from previous year)

## join rows to make one dataframe for all surveys ##

# need to make data types consistent first

# combine dataframes into a list
dataframes <- list(CF, CF2021,W,W2021,MM)

# get a list of column names present in all dataframes
common_columns <- Reduce(intersect, lapply(dataframes, colnames))

# get the data types of common columns in each dataframe
column_data_types <- map(dataframes, ~ sapply(.[common_columns], class))

# compare data types
# create a comparison dataframe
data_type_comparison <- data.frame(
  Column = names(column_data_types[[1]]),
  DataFrame1 = column_data_types[[1]],
  DataFrame2 = column_data_types[[2]],
  DataFrame3 = column_data_types[[3]],
  DataFrame4 = column_data_types[[4]],
  DataFrame5 = column_data_types[[5]])

# look at the comparison, then crosscheck
class(W$`deer pellets`) #will change to character before binding

# prepare dataframes to row bind
# add column to each for management unit
W <- W %>%
  mutate(`deer pellets` = case_when(
    `deer pellets` == 0 ~ 'A',
    `deer pellets` == 1 ~ 'P',
    TRUE ~ as.character(`deer pellets`)
  ))%>%
  mutate(`management.unit` = "Wapiti")%>%
  select(`management.unit`, everything())

W2021 <- W2021 %>% mutate(`management.unit` = "Wapiti")%>%
  select(`management.unit`, everything())

CF <- CF %>%
  mutate(`management.unit` = "Central Fiordland") %>%
  select(`management.unit`, everything()) %>%
  mutate(location = ifelse(location == "Namu River", "Namu", location))


CF2021 <- CF2021 %>%
  mutate(`management.unit` = "Central Fiordland") %>%
  select(`management.unit`, everything())

MM <- MM %>%
  mutate(notes = as.character(notes)) %>%
  rename("browse" = `deer browse`) %>%
```

```
  mutate(browse = as.numeric(coalesce(browse, NA))) %>%
  mutate(`management.unit` = "Murchison Mountains") %>%
  select(`management.unit`, everything())
# there are a couple of rows where browse is listed as NR (not recorded)
# we are treating them the same as NA, hence warning

# combine all dataframes from previous and most recent measures
alldata <- bind_rows(CF2021, W2021, MM, CF, W)
colnames(alldata)

# remove redundant columns
# keep only year (season) col to be comparable with previous data
alldata <- alldata %>%
  select(!c(...16, MixedCase_species, true_year, `possum pellets`, notes))%>%
  arrange(management.unit,location, year, transect, plot, desc('deer pellets'))


## update NVS codes in masterdata ##,
# i.e. change old codes to current preferred codes

# first change to lowercase to help match codes
alldata$species <- tolower(alldata$species)
NVS$NVSCode <- tolower(NVS$NVSCode) #this includes previous known codes for species
NVS$PreferredCode <- tolower(NVS$PreferredCode) #current preferred species code

# make a list of names in SRI data not in the list of current NVS codes
not_current_alldata <- alldata$species[!(alldata$species %in% NVS$PreferredCode)]
not_current_alldata<- unique(not_current_alldata)
print(not_current_alldata)

# remove spaces from the strings
not_current_alldata <- gsub(" ", "", not_current_alldata)

# find the indices of names that have a character length of 6
# (standard length for NVS codes)
LC6 <- which(nchar(not_current_alldata) == 6)

# get the list of outdated sp names that have a character length of 6
names_with_six_chars <- not_current_alldata[LC6]
names_with_six_chars

# which of these are listed in old code column in NVS df? 30/50
old_name <- names_with_six_chars[(names_with_six_chars %in% NVS$NVSCode)]
old_name

# make a df that shows species in SRI data which are listed in the NVS code col and their respective
        preferred NVS name
alldata_spcode_updates <- NVS[NVS$NVSCode %in% old_name, c("NVSCode", "PreferredCode")]

# replace old codes with preferred codes
# create a named vector for the lookup
lookup <- setNames(alldata_spcode_updates$PreferredCode, alldata_spcode_updates$NVSCode)
# replace values
alldata$species <- ifelse(alldata$species %in% names(lookup), lookup[alldata$species],
        alldata$species)
```

```
# find values that aren't listed in either the old or new name cols in NVS df
# that were listed in species col of field sheets
missing_values <- setdiff(names_with_six_chars,alldata_spcode_updates$NVSCode)
missing_values
missing_values<-as.data.frame(missing_values)

## how many rows with non-NVS sp values?##
# filter rows where species matches any of the missing_values
matching_rows <- alldata[alldata$species %in% missing_values$missing_values, ]
num_matching_rows <- nrow(matching_rows)
# print the number of matching rows
cat("Number of matching rows:", num_matching_rows, "\n")
# 128/26743, small proportion of data
# these will automatically be excluded from analysis as they have no palat class or SRI method

# repeat process to update codes in palatability sheet in the SRI spreadsheet
# as this sheet has some old NVS codes
pal.data <- read.csv("Data_Raw/palatability.fiordland.csv", header = TRUE, stringsAsFactors =
        FALSE)
not_current_pal.data <- pal.data$Species.code[!(pal.data$Species.code %in% NVS$PreferredCode)]
not_current_pal.data<- unique(not_current_pal.data)
print(not_current_pal.data)

# 6 letter codes not current
# remove spaces from the strings
not_current_pal.data <- gsub(" ", "", not_current_pal.data)

# find the indices of names that have a character length of 6
LC6.pal <- which(nchar(not_current_pal.data) == 6)

# get the list of names that have a character length of 6
names_with_six_chars.pal <- not_current_pal.data[LC6.pal]
names_with_six_chars.pal

# which of these are listed in old code column? 27/31
old_name.pal <- names_with_six_chars.pal[(names_with_six_chars.pal %in% NVS$NVSCode)]
old_name.pal

# make a dataframe that shows species in SRI data which are listed in the NVS (old) code col and
        their respective preferred NVS name
pala_spcode_updates <- NVS[NVS$NVSCode %in% old_name.pal, c("NVSCode", "PreferredCode")]

# replace old codes with preferred codes
# create a named vector for the lookup
lookup.pal <- setNames(pala_spcode_updates$PreferredCode, pala_spcode_updates$NVSCode)
# replace values
pal.data$Species.code <- ifelse(pal.data$Species.code %in% names(lookup.pal),
        lookup.pal[pal.data$Species.code], pal.data$Species.code)

# write csvs
write.csv(missing_values,"Data_Prep/sp_to_check.csv", row.names = FALSE)
write.csv(pala_spcode_updates,"Data_Prep/palatability.fiordland.edited.csv", row.names = FALSE)
write.csv(alldata_spcode_updates,"Data_Prep/FlandSRI_sp_changes.csv", row.names = FALSE)
```

```
# since checking with [redacted] some ambiguous codes will be updated

alldata$species <- replace(alldata$species, alldata$species == 'copcot', 'coprot')
alldata$species <- replace(alldata$species, alldata$species == 'micaui', 'micave')
alldata$species <- replace(alldata$species, alldata$species == 'copsil', 'copcil')
alldata$species <- replace(alldata$species, alldata$species == 'colves', 'polves')
alldata$species <- replace(alldata$species, alldata$species == 'cyajun', 'cytjun')
alldata$species <- replace(alldata$species, alldata$species == 'psefio', 'neocol')
alldata$species <- replace(alldata$species, alldata$species == 'copras', 'coprosma sp')

alldata<- alldata %>% rename(palatability.class = "palatability class", sri.sp = "sri sp", deer.pellets =
        "deer pellets", catchment = "location")

# classify whether species incl in SRI method and their palat class in R,
# now that sp codes in alldata and pal.data are to current NVS standard
# define the lookup table based on pal.data
palatability_lookup <- setNames(pal.data$Palatability.class, pal.data$Species.code)
sri_lookup <- setNames(pal.data$SRI, pal.data$Species.code)

# Update values in palatability class and sri sp columns
alldata <- alldata %>%
 mutate(palatability.class = ifelse(species %in% names(palatability_lookup),
        palatability_lookup[species], palatability.class),
     sri.sp = ifelse(species %in% names(sri_lookup), sri_lookup[species], sri.sp))

#--------------------------------------------------#

## FIORDLAND SEEDLING RATIO INDEX (SRI) ##
# by management unit (MU)

# define functions
# functionname <- function(x) operation(x)
se <- function(x) sqrt(var(x)/length(x))

## data prep cont. ##
fdata <- alldata %>%
 # remove any empty rows
 filter(!is.na(transect)) %>%
 # insert 0 for NAs in short and tall columns
 mutate_at(vars(c('short', 'tall')), ~replace_na(.,0))

# find species that don't have palatability assigned,
# get palatability for these species from nvs.names
unique(fdata$palatability.class)
species.add <- fdata %>%
 filter(palatability.class == "#N/A") %>%
 distinct(species)

# match the species with no palat class with NVS classes
species.add$NVSPalatability <- NVS$Palatibility[match(species.add$species, NVS$PreferredCode)]
# change classifications to abbreviations so dataframe cols consistent
species.add$Palatability <- ifelse(species.add$NVSPalatability == 'Avoided', 'A',
                    ifelse(species.add$NVSPalatability == 'Not Selected', 'NS', 'U'))
# Filter species.add to get valid NVSPalatability values
valid_substitutions <- species.add %>%
```

```
  filter(!is.na(Palatability))

# Update palatability.class values in fdata based on matching species
palatability_lookup2 <- setNames(valid_substitutions$Palatability, valid_substitutions$species)

palat_nvs_fill <- fdata %>%
  mutate(palatability.class = ifelse(species %in% names(palatability_lookup2),
         palatability_lookup2[species], palatability.class))

# done, perhaps unnecessary as these sp weren't listed in pala dataframe it means they aren't an SRI
         sp, but could be useful for BI analysis

write.csv(palat_nvs_fill, "Data_Prep/SRIdata_palat_fill.csv", row.names = FALSE)

# remove non-target species for SRI method
target_sp <- palat_nvs_fill %>%
  filter(sri.sp == "Y")
# remove Vines and Graminoids
nontarget_nvs <- NVS %>%
  filter(GrowthForm %in% c("Vine", "Graminoid"))
nontarget_nvs <- unique(nontarget_nvs)

target_sp2 <- target_sp %>%
  filter(!species %in% nontarget_nvs$PreferredCode)


#---------------------------------------------#
## explore/cross check the data ##
### check how many plots per transect per year
plots <- target_sp2 %>%
  group_by(management.unit, year, transect) %>%
  summarise(NPlots = length(unique(plot)))
unique(plots$NPlots)
# inconsistent because NM4 & NM5 transects in 2020 had 40 plots instead of usual 20, some of
         these plots had no species hence nplots 30 and 37
plots %>%
  group_by(management.unit, year) %>%
  summarise(Sample = length(unique(transect)))
# 30 transects for CF and W, 10 for MM
# 2 measures for MM
# 3 measures for CF & W

# see how many times each plot (within transect) is measured
measurement_counts <- target_sp2 %>%
  group_by(management.unit, catchment, plot, transect) %>%
  summarise(Count = n_distinct(year))

# 53 plots which were only measured once (out of 1450)
once_meas <- measurement_counts %>%
  filter(Count < 2)

# exclude c11 as whole transect only measured once
f.sri <- target_sp2 %>%
  filter(!transect == "C11")
# the rest are specific plots not remeasured
```

```
# advice from Ingrid Gruner 21/Aug/23 suggests that shouldn't be a problem
# as SRI is a transect average not plot-level average

any(is.na(f.sri$palatability.class)) # all species have data for palatability
unique(f.sri$palatability.class) # values are P - preferred, NS - not selected, A - avoided, U - unknown

# how many species are in each palatability class?

# count unique species for each Palatability level
length(unique(f.sri$species[f.sri$palatability.class == 'P'])) # 20
length(unique(f.sri$species[f.sri$palatability.class == 'NS'])) # 28
length(unique(f.sri$species[f.sri$palatability.class == 'A'])) # 49
length(unique(f.sri$species[f.sri$palatability.class == 'U'])) # 2
length(unique(f.sri$species)) # overall 99 species

# only 2 species with unknown class, exclude these
f.sri<-f.sri %>% filter(!f.sri$palatability.class == 'U')

# table number of species in each class by year
f.sri %>%
  group_by(year, palatability.class) %>%
  summarise(Nspecies = n_distinct(species))

# combine catchment and transect to give each measured transect a unique ID
f.sri$transect.ID <- paste(f.sri$catchment, f.sri$transect, sep = '_')
head(f.sri)

# add a measure column for plotting later
# 2010/11 = measured in 2010 or 2011 season
f.sri<- f.sri %>% mutate (measure = case_when(
  year %in% c(2010, 2011) ~ "2010/11",
  year %in% c(2015, 2016) ~ "2015/16",
  year %in% c(2019, 2021) ~ "2019/21",
  TRUE ~ NA_character_  # Handle other cases, if any
))

write.csv(f.sri, "Data_Prep/f.sri_cleaneddata.csv", row.names = FALSE)

#---------------------------------------------------#
# Calculate SRI

# data prep
## calculate transect SRI for each palatability class
colnames(f.sri)

# create df which has sp richness for each ht class, palatability class, transect combo
f.sri.sum <- f.sri %>%
  group_by(management.unit, catchment, measure, year, transect.ID, palatability.class) %>%
  summarise(div.short = sum(short), div.tall = sum(tall))
head(f.sri.sum)

# some more data checks when in this form
transect_count <- f.sri.sum %>%
  group_by(management.unit, measure, year) %>%
  summarise(unique_transect_count = n_distinct(transect.ID))
```

```
# looks good except wapiti 2015 has 1 fewer transects than expected
wapiti_15 <- f.sri.sum %>% filter(management.unit == "Wapiti" & year == "2015") %>%
  group_by(catchment) %>%
  summarise(unique_transect_count = n_distinct(transect.ID))
# simply because C3 wasn't measured in 2015
unique_palatability <- f.sri %>%
  distinct(transect.ID, year, palatability.class) %>%
  pivot_wider(names_from = palatability.class, values_from = palatability.class, values_fn = length)
# all the transects except em1_2019 have all 3 palat classes each year

# add column with calculated transect SRI by palatability class
f.sri.sum <- f.sri.sum %>%
  mutate(SRI.transect = (div.tall - div.short)/(div.tall + div.short))

# confirm all between -1 and 1
range(f.sri.sum$SRI.transect)

# summarise to give mean SRI for each year by palatability class, and associated standard error
f.sri.year <- f.sri.sum %>%
  group_by(management.unit, measure, year, palatability.class) %>%
  summarise(SRI = mean(SRI.transect), SE = se(SRI.transect))


# due to nested variables, confidence intervals in descriptive plots are catchment not management
        unit level

# transect count for each catchment, year, and palat class
transect_count2 <- f.sri.sum %>%
  group_by(management.unit, catchment, measure, year, palatability.class) %>%
  summarise(unique_transect_count = n_distinct(transect.ID))

# confidence intervals for catchment
f.sri.catch.meas <- f.sri %>%
  group_by(management.unit, catchment, measure, year, transect.ID, palatability.class) %>%
  summarise(div.short = sum(short), div.tall = sum(tall)) %>%
  mutate(SRI.transect = (div.tall - div.short)/(div.tall + div.short)) %>%
  ungroup() %>%
  group_by(management.unit, catchment, measure, year, palatability.class) %>%
  summarise(SRI = mean(SRI.transect), SE = se(SRI.transect))

sri_ci_all<-left_join (f.sri.catch.meas,transect_count2)%>%
  mutate(df = unique_transect_count-1,
      t = qt(0.975, df),
      Lower.ci = SRI - t * SE, Upper.ci = SRI + t * SE)

#-------------------------------------------------#
## Combine SRI with Browse, Browse Index, Pellets
# in case of future analysis or visualisation
# browse index calculation from Sweetapple and Nugent 2004
f.browse <- f.sri %>%
  filter(!is.na(browse))
# this removes 7 transect-time points compared to SRI dataframe

f.browse$browse <- as.numeric(f.browse$browse)
```

```
## mean browse per palatability class/transect ##
f.browse.transect <- f.browse %>%
  group_by(measure, year, management.unit, catchment, palatability.class, transect.ID) %>%
  summarise(mean.browse.trans = mean(browse, na.rm = TRUE))

trans_count_browse <- f.browse.transect %>%
  group_by(management.unit, catchment, year, palatability.class) %>%
  summarise(unique_transect_count = n_distinct(transect.ID))

f.sri.catch.meas <- f.sri %>%
  group_by(management.unit, catchment, measure, year, transect.ID, palatability.class) %>%
  summarise(div.short = sum(short), div.tall = sum(tall)) %>%
  mutate(SRI.transect = (div.tall - div.short)/(div.tall + div.short)) %>%
  ungroup() %>%
  group_by(management.unit, catchment, measure, year, palatability.class) %>%
  summarise(SRI = mean(SRI.transect), SE = se(SRI.transect))


# calculate catchment means with standard error
browse_ci <- f.browse.transect %>%
  group_by(management.unit, catchment, measure, year, palatability.class) %>%
  summarise(browse = mean(mean.browse.trans), SE = se(mean.browse.trans))

# add transect mean to transect count to use for confidence interval calculation

f.b.join<- left_join(browse_ci, trans_count_browse) %>%
mutate(df = unique_transect_count-1,
       t = qt(0.975, df),
       b.Lower.ci = browse - t * SE, b.Upper.ci = browse + t * SE) %>%
select(-unique_transect_count, -df, -SE, -t)


## Browse Index ##
# keep only preferred and not selected species
f.browse <- f.browse %>%
  filter(palatability.class %in% c('P', 'NS'))

# summarise data to give mean browse score by transect for each measure

# transect means
f.bi.trans.catch <- f.browse %>%
  group_by(measure, year, management.unit, catchment, transect.ID) %>%
  summarise(mean.browse.trans = mean(browse, na.rm = TRUE))

# divided by 5 (5 is max browse score)
# catchment
f.bi.catch <-  f.bi.trans.catch %>%
  group_by(measure, year, management.unit, catchment) %>%
  mutate(BI = -log(1 - mean.browse.trans / 5))

# add confidence intervals

f.bi.catch<- f.bi.catch%>%
  group_by(measure, year, management.unit, catchment) %>%
  summarise(mean.bi = mean(BI), SE = se(BI))
```

```
# all transects have ns or pref species so can be incl in BI degrees of freedom calculation
transect_count3 <- f.sri.sum %>%
  group_by(management.unit, catchment, measure, year) %>%
  summarise(unique_transect_count = n_distinct(transect.ID))

f.bi.join<- merge(f.bi.catch, transect_count3, by = c("management.unit", "catchment", "measure",
          "year"), all = FALSE) %>%
  mutate(df = unique_transect_count-1,
      t = qt(0.975, df),
      bi.Lower.ci = mean.bi - t * SE, bi.Upper.ci = mean.bi + t * SE) %>%
  select(-unique_transect_count, -df, -SE, -t)

## Pellets ##

f.catch.pellets <- f.sri %>% filter(!is.na(deer.pellets) & deer.pellets != "") %>%
  group_by(management.unit, catchment, measure, transect) %>%
  mutate(proportion_p = sum(deer.pellets == "P") / sum(deer.pellets %in% c("P", "A"))) %>%
  # removing outlier (W15, 4) because it is showing as 100% because only 1 plot measured for that
          transect in 2010 for deer presence
  # no other transects measured for pellets for wapiti river in 2010/11
 filter(!(catchment == "Wapiti River" & measure == "2010/11"))

# with confidence intervals
# summarise to get unique transects with their proportions
unique_transects <- f.catch.pellets %>%
  filter(!duplicated(transect.ID))
head(unique_transects)

f.pellet.se <- unique_transects %>%
  group_by(management.unit, catchment, measure, year) %>%
  summarise(prop_p = mean(proportion_p), SE = se(proportion_p))

# transect count for pellets
transect_count4 <- unique_transects %>%
  group_by(management.unit, catchment, measure, year) %>%
  summarise(unique_transect_count = n_distinct(transect.ID))

pellet_ci<-left_join(f.pellet.se,transect_count4)%>%
  mutate(df = unique_transect_count-1,
      t = qt(0.975, df),
      p.Lower.ci = prop_p - t * SE, p.Upper.ci = prop_p + t * SE) %>%
  select(-unique_transect_count, -df, -SE, -t)

## Combine dataframes to make plotting easier ##
# COMBINE TRANSECT-LEVEL DATA #
# i.e. proportion pellets & browse index

# catchment averages
catch.pell.bi<-merge(pellet_ci,f.bi.join, by = c("management.unit", "catchment", "measure", "year"), all =
          TRUE)

# COMBINE PALAT CLASS-LEVEL DATA #
# i.e. SRI, browse
```

```
catch.sri.browse<-merge(sri_ci_all,f.b.join, by = c("management.unit", "catchment", "measure", "year",
        "palatability.class"), all = TRUE)


#------------------------------------------------#
### ~ PLOTS ~ ###

## pre-model plots for cursory inspection ##

# colourblind friendly palette

cbPalette<- c("#000000","#E69F00","#56B4E9", "#009e73","#F0E442","#0072B2","#D55E00","#CC79A7")
#------------------------------------------------#
# SRI #

# summarise to give mean SRI for each measure by palatability class
f.sri.MU.meas <- f.sri %>%
 group_by(management.unit, catchment, measure, year, transect.ID, palatability.class) %>%
 summarise(div.short = sum(short), div.tall = sum(tall)) %>%
 mutate(SRI.transect = (div.tall - div.short)/(div.tall + div.short)) %>%
 ungroup() %>%
 group_by(management.unit, measure, year, palatability.class) %>%
 summarise(SRI = mean(SRI.transect), SE = se(SRI.transect))

# point/line graph of SRI by management unit
# no error bars as df hard to calculate for nested structure (catchment within management unit)
# each measure represented on x axis
(f.sri.plot <- ggplot(f.sri.MU.meas, aes(measure, SRI, colour = palatability.class, group =
        palatability.class)) +
  geom_point(size=2) +
  geom_line(linewidth = 0.5) +
  theme_bw() +
  labs(x = 'Measure', y = 'Mean Seedling Ratio Index') +
  scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
  scale_x_discrete(breaks = unique(f.sri.MU.meas$measure), labels =
        unique(f.sri.MU.meas$measure)) +
  scale_y_continuous(limits = c(-1, 1)) +
  theme(text = element_text(size = 10),
     axis.text.x = element_text(angle = 45, hjust = 1, margin = margin(b = 10)),  # Increase margin at
        the bottom
     legend.key.size = unit(0.5, "cm"),  # Adjust legend key size
     legend.position = "bottom",
     legend.title = element_text(size = 8), # Change the legend title size
     plot.margin = margin(1, 3, 1, 1)) +
  facet_wrap(. ~ management.unit,  ncol = 4) +
  theme(aspect.ratio = 1) +
  labs(colour = "Palatability Class"))  # Rename the legend title
# save plot
ggsave("Plots/SRI/sri_mu.png", plot = f.sri.plot, width = 8, height = 6, dpi = 300)

# add a layer to show catchment means
f.sri.catch.meas <- f.sri %>%
 group_by(management.unit, catchment, measure, year, transect.ID, palatability.class) %>%
 summarise(div.short = sum(short), div.tall = sum(tall)) %>%
 mutate(SRI.transect = (div.tall - div.short)/(div.tall + div.short)) %>%
```

```
 ungroup() %>%
 group_by(management.unit, catchment, measure, year, palatability.class) %>%
 summarise(SRI = mean(SRI.transect), SE = se(SRI.transect))

# remove murch mts as only one catchment within it
f.sri.catch.cf.w <- f.sri.catch.meas %>% mutate(measure=as.factor(measure)) %>%
 filter(!management.unit == "Murchison Mountains")

# triangles = management unit means, circles = catchment means
(f.sri.plot2 <- ggplot() +
  geom_point(data = f.sri.catch.cf.w, mapping = aes(measure, SRI, colour = palatability.class), alpha =
        0.3, position = position_dodge(width = 0.5), size=2) +
  geom_point(data = f.sri.MU.meas, mapping = aes(measure, SRI, colour = palatability.class),
        position = position_dodge(width = 0.5), size=2, shape=17) +
  theme_bw() +
  labs(x = 'Measure', y = 'Mean Seedling Ratio Index') +
  scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
  scale_x_discrete(breaks = unique(f.sri.catch.cf.w$measure), labels =
        unique(f.sri.catch.cf.w$measure)) +
  scale_y_continuous(limits = c(-1, 1)) +
  theme(text = element_text(size = 10),
     axis.text.x = element_text(angle = 45, hjust = 1, margin = margin(b = 10)),  # Increase margin at
        the bottom
     axis.ticks.x = element_blank(),  # Remove x-axis ticks
     legend.key.size = unit(0.5, "cm"),
     legend.position = "bottom",
     plot.margin = margin(1, 3, 1, 1),
     aspect.ratio = 1) +
  facet_wrap(. ~ management.unit, ncol = 3) +
  labs(colour = "Palatability Class"))  # Specify legend title only once
print(f.sri.plot2)
# save plot
ggsave("Plots/SRI/sri_mu_catch.png", plot = f.sri.plot2, width = 8, height = 6, dpi = 300)


## show catchments more clearly by using facetting ##
# this allows error visualisation
# first tried all plots together but couldn't coerce the order to have a row per management unit
# instead arrange separate plots on one page

# confidence intervals for just wapiti and cf
# central fiordland and wapiti
catch.sri.b.cfw<-catch.sri.browse %>% filter(!management.unit == "Murchison Mountains")


# plot for just wapiti and cf
sri.plot.cfw<-(ggplot() +
     geom_point(data = catch.sri.b.cfw, mapping = aes(measure, SRI, colour = palatability.class),
        position = position_dodge(width = 0.5), size=2) +
     geom_errorbar(data = catch.sri.b.cfw, aes(x = measure, ymin = Lower.ci, ymax = Upper.ci, colour
        = palatability.class), position = position_dodge(width = 0.5), width = 0.2) +
     theme_bw() +
     labs(x = 'Measure', y = 'Mean Seedling Ratio Index', title = NULL) +
     scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
```

```
    scale_x_discrete(breaks = unique(catch.sri.b.cfw$measure), labels =
      unique(catch.sri.b.cfw$measure)) +
    scale_y_continuous(limits = c(-1, 1)) +
    theme(text = element_text(size = 10),
       axis.text.x = element_text(angle = 45, hjust = 1, margin = margin(b = 10)),  # Increase margin
      at the bottom
       legend.key.size = unit(0.5, "cm"),
       legend.position = "bottom",
       aspect.ratio = 1) +
    facet_grid(management.unit ~ catchment, scales = "free_x", drop = TRUE) +
    labs(colour = "Palatability Class"))  # Specify legend title only once

(catch_mu_sri_cfw <- sri.plot.cfw + facet_wrap(management.unit ~ catchment))

# Murchison Mountains
catch.sri.b.mm<-catch.sri.browse %>% filter(management.unit == "Murchison Mountains")

sri.plot.mm <- ggplot() +
 geom_point(data = catch.sri.b.mm, mapping = aes(measure, SRI, colour = palatability.class),
      position = position_dodge(width = 0.5), size = 2) +
 geom_errorbar(data = catch.sri.b.mm, aes(x = measure, ymin = Lower.ci, ymax = Upper.ci, colour =
      palatability.class), position = position_dodge(width = 0.5), width = 0.2) +
 theme_bw() +
 labs(x = NULL, y = NULL, title = NULL) +  # Remove x-axis label
 scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
 scale_y_continuous(limits = c(-1, 1)) +
 theme(
  text = element_text(size = 10),
  axis.text.x = element_blank(),
  axis.ticks.x = element_blank(),
  legend.position = "none",  # Remove legend
  aspect.ratio = 1
 ) +
 facet_wrap(management.unit ~ catchment)

(catch_mu_sri_mm<- sri.plot.mm + theme(plot.margin = unit(c(5.5, 5.5, 0, 5.5), "pt")))

# Combine the plots using patchwork and plot_layout
sri_catch_plot <- (catch_mu_sri_mm + catch_mu_sri_cfw / NULL) +
 plot_layout(nrow = 2, heights = c(3, 7), guides = "collect")

# change legend to be at top of page
(final_sri_plot <- sri_catch_plot + plot_annotation(theme = theme(legend.position = "top")))

ggsave("Plots/SRI/combined_sri_plots.pdf", final_sri_plot, height = 8.1, width = 6)

# small issue is that the top plot is centred not left aligned
# would also prefer MU names don't repeat across plots
# could do cosmetic changes in InkScape (svg format) for final report
save_plot("Plots/SRI/combined_sri.svg", fig = final_sri_plot, width=24, height=18)

# add time since 2009 variable to enable plotting with sjplot later in script
f.sri.time<-f.sri.sum %>% mutate(time = year-2009)
```

```
# scatterplot of sri for each MU/palat class

(sri.pal.mu<-ggplot(f.sri.time, aes(x = palatability.class, y = SRI.transect, color = palatability.class)) +
  geom_point(alpha=0.3) +
  theme_bw()+
  labs(x = "", y = "Mean Transect SRI") +
  ggtitle("Scatterplot of SRI")+
  facet_wrap(~management.unit, ncol = 4)+
  coord_fixed(ratio = 1)+
  theme(legend.position = "bottom", plot.margin = margin(1, 3, 1, 1),
      text = element_text(size = 10),
      legend.key.size = unit(0.5, "cm"),
      aspect.ratio = 1)+
  scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
  labs(colour = "Palatability Class"))  # Rename the color legend title
ggsave("Plots/SRI/sri.pal.mu.png", sri.pal.mu, width = 8, height = 6, dpi = 300)


#-------------------------------------------------#
# Browse #
# with confidence intervals

# Central Fiordland and Wapiti
b.plot.cfw<-(ggplot() +
        geom_point(data = catch.sri.b.cfw, mapping = aes(measure, browse, colour = palatability.class),
          position = position_dodge(width = 0.5), size=2) +
        geom_errorbar(data = catch.sri.b.cfw, aes(x = measure, ymin = b.Lower.ci, ymax = b.Upper.ci,
          colour = palatability.class), position = position_dodge(width = 0.5), width = 0.2) +
        theme_bw() +
        labs(x = 'Measure', y = 'Mean Browse Score') +
        scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
        scale_x_discrete(breaks = unique(catch.sri.browse$measure), labels =
          unique(catch.sri.browse$measure)) +
        scale_y_continuous(limits = c(0, 4)) +
        theme(text = element_text(size = 10),
            axis.text.x = element_text(angle = 45, hjust = 1, margin = margin(b = 10)),  # Increase margin
          at the bottom
            axis.ticks.x = element_blank(),  # Remove x-axis ticks
            legend.key.size = unit(0.5, "cm"),
            legend.position = "bottom",
            plot.margin = margin(1, 3, 1, 1),
            aspect.ratio = 1) +
        facet_grid(management.unit ~ catchment, scales = "free_x", drop = TRUE) +  # Facet by two
          grouping variables
        labs(colour = "Palatability Class"))  # Specify legend title only once

(catch_mu_browse_cfw <- b.plot.cfw + facet_wrap(management.unit ~ catchment))


# Murchison Mts

b.plot.mm <- ggplot() +
  geom_point(data = catch.sri.b.mm, mapping = aes(measure, browse, colour = palatability.class),
          position = position_dodge(width = 0.5), size=2) +
```

```
  geom_errorbar(data = catch.sri.b.mm, aes(x = measure, ymin = b.Lower.ci, ymax = b.Upper.ci, colour
         = palatability.class), position = position_dodge(width = 0.5), width = 0.2) +
  theme_bw() +
  labs(x = NULL, y = NULL, title = NULL) +  # Remove x-axis label
  scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
  scale_x_discrete(breaks = unique(catch.sri.browse$measure), labels =
         unique(catch.sri.browse$measure)) +
  scale_y_continuous(limits = c(0, 4)) +
  theme(
   text = element_text(size = 10),
   axis.text.x = element_blank(),
   axis.ticks.x = element_blank(),
   legend.position = "none",  # Remove legend
   aspect.ratio = 1
  ) +
  facet_wrap(management.unit ~ catchment)

(catch_mu_browse_mm<- b.plot.mm + theme(plot.margin = unit(c(5.5, 5.5, 0, 5.5), "pt")))

# Combine the plots using patchwork and plot_layout
final_browse_plot <- (catch_mu_browse_mm +  catch_mu_browse_cfw/ NULL) +
  patchwork::plot_layout(nrow = 2, heights = c(3, 7), guides = "collect")

# change legend to be at top of page
(final_browse_plot <- final_browse_plot + patchwork::plot_annotation(theme =
         theme(legend.position = "top")))

ggsave("Plots/Browse/combined_browse_plots.pdf", final_browse_plot, height = 8.2, width = 6)

save_plot("Plots/Browse/combined_browse_plots.svg", fig = final_browse_plot, width=24, height=18)

## Scatterplot of browse and SRI ##

# combine f.sri.sum (transect SRI) with f.browse.transect
trans.sri.browse<-merge(f.sri.sum,f.browse.transect, by = c("management.unit", "catchment",
         "measure", "year", "palatability.class", "transect.ID"), all = TRUE)
# use different colours for management unit legend

(b.sri.plot<-ggplot(trans.sri.browse, aes(x = mean.browse.trans, y = SRI.transect, color =
         management.unit)) +
   geom_point(alpha=0.3) +
   theme_bw()+
   labs(x = "Mean Transect Browse", y = "Mean Transect SRI") +
   ggtitle("Scatterplot of SRI vs. Browse")+
   facet_wrap(~palatability.class, ncol = 4)+
   coord_fixed(ratio = 1)+
   theme(legend.position = "bottom", plot.margin = margin(1, 3, 1, 1),
   text = element_text(size = 10),
   axis.text.x = element_text(hjust = 1),
   legend.key.size = unit(0.5, "cm"),
   aspect.ratio = 1)+
   scale_color_viridis_d(labels = c('Central Fiordland', 'Murchison Mountains', 'Wapiti')) +
   labs(colour = "Management Unit"))  # Rename the color legend title
# 7 rows in SRI not with browse
# ignore warning, keep only transects with both variables
```

```
# save plot
ggsave("Plots/browse_sri.png", plot = b.sri.plot, width = 8, height = 6, dpi = 300)

# another way to visualise sri/browse relationship

cor_browse_sri<-ggpairs(trans.sri.browse, columns = c("SRI.transect", "mean.browse.trans"),
columnLabels = c("sri", "browse"), title="correlogram with ggpairs()", aes(color = palatability.class,
        alpha = 0.5),
upper = list(combo = "facetdensity")) +
 scale_color_manual(values = cbPalette) +
 scale_fill_manual(values = cbPalette)
# warning msg because some rows have NA browse (no sp >15cm)
# fine as is, comparing only rows that have both SRI and browse
na_count <- sum(is.na(trans.sri.browse$mean.browse.trans))

ggsave("Plots/browse_sri_cor.png", plot = cor_browse_sri, width = 8, height = 6, dpi = 300)



#-------------------------------------------------#
# Browse Index #
# black and white, faceting by both management unit and catchment

# some confidence interval limits are less than 0 or more than 1 which doesn't make sense, adjust
# as per https://www.stat.berkeley.edu/~stark/SticiGui/Text/confidenceIntervals.htm

catch.pell.bi <- catch.pell.bi %>%
 mutate(bi.Lower.ci = ifelse(bi.Lower.ci < 0, 0, bi.Lower.ci),
     p.Lower.ci = ifelse(p.Lower.ci < 0, 0, p.Lower.ci),
     bi.Upper.ci = ifelse(bi.Upper.ci > 1, 1, bi.Upper.ci),
     p.Upper.ci= ifelse(p.Upper.ci >1, 1, p.Upper.ci))

## Filter dataframe
# Central Fiordland and Wapiti
catch.pell.bi.cfw<-catch.pell.bi %>% filter(!management.unit == "Murchison Mountains")
# Murchison Mts
catch.pell.bi.mm<-catch.pell.bi %>% filter(management.unit == "Murchison Mountains")

## Plot
# Central Fiordland and Wapiti
bi.plot.cfw<-(ggplot() +
       geom_point(data = catch.pell.bi.cfw, mapping = aes(measure, mean.bi), position =
        position_dodge(width = 0.5)) +
       geom_errorbar(data = catch.pell.bi.cfw, aes(x = measure, ymin = bi.Lower.ci, ymax =
        bi.Upper.ci), position = position_dodge(width = 0.5), width = 0.2) +
       theme_bw() +
       labs(x = 'Measure', y = 'Mean Browse Index') +
       scale_x_discrete(breaks = unique(catch.pell.bi$measure), labels =
        unique(catch.pell.bi$measure)) +
       scale_y_continuous(limits = c(0, 1)) +
       theme(text = element_text(size = 10),
          axis.text.x = element_text(angle = 45, hjust = 1, margin = margin(b = 10)),  # Increase margin
        at the bottom
          axis.ticks.x = element_blank(),  # Remove x-axis ticks
```

```
            legend.key.size = unit(0.5, "cm"),
            legend.position = "bottom",
            plot.margin = margin(1, 3, 1, 1),
            aspect.ratio = 1) +
          facet_grid(management.unit ~ catchment, scales = "free_x", drop = TRUE))

(catch_mu_bi_cfw <- bi.plot.cfw + facet_wrap(management.unit ~ catchment))

# Murchison Mts
bi.plot.mm<-(ggplot() +
           geom_point(data = catch.pell.bi.mm, mapping = aes(measure, mean.bi), position =
           position_dodge(width = 0.5)) +
           geom_errorbar(data = catch.pell.bi.mm, aes(x = measure, ymin = bi.Lower.ci, ymax =
           bi.Upper.ci), position = position_dodge(width = 0.5), width = 0.2) +
           theme_bw() +
           labs(x = NULL, y = NULL, title = NULL) +  # Remove x-axis label
           scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
           scale_y_continuous(limits = c(0, 1)) +
           theme(
             text = element_text(size = 10),
             axis.text.x = element_blank(),
             axis.ticks.x = element_blank(),
             legend.position = "none",  # Remove legend
             aspect.ratio = 1)+
           facet_wrap(management.unit ~ catchment))
(catch_mu_bi_mm<- bi.plot.mm + theme(plot.margin = unit(c(5.5, 5.5, 0, 5.5), "pt")))

# Combine the plots using patchwork and plot_layout
final_bi_plot <- (catch_mu_bi_mm+ catch_mu_bi_cfw / NULL) +
  patchwork::plot_layout(nrow = 2, heights = c(3, 7), guides = "collect")

ggsave("Plots/Browse/combined_bi_plots.pdf", final_bi_plot, height = 7.4, width = 6)

save_plot("Plots/Browse/combined_bi_plots.svg", fig = final_bi_plot, width=24, height=18)

#--------------------------------------------------#
# Pellets #
# Central Fiordland and Wapiti
pell.plot.cfw<-ggplot() +
  geom_point(data = catch.pell.bi.cfw, mapping = aes(measure, prop_p), position =
           position_dodge(width = 0.5), size=2) +
  geom_errorbar(data = catch.pell.bi.cfw, aes(x = measure, ymin = p.Lower.ci, ymax = p.Upper.ci),
           position = position_dodge(width = 0.5), width = 0.2) +
  theme_bw() +
  labs(x = 'Measure', y = 'Mean Proportion of Pellets', title = NULL) +
  scale_color_manual(values = cbPalette)+
  scale_y_continuous(limits = c(0, 1)) +
  scale_x_discrete(breaks = unique(catch.pell.bi$measure), labels = unique(catch.pell.bi$measure)) +
  theme(text = element_text(size = 10),
      axis.text.x = element_text(angle = 45, hjust = 1, margin = margin(b = 10)),  # Increase margin at
           the bottom
      axis.ticks.x = element_blank(),  # Remove x-axis ticks
      legend.key.size = unit(0.5, "cm"),
      legend.position = "bottom",
      plot.margin = margin(1, 3, 1, 1),
```

```
      aspect.ratio = 1) +
  facet_grid(management.unit ~ catchment, scales = "free_x", drop = TRUE)

(catch_mu_p_cfw <- pell.plot.cfw + facet_wrap(management.unit ~ catchment))
# wapiti not measured for pellets in first survey

# Murchison Mts
pell.plot.mm<-(ggplot() +
        geom_point(data = catch.pell.bi.mm, mapping = aes(measure, prop_p), position =
        position_dodge(width = 0.5)) +
        geom_errorbar(data = catch.pell.bi.mm, aes(x = measure, ymin = p.Lower.ci, ymax =
        p.Upper.ci), position = position_dodge(width = 0.5), width = 0.2) +
        theme_bw() +
        labs(x = NULL, y = NULL, title = NULL) +  # Remove x-axis label
        scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
        scale_y_continuous(limits = c(0, 1)) +
        theme(
          text = element_text(size = 10),
          axis.text.x = element_blank(),
          axis.ticks.x = element_blank(),
          legend.position = "none",  # Remove legend
          aspect.ratio = 1)+
        facet_wrap(management.unit ~ catchment))
(catch_mu_p_mm<- pell.plot.mm + theme(plot.margin = unit(c(5.5, 5.5, 0, 5.5), "pt")))


# Combine the plots using patchwork and plot_layout
final_p_plot <- (catch_mu_p_mm + catch_mu_p_cfw / NULL) +
  plot_layout(nrow = 2, heights = c(3, 7), guides = "collect")

ggsave("Plots/Pellets/combined_pell_plots.pdf", final_p_plot, height = 7.4, width = 6)
save_plot("Plots/Pellets/combined_pell_plots.svg", fig = final_p_plot, width=24, height=18)
# ignore warnings: wapiti not measured for pellets in first survey


#--------------------------------------------------#
### ~ LINEAR MIXED EFFECTS MODEL: SRI ~ ###

# SRI #
f.sri.time$time <- as.numeric(f.sri.time$time)

# save dataframe used for model
write.csv(f.sri.time,"Data_Prep/FlandSRIdata.csv", row.names = FALSE)

# check distribution of data
hist<-hist(x=f.sri.time$SRI.transect, 25)

# pretty normal, a bit left skewed, and bounded by -1 and +1
# cluster around -1 seems legit, i.e. transects where no tall palat species, therefore SRI = -1

# open in window and save in Plots folder as "sri_hist", width = 500

# 3 way interaction #
# how does MU (and time, palat class) predict SRI
# trend through time
```

```
set.seed(123) # makes model reproducible
m.sri<-lmer(SRI.transect ~ time * management.unit * palatability.class +
          (1|catchment/transect.ID/palatability.class), data = f.sri.time)

three_intx_table<-sjPlot::tab_model(m.sri,transform=NULL,show.ci = FALSE, show.se = TRUE,
          show.est = TRUE, show.stat = TRUE, title = "Management Unit Seedling Ratio Index",
          dv.labels = "", string.est = " Estimate ", string.stat= " z ", CSS = css_theme("cells"))
three_intx_table
# open in browser, save as pdf to model_outputs as "m.sri_all" 70% full size to fit on one page
# check model assumptions with DHARMa
library(DHARMa)
m.sri.resids<-plot(simulateResiduals(m.sri))
# save plot from plot window, width 700, in Model_Output folder, as "m.sri.residuals"
# on advice, decided to continue as qqplot looks fine and want to retain SRI unscaled

# could model be simplified?
# lmerTest::step(
#  m.sri,
#  ddf = c("Satterthwaite"),
#  alpha.random = 0.1,
#  alpha.fixed = 0.05,
#  reduce.fixed = TRUE,
#  reduce.random = FALSE
#)

#it suggests 2 way interactions only
m.sri2<-lmer(SRI.transect ~ time + management.unit + palatability.class + (1 | catchment/transect.ID)
          + time:palatability.class + management.unit:palatability.class, data = f.sri.time)
m.sri.resids<-plot(simulateResiduals(m.sri2))
AIC(m.sri, m.sri2)
two_intx_mod<-sjPlot::tab_model(m.sri2,transform=NULL,show.ci = FALSE, show.se = TRUE,
          show.est = TRUE, show.stat = TRUE, title = "Management Unit Seedling Ratio Index",
          dv.labels = "", string.est = " Estimate ", string.stat= " z ", CSS = css_theme("cells"))
two_intx_mod
#2 way has lower AIC but doesn't improve residuals
#keep 3 way as trends of interest to managers

## compare levels of palat class within management unit ##
# when time is average (6.6)

emm.within.mu = emmeans(m.sri, specs = pairwise ~ palatability.class|management.unit|time, type =
          "response")
emm.within.mu
contrast_within <- contrast(emm.within.mu, method = "pairwise")
# palat class all sig diff from each other within cf and wapiti, but not sig differences for MM

# save as dataframe
w.in <- as.data.frame.list(summary(contrast_within))

# save as table
within_mu_emm <- kable(w.in, format = "html", caption = "Within Management Unit Contrasts",
          digits = 4) %>%
  kable_styling("striped", full_width = FALSE)
within_mu_emm
```

```
# from 'viewer' tab, open html and save as pdf, in Model_Output folder, named "w.in.mu.palat"

# plot
w.in.emm<-as.data.frame.list(summary(emm.within.mu))
#remove emm prefix
names(w.in.emm) <- sub("^emmeans\\.", "", names(w.in.emm))

(pal.mu<-ggplot(data = w.in.emm, aes(x = management.unit, y = emmean, color = palatability.class)) +
  geom_point(position = position_dodge(width = 0.8), size = 2) +
  geom_errorbar(aes(ymin = lower.CL, ymax = upper.CL), position = position_dodge(width = 0.8),
        width = 0.2) +
  scale_y_continuous(limits = c(-1, 1)) +
  labs(x = "Management Unit", y = "Estimated Marginal Mean SRI") +
  theme_bw() +
  scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
  theme(legend.position = "bottom",
     text = element_text(size = 10),
     axis.text.x = element_text(hjust = 0.5, size=10),
     legend.key.size = unit(0.5, "cm"),
     plot.margin = margin(1, 3, 1, 1),
     aspect.ratio = 1)+
  labs(colour = "Palatability Class"))

ggsave("Plots/Posthoc/mu.pal.emmeans.png", plot = pal.mu, width=8, height=6)
# could later add significance asterisks

## compare levels of palat class between management unit ##
# when time is average (6.6)
emm.btw.mu = emmeans(m.sri, specs = pairwise ~ management.unit|palatability.class|time, type =
        "response")
emm.btw.mu
contrast_btwn <- contrast(emm.btw.mu, method = "pairwise")
# the only sig difference here is MM has higher SRI for pref species than Central Fiordland

# save as dataframe
btwn <- as.data.frame.list(summary(contrast_btwn))

# save as table
btw_mu_emm <- kable(btwn, format = "html", caption = "Between Management Unit Contrasts",
        digits = 4) %>%
 kable_styling("striped", full_width = FALSE)
btw_mu_emm
# open html then save as pdf in Model_Output folder as "btw.mu.palat"


## compare trendlines for each palat/mu combo ##

# Use emtrends for pairwise comparisons
# compare slopes *within* management unit
em_three.trend <- emtrends(m.sri, pairwise ~ palatability.class | management.unit, var = "time")
em_trend_df <- as.data.frame.list(summary(em_three.trend))

# contrasts table is neater format
contrast_results <- contrast(em_three.trend, method = "pairwise")
em_trend.contrast<-as.data.frame(summary(contrast_results))
```

```
# save as table
trend.mu.w.in <- kable(em_trend.contrast, format = "html", caption = "Management Unit/Palatability
        over Time", digits = 4) %>%
  kable_styling("striped", full_width = FALSE)
trend.mu.w.in
# open html then save as pdf in Model_Output folder as "trend.mu.w.in"
# seems that no trends are sig diff except A + NS v P for wapiti

# compare slopes *between* management unit
em_trend.b <- emtrends(m.sri, pairwise ~ management.unit | palatability.class, var = "time")
em_trend_b.df <- as.data.frame.list(summary(em_trend.b))

# contrasts
contrast_results2 <- contrast(em_trend.b, method = "pairwise")
em_trend.contrast2<-as.data.frame(summary(contrast_results2))

# save as table
trend.mu.btwn <- kable(em_trend.contrast2, format = "html", caption = "Management
        Unit/Palatability over Time", digits = 4) %>%
  kable_styling("striped", full_width = FALSE)
trend.mu.btwn
# open html then save as pdf in Model_Output folder as "trend.mu.btw"
# wapiti v cf palatable species sig different slope

## plot management unit x palat trends ##
# sjplot = marginal means (predicted values from model)

# ignore warnings
(pred.plot<-sjPlot::plot_model(
  model = m.sri,
  type = "pred",
  terms = c("time", "palatability.class", "management.unit")) +
    ggplot2 ::scale_color_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred')) +
    scale_fill_manual(values = cbPalette, labels = c('Avoided', 'Not Selected', 'Preferred'))+
    scale_y_continuous(limits = c(-1, 1))+
    labs(x="Years Since 2009",y="Predicted SRI") +
    labs(colour = "Palatability Class", title = NULL)+
    theme_bw()+
    theme(legend.position = "bottom",
        text = element_text(size = 10),
        axis.text.x = element_text(hjust = 1),
        legend.key.size = unit(0.5, "cm"),
        plot.margin = margin(1, 3, 1, 1),
        aspect.ratio = 1))

ggsave("Plots/Posthoc/sri.pred.mu.png", plot = pred.plot, width=8, height=6)

## Random effects ##

# Extract random intercepts
random_intercepts <- ranef(m.sri)
random_intercepts_df<-as.data.frame(random_intercepts)
# Display random intercepts
print(random_intercepts)
```

```
# plot random effects
library(lattice) ; dotplot(ranef(m.sri,condVar=TRUE))

# Define a custom order for catchment (so in order of management unit)
custom_order <- c("Ettrick Burn", "Cozette Burn", "Delta Burn", "Namu", "Catseye", "Glaisnock",
        "Wapiti River")
custom_order<-as.factor(custom_order)
rev_custom_order <- rev(custom_order)

# Reorder the levels of grp based on custom_order

random_df_catchment<- random_intercepts_df %>% filter(grpvar == "catchment")

# 95% data falls between -2 SD and + 2 SD
random_df_catchment<-random_df_catchment%>%
  mutate(grp=factor(grp, levels = rev_custom_order),
     upper=condval+2*condsd,
     lower=condval-2*condsd) %>%
  rename(Intercept=condval) %>%
  arrange(grp)

# colour by management unit
mu.loc<-f.sri.time %>% group_by(management.unit,catchment) %>%
  select("management.unit","catchment") %>%
  distinct()

reff.mu<-merge(random_df_catchment,mu.loc, by.x= "grp", by.y="catchment")

# Create the dotplot

# open a png device for saving the plot
png("Plots/Posthoc/dotplot_r.eff.png", width = 1600, height = 1600, units = "px", res = 300)

dotplot(grp ~ Intercept, data = reff.mu, xlim = c(-0.3, 0.3),
    panel = function(x, y, groups, ...) {
     panel.abline(h = unique(y), col = "#E6E6E6")
     panel.arrows(x0 = reff.mu$lower, x1 = reff.mu$upper, y0 = as.numeric(y), y1 = as.numeric(y),
           length = 0.02, angle = 90, code = 3, lend = 2, grid = TRUE, ...)
     panel.xyplot(x, y, pch = 16, groups = groups, ...)
    },
    groups = reff.mu$management.unit)

dev.off()

#-----------------------------------------------#
#-----------------------------------------------#

ENDS
```

Department of Conservation
Te Papa Atawhai

Concession Number: -WARS

Concession – Wild Animal Recovery Operation Permit

South Island Schedule: ***Deer, pig, chamois and goat carcass recovery, and live capture of deer only***

THIS CONCESSION is made this day of 2023.

PARTIES:

1. **Minister of Conservation** ("the Grantor")
2. ______________________________________ ("the Concessionaire")

BACKGROUND

A. The Grantor administers and manages the public conservation land described in **Schedule 1** (the "Land").

B. Section 22 of the Wild Animal Control Act 1977 authorises the Grantor to grant, in accordance with Part 3B of the Conservation Act 1987, concessions authorising the holder of the concession to engage in wild animal recovery operations and, in so doing, to enter any land that is:

(a) a conservation area;

(b) a national park;

(c) a reserve (but not a reserve vested in an administering body);

(d) a wildlife sanctuary, wildlife refuge or wildlife management reserve under the Wildlife Act 1953;

(e) land to which the National Parks Act 1980 is applied as if the land were a national park.

C. The Concessionaire wishes to carry out the Concession Activity on the Land subject to the terms and conditions of this Concession.

D. The Concessionaire acknowledges that the Land may be the subject of Treaty of Waitangi claims and settlements.

E. The Grantor is satisfied that the requirements of Part 3B of the Conservation Act 1987 and section 23 of the Wild Animal Control Act 1977 have been complied with.

F. The parties wish to record the terms and conditions of the Concession.

OPERATIVE PARTS

G. In exercise of the Grantor's powers under section 22 of the Wild Animal Control Act 1977 and in accordance with Part 3B of the Conservation Act 1987 the Grantor **GRANTS** to the Concessionaire a **WILD ANIMAL RECOVERY OPERATION PERMIT** to carry out the Concession Activity on the Land subject to the terms and conditions contained in this Concession and its Schedules:

Schedule 1: Description of Concession Activity and Related Terms and Conditions

Schedule 2: Standard Conditions

Schedule 3: Special Conditions Applying to Concession Activity

Schedule 4: Roar and Christmas Closure Periods applying to Permitted Zones (coloured green) and Restricted Zones (coloured orange)

Schedule 5: Restricted Zones (coloured orange) where Additional Special Conditions apply

SIGNED on behalf of the Minister of Conservation by ________________________ Sarah Owen **Director, Office of Regulatory Services** acting under delegated authority in the presence of: ________________________ Witness Signature ________________________ Witness Name ________________________ Witness Occupation ________________________ Witness Address A copy of the Instrument of Delegation may be inspected at the Director-General's office at 18-32 Manners Street, Wellington.	*(Select **one** only of the following execution clauses and delete the other four)* **SIGNED** by *[insert name of Concessionaire if an individual]* ________________________ in the presence of: ________________________ Witness Signature ________________________ Witness Name ________________________ Witness Occupation ________________________ Witness Address Or **SIGNED** by *[insert name of Company]* Limited by: ____________________ Director *[insert name]* ____________________ Director *[insert name]* Or *NOTE: the following execution clause may only be used if you have checked the Company records at the Companies Office and have confirmed that the Company has only one Director* **SIGNED** by *[insert name of Company]* Limited by its Director *[insert name]*:

	in the presence of: Witness Signature Witness Name Witness Occupation Witness Address Or **SIGNED** on behalf of *[insert name of partnership]* by *[insert name of authorised signatory]* in the presence of: Witness Signature Witness Name Witness Occupation Witness Address

SCHEDULE 1

DESCRIPTION OF CONCESSION ACTIVITY AND RELATED TERMS AND CONDITIONS

Item	Title[1]	Description
1.	**Land** *(clause 1)*	(1) The Land over which the Concession Activity in Item 2(a)-(f) inclusive of this Schedule is authorised is that public conservation land identified on maps provided by the Grantor to the Concessionaire to download through a OneDrive link (emailed to the Concessionaire) being the areas shown zoned as:[2] • "Permitted" (coloured green); and • "Restricted" (coloured orange). (2) In addition to the Land identified in (1) above, the Concession Activity in Item 2(g) of this Schedule ONLY is authorised at any site on the public conservation land where the site is legally accessible by motor vehicle, such as a car park or formed road. For the avoidance of doubt, this includes areas on the Land shown zoned as "Not Permitted" (coloured red). (3) Other than as provided for in (2) above, the Concession Activity is NOT AUTHORISED on the public conservation land areas shown zoned as "Not Permitted" (coloured red). *Note: The Minister's delegate made separate decisions on classification of Land over which the Concession Activity is authorised or is not authorised on 1 June 2023.*
2.	**Concession Activity** *(clause 1)*	The use of aircraft (whether or not for hire or reward) to carry out one or more of the following activities: (a) the searching for, shooting, or immobilising of deer; (b) the searching for, shooting of pig, goat and chamois; (c) the capture and conveyance of live deer only; (d) the recovery of any dead deer, pig, goat, chamois or any part of such deer (including velvet), pig, goat, chamois for supply to a Ministry for Primary Industries registered primary processor; (e) the recovery of any dead deer, pig, goat, chamois or any part of such wild animals for the personal consumption of the Concessionaire or its employees or contractors, only where undertaking the activity in (d); (f) the carriage of persons, supplies, equipment, firearms, ammunition, or other things that may be used for the purposes of any of paragraphs (a), (b), (c), (d) or (e); (g) the use of aircraft to facilitate the offloading of any recovered deer, pig, goat, or chamois carcasses to a refrigerated truck or similar vehicle for transport; **BUT EXCLUDES THE FOLLOWING ACTIVITIES:**

[1] All references are to clauses in Schedule 2 unless specified.

[2] These areas are indicated on maps publicly available on the DOC website at: National wild animal recovery operations: Apply for permits (doc.govt.nz). Should there be any differences in mapped areas, the information provided through the OneDrive link prevails.

		(1) the live capture or carriage of any wild animal species other than deer, including pig, goat, or chamois; (2) the carriage of any other dead wild animal species; (3) the carriage of any passenger(s) apart from: i. an employee or contractor of the Concessionaire who is engaged in the Concession Activity, or ii. an employee or agent of the Grantor or the Ministry of Primary Industries or the Civil Aviation Authority where the employee or agent is monitoring or reviewing the Concession Activity. This passenger exclusion includes recreational hunters (whether ground-based or not) and any persons who are providing a guided hunting service; (4) the recovery of any wild animal or part thereof for the purpose of personal consumption other than in the circumstances provided for by (e) above; (5) the recovery of any wild animal for trophy-mounting purposes.
3.	**Aircraft type** *(Schedule 3, special condition 8)*	Prior to undertaking the Concession Activity, the Concessionaire must provide the following details in writing for all aircraft which it intends to use for the Concession Activity: *Aircraft make and model:* *Registration number:* *Colour:*
4.	**Term** *(clause 2)*	x years commencing on xxx 2023 (the commencement date)
5.	**Renewal(s)** *(clause 2)*	Nil / one right of renewal for a period of xxx years
6.	**Final Expiry Date** *(clause 2)*	Xxxx 20xx, being the day before the xxth anniversary of the commencement date /including a right of renewal. *Note: total term including renewals cannot exceed ten (10) years*
7.	**Processing Fee** *(clause 3)*	$x,xxx.00 plus GST
8.	**Concession Fee** *(clause 3)*	$0.00 per annum plus GST *In reliance upon section 17X(f)(i) of the Conservation Act 1987 due to the public/ conservation benefit of the Concession Activity a Concession Fee is not required*
9.	**Management Fee and Monitoring Costs** *(clause 3 and Schedule 3, special condition 35)*	**Management Fee** $x,xxx.00 per annum plus GST. **Monitoring Costs** Standard Departmental charge-out rates for staff time and mileage required to monitor the effects of the concession activity and compliance with concession conditions.
10.	**Fee Payment Date** *(clause 3)*	Payable on or before the date specified in any invoice issued by the Grantor.
11.	**Fee Review Date (s)** *(clause 3)*	The third anniversary of the commencement date, and every subsequent third anniversary until the final expiry date.

12.	**Penalty Interest Rate** *(clause 3)*	Double the current Official Cash Rate (OCR). See Reserve Bank of New Zealand website
13.	**Insurance** *(To be obtained by Concessionaire)* *(clause 6)*	Types and amounts: (a) General Public Liability for an amount no less than NZ$2,000,000. (b) Third Party Motor Vehicle Liability for an amount no less than NZ$1,000,000. (c) Aviation Legal Liability for an amount no less than NZ$2,000,000 Subject to review on each concession fee review date. *Certificates of Insurance Received: Yes/No [delete as appropriate]*
14.	**Addresses for Notices** *(clause 12)*	The Grantor's address is: National Transactions Centre Level 1 John Wickliffe House 265 Princes Street Dunedin 9016 **Postal address** National Transactions Centre P O Box 5244 Dunedin 9054 Phone: (03) 477 0677 Email: TransactionCentre@doc.govt.nz
		The Concessionaire's address in New Zealand is: ____________________________ ____________________________ ____________________________ ____________________________ Phone: Email: *Note: Use street address and postal address*
14.	**Special Conditions** *(clause 15)*	See **Schedules 3, 4 and 5.**

Note: The clause references are to the Standard Conditions set out in Schedule 2 unless otherwise stated.

SCHEDULE 2

STANDARD CONDITIONS

1. Interpretation and Concession Activity

1.1. Terms used in this Concession have the following meanings:

Commencement date means the date stated in Item 4 of Schedule 1.

Concession means this document including all Schedules.

Concession Activity means the activities described in Item 2 of Schedule 1 subject to the exclusions set out in that item.

Concessionaire includes the directors and shareholders if the Concessionaire is a company, the partners if the Concessionaire is a partnership, the trustees if the Concessionaire is a trust, and any employees, contractors, or agents of the Concessionaire.

Grantor means the Minister of Conservation and includes the Director-General of Conservation.

Fee includes the Processing Fee as stated in Item 7 of Schedule 1, Concession Fee as stated in Item 8 of Schedule 1, and Management Fee and Monitoring Costs as stated in Item 9 of Schedule 1

Final Expiry Date means the date stated in Item 6 of Schedule 1.

Land means the areas of public conservation land (including conservation areas, reserves and national parks) described in Item 1 of Schedule 1.

Working day means Monday to Friday inclusive excluding any Public Holidays, including the regional anniversary day for the region where the Concessionaire has its address as stated in Item 14 of Schedule 1.

1.2. The Concessionaire must not use the Land for any purpose other than the Concession Activity. The Concessionaire must not start the Concession Activity until the Concessionaire has signed the Concession and returned a signed copy of the Concession to the Grantor, as if it were a notice given under this Concession.

1.3. The Concessionaire is responsible for the acts and omissions of its employees, contractors, or agents. The Concessionaire is liable under this Concession for any breach of the Concession by its employees, contractors, or agents as if the breach had been committed by the Concessionaire.

2. Term and Renewals (if any)

2.1. The Concession term commences on the Commencement date and ends on the Final Expiry Date.

2.2. If there is a right of renewal, then the Grantor at the Concessionaire's cost must renew the Term for a further period as set out in Item 4 of Schedule 1 provided the Concessionaire:

(a) gives the Grantor at least three month's written notice before the end of the Term, which notice is to be irrevocable, of the Concessionaire's intention to renew this Concession; and

(b) at the time notice is given in accordance with this clause the Concessionaire is not in breach of this Concession.

2.3. The renewal is to be on the same terms and conditions expressed or implied in this Concession except that the Term of this Concession plus all further renewal terms is to expire on or before the Final Expiry Date.

3. Processing Fee, Concession Fee, Management Fee, Monitoring Costs and Review

3.1. The Concessionaire must pay the Processing Fee (Item 7 of Schedule 1) to the Grantor in the manner directed by the Grantor. Except where the Grantor's written consent has been given the Concessionaire cannot commence the Concession Activity until the Processing Fee has been paid.

3.2. The Concessionaire must pay to the Grantor in the manner directed by the Grantor the Concession Fee and the Management Fee (including any Monitoring Costs) plus GST on the Fee Payment Date(s) as specified in Item 10 of Schedule 1.

3.3. If payment is not made within 14 days of the Fee Payment Date, then the Concessionaire must pay interest on the unpaid Fees from the Fee Payment Date until the date of payment at the Penalty Interest Rate specified in Item 12 of Schedule 1.

3.4. The Grantor must review the Concession and Management Fee on the Fee Review Date specified in Item 11 of Schedule 1. If both parties cannot agree on the new fee within 30 working days of the Grantor's giving the Concessionaire written notice of the review, the provisions of clause 10 of this Schedule (Dispute Resolution) will apply.

4. Protection of Environment

4.1. Except for the purposes that are approved by this Concession, or except as otherwise approved in writing by the Grantor, the Concessionaire **must not**, whether by act or omission:

(a) interfere with, remove, damage, or endanger any natural feature, animal, plant, or historic resource on the Land; or

(b) bring any plant, animal, or firearm on to the Land; or

(c) deposit on the Land:

(i) debris, rubbish or other dangerous or unsightly matter, or contaminate any water body on the Land, and

(ii) 'gut bags' or similar animal bodily waste within 50 metres of any water body, water source, track, road, hut, or any other place likely to be used by members of the public; or

(d) pile or store materials in any place on the Land where it may obstruct the public or create a nuisance; or

(e) conduct any noxious, noisome, dangerous or offensive activity on the Land; or

(f) bury any toilet waste within 50 metres of any water source.

4.2. The Concessionaire must:

(a) take all reasonable precautions to ensure no fire hazard arises from its carrying out of the Concession Activity;

(b) not light or permit to be lit any fire on the Land;

(c) not store, or permit to be stored, fuel or other combustible materials on the Land without the prior written permission of the Grantor. Any storage of fuel and combustible materials must comply with the Hazardous Substances and New Organisms Act 1996;

4.3. Having regard to the Concession Activity, the Concessionaire must ensure it adheres to the international "Leave No Trace" Principles (www.leavenotrace.org.nz).

4.4. The Concessionaire must comply with all guidelines and notices issued by Ministry for Primary Industries on measures to avoid spreading the pest organism *Didymosphenia geminate* ("Didymo"),[3] and/ or any other pest organism identified during the term of this Concession.

4.5. The Grantor may require the Concessionaire to adopt new technology if:

(a) it would be likely to reduce any adverse environmental impact of the Concession Activity; and

(b) the Concessionaire can purchase that new technology and integrate the technology into the Concessionaire's operation without causing the Concessionaire unreasonable cost in the circumstances (i.e. not in excess of $1,000 plus GST).

5. Health and Safety

5.1. The Concessionaire must operate under this Concession in a safe and reliable manner and must comply with the Health and Safety at Work Act 2015 and its regulations and all other provisions or requirements of any competent authority, including the Civil Aviation Authority, relating to the performance of this Concession.

5.2. The Concessionaire must:

(a) eliminate risks to health and safety so far as is reasonably practicable; and

(b) if it is not reasonably practicable to eliminate risks to health and safety, minimise those risks so far as is reasonably practicable.

(c) record and report to the Grantor all accidents or incidents involving serious harm within 24 hours of their occurrence and forward an investigation report to the Grantor within 3 working days of the accident or incident occurring;

(d) at the request of the Grantor make available for interview any of the Concessionaire's directors, employees, contractors or agents who in the opinion of the Grantor might assist any investigation by the Grantor into the cause of any such serious harm accident or incident.

5.3. The Concessionaire must notify the Grantor as soon as practicable of any natural event or activity or other hazard on the Land or the surrounding area of which it is aware, and which may endanger the public or the environment.

6. Indemnities and Insurance

6.1. The Concessionaire agrees to use the Land at the Concessionaire's own risk and releases to the full extent permitted by law the Grantor and the Grantor's employees and agents from all

[3] Refer updated guidance at: https://www.mpi.govt.nz/outdoor-activities/boating-and-watersports-tips-to-prevent-spread-of-pests/check-clean-dry/

claims and demands of any kind and from all liability which may arise in respect of any accident, damage or injury occurring to any person or property in or about the Land.

6.2. The Concessionaire must indemnify the Grantor against all claims, actions, losses and expenses of any nature which the Grantor may suffer or incur or for which the Grantor may become liable arising from the Concessionaire's performance of the Concession Activity.

6.3. This indemnity is to continue after the expiry or other determination of this Concession in respect of those acts or omissions occurring or arising before its expiry or determination.

6.4. The Grantor is not liable and does not accept any responsibility for damage to or interference with the Land, the Concession Activity or any other indirect or consequential damage or loss due to any natural disaster, vandalism, sabotage, fire, or exposure to the elements except where, subject to clause 6.5, such damage or interference is caused by any wilful act or omission of the Grantor, or the Grantor's employees, agents or contractors.

6.5. Where the Grantor is found to be liable in accordance with clause 6.4, the total extent of the Grantor's liability is limited to $1,000,000.

6.6. Despite anything else in clause 6 neither the Grantor nor the Concessionaire are liable for any indirect or consequential damage or loss howsoever caused.

6.7. Without prejudice to or in any way limiting its liability under this clause 6 the Concessionaire, at the Concessionaire's expense, must take out, and keep current with a substantial and reputable insurer, policies for insurance and for amounts not less than the sums specified in Item 13 of Schedule 1.

6.8. After every three year period of the Term the Grantor may, on giving 10 working days' notice to the Concessionaire, alter the amounts of insurance required under clause 6.7. On receiving such notice, the Concessionaire must within 10 working days take out and keep current policies for insurance and for the amounts not less than the sums specified in that notice.

6.9. The Concessionaire must provide to the Grantor within 5 working days of the Grantor so requesting:

(a) details of any insurance policies required to be obtained under this Concession, including any renewal policies if such renewal occurs during the Term; and/ or;

(b) a copy of the current certificate of such policies.

7. Compliance

7.1. The Concessionaire must comply where relevant with:

(a) the provisions of any general policy statement made under the Conservation Act 1987, Reserves Act 1977, National Parks Act 1980, Wild Animal Control Act 1977, or Wildlife Act 1953; or any conservation management strategy or conservation management plan under the Conservation Act 1987 or Part 2A of the Reserves Act 1977; or management plan under section 45 of the National Parks Act 1980, whichever is appropriate to the Land, together with any amendment or review of any policy, strategy or plan whether approved before, on, or after the date on which this Concession takes effect; and

(b) the Conservation Act 1987, the Reserves Act 1977, the National Parks Act 1980, the Wild Animal Control Act 1977 and any other Act, ordinance, regulation, bylaw, or other enactment (collectively the "Legislation") affecting or relating to the Land or affecting or relating to the Concession Activity, including any regulations made under the Conservation Act 1987 or bylaws made under the Reserves Act 1977 or the National Parks Act 1980; and

(c) all notices and requisitions of any responsible authority affecting or relating to the Land or affecting or relating to the conduct of the Concession Activity.

7.2. The Concessionaire must comply with all conditions imposed by the Grantor as set out in this Concession and supply the Grantor with evidence of compliance within three working days of a written request by the Grantor.

7.3. A breach or contravention by the Concessionaire of:

(a) any statement of general policy or any relevant conservation management strategy, conservation management plan, management plan referred to in clause 7.1(a); or

(b) any Legislation affecting or relating to the Land or affecting or relating to the Concession Activity;

is deemed to be a breach of this Concession.

7.4. The Concessionaire, and any pilot of an aircraft operating under this Concession, must:

(a) hold the applicable aviation document and privileges to conduct the Concession Activity under the Civil Aviation Act 1990 (or any Act passed in replacement of that Act) and Rules made under that Act or any replacement Act; and

(b) comply with any, and all, Civil Aviation legal requirements applying to the Concession Activity; and

(c) produce to the Grantor (or the Grantor's delegate), if so requested, and as soon as is reasonably possible, any document or privilege referred to in this clause 7.4(a) and (b).

8. Suspension

8.1. The Grantor may suspend this Concession either in whole or in relation to any part of the Land if, in the Grantor's opinion, there is a temporary risk to any natural or historic resource on, or in the vicinity of, the Land or to public safety whether arising from natural events such as earthquake, land slip, volcanic activity, flood, or arising in any other way, including from the activities of the Concessionaire.

8.2. The Grantor may suspend this Concession either in whole or in relation to any part of the Land if, in the Grantor's opinion, the activities of the Concessionaire are having or may have an adverse effect on the natural, historic or cultural values or resources of the Land and the Grantor considers that the effect can be avoided, remedied or mitigated to an extent satisfactory to the Grantor, until the Concessionaire avoids, remedies or mitigates the adverse effect to the Grantor's satisfaction.

8.3. The Grantor may suspend the Concession either in whole or in relation to any part of the Land for such period as the Grantor determines where the Concessionaire has breached any condition of this Concession, without prejudice to any other rights the Grantor may have.

8.4. The Grantor may suspend this Concession while the Grantor investigates:

(a) any circumstance contemplated in clauses 8.1 and 8.2, or

(b) any potential breach of the Concession under clause 8.3, or

(c) any possible offence by the Concessionaire, whether or not related to the Concession Activity, under the Conservation Act 1987 or any Act mentioned in Schedule 1 of the

Conservation Act; or

(d) any possible offence by the Concessionaire under any other enactment affecting or relating to the Land or which, in the Grantor's opinion, relates to the Concession Activity.

8.5. The Grantor may suspend this Concession while any responsible authority, including the Grantor, undertakes an investigation into the cause of any accident or incident involving serious harm and reported to the Grantor under clause 5.2(c); or while any other responsible authority is undertaking an investigation into a possible offence by the Concessionaire affecting or relating to the Land or which in the Grantor's opinion affects or relates to the Concession Activity.

8.6. The word "investigates" in clauses 8.4 and 8.5 includes the filing of charges and awaiting any decision of a Court or Tribunal.

8.7. The Grantor must notify any temporary suspension of the Concession to the Concessionaire as soon as reasonably practicable. Such suspension shall not take effect until the Grantor has notified the Concessionaire.

8.8. During any period of temporary suspension arising under clauses 8.1 or 8.2 the Concession Fee payable by the Concessionaire is to abate in fair proportion to the loss of use by the Concessionaire of the Land.

8.9. The Grantor is not liable to the Concessionaire for any loss sustained by the Concessionaire by reason of the temporary suspension of the Concession under this clause 8 including loss of profits.

9. Termination

9.1. The Grantor may terminate this Concession either in whole or in part:

(a) by 5 working days' notice to the Concessionaire if any Fee or other money payable to the Grantor under this Concession is in arrears and unpaid for 14 days after any day appointed for payment whether it has been lawfully demanded or not; or

(b) by 14 days' notice to the Concessionaire or such sooner period as it appears necessary and reasonable to the Grantor if:

(i) the Concessionaire breaches any terms of this Concession and, in the Grantor's sole opinion, the breach is able to be rectified; and

(ii) the Grantor has notified the Concessionaire of the breach; and

(iii) the Concessionaire does not rectify the breach within 7 days of receiving notification, or such earlier time as specified by the Grantor; or

(c) by notice in writing to the Concessionaire where the Concessionaire breaches any condition of this Concession and, in the sole opinion of the Grantor, the breach is not capable of being rectified; or

(d) immediately by notice in writing to the Concessionaire where the Concessionaire breaches clause 5 (Health and Safety) or clause 6.7 (Insurance), including where an enquiry into an incident or accident reported by the Concessionaire in accordance with clause 5.2(c) by a responsible authority reveals that a reasonable standard of safety was not maintained, and/or the Concessionaire was negligent; or

(e) by notice in writing to the Concessionaire if the Concessionaire ceases to conduct the Concession Activity or where, in the Grantor's opinion, the conduct of the Concession Activity is manifestly inadequate; or

(f) by notice in writing to the Concessionaire if the Concessionaire is convicted of an offence under:

(i) the Conservation Act 1987 or any of the Acts listed in Schedule 1 of the Conservation Act; or

(ii) any other legislation affecting or relating to the Land or which, in the Grantor's opinion, affects or relates to the Concession Activity; or

(g) by notice in writing to the Concessionaire if the Concessionaire or the Guarantor –

(i) is dissolved; or

(ii) enters into any composition with or assignment for the benefit of its creditors; or

(iii) is adjudged bankrupt; or

(iv) being a company, has a receiver appointed; or

(v) is put into liquidation; or

(vi) is placed under statutory management; or

(vii) has a petition for winding up presented against it; or

(viii) is otherwise unable to pay its debts as they fall due; or

(ix) the estate or interest of the Concessionaire is made subject to a Writ of Sale or charging order; or

(x) the Concessionaire ceases to function or operate; or

(h) immediately if there is, in the sole opinion of the Grantor:

(i) a permanent risk to public safety or to the natural and historic resources of the Land whether arising from the conduct of the Concession Activity; or

(ii) from natural causes such as earthquake, land slip, volcanic activity, flood, or

(iii) arising in any other way whether or not from any breach of this Concession on the part of the Concessionaire.

9.2. The Grantor may exercise its power to terminate under clause 9.1(h) without giving notice.

9.3. The Grantor may exercise the Grantor's right under this clause to terminate the Concession notwithstanding any prior waiver or failure to take action by the Grantor or any indulgence granted by the Grantor for any matter or default.

9.4. Termination of the Concession is not to prejudice or affect the accrued rights or claims and liabilities of the parties.

10. Dispute Resolution

10.1. If a dispute arises between the parties in connection with this Concession the parties must, without prejudice to any other rights or entitlements they may have:

(a) meet to discuss the dispute to see whether the parties can agree to a means to resolve the dispute;

(b) if the parties are unable to resolve the dispute at a meeting, attempt to resolve the dispute by agreement using informal dispute resolution techniques such as negotiation, mediation, independent expert appraisal or any other alternative dispute resolution technique. The rules governing any such technique adopted are to be agreed between the parties, and the parties are to share equally in the costs of any agreed dispute resolution process.

(c) if a dispute is not capable of resolution by agreement within 20 working days of written notice by one party to the other (or such further period as the parties may agree to in writing) either party may refer the dispute to the Disputes Tribunal.

(d) The decision of the Disputes Tribunal is to be final, subject to any remedies available to either party under the Disputes Tribunal Act 1988.

10.2. Despite the existence of a dispute, each party must continue to perform its obligations under this Concession.

11. Assignment

11.1. Notwithstanding any other provision of this Concession, the Concessionaire must not transfer, sub-licence, assign, mortgage or otherwise dispose of the Concessionaire's interest under this Concession or any part of it (which includes the Concessionaire's entering into a contract or any other arrangement of any type whereby the Concession Activity would be carried out by a person other than the Concessionaire) without the prior written consent of the Grantor.

11.2. Sections 17P, 17S, 17SA – 17SE, 17T, 17U, 17W, 17X, 17ZB and 17ZC of the Conservation Act 1987 apply to applications for consent under this clause unless the Grantor, in the Grantor's discretion, decides otherwise.

11.3. If the Grantor gives consent under this clause, the Concessionaire remains liable to observe and perform the terms and conditions of this Concession throughout the Term and must procure from the transferee, contractor, agent or assignee a covenant to be bound by the terms and conditions of this Concession.

11.4. The Concessionaire must pay the costs reasonably incurred by the Grantor incidental to any application for consent, whether or not such consent is granted.

11.5. Where the Concessionaire is a company then any change in company shareholding which would alter the effective control of the Concessionaire is deemed to be an assignment and requires the consent of the Grantor.

12. Notices

12.1. Any notice to be given under this Concession which is required to be in writing is to be made by personal delivery, email or by pre-paid post to the receiving party at the address or email address specified in Item 15 of Schedule 1. Any such notice is to be deemed to have been received:

(a) in the case of personal delivery, on the date of delivery;

(b) in the case of email, on the date of dispatch if that day is a working day and the email is received prior to 5 pm, otherwise on the next working day;

(c) in the case of post, on the 3rd working day after posting.

13. Costs

13.1. The Concessionaire must pay the Grantor's legal costs and expenses and any other administrative costs of, and incidental to, preparing and signing this Concession or any renewal, extension or variation of it.

13.2. The Concessionaire must pay in full immediately and on demand all costs and fees (including solicitor's costs and fees of debt collecting agencies engaged by the Grantor) arising out of and associated with steps taken by the Grantor to enforce, or attempt to enforce, the Grantor's rights and powers under this Concession including the right to recover outstanding money owed to the Grantor.

14. Grantor's Consent or Approval

14.1. Where the Grantor's consent or approval is expressly required under this Concession, or the Concession requires the Grantor to exercise a discretion, the Concessionaire must seek that approval or consent or exercise of discretion for each separate time it is required even if the Grantor may have given approval or consent or exercised a discretion for a like purpose on a prior occasion. Provided the Grantor must act reasonably and within a reasonable time, any such consent or approval or exercise of discretion may be made on such conditions as the Grantor considers appropriate.

15. Special Conditions

15.1. Special conditions are set out in Schedules 3, 4 and 5.

15.2. The standard conditions in this Schedule 2 are subject to the special conditions in Schedules 3, 4 and 5.

16. The Law

16.1. This Concession is governed by the laws of New Zealand.

SCHEDULE 3

Special Conditions Relating to Concession Activity

No priority over the Land

1. This Concession does not give the Concessionaire any priority over other users of the Land to use huts or other public facilities on the Land.

2. The Concessionaire must avoid, where possible, overflying tramping routes, tracks, and other visitor facilities.

3. The Concessionaire must not capture or kill any wild animal with a radio-tracking device attached by a neck collar. If an animal with a collar is shot, the Concessionaire must advise the nearest Department of Conservation office within three working days and return the collar to the office as soon as reasonably practicable.

Use of firearms, ammunition, and associated equipment

4. During the hours of darkness, the Concessionaire must not discharge a firearm or conduct spotlighting operations or use night vision sights or other related equipment while undertaking the Concession Activity.

5. The Concessionaire may only use thermal imaging or similar equipment to undertake the Concession Activity during the hours of daylight.

6. The Concessionaire must ensure, in respect of any person who carries and uses firearms and ammunition as part of undertaking the Concession Activity, that person holds a current firearms licence with relevant endorsements and exemptions as required under the Arms Act 1983.

Aircraft, pilots, and landing requirements

7. Prior to undertaking any flight (take-off and landing) under this Concession, any pilot in command of aircraft on behalf of the Concessionaire must review this Concession.

8. The Concessionaire must only use aircraft to conduct the Concession Activity as specified in Item 3 of Schedule 1 of this Concession, or as notified by the Concessionaire to the Grantor in writing prior to use. The Concessionaire must notify the Grantor of any changes to the aircraft make, model, registration number, or colour(s) before carrying out the Concession Activity using a different aircraft.

9. Where a helicopter is used in carrying out the Concession Activity, the Concessionaire must adhere to the Helicopter Association International "Fly Neighbourly" Guide at all times.

10. Further to Schedule 2 clause 7.4, where the Concessionaire is undertaking the Concession Activity using a Robinson R22 or R44 helicopter, the pilot in command of the aircraft must comply with any safety training requirements for those models of aircraft as may be issued by the Director of Civil Aviation from time to time.[4]

11. Where appropriate the Concessionaire must contact and adhere to the procedures of any relevant aircraft user group e.g., the Mount Cook and Westland National Parks User Group, and the Queenstown Milford User Group.

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[4] At the Commencement Date Notice of Requirement NTC 61.365 is in force requiring pilots complete approved safety training every 24 months: https://www.aviation.govt.nz/safety/safety-advice/helicopter-safety/robinson-helicopter-safety-training/

12. Subject to compliance with Civil Aviation Rules, the Grantor may send any officer of the Department of Conservation to observe any of the activities authorised by this Concession for the purpose of assessing the effects of the Concession Activity.

13. Further to special condition 1 above, the Concessionaire does not have priority use of any landing site located on the Land and may only land if such landing site is clear of other users including recreationalists. If any other aircraft is present on a site, the pilot may land only if no hazard is caused and provided Civil Aviation Rules are complied with.

Supplier contract requirements

14. During the Term the Concessionaire must either hold a current supply contract for the supply of deer, pig, goat, chamois carcasses, with a registered Ministry for Primary Industries ("MPI") primary processor **or** have a contract with a marketing entity which holds a current supply contract with a registered MPI primary processor.

15. Where the Concessionaire enters into a contract with a marketing entity, it must be an essential condition of any such contract that the marketing entity holds a current supply contract for the supply of deer, pig, goat, chamois carcasses with a registered MPI primary processor at all times.

16. The Concessionaire must ensure that any relevant supply contract remains current whenever the concession activity is undertaken, and the Grantor may seek confirmation of this from any or all of the Concessionaire, the nominated primary processor, or, where relevant, the marketing entity at any time.

17. The Concessionaire must provide evidence of either:

    (a) a current supply contract (for the supply of deer, pig, goat, and chamois carcasses) with a registered MPI primary processor, or

    (b) a current contract with a marketing entity that has a supply contract with a registered MPI primary processor,

    to the Grantor annually on 1 July.

18. The Concessionaire must not take any wild animal that has been hunted or killed in an area defined within the Department of Conservation Pesticide Summaries where it specifies "pesticides have been laid".

19. The Concessionaire authorises the Grantor to contact the MPI primary processor or marketing entity to update any relevant changes to any supply agreement if required.

Temporary Land Restrictions or Exclusions

20. The Concessionaire acknowledges the Grantor may, in his or her discretion at any time, and on giving written notice to the Concessionaire, temporarily rezone any area(s) of the Land as "Restricted" or "Not Permitted" for the purposes of this Concession if the Grantor considers it is necessary to do so for management purposes. In such circumstances the Grantor must:

    (a) notify the Concessionaire as soon as reasonably practicable of the change in Land zoning and the Grantor's reasons for the change; and

    (b) confirm the date when the change in Land zoning will take effect, which must be at least 5 working days after the date of the written notice; and

    The Grantor may also, at his or her discretion, provide the Concessionaire with updated maps for the Land through the OneDrive link (or by such other data sharing method as the Grantor in his or her opinion considers appropriate) and which shall take effect from the date stated by the Grantor.

21. Where, in the Grantor's opinion, the reason for rezoning an area of the Land as "Restricted" or "Not Permitted" ceases to apply, and there is no other reason for continuing to restrict the area from the Concessionaire's use for the Concession Activity, the Grantor must reinstate the area to its previous zoning for use by the Concessionaire under this Concession and notify the Concessionaire of the reinstatement and the date when the reinstatement takes effect.

22. The Grantor is not liable to the Concessionaire for any loss which may be sustained by the Concessionaire by reason of any action being taken under special conditions 20-21 inclusive, including loss of profits.

Information requirements

23. The Concessionaire must record a Global Positioning System (GPS) flight track log of all flights conducted while undertaking the Concession Activity. Recording intervals are to be in line with MPI specifications. This data must be stored in line with MPI specifications. The Concessionaire must retain such data for the duration of this Concession and for one year after the final expiry date.

24. The Concessionaire must record GPS waypoints of all animals shot or captured while undertaking the Concession Activity in line with MPI specifications. The Concessionaire must retain such data for the duration of this Concession and for one year after the final expiry date.

25. The Concessionaire must provide returns, within 10 working days of animals being shot or captured while undertaking the Concession Activity, and in an electronic form acceptable to the Grantor, to WAROharvestdata@doc.govt.nz (or such alternative email address as is advised in writing by the Grantor to the Concessionaire). These returns must contain the following information:

    (a) GPS waypoints (X/Y – NZTM coordinates) for flightpaths/ tracked flightlogs in accordance with MPI specifications,

    (b) Location animal killed or captured (X/Y – NZTM coordinates, if not shown by (a) above),

    (c) Date animal is killed or captured,

    (d) animal species name (common name is acceptable),

    (e) sex of animal, and

    (f) provided the Concessionaire usually collects this information, animal age estimate, i.e. adult or yearling.

26. The Grantor may ONLY use the information provided under special condition 25 for compliance, monitoring, and conservation management purposes.

27. The expression "conservation management purposes" as used in special condition 26 means the control of wild animals and the better co-ordination of control measures on the Land (e.g., national vegetation monitoring programme, wild animal population densities).

28. The Grantor must not supply information received under special condition 25 in respect of any Individual Concessionaire to any third party other than a responsible authority (e.g. Police, MPI, Civil Aviation Authority, WorkSafe New Zealand). This special condition is subject to the

Official Information Act 1982 including having regard to any potential prejudice to the commercial position of the Concessionaire.

29. Where requested, the Grantor may provide to third parties summarised information on wild animal numbers and trends derived from returns provided under special condition 25. The Grantor may also publish summaries of similar information on the Department of Conservation website or include this information in departmental annual reports or ministerial briefings. Individual Concessionaires should not be identifiable in any such summarised information.

Concession Activity – paragraph (g)

30. When undertaking the activity described in paragraph (g) of the Concession Activity, the Concessionaire must take care to reduce impacts on other users of the Land by operating to minimise disturbance to any such other users.

Review conditions

31. The Grantor may assess the returns provided by the Concessionaire under special condition 25 to determine the total number of animals the Concessionaire has killed or captured on the Land while undertaking the Concession Activity for the previous year ending 30 June.

32. Where the total number of animals the Concessionaire has killed or captured on the Land is fewer than 200 animals in any 12 month period commencing on 1 July and ending on 30 June during the term of this Concession, the Grantor may, at the Grantor's sole option after giving the Concessionaire 10 working days' notice, terminate the Concession in whole or in part in accordance with Schedule 2 clause 9.1(e).

33. In considering whether to terminate the Concession under special condition 32, the Grantor must have regard to any matters raised by the Concessionaire (including factors outside the Concessionaire's control and any extenuating personal circumstances).

Live deer conveyance

34. The Concessionaire must only convey live deer to a location in accordance with the Deer Farming Notice No.5, 2008,[5] or any amendment or replacement of that Notice.

Monitoring

35. If the Grantor determines that the conditions of this Concession or the effects of the Concession Activity should be monitored, the Concessionaire shall meet, either:

(a) the full costs of any monitoring programme that is implemented; or

(b) if the Grantor determines that the costs should be apportioned equally among several Concessionaires, part of the costs of the monitoring programme as so apportioned.

These costs will include the Department's standard charge-out rates for staff time and the mileage rates for vehicle use associated with the monitoring programme.

[5] https://gazette.govt.nz/notice/id/2008-go6534

SCHEDULE 4

ROAR AND CHRISTMAS CLOSURE PERIODS APPLYING TO PERMITTED ZONES (COLOURED GREEN) AND RESTRICTED ZONES (COLOURED ORANGE)

1. In the following areas, other than in Kahurangi National Park, the Concessionaire **must not** undertake the Concession Activity on the areas of the Land zoned on maps provided to the Concessionaire by the Grantor as:[6]
   - "Permitted" (coloured green), or
   - "Restricted" (coloured orange)

   during the following periods:

Roar Closure Periods	**Standard Closure Dates (Inclusive)**	**ADDITIONAL CLOSURE DATES (Inclusive) where Easter falls outside Standard Closure Dates**
2024	**29 March – 15 April**	
2025	**29 March – 15 April**	**18 April – 21 April**
2026	**29 March – 15 April**	
2027	**29 March – 15 April**	**26 March – 28 March (Easter Monday is 29 March)**
2028	**29 March – 15 April**	**16 – 17 April (Easter Sunday and Monday)**

2. In **Kahurangi National Park only**, the Concessionaire **must not** undertake the Concession Activity on the areas of the Land zoned on maps provided to the Concessionaire by the Grantor as:
   - "Permitted" (coloured green), or
   - "Restricted" (coloured orange)

   during the following periods:

Roar Closure Periods	**Standard Closure Dates (Inclusive)**	**ADDITIONAL CLOSURE DATES (Inclusive) where Easter falls outside Standard Closure Dates**
2024	**23 March – 9 April**	
2025	**23 March – 9 April**	**18 April – 21 April**
2026	**23 March – 9 April**	
2027	**23 March – 9 April**	
2028	**23 March – 9 April**	**14 April – 17 April**

[6] Refer Schedule 1, Item 1 – Land

3. The Concessionaire **must not** undertake the Concession Activity on the areas of the Land zoned on maps provided to the Concessionaire by the Grantor as:
   - "Permitted" (coloured green), or
   - "Restricted" (coloured orange)

   during the following period:

Christmas Closure Period	**CLOSURE DATES (Inclusive)**
Annually during the term	**22 December – 5 January**

SCHEDULE 5

RESTRICTED ZONES (COLOURED ORANGE) WHERE ADDITIONAL SPECIAL CONDITIONS APPLY

The Concessionaire **must comply** with the following Special Conditions in relation to the specified areas of the Land zoned as "Restricted" (coloured orange) on maps provided to the Concessionaire by the Grantor:[7]

SOUTH ISLAND

PART A – Tasman, Nelson, Marlborough

A1. The Concession Activity **may only** be undertaken in the areas of the Nelson Lakes National Park zoned as "Restricted" during the period between **1 June – 31 October inclusive**. The Concession Activity must not be undertaken in any part of Nelson Lakes National Park at any other time.

A2. Refer Schedule 4 item 2, for the Roar Closure Period dates applying in Kahurangi National Park.

PART B – West Coast

B1. The Concessionaire must not undertake the Concession Activity in the Hooker/Landsborough and Adams Wilderness Areas during the period from **the Saturday of the last weekend in April to the Sunday of the last weekend in June (inclusive) annually.**

B2. In addition to the Standard Roar Closure Period in Schedule 4 item 1, the Concessionaire must not undertake the Concession Activity in the South Westland Roar Blocks listed below during the period from **the last Sunday in March to the last Saturday in April (inclusive) annually**:

- Arawhata
- Arawhata Riverbed
- Conservation Area – Grassy Creek
- Cook River to Haast River
- Cringe Creek
- Dancing Creek
- Greenstone Creek
- Hooker/Landsborough Wilderness Area
- Knights Point
- Lake Ellery
- Marginal Strip – Bayou Creek
- Marginal Strip – Haast River
- Okuru Scenic Reserve
- Okuru-Turnbull River
- Okuru-Waiatoto

[7] Refer Schedule 1, Item 1 – Land

- Scenic Reserve – Landsborough
- Scenic Reserve – Pleasant Flat
- Turnbull River
- Unnamed Creek
- Waiatoto Valley

B3. In addition to the Standard Roar Closure Period in Schedule 4 item 1, the Concessionaire must not undertake the Concession Activity in Mount Aspiring National Park (excluding Tititea Topuni) during the period from **23 March to 20 April or Easter Monday (inclusive)**, whichever is later.

B4. The Concessionaire must not undertake the Concession Activity on **19 November annually** (being the anniversary of the Pike River Mine tragedy on 19 November 2010) within 500 metres of the areas of the Land in and around:

- the Pike29 Memorial Track, and
- the Pike River Mine site,

within the Tī Kouka place in Paparoa National Park.

PART C – Canterbury Waitaha

C1. The Concessionaire **may only** undertake the Concession Activity in the parts of the St James Conservation Area zoned as "Restricted" during the following periods (all inclusive):

- **1 October – 22 December**
- **1 February – 23 March**; and
- **1 May – 30 June**.

The Concession Activity must not be undertaken in the St James Conservation Area at any other time.

Part D – Otago

D1. In addition to the Standard Roar Closure Period in Schedule 4 item 1, the Concessionaire must not undertake the Concession Activity in Mount Aspiring National Park (excluding areas zoned "Not Permitted") during the period from **23 March to 20 April or Easter Monday (inclusive)**, whichever is later.

D2. In addition to the Standard Roar Closure Period in Schedule 4 item 1, the Concessionaire must not undertake the Concession Activity in the following areas during the period from **23 March to 20 April or Easter Monday (inclusive)**, whichever is later:

- Albert Burn Conservation Area
- Bendigo Conservation Area
- Hāwea Conservation Area (excluding Lake Hāwea faces)
- Hāwea Conservation Park (excluding closed area shown marked red)
- Hunter River Marginal Strip
- Lauder Basin Conservation Area
- Mt Alta Conservation Area

- Mt Aurum Recreation Reserve
- Neinei i kura Conservation Area
- Pisa Conservation Area
- Remarkables Conservation Area
- Te Wai-o-koroiko Scenic Reserve
- The Stack Conservation Area
- West Wanaka Conservation Area
- Whakaari Conservation Area

D3. The Concessionaire **may only** undertake the Concession Activity in the Kopuwai Conservation Area **new addition** in the period between 1 June – 31 October (inclusive). The Concession Activity must not be undertaken in these areas at any other time.

PART E – Southland Murihiku

E1. I In addition to the Standard Roar Closure Period in Schedule 4 i em 1, the Concessionaire **must not** undertake the Concession Activity within the Waituna/ Awarua Wetland area (Waituna Wetlands Scientific Reserve) during the period **1 May – 31 July (inclusive)**.

E2. The Concessionaire **may only** undertake the Concession Activity in the Takitimu Range (Plan MS 5) (Conservation Area - Takitimu Conservation Area and Conservation Area – Robertson FHF Acquisition) and Tutuko (Plan MS 3) (Fiordland National Park) Tōpuni Areas as described in the Ngāi Tahu Deed of Settlement (Plan MS 264)), subject to the following conditions:

(a) The Concessionaire must remove all animals, whole, from these areas.

(b) The Concessionaire must not dispose of any human or animal waste within these areas.

E3. The Concessionaire must not undertake the Concession Activity within 500 metres each side of the Milford, Kepler, Hollyford and the Hump Ridge Tracks during the annual Great Walks season, which runs from the **Saturday of Labour weekend in October through to 30 April (inclusive)**.

E4. In addition to the Standard Roar Closure Period in Schedule 4 item 1, the Concessionaire must not undertake the Concession Activity in the following areas marked orange during the period **23 March through to 20 April or Easter Monday (inclusive)**, whichever is the later:

- Back Creek (Tahakopa) Marginal Strip
- Catlins Conservation Park
- Chaslands Scenic Reserve
- Conservation Area – Catlins Conservation Park
- Conservation Area – Maclennan Forest
- Conservation Area – Stott Acquisition
- Conservation Area – Tahakopa (Table Ridge)
- Conservation Area – Tautuku Forest
- Glenomaru Valley Scenic Reserve
- Table Hill Scenic Reserve

- Tahakopa Bay Scenic Reserve
- Wairepa Scenic Reserve
- Waipati Beach Scenic Reserve

E5. The Concessionaire **may only** undertake the Concession Activity in the areas listed below and zoned as "Restricted" during the period between **1 June – 30 September inclusive**. The Concession Activity must not be undertaken in these areas at any other time.

- Conservation Area – Blackhill Forest
- Conservation Area - Cupola Mid Dome
- East Dome Scenic Reserve
- Mataura Range Scenic Reserve
- Mid Dome Scenic Reserve

Department of Conservation
Te Papa Atawhai

Concession Number: -WARS

Concession Document – Wild Animal Recovery Operation Permit

South Island Schedule: *Deer, pig, chamois and goat carcass recovery and live capture of deer only*

THIS CONCESSION is made this day of 2015.

PARTIES:

1. **Minister of Conservation**, (the Grantor)
2. (the Concessionaire)

BACKGROUND

A. The Grantor administers and manages the public conservation lands described in Schedule 1 (the "Land").

B. Section 22 of the Wild Animal Control Act 1977 authorises the Grantor to grant, in accordance with Part 3B of the Conservation Act 1987, concessions authorising the holder of the concession to engage in wild animal recovery operations and, in so doing, to enter any land that is:

- a conservation area;
- a national park;
- a reserve (but not a reserve vested in an administering body)
- a wildlife sanctuary, wildlife refuge or wildlife management reserve under the Wildlife Act 1953
- land to which the National Parks Act 1980 is applied as if the land were a national park

C. The Concessionaire wishes to carry out the Concession Activity on the Land subject to the terms and conditions of this Document.

D. The Concessionaire acknowledges that the Land may be the subject of Treaty of Waitangi claims and settlements

E. The Grantor is satisfied that the requirements of Part 3B of the Conservation Act 1987 and section 23 of the Wild Animal Control Act 1977 have been complied with.

F. The parties wish to record the terms and conditions of the Concession in this Document and its Schedules.

OPERATIVE PARTS

G. In exercise of the Grantor's powers under section 22 of the Wild Animal Control Act 1977 and section 17Q of the Conservation Act 1987 the Grantor **GRANTS** to the Concessionaire a **WILD ANIMAL RECOVERY OPERATION PERMIT** to carry out the Concession Activity on the Land subject to the terms and conditions contained in this Document and its Schedules as listed below:

Schedule 1: Definition of Concession Activity and Related Terms and Conditions

Schedule 2: Standard Conditions

Schedule 3: Special Conditions – Deer, pig, chamois and goat carcass recovery and live deer capture only

Schedule 4: Permitted Zones Roar and Christmas Closure Periods

Schedule 5: Restricted Zones with Special Conditions over the land.

SIGNED on behalf of the Minister of Conservation by

____

Michael Slater
Acting Deputy Director-General Conservation Services

acting under delegated authority in the presence of:

____

Witness Signature

____

Witness Name

____

Witness Occupation

____

Witness Address

A copy of the Instrument of Delegation may be inspected at the Director-General's office at 18-32 Manners Street, Wellington.

*(Select **one** only of the following execution clauses and delete the other four)*

SIGNED by *[insert name of Concessionaire if an individual]*

____

in the presence of:

____

Witness Signature

____

Witness Name

____

Witness Occupation

____

Witness Address

Or

SIGNED by *[insert name of Company]* Limited by:

__________________________ Director
[insert name]

__________________________ Director
[insert name]

Or

NOTE: the following execution clause may only be used if you have checked the Company records at the Companies Office and have confirmed that the Company has only one

	Director SIGNED by *[insert name of Company]* Limited by its Director *[insert name]*: ____________________ in the presence of: ____________________ Witness Signature ____________________ Witness Name ____________________ Witness Occupation ____________________ Witness Address Or SIGNED on behalf of *[insert name of partnership]* by *[insert name of authorised signatory]* in the presence of: ____________________ Witness Signature ____________________ Witness Name ____________________ Witness Occupation ____________________ Witness Address Or The seal of *[insert name of Incorporated Society]* was affixed in the presence of :

	Authorised Signatory Authorised Signatory

SCHEDULE 1

DEFINITION OF CONCESSION ACTIVITY AND RELATED TERMS AND CONDITIONS

1.	**Land**	The land over which the Concession Activity is authorised being that land identified on the attached CD dated 1 July 2015, which shows areas of land zoned as: • "Permitted" (coloured green) • "Restricted" (coloured orange) Other than in relation to paragraph (g), the Concession Activity MUST NOT take place on any land zoned as: • "Not Permitted" (coloured red) In relation to paragraph (g) ONLY the Concession Activity may occur at additional sites on the Land including land zoned as "Not Permitted" where these sites are legally accessible by motor vehicle, such as car parks and formed roads.
2.	**Concession Activity** *(clause 1)*	The use of aircraft (whether or not for hire or reward) to carry out one or more of the following activities: (a) the searching for, shooting, or immobilising of deer (b) the searching for, shooting of pig, goat and chamois. (c) The recovery of dead deer, pig, goat, chamois or any part of such deer (including velvet), pig, goat, chamois for supply to a MPI registered processing facility: (d) The recovery of dead deer, pig, goat, chamois or any part of such deer (including velvet), pig, goat, chamois for the personal consumption of the Concessionaire or its employees, only where undertaking the activity in (c). (e) The capture and conveyance of live deer only: (f) The carriage of persons, supplies, equipment, firearms, ammunition, or other things that may be used for the purposes of paragraph (a) or paragraph (b) or paragraph (c) or paragraph (d) or paragraph (e): (g) The use of aircraft to facilitate the offloading of recovered deer, pig, goat, or chamois carcasses to a refrigerated truck or similar vehicle for transport. **BUT EXCLUDING THE FOLLOWING ACTIVITIES** (1) Live capture or carriage of other species of live wild animals including pig, goat, and chamois. (2) Carriage of any other species of wild animal (3) Carriage of recreational hunters involved with the searching for, shooting or immobilising and recovery of wild animals (e.g. heli-hunting) (4) Carriage of ground-based hunters who are not employees of the Concessionaire (5) Carriage of individuals who are providing a guided hunting service (6) Carriage of any passenger other than employees of the Concessionaire who are engaged in the Concession Activity (7) Subject to (d) above the recovery of wild animals for the purpose of personal consumption

		(8) Recovery of wild animals for trophy mounting purposes
3.	**Aircraft type** *(clause 15)*	The Concessionaire must provide the following details for all aircraft to be used to undertake the Concession activity, prior to the Concession Activity being undertaken: *Aircraft make and model:* *Registration number:* *Colour:*
4.	**Term** *(clause 2)*	3 years commencing on 1 July 2015
5.	**Renewal(s)** *(clause 2)*	*Nil*
6.	**Final Expiry Date** *(clause 2)*	30 June 2018
7.	**Concession Fee** *(clause 3)*	$0.00 per annum plus GST *In reliance upon section 17X(f)(i) of the Conservation Act 1987 a Concession Fee is not required*
8.	**Management Fee** *(clause 3)*	$1,000 per annum plus GST
9.	**Fee Payment Date** *(clause 3)*	1 July annually in advance
10.	**Fee Review Date (s)** *(clause 3)*	Does not apply
11.	**Penalty Interest Rate** *(clause 3)*	10% per annum
12.	**Insurance** *(To be obtained by Concessionaire)* *(clause 6)*	A. Types and amounts: (a) General Public Liability for an amount no less than NZ$2,000,000 including Forest & Rural Fires Act Extension with this extension having a sub-limit of no less than NZ$1,000,000. (b) Third Party Motor Vehicle Liability for an amount no less than NZ$1,000,000. (c) Aviation Legal Liability for an amount of no less than NZ$2,000,000 including Forest & Rural Fires Act Extension with this extension having a sub-limit of no less than NZ$1,000,000. B. Other Policies and amounts: n/a Certificates of Insurance Received: Yes/No *[delete as appropriate]*
13.	**Addresses for Notices** *(clause 12)*	The Grantor's address is: Department of Conservation 70 Moorhouse Avenue Addington Christchurch 8011

		Phone: 03 371 3700 Email: permissionschristchurch@doc.govt.nz *NB: Use street address only*
		The Concessionaire's address in New Zealand is: __________ __________ __________ __________ Phone: Email: *NB: Use street address only*
14.	**Special Conditions** *(clause 17)*	See Schedules 3, 4 and 5.

Note: The clause references are to the Standard Conditions set out in Schedule 2.

SCHEDULE 2

STANDARD CONDITIONS

1. Concession Activity

1.1. The Concessionaire must not use the Land for any purpose other than the Concession Activity.

1.2. The Concessionaire is responsible for the acts and omissions of its directors, employees, contractors or agents. The Concessionaire is liable under this Concession for any breach of the Concession by its directors, employees, contractors or agents as if the breach had been committed by the Concessionaire.

2. Term and Renewals (if any)

2.1. The Concession term commences on the date set out in Item 4 of Schedule 1 and ends on the Final Expiry Date specified in Item 6 of Schedule 1.

2.2. There is no right to renew this Concession.

3. Concession Fee, Management Fee and Review

3.1. The Concessionaire must pay to the Grantor in advance and in the manner directed by the Grantor the Concession Fee and the Management Fee plus GST on the Fee Payment Date(s) as specified in Item 9 of Schedule 1.

3.2. If payment is not made within 14 days of the Fee Payment Date then the Concessionaire is to pay interest on the unpaid Fees from the Fee Payment Date until the date of payment at the Penalty Interest Rate specified in Item 11 of Schedule 1.

3.3. The Concession and Management Fee are to be reviewed by the Grantor on the Fee Review Date specified in Item 10 of Schedule 1. Both parties are to agree on the new fee within 30 working days of the Grantor giving the Concessionaire written notice of the review. If the parties cannot so agree then the provisions of clause 10 apply.

4. Protection of Environment

4.1. Except for the purposes that are approved by this Concession or except as otherwise approved in writing by the Grantor the Concessionaire must not, whether by act or omission:

(a) interfere with, remove, damage, or endanger the natural features, animals, plants, or historic resources on the Land; or

(b) bring any plants, animals, or firearms on to the Land; or

(c) deposit on the Land debris, rubbish or other dangerous or unsightly matter, or contaminate any water body on the Land; or

(d) pile or store materials in any place on the Land where it may obstruct the public or create a nuisance; or

(e) conduct any noxious, noisome, dangerous or offensive activity on the Land.

4.2. The Concessionaire must:

(a) take all reasonable precautions to ensure no fire hazards arise from its carrying out of the Concession Activity;

(b) not light or permit to be lit any fire on the Land;

(c) not store or permit to be stored fuels or other combustible materials on the Land without the prior written permission of the Grantor. In that event storage of fuels and combustible materials must be in accordance with the provisions of the Hazardous Substances and New Organisms Act 1996;

(d) comply with any of the Grantor's requirements for fire warning and safety equipment and for fire fighting equipment to be kept on the Land at all times.

4.3. Having regard to the Concession Activity, the Concessionaire must ensure it adheres to the international "Leave No Trace" Principles (www.leavenotrace.org.nz).

4.4. The Concessionaire must comply with all guidelines and notices put out by Biosecurity New Zealand regarding measures to avoid spreading the pest organism Didymosphenia geminate ("Didymo"), and or any other pest organism identified during the term of this Concession.

5. Health and Safety

5.1. The Concessionaire must exercise the rights granted by this Concession in a safe and reliable manner and must comply with the Health and Safety in Employment Act 1992 and its regulations and all other provisions or requirements of any competent authority relating to the performance of this Concession.

5.2. The Concessionaire must:

(a) take all reasonable steps to protect the safety of all persons present on the Land in the vicinity of the Concession Activity; and

(b) take all reasonable steps to eliminate any dangers to the public of which the Concessionaire is aware; and

(c) record and report to the Grantor all accidents or incidents involving serious harm within 24 hours of their occurrence and forward an investigation report to the Grantor within 3 working days of the accident or incident occurring;

(d) at the request of the Grantor make available any of the Concessionaire's directors, employees, servants or agents who in the opinion of the Grantor might assist any investigation by the Grantor into the cause of any such serious harm accident or incident.

5.3. The Concessionaire is requested to notify the Grantor as soon as practicable of any natural events or activities on the Land or the surrounding area which may endanger the public or the environment.

6. Indemnities and Insurance

6.1. The Concessionaire agrees to use the Land at the Concessionaire's own risk and releases to the full extent permitted by law the Grantor and the Grantor's employees and agents from all claims and demands of any kind and from all liability which may arise in respect of any accident, damage or injury occurring to any person or property in or about the Land.

6.2. The Concessionaire must indemnify the Grantor against all claims, actions, losses and expenses of any nature which the Grantor may suffer or incur or for which the Grantor may become liable arising from the Concessionaire's performance of the Concession Activity.

6.3. This indemnity is to continue after the expiry or other determination of this Concession in respect of those acts or omissions occurring or arising before its expiry or determination.

6.4. The Grantor is not liable and does not accept any responsibility for damage to or interference with the Land, the Concession Activity or any other indirect or consequential damage or loss due to any natural disaster, vandalism, sabotage, fire or exposure to the elements except where, subject to clause 6.5, such damage or interference is caused by any wilful act or omission of the Grantor, the Grantor's employees, agents or contractors.

6.5. Where the Grantor is found to be liable in accordance with clause 6.4, the total extent of the Grantor's liability is limited to $1,000,000.

6.6. Despite anything else in clause 6 neither the Grantor nor the Concessionaire are liable for any indirect or consequential damage or loss howsoever caused.

6.7. Without prejudice to or in any way limiting its liability under this clause 6 the Concessionaire at the Concessionaire's expense must take out and keep current policies for insurance and for amounts not less than the sums specified in Item 12 of Schedule 1 with a substantial and reputable insurer.

6.8. After every three year period of the Term the Grantor may, on giving 10 working days notice to the Concessionaire, alter the amounts of insurance required under clause 6.7. On receiving such notice the Concessionaire must within 10 working days take out and keep current policies for insurance and for the amounts not less than the sums specified in that notice.

6.9. The Concessionaire must provide to the Grantor within 5 working days of the Grantor so requesting:

(a) details of any insurance policies required to be obtained under this Concession, including any renewal policies if such renewal occurs during the Term; and/ or;

(b) a copy of the current certificate of such policies.

7. Compliance

7.1. The Concessionaire must comply where relevant:

(a) with the provisions of any conservation management strategy or conservation management plan under the Conservation Act 1987 or Part 2A of the Reserves Act 1997, or any general policy statement made under the Conservation Act 1987, or any general policy statement made under the Conservation Act 1987; Reserves Act 1977, National Parks Act 1980, or Wildlife Act 1953, or management plan under section 45 of the National Parks Act 1980, whichever is appropriate to the Land, together with any amendment or review of any policy, strategy or plan whether approved before, on, or after the date on which this Concession takes effect; and

(b) with the Conservation Act 1987, the Reserves Act 1977, the National Parks Act 1980, the Wild Animal Control Act 1977 and any other Act, ordinance, regulation, bylaw, or other enactment (collectively the "Legislation") affecting or relating to the Land or affecting or relating to the Concession Activity, including any regulations made under the Conservation Act 1987 or bylaws made under the Reserves Act 1977 or the National Parks Act 1980; and

(c) with all notices and requisitions of any responsible authority affecting or relating to the Land or affecting or relating to the conduct of the Concession Activity.

7.2. The Concessionaire must comply with all conditions imposed by the Grantor in granting this Concession and supply the Grantor with evidence of compliance within three working days of a written request by the Grantor.

7.3. A breach or contravention by the Concessionaire of a relevant conservation management strategy, conservation management plan, management plan or any statement of general policy referred to in clause 7.1(a) is deemed to be a breach of this Concession.

7.4. A breach or contravention by the Concessionaire of any legislation affecting or relating to the Land or affecting or relating to the Concession Activity is deemed to be a breach of this Concession.

7.5. A breach or contravention by the Concessionaire of any notices and requisitions of any competent authority affecting or relating to the Land or affecting or relating to the conduct of the Concession Activity is deemed to be a breach of this Concession.

7.6. The Concessionaire, and any pilot of an aircraft operating under this Concession, must hold the applicable aviation document and privileges to conduct the Concession Activity under the Civil Aviation Rules and must comply with any and all Civil Aviation law requirements applying to the Concession Activity.

8. Suspension

8.1. If, in the Grantor's opinion, there is a temporary risk to any natural or historic resource on or in the vicinity of the Land or to public safety whether arising from natural events such as earthquake, land slip, volcanic activity, flood, or arising in any other way including the activities of the Concessionaire or its employees, then the Grantor may suspend this Concession.

8.2. If, in the Grantor's opinion, the activities of the Concessionaire are having or may have an adverse effect on the natural, historic or cultural values or resources of the Land and the Grantor considers that the effect can be avoided, remedied or mitigated to an extent satisfactory to the Grantor, then the Grantor may suspend this

Concession until the Concessionaire avoids, remedies or mitigates the adverse effect to the Grantor's satisfaction.

8.3. The Grantor may suspend the Concession for such period as the Grantor determines where the Concessionaire has breached any terms of this Concession.

8.4. The Grantor may suspend this Concession while the Grantor investigates any of the circumstances contemplated in clauses 8.1 and 8.2, and also while the Grantor investigates any potential breach of the Concession under clause 8.3, or while the Grantor investigates any possible offence by the Concessionaire whether or not related to the Concession Activity under the Conservation Act 1987 or any of the Acts mentioned in the First Schedule of that Act.

8.5. The Grantor may suspend this Concession while any responsible authority, including the Grantor, is undertaking an investigation into the cause of any accident or incident involving serious harm and reported to the Grantor under clause 5.2(c); or while any other responsible authority is undertaking an investigation into a possible offence by the Concessionaire affecting or relating to the Land or which in the Grantor's sole opinion affects or relates to the Concession Activity.

8.6. The word "investigates" in clauses 8.4 and 8.5 includes the laying of charges and awaiting the decision of the Court.

8.7. Any suspension of the Concession may be in full or in part and shall be notified to the Concessionaire as soon as reasonably practicable.

8.8. During any period of suspension arising under clauses 8.1 or 8.2 the Concession Fee payable by the Concessionaire is to abate in fair proportion to the loss of use by the Concessionaire of the Land.

8.9. The Grantor is not to be liable to the Concessionaire for any loss sustained by the Concessionaire by reason of the suspension of the Concession under this clause 8 including loss of profits.

9. <u>Termination</u>

9.1. The Grantor may terminate this Concession either in whole or in part:

(a) by 5 working days notice to the Concessionaire if any Fee or other money payable to the Grantor under this Concession is in arrears and unpaid for 14 days after any of the days appointed for payment whether it has been lawfully demanded or not; or

(b) by 14 days notice to the Concessionaire or such sooner period as it appears necessary and reasonable to the Grantor if-.

(i) the Concessionaire breaches any terms of this Concession and in the Grantor's sole opinion the breach is able to be rectified; and

(ii) the Grantor has notified the Concessionaire of the breach; and

(iii) the Concessionaire does not rectify the breach within 7 days of receiving notification, or such earlier time as specified by the Grantor; or

(c) by notice in writing to the Concessionaire where the Concessionaire breaches any terms of this Concession and in the sole opinion of the Grantor the breach is not capable of being rectified; or

(d) immediately by notice in writing to the Concessionaire where the Concessionaire breaches clauses 5 or 6.7, including where an enquiry into an incident or accident reported by the Concessionaire in accordance with clause 5.2(c) by a responsible authority reveals that a reasonable standard of safety was not maintained and/or the Concessionaire or the Concessionaire's servants, employees or agents were negligent; or

(e) by notice in writing to the Concessionaire if the Concessionaire ceases to conduct the Concession Activity or, in the reasonable opinion of the Grantor, the conduct of the Concession Activity is manifestly inadequate; or

(f) by notice in writing to the Concessionaire if the Concessionaire is convicted of an offence under the Conservation Act 1987 or any of the Acts listed in the First Schedule to that Act or any statute, ordinance, regulation, bylaw, or other enactment affecting or relating to the Land or which in the Grantor's sole opinion affects or relates to the Concession Activity; or

(g) by notice in writing to the Concessionaire if the Concessionaire or the Guarantor is dissolved; or enters into any composition with or assignment for the benefit of its creditors; or is adjudged bankrupt; or being a company, has a receiver appointed; or is put into liquidation; or is placed under statutory management; or has a petition for winding up presented against it; or is otherwise unable to pay its debts as they fall due; or the estate or interest of the Concessionaire is made subject to a Writ of Sale or charging order; or the Concessionaire ceases to function or operate; or

(h) immediately if there is, in the opinion of the Grantor, a permanent risk to public safety or to the natural and historic resources of the Land whether arising from the conduct of the Concession Activity or from natural causes such as earthquake, land slip, volcanic activity, flood, or arising in any other way, whether or not from any breach of the terms of this Concession on the part of the Concessionaire.

9.2. The Grantor may exercise its power to terminate under clause 9.1(h) without giving notice.

9.3. The Grantor may exercise the Grantor's right under this clause to terminate the Concession notwithstanding any prior waiver or failure to take action by the Grantor or any indulgence granted by the Grantor for any matter or default.

9.4. Termination of the Concession is not to prejudice or affect the accrued rights or claims and liabilities of the parties.

10. <u>Dispute Resolution</u>

10.1. If a dispute arises between the parties in connection with this Concession the parties must, without prejudice to any other rights or entitlements they may have, attempt to resolve the dispute by agreement using informal dispute resolution techniques such as negotiation, mediation, independent expert appraisal or any other alternative dispute resolution technique. The rules governing any such technique adopted are to be agreed between the parties.

10.2. If the dispute is not capable of resolution by agreement within 14 days of written notice by one party to the other (or such further period as the parties may agree to in writing) either party may refer the dispute to the Disputes Tribunal, where relevant, or to arbitration which arbitration is to be carried out in accordance with the provisions of the Arbitration Act 1996.

10.3. If the parties do not agree on an arbitrator within 10 working days of a party giving written notice of the requirement to appoint an arbitrator the President of the New

Zealand Law Society is to appoint the arbitrator. In either case the arbitrator must not be a person who has participated in an informal dispute resolution procedure in respect of the dispute.

10.4. The arbitrator must include in the arbitration award reasons for the determination.

10.5. The decision of the Disputes Tribunal or of the arbitrator is to be final, subject to any remedies available to either party under the Disputes Tribunal Act 1988 or Arbitration Act 1996.

10.6. Despite the existence of a dispute, each party must continue to perform its obligations under this Concession.

11. <u>Assignment</u>

11.1. The Concessionaire must not transfer, sub licence, assign, mortgage or otherwise dispose of the Concessionaire's interest under this Concession or any part of it (which includes the Concessionaire entering into a contract or any other arrangement whatsoever whereby the Concession Activity would be carried out by a person other than the Concessionaire) without the prior written consent of the Grantor.

11.2. Sections 17P, 17S, 17T, 17U, 17W, 17X, 17ZB and 17ZC of the Conservation Act 1987 apply to applications for consent under this clause unless the Grantor, in the Grantor's discretion, decides otherwise.

11.3. If the Grantor gives consent under this clause the Concessionaire is to remain liable to observe and perform the terms and conditions of this Document throughout the Term and is to procure from the transferee, sub licensee, or assignee a covenant to be bound by the terms and conditions of this Document.

11.4. The Concessionaire must pay the costs reasonably incurred by the Grantor incidental to any application for consent, whether or not such consent is granted.

11.5. If the Concessionaire is not a publicly listed company then any change in the shareholding of the Concessionaire altering the effective control of the Concessionaire requires the consent of the Grantor.

12. <u>Notices</u>

12.1. Any notice to be given under this Concession which is required to be in writing is to be made by personal delivery, email or by pre paid post to the receiving party at the address or email address specified in Item 13 of Schedule 1. Any such notice is to be deemed to have been received:

(a) in the case of personal delivery, on the date of delivery;

(b) in the case of email, on the date of dispatch if that day is a working day and the email is received prior to 5 pm, otherwise on the next working day;

(c) in the case of post, on the 3rd working day after posting.

13. <u>Costs</u>

13.1. The Concessionaire must pay the Grantor's legal costs and expenses of and incidental to preparing and signing this Concession or any renewal, extension or variation of it.

13.2. The Concessionaire must pay in full immediately and on demand all costs and fees (including solicitor's costs and fees of debt collecting agencies engaged by the Grantor) arising out of and associated with steps taken by the Grantor to enforce or attempt to enforce the Grantor's rights and powers under this Concession including the right to recover outstanding money owed to the Grantor.

14. Grantor's Consent or Approval

14.1. Where the Grantor's consent or approval is expressly required under this Concession then the Concessionaire must seek that approval or consent for each separate time it is required even though the Grantor may have given approval or consent for a like purpose on a prior occasion. Any such consent or approval may be made on such conditions as the Grantor considers appropriate.

15. Conditions Relating to the Concession Activity

15.1. This Concession does not confer on the Concessionaire the right to use huts or other public facilities on the Land in priority to other users of the Land.

15.2. The Concessionaire must not capture or kill any wild animal with a radio tracking device attached by a neck collar. If an animal with a collar is accidentally shot the collar should be returned to the nearest Department of Conservation Office.

15.3. The Concessionaire must not discharge a firearm during the hours of darkness or conduct spotlighting operations or use night vision sights or other related equipment.

15.4. Before commencing the Concession Activity the Concessionaire must obtain Concessionaire Identification cards from the Grantor. The Concessionaire, its employees and any person acting under the authority of the Concession must carry and display a Concessionaire Identification card when carrying out the Concession Activity. The Concessionaire must obtain sufficient cards to ensure all its employees and people acting under the authority of the concession can carry and display such cards when undertaking the Concession Activity. The Grantor is to supply replacement cards to the Concessionaire on a cost recovery basis.

15.5. The Concessionaire must only use aircraft specified in Item 3 of Schedule 1 of this Concession Document, or as notified in advance to the Grantor, to conduct the Concession Activity. The Concessionaire must notify the Grantor of any changes to the aircraft make, aircraft model, aircraft registration, or aircraft colour(s) before carrying out the Concession Activity.

15.6. Prior to undertaking any flights (take off and landing) under this Concession, any pilot in command of the aircraft on behalf of the Concessionaire shall review this Concession.

15.7. Subject to compliance with Civil Aviation Authority Rules, the Grantor may send any officer of the Department of Conservation to observe any of the activities authorised by this Concession for the purpose of assessing the effects of the Concession Activity.

15.8. The Concessionaire must avoid, where possible, overflying tramping routes, tracks and other visitor facilities.

15.9. The Concessionaire must where a helicopter is used in carrying out the Concession Activity adhere to the Helicopter Association International "Fly Neighbourly" Guide at all times.

15.10. Where appropriate the Concessionaire must contact and adhere to the procedures of any relevant aircraft user group such as the Mount Cook and Westland National Parks User Group.

15.11. The Concessionaire does not have priority use of any landing site located on the Land and may only land if such landing site is clear of other users including recreationalists. If other aircraft users are present on the sites the pilot may land only if no hazard is caused and if Civil Aviation Authority regulations are complied with.

16. Land Exclusions

16.1. The Concessionaire acknowledges the Grantor in his or her discretion may at any time, on giving prior written notice to the Concessionaire, restrict any area of the Land or exclude any area of the Land from use under this Concession by the Concessionaire where the Grantor considers it is necessary to do so for any reason, and the Grantor must notify the Concessionaire of its reason for so doing accordingly.

16.2. The Grantor is not to be liable to the Concessionaire for any loss sustained by the Concessionaire by reason of any action being taken under this Clause 16, including loss of profits.

16.3. Where in the Grantor's opinion the reason for excluding the area of the Land ceases to apply and there is no other reason for continuing to exclude the area from the Concessionaire's use, the Grantor must reinstate the area for use by the Concessionaire under this Concession and notify the Concessionaire of the reinstatement.

17. Special Conditions

17.1. Special conditions are set out in Schedules 3, 4 and 5.

17.2. The standard conditions in this Schedule 2 are subject to the special conditions.

18. The Law

18.1. This Concession is governed by New Zealand law.

SCHEDULE 3

SPECIAL CONDITIONS – <u>SOUTH ISLAND:</u>
Deer, Pig, Goat, Chamois Carcass Recovery and Live Deer Capture Only

<u>Supplier contract requirements</u>

1. During the term the Concessionaire must either hold a current supply contract, for the supply of deer, pig, goat, chamois carcasses, with a registered MPI processor <u>or</u> have a contract with a marketing entity which holds a current supply contract with a registered MPI processor.

2. Where the Concessionaire enters into a contract with a marketing entity, it shall be an essential condition of any such contract that the marketing entity holds a current supply contract for the supply of deer, pig, goat, chamois carcasses with a registered MPI processor at all times.

3. A relevant supply contract must remain current whenever the concession activity is undertaken and the Grantor may seek confirmation of this from any of the Concessionaire, the nominated processor, or, where relevant, the marketing entity at any time.

4. Evidence of a current supply contract (for the supply of deer, pig, goat, and chamois carcasses) with a registered MPI processor must be provided to the Grantor annually on 1 July. Where relevant evidence of a current contract by the Concessionaire with a marketing entity must also be provided by 1 July

5. The Concessionaire must not take any wild animal that has been hunted or killed in an area defined within the Department of Conservation Pesticide Summaries where it specifies "pesticides have been laid".

6. The Concessionaire authorises the Grantor to contact the MPI primary processor or marketing entity to update any relevant changes to any supply agreement if required.

<u>Information requirements</u>

7. The Concessionaire must record a Global Positioning System (GPS) flight track log of all flights conducted while undertaking the concession activity. Recording intervals are to be in line with MPI specifications. This data must be stored in line with MPI specifications. The Concessionaire must retain such data for the duration of this Concession.

8. The Concessionaire must record all GPS waypoints of all animals shot or captured while undertaking the concession activity. One waypoint recorded is to equal one animal captured or shot in line with MPI specifications. The Concessionaire must retain such data for the duration of this Concession.

9. The Concessionaire must provide a return to the Grantor by 30 July in each year during the term of this Concession in relation to any live capture operations under this Concession. The return is to be for the year ending 30 June and the information provided must cover GPS records of all animals captured, including numbers of animals and locations where animals were recovered from. The Grantor may use this information for compliance and or conservation management purposes only.

10. The Concessionaire authorises the Grantor to obtain from any primary processor all supplier declarations and/or GPS records of animals presented (including numbers

of animals, locations where animals were recovered from, types and species of wild animal) individually by the Concessionaire to the processing plant, and the day-to-day manager of the primary processing premises is authorised to supply such information to the Grantor. The Grantor may request this information for compliance and or conservation management purposes only.

11. Conservation management purposes as used in special conditions 9 and 10 means the control of wild animals and the better co-ordination of control measures on public conservation land (e.g. national vegetation monitoring programme, wild animal population densities).

12. Other than as set out above, the Grantor is not to supply the individual Concessionaire information obtained under special conditions 9 and 10 to any third party other than a regulatory or enforcement agency (e.g. Ministry for Primary Industries, Civil Aviation Authority, WorkSafe New Zealand). This special condition is subject to the Official Information Act 1982 including having regard to any potential prejudice to the commercial position of the Concessionaire.

13. The live capture returns required under special condition 9 may be provided in a summarised form to third parties if requested. Individual Concessionaires should not be identifiable in any such summary.

14. The Concessionaire authorises the Grantor to obtain from any primary processor GPS records of animals presented by the Concessionaire to that primary processor (including numbers of animals, locations where animals were recovered from, species of wild animal) in a summarised form, on an annual basis, the day-to-day manager of the primary processing premises is authorised to supply such information to the Grantor. The Grantor may supply this information to third parties if requested. Individual Concessionaires should not be identifiable in any such summary.

15. The Concessionaire must within 3 working days of receiving a request in writing from the Grantor supply the Grantor, for compliance purposes, with any specified GPS flight track logs recorded by the Concessionaire under this Concession.

16. The Concessionaire must within 3 working days of receiving a request in writing from the Grantor make available to the Grantor, for compliance purposes, the Concessionaire's GPS waypoints of all animals shot and recovered for sale to a registered MPI processor, including through a marketing entity.

Concession Activity – paragraph (g) conditions

17. Prior to the Concessionaire using any "Not Permitted" parts of the Land to undertake paragraph (g) of the Concession Activity, the Concessionaire must notify the relevant District Office in writing (including by email) in advance if reasonably practicable, or otherwise within 24 hours of the activity taking place. This notification is for information purposes only.

18. When undertaking paragraph (g) of the Concession Activity, the Concessionaire must take care to minimise impacts on other users of the Land, in particular by operating so as to minimise disturbance to any other users present or nearby on the Land.

Review condition

19. Should the return provided to the Grantor under special condition 9 and the information provided under special condition 10 indicate the Concessionaire has killed or captured less than 200 animals while undertaking the Concession activity in the previous year ending 30 June, the Grantor may at her sole option after giving

the Concessionaire 14 days notice terminate the Concession in whole or in part. In considering whether to terminate under this special condition, the Grantor must have regard to any matters raised by the Concessionaire (including factors outside the Concessionaire's control and any extenuating personal circumstances).

Live deer

20. Live deer can only be conveyed to locations in accordance with the Deer Farming Notice No.5, 2008, or any subsequent amendment to that notice.

SCHEDULE 4

Permitted Zones - Roar and Christmas Closure Periods

The Concession Activity must not take place on the Land marked in green on the attached CD dated 1 July 2015 during the term of the Concession during the following periods:

Roar Closure Periods	Standard Closure Dates (Inclusive)	ADDITIONAL CLOSURE DATES where Easter falls outside Standard Closure Dates (Inclusive)
2016	23 March – 9 April	
2017	23 March – 9 April	14 – 17 April
2018	23 March – 9 April	

Christmas Closure Period	CLOSURE DATES (Inclusive)
Annually during the term	22 December – 5 January

SCHEDULE 5

Restricted Zones – Special Conditions applying to Parts of the Land

In addition to the standard Roar and Christmas Closure periods set out in Schedule 4, while undertaking the concession activity on those specified parts of the Land shown marked orange on the attached CD dated 1 July 2015, the Concessionaire **must comply** with the following Special Conditions in relation to the parts of the Land shown marked orange:

SOUTH ISLAND

PART A – Nelson, Marlborough

A1. The Concessionaire must not conduct the Concession Activity in the areas of the Nelson Lakes National Park shown marked orange during the period 1 November – 31 May (inclusive).

PART B – West Coast

B1. The Concessionaire must not undertake the Concession Activity in the Hooker/Landsborough and Adams Wilderness Areas during the period from the Saturday of the last weekend in April to the Sunday of the last weekend in June (inclusive).

B2. Further to the standard Roar Period Closure in Schedule 4, the Concessionaire must not undertake the Concession Activity in the following South Westland Roar Block areas shown marked orange during the period from the last Sunday in March to the last Saturday in April (inclusive):

- Arawhata
- Arawhata Riverbed
- Cook River to Haast River
- Cringe Creek
- Dancing Creek
- Knights Point
- Lake Ellery
- Okuru-Waiatoto
- Okuru-Turnbull River
- Turnbull River
- Waiatoto Valley
- Hooker/Landsborough Wilderness Area
- Marginal Strip – Bayou Creek
- Greenstone Creek
- Marginal Strip -Haast River
- Unnamed Creek
- Okuru Scenic Reserve
- Scenic Reserve – Pleasant Flat

- Scenic Reserve – Landsborough
- Conservation Area – Grassy Creek

B3. Further to the standard Roar Period Closure in Schedule 4, the Concessionaire must not undertake the Concession Activity in Mount Aspiring National Park (excluding Tititea Topuni) during the period 23 March through to 20 April or Easter Monday (inclusive), whichever is later.

PART C – Canterbury

C1. The Concessionaire must only undertake the Concession Activity in the part of the St James Conservation Area shown marked orange during the periods (all inclusive):

- 1 October – 22 December, and
- 1 February – 23 March, and
- 1 May – 30 June.

Part D – Otago

D1. Further to the standard Roar Period Closure in Schedule 4 the Concessionaire must not undertake the Concession Activity in the Mount Aspiring National Park (excluding Tititea Topuni) during the period 23 March through to 20 April or Easter Monday (inclusive), whichever is later.

D2. Further to the standard Roar Period Closure in Schedule 4, the Concessionaire must not undertake the Concession Activity in the following areas shown marked orange during the period 23 March through to 20 April or Easter Monday (inclusive), whichever is later:

- Albert Burn Conservation Area
- West Wanaka Conservation Area
- Mt Alta Conservation Area
- Hawea Conservation Park (excluding closed area shown marked red)
- Lauder Basin Conservation Area
- Bendigo Conservation Area
- Neinei i kura Conservation Area
- Hawea Conservation Area (excluding Lake Hawea faces)
- Hunter River Marginal Strip
- Pisa Conservation Area
- Te Wai-o-koroiko Scenic Reserve
- The Stack Conservation Area

PART E – Southland

E1. The Concessionaire must not undertake the Concession Activity within the Waituna/Awarua Wetland area (Waituna Wetlands Scientific Reserve) during the period 1 May – 31 July (inclusive).

E2. The Concessionaire must only undertake the Concession Activity in the Takitimu Range (Plan MS 5) (Conservation Area - Takitimu Conservation Area and

Conservation Area – Robertson FHF Acquisition) and Tutuko (Plan MS 3) (Fiordland National Park) Topuni Areas as described in the Ngai Tahu Deed of Settlement (Plan MS 264)), subject to the following conditions:

(a) The Concessionaire must remove all animals whole from these areas.

(b) The Concessionaire must not dispose of any human or animal waste within these areas.

E3. Within 10 working days of taking deer (live capture or carcass recovery) from Fiordland National Park, and Fiordland National Park Addition – Cromarty Sections, Conservation Area – Borland Lodge, Fiordland National Park Addition – O'Briens Block, and Conservation Area – Paddock Hill, the Concessionaire must provide the Conservation Services Manager, Te Anau with the GPS waypoints of each deer killed, in an electronic form acceptable to the Grantor.

E4. The Concessionaire must not undertake the Concession Activity in Fiordland National Park within 500 metres each side of the Routeburn, Milford, Kepler, Hollyford and the Hump Ridge Tracks during the annual Great Walks season, which runs from the Saturday of Labour weekend in October through to April 30 (inclusive).

E5. Further to the standard Roar Period Closure in Schedule 4, the Concessionaire must not undertake the Concession Activity in the following areas marked orange during the period 23 March through to 20 April or Easter Monday (inclusive), whichever is the later:

- the Catlins Conservation Park
- Conservation Area – Catlins Conservation Park (proposed addition)
- Conservation Area – Maclennan Forest
- Back Creek (Tahakopa) Marginal Strip
- Glenomaru Valley Scenic Reserve
- Conservation Area – Stott Acquisition
- Conservation Area – Tahakopa (Table Ridge)
- Conservation Area – Tautuku Forest
- Waipati Beach Scenic Reserve
- Tahakopa Bay Scenic Reserve
- Table Hill Scenic Reserve
- Chaslands Scenic Reserve
- Wairepa Scenic Reserve

Department of Conservation
Te Papa Atawhai

Concession Number: -WARS

<u>**Concession – Wild Animal Recovery Operation Permit**</u>

North Island Schedule: ***Deer, pig and goat carcass recovery, and live capture of deer, pig and goat***

THIS CONCESSION is made this day of 2023.

PARTIES:

1. **Minister of Conservation** ("the Grantor")
2. ______________________________ ("the Concessionaire")

BACKGROUND

A. The Grantor administers and manages the public conservation land described in <u>**Schedule 1**</u> (the "Land").

B. Section 22 of the Wild Animal Control Act 1977 authorises the Grantor to grant, in accordance with Part 3B of the Conservation Act 1987, concessions authorising the holder of the concession to engage in wild animal recovery operations and, in so doing, to enter any land that is:

(a) a conservation area;

(b) a national park;

(c) a reserve (but not a reserve vested in an administering body);

(d) a wildlife sanctuary, wildlife refuge or wildlife management reserve under the Wildlife Act 1953;

(e) land to which the National Parks Act 1980 is applied as if the land were a national park.

C. The Concessionaire wishes to carry out the Concession Activity on the Land subject to the terms and conditions of this Concession.

D. The Concessionaire acknowledges that the Land may be the subject of Treaty of Waitangi claims and settlements.

E. The Grantor is satisfied that the requirements of Part 3B of the Conservation Act 1987 and section 23 of the Wild Animal Control Act 1977 have been complied with.

F. The parties wish to record the terms and conditions of the Concession.

OPERATIVE PARTS

G. In exercise of the Grantor's powers under section 22 of the Wild Animal Control Act 1977 and in accordance with Part 3B of the Conservation Act 1987 the Grantor **GRANTS** to the Concessionaire a **WILD ANIMAL RECOVERY OPERATION PERMIT** to carry out the Concession Activity on the Land subject to the terms and conditions contained in this Concession and its Schedules:

Schedule 1: Description of Concession Activity and Related Terms and Conditions

Schedule 2: Standard Conditions

Schedule 3: Special Conditions Applying to Concession Activity

Schedule 4: Roar and Christmas Closure Periods applying to Permitted Zones (coloured green) and Restricted Zones (coloured orange)

Schedule 5: Restricted Zones (coloured orange) where Additional Special Conditions apply

<table>
<tr>
<td>

SIGNED on behalf of the Minister of Conservation by

Sarah Owen
Director Office of Regulatory Services
acting under delegated authority
in the presence of:

Witness Signature

Witness Name

Witness Occupation

Witness Address

A copy of the Instrument of Delegation may be inspected at the Director-General's office at 18-32 Manners Street, Wellington.

</td>
<td>

*(Select **one** only of the following execution clauses and delete the other four)*

SIGNED by *[insert name of Concessionaire if an individual]*

in the presence of:

Witness Signature

Witness Name

Witness Occupation

Witness Address

Or

SIGNED by *[insert name of Company]* Limited by:

Director
[insert name]

Director
[insert name]

Or

NOTE: the following execution clause may only be used if you have checked the Company records at the Companies Office and have confirmed that the Company has only one Director

SIGNED by *[insert name of Company]* Limited by its Director *[insert name]*:

</td>
</tr>
</table>

	__________________________ in the presence of: __________________________ Witness Signature __________________________ Witness Name __________________________ Witness Occupation __________________________ Witness Address Or **SIGNED** on behalf of *[insert name of partnership]* by *[insert name of authorised signatory]* in the presence of: __________________________ Witness Signature __________________________ Witness Name __________________________ Witness Occupation __________________________ Witness Address

SCHEDULE 1

DESCRIPTION OF CONCESSION ACTIVITY AND RELATED TERMS AND CONDITIONS

Item	Title[1]	Description
1.	**Land** *(clause 1)*	(1) The Land over which the Concession Activity in Item 2(a)-(f) inclusive of this Schedule is authorised is that public conservation land identified on maps provided by the Grantor to the Concessionaire to download through a OneDrive link (emailed to the Concessionaire) being the areas shown zoned as:[2] • "Permitted" (coloured green); and • "Restricted" (coloured orange). (2) In addition to the Land identified in (1) above, the Concession Activity in Item 2(g) of this Schedule ONLY is authorised at any site on the public conservation land where the site is legally accessible by motor vehicle, such as a car park or formed road. For the avoidance of doubt, this includes areas on the Land shown zoned as "Not Permitted" (coloured red). (3) Other than as provided for in (2) above, the Concession Activity is NOT AUTHORISED on the public conservation land areas shown zoned as "Not Permitted" (coloured red). *Note: The Minister's delegate made separate decisions on classification of Land over which the Concession Activity is authorised or is not authorised on 1 June 2023.*
2.	**Concession Activity** *(clause 1)*	The use of aircraft (whether or not for hire or reward) to carry out one or more of the following activities: (a) the searching for, shooting, or immobilising of deer, pig or goat; (b) the capture and conveyance of live deer, pig or goat; (c) the recovery of any dead deer, pig, goat or any part of such deer (including velvet), pig, goat for supply to a Ministry for Primary Industries registered primary processor; (d) the recovery of any dead deer, pig, goat or any part of such wild animals for the personal consumption of the Concessionaire or its employees or contractors, only where undertaking the activity in (d); (e) the carriage of persons, supplies, equipment, firearms, ammunition, or other things that may be used for the purposes of any of paragraphs (a), (b), (c) or (d); (f) the use of aircraft to facilitate the offloading of any recovered deer, pig, or goat carcasses to a refrigerated truck or similar vehicle for transport; **BUT EXCLUDES THE FOLLOWING ACTIVITIES:** (1) the live capture or carriage of any wild animal species other than deer, pig or goat;

[1] All references are to clauses in Schedule 2 unless specified.
[2] These areas are indicated on maps publicly available on the DOC website at: [National wild animal recovery operations: Apply for permits (doc.govt.nz)](). Should there be any differences in mapped areas, the information provided by the Department to the Concessionaire through the OneDrive link prevails.

		(2) the carriage of any other dead wild animal species; (3) the carriage of any passenger(s) apart from: i. an employee or contractor of the Concessionaire who is engaged in the Concession Activity, or ii. an employee or agent of the Grantor or the Ministry of Primary Industries or the Civil Aviation Authority where the employee or agent is monitoring or reviewing the Concession Activity. This passenger exclusion includes recreational hunters (whether ground-based or not) and any persons who are providing a guided hunting service; (4) the recovery of any wild animal or part thereof for the purpose of personal consumption other than in the circumstances provided for by (d) above; (5) the recovery of any wild animal for trophy-mounting purposes.
3.	**Aircraft type** *(Schedule 3, special condition 8)*	Prior to undertaking the Concession Activity, the Concessionaire must provide the following details in writing for all aircraft which it intends to use for the Concession Activity: *Aircraft make and model:* *Registration number:* *Colour:*
4.	**Term** *(clause 2)*	x years commencing on xxx 2023 (the commencement date)
5.	**Renewal(s)** *(clause 2)*	Nil / one right of renewal for a period of xxx years
6.	**Final Expiry Date** *(clause 2)*	Xxxx 20xx, being the day before the xxth anniversary of the commencement date /including a right of renewal. *Note: total term including renewals cannot exceed ten (10) years*
7.	**Processing Fee** *(clause 3)*	$x,xxx.00 plus GST
8.	**Concession Fee** *(clause 3)*	$0.00 per annum plus GST *In reliance upon section 17X(f)(i) of the Conservation Act 1987 due to the public/ conservation benefit of the Concession Activity a Concession Fee is not required*
9.	**Management Fee and Monitoring Costs** *(clause 3 and Schedule 3, special condition 35)*	**Management Fee** $x,xxx.00 per annum plus GST **Monitoring Costs** Standard Departmental charge-out rates for staff time and mileage required to monitor the effects of the concession activity and compliance with concession conditions.
10.	**Fee Payment Date** *(clause 3)*	Payable on or before the date specified in any invoice issued by the Grantor.
11.	**Fee Review Date (s)** *(clause 3)*	The third anniversary of the commencement date, and every subsequent third anniversary until the final expiry date.
12.	**Penalty Interest Rate** *(clause 3)*	Double the current Official Cash Rate (OCR). See Reserve Bank of New Zealand website
13.	**Insurance** *(To be obtained by Concessionaire)*	Types and amounts: (a) General Public Liability for an amount no less than NZ$2,000,000.

	(clause 6)	(b) Third Party Motor Vehicle Liability for an amount no less than NZ$1,000,000. (c) Aviation Legal Liability for an amount no less than NZ$2,000,000 Subject to review on each concession fee review date. *Certificates of Insurance Received: Yes/No [delete as appropriate]*
14.	**Addresses for Notices** *(clause 12)*	The Grantor's address is: National Transactions Centre Level 1 John Wickliffe House 265 Princes Street Dunedin 9016 **Postal address** National Transactions Centre P O Box 5244 Dunedin 9054 Phone: (03) 477 0677 Email: TransactionCentre@doc.govt.nz
		The Concessionaire's address in New Zealand is: ____________________________ ____________________________ ____________________________ ____________________________ Phone: Email: *Note: Use street address and postal address*
14.	**Special Conditions** *(clause 15)*	See **Schedules 3, 4 and 5.**

Note: The clause references are to the Standard Conditions set out in Schedule 2 unless otherwise stated.

SCHEDULE 2

STANDARD CONDITIONS

1. Interpretation and Concession Activity

1.1. Terms used in this Concession have the following meanings:

Commencement date means the date stated in Item 4 of Schedule 1.

Concession means this document including all Schedules.

Concession Activity means the activities described in Item 2 of Schedule 1 subject to the exclusions set out in that item.

Concessionaire includes the directors and shareholders if the Concessionaire is a company, the partners if the Concessionaire is a partnership, the trustees if the Concessionaire is a trust, and any employees, contractors, or agents of the Concessionaire.

Grantor means the Minister of Conservation and includes the Director-General of Conservation.

Fee includes the Processing Fee as stated in Item 7 of Schedule 1, Concession Fee as stated in Item 8 of Schedule 1, and Management Fee and Monitoring Costs as stated in Item 9 of Schedule 1

Final Expiry Date means the date stated in Item 6 of Schedule 1.

Land means the areas of public conservation land (including conservation areas, reserves and national parks) described in Item 1 of Schedule 1.

Working day means Monday to Friday inclusive excluding any Public Holidays, including the regional anniversary day for the region where the Concessionaire has its address as stated in Item 14 of Schedule 1.

1.2. The Concessionaire must not use the Land for any purpose other than the Concession Activity. The Concessionaire must not start the Concession Activity until the Concessionaire has signed the Concession and returned a signed copy of the Concession to the Grantor, as if it were a notice given under this Concession.

1.3. The Concessionaire is responsible for the acts and omissions of its employees, contractors, or agents. The Concessionaire is liable under this Concession for any breach of the Concession by its employees, contractors, or agents as if the breach had been committed by the Concessionaire.

2. Term and Renewals (if any)

2.1. The Concession term commences on the Commencement date and ends on the Final Expiry Date.

2.2. If there is a right of renewal, then the Grantor at the Concessionaire's cost must renew the Term for a further period as set out in Item 4 of Schedule 1 provided the Concessionaire:

(a) gives the Grantor at least three month's written notice before the end of the Term, which notice is to be irrevocable, of the Concessionaire's intention to renew this Concession; and

(b) at the time notice is given in accordance with this clause the Concessionaire is not in breach of this Concession.

2.3. The renewal is to be on the same terms and conditions expressed or implied in this Concession except that the Term of this Concession plus all further renewal terms is to expire on or before the Final Expiry Date.

3. Processing Fee, Concession Fee, Management Fee, Monitoring Costs and Review

3.1. The Concessionaire must pay the Processing Fee (Item 7 of Schedule 1) to the Grantor in the manner directed by the Grantor. Except where the Grantor's written consent has been given the Concessionaire cannot commence the Concession Activity until the Processing Fee has been paid.

3.2. The Concessionaire must pay to the Grantor in the manner directed by the Grantor the Concession Fee and the Management Fee (including any monitoring costs) plus GST on the Fee Payment Date(s) as specified in Item 10 of Schedule 1.

3.3. If payment is not made within 14 days of the Fee Payment Date, then the Concessionaire must pay interest on the unpaid Fees from the Fee Payment Date until the date of payment at the Penalty Interest Rate specified in Item 12 of Schedule 1.

3.4. The Grantor must review the Concession and Management Fee on the Fee Review Date specified in Item 11 of Schedule 1. If both parties cannot agree on the new fee within 30 working days of the Grantor's giving the Concessionaire written notice of the review, the provisions of clause 10 of this Schedule (Dispute Resolution) will apply.

4. Protection of Environment

4.1. Except for the purposes that are approved by this Concession, or except as otherwise approved in writing by the Grantor, the Concessionaire **must not**, whether by act or omission:

(a) interfere with, remove, damage, or endanger any natural feature, animal, plant, or historic resource on the Land; or

(b) bring any plant, animal, or firearm on to the Land; or

(c) deposit on the Land:

(i) debris, rubbish or other dangerous or unsightly matter, or contaminate any water body on the Land, and

(ii) 'gut bags' or similar animal bodily waste within 50 metres of any water body, water source, track, road, hut, or any other place likely to be used by members of the public; or

(d) pile or store materials in any place on the Land where it may obstruct the public or create a nuisance; or

(e) conduct any noxious, noisome, dangerous or offensive activity on the Land; or

(f) bury any toilet waste within 50 metres of any water source.

4.2. The Concessionaire must:

(a) take all reasonable precautions to ensure no fire hazard arises from its carrying out of the Concession Activity;

(b) not light or permit to be lit any fire on the Land;

(c) not store, or permit to be stored, fuel or other combustible materials on the Land without the prior written permission of the Grantor. Any storage of fuel and combustible materials must comply with the Hazardous Substances and New Organisms Act 1996;

4.3. Having regard to the Concession Activity, the Concessionaire must ensure it adheres to the international "Leave No Trace" Principles (www.leavenotrace.org.nz).

4.4. The Concessionaire must comply with all guidelines and notices issued by Ministry for Primary Industries on measures to avoid spreading the pest organism *Didymosphenia geminate* ("Didymo"),[3] and/ or any other pest organism identified during the term of this Concession.

4.5. The Grantor may require the Concessionaire to adopt new technology if:

(a) it would be likely to reduce any adverse environmental impact of the Concession Activity; and

(b) the Concessionaire can purchase that new technology and integrate the technology into the Concessionaire's operation without causing the Concessionaire unreasonable cost in the circumstances (i.e. not in excess of $1,000 plus GST).

5. Health and Safety

5.1. The Concessionaire must operate under this Concession in a safe and reliable manner and must comply with the Health and Safety at Work Act 2015 and its regulations and all other provisions or requirements of any competent authority, including the Civil Aviation Authority, relating to the performance of this Concession.

5.2. The Concessionaire must:

(a) eliminate risks to health and safety so far as is reasonably practicable; and

(b) if it is not reasonably practicable to eliminate risks to health and safety, minimise those risks so far as is reasonably practicable.

(c) record and report to the Grantor all accidents or incidents involving serious harm within 24 hours of their occurrence and forward an investigation report to the Grantor within 3 working days of the accident or incident occurring;

(d) at the request of the Grantor make available for interview any of the Concessionaire's directors, employees, contractors or agents who in the opinion of the Grantor might assist any investigation by the Grantor into the cause of any such serious harm accident or incident.

5.3. The Concessionaire must notify the Grantor as soon as practicable of any natural event or activity or other hazard on the Land or the surrounding area of which it is aware, and which may endanger the public or the environment.

6. Indemnities and Insurance

6.1. The Concessionaire agrees to use the Land at the Concessionaire's own risk and releases to the full extent permitted by law the Grantor and the Grantor's employees and agents from all

[3] Refer updated guidance at: https://www.mpi.govt.nz/outdoor-activities/boating-and-watersports-tips-to-prevent-spread-of-pests/check-clean-dry/

claims and demands of any kind and from all liability which may arise in respect of any accident, damage or injury occurring to any person or property in or about the Land.

6.2. The Concessionaire must indemnify the Grantor against all claims, actions, losses and expenses of any nature which the Grantor may suffer or incur or for which the Grantor may become liable arising from the Concessionaire's performance of the Concession Activity.

6.3. This indemnity is to continue after the expiry or other determination of this Concession in respect of those acts or omissions occurring or arising before its expiry or determination.

6.4. The Grantor is not liable and does not accept any responsibility for damage to or interference with the Land, the Concession Activity or any other indirect or consequential damage or loss due to any natural disaster, vandalism, sabotage, fire, or exposure to the elements except where, subject to clause 6.5, such damage or interference is caused by any wilful act or omission of the Grantor, or the Grantor's employees, agents or contractors.

6.5. Where the Grantor is found to be liable in accordance with clause 6.4, the total extent of the Grantor's liability is limited to $1,000,000.

6.6. Despite anything else in clause 6 neither the Grantor nor the Concessionaire are liable for any indirect or consequential damage or loss howsoever caused.

6.7. Without prejudice to or in any way limiting its liability under this clause 6 the Concessionaire, at the Concessionaire's expense, must take out, and keep current with a substantial and reputable insurer, policies for insurance and for amounts not less than the sums specified in Item 13 of Schedule 1.

6.8. After every three year period of the Term the Grantor may, on giving 10 working days' notice to the Concessionaire, alter the amounts of insurance required under clause 6.7. On receiving such notice, the Concessionaire must within 10 working days take out and keep current policies for insurance and for the amounts not less than the sums specified in that notice.

6.9. The Concessionaire must provide to the Grantor within 5 working days of the Grantor so requesting:

(a) details of any insurance policies required to be obtained under this Concession, including any renewal policies if such renewal occurs during the Term; and/ or;

(b) a copy of the current certificate of such policies.

7. Compliance

7.1. The Concessionaire must comply where relevant with:

(a) the provisions of any general policy statement made under the Conservation Act 1987, Reserves Act 1977, National Parks Act 1980, Wild Animal Control Act 1977, or Wildlife Act 1953; or any conservation management strategy or conservation management plan under the Conservation Act 1987 or Part 2A of the Reserves Act 1977; or management plan under section 45 of the National Parks Act 1980, whichever is appropriate to the Land, together with any amendment or review of any policy, strategy or plan whether approved before, on, or after the date on which this Concession takes effect; and

(b) the Conservation Act 1987, the Reserves Act 1977, the National Parks Act 1980, the Wild Animal Control Act 1977 and any other Act, ordinance, regulation, bylaw, or other enactment (collectively the "Legislation") affecting or relating to the Land or affecting or relating to the Concession Activity, including any regulations made under the Conservation Act 1987 or bylaws made under the Reserves Act 1977 or the National Parks Act 1980; and

(c) all notices and requisitions of any responsible authority affecting or relating to the Land or affecting or relating to the conduct of the Concession Activity.

7.2. The Concessionaire must comply with all conditions imposed by the Grantor as set out in this Concession and supply the Grantor with evidence of compliance within three working days of a written request by the Grantor.

7.3. A breach or contravention by the Concessionaire of:

(a) any statement of general policy or any relevant conservation management strategy, conservation management plan, management plan referred to in clause 7.1(a); or

(b) any Legislation affecting or relating to the Land or affecting or relating to the Concession Activity;

is deemed to be a breach of this Concession.

7.4. The Concessionaire, and any pilot of an aircraft operating under this Concession, must:

(a) hold the applicable aviation document and privileges to conduct the Concession Activity under the Civil Aviation Act 1990 (or any Act passed in replacement of that Act) and Rules made under that Act or any replacement Act; and

(b) comply with any, and all, Civil Aviation legal requirements applying to the Concession Activity; and

(c) produce to the Grantor (or the Grantor's delegate), if so requested, and as soon as is reasonably possible, any document or privilege referred to in this clause 7.4(a) and (b).

8. Suspension

8.1. The Grantor may suspend this Concession either in whole or in relation to any part of the Land if, in the Grantor's opinion, there is a temporary risk to any natural or historic resource on, or in the vicinity of, the Land or to public safety whether arising from natural events such as earthquake, land slip, volcanic activity, flood, or arising in any other way, including from the activities of the Concessionaire.

8.2. The Grantor may suspend this Concession either in whole or in relation to any part of the Land if, in the Grantor's opinion, the activities of the Concessionaire are having or may have an adverse effect on the natural, historic or cultural values or resources of the Land and the Grantor considers that the effect can be avoided, remedied or mitigated to an extent satisfactory to the Grantor, until the Concessionaire avoids, remedies or mitigates the adverse effect to the Grantor's satisfaction.

8.3. The Grantor may suspend the Concession either in whole or in relation to any part of the Land for such period as the Grantor determines where the Concessionaire has breached any condition of this Concession, without prejudice to any other rights the Grantor may have.

8.4. The Grantor may suspend this Concession while the Grantor investigates:

(a) any circumstance contemplated in clauses 8.1 and 8.2, or

(b) any potential breach of the Concession under clause 8.3, or

(c) any possible offence by the Concessionaire, whether or not related to the Concession Activity, under the Conservation Act 1987 or any Act mentioned in Schedule 1 of the

Conservation Act; or

(d) any possible offence by the Concessionaire under any other enactment affecting or relating to the Land or which, in the Grantor's opinion, relates to the Concession Activity.

8.5. The Grantor may suspend this Concession while any responsible authority, including the Grantor, undertakes an investigation into the cause of any accident or incident involving serious harm and reported to the Grantor under clause 5.2(c); or while any other responsible authority is undertaking an investigation into a possible offence by the Concessionaire affecting or relating to the Land or which in the Grantor's opinion affects or relates to the Concession Activity.

8.6. The word "investigates" in clauses 8.4 and 8.5 includes the filing of charges and awaiting any decision of a Court or Tribunal.

8.7. The Grantor must notify any temporary suspension of the Concession to the Concessionaire as soon as reasonably practicable. Such suspension shall not take effect until the Grantor has notified the Concessionaire.

8.8. During any period of temporary suspension arising under clauses 8.1 or 8.2 the Concession Fee payable by the Concessionaire is to abate in fair proportion to the loss of use by the Concessionaire of the Land.

8.9. The Grantor is not liable to the Concessionaire for any loss sustained by the Concessionaire by reason of the temporary suspension of the Concession under this clause 8 including loss of profits.

9. Termination

9.1. The Grantor may terminate this Concession either in whole or in part:

(a) by 5 working days' notice to the Concessionaire if any Fee or other money payable to the Grantor under this Concession is in arrears and unpaid for 14 days after any day appointed for payment whether it has been lawfully demanded or not; or

(b) by 14 days' notice to the Concessionaire or such sooner period as it appears necessary and reasonable to the Grantor if:

(i) the Concessionaire breaches any terms of this Concession and, in the Grantor's sole opinion, the breach is able to be rectified; and

(ii) the Grantor has notified the Concessionaire of the breach; and

(iii) the Concessionaire does not rectify the breach within 7 days of receiving notification, or such earlier time as specified by the Grantor; or

(c) by notice in writing to the Concessionaire where the Concessionaire breaches any condition of this Concession and, in the sole opinion of the Grantor, the breach is not capable of being rectified; or

(d) immediately by notice in writing to the Concessionaire where the Concessionaire breaches clause 5 (Health and Safety) or clause 6.7 (Insurance), including where an enquiry into an incident or accident reported by the Concessionaire in accordance with clause 5.2(c) by a responsible authority reveals that a reasonable standard of safety was not maintained, and/or the Concessionaire was negligent; or

(e) by notice in writing to the Concessionaire if the Concessionaire ceases to conduct the Concession Activity or where, in the Grantor's opinion, the conduct of the Concession Activity is manifestly inadequate; or

(f) by notice in writing to the Concessionaire if the Concessionaire is convicted of an offence under:

 (i) the Conservation Act 1987 or any of the Acts listed in Schedule 1 of the Conservation Act; or

 (ii) any other legislation affecting or relating to the Land or which, in the Grantor's opinion, affects or relates to the Concession Activity; or

(g) by notice in writing to the Concessionaire if the Concessionaire or the Guarantor –

 (i) is dissolved; or

 (ii) enters into any composition with or assignment for the benefit of its creditors; or

 (iii) is adjudged bankrupt; or

 (iv) being a company, has a receiver appointed; or

 (v) is put into liquidation; or

 (vi) is placed under statutory management; or

 (vii) has a petition for winding up presented against it; or

 (viii) is otherwise unable to pay its debts as they fall due; or

 (ix) the estate or interest of the Concessionaire is made subject to a Writ of Sale or charging order; or

 (x) the Concessionaire ceases to function or operate; or

(h) immediately if there is, in the sole opinion of the Grantor:

 (i) a permanent risk to public safety or to the natural and historic resources of the Land whether arising from the conduct of the Concession Activity; or

 (ii) from natural causes such as earthquake, land slip, volcanic activity, flood, or

 (iii) arising in any other way whether or not from any breach of this Concession on the part of the Concessionaire.

9.2. The Grantor may exercise its power to terminate under clause 9.1(h) without giving notice.

9.3. The Grantor may exercise the Grantor's right under this clause to terminate the Concession notwithstanding any prior waiver or failure to take action by the Grantor or any indulgence granted by the Grantor for any matter or default.

9.4. Termination of the Concession is not to prejudice or affect the accrued rights or claims and liabilities of the parties.

10. Dispute Resolution

10.1. If a dispute arises between the parties in connection with this Concession the parties must, without prejudice to any other rights or entitlements they may have:

(a) meet to discuss the dispute to see whether the parties can agree to a means to resolve the dispute;

(b) if the parties are unable to resolve the dispute at a meeting, attempt to resolve the dispute by agreement using informal dispute resolution techniques such as negotiation, mediation, independent expert appraisal or any other alternative dispute resolution technique. The rules governing any such technique adopted are to be agreed between the parties, and the parties are to share equally in the costs of any agreed dispute resolution process.

(c) if a dispute is not capable of resolution by agreement within 20 working days of written notice by one party to the other (or such further period as the parties may agree to in writing) either party may refer the dispute to the Disputes Tribunal.

(d) The decision of the Disputes Tribunal is to be final, subject to any remedies available to either party under the Disputes Tribunal Act 1988.

10.2. Despite the existence of a dispute, each party must continue to perform its obligations under this Concession.

11. Assignment

11.1. Notwithstanding any other provision of this Concession, the Concessionaire must not transfer, sub-licence, assign, mortgage or otherwise dispose of the Concessionaire's interest under this Concession or any part of it (which includes the Concessionaire's entering into a contract or any other arrangement of any type whereby the Concession Activity would be carried out by a person other than the Concessionaire) without the prior written consent of the Grantor.

11.2. Sections 17P, 17S, 17SA – 17SE, 17T, 17U, 17W, 17X, 17ZB and 17ZC of the Conservation Act 1987 apply to applications for consent under this clause unless the Grantor, in the Grantor's discretion, decides otherwise.

11.3. If the Grantor gives consent under this clause, the Concessionaire remains liable to observe and perform the terms and conditions of this Concession throughout the Term and must procure from the transferee, contractor, agent or assignee a covenant to be bound by the terms and conditions of this Concession.

11.4. The Concessionaire must pay the costs reasonably incurred by the Grantor incidental to any application for consent, whether or not such consent is granted.

11.5. Where the Concessionaire is a company then any change in company shareholding which would alter the effective control of the Concessionaire is deemed to be an assignment and requires the consent of the Grantor.

12. Notices

12.1. Any notice to be given under this Concession which is required to be in writing is to be made by personal delivery, email or by pre-paid post to the receiving party at the address or email address specified in Item 15 of Schedule 1. Any such notice is to be deemed to have been received:

(a) in the case of personal delivery, on the date of delivery;

(b) in the case of email, on the date of dispatch if that day is a working day and the email is received prior to 5 pm, otherwise on the next working day;

(c) in the case of post, on the 3rd working day after posting.

13. Costs

13.1. The Concessionaire must pay the Grantor's legal costs and expenses and any other administrative costs of, and incidental to, preparing and signing this Concession or any renewal, extension or variation of it.

13.2. The Concessionaire must pay in full immediately and on demand all costs and fees (including solicitor's costs and fees of debt collecting agencies engaged by the Grantor) arising out of and associated with steps taken by the Grantor to enforce, or attempt to enforce, the Grantor's rights and powers under this Concession including the right to recover outstanding money owed to the Grantor.

14. Grantor's Consent or Approval

14.1. Where the Grantor's consent or approval is expressly required under this Concession, or the Concession requires the Grantor to exercise a discretion, the Concessionaire must seek that approval or consent or exercise of discretion for each separate time it is required even if the Grantor may have given approval or consent or exercised a discretion for a like purpose on a prior occasion. Provided the Grantor must act reasonably and within a reasonable time, any such consent or approval or exercise of discretion may be made on such conditions as the Grantor considers appropriate.

15. Special Conditions

15.1. Special conditions are set out in Schedules 3, 4 and 5.

15.2. The standard conditions in this Schedule 2 are subject to the special conditions in Schedules 3, 4 and 5.

16. The Law

16.1. This Concession is governed by the laws of New Zealand.

SCHEDULE 3

Special Conditions Relating to Concession Activity

No priority over the Land

1. This Concession does not give the Concessionaire any priority over other users of the Land to use huts or other public facilities on the Land.

2. The Concessionaire must avoid, where possible, overflying tramping routes, tracks, and other visitor facilities.

3. The Concessionaire must not capture or kill any wild animal with a radio-tracking device attached by a neck collar. If an animal with a collar is shot, the Concessionaire must advise the nearest Department of Conservation office within three working days and return the collar to the office as soon as reasonably practicable.

Use of firearms, ammunition, and associated equipment

4. During the hours of darkness, the Concessionaire must not discharge a firearm or conduct spotlighting operations or use night vision sights or other related equipment while undertaking the Concession Activity.

5. The Concessionaire may only use thermal imaging or similar equipment to undertake the Concession Activity during the hours of daylight.

6. The Concessionaire must ensure, in respect of any person who carries and uses firearms and ammunition as part of undertaking the Concession Activity, that person holds a current firearms licence with relevant endorsements and exemptions as required under the Arms Act 1983.

Aircraft, pilots, and landing requirements

7. Prior to undertaking any flight (take-off and landing) under this Concession, any pilot in command of aircraft on behalf of the Concessionaire must review this Concession.

8. The Concessionaire must only use aircraft to conduct the Concession Activity as specified in Item 3 of Schedule 1 of this Concession, or as notified by the Concessionaire to the Grantor in writing prior to use. The Concessionaire must notify the Grantor of any changes to the aircraft make, model, registration number, or colour(s) before carrying out the Concession Activity using a different aircraft.

9. Where a helicopter is used in carrying out the Concession Activity, the Concessionaire must adhere to the Helicopter Association International "Fly Neighbourly" Guide at all times.

10. Further to Schedule 2 clause 7.4, where the Concessionaire is undertaking the Concession Activity using a Robinson R22 or R44 helicopter, the pilot in command of the aircraft must comply with any safety training requirements for those models of aircraft as may be issued by the Director of Civil Aviation from time to time.[4]

11. Where appropriate the Concessionaire must contact and adhere to the procedures of any relevant aircraft user group e.g., the Mount Cook and Westland National Parks User Group, or the Queenstown Milford User Group.

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[4] At the Commencement Date Notice of Requirement NTC 61.365 is in force requiring pilots complete approved safety training every 24 months: https://www.aviation.govt.nz/safety/safety-advice/helicopter-safety/robinson-helicopter-safety-training/

12. Subject to compliance with Civil Aviation Rules, the Grantor may send any officer of the Department of Conservation to observe any of the activities authorised by this Concession for the purpose of assessing the effects of the Concession Activity.

13. Further to special condition 1 above, the Concessionaire does not have priority use of any landing site located on the Land and may only land if such landing site is clear of other users including recreationalists. If any other aircraft is present on a site, the pilot may land only if no hazard is caused and provided Civil Aviation Rules are complied with.

Supplier contract requirements

14. During the Term the Concessionaire must either hold a current supply contract for the supply of deer, pig, goat carcasses, with a registered Ministry for Primary Industries ("MPI") primary processor **or** have a contract with a marketing entity which holds a current supply contract with a registered MPI primary processor.

15. Where the Concessionaire enters into a contract with a marketing entity, it must be an essential condition of any such contract that the marketing entity holds a current supply contract for the supply of deer, pig, goat carcasses with a registered MPI primary processor at all times.

16. The Concessionaire must ensure that any relevant supply contract remains current whenever the concession activity is undertaken, and the Grantor may seek confirmation of this from any or all of the Concessionaire, the nominated primary processor, or, where relevant, the marketing entity at any time.

17. The Concessionaire must provide evidence of either:

    (a) a current supply contract (for the supply of deer, pig, goat, and chamois carcasses) with a registered MPI primary processor, or

    (b) a current contract with a marketing entity that has a supply contract with a registered MPI primary processor,

    to the Grantor annually on 1 July.

18. The Concessionaire must not take any wild animal that has been hunted or killed in an area defined within the Department of Conservation Pesticide Summaries where it specifies "pesticides have been laid".

19. The Concessionaire authorises the Grantor to contact the MPI primary processor or marketing entity to update any relevant changes to any supply agreement if required.

Temporary Land Restrictions or Exclusions

20. The Concessionaire acknowledges the Grantor may, in his or her discretion at any time, and on giving written notice to the Concessionaire, temporarily rezone any area(s) of the Land as "Restricted" or "Not Permitted" for the purposes of this Concession if the Grantor considers it is necessary to do so for management purposes. In such circumstances the Grantor must:

    (a) notify the Concessionaire as soon as reasonably practicable of the change in Land zoning and the Grantor's reasons for the change; and

    (b) confirm the date when the change in Land zoning will take effect, which must be at least 5 working days after the date of the written notice; and

    The Grantor may also, at his or her discretion, provide the Concessionaire with updated maps for the Land through the OneDrive link (or by such other data sharing method as the Grantor in his or her opinion considers appropriate) and which shall take effect from the date stated by the Grantor.

21. Where, in the Grantor's opinion, the reason for rezoning an area of the Land as "Restricted" or "Not Permitted" ceases to apply, and there is no other reason for continuing to restrict the area from the Concessionaire's use for the Concession Activity, the Grantor must reinstate the area to its previous zoning for use by the Concessionaire under this Concession and notify the Concessionaire of the reinstatement and the date when the reinstatement takes effect.

22. The Grantor is not liable to the Concessionaire for any loss which may be sustained by the Concessionaire by reason of any action being taken under special conditions 20-21 inclusive including loss of profits.

Information requirements

23. The Concessionaire must record a Global Positioning System (GPS) flight track log of all flights conducted while undertaking the Concession Activity. Recording intervals are to be in line with MPI specifications. This data must be stored in line with MPI specifications. The Concessionaire must retain such data for the duration of this Concession and for one year after the final expiry date.

24. The Concessionaire must record GPS waypoints of all animals shot or captured while undertaking the Concession Activity in line with MPI specifications. The Concessionaire must retain such data for the duration of this Concession and for one year after the final expiry date.

25. The Concessionaire must provide returns, within 10 working days of animals being shot or captured while undertaking the Concession Activity, and in an electronic form acceptable to the Grantor, to WAROharvestdata@doc.govt.nz (or such alternative email address as is advised in writing by the Grantor to the Concessionaire). These returns must contain the following information:

    (a) GPS waypoints (X/Y – NZTM coordinates) for flightpaths/ tracked flightlogs in accordance with MPI specifications,

    (b) Location animal killed or captured (X/Y – NZTM coordinates, if not shown by (a) above),

    (c) Date animal is killed or captured,

    (d) animal species name (common name is acceptable),

    (e) sex of animal, and

    (f) provided the Concessionaire usually collects this information, animal age estimate, i.e. adult or yearling.

26. The Grantor may ONLY use the information provided under special condition 25 for compliance, monitoring, and conservation management purposes.

27. The expression "conservation management purposes" as used in special condition 26 means the control of wild animals and the better co-ordination of control measures on the Land (e.g., national vegetation monitoring programme, wild animal population densities).

28. The Grantor must not supply information received under special condition 25 in respect of any Individual Concessionaire to any third party other than a responsible authority (e.g. Police, MPI, Civil Aviation Authority, WorkSafe New Zealand). This special condition is subject to the

Official Information Act 1982 including having regard to any potential prejudice to the commercial position of the Concessionaire.

29. Where requested, the Grantor may provide to third parties summarised information on wild animal numbers and trends derived from returns provided under special condition 25. The Grantor may also publish summaries of similar information on the Department of Conservation website or include this in departmental annual reports or ministerial briefings. Individual Concessionaires should not be identifiable in any such summarised information.

Concession Activity – paragraph (f)

30. When undertaking the activity described in paragraph (f) of the Concession Activity, the Concessionaire must take care to reduce impacts on other users of the Land by operating to minimise disturbance to any such other users.

Review conditions

31. The Grantor may assess the returns provided by the Concessionaire under special condition 25 to determine the total number of animals the Concessionaire has killed or captured on the Land while undertaking the Concession Activity for the previous year ending 30 June.

32. Where the total number of animals the Concessionaire has killed or captured on the Land is fewer than 200 animals in any 12 month period commencing on 1 July and ending on 30 June during the term of this Concession, the Grantor may, at the Grantor's sole option after giving the Concessionaire 14 days' notice, terminate the Concession in whole or in part in accordance with Schedule 2 clause 9.1(e).

33. In considering whether to terminate the Concession under special condition 32, the Grantor must have regard to any matters raised by the Concessionaire (including factors outside the Concessionaire's control and any extenuating personal circumstances).

Live deer conveyance

34. The Concessionaire must only convey live deer to a location in accordance with the Deer Farming Notice No.5, 2008,[5] or any amendment or replacement of that Notice.

Monitoring

35. If the Grantor determines that the conditions of this Concession or the effects of the Concession Activity should be monitored, the Concessionaire shall meet, either:

(a) the full costs of any monitoring programme that is implemented; or

(b) if the Grantor determines that the costs should be apportioned equally among several Concessionaires, part of the costs of the monitoring programme as so apportioned.

These costs will include the Department's standard charge-out rates for staff time and the mileage rates for vehicle use associated with the monitoring programme.

[5] https://gazette.govt.nz/notice/id/2008-go6534

SCHEDULE 4

ROAR AND CHRISTMAS CLOSURE PERIODS APPLYING TO PERMITTED ZONES (COLOURED GREEN) AND RESTRICTED ZONES (COLOURED ORANGE)

The Concessionaire **must not** undertake the Concession Activity on the areas of the Land zoned on maps provided to the Concessionaire by the Grantor as:[6]

- "Permitted" (coloured green), or
- "Restricted" (coloured orange)

during the following periods:

Roar Closure Period	Standard Closure Dates (Inclusive)
Annually during the term	**15 March – 30 April**

Christmas Closure Period	CLOSURE DATES (Inclusive)
Annually during the term	**22 December – 15 January**

[6] Refer Schedule 1, Item 1 – Land

SCHEDULE 5

RESTRICTED ZONES (COLOURED ORANGE) WHERE ADDITIONAL SPECIAL CONDITIONS APPLY

The Concessionaire **must comply** with the following Special Conditions in relation to the specified areas of the Land zoned as "Restricted" (coloured orange) on maps provided to the Concessionaire by the Grantor:[7]

NORTH ISLAND

PART A – Waikato

A1. In addition to the standard closures set out in Schedule 4, the Concessionaire **must not** undertake the Concession Activity during the period between 1 May to 31 July (inclusive) in the following areas:

- Awaroa Swamp Wildlife Management Reserve
- Lake Rotongaro Wildlife Management Reserve
- Lake Whangape Wildlife Management Reserve
- Conservation Area – Lake Ohinewai
- Conservation Area – Lake Rotokawau

PART B – Tongariro/ Taupo

B1. The Concessionaire **may only** undertake the Concession Activity in the areas zoned as "Restricted" in the Kaimanawa Forest Park and the Waingakia Stream Conservation Area during the period between 1 June to 31 October (inclusive). The Concession Activity must not be undertaken in these areas at any other time.

B2. Subject to B3 below, the Concessionaire **may only** undertake the Concession Activity in the areas zoned as "Restricted" in Tongariro National Park and the adjacent areas listed below during the period between 1 May – 31 May (inclusive):

- Highway 47 Conservation Area
- Horopito-Ohakune Rail Conservation Area
- Hospital Conservation Area
- Makatote Scenic Reserve
- Manganui Conservation Area
- Mangaturuturu Viaduct Gravel Local Purpose Reserve
- Matapuna Road Conservation Area
- Moturoa Conservation Area
- Railway Row Conservation Area
- Rangataua Conservation Area
- Taonui Conservation Area

[7] Refer Schedule 1, Item 1 – Land

The Concession Activity must not be undertaken in Tongariro National Park or these areas at any other time.

B3. The Concessionaire **must give** at least 24 hours' notice to the Tongariro National Park Visitor Centre before undertaking the Concession Activity in Tongariro National Park or any of the adjacent areas listed in B2 above.

Note: Contact details for the Tongariro National Park Visitor Centre are –
Physical address: Whakapapa Village, State Highway 48, Mount Ruapehu
Postal: P O Box 71029, Whakapapa Village, Mount Ruapehu 3951
Phone: (07) 892 3729
Email: tongarirovc@doc.govt.nz

PART C – Manawatu/ Whanganui/ Wellington

C1. The Concessionaire **may only** undertake the Concession Activity in the areas zoned as "Restricted" along the Whanganui Journey Great Walk within "The River Trench" in the Whanganui National Park and Mangatiti Landing Local Purpose Reserve during the period between 1 May – 30 September (inclusive). The Concession Activity must not be undertaken in these areas at any other time.

C2. The Concessionaire **may only** undertake the Concession Activity in the areas zoned as "Restricted" in the Ruahine Forest Park and the adjacent areas listed below during the period between 1 May – 30 November (inclusive):

- Awarua Conservation Area
- Ruahine Forest (East) Conservation Area
- Ruahine Forest (West) Conservation Area

The Concession Activity must not be undertaken in the Ruahine Forest Park or these areas at any other time.

C3. The Concessionaire **may only** undertake the Concession Activity in the areas zoned as "Restricted in the Tararua Forest Park during the period between 1 May – 30 September (inclusive). The Concession Activity must not be undertaken in these areas at any other time.

Department of Conservation
Te Papa Atawhai

Concession Number:

Concession Document (Wild Animal Recovery Operation Permit)

North Island Schedule: *Deer, pig and goat carcass recovery and live capture of deer, pig and goat*

THIS CONCESSION is made this day of

PARTIES:

1. **Minister of Conservation** (the Grantor)
2. (the Concessionaire)

BACKGROUND

A. The Grantor administers and manages the public conservation lands described in Schedule 1 (the "Land").

B. Section 22 of the Wild Animal Control Act 1977 authorises the Grantor to grant, in accordance with Part 3B of the Conservation Act 1987, concessions authorising the holder of the concession to engage in wild animal recovery operations and, in so doing, to enter any land that is:

- a conservation area;
- a national park;
- a reserve (but not a reserve vested in an administering body)
- a wildlife sanctuary, wildlife refuge or wildlife management reserve under the Wildlife Act 1953
- land to which the National Parks Act 1980 is applied as if the land were a national park

C. The Concessionaire wishes to carry out the Concession Activity on the Land subject to the terms and conditions of this Document.

D. The Concessionaire acknowledges that the Land may be the subject of Treaty of Waitangi claims and settlements.

E. The Grantor is satisfied that the requirements of Part 3B of the Conservation Act 1987 and section 23 of the Wild Animal Control Act 1977 have been complied with.

F. The parties wish to record the terms and conditions of the Concession in this Document and its Schedules.

OPERATIVE PARTS

G. In exercise of the Grantor's powers under section 22 of the Wild Animal Control Act 1977 and section 17Q of the Conservation Act 1987 the Grantor **GRANTS** to the Concessionaire a **WILD ANIMAL RECOVERY OPERATION PERMIT** to carry out the Concession Activity on the Land subject to the terms and conditions contained in this Document and its Schedules as listed below:

<table>
<tr>
<td>
SIGNED on behalf of the Minister of Conservation by

____
Michael Slater
Deputy Director-General Operations

acting under delegated authority in the presence of:

____
Witness Signature

____
Witness Name

____
Witness Occupation

____
Witness Address

A copy of the Instrument of Delegation may be inspected at the Director-General's office at 18-32 Manners Street, Wellington.
</td>
<td>
(Select one only of the following execution clauses and delete the other four)

SIGNED by [insert name of Concessionaire if an individual] in the presence of:

Witness Signature:
____
Witness Name:
____
Witness Occupation:
____
Witness Address:
____

Or

SIGNED by [insert name of Company] Limited by:

____
Director

____
Director

Or

NOTE: the following execution clause may only be used if you have checked the Company records at the Companies Office and have confirmed that the Company has only one Director

SIGNED by [insert name of Company] Limited by its Director [insert name]:

____

in the presence of:

Witness Signature:_______________________
Witness Name:_______________________
Witness Occupation:_______________________
Witness Address:_______________________

Or

SIGNED on behalf of [insert name of partnership] by [insert name of authorised signatory] in the presence of:

Witness Signature:_______________________
Witness Name:_______________________
</td>
</tr>
</table>

	Witness Occupation:______________________ Witness Address:_________________________ Or The seal of *[insert name of Incorporated Society]* was affixed in the presence of : ________________________________ Authorised Signatory ________________________________ Authorised Signatory

SCHEDULE 1

DEFINITION OF CONCESSION ACTIVITY AND RELATED TERMS AND CONDITIONS

1.	**Land**	The land over which the Concession Activity is authorised being that land identified on the attached CD dated 13 January 2016 which shows areas of land zoned as: • "Permitted" (coloured green) • "Restricted" (coloured orange) Other than in relation to paragraph (g), the Concession Activity MUST NOT take place on any land zoned as: • "Not Permitted" (coloured red) In relation to paragraph (g) ONLY the Concession Activity may occur at additional sites on the Land including land zoned as "Not Permitted" where these sites are legally accessible by motor vehicle, such as car parks and formed roads.
2.	**Concession Activity** *(clause 1)*	The use of aircraft (whether or not for hire or reward) to carry out one or more of the following activities: (a) the searching for, shooting, or immobilising of deer, pig and goat: (b) the searching for, shooting of pig and goat. (c) The recovery of dead deer, pig, and goat or any part of such deer (including velvet), pig and goat for supply to a MPI registered processing facility: (d) The recovery of dead deer, pig or goat or any part of such deer (including velvet), pig or goat for the personal consumption of the Concessionaire or its employees, only where undertaking the activity in (c): (e) The capture and conveyance of live deer, pig or goat: (f) The carriage of persons, supplies, equipment, firearms, ammunition, or other things that may be used for the purposes of paragraph (a) or paragraph (b) or paragraph (c) or paragraph (d) or paragraph (e): (g) The use of aircraft to facilitate the offloading of recovered deer, pig, or goat carcasses to a refrigerated truck or similar vehicle for transport. **BUT EXCLUDING THE FOLLOWING ACTIVITIES** (1) Live capture of any other species of live wild animals. (2) Carriage of any other species of wild animal. (3) Carriage of recreational hunters involved with the searching for, shooting or immobilising and recovery of wild animals (e.g. heli-hunting). (4) Carriage of ground-based hunters who are not

		employees of the Concessionaire. (5) Carriage of individuals who are providing a guided hunting service. (6) Carriage of any passenger other than employees of the Concessionaire who are engaged in the Concession Activity (7) Subject to (d) above the recovery of wild animals for the purpose of personal consumption (8) Recovery of wild animals for trophy mounting purposes
3.	**Aircraft type** *(clause 15)*	The Concessionaire must provide a list of the following details of all aircraft to be used to undertake the Concession activity, prior to the Concession Activity being undertaken: *Aircraft make and model:* *Registration number:* *Colour:*
4.	**Term** *(clause 2)*	3 years commencing on 1 July 2015
5.	**Renewal(s)** *(clause 2)*	*Nil*
6.	**Final Expiry Date** *(clause2)*	30 June 2018
7.	**Concession Fee** *(clause 3)*	$0.00 per annum plus GST *In reliance upon S.17X(f)(i) of the Conservation Act 1987 a Concession Fee is not required*
8.	**Management Fee** *(clause 3)*	$1,000 per annum plus GST
9.	**Fee Payment Date** *(clause 3)*	1 July annually in advance
10.	**Fee Review Date (s)** *(clause 3)*	Does not apply
11.	**Penalty Interest Rate** *(clause 3)*	10% per annum
12.	**Insurance** *(To be obtained by Concessionaire)* *(clause 6)*	A. Types and amounts: (a) General Public Liability for an amount no less than NZ$2,000,000 including Forest & Rural Fires Act Extension with this extension having a sub-limit of no less than NZ$1,000,000. (b) Third Party Motor Vehicle Liability for an amount no less than NZ$1,000,000. (c) Aviation Legal Liability for an amount of no less than NZ$2,000,000 including Forest & Rural Fires Act Extension with this extension having a sub-limit of no less than NZ$1,000,000. B. Other Policies and amounts: n/a

		Certificates of Insurance Received*:* Yes/No *[delete as appropriate]*
13.	**Addresses for Notices** *(clause 12)*	The Grantor's address is: Department of Conservation 70 Moorhouse Avenue Addington Christchurch 8011 Phone: 03 371 3700 Email: permissionschristchurch@doc.govt.nz *NB: Use street address only*
		The Concessionaire's address in New Zealand is: __________________________ __________________________ __________________________ __________________________ *Phone:* *Email:* *NB: Use street address only*
14.	**Special Conditions** *(clause 17)*	See Schedules 3, 4, and 5.

Note: The clause references are to the Standard Terms and Conditions in Schedule 2.

SCHEDULE 2

STANDARD CONDITIONS

1. <u>Concession Activity</u>

1.1. The Concessionaire must not use the Land for any purpose other than the Concession Activity.

1.2. The Concessionaire is responsible for the acts and omissions of its directors, employees, contractors or agents. The Concessionaire is liable under this Concession for any breach of the Concession by its directors, employees, contractors or agents as if the breach had been committed by the Concessionaire.

2. <u>Term and Renewals (if any)</u>

2.1. The Concession term commences on the date set out in Item 4 of Schedule 1 and ends on the Final Expiry Date specified in Item 6 of Schedule 1.

2.2. There is no right to renew this Concession.

3. <u>Concession Fee, Management Fee and Review</u>

3.1. The Concessionaire must pay to the Grantor in advance and in the manner directed by the Grantor the Concession Fee and the Management Fee plus GST on the Fee Payment Date(s) as specified in Item 9 of Schedule 1.

3.2. If payment is not made within 14 days of the Fee Payment Date then the Concessionaire is to pay interest on the unpaid Fees from the Fee Payment Date until the date of payment at the Penalty Interest Rate specified in Item 11 of Schedule 1.

3.3. The Concession and Management Fee are to be reviewed by the Grantor on the Fee Review Date specified in Item 10 of Schedule 1. Both parties are to agree on the new fee within 30 working days of the Grantor giving the Concessionaire written notice of the review. If the parties cannot so agree then the provisions of clause 10 apply.

4. <u>Protection of Environment</u>

4.1. Except for the purposes that are approved by this Concession or except as otherwise approved in writing by the Grantor the Concessionaire must not, whether by act or omission:

(a) interfere with, remove, damage, or endanger the natural features, animals, plants, or historic resources on the Land; or

(b) bring any plants, animals, or firearms on to the Land; or

(c) deposit on the Land debris, rubbish or other dangerous or unsightly matter, or contaminate any water body on the Land; or

(d) pile or store materials in any place on the Land where it may obstruct the public or create a nuisance; or

(e) conduct any noxious, noisome, dangerous or offensive activity on the Land.

4.2. The Concessionaire must:

(a) take all reasonable precautions to ensure no fire hazards arise from its carrying out of the Concession Activity;

(b) not light or permit to be lit any fire on the Land;

(c) not store or permit to be stored fuels or other combustible materials on the Land without the prior written permission of the Grantor. In that event storage of fuels and combustible materials must be in accordance with the provisions of the Hazardous Substances and New Organisms Act 1996;

(d) comply with any of the Grantor's requirements for fire warning and safety equipment and for fire fighting equipment to be kept on the Land at all times.

4.3. Having regard to the Concession Activity, the Concessionaire must ensure it adheres to the international "Leave No Trace" Principles (www.leavenotrace.org.nz).

4.4. The Concessionaire must comply with all guidelines and notices put out by Biosecurity New Zealand regarding measures to avoid spreading the pest organism Didymosphenia geminate ("Didymo"), and or any other pest organism identified during the term of this Concession.

5. Health and Safety

5.1. The Concessionaire must exercise the rights granted by this Concession in a safe and reliable manner and must comply with the Health and Safety in Employment Act 1992 and its regulations and all other provisions or requirements of any competent authority relating to the performance of this Concession.

5.2. The Concessionaire must:

(a) take all reasonable steps to protect the safety of all persons present on the Land in the vicinity of the Concession Activity; and

(b) take all reasonable steps to eliminate any dangers to the public of which the Concessionaire is aware; and

(c) record and report to the Grantor all accidents or incidents involving serious harm within 24 hours of their occurrence and forward an investigation report to the Grantor within 3 working days of the accident or incident occurring;

(d) at the request of the Grantor make available any of the Concessionaire's directors, employees, servants or agents who in the opinion of the Grantor might assist any investigation by the Grantor into the cause of any such serious harm accident or incident.

5.3. The Concessionaire is requested to notify the Grantor as soon as practicable of any natural events or activities on the Land or the surrounding area which may endanger the public or the environment.

6. Indemnities and Insurance

6.1. The Concessionaire agrees to use the Land at the Concessionaire's own risk and releases to the full extent permitted by law the Grantor and the Grantor's employees and agents from all claims and demands of any kind and from all liability which may arise in respect of any accident, damage or injury occurring to any person or property in or about the Land.

6.2. The Concessionaire must indemnify the Grantor against all claims, actions, losses and expenses of any nature which the Grantor may suffer or incur or for which the Grantor may become liable arising from the Concessionaire's performance of the Concession Activity.

6.3. This indemnity is to continue after the expiry or other determination of this Concession in respect of those acts or omissions occurring or arising before its expiry or determination.

6.4. The Grantor is not liable and does not accept any responsibility for damage to or interference with the Land, the Concession Activity or any other indirect or consequential damage or loss due to any natural disaster, vandalism, sabotage, fire, or exposure to the elements except where, subject to clause 6.5, such damage or interference is caused by any wilful act or omission of the Grantor, the Grantor's employees, agents or contractors.

6.5. Where the Grantor is found to be liable in accordance with clause 6.4, the total extent of the Grantor's liability is limited to $1,000,000.

6.6. Despite anything else in clause 6 neither the Grantor nor the Concessionaire are liable for any indirect or consequential damage or loss howsoever caused.

6.7. Without prejudice to or in any way limiting its liability under this clause 6 the Concessionaire at the Concessionaire's expense must take out and keep current policies for insurance and for amounts not less than the sums specified in Item 12 of Schedule 1 with a substantial and reputable insurer.

6.8. After every three year period of the Term the Grantor may, on giving 10 working days notice to the Concessionaire, alter the amounts of insurance required under clause 6.7. On receiving such notice the Concessionaire must within 10 working days take out and keep current policies for insurance and for the amounts not less than the sums specified in that notice.

6.9. The Concessionaire must provide to the Grantor within 5 working days of the Grantor so requesting:

(a) details of any insurance policies required to be obtained under this Concession, including any renewal policies if such renewal occurs during the Term; and/or;

(b) a copy of the current certificate of such policies.

7. Compliance

7.1. The Concessionaire must comply where relevant:

(a) with the provisions of any conservation management strategy or conservation management plan under the Conservation Act 1987 or Part 2A of the Reserves Act 1997, or any general policy statement made under the Conservation Act 1987, or any general policy statement made under the Conservation Act 1987; Reserves Act 1977, National Parks Act 1980, or Wildlife Act 1953, or management plan under section 45 of the National Parks Act 1980, whichever is appropriate to the Land, together with any amendment or review of any policy, strategy or plan whether approved before, on, or after the date on which this Concession takes effect; and

(b) with the Conservation Act 1987, the Reserves Act 1977, the National Parks Act 1980, the Wild Animal Control Act 1977 and any other Act, ordinance, regulation, bylaw, or other enactment (collectively the "Legislation") affecting or relating to the Land or affecting or relating to the Concession Activity, including any regulations made under the Conservation Act 1987 or bylaws made under the Reserves Act 1977 or the National Parks Act 1980; and

(c) with all notices and requisitions of any competent authority affecting or relating to the Land or affecting or relating to the conduct of the Concession Activity.

7.2. The Concessionaire must comply with all conditions imposed by the Grantor in granting this Concession and supply the Grantor with evidence of compliance within three working days of a written request by the Grantor.

7.3. A breach or contravention by the Concessionaire of a relevant conservation management strategy, conservation management plan, management plan or any statement of general policy referred to in clause 7.1(a) is deemed to be a breach of this Concession.

7.4. A breach or contravention by the Concessionaire of any legislation affecting or relating to the Land or affecting or relating to the Concession Activity is deemed to be a breach of this Concession.

7.5. A breach or contravention by the Concessionaire of any notices and requisitions of any competent authority affecting or relating to the Land or affecting or relating to the conduct of the Concession Activity is deemed to be a breach of this Concession.

7.6. The Concessionaire, and any pilot of an aircraft operating under this Concession, must hold the applicable aviation document and privileges to conduct the Concession Activity under the Civil Aviation Rules and must comply with any and all Civil Aviation law requirements applying to the Concession Activity.

8. Suspension

8.1. If, in the Grantor's opinion, there is a temporary risk to any natural or historic resource on or in the vicinity of the Land or to public safety whether arising from natural events such as earthquake, land slip, volcanic activity, flood, or arising in any other way including the activities of the Concessionaire or its employees, then the Grantor may suspend this Concession.

8.2. If, in the Grantor's opinion, the activities of the Concessionaire are having or may have an adverse effect on the natural, historic or cultural values or resources of the Land and the Grantor considers that the effect can be avoided, remedied or mitigated to an extent satisfactory to the Grantor, then the Grantor may suspend this Concession until the Concessionaire avoids, remedies or mitigates the adverse effect to the Grantor's satisfaction.

8.3. The Grantor may suspend the Concession for such period as the Grantor determines where the Concessionaire has breached any terms of this Concession.

8.4. The Grantor may suspend this Concession while the Grantor investigates any of the circumstances contemplated in clauses 8.1 and 8.2, and also while the Grantor investigates any potential breach of the Concession under clause 8.3, or while the Grantor investigates any possible offence by the Concessionaire whether or not related to the Concession Activity under the Conservation Act 1987 or any of the Acts mentioned in the First Schedule of that Act.

8.5. The Grantor may suspend this Concession while any responsible authority, including the Grantor, is undertaking an investigation into the cause of any accident or incident involving serious harm and reported to the Grantor under clause 5.2(c); or while any other responsible authority is undertaking an investigation into a possible offence by the Concessionaire affecting or relating to the Land or which in the Grantor's sole opinion affects or relates to the Concession Activity.

8.6. The word "investigates" in clauses 8.4 and 8.5 includes the laying of charges and awaiting the decision of the Court.

8.7. Any suspension of the Concession may be in full or in part and shall be notified to the Concessionaire as soon as reasonably practicable.

8.8. During any period of suspension arising under clauses 8.1 or 8.2 the Concession Fee payable by the Concessionaire is to abate in fair proportion to the loss of use by the Concessionaire of the Land.

8.9. The Grantor is not to be liable to the Concessionaire for any loss sustained by the Concessionaire by reason of the suspension of the Concession under this clause 8 including loss of profits.

9. Termination

9.1. The Grantor may terminate this Concession either in whole or in part:

(a) by 5 working days notice to the Concessionaire if any Fee or other money payable to the Grantor under this Concession is in arrears and unpaid for 14 days after any of the days appointed for payment whether it has been lawfully demanded or not; or

(b) by 14 days notice to the Concessionaire or such sooner period as it appears necessary and reasonable to the Grantor if-.

(i) the Concessionaire breaches any terms of this Concession and in the Grantor's sole opinion the breach is able to be rectified; and

(ii) the Grantor has notified the Concessionaire of the breach; and

(iii) the Concessionaire does not rectify the breach within 7 days of receiving notification, or such earlier time as specified by the Grantor; or

(c) by notice in writing to the Concessionaire where the Concessionaire breaches any terms of this Concession and in the sole opinion of the Grantor the breach is not capable of being rectified; or

(d) immediately by notice in writing to the Concessionaire where the Concessionaire breaches clauses 5 or 6.7, including where an enquiry into an incident or accident reported by the Concessionaire in accordance with clause 5.2(c) by a responsible authority reveals that a reasonable standard of safety was not maintained and/or the Concessionaire or the Concessionaire's servants, employees or agents were negligent; or

(e) by notice in writing to the Concessionaire if the Concessionaire ceases to conduct the Concession Activity or, in the reasonable opinion of the Grantor, the conduct of the Concession Activity is manifestly inadequate; or

(f) by notice in writing to the Concessionaire if the Concessionaire is convicted of an offence under the Conservation Act 1987 or any of the Acts listed in the First Schedule to that Act or any statute, ordinance, regulation, bylaw, or other enactment affecting or relating to the Land or which in the Grantor's sole opinion affects or relates to the Concession Activity; or

(g) by notice in writing to the Concessionaire if the Concessionaire or the Guarantor is dissolved; or enters into any composition with or assignment for the benefit of its creditors; or is adjudged bankrupt; or being a company, has a receiver appointed; or is put into liquidation; or is placed under statutory management; or has a petition for winding up presented against it; or is otherwise unable to pay its debts as they fall due; or the estate or interest of the Concessionaire is made subject to a Writ of Sale or charging order; or the Concessionaire ceases to function or operate; or

(h) immediately if there is, in the opinion of the Grantor, a permanent risk to public safety or to the natural and historic resources of the Land whether arising from the conduct of the Concession Activity or from natural causes such as earthquake, land slip, volcanic activity, flood, or arising in any other way, whether or not from any breach of the terms of this Concession on the part of the Concessionaire.

9.2. The Grantor may exercise its power to terminate under clause 9.1(h) without giving notice.

9.3. The Grantor may exercise the Grantor's right under this clause to terminate the Concession notwithstanding any prior waiver or failure to take action by the Grantor or any indulgence granted by the Grantor for any matter or default.

9.4. Termination of the Concession is not to prejudice or affect the accrued rights or claims and liabilities of the parties.

10. <u>Dispute Resolution</u>

10.1. If a dispute arises between the parties in connection with this Concession the parties must, without prejudice to any other rights or entitlements they may have, attempt to resolve the dispute by agreement using informal dispute resolution techniques such as negotiation, mediation, independent expert appraisal or any other alternative dispute resolution technique. The rules governing any such technique adopted are to be agreed between the parties.

10.2. If the dispute is not capable of resolution by agreement within 14 days of written notice by one party to the other (or such further period as the parties may agree to in writing) either party may refer the dispute to the Disputes Tribunal, where relevant, or to arbitration which arbitration is to be carried out in accordance with the provisions of the Arbitration Act 1996.

10.3. If the parties do not agree on an arbitrator within 10 working days of a party giving written notice of the requirement to appoint an arbitrator the President of the New Zealand Law Society is to appoint the arbitrator. In either case the arbitrator must not be a person who has participated in an informal dispute resolution procedure in respect of the dispute.

10.4. The arbitrator must include in the arbitration award reasons for the determination.

10.5. The decision of the Disputes Tribunal or of the arbitrator is to be final, subject to any remedies available to either party under the Disputes Tribunal Act 1988 or Arbitration Act 1996.

10.6. Despite the existence of a dispute, each party must continue to perform its obligations under this Concession.

11. Assignment

11.1. The Concessionaire must not transfer, sub licence, assign, mortgage or otherwise dispose of the Concessionaire's interest under this Concession or any part of it (which includes the Concessionaire entering into a contract or any other arrangement whatsoever whereby the Concession Activity would be carried out by a person other than the Concessionaire) without the prior written consent of the Grantor.

11.2. Sections 17P, 17S, 17T, 17U, 17W, 17X, 17ZB and 17ZC of the Conservation Act 1987 apply to applications for consent under this clause unless the Grantor, in the Grantor's discretion, decides otherwise.

11.3. If the Grantor gives consent under this clause the Concessionaire is to remain liable to observe and perform the terms and conditions of this Document throughout the Term and is to procure from the transferee, sub licensee, or assignee a covenant to be bound by the terms and conditions of this Document.

11.4. The Concessionaire must pay the costs reasonably incurred by the Grantor incidental to any application for consent, whether or not such consent is granted.

11.5. If the Concessionaire is not a publicly listed company then any change in the shareholding of the Concessionaire altering the effective control of the Concessionaire requires the consent of the Grantor.

12. Notices

12.1. Any notice to be given under this Concession which is required to be in writing is to be made by personal delivery, email or by pre paid post to the receiving party at the address or email address specified in Item 13 of Schedule 1. Any such notice is to be deemed to have been received:

(a) in the case of personal delivery, on the date of delivery;

(b) in the case of email, on the date of dispatch if that day is a working day and the email is received prior to 5 pm, otherwise on the next working day;

(c) in the case of post, on the 3rd working day after posting.

13. Costs

13.1. The Concessionaire must pay the Grantor's legal costs and expenses of and incidental to preparing and signing this Concession or any renewal, extension or variation of it.

13.2. The Concessionaire must pay in full immediately and on demand all costs and fees (including solicitor's costs and fees of debt collecting agencies engaged by the Grantor) arising out of and associated with steps taken by the Grantor to enforce or attempt to enforce the Grantor's rights and powers under this Concession including the right to recover outstanding money owed to the Grantor.

14. <u>Grantor's Consent or Approval</u>

14.1. Where the Grantor's consent or approval is expressly required under this Concession then the Concessionaire must seek that approval or consent for each separate time it is required even though the Grantor may have given approval or consent for a like purpose on a prior occasion. Any such consent or approval may be made on such conditions as the Grantor considers appropriate.

15. <u>Conditions Relating to the Concession Activity</u>

15.1. This Concession does not confer on the Concessionaire the right to use huts or other public facilities on the Land in priority to other users of the Land.

15.2. The Concessionaire must not capture or kill any wild animal with a radio tracking device attached by a neck collar. If an animal with a collar is accidentally shot the collar should be returned to the nearest Department of Conservation Office

15.3. The Concessionaire must not discharge a firearm during the hours of darkness or conduct spotlighting operations or use night vision sights or other related equipment.

15.4. Before commencing the Concession Activity the Concessionaire must obtain Concessionaire Identification cards from the Grantor. The Concessionaire, its employees and any person acting under the authority of the Concession must carry and display a Concessionaire Identification card when carrying out the Concession Activity. The Concessionaire must obtain sufficient cards to ensure all its employees and people acting under the authority of the concession can carry and display such cards when undertaking the Concession Activity. The Grantor is to supply replacement cards to the Concessionaire on a cost recovery basis.

15.5. The Concessionaire must only use aircraft specified in Item 3 of Schedule 1 of this Concession Document, or as notified in advance to the Grantor, to conduct the Concession Activity. The Concessionaire must notify the Grantor of any changes to the aircraft make, aircraft model, aircraft registration, or aircraft colour(s) before carrying out the Concession Activity.

15.6. Prior to undertaking any flights (take off and landing) under this Concession, any pilot in command of the aircraft on behalf of the Concessionaire shall review this Concession.

15.7. Subject to compliance with Civil Aviation Authority Rules, the Grantor may send any officer of the Department of Conservation to observe any of the activities authorised by this Concession for the purpose of assessing the effects of the Concession Activity.

15.8. The Concessionaire must avoid, where possible, overflying tramping routes, tracks and other visitor facilities.

15.9. The Concessionaire must where a helicopter is used in carrying out the Concession

Activity adhere to the Helicopter Association International "Fly Neighbourly" Guide at all times.

15.10. Where appropriate the Concessionaire must contact and adhere to the procedures of any relevant aircraft user group.

15.11. The Concessionaire does not have priority use of any landing site located on the Land and may only land if such landing site is clear of other users including recreationalists. If other aircraft users are present on the sites the pilot may land only if no hazard is caused and if Civil Aviation Authority regulations are complied with.

16. <u>Land Exclusions</u>

16.1. The Concessionaire acknowledges that the Grantor in his or her discretion may at any time, on giving prior written notice to the Concessionaire, exclude any area of the Land from use under this Concession by the Concessionaire where the Grantor considers it is necessary to do so for any reason, and the Grantor must notify the Concessionaire of its reason for so doing accordingly.

16.2. The Grantor is not to be liable to the Concessionaire for any loss sustained by the Concessionaire by reason of any action being taken under this Clause 16, including loss of profits.

16.3. Where in the Grantor's opinion the reason for excluding the area of the Land ceases to apply and there is no other reason for continuing to exclude the area from the Concessionaire's use, the Grantor must reinstate the area for use by the Concessionaire under this Concession and notify the Concessionaire of the reinstatement.

17. <u>Special Conditions</u>

17.1. Special conditions are set out in Schedules 3, 4 and 5.

17.2. The standard conditions in this Schedule 2 are subject to the special conditions.

18. <u>The Law</u>

18.1. This Concession is governed by New Zealand law.

SCHEDULE 3

SPECIAL CONDITIONS – NORTH ISLAND:
Deer, Pig and Goat Carcass Recovery and Live Deer, Pig and Goat Capture

Supplier contract requirement

1. During the term the Concessionaire must either hold a current supply contract, for the supply of deer, pig, goat carcasses, with a registered MPI processor or have a contract with a marketing entity which holds a current supply contract with a registered MPI processor.

2. Where the Concessionaire enters into a contract with a marketing entity, it shall be an essential condition of any such contract that the marketing entity holds a current supply contract for the supply of deer, pig, goat carcasses with a registered MPI processor at all times.

3. A relevant supply contract must remain current whenever the concession activity is undertaken and the Grantor may seek confirmation of this from any of the Concessionaire, the nominated processor, or, where relevant, the marketing entity at any time.

4. Evidence of a current supply contract (for the supply of deer, pig and goat carcasses) with a registered MPI processor must be provided to the Grantor annually on 1 July. Where relevant evidence of a current contract by the Concessionaire with a marketing entity must also be provided by 1 July.

5. The Concessionaire must not take any wild animal that has been hunted or killed in an area defined within the Department of Conservation Pesticide Summaries where it specifies "pesticides have been laid".

6. The Concessionaire authorises the Grantor to contact the MPI primary processor or marketing entity to update any relevant changes to any supply agreement if required.

Information requirements

7. The Concessionaire must record a Global Positioning System (GPS) flight track log of all flights conducted while undertaking the concession activity. Recording intervals are to be in line with MPI specifications.. This data must be stored in line with MPI specifications. The Concessionaire must retain such data for the duration of this Concession.

8. The Concessionaire must record all GPS waypoints of all animals shot or captured while undertaking the concession activity. One waypoint recorded is to equal one animal captured or shot in line with MPI specifications. The Concessionaire must retain such data for the duration of this Concession.

9. The Concessionaire must provide a return to the Grantor by 30 July in each year during the term of this Concession in relation to any live capture operations under this Concession. The return is to be for the year ending 30 June and the information provided must cover GPS records of all animals captured, including numbers of animals and locations where animals were recovered from. The Grantor may use this information for compliance and or conservation management purposes only.

10. The Concessionaire authorises the Grantor to obtain from any primary processor all supplier declarations and/or GPS records of animals presented (including

numbers of animals, locations where animals were recovered from, types and species of wild animal) individually by the Concessionaire to the processing plant, and the day-to-day manager of the primary processing premises is authorised to supply such information to the Grantor. The Grantor may request this information for compliance and or conservation management purposes only.

11. Conservation management purposes as used in special conditions 9 and 10 means the control of wild animals and the better co-ordination of control measures on public conservation land (e.g. national vegetation monitoring programme, wild animal population densities).

12. Other than as set out above, the Grantor is not to supply the individual Concessionaire information obtained under special conditions 9 and 10 to any third party other than a regulatory or enforcement agency (e.g. Ministry for Primary Industries, Civil Aviation Authority, WorkSafe New Zealand). This special condition is subject to the Official Information Act 1982 including having regard to any potential prejudice to the commercial position of the Concessionaire.

13. The live capture returns required under special condition 9 may be provided in a summarised form to third parties if requested. Individual Concessionaires should not be identifiable in any such summary.

14. The Concessionaire authorises the Grantor to obtain from any primary processor GPS records of animals presented by the Concessionaire to that primary processor (including numbers of animals, locations where animals were recovered from, species of wild animal) in a summarised form, on an annual basis, the day-to-day manager of the primary processing premises is authorised to supply such information to the Grantor. The Grantor may supply this information to third parties if requested. Individual Concessionaires should not be identifiable in any such summary.

15. The Concessionaire must within 3 working days of receiving a request in writing from the Grantor supply the Grantor, for compliance purposes, with any specified GPS flight track logs recorded by the Concessionaire under this Concession.

16. The Concessionaire must within 3 working days of receiving a request in writing from the Grantor make available to the Grantor, for compliance purposes, the Concessionaire's GPS waypoints of all animals shot and recovered for sale to a registered MPI processor, including through a marketing entity.

Concession Activity – paragraph (g) conditions

17. Prior to the Concessionaire using any "Not Permitted" parts of the Land to undertake paragraph (g) of the Concession Activity, the Concessionaire must notify the relevant District Office in writing (including by email) in advance if reasonably practicable, or otherwise within 24 hours of the activity taking place. This notification is for information purposes only.

18. When undertaking paragraph (g) of the Concession Activity, the Concessionaire must take care to minimise impacts on other users of the Land, in particular by operating so as to minimise disturbance to any other users present or nearby on the Land.

Review condition

19. Should the return provided to the Grantor under special condition 9 and the information provided under special condition 10 indicate the Concessionaire has

killed or captured less than 200 animals while undertaking the Concession activity in the previous year ending 31 May, the Grantor may at her sole option after giving the Concessionaire 14 days notice terminate the Concession in whole or in part. In considering whether to terminate under this special condition, the Grantor must have regard to any matters raised by the Concessionaire (including factors outside the Concessionaire's control and any extenuating personal circumstances).

Live deer

20. Live deer can only be conveyed to locations in accordance with the Deer Farming Notice No.5, 2008, or any subsequent amendment to that notice.

SCHEDULE 4

Permitted Zones - Roar and Christmas Closure Periods

The Concession Activity must not take place on the land marked in green on the attached CD dated 13 January 2016 during the term of the Concession during the following periods:

Roar Closure Period	CLOSURE DATES (Inclusive)
Annually during the term	15 March – 30 April

Christmas Closure Period	CLOSURE DATES (Inclusive)
Annually during the term	22 December – 15 January

SCHEDULE 5

Restricted Zones – Special Conditions applying to Parts of the Land

In addition to the standard Roar and Christmas Closure periods set out in Schedule 4, while undertaking the concession activity on those specified parts of the Land shown marked orange on the attached CD dated 13 January 2016, the Concessionaire **must comply** with the following Special Conditions in relation to the parts of the Land shown marked orange:

NORTH ISLAND

PART A – Waikato

A1. The Concessionaire must not undertake the Concession Activity during the period 1 April to 31 July (inclusive) in the following areas marked orange:

- Lake Rotongaro Wildlife Management Reserve
- Awaroa Swamp Wildlife Management Reserve
- Lake Whangape Wildlife Management Reserve
- Conservation Area – Lake Rotokawau
- Conservation Area – Lake Ohinewai

PART B – Tongariro/ Taupo

B1. The Concessionaire must only undertake the Concession Activity in the areas shown marked orange in the Kaimanawa Forest Park during the period 1 June to 31 October (inclusive).

B2. The Concessionaire must only undertake the Concession Activity during the period 1 May to 31 May (inclusive) in the areas shown marked orange in Tongariro National Park and adjacent public conservation land as follows:

- Rangataua Conservation Area,
- Makatote Scenic Reserve,
- Highway 47 Conservation Area,
- Moturoa Conservation Area,
- Mangaturuturu Viaduct Gravel Local Purpose Reserve,
- Manganui Conservation Area,
- Horopito-Ohakune Rail Conservation Area,
- Matapuna Road Conservation Area,
- Taonui Conservation Area,
- Railway Row Conservation Area,
- Hospital Conservation Area)

B3. Prior to the Concessionaire undertaking the Concession Activity in Tongariro National Park and adjacent public conservation land as listed under special condition B2 above, the Concessionaire must give at least 24 hours notice to the Tongariro National Park Visitor Centre, P O Box 71029, Whakapapa Village, Mount Ruapehu 3951, Phone (07) 892 3729 or email tongarirovc@doc.govt.nz.

PART C – East Coast / Bay of Plenty

C1. The Concessionaire must not undertake the Concession Activity in the area shown marked orange in the Awarua Conservation Area during the period 1 July to 31 December (inclusive).

PART D – Manawatu

D1. The Concessionaire must not undertake the Concession Activity in the areas shown marked orange in the Whanganui National Park and Mangatiti Landing Local Purpose Reserve in the area defined as 'The River Trench' during the period 1 October – 30 April (inclusive) annually.

D2. The Concessionaire must only undertake the Concession Activity during the period 1 May to 30 November (inclusive) in the areas shown marked orange in the Ruahine Forest Park and adjacent public conservation land as follows:

- Awarua Conservation Area
- Ruahine Forest (East) Conservation Area and
- Ruahine Forest (West) Conservation Area.

PART E – Wellington / Hawke's Bay

E1. The Concessionaire must not conduct the Concession Activity in the areas shown marked orange in the Tararua Forest Park during the period 1 October to 30 April (inclusive).

Manaaki Whenua
Landcare Research

The effects of deer control on alpine plant browse in Fiordland National Park from 2006–2024

Prepared for: Department of Conservation

October 2024

The effects of deer control on alpine plant browse in Fiordland National Park from 2006–2024

Contract Report: LC4545

[redacted], [redacted], [redacted]

Manaaki Whenua – Landcare Research

Reviewed by:	*Approved for release by:*
[redacted]	[redacted]
Senior Researcher – Ecosystems & Conservation	Portfolio Leader – Plant Biodiversity & Biosecurity
Manaaki Whenua – Landcare Research	Manaaki Whenua – Landcare Research

Contents

Summary

Project and client

- The Department of Conservation (DOC) requested an analysis of deer control and alpine vegetation monitoring data collected from 2006 – 2024 within Fiordland National Park. Deer are controlled in Fiordland National Park under three differing regimes: DOC-led suppression in the Murchison Mountains for the conservation of takahē (*Porphyrio hochstetteri*); maintenance of the wapiti herd quality in the Wapiti Area managed by the Fiordland Wapiti Foundation (FWF); and commercial removal of red deer for the venison market by wild animal recovery operators (WARO) across the remainder of Fiordland National Park.
- This work will help stakeholders to better understand the effectiveness of the three deer control regimes for reducing deer impacts on browse-sensitive alpine plant species and inform whether the trajectory of these regimes is meeting the Fiordland National Park Management Plan goal of promoting the regeneration of browsed indigenous flora.

Objectives

- The overall objective of this report is to determine the relationships between deer browse on monitored alpine plant species, deer activity, and the number and timing of deer harvested within and between the three management areas, over time. Specifically, we used long-term data to quantitatively assess the following five questions.

1. How does hunting effort and harvest rate vary in space and time?
2. Is deer activity related to hunting effort or harvest rate?
3. How does alpine plant browse vary with respect to deer activity, harvest rate and hunting effort?
4. What is the relationship between plant abundance and deer browse?
5. Does the size class structure of *Ranunculus lyallii* (Mount Cook buttercup) change over time, and is this related to deer browse, deer activity and harvest rate?

Methods

- All data were supplied by DOC. Transects to monitor browse on alpine vegetation were established at 54 sites across the three management areas in Fiordland National Park and have been remeasured 2 – 5 times since 2006. At each site, the number of browsed and unbrowsed plants of three palatable species (*Celmisia verbascifolia* subsp. *verbascifolia* – purple-stalked mountain daisy, *Dolichoglottis scorzoneroides* – snow groundsel, and *Ranunculus lyallii*) were recorded. The relative level of deer activity at each site was estimated using the number of pellet groups present.
- The location of all deer shot by helicopter operators within the three management areas was recorded by GPS, with these data used to estimate metrics of annual hunting effort and harvest rate. We also calculated proximity metrics of harvest rate by identifying the number of deer removed within all combinations of three spatial

buffers (1 km, 5 km, 10 km) of each vegetation transect within the preceding 180, 365 and 730 days.

- We assessed the following relationships using generalised linear mixed effects models, focusing on potential differences between the three management areas.
  - Changes in hunting effort, harvest rate, alpine plant abundance and browse over time.
  - Relationships between hunting effort, harvest rate and deer activity (measured as pellet group counts).
  - The relationship between alpine plant browse (each indicator plant species and all species combined) and harvest rates or deer activity.
  - The relationship between alpine plant abundance and proportion of browse for each indicator species and all species combined.
  - Changes in size class of *Ranunculus lyallii* over time and in relation to harvest rate, deer activity or the proportion of browsed *Ranunculus lyallii*.

Results and discussion

- Both hunting effort and deer harvest rate were highly variable over time, particularly with respect to management area. Overall, harvest rates have increased in the Murchison Mountains, decreased in the WARO Area and remained stable in the Wapiti Area since 2006.
- Deer activity significantly declined in the WARO Area as harvest rate increased but there was no significant relationship in the Murchison Mountains or Wapiti Area. These results suggest that the fixed targets for management have not been sufficient to reduce deer activity, while the commercial recovery model was associated with lower deer activity only under favourable economic conditions. While fixed targets are useful for management, the results suggest they should not be relied on to infer environmental outcomes are being attained without supporting outcome data.
- Browse observed on selected alpine plant species was related to deer activity, harvest rate and management area in complex ways. However, browse significantly increased with increasing deer activity for most species in most areas.
- The relationship between plant abundance and browse was highly variable among species, sites and management areas. However, despite high variation in deer activity, harvest rate and browse damage, we did not detect any significant changes in overall plant abundance (total number of plants observed within sites) over time across the three indicator species monitored.
- The proportion of large *Ranunculus lyallii* in populations within a site decreased with increasing deer activity across all management areas. *Ranunculus lyallii* is considered highly sensitive to deer browse and our finding suggest that increasing deer activity, even at the very low deer densities in the Murchison Mountains, is associated with a decline in larger *Ranunculus lyallii* in the most recent survey.

Recommendations

- Collect more detailed information about management activities, particularly helicopter flight logs, to enable better estimation of management effort and the frequency of disturbance to deer.
- Consider using browse metrics to update management targets in the Murchison Mountains and Wapiti Area rather than a fixed harvest target.
- Use harvested deer or deer pellets to determine the relative contribution of the monitored alpine species to deer diet using molecular techniques.
- Widen measurements of the indicator alpine plant species to include demographic measures of plant mortality and reproduction to evaluate long-term population viability.
- Consider including measurement of dominant plant species on monitoring transects to determine whether browse is driven by the palatability of other plant species that co-occur within sites and enable assessment of other drivers of long-term change in alpine communities.

1 Introduction

Non-native (introduced) wild animals, such as deer, can damage vulnerable ecosystems and vegetation. Most management of deer seeks to prevent or reverse these impacts by reducing population size within management areas (e.g. Coomes et al. 2003). Much of the research to date has focused on the effects of deer within indigenous forests on plant biodiversity, or potential carbon sequestration (see reviews of Carswell et al. 2015; Allen et al. 2023; Peltzer & Nugent 2023). Across most studies, the effects of deer are highly variable among sites and rarely linked quantitatively to management efforts (Husheer & Tanentzap 2023; Peltzer et al. 2024). Despite the long-term interest in deer management, relatively little effort has gone into monitoring and understanding their effects in non-forest vegetation including alpine communities.

In the early 20th century, red deer (*Cervus elaphus*) and wapiti (*Cervus canadensis*) were introduced into Fiordland National Park (FNP)[1]. Being adaptable generalist browsers, the deer found the environment highly suitable, leading to a steady increase in their population. By the 1960s, deer numbers had reached peak levels across the park, resulting in significant browsing pressure on both forest and alpine ecosystems (Rose & Platt 1987; Stewart et al. 1987; Mark 1989). However, the establishment of a feral venison industry in the 1960s led to a sharp decline in deer populations (Nugent et al. 1987; Nugent & Sweetapple 1989). Between 1969 and 1984, alpine deer numbers in northern Fiordland dropped by approximately 81% (Nugent et al. 1987), with an overall population reduction of c. 90% from peak levels, and this reduction was sustained for three decades (Challies 1991). Research showed that decreased deer browsing, especially in alpine regions, facilitated partial vegetation recovery in many areas (Rose & Platt 1987; Stewart et al. 1987).

Deer are managed by the Department of Conservation (DOC) in Fiordland under the Fiordland National Park Management Plan (FNPMP) to reduce the impacts of herbivory on sensitive vegetation. This management uses three primary mechanisms (Department of Conservation 2007).

1. Suppression in the Murchison Mountains managed by DOC for the conservation of takahē (*Porphyrio hochstetteri*).
2. Maintenance of the wapiti herd (within acceptable environmental limits) managed by the Fiordland Wapiti Foundation (FWF) through the use of wild animal recovery operators and recreational hunting within the Wapiti Area.
3. Commercial removal of red deer for the venison market by wild animal recovery operators (WARO) across the remainder of Fiordland National Park.

As a consequence, the control of deer in these three areas of Fiordland National Park is driven by different management objectives.

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[1] A glossary of terms and abbreviations is provided in Section 8 at the end of this report.

In some areas, conservation and threatened species management is prioritised, and largely driven by long-term takahē recovery. Red deer have been managed by the New Zealand Government in the Murchison Mountains since 1948 to protect takahē habitat, with a range of control strategies employed over that time. Early control efforts were based on ground control by government cullers, with commercial hunting (both ground and aerial control) becoming more prevalent from the late 1970s. As a result of these management efforts, significant declines in deer numbers were recorded from the 1960s to 1980s. From 2006–2013, deer control in the Murchison Mountains was a mix of ground and aerial control, with a target of 120 animals per year. The management strategy changed to a wild animal recovery model from 2014–2018, with commercial operators removing 120 animals per year over approximately six flights. From 2019– 021, DOC moved to a 'search and destroy' model, where commercial operators removed the target 120 animals per year on a fixed price contract. Finally, DOC led a series of control flights from 2022–2024 to achieve, and in one year significantly exceed, the target level of control with an increased number of flights.

The FWF undertake wapiti management, alongside other conservation activities, in the core area of the wapiti distribution through a community agreement established with DOC (Fiordland Wapiti Foundation 2024). This core area, known as the Wapiti Area, covers 175,000 ha of FNP. The community agreement requires the development of annual Animal Control Plans to achieve the relevant biodiversity objectives in the FNPMP, particularly around the maintenance of browse-sensitive indigenous flora species. The management is funded by the FWF and has required the removal of at least 900 deer each year, intended to benefit both the quality of the herd for recreational hunting and conservation values within the area. Targets are guided by vegetation monitoring results as part of an adaptive management framework established to meet the goals of the community agreement. Herd management has focused on three key aspects: genetics, age, and food availability – with some changes in strategy since the agreement was signed. Early management efforts were largely based on phenotype, with any deer that looked like a red deer removed from the population. Since 2015, female deer have been controlled by phenotype, while most males have been left until they are four years old and then managed for antler quality.

Finally, over extensive areas of Fiordland, deer numbers have been primarily regulated by broad-scale commercial aerial recovery. WARO management is driven by economic factors such as venison prices, processor demand and operational costs. As a consequence, the number of deer harvested by commercial operators has varied dramatically over the decades since the inception of the industry in the late 1960s, with a general decline over the past decade. When commercial returns are low, the number of operators reduces along with the number of deer harvested and the geographic extent they are harvested from (e.g. deer in remoter areas are overlooked in favour of deer closer to collection points that are cheaper to recover). Higher commercial returns result in more deer being removed from the National Park over a wide geographical area.

Each of these control regimes has spanned several decades, and they provide crucial long-term information about changes in both deer activity and conservation outcomes (e.g. Tanentzap et al. 2009). Since 2006, DOC has been monitoring sites established in alpine areas across FNP that are under the three different deer control regimes (Figure 1). The three regimes include areas where deer are controlled by DOC (Murchison Mountains), WARO (Wild Animal Recovery Operators, wider FNP) and FWF (Fiordland Wapiti Foundation, Wapiti Area). Outside the Murchison Mountains and the Wapiti Area, the general approach to deer control across FNP is to encourage commercial recovery operations (WARO), with operators authorised through a concession.

The original purpose of this monitoring program was to evaluate the link between WARO, deer activity, and deer browse patterns across the whole of FNP through time. The subsequent changes in WARO activity and effects on browse, and the inception of the community agreement with the Fiordland Wapiti foundation that established deer harvest targets, occurred after the monitoring programme was established. The monitoring program has since been expanded to enable comparisons of browse and deer activity between different control areas.

The Department of Conservation requested an analysis of deer management and alpine vegetation monitoring data collected from 2006–2024 within FNP. The results and interpretation of key findings from these analyses are to be shared with stakeholders, with a goal of their better understanding the effectiveness of the three deer management regimes (i.e. DOC-led, FWF-led, WARO-led) for reducing deer impacts on selected alpine plant species. This information is also intended to support managers and stakeholders to understand if the trajectory of these management programs is meeting the FNPMP goal of promoting the regeneration of browsed indigenous flora (Department of Conservation 2007).

The purpose of this report is to quantify, in a robust manner, the effectiveness of these three deer management regimes in limiting or reversing deer impacts on selected indigenous alpine plant species.

2 Objectives

The overall objective of this work is to determine the relationships among deer browse on monitored alpine plant species, deer activity, and the number and timing of animals harvested within and between the three management areas over time. Specifically, we used long-term data to quantitatively assess five questions:

1. How does hunting effort and harvest rate vary in space and time?
2. Is deer activity related to hunting effort or harvest rate?
3. How does alpine plant browse vary with respect to deer activity, harvest rate and hunting effort?
4. What is the relationship between plant abundance and browse?
5. Does the size class structure of *Ranunculus lyallii* (Mount Cook buttercup) change over time, and is this related to deer browse, deer activity and harvest rate?

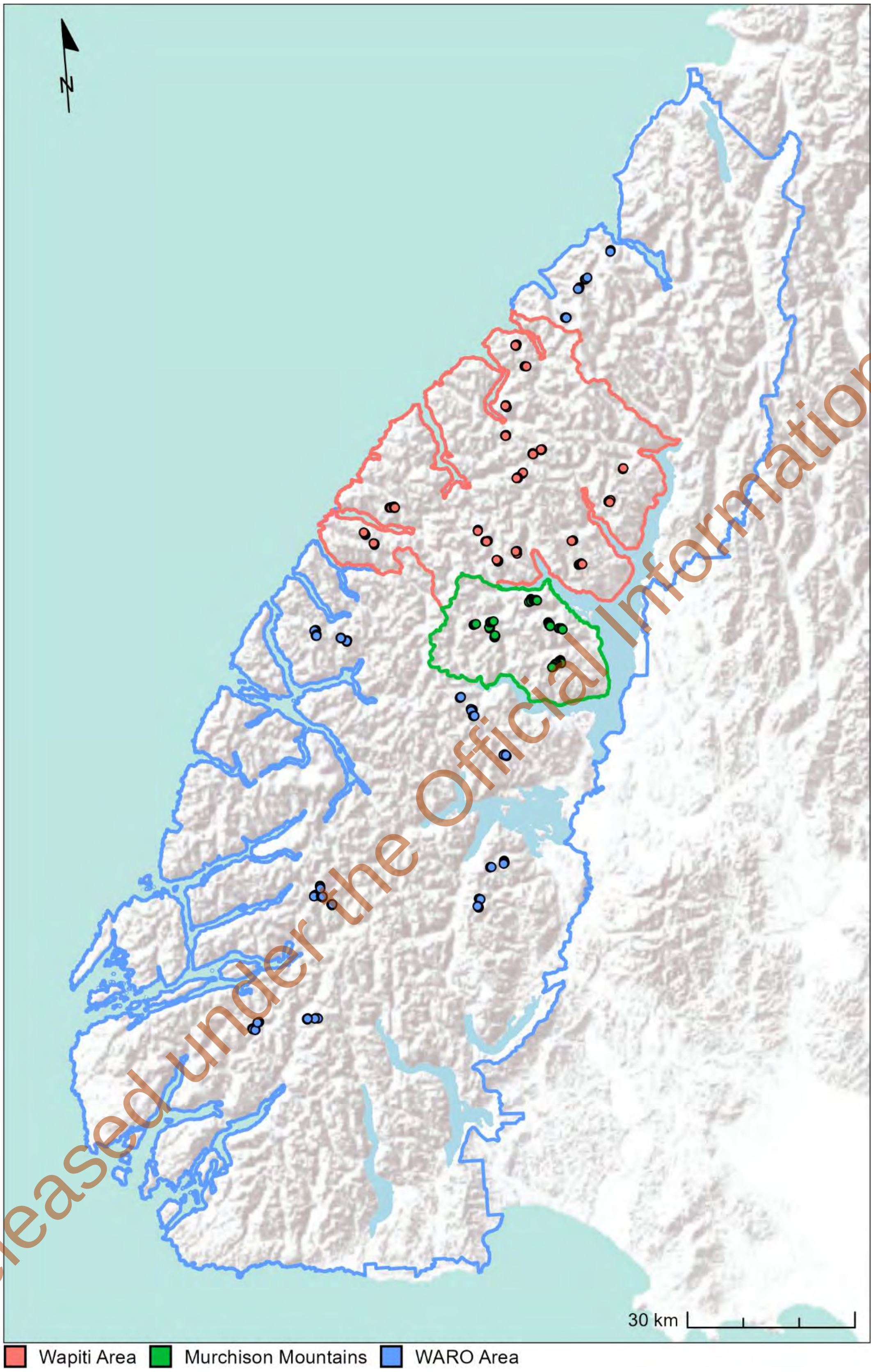

Figure 1. Map of the three management areas (coloured lines) and location of the alpine vegetation monitoring sites (coloured dots). Basemap © Esri — Source: USGS, Esri, TANA, DeLorme, and NPS.

3 Methods

3.1 Study area

We evaluated long-term alpine plant monitoring and operational data from throughout FNP to resolve the five questions posed above. This report focuses on three large management areas in FNP under different deer management regimes (Figure 1): the Murchison Mountains (DOC-led), WARO Area (WARO-led) and Wapiti Area (FWF-led).

Alpine grasslands in Fiordland are generally dominated by snow tussocks (*Chionochloa* spp.). Snow tussocks, along with large herbs and some woody species, are all major components of deer diet in alpine grasslands (Lavers et al. 1983). In Fiordland, deer show a strong preference for grasslands characterised by *Chionochloa pallens* and large-leaved herbs (Rose & Platt 1987).

Several herbaceous species above the treeline that appear to be particularly vulnerable to deer include *Anisotome haastii, Celmisia verbascifolia, Celmisia holosericea, Dolichoglottis scorzoneroides, D. lyallii, Ranunculus lyallii, Ourisia macrophylla, O. macrocarpa* and *Gentiana* spp. (Rose & Platt 1987; Mark 1989; Lee 1990; Lee et al. 2003). Three of these herbaceous species (*Celmisia verbascifolia* subsp. *verbascifolia* [hereafter referred to as *Celmisia verbascifolia*] -– purple-stalked mountain daisy, *Dolichoglottis scorzoneroides* – snow groundsel, and *Ranunculus lyallii* – Mount Cook buttercup) were selected as indicator species due to their widespread abundance across FNP and the ease with which they could be assessed for browse. *Celmisia holosericea* was also recorded at some sites but not consistently across the monitoring period and was, therefore, not considered further in this report.

3.2 Data collection

All data for this report were provided by DOC. We provide a brief description of the data collection methods below.

3.2.1 Alpine vegetation and deer pellet data

Across the three management areas in FNP, twelve subregions were selected in 2005 to represent a range of geographical locations, deer numbers and control histories (Figure 1, Table 1). Within these subregions, 44 sites were initially established in 2006 in habitats representing alpine head basins, terraces or faces based on accessibility and the presence of at least one of the three indicator species. An additional 8 sites were established in the Wapiti Area in 2015 and 2016 to enable more robust long-term comparisons with the other management areas (Ledgard 2018), and an additional 6 sites were established in the Murchison Mountains in 2019. Within each site, 5 browse transects were established and remeasured by DOC. Transects were relocated using GPS coordinates and detailed photographs taken during the first survey. Each transect was measured 2–6 times between 2006 and 2024 (Figure 2). Given that both management operations and alpine surveys were carried out over the austral summer, we use financial year (i.e. July-June) for analyses and when describing results.

On each 50 × 2 m belt transect, the number of browsed and unbrowsed individual rosettes (plants) of each indicator species rooted within the transect area was recorded for rosettes having leaves at least 8 cm long (*Celmisia verbascifolia, Dolichoglottis scorzoneroides*;

Table 2). These size thresholds were selected to balance the ability to detect browse on individual plants likely to be impacted by deer and monitoring efficiency (Lake & Ewans 2005). *Ranunculus lyallii* plants are highly palatable to deer but the seedlings are very low to the ground and difficult for deer to access. This means that monitoring in areas with high deer activity may not portray the impacts of deer accurately as the proportion of browsed plants is often low. Therefore, browsed and unbrowsed *Ranunculus lyallii* plants were counted for individuals in two size classes based on maximum leaf width: 3–8cm and > 8cm. Changes in browse and abundance of plants in each size range over time should reflect the condition of this species in each area more accurately (Lake & Ewans 2007).

Most sites are located away from the main chamois (*Rupicapra rupicapra*) populations identified in FNP. However, on the seven occasions (0.57% of observations) where both deer and chamois pellets were observed at a site, all ungulate browse on indicator species was recorded as deer browse. Insect browse was easily distinguished from deer browse by experienced observers and, where plant damage could not be confidently attributed to ungulates, no browse was recorded.

Table 1. Summary of sample design (number of subregions, sites and transects) and mean number of surveys for each management area. Mean deer pellet groups, proportion of browsed and mean total number of plants (browsed and unbrowsed) for each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*)[2], mean proportion of browsed Ranlya by structural class and mean proportion of large Ranlya (>8cm) with standard deviation (± SD) are calculated by transect across all surveys based on raw data.

Metric	Murchison Mountains	Wapiti Area	WARO Area
Number of subregions	1	5	6
Number of sites	10	20	24
Number of transects	50	100	120
Mean (± SD) number of surveys	2.44 ± 1.37	3.13 ± 1.7	2.99 ± 1.41
Mean deer pellet groups	0.26 ± 0.75	1.07 ± 2.23	0.85 ± 1.77
Mean proportion of browsed Celver	0.08 ± 0.14	0.11 ± 0.16	0.09 ± 0.18
Mean proportion of browsed Ranlya	0.08 ± 0.18	0.08 ± 0.15	0.07 ± 0.12
Mean proportion of browsed Dolsco	0.12 ± 0.22	0.25 ± 0.27	0.20 ± 0.25
Mean number of Celver	210.48 ± 176.10	184.21 ± 179.5	97.25 ± 125.09
Mean number of Ranlya	81.46 ± 95.26	36.28 ± 51.91	46.57 ± 62.08
Mean number of Dolsco	135.22 ± 159.29	69.56 ± 87.85	79.07 ± 114.94
Mean proportion of browsed Ranlya 3 to 8cm	0.04 ± 0.13	0.07 ± 0.15	0.04 ± 0.09
Mean proportion of browsed Ranlya >8cm	0.1 ± 0.19	0.12 ± 0.25	0.1 ± 0.22
Mean proportion of Ranlya >8cm	0.66 ± 0.29	0.20 ± 0.26	0.34 ± 0.32

Table 2. Criteria defining the three indicator plant species monitored for alpine deer browse. Individual plants were only recorded if the leaf size was greater than or equal to the specified metric size threshold.

Indicator species	Metric	Size threshold (cm)
Celmisia verbascifolia	Leaf length	8
Dolichoglottis scorzoneroides	Leaf length	8
Ranunculus lyallii	Leaf width	3 – 8 & >8

[2] See also glossary of terms and abbreviations provided in Section 8 at the end of this report.

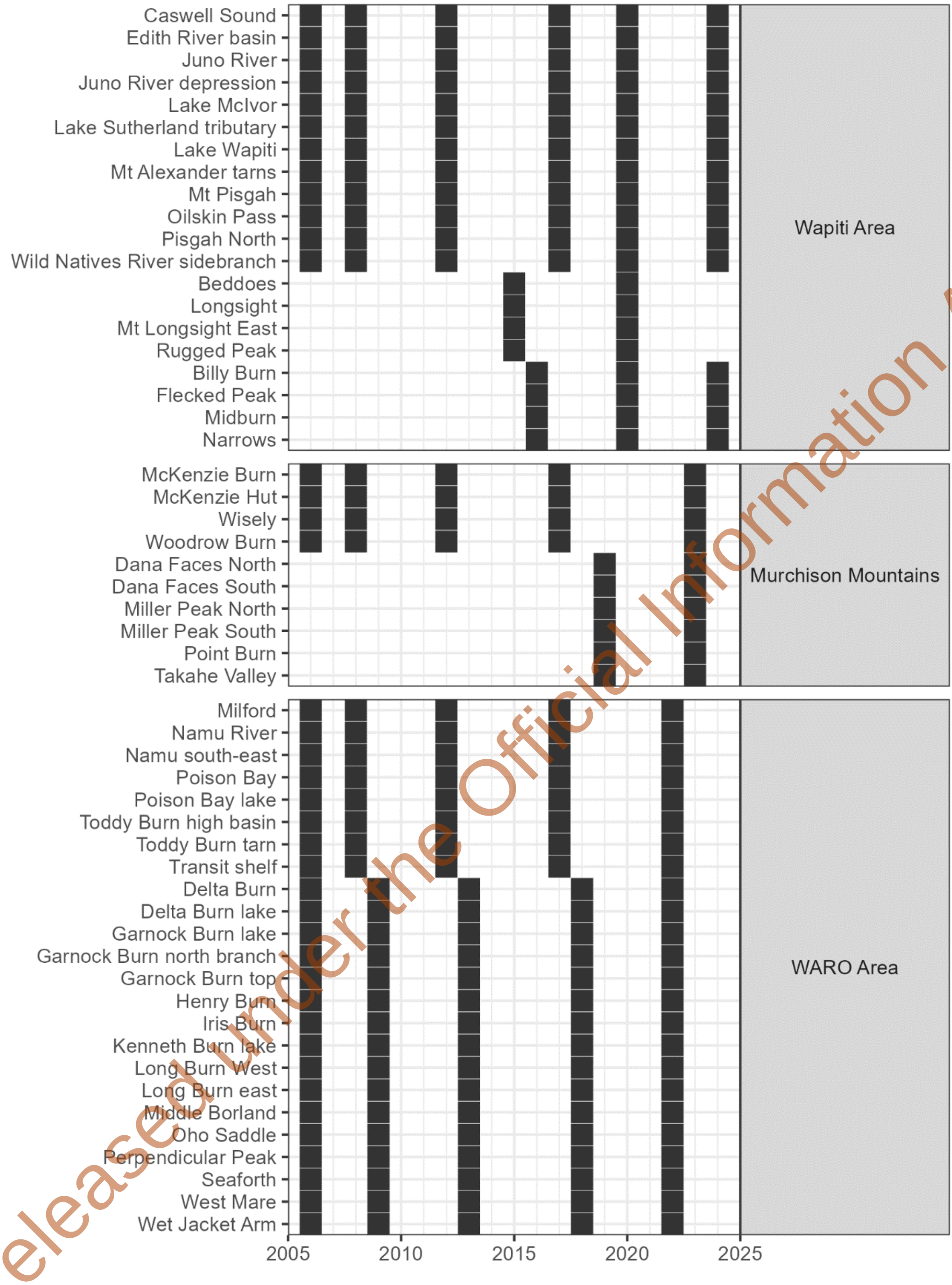

Figure 2. The timing of browse surveys (*x*-axis, black cells) within sites (*y*-axis) grouped by management area (grey cells). Five alpine transects were monitored within each site on each sampling date. Data were grouped into distinct survey periods for each management area when the monitoring occurred over consecutive years (e.g. sites measured in the WARO Area in 2008 and 2009 were grouped into one survey period).

The number of deer pellet groups per transect was also recorded. A pellet group has been previously defined as 'intact pellets voided in the same defecation' (see section 3.3.3 in Forsyth 2005). Here, all deer pellet groups were counted regardless of whether pellets were intact or not. This metric provides a relative index of deer activity in the absence of counts of individual animals (Forsyth et al. 2011; Moloney et al. 2021).

For each indicator plant species, and for all species combined, we calculated the total number of plants by summing the number of browsed and unbrowsed plants; and we calculated the proportion of browsed plants by dividing the number of browsed plants by the total number of plants. We used a similar method to calculate the proportion of large *Ranunculus lyallii* (leaf width >8 cm; hereafter referred as 'large Ranlya') by first calculating the total number of *Ranunculus lyallii* by size class (large Ranlya: > 8cm leaf width, and small Ranlya: 3–8 cm leaf width), combining browsed and unbrowsed plants; and then dividing the number of large Ranlya by the total number of Ranlya.

Because not all sites within a management area were always measured in the same year (Figure 2), we pooled data in consecutive years into discrete survey periods to better reflect the overall values of the deer pellet groups, alpine plant abundance and browse within each management area. These survey periods were included in some of the statistical analyses described in Section 3.3 below.

3.2.2 Hunting effort and harvest rate

The date and location of each deer harvested during aerial hunting operations within each management area was collected by helicopter operators between 2006–2024 and provided to DOC. However, the GPS tracks of each helicopter flight were not available. Additional information on the total number of deer harvested and the number of operational flights within the Murchison Mountains in each financial year (July–June) between 2002 and 2005 was collated by DOC from annual reports. A small number of harvest records (1,110 or 1.7% of all records) were missing dates, although the financial year in which they occurred was known. Missing dates were imputed by randomly selecting a day of the year from the known distribution for each management area, whereby days (1–365) that were more commonly hunted were more likely to be selected. An additional 189 records for the 2022/2023 financial year were known to be missing from the Wapiti Area s9(2)(g)(ii) DOC, pers. comm., 13 August 2024). These records were included in the total number of deer removed and were assigned an imputed date. However, they were not included in any calculations that required their spatial location to be known. A further 221 records (0.3%) were also excluded from the proximity metrics due to missing location data.

The harvest data were summarised to generate annual metrics of hunting effort (operator days per year) and harvest rate (deer removed per year) within each management area from July–June. In addition, we generated area-scaled versions of these metrics by dividing by the total huntable region within each management area (operator days per year per km^2, deer removed per year per km^2), where the huntable region for helicopters was considered to be any habitat within the following vegetation classes in the Land Cover Database (Manaaki Whenua – Landcare Research 2020, Version 5): alpine grass/herbfield, gravel or rock, landslide, sub alpine shrubland, or tall tussock grassland.

Because the proximity of harvest in both space and time to the vegetation browse monitoring sites could influence the likelihood of browse (i.e. by creating a 'landscape of fear' to aerial operations; Latham et al. 2018), we also generated a range of harvest rate proximity metrics that calculated the number of deer removed within a specified number of days preceding the vegetation monitoring and within a specified spatial buffer of the site location. We considered time windows of 180, 365 and 730 days before the vegetation monitoring and spatial buffers of 1 km, 5 km and 10 km, calculating harvest rates (deer removed per km^2) for all combinations (e.g. the number of deer removed within 1 km of a site in the 180 days before the vegetation monitoring). However, we were unable to calculate these metrics for years where we were missing data for a period within the time window (e.g. harvest records prior to 2006). We also calculated hunting effort (operator days per km^2) within the same time windows for each management area. However, because we did not have the GPS tracks for the operational helicopter flights, we were unable to calculate effort within the spatial buffers. These metrics are subsequently referred to as 'proximity metrics' (see Glossary)

3.3 Statistical analyses

All statistical analyses were conducted in R (R Core Team 2024, Version 4.4.0). A brief description of the general modelling approach used to develop and assess the statistical models generated for this report is described below, with specific model details described under each section.

For each response variable (described in more detail below), we first used the *fitdistrplus* package (Delignette-Muller 2015) to identify the most appropriate distribution to use for subsequent modelling. We then developed a candidate set of models that included all sensible combinations of the available predictor variables required to answer the specific question. Individual models were developed using the *glmmTMB* package (Brooks et al. 2017) and the best model within the candidate set was identified as the model with the lowest corrected Akaike's Information Criterion (AICc) value using the *MuMIn* package (Bartoń 2024). The best model for each response was assessed to ensure that it met assumptions of homoscedasticity, overdispersion and zero-inflation using the *DHARMa* package (Hartig 2022). We identified significant covariates using a Wald chi-square test with the *Anova* function from the *car* package (Fox & Weisberg 2019). Model predictions for the significant fixed effects were generated using the *ggeffects* package (Lüdecke 2018) and plotted against the raw data to visualise the relationships. Post-hoc analyses were conducted using the *emmeans* package (Lenth 2024) to identify significant differences between groups (e.g. pairwise comparisons between survey periods or management areas).

All work was conducted within a version-controlled git repository and this repository was made available to DOC at the completion of the contract. This approach was adopted to ensure the entire workflow from raw data through to the production and presentation of results in this report is transparent and reproducible. All data and code are available upon request.

3.3.1 How does hunting effort and harvest rate vary in space and time?

To understand how hunting effort and harvest rate changed over time and space within FNP, we developed a series of generalised linear models (GLM) that included management area and year (as a continuous variable) as fixed effects. We developed an initial candidate set of models that used a negative binomial distribution to assess two response variables: total annual hunting effort (operator days) and total annual harvest rate (animals removed).

We then fitted a second candidate set of models with a Gaussian distribution where the response variables were the annual hunting effort and harvest rate scaled by the huntable region within each management area (operator days per km^2 and deer removed per km^2, respectively).

Finally, we assessed the relationship between annual harvest rate and hunting effort to determine if there were differences in the apparent efficiency of hunting among the management areas. We developed a candidate set of models using generalised linear mixed-effects models (GLMM) for the total annual and area-scaled metrics, with negative binomial and Gaussian distributions, respectively. Annual hunting effort and management area were included as fixed effects, while year (as a continuous variable) was included as a random effect.

3.3.2 Is deer activity related to hunting effort or harvest rate?

The number of faecal pellet groups is often used as an indicator of the likely browsing pressure of ungulates at a site, with higher values typically associated with higher deer activity and densities of animals. Therefore, it is often assumed that higher rates of hunting effort or harvest will reduce the number of pellet groups at a site.

We assessed the relationship between deer activity (measured as the number of pellet groups) and harvest rate by developing a candidate set of GLMMs that included management area and each of the harvest proximity metrics. All models were fitted with a negative binomial distribution, with line nested within site included as a random effect.

3.3.3 How does alpine plant browse vary with respect to deer activity, harvest rate and hunting effort?

For each indicator plant species and all species combined, we investigated the relationship between the proportion of browsed plants and deer activity (measured as the number of pellet groups), harvest rate or hunting effort. We ran zero-inflated and non-zero-inflated GLMMs with a binomial error distribution. To account for the survey design (Table 1), site nested within subregion, line or site by itself, and survey period were included in the models as random factors. Due to high correlation between some variables of interest, we ran multiple models across and within management areas including only one variable of interest – and then retained the best-fitting model per category (e.g. pellet groups, harvest rate and hunting effort) based on AICc values and model diagnostics.

As we were not able to calculate variables corresponding to harvest rates within a buffer for the first two surveys in the Murchison Mountains, we excluded the 2006 and 2008 surveys for all management areas *only* when comparing the relevance of the different variables of interest for predicting alpine plant browse. We were unable to investigate the role of hunting effort as most models failed to converge for some combinations of management area and alpine plant species.

3.3.4 What is the relationship between plant abundance and browse?

For each indicator plant species and all species combined, we investigated the relationship between plant abundance and the proportion of browsed plants within and across management area (modelled with or without an interaction term). We ran zero-inflated and non-zero-inflated GLMM with either Poisson or negative-binomial error distribution. Line nested within site, line or site by itself, and survey period were included in the models as random factors. Due to the poor fit of the models predicting the abundance of alpine plants, the total number of alpine plants per transect was log-transformed (i.e. $\log(x+1)$) before being used as a response variable in a GLMM with a Gaussian error distribution. Multiple models were run with a combination of predictor variables including management area modelled with or without an interaction term with the proportion of browsed plants. The best-fitting model was selected based on AICc values and model diagnostics.

3.3.5 How does alpine plant browse and plant abundance change over time?

To investigate changes in alpine plant browse and abundance between survey periods, we ran a GLMM for each indicator species and management area separately with site, line nested within site, or line included as a random factors; and with survey period included as an explanatory variable. For models predicting plant browse, both the zero-inflated and non zero-inflated models were fitted with a binomial error distribution. For models predicting plant abundance, the models were fit with either a negative-binomial or zero-inflated negative binomial error distribution. The best-fitting model was selected based on AICc values and model diagnostics.

3.3.6 Does the size class structure of *Ranunculus lyallii* change over time, and is this related to browse, deer activity and harvest?

We assessed the relationship between the size class structure of *Ranunculus lyallii* and deer activity and harvest by focusing on the proportion of large *Ranunculus lyallii* (leaf width > 8cm) within the total observed plants in each transect. We ran a GLMM with a binomial or zero-inflated binomial distribution and line nested within site or line by itself and survey period included as random factors. The proportion of large *Ranunculus lyallii* was predicted from the proportion of browsed *Ranunculus lyallii*, pellet groups, or harvest rate with or without an interaction term with management area.

We investigated whether the size class structure of *Ranunculus lyallii* changed over time by running a GLMM with a binomial distribution with line nested within site included as a random factor. The survey period was included as a discrete explanatory variable. The survey period including the calendar year 2006 was not included in this analysis as the size class structure of *Ranunculus lyallii* was not recorded at that time. Model diagnostics confirmed that zero-inflated binomial models were not required.

4 Results

4.1 How does hunting effort and harvest rate vary in space and time?

Approximately 65,200 deer were removed from FNP for management purposes between July 2006 and June 2024. Annual hunting effort varied across the three management areas, with the highest average total values observed in the WARO Area (Table 3). However, the average area-scaled hunting effort was similar across the management areas, ranging from 0.05–0.07 operator days per km^2 of alpine habitat. The highest annual harvest rates were observed in the WARO Area, with 2,623 deer removed on average per year. In comparison, an average of 110 and 903 deer were removed from the Murchison Mountains and Wapiti Area, respectively. The highest area-scaled harvest rate was observed within the Wapiti Area, with an average of 1.59 deer removed per km^2 of alpine habitat.

Table 3. Mean (± SD) annual hunting effort (operator days) and harvest rate (deer removed) within the three management areas.

Management area	Annual hunting effort		Annual harvest rate	
	Total	Per km^2	Total	Per km^2
Wapiti Area	48.06 ± 13.57	0.08 ± 0.02	903.11 ± 200.15	1.59 ± 0.35
Murchison Mountains	10.47 ± 8.85	0.05 ± 0.04	102.18 ± 59.31	0.49 ± 0.28
WARO Area	199.89 ± 147.63	0.07 ± 0.05	2623.56 ± 1320.68	0.93 ± 0.47

Hunting effort and annual harvest rates (Figure 3) also varied over time and space, with the best models describing temporal trends including a significant interaction between year and management area (Table in Appendix 1).[3] For example, temporal trends in hunting effort varied between management areas (Figure 4a, Table 4), with significant declines over time in both total annual hunting effort and area-scaled effort in the Murchison Mountains and WARO Area. However, no significant change was observed in the Wapiti Area for either metric of annual hunting effort.

Harvest rate also varied between management areas over time (Figure 4b, Table 4), with both total annual harvests and area-scaled harvests increasing significantly over time in the Murchison Mountains and significantly decreasing in the WARO Area. No significant change was observed in the Wapiti Area for either metric of annual harvest rate.

[3] Tables and figures in appendices are prefixed by the letter A and the relevant appendix number, and numbered within each appendix (e.g. Table A1.1 is the first table in Appendix 1, Tables A2.1–A2.x are the first to xth tables in Appendix 2.

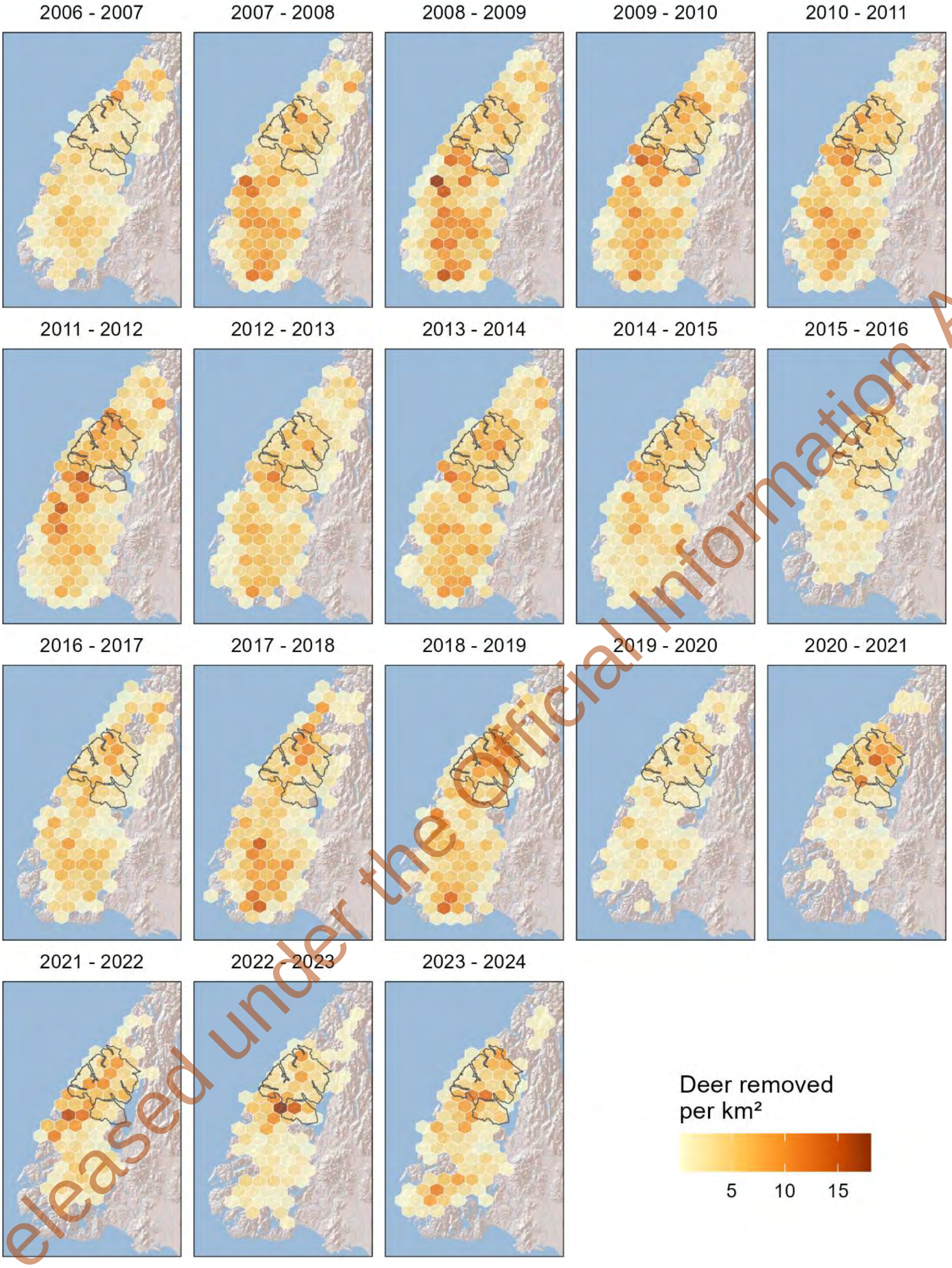

Figure 3. The harvest rate (deer removed per km^2) across Fiordland National Park from 2006–2024, where each panel represents one financial year (1 July to 30 June). Each hexagon covers an area of 10 km^2, and missing hexagons indicate zero recorded kills in that location. The boundaries for the Murchison Mountains and Wapiti Area are shown (see Figure 1 for more details). Tiles © Esri — Source: Esri.

Table 4. Relationship between management area and year for four response variables relating to annual hunting effort and harvest rate. Shading indicates management areas with significant positive (orange) or negative (blue) relationships. Estimate (± SEM) values for year represent the direction and magnitude of the slope (Figure 4), with the estimates for total annual effort and harvest rate presented on the log scale. The error distribution used is shown under each model, with the full candidate model sets provided in Table in Appendix 1.

Response	Model	Management area	Estimate ± SEM	Statistic	p value
Annual effort	year (Negative binomial)	Wapiti Area	-0.026 ± 0.018	-1.467	0.142
		Murchison Mountains	-0.090 ± 0.023	-3.964	<0.001
		WARO Area	-0.154 ± 0.018	-8.690	<0.001
Annual effort per km²	year (Gaussian)	Wapiti Area	-0.002 ± 0.001	-1.614	0.113
		Murchison Mountains	-0.005 ± 0.001	-3.497	0.001
		WARO Area	-0.008 ± 0.001	-6.638	<0.001
Annual harvest	year (Negative binomial)	Wapiti Area	0.015 ± 0.022	0.690	0.490
		Murchison Mountains	0.058 ± 0.022	2.668	0.008
		WARO Area	-0.076 ± 0.022	-3.459	0.001
Annual harvest per km²	year (Gaussian)	Wapiti Area	0.023 ± 0.013	1.720	0.092
		Murchison Mountains	0.030 ± 0.014	2.156	0.036
		WARO Area	-0.063 ± 0.013	-4.737	<0.001

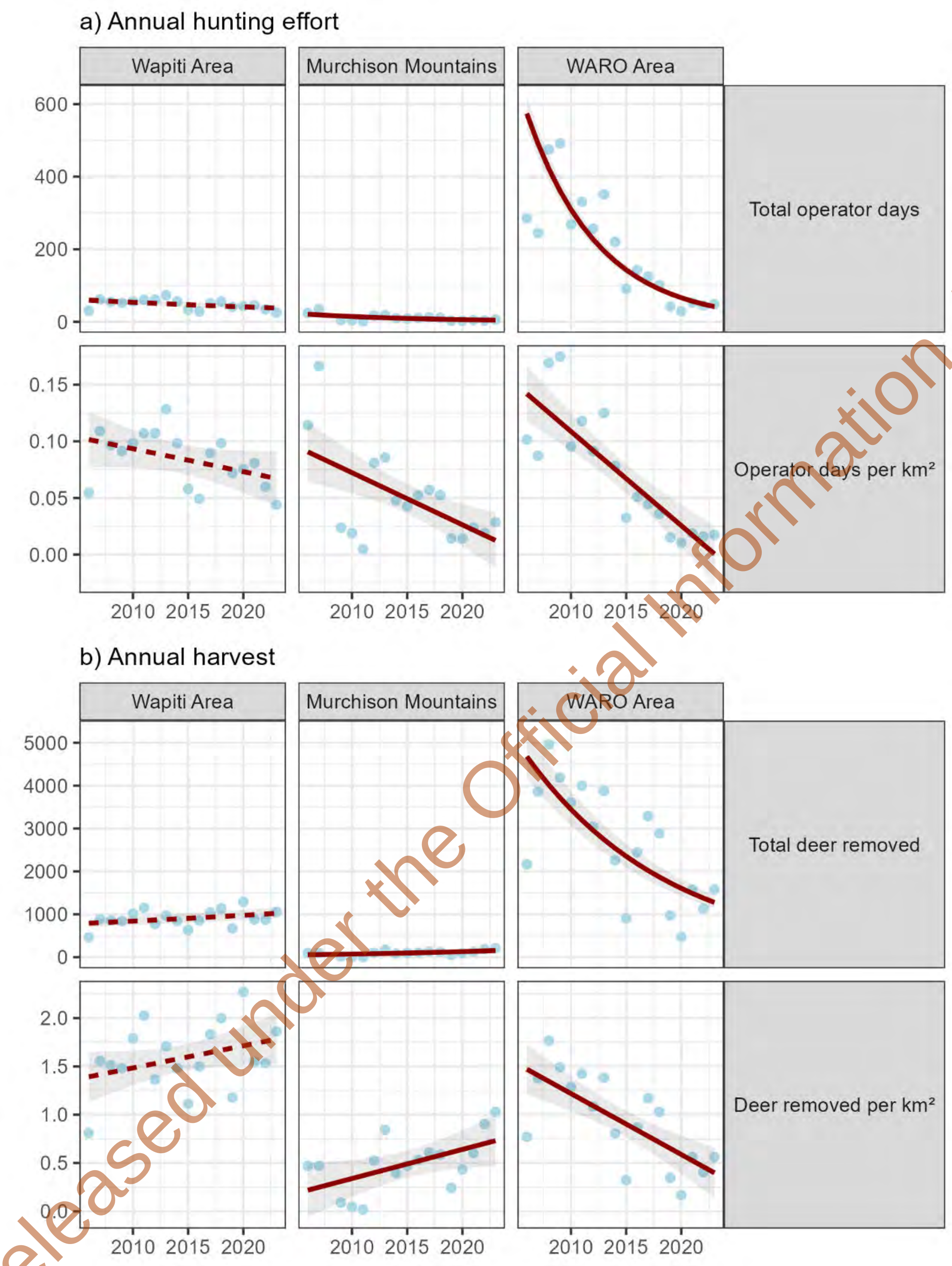

Figure 4. Annual data within the three management areas: a) hunting effort; b) deer harvest. Blue points show the annual data, while red lines represent the regression line (± 95% confidence intervals, shown by grey shading) derived from a GLM, where a separate model was fitted for each response variable (Table 4). Solid lines indicate a significant slope, while dashed lines indicate a non-significant slope at α = 0.05.

The best model predicting the relationship between area-scaled harvest rate and area-scaled hunting effort included management area, with year as a random effect (see Table A1.2). There was a significant interaction between hunting effort and management area, with a significant increase in harvest rate observed with increasing effort in the WARO Area (Figure 5, Table 5). However, there no significant relationships were observed in the Murchison Mountains or Wapiti Area.

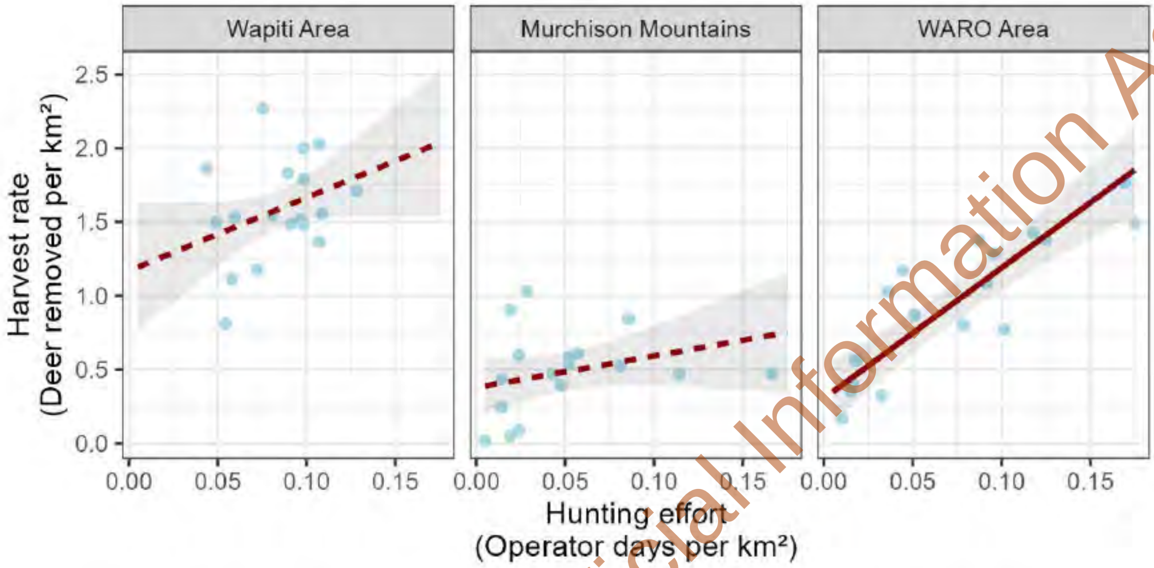

Figure 5. The relationship between area-scaled annual harvest rate and hunting effort. Blue points show the annual data, while the lines represent the regression line (± 95% confidence intervals, shown by grey shading) derived from a GLM (Table 5).

Table 5. Relationship between management area and hunting effort with respect to annual harvest rate. Shading indicates management areas with significant positive (orange) relationships. Estimate (± SEM) values represent the direction and magnitude of the slope (Figure 5). The model used a Gaussian error distribution, with the full candidate model set provided in Table (in Appendix 1).

Model	Management area	Estimate ± SEM	Statistic	p value
annual effort per km^2 * management area +(1 | year) (Gaussian)	Wapiti Area	4.957 ± 2.685	1.846	0.071
	Murchison Mountains	2.134 ± 1.583	1.348	0.184
	WARO Area	8.846 ± 1.330	6.653	<0.001

4.2 Is deer activity related to hunting effort or harvest rate?

The number of pellet groups are typically associated with the density or activity levels of ungulates, so it would be expected that high hunting effort or harvest rate should result in lower numbers of pellet groups. The best predictor of deer pellet groups was the harvest rate within a 5 km buffer of each site in the preceding two years (Table A2.1 in Appendix 2). Overall, there was a significant interaction between management area and the harvest metric, with deer pellets significantly decreasing in the WARO Area as the harvest rate increased (Figure 6, Table 6). However, no significant relationships were observed in the Murchison Mountains or Wapiti Area.

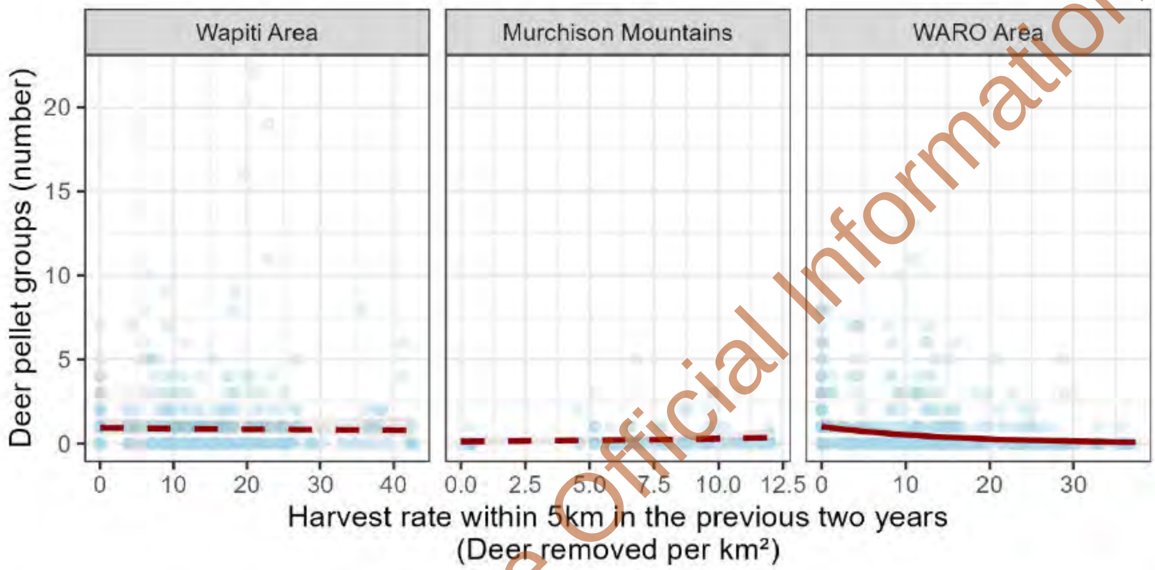

Figure 6. Relationship between the deer pellet groups (number per transect) and harvest rate within a 5 km buffer in the previous two years (deer removed per km²). Note that the *x*-axis range differs across panels. Blue points show the annual data, while red lines represent the regression line (± 95% confidence intervals, shown by grey shading) derived from a GLMM (Table 6). Solid lines indicate a significant slope, while dashed lines indicate a non-significant slope at α = 0.05.

Table 6. Relationship between the number of deer pellet groups observed on transects and harvest rate within a 5 km buffer in the previous two years. Shading indicates management areas with significant negative (blue) relationships. Estimate (± SEM) values for harvest rate show the direction and magnitude of the slope presented on the log scale (Figure 6). The full candidate model set provided in Table A2.1 (Appendix 2).

Model	Management area	Estimate ± SEM	Statistic	p value
harvest_km_5000_730 + (1|site/line) + (1|year) (Negative binomial)	Wapiti Area	-0.004 ± 0.009	-0.456	0.648
	Murchison Mountains	0.089 ± 0.071	1.252	0.211
	WARO Area	-0.067 ± 0.010	-6.774	<0.001

4.3 How does alpine plant browse vary with respect to deer activity, harvest rate and hunting effort?

To identify the measure of the deer population that best explained the variation in alpine plant browse, the surveys done in and before 2008 were excluded from the analysis, as spatial data on the harvest rate in the preceding two years was not available. Across all plant species, deer pellet groups better predicted the variation in alpine plant browse compared to models including harvest rate (either within a 5 or 10 km buffer) or hunting effort (Table A3.1 in Appendix 3). When focusing on harvest rate, models with harvest rate within 10 km showed a better fit for *Celmisia verbascifolia* and *Ranunculus lyallii*, whereas models that included harvest rate within 5 km were better for all species combined and *Dolichoglottis scorzoneroides*.

Although the magnitude of the slope of the relationship between alpine plant browse and deer pellet activity varied by plant species and management area, there was a consistent positive relationship (i.e. browse increased with increasing pellet groups) for almost all species and areas; the two exceptions were non-significant relationships for *Dolichoglottis scorzoneroides* and *Ranunculus lyallii* in the Murchison Mountains (Figure 7, Table A3.2, Table A3.4).

When considering all indicator species combined, the influence of harvest rate on alpine plant browse varied among management areas and species. To facilitate comparisons among areas over similar spatial scales, we present results from models that included harvest rate calculated within 10 km (Figure 8, Table A3.3, Table). Alpine plant browse significantly increased with increasing harvest rate in the Wapiti Area for all species combined, *Celmisia verbascifolia* and *Dolichoglottis scorzoneroides.* Similarly, alpine plant browse also significantly increased with increasing harvest rate in the Murchison Mountains for all species combined and *Dolichoglottis scorzoneroides* but declined for *Celmisia verbascifolia.* In the WARO Area, there was a significant increase in the proportion of *Dolichoglottis scorzoneroides* and *Ranunculus lyallii* plants browsed with increasing harvest rate, while browse on *Celmisia verbascifolia* significantly decreased.

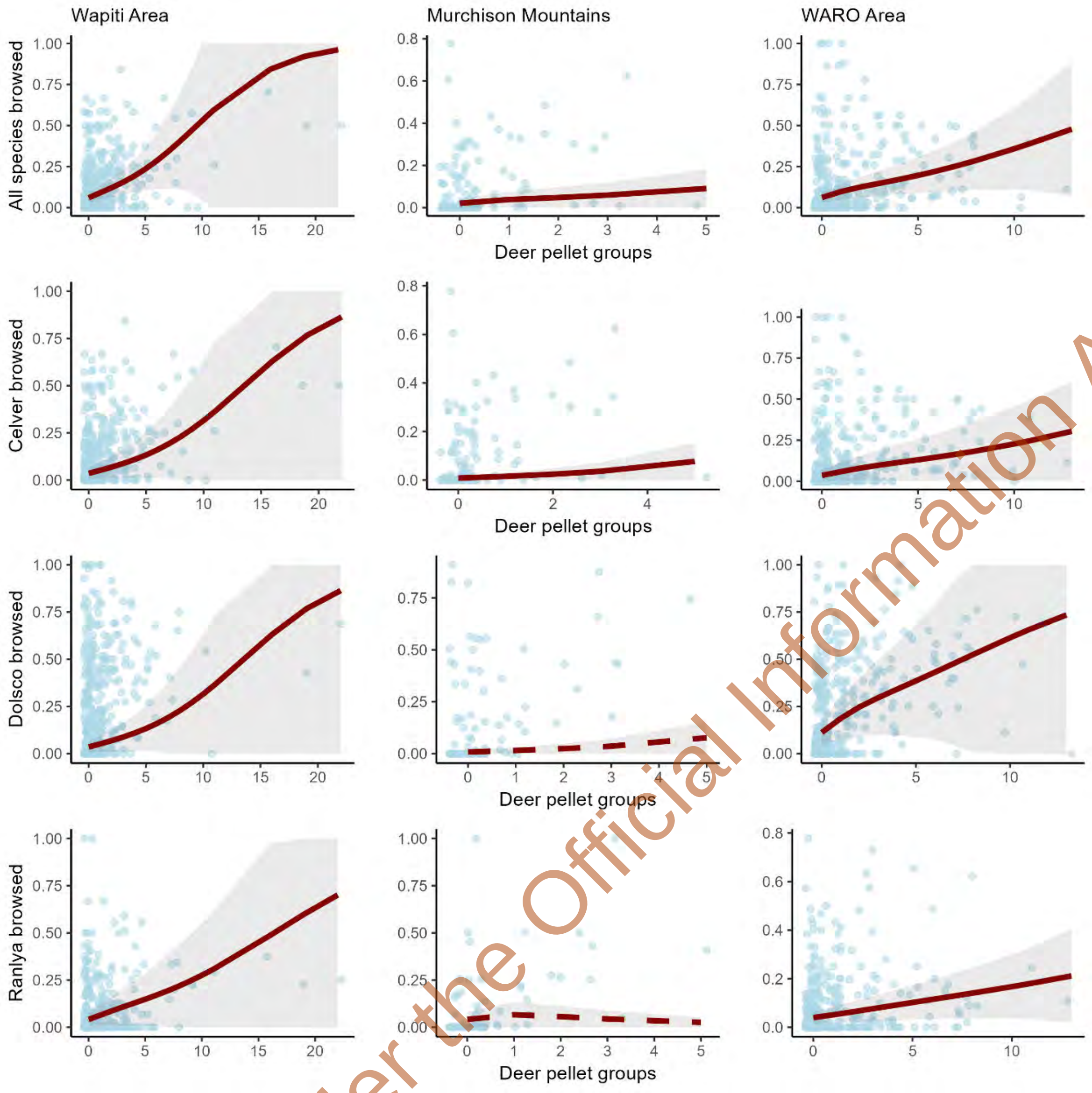

Figure 7. Mean (± 95% confidence intervals, shown by grey shading) relationship between the proportion of alpine plants browsed (all species combined, Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) and deer pellet groups (number per transect) for each management area (Wapiti Area, Murchison Mountains, WARO Area). Solid lines indicate a significant slope, while dashed lines indicate a non-significant slope at α = 0.05. The *y*-axes represent the proportion of each species browsed, with both the *x* and *y* axis values varying across the panels. See Table A3.2 and Table (both in Appendix 3) for detailed outputs.

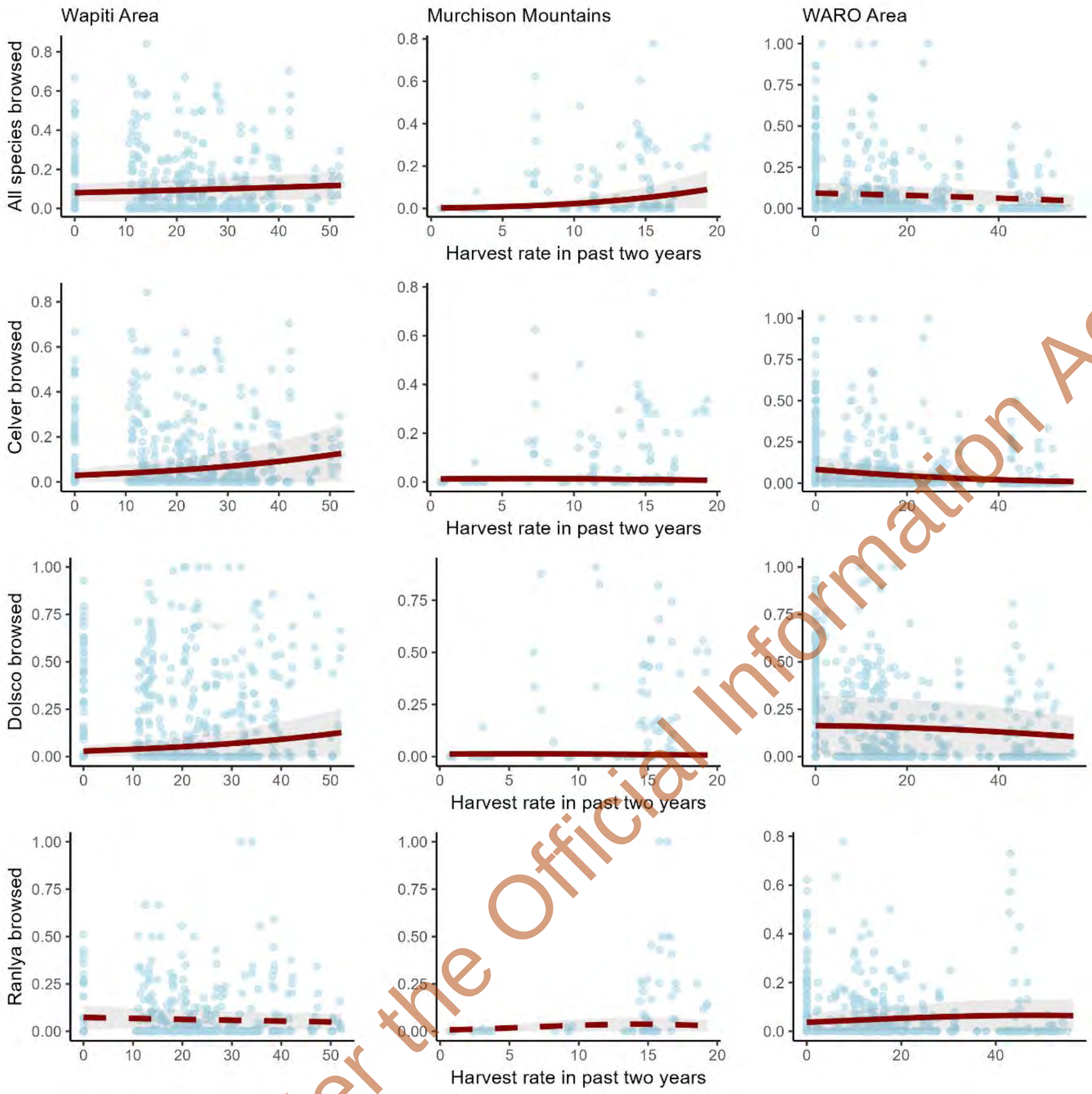

Figure 8. Mean (± 95% confidence intervals, shown by grey shading) relationship between the proportion of alpine plants browsed (all species combined, Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) and harvest rate within a 10 km buffer in the previous two years (deer removed per km^2) for each management area (Wapiti Area, Murchison Mountains, WARO Area). Solid lines indicate a significant slope, while dashed lines indicate a non-significant slope at α = 0.05. The *y*-axes represent the proportion of each species browsed, with both the *x* and *y* axis values varying across the panels. See Table A3.3 and Table A3.5 (both in Appendix 3) for detailed outputs.

4.4 What is the relationship between plant abundance and browse?

When assessing the influence of browse on alpine plant abundance, the most robust models fit to the data included log-transformed plant abundance with a Gaussian distribution (Table A4.2 in Appendix 4). We found no significant relationship between alpine plant abundance and the proportion of browse when considering all species combined and *Ranunculus lyallii* (Figure 9, Table A4.3). In contrast, the abundance of *Dolichoglottis scorzoneroides* increased in the WARO Area with increasing browse. *Celmisia verbascifolia* increased across all management areas. No significant relationships between browse and the abundance of *Dolichoglottis scorzoneroides* were observed in the Wapiti Area or Murchison Mountains.

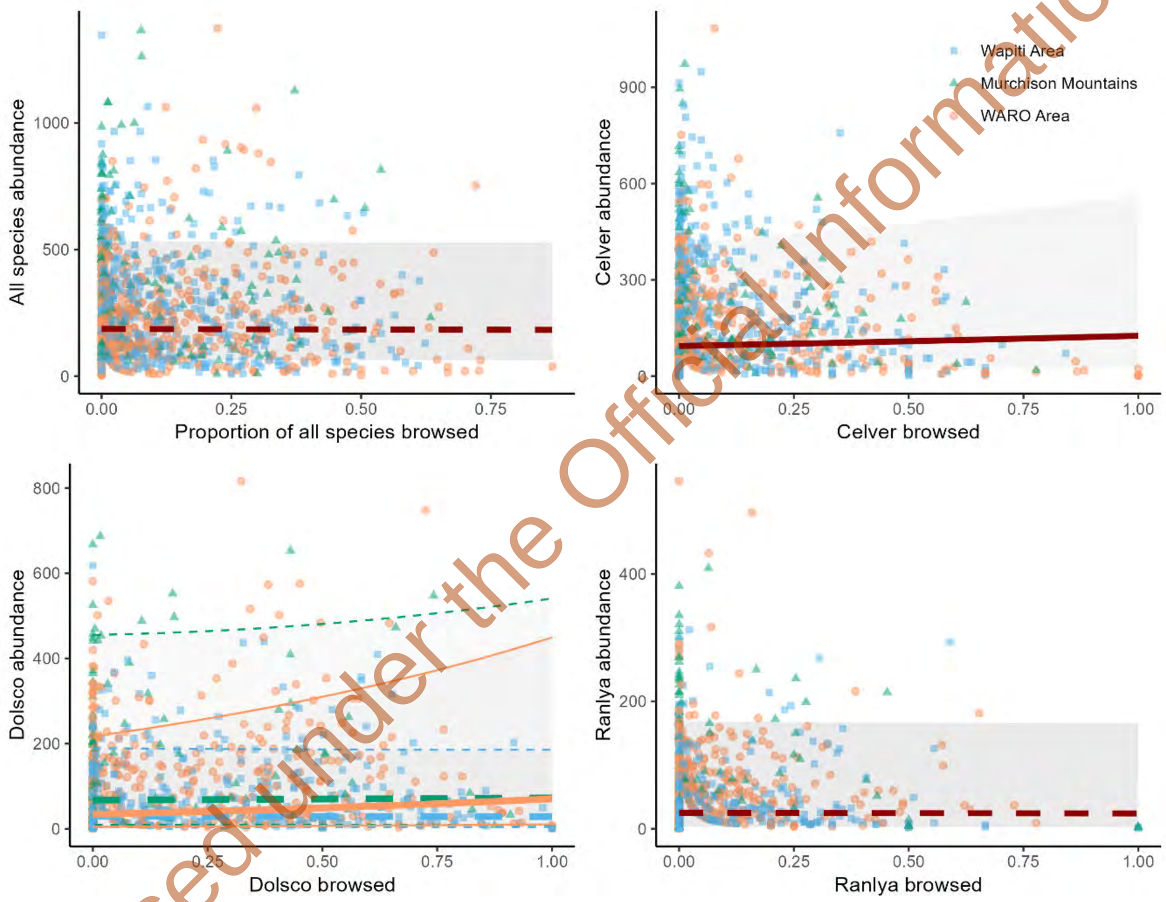

Figure 9. Mean (± 95% confidence intervals, shown by grey shading) relationship between alpine plant abundance (number of plants per transect) and the proportion of plants browsed (all species combined, Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*). Solid lines indicate a significant slope, while dashed lines indicate a non-significant slope at α = 0.05. Thinner lines for Dolsco shows the limits of CI for each management area. Raw data from the three management areas are displayed with: Wapiti Area (blue square), Murchison Mountains (green triangle) and WARO Area (orange circle). Detailed model output is in Table A4.3 (in Appendix 4).

4.5 How does alpine plant abundance and browse change over time?

4.5.1 Alpine plant abundance

To investigate how alpine plant abundance changed over time, we ran multiple models including survey period as a predictor variable and site, line nested within site or line as random factors for each alpine plant species and management area. Depending on the combination of management area and plant species, zero-inflated models with a negative binomial error distribution provided a better fit (Table A4.1 in Appendix 4).

Overall, we found that alpine plant abundance varied across the survey periods, but this was dependent on the management area and plant species. For instance, we observed a slight decline in *Dolichoglottis scorzoneroides* and *Ranunculus lyallii* abundance in the Murchison Mountains when focusing on the last survey periods (Figure 10, Table A4.5). The abundance of *Celmisia verbascifolia* was higher in the surveys conducted after 2012 in the Wapiti Area, with an increase from 150 ± 148 plants (2011–2012) to 198 ± 189 plants (2014–2017) per monitoring line (Figure 10, Table A4.4). The change in alpine plant abundance between survey period in the WARO were less marked than in the other two management areas.

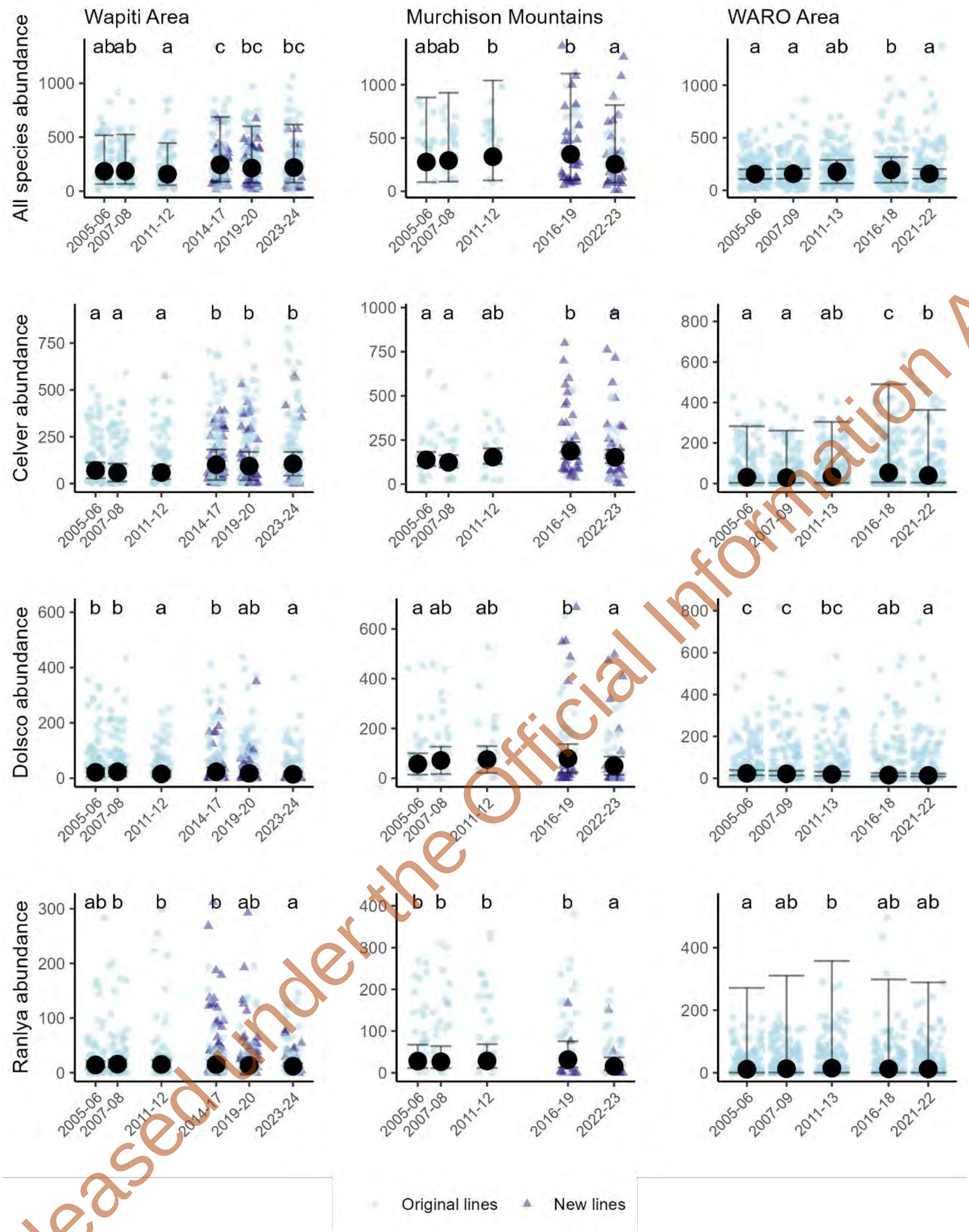

Figure 10. Mean (± 95% confidence intervals, shown as error bars) abundance of alpine plants (total number of plants per transect) per survey period for each indicator species (all species combined, Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*). Points show the raw data differentiated by when the monitoring lines were established (original lines – blue circle; new lines – purple triangle). Letters highlight significant differences between survey periods (see Table 5 in Appendix 4 for detailed outputs). The *x*-axis represents the survey periods for each management area.

4.5.2 Alpine plant browse

Overall, how the proportion of alpine browse changed over time varied between management areas, with a gradual increase of alpine plant browse in the Murchison Mountains and a more heterogenous variation among years in the Wapiti and WARO Areas (Figure 11, Table A3.6).

Alpine browse in the Murchison Mountains was very low in the initial survey period (2005–2006), with the mean proportion of *Celmisia verbascifolia* plants browsed per monitoring line recorded at 0.02 ± 0.08 and effectively zero browse recorded for all species combined (0.00 ± 0.02), *Dolichoglottis scorzoneroides* (0.00 ± 0.01) and *Ranunculus lyallii* (0.00 ± 0.00). Rates of browse started to increase in the 2016–2019 survey period across all species combined and individually and reached 0.16–0.29 in the 2022–2023 survey period, depending on the species (Figure 11, Table A3.7, Table A3.8)

In the Wapiti Area, overall alpine plant browse across all species initially declined from 0.19 ± 0.18 of plants browsed (2005–2006) to 0.05 ± 0.08 (2011–2012), then increased to 0.17 ± 0.16 (2014–2017) before declining again to 0.08 ± 0.09 (2023–2024, Table A3.7, Table A3.8). Similar patterns were observed for the three species individually, with relatively low browse recorded in 2011–2012 and higher browse in the 2014-2017 or 2019–2020 survey periods, depending on the species. In addition, both *Dolichoglottis scorzoneroides* and *Ranunculus lyallii* had significantly lower browse recorded in the last survey period compared to the first survey period

In the WARO Area, alpine plant browse varied among years and plant species. However, we can identify an overall decline from 2005–2006 to a low in 2012-2013 followed by a slow increase (Figure 11, Table A3.7, Table A3.8). The latest trend is more marked when focusing on *Dolichoglottis scorzoneroides*, with the mean proportion of browsed plants dropping from 0.35 ± 0.27 in 2005–2006 to a low of 0.05± 0.10 in 2011–2013 and then increasing back up to 0.27 ± 0.27 in the 2021–2022 survey period.

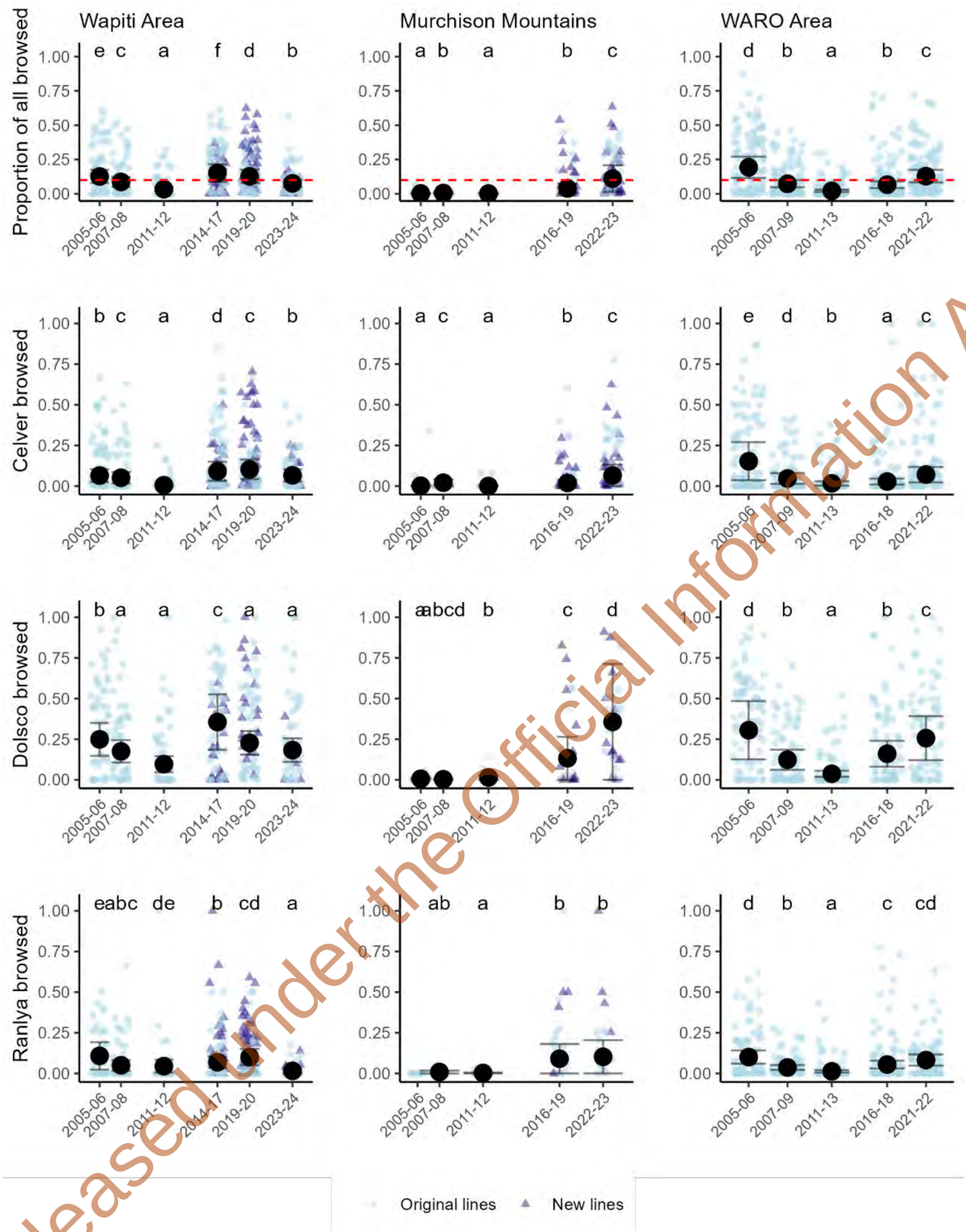

Figure 11. Mean (± 95% confidence intervals, shown by error bars) proportion of alpine plant browse per survey period for each indicator species (all species combined, Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*). Points show the raw data differentiated by when the monitoring lines were established (original lines – blue circle; new lines – purple triangle). Letters highlight significant differences between survey periods (see Table A3.7 in Appendix 3 for detailed outputs). The *x*-axis represents the survey periods for each management area. The red dotted line in the top panel represents the 10% browse target across all monitored species that DOC has set as an interim target for the Wapiti Area.

4.6 Does the size class structure of *Ranunculus lyallii* change over time, and is this related to browse, deer activity and harvest?

4.6.1 Relationship between size class structure and browse, deer activity and harvest

Models including an interaction term between management area and harvest rate, deer pellet groups or the proportion of browsed alpine plants provided the best fit (Table A5.1). The proportion of large *Ranunculus lyallii* (leaf width >8cm) significantly decreased with increasing deer pellet groups across all management area (Figure 12, Table A5.2 in Appendix 5). When focusing on harvest rate, the proportion of large *Ranunculus lyallii* decreased with increasing harvest rate in the Wapiti Area, contrasting with the positive relationship observed in the Murchison Mountains and WARO Area (Figure 12, Table A5.2). The relationship between the proportion of large *Ranunculus lyallii* and the proportion of browsed *Ranunculus lyallii* (small and large plants combined) varied between management area, with a positive relationship observed in the Wapiti Area and a negative relationship found in the WARO Area (Figure 12, Table A5.2). No significant relationship was observed in the Murchison Mountains (Figure 12, Table A5.2).

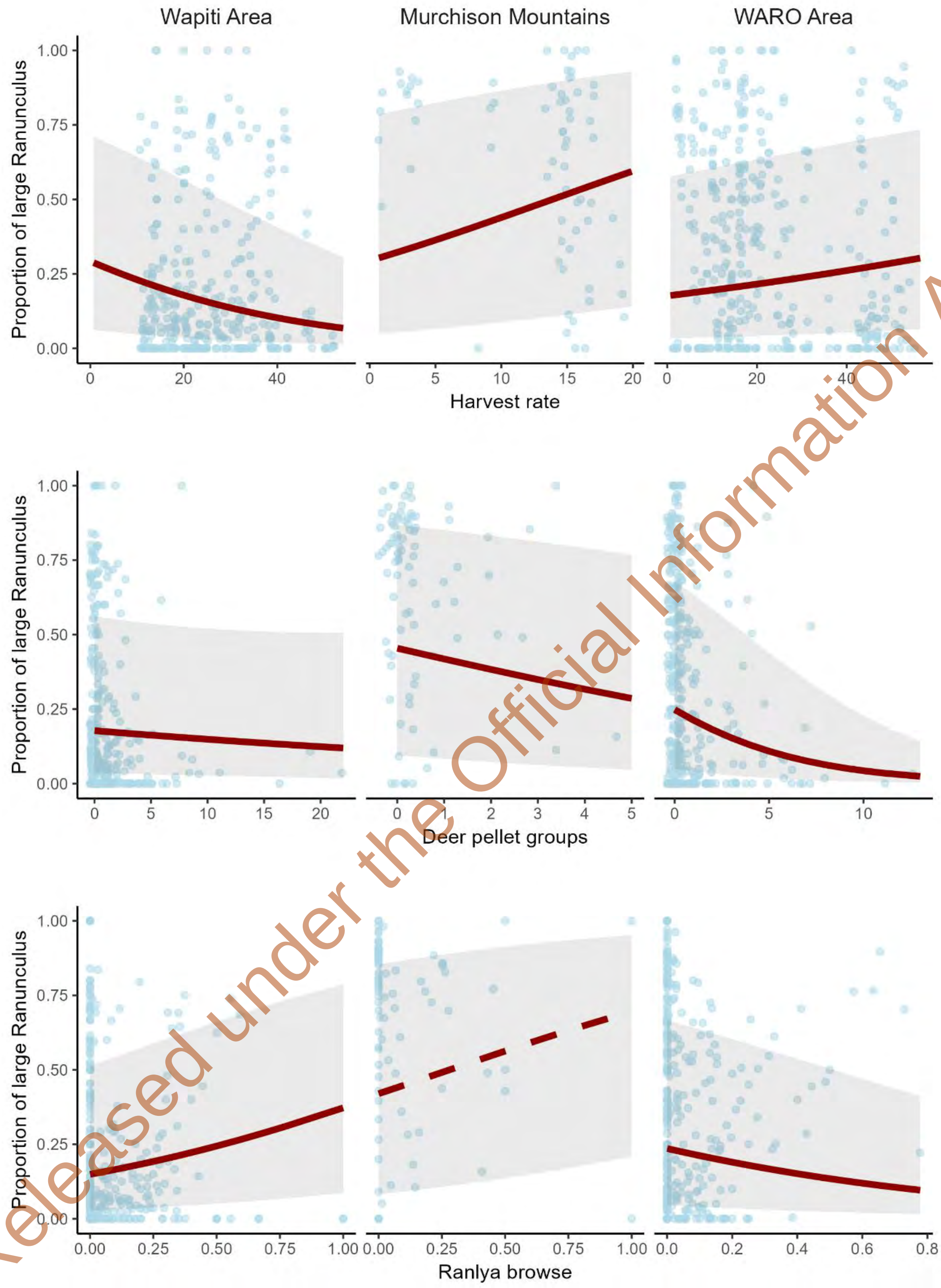

Figure 12. Mean (± 95% confidence intervals, shown by grey shading) relationship between the proportion of large *Ranunculus lyallii* (size class: >8cm) and harvest rate within a 10 km buffer in the previous two years (deer removed per km^2), deer pellet groups (number per transect) or the proportion of browsed *Ranunculus lyallii* by management area. Solid lines indicate a significant slope, while dashed lines indicate a non-significant slope at α = 0.05. The *y*-axes represent the proportion of each species browsed, with the *x*-axis values varying across the panels. Detailed model output in Table A5.2 (in Appendix 5).

4.6.2 Change of size class structure over time

The proportion of large *Ranunculus lyallii* changed over time with trends differing between management areas (Figure 13; and see Table A5.3, Table A5.4 in Appendix 5). In the Wapiti Area, the proportion of large *Ranunculus lyallii* per monitoring line gradually declined from 0.31 ± 0.32 (2011–2012) to 0.12 ± 0.18 (2023–2024). In the Murchison Mountains, a significant drop in the proportion of large *Ranunculus lyallii* was observed, with 0.76 ± 0.28 in 2011–2012 to 0.50 ± 0.31 in 2023–2024. When focusing on the WARO Area, we observed significant variation from one survey period to another but there was no clear overall trend.

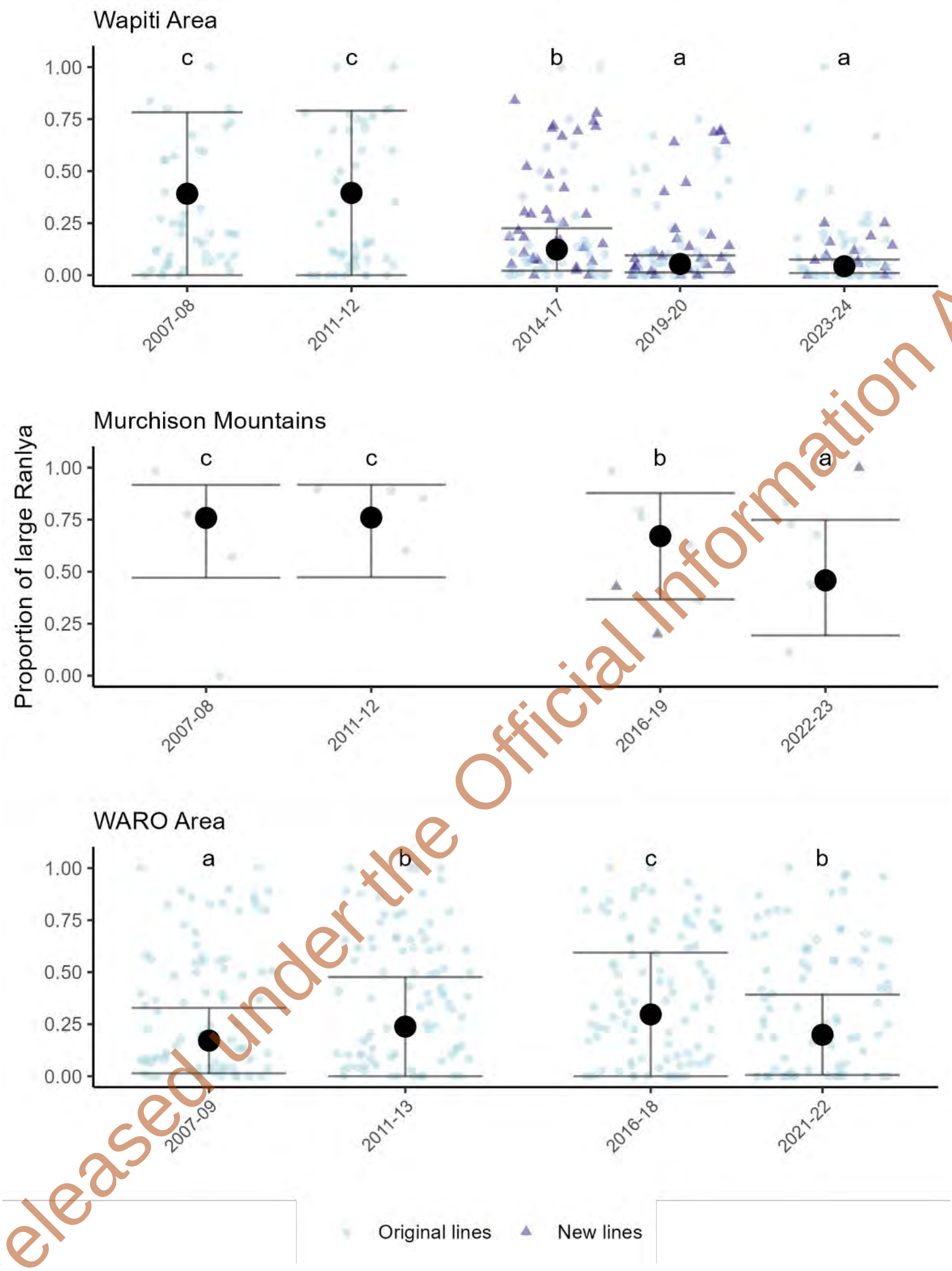

Figure 13. Mean (±95% confidence intervals, shown by error bars) proportion of large *Ranunculus lyallii* (Ranlya, size class: >8cm) per survey period across the three management areas. Points show the raw data differentiated by when the monitoring lines were established (original lines – blue circle; new lines – purple triangle). Letters indicate significant differences between survey periods, The x-axis represents the survey periods for each management area. See Table A5.3 (in Appendix 5) for detailed outputs.

5 Discussion

In this discussion we will comment on each of the five major questions posed in this work and provide more general interpretation of our findings.

5.1 Control effort has shifted over time

Both hunting effort and deer harvest rate was highly variable over time and across management areas (Question (Q)1). Overall, observed alpine plant browse and pellet group counts declined from 2006–2013 coinciding with the removal of c. 35,000 animals from FNP over this period. Change in hunting effort and harvest rate has been variable over time, particularly with respect to management area. Overall, harvest rates have increased in the Murchison Mountains, decreased in the WARO Area and remained stable in the Wapiti Area since 2006.

In the Wapiti Area, FWF-led management has been relatively stable over the nearly 20 years considered in this report, reflecting a target of ≥900 deer harvested per year as an agreed goal. Minor shifts from harvest based on phenotype that removed red deer in preference to wapiti occurred from 2006–2014. From 2015, females continued to be harvested based on phenotype, but males were selectively harvested at maturity (about 4 years old) based on antler quality. Despite high consistency in management effort and harvest over the entire period considered, there was a significant decrease in browse around 2012 for unknown reasons.

The Murchison Mountains has had the longest running management of deer in New Zealand, primarily for habitat protection of threatened species. From 2009, there has been a harvest target of c. 120 deer each year, although the management methods have changed over time. From 2006–2013, a period of low estimated animal densities (<1 deer per km^2), management included both ground and aerial hunting. From 2014–2018, WARO was used to remove the same number of deer per year. WARO ceased in 2019–2021, with aerial 'search and destroy' (i.e. rather than commercial venison recovery) used instead. These strategies resulted in different frequencies of management: WARO required more flights to meet the target (about six or more flights per year) compared to search and destroy aerial control, which reached the target number of animals in far fewer flights per year. Less frequent management could create a reduced 'landscape of fear' (Latham et al. 2018), allowing deer to feed in alpine areas longer even with the same number of animals removed per year. This appears to be consistent with a shift toward greater deer activity (pellet counts) and browse despite more effective deer harvest rates from 2019 onwards (Figure 7, Figure 8). Most recently (2022–2023) DOC-led aerial management has increased with support from DOC's National Wild Animal Management (WAM) programme, resulting in increased effort particularly in the 2023 season. Given the lags between management effort and alpine plant responses (i.e. in most models the two-year previous effort was the best predictor of browse), we would expect to see responses in alpine browse from 2025 for the current increase in management effort.

The relatively large area of FNP under WARO management is not driven by consistent targets in deer harvest but rather by commercial recovery influenced by economic factors, including fuel and venison prices, and the ability to process recovered animals (Warburton et al. 2016). Management effort from WARO has declined strongly since 2006 (Figure 4). From 2006–2013 there were more commercial operators harvesting relatively high numbers of deer but, as venison export prices declined and fuel prices increased, many commercial operators stopped harvesting. From 2019, both low venison prices and limited demand further reduced the number of operators and the harvest rate.

Overall, both estimates of browse and deer activity (pellet counts) were extremely low in the Murchison Mountains (Ewans 2013), and higher, but also highly variable, among sites in the much larger Wapiti and WARO management areas. The number of deer removed increases with increasing area-scale hunting effort in the WARO Area, but not elsewhere, reflecting the different management objectives of the areas (i.e. set targets for the Murchison Mountains and Wapiti Area, but commercial viability in the WARO Area). It is difficult to determine whether greater increases in harvest efficiency in WARO are driven by increasing numbers of deer, or greater efficiency of operations; more information about true effort (e.g. GPS tracks and duration of effort) is required. However, management/hunting effort and harvest rate per se were both poor metrics for assessing browse impacts on vegetation compared to a direct measure of deer activity (pellet counts). Therefore, using a set number of animals to remove each year as a management strategy may not achieve the protection of vulnerable plant species (Whitmore 2023). Put another way, operational effort itself is not strongly linked to browse impacts; a more robust approach requires understanding thresholds of deer impacts and using this as evidence to determine the level of management effort that is required.

5.2 Deer activity and management effort

Pellet group counts were often related to hunting effort and deer harvest rate (Q2) but reflect different measures of potential deer activity or the likely effects on vegetation. For these relationships, harvest rate within a 5 km buffer over the previous 2 years was identified in statistical models as the best spatial predictor of pellet group counts (Table). Deer pellet group counts declined with increasing deer harvest only in the WARO Area; in contrast, pellet counts tended to increase with increasing harvest in both the Wapiti and Murchison Mountain areas (Figure 6). Pellet counts are an indirect proxy of deer population size and are better interpreted as a metric of deer activity within a site (Forsyth 2005; Forsyth et al. 2011).

While deer pellet counts are correlated with deer density (Forsyth et al. 2007), more robust measures of deer density and movement patterns across the landscape may prove to be more useful for guiding management decisions, particularly with respect to setting harvest targets that are responsive to both population size and vegetation browse (see also Forsyth et al. 2022). We recommend continuing to monitor deer pellet counts at the alpine browse sites but suggest that additional methods for estimating density be considered. For example, the addition of trail cameras as a monitoring tool at each site may enable both the estimation of deer density and provide information about other browsing species (e.g. chamois, hares) that might be influencing vegetation browse and recovery (Hickling et al. 2024). DOC has already been trialling new emerging monitoring techniques for estimating deer densities, including thermal imagery and genetic samples from deer pellets or culled animals, in the Snag Burn catchment of the Murchison Mountains (G. Ledgard, DOC, pers. comm., 13 August 2024) with reasonable success.

What the contrasting results among management areas suggest is that management effort and deer activity are positively related in the two areas where fixed targets for management occur, but that increased commercial recovery is associated with lower deer activity. Furthermore, the retrospective application of monitoring alpine areas does not generate the data or evidence needed for understanding the impacts that management effort or regime are having on deer populations overall or movement among habitats (e.g more frequent helicopter disturbance creating a landscape of fear). The pellet count data reflects deer activity that occurs along the alpine plant monitoring transects but may not capture important effects of management on deer population changes or impacts over larger scales. Finally, given the high variability of pellet counts among sites, there is relatively low statistical power to detect threshold effects or to quantify relationships with operational effort (Mason et al. 2019). Without quantitative estimates of population abundance, or spatial information about the movement of deer among habitats under different management regimes, the actual effectiveness of management on deer populations themselves cannot be assessed.

5.3 Relationships between browse, deer activity and management

Browse observed on selected alpine plant species was related to deer activity, harvest rate and management area (Q3) in complex ways. The proportion of browsed plants increased with increasing deer activity (pellet groups) for all species, both separately and combined. In contrast, the relationship between plant browse and deer harvest rate was more complex, with differing patterns depending on the species and management area being considered. Overall, the positive relationships between proportion of plants browsed and pellet counts make intuitive sense because pellet counts should reflect deer activity within a site and in close proximity to monitored plant populations.

However, the more complex responses of browse to harvest rate are harder to interpret with the available data. One possibility is that the spatial buffers (5 or 10 km) and lags considered (previous 2 years of management) will include multiple drivers of variation in deer activity and consumption, including seasonal movement and diet effects, and behavioural changes in the use of habitats through management effort and frequency of disturbance (e.g. Latham et al. 2018). Other interactions among deer and vegetation are likely, but cannot be evaluated with the available data collected for few alpine species. For example, additional information about other plant species within sites is needed to understand if the browse damage of the indicator species reflects wider vegetation impacts. Similarly, previous studies have demonstrated that browse damage varies widely even within species because of environmental effects, such as soil fertility, or the palatability of neighbouring species (Coomes et al. 2003). Moreover, browsing animals can exert important indirect effects in ecosystems or communities through, for example, soil compaction, nutrient deposition or selective damage of some species (see review by Peltzer & Nugent 2023). What these and other studies demonstrate is that browsing impacts are complex, and driven only in part by interactions among browsing animals and management. Regardless of the mechanisms involved, management effort and harvest rates are far poorer predictors of browse damage than measurements of deer activity within a site.

5.4 Alpine plant abundance and browse

The relationship between plant abundance and browse (Q4) was highly variable among species, sites and management areas. Estimates of browse are important for monitoring damage to individual plants. However, understanding the cumulative effects of repeated damage to plants and whether these drive long-term changes in populations or communities is the ultimate goal. Moreover, changes in the distribution and abundance of native species, and the composition of communities, underly both biodiversity monitoring and additional considerations, such as ecological integrity (e.g. Lee et al. 2005; McGlone et al. 2020; Bellingham et al. 2021). Despite high variation in deer activity, management effectiveness and browse damage, we did not detect any significant changes in overall plant abundance over time (i.e. the total number of plants across all indicator species observed within sites). However, individual species responses differed among management areas. There was a slight decline in *Dolichoglottis scorzoneroides* and *Ranunculus lyallii* abundance in the Murchison Mountains in the last two survey periods (Figure 10). In contrast, *Celmisia verbascifolia* abundance was higher in the surveys conducted after 2012 in the Wapiti Area. What these findings suggest is that, for the period considered in this report, deer were not having a significant impact on these three plant species at the population level. Nevertheless, previous studies suggest that repeated browse damage can have threshold effects on plant populations, including perennial herbs, and especially when browsing lowers plant survival or reproductive output repeatedly (e.g. Knight et al. 2009). Additional information on population responses (i.e. recruitment, growth and mortality of species), and whether these are affected by other components of vegetation (e.g. suppression by increases in unpalatable plant species) is not available, but is needed to understand the long-term changes in alpine plant abundance (or any other species of interest).

Despite the more detailed understanding of population changes and demographic consequences of deer browse on the alpine species reported in this study, a crucial gap still remains in understanding both diet selection by deer of these species, and the responses or changes in other species even within monitored sites. Some of the interannual variation in abundance or browse is assumed to be related to preference and selective damage by deer, and this should be confirmed with independent analyses of deer diet within a site or the spatial buffers used in our analyses. Our results showing higher browse damage of *Ranunculus lyallii* associated with modest increases in deer activity in the Murchison Mountains, and longer term potential declines in *Dolichoglottis scorzoneroides* in the Wapiti and WARO areas are consistent with early selection of *Ranunculus lyallii* by deer, but perhaps diet switching or greater sensitivity of *Dolichoglottis scorzoneroides* to browse over the longer term. There are currently no data available to determine whether these changes are caused by deer selection and damage per se. These responses probably depend on multiple mechanisms such as lags in population responses, compensatory growth of co-occurring species, and the palatability of neighbouring plants (e.g. Coomes et al. 2003).

5.5 Size class responses of *Ranunculus lyallii*

We assessed whether the size class structure of *Ranunculus lyallii* has changed over time, and if so, whether this was related to browse, deer activity and harvest rate (Q5). The proportion of large *Ranunculus lyallii* in populations within a site increased with fewer deer pellet groups across all management areas. However, the pattern was not as straightforward when considering harvest rate or the proportion of browsed *Ranunculus lyallii* plants. The proportion of large *Ranunculus lyallii* decreased with increasing harvest rate in the Wapiti Area but the opposite pattern was observed in the Murchison Mountains and WARO Area. In addition, large *Ranunculus lyallii* were more prevalent in the population with increased levels of browse on *Ranunculus lyallii* plants in the Wapiti Area, while the WARO Area showed the opposite relationship. *Ranunculus lyallii* is considered highly sensitive to deer browse and our findings suggest that increasing deer activity, even at the very low deer densities that occur in the Murchison Mountains, is associated with a decline in larger *Ranunculus lyallii* in the most recent survey. Size class change is a first proxy of demographic changes in the population, but a more detailed understanding of population dynamics and the long-term viability of this species is needed to confidently set targets across all management areas.

5.6 Interpreting changes in management and vegetation responses

Despite different operational effort over time and large spatial scales among management areas (Figure 4), these differences were not strongly reflected in observed deer activity or browse damage at sites (Figure 6). Nevertheless, browse damage was most strongly associated with deer activity (pellet counts) within sites. What these findings demonstrate is that attributing broad-scale management approaches to responses of alpine plant populations requires additional knowledge of the biology and ecology of the alpine plants themselves, and of the responses of deer populations to management (e.g. density threshold impacts and altered movement and seasonal behaviours; see the general discussions of Côté et al. 2004; Tanentzap et al. 2012; Forsyth et al. 2022). One such unresolved issue is an understanding of to what level deer densities should be managed, and for what duration, to achieve one or more objectives. For example, management in the Murchison Mountains has maintained relatively low deer numbers over several decades but some ungulate impacts from historical population highs were detectable for decades (40+ years; Tanentzap et al. 2009). Moreover, even with sustained management to low densities using set harvest targets, very recent observed increases in deer activity have been associated with declines in large *Ranunculus lyallii* (but not in other species), suggesting that the previous management regime may not have been sufficient in preventing damage to the most highly selected or sensitive plant species. These observations are consistent with the much larger literature of deer impacts in forest vegetation that suggest highly palatable or selected plant species are affected at very low deer densities, and that if a management goal is to maintain biodiversity, sustain threatened populations, or ecological integrity, then adaptive management underpinned by evidence is required (Peltzer & Nugent 2023; Hawcroft et al. 2024).

The outcome monitoring in this project was initially designed to determine changes in the condition of three widespread indicator alpine plant species, and retrospectively used to relate alpine plant browse to management and deer activity to understand changes in deer impacts. The wider goal for this outcome monitoring was to provide the data to ensure that the FNPMP goal of 'promoting the regeneration of browsed indigenous flora' is met within the three management areas (Department of Conservation 2007).

While the monitoring and operational data allowed us to broadly address this goal, the monitoring design limits our ability to make some key inferences. For example, the browse monitoring focusses on three indicator species of alpine vegetation as a proxy for the overall impacts of deer. These species were selected because they are known to be susceptible to deer browse and are present at all monitored sites. While restricting monitoring to these species simplified the methodology, it did not allow us to investigate whether the level of browse was linked to the responses of other species within sites or whether shifts in vegetation composition towards non-palatable species in response to browse or other drivers is occurring.

Some additional information or data collection could improve our ability to understand changes in alpine communities, and attribute these changes to the effects of deer and their management. At a minimum, including cover estimates of common plant species within sites is needed to determine if browse is driven by the palatability of other plant species that co-occur within sites and enable assessment of additional drivers of long-term changes in alpine communities, such as compensatory growth of unpalatable species, or progressive changes or turnover in species composition (see also recommendations of Day et al. 2023 for understanding changes in tussock grasslands).

Such an approach could also be applied for monitoring the impacts of other wild animals on alpine vegetation such as tahr (*Hemitragus jemlahicus*) (Cruz et al. 2017). For the indicator species themselves, including demographic measures of plant mortality and reproduction is needed to evaluate long-term population viability within sites, regardless of whether these changes are caused by browse or other drivers.

It could also be valuable to consider including measurement of the dominant (> 5% cover) plant species along monitoring transects. This could be used to determine if browse is driven by the palatability of other plant species that co-occur within sites and enable assessment of additional drivers of long-term changes in alpine communities, such as compensatory growth of unpalatable species, or progressive changes or turnover in species composition.

6 Recommendations

Our analyses of monitoring data from 2006–2024 for selected alpine plant species, deer activity and management effort, and results for the questions posed relating management effort to browse impacts, demonstrate the crucial importance of long-term evidence for understanding the effectiveness of different deer management approaches. However, our findings also reveal several opportunities for supporting more robust data and evidence to better resolve issues around critical thresholds of deer abundance and impact, linking broad-scale deer management to their population control, and determining the long-term effects on species viability and vegetation. Our recommendations include:

- Capture flight information (e.g., helicopter track logs) for all aerial control activities. This is typically required for helicopter activity as part of operational work and would provide valuable additional information on the frequency of disturbance to deer, spatial distribution and coverage of operational effort, and return interval of management. In the absence of such information, the best metrics of harvest determined quantitatively here (e.g., deer harvested within a 10 km buffer in the previous two years) could be retained.
- Consider using browse metrics to actively update management targets for management of the Murchison Mountains and Wapiti Area. Our results demonstrate that harvest rate and management effort are poor predictors of browse compared to deer activity. Pellet counts could be used to update the following round of management with at least 1–2 years lead time for planning and resourcing of operations.
- Use harvested deer or deer pellets to determine the relative contribution of the monitored alpine species to deer diet using molecular techniques (de Sousa et al. 2019). This information is needed to determine if the three alpine plant species currently monitored reflect wider browse effects in alpine vegetation. In addition, a better understanding of the relative palatability or diet selection is needed to determine if threshold browse targets used to plan management interventions also benefit other alpine vegetation species.
- Widen measurements of the selected alpine plant species to include demographic measures of plant mortality and reproduction. Together with current monitoring data, this is needed to evaluate the long-term population viability within sites. Put another way, this information is needed to understand if repeated or long-term browsing increases plant mortality or reduces reproduction, both of which affect population growth.
- Consider including measurement of the dominant (>5% cover) plant species along monitoring transects with sites. This information could be used to determine if browse is driven by the palatability of other plant species that co-occur within sites and enable assessment of additional drivers of long-term changes in alpine communities, such as compensatory growth of unpalatable species, or progressive changes or turnover in species composition.

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8 Glossary of abbreviations and terms

AICc	Corrected Akaike's Information Criterion
Celver	*Celmisia verbascifolia* subsp. *verbascifolia*
CI	Confidence interval
CL	Confidence limit
DOC	Department of Conservation
Dolsco	*Dolichoglottis scorzoneroides*
FNP	Fiordland National Park
FNPMP	Fiordland National Park Management Plan
FWF	Fiordland Wapiti Foundation
GLM	Generalised linear model – a regression model that does not include random effects
GLMM	Generalised linear mixed-effects model – a regression model that includes random effects
Murchison Mountains	The area of Fiordland National Park where deer are managed by DOC for the conservation of takahē (*Porphyrio hochstetteri*) (Figure 1)
MWLR	Manaaki Whenua – Landcare Research
Proximity metrics	Hunting effort (operator days per year) or harvest rate (deer removed per year) calculated within a specified spatial buffer (in m) of a vegetation monitoring transect within the specified preceding days
Ranlya	*Ranunculus lyallii*
SD	Standard deviation
SEM	Standard error of the mean
WAM	Wild Animal Management program run by the Department of Conservation
Wapiti Area	The area of Fiordland National Park that is managed by the Fiordland Wapiti Foundation (Figure 1)
WARO	Wild Animal Recovery Operators
WARO Area	The area of Fiordland National Park that is available for commercial wild animal recovery operators to recover deer outside the Wapiti Area and the Murchison Mountains (Figure 1)

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Appendix 1 – Model selection and analyses of hunting effort & harvest rate (Q1)

Table A1.1. Candidate model sets for a) total annual and b) area-scaled annual hunting effort and c) total annual and d) area-scaled annual harvest rate as evaluated by comparing corrected Akaike's Information Criterion (AICc). Models for the total annual metrics (a, c) used a negative binomial error distribution, while the models for the area-scale annual metrics (b, d) used a Gaussian error distribution. The log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. The best model for each response variable (in bold) were identified using ΔAICc and model diagnostics.

	logLik	AICc	ΔAICc	df	weight
a) Annual hunting effort (operator days per year)					
year * management_area	**-227.52**	**471.54**	**0.00**	**7**	**0.999**
year + management_area	-237.29	485.85	14.31	5	0.001
management_area	-250.17	509.18	37.64	4	0.000
year	-281.24	568.98	97.44	3	0.000
1 (Intercept only)	-288.82	581.88	110.34	2	0.000
b) Annual harvest rate (deer removed per year)					
year * management_area	**-375.11**	**766.71**	**0.00**	**7**	**0.993**
management_area	-384.18	777.19	10.48	4	0.005
year + management_area	-384.11	779.50	12.78	5	0.002
year	-427.23	860.95	94.24	3	0.000
1 (Intercept only)	-428.52	861.28	94.57	2	0.000
c) Area-scaled annual hunting effort (operator days per year per km^2)					
year * management_area	**113.69**	**-210.89**	**0.00**	**7**	**0.946**
year + management_area	107.99	-204.70	6.19	5	0.043
year	104.30	-202.11	8.78	3	0.012
management_area	95.49	-182.14	28.75	4	0.000
1 (Intercept only)	92.83	-181.43	29.47	2	0.000
d) Area-scaled annual harvest rate (deer removed per year per km^2)					
year * management_area	**-13.67**	**43.82**	**0.00**	**7**	**1.000**
management_area	-25.49	59.81	15.99	4	0.000
year + management_area	-25.48	62.24	18.42	5	0.000
1 (Intercept only)	-46.87	97.97	54.15	2	0.000
year	-46.84	100.18	56.36	3	0.000

Table A1.2. Candidate model sets for area-scaled harvest rate (deer removed per year per km^2) as evaluated by comparing corrected Akaike's Information Criterion (AICc). All models used a Gaussian error distribution. The log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. The best model (in bold) was identified using ΔAICc and model diagnostics.

Model	logLik	AICc	ΔAICc	df	weight
Area-scaled annual harvest rate (deer removed per year per km^2)					
annual_effort_km * management_area + (1 | year)	**-5.43**	**30.14**	**0.00**	**8**	**0.525**
annual_effort_km * management_area	-7.19	30.87	0.73	7	0.365
annual_effort_km + management_area	-11.39	34.06	3.92	5	0.074
annual_effort_km + management_area + (1 | year)	-10.86	35.54	5.40	6	0.035
management_area	-22.09	53.02	22.88	4	0.000
annual_effort_km	-34.93	76.34	46.20	3	0.000
1 (Intercept only)	-46.44	97.11	66.97	2	0.000

annual_effort_km = area-scaled hunting effort (operating days per year per km^2).

Appendix 2 – Model selection and analyses of deer pellet groups (Q2)

Table A2.1. Candidate model sets for the number of pellet groups as evaluated by comparing corrected Akaike's Information Criterion (AICc). All models used a negative binomial error distribution. The log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. The best model (in bold) was identified using ΔAICc and model diagnostics.

Model	logLik	AICc	ΔAICc	df	weight
harvest_km_5000_730 * management_area + (1 | site/line)	**-1357.42**	**2732.99**	**0.000**	**9**	**0.924**
harvest_km_10000_730 * management_area + (1 | site/line)	-1359.92	2738.00	5.010	9	0.075
harvest_km_10000_730 + management_area + (1 | site/line)	-1368.36	2750.82	17.820	7	0.000
harvest_km_10000_365 * management_area + (1 | site/line)	-1366.81	2751.78	18.780	9	0.000
harvest_km_10000_365 + management_area + (1 | site/line)	-1369.25	2752.60	19.610	7	0.000
harvest_km_5000_730 + management_area + (1 | site/line)	-1369.53	2753.15	20.160	7	0.000
harvest_km_5000_365 * management_area + (1 | site/line)	-1367.58	2753.32	20.330	9	0.000
harvest_km_10000_180 + management_area + (1 | site/line)	-1370.98	2756.05	23.060	7	0.000
harvest_km_10000_180 * management_area + (1 | site/line)	-1369.20	2756.55	23.550	9	0.000
harvest_km_5000_365 + management_area + (1 | site/line)	-1372.28	2758.65	25.660	7	0.000
harvest_km_5000_180 * management_area + (1 | site/line)	-1372.56	2763.28	30.290	9	0.000
harvest_km_1000_730 + management_area + (1 | site/line)	-1375.41	2764.92	31.920	7	0.000
harvest_km_5000_180 + management_area + (1 | site/line)	-1376.29	2766.67	33.680	7	0.000
harvest_km_1000_730 * management_area + (1 | site/line)	-1374.76	2767.67	34.670	9	0.000
harvest_km_1000_365 + management_area + (1 | site/line)	-1378.29	2770.68	37.690	7	0.000
harvest_km_1000_365 * management_area + (1 | site/line)	-1378.14	2774.43	41.440	9	0.000
management_area + (1 | site/line)	-1381.92	2775.91	42.920	6	0.000
harvest_km_1000_180 + management_area + (1 | site/line)	-1380.96	2776.02	43.030	7	0.000
harvest_km_1000_180 * management_area + (1 | site/line)	-1379.54	2777.24	44.250	9	0.000
1 (Intercept only) + (1 | site/line)	-1386.70	2781.43	48.440	4	0.000

harvest_km_*buffer*_*days* = area-scaled harvest within a spatial *buffer* (in m) of a site within the preceding *days*.

Appendix 3 – Model selection and analyses of alpine plant browse (Q3)

Table A3.1. Identification of the best predictor of alpine browse between deer pellet groups, harvest rate within 10 or 5 km (harvest_km_10000_730 or harvest_km_5000_730) and hunting effort (effort_km_730) by comparing corrected Akaike's Information Criterion (AICc). The log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. All models were zero-inflated mixed models with a binomial error distribution. The best model for each response variable (in bold) were identified using ΔAICc and model diagnostics.

Plant species	Formula	df	logLik	AICc	ΔAICc	weight
All	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-6996.2**	**14006.52**	**0**	**1**
	deer_pellets + (1 | line) + (1 | financial_year_cont2)	6	-7057.59	14127.28	120.76	0
	effort_km_site_730 + (1 | site/line) + (1 | financial_year_cont2)	7	-7120.33	14254.79	248.27	0
	harvest_km_5000_730 + (1 | site/line) + (1 | financial_year_cont2)	7	-7585.32	15184.76	1178.24	0
	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	7	-7589.27	15192.67	1186.14	0
Celver	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-3266.04**	**6546.21**	**0**	**1**
	effort_km_site_730 + (1 | site/line) + (1 | financial_year_cont2)	7	-3311.43	6636.98	90.77	0
	deer_pellets + (1 | line) + (1 | financial_year_cont2)	6	-3346.26	6704.62	158.4	0
	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	7	-3549.37	7112.86	566.64	0
	harvest_km_5000_730 + (1 | site/line) + (1 | financial_year_cont2)	7	-3550.9	7115.92	569.71	0
Dolsco	**deer_pellets + (1 | site) + (1 | financial_year_cont2)**	**6**	**-5562.49**	**11137.09**	**0**	**1**
	effort_km_site_730 + (1 | site) + (1 | financial_year_cont2)	6	-5671.56	11355.22	218.14	0
	harvest_km_5000_730 + (1 | site) + (1 | financial_year_cont2)	6	-5823.9	11659.9	522.82	0
	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-5834.85	11681.79	544.70	0
Ranlya	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-447.07**	**908.56**	**0**	**1**
	deer_pellets + (1 | line) + (1 | financial_year_cont2)	6	-454.46	921.24	12.68	0
	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-567.3	1146.91	238.36	0
	effort_km_site_730 + (1 | site) + (1 | financial_year_cont2)	6	-578.69	1169.68	261.13	0
	harvest_km_5000_730 + (1 | site) + (1 | financial_year_cont2)	6	-579.5	1171.32	262.77	0

Note: Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii* .

Table A3.2. Identification of the best combination of error distribution and random factors for models predicting the proportion of alpine browse of all species combined and each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) from deer pellet groups per management area by comparing corrected Akaike's Information Criterion (AICc). The log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. The best model for each response variable (in bold) were identified using ΔAICc and model diagnostics.

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
Murchison Mountains	All species	**Zi-binomial**	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-944.89**	**1904.78**	**0.00**	**1**
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-1042.57	2095.68	190.90	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-1052.73	2113.82	209.04	0
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-1617.37	3247.49	1342.7	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-1826.19	3660.73	1755.95	0
	Celver	**Zi-binomial**	**deer_pellets + (1 | line) + (1 | financial_year_cont2)**	**6**	**-419.8**	**852.35**	**0.00**	**0.86**
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-422.76	856.05	3.71	0.14
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-443.66	895.66	43.31	0
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-503.38	1019.5	167.16	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-615.78	1239.91	387.56	0
	Dolsco	**Zi-binomial**	**deer_pellets + (1 | line) + (1 | financial_year_cont2)**	**6**	**-615.87**	**1244.56**	**0.00**	**1**
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-806.31	1623.21	378.65	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-809.54	1627.47	382.91	0
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-1051.29	2115.39	870.83	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-1299.87	2608.12	1363.56	0
	Ranlya	Zi-binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	7	-177.12	369.79	0.00	0.74
		Zi-binomial	**deer_pellets + (1 | line) + (1 | financial_year_cont2)**	**6**	**-179.35**	**371.85**	**2.07**	**0.26**
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-253.42	519.98	150.20	0
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-304.86	620.52	250.73	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-311.25	631.04	261.25	0

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-366.21	740.95	371.16	0
Wapiti Area	All species	**Zi-binomial**	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-4645.93**	**9306.11**	**0.00**	**1**
		Zi-binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	6	-4658.00	9328.18	22.07	0
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-5734.65	11479.44	2173.33	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-5747.33	11502.76	2196.65	0
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-6322.97	12658.13	3352.02	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-7681.04	15370.17	6064.07	0
	Celver	**Zi-binomial**	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-2550.62**	**5115.49**	**0.00**	**1**
		Zi-binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	6	-2573.51	5159.2	43.71	0
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-2901.04	5812.21	696.72	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-2926.17	5860.43	744.94	0
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-3090.27	6192.72	1077.23	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-3469.95	6947.99	1832.5	0
	Dolsco	**Zi-binomial**	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-2729.61**	**5473.46**	**0.00**	**1**
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-3471.56	6955.31	1481.85	0
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-3921.31	7852.75	2379.29	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-3925.32	7858.73	2385.26	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-4707.65	9423.39	3949.93	0
	Ranlya	**Zi-binomial**	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-868.24**	**1750.72**	**0.00**	**1**
		Zi-binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	6	-880.11	1772.4	21.68	0
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-925.79	1863.76	113.04	0
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-1088.86	2187.84	437.12	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-1099.46	2207.00	456.28	0

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-1194.16	2396.4	645.68	0
WARO Area	All species	Zi-binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	7	-5126.99	10268.17	**0.00**	1
		Zi-binomial	**deer_pellets + (1 | line) + (1 | financial_year_cont2)**	**6**	**-5149.76**	**10311.65**	**43.49**	**0**
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-6071.83	12155.8	1887.63	0
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-6603.02	13216.13	2947.97	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-6630.95	13269.96	3001.79	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-7575.06	15158.18	4890.02	0
	Celver	**Zi-binomial**	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-1928.63**	**3871.46**	**0.00**	**1**
		Zi-binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	6	-1958.92	3929.98	58.52	0
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-2137.78	4287.71	416.25	0
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-2432.48	4875.05	1003.59	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-2468.83	4945.72	1074.26	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-2694.97	5398.01	1526.55	0
	Dolsco	**Zi-binomial**	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-2852.1**	**5718.41**	**0.00**	**0.98**
		Zi-binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	6	-2856.81	5725.77	7.36	0.02
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-3494.83	7001.82	1283.41	0
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-4074.20	8158.5	2440.09	0
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-4084.53	8177.12	2458.71	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-4689.39	9386.86	3668.45	0
	Ranlya	**Zi-binomial**	**deer_pellets + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-1178.65**	**2371.5**	**0.00**	**0.92**
		Zi-binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	6	-1182.07	2376.29	4.79	0.08
		Zi-binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	6	-1354.46	2721.07	349.57	0
		binomial	deer_pellets + (1 | site/line) + (1 | financial_year_cont2)	5	-1748.25	3506.61	1135.11	0

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
		binomial	deer_pellets + (1 | line) + (1 | financial_year_cont2)	4	-1751.88	3511.83	1140.33	0
		binomial	deer_pellets + (1 | site) + (1 | financial_year_cont2)	4	-1913.94	3835.96	1464.46	0

Table A3.3. Identification of the best combination of error distribution and random factors for models predicting the proportion of alpine browse of all species combined and each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) from harvest rate (harvest_km_10000_730) per management area by comparing corrected Akaike's Information Criterion (AICc). The log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. The best model for each response variable (in bold) was identified using ΔAICc and model diagnostics.

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
Murchison Mountains	All species	**Zi-binomial**	**harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)**	**6**	**-972.13**	**1957**	**0.00**	**1**
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-1091.94	2194.42	237.41	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-1102.80	2213.94	256.94	0
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-1979.49	3971.73	2014.73	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-2228.98	4466.32	2509.31	0
	Celver	**Zi-binomial**	**harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)**	**6**	**-442.60**	**897.95**	**0.00**	**1**
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-450.20	910.93	12.98	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-470.48	949.31	51.36	0
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-560.37	1133.49	235.54	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-681.80	1371.96	474.01	0
	Dolsco	Zi-binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	7	-431.93	878.96	**0.00**	1
		Zi-binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	6	-444.85	902.52	23.55	0
		binomial	**harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)**	**5**	**-611.04**	**1232.66**	**353.7**	**0**
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-616.83	1242.04	363.07	0
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-1153.54	2319.9	1440.94	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-1424.54	2857.46	1978.50	0
	Ranlya	**Zi-binomial**	**harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-160.83**	**337.22**	**0.00**	**0.73**
		Zi-binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	6	-163.04	339.22	2.00	0.27
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-248.09	509.33	172.11	0

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-323.68	658.18	320.95	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-334.55	677.64	340.42	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-394.51	797.56	460.33	0
Wapiti Area	All species	**Zi-binomial**	**harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-5495.67**	**11005.59**	**0.00**	**1**
		Zi-binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	6	-5517.32	11046.82	41.23	0
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-6887.11	13784.36	2778.77	0
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-6908.05	13828.28	2822.69	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-6912.10	13832.28	2826.69	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-8387.62	16783.32	5777.73	0
	Celver	**Zi-binomial**	**harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-2755.21**	**5524.66**	**0.00**	**1**
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-3203.07	6416.27	891.61	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-3238.88	6485.84	961.18	0
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-3293.75	6599.69	1075.03	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-3726.26	7460.61	1935.96	0
	Dolsco	**Zi-binomial**	**harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)**	**6**	**-3078.63**	**6169.45**	**0.00**	**0.52**
		Zi-binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	7	-3077.67	6169.6	0.14	0.48
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-3687.86	7387.9	1218.45	0
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-4664.76	9339.66	3170.20	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-4669.29	9346.67	3177.22	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-5104.09	10216.27	4046.82	0
	Ranlya	**Zi-binomial**	**harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-906.36**	**1826.97**	**0.00**	**1**
		Zi-binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	6	-918.48	1849.16	22.19	0
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-953.68	1919.54	92.57	0

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-1136.16	2282.45	455.48	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-1147.54	2303.16	476.19	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-1241.30	2490.68	663.71	0
WARO Area	All species	**Zi-binomial**	**harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-5674.55**	**11363.29**	**0.00**	**1**
		Zi-binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	6	-5697.25	11406.65	43.35	0
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-6985.57	13983.28	2619.99	0
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-7286.86	14583.83	3220.53	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-7318.15	14644.36	3281.07	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-8509.60	17027.27	5663.98	0
	Celver	**Zi-binomial**	**harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-2019.69**	**4053.57**	**0.00**	**1**
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-2351.91	4715.97	662.40	0
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-2567.36	5144.81	1091.25	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-2605.60	5219.26	1165.70	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-2955.45	5918.97	1865.41	0
	Dolsco	**Zi-binomial**	**harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-3174.37**	**6362.95**	**0.00**	**1**
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-3871.05	7754.26	1391.31	0
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-4516.31	9042.73	2679.78	0
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-4531.48	9071.02	2708.07	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-5167.79	10343.65	3980.70	0
	Ranlya	**Zi-binomial**	**harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)**	**7**	**-1174.45**	**2363.09**	**0.00**	**0.94**
		Zi-binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	6	-1178.26	2368.67	5.57	0.06
		Zi-binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	6	-1297.56	2607.27	244.18	0
		binomial	harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_cont2)	5	-1835.00	3680.11	1317.02	0

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
		binomial	harvest_km_10000_730 + (1 | line) + (1 | financial_year_cont2)	4	-1843.28	3694.64	1331.55	0
		binomial	harvest_km_10000_730 + (1 | site) + (1 | financial_year_cont2)	4	-1947.09	3902.24	1539.15	0

Table A3.4. Best conditional models predicting the proportion of alpine plant browse from deer pellet groups for all species and each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) per management area. See Table A3.2 for detailed model selection.

Management area	Plant species	Variable	Estimates	Standard error	z value	*P*-value
Murchison Mountains	All species	(Intercept)	-3.445	0.880	-3.914	<0.001
		Deer pellets	0.228	0.027	8.347	<0.001
	Celver	(Intercept)	-4.483	1.186	-3.781	<0.001
		Deer pellets	0.399	0.055	7.292	<0.001
	Dolsco	(Intercept)	-1.549	0.533	-2.907	0.004
		Deer pellets	0.011	0.044	0.243	0.808
	Ranlya	(Intercept)	-2.265	0.796	-2.847	0.004
		Deer pellets	-0.273	0.124	-2.204	0.027
Wapiti Area	All species	(Intercept)	-2.476	0.215	-11.521	<0.001
		Deer pellets	0.259	0.007	39.797	<0.001
	Celver	(Intercept)	-2.958	0.361	-8.196	<0.001
		Deer pellets	0.218	0.010	22.18	<0.001
	Dolsco	(Intercept)	-1.352	0.231	-5.863	<0.001
		Deer pellets	0.255	0.01	24.615	<0.001
	Ranlya	(Intercept)	-2.483	0.356	-6.966	<0.001
		Deer pellets	0.152	0.022	6.763	<0.001
WARO Area	All species	(Intercept)	-2.231	0.217	-10.285	<0.001
		Deer pellets	0.165	0.005	32.249	<0.001
	Celver	(Intercept)	-2.544	0.377	-6.749	<0.001
		Deer pellets	0.132	0.01	13.408	<0.001
	Dolsco	(Intercept)	-1.388	0.246	-5.642	<0.001
		Deer pellets	0.185	0.008	24.455	<0.001
	Ranlya	(Intercept)	-2.501	0.272	-9.188	<0.001
		Deer pellets	0.092	0.017	5.323	<0.001

Table A3.5. Best conditional models predicting the proportion of alpine plant browse from harvest rate for all species and each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) per management area. See Table A3.3 for detailed model selection.

Management area	Plant species	Variable	Estimates	Standard error	z value	P-value
Murchison Mountains	All species	(Intercept)	-4.541	0.582	-7.809	<0.001
		Harvest rate	0.119	0.020	5.974	<0.001
	Celver	(Intercept)	-3.014	1.258	-2.396	0.017
		Harvest rate	-0.095	0.028	-3.452	0.001
	Dolsco	(Intercept)	-12.335	1.492	-8.267	<0.001
		Harvest rate	0.81	0.046	17.454	<0.001
	Ranlya	(Intercept)	-1.405	1.706	-0.824	0.410
		Harvest rate	-0.103	0.110	-0.931	0.352
Wapiti Area	All species	(Intercept)	-2.263	0.256	-8.823	<0.001
		Harvest rate	0.009	0.002	4.919	<0.001
	Celver	(Intercept)	-3.270	0.492	-6.640	<0.001
		Harvest rate	0.031	0.003	11.54	<0.001
	Dolsco	(Intercept)	-0.720	0.182	-3.964	<0.001
		Harvest rate	-0.008	0.003	-2.647	0.008
	Ranlya	(Intercept)	-1.957	0.355	-5.516	<0.001
		Harvest rate	-0.012	0.007	-1.901	0.057
WARO Area	All species	(Intercept)	-2.093	0.299	-7.005	<0.001
		Harvest rate	-0.001	0.002	-0.451	0.652
	Celver	(Intercept)	-2.118	0.399	-5.311	<0.001
		Harvest rate	-0.022	0.004	-6.140	<0.001
	Dolsco	(Intercept)	-1.384	0.351	-3.939	<0.001
		Harvest rate	0.006	0.002	2.691	0.007
	Ranlya	(Intercept)	-2.959	0.417	-7.090	<0.001
		Harvest rate	0.034	0.006	6.086	<0.001

Table A3.6. Candidate model sets to investigate alpine plant browse over time as evaluated by comparing corrected Akaike's Information Criterion (AICc). The family error distribution (binomial, zero-inflated binomial: zi-bino), log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. The best model for each response variable (in bold) were identified using ΔAICc and model diagnostics.

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
Murchison Mountains	**All species**	**zi-bino**	**financial_year_fctv2 + (1 | site/line)**	**12**	**-1028.47**	**2083.08**	**0.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | site/line)	7	-1272.02	2558.79	475.71	0.00
		binomial	financial_year_fctv2 + (1 | line)	6	-1281.34	2575.23	492.15	0.00
		binomial	financial_year_fctv2 + (1 | site)	6	-2410.12	4832.79	2749.71	0.00
	Celver	**zi-bino**	**financial_year_fctv2 + (1 | site/line)**	**12**	**-455.61**	**937.35**	**0.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | site/line)	7	-561.35	1137.43	200.08	0.00
		binomial	financial_year_fctv2 + (1 | line)	6	-581.51	1175.57	238.22	0.00
		binomial	financial_year_fctv2 + (1 | site)	6	-789.85	1592.25	654.9	0.00
	Dolsco	**binomial**	**financial_year_fctv2 + (1 | site/line)**	**7**	**-851.61**	**1718.01**	**0.00**	**0.85**
	Dolsco	binomial	financial_year_fctv2 + (1 | line)	6	-854.41	1721.41	3.40	0.15
	Dolsco	zi-bino	financial_year_fctv2 + (1 | site)	11	-1327.92	2679.77	961.76	0.00
	Dolsco	binomial	financial_year_fctv2 + (1 | site)	6	-1630.3	3273.18	1555.17	0.00
	Ranlya	**binomial**	**financial_year_fctv2 + (1 | site/line)**	**7**	**-346.63**	**708.26**	**0.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | line)	6	-354.70	722.14	13.88	0.00
		binomial	financial_year_fctv2 + (1 | site)	6	-408.27	829.29	121.03	0.00
Wapiti Area	**All species**	**zi-bino**	**financial_year_fctv2 + (1 | site/line)**	**14**	**-5461.76**	**10952.46**	**0.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | site/line)	8	-6916.79	13849.9	2897.44	0.00
		binomial	financial_year_fctv2 + (1 | line)	7	-6942.11	13898.46	2945.99	0.00
		binomial	financial_year_fctv2 + (1 | site)	7	-8412.18	16838.61	5886.15	0.00
	Celver	**zi-bino**	**financial_year_fctv2 + (1 | site/line)**	**14**	**-2771.69**	**5572.33**	**0.00**	**1.00**

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
		binomial	financial_year_fctv2 + (1 | site/line)	8	-3258.67	6533.67	961.34	0.00
		binomial	financial_year_fctv2 + (1 | line)	7	-3293.14	6600.53	1028.20	0.00
		binomial	financial_year_fctv2 + (1 | site)	7	-3778.01	7570.27	1997.94	0.00
	Dolsco	**zi-bino**	**financial_year_fctv2 + (1 | site/line)**	**14**	**-3049.58**	**6128.11**	**0.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | site/line)	8	-4651.66	9319.64	3191.53	0.00
		binomial	financial_year_fctv2 + (1 | line)	7	-4655.69	9325.63	3197.52	0.00
		binomial	financial_year_fctv2 + (1 | site)	7	-5096.01	10206.26	4078.15	0.00
	Ranlya	**zi-bino**	**financial_year_fctv2 + (1 | line)**	**13**	**-883.00**	**1792.81**	**0.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | site/line)	8	-1122.33	2260.98	468.17	0.00
		binomial	financial_year_fctv2 + (1 | line)	7	-1133.16	2280.56	487.75	0.00
		binomial	financial_year_fctv2 + (1 | site)	7	-1227.85	2469.95	677.14	0.00
WARO Area	**All species**	**zi-bino**	**financial_year_fctv2 + (1 | site/line)**	**12**	**-5630.47**	**11285.48**	**0.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | site/line)	7	-7269.76	14553.7	3268.22	0.00
		binomial	financial_year_fctv2 + (1 | line)	6	-7300.28	14612.71	3327.23	0.00
		binomial	financial_year_fctv2 + (1 | site)	6	-8494.06	17000.27	5714.79	0.00
	Celver	**zi-bino**	**financial_year_fctv2 + (1 | site)**	**11**	**-2331.97**	**4686.40**	**0.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | site/line)	7	-2585.41	5185.00	498.61	0.00
		binomial	financial_year_fctv2 + (1 | line)	6	-2620.54	5253.22	566.82	0.00
		binomial	financial_year_fctv2 + (1 | site)	6	-2970.41	5952.97	1266.57	0.00
	Dolsco	**zi-bino**	**financial_year_fctv2 + (1 | site/line)**	**12**	**-3149.00**	**6322.56**	**0.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | site/line)	7	-4506.63	9027.46	2704.90	0.00
		binomial	financial_year_fctv2 + (1 | line)	6	-4521.26	9054.68	2732.12	0.00
		binomial	financial_year_fctv2 + (1 | site)	6	-5154.1	10320.36	3997.80	0.00

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
	Ranlya	**zi-bino**	**financial_year_fctv2 + (1 | site/line)**	**12**	**-1182.12**	**2388.79**	**00.00**	**1.00**
		binomial	financial_year_fctv2 + (1 | site/line)	7	-1837.03	3688.25	1299.46	0.00
		binomial	financial_year_fctv2 + (1 | line)	6	-1844.99	3702.13	1313.34	0.00
		binomial	financial_year_fctv2 + (1 | site)	6	-1957.75	3927.64	1538.86	0.00

Table A3.7. Summary of the raw mean proportion of browsed alpine plants for all species combined and each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) and associated standard deviation (±SD) per survey period with the number of surveyed transects (No line).

Management area	Survey period	No line	All species browsed	Celver browsed	Dolsco browsed	Ranlya browsed
Wapiti Area	2005 - 2006	60	0.19 ± 0.18	0.15 ± 0.17	0.31 ± 0.27	0.09 ± 0.15
	2007 - 2008	60	0.12 ± 0.14	0.08 ± 0.15	0.21 ± 0.25	0.07 ± 0.13
	2011 - 2012	60	0.05 ± 0.08	0.02 ± 0.05	0.12 ± 0.21	0.04 ± 0.15
	2014 - 2017	100	0.17 ± 0.16	0.14 ± 0.19	0.30 ± 0.28	0.11 ± 0.17
	2019 - 2020	100	0.18 ± 0.15	0.16 ± 0.18	0.32 ± 0.28	0.13 ± 0.15
	2023 - 2024	80	0.08 ± 0.09	0.08 ± 0.1	0.19 ± 0.25	0.01 ± 0.04
Murchison Mountains	2005 - 2006	20	0.00 ± 0.02	0.02 ± 0.08	0.00 ± 0.01	0.00 ± 0.00
	2007 - 2008	20	0.00 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.01
	2011 - 2012	20	0.01 ± 0.02	0.01 ± 0.02	0.01 ± 0.04	0.00 ± 0.01
	2016 - 2019	50	0.10 ± 0.13	0.07 ± 0.12	0.14 ± 0.24	0.17 ± 0.24
	2022 - 2023	50	0.18 ± 0.16	0.16 ± 0.18	0.29 ± 0.26	0.16 ± 0.23
WARO Area	2005 - 2006	120	0.23 ± 0.20	0.19 ± 0.23	0.35 ± 0.27	0.11 ± 0.15
	2007 - 2009	120	0.08 ± 0.12	0.05 ± 0.10	0.12 ± 0.18	0.04 ± 0.06
	2011 - 2013	120	0.03 ± 0.06	0.03 ± 0.07	0.05 ± 0.10	0.02 ± 0.07
	2016 - 2018	119	0.10 ± 0.15	0.07 ± 0.16	0.19 ± 0.24	0.08 ± 0.16
	2021 - 2022	119	0.16 ± 0.17	0.14 ± 0.22	0.27 ± 0.27	0.08 ± 0.12

Table A3.8. Results from Tukey Post-hoc analysis of models predicting the change in the proportion of alpine plant browse over time (survey period) for all species combined and each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) in each management areas (Murchison Mountains, Wapiti Area and WARO Area). For each survey period, emmean values, standard error (SEM), lower confidence limits (asymp.LCL) and upper confidence limits (asymp.UCL) are provided with associated compact letter displaying pair-wise comparisons.

Management area	Plant species	Survey period	emmean	SEM	asymp.LCL	asymp.UCL	Letters
Murchison Mountains	All species	2005 - 2006	-4.57	0.41	-5.62	-3.52	a
		2007 - 2008	-3.57	0.48	-4.81	-2.32	b
		2011 - 2012	-5.02	0.42	-6.11	-3.94	a
		2016 - 2019	-2.78	0.37	-3.73	-1.83	b
		2022 - 2023	-2.02	0.37	-2.96	-1.07	c
	Celver	2005 - 2006	-4.62	0.63	-6.25	-3.00	a
		2007 - 2008	-1.83	0.79	-3.86	0.20	c
		2011 - 2012	-5.50	0.82	-7.62	-3.39	a
		2016 - 2019	-3.56	0.6	-5.09	-2.03	b
		2022 - 2023	-2.62	0.59	-4.14	-1.09	c
	Dolsco	2005 - 2006	-3.16	0.56	-4.61	-1.71	a
		2007 - 2008	-2.99	1.25	-6.21	0.23	abcd
		2011 - 2012	-1.89	0.54	-3.26	-0.51	b
		2016 - 2019	-1.08	0.47	-2.29	0.14	c
		2022 - 2023	-0.29	0.47	-1.51	0.92	d
	Ranlya	2007 - 2008	-2.47	0.7	-4.2	-0.73	ab
		2011 - 2012	-4.25	0.76	-6.13	-2.37	a
		2016 - 2019	-1.85	0.47	-3.03	-0.68	b
		2022 - 2023	-1.98	0.47	-3.15	-0.81	b
Wapiti Area	All species	2005 - 2006	-1.79	0.17	-2.23	-1.35	e
		2007 - 2008	-2.12	0.17	-2.56	-1.68	c
		2011 - 2012	-2.68	0.17	-3.13	-2.22	a
		2014 - 2017	-1.54	0.17	-1.98	-1.10	f
		2019 - 2020	-1.89	0.17	-2.33	-1.46	d
		2023 - 2024	-2.44	0.17	-2.88	-2.00	b
	Celver	2005 - 2006	-2.49	0.27	-3.19	-1.79	b
		2007 - 2008	-2.27	0.27	-2.98	-1.56	c
		2011 - 2012	-4.10	0.30	-4.88	-3.32	a
		2014 - 2017	-2.01	0.26	-2.70	-1.31	d
		2019 - 2020	-2.12	0.26	-2.82	-1.43	c
		2023 - 2024	-2.55	0.27	-3.25	-1.85	b

Management area	Plant species	Survey period	emmean	SEM	asymp.LCL	asymp.UCL	Letters
	Dolsco	2005 - 2006	-0.74	0.12	-1.05	-0.44	b
		2007 - 2008	-1.14	0.12	-1.45	-0.83	a
		2011 - 2012	-1.30	0.13	-1.64	-0.95	a
		2014 - 2017	-0.19	0.11	-0.49	0.11	c
		2019 - 2020	-1.11	0.12	-1.41	-0.80	a
		2023 - 2024	-1.12	0.12	-1.44	-0.79	a
	Ranlya	2005 - 2006	-1.29	0.24	-1.92	-0.65	e
		2007 - 2008	-2.47	0.25	-3.13	-1.81	abc
		2011 - 2012	-1.65	0.25	-2.31	-0.99	de
		2014 - 2017	-2.33	0.22	-2.91	-1.74	b
		2019 - 2020	-2.06	0.22	-2.64	-1.48	cd
		2023 - 2024	-3.08	0.33	-3.94	-2.21	a
WARO Area	All species	2005 - 2006	-1.28	0.16	-1.68	-0.88	d
		2007 - 2009	-2.21	0.16	-2.61	-1.81	b
		2011 - 2013	-2.97	0.16	-3.39	-2.56	a
		2016 - 2018	-2.20	0.16	-2.60	-1.80	b
		2021 - 2022	-1.84	0.16	-2.24	-1.44	c
	Celver	2005 - 2006	-1.41	0.29	-2.15	-0.66	e
		2007 - 2009	-2.30	0.29	-3.05	-1.55	d
		2011 - 2013	-2.79	0.3	-3.55	-2.03	b
		2016 - 2018	-3.08	0.29	-3.83	-2.33	a
		2021 - 2022	-2.50	0.29	-3.25	-1.76	c
	Dolsco	2005 - 2006	-0.57	0.18	-1.03	-0.12	d
		2007 - 2009	-1.34	0.18	-1.80	-0.89	b
		2011 - 2013	-2.25	0.18	-2.72	-1.78	a
		2016 - 2018	-1.25	0.18	-1.71	-0.80	b
		2021 - 2022	-0.89	0.18	-1.34	-0.44	c
	Ranlya	2005 - 2006	-1.79	0.15	-2.17	-1.40	d
		2007 - 2009	-2.79	0.16	-3.19	-2.38	b
		2011 - 2013	-3.21	0.19	-3.70	-2.71	a
		2016 - 2018	-2.19	0.15	-2.58	-1.79	c
		2021 - 2022	-1.99	0.15	-2.37	-1.60	cd

Appendix 4 – Model selection and analyses of alpine plant abundance (Q4)

Table A4.1. Candidate model sets to investigate alpine plant abundance over time as evaluated by comparing corrected Akaike's Information Criterion (AICc). The family error distribution (negative binomial: ng bino, zero-inflated negative binomial: zi-ng bino), log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. The best model for each response variable (in bold) were identified using ΔAICc and model diagnostics.

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
Murchison Mountains	All species	**ng bino**	**financial_year_fctv2 + (1 | site/line)**	**8**	**-1027.91**	**2072.78**	**0.00**	**1**
		zi-ng bino	financial_year_fctv2 + (1 | site/line)	13	-1027.91	2084.33	11.55	0
		ng bino	financial_year_fctv2 + (1 | line)	7	-1036.38	2087.51	14.73	0
		ng bino	financial_year_fctv2 + (1 | site)	7	-1074.12	2162.98	90.20	0
	Celver	ng bino	financial_year_fctv2 + (1 | site/line)	8	-922.22	1861.39	0.00	0.7
		ng bino	**financial_year_fctv2 + (1 | line)**	**7**	**-924.20**	**1863.13**	**1.74**	**0.29**
		zi-ng bino	financial_year_fctv2 + (1 | site/line)	13	-922.22	1872.93	11.54	0
		ng bino	financial_year_fctv2 + (1 | site)	7	-981.06	1976.86	115.47	0
	Dolsco	**ng bino**	**financial_year_fctv2 + (1 | site/line)**	**8**	**-780.88**	**1578.78**	**0.00**	**0.76**
		zi-ng bino	financial_year_fctv2 + (1 | site/line)	13	-776.36	1581.41	2.63	0.2
		ng bino	financial_year_fctv2 + (1 | line)	7	-785.11	1585.01	6.23	0.03
		ng bino	financial_year_fctv2 + (1 | site)	7	-843.72	1702.23	123.44	0
	Ranlya	ng bino	financial_year_fctv2 + (1 | site/line)	8	-565.71	1148.73	0.00	0.95
		ng bino	**financial_year_fctv2 + (1 | line)**	**7**	**-569.94**	**1154.87**	**6.14**	**0.04**
		zi-ng bino	financial_year_fctv2 + (1 | site/line)	13	-565.71	1160.86	12.14	0
		ng bino	financial_year_fctv2 + (1 | site)	7	-657.64	1330.29	181.56	0

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
Wapiti Area	All species	**ng bino**	**financial_year_fctv2 + (1 | site/line)**	**9**	**-2784.41**	**5587.23**	**0.00**	**1**
		zi-ng bino	financial_year_fctv2 + (1 | site/line)	15	-2784.41	5599.91	12.68	0
		ng bino	financial_year_fctv2 + (1 | line)	8	-2809.60	5635.52	48.29	0
		ng bino	financial_year_fctv2 + (1 | site)	8	-2891.86	5800.04	212.81	0
	Celver	**zi-ng bino**	**financial_year_fctv2 + (1 | site/line)**	**15**	**-2501.98**	**5035.03**	**0.00**	**1**
		ng bino	financial_year_fctv2 + (1 | site/line)	9	-2517.31	5053.03	17.99	0
		ng bino	financial_year_fctv2 + (1 | line)	8	-2542.93	5102.17	67.14	0
		ng bino	financial_year_fctv2 + (1 | site)	8	-2681.27	5378.85	343.82	0
	Dolsco	**zi-ng bino**	**financial_year_fctv2 + (1 | site/line)**	**15**	**-2084.74**	**4200.57**	**0.00**	**1**
		ng bino	financial_year_fctv2 + (1 | site/line)	9	-2100.29	4218.99	18.42	0
		ng bino	financial_year_fctv2 + (1 | line)	8	-2113.68	4243.68	43.11	0
		ng bino	financial_year_fctv2 + (1 | site)	8	-2263.69	4543.7	343.13	0
	Ranlya	ng bino	financial_year_fctv2 + (1 | site/line)	9	-1717.64	3453.67	00.00	0.96
		ng bino	**financial_year_fctv2 + (1 | line)**	**8**	**-1722.1**	**3460.53**	**6.85**	**0.03**
		zi-ng bino	financial_year_fctv2 + (1 | line)	14	-1717.63	3464.21	10.54	0
		ng bino	financial_year_fctv2 + (1 | site)	8	-1974.07	3964.46	510.78	0
WARO Area	All species	**zi-ng bino**	**financial_year_fctv2 + (1 | site/line)**	**13**	**-3558.78**	**7144.19**	**0.00**	**1**
		ng bino	financial_year_fctv2 + (1 | site/line)	8	-3584.98	7186.21	42.02	0
		ng bino	financial_year_fctv2 + (1 | line)	7	-3618.47	7251.13	106.94	0
		ng bino	financial_year_fctv2 + (1 | site)	7	-3648.86	7311.9	167.71	0
	Celver	**zi-ng bino**	**financial_year_fctv2 + (1 | site/line)**	**13**	**-2855.85**	**5738.32**	**0.00**	**1**
		ng bino	financial_year_fctv2 + (1 | site/line)	8	-2879.41	5775.06	36.73	0
		ng bino	financial_year_fctv2 + (1 | line)	7	-2913.67	5841.54	103.21	0

Management area	Plant species	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
		ng bino	financial_year_fctv2 + (1 | site)	7	-3014.40	6042.99	304.66	0
	Dolsco	zi-ng bino	financial_year_fctv2 + (1 | site/line)	13	-2516.80	5060.26	0.00	1
		ng bino	financial_year_fctv2 + (1 | site/line)	8	-2534.15	5084.56	24.30	0
		ng bino	**financial_year_fctv2 + (1 | line)**	**7**	**-2549.61**	**5113.42**	**53.16**	**0**
		ng bino	financial_year_fctv2 + (1 | site)	7	-2734.90	5484.01	423.75	0
	Ranlya	zi-ng bino	financial_year_fctv2 + (1 | site/line)	13	-2313.33	4653.31	0.00	1
		ng bino	**financial_year_fctv2 + (1 | site/line)**	**8**	**-2354.13**	**4724.52**	**71.20**	**0**
		ng bino	financial_year_fctv2 + (1 | line)	7	-2374.60	4763.40	110.09	0
		ng bino	financial_year_fctv2 + (1 | site)	7	-2562.28	5138.75	485.44	0

Table A4.2. Candidate model sets for the relationship between alpine plant abundance and proportion of plant browse as evaluated by comparing corrected Akaike's Information Criterion (AICc). All models were fitted with a normal distribution with alpine plant abundance log transformed. The log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model The best model for each response variable (in bold) were identified using ΔAICc and model diagnostics.

Plant species	Formula	df	logLik	AICc	ΔAICc	weight
All species	**management_area + Prop_Browse_All + (1 | site/line) + (1 | financial_year_fctv2)**	**8**	**-1080.03**	**2176.18**	**0.00**	**0.46**
	management_area * Prop_Browse_All + (1 | site/line) + (1 | financial_year_fctv2)	10	-1078.48	2177.14	0.96	0.29
	Prop_Browse_All + (1 | site/line) + (1 | financial_year_fctv2)	6	-1082.67	2177.41	1.22	0.25
	management_area + Prop_Browse_All + (1 | line) + (1 | financial_year_fctv2)	7	-1148.32	2310.72	134.54	0.00
	management_area * Prop_Browse_All + (1 | line) + (1 | financial_year_fctv2)	9	-1146.37	2310.9	134.71	0.00
	Prop_Browse_All + (1 | line) + (1 | financial_year_fctv2)	5	-1156.90	2323.85	147.67	0.00
Celver	**management_area + Prop_Browse_Celver + (1 | site/line) + (1 | financial_year_fctv2)**	**8**	**-1317.35**	**2650.83**	**0.00**	**0.81**
	management_area * Prop_Browse_Celver + (1 | site/line) + (1 | financial_year_fctv2)	10	-1317.02	2654.23	3.40	0.15
	Prop_Browse_Celver + (1 | site/line) + (1 | financial_year_fctv2)	6	-1322.41	2656.9	6.07	0.04
	management_area + Prop_Browse_Celver + (1 | line) + (1 | financial_year_fctv2)	7	-1377.50	2769.1	118.27	0.00
	management_area * Prop_Browse_Celver + (1 | line) + (1 | financial_year_fctv2)	9	-1377.44	2773.03	122.2	0.00
	Prop_Browse_Celver + (1 | line) + (1 | financial_year_fctv2)	5	-1392.00	2794.05	143.23	0.00
Dolsco	**management_area * Prop_Browse_Dolsco + (1 | site/line) + (1 | financial_year_fctv2)**	**10**	**-1241.24**	**2502.71**	**0.00**	**0.96**
	management_area + Prop_Browse_Dolsco + (1 | site/line) + (1 | financial_year_fctv2)	8	-1247.13	2510.41	7.70	0.02
	Prop_Browse_Dolsco + (1 | site/line) + (1 | financial_year_fctv2)	6	-1249.32	2510.73	8.03	0.02
	management_area * Prop_Browse_Dolsco + (1 | line) + (1 | financial_year_fctv2)	9	-1268.00	2554.2	51.49	0.00
	management_area + Prop_Browse_Dolsco + (1 | line) + (1 | financial_year_fctv2)	7	-1273.94	2561.99	59.28	0.00
	Prop_Browse_Dolsco + (1 | line) + (1 | financial_year_fctv2)	5	-1279.17	2568.41	65.7	0.00
Ranlya	**Prop_Browse_Ranlya + (1 | site/line) + (1 | financial_year_fctv2)**	**6**	**-1042.32**	**2096.73**	**0.00**	**0.57**
	management_area + Prop_Browse_Ranlya + (1 | site/line) + (1 | financial_year_fctv2)	8	-1040.77	2097.69	0.96	0.36

Plant species	Formula	df	logLik	AICc	ΔAICc	weight
	management_area * Prop_Browse_Ranlya + (1 | site/line) + (1 | financial_year_fctv2)	10	-1040.36	2100.94	4.21	0.07
	management_area + Prop_Browse_Ranlya + (1 | line) + (1 | financial_year_fctv2)	7	-1059.43	2132.98	36.25	0.00
	management_area * Prop_Browse_Ranlya + (1 | line) + (1 | financial_year_fctv2)	9	-1059.01	2136.21	39.48	0.00
	Prop_Browse_Ranlya + (1 | line) + (1 | financial_year_fctv2)	5	-1064.21	2138.49	41.76	0.00

Table A4.3. Conditional model of best fitted models predicting the abundance of alpine plant from the proportion of browse for all species and each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*). See Table for detailed information about the model and selection.

Plant species	Variable	Estimates	Standard error	z value	P-value
All species	(Intercept) *Wapiti Area*	5.234	0.172	30.446	<0.001
	Murchison Mountains	0.458	0.294	1.559	0.119
	WARO Area	-0.214	0.229	-0.933	0.351
	Prop_Browse_All	-0.023	0.111	-0.208	0.835
Celver	(Intercept) *Wapiti Area*	4.553	0.237	19.208	<0.001
	Murchison Mountains	0.524	0.401	1.308	0.191
	WARO Area	-0.593	0.315	-1.884	0.060
	Prop_Browse_Celver	0.290	0.142	2.044	0.041
Dolsco	(Intercept) *Wapiti Area*	3.419	0.234	14.593	<0.001
	Murchison Mountains	0.809	0.406	1.992	0.046
	WARO Area	0.140	0.315	0.444	0.657
	Prop_Browse_Dolsco	-0.032	0.142	-0.227	0.821
	Murchison Mountains:Prop_Browse_Dolsco	0.100	0.383	0.262	0.793
	WARO Area:Prop_Browse_Dolsco	0.743	0.218	3.403	0.001
Ranlya	(Intercept) *Wapiti Area*	3.259	0.143	22.798	<0.001
	Prop_Browse_Ranlya	-0.040	0.145	-0.278	0.781

Table A4.4. Summary of the raw mean abundance of alpine plants for all species combined and each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) and associated standard deviation (±SD) per survey period with the number of surveyed transects (No line).

Management area	Survey period	No line	All species abundance	Celver abundance	Dolsco abundance	Ranlya abundance
Wapiti Area	2005 - 2006	60	283.28 ± 195.94	161.07 ± 139.86	87.87 ± 93.92	34.35 ± 53.06
	2007 - 2008	60	275.62 ± 189.65	148.92 ± 140.95	90.78 ± 91.09	35.92 ± 49.61
	2011 - 2012	60	250.22 ± 195.34	150.33 ± 147.85	61.63 ± 61.67	38.25 ± 64.1
	2014 - 2017	100	319.64 ± 236.18	198.13 ± 189.21	77.28 ± 104.82	44.23 ± 58.81
	2019 - 2020	100	293.72 ± 216.61	194.24 ± 179.96	63.13 ± 90.06	36.35 ± 49.12
	2023 - 2024	80	294.29 ± 240.22	223.51 ± 227.63	44.25 ± 62.16	26.52 ± 33.23
Murchison Mountains	2005 - 2006	20	432.75 ± 201.77	176.75 ± 141.02	126.4 ± 124.47	129.6 ± 85.03
	2007 - 2008	20	457.75 ± 197.81	159.80 ± 126.03	168.25 ± 138.97	129.7 ± 91.14
	2011 - 2012	20	514.80 ± 214.65	199.50 ± 145.62	174.70 ± 172.94	140.6 ± 100.38
	2016 - 2019	50	455.78 ± 327.39	239.34 ± 184.44	154.00 ± 195.61	67.68 ± 104.62
	2022 - 2023	50	344.14 ± 278.22	219.78 ± 204.97	91.34 ± 125.72	33.02 ± 51.58
WARO Area	2005 - 2006	120	195.19 ± 138.79	83.27 ± 98.91	75.78 ± 92.58	36.15 ± 42.58
	2007 - 2009	120	207.57 ± 165.88	73.23 ± 86.82	89.12 ± 128.01	45.21 ± 47.44
	2011 - 2013	120	221.10 ± 158.72	83.36 ± 95.15	81.17 ± 112.27	56.57 ± 78.55
	2016 - 2018	119	253.51 ± 220.64	127.57 ± 135.29	76.36 ± 119.16	49.10 ± 75.79
	2021 - 2022	119	228.78 ± 224.49	110.13 ± 147.76	72.82 ± 120.81	45.83 ± 56.68

Table A4.5. Results from Tukey Post-hoc analysis of models predicting the change in the abundance of alpine plants over time (survey period) for all species combined and each indicator species (Celver: *Celmisia verbascifolia*, Dolsco: *Dolichoglottis scorzoneroides*, Ranlya: *Ranunculus lyallii*) in each management areas (Murchison Mountains, Wapiti Area and WARO Area). For each survey period, emmean values, standard error (SEM), lower confidence limits (asymp.LCL) and upper confidence limits (asymp.UCL) are provided with associated compact letter displaying pair-wise comparisons.

Management area	Plant species	Survey period	emmean	SEM	asymp.LCL	asymp.UCL	Letters
Murchison Mountains	All species	2005 - 2006	5.62	0.22	5.06	6.17	ab
		2007 - 2008	5.67	0.22	5.11	6.22	ab
		2011 - 2012	5.78	0.22	5.23	6.34	b
		2016 - 2019	5.85	0.21	5.32	6.38	b
		2022 - 2023	5.54	0.21	5.01	6.07	a
	Celver	2005 - 2006	4.92	0.14	4.55	5.29	a
		2007 - 2008	4.82	0.14	4.45	5.19	a
		2011 - 2012	5.03	0.14	4.66	5.40	ab
		2016 - 2019	5.23	0.13	4.90	5.55	b
		2022 - 2023	5.03	0.13	4.7	5.36	a
	Dolsco	2005 - 2006	4.1	0.37	3.15	5.04	a
		2007 - 2008	4.37	0.37	3.43	5.32	ab
		2011 - 2012	4.37	0.37	3.43	5.31	ab
		2016 - 2019	4.60	0.36	3.69	5.52	b
		2022 - 2023	4.13	0.36	3.22	5.05	a
	Ranlya	2005 - 2006	3.33	0.45	2.18	4.48	b
		2007 - 2008	3.28	0.45	2.13	4.43	b
		2011 - 2012	3.35	0.45	2.19	4.50	b
		2016 - 2019	3.45	0.45	2.30	4.6	b
		2022 - 2023	2.74	0.45	1.59	3.89	a
Wapiti Area	All species	2005 - 2006	5.21	0.17	4.78	5.65	ab
		2007 - 2008	5.23	0.17	4.79	5.67	ab
		2011 - 2012	5.06	0.17	4.62	5.5	a
		2014 - 2017	5.50	0.16	5.07	5.93	c
		2019 - 2020	5.37	0.16	4.94	5.79	bc
		2023 - 2024	5.39	0.16	4.96	5.82	bc
	Celver	2005 - 2006	4.28	0.29	3.51	5.05	a
		2007 - 2008	4.07	0.29	3.30	4.84	a
		2011 - 2012	4.09	0.29	3.32	4.86	a
		2014 - 2017	4.61	0.29	3.85	5.37	b
		2019 - 2020	4.54	0.29	3.78	5.30	b
		2023 - 2024	4.69	0.29	3.92	5.45	b

Management area	Plant species	Survey period	emmean	SEM	asymp.LCL	asymp.UCL	Letters
	Dolsco	2005 - 2006	3.09	0.37	2.13	4.06	b
		2007 - 2008	3.15	0.37	2.19	4.12	b
		2011 - 2012	2.74	0.37	1.78	3.71	a
		2014 - 2017	3.17	0.36	2.22	4.12	b
		2019 - 2020	2.97	0.36	2.01	3.92	ab
		2023 - 2024	2.66	0.36	1.71	3.62	a
	Ranlya	2005 - 2006	2.66	0.21	2.11	3.20	ab
		2007 - 2008	2.76	0.21	2.21	3.31	b
		2011 - 2012	2.73	0.21	2.18	3.27	b
		2014 - 2017	2.71	0.2	2.17	3.24	b
		2019 - 2020	2.59	0.20	2.06	3.13	ab
		2023 - 2024	2.47	0.21	1.93	3.01	a
WARO Area	All species	2005 - 2006	5.05	0.15	4.65	5.44	a
		2007 - 2009	5.07	0.15	4.68	5.47	a
		2011 - 2013	5.18	0.15	4.78	5.57	ab
		2016 - 2018	5.27	0.15	4.87	5.66	b
		2021 - 2022	5.06	0.15	4.67	5.46	a
	Celver	2005 - 2006	3.44	0.33	2.58	4.3	a
		2007 - 2009	3.36	0.33	2.5	4.22	a
		2011 - 2013	3.51	0.33	2.65	4.37	ab
		2016 - 2018	3.99	0.33	3.13	4.84	c
		2021 - 2022	3.69	0.33	2.83	4.55	b
	Dolsco	2005 - 2006	3.14	0.26	2.46	3.81	c
		2007 - 2009	3.05	0.26	2.37	3.72	c
		2011 - 2013	2.91	0.26	2.24	3.59	bc
		2016 - 2018	2.70	0.26	2.02	3.37	ab
		2021 - 2022	2.58	0.26	1.90	3.26	a
	Ranlya	2005 - 2006	2.43	0.38	1.45	3.42	a
		2007 - 2009	2.57	0.38	1.58	3.56	ab
		2011 - 2013	2.71	0.38	1.72	3.70	b
		2016 - 2018	2.53	0.38	1.54	3.52	ab
		2021 - 2022	2.50	0.38	1.51	3.49	ab

Appendix 5 – Model selection and analyses of *Ranunculus lyallii* size class (Q5)

Table A5.1. Candidate model sets for the relationship between the proportion of large *Ranunculus lyallii* (size class: 8cm or more) and harvest rate, deer pellet groups or proportion of browsed Ranlya as evaluated by comparing corrected Akaike's Information Criterion (AICc). The model with the lowest AICc value for each response variable was chosen as the best model. The log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. The best model for each predictor (in bold) were identified using ΔAICc and model diagnostics.

Formula	df	logLik	AICc	ΔAICc	weight
management_area * harvest_km_10000_730 + (1 | area/line) + (1 | financial_year_fctv2)	**9**	**-3364.8**	**6747.79**	**0**	**1**
harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_fctv2)	5	-3394.74	6799.55	51.76	0
management_area + harvest_km_10000_730 + (1 | site/line) + (1 | financial_year_fctv2)	7	-3393.05	6800.22	52.43	0
harvest_km_10000_730 + (1 | line) + (1 | financial_year_fctv2)	4	-3478.1	6964.25	216.46	0
management_area * deer_pellets + (1 | site/line) + (1 | financial_year_fctv2)	**9**	**-3482.99**	**6984.17**	**236.38**	**0**
deer_pellets + (1 | area/line) + (1 | financial_year_fctv2)	5	-3503.56	7017.17	269.38	0
management_area + deer_pellets + (1 | site/line) + (1 | financial_year_fctv2)	7	-3502.21	7018.54	270.75	0
management_area * Prop_Browse_Ranlya + (1 | site/line) + (1 | financial_year_fctv2)	**9**	**-3520.81**	**7059.85**	**312.06**	**0**
1 + (1 | site/line) + (1 | financial_year_fctv2)	4	-3571.41	7150.87	403.08	0
Prop_Browse_Ranlya + (1 | site/line) + (1 | financial_year_fctv2)	5	-3571.41	7152.89	405.1	0
management_area + Prop_Browse_Ranlya + (1 | site/line) + (1 | financial_year_fctv2)	7	-3569.85	7153.84	406.05	0
deer_pellets + (1 | line) + (1 | financial_year_fctv2)	4	-3582.3	7172.63	424.84	0
Prop_Browse_Ranlya + (1 | line) + (1 | financial_year_fctv2)	4	-3653.29	7314.63	566.84	0

Table A5.2. Conditional model of best fitted models predicting the proportion of large *Ranunculus lyallii* (size class: 8 cm or more) from harvest rate, deer pellet groups or the proportion of browsed Ranlya. See Table A5.1 for detailed information about the model selection.

Variable of interest	Variable	Estimates	Standard error	z value	P-value
Harvest rate	(Intercept) *Wapiti Area*	-0.885	0.520	-1.701	0.089
	Murchison Mountains	0.010	0.801	0.012	0.990
	WARO Area	-0.657	0.760	-0.865	0.387
	harvest_km_10000_730	-0.032	0.006	-5.817	<0.001
	Murchison Mountains : harvest_km_10000_730	0.095	0.028	3.449	0.001
	WARO Area : harvest_km_10000_730	0.045	0.006	7.121	<0.001
Deer pellet groups	(Intercept) *Wapiti Area*	-1.533	0.493	-3.112	0.002
	Murchison Mountains	1.350	0.734	1.839	0.066
	WARO Area	0.425	0.747	0.569	0.569
	deer_pellets	-0.021	0.024	-0.889	0.374
	Murchison Mountains : deer_pellets	-0.125	0.054	-2.325	0.020
	WARO Area : deer_pellets	-0.178	0.029	-6.165	<0.001
Browsed Ranlya	(Intercept) *Wapiti Area*	-1.738	0.494	-3.519	<0.001
	Murchison Mountains	1.416	0.741	1.911	0.056
	WARO Area	0.563	0.748	0.752	0.452
	Prop_Browse_Ranlya	1.217	0.220	5.530	<0.001
	Murchison Mountains : Prop_Browse_Ranlya	-0.064	0.382	-0.169	0.866
	WARO Area : Prop_Browse_Ranlya	-2.585	0.288	-8.988	<0.001

Table A5.3. Raw mean of proportion of large *Ranunculus lyallii* (size class: 8 cm or more) with standard deviation (±SD) and results from Tukey Post-hoc analysis of models predicting the change in the proportion of large *Ranunculus lyallii* in each management areas (Murchison Mountains, Wapiti Area and WARO Area) over time (survey period). For each survey period, emmean values, standard error (SEM), lower confidence limits (asymp.LCL) and upper confidence limits (asymp.UCL) are provided with associated compact letter displaying pair-wise comparisons.

Management area	Survey period	Raw means	emmean	SEM	asymp.LCL	asymp.UCL	Letters
Murchison Mountains	2007 - 2008	0.73 ± 0.28	1.14	0.32	0.36	1.93	c
	2011 - 2012	0.76 ± 0.22	1.15	0.31	0.37	1.94	c
	2016 - 2019	0.66 ± 0.29	0.71	0.31	-0.07	1.49	b
	2022 - 2023	0.50 ± 0.31	-0.17	0.31	-0.95	0.62	a
Wapiti Area	2007 - 2008	0.25 ± 0.28	-0.44	0.35	-1.33	0.44	c
	2011 - 2012	0.31 ± 0.32	-0.28	0.35	-1.17	0.61	c
	2014 - 2017	0.22 ± 0.27	-1.93	0.34	-2.82	-1.05	b
	2019 - 2020	0.15 ± 0.21	-2.82	0.35	-3.71	-1.93	a
	2023 - 2024	0.12 ± 0.18	-3.06	0.35	-3.97	-2.15	a
WARO Area	2007 - 2009	0.31 ± 0.31	-1.50	0.35	-2.36	-0.63	a
	2011 - 2013	0.35 ± 0.31	-1.16	0.35	-2.02	-0.30	b
	2016 - 2018	0.39 ± 0.32	-0.84	0.35	-1.70	0.03	c
	2021 - 2022	0.32 ± 0.32	-1.26	0.35	-2.13	-0.40	b

Table A5.4. Candidate model sets to investigate the proportion of large *Ranunculus lyallii* (size class: 8cm or more) over time as evaluated by comparing corrected Akaike's Information Criterion (AICc). The family error distribution (binomial, zero-inflated binomial: zi-bino), log likelihood (logLik), differences in model AICc value from the best model (ΔAICc), degrees of freedom (df) and Akaike weights are shown for each model. The best model for each response variable (in bold) were identified using ΔAICc and model diagnostics.

Management area	Distribution	Formula	df	logLik	AICc	ΔAICc	weight
Murchison Mountains	binomial	financial_year_fctv2 + (1 | area/line)	6	-693.3	1399.51	0	0.81
	binomial	financial_year_fctv2 + (1 | line)	5	-695.96	1402.55	3.04	0.18
	zi-bino	financial_year_fctv2 + (1 | area/line)	10	-693.3	1409.08	9.57	0.01
	binomial	financial_year_fctv2 + (1 | area)	5	-824.94	1660.52	261.01	0
Wapiti Area	zi-bino	financial_year_fctv2 + (1 | area/line)	12	-1182.66	2390.13	0	1
	binomial	financial_year_fctv2 + (1 | area/line)	7	-1229.08	2472.44	82.3	0
	binomial	financial_year_fctv2 + (1 | line)	6	-1251.39	2514.99	124.85	0
	binomial	financial_year_fctv2 + (1 | area)	6	-1540.24	3092.7	702.56	0
WARO Area	zi-bino	financial_year_fctv2 + (1 | area/line)	10	-1589.17	3198.84	0	1
	binomial	financial_year_fctv2 + (1 | area/line)	6	-1605.58	3223.35	24.51	0
	binomial	financial_year_fctv2 + (1 | line)	5	-1657.65	3325.44	126.6	0
	binomial	financial_year_fctv2 + (1 | area)	5	-1899.69	3809.52	610.68	0

DRAFT Internal Report:

Item 9

Analysis of Fiordland WARO Incentivisation Trail

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Department of Conservation
Te Papa Atawhai

Te Kāwanatanga o Aotearoa
New Zealand Government

Contents

Purpose of this investigation

To determine if the incentivisation of venison recovery by commercial Wild Animal Recovery Operators (WARO) from an identified geographical area would increase deer offtake to levels known to reduce browse damage on sensitive alpine species. This was compared to an adjacent area with similar deer densities, which underwent DOC-led deer management without recovery, to compare the efficiency and effectiveness of both control models.

Key takeaways

- DOC led control removed deer above the rate predicted to reduce plant browse
- WARO incentivisation did not remove deer at the rate predicted to reduce plant browse
- Limited processor demand affected WARO deer removal rates
- Overall economic viability of the wild venison industry means reaching targets was still unlikely if the trial ran for a full season
- Potential improvements/options:
    - An incentivised, hybrid WARO-Ungulate control model in areas where the conservation goal is focused on limiting transformational ungulate impacts warrants further investigation
    - Including unrecoverable animals (including chamois) in the incentivisation scheme will deliver a more efficient reduction in ungulate numbers by WARO

Geographical Area

The areas where both control approaches were trialled were in Southern Fiordland (Figure 1). Southern Fiordland was chosen for several reasons:

- It has been subject to low WARO recovery effort over the past 4 years
- Deer numbers were thought to be relatively uniform through the area
- Very little recreational hunting occurs outside of the roar in this part of Fiordland
- No other deer control has occurred in the area
- 1080 operations hadn't recently occurred in this area
- A large WARO area needed to be available to allow multiple WARO to participate in the incentivisation trial
- The community is supportive of deer management and exploring new options in this remote area

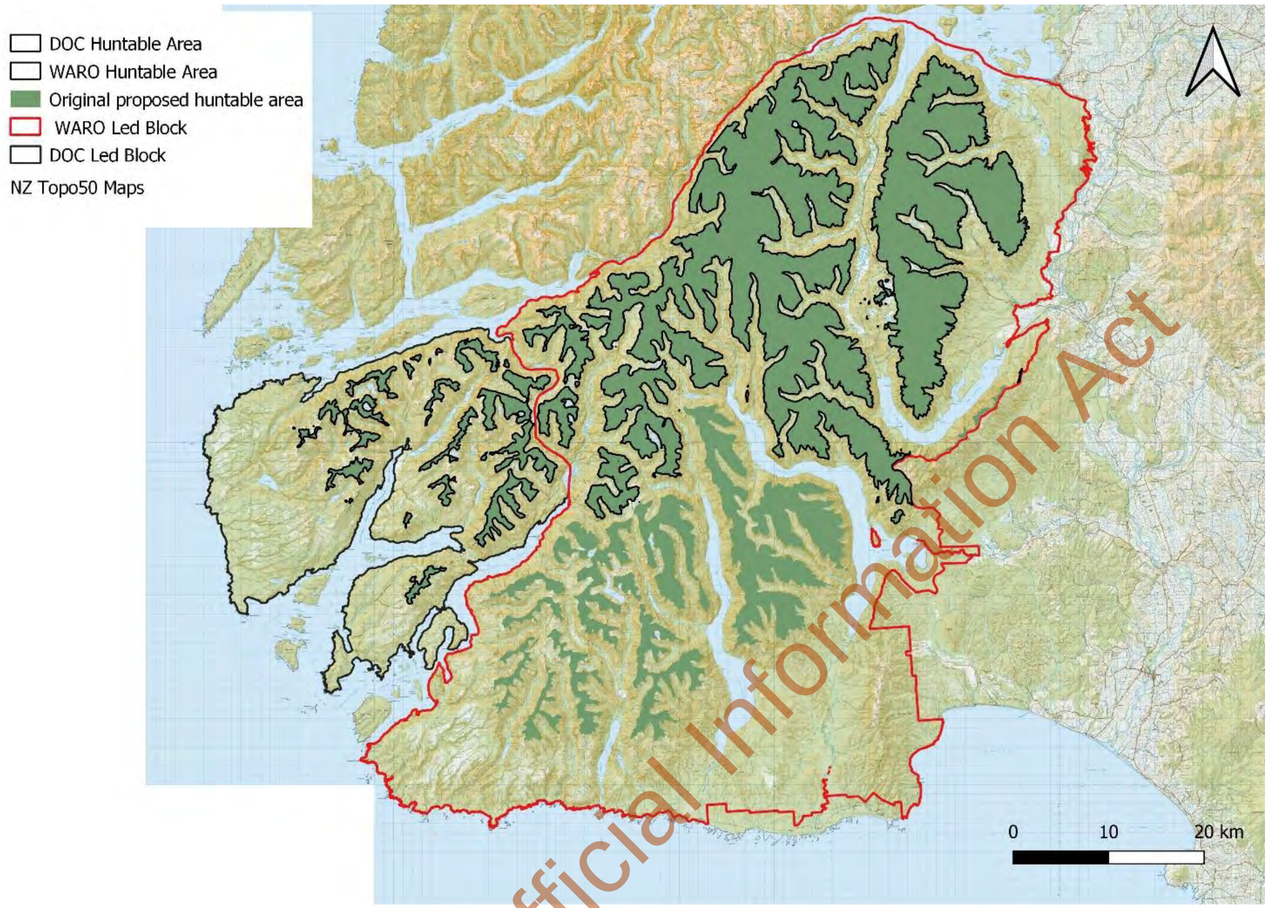

Figure 1: Map of incentivisation trial operational area (huntable area).

Method of incentivisation

Please read documents DOC-7711828 and DOC-7480096 for a detailed description of the incentivisation approach trialled for the WARO operators and the duration of it.

For a wider overview of the subject matter see "Evaluation of the Cost, Risks and Effectiveness of Incentivising Commercial Deer Recover Operations to Achieve Targeted Ecological Outcomes" DOC-7457385.

Operational area Statistics

The total operational area of each block was 360,805 ha for the WARO block and 82,448 ha for the DOC led block. In Fiordland, more than 90% of the deer are hunted in alpine or alpine adjacent areas. Our monitoring shows annually harvesting more than1.25 deer /km^2 from alpine areas reduces deer browsing on sensitive alpine plants used as indicator species (Whitehead 2024). However, this response was not observed for similarly sensitive plants in forested environments (Clarke 2024). This illustrates that while relatively high WARO offtake results in declines in alpine plant browse, the same cannot be said for sensitive forest species. Therefore, we focussed our analysis on deer extracted from alpine and alpine adjacent areas. I called these areas the Huntable Area.

The original designated WARO led operational area was much larger (see DOC-7480096), but due to the low number of processors that were engaged in the trial (2), we reduced the operational area of the WARO led block to reflect the area that was searched by the operator engaged by the processors, which enabled us to fairly compare the effectiveness of the operations in the areas actually hunted. This resulted in the WARO led area being reduced by approximately 30%.

Deer kills included in the analysis:

Because we are interested in deer that had the potential to be using alpine areas, I included all deer removed >500m above sea level (ASL). The alpine bush line extends down to around 700m in many places of therefore I determined deer >500m ASL were likely to be using alpine areas based on a minimum home range of an adult red deer being 400m (Nugent 1993). This resulted in 303 and 505 deer being included in the analysis for the WARO and DOC led blocks respectively (Figure 2).

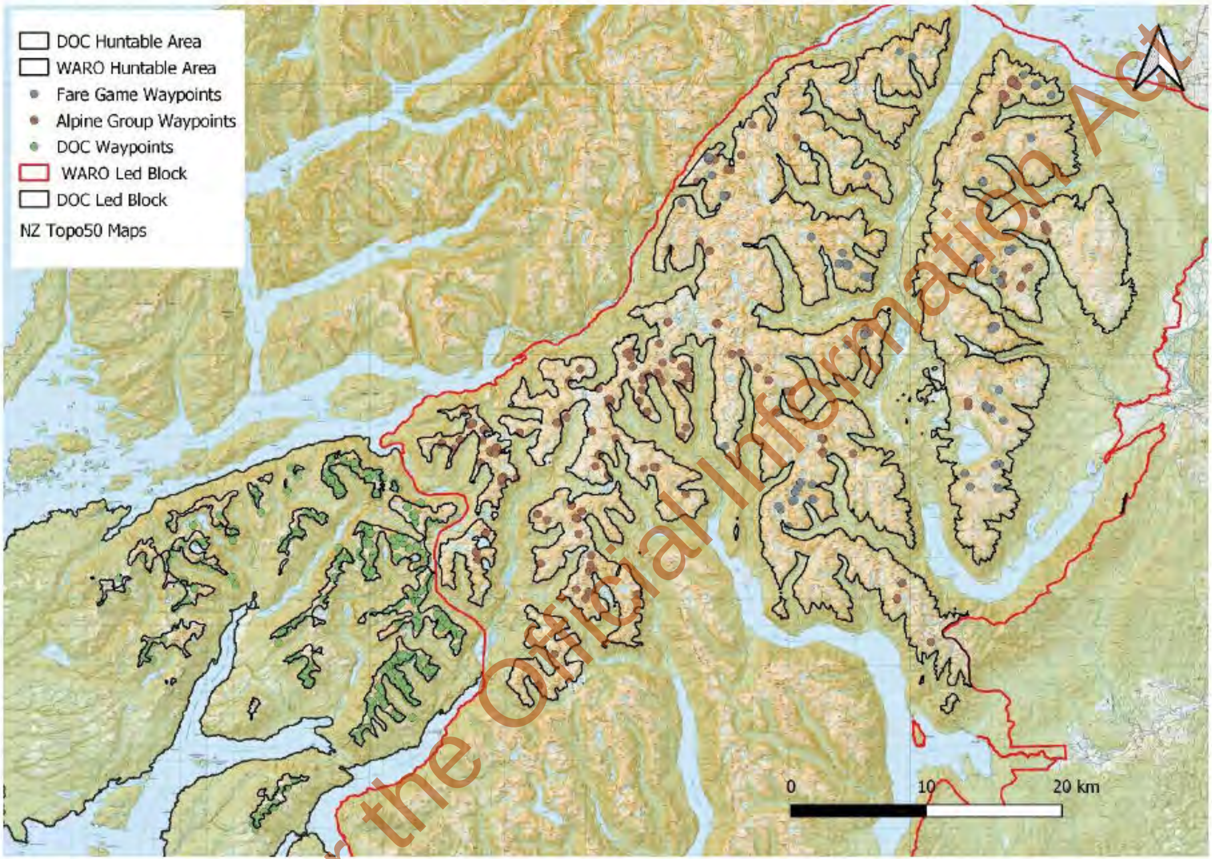

Figure 2: Location of deer kills >500m ASL delivered during the trial

Calculation of Huntable Area

Huntable area was originally going to be LCDB5 areas of 'open' habitat (LCDB5 classes: tussock, bare rock, etc), however parts of Southwest Fiordland are a mosaic of shrub, forest and alpine, so a more generic classification of huntable area was used. The area used was all land above 800m ASL, above which was mostly dominated by 'open' habitat types.

	Hectares	Km²
WARO Total Area	360,805	3,608
DOC Total Area	82,448	824
WARO Huntable Area:	87,917	879.17
DOC Huntable Area:	8,835	88.35

Huntable Area searched = Active hunting area

Active hunting area is the Huntable Area searched each flight. To calculate this, tracklogs are buffered by 500m, and then clipped to the treatment area (>800m ASL polygon) (Figure 3). To remove overlapping search areas e.g. when a helicopter is going back over ground previously searched in that same flight, the polygons are dissolved into one flattened shape, from which area (km^2) can be calculated from.

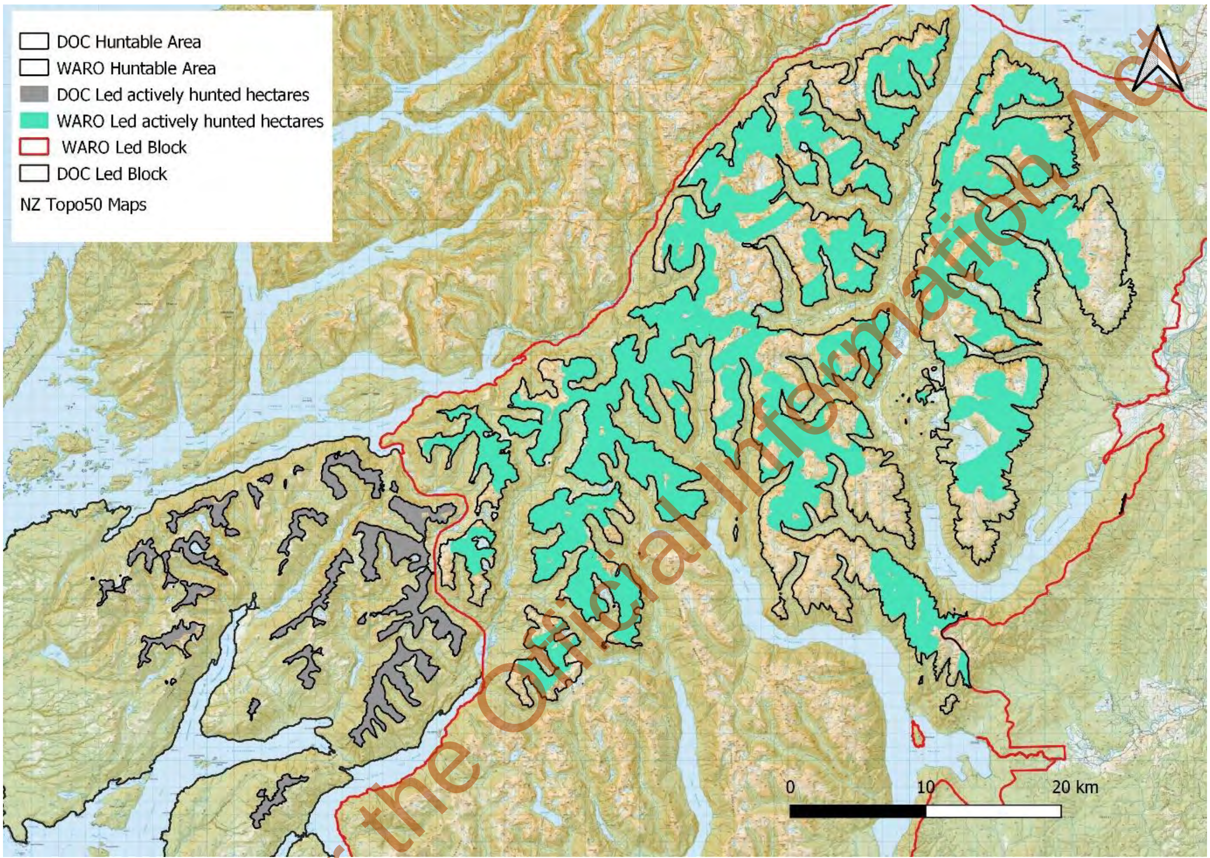

Figure 3: Area actively searched within treatment area

Active hunting distance

Active hunting distance was calculated by clipping flight tracklogs to the huntable area polygon (Figure 4). Because active searching often begins before helicopters are over huntable territory (i.e. pilots and shooters are looking for deer up to 500m away) I buffered the huntable areas by a further 250m and clipped all tracklogs to this to calculate distance flown while actively hunting.

How to account for Ferry Time costs to reach hunting areas?

Because ferry times were different to each block, I wanted to remove these, so we can compare the hunting results equally between blocks. I calculated ferry time cost based on mean flying time to reach the centre of each control block and deducted this as a percentage off the total costs of each control block. For the DOC led block this was calculated as 30% of the total flying costs, which aligned with ferry time estimates recorded by staff. For the WARO block we calculated ferry time accounting for 15% of the flying costs, given the centre of the block was approximately half the distance from the heliports used by helicopters servicing both blocks.

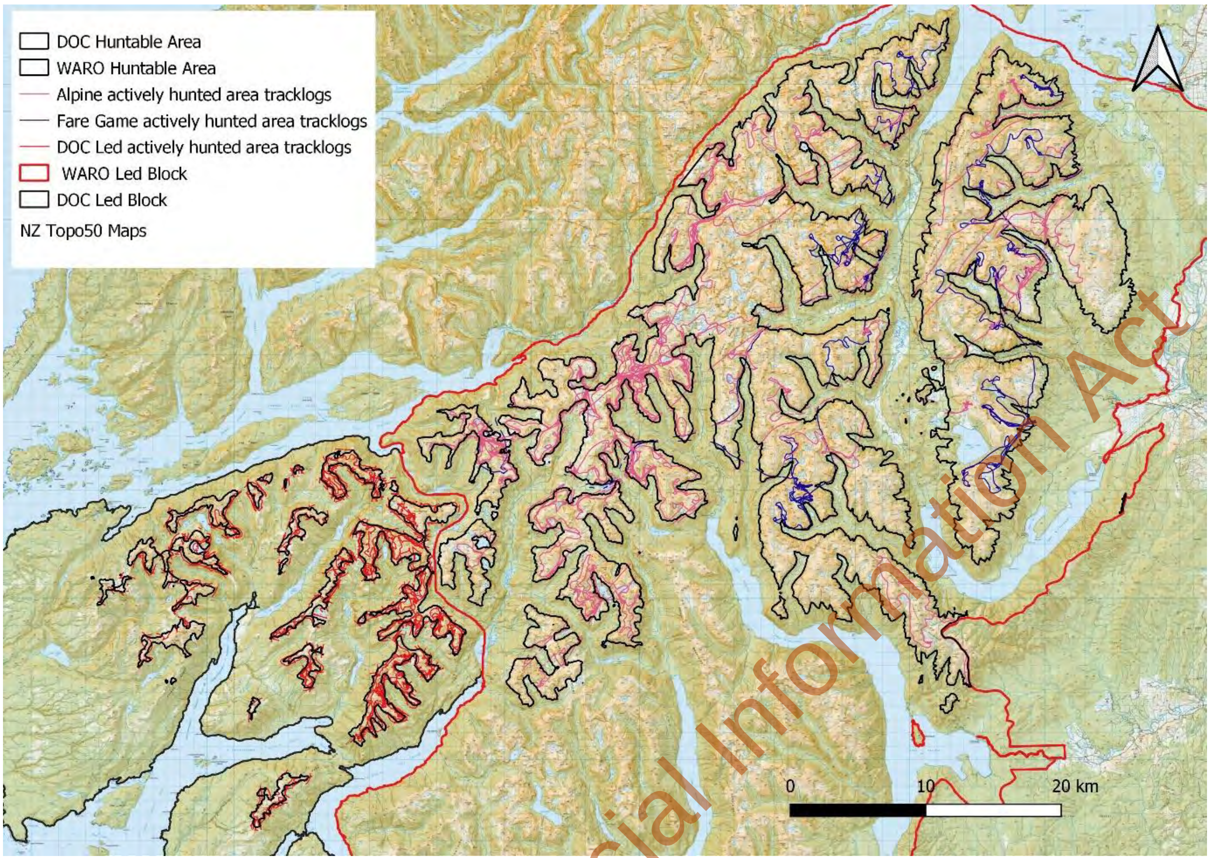

Figure 4: Active hunting tracklogs within the operational areas

Metrics to analyse

Choosing what metrics to use depends on the questions we are trying to ask. Several metrics can be looked at, please see Appendix 1 for a brief overview of metrics considered. There are two key elements we are interested in – Operational area questions (how effectively the entire operational areas were treated?) and treatment efficiency questions (of the areas treated, how intensive was the control and search effort?).

Operational area comparisons: I used the entire operational area to compare the following

- **\$/km2 of huntable area**: A simple metric enabling the manager to understand the cost per hectare of treating the huntable area (but it doesn't tell you what you got for that cost i.e. quality (search coverage) or quantity (catch per unit effort))
- **\$/deer**: A simple metric enabling the manager to understand the cost per deer removed. This enables us to compare how much each deer cost to remove from the area we are trying to protect - our huntable area, sic. Alpine areas.
- **Deer/km^2 of total huntable area:** A catch per unit area metric, this enables us to compare removal rates between blocks and to historic rates from across Fiordland that are known to reduce browse on preferred alpine species.
- **Deer/km flown in huntable area:** This could be considered duplication to the above, as this is a catch per unit effort metric which allows us to compare deer capture rates. However, it is useful to compare.
- **\$/km flown in huntable area:** another cost metric useful to compare to \$/km^2

Treatment efficiency: I used the actively hunted area to compare the following

- **% of block treated:** This provides an indication of search effort intensity - huntable area (forecast) vs. actively hunted area (actual).
- **Deer/km^2 of actively hunted area:** this enables us to compare harvest rates per unit area searched within the huntable area (tracklogs buffered by 500m clipped to >800m contour).

- **\$/km2 of actively hunted area:** This factors in the total coverage (treated hectares) of each flight to show the cost per square kilometre actively hunted.
- **\$/deer/km2 of actively hunted area:** The efficiency of each control program can really only be compared by dividing the cost of control per hectare of area actively hunted with the number of deer removed per hectare of actively hunted area – this tells us effectiveness between each program by giving us the metric of cost to remove 1 deer per km^2 of actively hunted area.

Results:

Huntable Area and actively hunted area results are presented in tabular form in Table 1 and Table 2

Table 1: Operational Area Results

	WARO led	DOC led
Operational Area km^2	**879.00**	**88.00**
Total treatment costs excl. ferry time	**\$ 24,820.00**	**\$ 31,685.50**
Deer Shot	**303**	**505**
Number of flights	**18**	**6**
Total flying time		
km flown in treatment area	**2121**	**850**
\$ / km^2	\$ 28.23	\$ 358.64
\$ / deer	\$ 80.00	\$ 62.74
deer removed / km^2	0.3446432	5.715903

Table 2: Operational efficiency results

	WARO led	DOC led
Operational Area km^2	**879**	**88**
km^2 treated	**737**	**215**
Total treatment costs excl. ferry time	**\$24,820.00**	**\$31,685.50**
Mean % op. area treated per flight	6% (±0.02)	41% (±0.11)
Deer/km^2	0.41	2.34
Deer/hour		

deer/ lineal km flown	0.1428571	0.594118
$ / lineal km flown	$ 11.70	$ 37.28
$/km^2 treated	$ 33.66	$ 147.09
$/deer/km^2	$ 81.91	$ 62.74

Discussion:

This analysis has focussed on the return per unit of investment for DOC. Any incentivisation scheme invested in on Public Conservation Land (PCL) must return positive ecological benefits. There are complex social and economic benefits arising from meat recovery, but these are not the focus of this analysis.

I have tried to manipulate the data, so we are able to fairly compare the performance of both types of management, however there is one important piece of data we did not have for this trial; deer density information. There is the assumption that deer numbers are relative y even across the treated areas, however we must consider that some of the differences in efficiency (catch per unit effort (CPUE)) may be attributable to differences in deer density i.e. densities could well be (and probably are) higher in the DOC led operational area due to WARO activity being lower in this southwestern part of Fiordland. Just how much higher is not known.

Nevertheless, there are clear differences between both operations. While the DOC operation at face value appeared more expensive, costing $358/km^2 vs $28/km^2 to treat the huntable area, this hides the fact that the DOC operation searched the area more thoroughly and removed more deer. The two key illustrations of this in the data are a higher number of deer shot per km^2 searched in the DOC led block (2.34 DOC; 0.41 WARO) and approximately 3x more intensive search effort per unit area in the DOC led block.

When we look at the cost per deer removed, DOC were 22% cheaper at $62.74 per deer vs. WARO at $80.00. So, while DOC control cost more per unit area, it was more intensive and removed more deer at levels significantly exceeding those predicted to benefit alpine vegetation (>1.5 deer km^2). This higher CPUE may be an artefact of higher deer numbers in the DOC led block, however the removal rates, being almost five-fold that of the WARO block, are well beyond any plausible population differences.

Further refining the analysis to focus on actively treated areas of each of the blocks revealed significantly higher search coverage was achieved in the DOC led block, but focusing analysis on actual area treated closed the gap between the $/deer and deer/km^2 figures. This illustrates the importance of focusing on the area treated to get a true understanding of the effectiveness of your operation.

Unfortunately, due to operational signoff delays, the trial began almost halfway through the recovery season. Given this, total removal rates by WARO would have increased if the trial was able to run the full length of the season. However, to reach a >1.5 deer /km^2 removal rate, a further 1016 deer would have needed to be removed from the operational area. Based on removal rates during the trial, this would have not been met, with the critical restraint on harvest rates being processor demand which remained static through the trial.

Conclusions and Recommendations:

DOC deer management without recovery and commercial Wild Animal Recovery are completely different models to remove deer from the landscape, one motivated by conservation outcomes, the other primarily motivated by economic return. From a conservation management perspective, we are trying to lower numbers to a level that restricts or removes their detrimental impact on the landscape i.e. success is governed by what you have left behind, and the response of the vegetation. As numbers are lowered, the economics of deer recovery diminish, and in the current economic climate wild animal recovery operations are only just viable, so, operators must achieve a catch rate that exceeds operating costs. This can result in some deer being left behind, due to carcase weight restrictions or recovery barriers e.g. unrecoverable animals being left.

In this trial, low demand (and prices) coupled with high operating costs have resulted in WARO harvest rates being well below levels hypothesised to improve vulnerable alpine vegetation. The stimulus provided by DOC did not appear to increase harvest rates above those observed in recent years (0.41 deer/ km^2 in this trial vs. ~0.5 deer/ km^2 across Fiordland since 2021). If a full season was available to these operators more deer would have been removed, but to achieve significantly higher removal rates, fundamental economic factors need to change within the industry.

If a removal rate was the conservation result target e.g. 1.5 deer/km^2 of a pine habitat, a hybrid model could be implemented whereby unrecoverable animals (including chamois) could be included in the incentivisation scheme. This would improve the economics of the operation as lighter/undesirable animals or animals in unrecoverable locations could be dispatched quickly at no more expense than DOC led operations. Based on data from this operation, $62 could be paid for any animal, with a targeted minimum number required to be removed from a defined area e.g. 1000 km^2 @ 1.5 deer/km^2 (>800m ASL) = 1500 deer x $62 = $93,000. This could be let out to tender or as a contract, with the operator/processor required to remove that target whichever way they choose. There are details that need to be considered such as kill and location verification, milestone payments and helicopter type used, however similar procurement arrangements have occurred before within the department. Additionally, any incentivisation scheme needs to take consideration of international trade agreements and rules surrounding these.

Any model such as this needs to be supported by ecological evidence. Thought needs to be given to the certainty of targets achieving outcomes, and the monitoring required to support the adaptive management of targets to ensure conservation goals are met.

It is clear from the data that DOC led control was efficient and effective in removing deer from the landscape. Where there is the requirement for control to low densities to achieve conservation outcomes on PCL, DOC led control is efficient and cost effective, however with that comes expense ($142 / km^2). Where the ecological priority for PCL is lower, intermediate levels of control could be considered, whereby ungulates are kept to densities that allow the structural integrity of alpine landscapes to persist, enabling the provision of ecosystem services and persistence of ungulate vulnerable species. This may be achievable through an incentivised hybrid WARO-Ungulate control model at locations deemed a priority. This could be an intermediate management option for over abundant ungulate landscapes until such a time that the WARO industry can contribute more (increase offtake) through its own economic success.

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Appendix 1: Possible analysis metrics

1. Catch per unit area or length treated: For this we could naturally look at deer dispatched per km^2 of treatment area, however this can also be represented by how many kilometres were flown in the treatment area. We chose to calculate the following metrics:
    a. Deer removed / km^2
    b. Deer removed per km flown of active hunting
2. Cost per unit extracted: After the removal of ferry time costs, the cost of the operation areas can simply be divided by the number of deer shot in alpine and alpine adjacent.
    a. $/deer (excl. Ferry time costs)
3. Cost per unit area needing treatment: This is calculated once again by dividing the total cost (excl. Ferry Time) by the treatment area.
    a. $/ha of treatment area
4. Cost per unit area treated (searched). This can be done in two ways:
    a. $/km flown
    b. $/ha searched
5. Cost per deer per length or unit area treated: this is best represented by the below two metrics which are essentially metrics of efficiency.
    a. $/deer/$km^2$ treatment area
    b. $/deer/km active flying

Department of Conservation
Te Papa Atawhai

Item 10

File Ref DOC-7711828

Date: 05 August 2024

To: Mike Perry

CC:

From: Chris Wootton

Subject: Summary of Fiordland WARO Trial 2023-2024

Purpose

To provide a high-level summary of the Fiordland WARO Trial undertaken by the Wild Animal Management programme in 2023-24. A final report is being prepared, this memo serves to provide interim findings from this work.

Background

The DOC national Wild Animal Management (WAM) programme has been exploring how to increase the effectiveness and contribution of the wild deer industry at selected areas of Public Conservation Land (PCL). DOC is testing working with the industry and associated aerial venison recovery (WARO) operators to see how DOC can collaborate more closely with the industry.

The key outcome sought is development of more WAM ‘tools in the box’ we can use to reduce deer browse pressure on native plants and habitats and support conservation values on PCL.

The trial concept was developed from mid-2023 for testing within Fiordland National Park. Two blocks within Fiordland National Park were identified for the trial. One block was set aside for WARO led work (360,000ha). A comparative block (82,000 ha) was set aside for DOC led conventional aerial control work.

March 2023 example map shows data captured including flight paths and kills for the two adjacent blocks as the trial approached its conclusion.

We set up contracts for services with 4 meat processing companies and set a simple $80/head incentive figure with a quota of 300/carcasses (target of 1200 animals total) for harvest from the defined WARO led block. We set contracts specifically with meat processing companies who then were able to work with their elected WARO operators to harvest deer, under normal conditions of their WARO permit.

Our intention through the trial and contracts, was to let the market run, with minimal interference by DOC. Then observe and interpret the market outcomes.

Uptake in contracts and interest in participating in the trial from the commercial sector was high from 2023.

The trial start was delayed to early February 2024 which influenced the original target of 1200 animals sought. By May 2024, weather conditions and market factors meant that fewer deer than originally planned had been harvested.

We found that market activity was also influenced by meat plant capacity to take feral venison (in turn influenced by farmed venison demand & schedules) and the attention drawn to more accessible and economic returns available for feral deer on private property.

The remote nature of the WARO block in Fiordland, with associated high ferry times and harvesting costs, possibly influenced the amount of activity that occurred by meat processors and their elected WARO operators during the trial.

Total deer harvested through the WARO trial was 436, with 365 deer qualifying for an incentive payment (i.e. deer harvested from the trial block and having data supplied enabling this to be verified). These deer were harvested by two of the four companies contracted.

The **DOC led component of the trial in comparison resulted in 520 deer and 63 chamois shot in the adjacent DOC trial block**. Costs of helicopter hire (excluding DOC staff costs) were $46,735 with a $80.16 $/head cost for control.

Preliminary findings

- Commercial sector (meat processors + WARO) remain enthusiastic about some form of collaboration with DOC to achieve joint benefits through targeted WARO on Public Conservation Land.

- Targeted DOC led (search & leave) control is very similar in cost and enables intensive direction of control by DOC where required.

- Additional economic and social benefits of meat harvest into food chain (through WARO led approach) need more work to determine.

- Abundance of feral deer on private property influences economic activity of meat processing industry and therefore activity in more remote (less economic) public conservation lands.

- Timing of any WARO incentivisation needs to conform with seasonal meat processing plant demand and its interaction or preference for farmed venison processing.

- Feral venison remains a small part of the wider and more significant farmed venison sector, we need to understand better the interplay of these factors within the commercial industry.

- Any wider extension of WARO incentivisation needs to ensure it conforms with NZ international trade obligations.

- Maintaining a strong level of dialogue with the meat processing and WARO industry is critical to help understand how to make the industry more effective in terms of contributing to conservation outcomes sought by DOC.

We plan to develop and understand the results from this work in more depth in 2024.

We are also working to adapt this model for Ruahine Forest Park in 2024/25. We are working alongside the commercial and recreational hunting sectors to develop a model that targets lighter carcass weight animals – normally less attractive to meat processors – as well as recreational hunters.

This approach is more agreeable with recreational hunters who see the need for reducing deer abundance in Ruahine Forest Park. Consensus amongst the community is that managing the Ruahine deer population is needed to help ensure higher quality deer remain available for recreational hunters.

A report prepared for:

Department of Conservation

Deer recovery predictive model

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16 June 2023

Summary

This document reports on an analysis of Fiordland deer recovery data. The purpose of this analysis was to understand the potential of the price of venison, Jet A1 fuel, and hunting effort in predicting the number of deer carcasses recovered by commercial aerial operations with a focus on the Waro block. This analysis was tangential to an analysis investigating the impact of deer recovery operations on vulnerable alpine plants known to be palatable to deer. The analysis reported here is not regarded as comprehensive, merely indicative.

The analysis suggests the number of deer recovered can be predicted with a good degree of accuracy from a metric of past hunting efficiency, the price of venison, and Jet A1 fuel. The prediction is, however, reliant on knowledge of the number of monthly hunting days. Any future modelling work should examine if hunting days can themselves be independently predicted. Effectively this would give rise to a two-stage model that could predict both the number of hunting days and the number of deer killed.

Method

This document reports on an analysis of Fiordland deer recovery data. The purpose of this analysis was to understand the potential of the price of venison, Jet A1 fuel, and hunting effort in predicting the number of deer carcasses recovered by commercial aerial operations with a focus on the Waro block. All data was provided by the Department of Conservation. This analysis was tangential to an analysis investigating the impact of deer recovery operations on vulnerable alpine plants known to be palatable to deer.

Statistical analysis

All analyses, graphing, and examination of model diagnostics occurred in Program R (version 4.2.1) (R Core Team, 2022) with additional functionality provided by the packages: 'DHARMa' (Hartig, 2022), 'kableExtra' (Zhu, 2021)', 'glmmTMB' (Brooks et al., 2017), 'lubridate' (Grolemund and Wickham, 2011),'mgcv' (Wood, 2022), 'MuMIn' (Bartoń, 2022), ‘readxl’ (Wickham and Bryan, 2022), and the ‘tidyverse’ (Wickham et al., 2019).

A suite of candidate models representing different hypotheses (i.e. different explanations of how explanatory variables present in the data could predict the observations) including an intercept only ‘null’ model (which acts as an uniformative model for comparison purposes) were developed. Models were tested in a model selection process using Akaike’s Information Criterion (with small sample adjustment) via the ‘MuMIn’ package to rank the models in terms of parsimony (Burnham and Anderson, 2002).

As the raw data was whole number counts (i.e. integers) the standard approach involves Poisson regression. Parametric modelling approaches, such as Poisson regression, demand that the underlying assumptions of the models are fulfilled. As the amount of effort (monthly hunting days) varied an offset based on hunting days was used. Diagnostic checks were conducted using the ‘DHARMa’ package. Overdispersion was detected so a negative binomial distribution family was used instead of a Poisson distribution. Rechecking of the residuals suggested some minor issues remained but the model was generally much better.

Results

Data exploration

The number of deer killed (Figure 1) is very clearly a function of the number of hunting days (Figure 2). The relationship between the two is a log-log relationship (without transformation the amount of variability in the relationship increases exponentially) and rather tight ($r^2 = 0.81$; Figure 3).

There was a reasonable strong pattern of variation in deer kills between months (Figure 4) with most kills occurring from late spring to mid summer, albeit with a notable reduction in December. The amount of deer recovered from different management locations has shifted through time with the Wapiti kills becoming more prevalent in recent years (Figure 5).

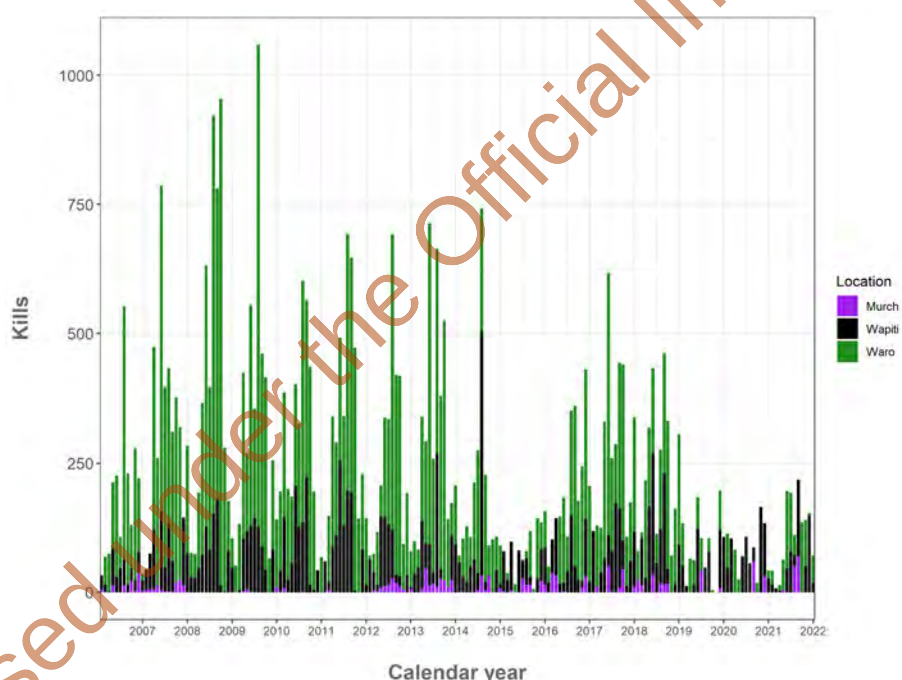

Figure 1: Annual kills for each hunting area.

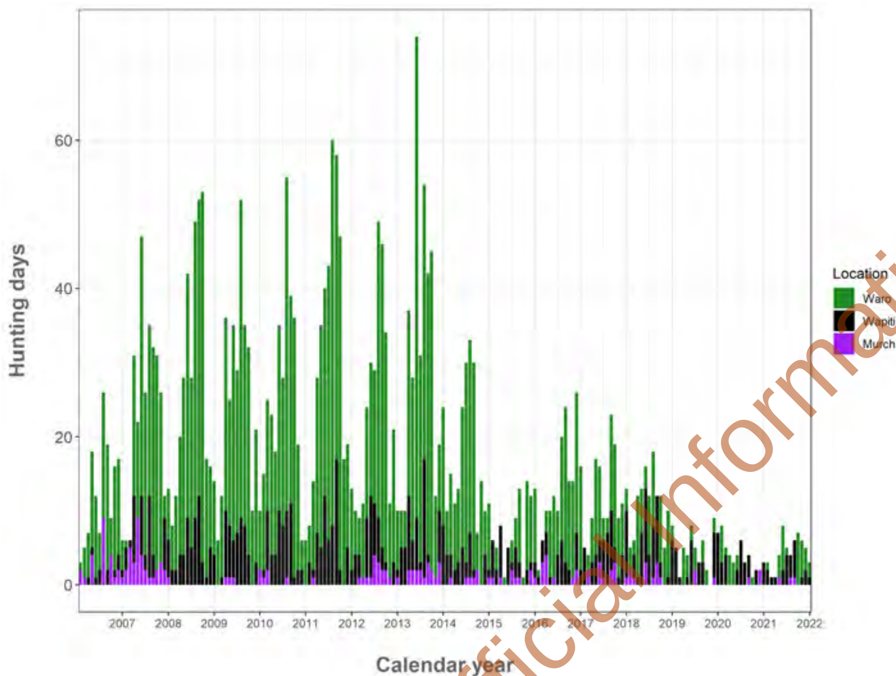

Figure 2: Variation in hunting days for each hunting area.

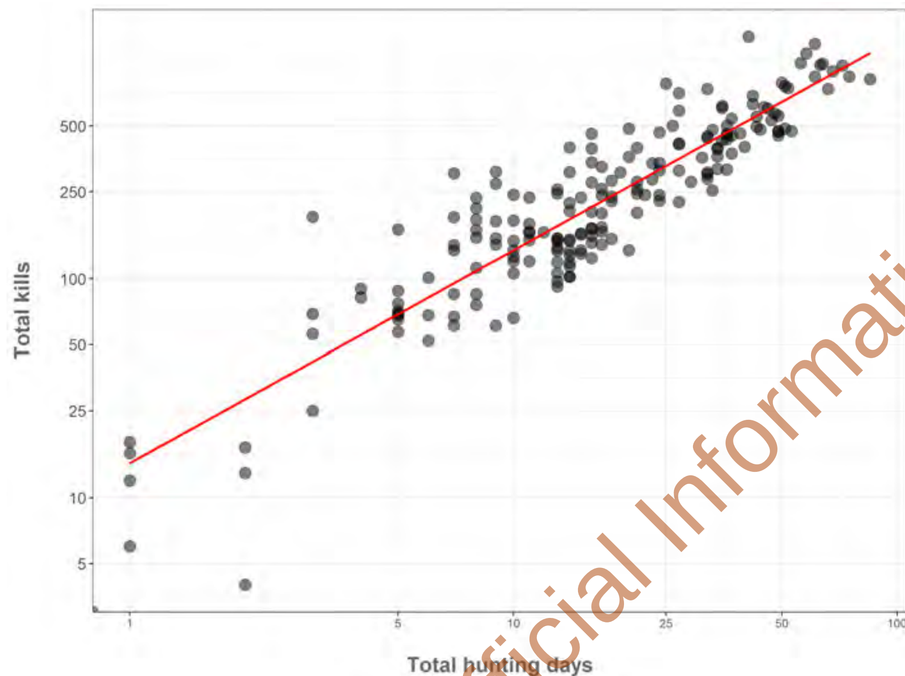

Figure 3: The log-log relationship between total kills and total hunting days ($r^2 = 0.81$)

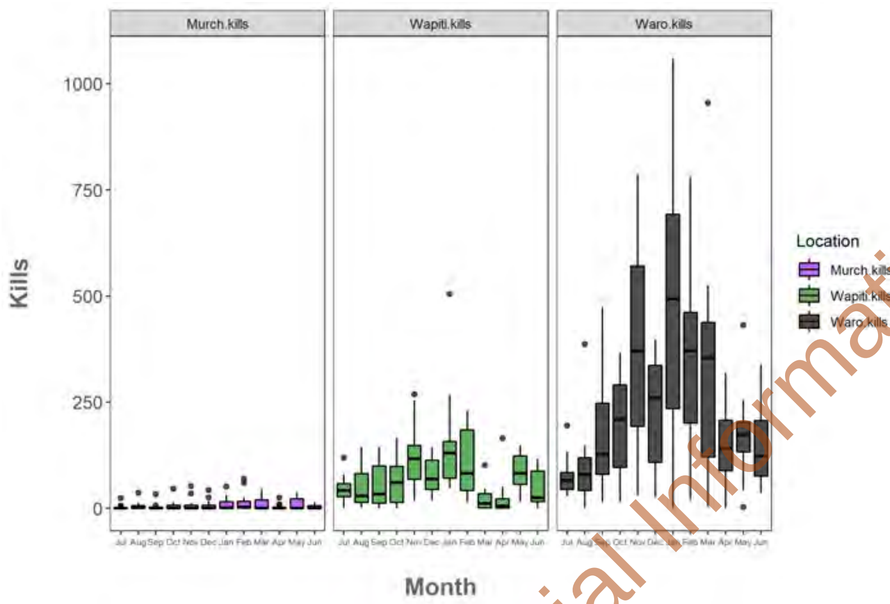

Figure 4: Variation in the number of deer kills by month.

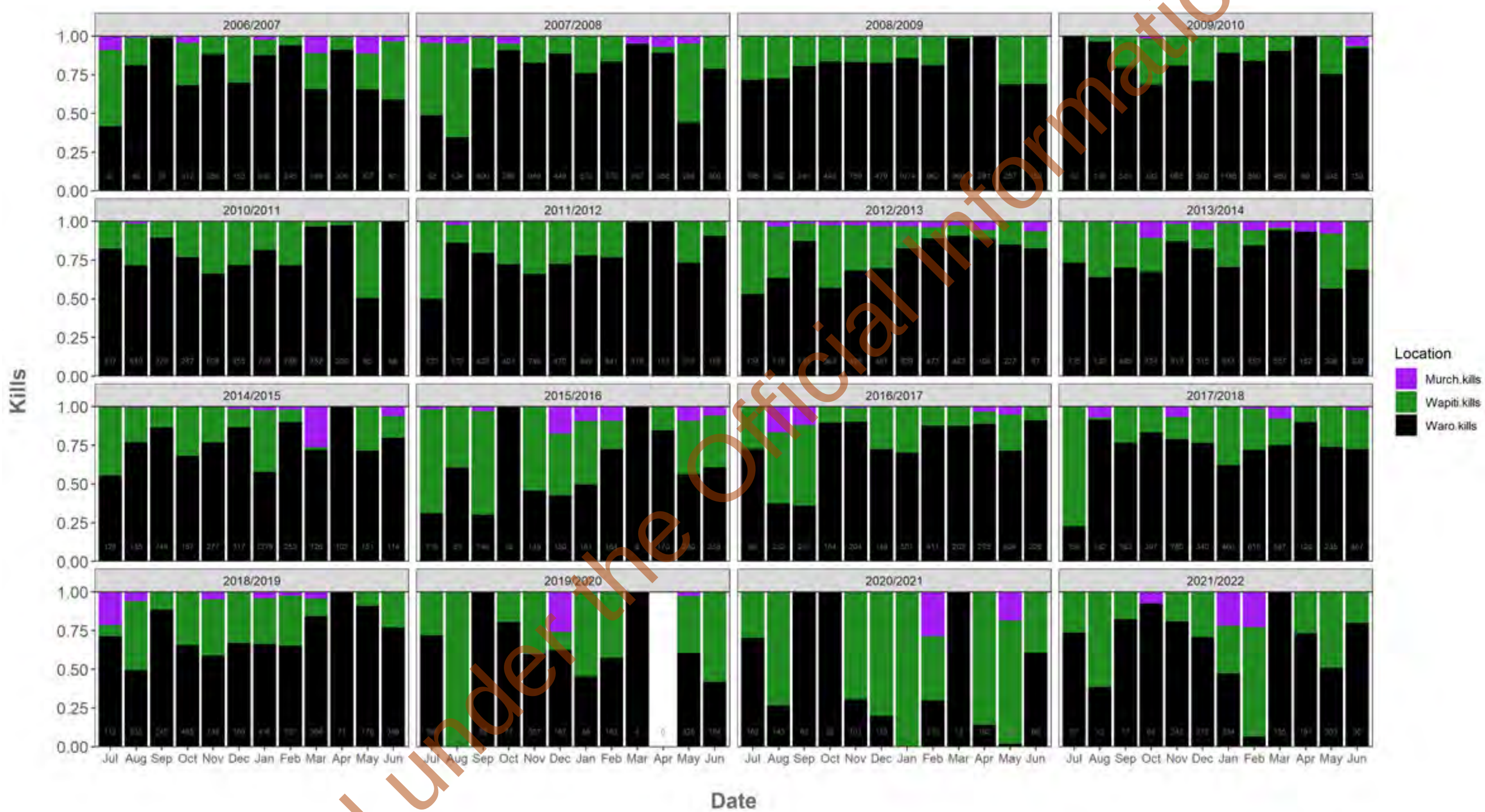

Figure 5: Proportion of deer kills by location.

Hunting efficiency

After a preliminary analysis it became apparent that hunting efficiency (kills per hunting day) appeared to be increasing over time (despite hunting days decreasing over time, as seen in Figure 2). In order to account for this in later modelling a simple general additive model (GAM) was used to model the crude trend (Figure 7)[1], based on a 12 month rolling average. Due to the length of the rolling average, the first 12 months of data was removed from the predictive analysis (as the explanatory variable would be incalculable over this period).

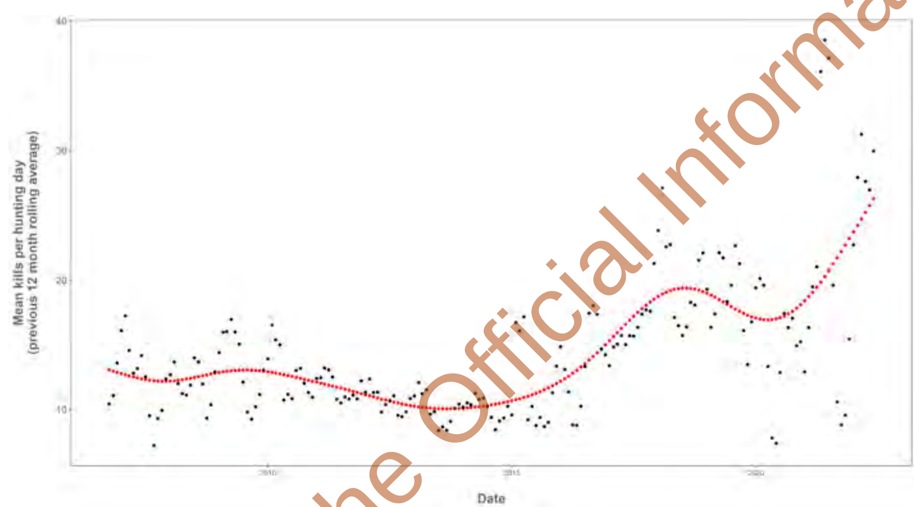

Figure 6: The GAM used to model changes in hunting efficiency.

The predictions from this GAM model were then used as a new explanatory variable for later modelling. In order to prevent self prediction, a time lag of a month was used so that the prediction for a particular month was based on the hunting efficiency recorded up until the previous month.

Results

Model selection revealed there was a single model with near unanimous support (0.99 model weight) which could successfully predict the number of Waro kills: ~*log(Hunting.eff.days.smooth.waro)* + *Venison.price* + *Jet.A1* + *offset(log(Waro.days))* (Table 1).

Examination of the coefficients (see Appendix 1) shows that the number of deer killed in the Waro block increases with greater hunting efficiency and the price of vension but declines with an increase in the

[1]monthly effects were accounted for separately in the formal modelling process

price of Jet A1 fuel. The model appears to have high predictive power with a naive (observed vs predicted) $r^2 = 0.88$ [2]

Discussison

The results of this modelling exercise suggests that the number of deer killed in the Waro block can be predicted with some accuracy based on venison and Jet A1 fuel prices, but more importantly, previous hunting efficiency. Hunting efficiency can be though of a conversion rate in which the kills in a particular month is dependent on the success rate up until the previous month. The direction of the venison price and Jet A1 can be interpreted as a simple motivating factor: operators hunt more when the venison price is high and the price of fuel is cheap. There is, however, one outstanding element to the equation, the number of monthly hunting days. It is knowledge of the number of monthly days which is the deciding factor in producing an accurate estimate. Consequently, any further analysis should focus on developing a predictive model for the number of monthly Waro hunting days. Such an approach would eventually result in the number of Waro kills being predicted without requiring the use of an offset. This would, effectively, give rise to a two-stage model that could predict both the number of hunting days and the number of deer killed.

[2] the calcultion of r^2 for such models is generally not widely support but is included here for indicative purposes only.

Table 1: Model selection table: prediction of Waro kills via GLM. Models ranked by AICc (AIC with a small sample correction). All models contained a log offset for the number of hunting days in the Waro block. Key: K = number of parameters, AICc = AIC with a small sample correction, Δ AICc = difference in AICc value between the model and the top-ranked model, Weight = model weight (likelihood), LL = log-likelihood (a measure of goodness of fit).

Model name	**K**	**AICc**	**Δ AICc**	**Weight**	**Log-likelihood**
log(Hunting.eff.days.smooth.waro) + Venison.price + Jet.A1 + offset(log(Waro.days))	5	2037.45	0.00	0.99	-1013.56
log(Hunting.eff.days.smooth.waro) + Venison.price + Month + Jet.A1 + offset(log(Waro.days))	16	2046.46	9.01	0.01	-1005.62
log(Hunting.eff.days.smooth.waro) + Venison.price + Month + offset(log(Waro.days))	15	2067.26	29.81	0.00	-1017.22
log(Hunting.eff.days.smooth.waro) + offset(log(Waro.days))	3	2075.39	37.94	0.00	-1034.63
log(Hunting.eff.days.smooth.waro) + offset(log(Waro.days))	3	2075.39	37.94	0.00	-1034.63
Venison.price + Jet.A1 + Month + offset(log(Waro.days))	15	2077.34	39.89	0.00	-1022.26
Venison.price + Month + offset(log(Waro.days))	14	2089.63	52.18	0.00	-1029.59
Venison.price + Month + offset(log(Waro.days))	14	2089.63	52.18	0.00	-1029.59
Jet.A1 + Month + offset(log(Waro.days))	14	2104.54	67.09	0.00	-1037.04
null (intercept only) model + offset(log(Waro.days))	2	2107.81	70.37	0.00	-1051.87

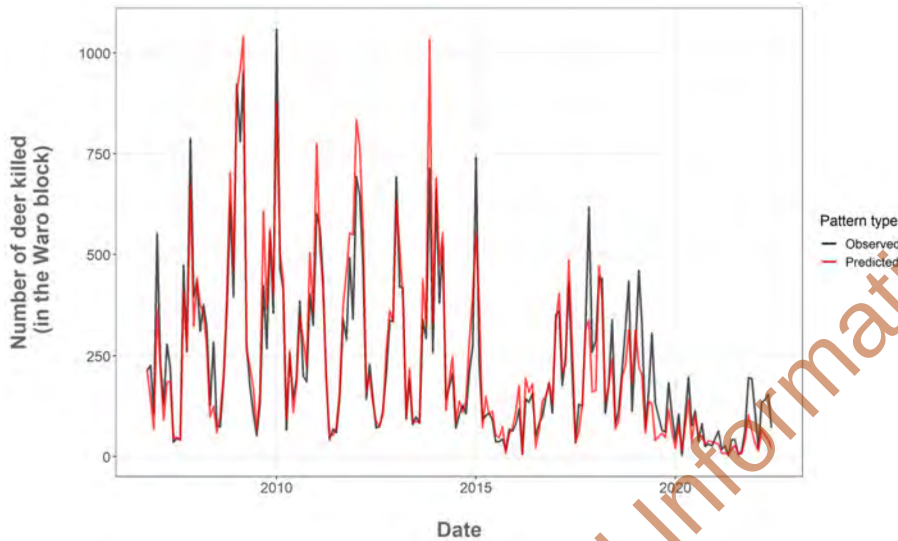

Figure 7: The top-ranked GLM successfully predicts the number of kills based on changes in hunting efficiency, the price of Jet A1 fuel and venison.

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Acknowledgements

I would like to thank George Ledgard and Richard Ewans for the provision of the data sets and background information.

Appendix 1: Model coefficients

```
 Family: nbinom1  ( log )
Formula:
Waro.kills ~ log(Hunting.eff.days.smooth.waro) + Venison.price +
    Jet.A1 + offset(log(Waro.days))
Data: df

     AIC      BIC   logLik deviance df.resid
  2037.1   2053.2  -1013.6   2027.1      181


Dispersion parameter for nbinom1 family (): 16.8

Conditional model:
                                  Estimate Std. Error z value Pr(>|z|)
(Intercept)                        0.90290    0.26073   3.463 0.000534 ***
log(Hunting.eff.days.smooth.waro)  0.20107    0.02858   7.034 2.00e-12 ***
Venison.price                      0.06273    0.01548   4.053 5.05e-05 ***
Jet.A1                            -0.14900    0.02968  -5.021 [illegible].14e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

A report prepared for:

Department of Conservation

The effect of current Fiordland deer managment on the browsing rates of sensitive alpine plants in the WARO and Wapiti management areas

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30 October 2023

Summary

The number of deer being harvested from Fiordland has been decreasing for some time (especially in the WARO management area), at the same time the proportion of vulnerable alpine plants subject to deer browsing has been increasing and Department of Conservation management targets for preferred browsing rates (10%) are now being regularly exceeded.

The proportion of palatable plants browsed by deer in Fiordland appears to be a complex function of the management area, the plant species being monitored, number of deer kills within a 1 km radius of the monitoring transect, and a suite of components derived from the number of hunting days, the number of annual kills, the price of venison, the number of deer scat clusters near the transect lines, and the mean distance deer are killed from the forest edge in the preceding 12 months. However, this model, being reliant on variables obtained from dimension reduction, suffered from low tangibility. A more tangible predictive model was obtained from a function involving the management area, the plant species being monitored, the number of deer scat clusters near the transect lines, the number of local deer kills, and the mean distance deer were killed from the forest edge in the preceding 12 months.

Dolichoglottis scorzoneroides appeared to be the species most vulnerable to browsing, in comparison *Ranunculus lyallii* and the *Celmisia* genus, were similar and were less prone to browsing. The Wapiti management area appears to suffer from elevated rates of browsing compare to the WARO management area, echoing the previous findings of Mason et al. (2019). There was also a general trend of recent browsing rates increasing across both management areas compared to the 2007/2008 – 20013/2014 period which was notable for its comparatively low browse rates and consistent harvest rates.

Deer harvests from WARO and Wapiti management areas will likely have to be increased if browsing by deer is to be constrained within acceptable limits. While there was no support for the number of annual kills within each management area being a direct predictor of the amount of browsing, the mean distance deer were killed from the forest edge in the preceding 12 months, appeared to be a very influential predictor, and was moderately correlated with the number annual kills in each management area. This relationship could be used to draw a crude annual target. On this basis we recommend that annual deer harvest targets should aim to exceed, or at least match, 1,095 for the Wapiti management area and 3,350 for the WARO management area. Such thresholds are well within the bounds of historical norms. If the

'ecology of fear' is in play (i.e. helicopters alter deer behavior due to an anti-predator response) this has direct ramifications for how management should be employed and failure to understand this phenomenon could lead to misapplied management.

Recommendations

- Annual harvests of 1,095 deer in the Wapiti management area and 3,350 deer in the WARO management area will likely be required to constrain their alpine browsing within acceptable limits. Such targets are within the bounds of historic norms and should be achievable.
- The current practice of only sampling one management area any any given year should be discouraged in favour of splitting annual survey effort across management areas to avoid possible bias associated with conflating year-specific effects with management area effects.
- DOC needs to establish a national database for the storing of data associated with long-term programmes (e.g. deer control in Fiordland). Such a database would facilitate quicker and more regular data analysis, and provide a definitive record of management for all stakeholders.
- A more nuanced understanding of the 'ecology of fear' and annual variation in the Fiordland deer population will be required to adequately model and manage deer impacts in Fiordland.

Purpose

The purpose of this analysis was to determine what impact deer management (utilising wild animal recovery operators) is having on the browse rates sustained by vulnerable alpine plants, and to offer guidance on the hunting pressure necessary to keep required to keep browsing within acceptable ecological limits defined by target browse levels set by the Department of Conservation (DOC). The three alpine plants monitored by DOC subject are *Dolichoglottis scorzoneroides*, *Ranunculus lyallii*, and those in the *Celmisia* genus.

Background

In Fiordland National Park DOC manages deer to reduce the impact of their herbivory employing a variety of objectives and management techniques:

1. Suppression in the Murchison Mountains for the conservation of takahē (*Porphyrio hochstetteri*) via an annual cull managed by DOC.
2. Maintenance of herd quality for the wapiti population (within acceptable environmental limits), through a combination of recreational hunting and the involvement of wild animal recovery operators managed by the Fiordland Wapiti Foundation.
3. The commercial for-profit extraction of red deer for the venison market via wild animal recovery operators (WARO) for areas not already covered by one of the aforementioned regimes. The WARO area is managed by the operators themselves.

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For purposes of this analysis only the last two management regimes are considered and are hereafter referred to as the 'Waipiti' and 'WARO' areas respectively.

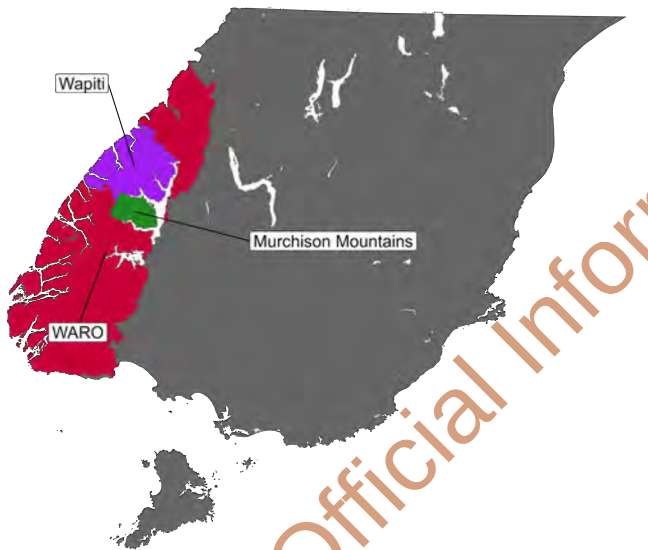

Figure 1: Management areas

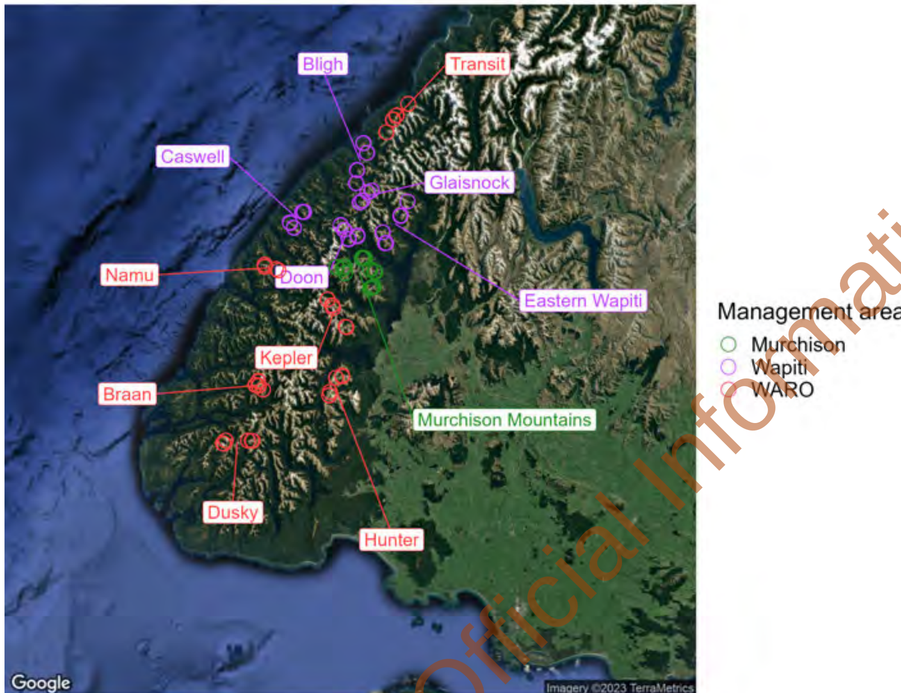

Figure 2: Plot locations in relation to management regime and subregion (note: Murchison Mountains was not considered in this analysis)

Methods

Data was provided by the Department of Conservation. Data from four sources were collate into a singular data set:

1. Browse rates recorded by transect based field methods undertaken by DOC.
2. Environmental data associated with the DOC transects.
3. Kill location data provided to DOC by wild animal recovery operators.
4. Annual venison price and number of hunting days provided by DOC.

Only data from WARO and Wapiti areas were considered. Browse data collected in 2005/2006 was removed from the analysis owing to the lack of matching spatial covariates. However, visualisations of the

2005/2006 data and the Murchison Mountains management area are given in the Appendix.

Data analysis

All analyses, graphing, and examination of diagnostics occurred in Program R (version 4.2.1) (R Core Team, 2022) with additional functionality provided by the packages 'AICcmodavg' (Mazerolle, 2020), 'corrplot' (Wei and Simko, 2021), 'DHARMa' (Hartig, 2022), 'factoextra' (Kassambara and Mundt, 2020), 'FactoMineR' (Lê et al., 2008), 'glmmTMB' (Brooks et al., 2017), 'ggrepel' (Slowikowski, 2021), 'kableExtra' (Zhu, 2021) , 'lubridate' (Grolemund and Wickham, 2011), 'olsrr' (Hebbali, 2020), 'performance' (Lüdecke et al., 2021), 'randomcoloR' (Ammar, 2019), 'zoo' (Zeileis and Grothendieck, 2005), and the 'tidyverse' (Wickham et al., 2019).

As the response variable in this analysis was the proportion of plants browsed a binomial regression approach was applied within a generalised linear mixed-effect model (GLMM) framework. Binomial regression allows the prediction of proportions weighted by the number of trials (where the trials represent the total number of plants available to be browsed). A GLMM is appropriate when sites are being repeatedly remeasured and where there is suspected non-independence between sampling units (i.e. in situations where a nested structure exists between spatially distributed sampling sites). The GLMM was undertaken using the 'glmmTMB' package in which the explanatory variables were separated into fixed effects which attempt to explain the amount of browsing, and random effects which describe the nested structure of the design. A suite of candidate models representing different hypotheses (i.e. different, yet reasonable combinations of explanatory variables present in the data) including an intercept only uninformative model (i.e. a 'null' model) were tested in a model selection process using Akaike's Information Criterion (with small sample adjustment) to rank the models in terms of parsimony (*sensu* Burnham and Anderson 2002).

The explanatory variables under consideration as fixed effects were: management area (*management.area*), species (*species*), frequency of deer pellets around the plot transect (*deer.pellets*), number of [annual] hunting days (*hunting.days*), kills within a 1 km radius in the preceding 12 months (*local.kills*)[1], annual [financial year] kills (*annual.kills*), mean [annual] distance of deer kills from forest edge (*for.edge*), the altitude of the plot transect (*altitude*), and distance of the plot transect from the forest edge (*plot.distance*). A categorical year effect (*year*) was only considered in one model due to issues of multicollinearity.

[1]In 2008 and 2009 247 and 377 kills respectively lacked dates, in order to retain this data random dates were imputed

Parametric modelling approaches, such as GLMM, demand that the underlying assumptions of the models are fulfilled. In practice for a GLMM involving a binomial distribution family this means ensuring that the modelling accounts for the possibility of zero-inflation (meaning zero counts are not more common than expected). Diagnostic testing (via the 'DHARMa' package) revealed that there were issues associated with zero-inflation. Zero inflation was handled by employing an additional modelling procedure to model the inflated number of zeros (via logistic regression).

Fixed effects: binomial regression

Like all linear and generalised models, GLMMs have an underlying assumption of the absence of collinearity and multicollinearity – meaning the explanatory variables of the model must be independent (i.e. not overly correlated with each other, nor capable of being predicted as a linear combination of each other). A failure to ensure independence will affect the validity and accuracy of the coefficients[2] (but not goodness-of-fit or predictive accuracy).

A number of the explanatory variables were suspected of being collinear and or likely to result in multicollinearity. Previous work by (Whitmore, 2023) identified that the number of deer harvested in each year could be predicted from the hunting days and venison price and therefore were known to be multicollinear and therefore could not be present as variables in the same model. The suite of potentially multicollinear variables affecting the binomial regression portion of the analysis was extended to include: hunting days, annual kills, deer pellets, venison price, local kills, and kill distance from forest edge. Given that a plausible narrative could be constructed describing how they might be able to affect each other a correlation matrix was used to identify potential issues (Figure 4) followed by a test of multicollinearity via a condition index (*sensu* Belsley 1991). For explanatory variables to be retained in any given model the condition index had to be < 30.

In order to fully mitigate issues of multicollinearity and the potential loss of information by the exclusion of certain variables dimension reduction via principle component analysis (PCA) was conducted to yield non-correlated surrogate variables for use in a supplementary modelling process. In this process, the original candidate model suite was rerun with the inclusion of supplementary models derived from dimension reduction. If this resulted in a new top-ranked model it would be potentially indicative that observed browsing is the product of a complex feedback process. While such a result might lead to better prediction, it would effectively be uninterpretable and therefore of lower utility

[2]e.g. this was found to be the case with the inclusion of year effects in preliminary models which resulted in spurious coefficients being produced, as a consequence year effects were not further investigated

to management than potentially weaker but more tangible models.

Fixed effects: Zero inflation

A two stage process was used to identify an adequate zero-inflation model for the fixed effects[3]. The initial binomial regression modelled the zero-inflation term as relating to plot distance from forest edge and species (across all models based on the assumption that an absence of browsing would relate to proximity with deer and the palatablity of the plant). Once the top-ranked model was identified seven different models, only differing in terms of the zero inflation formula were tested against each other. All of these formulae related to the likely encounter rate between deer and the plants. Due to high levels of multicollinearity only one of the continuous variables could be used in the equation formula at any given time. The seven models were:

1. an uninformative intercept only model
2. species
3. species + altitude
4. species + mean (annual) distance of kill location from forest edge
5. species + plot distance from forest edge
6. species + deer pellets (numeric)
7. species + deer pellets (presence-absence)

The zero inflation term from top-ranked model was then applied uniformly to all the binomial regression models, and then the model selection process was repeated.

Random effects

GLMMs rely upon structuring the nesting of the random effects correctly to explicitly model the non-independence inherent in the data. Random effects in this context represents spatial variation that we know likely exists but is conceptually uninteresting – essentially behaving as a set of nuisance variables. In order to identify the correct nesting structure we employed a three-step model selection procedure:

1. we ran a suite of models with intercept only fixed effect and zero-inflation term, but variable random effects. These model were assessed using Restricted Maximum Likelihood (in a manner outlined by Zuur et al. 2009). The models describing the random effects were:

    - Subregion only

[3] this was done to prevent testing an overly large number of models unnecessarily

- Area nested within Subregion
- Line nested within Area and Subregion
- Line nested within Area
- Line only
- no random effect

'Line nested within Area and Subregion' proved the most parsimonious of the candidate models.

2. The set of random effects from the top-ranked model was then used for all subsequently modelling of the fixed effects (involving Maximum Likelihood estimation).

3. Once we had identified a preliminary top-ranked fixed effect model with a corrected zero inflation formula the structure of the random effects was then rechecked by rerunning the random-effect modelling procedure but substituting the old intercept-only fixed effects with the newly identified fixed effects from the hither-to top-ranked model. However, no change was made as 'Line nested within Area and Subregion' remained the top-ranked model for random-effects.

Management utility

We are cognisant that current deer management in Fiordland is entirely dependent on control of the herd size by hunting and that the only management lever involves setting target harvest levels. Consequently, there was the possibility that the best model predicting the proportion of plants browsed might be somewhat dislocated from the annual number of deer killed. It is important to understand that there is an implicit assumption that the number of deer killed is a proxy for the deer abundance and hence browsing pressure. Such an assumption is logically tenuous but advice on deer harvest settings is nevertheless required. Consequently, we would need to delineate a relationship between browse and the number of deer killed regardless of the outcome of the main modelling procedure.

Results

Vegetation plots were monitored in a variable, staggered fashion every few years with the amount of browsing varying with year and species (Figure 3). Importantly, since 2017 management areas have been surveyed in alternate years. Hunting pressure varied spatially and through time (Figure 4) with the number of deer killed in the WARO area declining markedly in recent years (Figure 5).

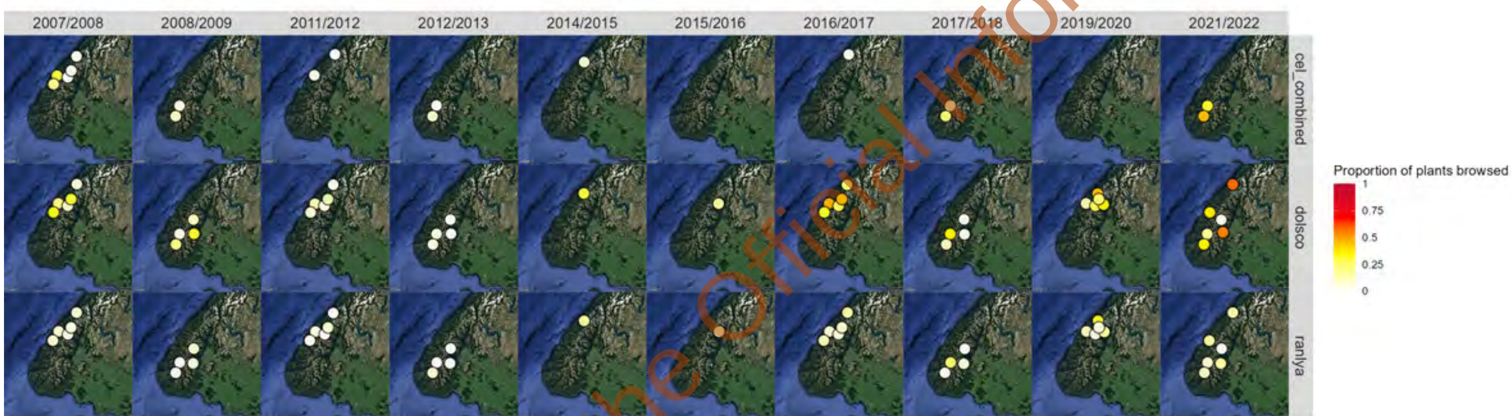

Figure 3: Mean browse rates at the area level (for visualisation purposes only). Note: areas were not monitored every year.

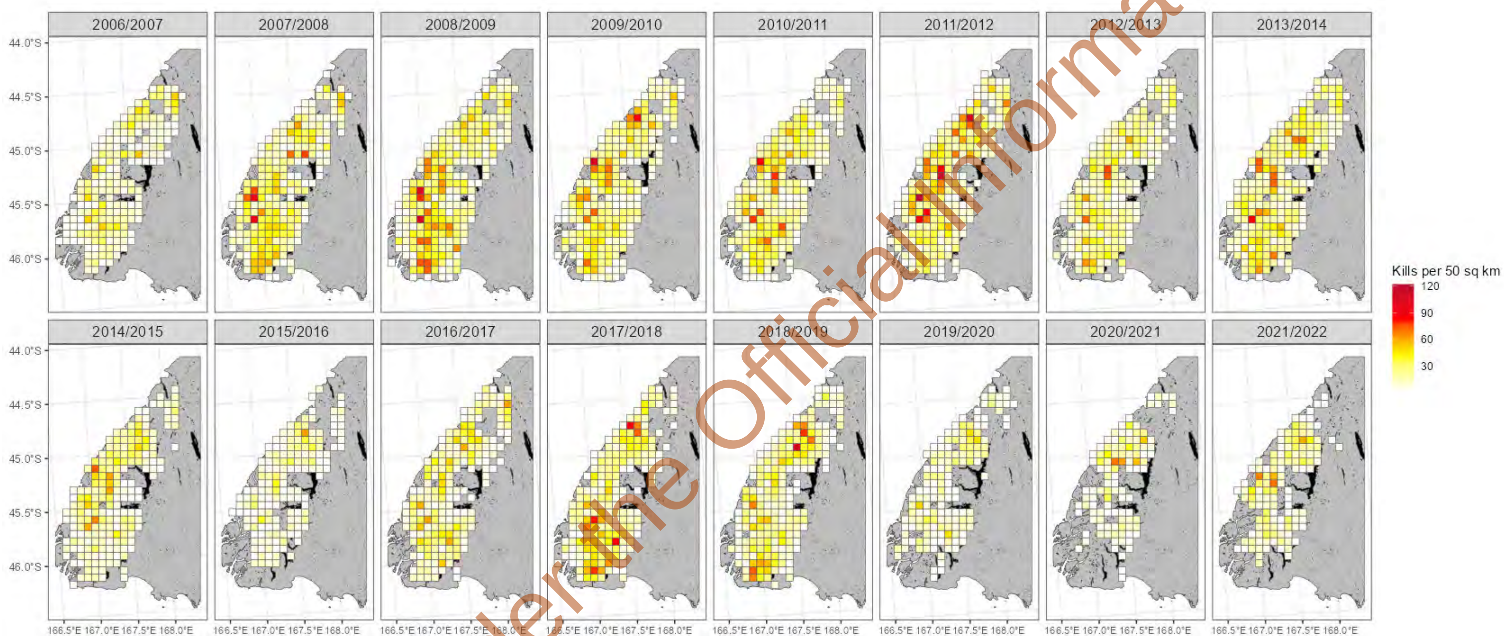

Figure 4: Map of deer kills (Murchison mountains excluded).

Management targets for the acceptable levels of browse of 5% (desired) and 10% (preferred) were regularly exceeded from 2016/2017 onwards for *Dolichoglottis scorzoneroides*, more so that those in the *Ranunculus lyallii*, and *Celmisia* genus (Figure 12).

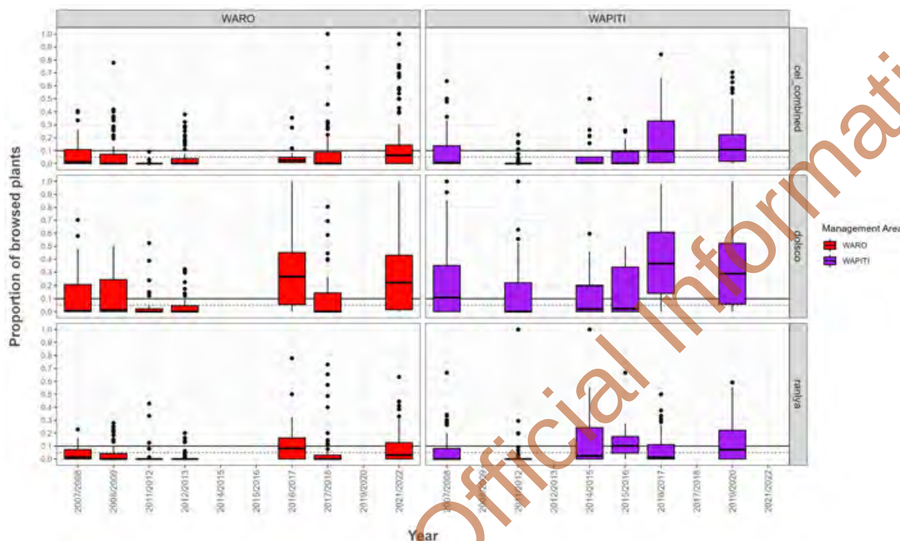

Figure 6: Crude trend in browse rates. Boxplot key: box = interquartile range, central line = median, whiskers = 1.5 × interquartile range, dots = outliers. General key: dotted line = 5% threshold (desired), solid line = 10% threshold (preferred).

A correlation matrix indicated that, as suspected, there was substantial collinearity within the variables we identified (Figure 7). However, there was little evidence to suggest that *local.kills* was problematic and as a consequence it was used freely as an explanatory variable in the model suite. Running a condition index test found that all the remaining variables had moderate or exceptionally high levels of multicollinearity. The principle component analysis generated five dimensions, of which the top four accounted for 98.3% of the variance (Table 1). As a result only the top four dimensions were included in the supplementary modelling.

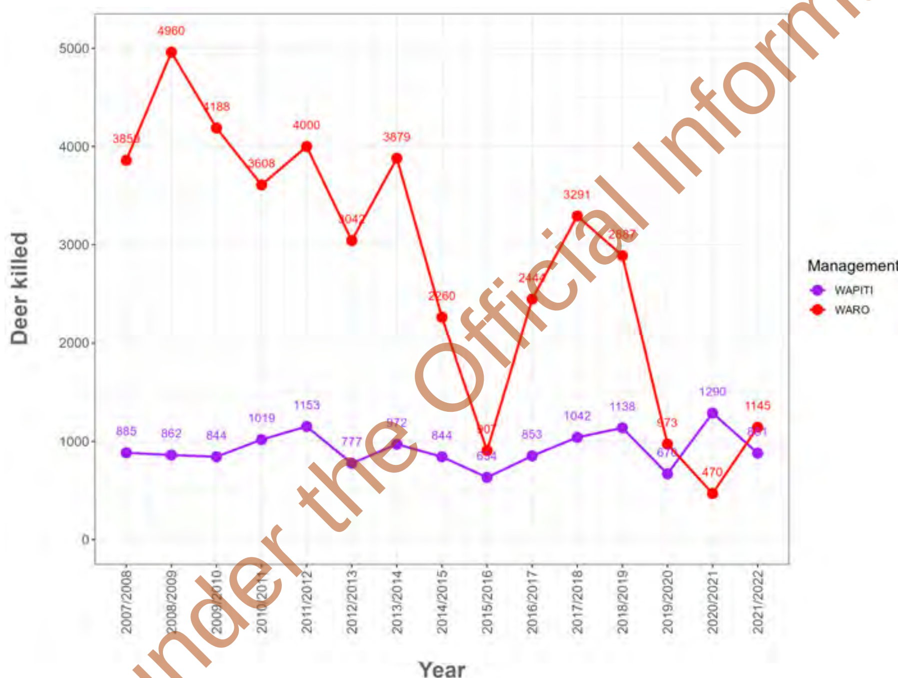

Figure 5: Total deer killed (Murchison mountains excluded).

Figure 7: A visual depiction of the correlation matrix. Values given are the correlation coefficient, circle size represents the size of correlation, colour presents direction of correlation (red = negative, blue = positive).

Model selection revealed the top-ranked standard model to be ~*deer.pellets* + *management.area* * *for.edge* + *local.kills* + *species*[4] with unanimous support (~100% model weight) (Table 3). The top-ranked model had no direct competitors within the model suite. Separate zero-inflation modelling confirmed ~*species* + *for.edge* was the best descriptor of zero-inflation (having 100% model weight)(Table 4). Scaled model coefficients revealed that in terms of relative importance browsing was most strongly influenced by *species*, browsing in the Wapiti management area increased more rapidly than the WARO area when the mean

[4]with random effects being best described as line nested within area and subregion

Table 1: The eigenvalues associated with each of the dimensions generated from the principle component analysis and the percentage of variance they explain.

Component	eigenvalue	% of variance	cumulative %
Dim 1	2.306	46.129	46.129
Dim 2	0.929	18.577	64.706
Dim 3	0.913	18.256	82.962
Dim 4	0.769	15.382	98.344
Dim 5	0.083	1.656	100.000

annual kill distance from forest edge increased, and browsing increased when more deer pellets were in the vicinity of the transect (Figure 8). Browsing also reduced when there were more local kills within in a 1 km radius of the transect (Figure 9) but this variable was less influential. *Dolichoglottis scorzoneroides* appeared to be the species most vulnerable to browsing, while plants in the *Ranunculus lyallii* genus, and *Celmisia* were more resistant and comparatively very similar in their vulnerabililty to browsing (Figure 8 & 9, see Appendix A for unscaled and B for scaled outputs).

Supplementary modelling with models derived from dimension reduction revealed that the ~*management.area* + *species* + *local.kills* + *Dim.1* + *Dim.2* + *Dim.3* + *Dim.4* model could outcompete the top-ranked standard model. This supplementary model reveals that as the number of deer killed locally increased the amount of browsing decreased. However, scaled model coefficients revealed that in terms of relative importance browsing was most strongly predicted by *species* and the dimension reduced variables (see Appendix C).

Table 2: Model selection table: prediction of proportion of browse via binomial regression via GLMM (standard models only). Models ranked by AICc (AIC with a small sample correction). Key: K = number of parameters, AICc = AIC with a small sample correction, Δ AICc = difference in AICc value between the model and the top-ranked model, Weight = model weight (model support), LL = log-likelihood (a measure of goodness of fit).

Model name	**K**	**AICc**	**Δ AICc**	**Weight**	**Log-likelihood**
deer.pellets + management.area * for.edge + local.kills + species	18	22221.69	0.000	1	-11092.68
deer.pellets + management.area * hunting.days + local.kills + species	18	22294.31	72.616	0	-11128.99
deer.pellets + management.area * for.edge + species	17	22349.07	127.373	0	-11157.38
deer.pellets + management.area * hunting.days + species	17	22482.38	260.689	0	-11224.04
deer.pellets + management.area * kills_sq_km + local.kills + species	18	22600.17	378.475	0	-11281.92
for.edge + deer.pellets + management.area + species	16	22602.96	381.264	0	-11285.35
deer.pellets + management.area + local.kills + species	16	22662.16	440.470	0	-11314.95
hunting.days + deer.pellets + management.area + species	16	22702.54	480.846	0	-11335.14
deer.pellets + management.area * kills_sq_km + species	17	22738.16	516.463	0	-11351.93
kills_sq_km + deer.pellets + management.area + species	16	22752.15	530.452	0	-11359.94
kills_sq_km + plot.distance + deer.pellets + management.area + species	17	22754.12	532.431	0	-11359.91
deer.pellets + management.area + species	15	22772.37	550.671	0	-11371.06
year + management.area + species	23	22872.26	650.564	0	-11412.86
management.area * for.edge + species	16	23807.60	1585.904	0	-11887.66
for.edge + management.area + species	15	23983.20	1761.508	0	-11976.48
for.edge + altitude + management.area + species	16	23984.64	1762.946	0	-11976.19
for.edge + plot.distance + management.area + species	16	23985.14	1763.448	0	-11976.44
management.area * hunting.days + species	16	24087.46	1865.765	0	-12027.60
hunting.days + management.area + species	15	24246.15	2024.456	0	-12107.96
hunting.days + altitude + management.area + species	16	24247.53	2025.836	0	-12107.63
hunting.days + plot.distance + management.area + species	16	24248.13	2026.438	0	-12107.93
management.area * kills_sq_km + species	16	24463.40	2241.708	0	-12215.57
kills_sq_km + management.area + species	15	24468.11	2246.415	0	-12218.94
kills_sq_km + altitude + management.area + species	16	24469.54	2247.844	0	-12218.63
venison.price + management.area + species	15	24776.06	2554.363	0	-12372.91
management.area + local.kills + species	15	24868.26	2646.562	0	-12419.01
management.area + species	14	24870.23	2648.533	0	-12421.01
intercept only (null) model	11	29732.90	7511.203	0	-14855.38
management.area	12	29734.49	7512.793	0	-14855.17

Table 3: Supplementary model selection table: prediction of proportion of browse via binomial regression via GLMM including variables derived from PCA. Models ranked by AICc (AIC with a small sample correction). Key: K = number of parameters, AICc = AIC with a small sample correction, Δ AICc = difference in AICc value between the model and the top-ranked model, Weight = model weight (model support), LL = log-likelihood (a measure of goodness of fit).

Model name	K	AICc	Δ AICc	Weight	Log-likelihood
management.area + species + local.kills + Dim.1 + Dim.2 + Dim.3 + Dim.4	19	22186.20	0.000	1	-11073.91
deer.pellets + management.area * for.edge + local.kills + species	18	22221.69	35.496	0	-11092.68
deer.pellets + management.area * hunting.days + local.kills + species	18	22294.31	108.112	0	-11128.99
deer.pellets + management.area * for.edge + species	17	22349.07	162.869	0	-11157.38
species + Dim.1 + Dim.2 + Dim.3 + Dim.4	17	22360.37	174.170	0	-11163.03
management.area + species + Dim.1 + Dim.2 + Dim.3 + Dim.4	18	22362.34	176.145	0	-11163.00
deer.pellets + management.area * hunting.days + species	17	22482.38	296.186	0	-11224.04
deer.pellets + management.area * kills_sq_km + local.kills + species	18	22600.17	413.971	0	-11281.92
for.edge + deer.pellets + management.area + species	16	22602.96	416.760	0	-11285.35
deer.pellets + management.area + local.kills + species	16	22662.16	475.966	0	-11314.95
hunting.days + deer.pellets + management.area + species	16	22702.54	516.342	0	-11335.14
deer.pellets + management.area * kills_sq_km + species	17	22738.16	551.960	0	-11351.93
kills_sq_km + deer.pellets + management.area + species	16	22752.15	565.948	0	-11359.94
kills_sq_km + plot.distance + deer.pellets + management.area + species	17	22754.12	567.927	0	-11359.91
deer.pellets + management.area + species	15	22772.37	586.167	0	-11371.06
year + management.area + species	23	22872.26	686.061	0	-11412.86
management.area * for.edge + species	16	23807.60	1621.400	0	-11887.66
for.edge + management.area + species	15	23983.20	1797.004	0	-11976.48
for.edge + altitude + management.area + species	16	23984.64	1798.442	0	-11976.19
for.edge + plot.distance + management.area + species	16	23985.14	1798.944	0	-11976.44
management.area * hunting.days + species	16	24087.46	1901.261	0	-12027.60
hunting.days + management.area + species	15	24246.15	2059.952	0	-12107.96
hunting.days + altitude + management.area + species	16	24247.53	2061.332	0	-12107.63
hunting.days + plot.distance + management.area + species	16	24248.13	2061.934	0	-12107.93
management.area * kills_sq_km + species	16	24463.40	2277.204	0	-12215.57
kills_sq_km + management.area + species	15	24468.11	2281.912	0	-12218.94
kills_sq_km + altitude + management.area + species	16	24469.54	2283.340	0	-12218.63
venison.price + management.area + species	15	24776.06	2589.859	0	-12372.91
management.area + local.kills + species	15	24868.26	2682.058	0	-12419.01
management.area + species	14	24870.23	2684.029	0	-12421.01
intercept only (null) model	11	29732.90	7546.700	0	-14855.38
management.area	12	29734.49	7548.289	0	-14855.17

Table 4: Zero-inflation component - model selection table: using fixed effects from the top-ranked standard model for the non-inflated component ~*deer.pellets* + *management.area* * *for.edge* + *local.kills* + *species*. Models ranked by AICc (AIC with a small sample correction). Key: K = number of parameters, AICc = AIC with a small sample correction, Δ AICc = difference in AICc value between the model and the top-ranked model, Weight = model weight (model support), LL = log-likelihood (a measure of goodness of fit).

Model name	**K**	**AICc**	**Δ AICc**	**Weight**	**Log-likelihood**
species + for.edge	18	22221.69	0.000	1	-11092.68
species + deer.pellets	18	22307.74	86.044	0	-11135.70
species + deer.pellets (presence-absence))	18	22317.05	95.355	0	-11140.36
species + plot.distance	18	22407.27	185.579	0	-11185.47
intercept only (null) model	15	22415.03	193.336	0	-11192.40
species	17	22417.10	195.410	0	-11191.40
species + altitude	18	22417.62	195.924	0	-11190.64

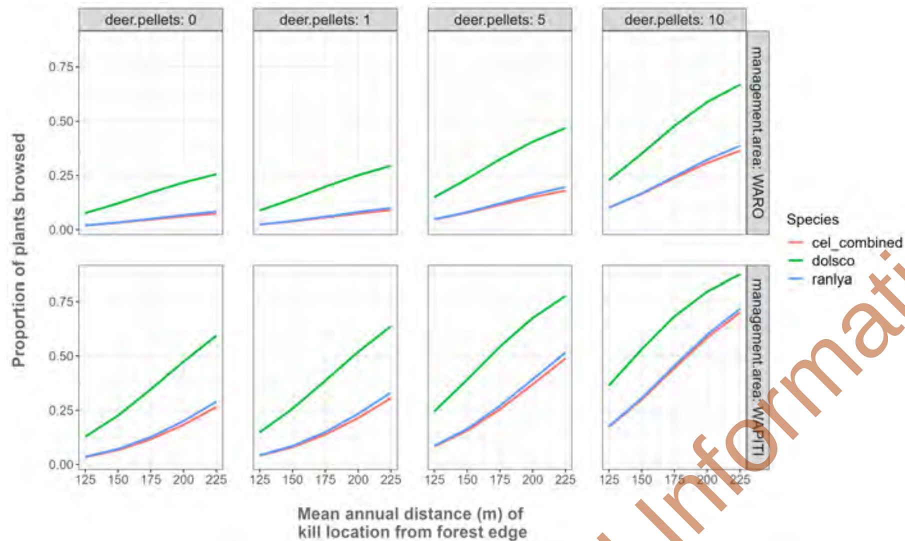

Figure 8: Visualisation of the top-ranked (standard) model in relation to variation in the numbers of deer pellet clusters and mean annual distance of kill location from forest edge for two randomly selected transects (the number of local kills is held constant as a mean value). WARO: Subregion = Nancy-Thompson, Area = Namu River, Line = NRIV1; WAPITI: Subregion = Caswell, Area = Caswell Sound, Line = CSOU1.

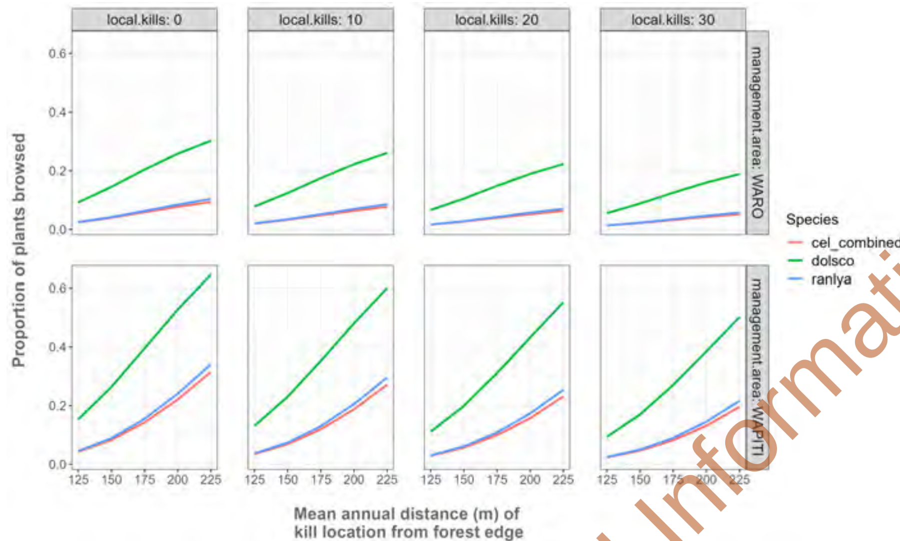

Figure 9: Visualisation of the top-ranked (standard) model in relation to variation in the number of local kills (within a 1 km radius) and mean annual distance of kill location from forest edge for two randomly selected transects (the number of deer pellets is held constant as a mean value). WARO: Subregion = Nancy-Thompson, Area = Namu River, Line = NRIV1; WAPITI: Subregion = Caswell, Area = Caswell Sound, Line = CSOU1.

The DOC target threshold (having the overall browsing rate $< 10\%$) was found to be increasingly exceeded (Figure 10). While the top-ranked (standard) model appeared to do a good job of predicting the amount of excess browsing in the WARO management area it was far less accurate for the Wapiti management area (Figure 10).

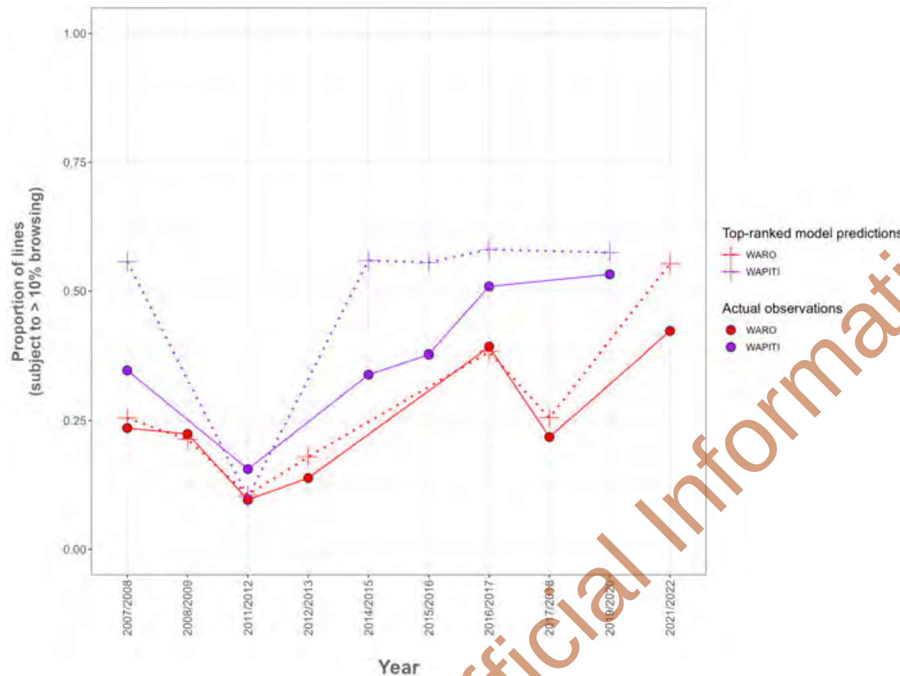

Figure 10: Proportion of lines subject to excess browsing (i.e. $> 10\%$) with a comparison between actual observations and the predictions of the top-ranked model. Note the staggered nature of the surveys and how, increasingly, in any given year only one of the areas is monitored.

If we explore the relationship between the mean (annual) distance of kill location from forest edge (*for.edge*) and the annual number of kills (via a general linear model with an interaction between *annual.kills* and *management.area*), we find that there is a clear negative relationship between the two variables (adjusted r^2 = 0.34). If we adopt a target of maintaining a mean annual kill distance from the forest edge of 150m, which would prevent excess browsing in 9 out of 10 scenarios, then this would recommend an annual harvest of 1,094 deer in the Wapiti management area and 3,349 in the WARO management area (Figure 11).

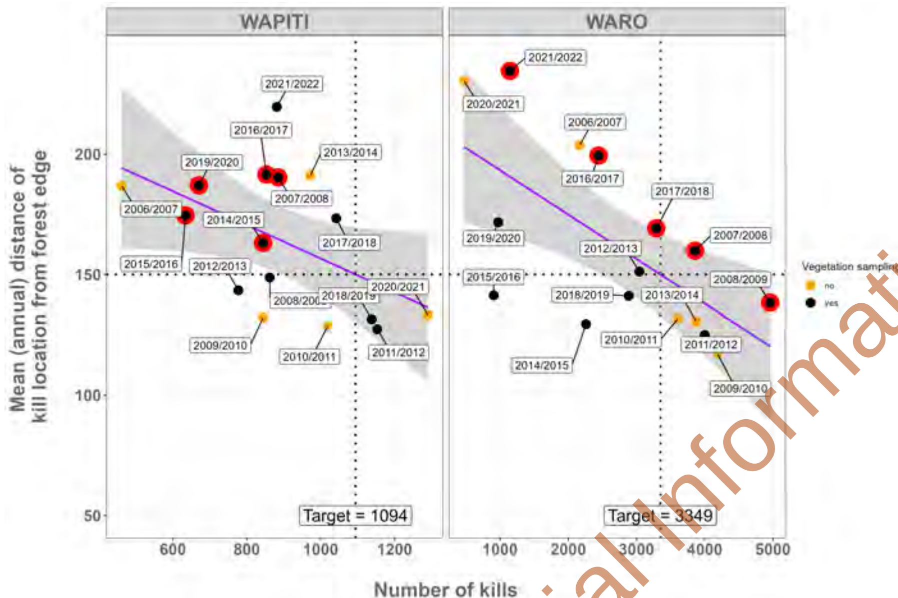

Figure 11: The relationship between mean (annual) distance of kill location from forest edge and the annual number of kills (as modelled by a general linear model with an interaction between *annual.kills* and *management.area*) and excess browse. Key: purple line = line of best fit, grey fill = 95% confidence interval, red surrounding = instances of high browsing (i.e.> 20% of lines exhibiting > 10% of browsing)

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Discussion

Given the success of the top-ranked supplementary model, which included dimension reduced variables, it is clear that the price of venison, hunting effort and success, frequency of deer scat clusters, deer behaviour, and proportion of browsing of palatable alpine plants appear to be inextricably interlinked. The strength of multicollinearity amongst these variables and the prior knowledge of a predictive relationship between annual kills, hunting days, and venison price (Whitmore, 2023) suggests that there is likely a strong (and possibly highly complex) feedback mechanism in operation between these variables.

There was no support for the number of annual kills within each management area being a good explanation of the amount of browsing observed. This is likely because the number of deer removed from the ecosystem is not a useful proxy for the number of deer remaining – and by inference, this suggests that deer numbers must fluctuate year-to-year. This highlights the complexity of determining harvest thresholds without some knowledge of the year-on-year variation in population size. Consequently, this may, to some extent, preclude the usefulness of using a stipulated number of deer kills as a singular management tool for achieving the protection of vulnerable plants. Interestingly, the number of deer killed locally did reduce the amount browsing which supports a causal link between harvest and browse levels, although the impact of the harvest, on a local scale, appears relatively small.

While the top-ranked supplementary model overcomes issues of multicollinearity and has better goodness-of-fit than the top-ranked standard model (as determined from the log-likelihood) and hints at the existence of a complex ecological-economic feedback system, it is, from a management point of view, largely unhelpful due to the inability of its variables to correspond to the singular management lever of annual kills (or annual kills per km^2). Unhelpfully, the top-ranked standard model also does not contain annual kills per km^2 as a variable either. This, to some extent, precludes the usefulness of using a stipulated number of deer kills as a singular management tool for achieving the protection of vulnerable plants. However, given that the only management tool used by DOC revolves around harvest targets there is a requirement for guidance around the setting of those targets. Fortunately, there is a moderate relationship between annual kills in each management area and mean annual kill distance from forest edge which provides some basis for deriving a harvest target from a simplistic linear model. The harvest targets offered by this model (1,094 for Wapiti and 3,349 for WARO), while arguably crude, have high tangibility and fall in line with historic norms.

The predictive power of the top-ranked standard model is probably sufficient for basic management purposes in that it predicts the amount of excess browsing reasonably well, however, for reasons which are not fully understood it appears to be much better at predicting outcomes in the WARO management area rather than the Wapiti area. Echoing the previous findings of Mason et al. (2019) the Wapiti management area appears to suffer from elevated rates of browsing compared to the WARO management area. From the top-ranked (standard) model this appears to be attributable to a more sensitive relationship with the mean distance deer were killed from the forest edge – with more browsing occurring in the Wapiti management area compared to the WARO management area for any given value. However, this may be an artefact of a more complex behavioural / management effect caused by the wapiti herd being managed for trophy heads which may lead to older male wapiti being deliberately ignored in culling operations (George Ledgard pers. comments). In this way male wapiti may passively, or actively ‘learn’ they can graze on the open tops with impunity (unlike male deer in the WARO management area).

Importantly, there is a negative relationship between the number of annual kills and the mean (annual) distance of kill location from forest edge. Naively, this might be interpreted as hunting reduces deer density which leads to fewer deer venturing out into the open, and therefore fewer deer browsing palatable alpine plants. However, this explanation is conflated as it ignores the possibility that the use of helicopters, indirectly, could be contributing to the perceived effect. Under this hypothesis it is helicopters themselves that inadvertently scare deer off the open tops thereby reducing browsing in a phenomenon known as the 'ecology of fear' (Zanette and Clinchy, 2019). As helicopter activity and the number of hunting days, and annual kills are entangled we, at this stage, cannot determine their relative contribution. Regardless of the mechanism, we speculate that the mean distance deer were killed from the forest edge could be used as a proxy metric of management effectiveness, as it directly relates to the exposure of palatable alpine plants to deer.

The 'ecology of fear' recognizes that predators play a dual role in affecting prey populations: directly through killing prey, and indirectly by altering prey behaviour. Increasingly, the 'ecology of fear' has been recognised as having an effect on deer and ungulate browsing (Cromsigt et al., 2013), and is increasingly being mooted as a possible management tool. Preliminary work (Whitmore, 2023) posited that hunter efficiency in Fiordland is increasing. If improvements in hunter efficiency are true, and the amount of deer browsing on alpine plants is a function of helicopter fear then it is possible that the amount of deer browsing could increase despite annual kills increasing if the coverage by helicopters decreases due to increased hunting efficiency.

Given the analytical process has revealed that the 'ecology of fear' may help define the nature of browsing and could impact the effectiveness of management interventions serious field study is warranted. If the goal is to develop a mechanistic model to guide deer management in Fiordland then determining whether or not the 'ecology of fear' is a major contributing factor should be a priority.

There were certain limitations to our data set as not all transects were monitored every year and the 2005/2006 browse data lacked matching covariates (as recording spatial information relating to kills was not yet a practice). Additionally, the current practice of only sampling one management area in any any given year should be discouraged in favour of splitting annual survey effort across management areas. This avoids the possible bias associated with conflating year-specific effects with area effects (e.g if there is a drought one year and only the Wapiti area is surveyed the impact risks being subsumed as an effect of management - even though the WARO area would be likely experiencing the same impacts at the same time). Similarly, as the sampling alternated between the Waipiti and WARO management areas in later years we could not repeat the randomisation test previously carried out by Mason et al. (2019) which was reliant on same-year monitoring.

As with many other long term New Zealand conservation programmes the management of Fiordland deer could benefit from the development of a national database. Such a database would pervent formatting and data entry errors, facilitate quicker and more regular data analysis, and provide a definitive record of management for all stakeholders.

We postulate that information from a field study monitoring deer density or abundance, food availability, deer and helicopter operator behaviour, and levering off spatial information from helicopter flight logs could lead to a good mechanistic management model. We are conscious that such a project is not a trivial exercise and would likely involve at least one dedicated researcher or possibly a small team over a number of years. In the absence of such information, any setting of thresholds, such as in this study will remain rather crude. The perception that browsing pressure by deer can be simply be understood as a function of the number of deer harvested is somewhat misguided. Such thinking is detrimental to the development of a sophisticated management model for an ecosystem which appears to exhibit complex ecological and economic feedback processes.

Conclusions

This analysis shows that the number of deer being harvested from Fiordland has been decreasing for some time (especially in the WARO management area), at the same time the proportion of vulnerable alpine plants subject to deer browsing has been increasing and Department of Conservation management targets for preferred browsing rates (10%) are now being regularly exceeded. Deer harvests from both WARO and Wapiti management areas will likely have to be increased to obtain the desired environmental outcomes. We recommend that annual harvests targets should aim to exceed, or at least match, 1,095 for the Wapiti management area and 3,350 for the WARO management area. Such thresholds are well within the bounds of historical norms. If ‘ecology of fear’ is in play (i.e. helicopters alter deer behavior due to an anti-predator response) this has direct ramifications for how management should be employed and failure to understand this phenomenon could lead to misapplied management.

Recommendations

- Annual harvests of 1,095 in the Wapiti management area and 3,350 deer in the WARO management area will likely be required to constrain alpine browsing within acceptable limits. Such targets are within the bounds of historic norms and should be achievable.

- The current practice of only sampling one management area any any given year should be discouraged in favour of splitting annual survey effort across areas to avoid possible bias associated with conflating year-specific effects with area effects.

- DOC needs to establish a national database for the storing of data associated with long-term programmes (e.g. deer control in Fiordland). Such a database would facilitate quicker and more regular data analysis, and provide a definitive record of management for all stakeholders.

- A more nuanced understanding of the 'ecology of fear' and annual variation in the Fiordland deer population will be required to adequately model and manage deer impacts in Fiordland.

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I would like to thank George Ledgard and Richard Ewans for the provision of the data sets and background information.

A Top-ranked model coefficients (untransformed)

```
 Family: binomial  ( logit )
Formula:          proportion ~ deer.pellets + management.area * for.edge + local.kills +
    species + (1 | subregion/area/line)
Zero inflation:              ~species + for.edge + (1 | subregion/area/line)
Data: ones
Weights: no.plants

     AIC      BIC   logLik deviance df.resid
 22221.4  22322.6 -11092.7  22185.4     2027

Random effects:

Conditional model:
 Groups              Name        Variance Std.Dev.
 line:area:subregion (Intercept) 0.46749  0.6837
 area:subregion      (Intercept) 0.31923  0.5650
 subregion           (Intercept) 0.09383  0.3063
Number of obs: 2045, groups:  line:area:subregion, 230; area:subregion, 46; subregion, 11

Zero-inflation model:
 Groups              Name        Variance  Std.Dev.
 line:area:subregion (Intercept) 1.942e-07 0.0004407
 area:subregion      (Intercept) 7.658e-01 0.8750935
 subregion           (Intercept) 2.627e-01 0.5125120
Number of obs: 2045, groups:  line:area:subregion, 230; area:subregion, 46; subregion, 11

Conditional model:
                             Estimate Std. Error z value Pr(>|z|)
(Intercept)                -3.1740199  0.1935873  -16.40  < 2e-16 ***
deer.pellets                0.2043570  0.0053292   38.35  < 2e-16 ***
management.areaWAPITI      -2.3050167  0.3188491   -7.23 4.86e-13 ***
for.edge                    0.0028162  0.0003525    7.99 1.35e-15 ***
local.kills                -0.0216893  0.0019170  -11.31  < 2e-16 ***
speciesdolsco               1.4569500  0.0214369   67.96  < 2e-16 ***
speciesranlya               0.1396549  0.0311874    4.48 7.54e-06 ***
management.areaWAPITI:for.edge  0.0133054  0.0009328   14.26  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Zero-inflation model:
               Estimate Std. Error z value Pr(>|z|)
(Intercept)    3.948103   0.434248   9.092   <2e-16 ***
speciesdolsco -0.185028   0.150431  -1.230    0.219
speciesranlya  0.125481   0.162642   0.772    0.440
for.edge      -0.027290   0.002198 -12.416   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’
```

B Top-ranked model coefficients (scaled)

```
Family: binomial  ( logit )
Formula:          proportion ~ deer.pellets + management.area * for.edge + local.kills +
    species + (1 | subregion/area/line)
Zero inflation:             ~species + for.edge + (1 | subregion/area/line)
Data: scaled
Weights: no.plants

     AIC      BIC   logLik deviance df.resid
 22221.4  22322.6 -11092.7  22185.4     2027

Random effects:

Conditional model:
 Groups                Name        Variance Std.Dev.
 line:area:subregion (Intercept) 0.46749  0.6837
 area:subregion      (Intercept) 0.31922  0.5650
 subregion           (Intercept) 0.09386  0.3064
Number of obs: 2045, groups:  line:area:subregion, 230; area:subregion, 46; subregion, 11

Zero-inflation model:
 Groups                Name        Variance  Std.Dev.
 line:area:subregion (Intercept) 9.892e-08 0.0003145
 area:subregion      (Intercept) 7.658e-01 0.8750926
 subregion           (Intercept) 2.626e-01 0.5124175
Number of obs: 2045, groups:  line:area:subregion, 230; area:subregion, 46; subregion, 11

Conditional model:
                              Estimate Std. Error z value Pr(>|z|)
(Intercept)                  -2.551910   0.182194  -14.01  < 2e-16 ***
deer.pellets                  0.428266   0.011168   38.35  < 2e-16 ***
management.areaWAPITI         0.025061   0.268401    0.09    0.926
for.edge                      0.093788   0.011738    7.99 1.35e-15 ***
local.kills                  -0.089802   0.007937  -11.31  < 2e-16 ***
speciesdolsco                 1.456947   0.021437   67.96  < 2e-16 ***
speciesranlya                 0.139660   0.031187    4.48 7.53e-06 ***
management.areaWAPITI:for.edge  0.443111   0.031064   14.26  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Zero-inflation model:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   -0.83101    0.22842  -3.638 0.000275 ***
speciesdolsco -0.18504    0.15043  -1.230 0.218675
speciesranlya  0.12548    0.16264   0.772 0.440399
for.edge      -0.90887    0.07321 -12.415  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
```

C Top-ranked PCA model coefficients (scaled)

```
Family: binomial  ( logit )
Formula:
proportion ~ management.area + species + local.kills + Dim.1 +
    Dim.2 + Dim.3 + Dim.4 + (1 | subregion/area/line)
Zero inflation:
~species + for.edge + (1 | subregion/area/line)
Data: ones
Weights: no.plants

     AIC      BIC   logLik deviance df.resid
 22183.8  22290.6 -11072.9  22145.8     2026

Random effects:

Conditional model:
 Groups              Name        Variance Std.Dev.
 line:area:subregion (Intercept) 0.4824   0.6945
 area:subregion      (Intercept) 0.3300   0.5745
 subregion           (Intercept) 0.0752   0.2742
Number of obs: 2045, groups:
line:area:subregion, 230; area:subregion, 46; subregion, 11

Zero-inflation model:
 Groups              Name        Variance  Std.Dev.
 line:area:subregion (Intercept) 1.659e-07 0.0004074
 area:subregion      (Intercept) 7.687e-01 0.8767535
 subregion           (Intercept) 2.413e-01 0.4912638
Number of obs: 2045, groups:
line:area:subregion, 230; area:subregion, 46; subregion, 11

Conditional model:
                       Estimate Std. Error z value Pr(>|z|)
(Intercept)           -2.423099   0.176839  -13.70  < 2e-16 ***
management.areaWAPITI -0.066156   0.263145   -0.25   0.8015
speciesdolsc           1.468103   0.021438   68.48  < 2e-16 ***
speciesranlya          0.132609   0.031330    4.23 2.31e-05 ***
local.kills           -0.026591   0.001993  -13.35  < 2e-16 ***
Dim.1                 -0.173336   0.006707  -25.84  < 2e-16 ***
Dim.2                  0.407940   0.018094   22.55  < 2e-16 ***
Dim.3                  0.245362   0.012488   19.65  < 2e-16 ***
Dim.4                  0.102618   0.034456    2.98   0.0029 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Zero-inflation model:
               Estimate Std. Error z value Pr(>|z|)
(Intercept)    4.175569   0.432949   9.644   <2e-16 ***
speciesdolsco -0.183086   0.150680  -1.215    0.224
speciesranlya  0.142382   0.161994   0.879    0.379
for.edge      -0.028603   0.002213 -12.925   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
```

D Trend in proportion of plants browsed for all years and areas

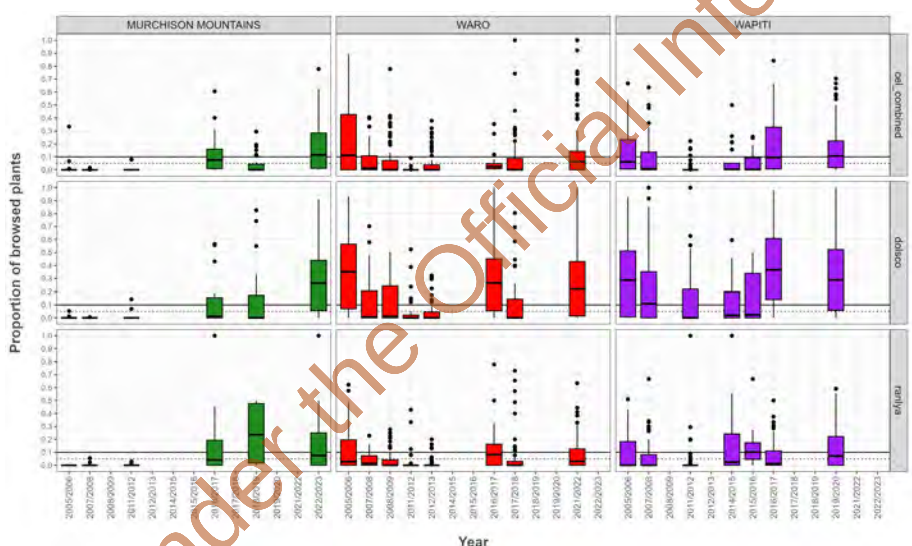

Figure 12: Crude trend in browse rates (for all sites and all valid lines within management areas). Boxplot key: box = interquartile range, central line = median, whiskers = 1.5 × interquartile range, dots = outliers. General key: dotted line = 5% threshold (desired), solid line = 10% threshold (preferred).

E Trend in deers killed for all years and areas

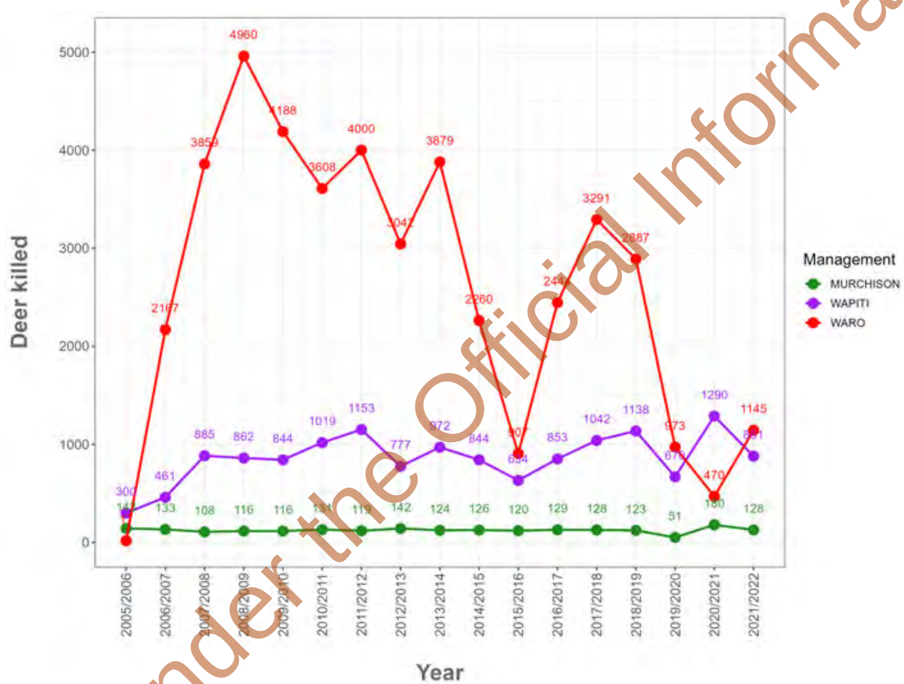

Figure 13: Total deer killed from all managment areas from 2005 onwards.

Holder Name	South Island National WARO Permit No.
Action Helicopters Limited	74061-WARS
Ahaura Helicopters	74123-WARS
The Alpine Group (Alpine Helicopters)	74124-WARS
Back Country Helicopters (2022) Limited T/A Back Country Helicopters	74125-WARS
Barn Bay Fishing Co Limited	74126-WARS
Fiordland Enterprises Limited	74127-WARS
Fiordland Helicopters Ltd	74128-WARS
Glacier Country Helicopters Ltd	74129-WARS
s9(2)(a) [redacted]	74130-WARS
Hawkeye Helicopters Limited	74131-WARS
Helipark Limited	74132-WARS
Heliventures NZ Limited	74133-WARS
Back to Bush Limited	74134-WARS
s9(2)(a) [redacted]	74135-WARS
DJ & N A Shanks Limited	74136-WARS
Minaret Station Limited	74138-WARS
Mountain Helicopters Fox Glacier Ltd	74139-WARS
Nokomai Helicopters Limited	74140-WARS
North West Livestock Ltd	74141-WARS
s9(2)(a) [redacted]	74142-WARS
Ranger Helicopters Limited	74143-WARS
Snowline Safaris Limited	74144-WARS

Southern Lakes Helicopters Ltd	74145-WARS
Te Anau Deer Ltd	74146-WARS
Te Anau Helicopter Services Limited	74147-WARS
Wild Animal Management Ltd	74148-WARS
s9(2)(a) [redacted]	74150-WARS
s9(2)(a) [redacted]	101776-WARS
Alpine Springs Helicopters Agricultural Limited	94858-WARS
P F Sugrue Limited	91748-WARS
Hokitika Helicopter Services Limited	93148-WARS
Silver Fern Petfoods Ltd	94679-WARS

Holder Name	North Island National WARO Permit No.
Helipark Limited	74132-WARS
McNicholas Aviation Limited	74160-WARS
s9(2)(a) [redacted]	74161-WARS
Wairarapa Helicopters Limited	74162-WARS
Central Helicopters (2014) Limited	74163-WARS
Amalgamated Helicopters NZ Limited	74164-WARS
Alpha Helicopters ltd	74165-WARS
Hokitika Helicopter Services Limited	93148-WARS
Silver Fern Petfoods Ltd	96086-WARS
Helihunt 'n' Fish Taupo Limited	82333-WARS