McLeans Island

Dry plains ecological restoration plan

Nicholas Head / March 2022

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Christchurch City Council

Approvals Panel			
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Introduction

The Canterbury Plains has undergone extreme levels of loss of indigenous biodiversity owing to conversion into arable farmland. Less than 1% retains indigenous cover making it one of the most developed landforms in New Zealand if not the world.

Owing to extreme loss, remaining indigenous ecosystems on the Canterbury Plains are acutely threatened[1]. The protection and restoration of indigenous biodiversity remaining on the plains is therefore a national priority for nature conservation[2] and is an obligation for Council as a matter of national importance.

Site description

The McLeans Island dry plains (herein referred to as McLeans) is an area of Christchurch City Council (CCC) administered land that is located within the north-west city boundary immediately, west of the airport, broadly between McLeans Island Road and the Old West Coast Road (Figure 1). It comprises 158 ha in area separated into 2 major land parcels by Conservators Road of approximately ~90ha west and ~68 east of Conservators Road respectively. It forms the eastern part of a more extensive area of ECan land that adjoins the western boundary of McLeans, extending ~12km to NZ defence force land north of Ross Road. This is the largest contiguous area of largely undeveloped alluvial soils remaining on the Canterbury Plains.

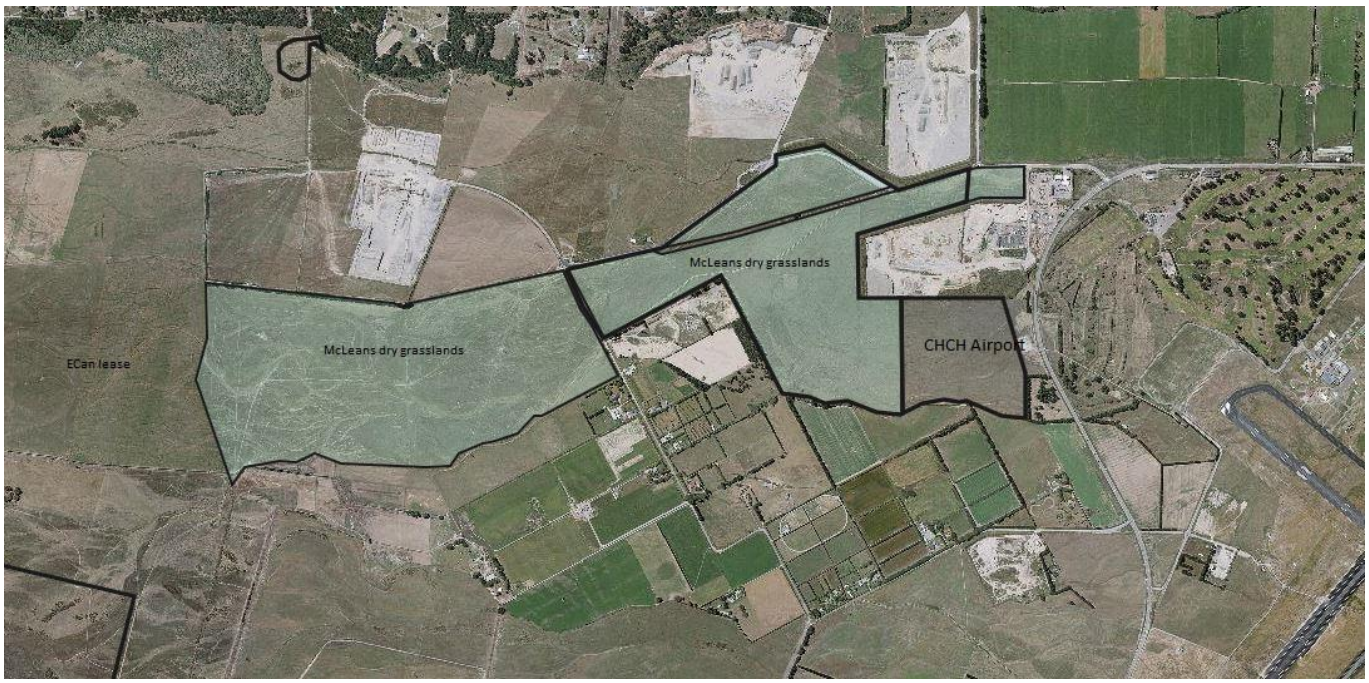

Figure 1: McLeans Island dry grasslands spanning Conservators Road

[1] Walker, S.; Cieraad, E.; Barringer, J. 2015. The Threatened Environment Classification for New Zealand 2012: a guide for users. Landcare Research, 27 p. Landcare Research New Zealand ltd, Dunedin.

[2] Protecting our places: Introducing the national priorities for protecting rare and threatened biodiversity on private land. Available at https://www.biodiversity.govt.nz/land/guidance/.

It occurs in the Low Plains Ecological District (ED) in the Plains Ecological Region (ER)[3]. It corresponds with the J2 (central well drained recent soils) land environment (LENZ)[4]. The J2 land environment is characterised by mild dry climates, high solar radiation, and moderate annual water deficits. Greywackee alluvium is the parent material with a predominance of coarse gravels and sands. Soils are in the Rangitata 6 series broadly described as recent, shallow, well drained, moderately high soil fertility, very low soil moisture (ref). There is a high degree of fine scale topographical variation associated with numerous stony channels and silt mounds of deeper soils that provides micro-habitats for various native plant communities and biota generally.

Natural history

Historically McLeans was part of the active flood plain of the Waimakariri River that formed a wide unstable riverbed of rocks, gravel, silt/sand bars and dunes. Semi stable islands were most likely present on thicker alluvial deposits.

There is little information available on what comprised the pre-human vegetation (or fauna) of the area. Maori burning had removed much of the 'original' woody cover predicted to have been present across stable alluvial surfaces of the lower Canterbury Plains. Early European descriptions are also scarce on any detail but for generically describing the plains as "grassland", "fernland", "broken ground", "sandy knolls with scattered tussocks" (ref map).

Armstrong (1879)[5] states of the plains as:

> *"The most abundant grasses are the tussock-grass, Poa caespitose, etc, an undescribed species of fescue usually referred to as Festuca duriuscula …the hassock-grass, Aira caspitosa, Agrostis amula, the holy grass, Hierochloe redolens, the plume grass Dichelachne crinite; and the blue grass, Triticum squarrosum. Among these grasses grew a few pretty little herbaceous plants belonging to the genera Raoulia , Craspedia, Cotula, Wahlenbergia, Pelargonium, Geranium, and Geum and in the wet places many interesting little plants, such as species of Pratia, Ranunculus, Lomaria, Triglochin, Miromeria and others."*[6]

And from Armstrong of shrublands;

> *"A few patches of shrubs were occasionally to be found on the plains, and were formed of Discaria toumatou, Coprosma parviflora*[7]*, Leptospermum scoparium, Olearia virgata*[8] *and Cassinia vauvilliersii. The common cabbage tree of the South Island, rather common, and helped to enliven what was at best a dreary scene"*

[3] McEwen, W. M. (editor) 1987. Ecological regions and districts of New Zealand, third revised edition (Sheet s). New Zealand Biological Resources Centre Publication No 5. Department of Conservation, Wellington.

[4] Leathwick, J. R.; Wilson, D.; Rutledge, D.; Wardle, P.; Morgan, F.; Johnston, K.; McLeod, M.; Kirkpatrick, R. 2003. Land Environments of New Zealand, Nga Taiao o Aotearoa. David Bateman Ltd, Auckland. 184 pp.

[5] Armstrong, J. B. 1879. A short Sketch of the Flora of the Province of Canterbury, with Catalogue of Species. Art . XLIX – Transactions. Botany.

[6] *Poa caespitose* =silver tussock, *Festuca duriuscula* = fescue tussock, hassock-grass = Carex?, *Aira caspitosa* = *Deschampsia cespitosa , Agrostis amula* = *Lachnagrostis filiformis, Lomaria* = *Blechnum*

[7] Probably *Coprosma propinqua*

[8] Probably *Olearia adenocarpa*

From these descriptions, it seems most likely that the active floodplain of McLeans comprised colonising native plant communities of chiefly silver tussock *(Poa cita)* and fescue tussock *(Festuca novae-zelandiae)*, tutu *(Coriaria spp)*, dwarf coprosma *(Coprosma brunnea, C. petriei), Raoulia spp*, and dwarf pohuehue *(Muehlenbeckia axillaris)* and a high diversity of associated native herbs and grasses. Ephemeral 'wetland' plants were in channels as described above. Similar examples are still present in the upper reaches of the major Canterbury rivers today where the active floodplains remain relatively natural.

On stable terraces and deeper soils, it is less certain but is likely to have supported shrubs as described above. Early descriptions of shrublands accord generally with the composition of the few shrubland remnants present today on similar soils in the McLeans vicinity (except for the presence of common broom *(Carmichaelia australis)* and South Island kowhai *(Sophora microphylla)* strangely not mentioned by Armstrong, and for the lack of kanuka *(Kunzea serotina[9])*.

Permanent stop banks were constructed in the 1930s to protect the western suburbs of Christchurch City. This halted all disturbance associated with periodic flooding resulting in a stabilised floodplain. With the loss of flooding and associated disturbance, post 1930, provided the potential for natural vegetation succession to occur overtime. Aerial photos from around 1940 show relatively widespread (albeit sparse) cover of what appears to be shrubs, most likely dominated by matagouri *(Discaria toumatou)*. Tussock, most probably silver tussock *(Poa cita)*[10], also appears widespread, and scattered 'savannah' trees of kowhai appeared to be a feature of the stable flood plain. Although the botanical composition shown in the photos is by no means certain, it suggests that succession from seral native plant communities into greater cover of native shrubs was occurring as would be predicted in the course of natural ecological functioning.

Following initial increases in tussock and shrub cover ecological regression has since occurred with the composition of the vegetation becoming shorter, less diverse with increasing proportions of exotic species. This is demonstrated by the reduction in numbers of trees, shrubs and native tussock grasses previously recorded as common, and apparent in early photos. Losses in the numbers and diversity of native species previously present has also occurred when early species lists are compared to today. Species lost from McLeans in recent decades *Coprosma petriei, C. brunnea*, fescue tussock, *Carex comans*, tauhinu, among others.

[9] The exception to the largely depauperate extent of native trees and shrubs south of the Waimakariri River was dense kanuka that formed extensive cover on the north bank.

[10] Could also comprise *Carex comans* that was recorded as common.

Ecological values

Vegetation

Today the dominant vegetation at McLeans is primarily extensive native mossfield of chiefly woolly moss *(Racomitrium pruinosum)*, wire moss *(Polytrichum juniperinum)* and Triquitrella, with exotic herbfield and grasses forming a secondary component. Composition varies depending on local environmental conditions, history of use, and time of year. Considerable areas are now dominated in exotic grasses and herbs primarily on deeper soils and in areas possibly modified to a greater extent by pastoralism. The effects of different management can be seen along the fence line between the un-grazed northern paddocks and the heavily grazed southern paddocks where the mossfields in the adjoining paddock are considerably depleted and have been replaced exotic herbs and grasses.

Native herbs, subshrubs and grasses, occur sporadically throughout the mossfield, such as oxalis *(Oxalis exilis)*, *Geranium brevicaule,* dwarf pohuehue, dwarf heath *(Leucopogon fraserii), Carex breviculmis, Rytidosperma pumillum* and the 'native' bunch grass *R. clavatum.*

A feature of McLeans flora is the relatively high proportion of native seasonal 'spring annual' vascular plants present which is indicative of the stressed drought prone climate. Onion orchid *(Microtis uniflorus)* is notably abundant, with sun orchids *(Thelymitra pauciflorus, T. longifolia)*, adder's tongue fern *(Ophioglossum coreacium)*, and *Stackhousia minima* locally common through spring and early summer. Other perennial native vascular plants persist as scattered individuals in so few numbers that they barely constitute viable populations. These include scabweed *(Raoulia australis), Scleranthus uniflorus,* multi-headed orchid *(Pterostylis tristis),* leafless pohuehue *(Muehlenbeckia ephedrioides), Chielanthes distans, Leptinella serrulata.*

Native shrubs are extremely sparse occurring very occasionally in open patches, but mostly as senescent isolated individuals. Matagouri, porcupine shrub *(Melicytus alpinus)* and common broom are the prevailing species where they typically occur on sheltered aspects of silt banks. Two plants of the Plains Olearia *(Olearia adenocarpa)* are present and one tree of South Island kowhai remains in-situ. A few silver tussocks occur within one of the fenced shrubland remnants. Gorse *(Ulex europeaus)* is locally common, typically on silt mounds and banks.

Threatened Plants

Despite the depleted ecology of McLeans it provides important habitats for many nationally rare and threatened dryland vascular plants as listed in Table 2 below.

Species	Common Name	Threat Rank 2017 revision
Olearia adenocapa	Plains olearia	Threatened - Nationally Critical
Carmichaelia corrugata	Dwarf broom	Threatened - Nationally Vulnerable
Geranium retrorsum	Turnip-rooted geranium	Threatened - Nationally Vulnerable
Muehlenbeckia ephedroides	Leafless pohuehue	Threatened - Nationally Vulnerable
Raoulia monroi	Fan-leaved daisy	Threatened - Nationally Vulnerable
Discaria toumatou	Matagouri	At Risk -Declining
Leptinella serrulata	Button daisy	At Risk -Declining
Pterostylis tristis	Multi-headed orchid	At Risk -Declining
Raoulia australis	Scabweed	At Risk -Declining

Fauna

Invertebrates

McLeans provides significant habitats for numerous species of invertebrates that have been determine from several surveys undertaken over the years[11].

Birds

Several species of native birds use McLeans as breeding and feeding, including:

Species	Common Name	Threat Rank 2017 revision[12]
Charadrius bicinctus	Banded dotterel	Nationally Vulnerable
Circus approximans	Harrier hawk	Not Threatened
Tadoma variegata	Paradise shelduck	Not Threatened
Haematopus finschi	South Island Pied oyster catchers	Declining
Anthus novaeseelandiae	Pipit	Declining
Haematopus unicolor	Variable oyster catchers	Recovering

Lizards

Common name	Scientific name	Conservation status[13]
Canterbury spotted skink[14]	*Oligosoma aff. lineoocellatum 'central Canterbury'*	Nationally Vulnerable
Southern grass skink	*Oligosoma aff. polychroma Clade 5*	At Risk - Declining
Canterbury/Waitaha gecko	*Woodworthia cf. brunnea*	At Risk - Declining
McCann's skink	*Oligosoma maccanni*	Not Threatened

[11] Chinn, W. 2004. Invertebrate survey of the McLeans Island ecological heritage site and West Melton. A report prepared for the Parks and Waterways Unit for the Christchurch City Council in conjunction with the department of conservation, Canterbury Conservancy. Department of Conservation, Unpublished report.

Chinn, W. 2005. Insect pollination of four native plant species at McLeans Island, Canterbury. A report for the Department of Conservation and the Christchurch City council, Department of conservation, unpublished report.

Macfarlane, P. R; Patrick, B.h.; Vink, C.J.1999. McLeans Island invertebrate inventory and analysis. Unpublished report to the Christchurch City Council.

[12] Robertson et al. 2017. Conservation status of New Zealand birds, 2016. Department of Conservation, Wellington New Zealand.

[13] Hitchmough R, Barr B, Lettink M, Monks J, Reardon J, Tocher M, van Winkel D & Rolfe J 2016. Conservation status of New Zealand reptiles, 2015. New Zealand Threat Classification Series 17. Department of Conservation, Wellington. 14 p.

[14] Not recorded form the McLeans site but a population is nearby at Orana Park. The re-introduction and of spotted skinks at McLeans could be a key initiative.

Ecological restoration

The key objective of ecological restoration is to undertake management that shifts the ecosystem from a degraded state to a less degraded or a more natural state. Successful restoration ultimately leads to natural ecological functioning, which in turn builds ecological resilience and long term sustainability.

Given the dynamic nature of ecosystems, determining restoration success can be difficult. Measures of successful ecological restoration include increasing native species dominance, decreasing exotic species presence and abundance, seedling recruitment and survival of perennial native species, increasing ecological complexity, and ultimately self-perpetuating healthy native plant communities.

In young ecosystems supporting seral native plant communities, ecological succession to taller more complex vegetation is a natural outcome of healthy ecological functioning. However, a consequence of natural succession can be the reduction and eventual loss of early colonising plant communities as they are replaced by other native species. The loss or reduction of some early successional plant communities and species should not be seen as a negative outcome if it is a consequence of ecological recovery.

In the event of ecological recovery occurring at McLeans, it is highly unlikely that the seral mossfields that dominate the cover today, and associated herbaceous native vascular plants, will be entirely lost. This is because of the relatively large size of McLeans and associated subtle habitat variation that is present. This includes many young environmentally stressed habitats that are expected to support mossfields and associated vascular plants for long time periods, subject to appropriate management. However, the full range of habitats required to sustain all early successional species previously more abundant at McLeans, such as mat daisies on gravels, have largely been lost. These species are likely to disappear in the absence of large scale disturbance events that replicate flooding.

As environmental conditions have changed from active riverbed to stable floodplain, it is assumed that the successional trajectory would go from primary mossfields to tussock grasslands and shrublands (as initially appeared to occur), and over the long term into denser shrublands and forest. Silver tussock and shrublands, similar to that described above, most likely forms the physiognomically dominant vegetation resulting from natural succession. LENZ predicts podocarp forest (totara, matai) as the eventual dominant cover[15]. This is certainly a very long term proposition, if not an overstatement of the ecological potential of the McLeans ecology.

It is assumed that kanuka would be a key successional species at McLeans as it occurs in reserves on similar environments on the Canterbury Plains and Culverden Basin. Although kanuka is not present at McLeans a few natural plants occur nearby on the same landform and soils, and it once formed extensive cover nearby prior to land development on the north bank of the Waimakariri River. Although the soils are older on the Nth Bank of the Waimakariri, there appears no natural ecological barrier that would have prevented kanuka colonisation and spread on the more recent soils at McLeans. Over the long term it could be expected to form extensive albeit patchy cover in the natural course of ecological succession and successful restoration.

[15] Leathwick, J. R.; Wilson, D.; Rutledge, D.; Wardle, P.; Morgan, F.; Johnston, K.; McLeod, M.; Kirkpatrick, R. 2003. Land Environments of New Zealand, Nga Taiao o Aotearoa. David Bateman Ltd, Auckland. 184 pp.

Management opportunities & constraints

McLeans has been farmed throughout the 20th century chiefly by extensive sheep grazing. This has most likely induced and maintained the extensive mossfields that is the dominant native vegetation today, albeit largely artificial. Previous management practises have also had a marked impact on the vegetation, such as fire and the physical removal of native plants (matagouri and tussocks) apparently mistaken as pests[16].

Other likely influences on the vegetation include loss of fauna/plant associations, weed competition, and edge effects from adjoining land use, harsh environmental conditions; the effects of which are inter-related.

Given the very depleted and modified condition of McLeans today, combined with naturally stressed environmental conditions, it is highly unlikely that ecological recovery and natural succession will occur without considerable intervention, including ceasing or reducing considerably stock grazing, animal and weed control, planting appropriate shrubs and the augmentation of seed sources generally.

Restoration methods

Fencing

The entire perimeter of McLeans is fenced. Further internal fencing divides McLeans into 5 large irregularly sized paddocks shown as areas A=E on the following map. There are also several fenced 'study' plots of varying size, and most of the remnant shrubs are fenced. At least one paddock is rabbit fenced but most other fences, including the perimeter fence, are not rabbit proof.

Maintaining the general standard of the fences is necessary to provide for management options generally, not least the control of grazing. With the exception of some fenced plots and shrubs, fences are not rabbit proof which is an impediment to managing rabbits effectively. Rabbit fencing of the perimeter as a minimum should be undertaken but could also be considered for internal fences so as to enhance management and monitoring options to increase understanding.

Internal fencing provides an opportunity to alter grazing to manage for 'conservation' purposes, either through stock exclusion or differing grazing regimes within the site. However, currently McLeans appears to be grazed as one large paddock, with fences generally left open for free stock movement. Consequently, the internal fences are redundant in terms of their potential to contribute to better management of McLeans, and as a result they serve to detract from the naturalness of the site.

Summary of management actions

- Maintain all fences in good condition, and
- Rabbit fence perimeter of McLeans area.

[16] Previous weed contractors sprayed out matagouri and silver tussock that they considered as weeds. pers com. Arthur Adcock

Grazing

Ridgen (2005) in her ecological study of McLeans[17] concluded that overgrazing by sheep, rabbits and hares was probably the primary reason for ecological decline at McLeans. This has caused the loss of palatable species, loss of structure, declining species richness, loss of seed sources, and halted ecological succession. She recommended retiring all sheep grazing in order to promote the recovery of native plant communities present, acknowledging the increased risk of fire in doing so.

Since Ridgen's study, anecdotal evidence[18] indicates that in areas continually grazed moss cover has become less intact, with exotic grasses and flat weeds increasing in cover. This is primarily attributed to the combined effects of heavy grazing, ground disturbance from trampling, and nutrient inputs that are collectively favouring exotic species colonisation.

However, ceasing stock grazing entirely carries the risk of losing indigenous biodiversity through increased competition resulting from the flush of exotic species that will inevitably occur. This conundrum of management is evident in the exclosure plots present, within which the response of the vegetation varies depending on some 'unmeasured' local environmental and/or historical differences[19] in management. In all plots there has been marked recovery of vegetation resulting in considerably greater biomass inside compared to outside. In some plots, however, exotic grasses completely dominate the vegetation presumably at the expense of the native flora previously present. In other plots, recovery of the native dryland ecosystem is notable with more intact mossfields, increased size and numbers of native vascular plants, including threatened species. Improved habitats for fauna, especially observed for lizards, is commensurate with vegetation recovery from excluding stock grazing.

Overall, it is my view that the ecological benefits as a whole from ceasing grazing most likely outweighs the perceived benefits of ongoing grazing, certainly under current intensive grazing levels. However, owing to the increasingly degraded state of McLeans means that the effects of retiring grazing may be more deleterious on native species than may have otherwise occurred if the mossfields remained more intact. Ironically, a consequence of over grazing may necessitate ongoing grazing to mitigate against the major loss of the native moss fields and associated native species.

Should grazing be continued, it must be undertaken to facilitate ecosystem recovery, where the cover and abundance of exotic species is permanently reduced, outcomes that are possibly incompatible with ongoing grazing of any kind at McLeans. In any case it is imperative that grazing is vastly reduced from current levels, and it needs to be carefully timed to have the least detrimental effects on indigenous biodiversity present.

Grazing trials

McLeans is fenced into several separate paddocks, this provides opportunities to manage grazing levels, either by altering grazing patterns and/or ceasing grazing altogether. A more sensitive and informative grazing regime should be adopted where grazing is maintained but at reduced levels from current for paddocks A and C, with all sheep grazing excluded from other paddocks (B, D, E). For paddocks that continue to be grazed, a more sensitive

[17]Ridgen, J. 2005. Conservation of the Dry Plains Grasslands at McLeans Island, Canterbury. A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Environmental Science University of Canterbury.

[18] Photo 2.4 pg 27 and 2.6 pg 29 in Ridgen thesis show more intact mossfield and grassland under a grazing regime compared to today.

[19] Photo 2.7. pg 31, shows dense exotic grassland existing in the plot at the time of the study.

grazing regime equates to a mob[20] of merinos twice a year for a week in early summer and a week in late autumn. It is imperative that grazing trials occur concurrently with adequate vegetation monitoring to understand the ecological impacts of altered grazing regimes. This is important to decide on whether to continue the cessation of grazing, or to resume grazing if monitoring data shows is justified.

The effects of rabbits browse on exotic grass cover should also be investigated. The invasion of exotic grasses, such as Chewings fescue, is a major threat to the long-term ecological health of McLeans. The impact of Chewings fescue can be seen in the exclosure plot in paddock D, where it forms a complete sward at the expense of native species. Control of Chewing fescue (and other grasses) by sheep grazing is not an effective long-term option and may in fact facilitate the spread of exotic grasses overtime. Whereas rabbit browsing has been anecdotally attributed to the elimination of exotic grass species under sustained 'high' rabbit numbers that hastened ecological recovery post rabbit control. Consequently, it is proposed that paddock D is rabbit fenced and rabbit numbers are allowed to build up so as to monitor their impact on vegetation composition as a potential tool to control exotic grass species after which rabbit control would occur[21]. Paddock D is considered suitable to undertake this trial owing to its smaller size and greater cover of exotic grasses which also corresponds with fewer (vulnerable) native species present compared to other paddocks.

Alternatively, the existing exclosure plots could be used to investigate the effects of rabbits (or an appropriate surrogate such as Guinee pigs, or mowing) could be utilised to undertake this study as a smaller scale trial. Depending on the results, if it shows potential, it could then be undertaken at a larger scale.

Summary of management actions

- Undertake sheep grazing trials as outlined above, and
- Consider investigating the effects of rabbits as a control tool for exotic species utilising either the existing exclosure plots or within paddock D.

Inventory & monitoring

Measuring ecosystem change is essential to undertake effective management to meet restoration goals. To do this requires a good understanding of the full extent of ecological attributes present, especially those of particularly significance and are sensitive to change. Therefore, monitoring needs to operate at the ecosystem scale and at the species scale.

Previous monitoring established by Ridgen provides important baseline information and comparisons of vegetation between grazed and non-grazed sites. However, these plots lack adequate replication to provide sufficient information on the effects of grazing at the ecosystem scale, nor do they capture many of the rare and threatened species that are sparsely distributed.

The establishment of additional vegetation monitoring plots should be undertaken to better monitor the responses of vegetation to future management, such as reduced or ceased stock grazing. Sufficient plots need to be established to account for the subtle diversity present at McLeans relating primarily to soil depth, and to account for different management relating to varied grazing regimes that may be implemented. This will require

[20] What constitutes a mob - 50, 100, 150?

[21] Obviously this is a controversial plan that carries some risk, not least to native species present within the study site, and from the potential for disturbance from digging. Conversely there is little really to lose and potentially much to gain if rabbits can be used as an effective tool to control otherwise tenacious exotic grasses. It may also require agreements with ECan to allow rabbit numbers to increase to high levels until such a time control would be undertaken.

relatively fine scale mapping of landforms and soil patterns[22] to stratify the McLeans area in order to ensure adequate plot representation.

Plot monitoring protocols and data recorded should be consistent with standard practice and include recording the nearest percentage cover of every species present including non-vascular species. Monitoring of fauna (invertebrates and lizards) should occur concurrently with vegetation monitoring. Fine scale topographic/soil mapping in combination with vegetation monitoring should also enable modelling of predicted vegetation change at a fine scale in response to changed grazing.

Baseline inventories of threatened and notable/sensitive species should be undertaken to understand more fully their population parameters, which in turn will form baseline information for future monitoring. Thorough inventories will require systematic surveys for threatened taxa along transects, recording locations of threatened and/or notable species when found. Timing of surveys is an important consideration given the ephemeral spring annual nature of some species. Depending on the number, size, and location of threatened species populations recorded will determine the type and efficacy of future species monitoring. Monitoring options include a census for species in very low numbers, or permanent plot monitoring of a representative sample for species that have larger more widespread populations.

Summary of management actions

- Undertake vegetation monitoring by establishing at least 5 20X20 monitoring plots. Monitoring to occur annually in spring and to be conducted in accordance with standard practice,
- Inventory threatened plant populations along transects recording each population of target species with GPS and noting specific site/population parameters,
- Commission topographic drone survey of fine scale soil patterns, and
- Liaise with research organisations for study opportunities for students.

Restoration planting

Restoration planting is necessary to reintroduce key species lost and/or to increase the numbers of species vastly reduced in abundance. However, it is important that restoration planting is sympathetic to natural patterns, so it is authentic and does not appear contrived. Planting should initially be small scale so as to understand more clearly the efficacy of planting to ensure future success that in turn leads to the expansion of areas planted in any one year. Planting needs to be undertaken sensitively and in accordance to best practice for dryland ecosystems to avoid damaging other values that could be present, and to increase the likelihood of survival in harsh environments.

There is a high degree of landform subtlety and associated habitat variation present at McLeans, with remnant tussocks and shrubs typically occurring (sparsely) on sandy mounds and on shady banks as preferred habitats and/or refugia. These habitats and the remnant shrubs on them provide a template for where restoration planting should initially be undertaken, and what it should replicate.

As a general rule shrubland restoration should comprise matagouri, porcupine shrubs and common broom as the dominant species. These should be planted together in ‘sparse’ groups concentrating on south facing banks

[22] Ortho-topographical drone imagery of McLeans should be investigated.

and lower edges of channels. *Olearia adenocarpa* and tauhinau could also be included in shrubland plantings but only as a minor component at ~ 20% (equates to 2 plants for every 10 planted of the other common species combined).

Silver tussock planted abundantly albeit as sparse clumps on the same habitats as the shrublands on any aspect.

Kowhai planting should replicate the patterning to that historically present from old photos, and/or replicate trees surviving today across similar floodplains. Examples that provide guidance of the natural patterns of kowhai include Courtenay, or the Templeton golf course.

Prostrate kowhai should also be planted at the base of shady banks as was historically described and/or on habitats similar to those where remnant plants of prostrate kowhai occur today.

The introduction of kanuka should be undertaken primarily to introduce seed sources to facilitate future ecological succession. This should occur around the margins of McLeans land on the phases of deeper soils that tend to be dominated by exotic grasses. If possible, the embankments of adjoining quarries should also be planted in kanuka. Planting groups of kanuka on deeper soils could also be trialled, but on a small scale initially and separate from shrubland plantings. Matagouri and *Coprosma propinqua* could be included with kanuka planted sites but in minor proportions and generally on the edges of kanuka stands. Kanuka should be quite densely planted ~1m spacing. Laying kanuka slash to establish plants from seed should also be trailed as an alternative and more natural method to planting.

The re-introduction of species likely lost from McLeans should also be trialled. Species such as fescue tussock, *Carex comans*, tauhinau, *Coprosma brunnea*, *C. intertexta*, bracken (*Pteridium esculatum*) were all recorded from McLeans or are known from the vicinity on similar landforms. Fescue tussock and bracken were historically recorded as common and could naturally form an important component of the vegetation especially as fertility declines. Re-introducing these species should initially be small scale in order to better understand the efficacy and authenticity of such an approach.

Summary of management actions

- Determine appropriate planting sites (banks and mounds) within paddock B and paddock E for planning over 5-year period,
- Establish numbers of plants required in accordance to the desired composition and abundance, and
- Site preparation and planting at appropriate time of year.

Landform	Species	Abundance
South facing banks	Key species: matagouri, porcupine shrub, common broom. Secondary species: *Olearia adenocarpa,* kowhai. Trial species: tauhinau, *Coprosma intertexta,* kanuka.	Scattered clumps forming discrete patches Trial kanuka planted together as clumps - ~5 -10 plants.
Channel edges	Key species: matagouri, porcupine shrub, common broom, Secondary species: kowhai Secondary (trial) species: prostrate kowhai	Planted to form interconnected strips and clumps
Channels	Key species: *Carex comans* Secondary species: porcupine shrub	Irregular clumpy planting of *Carex comans,* occasional planting of procupines
Top of banks and sunny aspects	Key species: silver tussock, common broom, matagouri, Secondary species: *Olearia adenocarpa,* Trial species: tauhinau, fescue tussock, *Coprosma brunnea,*	Silver tussock key species planted irregularly but frequently; shrubs planted sparsely as scattered 'individuals'
Silt mounds, banks any aspect	Key species: silver tussock Secondary species: common broom, matagouri, *Olearia adenocarpa*, kowhai Trial species: *fescue tussock, bracken	Silver tussock planted frequently but in irregular pattern, scattered shrubs sparsely planted
Grassy margins	Key species: kanuka, kowhai, matagouri, *Coprosma propinqua,*	Kanuka planted densely, other species sparely included , shrubs on margins
Bunds	Key species: kanuka. Secondary species: *Coprosma propinqua,* cabbage trees, kowhai. Trial species: bracken	Kanuka planted densely, other species sparely included , shrubs on margins

Weed and pest control

Weed and animal pest control is necessary to prevent further ecological degradation at McLeans. Woody weeds, especially gorse and broom, pose a considerable threat to the native plant communities present and controlling them should be a management priority. Eradication of woody weeds from McLeans should be the management target. Other serious weeds are occasionally present, such as nasella tussock, need to be controlled as and when they occur. General monitoring of McLeans for new weed incursions should occur concurrently with general weed management.

Many other ubiquitous exotic species commonly occur at McLeans, such as Chewings fescue, sweet vernal, brown top, sheep sorrel, Bromus spp. Although they contribute to general ecological malaise and are an impediment to ecological recovery through habitat exclusion and competition, there are few practical ways to effectively control these weeds without the risk of causing considerable damage to ecological values present. General vegetation monitoring and grazing trials outlined in section 8 and 9 above will go some way to better understanding their impacts, and responses to potentially different management approaches to control exotic species that could be trialled in the future.

Animal pests need to be controlled to low levels. Rabbits and hares are present and browse native vegetation. They can have a particular impact on native shrubs such as native broom, matagouri and Plains olearia for which they appear to have a preference. Limiting the impact of browsing will be imperative to the success of restoration planting, seedling recruitment and shrubland regeneration.

McLeans is periodically an important nesting area of braided river birds, such as banded dotterels, South Island oyster catchers, and pied stilt. Given the all-pervasive loss of habitat, the chronic and increasing threat to New Zealand's native birds, predator trapping should be undertaken if it is seen as worthwhile. The gentle terrain aids efficiency in operating of an effective network of traps to alleviate the threat of predation to nesting native birds.

Summary of management actions

- Eradicate woody weeds (gorse, broom etc) from McLeans,
- Eradicate any RPMS species incursion, such as nasella tussock,
- Maintain vigilance for new incursions of exotic species generally,
- Control animal pests (rabbits and hares) to low levels, and
- In the case of nesting threatened native birds, such as banded dotterel and variable oyster catchers, undertake effective predator control (cats, hedgehogs, stoats, ferrets etc).

Fire management

The climate at McLeans leaves it vulnerable to fires. Currently the lack of biomass limits the fuel available and assumingly the intensity of a wildfire at McLeans. Increasing biomass is an expected outcome of ecological recovery at McLeans. This in turn will increase the potential intensity and threat of wildfire at McLeans. Reduction of fuel loads around the perimeter of McLeans is one possible way to mitigate fire risk, but such an approach needs to be sensitive to ecological values present. Increasing fuel loads will likely occur gradually over time allowing for time to implement appropriate mitigation measures.

Summary of management actions

- Prepare a fire management plan for McLeans area.

Adjoining land

Edge effects

Edge effects result from discharges (containments) coming from neighbouring land and are a pervasive threat to indigenous ecosystems. Discharges include dust, soil, seed, fertiliser, and moisture. They typically have an adverse effect on natural vegetation changing the composition toward increased exotic species, and facilitating weed ingress. The more intensive the land use occurring on adjoining (especially downwind) land the greater the edge effects will be, with narrow and smaller areas especially vulnerable to edge effects owing to having high edge to interior ratios.

Buffer zones that prevents contaminants crossing onto adjoining land are common mechanisms used to avoid or mitigate edge effects. An effective buffer zone is one that prevents all discharges, and related effects thereof, from crossing the boundary and causing any induced change. Planting buffer zones can enhance their

effectiveness by increasing the buffer's ability to intercept discharges. When planting buffer zones, it is important that it does not have additional adverse effects. For example the pine shelter belt along the south eastern boundary has negatively impacted on the vegetation at McLeans through depositing dense litter (needles etc) in combination with root competition for moisture. As a result, the adjoining edge is largely absent in native flora and dominated by drought tolerant sparsely distributed exotic herbs.

Quarrying

Quarrying is predominate land use on neighbouring land. It occurs close to and along almost the entire northern boundary of McLeans. A constructed bank approximately 2.5m tall separates the active quarries from McLeans land. Although the banks serve as a visual screen they are largely ineffectual at intercepting dust that can be regularly be seen coming from the quarries and travelling considerable distances across the boundary, especially on windy days.

Planting the perimeter banks (and the boundary per se) in native species, such as kanuka, would enhance the effectiveness as buffer zones. Kanuka is the appropriate species as it provides necessary structure (height and density) to form a continuous barrier. It also has the added potential to be a seed source to facilitate seedling recruitment into McLeans. Kowhai, cabbage trees, *Coprosma propinqua* and matagouri shrubs could also be included as an appropriate species mix if not as an effective barrier in their own right.

The adjoining quarries also present an opportunity for enhancing ecological values generally depending on how they are used once quarrying has ceased. Incorporating old quarries into the wider McLeans 'reserve' provides opportunities to utilise the exposed gravels as primary habitats. These habitats have largely been lost resulting in declining native seral plant communities and species.

Reinstating gravel habitats is necessary to maintain the full suite of native seral plant communities and species that were originally present at McLeans along the ecological continuum from active river bed to stable floodplain. Acquiring adjoining quarries also provides more habitat per se and restoration options over time. This takes on some importance given the seriously parlous state of remaining indigenous biodiversity and habitats on the Canterbury Plains.

Approaches should be made to quarry owners to plant the banks as discussed above and to enquire about their future use and potential acquisition. This should be undertaken as a priority as their potential for dryland biodiversity restoration could be rapidly lost given that quarries in the vicinity are being used for landfill once gravel has been extracted.

Summary of management actions

- Engage with quarry owners over their potential inclusion into a wider drylands recovery area, and
- Discuss with quarry owners planting the banks along the perimeter in kanuka etc to enhance them as a barrier.

Airport land

The eastern portion of McLeans land that adjoins Pound Road is owned by the Airport Company. This land forms an integral part of the wider McLeans dryland ecosystem on CCC land to which it is contiguous. It supports the same plant communities and species, and because it is unfenced with CCC land, by default it is managed more or less in the same way.

It is imperative that relevant Airport staff have full awareness of the high ecological values of this area, and that there is shared understanding of what constitutes appropriate management. Formalising the relationship between CCC and the Airport is important, as the respective areas are one ecosystem managed consistently in accordance with practises that will maintain and enhance the values present. Possible purchase of the area should also be considered by CCC.

Summary of management actions

- Liaise with Airport staff over joint management of McLeans land. and
- Investigate options to incorporate airport land into CCC land as potential purchase.

Canterbury Regional Council (ECan) land

Environment Canterbury Land occurs to the west forms the natural extension of the floodplain in which McLeans occurs. Although much of the ECan land is outside the City boundary, McLeans comprises the eastern section of what is in effect one relatively intact ecosystem. The ecological values of the whole system outweigh the particular values of any one part in terms of ecological values attributed to large size and ecological connectivity.

In addition to widespread ecological depletion that has occurred on McLeans, piecemeal land development over the years has modified to varying degrees considerable areas within the wider ECan lease land resulting in mosaic of semi-connected dryland vegetation. Maintaining and enhancing the extent of values present across the entire ECan and Council floodplain landform should be an imperative. Moreover, improving ecological connectivity through re-acquiring leases should be undertaken when and where-ever possible and land uses implemented that are compatible with ecological recovery.

An investigation should be undertaken into the feasibility of utilising the extensive largely modified lease land (taking account of existing values) for the possibility of re-instating some of the old flood channels. Returning the ecological processes necessary to provide the full range of habitats that were once present along the ecological continuum, from primary surface to stable floodplain, has considerable potential to restore and sustain the 'full' suite of seral native plant communities and species that are otherwise declining (or gone) at McLeans because of the loss of open habitats.

Summary of management actions

- Liaise with ECan staff on joint management initiatives and restoration of Dryland restoration,
- Advocate for floodplain restoration with ECan staff options,
- Propose floodplain restoration feasibility study funded through zone committee, and
- Liaise with research organisations, such as landscape students, to undertake scoping study of floodplain restoration.

Collaborative working group (recovery group)

In view of the inter-relationships between ECan land, CCC land, and Airport Company land, an inter-agency working group should be established so that the synergies from combined ecological understanding are used to learn, share, and adopt best management practices for the respective areas. Representatives should include at least 2 CCC staff, 2 ECan staff, Airport Staff, McLeans associates, and local tertiary education institutions. They should meet at least once annually to report on progress and discuss management.

Advocacy

There is a lack of understanding and appreciation of the high ecological values present at McLeans. The depleted state of the ecosystem generally, the small stature and cryptic nature of the native species present has contributed to this impression. The lack of awareness of the values present raises the risk of inappropriate activity occurring, or neglect, that could cause ecological damage and loss. Currently the McLeans west of Chattertons Road is not designated as an SES despite having high ecological values, putting the area at risk through misunderstanding. Raising awareness of the values present at McLeans is important to gain resources for its protection and restoration and ameliorate the risk of inappropriate use.

Summary of management actions

- Designate McLeans in its entirety[23] as a Significant Ecological Site (SES) in the Christchurch District Plan,
- Investigate changing the legal status of McLeans land to an appropriate designation that reflects its high ecological values,
- Give presentations to Council Parks and Planning staff on the ecology and natural history of McLeans when opportunities arise,
- Liaise with research organisations for research projects, and
- Establish interpretation panels on the values of McLeans at Conservators Rd walkway entrance into the reserve.

[23] This should include all the CCC land at McLeans including the parcel north of Conservators Road, and the Airport Company Land

Research

Dryland ecosystems are one of the least understood terrestrial ecosystems in New Zealand. The lack of understanding of key ecological processes necessary to facilitate ecological recovery and natural ecological functioning remains a major impediment to their management. More specifically, the lack of any meaningful understanding on methods to combat the ingress of highly competitive exotic grasses at the ecosystem scale is the primary challenge confronting the future health and sustainability of indigenous dryland ecosystems and their biota throughout New Zealand. Understanding more fully the effective use of sheep grazing is important, but methods to eliminate exotic grasses need greater exploration over and above the efficacy of sheep grazing, or lack thereof.

- Breeding systems
- Seed viability
- Seedling germination
- Disturbance experiments
- Isolation
- Modelling potential change
- Soil mapping
- Objectives
- Research

Christchurch City Council