Ecological Restoration/Rehabilitation Framework for Batger Quarry (and Adjoining Units) MAUNGAWHAU

I ♥ MY MOUNTAIN MT EDEN MAUNGAWHAU

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Te Kaitiaki Putea o Tamaki o Tai Tokerau

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TABLE OF CONTENTS

1. INTRODUCTION

This report and plan was commissioned by Friends of Maungawhau (FoM) who are seeking an ecological opinion regarding the practical aspects of weed management and planting of Batger Quarry, and surrounds, below the summit road.

The objectives of this report are to:

- Review FoM ecological achievements to date
- Define the desirable ecological outcomes
- Describe the ecological framework for Batger Quarry and adjoining areas
- Provide advice on weed management and planting techniques
- Provide advice on the location for plantings and information on suitable plant species that will lead to appropriate or self-sustaining cover
- Provide a guideline regarding the timing and priorities for implementation of restoration work
- Supply additional relevant supporting information (refer to the appendices)

2. FOM ECOLOGICAL ACHIEVEMENTS TO DATE – A BRIEF REVIEW

The Friends of Maungawhau efforts have mainly focused on revegetation work, weed control and advocacy.

Their core restoration group presently consists of 5 – 7 people who meet once weekly to carry out practical weed management. They also undertake planting activities during the planting season.

FoM have expressed a desire to consolidate their work and to limit their area of operation to a few key areas in Batger Quarry and to the grassland on the southern slope below the summit road.

A clear distinction needs to be made between Batger Quarry (management units 6-11), which is a highly modified environment requiring *rehabilitation*, and the much less modified management units (1-5), which have tracks, a scattering of exotic and native trees, exotic grassland and weeds, but a largely intact substrate. This area lends itself to *restoration* of scoria cone vegetation communities. A plan showing the FoM management units (MU) can be found in Appendix A.

FoM have directed much of their effort in recent years to areas between MU 1 through to MU 11.

The units that have received most attention are: Batger Quarry (MU 9 and MU 10) and the management units either side of this, particularly MU 11 to the east of the quarry, and MU 5, MU 4, and MU 3 to the west.

Other management units in Batger Quarry that are not managed by FoM are:

- MU 6 managed separately by an independent volunteer. This area has been planted mostly with a variety of native species naturally occurring in the Tamaki Ecological District (Auckland Isthmus). Natural establishment has also occurred.
- MU 7 which is highly unstable and unsafe for volunteers.
- MU 8 ("Townsend's Bush") managed by a private landowner

FoM have carried out some neighbourhood work, funded by the Albert-Eden Local Board (AELB), to limit the spread of weeds from neighbouring properties onto the maunga.

2.1 Rehabilitation/restoration methodology and effort:

Open grassland (*Restoration*)

Environmental weeds have been controlled by manual and chemical means. Regular hand releasing (or mechanical cutting) of grass has been carried out around new plantings.

Natural regeneration has occurred in the open grassland zones, with the establishment of pioneer species such as *Coprosma robusta* and *Coprosma macrocarpa subsp. minor*. Hardy native canopy species such as totara are also regenerating. In places where there is existing canopy understorey shade-loving species such as kawakawa are expanding. Taraire has germinated in MU 2 in shadier spots under mature trees, presumably dispersed by kereru. Several ferns are present including *Doodia australis, Pteris tremula,* and mamaku. The latter appears to have established naturally.

A variety of hardy trees and shrubs have been planted. Some are pioneer species thought to be natural to a scoria cone environment. The following appear to be growing well e.g.

- Kanuka
- Karamu
- Kohekohe
- Rewarewa
- Whau
- Kowhai (*Sophora microphylla*)
- Houpara (*Pseudopanax lessonii*)
- *Coprosma rhamnoides*
- Karo
- Tanekaha
- Pohutukawa

Low growing harakeke and *Astelia banksii* have also been planted, along with toe toe that appears to grow in the damper parts closer to the bottom of the slope and ti kouka which is more drought-tolerant.

Species **not** thought to be a normal component of scoria cone vegetation have been trialled; Kahikatea, for example, has survived closer to the slope base but may eventually block views to other cones from the lower path.

Batger Quarry (*Rehabilitation*)

One of the primary goals has been to stabilise the quarry surface while finding ways to manage and reduce pest plants, replacing these instead with suitable native species.

The approach in terms of revegetation is to rehabilitate this area as well as possible within the resources available to FoM.

This is a highly modified site for which no reference site exists, in terms of providing a model for a natural vegetation type. Plants thought to be associated (or possibly associated) with scoria cone vegetation have been trialled with varying success.

The coarse scoria substrate no longer has a natural soil profile. Volcanic ash and organic material has been removed by past quarrying activities

Indigenous plants have been deliberately selected by FoM to provide an essential ecological or "soft engineering" function in the quarry. Exotic species have been retained where they are performing an essential function (e.g. stabilising a bank).

The technique used in Batger Quarry ("micro weeding") is more akin to a horticultural approach, often working with more diminutive groundcover or field layer (herb) species.

Additional techniques have been developed, such as the use of low wooden terraces, constructed from horizontal stacked branches, which are secured to help prevent surface erosion. These do not provide a permanent solution and eventually break down.

FoM are fortunate to have access to a water supply and during dry summers have been able to carry out watering.

Trial and error has been an important part of the revegetation process and this informs much of the current thinking and approach by FoM.

Pest monitoring and trapping lines have been set up (see Appendix H) under the supervision of David Bowden, Parks Volunteer and Biodiversity Coordinator. A monitoring line runs through the top of Batger Quarry and one of the FoM members currently carries out animal pest control work in the quarry in MU 9.

2.2 Summary of *revegetation progress and effectiveness*

Open grassland

Revegetation efforts in the open grassland areas (mainly MU 5, MU 4 and MU 3) have been generally successful. Periodic weed control is still necessary.

Batger Quarry

MU 9 is now fairly well revegetated. The southernmost section of MU 9, between MU 6 and MU 8 ("Townsend's Bush"), is the most diverse, moist, and shady. It is also the most readily and regularly irrigated.

The section of MU 9, adjacent to MU 7, is steep, unstable, and suffers from weed invasion principally from MU 7. There are some rather unhealthy large pohutukawa, (which look to be hybrids (or subspecies) not natural to this area) that pose a potential risk to property owners below the slope. This hazard might need an opinion from an arborist. Shrubby pioneer species like *Coprosma robusta* are not doing well particularly under drought conditions and are very leggy and spindly.

The northern end of MU 9 (closest to MU 10) is shady in parts. Predictably the base of the slope is damper. Conditions here are more similar to the Batger Road end, although the northern part is not as well buffered by native bush.

MU 10 is receiving some fairly labour-intensive attention above the path near the "Hall Park" entrance. The planted area contains a diverse array of mainly groundcover and herb layer plants. There is more work that could happen further up the slope in MU 10 as time and resources allow.

MU 11 has some healthy natural regeneration of karamu. Weed control has been carried out in times past and recently tree privet has been coppiced to encourage native regeneration and to prevent privet seeding. The cut material is best stacked carefully to make this area accessible for weed control and planting. This management unit has a huge infestation of honeysuckle that is at present performing a function in providing ground cover on unstable banks.

3. DESIRABLE ECOLOGICAL OUTCOMES FOR THE MANAGEMENT UNITS

- To promote the restoration of indigenous flora and fauna, the reestablishment of the pre-human ecosystem type and natural scoria cone vegetation in the units beyond the quarry.

- To promote the re-vegetation of Batger Quarry; and promote the establishment of indigenous flora and fauna according to the pre-human ecosystem type as far is possible. The use of some un problematic native plants for functional purposes – for ground cover, land stability or native fauna habitat (eg *Phormium cookianum* or rengarenga) may be appropriate as part of this rehabilitation process.

- To control and where practicable eradicate exotic plant pests

- To control exotic animals to levels which allow protection and restoration of native plants, animals, and habitats
- To preserve and where practicable enhance the natural landscape values

4. ECOLOGICAL FRAMEWORK FOR BATGER QUARRY AND ADJOINING AREAS.

Key Elements

An ecological restoration programme for Batger Quarry and the adjoining scoria cone areas should include and address the following elements:

- Increase in native plant abundance, diversity, and indigenous vegetation cover (low scrub through to climax forest) in Batger Quarry (MU 9, 10, 11) and in the grassland in MU 5, 4, 3; using species thought to occur naturally on Auckland scoria cones and naturally believed to be part of the prehuman ecosystem type for this site.

- Use of plants ecosourced from the Tamaki Ecological District and local to Maungawhau where possible.

- Encouragement of natural regeneration of indigenous scoria cone species

- Protection and enhancement of indigenous vertebrate and invertebrate fauna

- Sustained control (or local eradication) of pest plant species

- Sustained control (or local eradication) of pest animal species

- Creation of regular monitoring and assessment programmes

- Creation and maintenance of infrastructure for ongoing ecological restoration

Overview

This plan aims to provide guidance to further enhance the work that FoM have undertaken at Batger Quarry in MU 9, 10, 11, and in the grassland on the southern slope of Maungawhau below the summit road in MU 3, 4, and 5.

Within individual management units there are differences in terms of weed competition, topography, light, substrate composition, moisture, disturbance, and exposure to wind. This affects the choice of plants as well as management. The desire to retain view shafts and concerns about the stability of slopes (and the possible effects of, for example, tree fall or slope failures on properties below or on people using the tracks) influences planting plans.

Much of the work in Batger Quarry requires a high level of skill and knowledge and physical agility. It is not a suitable site for untrained volunteers or for large groups of volunteers as the surface is easily disturbed. Manual clearing around saplings in the grassland areas (in the MUs specified above) is more appropriate work for teams of less skilled but agile people.

Weed control and revegetation work is also required in MU 1 and 2, and in Batger Quarry in MU 7 and the upper parts of MU 11, beneath the summit road. This work would be best contracted out to professionals, given the current limitations in terms of FoM resources and given that MU 7 and upper MU 11 are extremely steep and unstable. MU 7 requires professional stabilisation of the surface and engineering expertise. It is my opinion that MU 7 should not be planted until there is a proper plan in place to stabilise this unit. Any planting plan must be produced in consultation with Auckland Council. A plan for this area may be best left to plant ecologists, geotechnical engineers and landscape architects specialising in this field of landscape remediation work. It is important to note that natural populations of *Pellaea falcata* have been found in MU 7 and on a "cliff" accessible from the main track through Batger along with *Asplenium flabellifolium.* These populations and areas close to the track could potentially be managed by knowledgeable FoM volunteers.

A self-sustaining indigenous ecosystem is not possible to achieve in an urban area subject to all manner of pressures; however, a huge improvement can be made and those working towards this goal deserve support. Realistically all urban sites require some level of ongoing management. The re-vegetation project at "Tower Hill Reserve" in Victoria, Australia provides an encouraging model of what can be achieved. This project began in the late 1950s and has been a great success.

Key Ecological Rehabilitation Objectives

4.1. Indigenous re-vegetation and conservation

Please refer to Appendix E for details on existing species (native and weed plants) for Batger Quarry units – MU 9, MU 10 and MU 11. A plant list of suitable native species for planting in the quarry or other management units can be found in Appendix F.

Grassland:

It is feasible to implement the planting of further suitable scoria cone plant species to augment existing plantings in MU 3, 4, 5; this must be done at a rate that FoM can manage, both in terms of time and cost, bearing in mind the additional maintenance required with new plants, safety issues with regard to large trees above and near tracks, and view shaft and boundary considerations.

Once the canopy is more established, suitable understorey species can be planted; and, in the longer term, when weed-free gaps on the forest floor exist, extra numbers of groundcover plants could be introduced (e.g. scoria cone ferns like *Doodia australis*) along with native climbers in areas of light shade (eg *Muehlenbeckia complexa*). Scoria cone plants that are uncommon or rare could be trialled.

The banks beside tracks are particularly interesting and challenging to plant. They are mini scoria "cliffs" and they should be treated as such in terms of the choice of species. Plants such as *Muehlenbeckia complexa*, *Doodia australis, Pellaea falcata* or *Pteris tremula* may be useful. It may be good to undertake limited areas of site preparation followed by dense planting with suitable highly drought-resistant, light-loving groundcover or scrambling scoria cone plants, tackled in a patchwork fashion that is both manageable in terms of weed control and also avoids the danger of bank collapse and erosion. Forest edge areas like this will provide good habitat for native skinks.

Whau grows very well at this site. It has cultural significance, having been useful to Maori, and is fast growing and short lived. It is an excellent plant to provide temporary shade, to species that require this, in open but sheltered sites closer to the base of the mountain.

<u>Batger Quarry:</u>

There is a need for a more pragmatic and fine-grained approach to re-vegetation in this area:

MU 9

- Where there is reasonable canopy cover, there is a need to establish suitable functional groundcover to protect the quarry surface and stabilise this. This will create habitat for native invertebrates and lizards (ornate and copper skinks for example) and help retain soil moisture and prevent loss of surficial organic material. Native plants like rengarenga and *Dianella nigra* may prove useful, as practical rehabilitation species, even though rengarenga may not be found naturally as part of scoria cone vegetation. Other fairly robust groundcover species found on scoria cone substrate eg *Pellaea falcata and Muehlenbeckia complexa* may be useful in areas of light shade.
- In very steep and more exposed parts of MU 9 (e.g. the north-west facing sections) it may be better to remove or coppice species like karamu, to maintain a low growth and cover, and to retain view shafts in some cases. It makes sense to manage these sub-units as a plagioclimax scoria cone vegetation community in the interests of safety and for other aforementioned reasons (spindly growth habit leading to huge canopy gaps etc.). Low-growing, drought resistant, "cliff" plants such as *Phormium cookianum subsp. hookeri* , *Astelia banksii* and *Muehlenbeckia complexa* may be more suitable.
- Small delicate species are best introduced when weeds are really well under control. MU 9 could be a very good site to promote small rare or uncommon or relict or rare scoria cone species that may be suited to conditions in this unit (eg *Pellaea falcata* and *Anogramma leptophylla*.)

MU 10 and MU 11

- Phased removal of current groundcover weeds like jasmine and honeysuckle is recommended so the slopes are not destabilised. There is a need to establish a groundcover or field layer canopy of low-growing species, where a tall canopy is undesirable, for example in lower MU 11 (in the area of the pine stumps) and in upper MU 10. *Muehlenbeckia australis* may be useful as a replacement species for jasmine and honeysuckle in some very steep sections. In less unstable areas *Muehlenbeckia complexa* could be planted alongside low growing but robust species like *Astelia banksii* and *Phormium cookianum* and low drought resistant shrubs.

Other general restoration considerations:

Natural regeneration of indigenous scoria cone species, both in the grassland and at Batger Quarry, should be encouraged wherever possible; however, consideration may have to be given to large species which could block view shafts or present H&S risks.

Native seedlings (or saplings) of canopy species that could become very abundant, because of earlier anthropogenic interference, should be judiciously thinned where expedient to do so. Totara, for example, having been once planted extensively, is perhaps unnaturally dominant on Maungawhau; aided in times past by its natural resistance to stock grazing. Dense existing stands of mature totara on the maunga, appear to lack understorey and groundcover diversity at present (aside from exotics!) and invite surface erosion. Continued expansion of totara dominated forest, deserves some early consideration regarding the management of natural regeneration.

Any species, that might be considered ecologically “unhelpful”, whether native or not, or potentially a H&S hazard (now or in the future) may need to be controlled. It is recommended that managing regeneration, as part of a weed control programme, rather than thinning existing mature native trees, may be a better way forward. Clearly not all totara regeneration is unwanted but it may be wise to consider removing an agreed percentage of seedlings and reviewing this practice annually.

In terms of planting technique, planting the plants as deeply as possible is advised. Normally potted plants are planted with the top of the potting mix (in the pot) roughly level with the soil level at the site. In the case of planting at Maungawhau it would be advisable to sink the new plants below the soil surface by at least an inch.

Fine mulch, mixed with volcanic soil, would certainly be useful at Batger Quarry. In unstable areas, the use of coconut fibre or similar matting (secured) would be helpful. Adding slow release pellet fertiliser at the base of the planting hole may also

give the young plants an advantage over competing weeds, particularly in the quarry where nutrient retention is difficult.

4.2. Control and monitoring of pest animals

Possums, rats, mice, cats, potentially mustelids (e.g. stoats), and hedgehogs present a threat to native fauna and flora at this site (refer to Appendix H for details of pest control and initial monitoring studies). Rats, cats, mustelids and hedgehogs threaten skinks, native invertebrates and birds. Possum damage to native flora is well documented. Mice threaten invertebrates and interfere with plant regeneration. Rats commonly damage and consume plant seeds. Interestingly the latter have also been shown to have a positive role in the pollination of certain tree species (e.g. pohutukawa), replacing birds and bats lost from an ecosystem (David Pattimore *pers comm.* 2012) - particularly in places like the Auckland Isthmus where many native pollinators have disappeared.

The long-term effect of impaired pollination and seed recruitment on natural vegetation communities and healthy ecosystem process is of concern. For an ecosystem to be viable over time these natural processes, often animal assisted, do need to occur. Animal pest control which aims to enhance natural ecosystem process is an essential part of an ecological rehabilitation project, as is the enhancement of native fauna to assist these processes.

Sustained control of possums, rats, mice and hedgehogs to low levels (e.g. <5% residual trap catch (RTC) or tracking tunnels) across the maunga as a whole including the FoM management units, using ground-based methods (e.g. traps and bait stations), is essential to the success of revegetation and native fauna enhancement programmes.

Rat control is likely to result in higher numbers of mice. Mice are resource-intensive to control and generally this is difficult to do effectively without predator-proof exclosures. Predator-proof fencing to protect specific “ecological sanctuary zones” may be something worth considering in the future, once native vegetation is more established, particularly if native fauna translocations and re-introductions are being considered.

4.3. Pest plant control and monitoring

Ongoing control of weed species within the FoM management sites is essential to enable natural regeneration and the establishment of indigenous vegetation in these areas. (Refer to Appendix E for further details re: weed species).

<u>Grassland (MU 3, 4, 5):</u>

Management units 3, 4, and 5 have been selected because the majority of FoM planting work in the grassland has been carried out in these units. They are also closest to the quarry.

Pest plant monitoring is recommended for these units:

- Six monthly inspections of the grassland (spring – September/October, and autumn – March/April) for woody and herbaceous pest plants (e.g. tree privet, Chinese privet, Montpellier broom, boneseed, wattle, mist flower, gorse, Mexican daisy etc) and other unwanted seedlings (e.g. oak, excessive totara) and including climbers (e.g. honeysuckle).
- Inspections under canopy areas for shade tolerant weeds such as *Tradescantia,* veldt grass, *Carex divulsa*, and ginger in damper areas.
- Inspections of known previous weed infection sites

Weed control is generally best carried out before weeds go to seed and when plants are actively growing, normally in spring - October and November, with a follow up treatment if necessary in autumn. Setting up an online web calendar where the weed control programme can be put in place for the year (and for others to access) may be useful.

Where it is counterproductive to remove weeds, because this work cannot be followed up by planting, the seed heads of prolific seeding plants (e.g. boneseed or mist flower) should be removed to stop dispersal. This applies especially to high erosion zones (e.g. crumbling banks) which will be destabilised unless there is a proper follow up plan for planting.

A biological control agent for mist flower (e.g. mist flower gall *Procecidochares alani*) is assisting with the control of this species. There are several biological control agents that also control broom. Landcare Research will be able to provide advice and updates on the progress of the mist flower gall in reducing mist flower abundance at Maungawhau.

Generally it is best to tackle weeds one management unit at a time (site-led control). This needs to be programmed according to seeding times. Weeds like veldt grass, which produce seed over a large number of months of the year, may need specific more regular control across all the MUs if chemical weed control is being employed.

Working horizontally along contour lines, from the bottom to the top of the slope, is the safest method.

Kikuyu is troublesome to native grasses and sedges, and also to young or small plants. Mechanical cutting or hand cutting around new plants with grass hooks or Niwashi “Sharks” with groups of volunteers at two-monthly intervals during the active growing season (Oct – June) can keep it under control. The latter is a good activity for responsible but fairly unskilled help. Mulching with cut grass helps to retain soil moisture around the base of newly established plants and as this mulched material breaks down, nutrients are returned to the soil.

Planting small or slow growing native plants like *Astelia banskii* or scoria cone ferns and small plants into grassland is likely to prove labour intensive to manage, although *Doodia australis* commonly grows in rough pasture. Native scramblers (e.g. *Muehlenbeckia complexa)* are also fiddly unless weeds (including exotic grasses) are already well controlled. Good site preparation and grass mulch and staking, and dense planting of particular areas with these types of species, is recommended. A considerable border of fine mulch around the area planted in this manner is useful and this border can be patrolled for incursions. Where loose mulch isn't possible to use (e.g. on banks or areas that are prone to overland flows) use pegged sacking or coconut fibre matting.

A logical place for small groundcover plantings are on the bank areas. It would be sensible to tackle one small bank planting like this each year, alongside a less fussy planting in the open grassland, and not start another until those plants are well established and weeds are well controlled. Ideally plantings would be done in a methodical manner along a bank, a little bit each year.

In areas that already have natural bush and canopy established, *Tradescantia* is important to control to prevent inhibition of natural forest regeneration. Weed species like veldt grass and *Carex divulsa* on forest margins and in glades tend to compete with native grasses such as patiti (*Microlaena stipoides*). In terms of invertebrate and skink habitat, it is essential after weed removal to establish an alternative native groundcover that creates a similar habitat for indigenous invertebrates and vertebrates, as well as helping to prevent surface erosion and surface desiccation, loss of soil organic material etc.

<u>Batger Quarry</u>

Control of light-dependent weeds: Whau trees are very useful for rapid pioneer canopy establishment. Keeping these coppiced periodically will prevent them getting too tall and leggy. When whau become tall they often have smaller leaves, provide less shade and are more susceptible to windthrow. The same may apply to karamu which may benefit from periodic hard pruning and being planted less densely. Karamu provide less shade when they are tall and thin and can become unstable on steep banks when leggy. Rotating the pruning and coppicing would be useful, so that heights of plants are staggered. This ensures a percentage of the canopy is retained, the plants have more space, there is diversity of structure, and it spreads the work load and the amount of cut wood produced each year. From an aesthetic point of view this may also be an advantage.

With regard to *Tradescantia* control in Batger Quarry, this is best controlled from the bottom of the slope to the top, if it is an *uninterrupted infestation*. If it is an *interrupted infestation* (i.e. with several different (separate) areas of infestation occurring down a slope) it is best to start at the lowest point of the uppermost infestation and work carefully upwards to clear this entire infestation, gradually clearing each infestation progressively down the slope. There is little point in

clearing an infestation low down on a slope when there is another above it. Because of slope instability, it is important to remove all pieces of *Tradescantia* in any given infestation working upwards, so that broken pieces don't move down the slope and get buried by shifting scoria from above. Spraying might also be a useful method with a non-residual spray (e.g. glyphosate) as this will be less disruptive where the area can be reached relatively easily. If native seedlings and plants are present in an infestation then an integrated approach, with some hand pulling, may be a better option.

There are constraints in place regarding the spraying of chemicals in reserves and it would be advisable to check the regulations with Auckland Council.

It makes sense to break the planted areas within MU 9 into smaller sections and programme weed control for each consecutive sub-section. I would suggest 5 – 6 sub-sections are created and that one section is weeded each week, working in a 5 or 6 week rotation; so each part will be weeded every 6 weeks particularly during spring-autumn. Any coppicing or pruning work can also be done in the appropriate sub-section as required. Numbered pegs could be used to delineate the sections. The same advice would apply to the lower half of MU 10 which could be managed as an additional sub-unit that requires once-monthly micro-weeding.

The top area of MU 10 and the whole of MU 11 need to be treated differently. The work in these areas can be more "broad-brush". It will be a matter of managing weeds around fairly robust species which will be added slowly over time, as recommended under the revegetation section for Batger Quarry (page 7) Honeysuckle, jasmine and periwinkle would be best sprayed out in a patch-work fashion over several years, with each patch being revegetated and established before further areas are tackled, starting at the top of the slope and working downhill. This work would be best left until other areas in MU 9 and MU 10 are well under control.

4.4. Ecological outcome monitoring

Additional monitoring can be potentially carried out in the FoM management units. This may be more appropriate once vegetation is more established and weeds are reasonably under control. Techniques are as follows:

- Five-minute bird counts
- Permanent plot vegetation monitoring
- Seedling Ratio Index (SRI) monitoring to provide information on the understorey response to browser control and as an indication whether control effort needs to be altered
- Foliar Browse Index (FBI) monitoring to provide information on canopy vegetation (response to possum control)

- "Weta condos" and pitfall traps installed to monitor the response of invertebrate communities to pest control
- Artificial cover objects (ACOs) installed to monitor lizards, including closed foam retreats (CFRs) for geckos

4.5. Reintroductions of taxa that are likely to have been formerly present

Once effective pest management and suitable habitat is in place, species that are likely to have been present on the maunga could be considered for reintroduction. Logical choices would be invertebrate species and suitable lizard species (see lizard section Appendix G). Inventory surveys to establish the presence or absence of species would have to be done first and the normal translocation protocols would need to be followed.

4.6. Creation and maintenance of infrastructure for ongoing ecological restoration

In order to carry out effective restoration work the following resources will be required

- Annual funding for plants. A recommended figure for plants for the coming 5 years is a maximum of $3,000.00 per annum which will provide for approximately 500 plants, depending on size. Clearly if FoM feel they cannot manage plantings of this number the plant orders and funding requests can be down-scaled to match human resources.
- Funding to cover mulch, volcanic soil (Batger Quarry), or coconut fibre matting and pegs. This would be matched to the quantity of plants to be planted each year.
- Possible funding to pay for professional weed control contracting work
- Stakes and ribbon which Council may be able to supply
- Replacement tools as necessary
- Support with chemicals as is appropriate under the Auckland Council volunteer guidelines
- Support and biodiversity expertise and guidance from Auckland Council or others (e.g. Landcare Research or DOC) in helping to guide native animal monitoring programmes and animal pest control work.
- Continued access to a water supply
- Access to the nursery facilities at Mt Eden if this is required.
- Adequate track maintenance in Batger Quarry.

5. GLOSSARY

- *Foliar Browse Index (FBI)* The foliar browse index method (Payton et al. 1999) is a nationally consistent method that was developed to measure the impacts of possum browsing on natural area "health" by monitoring trends in canopy and sub-canopy tree condition. The FBI method uses observers to subjectively measure canopy cover, possum browse, stem use by possum, canopy dieback, recovery and fruiting and flowering levels of individual trees of palatable species. This is useful as an indicator of trends in tree canopy condition, but it does not provide answers to longer-term questions such as recruitment rates of palatable species.

- *Plagioclimax (community)* is a vegetation community which is kept at a particular stage of development by human intervention

- *Residual Trap Catch (RTC)* The residual trap-catch (RTC) index is a simple method of determining relative possum abundance. The protocol requires that lines of 10 leg-hold traps, with the traps spaced 20 metres apart, are set for three consecutive fine nights and are randomly located within the treatment area. Lines are in different locations, before and after control. The number of lines to be used is determined by the size of the management area.

  The standard performance target commonly set for a reduction in possum densities, is a residual trap catch of < 5% (i.e. less than 5 possums caught for every 100 trap-nights).

- *Seral (community)* is a stage in ecological succession in a vegetation community advancing towards its climax state.

- *Soft engineering* is the use of ecological principles by engineers often using vegetation to stabilise sites and to prevent erosion where this is a feasible alternative to hard engineering. The use of plants is visually less severe and can save money. It is not always appropriate however.

6. SUMMARY OF SUGGESTED TIMELINE AND PRIORITIES

The following are recommended as the main priorities in terms of FoM management:

Weed control

1. Protect existing plantings or indigenous vegetation in FoM primary units (MU 9 and 10, and MU 3, 4, and 5).
2. Advocate for professional input to the neighbouring units (MU 1 and 2, MU 7 and MU 11). In time the lower part of MU 11 could perhaps be managed by FoM.

In terms of which weeds to prioritise in general:

1. ***Site-led approach*:** prioritise species that have a large impact on indigenous biodiversity and goals of each MU by dominating native vegetation at various structural levels:
   a. Kikuyu and exotic climbers (e.g. convolvulus, jasmine, periwinkle or honeysuckle) are particularly aggressive and threatening to scrubby vegetation below 1.5 m in open conditions [Refer to Area's 10 and 11, Appendix C and D.]
   b. Tuber ladder fern, montbretia, *Carex divulsa, Veldt grass* and plants like agapanthus will dominate the more delicate native species like small ferns and smaller native carex or grass species in the absence of aggressive grasses like kikuyu
   c. Tradescantia will dominate groundcover in shade and will inhibit forest regeneration. Veldt grass will compete with patiti and *Oplismenus* in forest glades, scrub areas, and forest margins. [Refer to Area 4, Appendix C and D re tradescantia infestation.]
   d. Taller species like ginger, bamboo, woolly nightshade, Montpellier broom, gorse and Chinese privet are capable of dominating understorey particularly where canopy is a bit thin [Refer to Area 4, Appendix C and D re: ginger infestation.]
   e. Exotic trees like tree privet, wattle, pine that do well on dry land are capable of dominating the canopy or sub canopy – long-living trees are of particular concern

   Priorities for control in any given area depend on the end goal of revegetation (i.e. type of vegetation community that FoM are aiming to establish in the long-term).

2. ***Weed-led approach***: prioritise species that are listed as total control, containment or surveillance plants by Auckland Council (under the Auckland Regional Pest Strategy (RPMS) 2007-2012) should be targeted in that order of priority.

   [For further information about these two different approaches refer to http://www.doc.govt.nz/documents/science-and-technical/sops/weeds/sop-weed-planner.pdf.]

Native plant revegetation:

Planting sub-zones need to be identified for particular types of scoria cone vegetation. It is suggested that the aim should be to attain a *mosaic* of different scoria cone vegetation communities, rather than a uniform type – both in the quarry and in the grassland units. Creating a mosaic will have benefits in terms of structural diversity, vegetation diversity, and animal habitat diversity, as well as being useful from a practical point of view with respect to view shafts, public safety, and in consideration of neighbours. In large part the site conditions will influence choices in terms of vegetation community types.

Batger Quarry

1. *In less steep and shady areas*: Focus on establishing good robust, dense, shade-tolerant groundcover in areas that have a satisfactory canopy – particularly plants that will benefit native invertebrates and lizards, will generate organic matter and will help to retain soil moisture.
2. *In steep, unstable, very dry areas or spots where retaining a view is desirable*: Focus on establishing a robust low scrub to provide a low canopy in areas where establishing a taller canopy is problematic and potentially unwise due to extreme slopes and dry and unstable and exposed aspects, particularly in areas below pathways, or above private property, or where view shafts may need to be retained. Plants that will benefit native animal species – birds, lizards and invertebrates would be particularly useful. [Refer to Area 9 - Appendix C and D.]

Grassland Units

3. *Scoria cone forest*: Focus on infill planting the areas that are being prioritised for scoria-cone forest regeneration and aim to establish robust scoria cone scrub or forest canopy to shade out exotic grasses and other light-dependent weeds in MU 3, 4, and 5.
4. *Forest margins and views:* Focus on edge areas (e.g. banks, private property boundaries) or view shafts) and develop lower scoria cone vegetation cover for these zones within MU 3, 4 and 5. [Area 3 – Appendix C and D – applies to any open steep bank cutting above a track in MU 3 and in places in MU 5 also]

A four year weed control/planting plan (500 plants to be planted/year) is tabled as follows:

Year	MU	Priority	Sub-Unit Tasks
2013	MU 9	1	• Divide MU 9 into 6 vertical sections from top to the bottom of the unit and mark with pegs.
		2	• Weed control and coppicing work in each section every 6 weeks (less frequently in winter) targeting weeds that threaten the plantings or are problematic under the RPMS 2012.
		3	• Plant groundcover species starting this **winter** with the steepest sub-unit with the least effective canopy (refer to Area 9, Appendix C).
	MU 10	1	• Continue weed control of existing planted area targeting weeds that threaten the plantings or are problematic under the RPMS 2012
		2	• If there is time available, tackle the tradescantia (from the bottom upwards) working horizontally to prevent this growing towards the planted area below. Aim to reduce the area of infestation. Follow up.

	MU 5	1 2	• Maintain the 2012 planting in terms of weed control • Periodic control of target species e.g. honeysuckle, Montpellier broom etc
	MU 4	1 2	• Treat ginger infestation including on private land adjoining MU 4 • Periodic control of other target grassland weeds
	MU 3	2	• Periodic control of target grassland weeds

Year	MU	Priority	Sub-Unit Tasks
2014	MU 9	1 2	• Weed control and coppicing work in each section every 6 weeks (less frequently in winter) targeting weeds that threaten the plantings or are problematic under the RPMS 2012 • Plant groundcover species in **winter** continuing in the steepest unit with the least effective canopy (Area 9, Appendix C). Target other steep, dry, unstable, open areas next.
	MU 10	1 2	• Continue weed control of existing planted area targeting weeds that threaten the plantings or are problematic under the RPMS 2012 • If there is time available, finish removing tradescantia and follow up. Consider planting into this area in **winter** if tradescantia has been eradicated.
	MU 5	1 2	• Maintain 2012 planting in terms of weed control as required • Periodic control of target species e.g. honeysuckle, Montpellier broom etc to continue
	MU 4	1 2 2	• Follow up on ginger infestation including on private land. • Treat tradescantia infestation chemically. Plant this area sparsely with pioneer understorey or low scrub species as appropriate in winter. • Periodic control of other target grassland weeds
	MU 3	2	• Periodic control of target grassland weeds

Year	MU	Priority	Sub-Unit Task
2015	MU 9	1 2	• Weed control and coppicing work in each section every 6 weeks (less frequently in winter) targeting weeds that threaten the plantings or are problematic under the RPMS 2012 • Plant groundcover species in **winter**. Target any remaining steep, dry, unstable, open areas and then begin infill planting in consecutive subsections, beginning at the Batger Rd end.
	MU 10	1 2	• Continue weed control of existing planted area targeting weeds that threaten the plantings or are problematic under the RPMS 2012 • Consider carrying out patchwork weed control in upper MU 10 and planting in **winter** some low canopy shrub species eg mingimingi or robust monocots e.g. *Phormium cookianum*
	MU 5	1 2	• Maintain 2012 planting in terms of weed control as required • Periodic control of target species e.g. honeysuckle, Montpellier broom etc to continue.

		2	• Target tradescantia on bank above the track – weed control
	MU 4	1 1 2	• Plant suitable native replacement for ginger if this appears to have been eradicated e.g. *Phormium cookianum* if not too shady otherwise consider a largish fern like *Asplenium oblongifolium,* or king fern if this area is habitually damp. • Follow up tradescantia infestation chemically and maintain plantings. Planting to infill with pioneer understorey or low scrub species as appropriate. • Periodic control of other target grassland weeds
	MU 3	2	• Periodic control of target grassland weeds

Year	MU	Priority	Sub-Unit Tasks
2016	MU 9	1 2	• Weed control and coppicing work in each section every 6 weeks (less frequently in winter) targeting weeds that threaten the plantings or are problematic under the RPMS 2012 • Plant groundcover species in **winter**, infill planting in the next consecutive subsections.
	MU 10	1 2	• Continue weed control of existing planted area targeting weeds that threaten the plantings or are problematic under the RPMS 2012 • Consider carrying out further patchwork weed control in upper MU 10 and planting in **winter** more low canopy shrub species eg mingimingi or robust monocots e.g. *Phormium cookianum*
	MU 5	1 1	• Periodic control of target species e.g. honeysuckle, Montpellier broom etc to continue. • Follow up tradescantia on bank above the track. Plant bank in **winter**.
	MU 4	1 1	• Follow up weed control around planting into ginger area. • Follow up tradescantia infestation chemically and maintain plantings. Planting to infill with pioneer understorey or low scrub species as appropriate. • Periodic control of other target grassland weeds
	MU 3	2	• Periodic control of target grassland weeds

- Set up permanent photopoints in all active units in 2013, so that revegetation progress can be recorded.
- Consider getting guidance to set up bird, skink and weta monitoring programmes; and consider carrying out more extensive monitoring of animal pests, so that FoM have a comprehensive baseline against which they can measure future results.
- Consider setting up trial vegetation study plots in Batger Quarry
- Seek guidance from Council ecologists and the biodiversity team
- Review progress each year. Continue improving groundcover in the Batger Quarry units (MU 9 and 10) and managing weeds. The area closest to the track in MU 11 could be tackled in 2017 if satisfactory progress has been made in MU 9 and 10.
- Further infill planting or edge planting as required in MU 3, 4, and 5 focusing on planting MU 5 and 4 first. Continue pasture and shade weed control in these units

7. REFERENCES

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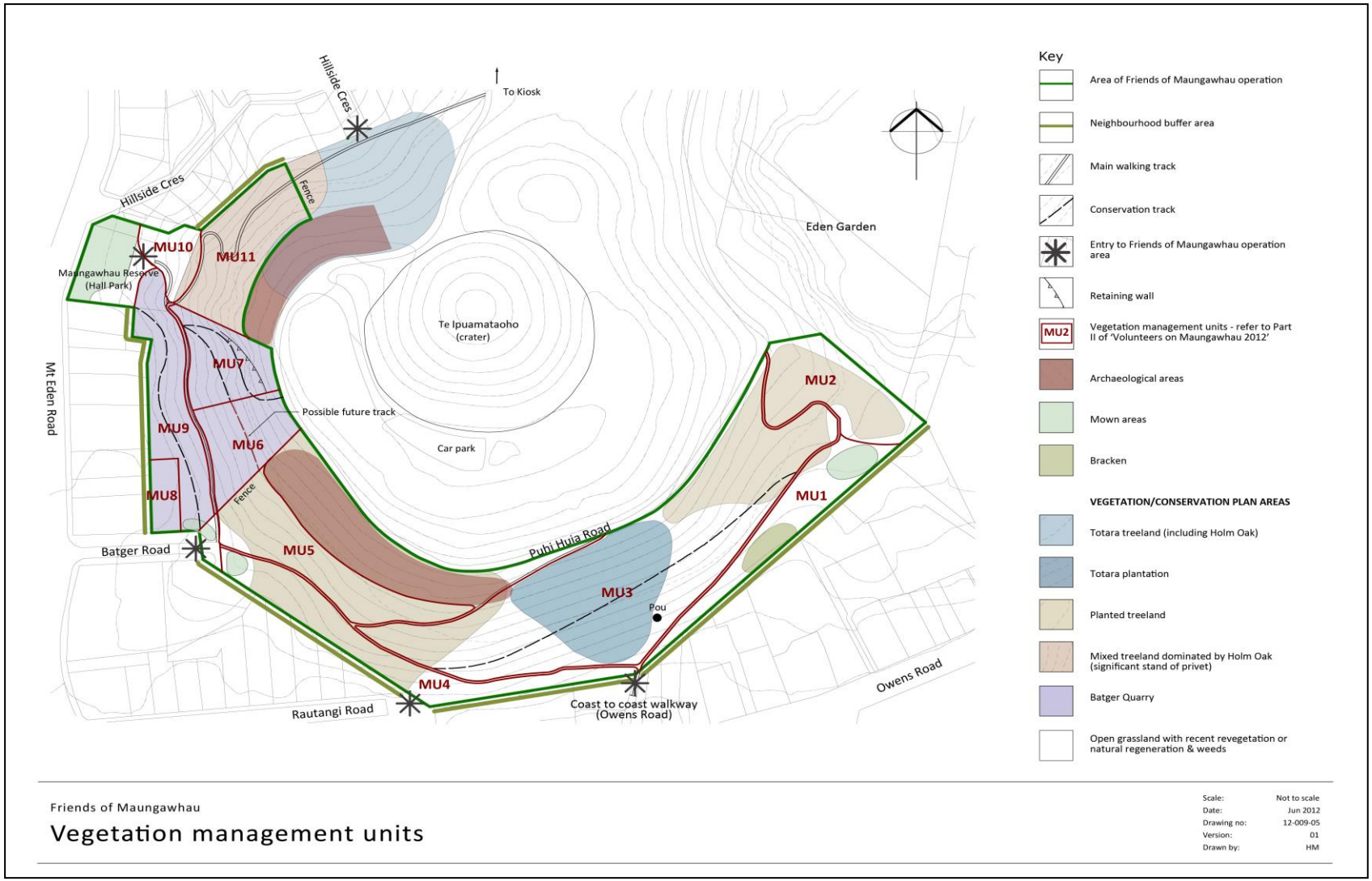
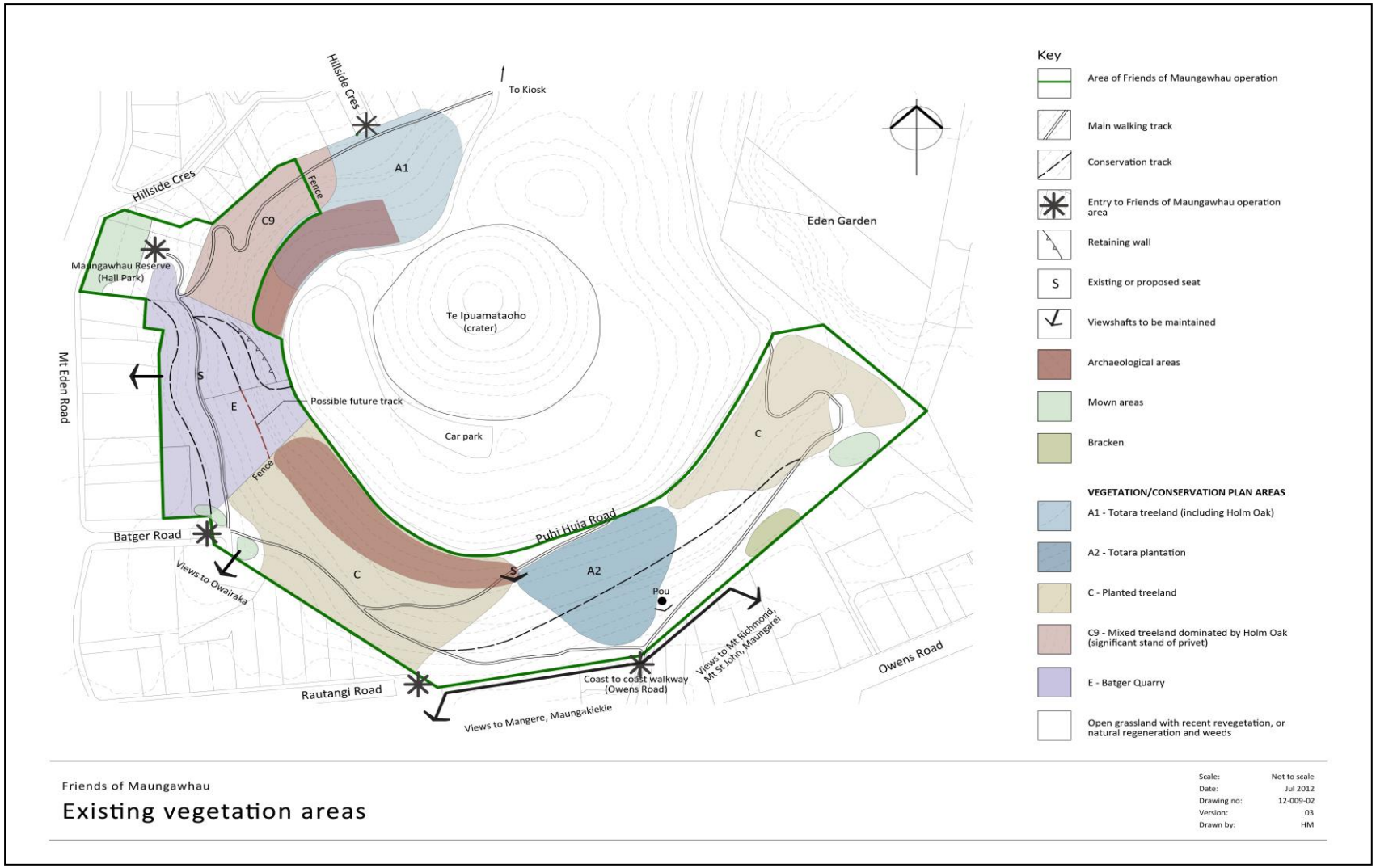
7. APPENDICES

Appendix A: Map of FoM Vegetation Management Units



APPENDIX B: Map of Existing Vegetation Areas



APPENDIX C: GIS Map of Vegetation Areas of Note (MU 3 -11).

(Source of original GIS base-map: Auckland Council)

APPENDIX D: Photographs of Vegetation Areas of Note (MU 3-11)

MU 3 (marked as **3** on GIS map**):** *Top photo* shows the banks formed by track formation. These areas could be used for planting of groundcover species eg ferns (*Doodia australis* or *Pteris tremula*) and species like *Muehlenbeckia complexa*. This could be good lizard habitat.

Species like *Phormium cookianum* might be useful along the top of the uppermost bank as a buffer to the scoria cone forest vegetation.

MU 4 (marked as **4** on the GIS map): *Bottom photo* – ginger and *Tradescantia* infestation at the slope bottom, close to Batger Road running into private property. This area needs to be treated and prioritised, including the bank above the track which is also infested with *Tradescantia*. Once weed are eradicated this area would be good to re-vegetate.

MU 9 (marked as **9** on GIS map): *Top photo:* Spindly karamu with little understorey on steep bank above housing, facing NW. This is an example of where low field-layer or ground-layer canopy species may be more appropriate and thinning out of karamu, or coppicing might be advisable.

Bottom photo: An example of a low field-layer canopy planting, with coppiced whau, karamu, and *Phormium cookianum.* More infill could be done in this area. *Muehlenbeckia complexa* may be useful here also. This would be good habitat for copper skinks.

MU 10 (marked as 10 on the GIS map): Top photo – shows the highest point of MU 10 below the track, which is open and covered by honeysuckle, with jasmine further towards the eastern end. In the interests of keeping a view, low vegetation might be appropriate – *Phormium cookianum, Astelia banskii* and *Muehlenbeckia complexa* may be useful, with other drought tolerant, low growing shrubs like *Coprosma rhamnoides* or *Leucopogon fasciculatus.*

MU 11 (marked as 11 on the GIS map) Bottom photo – shows the open weed infested bank in the open area created by the cutting of pines. Jasmine and honeysuckle are the predominant groundcover weeds, holding together a fairly unstable bank above the track. Phased chemical treatment of the weeds in a patchwork fashion, followed by planting is recommended, as for the upper part of MU 10. Similar plants are suggested, but further away from the path some larger species such as kanuka, pohutukawa, and whau might be suitable. Work on weeds higher up in the unit needs to be undertaken by professionals.

APPENDIX E: Species lists of existing vegetation in Batger Q (MU 9-11)

MU 9		
NATIVE SPECIES - botanical	**NATIVE SPECIES Maori/common**	**WEED SPECIES - botanical/common**
Adiantum hispidulum	rosy maidenhair	*Carex divulsa*
Alectryon excelsus	titoki	cherry
Asplenium bulbiferum	hen and chicken fern	climbing dock
Asplenium oblongifolium	huruhuru, shining spleenwort	convolvulus
Astelia banskii	wharawhara	cymbalaria
Brachyglottis repanda	rangiora	dock
Coprosma macrocarpa subsp. minor	karamu	ivy
Coprosma robusta	karamu	honeysuckle
Cordyline australis	ti kouka	privet (reported but not seen)
Corynocarpus laevigatus	karaka	mistflower
Dodonaea viscosa	akeake	tradescantia
Doodia australis	pukupuku	veldt grass
Dysoxylum spectabile	kohekohe	wattle (reported but not seen)
Entelea arborescens	whau	
Geniostoma rupestre	hangehange	
Griselinia lucida	puka	
Haloragis erecta	toatoa	
Hoheria populnea	houhere, lacebark	
Lastreopsis microsora		
Macropiper excelsum	kawakawa	
Melicytus ramiflorus	mahoe	
Metrosideros excelsa	pohutukawa	
Microsorum pustulatum	hound's tongue fern	
Muehlenbeckia australis	pohuehue, large leaved	
Myoporum laetum	ngaio	
Pellaea falcata	sickle fern	
Pellaea rotundifolia	button fern	
Phormium cookianum	coastal flax	
Phormium tenax	harakeke	
Pittosporum crassifolium	karo	
Pittosporum tenuifolium	kohuhu	
Pneumatopteris pennigera	gully fern	
Pseudopanax arboreus	whauwhaupaku	
Pseudopanax lessonii	houpara	
Pteris tremula	shaking brake	
Rhabdothamnus solandri	taurepo	
Rhopalostylis sapida	nikau	
Solanum aviculare	poroporo	
Vitex lucens	puriri	

MU 10		
NATIVE SPECIES - botanical	**NATIVE SPECIES Maori/common**	**WEED SPECIES botanical/common**
Acaena novae-zelandiae	red bidibid	bamboo
Alectryon excelsus	titoki	*Carex divulsa*
Arthropodium cirratum	rengarenga	celtis
Asplenium bulbiferum	hen and chicken fern	cherry
Astelia banskii	wharawhara	climbing dock
Carex flagellifera		homalanthus
Centella uniflora		honeysuckle
Coprosma macrocarpa subsp. minor	karamu	jasmine
Coprosma robusta	karamu	montbretia
Cordyline australis	ti kouka	periwinkle
Corynocarpus laevigatus	karaka	tradescantia
Doodia australis	pukupuku	tree privet
Entelea arborescens	whau	veldt grass
Geranium solandri		wattle
Griselinia lucida	puka	woolly nightshade
Haloragis erecta	toatoa	
Knightia excelsa	rewarewa	
Macropiper excelsum	kawakawa	
Melicytus ramiflorus	mahoe	
Microlaena stipoides	patiti	
Metrosideros excelsa	pohutukawa	
Myrsine australis	red mapou	
Muehlenbeckia australis	pohuehue, large leaved	
Phormium tenax	harakeke	
Pittosporum crassifolium	karo	
Pittosporum eugenioides	tarata	
Podocarpus totara var totara	totara	
Pseudopanax arboreus	whauwhaupaku	
Pseudopanax lessonii	houpara	
Pteris tremula	shaking brake	
Ranunculus reflexus		
Rhopalostylis sapida	nikau	
Solanum aviculare	poroporo	
Vitex lucens	puriri	

MU 11		
NATIVE SPECIES - botanical	**NATIVE SPECIES Maori/common**	**WEED SPECIES - botanical/common**
Asplenium oblongifolium	huruhuru, shining spleenwort	agapanthus
Coprosma macrocarpa subsp. minor	karamu	boneseed
Coprosma robusta	karamu	*Carex divulsa*
Cordyline australis	ti kouka	celtis
Corynocarpus laevigatus	karaka	chinese privet
Entelea arborescens	whau	cinararia
Haloragis erecta	toatoa	cotoneaster
Leptospermum scoparium	manuka	cymbalaria
Macropiper excelsum	kawakawa	deadly nightshade
Melicytus ramiflorus	mahoe	dock
Metrosideros excelsa	pohutukawa	euonymus
Pittosporum crassifolium	karo	*Fuchsia boliviana*
Podocarpus totara var. totara	totara	honeysuckle
Pseudopanax arboreus	whauwhaupaku	ivy
Pseudopanax lessonii	houpara	jasmine
Pteris tremula	shaking brake	Mexican daisy
Pyrrohosia elaeagnifolia	leather leaf fern	mist flower
Sophora microphylla	kowhai	montbretia
Vitex lucens	puriri	montpellier broom
		phoenix
		pinus radiata (including saplings)
		tradescantia
		tuber ladder fern
		veldt grass
		wattle
		woolly nightshade
		holm oak forms a major component
		of the canopy nearer to Hillside Cres
		but is not viewed as a weed *per se*

APPENDIX F: Plant list of suggested species for different areas.

*= lava flow forest species that might form part of a scoria cone ecotone at the base of slopes where there is more moisture

**= not known to be associated with scoria cone however might have conceivably been.

Species	Common Name	Open	Shade	Dry	Damp	Form	Comment
Alectryon excelsus *	titoki	✓	✓	✓	✓	Tree	Food – w/pigeon
Beilschmiedia tarairi	taraire	✓	✓	✓	✓	Tree	Food – woodpigeon
Coprosma macrocarpa subsp. minor	large berried karamu	✓	✓	✓	✓	Small tree	Food - birds
Coprosma rhamnoides		✓	✓	✓	✓	Shrub	Habitat - lizards
Coprosma robusta	karamu	✓	✓	✓	✓	Shrub	Food - birds
Cordyline australis	ti kouka	✓		✓	✓	Small tree	Food - birds
Corokia cotoneaster	korokio	✓	✓	✓	✓	Shrub	
Corynocarpus laevigatus	karaka		✓	✓		Tree	Food - birds
Cyathea medullaris	mamaku		✓		✓	T/fern	
Cyathodes juniperina	prickly mingimingi		✓	✓		Shrub	
Dysoxylum spectabile	kohekohe	✓	✓	✓	✓	Tree	Food - birds
Entelea arborescens	whau	✓		✓		Small tree	Cultural use
Geniostoma rupestre *	hangehange		✓		✓	Shrub	
Griselinia lucida *	puka	✓	✓	✓		Tree - epiphy	
Hebe stricta var. stricta	koromiko	✓		✓	✓	Shrub	
Hedycarya arborea	porokaiwhiri		✓	✓	✓	Tree	Food - birds
Knightia excelsa	rewarewa	✓	✓	✓	✓	Tree	Food - birds
Kunzea ericoides	kanuka	✓		✓	✓	Tree	Habitat - geckos
Leptospermum scoparium	manuka	✓			✓	Small tree	Habitat - geckos
Macropiper excelsum *	kawakawa		✓		✓	Shrub	Cultural use
Melicytus ramiflorus	mahoe	✓	✓		✓	Small tree	Food - birds
Metrosideros excelsa	pohutukawa	✓		✓		Tree	Food - birds
Myrsine australis	mapou	✓	✓	✓		Small tree	Food - birds
Olearia furfuracea	akepiro	✓	✓	✓	✓	Shrub	
Phyllocladus trichomanoides	tanekaha	✓		✓	✓	Tree	
Podocarpus totara	totara	✓		✓	✓	Tree	
Pomaderris amoena	tauhinu	✓	✓	✓		Shrub	
Pseudopanax arboreus	5 finger	✓	✓	✓		Tree - s	Food - birds
Pseudopanax lessonii	houpara	✓	✓	✓		Tree - s	Food - birds
Sophora chathamica	kowhai	✓			✓	Tree	Food - birds
Vitex lucens	puriri	✓	✓		✓	Tree	Food - birds

Species	Common Name	Open	Shade	Dry	Damp	Form	Comment
Acaena sp	bidibid	✓	✓	✓		Ground-cover	
Arthropodium cirratum **	rengarenga	✓		✓		Clump-forming	Habitat and food for lizards. Cultural use.
*Asplenium oblongifolium**	huruhuru whenua		✓	✓	✓	Fern	
Astelia banskii	wharawhara	✓		✓		Epiph	Fruit - birds
Carex flagellifera		✓		✓	✓	Sedge	Habitat for skinks
Dianella nigra	turutu		✓	✓		Flax-like	Food for lizards
Doodia australis	pukupuku	✓	✓	✓		Fern	
Haloragis erecta	toatoa	✓	✓	✓	✓	Herb	Excellent early coloniser
Microlaena stipoides	patiti	✓		✓	✓	Grass	
Muehlenbeckia complexa	pohuehue	✓		✓		Climber	Skink habitat
Pellaea falcata	sickle fern	✓	✓	✓		Fern	Good groundcover - relict
*Pellaea rotundifolia **	button fern		✓	✓	✓	Fern	
*Phormium cookianum **	coastal flax	✓		✓	✓	Flax	Nectar - birds and lizards
Phormium tenax	harakeke	✓		✓	✓	Flax	Nectar - birds and lizards Cultural use
Pteridium esculentum	rarahu	✓	✓	✓	✓	Fern	Cultural use - dye
Pteris tremula	shaking brake	✓		✓	✓	Fern	Drought hardy
Solanum aviculare	poroporo	✓		✓	✓	Shrub	Good coloniser

APPENDIX G : Indigenous Fauna

Lizards:

Occasional sightings of large lizards on Maungawhau suggest the presence of moko skink (*Oligosoma moco)* and/or the ornate skink (*Cyclodina ornata*). These species have yet to be positively identified on the mountain. They were not found in a recent survey conducted by Boffa Miskell (Maungawhau-Mt Eden Lizard Study, 2008) in the upper part of Tahaki Reserve; however the authors concluded that they may be present in "very low numbers" elsewhere on the mountain. Dr Julian also considered this was possible and reported in the Conservation Plan 2005 (Appendix 4, section 7.3) that "a couple of larger skinks were seen moving with the crevices [of rocks] but could not be seen well enough for a definitive identification". She thought these may be ornate skinks - "a species that is likely to persist on the maunga," however she considered it might also be possible they were the much rarer moko skink. Maungarei-Mt Wellington is known to have ornate skinks. Moko skink has also been recorded there according to Boffa Miskell herpetology specialists.

Both of the above skink species are threatened (Hitchmough *et al.* 2007), as are Auckland green geckos (*Naultinus elegans),* and Pacific geckos (*Hoplodactylus pacificus*), according to the Maungawhau-Mt Eden Lizard Study (2008). The authors of this study considered that gecko species may be present in bush areas on the maunga. Julian (2005) suggests that "the nearby forest remnants at Government House and Almorah Rd may have provided a source for re-establishment of these [green geckos] tree dwellers on the maunga as trees became established".

Results of the 2008 survey show that "the endemic copper skink (*Cyclodina aenea*) and the introduced rainbow skink (*Lampropholis delicata)"* are present on Maungawhau – the latter being more abundant in the study area. The survey site was described as a "stronghold for copper skinks" which are, along with other native lizards, "absolutely protected" (Wildlife Act 1953). Creating and protecting habitat for these species is therefore a priority. In the Conservation Plan (2005), Dr Julian makes the following observation which points to the importance of good pest control in known skink sites:

> *The provision and maintenance of habitat is not in itself sufficient to maintain populations of native skinks. It has been found that habitat quality is not a predictor of the abundance and diversity of skinks. Similar habitats may have completely different lizard numbers with areas that have been invaded by rats, stoats or weasels sometimes being cleaned out.*

Given Julian's opinion (2005) about the threat posed to skinks by rodents and mustelids, there seems to be a clear case to conserve specific areas for lizards and to control their key predators religiously at these sites. A predator control buffer zone may also be indicated. Locating specific lizard areas away from local domestic cats is sensible.

Key findings of the 2008 Boffa Miskell Maungawhau lizard study support pest control and inform future vegetation management. Their conclusions are summarized as follows:

1. *Copper skink abundance was greatest where habitat was a combination of rocks and dense low-growing vegetation.*
2. *Management activities most likely to affect lizards on Maungawhau are increased grazing intensity (ie stocking rates) and vegetation clearance (including weed control and replacing exotic pasture with native vegetation).*
3. *The lizard habitat on Maungawhau should be restored to native vegetation known to favour lizards. A combination of meadow rice grass (Microlaena stipoides) and patches of pohuehue (Muehlenbeckia complexa) and flax (Phormium tenax) is recommended.*
4. *Replacement of exotic pasture with native vegetation should be phased to ensure that sufficient lizard habitat is continually [sic] available throughout the process.*
5. *Pest control should be implemented on Maungawhau to protect native lizard communities. In particular, rats (Rattus spp.) are known to suppress lizard populations (Towns 1994).*

Butterflies and other invertebrates (Supplied by Sel Arbuckle)

None of New Zealand's eleven endemic species of butterfly is endangered, but their numbers are decreasing.

According to Rob Jones (pers.comm.), a FOM supporter and butterfly enthusiast, a prime candidate for re-introduction to Maungawhau is kahukura or red admiral (*Bassaris gonerilla*). The Maori name can refer to a "red garment", or to a rainbow. Its decline is due, according to Gibbs (1980:115), to a parasitic wasp introduced as a biological control for the white butterfly, and to "destruction of its larval food plant close to suburban areas". The caterpillars feed on the ferocious native nettle, *Urtica ferox* which a volunteer planted at Eden Garden.

The yellow admiral (*Bassaris itea*) we share with Australia. It is ecologically separated from the red admiral by its caterpillars' preference for the introduced nettle *Urtica urens* – the dwarf nettle.

Muehlenbeckia complexa, the proposed ground cover for scarps of the earthworks, is the food plant of the common copper butterfly *Lycaena salustius.* The glade copper butterfly *Lycaena feredayi* feeds on the climber *Muehlenbeckia australis,* which could be planted here once the re-vegetation plantings are well established.

Grazing management on the maunga sought to encourage a standard ryegrass-clover sward. As long as the clovers or pasture legumes persist, the common blue butterfly *Zizinia otis* will continue to be seen as its larvae depend on these plants. Clover nectar is also taken by the admirals.

Among the new native plantings are koromiko (*Hebe* spp.) and houhere (*Hoheria* spp.), both good nectar sources. Another resource for butterflies at Maungawhau is its summit. Butterflies gravitate to high places as a likely place to encounter a potential mate (hill-topping).

A variety of moths are also seen. There are puriri, and where there are puriri there are puriri moths; along with kowhai go kowhai-defoliator moths. If traditional Maori gardening is resumed on Maungawhau, the horned awheto caterpillar (*Sphinx convolvuli*) will find its way to kumara plants.

Rehabilitation and restoration work will enhance insect populations in general. There are weta already. Planting of kanuka will encourage stick insects, planting of manuka the green manuka beetle, and so on. And all of this adds up to a richer food supply for insectivorous birds.

Birds (Supplied by Sel Arbuckle)

Probably the only full-time resident birds on Maungawhau are small birds: welcome swallow, the native songbirds - fantail and grey warbler; the silvereye or tauhou (self – introduced in 1840); and the purposely introduced passerines such as finches.

Seasonal visitors in bush areas include shining cuckoo, feeding largely on caterpillar species unpalatable to other birds; and kingfisher, feeding on lizards and insects.

Ruru (morepork) and kahu (harrier hawk) hunt here periodically, in bush and over open country respectively.

Rosellas (Australian) and occasionally kaka (endemic, threatened) are also visitors, as are tui and kereru. The two parrots eat fruit but crush and digest the seeds; the other two species are seed dispersers. Tuis disperse a wide range of smaller seeds, unfortunately including weed species like privet and laurel. They pollinate trees too; they appear in large numbers when the Taiwan cherry trees in Government House grounds flower in midwinter, and they feed on their fruit in summer.

Kereru, woodpigeon, can swallow quite large “stone” fruit such as karaka and taraire, regurgitating the seeds soon afterwards. They are even more mobile than tui. The mangeao and taraire seedlings, now appearing near the large protected puriri on the eastern slope, are brought by kereru. Other pigeon favourites are puriri and kohekohe; also tawa and tawapou. The first two would have grown on Maungawhau in pre-human times; the latter two may have as well.

Inferring a past pattern of vegetation from pollen records or from the present-day vegetation of Rangitoto and the Northland cones is not an exact process. Current natural regeneration from seeds that arrive at the mountain, mostly in birds, suggest these plant species are well suited to this environment and may have been here in pre-human times.

APPENDIX H : Pest Control

This volunteer trapping work follows on from the Maungawhau-Mt Eden Animal Pest Baseline Survey, carried out in 2010 by Te Ngahere ecologist, Samantha Happy (on behalf of Auckland City Council) to determine the need for a volunteer pest control programme on the mountain. Findings showed the relative abundance (RA) of animal pests (rodents and possums). It is not clear why mustelids were not assessed. Results indicated that "the RA of possums (6%)" demonstrated a need to control possums to bring the RA "down to the desired level of at or less than 5% (Happy, 2010). The tracking tunnels showed no rat tracking. According to Happy, however, both live and dead rats were seen in the area. Mice tracks "in 33% of tracking tunnels" indicated high abundance of these rodents. FoM report having seen both live rats and mice. Cat tracks (6%) were also found in the 2010 survey.

Research aimed at assessing the effects of pest control programmes on the maunga, and the impact of this, on native and exotic species, would be useful and is recommended. Happy (2010) suggests annual monitoring "to measure control success". David Bowden (pers. comm.) would like to see this monitoring frequency increased to three times a year and has set up monitoring lines. One runs through the top of the Friends of Maungawhau operational area, and another through the lizard area adjoining Tahaki Reserve

(Source of pest control map: Auckland Council - supplied by David Bowden)

APPENDIX I Weed Control Methods

WEED SPECIES BOTANTICAL NAME	WEED SPECIES COMMON NAME	CONTRACTOR OR *GROWSAFE* TRAINED PERSON	VOLUNTEER GROUPS	TIMING
	Thistles – various species		Grub out	Spring
Acacia longifolia	Sydney golden wattle	Drill larger trees - Met 5g/l	Pull small seedlings, cut	All year around
Acanthus mollis	acanthus, bear's breeches	FS Tri 6ml/l	Hand dig where plants are near broadleaved native seedlings	Spring/Summer
Agapanthus orientalis	agapanthus	FS Tri 6ml/l	Dig out tubers	All year
Alocasia brisbanensis	elephant's ears	CS Met 1.25g/l + Gly 100ml/l	CS Vigilant	
Anredera cordifolia	madeira vine	FS Met 0.33g/l = Gly 15ml/l	CS Vigilant, bag nuts	All year
Araujia sericifera	moth plant	FS Tri 6ml/l	CS Vigilant or dig out, bag pods	All year
Aristea ecklonii	aristea	FS Met 0.50g/l + Gly 15ml/l	Dig out before seeding	Spring
Asparagus scandens	climbing asparagus	FS Gly 15 ml/l	Cut to 4 inches before seeding, dig tubers	Spring
Carex divulsa		FS Gly 15 ml/l		All year
Carex longebrachiata	Australian carex	FS Gly 15 ml/l		All year
Cestrum nocturnum	Queen of the Night		CS Vigilant (hang up) or pull small seedlings	All year
Chrysanthemoides monilifera ssp. monilifera	boneseed	CS Met 5g/l	CS Vigilant before seeding	All year
Cortederia selloana (and jubata)	pampas grass	FS Gly 15 ml/l	Dig out small plants	Spring/summer before flowering
Crataegus monogyna	hawthorn	Drill Met 5g/l	CS Vigilant or pull small plants	Spring/summer
Crocosmia X crocosmiiflora	montbretia	FS Met 0.50g/l + Gly 15 ml/l		Spring/summer
Cyperus eragrostis	umbrella sedge	FS Gly 15 ml/l	Cut and bag heads late spring/early summer	All year
Cyperus rotundus	nut grass	FS Gly 15 ml/l		All year
Ehrharta erecta	panic veldt grass	FS Gly 15 ml/l		All year
Erigeron karvinskianus	Mexican daisy	FS Gly 15 ml/l		All year

WEED SPECIES BOTANTICAL NAME	WEED SPECIES COMMON NAME	CONTRACTOR OR *GROWSAFE* TRAINED PERSON	VOLUNTEER GROUPS	TIMING
Erythrina indica	flame tree	CS Met 5 g/l	Pull small seedlings, CS Vigilant small saplings	All year
Euonymus japonicus	spindleberry	CS Met 1.25g/l + Gly 100ml/l	CS Vigilant, hand pull small seedlings	All year
Hedera helix	*English ivy*	FS Met 0.33 g/l		All year
Hedychium gardnerianum	kahili ginger	CS Met 1.25g/l	CS Vigilant or Gly gel, cut off seedheads and bag	All year
Ipomoea indica	blue morning glory	FS Gly 15ml/l or Tri 6 ml/l	Release from natives	All year
Iris foetidissima	stinking iris	FS Met 0.33g/l = Gly 15ml/l	Dig out tubers before seeding	Spring/Summer
Jasminum polyanthum	jasmine	FS Met 0.33g/l = Gly 15ml/l	Cut and release from natives	All year
Ligustrum lucidum	tree privet	Drill Met 5 g/l	CS saplings with Vigilant, hand pull small	All year
Ligustrum sinense	Chinese privet	CS Met 1.25g/l	CS saplings with Vigilant, hand pull small	All year
Lonicera japonica	Japanese honeysuckle	FS Met 0.33g/l = Gly 15ml/l	Cut and release from natives	
Pennisetum clandestinum	kikuyu	FS Gly 15 ml/l		Spring/summer
Phoenix canarensis	*Phoenix palm*	Drill Gly 500 ml/l, FS small plants Met 0.5g/l	Pull or dig small seedlings	All year
Phytolacca octandra	inkweed		CS Vigilant or pull small	Spring/Summer
Prunus campanulata	Taiwan cherry	CS Met 1.25g/l	CS Vigilant or pull small	All year
Pteris cretica	Cretan brake	FS Gly 15ml/l		All year

WEED SPECIES BOTANTICAL NAME	WEED SPECIES COMMON NAME	CONTRACTOR OR *GROWSAFE* TRAINED PERSON	VOLUNTEER GROUPS	TIMING
Rubus fruticosus	blackberry	FS Met 0.33g/l = Gly 15ml/l	Hand pull tiny plants – bag.	Spring/Summer
Rumex sagittatus	climbing dock	FS Met 0.33g/l = Gly 15ml/l	Release from natives	Spring/Summer
Selaginella kraussiana	African clubmoss		Hand remove tiny patches + bag (rubbish)	All year
Solanum mauritianum	woolly nightshade	FS Gly 15 ml/l	CS Gly or Vigilant gel, hand pull small	All year
Syzygium smithii	monkey apple		CS saplings Gly or Vigilant gel, hand pull	All year
Tradescantia fluminensis	tradescantia	FS Tri 6ml/l	Careful hand clearing around native seedlings – bag ALL fragments.	Best in late spring early autumn when ground is damp, but not wet or very dry.
Tropaeolum majus	nasturtium	FS Gly 15 ml/l	Pull off young natives	Spring/summer
Ulex europaeus	gorse	FS small plants Tri 6 ml/l	CS Viglilant, pull small	All year
Vinca major	periwinkle	FS Met 0.33g/l = Gly 15ml/l		All year
Zantedeschia aethiopica	arum lily	FS Met 0.33g/l = Gly 15ml/l	Dig out tubers	All year

Key:

FS = Foliar Spray

CS = Cut stump

Gly: Glyphosate (360)

Met =Metsulfuron (eg. Escort)

Tri = Triclopyr (eg Grazon)