LEMP vegetation survey 2020

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on behalf of

Lansdcape and Ecology Mitigation Programme

St Helena Government

March 2021

Contents

Cover Photographs

Top left: Mature scrubwood (*Commidendrum rugosum*) in flower at Flagstaff compensatory area.
Lower: Rehabilitation plot at Colt Sheds. Two halves of the same plot in 2017 (left) and 2020 (right) with hair grass (*Eragrostis saxatilis*) in the foreground

The author would like to acknowledge the assistance given by the LEMP team leader, Shayla Ellick, in guidance on the survey methodology, answering queries that arose throughout the survey and useful comments on the report, all were much appreciated.

1 Introduction

The St Helena Airport Project's Landscape and Ecological Mitigation Programme (LEMP) was established to reinstate, or actively improve areas temporarily disturbed; and to compensate for areas permanently lost to airport construction activities following the construction of the airport on St Helena. This report is one of a series that detail the results of vegetation surveys carried out periodically under the LEMP. Their purpose is to monitor and assess survival rates and the change in vegetation cover in the restoration areas over time.

The report covers the outcome of a survey of 130 designated plots. The plots were randomly selected as representations of the larger areas of rehabilitation and compensatory works that have been carried out under the LEMP; plant numbers and coverage data in the report relate only to those elements measured within the specified plots. The survey, designated '2020-B', measured components within each plot to allow the progress of the restoration works to be assessed. Data recorded during the survey was entered into the LEMP biological monitoring database.

The outcomes of the 2020-B survey, undertaken between September 2020 and January 2021 are compared and discussed in relation to baselines established earlier in the LEMP. Whilst analysing the LEMP biological monitoring database, anomalies in a small number of the 2017-B survey records were discovered. The 2017-B survey was the first of the LEMP follow up surveys and some comparisons are made with it in this report. Thus, in the sections of the report that are affected, the anomalies are explained and the corrected figures for 2017-B are re-presented. The differences cause small changes in some figures but the trends and discussions presented in the 2017-B LEMP vegetation survey report[1] remain valid.

Current indications are that the LEMP will wind down in March 2021 and this report includes recommendations pertinent to securing the works undertaken to date and to sustaining the survival of the native plants that have been established.

2 Notes to the 2020-B survey

The methodology employed for LEMP vegetation surveying has been previously published[1]. For reference a copy is included at appendix 1. The following notes relate to this survey (2020-B).

During the surveying period a new plot, with randomly generated coordinates, was positioned in an amenity area recently created by the LEMP. A survey of the plot was carried out to measure baseline values; these have been recorded in the database under the appropriate baseline survey designation, 2020-BL-B and are not considered further in this report.

2.1 Plot location

Prior LEMP surveys installed a centre peg to pinpoint the exact location of each plot for repeat visits. The 2020-B survey made use of these pegs when they were found *in situ*. The pegs at some plots had obviously been displaced or were missing; in these cases GPS coordinates (from baseline survey records) were used to approximate a centre point. Trials, at sites with fixed pegs, indicated that location accuracy using GPS coordinates was within 2 linear metres of the original point or within an area of approximately $12m^2$.

2.2 Definitions

Unfortunately the original methodology has no definitions for the ground cover components that are measured. The following criteria were used to standardise measurements across the 2020-B survey.

Ground component	**Criteria for survey**
Vegetation	This was taken as the overall (combined) vegetation cover of species at the <0.1m height category.
Bare	This was taken as the area of exposed soils including an allowance for areas (typical in semi-desert) where rocky material and soils coexist. The allowance was assessed a quarter plot at a time and was based on a subjective assessment of the percentage of each component in the mix (e.g. 30% rock + 70% soils).
Rock	This was taken as the area of rocky material from exposed bedrock to surface gravel (~10mm diameter). As with the bare category an allowance was assessed for rocky materials coexisting with soils.
Soil crust	This was taken as an area of soils bound together by a biological component(typically lichens and/or mosses) Areas of soil which were 'crusty' by action of compression and/or drying were not included, these would be counted as bare soils.
Humus	Humus was taken to be any dead or decaying biological material which would be expected to have broken down to 'compost' within a year (for example leaf litter, dead annual weeds). It also included any indefinable organic or compost like material on the ground surface
Brash	Brash includes biological material unlikely to break down within a year and is principally composed of dead woody plant parts (for example shrub and tree branches and woody twigs)
Moss	All bryophytes directly on the soil or on rocky material <0.1m

	above ground level. Mosses growing epiphytically on plants were not included.
Lichens	All lichens directly on the soil or on rocky material <0.1m above ground level. Lichens growing epiphytically on plants were not included.

2.3 Counts of native species

In order to ascertain survival rates, all endemic, native and probably native species in a plot were counted. In plots where drip lines had been installed, each line was followed within the perimeter of the plot and the plants along it were counted. For other plots the radius marker string of the plot was pulled taut and rotated around the centre peg and plants were counted as they passed under the line.

Difficulties arose in counting some species, thatching rush (*Ficinia nodosum*) and samphire (*Sueda fruticosa*), because of their growth habits.

Thatching rush produces rhizomes from which further stems emerge. This can result in a group of individual plants merging to appear as one large clump with no visible division. Equally, a rhizome can give rise to an apparently separate plant close to the original.

Samphire has a spreading habit and adjacent plants can form dense interlocked clumps making it difficult to count individual plants. Additionally, samphire branches that make contact with the ground can layer and produce nodal roots which eventually form a separate clone.

In the 2020-B survey the following approach was taken: for thatching rush individuals were counted when a clear gap existed all the way around a group of stems. This would have more consequence on closely planted groups; numbers would appear to decline as separate plants merged; for samphire, an attempt was made to locate the central vertical stem of each individual. Where clumps were too large for this a pole was used to agitate possible individuals and observe the movement along the extent of its branches. Where branches layered below the surface an assessment was made as to whether the re-emerging end was still attached or separate. The consequence of counting samphire in this way is a potential under count in plots with large clumps of interlocked plants.

Other difficulties arose from counting seedlings when many were germinating in densely packed patches as a ‘carpet’ or ‘flush’. This arose in species such as scrubwood (*Commidenrum rugosum*) and the native grasses. Where practical, individual plants were counted; typically when overall numbers or density of individuals was low. When high densities of small plants were encountered then, an accurate count was made of three small measured areas and the average used to calculate numbers in the remaining area covered.

3 Results and discussion

In this section the results from the survey are first introduced, in form of tables and visual charts. After, there is a section for discussion of the results.

3.1 List of vascular plant species

The full list of vascular plant species recorded in the LEMP vegetation survey 2020-B can be found at appendix 2. The LEMP has considered the nativity of vascular plants on St Helena following the definitions by Lambdon[2]. From this, and for the purposes of selecting appropriate species to use for the LEMP, plants were broadly divided into two groups; native and introduced. Thus, throughout the report discussion of native species will be inclusive of endemic, native and **probably** native species while introduced species will cover the remainder including the **possibly** native species.

Native species that are 'LEMP suitable' are mainly defined by their ability to grow and survive in the conditions met across the LEMP restoration areas. A large proportion of the island's other native species including many of the ferns thrive only in the cooler, moist upland areas associated with the Peaks and were thus precluded from inclusion in the LEMP. Additional restrictions on usage are imposed by consideration of species zones that have been identified to limit hybridisation between related species; such consideration has had to be employed in the use of scrubwood and gumwood which are known to hybridise if grown in close proximity. Finally, species were excluded even if deemed 'LEMP suitable' because of conservation issues arising from the rarity of a species and the shortage or unavailability of propagation material that could be employed by the LEMP. A detailed list of the native species that were deemed suitable for use in the LEMP is at appendix 3.

Table 1: Plant species found in the survey plots grouped by their nativity.

Nativity (after Lambdon[2]**)**	**LEMP Nativity Group**	**Number of species**		**Percentage of the total**	
		2017*	**2020**	**2017***	**2020**
Endemic	Native	12	12	16%	12%
Native	Native	4	4	5%	4%
Probably native	Native	3	5	4%	5%
Possibly native	Introduced	4	5	5%	5%
Naturalised	Introduced	48	69	65%	71%
Forestry species	Introduced	1	2	1%	2%
Adventive	Introduced	2	0	3%	0%
All together		**74**	**97**	**100%**	**100%**

*2017 figures vary slightly from those previously published[1].A number of the plots surveyed in 2017 have not been further considered under LEMP and consequently have been excluded from current comparisons.

Table 2: The number of native and introduced species on the survey plots in late 2017 and late 2020. Native and introduced groups defined by the LEMP are highlighted.

Nativity	Number of species		Percentage of the total	
	2017	2020	2017	2020
Endemic	12	12	16%	12%
Endemic + Native	16	16	21%	16%
Endemic + Native + Probably native	19	21	25%	21%
Endemic + Native + Probably native + Possibly native	23	26	30%	26%
Introduced	51	71	69%	73%
Introduced + Possibly native	55	76	74%	78%

Discussion on the list of vascular plant species

Values in tables 1 & 2 above arise from 45 surveyed plots in 2017 and 130 plots in 2020.

The species list (appendix 2) shows that a quarter (25%) of the vascular plants species present in the 2017-B vegetation survey plots are considered native to St Helena. In the 2020-B survey, with nearly three times the number of plots, the native component had dropped to around a fifth (21%). Introduced species make up the remaining numbers with three quarters (74%) in 2017-B and closer to four-fifths (78%) in 2020-B. With the pool of native species being much smaller it is not surprising that their representation as an island wide proportion would drop as more plots are surveyed, taken to its conclusion with plots island-wide the figure would decline to a theoretical minimum of 14% (Table 3). Conversely, the increase in plot numbers is more likely to feature additional introduced species because of their greater number and more abundant distribution across the island.

Table 3 shows that from an island wide vascular plant flora of 512 species, only 71 (14%) fit the LEMP's native group definition. Of these no more than 42 have been deemed suitable for use in the LEMP (see appendix 3). Table 3 shows a native species representation in the LEMP of 27% and 30%, from the island's native pool, for 2017-B and 2020-B respectively. Relative to the proportion of native species (14%) within the island's total flora the LEMP outstrips the 'base rate' by 13% and 16% respectively in the plots surveyed in 2017 and 2020. From the smaller group of 'LEMP suitable' natives, between 45-50% are represented in the LEMP plot surveys.

Table 3: Comparison of the number of native and introduced species on St Helena and in the LEMP vegetation surveys 2017-B and 2020-B.

Nativity group	St Helena	LEMP sites		Percentage of island total	
		2017	2020	2017	2020
Endemic + Native + Probably native	71	19	21	27%	30%
Introduced + Possibly native	440	55	76	13%	17%
Total	512	74	97	14%	19%

In the 2017-B survey it was noted that the presence of four native species, St Helena goosefoot (*Chenopodium helenense*), candlestick amaranth (*Amaranthus thunbergii*), St Helena plantain (*Plantago robusta*) and pagoda plant (*Cotula coronopifolia*) were known to be present naturally in LEMP areas but their rarity meant that the designated plots didn't include them. With the extra scope provided by an additional 85 plots in the 2020-B survey 2020 both the St Helena goosefoot and pagoda plant have been recorded.

St Helena tea plant (*Frankenia portulacifolia*) and boxwood (*Mellissia begoniifolia*) were more widely planted in LEMP areas after the 2017-B survey. Both were observed growing in LEMP areas during the 2020-B survey but only tea plant was found and recorded within the survey plots.

Five species identified in 2017 as being difficult to grow; neglected sedge (*Bulbostylisneglecta*), French grass (*Euphorbia heleniana*), crevice fern (*Cheilanthes multifida*), lily fern(*Ophioglossum polyphyllum*) and the Barn fern (*Ceterach haughtonii*) were not recorded in the 2020-B survey. Barn fern and neglected sedge are long time natural inhabitants of rocky outcrops around the airport; some barn fern was observed in small numbers outside survey plots during 2020. Neglected sedge has been planted by the LEMP but, as a winter annual, it would be unusual to have recorded live plants during the 2020-B survey.

Three native species, Angolan bristlegrass (*Setaria welwitschii*), hogweed (*Commicarpus helenae*) and bladder ketmia (*Hibiscus trionum*) were not used in the LEMP as their status was considered somewhat uncertain. Angolan bristlegrass can be an aggressive coloniser and its omission from LEMP planting was probably sage. Of these three species only Angolan bristle grass was recorded in 2020 where its previously known range overlapped a LEMP survey plot.

In 2017 three fern species, African spleenwort (*Asplenium aethiopicum*), hen-and-chicks fern (*Asplenium lunulatum*) and sticky fern (*Hypolepis villoso-viscida*) were considered potential candidates in the intermediate LEMP sites but only when the gumwood plantings mature enough to provide suitable ecological conditions. In 2020 this remains the case.

Proliferous spike-rush (*Isolepis prolifer*), has specific habitat requirements, mainly a permanent water source, that is not a common feature in the LEMP areas. It was observed outside the survey plots in 2017. It was not recorded in 2020.

The bastard gumwood (*Commidendrum rotundifolium*), was considered too rare in both the wild and in cultivation to be included in the LEMP plantings in 2017. Following the recovery success in

cultivation of this species over the past three years, its inclusion in any further restoration work in LEMP areas should be re-appraised.

Old-father-live-forever (*Pelargonium cotyledonis*) and salt drip sedge (*Cyperus laevigatus*), were not used in LEMP plantings. The rarity of propagation material of the correct provenance unfortunately precluded the inclusion of the pelargonium which does occur naturally as a small group of plants in Lower Dry Gut. As its name suggests salt drip sedge is associated with seeps and springs of which are not common features within the LEMP areas. As with the bastard gumwood it would be worthwhile to re-appraise any potential to use old-father-live-forever in any future restoration work in the LEMP areas.

In summary the LEMP plots overall can be said to strongly represent the diversity of the island's native species. The LEMP has utilised a majority of the native species deemed suitable for the restoration areas under its remit. A small number of native species naturally occurring in the LEMP areas may have been better utilised; lessons learned from the LEMP on habitat requirements and suitability would be useful additions to the island's conservation knowledge base. Plantings in survey plots show consideration has been given to: habitat matching to the species used; the need for species diversity; planting densities suitable for the species used and the developmental stage of the site.

3.2 Number of plants

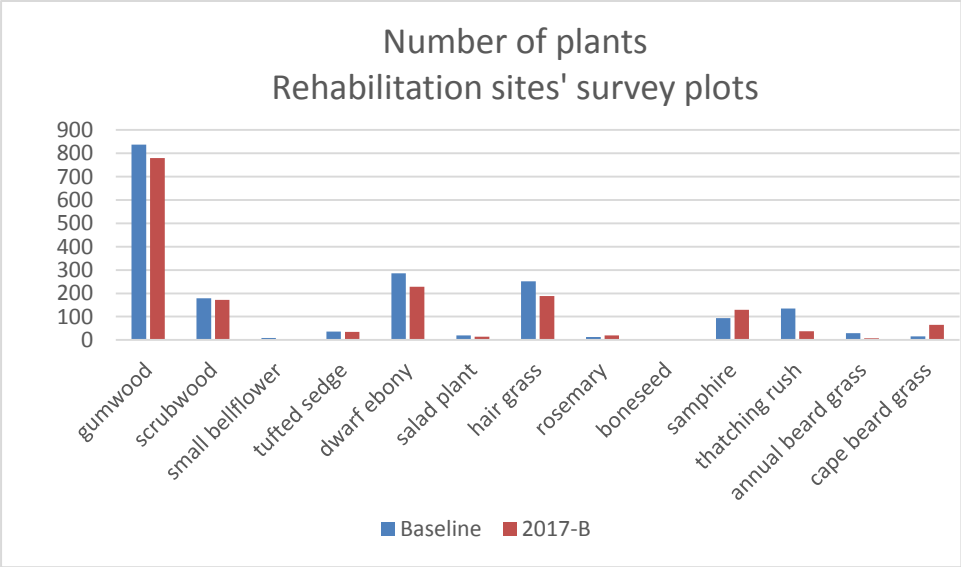
The number of native plants were counted in each survey plot and related to baseline values in order to determine survival rates. A separate count of recruits (seedlings produced by plantings) allowed a measure of natural regeneration.

Difficulties in counting certain species precisely and the methods adopted for the 2020-B survey are detailed in section 2.3. It should be recognised that for these species a higher margin of population error is to be expected.

3.2.1 Survival rate

The calculation of survival rates from the 2017-B survey was "*more complicated than originally anticipated due to the fact that replacement plantings were not taken into account in the surveys. In several places the baseline survey was not done immediately after the planting, resulting in plants that had already died before the survey and in some cases the replacement plantings took place between the baseline survey and follow up surveys*". For the 2020-B survey, baselines were taken as recorded in the LEMP database and compared directly with the 2020-B survey results. In order to standardise the process the 2017-B comparisons were re-run using the same method at which point it was noticed that a transpositional error in the original 2017-B calculations led to counts for plants of < 0.1m high being excluded from both baseline and follow up figures. Additionally some of the 2017-B plots were originally assigned dual status as rehabilitation and compensatory plots and the counts were summed in both categories. Since then all plots have been assigned a single category for comparative work. As a result, 2017-B survey values for rehabilitation baselines and corresponding follow up are now slightly reduced for hair grass (baseline -17 and follow up -20 plants), cliff hair grass (all 17 plants now excluded) and tufted sedge (baseline -14 and follow up -20 plants) from original published figures[1]. This gives a corresponding change in survival rates of 77 down to 75% for hair grass and 108% down to 96% for tufted sedge.

Figure 1a: Graph to show the number of individual plants, by species, on rehabilitation plots. Baseline surveys compared with the follow-up 2017-B survey (reworked values).

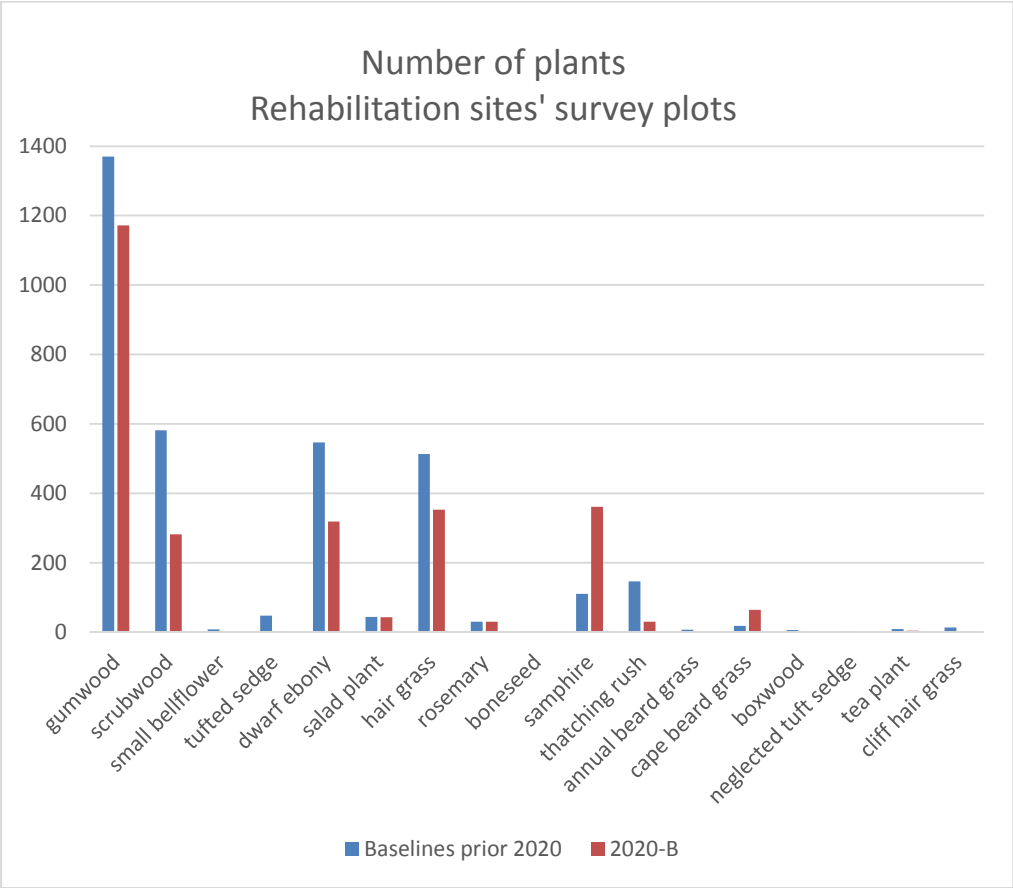


The breakdown of counts, by species, for 2020-B is given in table 4. Figure 1b below summarises the native plant counts carried out at LEMP survey plots in the 2020-B surveys. The baseline figures differ for the 2017-B survey because new areas and plantings were established during the intervening period. The 2017-B counts are based on 24 plots and the counts from 2020-B on 39 plots which equates to a total plot area of 2400m^2 and 3900m^2 respectively.

Table 4: Summarised native plant baselines compared with 2020-B survey counts across all rehabilitation plots at all height bands with survival rates as a percentage of the baseline value.

	Plant numbers			
Common Name	**Baselines prior to 2020**	**2020-B**	**Difference**	**Survival rate**
gumwood	1370	1172	-198	*86%*
scrubwood	581	262	-319	*45%*
small bellflower	8	0	-8	*0%*
tufted sedge	47	2	-45	*4%*
dwarf ebony	546	319	-227	*58%*
salad plant	35	43	8	*123%*
hair grass	513	353	-160	*69%*
rosemary	30	30	0	*100%*
boneseed	2	1	-1	*50%*
samphire	110	361	251	*328%*
thatching rush	146	30	-116	*21%*
annual beard grass	7	0	-7	*0%*
Cape beard grass	18	64	46	*356%*
boxwood	6	0	-6	*0%*
neglected tuft sedge	1	0	-1	*0%*
tea plant	9	4	-5	*44%*
cliff hair grass	13	1	-12	*8%*
All species	*3442*	*2642*	-800	77%

Figure 1b: Graph to show the number of individual plants, by species, on rehabilitation plots. Baseline surveys compared with the follow-up 2020-B survey.



Discussion of survival rates

The 2017-B survey reported survival rates of LEMP plantings at between 65 and 90% (in most cases). Intensive maintenance, drip irrigation and to a certain extent replacement plantings were deemed responsible for this level of success.

Before considering the 2020-B survival rates it should be noted that the island was subjected to a severe drought in 2018 into 2019 which from photographic evidence alone shows a devastating impact on the vigour of areas under the LEMP. The drip irrigation installed in some areas undoubtedly mitigated some of the effects but couldn't fully compensate for the extended period of severely reduced rainfall. This single extended event will have had a negative impact on each of the species considered.

The survival rates from the 2020-B survey show that the two tree species, gumwood (*Commidendrum robustum*) and rosemary (*Phylica polifolia*) have shown the best survival rates at 86-100%. For rosemary this equates, in the survey plots, to a modest 30 plants but for gumwood close to 1200 trees have survived from a baseline figure of nearly 1400. This is a commendable result and very encouraging given the large swathes of gumwood that have been planted across many of the LEMP areas.

The perennial shrubs fared less well with dwarf ebony (*Trochetiopsis ebenus*), scrubwood (*Commidendrum rugosum*) and tea plant (*Frankenia portulacifolia*) showing survival rates of 58%,

45% and 44% respectively. The drought may be largely responsible for many of the losses, certainly during the 2020-B survey the remaining dwarf ebony and scrubwoods were growing vigorously and in many cases flowering moderately. Dwarf ebony is known to be slow to respond to transplantation in dry areas, previous works at High Hill have shown a period of a year between planting and signs of new growth. Tea plant similarly suffers transplantation stresses in dry areas. In the wild it develops a wide network of very fine roots that capitalise on available moisture; these obviously aren't developed in a pot grown plant. The loss in scrubwoods may similarly be a stress factor transferring between a pot and exposed environment.

Salad plant (*Kewa acida*) is considered a short lived perennial. The surveyed population has expanded (by 8 plants) between the baseline and 2020-B counts. It was not obvious from field observations whether this was as a result of supplemental planting or the germination and maturing of recruits; the relatively short live cycle of salad plant would support the latter. At the time of survey there was evidence of recent recruitment.

Of the native grasses, hair grass (*Eragrostis saxatilis*) showed the best survival rates at 69%. This is to be expected from a species which forms new roots quickly, prefers loose soils, tolerates drought and recovers rapidly at the onset of rainfall. Cliff hair grass (*Eragrostis episcopulus*) was only planted in small numbers (13 recorded in baselines) and the majority failed to survive. It is suspected that its niche is narrower than previously considered; naturally it inhabits rocky outcrops and clifftops in dry areas that though are subject to exposure from regular wind driven mist. Both native *Polypogon spp*. grasses were recorded in small numbers in the survey plots. Annual Cape grass (*P. montspelensis*) failed to survive while the bearded Cape grass (*P. tenuis*) has increased over threefold since planting. Annual cape grass is again probably a little more niche specific than realised; naturally it is more typically found in stream bed margins, seeps and salt drips indicating the need for more moisture than found in many LEMP areas.

The near failure of tufted sedge (4% survival) is a disappointment. Once again reference to where it grows well naturally indicates dry habitats but less exposed than many of the LEMP rehabilitation plots; it is often distributed throughout open woodland such as acacia thickets.

The difficulties in accurately counting samphire and thatching rush have been described above (section 2.3) and may account for the apparent 20% survival of the latter. Anecdotally, and from photo evidence the thatching rush on most plots appeared to be thriving. The large clump sizes observed are indicative that closely planted individuals have successfully covered the intervening ground. Samphire, widely found and, planted in semi-desert areas was badly impacted by the extended drought as the photo archive for 2019 shows. Since then, under more favourable conditions many seedlings have germinated and developed; leading to a threefold increase in samphire survival figures.

Of the remaining species, each had a count of less than 10 in the baseline survey and all suffered losses: extrapolation from such small numbers is not considered sensible. From these results however, the plantings of neglected sedge (Bulbostylis neglecta), boxwood (*Mellisia begoniifolia*) and small bellflower (Wahlenbergia angustifolia) within the survey plots all failed, and one of the two boneseeds in the baseline was not recorded in the follow up survey. Small bellflower and neglected sedge are not naturally found in the rehabilitation areas and possibly the microclimate is unsuitable for their success. Naturally these species inhabit exposed ridge lines and cliff tops that are frequently subject to wind driven mist.

The future survival of existing plants at the survey plots in the medium term will continue to decline as the factors of weather, pests, competition (and human incursions) continue. Sustainable survival

of the native species at the plots and across the LEMP areas generally will only be achieved if sufficient replacement plants are produced by the existing communities to offset their losses. Some of the gumwood planted sites are moving toward this. In the better developed plots plant density and growth: are sufficient for the canopy to have closed; shade the ground limiting weed growth and introduction; provide a less exposed microhabitat allowing increased humidity levels; anchor increasing volumes of leaf litter; provide the conditions necessary to establish and build a soil seed bank to promote germination under ideal conditions. This, however, is a process that is only just beginning and until sustainable regeneration is achieved, many of the gains made are still at risk from the factors noted above.

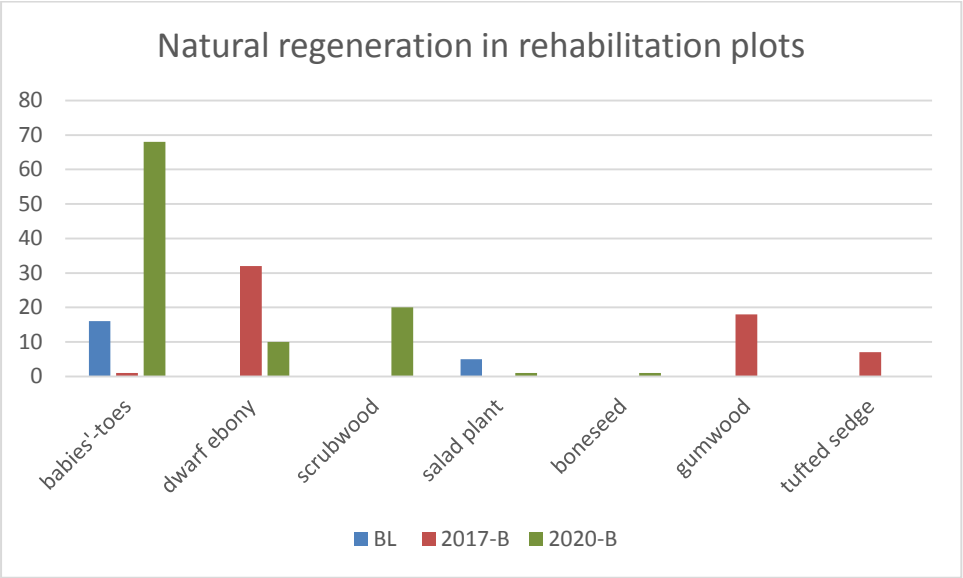
There are some large fluctuations in survival rates between the native species. Reasons for some of changes have been given: counting difficulties; inappropriate habitat selection for the species in question; inability to adapt from nursery to wild situations; extended drought. The overall survival rate to date of 77%, or about 3 survivors for every 4 four plantings, should thus be viewed cautiously. Bolstering the remaining plant population with timely replacements, ensuring their establishment and undertaking necessary control of invasive incursions will be necessary for the medium term in order that the success achieved under the LEMP comes to fruition.

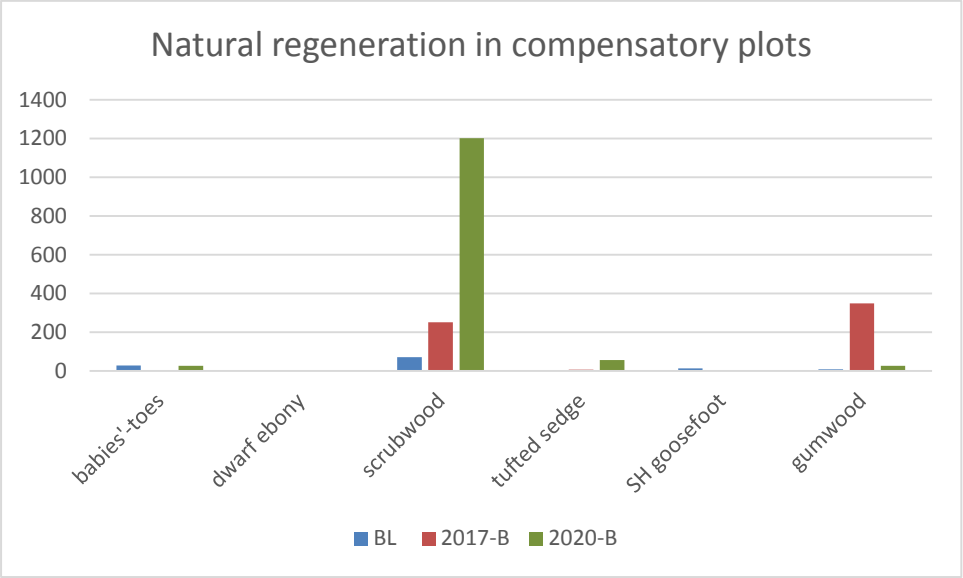
3.2.2 Natural regeneration

As mentioned in the previous section, natural regeneration is the key to sustaining the plant communities established under the LEMP. Regeneration has to progress beyond the production of a ‘flush’ of seedlings in a good year. A species community needs to develop as a ‘pyramid’ of individuals with each level representing a different age profile. In practice: one old mature tree needs to be underpinned by a few young trees; these in turn are underpinned by many more saplings; these are replenished from the regular or irregular flush of seedlings, and these are underpinned by reliable and genetically diverse seed production.

Established native species in the compensatory sites are already mature enough to reproduce and, an increasing number of the plantings in the rehabilitation sites are beginning to mature and produce seedlings. The charts below show only seedlings counted at the time of the respective surveys and as such only assess one aspect of natural regeneration at a moment in time; tracking the development of successive generations was beyond the scope of the surveys undertaken.

Figures 2 and 3: Graphs to show the number of natural seedlings, by species on rehabilitation plots and on compensatory plots in the baseline survey compared with the follow-up surveys.





Discussion of natural regeneration

The scale of seedling generation between the more recently planted rehabilitation sites and the longer established compensatory plots is significant. This is particularly noticeable with scrubwood which at the time of the 2020-B survey had produced a significant flush of seedlings in the communities at Flagstaff and Pipe Ridge. In 2017 gumwood had a similar flush of seedlings at the time of survey. Given the relative stability of mature plant numbers at the compensatory sites this illustrates a considerable variation in seedling production year on year.

It is encouraging to see a number of native species beginning to produce seed in the rehabilitation plots. Although numbers are not high it demonstrates that the plantings are beginning to mature. The annual babies' toes recorded include maturing plants; these have all grown in situ and are likely to have germinated from both the natural soil borne seed bank and supplemental seed sowing

carried out under the LEMP. The remainder of the regeneration is derived from solely from LEMP plantings.

Seedlings are particularly vulnerable to a number of threats including desiccation, shading, browsing and trampling; despite adaptations many fail. At Flagstaff for example there is little evidence that previous seedling flushes have survived beyond the small seedling stage, from the 100+ plants counted in the survey plots only 3 were in the 10-30cm range; the remainder were decades old mature plants. One possible factor for this lack of succession is the nipping off of plant tips by rabbits, frequently observed during the 2020-B survey. The extended drought in 2018-19 is also likely to have depressed recent seedling survival.

Maximising seed production and reducing the impact of threats is essential for successful regeneration and this will be an ongoing challenge for St Helena in order to fully capitalise on the LEMP. As mentioned in the 2017 report and iterated here, further work to examine the impact of these factors on seedling numbers and the success rates of recruits through to maturity would be valuable for future conservation efforts.

3.3 Plot coverage

Assessments of a number of components were made in each plot to determine the area covered. The DOMIN scale is a recognised surveying scale for such measurements and the definitions for each level are given at appendix 1. In the 2017-B survey it was recognised that the value ranges in DOMIN would make coverage comparisons complicated. Therefore, the median of each range (further modified for levels 1 to 3) was used to allow a single value to represent the area for each level on the DOMIN scale. In order to replicate calculations consistently the same values will be employed in this report:

Table 5. Conversion of DOMIN scale values into square meters (m^2).

DOMIN scale	Definition	Representative value m^2 based on $100m^2$ plot
0	Not present	0
1	<4%, few (up to 6) individuals	1
2	<4%, few (7-14) individuals	2
3	<4%, few (over 14) individuals	3
4	4%-10%	7
5	11%-25%	17.5
6	26%-33%	29
7	34%-50%	41.5
8	51%-75%	62.5
9	76%-90%	82.5
10	91%-100%	95

At ground level, in addition to vegetation (vascular plants), the bryophyte, lichen and non-living components of each plot were assessed and had their coverage of the ground layer recorded. Above ground level, vegetation coverage at each of the predefined height bands (see appendix 1 for details), was assessed for each species. Finally, a combined coverage for all species at each height band was recorded.

3.3.1 Ground cover

From the 2017-B report[1] ground cover is defined as "*the vegetation cover lower than 10 cm (excluding mosses and lichens), and the non-vegetation cover (which is broken down into seven components, including mosses and lichens) on the surface of the ground*". The components of non-vegetation ground cover have been defined for the purpose of the current survey in section 2.2.

Understanding the ground cover can indirectly support the assessment of plant development. Plant growth will impact on the ground cover components in reasonably predictable ways. If the plant community has a number of species with a low lying, creeping or sprawling habit it is expected that as the plants develop the ground components would decline proportionately. If tree species are planted their foliage may initially cover the ground components, however, as the canopy rises the ground layer becomes more exposed again but with bare soils covered by increasing amounts of leaf litter. Mosses, lichens and soil crust are unlikely to be present where the soil surface is being constantly eroded or disturbed and so give an indication of the stability of the ground layer; developing plant roots will bind the subsoil improving the stability of the surface layer. Rocky material can also assist in the stability of the surface layer and additionally create micro-climatic conditions of shade, moisture and shelter suitable for germination.

Table 6: Percentage ground cover of vegetation and the seven non-vegetation seven sub-categories.

Ground cover component	Pre 2017 baselines	2017-B survey	Change	Pre 2020 baselines	2020-B survey	Change
Vegetation	18%	17%	-1%	18%	32%	14%
Bare soils	55%	47%	-8%	48%	32%	-15%
Rock	17%	11%	-6%	18%	22%	5%
Humus	9%	14%	5%	7%	10%	3%
Brash	2%	2%	0%	2%	2%	-1%
Soil crust	5%	9%	4%	7%	1%	-6%
Mosses	0%	0%	0%	1%	1%	0%
Lichens	1%	1%	0%	2%	1%	0%

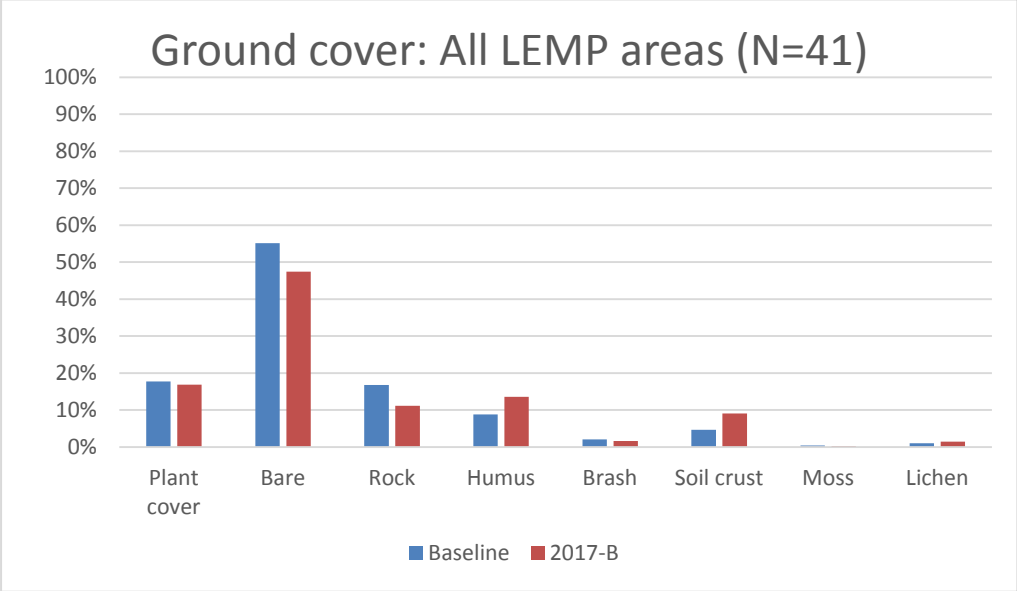
Notes to the 2017-B results. The 2017 figures vary slightly from those previously published[1]. A number of exclusions were made from the original report because of incomplete baseline records (some components missing). As a result only 34 of the potential 45 survey plots were represented. For the current report, the recorded information has been re-assessed and it has been possible to now include 7 of the previously excluded plots with completed baselines. Insufficient evidence still precludes the remaining four plots which still have incomplete baselines prior to 2017 and they remain omitted. The changes arising from inclusion of the additional sites don't modify any value by more than a single percentage point except bare soil reduction which changes from a 10% decline to a more modest 8% decline.

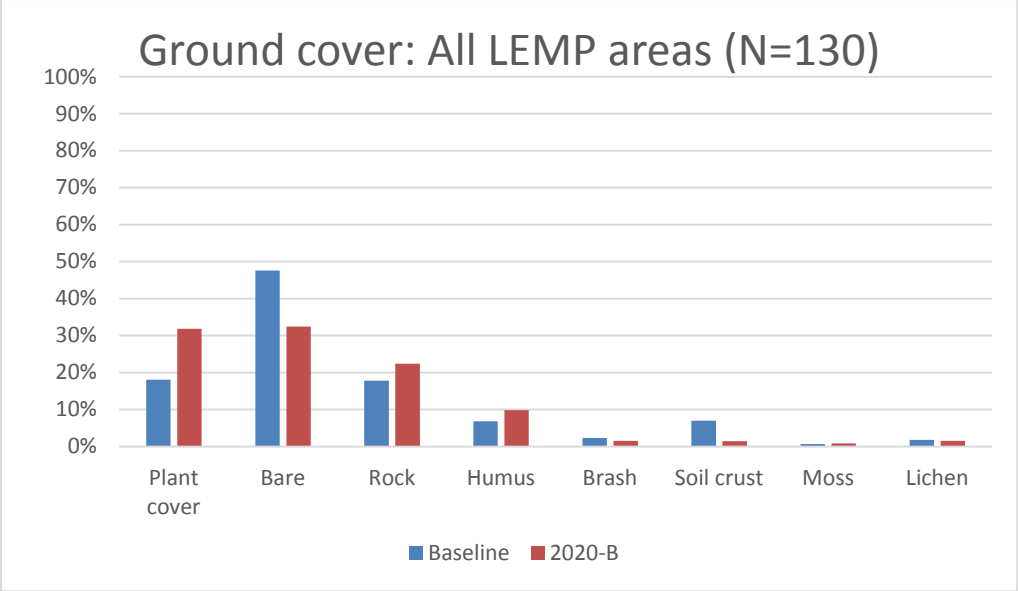
Discussion of overall ground cover

The 2020-B values in the table represent ground cover across 130 LEMP survey plots. From the presented data it is noticeable that vegetation cover (native + introduced) has increased in inverse proportion to bare soil reduction relative to the baseline. The vegetation percentages are likely to be an accurate representation within the limits of field assessment method. The bare soil component figure is potentially complicated by, the subjective nature of, the definition of each component type between the baseline and 2020-B. For example, it is unlikely that the rock component of a survey

plot has increased by 5% over the LEMP lifetime; the only way for this to occur is the removal of an equivalent area of vegetation (or soil erosion) to expose underlying rock at ground level. It is more likely that a more precise definition and assessment of rocky material in 2020, including that contained in mixed soil/rock substrate, has led to an increased area being recorded; a corresponding decrease in bare soil is likely to have occurred too. Combining the two components (soil + rock) at both baseline and 2020-B shows a more modest decline of around 12% (66% to 54%). The only other moderate change is the apparent decline in the soil crust component from 7% to 1%. This may again have a basis in a more rigorous definition of the component in the 2020-B survey with bare soil claiming more of the original count. It is also possible that some visible soil crust has been covered by the increased vegetation recorded. At such a summarised level of data further interpretation would be speculative. The tabulated data is shown graphically below.

Figures 4a & 4b: Graphs to show percentage ground cover (at 2017 &2020) of vegetation and non-vegetation, including the breakdown of non-vegetation into seven sub-categories (including lichen and moss).

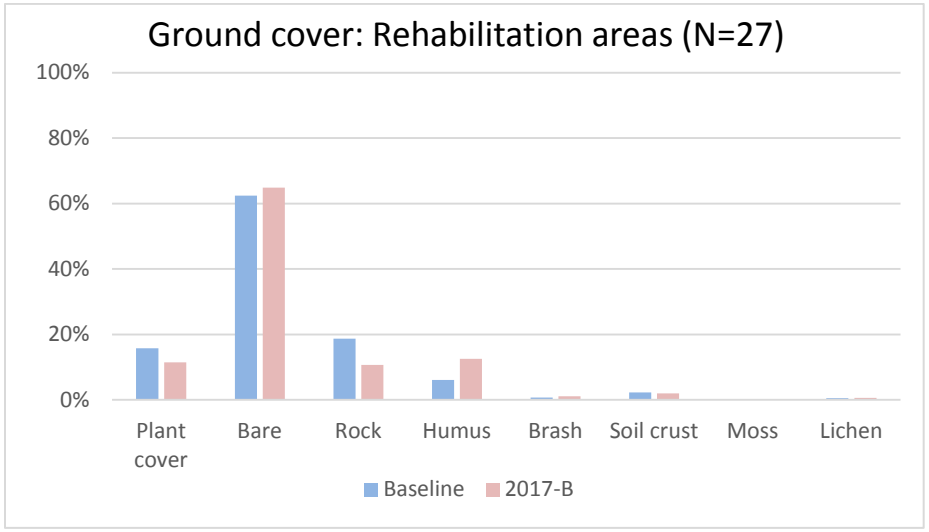


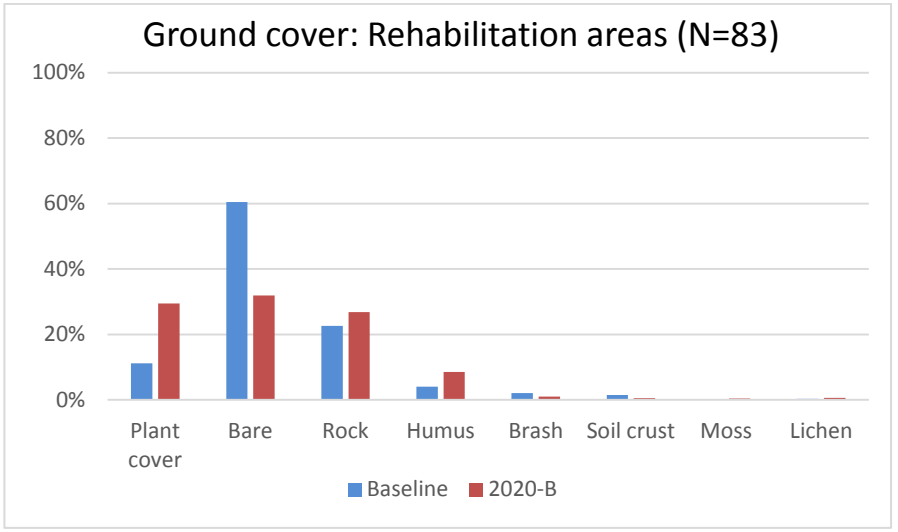


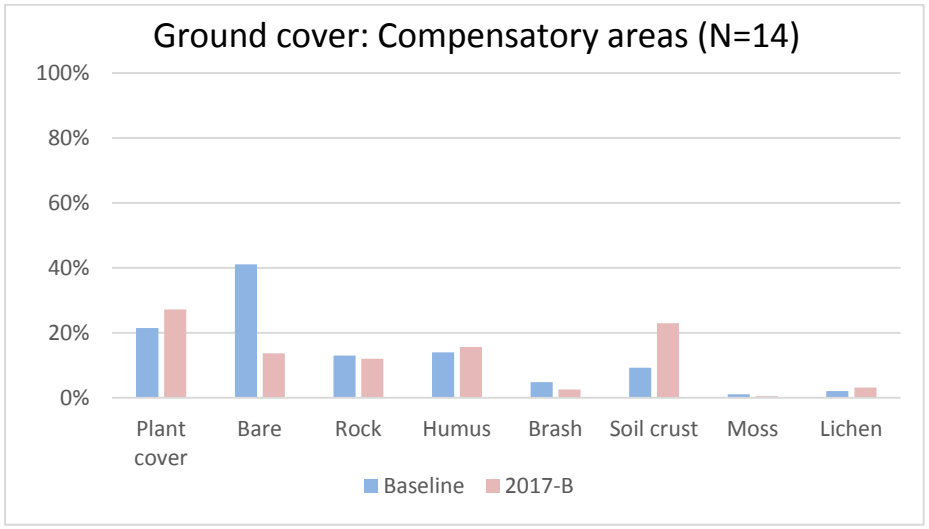
In summary, there has been a noticeable increase in vegetation at ground level across all LEMP sites with a corresponding decrease in the area combined physical components (soils and rock) between baseline measurement and the 2020-B survey.

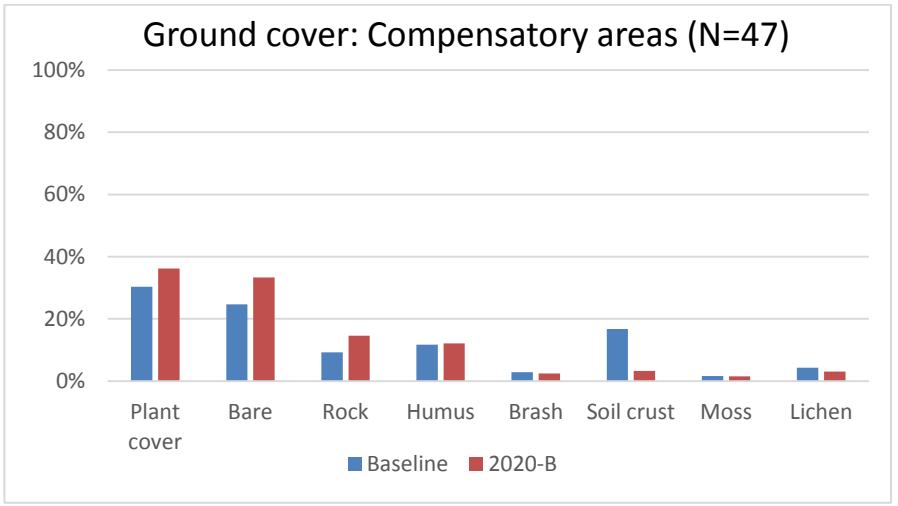
Ground cover, rehabilitation versus compensatory areas

Figures 5a & 5b and 6a & 6b: Graphs to show the differences in the ground cover layer in LEMP rehabilitation and compensatory areas between baseline surveys and the survey rounds 2017-B and 2020-B.









Discussion of ground cover between compensatory and rehabilitation areas

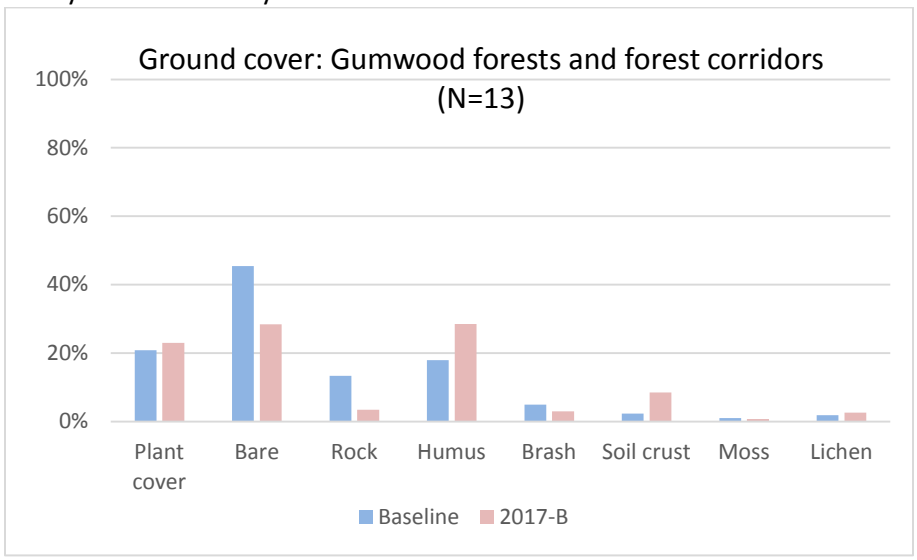
The 2017 and 2020 baselines have a very similar proportion of ground cover components, and are typified mainly by bare soils and rocky material. In the 2017-B survey, across 27 rehabilitation plots, the bare soil had increased slightly with a corresponding decrease in vegetation cover, not the trend wanted for restoration. By the time of the 2020-B survey, when 83 rehabilitation plots were under management, the trend was strongly favouring the increase of vegetation cover with a corresponding drop in bare soils. The rock component shows a slight increase. As explained above, this is probably an effect of surveying differences in defining the component rather than an increase in exposed rock at ground level. Humus coverage, particularly leaf litter and dead annuals, increased in line with vegetation coverage which would be expected. The presence of moss, lichen and soil crust are all indicative of long term stability; the rehabilitation plots are sited on areas disturbed during airport constructions so the low values for these components at this stage is expected. As the rehabilitation areas mature the values for these components should slowly increase.

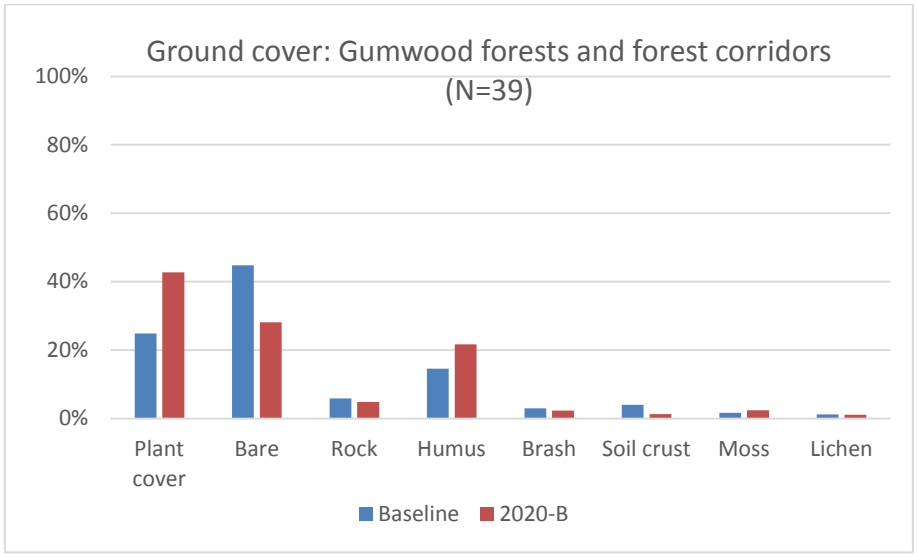
In the compensatory area plots, the 2020-B survey shows small increases in both the vegetation cover and bare soils component with a strong decline in soil crust. If however the soil crust and bare soil components are added together at both baseline (42%) and 2020-B (36%) then a slight drop in coverage matching the cover increase from vegetation is seen. Again there is an anomalous increase in rocky material; as previously noted likely a surveying artefact due to a more rigorous definition of the component. Mosses and lichen coverage in, the generally more mature and stable, compensatory plots are between two and three times higher respectively than the rehabilitation plots. Humus and brash coverage in compensatory sites have remained stable over the lifetime of the LEMP and at slightly higher levels than the developing rehabilitation plots.

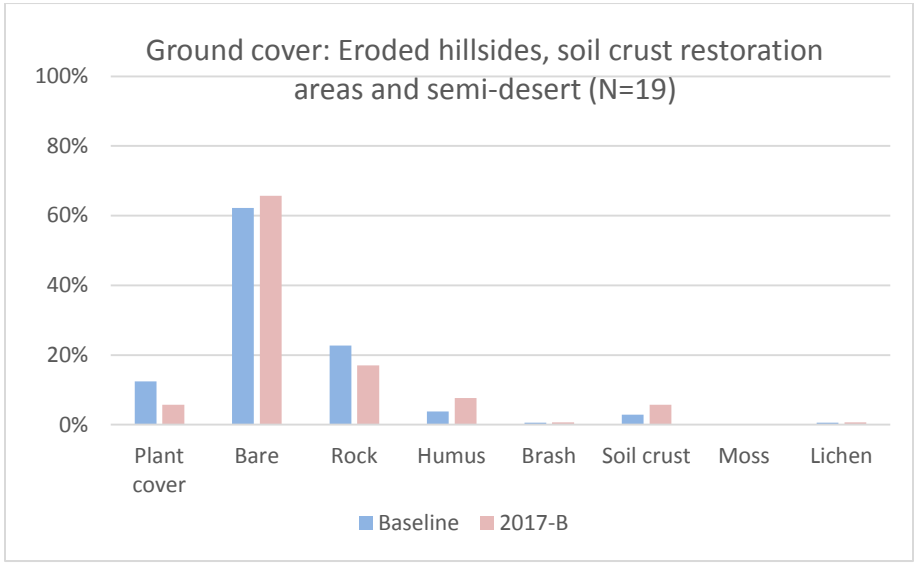
In summary, rehabilitation plots are trending toward increased vegetation and humus coverage with a corresponding drop in combined soil and rock components. Components in compensatory plots remain more stable over time. Stability indicator components, moss and lichen, are more prevalent in compensatory plots but showing small increases over time in rehabilitation plots.

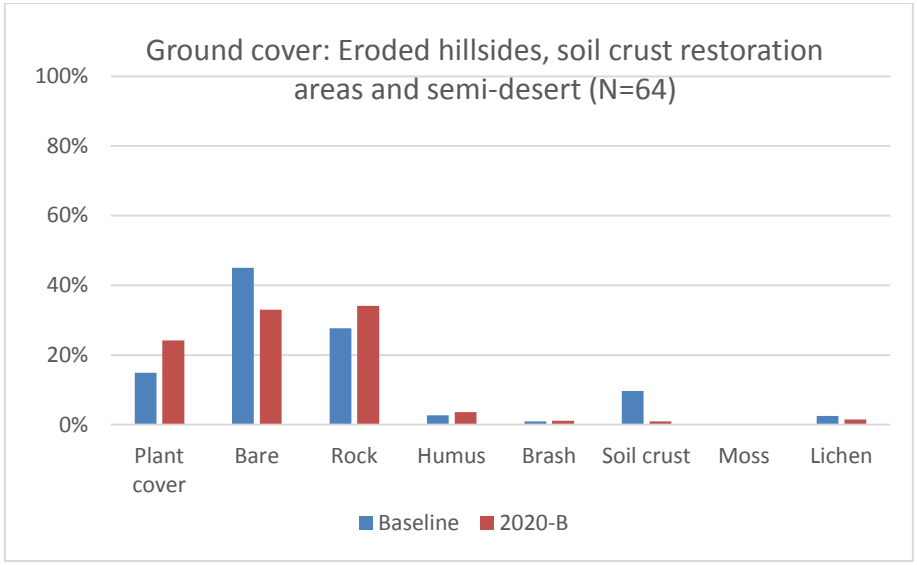
Ground cover, different habitat types

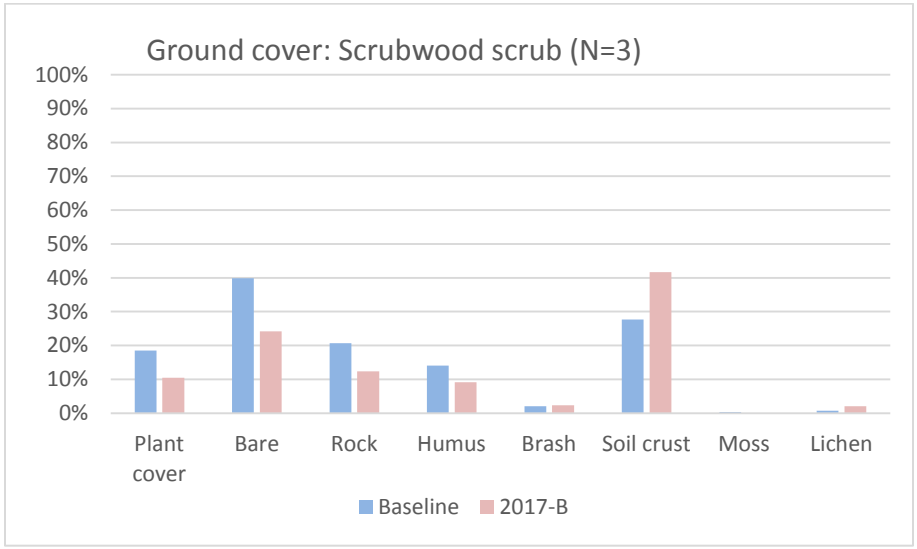
Figures 7a & 7b, 8a & 8b, 9a & 9b and 10a & 10b: Graphs to show the differences in the ground cover layer in four types of LEMP habitats, between baseline surveys and the surveyrounds 2017-B and 2020-B.

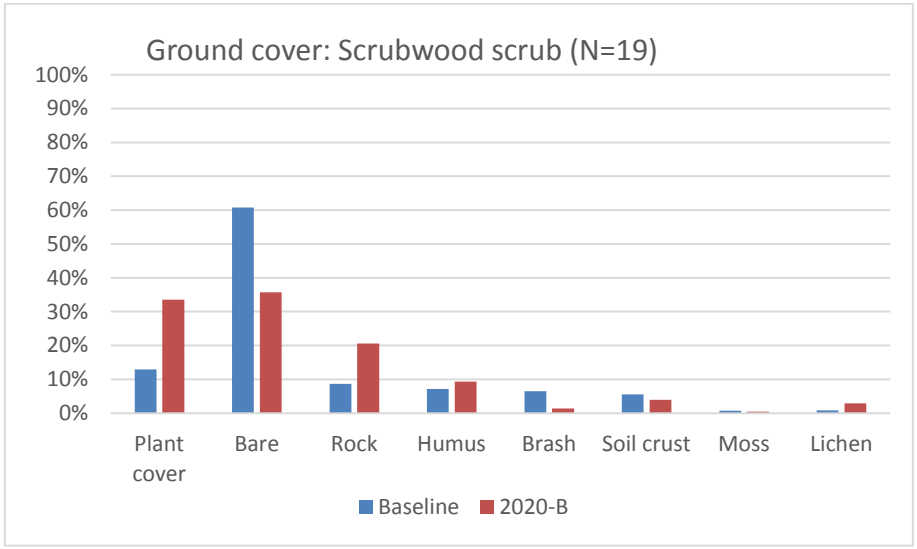


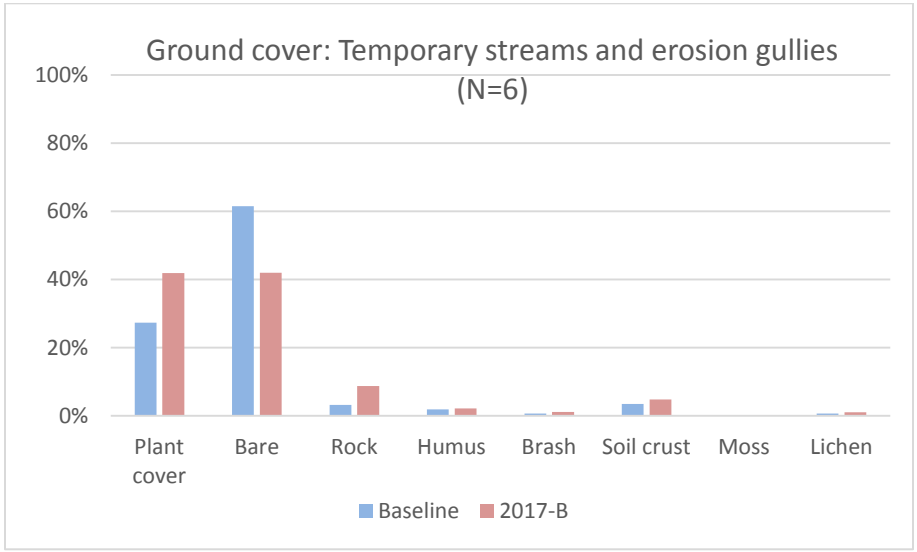


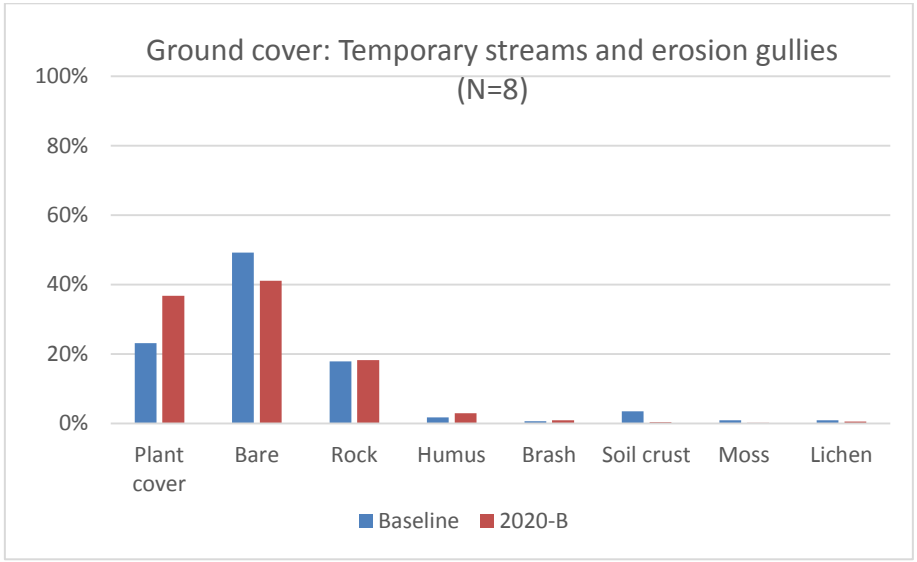





Ground cover: Scrubwood scrub (N=3)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Plant cover
Bare
Rock
Humus
Brash
Soil crust
Moss
Lichen
Baseline
2017-B


Ground cover: Scrubwood scrub (N=19)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Plant cover
Bare
Rock
Humus
Brash
Soil crust
Moss
Lichen
Baseline
2020-B


Ground cover: Temporary streams and erosion gullies (N=6)
100%
80%
60%
40%
20%
0%
Plant cover
Bare
Rock
Humus
Brash
Soil crust
Moss
Lichen
Baseline
2017-B


Ground cover: Temporary streams and erosion gullies (N=8)
100%
80%
60%
40%
20%
0%
Plant cover
Bare
Rock
Humus
Brash
Soil crust
Moss
Lichen
Baseline
2020-B

Discussion of ground cover in different habitats

All habitat types have seen an increase in plot numbers (N) surveyed and by implication areas under restoration management between the 2017-B and 2020-B surveys.

The 2020-B survey shows that all LEMP habitat types have shown noticeable increases in ground cover vegetation from their baseline values. This is an improvement on the earlier 2017-B survey where the only reasonable increase was in the temporary streams and erosion gullies habitat type. The 2020-B survey also shows a reduction in bare soils across all habitat types which is an expected result from the increased plant coverage. These are encouraging trends and more so as the 2020-B results incorporate many more plots representing the wider area under management compared to 2017.

As previously mentioned the increases in rock coverage are likely to include differences arising from the definition of what constitutes rocky material between successive surveys and how combined substrate of stone and soil is assessed. A more reliable gauge of change is to compare the trends of combined bare soil and rock results. This shows a large reduction of 18% of this component in the gumwood forest habitat and lower reductions between 6%-8% in the other three habitat types. Gumwood habitat also shows the largest increase in humus cover; photographic evidence shows that much of this humus is gumwood leaf litter being retained, under the young trees, as the plots become less exposed.

Soil crusts have shown a decline in coverage across all habitat types in 2020-B. As with rock the assessment of what constitutes this component may vary between surveys. A proportion of the baseline soil crust coverage may also have been obscured by the increasing ground cover vegetation. In the more exposed habitats, particularly the gullies and semi-desert types the extended drought in 2018-19 may have had a negative impact; cracking occurs in soil crusts exposed to prolonged desiccation which opens them to erosion and fragmentation, leading to an eventual reduction in coverage. Scrubwood scrub retains the highest proportion of soil crusts, contributed to the total principally by the stable mature natural scrubwood areas at Flagstaff and Pipe Ridge.

Mosses, lichens and brash form a very small proportion of the ground cover components and no discernible trends exist in relation to the habitat types recorded.

In summary, over the LEMP timeframe, all habitat types have shown a noticeable increase in ground cover vegetation with a corresponding reduction in the cover of the combined mineral components (soil and rock); gumwood habitat is the most productive in this respect. Soil crust coverage appears to have declined across all habitats though it is uncertain whether this has an environmental cause, is a surveying artefact or is a combination of the two.

3.3.2 Vegetation cover

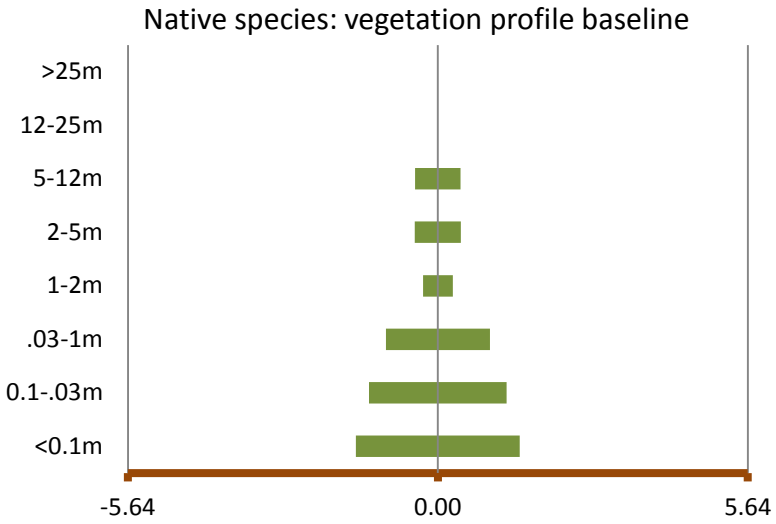
The methodology, employed in the surveys, assesses vegetation cover as the horizontal area occupied in a series of height ranges. This gives a rudimentary three dimensional view of the vegetation structure and over time how it changes as a plot develops. By comparing the two LEMP groups of plant species, native and introduced, an indication is given of how each contributes to the vegetation structure of the plots.

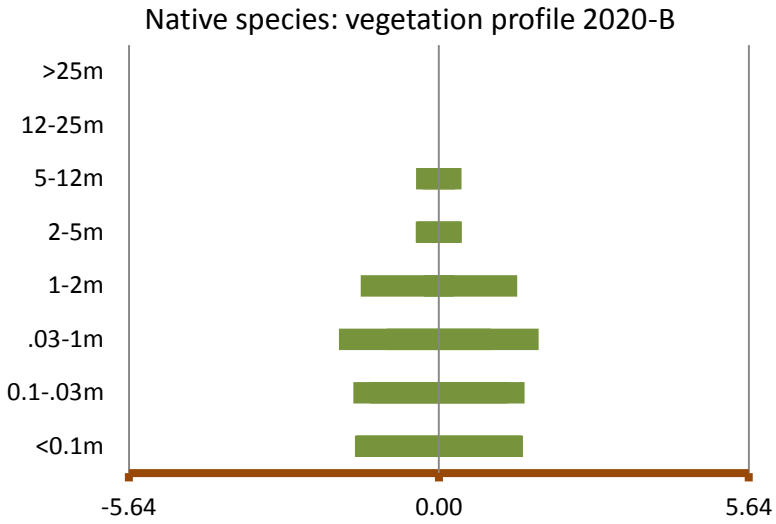
Table 7: Change in the coverage of native and introduced vegetation across all survey plots between the baseline and follow-up survey 2020-B (N=130).

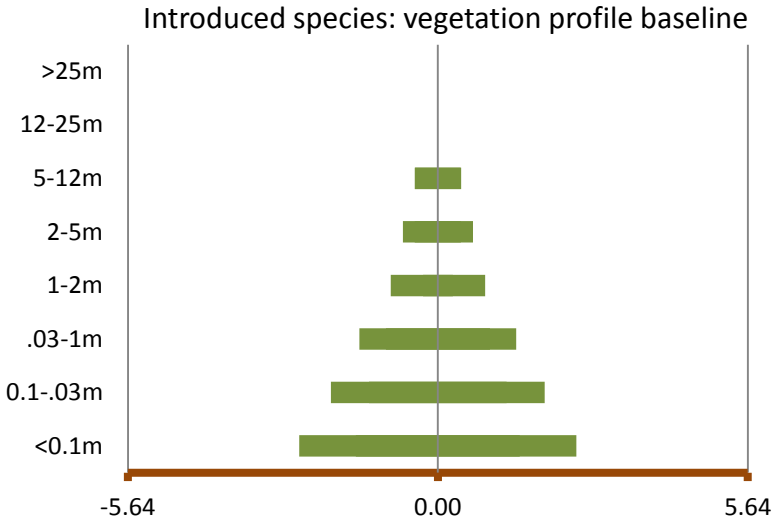
	LEMP native species		LEMP introduced species	
Plant height band	**Baseline**	**2020-B**	**Baseline**	**2020-B**
>25m	0%	0%	0%	0%
12-25m	0%	0%	0%	0%
5-12m	1%	0%	1%	0%
2-5m	1%	0%	1%	1%
1-2m	0%	6%	2%	2%
0.3-1m	3%	10%	6%	8%
0.1-0.3m	5%	8%	12%	17%
<0.1m	7%	7%	20%	27%

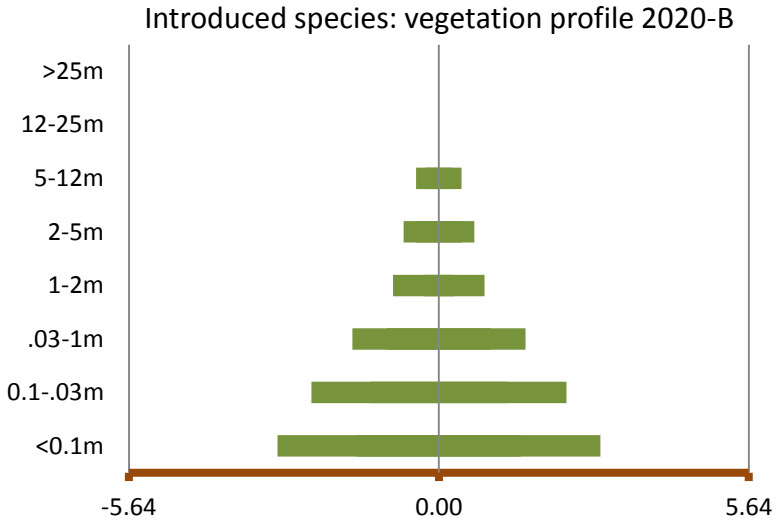
The following figures show the proportion of vegetation cover of native and introduced plant groups at both baseline and follow up survey in 2020-B. Rather than a bar chart of the above table which would contain four data series and be complicated to visually interpret the data is presented as a series of chart profiles which can be compared side by side. The profiles are presented as a section through the centre of a circular plot of 100m^2(radius of 5.64m) which represents the average of all plots. The profile chart shows a section through a circular 'plant', at the centre of the plot. The 'plant' represents the vegetation cover average of all plants in the survey at each height band.

Figures 11a, 11b, 11c and 11d: Graphs to show the change in the coverage of native and introduced vegetation across all LEMP plots between the baseline and 2020-B surveys (N=130).









Discussion of overall vegetation cover

From the above profiles it can be seen that for LEMP introduced species the variation between the baseline and 2020-B is relatively small. Overall coverage has increased at the lower height bands by 8%, 5% and 2% respectively from the ground to 1m; this is the range in which most annual weeds and new seedlings are found and would be expected to be more variable than the higher level vegetation which is provided by larger perennial species. In the bands above 1m the change in the average coverage, between surveys, at each level is less than 0.5%.

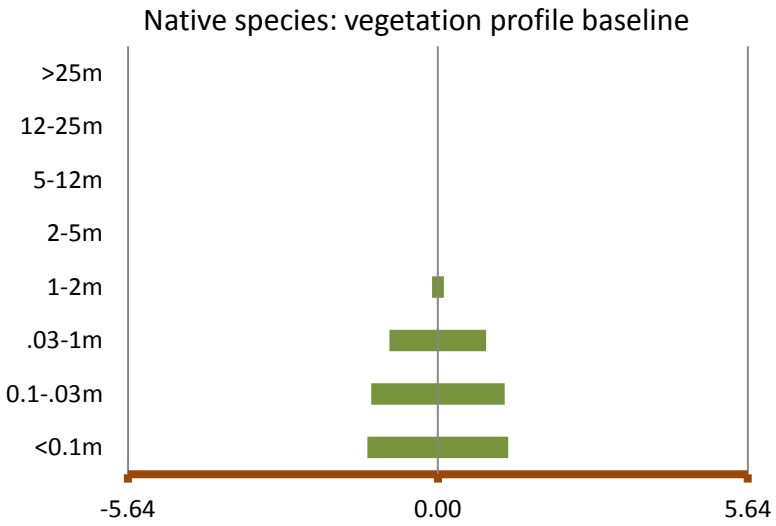
The profiles for the native species, many of which have been planted (under the LEMP) show a marked difference, from the corresponding introduced species profiles. There is also a marked difference between baseline and 2020-B surveys. The vegetation cover above 2m appears to be stable and is contributed mainly by mature gumwoods which pre-date the LEMP. A small contribution to the 2-5m band is contributed by early LEMP plantings of gumwood which by 2020 were just over 2m high; these offset some losses at Peak Dale where a number of larger mature trees were knocked down by wind prior to the 2020-B survey.

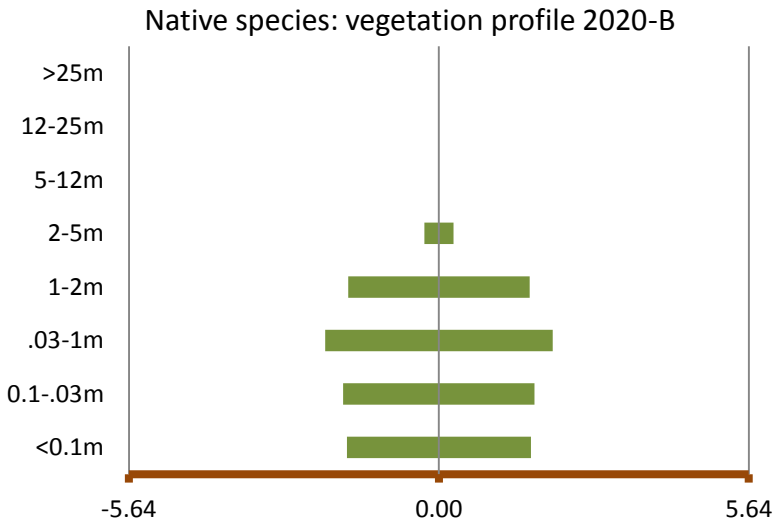
Over the lifetime of the LEMP the native vegetation coverage in the 0.1-0.3m band has increased by ~2% and more noticeably in the 0.3-1m and 1-2m bands by ~7% and ~6% respectively. These increases reflect to a large extent the average growth in height and breadth shown by the LEMP plantings, which as an average across all plots is commendable.

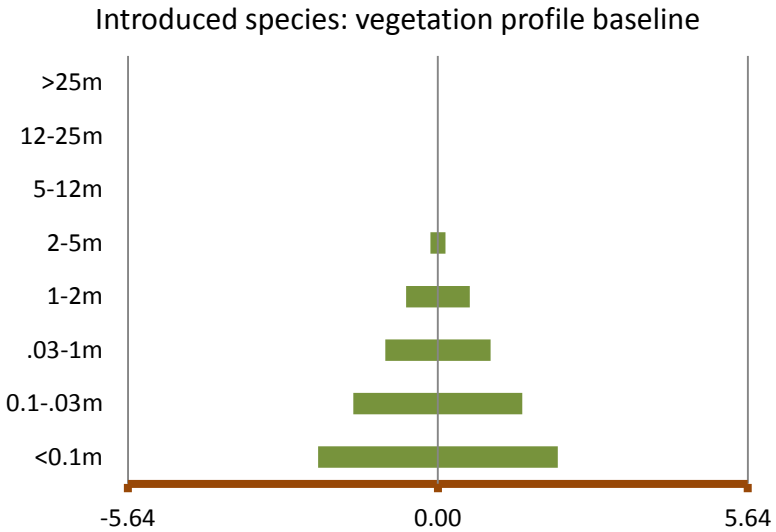
Rehabilitation and compensatory areas

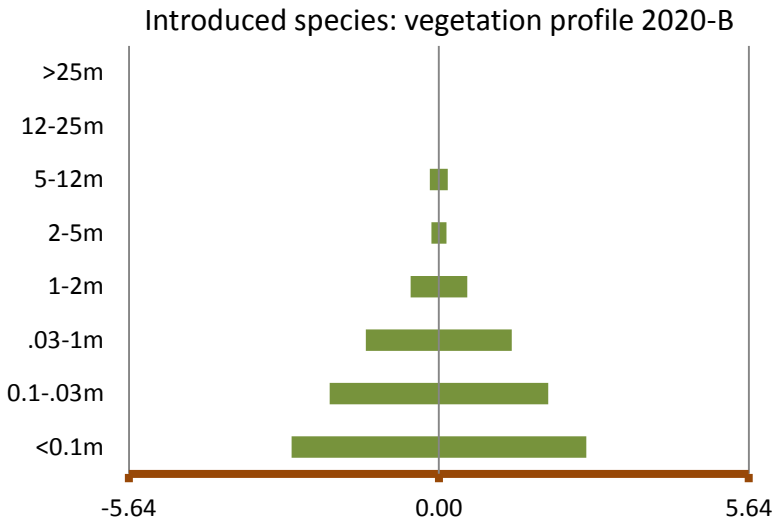
The following section of charts attempts to tease out more detail from the summary results above by comparing the vegetation cover between rehabilitation and compensatory plots (figures 12 & 13).

Figures 12a, 12b, 12c and 12d: Graphs showing the differences in vegetation coverage in LEMP **rehabilitation** sites between baseline and the 2020-B surveys.

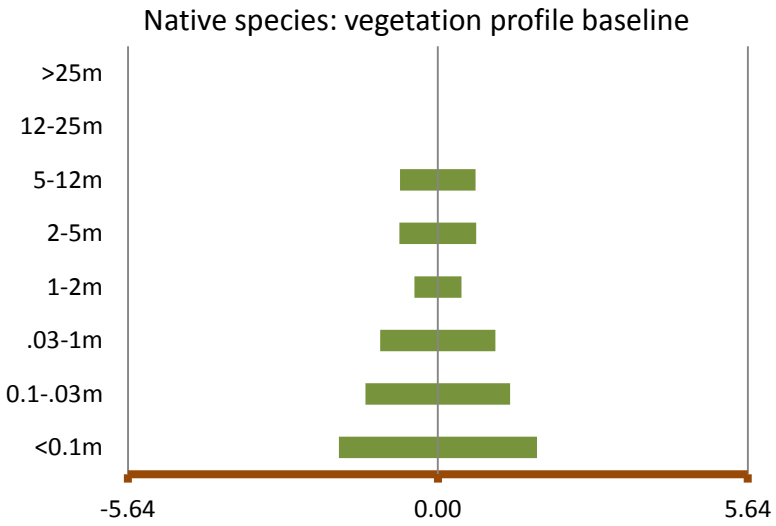


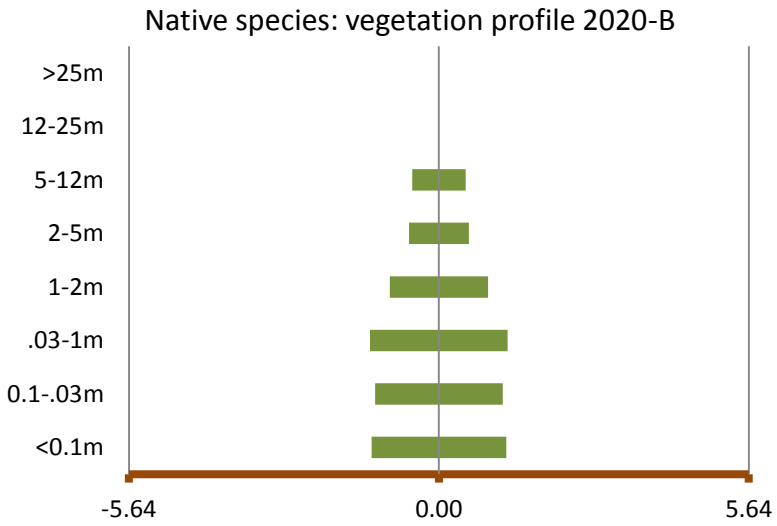


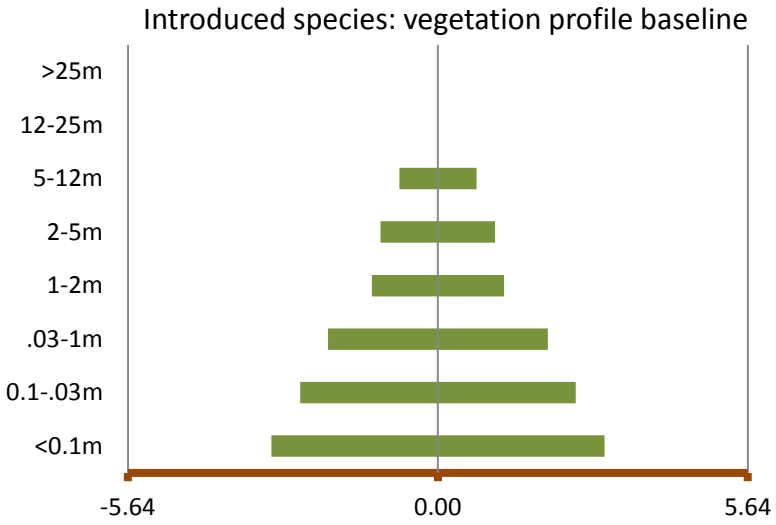


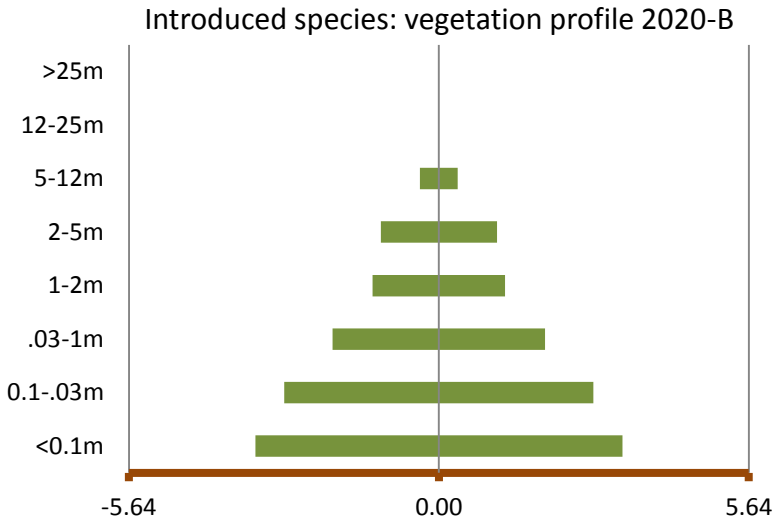


Figures 13a, 13b, 13c and 13d: Graphs showing the differences in vegetation coverage in LEMP **compensatory** sites between baseline and the 2020-B surveys.









Discussion on vegetation change in compensatory and rehabilitation areas

Comparing first the introduced species cover between the rehabilitation and compensatory plots, it is noticeable that the vegetation structure profile is very similar in shape, for both baseline and follow up surveys, with high percentage coverage at ground level gradually tapering off gradually in the higher bands. The more stable and longer established compensatory sites show greater percentage vegetation coverage at all heights bands and over the LEMP lifetime (baseline to 2020-B) the two lower bands up to .03m have shown about a 5% increase in coverage. This however may be a seasonal variation including annual weed populations.

The native species profiles vary considerably from those of the introduced species. While all the introduced species have pyramidal vegetation coverage as standard, the native species cover varies based on the site type and over time.

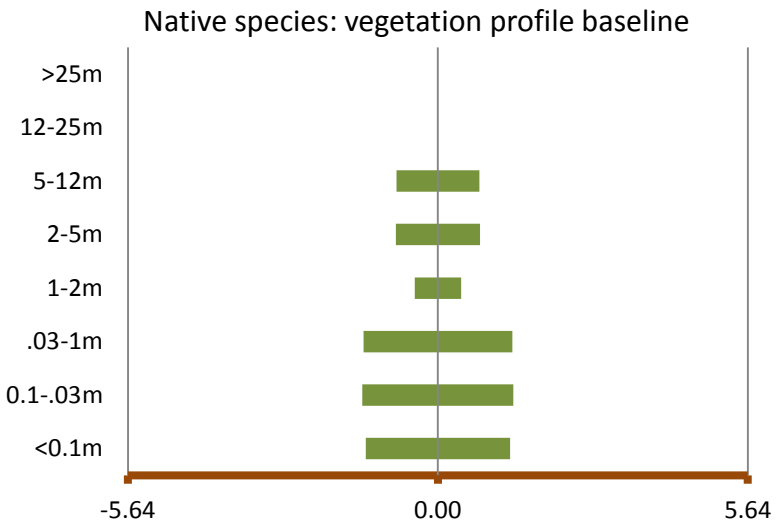
In rehabilitation sites the native species coverage baseline is relatively low with plants rarely exceeding 1m in height with structure as would be expected; most rehabilitation sites started as bare plots following disruption by airport construction activities. By 2020 the same plants have expanded their coverage and height considerably. Plants are now growing into the 2-5m band, all the lower bands show increased coverage from 4% at ground level to an impressive 11% in the 0.3-1m band. The 1-2m band which at baseline covered only about 0.25% of the plot now covers 9%. Most of the 1m plus growth is from gumwood plantings but as these grow taller their coverage in the lower bands occupied only by stems decreases. This however, is not shown in these results as the increases in vegetation from the other native species has compensated.

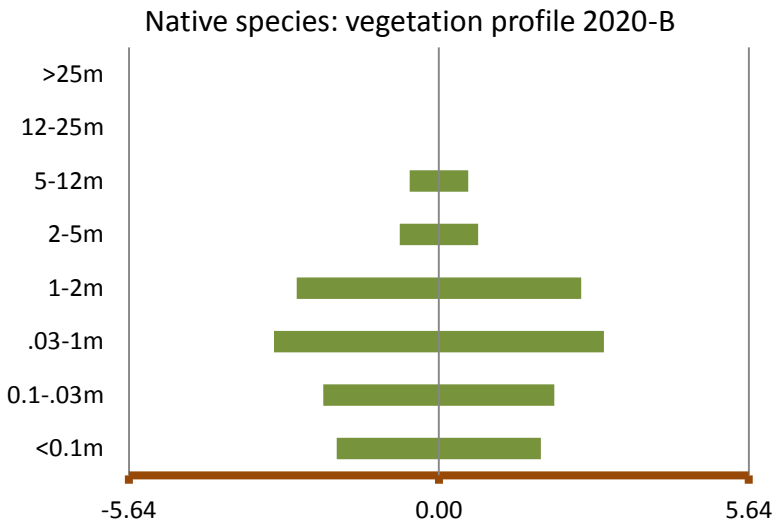
The results for native species in the compensatory plots are more difficult to interpret as a mixture of pre-LEMP and planted natives. The coverage in the lower two bands has reduced which indicates a reduction in younger and smaller plants over time, possibly the failure of some plantings in the compensatory areas. The greatest increase has been seen in the 1-2m band, probably again the result of planted gumwoods that have survived. The reduction in coverage between 2m and 12m was primarily the loss of a number of mature gumwood trees at Peak Dale which were knocked down by wind prior to the 2020-B survey.

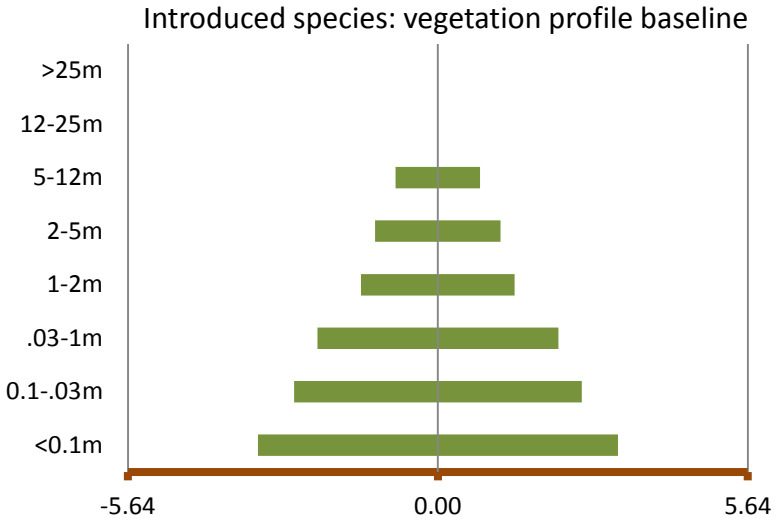
LEMP habitat categories

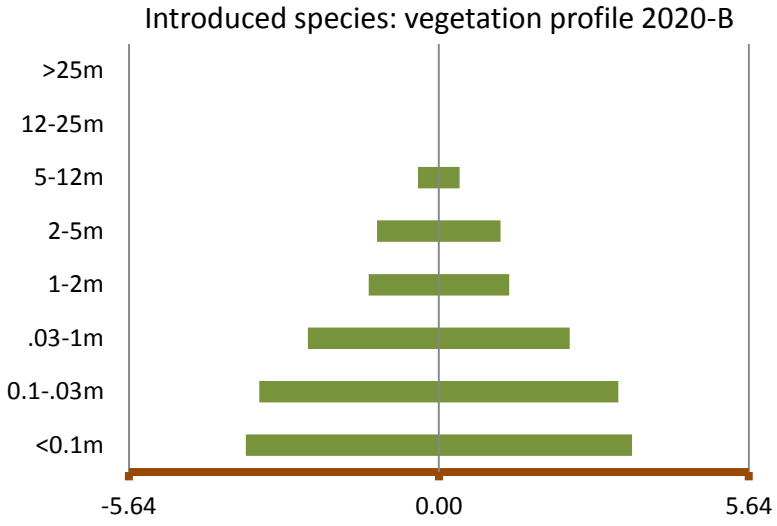
The following section of charts break down the vegetation cover changes in the different LEMP habitat categories. Figures 14-16).

Figures 14a, 14b, 14c and 14d: These graphs show the differences in native and introduced vegetation coverage in the LEMP **gumwood forest and forest corridors** habitat category between baseline and the 2020-B surveys (N=39).

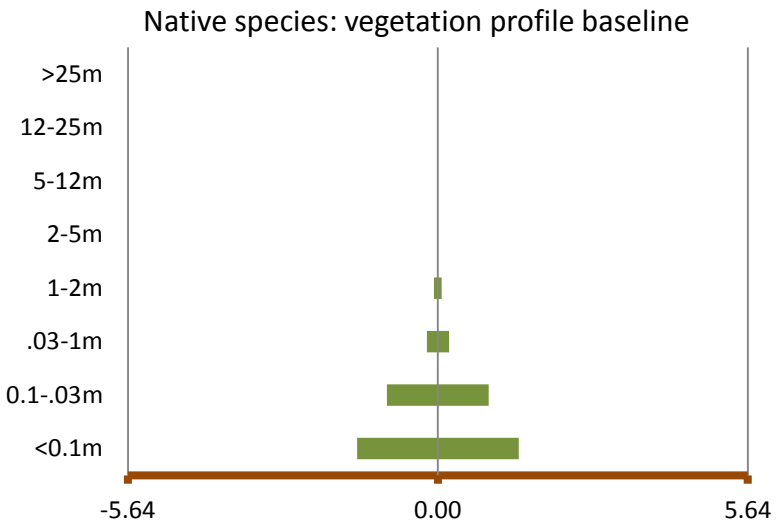


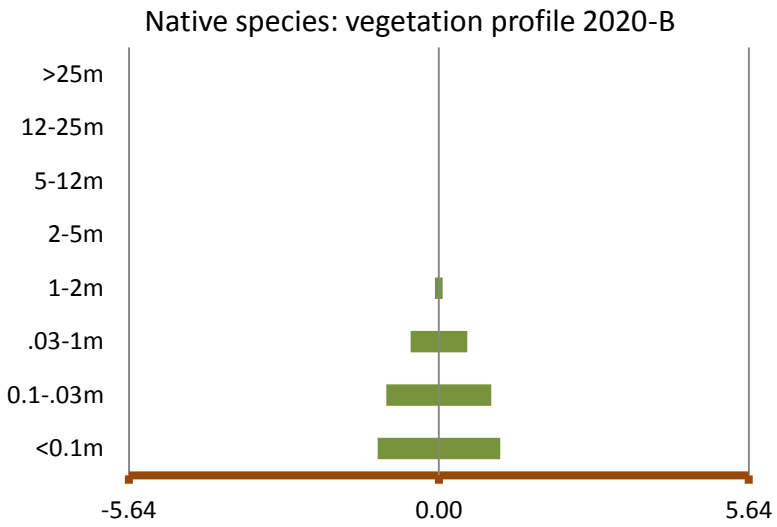


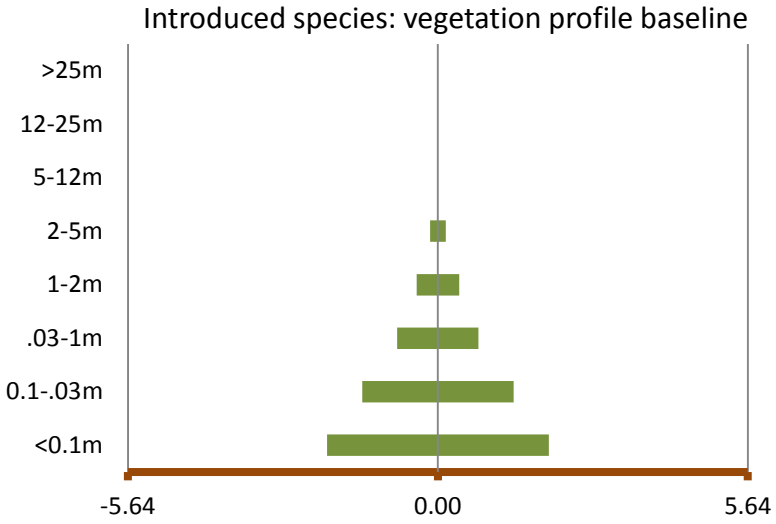


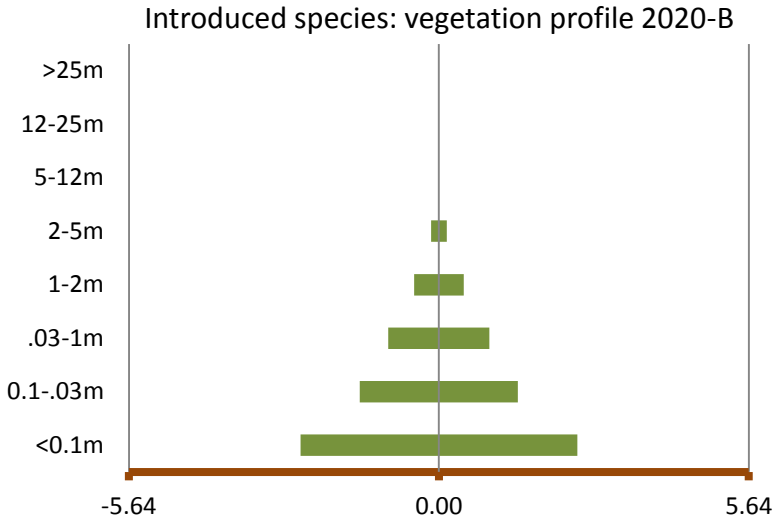


Figures 15a, 15b, 15c and 15d: These graphs show the differences in native and introduced vegetation coverage in the LEMP **eroded hillsides, soil crust restoration and semi-desert** habitat category between baseline and the 2020-B surveys (N=64).

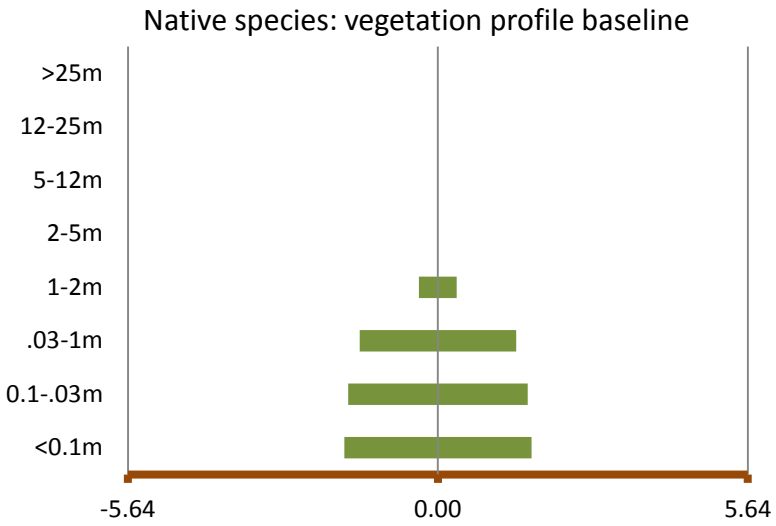


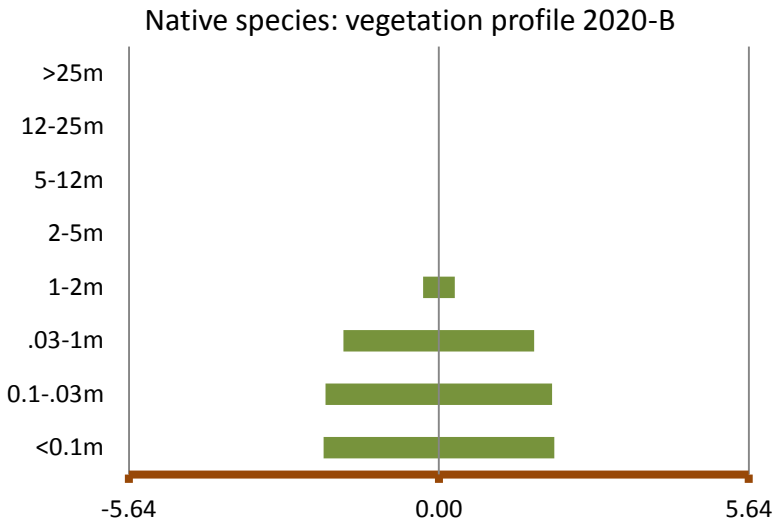


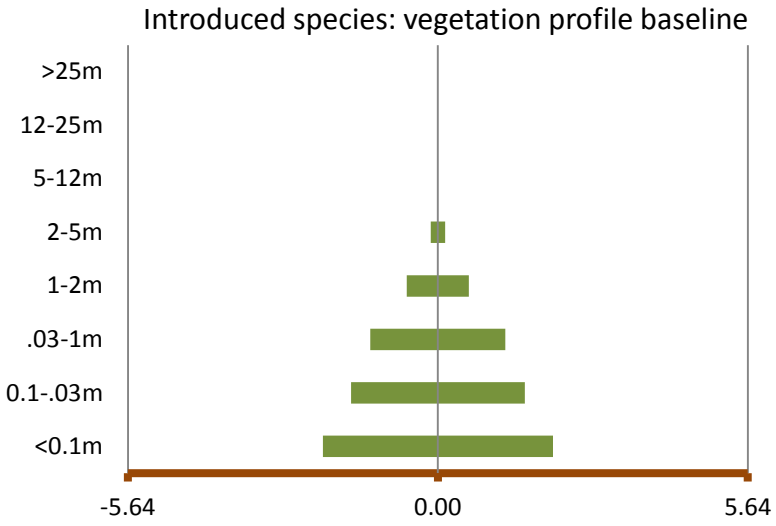


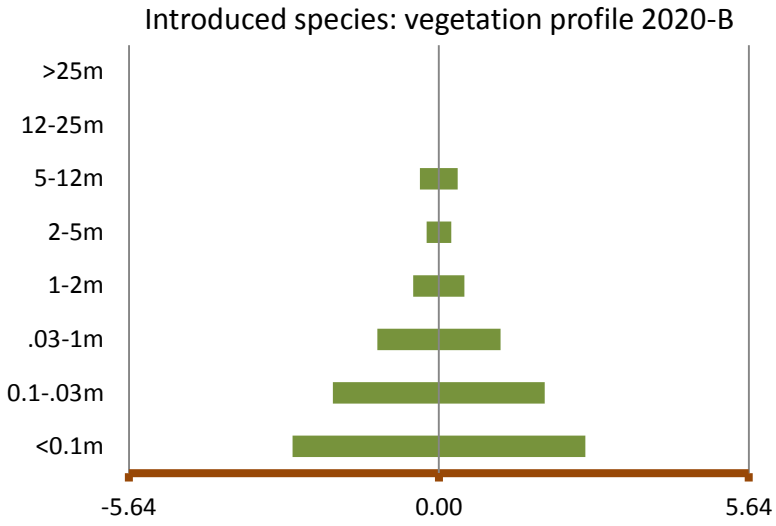


Figures 16a, 16b, 16c and 16d: These graphs show the differences in native and introduced vegetation coverage in the LEMP **scrubwood scrub** habitat category between baseline and the 2020-B surveys (N=19).

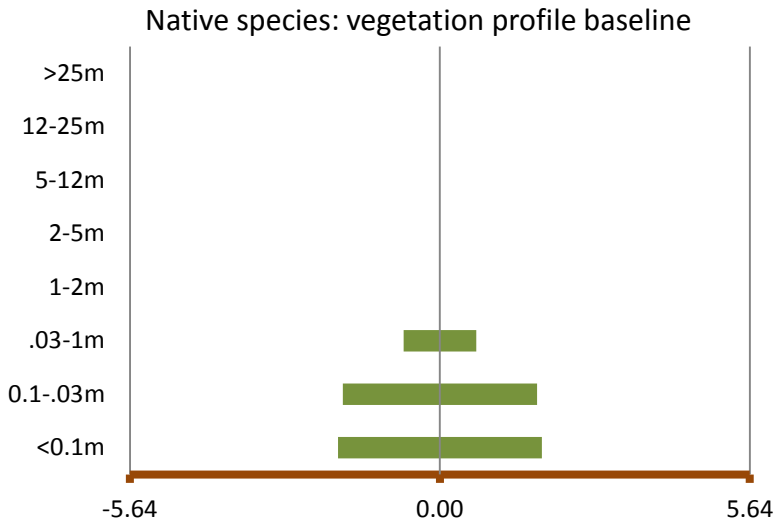


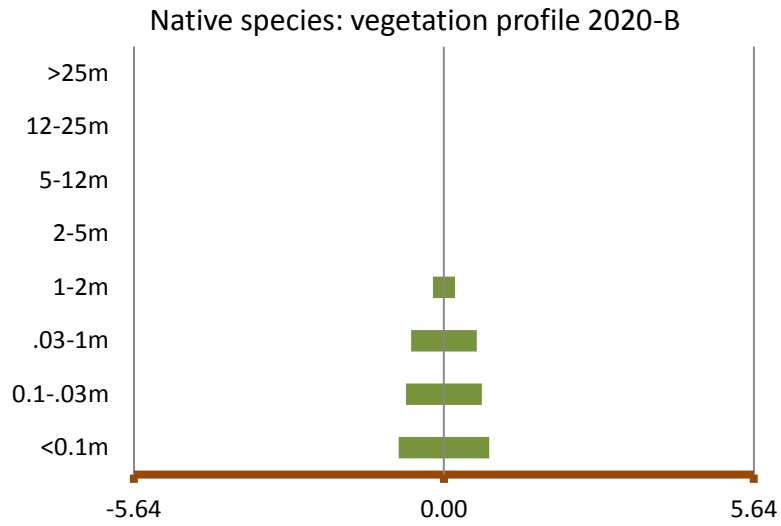


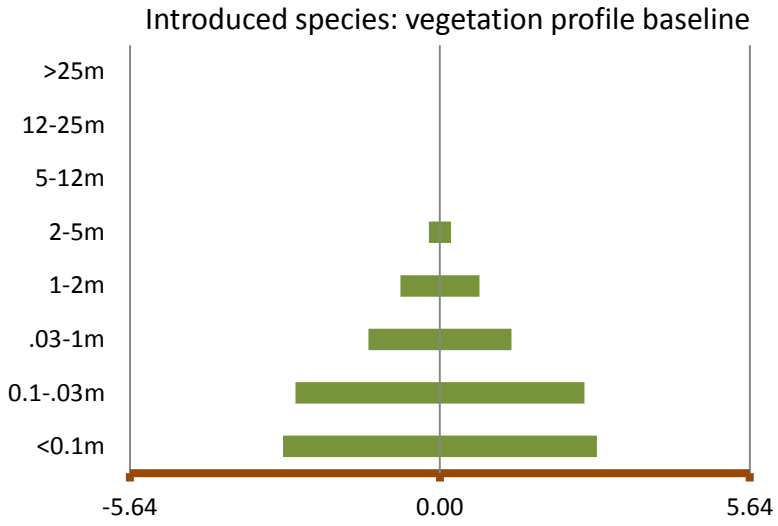


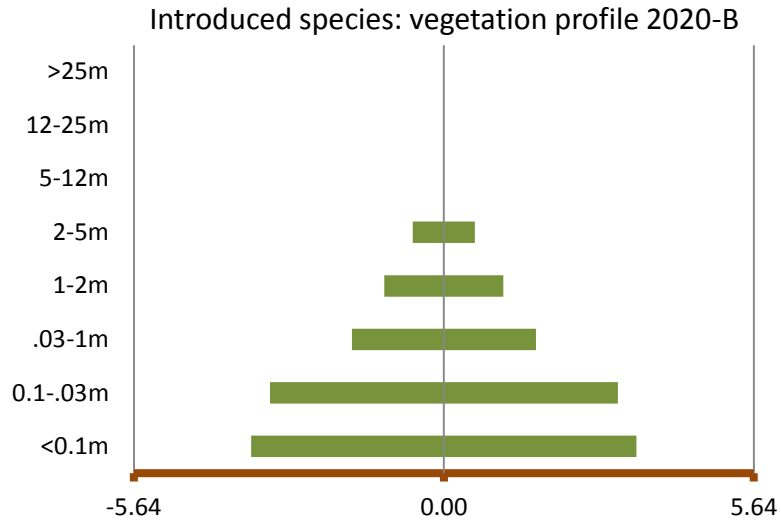


Figures 17a, 17b, 17c and 17d: These graphs show the differences in native and introduced vegetation coverage in the LEMP **temporary streams and erosion gullies** habitat category between baseline and the 2020-B surveys (N=8).









Discussion on the vegetation coverage in different habitats

As in earlier comparisons, the profile of introduced species vegetation coverage is very similar in all habitats. Over time the percentage cover at each height band has remained stable or shown slight increases. This suggests that the introduced species community in each habitat is well adapted and reasonably constant, a hypothesis borne out by the persistence of introductions and invasive species in most habitats across the island.

The native profiles of the gumwood habitats include the mature area at Peak Dale. The baseline survey vegetation profile above 1m is mainly the contribution of old wild trees, these have a lower coverage percentage at stem level .However, below 1m the widespread planting of gumwood saplings would be a major contributor to the coverage figure. The profile from 2020-B shows the 'explosion' of new growth, in the ground to 1-2m bands, contributed by the development of the gumwoods planted since the commencement of the LEMP. The higher bands still represent only the older mature trees.

The native species profile at baseline for the semi-desert habitat is similar in shape to that of the introduced species. Overall coverage is relatively low, reflecting the constraining characteristics of this type of habitat. During the LEMP the coverage at ground level has reduced with a corresponding increase in height and coverage at slightly higher levels. This would seem to indicate the gradual growth of the native plants over this time.

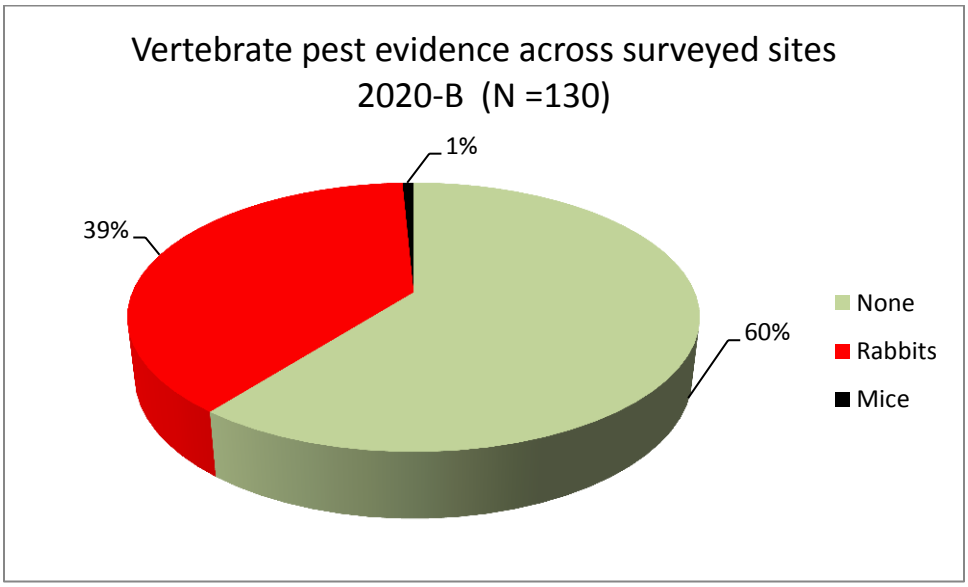
The native profile of scrubwood scrub is dominated by contributions from plots in the natural communities at Flagstaff and Pipe Ridge. These are mainly mature old plants so no overall height increase is observed; the coverage or growth has expanded horizontally in the lower three bands by between 3% and 5% which will include a contribution from LEMP plantings as well as growth of the established wild plants.

The erosion gullies habitat contains the smallest number of sites. A little like the semi-desert habitat the native species cover at the lower levels has declined over time with some increase in height. Unlike the semi-desert however there appears to have been a general loss of about 75% of total native vegetation coverage which indicates that natives in this habitat have performed less well than in the other three habitat types. An inverse increase in introduced species coverage over the same period suggests conditions were suitable for growth. It is possible the native species were out competed or had niche requirements not provided by this habitat type.

4 Vertebrate pests

In addition to invasive vegetation and the vagaries of weather, the LEMP restoration works are under considerable pressure from invasive vertebrates. In an attempt to mitigate the effects of vertebrate herbivory, extensive fencing has been installed and poison bait has been set across LEMP restoration areas. However, as the figure below shows there is still significant evidence of rabbit presence (faeces, burrowing, grazing) at almost 40% of sites. Mice, which are potential seed consumers, were observed at one site during the survey.

Figure 18: Percentage of survey plots impacted by invasive vertebrate pests.



5 Conclusions and recommendations

The 2020-B survey across 130 randomly designated plots gives a snapshot of the current state of restoration works across the areas under LEMP management. It is one of a series of vegetation surveys that have allowed restoration development under the LEMP to be monitored. The methodology and site locations are well documented and should be suitable for use in future assessments.

Ongoing management across these areas was evident during the survey. A small team with a regular maintenance programme is responsible for keeping the restoration areas secure from the impacts of invasive incursions.

Across the plots surveyed: there were generally appropriate species selected for planting in the habitat at each site, effort had been made to plant diverse species from a relatively small pool, planting densities were generally very good; closed up vegetation and canopies were a regular feature which in turn was beginning to contribute to sustainable maintenance by suppressing weed growth.

Most of the species employed are beginning to mature and good evidence of flowering and some fruiting were observed during the survey. Even more pleasing was the recording of possibly the first recruits in some plots. All this is an indication of the potential of the LEMP restorations to develop into self sustaining communities given enough support in the interim.

The 2018-19 extended drought period undoubtedly had a negative impact on this restoration programme with many of its management areas within the normally driest part of the island. Natives adapted to the habitats have recovered reasonably well, particularly samphire, where many of the large shrubs died; a new community of seedlings has emerged. The LEMP plantings which had been well established pre-drought suffered a knockback in growth vigour that is only now improving.

Despite the drought over the lifetime of the LEMP the overall result is successful to date; the continuing success and the securing of this important environmental asset is subject now to the future management plans and resources that can be allocated to it.

The following recommendations are made on the basis of: consolidating the effort and cost of the LEMP, protecting the endemic assets accumulated, promoting a positive public perception of the LEMP and conservation works in general, identifying further research needs.

A five year management plan for the LEMP areas is a recommended requirement as a framework for resource requirement and allocation and responsibilities post LEMP (it is understood that this is a requirement under the planning consent for the airport). This should include but not be restricted to: an invasive plant and vertebrate pest control programme; a maintenance programme for fencing and continuance of site access; a schedule for production, planting and care of replacement, supplemental and expansion planting; an indication of budgetary costs for unitised elements based on LEMP history.

It is recommended that the experience inherent in the LEMP team be retained or recorded, this is a valuable somewhat intangible resource but of great value to future management.

It is recommended that obvious landscaping areas, adjacent to the airport access roads, be regularly maintained, in order to promote the perception that 'institutional' St Helena values native species and is seen to be actively demonstrating this. This should not however become the sole focus of future works; the higher value often remotely situated natural communities of native species are the source of the diverse materials that have allowed the LEMP to be completed.

It is recommended that research possibilities arising from the LEMP activities and the considerable data set that has been accumulated are investigated. An example that arises from this survey is to further research on the impacts of rabbits and other negative impacts on the sustainable regeneration of native species.

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Lambdon P (2012) Flowering Plants & Ferns of St Helena. St Helena Nature Conservation Group. Pisces Publications.

Paajanen M (2017) LEMP vegetation survey 2017. Landscape and Ecology Mitigation Programme. St Helena Government.

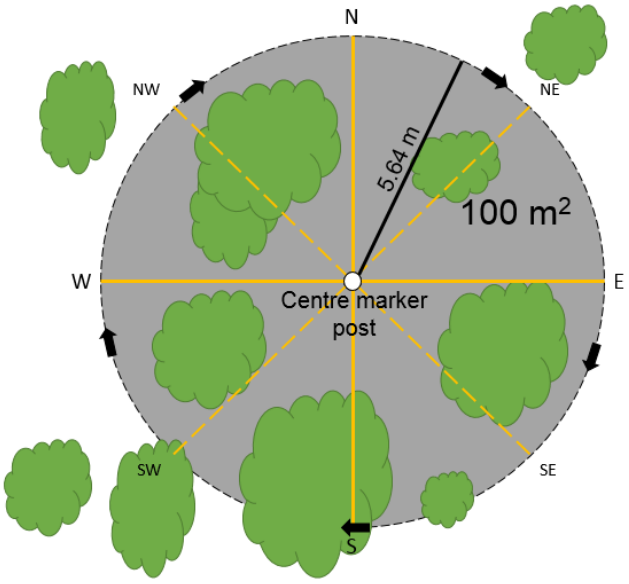
Appendix 1: LEMP Vegetation survey methodology

Equipment

- Central stake marker (or coordinates for marker if surveying an existing plot)
- 1 length of cord of 5.64m in length
- Four small stakes
- Compass
- 20 coloured balls
- 50x50cm divided quadrat
- 2m measuring pole with markings at 10cm, 30cm and 1m
- Data recording sheets
- Camera and GPS
- St Helena Flowering Plants and Ferns book (as required)

Marking out the survey plot (100m2)

- Identify the centre of the survey plot - using coordinates to find the marker stake for existing plots and for a new plot randomly identify the centre and secure a stake into ground then create as a GPS point.
- Secure the length of cord to the central marker and pull tight in the N, E, S & W directions, using the compass. Mark with four stakes.
- The coloured balls can be used to indicate the outer edge of the circular survey plot where vegetation crosses or is close to the line (defined by attaching the 5.64 m string to the centre marker and walking around the perimeter). Red biodegradable survey tape can also be used instead of the coloured balls if there is tall vegetation (tie to a branch on the perimeter).



- Eight photographs are taken, two from each direction (one at kneeling height and one at standing height – using the plot centre marker as the centre point of the photo), starting from North to South and continuing clockwise East to West, South to North and West to East.
- Two types of vegetation monitoring are then completed:
    - Native plant count
    - Total plant abundance

Vegetation monitoring

Native plant count

- Record living endemic and native (including probably native) species ONLY.
- Number of individual plants of each species are counted in the following height classes: Soil level (<0.1m); 0.1-0.3 m; 0.3-1 m; 1-2 m; 2-5 m; 5-12 m; 12-25 m; and recorded on a record sheet.
- When possible, a record is made of whether plants are planted or descendant of natural regeneration (planted are usually on irrigation – if in doubt the guys should know where they planted).
- Initial baseline survey only: record numbers of dead native/endemic plants (where evidence of them remains) separately to live plants.

Plant abundance

- Record ALL plant species present including native and endemic species.
- Estimate the abundance of species using % of ground coverage of each species present within the following height classes: Soil level; 0.1-0.3 m; 0.3-1 m; 1-2 m; 2-5 m; 5-12 m; 12-25 m and record in the table below.
- % coverage is estimated within the categories or 'DOMINs': 1=<4% (with few individuals); 2=<4% (with several individuals); 3=<4% (with many individuals); 4=4-10%; 5=11-25%; 6=26-33%; 7=34-50%; 8=51-75%; 9=76-90%; 10=91-100%.
    - <4% = <4 square meters. I usually find it helpful to estimate is the small bits would fit inside 4 square meters instead of thinking in terms of 4%.
- Overall cover of all vegetation is then estimated (using DOMIN scale)
- Soil cover is also estimated using DOMIN scale in the following types: bare earth; humus; rock; brash; lichen; moss; soil crust.
    - Overall cover of the soil layer is usually the inverse of the total for overall cover of the vegetation at soil level. E.g. if you estimates that the total abundance of vegetation cover at soil level is 30% or 6 on the DOMIN scale, then the overall soil cover would be 70% or 8 on the DOMIN scale.

Appendix 2: Species list from 2020-B survey

Species Name	Name	Family	Nativity
babies'-toes	Hydrodea cryptantha	Aizoaceae	Endemic
boneseed	Osteospermum sanctae-helenae	Asteraceae	Endemic
gumwood	Commidendrum robustum	Asteraceae	Endemic
scrubwood	Commidendrum rugosum	Asteraceae	Endemic
St Helena goosefoot	Chenopodium helenense	Chenopodiaceae	Endemic
tufted sedge	Bulbostylis lichtensteiniana	Cyperaceae	Endemic
tea plant	Frankenia portulacifolia	Frankeniaceae	Endemic
dwarf ebony	Trochetiopsis ebenus	Malvaceae - Dombeyoideae	Endemic
salad plant	Kewa acida	Molluginaceae	Endemic
cliff hair grass	Eragrostis episcopulus	Poaceae - Poaoideae	Endemic
hair grass	Eragrostis saxatilis	Poaceae - Poaoideae	Endemic
rosemary	Phylica polifolia	Rhamnaceae	Endemic
golden wreath wattle	Acacia saligna	Fabaceae - Mimosoideae	Forestry species
Red Mahogany gum	Eucalyptus resinfera	Myrtaceae	Forestry species
samphire	Suaeda fruticosa	Chenopodiaceae	Native
bayonet grass	Tribolium obliterum	Poaceae - Poaoideae	Native
fish-bone grass	Eragrostis cilianensis	Poaceae - Poaoideae	Native
purslane	Portulac oleracea	Portulacaceae	Native
English aloe	Furcraea foetida	Agavaceae	Naturalised
hedge aloe	Agave angustifolia	Agavaceae	Naturalised
creeper	Carpobrotus edulis	Aizoaceae	Naturalised
heart-leaf ice-plant	Aptenia cordifolia	Aizoaceae	Naturalised
New Zealand spinach	Tetragonia tetragonoides	Aizoaceae	Naturalised
sea spinach	Tetragonia microptera	Aizoaceae	Naturalised
wild mango	Schinus terebinthifolius	Anacardiaceae	Naturalised
monkey's ears	Centella asiatica	Apiaceae	Naturalised
blueweed	Ageratum conyzoides	Asteraceae	Naturalised
everlasting	Xerochrysum bracteatum	Asteraceae	Naturalised
fleabane	Conyza bonariensis	Asteraceae	Naturalised
pale cudweed	Gnaphalium luteoalbum	Asteraceae	Naturalised
prickly sow-thistle	Sonchus asper	Asteraceae	Naturalised
smooth sow-thistle	Sonchus oleraceus	Asteraceae	Naturalised
wild coffee	Chrysanthemoides monilifera	Asteraceae	Naturalised
African pepperwort	Lepidium africanum	Brassicaceae	Naturalised
swinecress	Coronopus didymus	Brassicaceae	Naturalised
wild raddish	Raphanus raphanistrum	Brassicaceae	Naturalised
red tungy	Opuntia elatior	Cactaceae	Naturalised
four-leaved allseed	Polycarpon tetraphyllum	Caryophyllaceae	Naturalised

green saltbush	Atriplex suberecta	Chenopodiaceae	Naturalised
nettle-leaved goosefoot	Chenopodium murale	Chenopodiaceae	Naturalised
old man saltbush	Atriplex nummularia	Chenopodiaceae	Naturalised
saltbush	Atriplex semibaccata	Chenopodiaceae	Naturalised
tallow-vine	Commelina diffusa	Commelinaceae	Naturalised
kidneyweed	Dichondra repens	Convolvulaceae	Naturalised
Bermudan cedar	Juniperus bermudiana	Cupressaceae	Naturalised
poison peach	Diospyros dichrophylla	Ebenaceae	Naturalised
common vetch	Vicia sativa	Fabaceae - Faboideae	Naturalised
furze	Ulex europaeus	Fabaceae - Faboideae	Naturalised
toothed medick	Medicago polymorpha	Fabaceae - Faboideae	Naturalised
red-eye acacia	Acacia cyclops	Fabaceae - Mimosoideae	Naturalised
willow	Acacia longifolia	Fabaceae - Mimosoideae	Naturalised
fumitory	Fumaria muralis	Fumariaceae	Naturalised
scarlet geranium	Pelargonium inquinans	Geraniaceae	Naturalised
New Zealand flax	Phormium tenax	Hemerocallidaceae	Naturalised
bull grass	Juncus capillaceus	Juncaceae	Naturalised
field woundwort	Stachys arvensis	Lamiaceae	Naturalised
least mallow	Malva parviflora	Malvaceae - Malvoideae	Naturalised
guava	Psidium guajava	Myrtaceae	Naturalised
black olive	Olea europaea subsp. africana	Oleaceae	Naturalised
creeping sorrel	Oxalis corniculata	Oxalidaceae	Naturalised
sour bell	Oxalis pes-caprae	Oxalidaceae	Naturalised
spoor	Pittosporum viridiflorum	Pittosporaceae	Naturalised
Cape grass	Sporobolus africanus	Poaceae - Poaoideae	Naturalised
cardinal grass	Paspalum urvillei	Poaceae - Poaoideae	Naturalised
cow grass	Paspalum scrobiculatum	Poaceae - Poaoideae	Naturalised
feathery windmill grass	Chloris virgata	Poaceae - Poaoideae	Naturalised
fowl's-foot grass	Eleusine indica	Poaceae - Poaoideae	Naturalised
giant rat's-tail grass	Sporobolus natalensis	Poaceae - Poaoideae	Naturalised
hay grass	Anthoxanthum odoratum	Poaceae - Poaoideae	Naturalised
kikuyu grass	Pennisetum clandestinum	Poaceae - Poaoideae	Naturalised
love grass	Setaria verticillata	Poaceae - Poaoideae	Naturalised
mat grass	Stenotaphrum secundatum	Poaceae - Poaoideae	Naturalised
nodding brome	Bromus pectinatus	Poaceae - Poaoideae	Naturalised
rescue brome	Bromus catharticus	Poaceae - Poaoideae	Naturalised
spreading meadow-grass	Poa pratensis	Poaceae - Poaoideae	Naturalised
spreading windmill grass	Chloris pycnothrix	Poaceae - Poaoideae	Naturalised
squirrel's-tail fesque	Vulpia bromoides	Poaceae - Poaoideae	Naturalised
summer grass	Ehrharta erecta	Poaceae - Poaoideae	Naturalised
Cape yew	Afrocarpus falcata	Podocarpaceae	Naturalised

blue pimpernel	Anagallis arvensis subsp. caerulea	Primulaceae	Naturalised
blackberry	Rubus pinnatus	Rosaceae	Naturalised
bilberry tree	Solanum mauritianum	Solanaceae	Naturalised
diddlydight	Solanum nigrum	Solanaceae	Naturalised
ink bush	Cestrum laevigatum	Solanaceae	Naturalised
wild billberry	Physalis peruviana	Solanaceae	Naturalised
wild tomato	Lycopersicon esculentum	Solanaceae	Naturalised
lantana	Lantana camara	Verbenaceae	Naturalised
ice plant	Mesembryanthemum crystallinum	Aizoaceae	Possibly native
bottle-brush sedge	Cyperus cyperoides	Cyperaceae	Possibly native
graceful sedge	Cyperus distans	Cyperaceae	Possibly native
wire grass	Cynodon dactylon	Poaceae - Poaoideae	Possibly native
pagoda plant	Cotula coronopifolia	Asteraceae	Probably native
thatching rush	Ficinia nodosa	Cyperaceae	Probably native
Angolan bristle-grass	Setaria welwitschii	Poaceae - Poaoideae	Probably native
annual beard grass	Polypogon monspeliensis	Poaceae - Poaoideae	Probably native
Cape beard-grass	Polypogon tenuis	Poaceae - Poaoideae	Probably native
tropical finger-grass	Digitaria ciliaris	Poaceae - Poaoideae	Probably native

Appendix 3: Native species considered for LEMP suitability

CommonName	Name	Family	Nativity (after Lambdon[1])	Suitable for LEMP?
babies'-toes	Hydrodea cryptantha	Aizoaceae	Endemic	Y
jellico	Berula bracteata	Apiaceae	Endemic	
dwarf jellico	Berula burchellii	Apiaceae	Endemic	
plastic fern	Asplenium compressum	Aspleniaceae	Endemic	
Barn fern	Ceterach haughtonii	Aspleniaceae	Endemic	y
gumwood	Commidendrum robustum	Asteraceae	Endemic	Y
bastard gumwood	Commidendrum rotundifolium	Asteraceae	Endemic	Y
scrubwood	Commidendrum rugosum	Asteraceae	Endemic	Y
false gumwood	Commidendrum spurium	Asteraceae	Endemic	
she cabbage tree	Lachanodes arborea	Asteraceae	Endemic	
black cabbage tree	Melanodendron integrifolium	Asteraceae	Endemic	
boneseed	Osteospermum sanctae-helenae	Asteraceae	Endemic	Y
whitewood	Petrobium arboreum	Asteraceae	Endemic	
he cabbage	Pladaroxylon leucadendron	Asteraceae	Endemic	
lobelia	Trimeris scaevolifolia	Campanulaceae	Endemic	
small bellflower	Wahlenbergia angustifolia	Campanulaceae	Endemic	Y
large bellflower	Wahlenbergia linifolia	Campanulaceae	Endemic	
St Helena goosefoot	Chenopodium helenense	Chenopodiaceae	Endemic	Y
tufted sedge	Bulbostylis lichtensteiniana	Cyperaceae	Endemic	Y
neglected tuft sedge	Bulbostylis neglecta	Cyperaceae	Endemic	Y
Diana's Peak grass	Carex dianae var. aequabilis	Cyperaceae	Endemic	
tree-fern	Dicksonia arborescens	Dicksoniaceae	Endemic	
large kidney-fern	Dryopteris cognata	Dryopteridaceae	Endemic	
small kidney fern	Dryopteris napoleonis	Dryopteridaceae	Endemic	
toothed tongue fern	Elaphoglossum dimorphum	Elaphoglossaceae	Endemic	
mossy fern	Elaphoglossum furcatum	Elaphoglossaceae	Endemic	
veined tongue fern	Elaphoglossum nervosum	Elaphoglossaceae	Endemic	
French grass	Euphorbia heleniana	Euphorbiaceae	Endemic	Y
tea plant	Frankenia portulacifolia	Frankeniaceae	Endemic	Y
old father live forever	Pelargonium cotyledonis	Geraniaceae	Endemic	Y
dwarf tongue fern	Grammitis ebenina	Grammitidaceae	Endemic	
St Helena filmy fern	Hymenophyllum capillaceum	Hymenophyllaceae	Endemic	
dwarf ebony	Trochetiopsis ebenus	Malvaceae - Dombeyoideae	Endemic	Y
redwood	Trochetiopsis erythoxylon	Malvaceae - Dombeyoideae	Endemic	
salad plant	Kewa acida	Molluginaceae	Endemic	Y
St Helena plantain	Plantago robusta	Plantaginaceae	Endemic	Y
cliff hair grass	Eragrostis episcopulus	Poaceae - Poaoideae	Endemic	Y
hair grass	Eragrostis saxatilis	Poaceae - Poaoideae	Endemic	Y

rock millet	Panicum joshuai	Poaceae - Poaoideae	Endemic	Y
lays back fern	Pteris paleacea	Pteridaceae	Endemic	
rosemary	Phylica polifolia	Rhamnaceae	Endemic	Y
dogwood	Nesohedyotis arborea	Rubiaceae	Endemic	
boxwood	Mellissia begoniifolia	Solanaceae	Endemic	Y
brown-scale fern	Pseudophegopteris dianae	Thelypteridaceae	Endemic	
black-scale fern	Diplazium filamentosum	Woodsiaceae	Endemic	
crevice fern	Cheilanthes multifida	Adiantaceae	Native	Y
African spleenwort	Asplenium aethiopicum	Aspleniaceae	Native	Y
hen-and-chicks fern	Asplenium lunulatum	Aspleniaceae	Native	Y
sickle fern	Asplenium platybasis	Aspleniaceae	Native	
samphire	Suaeda fruticosa	Chenopodiaceae	Native	Y
sticky fern	Hypolepis villoso-viscida	Dennstaedtiaceae	Native	Y
common tongue fern	Elaphoglossum conforme	Elaphoglossaceae	Native	
large buck's-horn	Huperzia saurus	Lycopodiaceae	Native	
buck's-horn	Lycopodiella cernua	Lycopodiaceae	Native	
hogweed	Commicarpus helenae	Nyctaginaceae	Native	Y
lily fern	Ophioglossum polyphyllum	Ophioglossaceae	Native	Y
fish-bone grass	Eragrostis cilianensis	Poaceae - Poaoideae	Native	Y
bayonet grass	Tribolium obliterum	Poaceae - Poaoideae	Native	Y
spotted tongue fern	Pleopeltis macrocarpa	Polypodiaceae	Native	
purslane	Portulaca oleracea	Portulacaceae	Native	Y
candlestick amaranth	Amaranthus thunbergii	Amaranthaceae	Probably native	Y
pagoda plant	Cotula coronopifolia	Asteraceae	Probably native	Y
salt-drip sedge	Cyperus laevigatus	Cyperaceae	Probably native	Y
thatching rush	Ficinia nodosa	Cyperaceae	Probably native	Y
proliferous spike-rush	Isolepis prolifer	Cyperaceae	Probably native	Y
bladder ketmia	Hibiscus trionum	Malvaceae - Malvoideae	Probably native	Y
annual beard grass	Polypogon monspeliensis	Poaceae - Poaoideae	Probably native	Y
Cape beard-grass	Polypogon tenuis	Poaceae - Poaoideae	Probably native	Y
Angolan bristle-grass	Setaria welwitschii	Poaceae - Poaoideae	Probably native	Y
comb-fern	Pteris dentata ssp. flabellata	Pteridaceae	Probably native	Y
plume fern	Christella parasitica	Thelypteridaceae	Probably native	Y

Appendix 4: Photographic record examples of changes at plots during the LEMP.

Figure A4.1: LEMP **gumwood forest and forest corridors** habitat category. Plot at Mulberry Gut.

Notes: Bare earth at commencement of project. Drip irrigation installed to establish plants. Significant growth in gumwoods over three years with canopy beginning to close. No significant flowering at this plot yet. Accumulation of leaf litter proving ground cover.

Figure A4.2: LEMP **eroded hillsides, soil crust restoration and semi-desert** habitat category. Plot at Bottomwoods.

Notes: Early planted hair grass has survived without irrigation and beginning to lay down leaf litter. LEMP maintenance team has held back incursion of introduced willow and poison peach but new seedlings are still germinating. Area to left of plot has been cleared and gumwoods planted.

Figure A4.3: LEMP **scrubwood scrub** habitat category. Plot at Cook's Bridge.

Notes: Bare earth starting point. Drip irrigation installed to help establish plants. Rabbit fencing essential to prevent damage from grazing. In 2020 irrigation has ceased, ebonies in top half of plot beginning to dry back as summer progresses. Scrubwoods well established and flowering moderately. Invasive wild mango bordering left of plot has been controlled by LEMP maintenance team.

Figure A4.4: LEMP **temporary streams and erosion gullies** habitat category. Plot in Dry Gut.

Notes: Thatching rush planted to reduce gully erosion has not survived. Saltbush and samphire are vigorous and dominant, habitat possibly too saline for thatching rush during drier periods. Salad plant planted in adjacent plot on left has been outcompeted by extensive dense samphire growth, some natural, some LEMP planted.

Appendix 5: Satellite photographs showing LEMP vegetation survey plot locations (copyright for all images from Airbus CNES 2017 with St Helena Government.)

Figure A5.1: Rupert's Valley

Figure A5.2: Haul Road pull in and Pipe Ridge

Figure A5.3: Haul Road at Mulberry Gut and Colt Sheds

Figure A5.4: Haul Road between Longwood Farm and Bottomwoods

Figure A5.5: Bottomwoods towards Millennium Forest

Figure A5.6: Weather Station junction

Figure A5.7: Millennium Forest to Bradley's junction

Figure A5.8: Cook's Bridge

Figure A5.9: Airport road from Cook's Bridge to Bone Gully

Figure A5.10: Central Basin

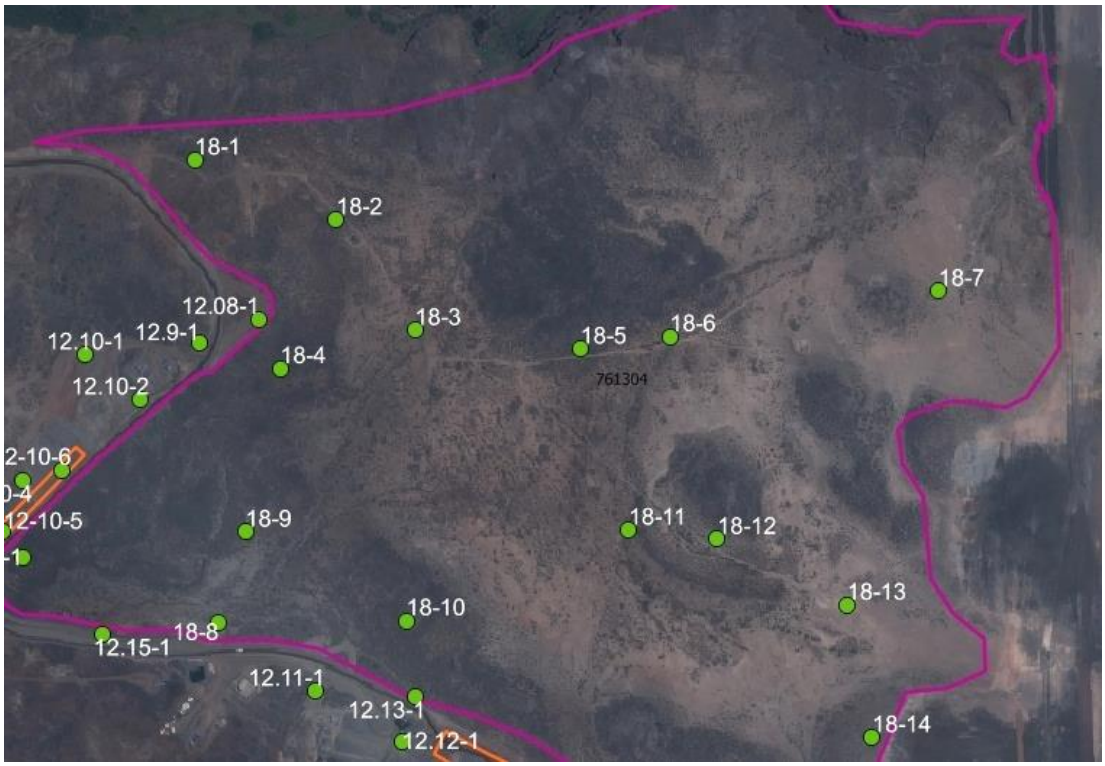


Figure A5.11: Airport road from Bone Gully to airport terminal and Dry Gut

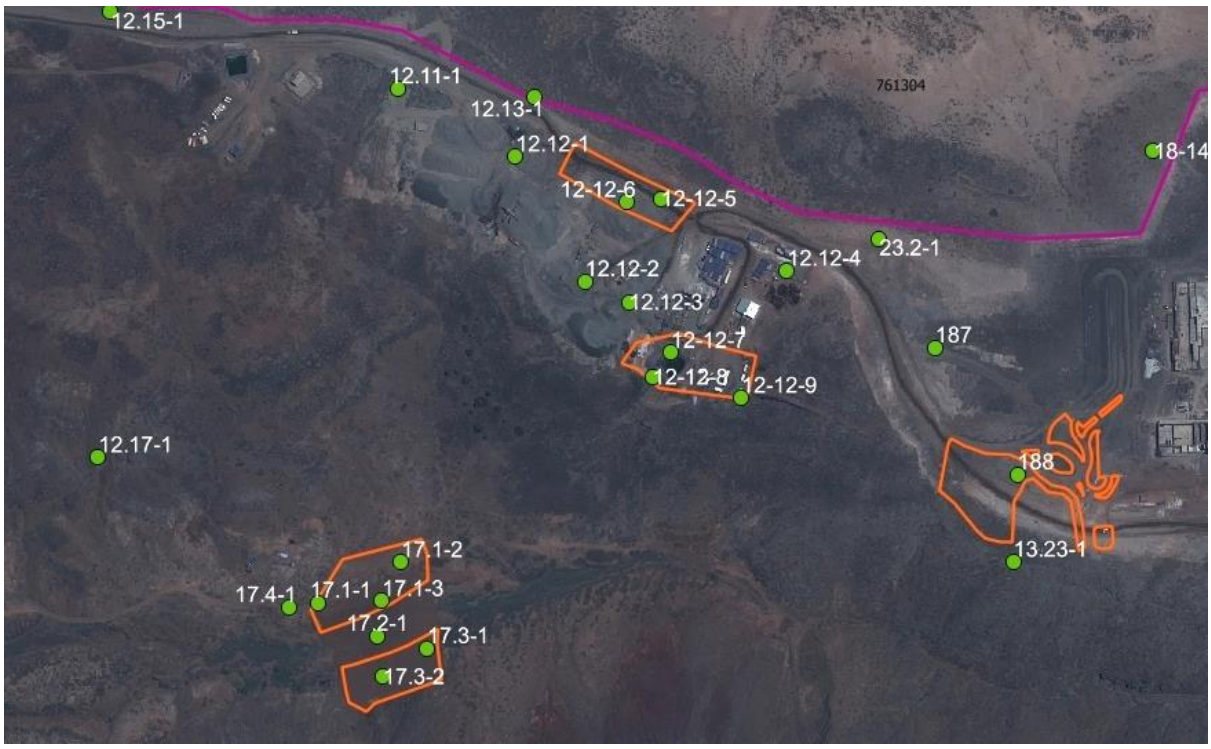


Figure A5.12: Runway terraces

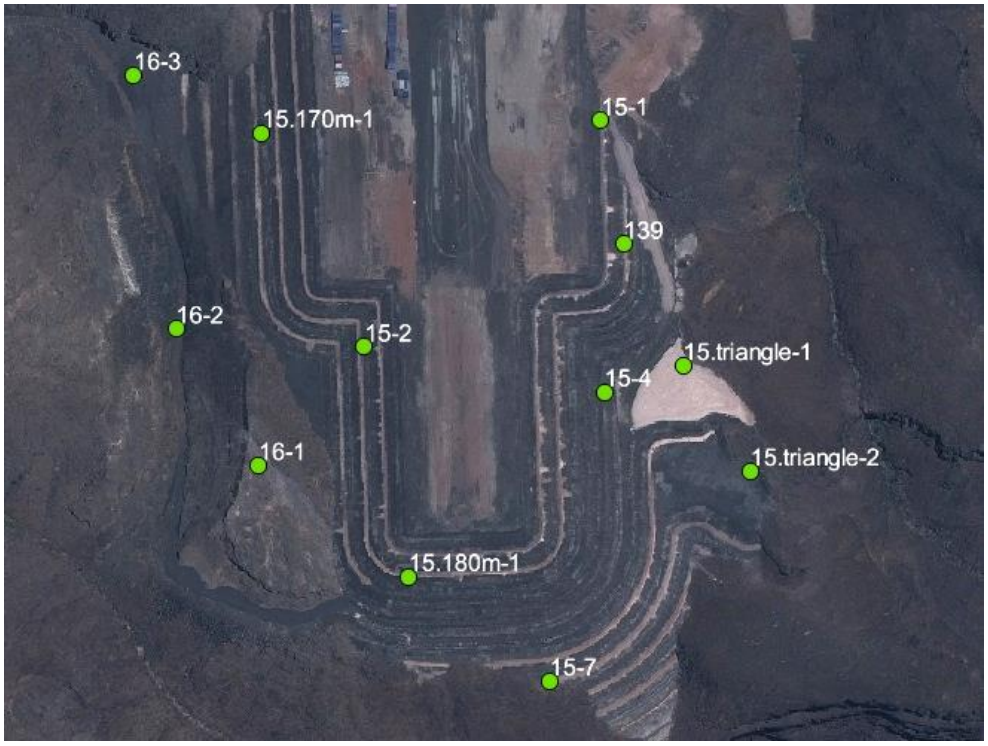


Figure A5.13: Peak Dale and Blue Point