

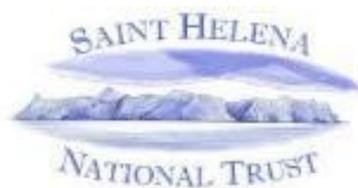
Invertebrate survey in LEMP zones

Final report

For the
Landscape and Ecology Mitigation Programme (LEMP)



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St Helena

St Helena is one of the UK's Overseas Territories. A small, volcanic, oceanic island located in the South Atlantic Ocean, approximately 1,800km from the west coast of Angola, and 3,200km from the east coast of Brazil. This island is home to many endemic plants, a single endemic land bird and substantial marine life, and it is host to a wide array of endemic invertebrates. Around 30% of the endemic species of the UK and its Overseas Territories together are found on St Helena (Churchyard *et al.*, 2014).



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Figure 1: Map of St Helena

Project objectives

The Landscape and Ecology Mitigation Programme (LEMP) for the St Helena Airport Project (SHAP) aims to reinstate, actively improve, or compensate for areas disturbed by, or lost to, the construction of St Helena's airport. This includes considerable work to recreate and restore areas of endemic habitat as well as work to protect and enhance existing natural areas.

Surveys were commissioned to investigate invertebrate presence within selected LEMP endemic planted zones, in particular whether endemic invertebrate species have migrated into and between the LEMP zones since planting started in 2016. Zones surveyed were in the areas of Prosperous Bay Plain, Bottom Woods and selected zones along the Haul Road to Mulberry Gut.

Aims of the surveys during this project were to investigate:

- Number of endemic and non-native species per zone, and comparisons between zones
- Any associations between the plant and invertebrate species
- Presence of specialist endemic and invasive species

Background

There have been studies on St Helena's invertebrate fauna as far as back as the 1700's, and more recently in 2017 through Darwin Plus funded projects (DPLUS040 & DPLUS029). The area of Prosperous Bay Plain alone presents high endemism with some 20 endemic species and 5 endemic genera of invertebrates (Ashmole and Ashmole, 2004).

This current survey has presented an opportunity to study whether invertebrates are utilising LEMP rehabilitated areas, no baseline surveys were undertaken in any of these areas before mitigation works began. In addition, the invertebrates which may be found in these habitats provide an indication of species mobility and ability to colonise areas, as well as the health of these ecosystems and their recovery.

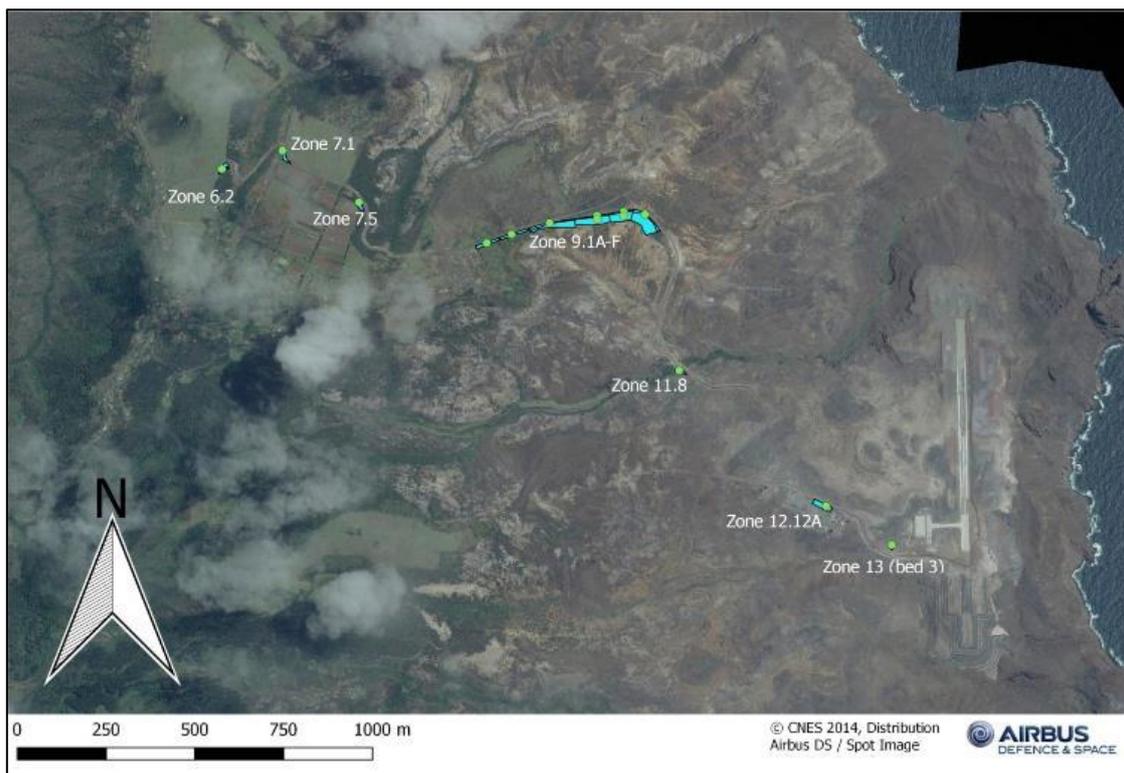


Figure 2: Map of LEMP zones surveyed

The LEMP zones (Fig 2) within the areas from the Millennium Forest, Bottom Woods to the Colt Sheds and Mulberry Gut were once known as the Great Wood. With a perimeter of 13.7 km (8.5 miles) enclosing some 1400 acres (570 hectares) in area (Ashmole and Ashmole, 2000), the Great Wood stretched from Horse Point to Bottom Woods, Flagstaff, Deadwood Plain and throughout Longwood, possibly further. This area was once a forest dominated by an endemic canopy forming plant species, the Gumwood (*Commidendrum robustum*), and was also a primary habitat for two iconic endemic invertebrates, the Giant ground beetle and the Giant earwig (Ashmole and Ashmole 2000). It is possible that the ground covering endemic plants such as Hair grass (*Eragrostis saxatilis*) and Dwarf ebony (*Trochetiopsis ebenus*) also existed there, as they can be found at similar altitudes elsewhere on the island. Endemic scrub such as the Scrubwood (*Commidendrum rugosum*) would likely have been found in the surrounding area.

Coexisting with these flora rich habitats would have been a unique and considerable assemblage of endemic fauna. Many of St Helena's endemic invertebrates are commonly associated with specific endemic plant species such as the Gumwood leafhopper (*Sanctahelenia decellei*) and the Scrubwood leafhopper (*Atlantocella leleupi*).

In the Prosperous Bay Plain area there is an extraordinary concentration of endemic invertebrates (Ashmole, 2004) in many taxa, some of which are only found in this area including spiders (e.g. the undescribed 'Mole spider' in the Lycosidae genus), beetles (e.g. the Giant ground beetle, *Aplothorax burchellii*) and moths (several flightless short winged moths in the *Opogona* genus).

Methodology

Surveys were conducted from the 11th May to 13th May 2020 in the selected LEMP zones. These zones were purposely chosen through consultation with LEMP staff, to investigate if the new plantings were providing habitat for associated invertebrates and in relation to endemic plant species that are found in naturally occurring or restored habitats in the surrounding areas. For example, in zone 11.8 at Cook's bridge, Scrubwoods were planted by LEMP due to the proximity of natural populations found at the nearby motocross track and Horse Point. In zone 7.5 (Piccolo), Gumwoods have been planted and maintained in close proximity by the St Helena Government (SHG) for many years, and old natural Gumwoods were once present in the area. Also, Gumwoods were planted at the Millennium Forest site in the 80's and intensive Gumwood habitat restoration efforts have been on-going since the Millennium Forest project was officially established in 2000, then led by the Trust since 2002.

All of the survey sites extend from the Airport along the Haul road to Mulberry Gut, which included the following Zones:

Table 1: Zones and their locations

ZONES	LOCATIONS
13 (BED 3)	Airport
12.12A	Site Compound
11.8	Cooks Bridge
9.1 A-F	Corridor that extends from Bottom Woods to the Millennium Forest; includes both reinstatement and compensatory areas
7.5	Piccolo near the LEMP nursery
7.1	Colt Sheds
6.10	Mulberry Gut

At each site a point was established within the restored habitat, GPS coordinates taken and a 5 meter radius measured or founded visually around the point if vegetation proved too dense; this method has been adapted from the DPLUS029 project survey methodology.

There were times when the 5 meter radius would extend past the fence line at the edge off the zones (anything outside of the LEMP fence was excluded), and some zones were also narrow (approx. 3-4 meters width) in places so a 5m radius was not always possible (Photo 1). Once the plot was marked out, this was followed by a vegetation survey, sweep netting of all vegetation present, and the collection and sieving of two random samples of leaf litter targeted to the endemic flora present (largely Gumwood, Scrubwood, Ebony), to investigate the ground dwelling invertebrate fauna within endemic leaf litter. All invertebrates were released after identification was completed.

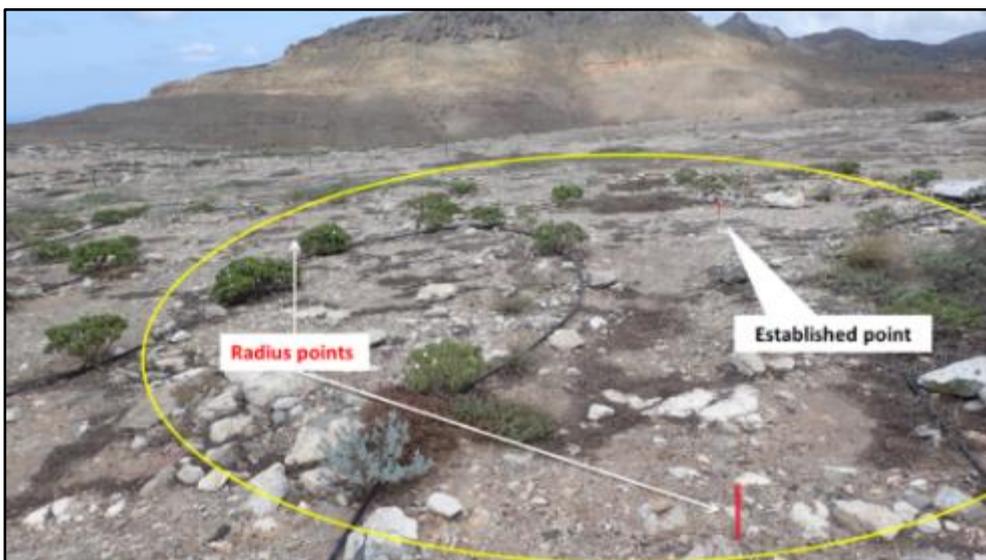
Both quantitative and qualitative data were used to inform the results. Quantitative data were obtained through the survey results (species counts etc.) and qualitative data were obtained through researching and referencing previous reports on species presence previously recorded in the surrounding areas (Fowler *et al*, 2018; Ashmole and Ashmole

2000; 2004). Additionally, observations were taken on weather conditions during the survey, vegetation presence and other potentially relevant information.

Photo 1: Narrow planting zone where the 5 meter radius extends beyond the fence.



Photo 2: Survey set up in zone 12.12A near Mole Spider Hill with 5m radius established.



Habitats Description

Prosperous Bay to Fisher's Valley is an arid, semi-desert area which has dryland perennial (e.g. Samphire, *Suaeda fruticosa*) and annual (e.g. Babies toes, *Hydrodea cryptantha*) vegetation, of endemic, native and non-native species.

Areas adjacent to the Millennium Forest are plagued by the effects of erosion which have left hard marl exposed. Efforts at the Millennium Forest and by LEMP are attempting to rehabilitate these areas by re-establishing and maintaining this endemic species rich habitat. Some of the LEMP zones, particularly in the Bottom woods area, have

been successfully established with native dryland vegetation. There is a noticeable improvement in vegetation growth and soil quality in the LEMP zones closer to Piccolo and Mulberry Gut (Appendix 3: map 2).

All areas surveyed consisted of dryland vegetation, Appendix 1: table 3 displays details of what plants were introduced into each zone from 2016-17. Appendix 2 shows habitat photographs.

Results & Discussion

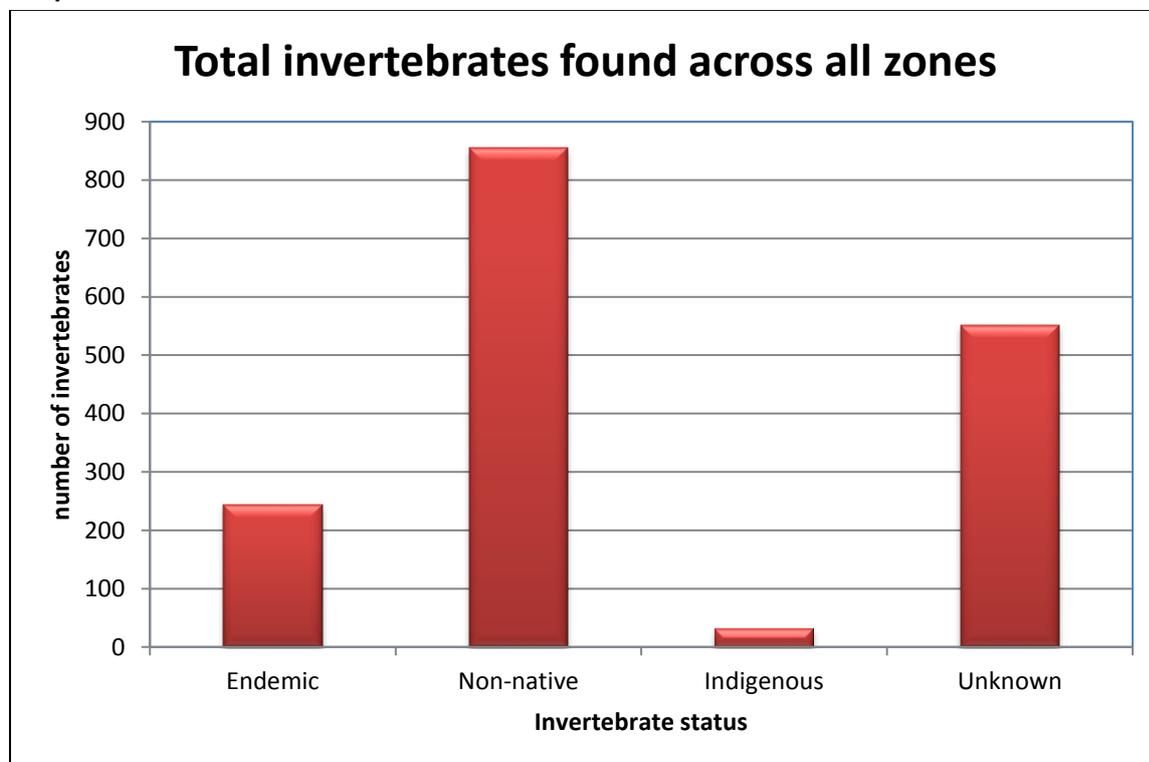
There was a total of one thousand six hundred and eighty-two invertebrates recorded collectively from the selected zones. The most abundant category amassed were non-native species with eight hundred and forty-four specimens (50%); followed by two hundred and forty two (14%) endemic specimens; and thirty one (2%) indigenous specimens; with the remaining number, five hundred and sixty-five (34%), of unknown status.

The specimens were identified in 36 Orders; non-natives totalled 15 Orders, the endemics made up three orders, the indigenous one Order, and the unknown were in 17 Orders (Appendix 1: table 10).

Although high invertebrate abundances were recorded, there were only 47 individual invertebrate species identified throughout the selected zones (Appendix 1: table 6). Most of these consisted of non-native species (31), which made up 66%, and five were endemic species, which makes up 11% of endemic species identified.

Graph 1 below shows the numbers of invertebrates recorded across all the selected LEMP zones. As noted above, the totals are dominated by non-native invertebrates. These are able to efficiently adapt to changes within their environment allowing shorter time to become established than the endemic species; this means non-natives eventually out-compete endemic species, as has been seen globally.

Graph 1: Invertebrates found across all zones

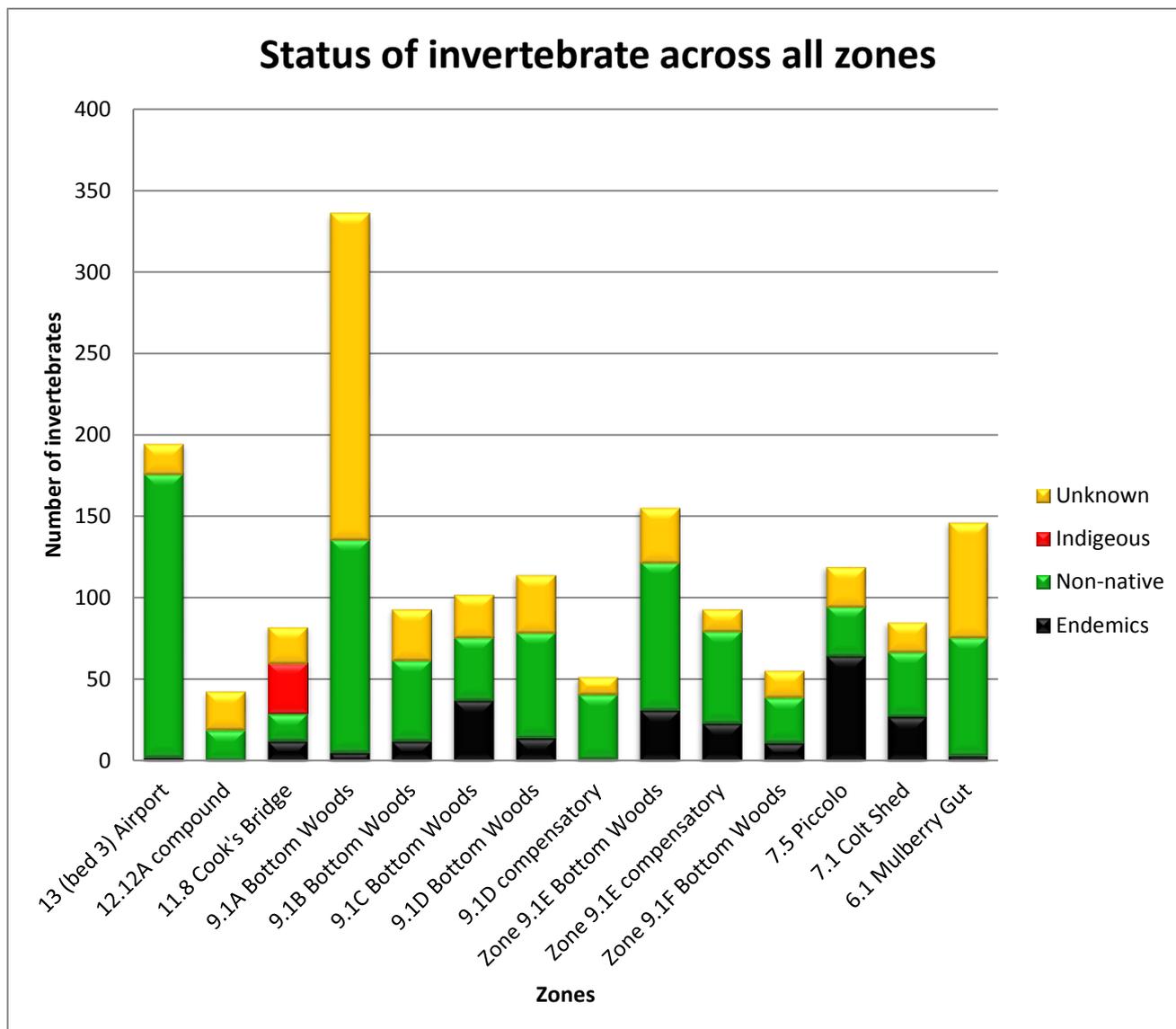


The survey data collected indicates that endemic invertebrates have recolonised all of the selected rehabilitated LEMP planting zones, except 12.12A. In this zone planting commenced in 2016-2017 (Appendix 1: table 9); however, only

invertebrates of non-native and unknown status were found, and are thus assumed to be established, during this survey. This highlights the potential issue the high number of non-native predatory invertebrate species recorded presents, which will need to be addressed for the benefit of the endemic flora and fauna.

The zones with the highest number of specimens recorded were 9.1A, 9.1E, and zone 13 (bed 3) at the Airport, with over 150 records in each of these three zones. Zones 6.1 Mulberry Gut, 9.1A and 9.1D compensatory and 13 (bed 3) Airport had the least endemic specimens recorded (less than 5). Zone 12.12A site compound had no endemic invertebrate presence identified; however it is possible that some of the unidentified invertebrates could be endemic.

Graph 2: Status of inverts across all zones



Endemic invertebrates in zones

The indigenous invertebrates were the least recorded; however, zone 7.5 Piccolo had the highest count of endemics specimens within the selected LEMP zones. The endemic vegetation in zone 7.5 Piccolo was planted in 2017, the vegetation (Appendix 1: table 1) in this zone is healthy and thriving; the young gumwood canopy is closing and has become very dense.

The high numbers of endemic invertebrates recorded in zone 7.5 could be attributed to the surrounding vegetation containing ground cover, shrub and larger non-native canopy species - which provide favourable conditions for the

invertebrates through the provision of shelter from the natural elements and moisture retention compared to zones 9.1 A or Zone 13 (bed 3) at the Airport.

In addition, the short distance between zone 7.5 and the SHG Conservation section's older Gumwood plantings at Piccolo Hill, could have encouraged migration of endemic species to this site. Records (extracted from the St Helena National Trust's St Helena Invertebrate records database¹) show that surveys conducted in 2006 documented the presence of the Gumwood leaf hopper at Piccolo Hill. The soil in the zones from 7.5 Piccolo, 7.1 Colt sheds and 6.1 Mulberry Gut is also likely to be especially fertile which in turn is beneficial for the endemic flora and consequently the endemic fauna.

Zones 9.1C, 9.1E and zone 7.1 Colt Sheds have similar invertebrate numbers recorded. Zone 7.1 is located near to zone 7.5 Piccolo Hill but is a more exposed site i.e. without larger canopy species nearby; however, the endemics planted are also growing densely. This lower portion of this zone is sheltered from strong winds from the formation of the landscape which descends into a gut.

It is interesting to compare these two zones (7.5 Piccolo and 7.1 Colt Sheds) to 9.1C Bottom Woods which also has a good number of endemic invertebrates recorded. Zone 9.1C is located in the middle of zones 9.1A-F of the Bottom Woods corridor (Appendix 3, map 2) and is somewhat more exposed to the coastal winds and elements than 7.1 and 7.5. The Gumwoods growing in zone 9.1C are also closely planted with older established Gumwoods forming a dense canopy therefore providing shelter. It is possible that the health of the Gumwood trees and the dense growth in these three zones has contributed to ensuring the establishment and retention of the endemic biodiversity within this whole area, where the Great Wood once existed.

Zone 13 (bed 3) had the lowest numbers of endemic specimens (2) recorded. The plantings in this zone consist of shrub and ground cover species such as the Scrubwood and Hair grass (Appendix 1: table 3). This zone was planted in 2016 and it was interesting to find the St Helenian long-winged stilt bug (*Metacanthus concolor*) there, considering there are no wild Scrubwoods present in the immediate surrounding area, the closest being across the airport at King and Queen Rocks, or across the valley at Great Stone Top. This invertebrate has found its way to its preferred plant species and over time the population will possibly increase. LEMP has recently increased the number of scrubwoods planted in the surrounding area which also has positive implications for this population over time.

Non-native invertebrates in zones

The non-native invertebrates were recorded in high numbers throughout all selected zones. Zone 13 at the Airport has the highest, closely followed by 9.1A and E.

Zone 13 (bed 3) was planted predominantly with Scrubwood, which is a low growing scrub species possibly providing shelter for invertebrates from the elements. This area is prone to strong winds and high moisture blown in from the sea that might be offering additional conditions that these non-native invertebrates find favourable.

In contrast to the Scrubwoods in zone 13 (bed 3), zone 9.1A and 9.1E contains Gumwoods, a tree (canopy) species. Slightly lower numbers of the non-native invertebrates were recorded in 9.1 A and 9.1E, possibly suggesting that the height of these trees are affecting the abundances of non-natives. Taller and sparser vegetation provides less protection from the elements. It is possible that many of these invertebrates have already evolved adaptations that allow them to occupy niches wherever possible for survival. There has been a common trend between the heights of the trees, and the reduction in invertebrate numbers recorded throughout the selected zones, see the specialised invertebrates section on page 11 for more detail.

¹ The master copy of this database is held by Roger Key (based in the UK) and updated periodically in collaboration with the St Helena National Trust.

Unknown and indigenous invertebrates in zones

Out of all the invertebrates found, those listed as indigenous have the lowest counts and the unknown had the most counts (graph 2) throughout the survey. These could only be identified to their Order and Family in the field; further work to identify these to species level would require microscope analysis and/or consultation with experts, and the agreed timescale for the survey did not allow for this further analysis. It is possible though, that some of these invertebrates recorded as unknown in the field were a mixture of endemic and/or non-native species.

Zone 11.8, which is planted predominantly with Scrubwoods, also has some endemic Boxwoods (*Melissia begoniifolia*) planted which is of the Solanaceae family. The Death's-head hawk moth larvae were the only indigenous species recorded from this zone. It is not unusual to find this larva on Boxwoods as this species has a preference for flora within the Solanaceae family.

Invertebrates found on plants

On the endemic plant species six hundred and seventy six invertebrate specimens were identified of which 212 (31%) invertebrates were endemic, 228 (34%) were non-native, 31 (5%) were indigenous and 205 (30%) were unknown. Compared to non-native plant species where three hundred and sixty eight invertebrate specimens were identified of which 28 (8%) invertebrates were classified as endemics and 135 (37%) as non-native and 205 (56%) were unknown.

The Gumwood leafhopper (*Sanctahelenia decellei*) was found on Gumwoods throughout the selected zones, and St Helenian long-winged stilt bug (*Metacanthus concolor*) was only found on the Scrubwoods in zone 13 (bed 3) at the Airport. These specific invertebrates have a symbiotic relationship with these endemic plant species.

The endemic flies, the St Helenian asteiid fly (*Anarista vittata*) and the St Helenian muscid (*Limnophora helenae*) were also recorded on Gumwoods and the endemic Dwarf Ebony. The St Helenian asteiid fly can be found in drier parts of the island (Rupert's, Fisher's Valley and Prosperous Bay Plain), and the St Helenian muscid is found across the island in a wide-range of habitats. Both of these species have been previously recorded in the area of the Millennium Forest (Fowler, L. *et al*, 2018).

The non-native invertebrates appear to have become established in the selected LEMP zones and 32 invertebrate species were also recorded on endemic plants throughout, but in low numbers.

The highest abundance of non-native invertebrates was found on Hair grass, Gumwoods, Scrubwoods and Dwarf Ebony; mainly consisting of ants and the Doherty's bug (*Trigonotylus tenuis*). Little is known about the Doherty's bug however, it has a preference for feeding on plants in the Poaoideae family. As a Poaoideae feeder, this 'true bug' may pose little threat to the endemic flora as other non-native grasses, rush and sedges are present in these zones and the surrounding areas.

Ants, in addition to being found on the aforementioned plant species, were also found on the endemic St Helena tea plant (*Frankenia portulacifolia*). Ants are a problematic species island-wide, including in the natural endemic habitats and restoration areas (e.g. Millennium Forest). Ants can degrade or alter ecosystems by creating nests underground or in hollow / dead trees which deteriorates the soil/ tree structure. They also strip decaying deadwood which is normally used by other invertebrates, for example, previous surveys in gumwood forest have revealed a very high proportion of larger deadwood harbours ant nests rather than endemic saproxylics (Roger Key, Pers. comm. January 2014). Ants also increase the presence of certain pest species as they have a symbiotic relationship with aphids and scale insects which they harvest for honeydew, in turn increasing pest populations. A method of control should be researched to reduce their numbers in conservation areas which will likely increase endemic invertebrate populations.

Invertebrates found in leaf litter

Leaf litter from the area immediately under or around the endemic plants were searched in all zones, apart from Zone 9.1 D compensatory; this zone had very little litter available for a comprehensive survey to be completed (as the plants have been planted relatively recently 2019).

Over 500 invertebrates were present in leaf litter across the zones, of which only two (less than 1%) of the total were identified as endemic invertebrates, 81% of the total were non-native and the rest were unknown invertebrates that were unable to be identified to species level.

Only one individual Gumwood leafhopper and St Helenian long-winged stilt bug were identified in the leaf litter. The Gumwood leafhopper was found amount St Helena Rosemary leaf litter, and the St Helenian long-winged stilt bug was unearthed amongst the Scrubwood leaf litter. These invertebrates might have been resting or travelling between plant species.

The Gumwood and Dwarf ebony leaf litter had the highest abundance of invertebrates recorded consisting mainly of ants and ghost cockroaches.

The Ghost cockroaches (*Balta longicercata*) were found in Zones 11.8, 6.2, 7.1 and in the Bottom Woods corridor (zone 9.1); in addition to the high numbers found in Gumwood and Dwarf ebony leaf litter, they were also present in leaf litter of the Hair grass and St Helena Rosemary.

There is very little information available on this species of cockroach, however, it is surmised that this cockroach has a preference for Gumwood leaf litter as they were found at all zones containing Gumwoods, in high quantities. It is found mainly outdoors on St Helena, it is assumed that it could be feeding on the dead and decaying plant matter in these areas.

A noteworthy find was of 8 false scorpions recorded in the Gumwood leaf litter at zone 6.1 Mulberry Gut which indicates that this site has a good ecosystem. This is because this species predated on smaller soft bodied invertebrates such as caterpillars and booklice, and their presence on this site likely means there are a lot of small arthropods to sustain them which is a positive result considering this is a rehabilitated site established in 2016. The false scorpion is very difficult to classify to species level without specialist examination. Further investigation on the false scorpion is needed to investigate why they were only found at Mulberry Gut.

Although the non-native invertebrates are dominant among the leaf litter in the LEMP zones; some small invertebrates (such as mites, which have not been identified to species level) could be predated on other arthropods in the leaf litter. A selected few which occur in the Millennium Forest supports the breakdown of natural matter creating a build-up of soil.

Specialised invertebrates

Sanctahelenia decellei (Hemiptera: *Sanctahelenia*)

The endemic Gumwood leafhopper has been assessed as Vulnerable on the IUCN Red List of Threatened Species, and is associated with the endemic Gumwood. Previous surveys have revealed a large population of Gumwood leafhoppers at the Millennium Forest, which is adjacent to some of the LEMP 9.1 zones, so it was anticipated that this species would be found in these LEMP zones.

During this survey this species was found on non-native plant species, as well as on endemics (see table 2 below). The majority were found on the Gumwoods which could indicate that they use other vegetation as a respite or as a stepping stone between the Gumwoods.

Table 2: Presence of Gumwood leafhopper on plant species

Types of plant species the Gumwood leafhopper were present on	
Endemic plant species	Non-native plant species
Dwarf ebony (<i>Trochetiopsis ebenus</i>)	Kikuyu grass (<i>Pennisetum clandestinum</i>),
Gumwood (<i>Commidendrum robustum</i>)	Kidney weed (<i>Dichondra repens</i>),
Hair grass (<i>Eragostis saxatilis</i>)	Smooth sow thistle (<i>Sonchus oleraceus</i>)
St Helena Rosemary (<i>Phyllica polifolia</i>)	Ink bush (<i>Cestrum laevigatum</i>)

Positively, the Gumwood leafhoppers were recorded from all survey zones in which Gumwoods have been planted, excluding zones 9.1 D compensatory and 9.1 E compensatory. These sections were more recently planted (in 2019) and the height of the Gumwoods ranges from 60-65cm. This shows that the species can successfully colonise areas of restored habitat. The likelihood of the Gumwood leafhopper colonising Zones 9.1 D compensatory and E compensatory is extremely high as they are already present in the Bottom Woods corridor (LEMP zones 9.1A to 9.1F), therefore it can be construed that once the plants in the compensatory areas have matured the Gumwood leafhopper will then start to colonise these zones.

From the data and observations recorded, it would appear that this species is not affected by density of the Gumwoods or exposure to the elements, as they were found in low numbers at Zone 9.1F where the Gumwoods are sparse and exposed and in Zone 6.2 where the Gumwoods are denser, and less exposed to the elements. However, it is possible that the population size could be associated with age and height of Gumwoods. For example, in zones 9.1E and 9.1F the maximum height of the Gumwoods (planted in 2017) was 90 cm and the leafhopper presence recorded was low. Leafhopper presence appears to increase in zones which are more established (older), and in which the Gumwoods are taller (above 90cm).

However, at zone 6.1 (Mulberry Gut) there were also low numbers of this species recorded. This zone is more established (planted in 2016) and has taller trees (over 150cm); the low numbers of leafhopper found could be due to the relative isolation of this zone (see map) as the nearest Gumwood population is at the Colt Sheds (planted by LEMP).

Photo 3: Gumwood leafhopper (*Sanctahelenia decellei*)



***Metacanthus concolor* (Hemiptera)**

The St Helenian long-winged stilt bug (*Metacanthus concolor*) is classed as Vulnerable on the IUCN Red List of Threatened Species. It is primarily associated with Scrubwood (*Commidendrum rotundifolium*), but can be occasionally found on other vegetation. *M.concolor* was thought to be extinct but rediscovered in 1995, feeding on Scrubwood at Flagstaff, Rupert's, Powell's Valley and Joan Hill (Ashmole and Ashmole, 2000).

Photo 4: The St Helenian long-winged stilt bug (*Metacanthus concolor*)



Two individuals were found on the Scrubwoods in Zone 13 (bed 3) at the Airport. Previous records show that they have been recorded from the surrounding areas of Turk's Cap, The Barn and can be regularly found at Pipe Path. This species has wings the length of its body, but there have been no studies to find out whether they have the ability to travel long distances; they could be mobile or it is possible that they are able to be relocated by wind. Records show that this species have been found in the neighbouring areas of Turk's Cap, The Barn, Flagstaff and Pipe Path and in areas of Joan Hill, Peak Dale, Sandy Bay and Pink Grove, Levelwood where they have been found on other plant species. This is an example where conservation efforts that have increased Scrubwood planting and distribution have increased this species' area of occupancy. This shows that endemic species will travel a great distance to find suitable new locations, as the closest site of this species is just under 6km away at The Barn.

The St Helenian asteiid fly, *Anarista vittata* is possibly an endemic, but little is known about this species or the Family. It has been suggested however, that they may be scavengers in the frass of other insects (Key, R. *et al* Terrestrial & Freshwater Invertebrates of St Helena (unpublished). This species was found in five of the LEMP zones (Appendix, table 7), and is not confined to just one habitat as zone 11.8 is Scrubwood dominated, whereas zone 9.1 is Gumwoods. Perhaps this species of fly has a preference for endemic plants in the Asteraceae family, which both the Scrubwoods and Gumwoods are.

The ground dwelling Simple darkling beetle, *Gonocephalum simplex hadroides* was found in Zone 9.1F, but it is not unusual to find them in this area as they were documented from previous records in the Millennium Forest and Prosperous Bay Plain.

Predators

Thirty three percent (33%) of the invertebrates identified during the survey were predators, of which 28% are non-native. Predator species that will cause the most harm in these zones are:

Ants (Hymenoptera: *Formicidae*)

There are 15 non-native ant species recorded on St Helena. They are very destructive predators and their food palate is very extensive (meat, plants, fungus, seeds, plants and sugary liquids like nectar). This species can survive in all conditions and terrains and they are often found nesting in the soil, under stone or logs and in decaying wood (both on the ground and in living trees).

Ants have been recorded at all zones, but the highest numbers were at the Airport, zone 13 and at Bottom Woods, zone 9.1A. The majority of the ants were found in the leaf litter. The vegetation at the Airport zone is predominantly endemic and ants are well established in this zone, considering it has recently been under construction (2016).

The majority (55%) of ants were recorded on Gumwood, Dwarf ebony and Scrubwood plants or in their leaf litter. It is unclear why a high number of ants were found on these endemic plant species, but one of the threats this group present to endemic plants is the protection of pest species such as mealy bugs and scale insects from predators, which will then increase the pests populations and cause stress to the plants.

Also, ants might affect the endemic invertebrates that are normally found in the leaf litter as a very high proportion of larger dead wood harbours ant nests rather than endemic detritivores (Key, 2014). If the ants are not managed they can threaten the endemic invertebrates as they have no natural defences towards this group, and ants can deteriorate or destroy sensitive habitats overtime.

Spiders (Araneae)

Spiders predate on a wide range of invertebrates; less than 100 spiders were recorded during the survey of all zones. Eighty one percent of the spiders found were on endemic plant species including the Dwarf ebony, Gumwood, Hair grass, Scrubwood and St Helena Rosemary (*Phyllica polifolia*). The Hairy Field spider, *Neoscona* sp. (*N. rufipalpis* and *N. hirta*) and Garden spider, *Argiope trifasciata* are known to be a major threat towards the endemic invertebrates in the Millennium Forest, where they have been observed catching the Gumwood leaf hopper in their webs. The Garden spider has also been listed among other spiders as likely threats to the St Helena's endemic species (Key, 2014).

The Hairy Field spider, *Neoscona* sp. was found on the endemic plant species Gumwood and St Helena Rosemary. These species are nocturnal, which means that they are a threat towards the endemic moth species, like the Daisy Tree Snout Moth (*Homoeosoma privata*), another species which is associated with the Gumwoods.

The Garden spider, *A.trifasciata* was recorded on endemic plant species of Gumwoods, Hair grass and St Helena Rosemary, and non-native plant species of Hairy fleabane (*Conyza bonariensis*) and Kikuyu grass. During the survey in zone 7.1 at the Colt Sheds, it was observed that Gumwood leafhoppers were caught in a Garden spider's web. Consequently, this species is a threat to endemic invertebrates and should be removed from endemic habitats where possible.

Spiders are generalised predators and pose threats to the endemic invertebrate fauna. *Neoscona* sp. and *Argiope trifasciata* are likely to cause a decline in endemic flying invertebrate's populations, such as the Gumwood leafhopper and Daisy Tree Snout Moth, over time if not controlled. Further spider studies are needed to find out the abundance and impact they are having on endemic invertebrates.

***Acherontia atropos* (Lepidoptera)**

Although, the Death's-head hawkmoth moth poses no threat to the flora, the larvae (caterpillar) is of concern, as it has a preference for the endemic Boxwoods (*Melissia begoniifolia*), and has been known to decimate these plants. This species is the largest moth on the island and so is their larvae. Thirty one *A.atropos* caterpillars were only recorded at Cook's Bridge (zone 11.8) on the endemic Boxwoods which is in the Solanaceae family. The LEMP staff regularly checks and remove caterpillars from the Boxwoods, which benefits the plants health; however, when the LEMP project ends, consideration should be given towards continuing this work to protect the Boxwoods, as they are particularly attracted to this species.

Conclusion

The established LEMP plantings are healthy; this is shown by the diversity of invertebrate fauna that has colonised endemic plants from their canopy to ground cover levels- including in leaf litter- in such a short period of time.

The non-native invertebrates have been noted to increase their population sizes quicker than the endemic. However, discovering the Scrubwood-associated invertebrate, the St Helenian long-winged stilt bug (*Metacanthus concolor*) at the airport zone 13 (bed 3) is positive as it has a larger distance to travel to seek its preferred habitat or host plant, than that of the Gumwood leafhopper.

It is also an encouragement to find that ground dwelling beetles have moved into these areas from the surrounding environment. This aids recognition of the potential for other scarce or rare invertebrates colonising new habitats.

Many of the unknown invertebrates recorded could possibly be endemic, particularly the very small wasps. Many wasps are parasitic to other invertebrates, which are possible natural bio-controls for small pest species in these ecosystems.

To find that endemic invertebrates have migrated into these restoration zones during the four years since planting began is a positive outcome following the construction and the disturbance caused by the airport project. It has been shown in the results of this survey that as endemic plants such as the Gumwoods mature, the associated endemic invertebrate populations (Gumwood leafhopper) will also largely increase.

Recommendations

Following this survey it is recommended that further seasonal and nocturnal invertebrate surveys should be conducted in the LEMP zones to establish a comprehensive baseline of the areas and encompass groups that are affected by weather, as many invertebrate have a specific breeding season (beetles), and others are sensitive to temperature changes, becoming less active in the cooler weather or light.

Restoration work should be continued, especially through the creation of corridors or stepping stones which link the new restoration areas (LEMP and Millennium Forest) with the older habitats wherever possible, particularly focussing on the surrounding areas of Prosperous Bay Plain, Longwood (Piccolo Hill), and Flagstaff, and beyond in the future. This would be beneficial in helping to assist species that can only move short distances increasing endemic invertebrate populations. Basic maintenance of habitats should also continue in order to maintain and improve the quality of the restored habitats.

It is highly recommended in future that surveying is carried out before initial mitigation works and after plantings have established in zones. As the data collected from these surveys can be analysed and used to compare existing species

and new species, this could potentially indicate the rate of colonisation of both endemic and non-native invertebrate species.

Targeted surveys on predator species such as spiders and ants should be considered to investigate their abundance so estimates can be made on their impact on the endemic invertebrate species (both daytime and nocturnal) and what potential control methods could be researched and trialled.

Limitations

Identifying invertebrates in the field can be very challenging due to their size and diagnostic attributes, which may require specialist or microscopic examination to determine the species. Many specimens from this survey were only identified to taxonomic groups. The life stages of some invertebrates can also make it difficult to determine species, for example some moth larvae would need to be bred out to adulthood before a positive ID could be made.

Many endemic invertebrates such as beetles are seasonal; beetles have been studied extensively and been found to be most active after the summer rains in February (Wollaston, T.V. 1877b). This survey was conducted outside of this period therefore very few ground dwelling beetles or other invertebrates were found.

Appendices

Appendix 1: Tables

Table 3:		Plants planted in each zone			
Zone	Locations	Date Planting begun	Perennial	Annual	Additional survey notes
6.2	Mulberry Gut	January 2017	Ebony, Hair grass, Gumwood, Rosemary, Small bellflower, Salad plant		Rock millet observed growing naturally
7.1	Colt Sheds	July 2017	Ebony, Hair grass, Gumwood, Rosemary		
7.5	Piccolo	September 2017	Ebony, Hair grass, Gumwood, Rosemary		
9.1A	Bottom Woods	January 2016	Ebony, Hair grass, Gumwood, Rosemary, Cape beard grass,	Annual Beard grass	Small bellflower died
9.1B		January 2016	Ebony, Hair grass, Gumwood, Rosemary, Cape beard grass, Small bellflower?	Annual Beard grass	
9.1C		June 2016	Ebony, Hair grass, Gumwood, Rosemary, , Thatching rush	Annual beard grass	
9.1D		August 2016	Ebony, Hair grass, Gumwood, Rosemary, Thatching rush	Annual beard grass	
9.1D compensatory		January 2019	Ebony, Hair grass, Gumwood, Rosemary, Salad plant		
9.1E		August 2016	Thatching rush		
		July 2017	Ebony, Hair grass, Gumwood, Rosemary, Salad plant, Samphire, Thatching rush		
9.1E compensatory		July 2019	Ebony, Gumwood, Hair grass, Rosemary, Salad plant		

9.1F		March 2017	Thatching rush		
		September 2017	Ebony, Hair grass, Gumwood, Salad plant		
11.8	Cook's Bridge	October 2016		Boneseed	
		February 2017	Boxwood, Cape beard grass, Ebony, Scrubwood, Thatching rush, Tufted sedge, Salad plant	Annual beard grass	
12.12A (Site compound)	Site Compound	November 2017	Boxwood, St Helena goosefoot, Hair grass, Salad plant, Scrubwood, Tufted sedge, Hair grass		
13 (bed 3)	Airport	February 2016	Scrubwood, Ebony, Tea plant, Thatching rush, Hair grass		

Table 4		Plants recorded in zones														
Plants common name	Plants scientific name	Status	13 Airport	12.12A Site Compound	11.8 Cooks Bridge	9.1 A Bottom Woods	9.1 B Bottom Woods	9.1C Bottom Woods	9.1D Bottom Woods	9.1D (com) Bottom Woods	9.1E Bottom Woods	9.1E (com) Bottom Woods	9.1F Bottom Woods	7.5 Piccolo	7.1 Colt Sheds	6.10 Mulberry Gut
African pepperwort	<i>Lepidium africanum</i>	Naturalised					✓									
Aloe/English aloe	<i>Furcraea foetida</i>	Naturalised								✓						
Blue pimpernels	<i>Anagallis arvensis</i>	Naturalised														✓

Blue weed	<i>Ageratum conyzoides</i>	Naturalised			✓	✓	✓		✓	✓	✓			✓		
Boneseed	<i>Osteospermum sanctae-helenae</i>	Native			✓											
Bottle-brush sedge	<i>Cyperus cyperoides</i>	Possibly native							✓							✓
Boxwood	<i>Melissia begoniifolia</i>	Native			✓											
Cliff Hair grass	<i>Eragrostis episcopus</i>	Native		✓												
Common saltbush	<i>Atriplex semibaccata</i>	Naturalised		✓	✓	✓	✓			✓	✓	✓	✓		✓	
Creeper	<i>Carpobrotus edulis</i>	Naturalised							✓	✓			✓			
Dwarf ebony	<i>Trochetiopsis ebnus</i>	Native	✓		✓	✓	✓	✓	✓		✓		✓	✓	✓	✓
Everlasting	<i>Xerochrysum bracteatum</i>	Naturalised				✓			✓		✓					
Field sedge	<i>Cyperus polystachyos</i>	Possibly native														
Field woundwort	<i>Stachys arvensis</i>	Naturalised														✓
Furze/Gorse	<i>Ulex europaeus</i>	Naturalised														✓
Giant rat's-tail grass	<i>Sporobolus natalensis</i>	Naturalised							✓			✓		✓		
Grass (not identified)		?												✓		
Gumwood	<i>Commidendrum robustum</i>	Native				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hair grass	<i>Eragrostis saxatilis</i>	Native	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓
Hairy fleabane	<i>Conyza bonariensis</i>	Naturalised				✓			✓						✓	
Heart-leaved Ice-plant	<i>Aptenia cordifolia</i>	Naturalised												✓		
Ice-plant	<i>Mesembryanthemum crystallinum</i>	Possibly native		✓												

Ink bush/poison ink	<i>Cestrum laevigatum</i>	Naturalised			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
Kidneyweed	<i>Dichondra repens</i>	Naturalised			✓			✓	✓				✓		✓	✓
kikuyu grass	<i>Pennisetum clandestinum</i>	Naturalised				✓	✓	✓			✓				✓	✓
Lesser swinecress	<i>Coronopus didymus</i>	Naturalised	✓													
New Zealand spinach	<i>Tetragonia tetragonioides</i>	Naturalised									✓		✓			
Poison Peach	<i>Diospyros dichrophylla</i>	Naturalised				✓	✓			✓						✓
Purple nut-sedge	<i>Cyperus rotundus</i>	Naturalised			✓											
Purslane	<i>Portulaca oleracea</i>	Native				✓	✓					✓				
Salad plant	<i>Hypertelis acida</i>	Native		✓	✓											
Samphire	<i>Suaeda fruticosa</i>	Native		✓												
Scrubwood	<i>Commidendrum rugosum</i>	Native	✓	✓	✓											
Sedge						✓			✓		✓					
Smooth sow thistle	<i>Sonchus oleraceus</i>	Naturalised			✓	✓	✓	✓	✓	✓	✓	✓		✓		
St Helena Rosemary	<i>Phyllica polifolia</i>	Native										✓		✓	✓	✓
St Helena tea plant	<i>Frankenia portulacifolia</i>	Native	✓													
Sweet spoor	<i>Pittosporum undulatum</i>	Naturalised													✓	
Tallow vine	<i>Commelin diffusa</i>	Naturalised												✓		
Thatching rush	<i>Ficinia nodosa</i>	Possibly native	✓		✓											
Tomato	<i>Lycopersicon esculentum</i>	Naturalised	✓													

Tropical finger-grass	<i>Digitaria ciliaris</i>	Possibly native				✓											
Tungi	<i>Opuntia sp.</i>	Naturalised											✓				
Wild bilberry	<i>Physalis peruviana</i>	Naturalised												✓			
Wild coffee	<i>Chrysanthemoides monilifera</i>	Naturalised								✓							
wild currant	<i>Lantana camara</i>	Naturalised				✓	✓		✓	✓	✓	✓			✓	✓	
Wild mango	<i>Schinus terebinthifolius</i>	Naturalised				✓							✓				
Wild radish	<i>Raphanus raphanistrum</i>	Naturalised									✓						
Willow	<i>Acacia longifolia</i>	Naturalised							✓	✓	✓	✓					
Wire Grass	<i>Cynodon dactylon</i>	Possibly native				✓											
			7	7	12	16	12	7	15	11	14	9	8	13	12	12	

Status	Zone 7.5 Piccolo	Zone 11.8 Cooks Bridge	Zone 12.12A Site Compound	Zone 13 Airport zone	Bottom Woods								Zone 6.2 Mulberry Gut	Zone 7.1 Colt Shed	Total
					Zone 9.1 A	Zone 9.1 B	Zone 9.1 C	Zone 9.1 D	Zone 9.1 D (com)	Zone 9.1 E (com)	Zone 9.1 E	Zone 9.1 F			
Indigenous		31													31
endemic genus and species	64				5	12	37	14			27	5	3	27	194
endemic species		12		2					1	23	4	5			47
endemic subspecies												1			1
Non-native	13	16	16	40	38	13	28	54	5	31	60	21	14	25	374
Unknown	5	10	3		8	4	4	12	4	1	25	13		2	91
Total	82	69	19	42	51	29	69	80	10	55	116	45	17	54	738

Species	Zone 7.5 Piccolo	Zone 11.8 Cooks Bridge	Zone 12.12A Site Compound	Zone 13 Airport zone	Bottom Woods								Zone 6.2 Mulberry Gut	Zone 7.1 Colt Shed	Total
					Zone 9.1 A	Zone 9.1 B	Zone 9.1 C	Zone 9.1 D	Zone 9.1 D (com)	Zone 9.1 E (com)	Zone 9.1 E	Zone 9.1 F			
endemic genus and species	1				1	1	1		1		1	1	1	1	1
endemic species		1		1				1		1	2	1			3
endemic subspecies												1			1
Indigenous		1													1
Non-native	6	5	5	7	5	8	3	5	10	3	8	5	7	6	31
Unknown	3	2	1		3	2	2	1	3	1	4	1		1	10
Total	10	9	6	8	9	11	6	7	14	5	15	9	8	8	47

Table 7		Top endemics found in all zones															
Common name	Scientific name	Order	Zone 7.5 Piccolo	Zone 11.8 Cooks Bridge	Zone 12.12A Site Compound	Zone 13 (bed 3) Airport	Bottom Woods								Zone 6.2 Mulberry Gut	Zone 7.1 Colt Shed	Total
							Zone 9.1 A	Zone 9.1 B	Zone 9.1 C	Zone 9.1 D	Zone 9.1 D (com)	Zone 9.1 E (com)	Zone 9.1 E	Zone 9.1 F			
Gumwood leafhopper Nymph	Sanctahelenia decellei	Hemiptera	64				5	12	37	14			27	5	3	27	194
St Helenian asteiid fly	Anarista vittata	Diptera		12								1	23	3	5		44
St Helenian long-winged stilt bug	Metacanthus concolor	Hemiptera				2											2
Simple darkling beetle	Gonocephalum simplex hadroides	Coleoptera												1			1
St Helenian muscid	Limnophora helenae	Diptera											1				1
		Total	64	12		2	5	12	37	14	1	23	31	11	3	27	242

Common name	Scientific name	Order	Zone 7.5 Piccolo	Zone 11.8 Cooks Bridge	Zone 12.12A Site Compound	Zone 13 Airport zone	Bottom Woods								Zone 6.2 Mulberry Gut	Zone 7.1 Colt Shed	Total
							Zone 9.1 A	Zone 9.1 B	Zone 9.1 C	Zone 9.1 D	Zone 9.1 D (com)	Zone 9.1 E	Zone 9.1 E (com)	Zone 9.1 F			
Ant	Formicidae indet	Hymenoptera	17	1	3	133	77	37	10	10	34	29	26	7	46	12	442
Ghost cockroach	Balta longicercata	Blattodea	1	9			33	7	11	32		33	9	3	6	16	160
Zebra-striped springtail	Entomobrya multifasciata	Entomobryomorpha	2			2			2	5	3	10	19				43
Doherty's bug Nymph	Trigonotylus tenuis	Hemiptera				16				4		7		12			39
Hairy field spider	Neoscona sp.	Araneae					5				1	2			6		14
Pale damsel bug	Tropiconabis capsiformis	Hemiptera				1		5		2		1	1	1	1	1	13
Beet Webworm	Spoladea recurvalis	Lepidoptera	1						9	2	1						13
Serpentine leaf-miner	Liriomyza brassicae	Diptera	2					1		2		1			2	4	12
Miller's Barkfly	Peripsocus milleri	Psocodea				12											12
Strauch's Barkfly	Ectopsocus strauchi	Psocodea			11												11
Button worm	Ommatoiulus moreleti	Julida								1		5		4			10
Mite	Sarcoptiformes	Sarcoptiformes					7								1		8
Fuller rose beetle	Naupactus godmanni	Coleoptera	3	2		1				1						1	8
		total	26	12	14	165	122	50	32	59	39	88	55	27	62	34	785

Table 9		Top 12 Predatory groups or species recorded in zones																
Scientific (Taxon) name	Common name	Status	Order	Piccolo, Zone 7.5	Cooks Bridge, Zone 11.8	Site Compound Zone 12.12A	Airport zone , Zone 13	Bottom Woods								Mulberry Gut, Zone 6.2	Colt Shed, Zone 7.1	Total
								Zone 9.1 A	Zone 9.1 B	Zone 9.1 C	Zone 9.1 D	Zone 9.1 D (new)	Zone 9.1 E (new)	Zone 9.1 E	Zone 9.1 F			
<i>Formicidae indet</i>	Ant	Non-native	Hymenoptera	17	1	3	133	77	37	10	10	34	26	29	7	46	12	442
<i>Araneae</i>	Spider	unknown	Araneae	6	2	2	1	8	10	1	4		1	3		7	4	49
<i>Salticidae</i>	Jumping spider	unknown	Araneae			1	2	2		3	1				1	6	1	17
<i>Neoscona sp.</i>	Hairy field spider	Non-native	Araneae					5				1		2		6		14
<i>Lyctocoris campestris</i>	Débris bug	?Indigenous	Hemiptera								2			6				8
<i>Pseudoscorpiones</i>	False scorpion	Unknown	Pseudoscorpiones													8		8
<i>Argiope trifasciata</i>	Garden spider	?Indigenous	Araneae	1				3									2	6
<i>Chrysopidae</i>	Green Lacewing larvae	unknown	Neuroptera		1						2							3
<i>Exochomus flavipes</i>	Orange-cheeked ladybird	Non-native	Coleoptera			2							1					3
<i>Euborellia annulipes</i>	Ring-legged earwig	Non-Native	Dermaptera				2											2
<i>Oecobius sp.</i>	Oecobius sp.	Unknown	Araneae				2											2
<i>Orius thripoborus</i>	Orius thripoborus	Non-native	Hemiptera											2				2

Order	Status	Zone 7.5 Piccolo	Zone 11.8 Cooks Bridge	Zone 12.12A Site Compound	Zone 13 Airport site	Bottom Woods								Zone 6.2 Mulberry Gut	Zone 7.1 Colt Shed	Total
						Zone 9.1 A	Zone 9.1 B	Zone 9.1 C	Zone 9.1 D	Zone 9.1 D (new)	Zone 9.1 E (new)	Zone 9.1 E	Zone 9.1 F			
Coleoptera	endemic species												1			1
Diptera	endemic species		1							1	1	2	1			2
Hemiptera	endemic species	1			1	1	1	1	1			1	1	1	1	2
Lepidoptera	Indigenous		1													1
Araneae	Non-native					1			1	1		1		1	1	3
Blattodea	Non-native	1	1			1	1	1	1		1	1	1	1	1	1
Coleoptera	Non-native	1	2	2	1	2		1	1		2		1		1	8
Dermaptera	Non-native				1											1
Diptera	Non-native	1	1			1	1	3	2			2		1	1	5
Embioptera	Non-native		1											1		1
Entomobryomorpha	Non-native	1			1			1	1	1	1	1				1
Hemiptera	Non-native			1	4		1	1	2	1	1	3	2	2	2	7
Hymenoptera	Non-native	2	2	1	2	2	1	1	2	2	1	1	1	1	2	2
Julida	Non-native								1			1	1			1
Lepidoptera	Non-native	1						2	1	1				1	1	3
Myriapoda	Non-native					1			1					1		2
Psocodea	Non-native	1		1	1									1	1	3

Sarcoptiformes	Non-native					1								1		1
Thysanoptera	Non-native			1		1										1
Araneae	Unknown	2	1	2	3	3	1	2	2		1	1	1	2	3	4
Coleoptera	Unknown			1	1			1								1
Collembola	Unknown		1		1							1	1	1		1
Diptera	Unknown	3				1	1	1	3					1	1	5
Hemiptera	Unknown		3	2	2	3	2	1	2	2	2	3	1	1		8
Isopoda	Unknown				1	1	1		1					1		1
Lepidoptera	Unknown	1	2	2	1	1		2	2	2	2	2	1	2	2	5
Neuroptera	Unknown		1					1								1
Orthoptera	Unknown						1	2	1			1				3
Pseudoscorpiones	Unknown													1		1
Psocodea	Unknown	1	1	1	1	1	1	1	1			1		1	1	1
Thysanoptera	Unknown			1										1		1

Total invertebrates recorded at all sites																			
Invertebrate Scientific name	Invertebrate Common name	Status	Order	Feeding & Pest status	13 Airport	12.12A Site Compound	11.8 Cooks Bridge	9.1 A Bottom Woods	9.1 B Bottom Woods	9.1C Bottom Woods	9.1D Bottom Woods	9.1D (com) Bottom Woods	9.1E Bottom Woods	9.1E (com) Bottom Woods	9.1F Bottom Woods	7.5 Piccolo	7.1 Colt Sheds	6.1 Mulberry Gut	Total
Acherontia atropos	Death's-head hawkmoth larva	Indigenous	Lepidoptera	Herbivore			3 1												31
Acrididae	Grasshopper	Unknown	Orthoptera	Herbivore						3	1								4
Aleyrodidae sp.	White Fly	Unknown	Hemiptera	Pest				3				1		1					5
Anarista vittata	St Helenian asteiid fly	Endemic species	Diptera	Unknown		1 2						1	3	2 3	5				44
Anypops stauntoni	Staunton's wall crab spider	Non-native	Araneae	Carnivore							1								1
Aphididae indet	Aphid	Non-native	Hemiptera	Pest													1		1
Araneae	Spider	Unknown	Araneae	Carnivore	1	2	2	8	1	1	4		3	1		6	4	7	49
Argiope trifasciata	Garden spider	Unknown	Araneae	Carnivore				3							1	2			6
Balta longicercata	Ghost cockroach	Non-native	Blattodea	Unknown			9	33	7	1 1	3 2		3 3	9	3	1	1 6	6	16
Cadrema pallida	Cadrema pallida	Unknown	Diptera	Unknown											3				3
Cardiastethus exiguus	Small orange flower bug	Unknown	Hemiptera	Carnivore			1												1
Chrysopidae	Green Lacwing larvae	Unknown	Neuroptera	Carnivore			1			2									3
Cnaphalocrocis poeyalis	Lesser Rice Leafroller	Non-native	Lepidoptera	Pest														1	1
Coccoidea	mealybug	Non-native	Hemiptera	Pest	1					1									2
Collembola	Springtail	Unknown	Collembola	Herbivore/ Detritivore	1		1						1		2			1	15
Creontiades pallidus	Cotton-shredder bug nymph	Unknown	Hemiptera	Omnivore		3	9	2	3	3		4	1 4	1	1 3				52
Culex quinquefasciatus	Five-banded mosquito	Non-native	Diptera	Pest						1									1

Scytodes sp.	Scytodes sp.	Non-native	Araneae	Carnivore														1		1	
Spodoptera littoralis	African Cotton leafworm caterpillar	Unknown	Lepidoptera	Pest														1		1	
Spoladea recurvalis	Beet Webworm	Non-native	Lepidoptera	Herbivore						9	2	1						1		13	
Staphylinidae indet	Rove beetle	Unknown	Coleoptera	Carnivore/Herbivore	1	1				1										3	
Taylorilygus apicalis	Broken back bug	Unknown	Hemiptera	Herbivore				3				9		4						16	
Teleonemia scrupulosa	Lantana Lace Bug	Non-native	Hemiptera	Herbivore									1							1	2
Thysanoptera	Thrip	Unknown	Thysanoptera	Pest		1														4	5
Trichopsocus clarus	Bright Barkfly	Non-native	Psocodea	Scavenger														4	2	1	7
Trigonotylus tenuis	Doherty's bug Nymph	Non-native	Hemiptera	Herbivore	16						4		7		1	2					39
Tropiconabis capsiformis	Pale damsel bug	Non-native	Hemiptera	Herbivore	1				5		2		1	1	1			1	1	1	13
Xylopsocus capucinus	False powderpost beetle	Non-native	Coleoptera	Carnivore				1													1

Appendix 2: Habitat photos.

Zone 13 Airport (bed 3)



Zone 12.12 Site Compound



Zone 11.8 Cooks Bridge, Fisher's Valley



Zone 9.1 A



Zone 9.1 B



Zone 9.1 C



Zone 9.1 D



Zone 9.1 D (NEW)



Zone 9.1 E



Zone 9.1 E (NEW)



Zone 9.1 F



Zone 7.5 Piccolo, near LEMP Nursery (front view)

Zone 7.5 (side view)



Zone 7.1 Colt Sheds (front view)



Zone 7.1 Colt Sheds (Side view)



Zone 6.10 Mulberry Gut (front view)



Zone 6.10 Mulberry Gut (side view)



Appendix 3: Maps

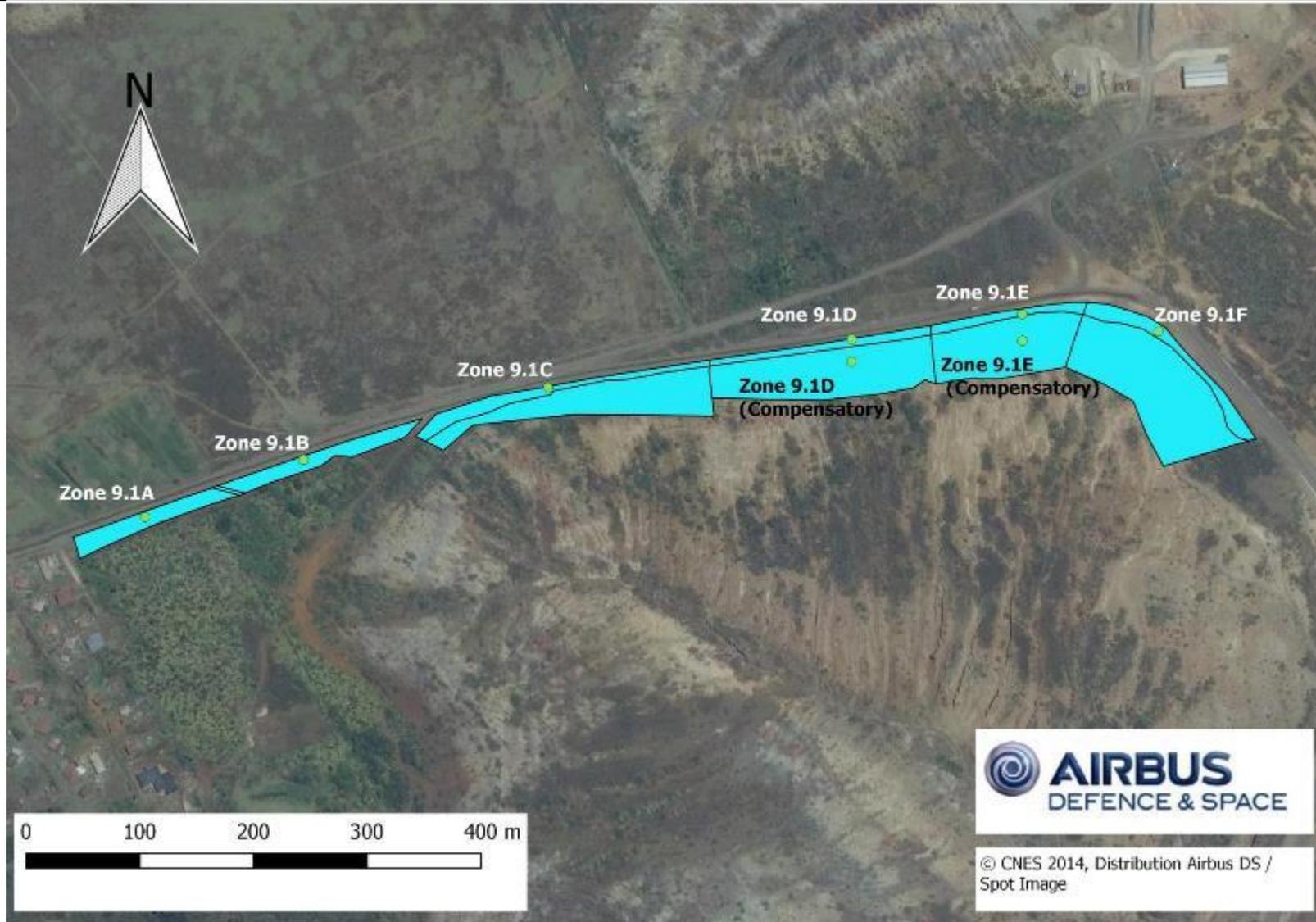
Map 1: Survey sites of all LEMP Zones



Map 2: Zones 6.2, 7.1 and 7.5 close-up view



Map 2: Zones 9.1 A-F close-up view



Map 2: Zones 11.8, 12.12A and 13 close-up view



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