

**Determining the habitat preferences of the Bermuda Land Snail
(*Poecilocyonites bermudensis*) on Port's Island, Bermuda.**



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Determining the habitat preferences of the Bermuda Land Snail (*Poecilozonites bermudensis*) on Port's Island, Bermuda.

Abstract

Port's Island supports the only known wild population of the endemic Bermudian land snail *Poecilozonites bermudensis*. Observations of zoo-reared *P.bermudensis* released elsewhere suggest an affinity for Bermuda Palmettos and limestone (Ovaska, 2017). These microhabitat associations are investigated in the wild population, along with a suspected aversion to invasive Casuarina trees and sea coasts.

Between May 2nd and June 14th 2018, 738 live *P.bermudensis* were found at 90 sites across Port's Island from the shoreline to 22m elevation. There is no correlation between the number of live snails at a site and either the number of plant species present, elevation above sea level, or distance from the shoreline. *P.bermudensis* is significantly less abundant at Casuarina-dominated sites, while the presence of palms does not affect snail abundance. Significantly more snails are found around limestone outcrops or rock piles in the woodland, indicating future re-introductions and searches for additional wild populations should focus on rocky features where Casuarina is absent. As there is no strong association with plant communities, a range of re-introduction locations can be considered.

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1.0 Introduction

1.1 Rediscovery of *Poecilonites bermudensis*

Poecilonites is a genus of land snails endemic to the Bermuda Archipelago (Gould, 1969). It formerly contained twelve species, of which two remain extant (Hearty and Olson, 2010; Outerbridge and Sarkis, 2018). The species *Poecilonites bermudensis* was believed extinct by the 1990's due to the introduction of predatory invertebrates, primarily the Rosy Wolf Snail (*Euglandina rosea*) and flatworm *Bipalium vagum* (Outerbridge and Sarkis, 2018). In September, 2014 a population of *P.bermudensis* was discovered in an alley within the City of Hamilton. A mark-recapture study estimated an adult population of 328 snails (Outerbridge, 2014). Construction soon destroyed the alley, and all snails that could be found were taken into captivity. Currently, there are captive populations at the Bermuda Aquarium, Museum and Zoo (about 250 – R.Marirea, pers.comm.) and in the UK at Chester Zoo (3134 in August 2018, G.Garcia, pers.comm) and London Zoo (estimated 5000).

In August, 2017 live *P.bermudensis* were found on Port's Island in the Great Sound (Fig. 1). The rediscovery of a wild population in a semi-natural habitat offers a unique opportunity to study the habitat preferences of the species to aid identification of suitable release sites for captive-bred snails. Improved habitat knowledge will also guide searches for further wild populations. A Protected Species Recovery Plan for *P.bermudensis* was published by the Bermuda Government in early 2018, which calls for habitat use surveys of the Port's Island population and the production of habitat management guidelines (Outerbridge and Sarkis, 2018).

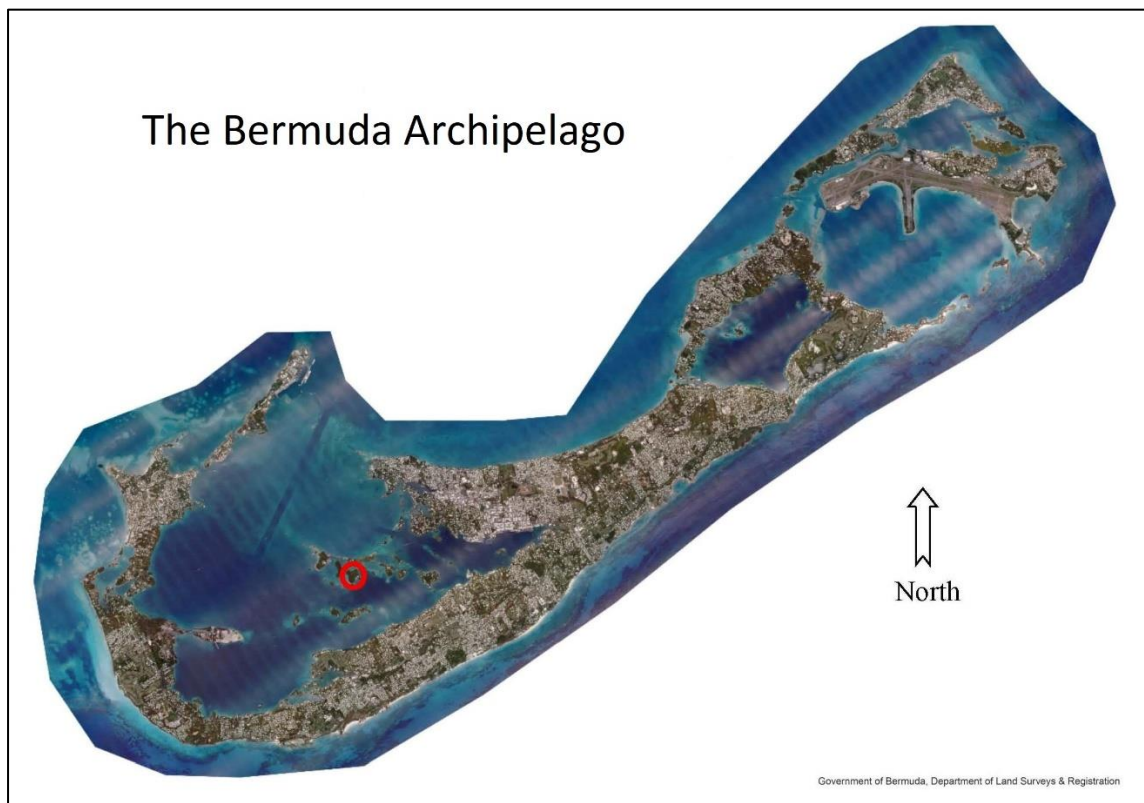


Figure 1: Map of Bermuda showing the location of Port's Island (red circle) within the Great Sound.

1.2 Study Site

Port's Island is a 6.7 ha island, located in the Great Sound, Bermuda (32.283°N, 64.821°W) (Fig. 1). It is managed by the Department of Youth, Sport and Recreation as a campground. Port's Island has an invasive-dominated secondary growth forest, with scattered introduced ornamental plants and some relict and planted endemic trees. Bermuda has no national vegetation classification or mapping system, so the island's habitats have not been characterised.

Woodland comprises 5.6 ha (83.4%) of the island, with lawns accounting for 0.97ha (14.5%) and buildings 0.14 ha (2.1%). The woodland is not managed, other than to keep paths clear. Damage from recent hurricanes, mainly rotting branches and uprooted trees, is evident. The woodland is divided into eastern and western sections, separated by open lawn (Fig. 4).

1.3 Snail Habitat

Habitat features considered key for snails are those which meet their needs for food and protection from predators, and offer refuge from moisture loss and extreme temperatures (Duncan et al., 2003). *P. bermudensis* does not seal the aperture of its shell in dry conditions and is therefore prone to desiccation during hot, dry weather (Outerbridge and Sarkis, 2018). Like other snails, it displays aestivation behaviour – a period of dormancy under unfavourable conditions. Surveying the population at the driest time of year (April – June) will show which microhabitats provide vital refuge, and are therefore required at any future reintroduction site.

Snails also require calcium for shell growth and egg formation (Anderson and Coppolino, 2009). Bermuda's geology is primarily marine limestone rich in calcium carbonate, and thin soils derived from erosion of this limestone. Bermudian limestone therefore provides a calcium-rich, moist microhabitat for snails, which *P. bermudensis* seems to favour (Gould, 1969; Outerbridge and Sarkis, 2018).

Observations of captive-bred *P. bermudensis* released on Nonsuch Island, Bermuda have shown that they are positively associated with endemic Bermuda Palmetto (*Sabal bermudana*) (Ovaska, 2017; Ovaska, 2018). A reconnaissance trip to Port's Island in February 2018 confirmed that they could also be found on invasive Chinese Fan Palms (*Livistonia chinensis*). Confirming how strong these affinities are would inform choosing future introduction sites at the scale of individual trees.

Like many of Bermuda's offshore islands, Port's Island contains significant stands of the invasive Australian Whistling Pine (*Casuarina equisetifolia*) – locally called 'Casuarina'. Due to its voluminous needle litter, *Casuarina* competitively excludes native plants by preventing seedling establishment (Chiba, 2009; Sugiura, 2016). Chiba (2009) suggests that snail foods such as fungi and algae are limited in a *Casuarina*-dominated forest. Ovaska (2017) reported grazing of algae, fungi and microbes made up at least 13.3% of feeding observations of *P. bermudensis*. Also, *Casuarina* litter is characteristically dry, compared to broad-leaf litter (Chiba, 2009; AC personal observation). Low moisture, combined with reduced plant diversity, and fewer foraging opportunities, likely make *Casuarina*-dominated sites poor habitat for *P. bermudensis*. The Protected Species Recovery Plan calls for the identification of islands within bays and harbours where introduction of captive-bred snails would be possible. As most of these islands host very dense stands of *Casuarina*, exploring this

tree's possible effect on *P.bermudensis* is critical to habitat management recommendations and introduction site selection.

2.0 Study Objectives and Research Questions

Objective: Determine the preferred microhabitats of *P.bermudensis* on Port's Island and investigate if they are more or less abundant around particular habitat features within the woodland.

Research Questions:

1. Is *P.bermudensis* abundance higher in habitat with higher plant species diversity?
2. Are *P.bermudensis* counts higher away from the coast?
3. Are *P.bermudensis* more abundant around Bermuda Palmetto, Chinese Fan Palm or limestone rock, than at sites without these features?
4. Are *P.bermudensis* less abundant at sites with Casuarina trees, than at sites without this species?

3.0 Methodology

3.1 Random Paired Snail and Vegetation Quadrats

A stratified random sampling method was used to select 30 random stations for nested snail and vegetation quadrat surveys. The contour lines of the island were used to stratify the random points. The total length of each contour was measured in ArcGIS 10.2.1 starting at the dock as metre 0, and going east. The elevation range of the island is 0-24m, so random numbers between 1 and 24 were generated to choose the contour line (0 was eliminated as no snails are expected at the tideline), then random numbers were generated between 0 and the total length of the contour to select a point along the line. Closed-loop contours (6m and 8m) in the eastern woodland were treated as continuations of the western contours (Fig. 4). Random points outside the woodland were discarded.

The 30 random points were located in the field with a hand-held GPS (Garmin Oregon 550) pre-programmed with the coordinates. A stake was hammered into the ground, marking the Northwest corner of the 2m² vegetation quadrat. Initially, a tape measure was used to string out the 2m² quadrat, but this became tedious, so pre-measured strings were tied to the stakes, with a loop on the end. A plastic set square was used to keep the strings straight (Fig. 2).

Datasheets were printed on waterproof paper with a vegetation side and snail side on the reverse (Appendix I). The top line of the datasheet with the quadrat number, date and lat/lon was photographed at the start of each new station to facilitate sorting of photos. The 2m² vegetation quadrat was surveyed first, then the 0.5m² PVC –framed snail quadrat was placed inside it

(Fig. 2). Whenever possible it was placed at the NW corner, as this is where the GPS location for the quadrat pair was recorded. If *Asparagus densiflorus* was present in the 0.5m² quadrat it was clipped out before surveying to avoid thorns. On particularly steep slopes, pegs were used to anchor the frame.



Figure 2: 2m² vegetation quadrat (orange string) with nested 0.5m² PVC snail quadrat at random site 1.

The snail quadrat was cleared, with all leaves, rocks, sticks etc. carefully checked for snails. Three plastic jars were used to sort live *Poecilozonites*, dead *Poecilozonites* and all other snails. Using the lid of the field box as a sorting tray, and putting handfuls of material from the quadrat onto it was the easiest way to avoid backache, while finding the most snails.

Once the quadrat had been cleared down to the soil surface, moisture and temperature readings were taken and a soil sample was collected. These were done from the centre of the quadrat whenever possible, using a Mini RayTemp Infrared thermometer (Electronic Temperature Instruments Ltd.) and SM200 soil moisture sensor with HH2 moisture meter (Delta-T Devices, Cambridge UK) (Fig. 3).

The dead *P.bermudensis* shells were counted, photographed and returned to the centre of the quadrat. The live *P.bermudensis* were returned to where they had been found. Initially, live snails were removed from their perches, but as the dry spell continued, we left them attached where they were found. No attempt to classify adults or sub-adults was made, but a photo was taken of the age/size distribution at each site.



Figure 3: Soil Moisture sensor in snail quadrat cleared of leaf litter at random site 16.

3.2 Targeted Feature Quadrats

Locations for paired surveys of habitat features and adjacent control areas were selected by chance in the field, with an effort made to spread them around the island if suitable features could be found. Initially, 10 Palmetto targets were planned, along with 10 Chinese Fan Palms, but due to time constraints, a total of 10 palm sites (4 Fan Palm, 6 Palmetto) were surveyed, along with 10 rocky features and 10 Casuarina trees (Fig. 4).

When a suitable feature was found, a snail survey was done at the feature and the paired site was chosen by moving 3m away in a random direction. The direction was chosen from a table of random 360° compass directions create in Excel using = RANDBETWEEN (0,359). The datasheet was printed with the feature on the front, and the paired site on the reverse (Appendix II).

The equipment and methodology for the feature quadrats was the same as described in section 3.1, except no soil was collected, and vegetation was not surveyed. At Palm and Casuarina sites, the quadrat was placed at the base of the tree on the south side, and at rocky sites directly over the feature.

3.3 Storage of Samples and Data

A compilation of all measurements and observations was filed at the Department of Environment and Natural Resources, along with 1078 photos, GIS shapefiles, sediment samples and dead shells. Selected photos were also sent to the Bermuda Natural History Museum, and a copy of this report will go to the Museum Library, and Department of Youth, Sport and Recreation.

3.4 Mapping

All sampled quadrats were mapped in ArcGIS 10.2.1 in decimal degrees using the Bermuda National Grid 2000. The Bermuda Government's 2012 airphoto mosaic was used as the base layer (Figs. 1,4&5). Elevation shapefiles were acquired from the Ministry of Public Works.

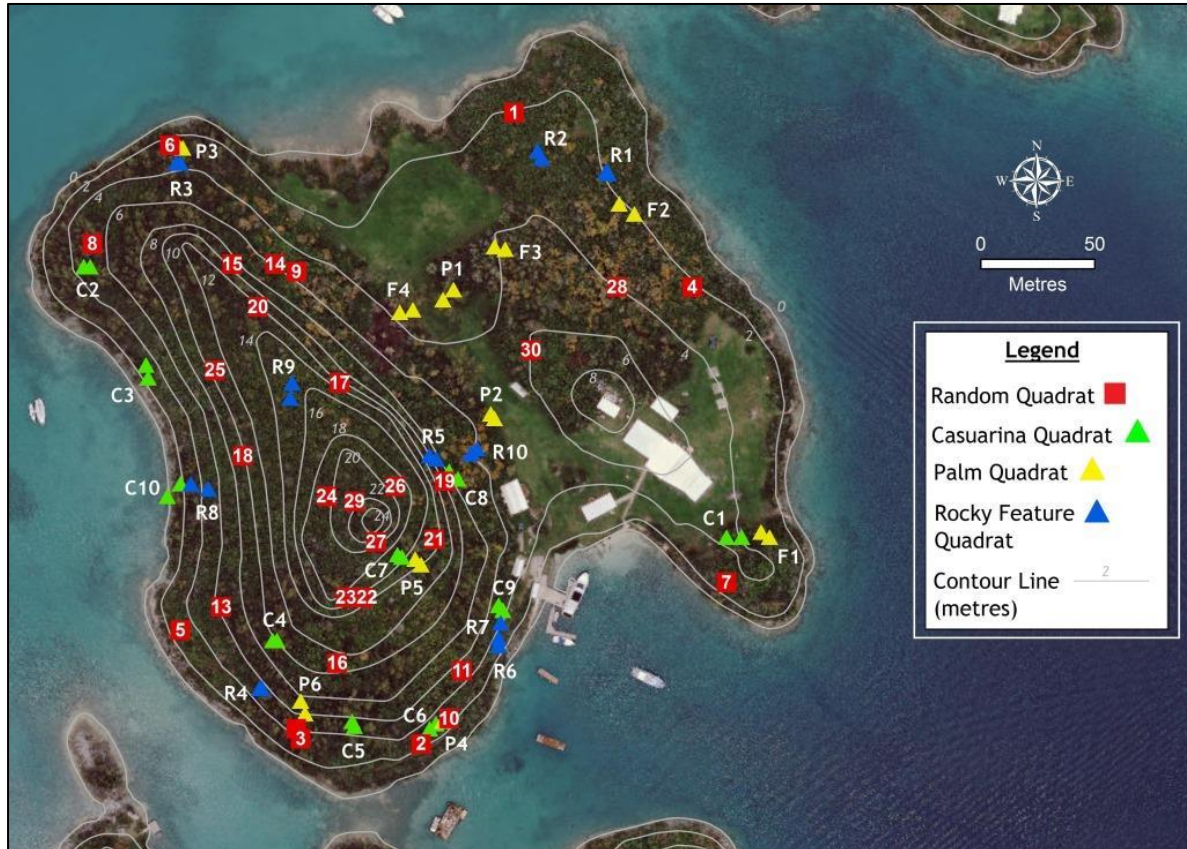


Figure 4: Map of Port's Island showing elevation contour lines, and sampled random quadrats (squares) and feature target pairs (triangles). NB random site 12 is behind site 3. C=Casuarina, F=Fan Palm, P=Palmetto and R=Rocky Feature.

3.5 Justification of Survey Techniques

Anderson and Coppolino (2009) state that land snails are known to have a clumped distribution, making stratified sampling necessary. Similarly, Cameron and Pokryszko (2005) note large-bodied species at low densities will often be missed by genuinely random sampling. They also note “rock-dwellers” and other snails occupying patchily distributed microhabitats will be missed. As patchy microhabitats are the focus of part of this study, stratified sampling was used to generate random samples, and targeted sampling similar to Solymos et al. (2009) was also used.

Much of the literature on land snail surveys are inventories of species and taxonomic richness against environmental gradients or survey methods (Tattersfield et al., 2001; Solymos et al., 2009), while few project focus on single species sampling (Bonham and Taylor, 1997; Forest Practices Authority, 2010).

The most commonly employed techniques are a standardised direct search constrained by space (Bonham and Taylor, 1997; Durkan et al., 2013) time (Tattersfield et al., 2001; Solymos et al., 2009), or search effort (Forest Practices Authority, 2010; Durkan et al. 2013); and sieving of a leaf litter and/or soil samples standardised by volume or area (Tattersfield et al., 2001; Solymos et al., 2009; Durkan et al., 2013). As most studies are inventories, the two techniques are often combined as searching is biased to large-bodied species, while sieving is appropriate for tiny species and juveniles (Durkan et al., 2013).

Poecilozonites bermudensis would be considered large-bodied by most authors (Solymos et al. 2009; Durkan et al., 2013), and is easily identified as an adult (Bieler and Salpcinsky, 2000), so timed searches are possible, however here a quadrat was chosen to give absolute abundance and because a quadrat was being used for the simultaneous vegetation survey. A 0.5m² quadrat was chosen because 1m² had previously been determined larger than necessary (Ovaska, 2017) and would be impractical to move through dense vegetation. Chiba (2009) suggests 0.5m² is adequate for snails the size of *P.bermudensis*.

Sieving litter amounts between 1L (Cameron and Pokryszko, 2005) and 4L (Tattersfield et al., 2001) are reported, but transporting such samples from the study site was not practical. Sieving also fails to give comparable numbers of absolute density (Cameron and Pokryszko, 2005). Carefully searching leaf litter in the field was time consuming, but allowed discovery of both hatchlings and adult *P.bermudensis*, and at approximately 1 hour per station, time taken per sample aligned with the timed searches of other authors (Tattersfield et al., 2001; Forest Practices Authority, 2010; Durkan et al., 2013). Durkan et al. (2013) noted that transporting litter off-site for later analysis precluded accurate recording of live or recently dead status of snails, as samples were not processed immediately and snails died. Searching the litter on-site avoided this issue, and reduced habitat disturbance.

Previous *Poecilozonites* surveys have recorded live snails and dead shells (Lines, 2002). Solymos et al. (2009) recommend that unless the differential preservation of shells in microhabitats is well understood, only live shells should be used. As land snails are known to destroy dead shells for calcium (Bonham and Taylor, 1997) shell accumulation likely varies Bermuda-wide where limestone (an alternative calcium source) is present or absent. Similarly, Bonham and Taylor (1997) caution that dead shells represent past populations that may have been subjected to different ecological conditions. This is obvious on Port's Island, where the present woodland is composed of plants introduced in the last 70 years (Appendix IV). For these reasons, dead shells were recorded (Appendix III), but only live snails used in data analysis.

4.0 Results

Between May 2nd and June 14th 2018, 738 live and 1889 dead *P.bermudensis* (2627 total) were found at 90 sites on Port's Island (Appendices III and IV). Surveyed sites are mapped in Figures 4 & 5.

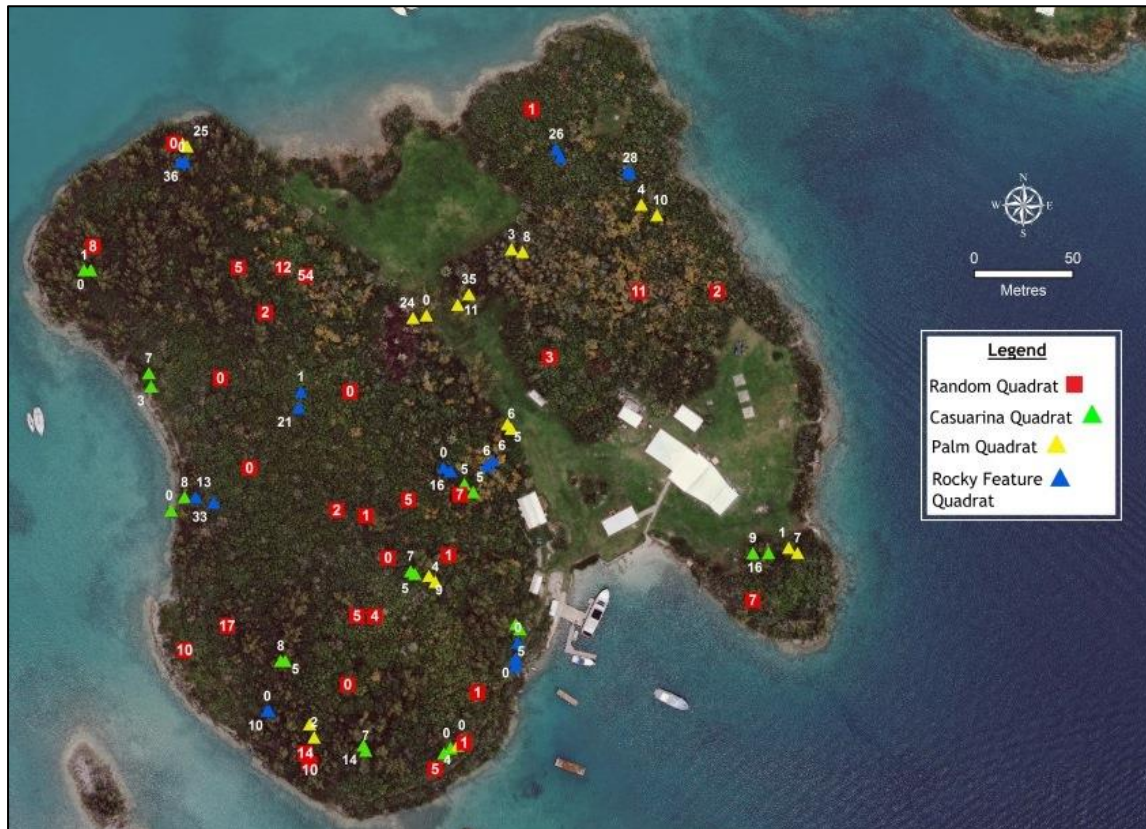


Figure 5: Map of Port's Island showing sampled sites, labelled with number of live snails found in random quadrats (squares) and feature target pairs (triangles).

4.1 Snail Abundance and Plant Species Diversity

In total 646 *P.bermudensis* were collected in 30 random 0.5m² quadrats, of which 188 were live, and 458 were dead. There was one outlier among the 30 quadrats – Quadrat 9 had 54 live snails and 29 dead shells. Quadrat 9 was removed from analysis, leaving 29 samples containing 134 live snails (Table 1).

Enumeration of the vegetation at the remaining 29 sites yielded 896 individual plants of 27 species (Appendix IV). Bermuda's most common invasive plant species dominated, with Asparagus Fern (*Asparagus densiflorus*) appearing in 24 of 29 quadrats, Allspice (*Pimenta dioica*) in 22, Brazil Pepper (*Schinus terebinthifolius*) in 13 and Suriname Cherry (*Eugenia uniflora*) in 10. Particular to Port's Island was the occurrence of seedling to fully grown European Olives (*Olea europaea*) at 12 of 29 sites, and a species of *Calophyllum*, (most likely *Calophyllum inophyllum* but possibly *Calophyllum calaba*) at 10 sites. *Calophyllum* densities were remarkable for Bermuda, with 59 in 2m² at site 11.

Table 1: Descriptive Statistics of Snails and Plants from 29 Random Quadrats

	Live <i>P. bermudensis</i>	Dead <i>P. bermudensis</i>	Snails Total	Plant Species	Individual Plants
Total Counts	134	429	563	27	896
Arithmetic Mean	5	15	19	5	31
Median	3	7	13	6	24
Min	0	0	0	2	9
Max	17	71	76	11	105
Standard Deviation (S)	5	15	18	2.02	23.30
Variance (S ²)	23	238	321	4.08	542.95

The raw live snail counts were not normally distributed (Shapiro-Wilk test, $W=0.868387$, $n=29$, $p<0.05$), so they were square root transformed in QED software. The transformed data were normal ($W=0.938528$, $n=29$, $p>0.05$). The number of plant species per quadrat was also normally distributed ($W=0.93031$, $n=29$, $p>0.05$), which allowed exploration of the relationship through a parametric test (Fowler et al., 2002).

Pearson's Product Moment Correlation showed there is no significant correlation between the number of live snails and the number of plant species found at the site ($r= -0.203045$, $t= -1.0775$, $df=27$, $p=>0.05$). A scatterplot of the data also shows no linear relationship (Fig. 6). It appears that factors other than plant diversity are more important for snail abundance in the woodland of Port's Island.

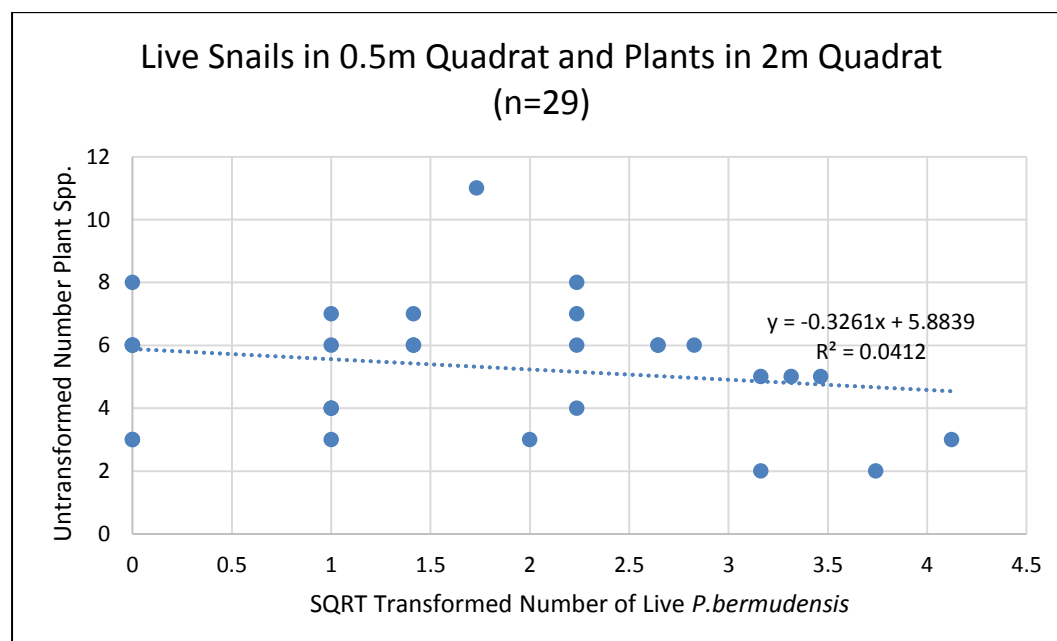


Figure 6: Scatterplot of square-root transformed live snail counts against the number of plant species found at sites, with regression line generated in Excel.

4.2 Proximity to the Coast

To increase geographic coverage, both the 30 random quadrats and the 60 feature targets were combined for this analysis. A box plot of the count of live snails found in the 90 samples showed that Quadrat 9 was an outlier, so it was removed leaving 89 samples (Fig. 7). The island has a maximum elevation of 24m, so the sample range of 1-22m is representative (Table 2).

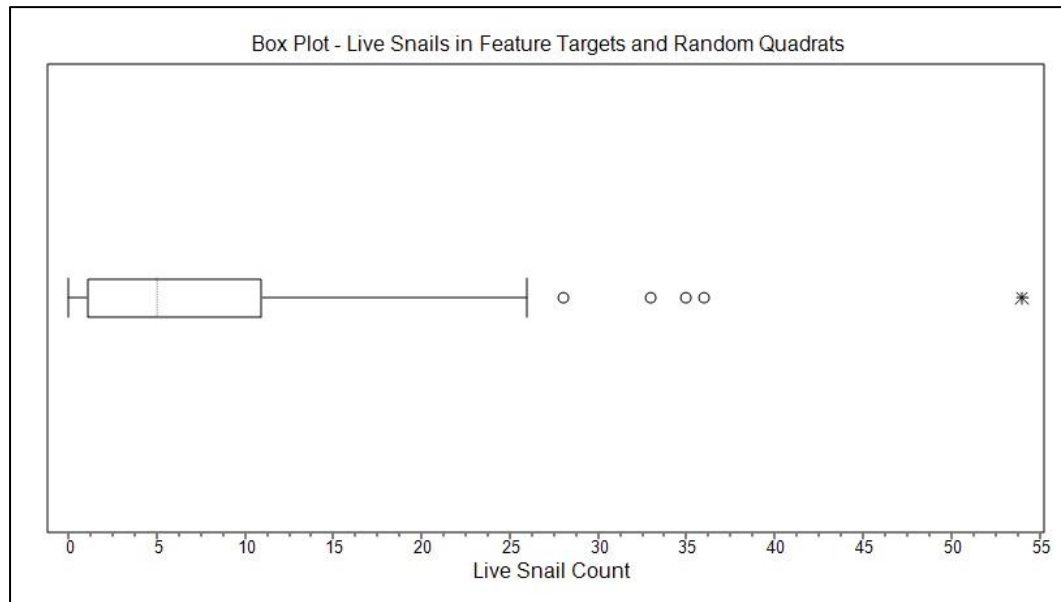


Figure 7: Box and whisker plot of all quadrat and feature target live snail counts (n=90) showing outliers (*) and extreme values (o).

Table 2: Descriptive Statistics of Snails and Distance Measures from 89 samples

	Live <i>P. bermudensis</i>	Distance to Nearest Coast (m)	Elevation (m)	Distance to Nearest Footpath (m)
Arithmetic Mean	8	36	7	12
Median	5	26	5	8
Min	0	2	1	0
Max	36	88	22	56
Standard Deviation (S)	8.53	24.81	5.11	12.33
Variance (S ²)	72.70	615.40	26.09	152.06

The live snail counts were not normally distributed and square-root transformation failed to normalise them (Shapiro-Wilk test, $W=0.947832$, $n=89$, $p<0.05$). As the variables 'elevation' ($W=0.806087$, $n=89$, $p<0.05$) and 'distance to the coast' ($W=0.897154$, $n=89$, $p<0.05$) deviated from normal, Spearman's Rank Correlations were carried out (Fowler et al., 2002).

There is no significant correlation between the number of live snails in a quadrat and its distance from the coast ($r = -0.0345123$, $DF=89$, $p>0.05$) (Fig. 8). Similarly, Spearman Rank Correlation of live snail count and elevation above sea level showed there is no significant correlation between these

variables ($r = -0.14803$, $DF=89$, $p > 0.05$) (Fig. 9). On Port's Island *P. bermudensis* is equally able to survive in coastal habitat as in interior woodland.

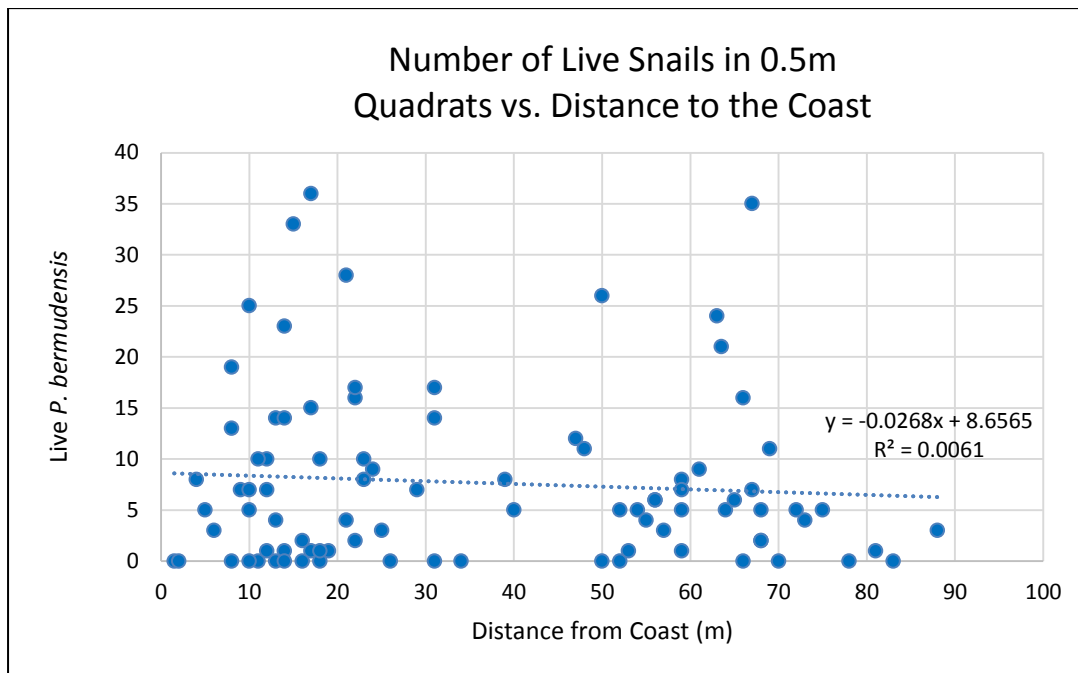


Figure 8: Scatterplot of live snail counts in quadrats, and the distance of quadrats from the coast ($n=89$), with regression line generated in Excel.

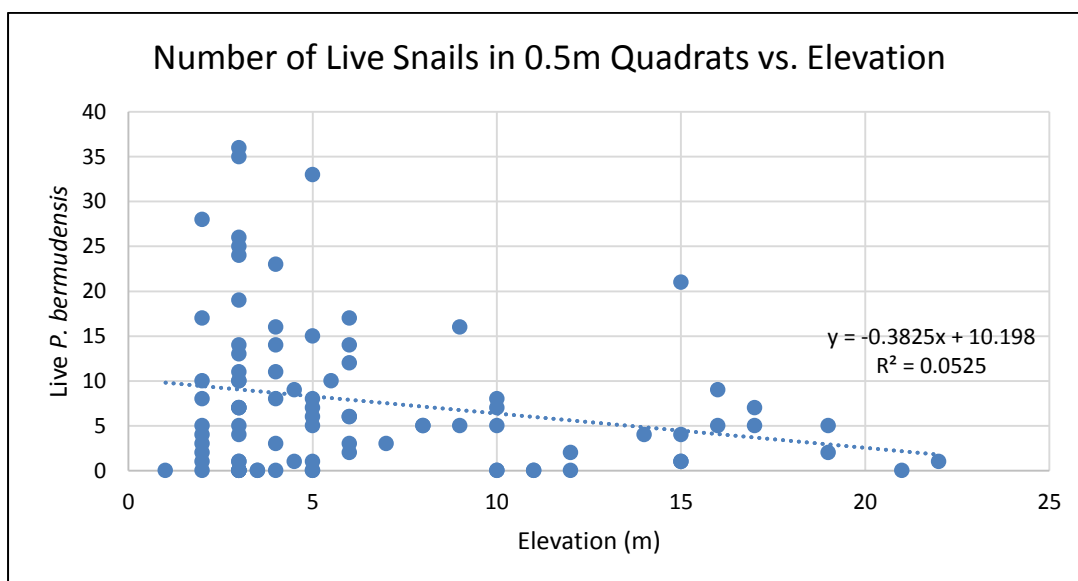


Figure 9: Scatterplot of live snail counts in quadrats, and the elevation of quadrats from the coast ($n=89$), with regression line generated in Excel

The hypothesis that vegetation diversity contributes to more snails inland, (as fewer plant species can tolerate the salt exposure at the coast) can be rejected. A Spearman's Rank Correlation of the number of plant species in 29 quadrats against their distance from the coast, showed no significant correlation ($r = 0.158189$, $DF=29$, $p > 0.05$). As most of the island is covered by adaptable invasive plants, this is not surprising.

4.3 Association with Habitat Features

If *P.bermudensis* is differentially drawn to, or repelled by, the habitat features examined, then different averages would be expected between the live snail counts in the 10 palm quadrats, the 10 Casuarina quadrats and the 10 rocky feature quadrats (Appendix V). A Kruskal-Wallis test showed there is a significant difference in medians between the feature types ($H= 6.81065$, $DF=2$, $p<0.05$).

4.4 Association with Palm Trees

The count of live *P.bermudensis* in both the 10 Palm target quadrats and the 10 paired quadrats deviated significantly from a normal distribution (palm target $W=0.807147$, $n=10$, $p<0.05$ and palm paired $W=0.772264$, $n=10$, $p<0.05$). A square root transformation was able to normalise the counts (sqrt palm target $W=0.912862$, $n=10$, $p>0.05$ and sqrt paired $W=0.950195$, $n=10$, $p>0.05$), and the variances were not significantly different ($F=1.9271$, $DF1=9$, $DF2=9$, $P>0.05$), therefore a paired t-test could be carried out. There was no significant difference between the number of live *P.bermudensis* at the base of Fan Palm or Palmetto trees, and counts taken at control sites a few metres away ($t= 0.652473$, $DF=9$, $P>0.05$).

4.5 Association with Limestone

The live snail counts from the rock target quadrats were normally distributed (Shapiro-Wilk test, $W = 0.958483$, $n=10$, $p = >0.05$), however the counts from the paired control quadrats were not ($W = 0.62275$, $n=10$, $p = <0.05$). Of the 10 paired quadrats, 6 had no live snails, so no transformations were able to normalise these data, even if a constant was added to transform the 0s, therefore a non-parametric Mann-Whitney test was applied. The variances were not significantly different ($F= 1.73512$, $DF1=9$, $DF2=9$, $P>0.05$).

The number of live *P.bermudensis* found associated with rocky features was significantly different from the number found at nearby control sites ($U= 18.5$, $n1=10$, $n2=10$, $P<0.05$). The count difference (Table 3), the descriptive statistics (Appendix V, table Vc) and Figure 10 confirm that more snails were found around limestone than at paired sites.

Table 3: Number of live *P.bermudensis* in feature target quadrats, paired control quadrats and the count differences

Casuarina Target	Casuarina Paired	Casuarina difference	Palm Target	Palm Paired	Palm Difference	Rock Target	Rock Paired	Rock Difference
9	16	-7	1	7	-6	17	28	-11
0	1	-1	4	10	-6	26	0	26
3	7	-4	8	3	5	36	0	36
5	8	-3	24	0	24	10	0	10
7	14	-7	11	35	-24	16	0	16
0	14	-14	5	6	-7	5	0	5
5	7	-2	25	19	-14	0	0	0
5	5	0	4	0	4	33	13	20
15	23	-8	9	4	5	21	1	20
0	8	-8	3	2	1	6	6	0

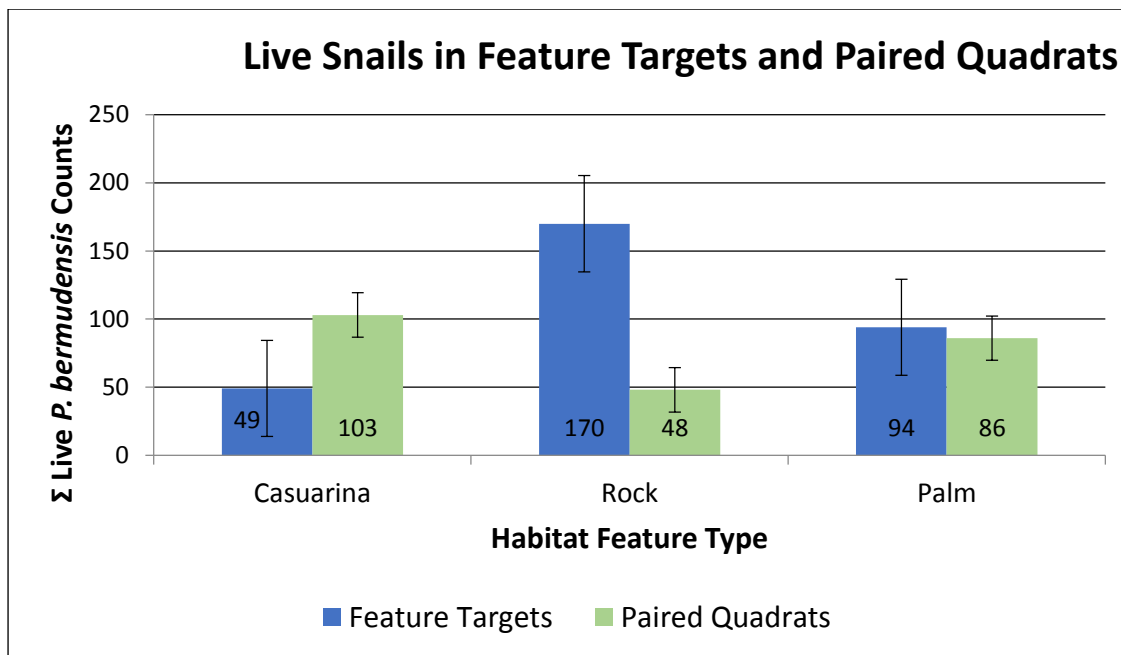


Figure 10: Sum of live *P.bermudensis* counted in 10 feature target quadrats per class (blue bars) and at 10 paired quadrats per class (green bars). Error bars represent standard error.

4.6 Association with Casuarina Trees

The count of live *P.bermudensis* in the 10 Casuarina target quadrats, and in the 10 paired quadrats are both normally distributed (Shapiro-Wilk test, Casuarina $W=0.891011$, $n=10$, $p=>0.05$ and Paired $W=0.939891$, $n=10$, $p=>0.05$) and do not have significantly different variances ($F=1.85068$, $DF1=9$, $DF2=9$, $P=>0.05$). A paired t-test indicates that the means are significantly different ($t= -4.04495$, $DF=9$, $P=<0.05$).

P.bermudensis is less abundant where Casuarina is present. The number of live snails in the paired quadrat was always higher than at the Casuarina tree (Table 3, Fig. 10; Appendix V, table Ve), except for Casuarina 8 which had 5 live snails in both, so the difference was 0.

5.0 Discussion

5.1 Port's Island Snail Habitat

This study confirmed that *Poecilozonites bermudensis* occurs in both the eastern and western woodland of Port's Island, and that a population of over 738 exists in a patchy distribution (Fig.5).

Tattersfield et. al. (2001) cautioned that the relationship between vegetation and molluscs may be complex and that soil conditions complicate it further. Additional analysis of vegetation cover estimates, litter type and soil samples, along with multivariate analysis of which plant species contribute to high *P.bermudensis* abundance maybe informative. Revising the vegetation survey may lead to stronger results. Some large tree species were under-recorded due to the size of the vegetation quadrat. For example Fiddlewood (*Citharexylum spinosum*) contributed significant leaf

litter to a number of snail quadrats (see Appendix III) but was only recorded in 4 vegetation samples (Appendix IV), while Casuarina did not appear at all. The result that plant diversity is not related to snail count was mainly determined by understory plants, which were not large contributors to leaf litter.

Moisture is a known limiting factor to snail populations (Anderson and Coppolino, 2009), and Casuarina litter is comparatively dry (Chiba, 2009; personal observation). Analysis of soil moisture and soil temperature indicated no significant differences between Casuarina sites and palm or rock sites for these variables (Appendix VI), nor between Casuarina quadrats and paired controls (Appendix VII). Therefore the reason for lower *P.bermudensis* abundance at Casuarina sites requires further exploration and may relate to soil chemistry (Chiba, 2009).

Calophyllum leaves and seed husks, and Bay Grape (*Coccoloba uvifera*) leaves appeared to be important perches for *P.bermudensis* during aestivation. Both of these coastal plants have rigid leaves, which maintain their structure once fallen. Plants provided other hard surfaces used by *P.bermudensis* for aestivation (Fig. 11) suggesting they use any refuge available to them, following the “survive where you are” life strategy proposed by Anderson and Coppolino (2009).

The finding of this study that vegetation does not strongly influence *P.bermudensis* distribution, and there is no significant preference for palms, suggests the association with Palmetto reported on Nonsuch Island (Ovaska, 2017) maybe snails simply using the plants closest to where they were released. However, 67.8% of *P.bermudensis* feeding observations reported by Ovaska (2017) were on Palmetto fruit, while green plants accounted for just 7.8%. Palmetto berries ripen in winter and were not present on Port’s Island during this study (Appendix III). Further exploration of palms on both islands would confirm seasonal associations.

Rock features in forests are known as good snail habitat (Anderson and Coppolino, 2009; Solymos et al., 2009). The dry season timing of this survey likely contributed to the strength of this association, as *P.bermudensis* are using damp rock surfaces as refugia. Land snails are reportedly prone to variation in detectability due to weather conditions (Bonham and Taylor, 1997; Cameron and Pokryszko, 2005) so it should be noted no attempt was made in this work to assess detection probabilities.

Tattersfield et al. (2001) reported snail abundance correlates significantly and positively with soil pH and calcium. The breeding season of *P.bermudensis* in the wild has not been documented, but a clutch of eggs was found on Port’s Island on May 4th. It is possible that concentrations of *P.bermudensis* under rocks were seeking calcium for shelling eggs. In breeding tanks, large *P.bermudensis* provided with limestone have demonstrated this behaviour (R.Marirea pers. comm.).

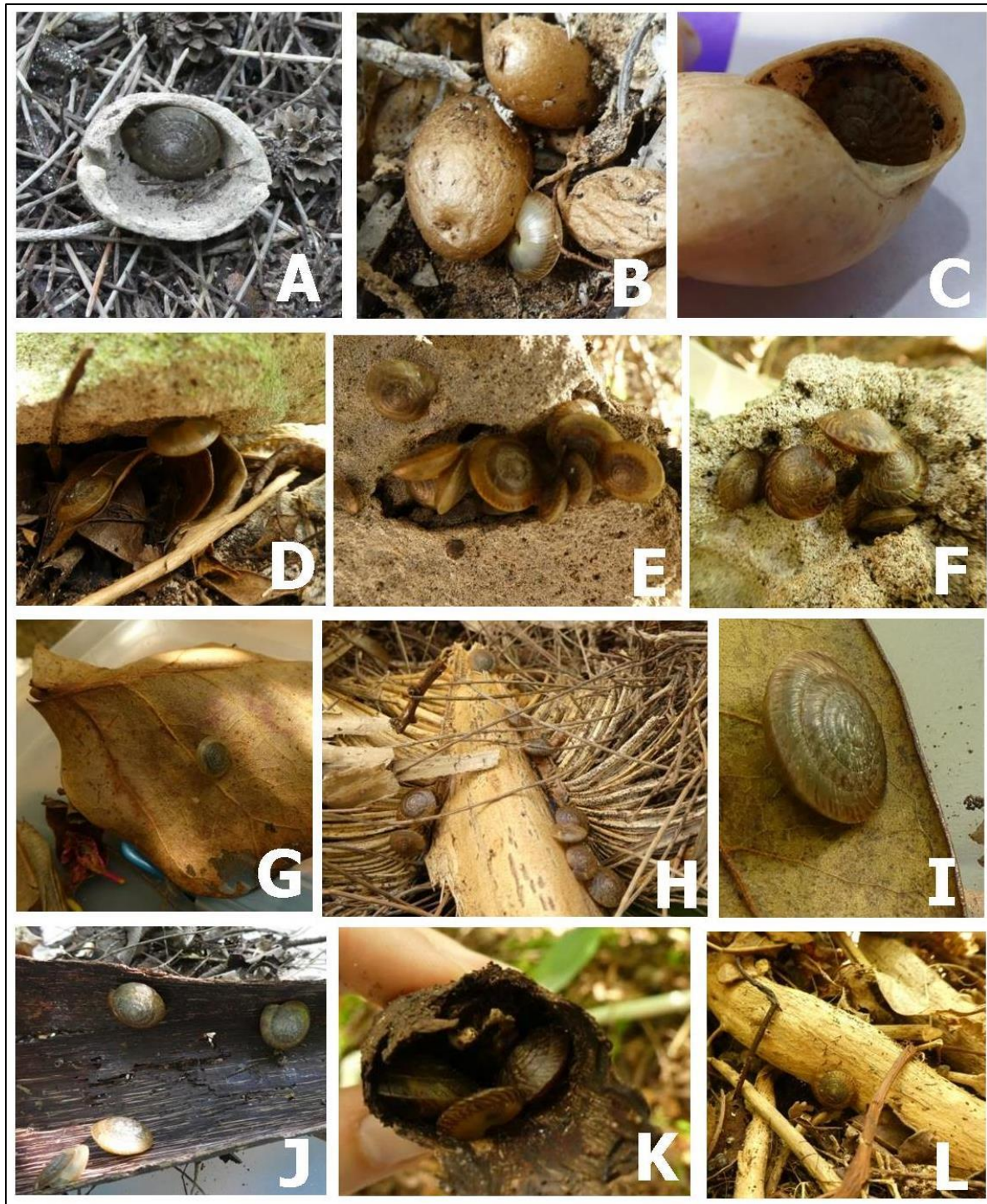


Figure 11: Surfaces used by *P.bermudensis* on Port's Island for aestivation. A: *Calophyllum* seed husk, B: *Asparagus densiflorus* tuber, C: Shell of *Rumina decollata*, D: Limestone ledge, E&F: underside of loose rock, G: *Coccoloba uvifera* leaf, H: *Livistonia chinensis* frond stem, I: *Calophyllum* leaf, J: *Casuarina* bark, K: *Schinus terebinthifolius* stick, L: tree root

5.2 Habitat and Protected Species Management

Knowing *Poecilozonites bermudensis* is abundant in invasive-dominated woodland is encouraging, given all of Bermuda's protected areas but one are now in this state. If *P.bermudensis* does not associate strongly with native plants, and therefore require a managed habitat; the number of possible reintroduction locations grows enormously.

Observation of hurricane-damaged uprooted Casuarinas showed that the extensive peeling bark provided aestivation sites (Figure 11 J). Therefore a Casuarina removal project that kills trees *in-situ* by girdling the bark may benefit *P.bermudensis*, and allow the understory plants to recover. The effect of future woodland management on Port's Island on the *P.bermudensis* population requires careful consideration. Habitat disturbance, for example clear-cutting the invasive forest, must be avoided.

Sugiura (2016) noted Black Rats (*Rattus rattus*) as a critical threat driving snail extinctions on the Ogasawara Islands. Chiba (2009) found that Casuarina litter actually provided refuge from rat predation for snails there. Therefore any Casuarina removal on Port's Island should be paired with intensified rat control.

Outerbridge (2014) suggested that *P.bermudensis* survived in Hamilton, as the urban environment isolated it from snail predators. It is likely the isolation of Port's Island from the rest of Bermuda (Fig. 1) similarly accounts for *P.bermudensis*' continued presence there. No predatory *Euglandina rosea*, live or dead, were seen on Port's Island during this study. This predator is present on neighbouring islands (see journal), and has been implicated in the extinction of snail species in Japan (Sugiura, 2016), Hawaii (Durkan et al., 2013) and Bermuda (Outerbridge and Sarkis, 2018). A biosecurity protocol for Port's Island should be prepared as a matter of urgency to prevent predator introduction.

5.3 Informing Future Searches

Searches for wild populations, as called for in the Recovery Plan, should consider the following:

- *P. bermudensis* utilise habitats close to the sea (Fig.8) and just above the shoreline (Fig. 9) so low elevation islands and coastal sites shouldn't be discounted.
- Rocks that are sunk into the soil (not easily moved) are unlikely to shelter snails. Piles of large, loose stones and ledges sheltered more *P.bermudensis* on Port's Island than smooth rockfaces and old quarries. This observation is consistent with Durkan et al. (2013) who reported no snails with rocks that could not be moved, and Solymos et al. (2009) who found few snails on smooth rockfaces.
- Dry, loosely consolidated Casuarina litter is less likely to have *P.bermudensis* than damp mats
- Adult *P.bermudensis* attach to hard surfaces on or under litter, while juveniles can be found in leaf litter (Fig.11).
- Targeting Palms is not a good search strategy
- Litter of poisonous plants (e.g Oleander) may contain *P.bermudensis*
- Predator-free offshore islands should be a search priority (per Outerbridge and Sarkis, 2018).

5.4 Informing Future Introductions

Available high quality habitat contributes to the success of reintroduction projects (Bonham and Taylor, 1997). This study of diurnal shelter use during drought conditions indicates future *P.bermudensis* introductions should consider the following:

- Plants that provide firm surfaces should be present, including palms and rigid-leafed coastal species
- Rotting branches and stumps should be left *in-situ*
- At least one large rock feature (preferably rubble pile) should be present
- Casuarina litter should be absent; or when mixed with broad-leaf litter not account for more than 50%.
- Coastal sites, above storm surge zone, can be considered
- Controls for invertebrate predators and rats should be undertaken

6.0 Conclusion

The adaptability of *Poecilozonites* species have been documented (Gould, 1969; Hearty and Olson, 2010). It appears that *P.bermudensis* in the woodlands of Port's Island have adapted successfully to an invasive plant dominated habitat. Their abundance is not affected by changes in plant species diversity across the landscape, and this hardy snail appears unaffected by proximity to saltwater. *P.bermudensis* is clearly attracted to limestone features in the woodland, and repelled by dense stands of *Casuarina equisetifolia*. These trends should inform searches for further wild populations and identification of introduction sites.

7.0 References

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Appendix I

Snail/Veg Quadrat Datasheet

Date:

Observers:

Snail Side

Quadrat Number:

GPS Lat: 32.

GPS Lon: -064.

GPS acc. m

Poecilozonites Tally

Live	
Recently Dead (periostracum present)	
Long Dead	

Other snails: photographed collected

Other invertebrates (flatworms, ants etc.)

From centre of 50x50 quadrat

Distance to nearest habitat edge or coast (m):

Elevation (m):

Distance to nearest footpath (m):

Aspect:

Surface Temperature (°C):

Soil Moisture (%):

Soil sample collected:

Canopy cover:

Present in 50x50 quadrat (circle): Palm litter Casuarina litter Other leaf litter Logs
rock pile rocky outcrop

Fallen fruit _____.

Plants currently fruiting _____.

Weather today:

Last rain:

Photos (features, veg., snails)

Notes:

Snail/Veg Quadrat Datasheet

Date:

Observers:

Veg. Side

Quadrat Number:

Braun-Blanquet Cover Classes: 1= solitary and less than 1% cover. 2= few with less than 1% cover. 3= 1-5% cover. 4= 5-25% cover. 5= 25-50% cover. 6=50-75% cover. 7=>75% cover

Species (seedling/sapling/mature)	Tally	B-B Cover	fruiting now	fallen fruit	leaf litter

Appendix II

Feature Targets Datasheet

Date:

Observers:

Target Type & Number:

GPS Lat: 32.

GPS Lon: -064.

GPS acc. m

Poecilozonites Tally (quadrat South side of trees)

Live				
Dead				

Other snails: photographed collected

Other invertebrates (flatworms, ants etc.)

From centre of quadrat

Distance to nearest habitat edge or coast (m):

Elevation (m):

Distance to nearest footpath (m):

Aspect:

Surface Temperature (°C):

Soil Moisture (%):

Present in quadrat (circle): Palm litter Casuarina litter Other leaf litter Logs

rock pile rocky outcrop full shade partial shade full sun

Fallen fruit _____.

Plants currently fruiting _____.

Weather today:

Last rain:

Photos (features, veg., snails)

Notes:

Feature Targets Datasheet

Paired Quadrat of:

Random Direction:

GPS Lat: 32.

GPS Lon: -064.

GPS acc. m

Poecilozonites Tally (quadrat South side of trees)

Live				
Dead				

Other snails: photographed collected

Other invertebrates (flatworms, ants etc.)

From centre of quadrat

Distance to nearest habitat edge or coast (m):

Elevation (m):

Distance to nearest footpath (m):

Aspect:

Surface Temperature (°C):

Soil Moisture (%):

Present in quadrat (circle): Palm litter Casuarina litter Other leaf litter Logs

rock pile rocky outcrop full shade partial shade full sun

Fallen fruit _____.

Plants currently fruiting _____.

Photos (features, veg., snails)

Notes:

Appendix III Snail Data

Target name	Live Poe	Dead Poe	Total Poe	Poecilonites Notes	Other snail	Other Inverts	Nearest coast (m)	Nearest Path (m)	Elevation (m)	Aspect	Soil temp °C	Soil Moisture %	Leaf Litter	Logs, Rocks, etc.	Notes	Shading	Fallen fruit	Currently fruiting	Weather	Days since last rain	Last rain	Date
Cas 1	9	9	18		2 live Oligyra, 2 long spirals live	churchworms , cockroach, slime trails	24	5	5	flat SE	21.0	21.6	Casuarina	None	Casuarina litter about 1.5 inches deep. Cas twigs and fallen berries and sticks, some Aspf leaves in litter. Aspfern nearby and baygrape sapling.	partial shade	old Casuarina berries	few Aspfern with berries	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Cas 1 paired	16	38	54	range of sizes of live Poe. large to v. small	5 dead and 1 live Oligyra	church worms	22	6	4	flat SE	21.8	14.7	Casuarina, Other	None	aspfern tubers. range of sizes of live Poe. large to v. small. Litter is Cas needles and twigs with some bay grape leaves and aspfern leaves	partial shade	lots old Cas berries	none	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Cas 2	0	1	1	1 long dead	1 live Oligyra	ants (sp.), milipedes	26	16	5	flat W	23.5	11	Casuarina, Other	None	hard to do moisture - hanging in litter. looked down 1.5 inches in litter. dense Cas litter with bay grape and snowberry leaves. humus not really soil, with thick mat of fine roots. Cas twigs	partial shade	casuarina	1 v.old aspfern	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Cas 2 paired	1	6	7		photo on BG of 1 live	milipedes, isopods	19	10	4.5	gentle WSW	21.5	14.7	Casuarina	None	dense Cas litter with bay grape and some snowberry leaves about 1.5 inches down in litter		casuarina	v. few developing snowberries . no bay grape	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Cas 3	3	0	3	2 of3 live were in damp patch in Cas litter not in dry part. not against root. above mold.	2 live Oligyra		6	4	2	flat SW	22.3	11.2	Casuarina	None	mold (white) in Cas litter. Litter is ~3 inches deep with 3 scattered bay grape leaves and one mature aspfern in quadrat. Canopy is Cas, baygrape, aspfern	partial shade	old and recent Casuarina, asparagus fern berries	casuarina	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Cas 3 paired	7	1	8	live snails in old aspfern leaves in litter	photo	isopods, 1 milipede	9	5	3	gentle WSW	22	8.0	Casuarina	None	dense Cas litter and aspfern in a sparse mat. Aspfern leaves in litter with ~4 bay grape leaves. canopy is Cas and sparse bay grape with oleander nearby. Mositure % is 8 for most of quadrat and 32.5 around aspfern base	full shade	few old aspfern berry husks, cas berries	casuarina	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Cas 4	5	1	6		0	?white worm	40	27	10	gentle SSW	22.2	8	Casuarina	None	white mold. litter is Cas needles and bark and twigs, aspfern leaves, few bay grape leaves. canopy is casuarina, calophyllum, brazil pepper, snowberry and sparse asparagus fern. aspf tubers in quadrat	partial shade	old casuarina and calophyllum, old aspfern berries nearby	snowberry nearby	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018

Cas 4 paired	8	14	22		none collected	isopod, white worm	39	26	10	?SSW didn't write down	21.7	12.4	Casuarina, Other	None	litter is Casuarina and Calophyllum. some aspfern, but sparse not a mat. some old aspf berries. white mold. cedar stump in quadrat and aspfert tubers. lots of fine roots.	full shade	old aspfert, casuarina and calophyllum	snowberry up high above quadrat, not really in it	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Cas 5	7	5	12		dead long spiral	cockroach	29	21	5	flat SW	21.4	21.3	Casuarina	None	canopy is Casuarina, calophyllum, oleander. litter is casuarina with 3 calophyllum leaves. litter ~1inch deep.	full shade	casuarina	none	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Cas 5 paired	14	19	33	3 live walking around in Cas litter (photo)	none collected		31	23	6	gentle WSW	22.2	20.7	Casuarina, Other	None	quadrat is cas litter with few bay grape and calophyllum. Cas twigs and old berries. canopy is casuarina, brazil pepper, oleander, spice and calophyllum saplings.	full shade	casurina	casuarina	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Cas 6	0	1	1	1 partial shell			13	7	3	gentle SSE	24	10.5	Casuarina	None	canopy is Cas, brazil pepper, asparagus fern sparse mat	partial shade	old Casuarina berries		max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Cas 6 paired	14	2	16	snails on damp sticks	not recorded	cockroach	13	6	3	gentle S	21.4	18.4	Casuarina, Other	None	Litter is 50% casuarina needles, 50% spice leaves. canopy is spice, brazil pepper, fiddlewood, a bit further away is a casuarina. one aspf tuber in quadrat.	full shade	old Casuarina berries	old asparagus fern berries on. fiddlewood nearby	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Cas 7	5	12	17	on Cas bark and in damp spots in leaf litter	live Oligyra and Zonitoides		64	17	16	flat S	22	16.5	Casuarina, Other	None	clipped aspf from quadrat. dense Cas litter with spice and calophyllum leaves, cas twigs, old cas berries. snowberry and aspfert near quadrat. canopy is forestiera, spice, casuarina, calophyllum. aspf tubers in quadrat. Moisture is 16.5 for most, dry area is 6.5%	full shade	casuarina, aspfert husks	casuarina	Max temp. 23.6C/ min. 18.5C. partly/mostly sunny. Max RH93%/ min. 60% 12.3hrs sunshine. Max wind 13 knots from 130 degrees SE.	5	April 29th 1.87 inches, april 30th 0.11 inches. last 7 days 51mm 1.99"	4th May 2018
Cas 7 paired	7	12	19	most live snails assoc with small stones or under big roots in middle. smal Poe in v.damp parts of litter up in leaves	live Brady and Oligyra		67	15	17	flat SE	21.3	17.1	Other	None	at base of big brzpep-lots of roots and some rocky bits. v.big fallen olive next to quadrat. dense litter olive leaves, brzp, brzpsticks,few spice leaves. olive litter very wet and sticky. very shady.	full shade	0	0	Max temp. 23.6C/ min. 18.5C. partly/mostly sunny. Max RH93%/ min. 60% 12.3hrs sunshine. Max wind 13 knots from 130 degrees SE.	5	April 29th 1.87 inches, april 30th 0.11 inches. last 7 days 51mm 1.99"	4th May 2018

Cas 8	5	6	11	none under green snowberry leaves. live against root at top of quadrat	dead spiral, 5 live Oligyra, dead shell looks like marine bubble shell??	big head ants nearby	54	3	8	moderate SSW	21.6	14.9	Casuarina	None	Litter=Casuarina needles, bark, twigs and berries; with few spice and aspferrn leaves. live snowberry in quadrat without fruit.	partial shade	few old Cas	few half mature snowberries	Max temp. 23.6C/ min. 18.5C. partly/mostly sunny. Max RH93%/ min. 60% 12.3hrs sunshine. Max wind 13 knots from 130 degrees SE.	5	April 29th 1.87 inches, april 30th 0.11 inches. last 7 days 51mm 1.99"	4th May 2018
Cas 8 paired	5	9	14	NB. 751 is start of this quad-forgot to photo board before. Poe mostly under bark esp big ones. possible egg clutch -photo with pepper berry for scale.	4 live Oligyra, 1 live Zonitoides	0	59	5	8	moderate ENE	21.8	10.6	Other	None	Below fallen dead Casuarina, lots of big bark fragments in quadrat. litter is spice, with few old casuarina needles and lots cas bark. canopy is brazil pepper, spice with flowers and fallen Cas.	partial shade	old brz pep berries, old Casuarina berries	none	Max temp. 23.6C/ min. 18.5C. partly/mostly sunny. Max RH93%/ min. 60% 12.3hrs sunshine. Max wind 13 knots from 130 degrees SE.	5	April 29th 1.87 inches, april 30th 0.11 inches. last 7 days 51mm 1.99"	4th May 2018
Cas 9	15	5	20	1 on stick, others on leaves. snails live in upper litter layer on leaves (not needles) or sticks - dead Poe in lower layers	3 live Zonitoides, 6 live Oligyra	whisltng frog	17	8	5	flat on steep slope, SSe	26.7	2.5	Casuarina, Other	None	Cas litter with some calophyllum leaves and aspferrn strings. canopy is calophyllum, brzp,baygrape and Cas. next to fallen Cas with sticks etc. cas still live but toppled, with snowberry and aspferrn on it. Hard to get moisture meter in = floating in litter	partial shade	aspferrn, calophyllum, casuarina	casuarina and calophyllum	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Cas 9 paired	23	36	59	no Poe in dry litter. all live Poe but 3 small were assoc with rock, and most dead near it.	live Zonitoides and Oligyra	cockroach	14	6	4	moderate ESE	33.1	6.2	Other	Loose rocks	litter is bay grape, calophyllum, calophyllum seeds, few casuarina needles, asparagus fern strings. no Poe in litter, v.dry. Loose stones with lots of snails between them	full sun	calophyllum, casuarina, brazil pepper	calophyllum	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Cas 10	0	0	0	snails only use Cas litter when it is wet and contains other leaves??	2 dead Oligyra, no live snails here		2	1	1	flat W	25.5	4.1	Casuarina	None	v.dry Cas litter with berries and twigs. v.few bay grape leaves (~5). Casuarina and bay grape over quadrat, oxeye and aspferrn nearby. stone in quad is dug in - none under	partial shade	casuarina	casuarina	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Cas 10 paired	8	25	33	live are mostly on bay grape leaves	live Oligyra and Zonitoides		4	2	2	gentle WNW	25.3	6.3	Palm, Casuarina, Other	None	asparagus fern in quadrat. Litter=aspferrn leaves, pink oleander leaves and flowers,palmetto frond peices, bay grape. some cas needles and berries ~33% cas in litter. canopy=palmetto, bay grape, oleander, aspferrn	partial shade	casuarina	none	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Fan 1	1	47	48	shells are clumped	3 dead milk, 7 dead Rumina, 3 dead brady, 3 dead Oligyra, 1 dead Succinea, 2 little white cones, 1 long spiral		14	1	3	flat NE	21.9	14.8	Palm, Other	None	Litter is twigs from brz pepper, brz pep seedlings, few stones. dead fronds at base of cfpalm, aspargus fern and St. augustine grass. Quadrat is more other than palm litter. Palm contribution is mostly frond stems	partial shade	none	none. no cfp berries	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018

Fan 1 paired	7	105	112	mostly in a line under root - possibly oleander root.	7 live and 3 dead Oligyra, 2 dead bradyb, 15 dead long slim spirals, 1 dead cone, 1 live and 1 dead Zonitoides photos in heand at 12:14	isopods, milipedes, spiders	12	4	3	flat SE	23.3	19.6	Other	Logs	lots asparagus fern, under pepper tree. lots of pepper sticks and rotting twigs. no rocks in quadrat, but nearby.	partial shade	none	1 or 2 aspfern old berries on vine	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Fan 2	4	34	38		1 live Oligyra, lots dead thin spirals		21	3	2	flat NW	19.9	15.4	Palm, Other	Loose rocks	lots of fiddlewood litter, about 2 inches deep. fan palm in a group of cfp in fw, spice, brz pepper canopy, with virginia creeper on. 2 stones in quadrat and root through it	partial shade	none	none	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Fan 2 paired	10	39	49	rock just outside quadrat with lots of live under	dead Rumina, bradyb and spirals	1 slug, milipede	23	5	2	flat NE	23.1	32	Other	None	dense, damp fiddlewood litter in quadrat with 1 aspfern seedling and sticks. Canopy=brz pepper, fw, spice and chinese fan palm. 2 v small stones.	partial shade	none	none	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Fan 3	8	21	29		2 dead spirals, 1 live Oligyra	small slugs, and brown slug with stripe	59	13	4	flat	19.5	30.7	Other	None	not really any faplm leaf litter - litter mainly fiddlewood. canopy=fiddlewood, cfpalm, cherry, jumbie, jap pitto, virginia creeper.	full shade	none	none	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Fan 3 paired	3	29	32		dead flatcoils and spirals	small slugs	57	9	4	flat	19.3	21.9	Other	None	canopy=chinese fan palm with fiddlewood, cherry with virginia creeper on it. lots of fan palm litter nearby. Some frond fragments in quadrat, but mostly fiddlewood litter and sticks.	full shade	old chfpalm seed and v.old cherry seeds	none	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Fan 4	24	2	26	Poe snails under fan palm fronds on ground- against stems of fronds and sticks (photo of 10 Poe on underside of frond).	lots of tiny cones	whistling frog	63	3	3	flat NNW	26	15.9	Palm, Casuarina	None	under fan palm litter is lots of Cas litter. canopy=fan palm and Casuarina. Lots of big chfp fronds on ground with Poe on fallen bark pieces and crown material and frond stems - all hard surfaces.	partial shade	old Casuarina and fan palm berries, brz pepper husks	v.small young fruit on fan palm	max temp 26.0C/min 21.6. mostly sunny. MaxRH93%/min67%. 11.4 hrs sunshine. max wind 14 knots at 230 degrees SW	3	Fri May 11th 0.04 inches, may 12th 0.02 inches	14th May 2018
Fan 4 paired	0	13	13		4 others, Oligyra, Bradyb		66	2	3	flat NE	26.4	14.2	Casuarina	Logs	quadrat is Cas litter and capeweeds. canopy=casuarina, brazil pepper, cane grass. asparagus fern and logs are nearby. feels dry. Cas needles are not matted	partial shade	old Casuarina, old chfpalm and brz pepper husks	Casuarina	max temp 26.0C/min 21.6. mostly sunny. MaxRH93%/min67%. 11.4 hrs sunshine. max wind 14 knots at 230 degrees SW	3	Fri May 11th 0.04 inches, may 12th 0.02 inches	14th May 2018

Palmetto 1	11	10	21	all live from damp rotting Cas root. rest of quad is dry and empty	live Oligyra and 1 live Bradyb. frond haning dead off trunk had 2 live v.small milk snails and lots of tiny cones- photo.		69	4	3	gentle NW	27.6	4.2	Palm	None	cane grass, some v.broken down palmetto but no real frond pile-frond haning dead off trunk had 2 live v.small milk snails and lots of tiny cones (photo).	full sun	old Cas berries and v.old fan palm fruit	none	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Palmetto 1 paired	35	29	64	live Poe in the palm litter and damp spot. damp area with snails is 19.9% other spot is 11.4%	1 live Oligyra	nemertean (photos) milipedes lots	67	8	3	flat	20.8	19.9	Palm	Logs	under Ch fan palm behind palmetto. lots fan palm litter (old fronds and stems), brz pepper and fw logs. some fw litter but little in quadrat.	full shade	none	none	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Palmetto 2	5	88	93	sandwiched in litter not on ground	dead milk and rumina, Oligyra	cockroach eggs, isopods, big headed ants nest, cockroad adult	68	2	5	flat E	17.9	15	Palm	None	under palmetto trunk there is palm litter, mostly frond stems and large bark peices. few brz pepper and fw nearby but not contributing to quadrat	full shade	few brz pepper	buds on palm	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Palmetto 2 paired	6	204	210	dead are mostly white, not at all recent	long dead rumina, Oligyra, ?bradyb?	isopods	65	4	5	flat	20.5	17.8	Other	None	fiddlewood and und. pittosporum litter with some brz pepper twigs. under sapling undulat. pittosporum with chf palm seedlings, aspfern and olive saplings. canopy=over quad is brz pepper and fiddlewood	partial shade	v.old pepper, 1 old fan palm seed	none	Max temp. 22.8C/min 17.9C. partly cloudy. MaxRH90%/min 60%. 12.3hrs sunshine. max wind 16knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Palmetto 3	25	2	27	lots under nearby rock.	2 live Oligyra, dead rumina		10	3	3	gentle N	20.2	11.2	Pal	None	some palm litter and decaying fronds haning from tree. Fallen berry stems significant. root through quadrat. fairly open-sparse canopy of Cas, fw, spice near but not over.	partial shade	Casuarina berries. no chfpalm in quad	snowberry nearby with fruit over quadrat	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Palmetto 3 paired	19	1	20	small snails like curled leaves. damp cas bark has snails in it. live just under lower horizon of litter(MO)	1 live flatcoil (photo)	milipedes	8	2	3	moderate NW	20.4	16.5	Other	None	mostly thick spice litter, some Cas bark (moldy+damp) with snails in. canopy=spice, fw, snowberry	partial shade	old casuarina	snowberry just beginning to fruit	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Palmetto 4	4	17	21	live snails under root in quadrat	not recorded	cockroach egg, milipede	13	6	3	flat SE	21.3	10.1	Palm	None	lots palmetto litter from fronds to fragments. Pile against palmetto trunk. canopy=palmetto, brz pepper, lantana. leaf litter is dry - snails on root.	partial shade	old palm berry husks	none	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018

Palmetto 4 paired	0	3	3				14	6	3	gentle ESE	22.9	9.6	Other	None	canopy=brz pepper, spice bay grape. quadrat has a sparse mat of aspferrn (few plants) and lots of litter-twigs, baygrape and spice.	full shade	few old Cas, old baygrape kernals	none	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Palmetto 5	9	10	19	Poe on Cas sticks and damp leaves not palm litter, only tiny cones in palm	2 live Oligyra, live tiny cones in palm litter, 1 dead bradyb		61	21	16	moderate SSE	23.4	7.1	Palm, Casuarina	None	canopy=casuarina, palmetto, spice, calophyllum saplings. litter is Cas needles, bark, twigs and berries. some palmetto, but more Casuarina dominated. snowberry stem across quadrat.	partial shade	calophyllum, casuarina, brz pepper	casuarina fruiting, flowers on spice	Max temp. 23.6C/ min. 18.5C. partly/mostly sunny. Max RH93%/ min. 60% 12.3hrs sunshine. Max wind 13 knots from 130 degrees SE.	5	April 29th 1.87 inches, april 30th 0.11 inches. last 7 days 51mm 1.99"	4th May 2018
Palmetto 5 paired	4	7	11		rumina. live Oligyra and long spirals		55	25	14	moderate E	22.2	8.1	Casuarina, Other	None	bay grape,calophyllum and spice litter with casuarina needles, twigs, berries underneath other leaves. cas are fallen around here, so litter is lower down strata. 1 olive seedling and 1 calophyllum in quadrat. canopy= spice, brz pep, fw, calo, olive.	partial shade	old calophyllum, old casuarina	calophyllum	Max temp. 23.6C/ min. 18.5C. partly/mostly sunny. Max RH93%/ min. 60% 12.3hrs sunshine. Max wind 13 knots from 130 degrees SE.	5	April 29th 1.87 inches, april 30th 0.11 inches. last 7 days 51mm 1.99"	4th May 2018
Palmetto 6	3	7	10	photo against half a calophyllum fruit husk	live Oligyra, Zonitoides and tiny cones		25	17	7	flat WSW	24.6	10.2	Other	None	quadrat against crown of fallen palmetto. some palm litter, mostly sticks, calophyllum and baygrape. canopy over fallen palm is calophyllum and bay grape.	partial shade	lots halves of old calophyllum fruit	calophyllum	max temp 25.5C/min 22.4C. partly/mostly cloudy, overcast. Max RH94%/min79%. 10.6 hrs sunshine. max wind 20 knots 200 degrees SSW.	11	April 29th. last 7 days 0mm, past 30 days 72mm/2.83"	10th May 2018
Palmetto 6 paired	2	42	44	live Poe in calo fruit halves and leaf. moved rock in quad and didn't find any near	live Zonitoides and Oligyra. Dead rumina		22	15	6	flat SW	25.8	7.3	Other	Loose rocks, rocky outcrop	litter is calophyllum, sticks, aspferrn leaves and few baygrape leaves. canopy is calophyllum and 1 baygrape.	partial shade	calophyllum halves	calophyllum	max temp 25.5C/min 22.4C. partly/mostly cloudy, overcast. Max RH94%/min79%. 10.6 hrs sunshine. max wind 20 knots 200 degrees SSW.	11	April 29th. last 7 days 0mm, past 30 days 72mm/2.83"	10th May 2018
Rocky 1	17	122	139	live are upside down on roof of overhang and in deepest recess of rock. dead shells in leaf litter. few live on surface of rock outcrop in leaf litter.	old rumina, spirals, ?bradyb.	small slugs	22	6	2	steep E	22.4	21.4	Other	rocky outcrop	rock outcrop with cracks and slightly mossy. litter=fiddlewood and spice. canopy=fw,spice,und. pittosporum, brz pepper. aspferrn seedlings but no mature - not established? damp litter against rock.	partial shade	old aspferrn berries	none	Max temp. 22.8C/ min 17.9C. partly cloudy. Max RH90%/min 60%. 12.3hrs sunshine. max wind 16 knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Rocky 1 paired	28	59	87	live juveniles here, mostly in leaf litter	not recorded	slugs	21	9	2	flat SE	23	14.6	Other	None	pitto sp? photo in hand. Litter=spice and pittosp leaves, brzp twigs and lots of sticks. quad against cedar stump under brzpep tree with spice, cherry, aspferrn seedling (no mat).	partial shade	old asparagus fern berries	none	Max temp. 22.8C/ min 17.9C. partly cloudy. Max RH90%/min 60%. 12.3hrs sunshine. max wind 16 knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Rocky 2	26	47	73	live Poe in crack at one end of outcrop (where spice sapling is in photo)	live ?bradyb?, dead brady, spirals	small slugs	50	1	3	NE facing rock	20.5	18.4	Other	rocky outcrop	canopy=spice, brzpepper. quadrat is brzpep twigs and fw litter, spice seedlings. aspf nearby. Rock outcrop in woodland. Like a ledge with soil and loose stones under overhang.	partial shade	none	none	Max temp. 22.8C/ min 17.9C. partly cloudy. Max RH90%/min 60%. 12.3hrs sunshine. max wind 16 knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018

Rocky 2 paired	0	2	2	one of dead is tiny	3 live Oligyra and spirals		52	5	3	flat	22.2	23.7	Other	None	fairly open canopy mostly spice with fw, cherry, brzpep, small cfpalm. ~2" litter=spice, fw, few twigs. no stones in quad.	partial shade	none	none	Max temp. 22.8C/ min 17.9C. partly cloudy. Max RH90%/min 60%. 12.3hrs sunshine. max wind 16 knots at 340 degrees NNW	3	April 29th 1.87 inches, April 30th 0.11 inches	2nd May 2018
Rocky 3	36	7	43	MO collected large Poe	not recorded	isopods	17	5	3	flat N	19.6	19.9	Other	Loose rocks, Rock pile	no canopy over quadrat. uprooted Casuarina over. small stones and scattered litter of spice with brz pepper and v.sparse Cas needles. Rock looked like an outcrop with ledge, but could be moved and searched under. Mossy. Temp is 19.2 in soil and 19.6 on rock where snails were	partial shade	few old Cas berries	none	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Rocky 3 paired	0	6	6		old Rumina	milipedes	16	3	3	gentle NW	34.3	17.6	Casuarina	Loose rocks	brz pepper and spice overhang quadrat. aspfern and jumbie seedlings in it, with sparse spice litter, few Cas berries. small stone in corner of quad.	full sun	few old Cas berries	flower on overhanging spice	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Rocky 4	10	2	12		3 live Oligyra, 1 walked away before photo	isopod	18	9	5.5	gentle S	19.2	20.5	Casuarina, Other	Loose rocks, Rock pile	canopy over is brzpep sapling, bay grape, calophyllum, sparse aspfern. litter is all of these. Cas uprooted and mossy exposed rock. aspfern tubers and stump in quadrat. dry rocky pile.	partial shade	calophyllum, casuarina	snowberry above, calophyllum	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Rocky 4 paired	0	2	2		not recorded		18	9	5	S?	24.7	16.1	Casuarina, Other	None	50% Casuarina litter, 50% bay grape. canopy=calophyllum, brzp sapling, sparse aspfern. bay grape and snowberry nearby. aspfern tubers in quad. nearby other rocky area.	partial shade	lots old Casuarina berries	none	max temp 22.6C/ min 17.0C. partly/mostly cloudy. Max RH94%/min.52% 12.5 hrs sunshine. max wind 18 knots at 060 degrees ENE	4	April 29th 1.87 inches, April 30th 0.11 inches	3rd May 2018
Rocky 5	16	58	74	live Poe under overhang rocks, not under soil or below top layer of rocks. dead shells under top layer	2 live Oligyra. Dead rumina, spiral, succinea, ?bradyb, Oligyra	milipede, brown centipede?	66	13	9	steep E	21.9	7.8	None	Loose rocks, Rock pile	quadrat in pile of large and small rocks exposed by uprooted Casuarina. Some mossy. Able to turn over and search under all rocks. canopy=brzpep, mglor, aspf, spice (flower buds), uprooted Cas. some litter=spice, brzp.	partial shade	none	none	Max temp. 23.6C/ min. 18.5C. partly/mostly sunny. Max RH93%/ min. 60% 12.3hrs sunshine. Max wind 13 knots from 130 degrees SE.	5	April 29th 1.87 inches, april 30th 0.11 inches. last 7 days 51mm 1.99"	4th May 2018
Rocky 5 paired	0	32	32	kept old high domed shell with ridge	1 live Zonitoides, 1 live Oligyra in litter	none	70	17	10	moderate E	22.5	18	Other	None	canopy is sparse-spice, fw. dense spice litter (smells spicy). dry litter with skeleton leaves. sunnier than other quadrats. some mglor vine in litter	partial shade	none	buds on spice	Max temp. 23.6C/ min. 18.5C. partly/mostly sunny. Max RH93%/ min. 60% 12.3hrs sunshine. Max wind 13 knots from 130 degrees SE.	5	April 29th 1.87 inches, april 30th 0.11 inches. 51mm 1.99"	4th May 2018
Rocky 6	5	67	72	1 live on aspf tuber (photo). Not assoc with rock wall	lots other snails here - didn't pick all up. fell from upslope?		5	0	3	moderate/steep ESE	24.3	8.4	Other	Loose rocks, rocky outcrop	aspfern tubers. rock wall under Jap Pittosporum with oleander canopy. aspf cut from quadrat. litter is oleander, some baygrape. dry and loose-falls downhill. Moisture is 12.3% where snail is on tuber, 8.4% in centre of quadrat	partial shade	old aspfern husks	none	max temp 25C/min 21.7C. partly/mostly sunny. Max RH93%/min78%. 11.6hrs sunshine. max wind 23knots at 170 degrees SSE	8	April 29th 1.87 inches, April 30th 0.11. most of april total	7th May 2018

Rocky 6 paired	0	0	0		1 dead flatcoil	bighead ants, milipede	2	1	3.5	flat SE	26.7	5.3	Other	loose rocks	spice seedling, sparse baygrape litter, aspfern, jumbie seedling, bermudiana, mint, grass. V.dry. 1 mossy rock=no snails here. Lots scattered small stones	full sun	old calophyllum, old brz pepper	none	max temp 25C/min 21.7C. partly/mostly sunny. Max RH93%/min78%. 11.6hrs sunshine. max wind 23knots at 170 degrees SSE	8	April 29th 1.87 inches, April 30th 0.11. most of april total	7th May 2018
Rocky 7	0	3	3	no snails associated with rockface	live Oligyra, Brady,Zonitoides and tiny cones		11	5	4	gentle SE	27.1	3.9	Other	rocky outcrop	quadrat at base of rock outcrop, pos old quarry. litter=spice, baygrape,calophyllum. aspfern and calophyllum seedlings in quadrat. canopy=spice, brazil pepper, calophyllum	partial shade	aspfern, calophyllum, ?coffee bean	green calophyllum, flowers on spice	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Rocky 7 paired	0	0	0		v.few snails. 1 live Oligyra and some tiny cones in baygrape	roach and eggs	10	4	3.5	flat SW	25.3	5	Casuarina	None	dense Cas needle litter with few baygrape leaves. Aspfern leaves in litter too, with Cas bark, berries and twigs.v.dry. canopy=cas, calophyllum,baygrape,jap pitto, brz pep.	partial shade	Casuarina and few calophyllum	casuarina, calophyllum	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Rocky 8	33	4	37	1 small Poe in Rumina shell.	2 live Oligyra,		15	10	5	moderate WSW	25.7	4.2	Other	Loose rocks, rocky outcrop	rock outcrop with loose stones and roots. Searched under loose and overhang of outcrop. old cedar stumps. canopy=oleander, brz pep. Aspfern on ground. litter is sparse - oleander leaves and flowers, some baygrape. cedar next to here.	partial shade	none	none	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Rocky 8 paired	13	13	26	1 live Poe on rolled oleander leaf, on baygrape leaf and on small stone. others loose in the litter or knocked off?	live Oligyra and Zonitoides. lots dead Brady		8	5	3	moderate W	0.0	0.0	Other	None	oleander leaves and flowers, sticks, few spice leaves. 1 aspfern seedling. canopy=oleander tree	partial shade	none	none	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Rocky 9	21	2	23	Poe under overhang upside down. also 4 on root under stones. together under stones with space and in litter. none under stones that hard to pull out of ground	live Oligyra and little cones in leaves	2 whistling frogs under rock with snails	64	56	15	moderate W	26.4	9	Other	Loose rocks, Rock pile	About 6 large rocks in woodland. Turned up to search under them. dense spice and fw litter with some brz pep. v.old cedar sticks and aspfern. canopy=dense spice and 2 brzpep, 1fw. fw too flimsy for snails?	partial shade	none	spice flowers	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Rocky 9 paired	1	0	1	1 live Poe on leaf on surface. no snails on sticks in quadrat	live Oligyra, tiny cones and Zonitoides		59	54	15	flat WSW	25.1	12.9	Other	None	dense spice litter. canopy=spice only, with flowers. logs nearby. aspfern seedling.	partial shade	none	spice flowers	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
Rocky 10	6	11	17	3 live Poe under rock, rest on litter in crevice under rock=damp	live Oligyra		56	3	6	steep NNW	25.3	11.4	Other	Loose rocks	2 large rocks in woodland, not really pile or outcrop. sparse litter on rock. pulled 1 up, snails under but other would not come up. litter=spice, fw leaves and lots of fw sticks. canopy=spice and fiddlewood	full sun and partial shade	? spice	spice flowers	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018

Rocky 10 paired	6	82	88	lots of dead - came down slope? some are in pockets so may have died in situ	live tiny cones in litter, live Oligyra. lots dead shells		56	4	6	moderate ENE	24.3	13.3	Other	None	Dense litter of fiddlewood with some spice, next to fallen live fiddlewood. lots of sticks and skeletonised leaves (no snails on these). canopy=50/50 spice and fiddlewood.	full shade	none	none	Max temp. 26.8C/min. 21.7C. Sunny-partly cloudy. MaxRH93%/min.65%. 12.2 hrs sunshine. Max wind 13 knots from 160 degrees SSE.	4	Fri May 11th 0.04 inches, may 12th 0.02 inches	15th May 2018
1	1	2	3	1 live on stick in litter	1 dead olygira, 1 live spiral	milipede, whistling frog, big head ant	17	18	2	flat NW	25.1	12.6	Other	None	brz sticks, bit of rotting cedar with nothing in. Dense spice, brz pep litter = dry. canopy - spice, brz pepper, dead brz pep. open understory. quarry nearby.		v old seed of spice	buds on spice	max temp 25C/min 21.7C. partly/mostly sunny. Max RH93%/min78%. 11.6hrs sunshine. max wind 23knots at 170 degrees SSE	8	April 29th 1.87 inches, April 30th 0.11. most of april total	May 7th 2018
2	5	22	27	1 live under root, 1 live stuck to leaf	live Zonitoides in litter	0	10	3	2	flat ESE	26.6	11.7	Other	None	Big oleanders here - low hanging with flowers. Fallen flowers and oleander leaves in litter. Aspf tubers and 1 root in quadrat. Litter is oleander, spice and calophyllum		old asparagus fern	old fruit still on asparagus fern	max temp 25.6C/min 22.2C. partly/mostly sunny. MaxRH95%min79%. 11.4hrs sunshine. max wind 22knots at 170 degrees SSE	9	April 29th 1.87 inches, April 30th 0.11. most of april total	May 8th 2018
3	10	4	14	found a few evasc. in bay grape leaf litter. live Poe are attached under damp bay grape leaves in litter	3 live Oligyra	0	12	8	3	gentle SSW	24.2	3.1	Casuarina, Other	None	Litter mostly Cas with Caolphyllum and bay grape on top. canopy=fallen Cas tree with live branches, calophyllum, sparse brz pepper. Bay grape litter is from upslope?		old Casuarina berries, old calophyllum husks	none	max temp 25.6C/min 22.2C. partly/mostly sunny. MaxRH95%min79%. 11.4hrs sunshine. max wind 22knots at 170 degrees SSE	9	April 29th 1.87 inches, April 30th 0.11. most of april total	May 8th 2018
4	2	24	26	1 on stick. Photo of small snail on leaf that isn't Poe, but looks like it	live Oligyra, spirals and Zonitoides in litter. Dead brady and Rumina	milipede, termites	16	20	2	gentle ENE	25.4	14.1	Other	None	quadrat SW corner. Canopy=spice, fw, cherry, brz pep. Litter is dense - fw, spice, brz pep. Seedlings of asparagus fern and cherry. Japanese pittosporum outside quadrat. Large stick pos Brz Pepper		old asparagus fern	none	max temp 25C/min 21.7C. partly/mostly sunny. Max RH93%/min78%. 11.6hrs sunshine. max wind 23knots at 170 degrees SSE	8	April 29th 1.87 inches, April 30th 0.11. most of april total	May 7th 2018
5	10	3	13		live Oligyra		11	4	3	gentle W	27.9	14.5	Other	Loose rocks	Litter is bay grape, European olive, and brz pepper. some dead St. Augustine grass and a few stone too. Aspf tubers in quadrat. Canopy=Euro olive, bay grape and Brz pepper. Buttonwood nearby.		old asparagus fern	none	max temp 25.6C/min 22.2C. partly/mostly sunny. MaxRH95%min79%. 11.4hrs sunshine. max wind 22knots at 170 degrees SSE	9	April 29th 1.87 inches, April 30th 0.11. most of april total	May 8th 2018
6	0	5	5		1 live Oligyra		8	6	2	moderate N	29.1	9	Casuarina, Other	None	Litter = oleander, asparagus fern leaves and strings, spice and about 50% Casuarina needles. cleared Aspf mat from quadrat. Big root in quadrat		old Casuarina berries, Asparagus fern husks	snowberry fruit on ground next to quadrat	max temp 26.0C/min 21.6. mostly sunny. MaxRH93%/min67%. 11.4 hrs sunshine. max wind 14 knots at 230 degrees SW	2	Fri May 11th 0.04 inches, may 12th 0.02 inches	May 14th 2018
7	7	28	35	all under rock not in litter	16 others, incl Succinea	church worm, baby roach	10	11	3	gentle SW	24.1	9.3	Other	Loose rocks	large rock in quadrat with snails underneath. Litter=olive tree, also olivewood overhangs quadrat, but few leaves in litter. Aspf fern tuber, sticks, aspf strings and v.sparse Cas needles also in litter. Canopy=dense olive, olivewood, brz pepper.		old Casuarina berries	none	max temp 26.0C/min 21.6. mostly sunny. MaxRH93%/min67%. 11.4 hrs sunshine. max wind 14 knots at 230 degrees SW	2	Fri May 11th 0.04 inches, may 12th 0.02 inches	May 14th 2018

8	8	29	37	live Poe on leaves and twigs	4 live Oligyra		23	13	5	flat N	28.8	7.9	Casuarina, Other	None	50/50 Casuarina needles and other leaf litter. other litter is spice, bay grape, snowberry, aspf leaves and strings and Casuarina bark and twigs.		old Casuarina berries	snowberry very near quadrat. no flower on spice	max temp 26.0C/min 21.6. mostly sunny. MaxRH93%/min67%. 11.4 hrs sunshine. max wind 14 knots at 230 degrees SW	2	Fri May 11th 0.04 inches, may 12th 0.02 inches	May 14th 2018
9	54	29	83	6 in stick, 1 in shell, most are tiny. tiny Poe in leaf litter - bigger in sticks and fallen out on ground. lots of hatchlings	live yellow spiral, Oligyra and flat coil	long ants, spiders	50	22	5	gentle ENE	27.3	14.9	Other	Loose rocks	dense fiddlewood litter. water is sitting in leaves. few brz pepper in litter, most is fw and sticks. Canopy over quad = fw, brz pepper, cherry and spice. collected pink nemertean in etoh here		none	flowers on fw and fallen in quadrat	max temp 28.3C/min 24.3C. partly/mostly sunny; windshift. Max RH93%/min76%. 11.3hrs sunshine. max wind 20 knots at 270 degrees W.	1	yesterday 0.08 inches thurs 7th	June 8th 2018
10	1	2	3	1 live on underside of thick root	1 live Oligyra		12	6	3	flat ESE	27.9	6.2	Casuarina, Other	None	Bay grape, spice, brz pepper, asparagus fern in litter with '25 % Casuarina needles. Canopy=bay grape, brz pepper, spice. logs and sparse asparagus fern mat nearby. snail quad is 1m down from NE pole of veg quadrat. Snail root which maybe baygrape		snowberry, old aspf, old bay grape, old brz pepper	spice flowering, snowberry with fruit	max temp 25.6C/min 22.2C. partly/mostly sunny. MaxRH95%min79%. 11.4hrs sunshine. max wind 22knots at 170 degrees SSE	9	April 29th 1.87 inches, April 30th 0.11. most of april total	May 8th 2018
11	1	3	4		2 live Oligyra and 2 live Zonitoides	live roach	18	12	5	gentle SE	24.7	11.1	Casuarina, Other	None	snail quad is 1m on SE side of veg. Litter is 50% Cas needles and 50% leaves, mainly bay grape, Calophyllum, spice and twigs. Old Calophyllum fruit husks. quadrat has asparagus fern tubers in (but not a mat) and calophyllum seedlings		Calophyllum and sparse Casuarina berries	flowers on spice, Calophyllum green fruit	max temp 25.6C/min 22.2C. partly/mostly sunny. MaxRH95%min79%. 11.4hrs sunshine. max wind 22knots at 170 degrees SSE	9	April 29th 1.87 inches, April 30th 0.11. most of april total	May 8th 2018
12	14	24	38	live Poe mainly attached to bay grape leaves. 1 live Poe in calophyllum berry shell (photo)	live Zonitoides and Oligyra		14	6	4	gentle SSW	24.3	11.7	Casuarina, Other	None	Litter is Casuarina with bay grape and calophyllum on top. Canopy=calophyllum, japanese pittosporum, bay grape, oleander and Casuarina. snail quad in NW corner of veg		old calophyllum and Casuarina berries	none	max temp 25.6C/min 22.2C. partly/mostly sunny. MaxRH95%min79%. 11.4hrs sunshine. max wind 22knots at 170 degrees SSE	9	April 29th 1.87 inches, April 30th 0.11. most of april total	May 8th 2018
13	17	29	46	1 live on stick with Zonitoides (photo)/ some quite small live Poe	live Brady., Oligyra and Zonitoides		31	17	6	flat W. slope moderate but flattens out here	25.1	10.8	Other	None	Litter - dense spice leaves, oleander leaves and fallen oleander flowers. Dense canopy of spice and oleander. several oleander are outside veg quadrat but overhang snail quadrat.		none	flowers on spice	max temp 26.0C/min 21.6. mostly sunny. MaxRH93%/min67%. 11.4 hrs sunshine. max wind 14 knots at 230 degrees SW	3	Fri May 11th 0.04 inches, may 12th 0.02 inches	May 14th 2018
14	12	22	34	photo of one tiny poe. litter feels dry-snails on wettest sticks - had to break open sticks. ?rotting brzp?	1 dead milk snail. live Oligyra and tiny cones	slug	47	22	6	moderate NNE	28.3	14.9	Other	None	Canopy=~50% open. dead cedar, brz pep with mglory on, fw, tall spice, tangle of brzp sticks and old mglory vines. Litter is some spice, mostly fw and brazil pep. Aspfern live and old strings inside the quadrat. site is a clearing under a brzp 'arch'.		very few brazil pepper husks	none	max temp 28.3C/min 24.3C. partly/mostly sunny; windshift. Max RH93%/min76%. 11.3hrs sunshine. max wind 20 knots at 270 degrees W.	1	yesterday 0.08" Thurs 7th	June 8th 2018
15	5	71	76	on stick and leaf, none around rock in quadrat	2 live Oligyra and live flatcoil. Dead rumina and spirals	long ants	52	36	9	flat NNE	28	8	Other	rocky outcrop	target is 9mNW but can't go further. quad on rock with moss under fallen brz branch by cedar stump. lots sticks in litter, few leaves. few blown in bay grape leaves. Litter Brzpep and spice. Canopy=dense brzp. Rock did not lift up and none on surface of it		brazil pepper husks	none	max temp 28.3C/min 24.3C. partly/mostly sunny; windshift. Max RH93%/min76%. 11.3hrs sunshine. max wind 20 knots at 270 degrees W.	1	yesterday 0.08" Thurs 7th	June 8th 2018

16	0	1	1	no Poe, but photo of one near quadrat. almost no dead snails here	lots and lots live little cones (photo), 1 dead Oligyra	roaches, spiders	50	45	11	flat SW	24.4	11	Other	None	canopy= sparse because brazil pepper has no leaves. canopy=Brz pepper, big spice, calophyllum saplings. dense spice litter with few calophyllum and brz pep leaves. flattens out here at base of hill	brazil pepper old	flowers on spice	max temp 25.5C/min 22.4C. partly/mostly cloudy, overcast. Max RH94%/min79%. 10.6 hrs sunshine. max wind 20 knots 200 degrees SSW.	11	April 29th. last 7 days 0mm, past 30 days 72mm/2.83"	May 10th 2018
17	0	2	2		live Oligyra and 2 long yellow spirals		83	40	12	flat E	27.7	11.7	Other	None	Litter is sticks of rotting brazil pepper and leaves of spice and brz pepper. leaves are wet. dense canopy og spice and large brazil pepper. root in quadrat.	brazil pepper few old husks	none	max temp 28.3C/min 24.3C. partly/mostly sunny; windshift. Max RH93%/min76%. 11.3hrs sunshine. max wind 20 knots at 270 degrees W.	1	yesterday 0.08" Thurs 7th	June 8th 2018
18	0	14	14	pocket of dead poe and rumina by rock	dead Rumina and Brady. 3 live Oligyra	church worm, spider	31	28	10	gentle W	28.2	17.7	Other	None	stones=no snails. Litter is spice, brz pepper, fiddlewood - mostly spice. Canopy= spice, big brazil pepper, fw with no leaves. Euro olive and cherry trees nearby but not over quadrat. Temo is 28.2 in sun, 25.3 in shade	brazil pepper husks	none	max temp 26.0C/min 21.6. mostly sunny. MaxRH93%/min67%. 11.4 hrs sunshine. max wind 14 knots at 230 degrees SW	3	Fri May 11th 0.04 inches, may 12th 0.02 inches	May 14th 2018
19	7	17	24	1 tiny on leaf with Oli. photo of 4 on bark, only 1 was inside quadrat. 1 live Poe on calophyllum leaf	live Oligyra and Zonitoides	lots tiny spiders, milepede, light straw coloured ants?	59	5	10	steep NE	25.6	6.8	Casuarina, Other	None	Bare soil @centre of quad. stones and Cas branches in. site next to uprooted Cas. litter=~25% Cas, plus spice, fw, few Calophyllum leaves. Canopy=flowering spice, snowberry, Justicia, brazil pepper and calophyllum	old Cas and old Brz pepper	spice flowering	max temp 25.5C/min 22.4C. partly/mostly cloudy, overcast. Max RH94%/min79%. 10.6 hrs sunshine. max wind 20 knots 200 degrees SSW.	11	April 29th. last 7 days 0mm, past 30 days 72mm/2.83"	May 10th 2018
20	2	33	35	2 tiny.	live Zon, Oligyra and yellow spiral	brown mili/centipede, isopods, round egg, long ants	68	49	12	flat NE	28.5	10.7	Other	None	canopy=v open. sparse brz pepper, spice with mglory. Cas nearby. cherry seedling in quadrat. litter feels dry, is sticks, spice, mgloryold vine, v few Cas needles	few old Cas berries, brz husks	fallen Cas flowers	max temp 28.3C/min 24.3C. partly/mostly sunny; windshift. Max RH93%/min76%. 11.3hrs sunshine. max wind 20 knots at 270 degrees W.	1	yesterday 0.08" Thurs 7th	June 8th 2018
21	1	12	13		live Oligyra and Zonitoides and tiny cones	spider, roach egg	53	20	15	moderate?	26.8	9.8	Other	None	primary litter of Calophyllum, spice, fiddlewood, Cas and Brz Pepper sticks. Canopy=dense spice some fiddlewood, calophyllum and brazil pepper	lots of half Calophyllum and some whole, old Casuarina berries	flowering spice	max temp 25.5C/min 22.4C. partly/mostly cloudy, overcast. Max RH94%/min79%. 10.6 hrs sunshine. max wind 20 knots 200 degrees SSW.	11	April 29th. last 7 days 0mm, past 30 days 72mm/2.83"	May 10th 2018
22	4	6	10	on decaying bay grape leaves - one on other side in photos. 1 tiny, thought was Zonitoides - is w/ cone in photo. quad 1m on NW side	3 live Oligyra and tiny cones	whistling frong	73	33	15	moderate S	24.1	9.0	Other	Loose rocks	Litter mostly baygrape with Aspfern strings, olive, spice, sticks fr fallen olive nearby. Stone in middle. Canopy=dense spice and olive, sparse bay grape. lots branches Brz and olive. pulled up large rock and others, nothing under - hard against soil	none	none	max temp 25.5C/min 22.4C. partly/mostly cloudy, overcast. Max RH94%/min79%. 10.6 hrs sunshine. max wind 20 knots 200 degrees SSW.	11	April 29th. last 7 days 0mm, past 30 days 72mm/2.83"	May 10th 2018
23	5	5	10	1 v tiny, photo in hand. tiny Poe on stick, bigger on baygrape leaves and 1 on rock outcrop under leaves	live long spiral and Oligyra	baby roaches	72	35	17	steep SW	29.7	7.1	Other	rocky outcrop	shallow leaf litter over rock outcrop. litter=bay grape, calophyllum, some brazil pepper and aspfern strings. lots sticks. mostly baygrape litter. canopy is open - calophyllum, bay grape and brazil pepper. Temp	old Cas, calophyllum, brz pepper, aspfern	calophyllum	max temp 25.5C/min 22.4C. partly/mostly cloudy, overcast. Max RH94%/min79%. 10.6 hrs sunshine. max wind 20 knots 200 degrees SSW.	11	April 29th. last 7 days 0mm, past 30 days 72mm/2.83"	May 10th 2018

24	2	7	9		live Oligyra, Zonitoides, spiral snail with white body. lots live snails here	whistling frong, long ants with eggs	68	10	19	gentle NW	25.4	18.1	Other	None	dense litter, feels wet just under surface. spice litter with some few fiddlewood and brazil pepper. few sticks. Canopy is dense spice, some holes.		none	flowers on Virginia creeper	max temp 27.5C/min 25.3C. partly/mostly cloudy, overcast; showers. Max RH92%/min73%. 11.1 hrs sunshine. max wind 21 knots from 220 degrees SW	2	12th June, 0.68 inches	June 14th 2018
25	0	1	1		20 tiny cones and small possibly Zonitoides	spider, ?flea	34	30	11	moderate WSW	25.5	15.4	Other	None	Dense litter of spice, some brz pep. fallen storm damage brz nearby=lots of sticks. no spice seedlings. no flowers on spice. ground v.hard and soil packed and flocculated. feels drier than 15%. Canopy=brz pepper tree and spice trees.		brz pepper husks	none	max temp 26.0C/min 21.6. mostly sunny. MaxRH93%/min67%. 11.4 hrs sunshine. max wind 14 knots at 230 degrees SW	3	Fri May 11th 0.04 inches, may 12th 0.02 inches	May 14th 2018
26	5	7	12	3 small in stick, photo of 2 others. on underside of cedar bark peice and brz pep stick	live Oligyra and Zonitoides	termites, brown milipede	75	10	19	moderate NE	27.7	17.2	Other	None	2 cedars not long dead. Canopy open b/c no leaves on brz pepper. Canopy is brz pep with spice. Litter is spcie, cedar sticks and brz sticks - lots. some brz pep leaves in litter but not lots.		brazil pepper husks	none	max temp 27.5C/min 25.3C. partly/mostly cloudy, overcast; showers. Max RH92%/min73%. 11.1 hrs sunshine. max wind 21 knots from 220 degrees SW	2	12th June, 0.68 inches	June 14th 2018
27	0	0	0	1 tiny looks like Poe but is not (photo in hand)	live Oligyra, live Zonitoides and spirals. live flat coil	no	78	8	21	flat SW	26.8	20.7	Other	None	at base of European olive with fallen branches. Canopy=olive, spice, fiddlewood. leaf litter is olive, fiddlewood, spice, lot of sticks. big root in quadrat - damp near it.		none	none	max temp 27.5C/min 25.3C. partly/mostly cloudy, overcast; showers. Max RH92%/min73%. 11.1 hrs sunshine. max wind 21 knots from 220 degrees SW	2	12th June, 0.68 inches	June 14th 2018
28	11	32	43	3 tiny live. photo of small Poe and Zonitoides todgether on leaf and hand	live Zonitoides in litter	big head ant, 2 small slugs	48	7	4	flat? SE	25.2	19.4	Other	None	dense litter = spice, fw. vrginia creeper sticks in litter. Canopy=spice, fw, cherry, big jumbie bean. understory=virginia creeper and white stopper seedlings. fw sticks and fallen fw tree stump. matted litter=damp with tiny Zonitoides and Poe here.		none	none	max temp 25C/min 21.7C. partly/mostly sunny. Max RH93%/min78%. 11.6hrs sunshine. max wind 23knots at 170 degrees SSE	8	April 29th 1.87 inches, April 30th 0.11. most of april total	May 7th 2018
29	1	4	5	1 on spice leaf	photo	no	81	5	22	flat NW	26.4	17.8	Casuarina, Other	None	litter is 50% Casuarina needles and berries, 50% olive, spice and aspfern leaves. Litter is dry with few snails of any spp. aspfern tubers in quadrat. Canopy=lots olive trees, 1 Casuarina and 1 spice tree.		old Casuarina berries	Casuarina fruiting	max temp 25.5C/min 22.4C. partly/mostly cloudy, overcast. Max RH94%/min79%. 10.6 hrs sunshine. max wind 20 knots 200 degrees SSW.	11	April 29th. last 7 days 0mm, past 30 days 72mm/2.83"	May 10th 2018
30	3	20	23	3 live inside brz pep stick (photo). old dead ones		caterpillar, worm under rock	88	15	6	flat NW	24.4	10.1	Other	None	asparagus fern tubers and old berry husks in quadrat. Canopy is brazil pepper and spice. thin litter layer over hard ground. schefflera nearby. snail quadrat in SW corner		old C.Fan Palm berries, old aspfern and brz pepper fruit	none	max temp 25C/min 21.7C. partly/mostly sunny. Max RH93%/min78%. 11.6hrs sunshine. max wind 23knots at 170 degrees SSE	8	April 29th 1.87 inches, April 30th 0.11. most of april total	May 7th 2018

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Appendix IV: Vegetation Data from Random 2m² Quadrats

Quadrat #	Number of plant species	% of all species in dataset	Number of morpho species	% of all morpho species in dataset	Number of individual plants	% individual plants	Species and Count
1	3	11.1	4	9.3	47	5.1	Asparagus fern seedling 37; Spice tree 5; spice sapling 4; palm seedling 1
2	7	25.9	11	25.6	29	3.2	Asparagus fern 3; Asp fern seedling 2, Brazil Pepper seedling 2; Spice tree 1; Spice sapling 5; bay grape sapling 1; Calophyllum seedling 2; oleander 1; Jumbie bean tree 2; Jumbie sapling 4; Jumbie seedling 6
3	2	7.4	4	9.3	18	2.0	Asparagus fern 1; Asp fern seedling 1; Calophyllum tree 3; Calophyllum seedling 13;
4	6	22.2	8	18.6	24	2.6	Asparagus fern 1; asp fern seedling 7; Brazil pepper tree 1; spice tree 3; cherry tree 1; cherry seedling 9; fiddlewood tree 1; Japanese pittosporum 1
5	5	18.5	7	16.3	15	1.6	Asparagus fern 4; cherry seedling 3; European olive tree 1; olive seedling 1; Jumbie bean sapling 2; Jumbie seedling 3; St. Augustine grass 1
6	6	22.2	9	20.9	14	1.5	Asparagus fern 2; Asp fern seedling 2; Brazil pepper 2; Brazil pepper seedling 1; European olive tree 1; olive seedling 1; oleander 2; Jumbie bean seedling 1; Snowberry 2
7	6	22.2	9	20.9	23	2.5	Asparagus fern 5; Asp fern seedlings 5; Spice sapling 1; bay grape sapling 1; European olive tree 2; European olive sapling 3; olive seedling 3; Jumbie bean sapling 2; Snowberry 1
8	6	22.2	8	18.6	9	1.0	Asparagus fern 1; asp fern seedling 1; Spice tree 1; spice sapling 1; bay grape tree 1; oleander 1; Jumbie bean tree 1; Snowberry 2;
9	10	37.0	11	25.6	20	2.2	Asparagus fern seedling 3; Brazil pepper 1; spice sapling 2; cherry sapling 1; cherry seedling 3; fiddlewood tree 2; Virginia creeper vine 2; morning glory vine 2; palm seedling 1; cedar stump 1; holly fern 2
10	4	14.8	5	11.6	13	1.4	Asparagus fern 2, Asp fern seedling 7; Brazil pepper tree 1; spice tree 1; Jumbie bean sapling 2;
11	7	25.9	11	25.6	97	10.6	Asparagus fern 2; asp fern seedling 12; Brazil pepper seedling 11; spice tree 3; spice seedling 5; spice sapling 2; Calophyllum sapling 3; Calophyllum seedling 56; European olive tree 1; Jumbie bean tree 1; St. Augustine grass 1

Quadrat #	Number of plant species	% of all species in dataset	Number of morpho species	% of all morpho species in dataset	Number of individual plants	% individual plants	Species and Count
12	2	7.4	5	11.6	50	5.5	Asparagus fern 1; asp fern seedling 2; Calophyllum tree 2; Calophyllum sapling 21; Calophyllum seedling 24;
13	3	11.1	5	11.6	25	2.7	Spice tree 1; spice sapling 17; spice seedling 3; cherry sapling 3; oleander 1
14	5	18.5	5	11.6	11	1.2	Asparagus fern 5; European olive 3; Jumbie bean seedling 1; morning glory vine 1; cedar stump 1
15	6	22.2	8	18.6	23	2.5	Asp fern seedling 4; Brazil pepper tree 2; Brazil pepper seedling 6; spice sapling 1; spice seedling 4; morning glory vine 3; palm seedling 1; Forestiera or <i>Pittosporum undulatum</i> 2
16	6	22.2	9	20.9	105	11.5	Asparagus fern 1; asp fern seedlings 3; Brazil pepper seedling 1; spice tree 1; spice sapling 54; spice seedling 3; Calophyllum sapling 14; Jumbie bean seedling 27; Japanese <i>Pittosporum</i> seedling 1;
17	3	11.1	5	11.6	48	5.2	Brazil pepper tree 1; spice tree 2; spice sapling 43; spice seedling 1; morning glory vine 1
18	8	29.6	10	23.3	37	4.0	Asparagus fern 2; Spice tree 3; spice sapling 7; spice seedling 3; cherry sapling 2; European olive tree 1; fiddlewood tree 1; Jumbie bean seedling 3; white stopper seedling 2; false freesia 13
19	6	22.2	8	18.6	24	2.6	Asparagus fern seedling 2; spice tree 1; spice sapling 3; spice seedling 8; Calophyllum tree 4; Jumbie bean seedling 1; Snowberry 2; <i>Justica secunda</i> (bloodroot) 3
20	7	25.9	8	18.6	11	1.2	Asparagus fern 1; Brazil Pepper tree 2; Spice tree 2; spice sapling 2; cherry seedling 1; European olive seedling 1; Jumbie bean seedling 1; morning glory vine 1
21	4	14.8	5	11.6	54	5.9	Asp fern seedling 4; spice sapling 4; spice seedling 7; Calophyllum seedling 36; cherry seedling 3;
22	3	11.1	7	16.3	13	1.4	Asparagus fern 2; asp fern seedling 4; spice tree 1; spice seedling 2; Calophyllum tree 1; Calophyllum sapling 2; Calophyllum seedling 1;

Quadrat #	Number of plant species	% of all species in dataset	Number of morpho species	% of all morpho species in dataset	Number of individual plants	% individual plants	Species and Count
23	4	14.8	5	11.6	15	1.6	Asparagus fern 5; Calophyllum tree 2; Calophyllum seedling 2; European olive sapling 5; Jumbie bean sapling 1
24	6	22.2	7	16.3	35	3.8	Asparagus fern 1; Brazil pepper tree 2; Spice tree 6; spice sapling 22; fiddlewood tree 1; white stopper sapling 1; Virginia creeper vine 2
25	3	11.1	5	11.6	16	1.7	Asp fern seedling 4; Brazil pepper tree 1; Brazil pepper seedling 1; Spice tree 4; Spice sapling 6
26	8	29.6	9	20.9	21	2.3	Brazil pepper tree 4; Spice sapling 10; Cherry seedling 1; European olive sapling 1; Jumbie bean seedling 1; white stopper seedling 1; morning glory vine 1; Bermuda cedar 1; cedar stump 1
27	6	22.2	9	20.9	36	3.9	Asparagus fern 6; asp fern seedling 3; Spice sapling 8; European olive tree 3; European olive sapling 6; European olive seedling 4; fiddlewood sapling 1; Jasmine 2; Flopper 3
28	5	18.5	7	16.3	24	2.6	Spice tree 9; spice seedling 3; cherry tree 1; cherry seedling 1; fiddlewood tree 1; white stopper seedling 1; Virginia creeper vine 8
29	6	22.2	6	14.0	17	1.9	Asparagus fern 4; Calophyllum sapling 1; cherry seedling 2; European olive tree 4; olive seedling 2; Virginia creeper vine 2; morning glory vine 1; wall fumitory 1
30	11	40.7	12	27.9	42	4.6	Asparagus fern 2; asp fern seedling 22; Brazil pepper tree 1; Spice sapling 2; cherry seedling 2; European olive sapling 3; Jumbie bean seedling 1; Virginia creeper vine 2; morning glory vine 3; unidentified palm seedling 1; Schefflera 1; Chinese fan palm seedling 2
					916		

Appendix V: Descriptive Statistics for Feature Targets and Paired Quadrats

Table V (a) : Descriptive Statistics Live and Dead Snails in Palm and Paired Quadrats

	Palm Live	Palm Dead	Palm Total	Palm Paired Live	Palm Paired Dead	Palm Paired Total
Sum count (n=10)	94	238	332	86	472	558
Mean	9.4	23.8	33.2	8.6	47.2	55.8
Median	6.5	13.5	26.5	5	29	38
Std Dev.S	8.5009803	26.73242	23.48427	10.85459	62.8557	62.9494
Variance S	72.266667	714.6222	551.5111	117.8222	3950.84	3962.62

Table V (b): Descriptive Statistics Surface Temperature and Soil Moisture % in Palm and Paired Quadrats

	Palm Temp. (°C)	Palm Soil Moisture (%)	Palm Paired Temp. (°C)	Palm Paired Soil Moisture (%)
n=	10	10	10	10
Mean	22.23	13.46	22.47	16.69
Median	21.6	13	22.55	17.15
Std Dev.S	3.10485283	7.182726192	2.330498278	7.453627007
Variance S	9.64011111	51.59155556	5.431222222	55.55655556

Descriptive Statistics of Rock Quadrats

Table V (c): Descriptive Statistics Live and Dead Snails in Rocky and Paired Quadrats

	Rock Live	Rock Dead	Rock Total	Rock Paired Live	Rock Paired Dead	Rock Paired Total
Sum count	170	323	493	48	196	244
Mean	17	32.3	49.3	4.8	19.6	24.4
Median	16.5	9	40	0	4	4
Std Dev.S	12.101423	40.43664	41.08812	9.186947	29.0601	35.1258
Variance S	146.44444	1635.122	1688.233	84.4	844.489	1233.82

Table V (d): Descriptive Statistics Surface Temperature and Soil Moisture % in Rocky and Paired

	Rocky Temp. (°C)	Rocky Soil Moisture (%)	Rocky Paired Temp. (°C)	Rocky Paired Soil Moisture (%)
n=	10	10	9	9
Mean	23.24	12.88	25.34444444	14.05555556
Median	23.35	11.85	24.7	14.6
Std Dev.S	2.9037141	6.747641563	3.658589589	5.981034842
Variance S	8.43155556	45.53066667	13.38527778	35.77277778

Descriptive Statistics of Casuarina Quadrats

Table V (e): Descriptive Statistics Live and Dead Snails in Casuarina and Paired Quadrats

	Casuarina Live	Casuarina Dead	Casuarina Total	Casuarina Paired Live	Casuarina Paired Dead	Casuarina Paired Total
Sum count (n=10)	49	40	89	103	162	265
Mean	4.9	4	8.9	10.3	16.2	26.5
Median	5	3	8.5	8	13	20.5
Std Dev.S	4.7010637	4.136558	7.694876	6.395311	13.1808	18.143
Variance S	22.1	17.11111	59.21111	40.9	173.733	329.167

Table V (f): Descriptive Statistics Surface Temperature and Soil Moisture % in Casuarina and Paired

	Casuarina Temp. (°C)	Casuarina Soil Moisture (%)	Casuarina Paired Temp. (°C)	Casuarina Paired Soil Moisture (%)
n=	10	9	10	10
Mean	23.02	11.15555556	23.21	12.91
Median	22.25	10.5	21.8	13.55
Std Dev.S	1.88077998	6.91738952	3.663164995	5.090394004
Variance S	3.53733333	47.85027778	13.41877778	25.91211111

Appendix VI: Analysis of Variance in Soil Moisture (%) and Soil Temperature (°C) between Palm, Rock and Casuarina Features

Soil Moisture (%)

Shapiro-Wilk test for Normality

- Casuarina Moisture is normally distributed ($W=0.926216$, $n=10$, $P=>0.05$)
- Palm Moisture is normally distributed ($W=0.858725$, $n=10$, $P=>0.05$)
- Rock Moisture is normally distributed ($W=0.898316$, $n=10$, $P=>0.05$)

F-test for Variance between pairs

- Palm + Casuarina moisture $F= 1.21296$, $DF1=9$, $DF2=9$, $P=>0.05$. The 2 variances are not significantly different.
- Rock + Casuarina moisture $F= 1.07046$, $DF1=9$, $DF2=9$, $P=>0.05$. The 2 variances are not significantly different.
- Palm + Rock moisture $F= 1.13312$, $DF1=9$, $DF2=9$, $P=>0.05$. The 2 variances are not significantly different.

1-way ANOVA, soil moisture between the 3 feature types

QED Statistics 1.5.1.456 - 3 targets moist

FileEditSimulationSingle SampleAnalysis of FrequencyTwo SamplesRegressionANOVASGLMPlanningHelp

Explore the Statistic: One way ANOVA

One Way ANOVA						
	DF	SS	MS	F	Prob. >F	Omega ²
Between	2	28.616	14.308	0.307355	0.737928	-0.0484118
Within	27	1256.9	46.552			
Total	29	1285.52	12.5			
This means	There is no significant difference in means between the treatments (F = 0.307355, DF1 = 2, DF2 = 27, P = >0.05)					
	Means and Variability					
Group	Mean	Variance	StdD	N		
Cas_moist	11.16	42.5338	6.52179	10		
Palm_moist	13.46	51.5916	7.18273	10		
Rock_moist	12.88	45.5307	6.74764	10		
Total	12.5	44.3283	6.65795	30		
	Homogeneity of Variance Tests					
Test	Statistic	DF1	DF2			
Hartley Fmax	1.21296	3	9			
Cochran C	0.369419	3	9			
Bartlett Chi-square	0.0829261	2				
Bartlett Probability > Chi-Square	0.959385					

Soil Temperature (°C)

Shapiro-Wilk test for Normality

- Casuarina Temperature is normally distributed (W=0.889535, n=10, P=>0.05)
- Palm Temperature is normally distributed (W=0.960294, n=10, P=>0.05)
- Rock Temperature is normally distributed (W=0.939814, n=10, P=>0.05)

F-test for Variance between pairs

- Palm + Casuarina temperature F= 2.72525, DF1=9, DF2=9, P=>0.05. The 2 variances are not significantly different.
- Rock + Casuarina temperature F= 2.25732, DF1=9, DF2=9, P=>0.05. The 2 variances are not significantly different.
- Palm + Rock temperature F= 1.20729, DF1=9, DF2=9, P=>0.05. The 2 variances are not significantly different.

1-way ANOVA, soil temperature between the 3 feature types

QED Statistics 1.5.1.456 - 3 targets temp

File	Edit	Simulation	Single Sample	Analysis of Frequency	Two Samples	Regression	ANOVAs	GLM	Planning	Help
Explore the Statistic: One way ANOVA										
One Way ANOVA										
	DF	SS	MS	F	Prob. >F	Omega ²				
Between	2	4.88867	2.44433	0.346512	0.710249	-0.0455503				
Within	27	190.461	7.05411							
Total	29	195.35	22.7967							
This means	There is no significant difference in means between the treatments (F = 0.346512, DF1 = 2, DF2 = 27, P = >0.05)									
	Means and Variability									
Group	Mean	Variance	StdD	N						
Cas_temp	23.02	3.53733	1.88078	10						
Palm_temp	22.23	9.64011	3.10485	10						
Rock_temp	23.14	7.98489	2.82575	10						
Total	22.7967	6.7362	2.59542	30						
	Homogeneity of Variance Tests									
Test	Statistic	DF1	DF2							
Hartley Fmax	2.72525	3	9							
Cochran C	0.455532	3	9							
Bartlett Chi-square	2.1786	2								
Bartlett Probability > Chi-Square	0.336452									

Appendix VII: Analysis of Soil Moisture and Soil Temperature between Casuarina Features and Paired Quadrats

Soil Moisture (%)

Shapiro-Wilk test for Normality

- Casuarina Moisture is normally distributed ($W=0.926216$, $n=10$, $P=>0.05$)
- Paired Casuarina Moisture is normally distributed ($W=0.945043$, $n=10$, $P=>0.05$)

F-test for Variance between pairs

- Paired Casuarina + Casuarina moisture $F= 1.64146$, $DF1=9$, $DF2=9$, $P=>0.05$. The 2 variances are not significantly different.

2-tailed paired t-test

$t=1.00586$, $DF=9$, $P=>0.05$. The two means are not significantly different

Soil Temperature (°C)

Shapiro-Wilk test for Normality

- Casuarina Temperature is normally distributed ($W=0.889535$, $n=10$, $P=>0.05$)
- Paired Casuarina Temperature is not normally distributed ($W=0.562169$, $n=10$, $P=<0.05$)

F-test for Variance between pairs

- Paired Casuarina + Casuarina temperature $F= 3.79347$, $DF1=9$, $DF2=9$, $P=>0.05$. The 2 variances are not significantly different.

Mann-Whitney U-test

$U=39.5$, $n1=10$, $n2=10$, $P=>0.05$. The two medians are not significantly different