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Lincoln University Wildlife Management Report No. 54

Department of Ecology
Faculty of Agriculture and Life Sciences

ISSN: 1177-6242 (Print)
ISSN: 1179-7738 (Digital)
ISBN: 978-0-86476-346-4 (Print)
ISBN: 978-0-86476-347-1 (Digital)

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Prepared for:
Josef Langer Trust

July 2013

Introduction

The eastern side of Banks Peninsula was created by eruptions and subsequent erosion of the Akaroa volcano which was active between 9 and 8 million years ago (Wilson 1992). Banks Peninsula was completely forested but due to human settlement approximately one percent of the forested area was left by the early 1900s. This large-scale removal of forest and the introduction of exotic mammals created a mass extinction of New Zealand's native biota (Wilson 1992).

The present day landscape is a mixture of bush occupying gullies which either escaped clearance or have regenerated due to more ideal moisture conditions and less disturbance from farming stock. The forested areas consist of either kanuka canopy or a mixed canopy of *Fuchsia*, mahoe, fivefinger, lemonwood, lacebark, ribbonwood, pigeonwood, kowhai and kaikomako (Wilson 1992).

Within the eastern side of Banks Peninsula, inland from Le Bons Bay, is an area called Panama Rock, also known as Keller's Peak. This peak is a trachyte dome with a feeder dike trending away south westwards. The top of the peak is 610 m with the bushy slopes extending down to about 280 m. The total area encompasses 40 ha and includes the parcel of land which extends down Lavericks Ridge Road and along Panama Road (Figure 1). The Panama Rock hut which is roughly the centre of the Panama Rock area (S43 44.865, E173 02.320). Within the last decade the area has been grazed and the majority of Panama Rock flora consists of secondary growth of mixed broadleaved trees (75%). The remaining flora consists of mostly pasture, ferns, scattered gorse patches and shrubs (Wilson 2010). Rainfall is around 2000 mm per year at the top of the peak and 500 mm at the bottom (Robin Burleigh, pers. comm. 2013). An invertebrate study on 19 covenant and reserves on eastern Banks Peninsula found that the Panama Rock remnant had high diversity compared to the others (Bowie et al. 2011).

The Panama Rock remnant was bought by the Joseph Langer Trust to conserve the native flora and fauna of the area and to make it available for the public to enjoy. This research aims to identify the native and pest fauna of the area. Monitoring will assist with management decisions by identifying: which native species are present, species in need of conservation, and exotic pests that need to be eradicated. Baseline surveys will allow the Trust to compare with future years and be able to gauge if their management actions are working. If the Trust is planning to trap introduced mammals at Panama Rock and/or the Stones remnant, monitoring will help to determine whether trapping is helping the native biodiversity.

Findings from Panama Rock were compared with those from a recently purchased remnant called Stones and a mature remnant reference site, Otepatotu Reserve (S43 45.125 E173 00.947, Figure 1). Otepatotu Reserve includes a crater rim, two steep valley heads, a spur and bluffs. The elevation at the reserve ranges from 610 m to 750 m and rainfall is estimated to be around 1250 mm per annum. The vegetation includes original patches of totara and regenerating mountain totara. The remaining vegetation is mostly broad leafed plants including lemonwood, black matipo and ribbonwood (Davies 1979).

The Stones remnant is located beside the Panama Rock area (Figure 1) and has not been grazed since spring in 2012 (Robin Burleigh, pers. comm. 2013). The canopy is mostly kanuka forest with a mixture of seedlings in the undergrowth including kawakawa, mahoe and *Coprosma* species.

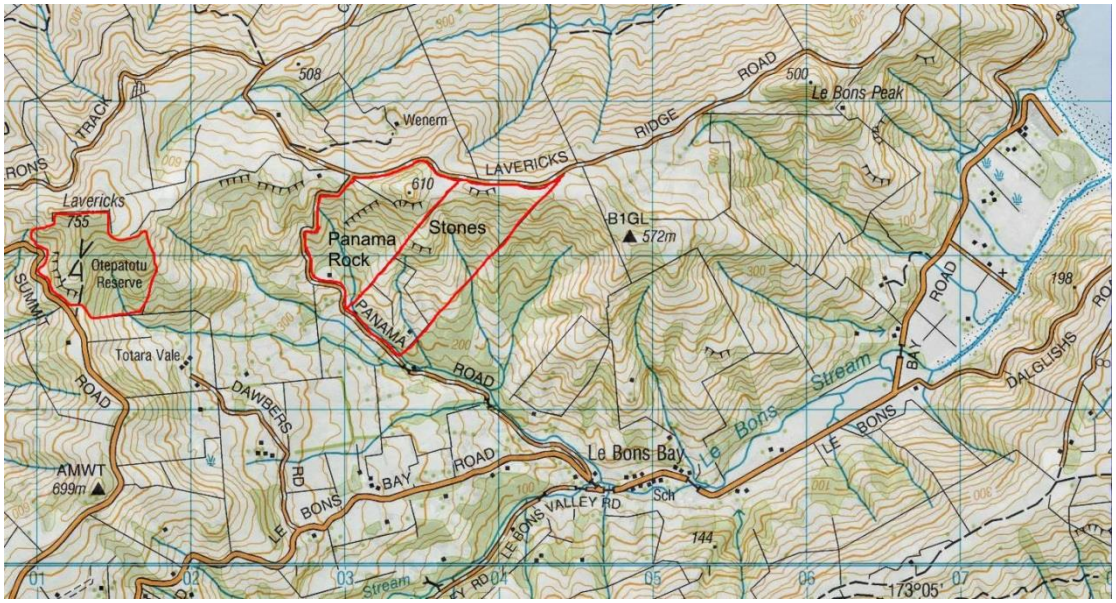

Figure 1: Map of three sites: Otepatotu Reserve, Panama Rock and Stones remnant (from left to right).

Aims of this research

- To establish an inventory of fauna found at the Panama Rock and Stones sites
- To establish a fauna baseline from scientifically replicated plots for long-term monitoring of changes.

Methods

Three sites were surveyed for invertebrates and birdlife. The three sites were Otepatotu Reserve, Panama Rock area and the Stones remnant (Figure 1). Monitoring for lizards (geckos and skinks) was also done at Panama Rock and aquatic sampling was done at the Stones remnant. A GPS device was used to record the locations of wooden discs, pitfall traps, lizard lodges and tracking tunnels and 5-minute bird count locations could be repeated in the same locations.

Table 1: Sites with GPS coordinates and elevations for lizard lodges, bird counts, and invertebrate sampling.

Lizard Lodges	**Recognizable feature**	**GPS Coordinates**	**Elevation**
lizard lodge 1	Near hut	S43 44.802 E173 02.303	451 m
lizard lodge 2	Near hut	S43 44.842 E173 02.351	407 m
lizard lodge 3	Near hut	S43 44.841 E173 02.355	407 m
lizard lodge 4	Near hut	S43 44.826 E173 02.365	419 m
lizard lodge 5	Near hut	S43 44.823 E173 02.373	426 m
lizard lodge 6 & 7	Cliff base	S43 44.865 E173 02.320	398 m
Lizard lodge 8 & 9	Hill peak	S43 44.740 E173 02.551	613 m
lizard lodge 10 & 11	Hill peak	S43 44.740 E173 02.573	610 m
Bird count Locations			
Panama - Bird 1	Cliff base	S43 44.764 E173 02.380	490 m
Panama - Bird 2	Panama Hut	S43 44.865 E173 02.320	391 m
Panama - Bird 3	Gate	S43 44.993 E173 02.132	331 m
Otepatotu - Bird 1	Car park	S43 45.125 E173 00.947	610 m
Otepatotu - Bird 2	First clearing	S43 45.019 E173 00.918	671 m
Otepatotu - Bird 3	Thick forest	S43 44.811 E173 01.053	741 m
Stones - Bird 1	Stones Creek	S43 45.138 E173 02.281	258 m
Stones - Bird 2	Rock on track	S43 45.048 E173 02.479	320 m
Stones - Bird 3	Wooden discs	S43 45.021 E173 02.764	340 m
Invertebrate sampling			
Stones - Invertebrate	Creek	S43 44.993 E173 02.132	331 m
Pitfall and wooden discs			
Panama	Old track	S43 44.826 E173 02.364	430 m
Otepatotu	Car park/toilet	S43 45.125 E173 00.947	610 m
Stones	Wooden discs	S43 45.021 E173 02.764	340 m
Aquatic sampling			
Stones	Stones Creek	S43 45.138 E173 02.281	258 m

Ground-dwelling Invertebrates

To survey for invertebrates both pitfall traps and wooden discs were used.

Pitfall trapping

Six pitfall traps were placed out at each site (Table 1). A hole was dug in the soil using a soil corer and the pots inserted in the hole flush with the soil surface. The pots were 350 ml plastic honey pots. Clear, colourless antifreeze (monopropylene glycol) was poured into the pots to a depth of 2 cm. Galvanized steel roofs with four wire legs were erected over the pitfall traps to reduce rain and leaves entering the pots. The traps were left on site between Dec. 10th 2012 and Jan. 11th 2013.

Wooden discs

Untreated pine discs (350-450 mm in diameter and 100-150 mm thick) were cut from a fallen tree (Bowie and Frampton 2003) and used as an additional method to sample invertebrates. Nine, eleven and six discs were used at Panama, Stones and at Otepatotu respectively and these were placed on bare soil. The discs were put out on the 6th of Nov 2011 and were monitored on the 23rd of Jan 2012 and the 9th of Jan 2013.

Aquatic invertebrates

Kick netting

An aquatic kick net was placed on the stream bed with the open part of the net facing upstream in a creek at the Stones remnant (Table 1). The stream bed directly upstream from the net was then disturbed by a kicking motion from the sampler's boots for approximately one minute to catch any dislodged invertebrates.

The contents of the net were then transferred into a white plastic tray filled with a 2 cm of water. The invertebrates were transferred into plastic vials containing 70% ethanol for identification later. This process was replicated at three different points of the stream. Each point was approximately 1 m apart. The short distance between points was due to the stream being narrow and only having a strong enough flow to perform kick netting in a small portion of the stream.

Samples were identified under a microscope and tolerance scores for each taxa were found. These scores were used to calculate a Quantitative Macroinvertebrate Community Index score (QMCI). QMCI is commonly used to indicate water quality in New Zealand streams (Winterbourne et al. 2006).

Birds

Otepatotu, Stones and Panama were also surveyed for bird populations (Figure 1). At each of these sites three sampling points were setup so that each point was at least 200 m apart from each other. At these points five minute bird counts took place whereby all birds (native and exotic) seen and heard were recorded. To help analyse the data, temperature and wind speed were recorded with a thermo-anemometer at each sampling event. Each site was revisited on three different days with only one bird count done at each location during one complete day.

Lizards

At Panama Rock five lizard lodges (Lettink & Cree 2007) were placed on the top of the peak, one by the cliff base and six near the grassy area by the hut (Table 1). Lizard lodges consist of two Onduline sheets (30-40 cm long x 20 cm) placed on top of another with five pieces of 10 mm dowel separating the two sheets. This allows space for lizards to safely rest and hide from predators.

At regular intervals along the Panama and Stones tracks, kanuka trees were surveyed for lizards. Surveys were carried out at two locations along the track for 15 minutes each and two days at Stones and eight days at Panama. Searching occurred when temperature was > 17˚C and the wind speed was low between midday and 3pm. Observations were made by positioning oneself between 5-20 m from a patch of kanuka trees and using binoculars to scour the trees for lizards. Surveying lasted between 5 and 20 minutes at each site depending on the size of the vegetation patch.

Mammal monitoring using tracking tunnels

Ten tracking tunnels were put out at each site (Figure 2, Appendix 1). Peanut butter was initially used for rodent bait and run overnight. The cards were then labelled and replaced with fresh tracking cards with rabbit meat and left for three nights before being removed for analysis.

Rifleman which were recorded at Stones, Panama Rock and Otepatotu Reserve.

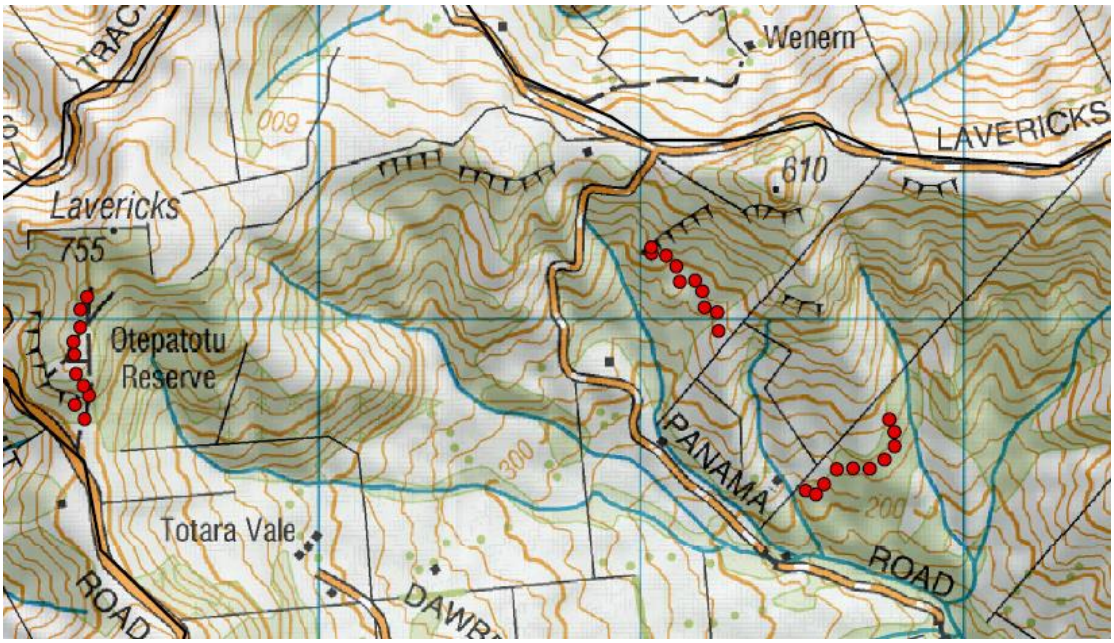

Figure 2: Map showing ten tracking tunnel locations (red dots) at Panama Rock, Stones Remnant and Otepatotu Reserve.

Analysis

Excel was used to calculate the means, abundance and standard errors. The Shannon–Wiener index was used to calculate diversity. This index incorporates species richness and number of each species to give a measure of the evenness of populations at each site. This information was then imported into Sigma Plot to create graphs of species richness, diversity and abundance.

New Zealand funnel-web spider found at Panama Rock.

Results

Invertebrates

Carabid richness in both 2012 and 2013 was higher in Panama than Otepatotu and Stones. At Panama a total of five carabid species were found in pitfall traps in 2012 and three in 2013 compared with only two species found in both years at Stones and Otepatotu (Figure 3).

Mean carabid diversity from pitfall traps for Panama was significantly higher compared to Stones and Otepatotu sites for both the years sampling occurred (Figure 4).

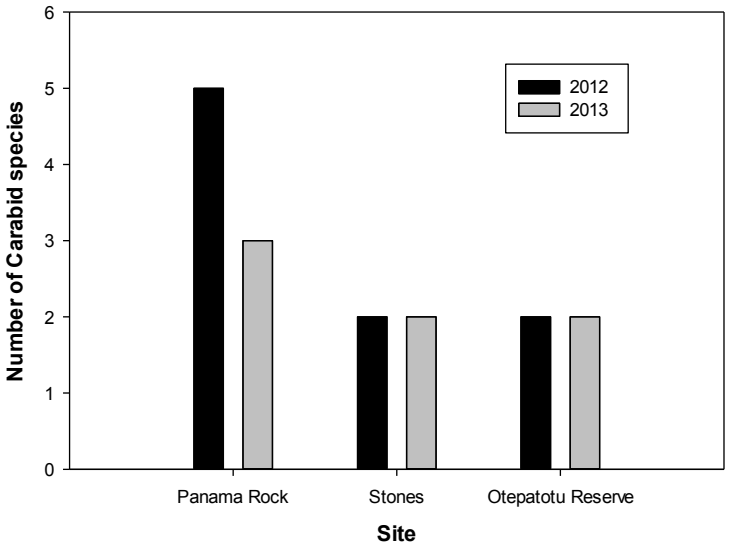

Figure 3: Carabid species richness caught in pitfall traps at three different sites during 2012 and 2013.

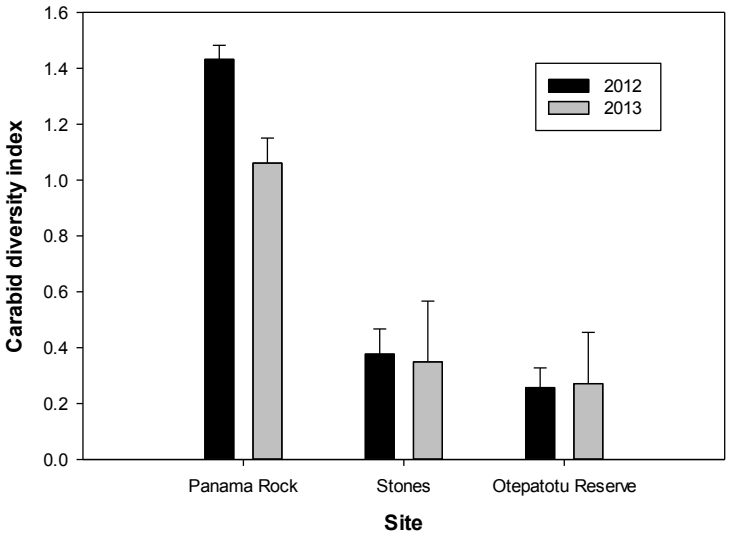

Figure 4: Carabid diversity from pitfall traps at three different sites during 2012 and 2013

Beetle diversity was higher at the Panama site for both 2012 and 2013 when each site was compared to the others from the same year (Figure 5). Mean number of beetles was higher at Stones though in 2012 with no significant difference between Otepatotu and Panama. In 2013 there was no significant difference between Stones and Otepatotu but both these sites had a higher mean number of beetles compared to Panama (Figure 6).

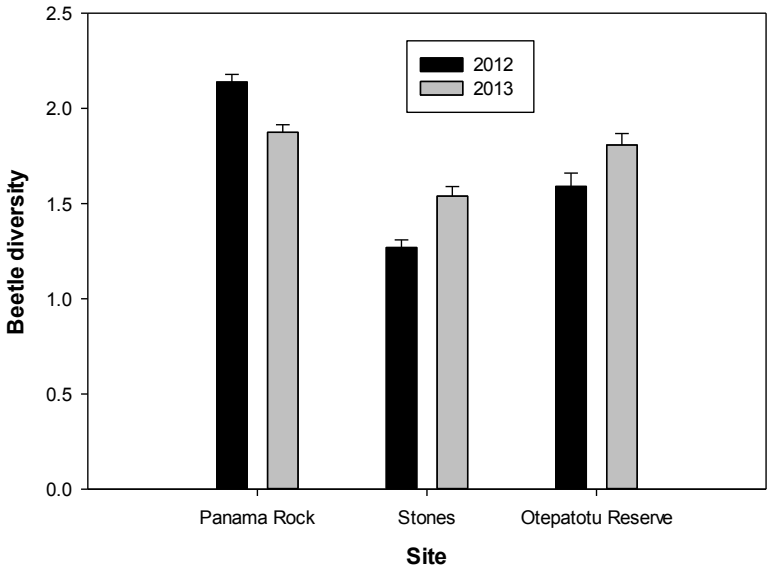

Figure 5: Beetle diversity from pitfall traps at three different sites during 2012 and 2013

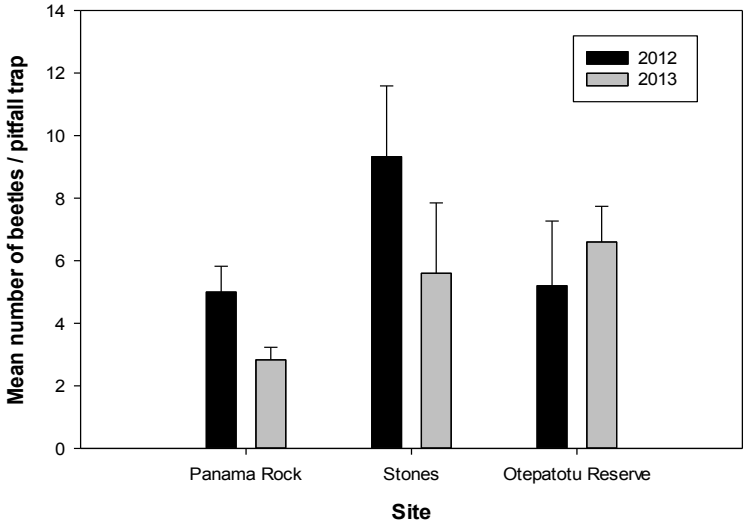

Figure 6: Mean number of beetles caught in pitfall traps at three different sites during 2012 and 2013

The mean number of carabids and carabid richness under wooden discs was larger at the Panama site for both 2012 and 2013. Three carabid species were found at Panama in 2012 with an average of 0.78 carabids found per wooden disc (Figure 7 & 8). In 2013 three species were found at Panama with an average of 1.2 carabid species per disc. At Otepatotu Reserve one carabid species was found with an average of 0.5 carabids per disc in 2012 and in 2013 one carabid species was also found with an average of 0.2 carabids per disc. In 2013 one carabid species was found at Stones with an average of less than 0.2 carabids per disc. No carabids were recorded under discs in 2012 at the Stones site (Figure 7 & 8).

Carabid species recorded under the wooden discs at Panama over the two years include: *Mecodema howitti*, *Megadromus guerinii* and four small carabids (unidentified species). At the Otepatotu Reserve *Megadromus guerinii* and *Mecodema oregoides* species were recorded and at the Stones site *Mecodema howittii* was the only species recorded.

The average number of *Periegops suterii* (NZ six-eyed spider) found under wooden discs in 2012 at Panama was 0.67/disc compared to 0.17/disc at Otepatotu (Figure 9). In total six were found at Panama and one at Otepatotu in 2012. In 2013 the mean number of six-eyed spiders found under the wooden discs at Panama was 0.45/disc compared to 0.35/disc at Otepatotu (Figure 9). A total of four were found at Panama and two at Otepatotu in 2013.

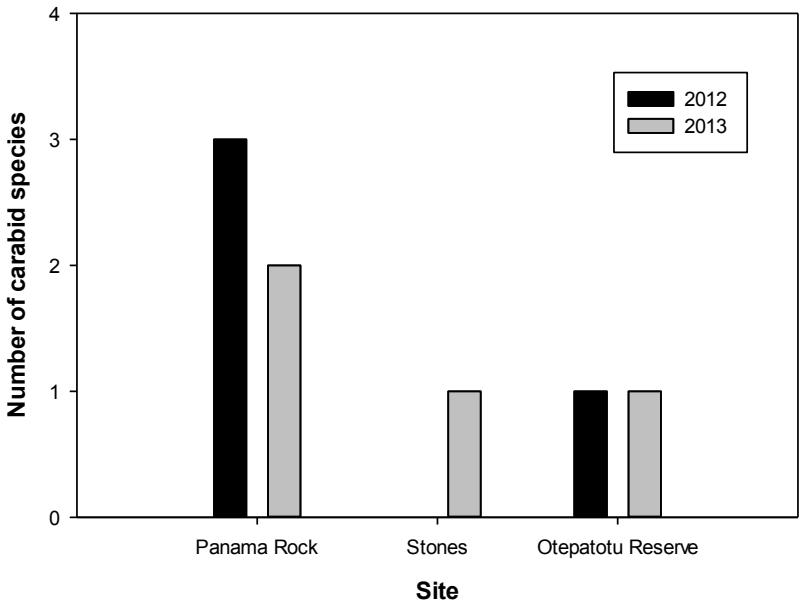

Figure 7: Number of carabid species found under wooden discs at three sites

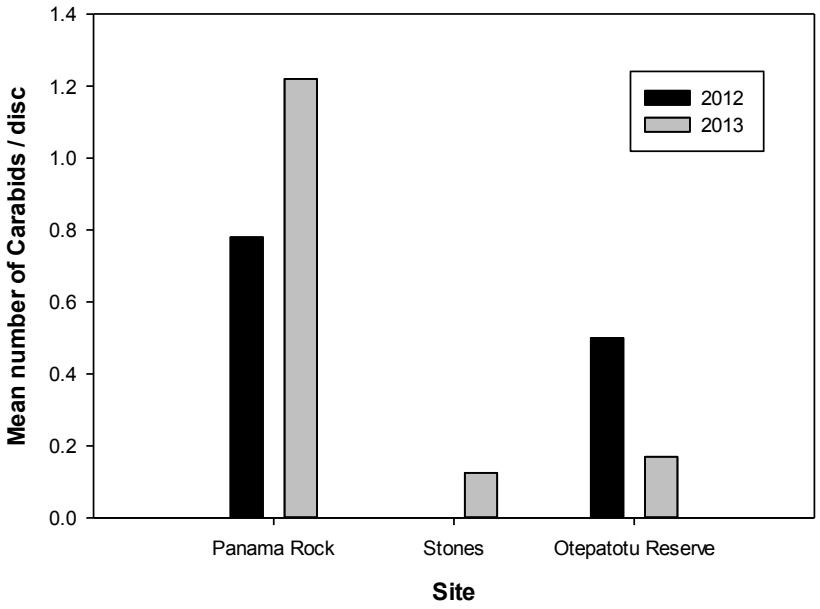

Figure 8: Mean number of carabids per wooden discs at three sites

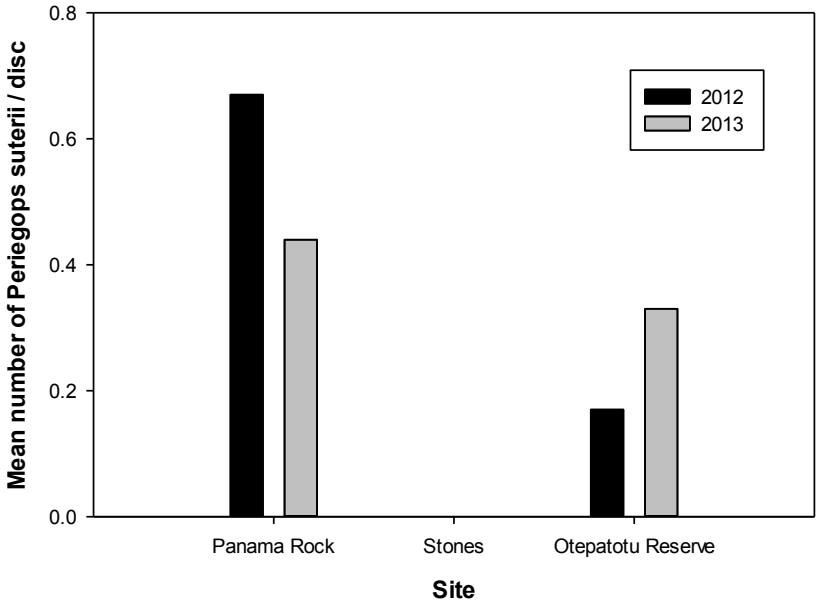

Figure 9: Mean number of *Periegops suterii* under discs at three sites

Red Admiral and Common Cooper butterflies were commonly observed in December and January. No Yellow admiral butterflies were observed at either Panama Rock or the Stones remnant. Only one Common Blue butterfly was sighted at Panama Rock with no individuals sighted at the Stones remnant (Table 2).

Butterfly species	**Panama Rock**					**Stones**		
Date ▸	08/12	10/12	08/1	09/1	11/1	08/1	09/1	11/1
Red Admiral	2		2	3		2	1	5
Common Copper		1	2	3	1	3	2	2
Common Blue					1			

Table 2: Butterfly observations at Panama and Stones in Dec 2012 and Jan 2013

Aquatic invertebrates

The water quality tolerance score of aquatic species found at stones ranged from 1 to 6. *Nesameletus austrinus* was the only species found at Stones that has a taxonomic rank which indicates sensitivity to pollution. All other species have a tolerance to pollution (Table 5; MDFRC, 2009). *Nesameletus austrinus* has never been found on Banks Peninsula before, despite numerous collecting over the years. The QMCI ranking of the stream was 6.73 which was good given anything above 6 indicates a healthy clean stream (Table 5, Stark & Maxted 2007).

Common name	**Taxonomic name**	**Tolerance score**
Mayfly	*Deleatidium vernale*	3
	Nesameletus austrinus	6
Flatworm	Platyhelminthes	3
Caddisfly	*Psilochorema* species	1
Midge	*Nothodixa species*	1
	Orthocladiinae	1
QMCI Score		**6.73**

Table 5: Aquatic invertebrates and water quality scores at Stones creek.

Birds

Panama Rock and Stones have a similar diversity index for native bird species with no significant difference between the two sites (Figure 10). Both sites though were found to have a significantly higher native bird diversity index than Otepatotu Reserve. Panama and Stones had no significant difference for exotic bird diversity but Panama was significantly higher in exotic diversity compared to Otepatotu (Figure 10).

Stones had the highest number of recorded native bird species with eight, while Panama had seven and at Otepatotu Reserve five species were recorded (Figure 11). When the percentage of native verses exotic bird species was compared, Panama was roughly 60:40 and both Stones and Otepatotu were 70:30 (Figure 11). On average Stones had the highest mean number of native species per day recorded with 6.0 and Panama was similar with 5.6 per day. Panama had a significantly higher mean number of recorded exotic species per day than Stones and Otepatotu, but it was not statistically significant (Figure 12).

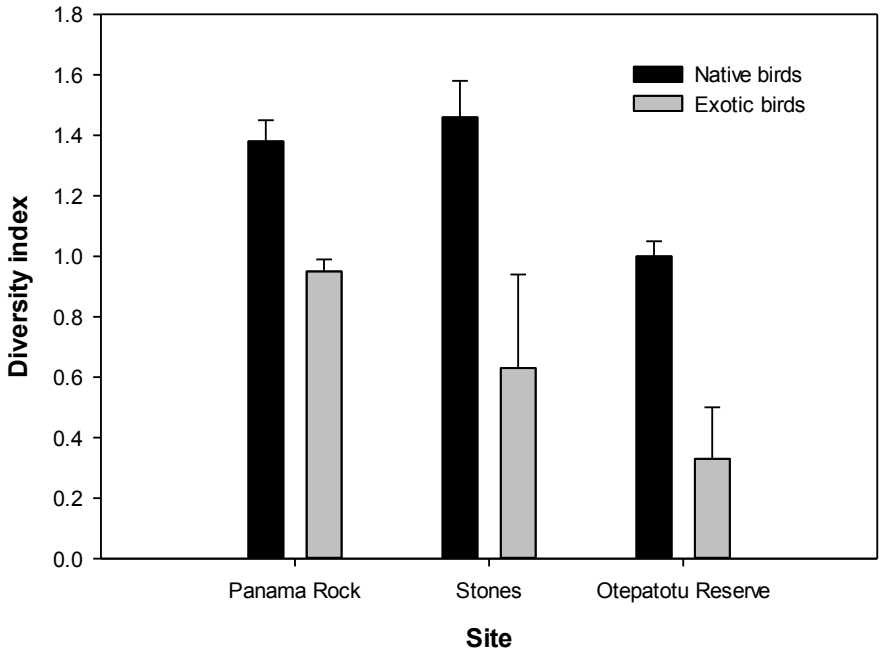

Figure 10: Diversity of the native and exotic birds recorded during 5-minute bird counts at three different sites.

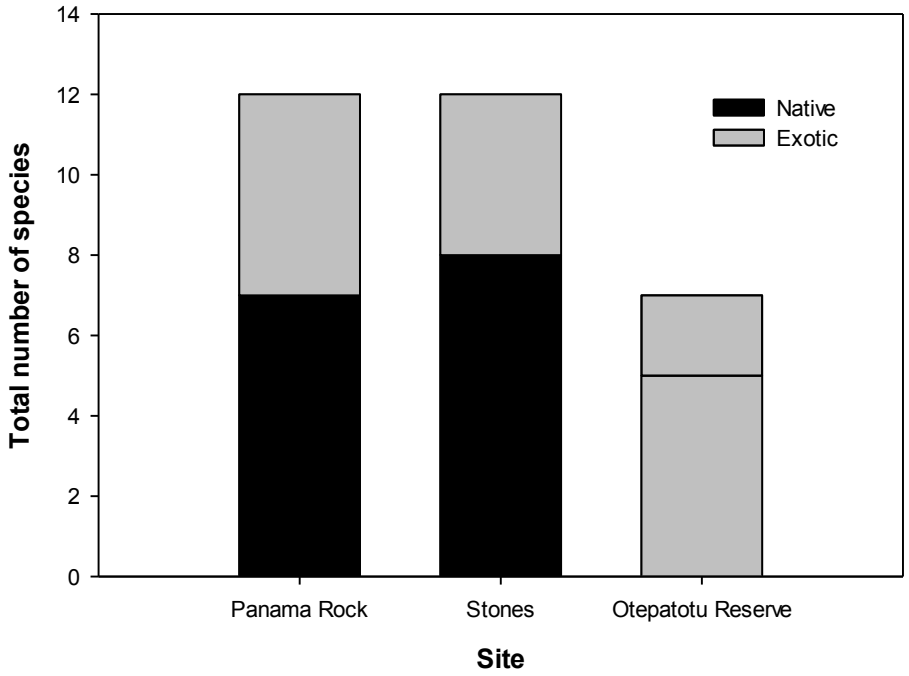

Figure 11: Number of native and exotic bird species identified during 5-minute bird counts at three different sites.

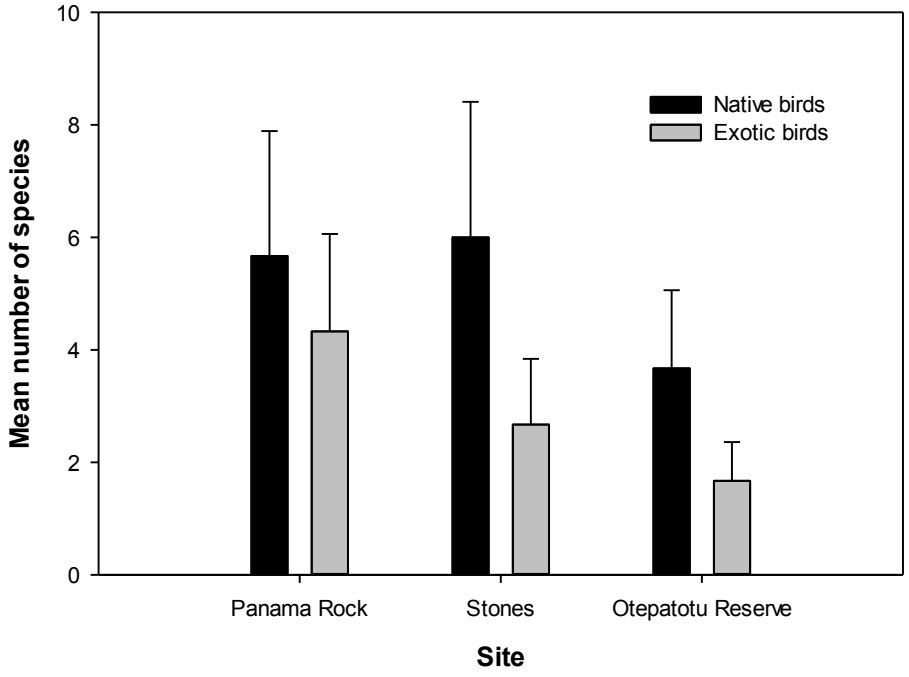

Figure 12: Mean number of native and exotic bird species recorded from three 5-minute bird counts at the three sites.

Bird species	Panama Rock	Stones remnant	Otepatotu Reserve
Bellbird	✓	✓	✓
Fantail	✓	✓	
Grey Warbler	✓	✓	✓
Kereru	✳	✓	
Tomtit	✓	✓	✓
Rifleman	✓	✓	✓
Shining Cuckoo	✳		
Silvereye	✓	✓	
Brown Creeper	✓	✓	✓
Hawk	✳		✳
Kingfisher	✳		
Blackbird	✓	✓	
Chaffinch	✓		
Redpoll	✓	✓	✓
Dunnock		✓	✓
Thrush	✓	✓	
Yellowhammer	✓		
Skylark	✳		

Table 3: Bird species recorded at three different sites (either seen or heard).
(Species in **bold** are native birds. ✳Indicates species observed outside of the 5-minute bird counts.)

Lizards

On the first day of sampling there were two Canterbury geckos found in separate lizard lodges. Both lodges were located on rocks in a grassy area (near hut, Table 4, Table 1). On the second day of sampling three geckos were found on the peak of Panama Rock. Two of the geckos were found under the same lizard lodge. Two geckos were also found under different lodges near the hut (Table 4). Skinks were observed in grassy areas on the way to the cliff base and around the lizard lodges closest to the hut. They are likely to be common New Zealand skinks.

Date	Near hut	Hill top	Cliff base	Temp (°C)
Feb. 11	2	0	0	17
Feb. 18	2	3	0	24

Table 4: Lizard lodges where Canterbury geckos where found on two days of searching in 2013 and the temperature of each day.

Predator tracking

At Panama Rock, 10 % of the tracking tunnels with peanut butter as the lure had tracking footprints from rats and 30 % had footprints from mice. No hedgehog presence was recorded in the tunnels with peanut butter at Panama. At the Stones site 20 % of tunnels with peanut butter had tracking foot prints from rats, 10 % had foot prints from mice and 50 % had foot prints from hedgehogs. At the Otepatotu reserve 30 % of tracking tunnels with peanut butter recorded mice foot prints and 20 % showed hedgehog presence. No rat presence was recorded in the tunnels with peanut butter at Otepatotu. None of the tunnels with peanut butter at the three sites showed the presence of mustelids (Figure 13).

When meat was used as the lure in the tracking tunnels, 20 % of the tunnels at Panama recorded rat footprints and 40 % of the tunnels recorded mice footprints. No hedgehogs were recorded when the meat lure was used in the tunnels at Panama. When meat was used in the tunnels at the Stones site, 20 % of the tunnels recorded rat foot prints, 80 percent of tunnels recorded hedgehog presence and 20% of prints were unidentified. The unidentified disturbance could be from possums. At the Otepatotu reserve, the tunnels with the meat lure had a 40 % tracking rate for mice and 20 % tracking rate for hedgehogs. No rats were recorded when the meat lure was used in tunnels at Otepatotu. Mustelids were not recorded in the tracking tunnels at any of the three sites (Figure 14).

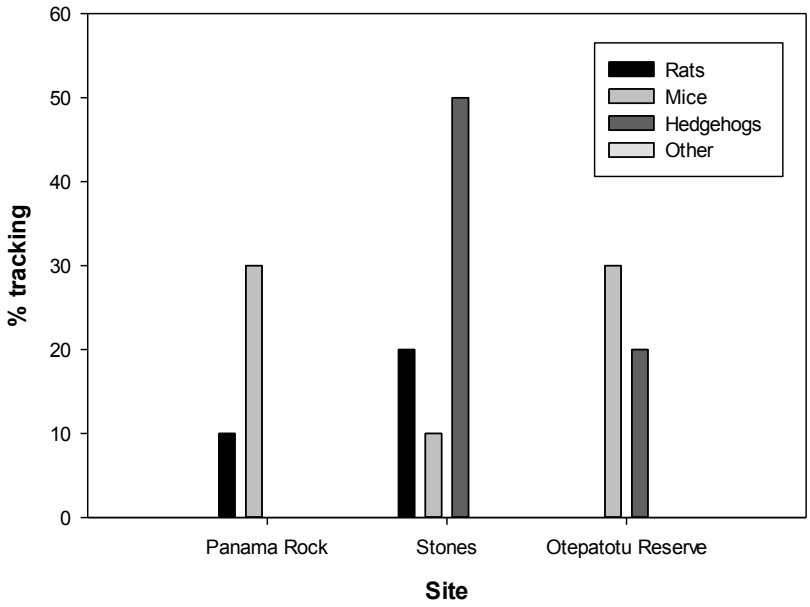

Figure 13: Tracking tunnel results with peanut butter lure, at Panama, Stones and Otepatotu Reserve.

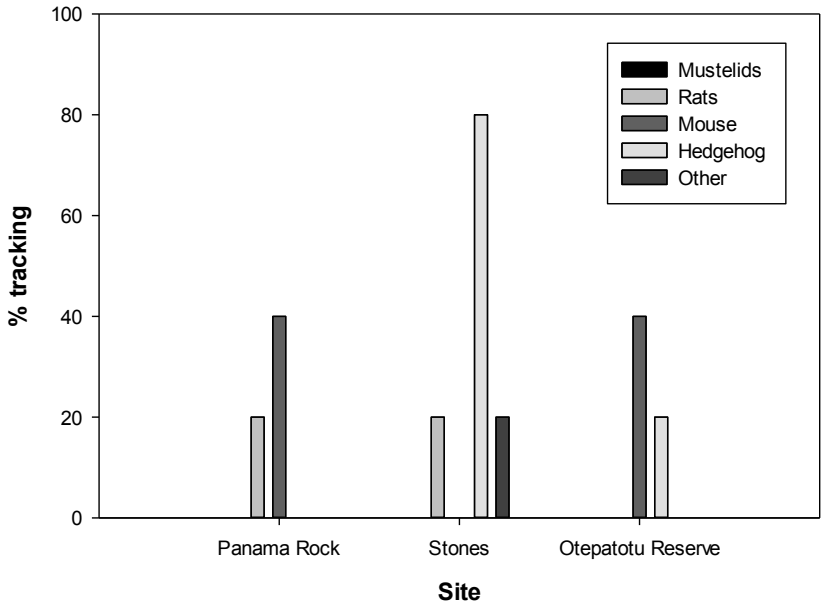

Figure 14: Tracking tunnel results with rabbit meat lure, at Panama, Stones and Otepatotu Reserve.

Conclusion

Panama Rock has a significantly higher carabid numbers and overall beetle diversity, and although the site does not have the highest native bird diversity, it was not significantly different to Stones. As well as having the highest native bird count, Stones also had the highest mean number of beetles per disc. It was not surprising that Panama had a significantly higher diversity of beetles as previous research by Bowie et al. (2011) had indicated that Panama Rock site had a higher invertebrate diversity than other Banks Peninsula remnants and reserves tested. The reasons for the higher diversity are not clear, especially since Otepatotu has a much older forest canopy and understory which usually corresponds to a higher diversity of invertebrates. It maybe that the higher altitude at Otepatotu contributes to colder conditions, more rainfall, and higher wind speeds, all contributing to less invertebrate activity, resulting in fewer captured in pitfall traps.

Low beetle diversity and richness at the Stones remnant was expected given the canopy at Stones is almost entirely kanuka and the understorey is not only sparse but low in native plant diversity. The lack of native plant diversity at Stones means that leaf litter on the forest floor is not varied and sufficiently thick to support a rich invertebrate community. The lack of complex habitat on the forest floor (low number of rocks, leaves, branches, logs, rocks) seems to advantage grass grubs possibly due to low numbers of predatory carabids.

No mustelids were recorded at any of the sites which may be why the rodents were fairly common. Stones also had a higher percentage of rats and hedgehog prints in the tracking tunnels than Otepatotu and Panama. Although the sample size was low (only one transect line per site), the results suggest that the bigger predators could be suppressing mice at

Stones. Rats and hedgehogs are also more likely to eat larger invertebrates such as carabids and beetles.

Significantly higher diversity of native birds at Panama and Stones compared to Otepatotu Reserve is also surprising. There does not appear to be higher predator numbers at Otepatotu which may indicate that environmental factors such as wind, temperature or other influences may be impacting native bird richness and abundance there. Although, Stones does not have the same plant diversity particularly species providing berries for native birds, it did have a higher native bird diversity average than Panama. Perhaps the Stones remnant was providing more shelter, less competition for food sources, or its open bush make birds more observable.

The only lizard species which was found during monitoring was the Canterbury gecko but was only monitored at Panama Rock. The Canterbury gecko preferred the rocky habitat at the top of the peak but was also found in lizard lodges placed on top of rocks near the hut.

Recommendations

- Set some achievable goals for the conservation of native biodiversity at both Panama and Stones sites. Write a Management Plan to document how this can be achieved.

- Extend permanent predator tracking tunnels down the edge of the tracks at 50m or 100m spacing. Tunnels could also be used for lizard monitoring prior to predator monitoring, using fruit bait.

- Rodent trapping should be undertaken potentially along the same tracking tunnel line at least initially, to confirm if rats are a problem throughout Panama or just around hut.

- Hedgehog trapping should be considered at Stones.

- 5-minute bird counts need to be done more regularly or transect bird monitoring method used up the track. Morepork monitoring should also be started.

- Wooden disc monitoring for ground beetles and 6-eyed spider should be continued.

- Pitfall trapping could be under-taken every second or third year.

- More aquatic invertebrate sampling should be undertaken to create inventory of fauna present in bush areas as well as open sites.

- Fish species present in creeks should be surveyed.

- Establish a repository to safely store collected data, documents and pictures on sites.

Acknowledgements

We would like to acknowledge the following people:

- Phil Cochrane (ECAN) for funding Frazer Maddigan to setup and running the tracking tunnels.
- Wayne Beggs (DOC) for providing wooden discs
- Robin Burleigh for providing wooden discs, logistical support and accommodation at the hut
- Milen Marinov and Steve Pohe (Canterbury University)
- Jono Dobbs and Lantz Chong Wu for helping with field work
- Jon Sullivan

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Appendix 1: Stones, Panama and Otepatotu tracking tunnel locations

Stones tracking tunnel locations

Tunnel No.	Easting	Northing
Tunnel 1	E 2513519	N 5717076
Tunnel 2	E 2513551	N 5717065
Tunnel 3	E 2513576	N 5717096
Tunnel 4	E 2513615	N 5717142
Tunnel 5	E 2513666	N 5717145
Tunnel 6	E 2513717	N 5717143
Tunnel 7	E 2513763	N 5717171
Tunnel 8	E 2513795	N 5717214
Tunnel 9	E 2513793	N 5717257
Tunnel 10	E 2513778	N 5717297

Otepatotu tracking tunnel locations

Tunnel No.	Easting	Northing
Tunnel 1	E 2511284	N 5717298
Tunnel 2	E 2511254	N 5717341
Tunnel 3	E 2511297	N 5717371
Tunnel 4	E 2511280	N 5717401
Tunnel 5	E 2511257	N 5717438
Tunnel 6	E 2511253	N 5717497
Tunnel 7	E 2511249	N 5717537
Tunnel 8	E 2511271	N 5717582
Tunnel 9	E 2511271	N 5717637
Tunnel 10	E 2511291	N 5717675

Panama tracking tunnel locations

Tunnel No.	Easting	Northing
Tunnel 1	E 2513249	N 5717570
Tunnel 2	E 2513244	N 5717628
Tunnel 3	E 2513206	N 5717643
Tunnel 4	E 2513198	N 5717692
Tunnel 5	E 2513176	N 5717726
Tunnel 6	E 2513129	N 5717723
Tunnel 7	E 2513118	N 5717770
Tunnel 8	E 2513087	N 5717803
Tunnel 9	E 2513042	N 5717810
Tunnel 10	E 2513040	N 5717829