Terrestrial Arthropod Abundance and Diversity at Four Reserves along the Styx River

ESTABLISHING BASELINE DATA AND LOOKING AT THE IMPACT OF SUBSTRATE AND VEGETATION ON ARTHROPOD COMMUNITIES

SUMMER STUDENT SCHOLARSHIP 2008/2009

Students: Aimee Robinson & Katie Collins | Supervisor: Kelly Walker, Lincoln University

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PREFACE

The Styx River ecosystem is an important natural asset located on the northern fringe of Christchurch city. In order to protect its natural and cultural values in the long term, a long-term vision has been developed and is now being implemented. Details of the vision can be found on the Styx website http://www.thestyx.org.nz/

The vision recognizes that not enough is known about the river and its values. In order to obtain a better understanding, the Styx Living Laboratory Trust has been established to actively promote the Styx River and its associated catchment as a place for research and learning. The Trust is working with its partners in the establishment of the Styx Summer Student Scholarship Programme. Each year over the summer break student(s) are funded to undertake research on some aspect of the Styx River ecosystem. Not only is more learnt about the Styx, but the students also gain valuable work experience that will benefit them in their chosen career paths.

This report by Aimee Robinson and Katie Collins, summer students for 2008 – 2009, documents their research into terrestrial arthropod abundance and diversity at four reserves along the Styx River. This report highlights the need for continued research on habitat restoration in order to achieve functioning ecosystems.

This scholarship was funded through the Styx Living Laboratory Trust, Lincoln University and their summer student programme, and the Shirley Papanui Community Board through its special projects funding. The Styx Living Laboratory Trust appreciates the efforts of the students Aimee Robinson and Katie Collins, their supervisor Kelly Walker, and the support of its partners in making the Styx Summer Student Scholarship Programme a success.

Christine Heremaia
Chairperson
Board of Management
Styx Living Laboratory Trust

Terrestrial Arthropod Abundance and Diversity at four Reserves along the Styx River

Establishing baseline data and looking at the impact of substrate and vegetation on Arthropod communities

Aimee Robinson and Katie Collins
Supervised by Kelly Walker

Abstract:

Terrestrial invertebrate monitoring was undertaken in Styx Mill Conservation, Redwood Springs, Janet Stewart and Spencerville Reserves by using pitfall traps between November 2008 and January 2009. The purpose of this monitoring was to compare arthropod abundance and diversity between the reserves and investigate the impact of substrate and vegetation on community composition.

Over the 40 sites and within the four reserves community composition was found to be diverse. The results collected showed that substrate and vegetation have no significant impact on the abundance or diversity of arthropod communities. While no significant conclusions can be drawn from the data collected, it seems that invertebrates are not recolonising newly planted areas. We believe a reason for this may be because of a significant distance between the reserves and a source population.

INTRODUCTION:

The Styx River is located in the northern suburbs of Christchurch. It is a spring fed river, which originates in the Harewood area and flows for 23.8km through reserves, rural, horticultural, and urban areas to where it enters the sea at Brooklands Lagoon (Hills, 2002).

The area surrounding the river continues to be restored as part of the Styx 'Source to Sea' Vision (Christchurch City Council, 2000). This vision aims to enhance the river through creating a continuous walkway along its length (Christchurch City Council, 2000). The Styx Mill Conservation, Janet Stewart, Redwood Springs and Spencerville Reserves are part of the existing network of reserves along the river. Native plantings in these reserves have been established over time to enhance the natural landscape (Christchurch City Council, 2000). Consequently vegetation in these reserves now consists of established willows and other exotics as well as more recently planted native shrubs, flax and cabbage trees, including within the last year. These reserves should also support populations of native birds, lizards and invertebrates (Meurk, 2004).

Styx Mill Conservation Reserve is 57 hectares in size and runs adjacent to the river for 1.6 km (Macfarlane, 2007). Vegetation in Styx Mill Conservation Reserve includes both native and exotic species, with some well established areas and others which have been more recently planted (Macfarlane, 2007)

Janet Stewart Reserve was created in 1996 and since then the 2 hectare reserve bordered with willows has been restored with native plantings to provide habitat for native wildlife (Christchurch City Council, 2009).

Redwood Springs is part of the Styx Esplanade Reserve which covers an area of almost 9 hectares (Zollhoefer, 2006). The reserve is bounded by the Styx River on its northern side and a residential development on its southern side (Zollhoefer, 2006). Redwood Springs Reserve is made up of a number of recently planted, fragmented areas of native vegetation surrounded by large areas of grass. Along the edge of the river there are large established willows with long grass as undergrowth.

Spencerville Park Reserve runs along the river between Lower Styx Road and Spencerville Road (Christchurch City Council, 2009). It is bordered by the river on its south western side and by residential and agricultural areas on its north eastern side. The Reserve contains newer plantings as well as some well established pine trees. The vegetation in Spencerville Reserve is in long narrow patches along both the south western and north eastern sides separated by a grass walkway.

In the past, restoration projects that have been undertaken in the Styx River area have focused on establishing native flora. In his 2004 report, Meurk states that the restoration of "terrestrial habitats would support viable populations of native birds, lizards and invertebrates…" (p.10). However, in his assessment of the Styx Mill Conservation Reserve, Macfarlane said that "replanted forest, which does not have the remnant bush for insect dispersal, should not be assumed to be recolonized readily by more than a minority of the more ecologically flexible (e.g. decomposers)" (p.11). While habitat for birds, lizards and invertebrates may be provided in a restoration programme, it is important to consider the distance from the nearest source populations of these species, and their dispersal abilities.

Bioindicators are a species or taxa group used to reflect the state of the surrounding environment and community diversity (Rainio and Niemela, 2003). Carabid beetles are a group commonly used as bioindicators (Berndt *et al.*, 2008). This is because they are well known, easily sampled, and threatened by habitat loss (Berndt *et al.*, 2008). Carabid beetles are predatory and are largely flightless which reduces their dispersal ability (Rainio and Niemela, 2003). One aim of this research was to evaluate the use of carabids as bioindicators of invertebrate diversity in the different reserves.

The objective of this research was to establish baseline data of ground dwelling invertebrates in Styx Mill Conservation, Redwood Springs, Janet Stewart and Spencerville Park Reserves. These four Reserves were used to provide a sample of habitats along the Styx River allowing us to compare the impact of vegetation composition and substrate on the terrestrial arthropod diversity and abundance.

It was hypothesised that Styx Mill Conservation Reserve would support a higher diversity and abundance of invertebrates due to its variety of habitats, age and composition of vegetation. It was expected that Redwood Springs Reserve would support less diverse invertebrate communities due to its dry and fragmented nature.

METHODS:

Monitoring was undertaken in four reserves of native plantings along the Styx River between November 2008 and January 2009. 40 sites were established in November 2008, six in both Spencerville and Redwood Springs Reserves, eight in Janet Stewart Reserve and 20 in Styx Mill Conservation Reserve. These sites were located in a way to gain samples from all vegetation types and ages, substrate type and the size of the planted area.

Pitfall traps were used to sample ground dwelling invertebrates in the four reserves. Pitfall traps are a type of arthropod trap where individuals walking along the ground fall into the trap and drown. A pitfall trap consists of a cup submerged in the soil covered by a metal roof to prevent rain and other debris from entering. It is important that the cup is flush with the ground and the surrounding area is not significantly disturbed (Pers. Comm. John Marris). The cup is half filled with water mixed with a preserving agent, in this case one teaspoon of sodium benzoate powder was used, and several drops of dishwashing liquid. The purpose of adding dishwashing liquid is to break the surface tension of the water. Either the sodium benzoate or the dishwashing liquid acted as an attractant to the invertebrates.

Plate 1: Pitfall traps in Styx Mill Conservation Reserve (SM 2) shows components of the trap which was used for all 40 sites.

One pitfall trap was placed at each of the 40 sites. The pitfall traps were collected weekly with three samples collected in November/December and three in collected in January. Arthropods collected in the pitfall traps were transferred into 70% ethanol and taken back to the lab to be identified using a microscope. Beetles (coleoptera), harvestman (opiliones) and spiders (araneae) from the samples were sorted into recognisable taxonomic units (RTUs). These groups were chosen as they are the types of arthropods pitfall traps are designed to catch. RTUs were used instead of identifying individuals down to a species level due to the difficulty of identification and short time period of the project. Beetle RTUs were identified to a family level using keys by J.C. Watt. Beetles were pinned and harvestmen and spiders were stored in vials so a reference collection of species found was created.

At each site global positioning system (GPS) software was used to record the location of the site. Vegetation and substrate type were also recorded.

Data was analysed using Microsoft Excel. Groups within each reserve were combined to produce averages from the total number of individuals and taxa over the whole reserve. RTUs were grouped into "beetle", harvestmen", "spider" and "other" to allow analysis by group. Sites at Styx Mill Conservation, Janet Stewart, Redwood Springs, and Spencerville Reserves were categorised into different substrates and vegetation composition (see Table 1 and Plate 2-10).

Two-factor ANOVA tests were carried out to determine if substrate, vegetation or reserve had an impact on the total number of individuals or RTUs. For an ANOVA test to be significant p values should be less than or equal to 0.05.

Plate 2: Example of a bark substrate (SP3)

Plate 3: Example of a grass substrate (SM2)

Plate 3: Example of a leaf litter substrate (JS4)

Plate 4: Example of a wood substrate (SM6)

Plate 5: Example of flax vegetation (SM10)

Plate 6: Example of cabbage tree vegetation

Plate 7: Example of native vegetation (SM 17)

Plate 8: Example of exotic vegetation (SP5).

Plate 9: Example of tussock vegetation (SP3)

Plate 10: Example of willow vegetation (RED)

Plate 11: Transferring trap contents into 70% ethanol for sorting later in the lab.

Plate 12: Site name and date was written in pencil and put in with the sample.

Plate 13: Location of SM1 and SM2 in Styx Mill Conservation Reserve.

Plate 14: Location of SM3 in Styx Mill Conservation Reserve.

Plate 15: Location of SM5, SM6, SM7, and SM8 in Styx Mill Conservation Reserve.

Plate 16: Location of SM10 in Styx Mill Conservation Reserve.

Plate 17: Location of SM15 in Styx Mill Conservation Reserve.

Plate 18: Location of SM16 in Styx Mill Conservation Reserve.

Plate 19: Location of SM18 in Styx Mill Conservation reserve.

Plate 20: Location of RED3 and RED4 Redwood Springs Reserve.

Plate 21: Location of JS8 in Janet Stewart Reserve.

Table 1: GPS location, vegetation and substrate description of each site studied in Styx Mill Conservation Reserve.

	Site	Easting	Northing	Vegetation	Vegetation classification	Substrate classification
Styx Mill Conservation Reserve	1	2478494.295	5749287.201	Cabbage tree, pittosporum	Cabbage tree	Grass
	2	2478480.862	5749264.1	Blackberry, shrub, cabbage trees	Cabbage tree	Grass
	3	2478461.366	5749289.506	Flax	Flax	Grass
	4	2478372.137	5749252.6	Flax	Flax	Grass
	5	2478328.263	5749330.768	Dead trees, young native plantings	Native other	Wood
	6	2478292.34	5749349.479	Willows, blackberry, young native plantings	Willow	Wood
	7	2478276.965	5749329.297	Dead willow, blackberry	Willow	Wood
	8	2478264.845	5749355.872	Willow, flax, young native plantings	Willow	Wood
	9	2478226.293	5749345.866	Manuka, totara, flax	Native other	Leaf litter
	10	2477934.404	5749356.251	Established flax planting	Flax	Grass
	11	2477909.378	5749376.127	Large native planting patch	Native other	Leaf litter
	12	2477944.102	5749260.547	Pittosporum, shrubs, cabbage tree	Native other	Grass
	13	2477931.342	5749241.309	Large introduced tree near flax, pittosporum	Exotic other	Grass
	14	2477950	5749141	Under large bush	Exotic other	Grass
	15	2477790.532	5749111.2	Flax bushes under established trees	Flax	Leaf litter
	16	2477842.55	5749127.791	Established patch made up of cabbage tree, pittosporum, mahoe surrounded by grass	Cabbage tree	Leaf litter
	17	2477874.722	5749177.483	Established native patch surrounded by grass	Native other	Leaf litter
	18	2477879.627	5749280.074	Cabbage trees, flax	Cabbage tree	Grass
	19	2477831.253	5749281.037	Pittosporum, mahoe	Native other	Leaf litter
	20	2477807.078	5749342.164	Pittosporum, other large natives	Native other	Leaf litter

Table 2: GPS location, vegetation and substrate description of each site studied in Redwood Springs, Janet Stewart and Spencerville Reserves.

	Site	Easting	Northing	Vegetation	Vegetation classification	Substrate classification
Redwood Springs	1	2479512.049	5749062.721	Flax bush, shrubs	Flax	Bark
	2	2479496.034	5749072.431	Shrub, divaricating shrub	Native other	Bark
	3	2479508.884	5749100.293	Flax, cabbage tree	Flax	Bark
	4	2479543.794	5749084.815	Flax, cabbage tree, toe toe	Flax	Bark
	5	2479629.082	5749072.23	Willow	Willow	Grass
	6	2479647.797	5749068.965	Willow	Willow	Grass
Janet Stewart Reserve	1	2482659.61	5749547.092	Cabbage tree, flax, totara, near fallen log	Flax	Wood
	2	2482644.743	5749525.288	Small isolated patch of totara and other shrub with fallen log	Native other	Grass
	3	2482615.588	5749488.529	Tussock	Tussock	Bark
	4	2482572.893	5749463.467	Coprosma, hebe, tussock, pittosporum	Native other	Leaf litter
	5	2482564.621	5749451.353	Tussock, cabbage tree, divaricating shrub	Tussock	Leaf litter
	6	2482552.839	5749441.268	Cabbage trees	Cabbage tree	Bark
	7	2482527.043	5749425.581	Flax, tussock, toe toe	Flax	Leaf litter
	8	2482436.088	5749440.133	Tussock, willows	Willow	Grass
Spencerville Reserve	1	2485037.559	5753062.117	Flax, hebe, cabbage trees	Flax	Bark
	2	2485069.748	5753016.787	Tussock, cabbage trees	Tussock	Bark
	3	2485114.223	5752959.422	Flax, tussock, hebe, cabbage tree, totara, divaricating shrub	Flax	Bark
	4	2485200.32	5752784.265	Toe toe, cabbage tree, hebe, divaricating shrub	Native other	Bark
	5	2485215.276	5752757.463	Pine tree, coprosma	Exotic other	Wood
	6	2485236	5752751	Cabbage tree, tussock, coprosma	Cabbage tree	Bark

Plate 22: Eastern Styx Mill Conservation Reserve showing site locations. Grid references and site descriptions can be found in Table 1.

Plate 23: Western Styx Mill Conservation Reserve showing site locations. Grid references and site descriptions can be found in Table 1. Note that site SM13 is located where SM14 is, and the location of SM14 is marked by an x.

Plate 24: Redwood Springs Reserve showing site locations. Grid references and site descriptions can be found in Table 1.

Plate 25 Janet Stewart Reserve showing site locations. Grid references and site descriptions can be found in Table 1.

Plate 26:. Spencerville Reserve showing site locations. Grid references and site descriptions can be found in Table 1. Note that site SP6 was excluded from this map and is marked by an x

Results:

1. Catch per trap:

Varying numbers of individuals were trapped at each site per week (Figures 1 and 2). The highest average trap catch was found was at site SM4, followed by SM12 and RED6 (Figures 1 and 2). Sites SM16, SM17 and SM19 had the lowest average trap catches (Figures 1 and 2).

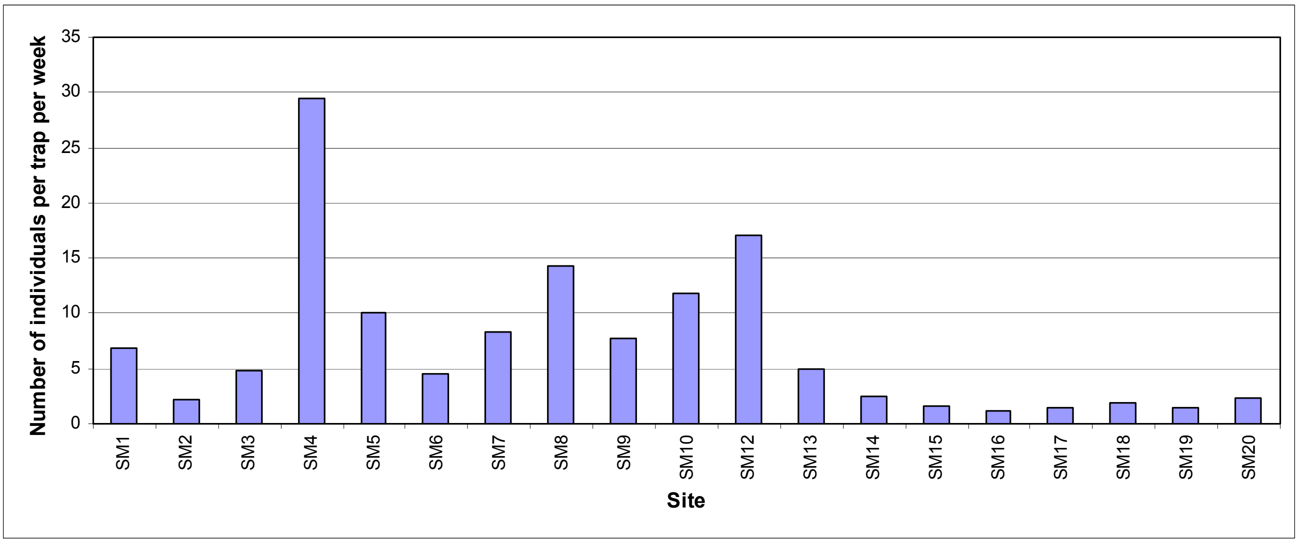


Figure 1: Average trap catch per week at each site in Styx Mill Conservation Reserve. It is important to note that Site SM11 was not included as this trap was removed by a member of the public during the first week of data collection.

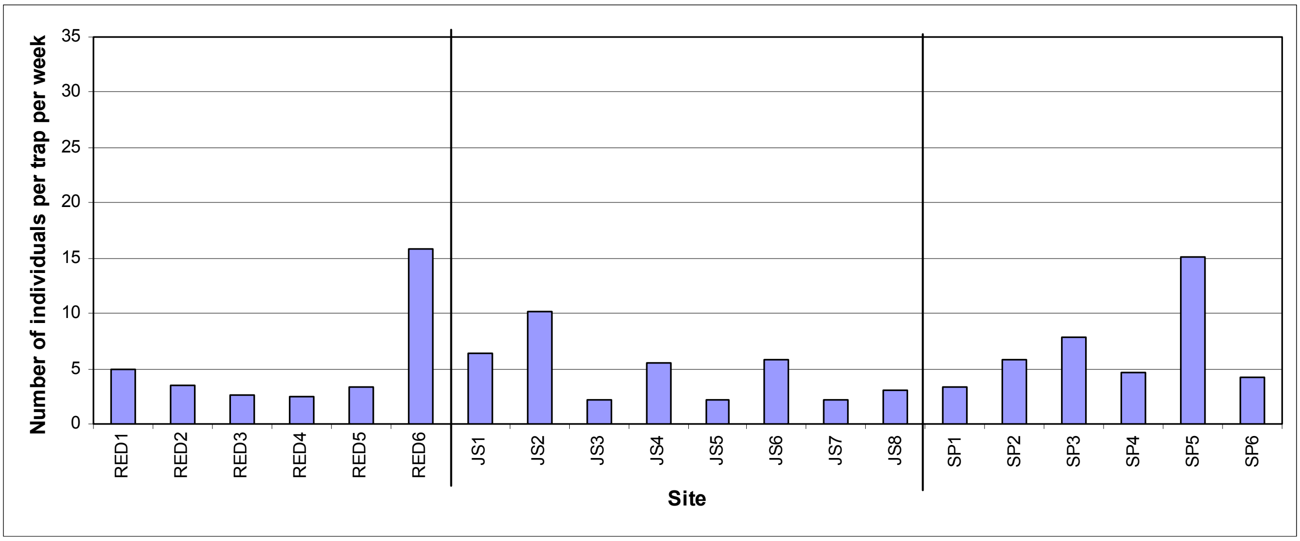


Figure 2: Average trap catch per week at each site in Redwood Springs, Janet Stewart and Spencerville Reserves.

The total number of Recognisable Taxonomic Units (RTUs) ranged from 4 to 23 (Figures 3 and 4). The highest number of RTUs were found at site JS2 followed by RED6 (Figure 4). The least number of RTUs were found at RED3, RED1 and RED2 (Figure 4).

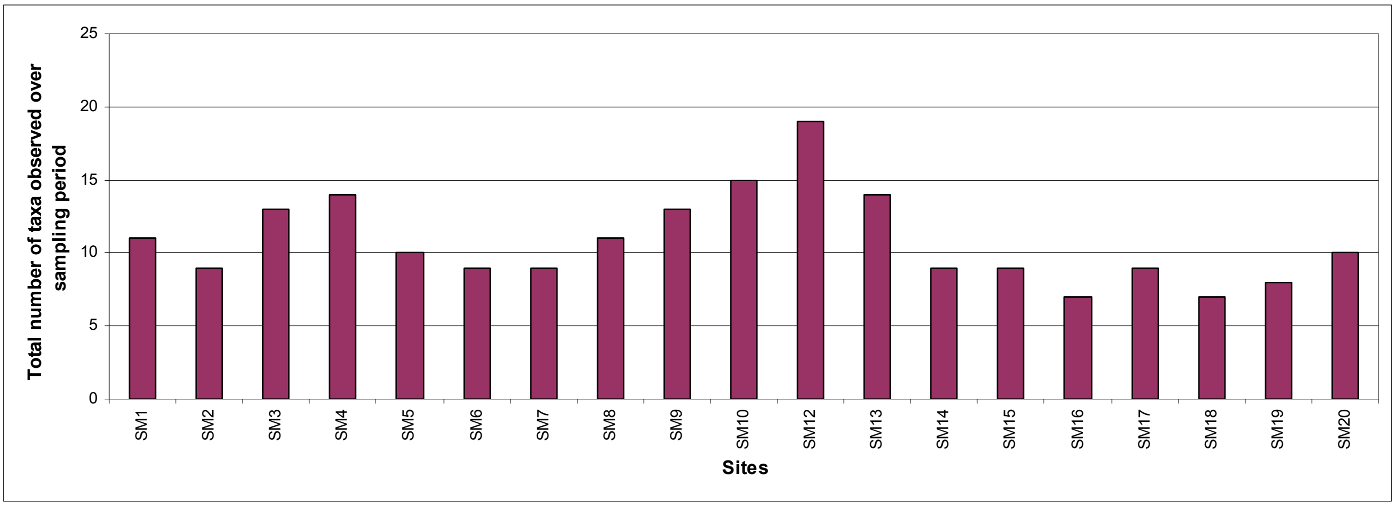


Figure 3: Total number of RTUs observed at each site in Styx Mill Conservation Reserve over the sampling period. It is important to note that Site SM11 was not included as this trap was removed by a member of the public during the first week of data collection.

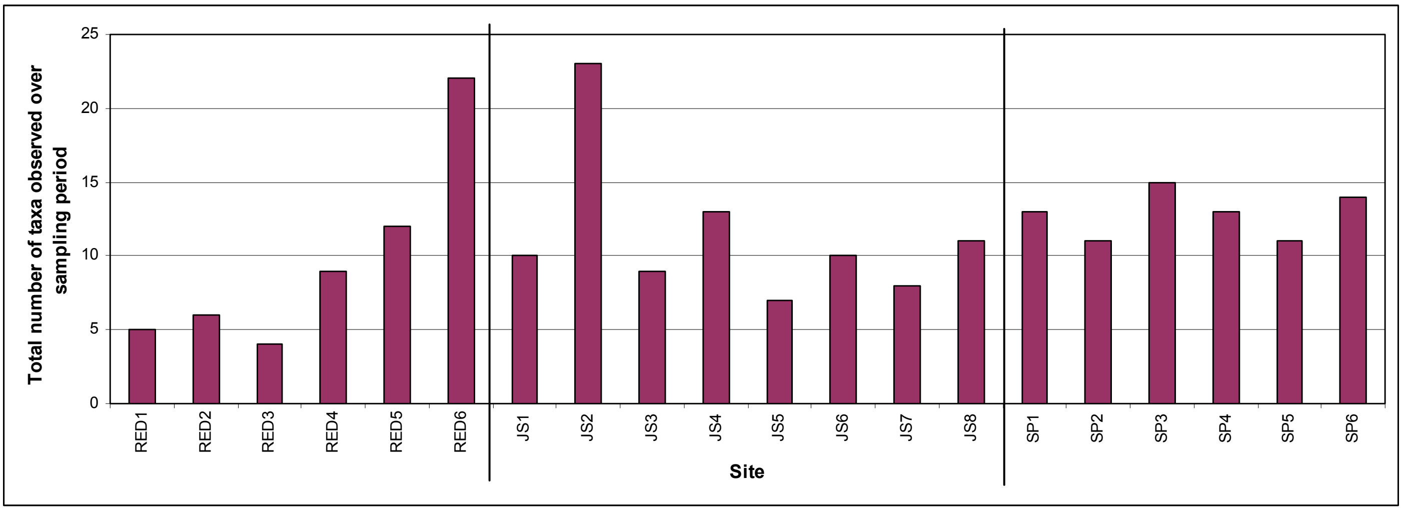


Figure 4: Total number of RTUs observed at each site in Redwood Springs, Janet Stewart and Spencerville Reserves.

Spider 1 was the most commonly found taxa, occurring at 36 of 40 sites. Taxa found at over half the sites (20 or more out of a possible 40) include spiders 1, 5, 10, amphipoda (amphipods) and carabidae (carabid beetles), (table 2). Harvestman 9, spider 11 and pseudoscorpionida (pseudoscorpions) were only found at one site.

Table 2: Presence/Absence diagram for all species found at each site.

		Styx Mill Conservation Reserve																			Redwood Springs						Janet Stewart								Spencerville						
		SM1	SM2	SM3	SM4	SM5	SM6	SM7	SM8	SM9	SM10	SM12	SM13	SM14	SM15	SM16	SM17	SM18	SM19	SM20	RED1	RED2	RED3	RED4	RED5	RED6	JS1	JS2	JS3	JS4	JS5	JS6	JS7	JS8	SP1	SP2	SP3	SP4	SP5	SP6	
Beetles	Cerylonidae		X						X	X		X	X														X	X									X	X			9
	Tenebrionidae									X									X	X						X											X	X			6
	Latridiidae		X		X	X	X	X					X	X	X								X	X	X	X		X		X							X		X		16
	Colydiidae				X															X																					2
	Cryptophagidae																													X						X	X	X		X	5
	Elateridae																				X	X				X		X							X		X	X		X	8
	Staphylinidae			X								X																X										X			3
	Beetle larvae										X				X										X			X						X							5
	Carabidae		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X					X	X	X	X	X	X	X	X		X	X	X			X		28
	Scarabaeidae	X	X	X					X			X					X	X		X	X					X		X	X	X			X		X			X			16
	Curulionidae	X			X					X	X		X													X						X		X		X	X	X		X	12
Harvestman	Harvestman 1									X																		X	X	X	X		X		X	X				X	9
	Harvestman 2							X			X		X														X	X							X						6
	Harvestman 3											X																	X						X	X	X				5
	Harvestman 4																							X									X								2
	Harvestman 5											X													X		X														3
	Harvestman 6						X					X	X													X															4
	Harvestman 7		X	X	X	X				X		X		X	X	X	X		X							X															12
	Harvestman 8	X			X												X					X			X	X	X														7
	Harvestman 9									X																															1
Spider	Spider 1	X		X						X	X	X	X				X								X	X	X	X		X					X			X	X	X	16
	Spider 2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X		X	X	X	X	X	X	X	36
	Spider 3	X		X		X			X				X					X		X	X					X		X		X		X		X	X		X	X		X	16
	Spider 4	X													X																			X					X		4
	Spider 5			X	X				X		X	X											X			X									X					X	9
	Spider 6	X	X	X	X	X	X	X	X	X	X			X			X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	X				29
	Spider 7							X				X		X				X								X								X							6
	Spider 8						X																					X								X	X				4
	Spider 9	X									X	X														X	X											X			6
	Spider 10			X	X	X	X	X	X	X	X	X	X	X	X			X							X	X		X		X	X	X					X		X	X	22
	Spider 11																																						X		1
	Spider 12										X	X		X		X																						X			5
	Spider 13				X																									X			X	X	X	X				X	7
	Spider 14				X	X					X	X	X		X									X		X			X			X					X			X	12
	Spider 15																		X			X																	X		3
	Spider 16																									X		X				X									3
	Spider 17																										X	X			X							X			4
	Spider 18											X												X												X					3
	Spider 19										X																						X							X	3
	Spider 20					X																			X																2
	Spider 21								X																		X	X		X		X		X							6
	Spider 22						X																	X	X			X					X								5
	Spider 23										X								X					X					X												4
Other	Acarina																			X						X													X		3
	Amphipoda	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X	X	X	X	X		X		X			X		X		X	X	27
	Chilopoda															X						X						X	X							X					5
	Dermaptera			X							X		X					X		X								X			X			X							8
	Diplopoda	X	X	X	X			X	X	X	X	X	X	X	X	X			X							X		X		X			X		X		X			X	21
	Pseudoscorpionida																																						X		1
		11	9	13	14	10	9	9	11	13	15	19	14	9	9	7	8	7	8	10	5	6	4	9	12	22	10	23	9	13	7	10	8	11	13	11	15	13	11	14	

2. **Catch per reserve:**

Spencerville Park and Styx Mill Conservation Reserve have higher average numbers of individuals than Redwood Springs and Janet Stewart Reserve. Although this trend is evident, the data shown is insignificant because the error bars overlap due large variation in the number of individuals caught. This shows that the four reserves have the potential to have similar average numbers of individuals across all traps (Figure 5).

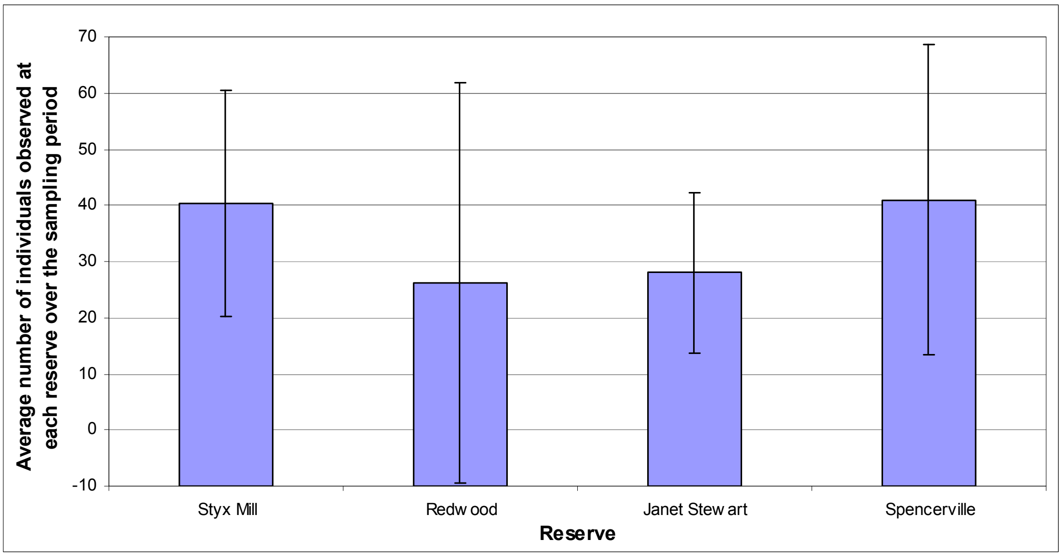


Figure 5: Average number of individuals found within each reserve with error bars showing 95% confidence intervals.

The average number of RTUs found in each site ranged from 10.8 – 12.8 (Figure 6). While the Spencerville Park has the highest average and Styx Mill Conservation has the lowest, no significant conclusions can be drawn as the error bars overlap. Because of this it means that there is potential for all four reserves to have the same average number of total RTUs.

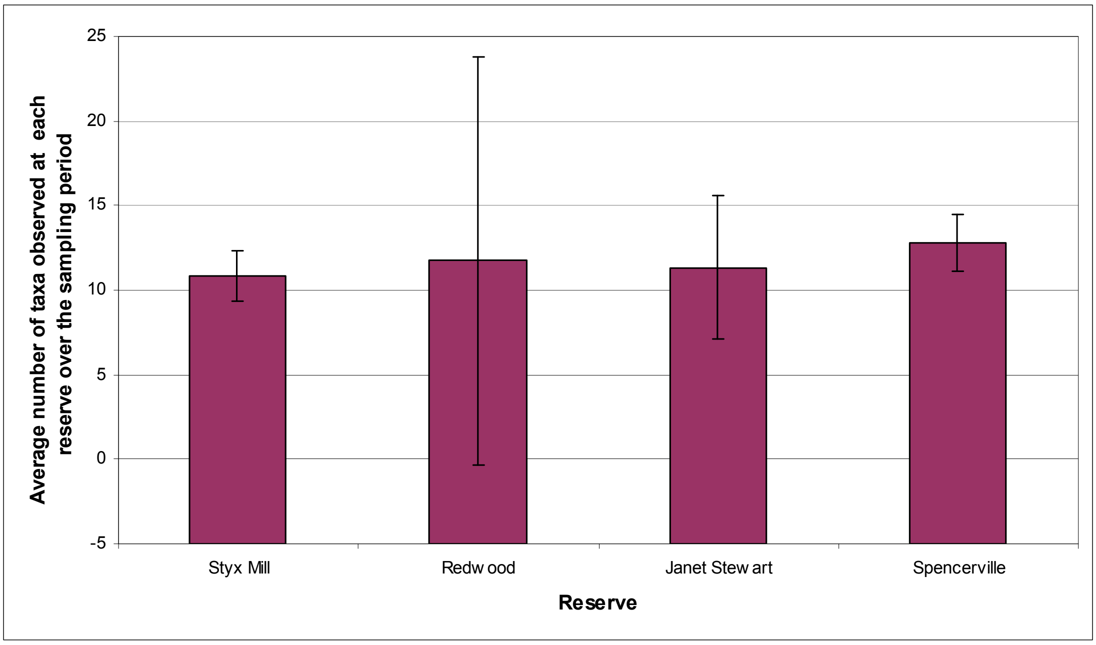


Figure 6: Average number of taxa found within each reserve with error bars showing 95% confidence intervals.

3. **Taxa composition of catch per site by reserve:**

There is high variation between sites (Figures 7 and 8). The highest average numbers of individuals per week were found in SM4 the lowest average was in SM16.

Group ‘other’ was found in high abundance in sites SM12, RED6, and SP5. SM4, SM5, SM10, RED4, and JS6 have high numbers of spiders. Harvestmen were found in JS1 and SP2 in high abundance. Beetles were found in high numbers in SM8, RED6 and JS2 (Figure 7 and 8).

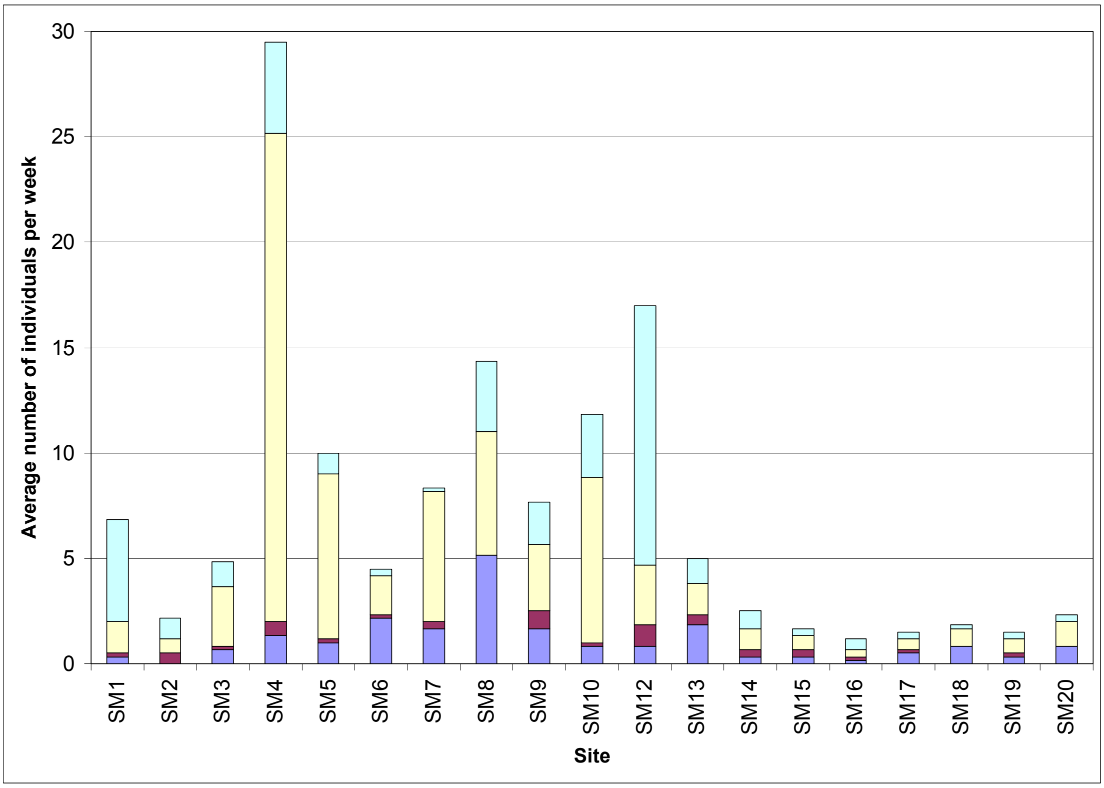


Figure 7: Composition of total number of invertebrates found at each site within Styx Mill Conservation Reserve.

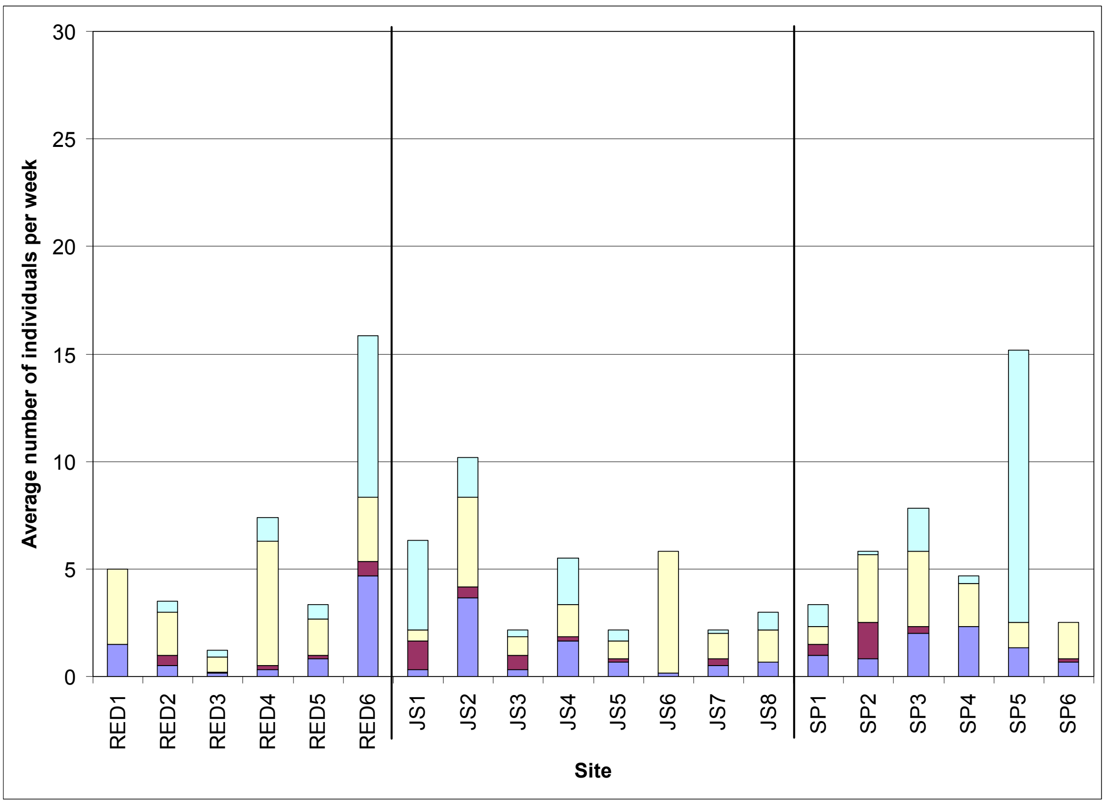
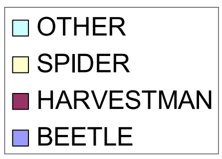


Figure 8: Composition of total number of invertebrates found at each site within Redwood Springs, Janet Stewart and Spencerville Reserves.



4. Catch by substrate:

Although high numbers of individuals were found in substrate type wood, no significant conclusions can be drawn as the error bars overlap (Figure 9).

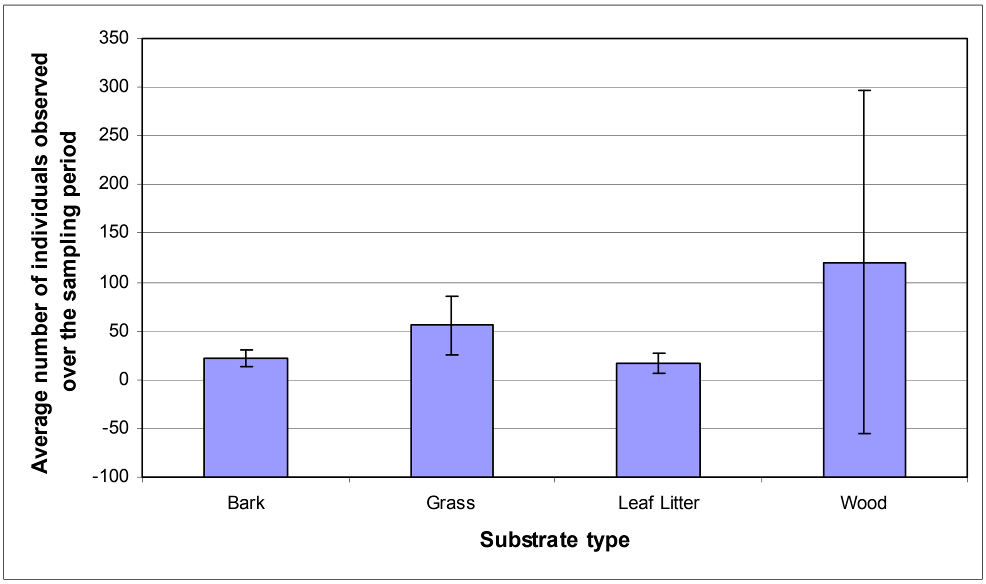


Figure 9: Average number of individuals observed in each substrate type.

Variation among the substrate for total RTUs was low. The highest numbers of RTUs were found in grass and the lowest found in leaf litter although no significant conclusion can be drawn as error bars overlap (Figure 10).

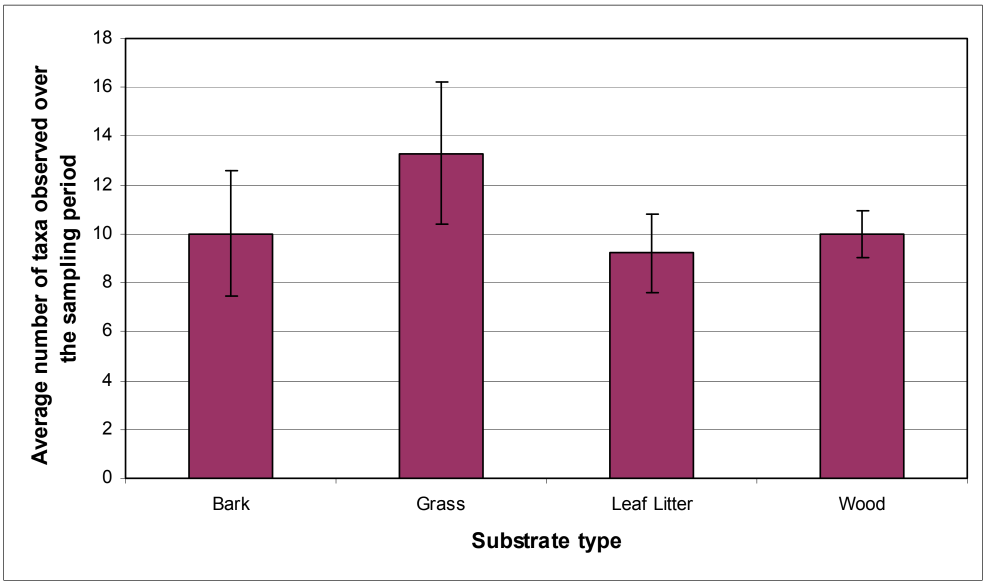


Figure 10: Average number of taxa observed in each substrate type.

The composition of each group is similar even though average numbers vary (Figure 11). Sites with a wood substrate had the highest average amount of groups other, spider, harvestman and beetle found (Figure 11). Other were found in low average numbers in bark. Spider, harvestman and beetle were found in low average numbers in leaf litter.

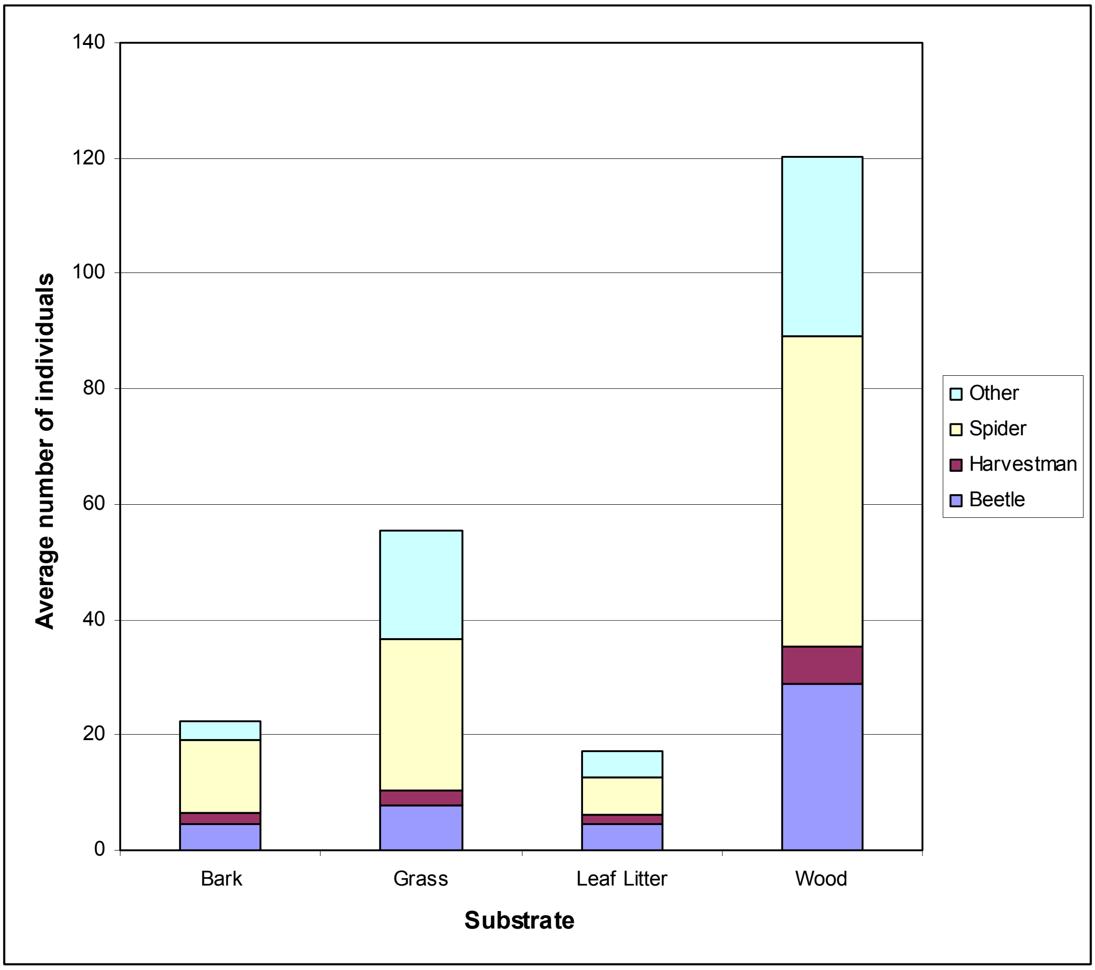


Figure 11: Composition of total number of invertebrates found at each site within each substrate type.

P values show that substrate and reserve have no impact on the number of individuals or taxa found (Tables 3 and 4).

Table 3: ANOVA tests of substrate/number of individuals

	Spencerville	Janet Stewart	Redwood	Styx Mill
Bark	31	24	10.5	0
Grass	0	39.5	70.5	55.67
Leaf Litter	0	19.67	0	15.83
Wood	25	38	0	55.75

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Bark	4	65.5	16.38	191.56
Grass	4	165. 67	41.42	922.64
Leaf Litter	4	35.5	8.88	107.47
Wood	4	118.75	29.69	550.56
Spencerville	4	56	14	267.33
Janet Stewart	4	121.17	30.29	98.89
Redwood	4	81	20.25	1146.75
Styx Mill	4	127.25	31.8125	803.13

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2490.25	3	830.08	1.68	0.24	3.86
Columns	858.61	3	286.20	0.58	0.64	3.86
Error	4458.08	9	495.34			
Total	7806.94	15				

Table 4: ANOVA tests of substrate/total number of taxa

	Spencerville	Janet Stewart	Redwood	Styx Mill
Bark	28	12	13	0
Grass	0	27	26	29
Leaf Litter	0	19	0	23
Wood	41	10	0	17

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Bark	4	53	13.25	131.58
Grass	4	82	20.5	188.33
Leaf Litter	4	42	10.5	149.67
Wood	4	68	17	304.67
Spencer	4	69	17.25	424.92
Janet	4	68	17	59.33
Redwood	4	39	9.75	154.92
Styx Mill	4	69	17.25	156.25

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	228.69	3	76.23	0.32	0.81	3.86
Columns	165.19	3	55.06	0.29	0.87	3.86
Error	2157.56	9	239.73			
Total	2551.44	15				

5. **Catch by vegetation:**

No significant differences were found between the number of individuals or taxa in vegetation types due to large variation between traps (Figure 12 and 13).

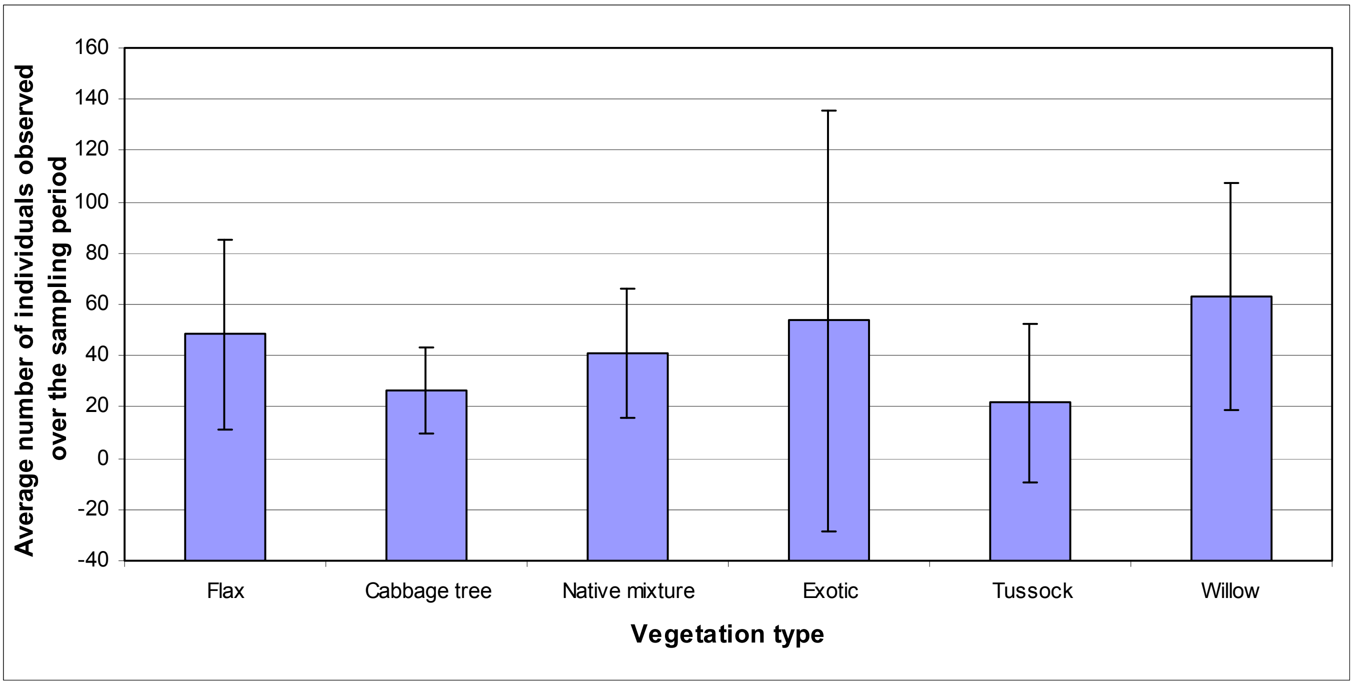


Figure 12: Average number of individuals observed in each vegetation type.

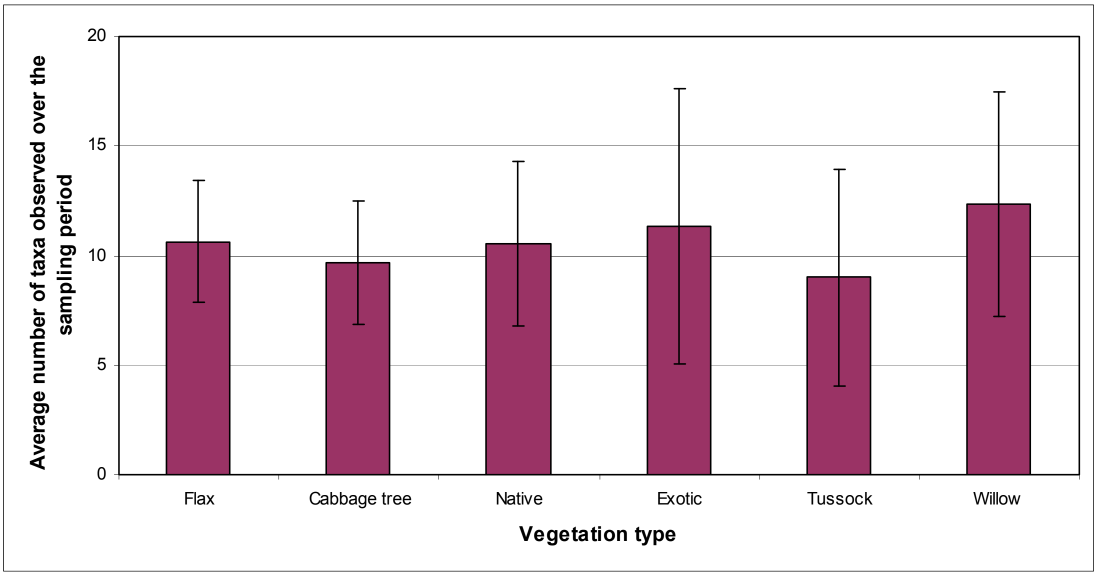


Figure 13: Average number of taxa observed in each vegetation type.

Percentage bar graphs for each of the vegetation composition show that exotic plantings had the highest percentage of RTU group 'other'. Flax had the highest Spider percentage. Harvestmen were highest in tussock and beetles were highest in willows (Figures 14).

The vegetation composition with the highest average number of individuals was willow. The lowest average number of individuals was found in Tussock (Figure 14)

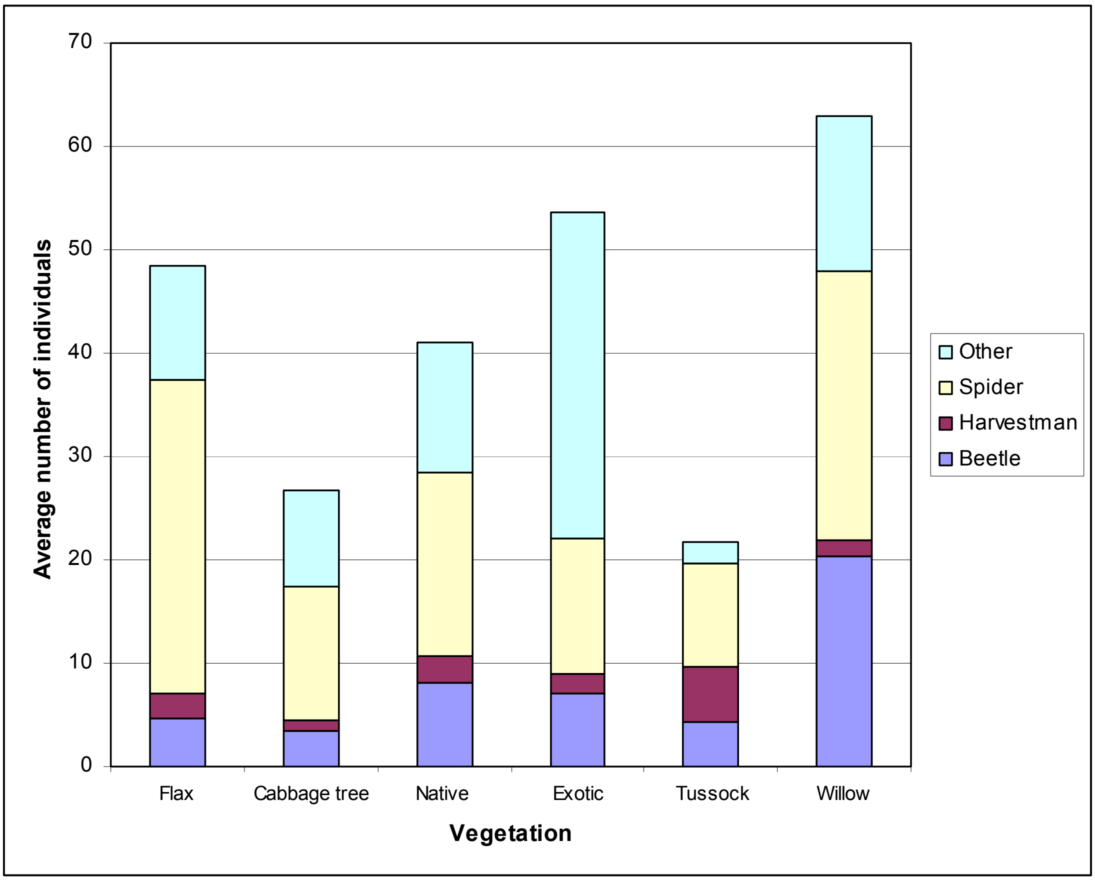


Figure 14: Composition of average number of invertebrates found at each site within each vegetation type.

P values show that vegetation and reserve have no impact on the number of individuals or taxa found (Tables 5 and 6).

Table 5: ANOVA tests of vegetation/number of individuals

	Spencerville	Janet Stewart	Redwood	Styx Mill
Flax	40.67	7	28.38	29
Cabbage tree	116	0	0	41.2
Native other	15	30	20	64
Exotic	91	0	0	47.6
Tussock	36	83.5	0	0
Willow	0	18	38.33	53

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Flax	4	170.42	42.60	1058.46
Cabbage tree	4	97	24.25	421.58
Native other	4	131.71	32.92	384.40
Exotic	4	126	31.5	1845.67
Tussock	4	50.5	12.63	289.56
Willow	4	161.5	40.38	1367.56
Spencerville	6	221.5	36.92	895.44
Janet Stewart	6	162	27	414.7
Redwood	6	91.17	15.19	764.16
Styx Mill	6	262.46	43.74	1077.94

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2436.91	5	487.38	0.55	0.74	2.90
Columns	2777.43	3	925.81	1.04	0.40	3.29
Error	13324.28	15	888.29			
Total	18538.62	23				

Table 6: ANOVA tests of vegetation/number of taxa

	Spencerville	Janet Stewart	Redwood	Styx Mill
Flax	22	18	13	26
Cabbage tree	14	10	0	19
Native other	13	25	6	33
Exotic	11	0	0	18
Tussock	11	12	0	0
Willow	0	11	26	17

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Flax	4	79	19.75	30.92
Cabbage tree	4	43	10.75	64.92
Native other	4	77	19.25	145.58
Exotic	4	29	7.25	78.25
Tussock	4	23	5.75	44.25
Willow	4	54	13.5	119
Spenerville	6	71	11.83	50.17
Janet Stweart	6	76	12.67	70.27
Redwood	6	45	7.5	108.7
Styx Mill	6	113	18.83	122.17

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	700.21	5	140.04	1.99	0.14	2.90
Columns	392.46	3	130.82	1.86	0.18	3.29
Error	1056.29	15	70.42			
Total	2148.96	23				

6. **Carabid catch by site and reserve:**

The number of carabid beetles caught per trap per week was highest in site SM8 (Figure 15). Sites RED1, RED2, RED3, RED4, JS6, JS7, SP3, SP4, SP6, SM11, SM14 and SM15 did not catch any carabids over the six week sampling (Figures 15 and 16).

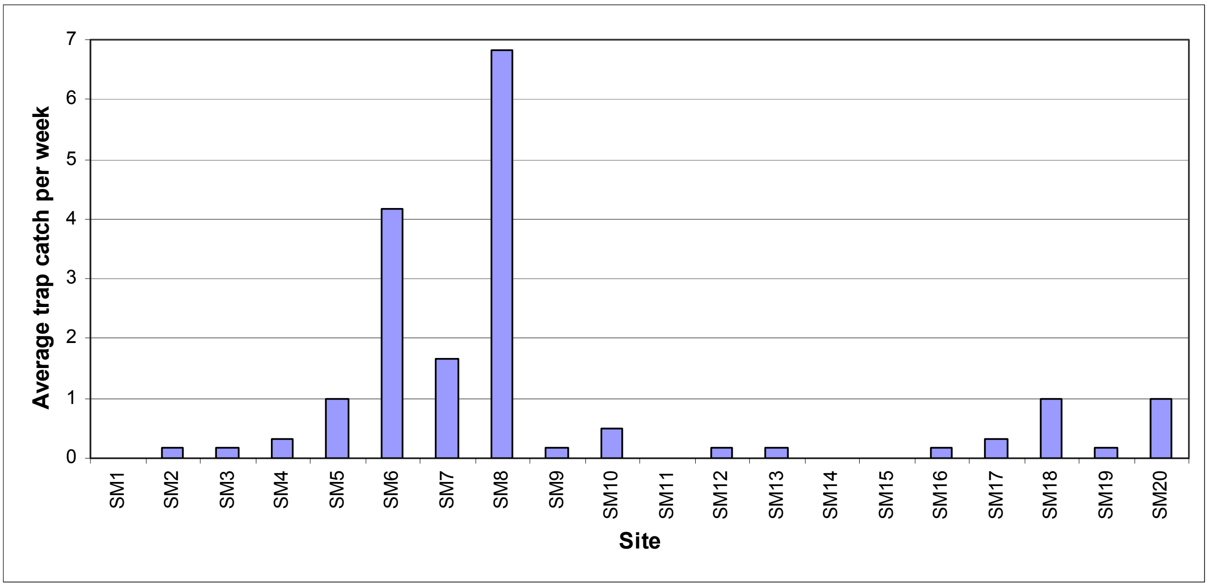


Figure 15: Average number of carabid beetles caught per trap per week at each trap in Styx Mill Conservation Reserve.

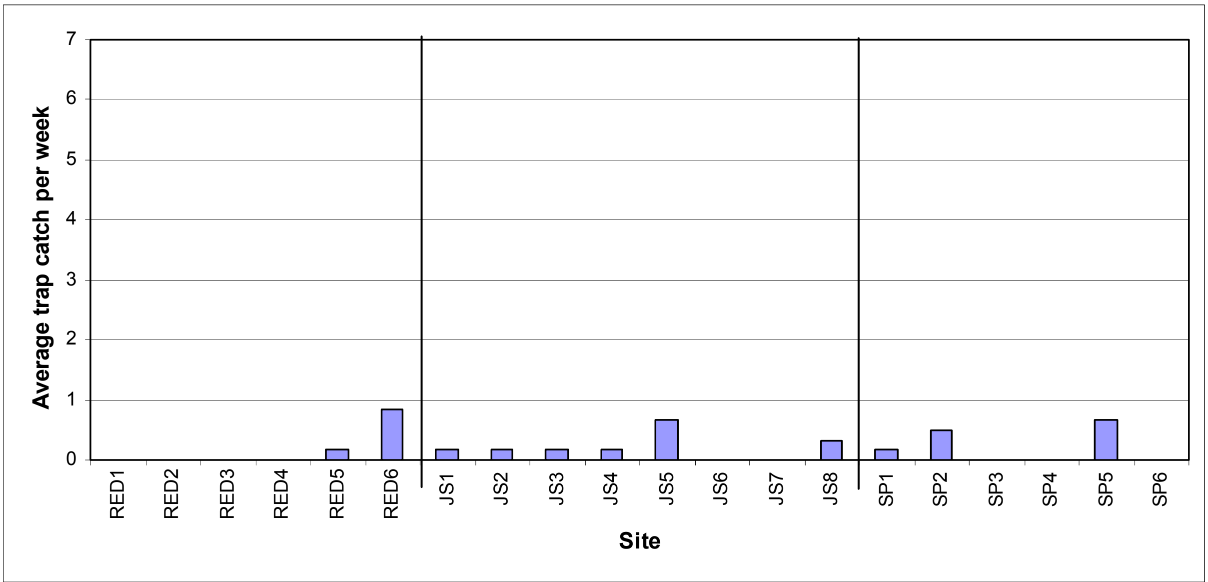


Figure 16: Average number of carabid beetles caught per trap per week at each trap in Redwood Springs, Janet Stewart and Spencerville Reserves.

Styx Mill Conservation Reserve had the highest total amount of carabids caught, however due variation there is no significant difference (Figure 17).

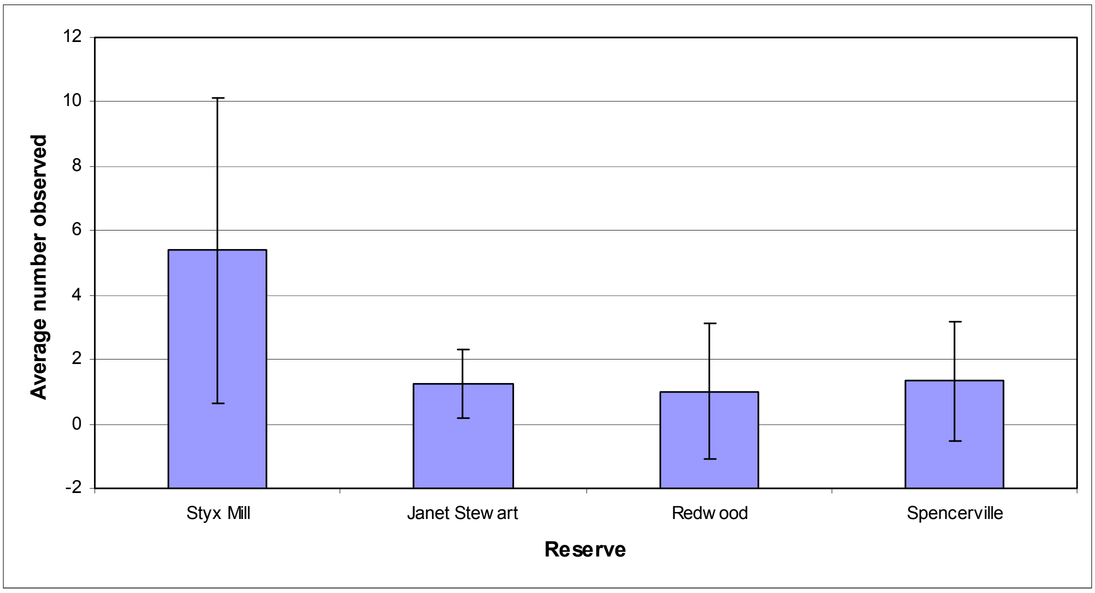


Figure 17: Average number of carabids found in each reserve.

Discussion:

Average trap catch per week was found to be low in Styx Mill sites SM16, SM17, SM18, SM19 and SM20 compared with other sites in the reserve (Figure 1). We expected that these sites would have a higher trap catch because they are in established native plantings. Although abundance at these sites was found to be low (Figure 1), diversity of these communities was found to reasonable compared with other sites (Figure 3).

Redwood site RED6 was found to have one of the highest average trap catches (Figure 2). This was unexpected as this site is under large established willows in long grass. This site was also found to have the second higher taxa (Figure 4). When compared to the other willow sites (SM6, SM7, SM8, RED5 and JS8), RED6 had a much higher average trap catch and number of taxa. While RED6 had a very high average trap catch, the other traps in willows also have a high number of individuals when compared with other vegetation types. This shows that willows support equally diverse and abundant invertebrate communities when compared to other vegetation types. This is important when considering future restoration projects. Perhaps it could be a good idea to plant natives underneath established willow trees. By felling willows to plant young natives these communities may be lost and may not reestablish due to difficulties in colonisation. It is possible that community diversity is similar between willows and native plantings because the taxa colonise from the willows nearby.

Spencerville site SP5 was also found to have a high average trap catch (Figure 2). This was unpredicted as the site is under a large pine tree, the ground was covered in pine needles, and the small patch was surrounded by grass. Although numbers of individuals were high, numbers of taxa were low. This suggests that the community is not very diverse but what is found there is abundant.

Janet Stewart site JS2 had the most taxa found over the sampling period (Figure 4). We thought that this was an interesting and unpredictable result because this site is a small patch with a totara tree surrounded by grass. We expected that larger, established patches such as SM16, SM17, SM18, SM19, SM20, JS4 and JS5 to support more abundant and diverse communities but this was not the case (Figures 1, 2, 3, and 4).

There was no significant difference between the average number of individuals and the average number of taxa in each reserve (Figures 5 and 6). This is suggested by the overlapping confidence intervals. Because the confidence intervals overlap, there is a possibility that the true mean of the number of individuals or taxa in the reserve could be the same.

Confidence intervals for Redwood could be high due to the low number of traps (6) within the reserve (Figures 5 and 6). The high confidence interval could also be attributed to the diverse environments within the reserve. Confidence intervals for Styx Mill could be lower because of higher number of traps (20) which were used in the reserve (Figures 5 and 6). To possibly lower the confidence intervals, more traps could be used in the future, in Redwood Springs, Janet Stewart and Spencerville Reserves. This could have allowed further analysis as more significant differences may have been seen in results.

Average number of total individuals and RTUs found in each different substrate or vegetation type were found to be insignificant (Figures 9, 10, 12 and 13). The ANOVA tests indicate that substrate, vegetation and reserve do not have an effect on the abundance or diversity of individuals at a site. However, if our reference collection was to be identified to a species level we could establish whether the taxa found were native or exotic.

It seems that the restoration programmes have provided habitat for fauna as suggested by Meurk (2004). While this habitat has been provided, we have found that arthropods are largely unable to recolonise these areas. This idea was put forward by Macfarlane in his 2007 survey of invertebrates in Styx Mill Conservation Reserve.

Carabid beetles were found in high numbers in sites SM8, SM6 and SM7 (Figure 15). This could be attributed to the favourable habitat for carabids as these sites were damp, with logs and chipped wood. In the future there is potential for the establishment of a long term study using carabids as an indicator of habitat health and species diversity. We feel that this would be valid because carabids were found to be widely distributed over the reserves. Further identification of carabids in the reference collection could show whether individuals collected were native or exotic and if new species migrated to the areas over time.

While much of the data collected in this project has proved to be insignificant, this report provides important baseline data for future research.

If this project was repeated again we suggest that the same number of traps be used for substrate and vegetation. This would allow easier comparison between types. Another suggestion is to measure other environmental factors such as humidity, temperature, soil moisture and light intensity. These factors could be useful when analysing data and finding similarities between sites. It may also explain why certain compositions of groups are found at different sites. Comparisons between restored sites and remnant bush could also be looked at. Remnant bush such as Riccarton Bush could be surveyed in a similar way to look at the differences in abundance and diversity of invertebrate in remnant and restored sites.

Several potential projects have arisen from this research. One of them is that invertebrates in our reference collection could be identified to a species level. This would suit someone who has done the 300 level entomology paper at Lincoln University. This would mean that the species found could be divided into native and exotic invertebrate species and data could be reanalysed. Another future project would be to repeat this research in five years using the suggested improvements. This would allow monitoring of species composition as the plantings mature over time. A long term carabid study could be carried out using them as a bioindicator. Another future project could be to research the role of willows in restoration. This information would be valuable for future planting programmes. The vertebrates such as lizards and birds could also be surveyed in the reserves. This would allow an overall diversity of a reserve to be catalogued.

From our data we found that willows provided a habitat for many individuals. This should be considered for future restoration projects. Planting native vegetation underneath willows means that invertebrate communities that are already present will not be lost due to felling. Colonisation of the native plantings by invertebrates will be easier as they will already be there. Planting underneath the willows also preserves the microclimate and natives which are planted there have a 90-100% survival rate (Pers. Comm. Trevor Patridge). Denser, larger and less fragmented plantings should be established especially in Redwood Springs. This will prevent the area from drying out and allow the plantings to support a higher amount of individuals and more diversity. It is also important to consider where the invertebrates are going to come from. Areas will not be colonised by animal species if a source population is too far away. Distance from a source population and the dispersal abilities of the species must be taken into account. If species are unable to recolonise translocation or corridors must be considered (Watts *et al.* 2008). Translocation is usually only used for larger and more endangered invertebrates but could be applied here. There is potential for reserves to be linked by corridors of native bush. These corridors would allow invertebrates to travel between reserves and population flow could be achieved.

What we gained from this research project:

- Learnt about how to plan and carry out our own project
- Learnt how to key out terrestrial invertebrates
- Learnt about insect taxonomy and how to preserve insects
- Learnt about how data should be shared and stored for future use
- Learnt how to collaborate and write a report together
- Increased skills using statistics and graphing
- Thought about how restoration plantings should be planned
- Gained an insight into restoration projects in urban areas, and saw the practical side of theories we learnt in lectures

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