Spatial Distribution of Aquatic Invertabrates

STYX RIVER, SMACKS CREEK & UPSTREAM OF STYX MILL CONSERVATION RESERVE

the styx-pūrākaunui
Waterways, Wetlands and Surface Water

SUMMER STUDENT SCHOLARSHIP 2007/2008

Student: Katie Collins | Supervisor: Kelly Walker, Lincoln University

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Abstract:

Aquatic invertebrate monitoring was carried out at 23 sites in Styx Mill Conservation Reserve and upstream in both the Styx River and Smacks Creek in November 2007 and January 2008 to establish patterns in invertebrate abundance and distribution. Community composition of sites in Styx Mill Conservation Reserve was similar, dominated by more sensitive species. Community composition of sites in the Styx River both upstream and downstream of the reserve and sites in Smacks Creek were dominated by *Potamopyrgus* snails.

Introduction:

The Styx River is located in Canterbury in the northern suburbs of Christchurch (Robb, 1989). There are at least 13 springs within the 55 km^2 catchment area and two tributaries, Smacks and Kaputone Creeks, which feed the Styx (Hulley and Little, 2000, Taylor *et al.* 2000). From the springs, the river flows approximately 24 km northeast where it discharges into the Waimakariri River at Brooklands Lagoon (Robb, 1980, Hill, 2002). The upper reaches of the Styx flow through the Styx Mill Conservation Reserve. Styx Mill Conservation Reserve is about 60 hectares, and is accessible from Hussey Road (Christchurch City Council, 2003, Macfarlane, 2007). Smacks Creek is 2km long and is also spring fed, from a spring south of Wilkinsons Road. It flows through Willowbank Wildlife Reserve to join the Styx just upstream of the conservation reserve (Hill, 2002).

The Styx flows through residential subdivisions, industrial areas, reserves and agricultural and horticultural properties. Urbanisation has a negative effect on waterways, especially on macroinvertebrates (Taylor *et al.* 2000). Research has shown that the Styx has higher macroinvertebrate richness (both abundance and diversity) than other Christchurch rivers including the Avon and the Heathcote (Robb, 1980). This could be attributed to the less developed nature of the Styx catchment at that time. There is now increasing pressure on the Styx catchment as urban sprawl causes landuse changes and development within the area (Hicks and Duncan, 1993, Rengard *et al.* 2004, Taylor *et al.* 2000).

Macroinvertebrates play two important roles in river ecosystems; as primary producers, and as indicators of water quality. As primary consumers they eat algae and other vegetation, converting it to energy available to other species, especially fish and birds (Taylor, 1999). The Styx catchment is seen as an important ecological habitat with 10 species of freshwater fish and 46 bird species (Christchurch City Council, 2003). Invertebrates provide an important food source for these organisms. Invertebrates are also important as biological indicators of water quality. This is because they have specialised habitat requirements, are found easily within most waterways and are reasonably easy to sample and identify (Taylor, 1999, Stark *et al.* 2001).

With increasing development, silt is becoming a problem in the Styx River (Hicks and Duncan, 1993). As the amount of sediment entering the river increases, a threshold is surpassed beyond which the river is unable to keep the particles in suspension. This results in deposition and accumulation of silt. Siltation causes negative effects to ecological, recreational, and aesthetic values (Hicks and Duncan, 1993, Taylor *et al.* 2000). Sensitive invertebrate species die or leave areas where silt covering the riverbed is present, due to lack of suitable habitat. This leads to decreasing diversity as silty habitats are dominated by tolerant species such as snails and worms (Taylor *et al.* 2000).

The objective of this study was to assess the spatial distribution patterns of aquatic invertebrates in the Styx River and Smacks Creek in and upstream of Styx Mill Conservation Reserve.

Methods:

Aquatic invertebrate monitoring was undertaken on the 6th, 7th, 19th, 23rd and 27th November 2007 at 15 sites in the Styx River and 8 sites in Smacks Creek. All sites were photographed and recorded using a GPS (see Figure 1, Plates 1-24 and Appendix 1). Sites in Styx Mill Conservation Reserve were established approximately 80 m apart, where access to the stream was possible. Smacks Creek sites were established where access from the road existed. Physical parameters were also measured instream at each site. Additional monitoring was undertaken on the 15th and 24th January 2008 to further explore the results of the November samplings.

Three samples of aquatic invertebrates were collected at each site using the kick-net sampling method. A D-frame net was placed slightly downstream of the sampler and the substrate on the bottom of the river was disturbed by kicking for 15 seconds. The invertebrate samples were then transferred to icecream containers with some stream water. Invertebrates were sorted from other debris and preserved in ethanol. Invertebrates were later identified and counted using a microscope and keys of Winterbourn *et al.* (2006).

At each site, temperature, dissolved oxygen, conductivity and flow were recorded. These variables were also recorded at the spring (on the upstream boundary of the reserve), the farm drain (entering the Styx between sites St11 and St12) and the ponds (entering the Styx between sites St13 and St 14) (Plates 4 and 13, Appendix one). Temperature and dissolved oxygen were measured using an LDO dissolved oxygen probe on HACH meter (HQ 40d). Conductivity was measured using a TDSTestr 3 0-1990uS conductivity probe. Velocity was measured using a tennis ball method. Ten metres of river was measured out along the bank and the time taken for the tennis ball to travel the distance was recorded. This was repeated three times. Surface velocity was calculated by dividing the distance (10m) by the average time taken by the tennis ball. The area of the stream cross section was calculated by multiplying the average width of the stream by the average depth. Flow was then calculated by multiplying the surface velocity by the area of the stream cross section. The pH was also recorded at selected sites using a Shindengen ISFET KS701 pH probe calibrated at pH 7.0 (pH was not recorded at all sites because the probe was unavailable for the November sampling dates).

Sediment mapping was carried out at the eight sites within Styx Mill Conservation Reserve. Sediment depths were measured at three points (25%, 50% and 75% across the stream profile) across the river profile every 2 m over a 10 m stretch of bank surrounding the sample site.

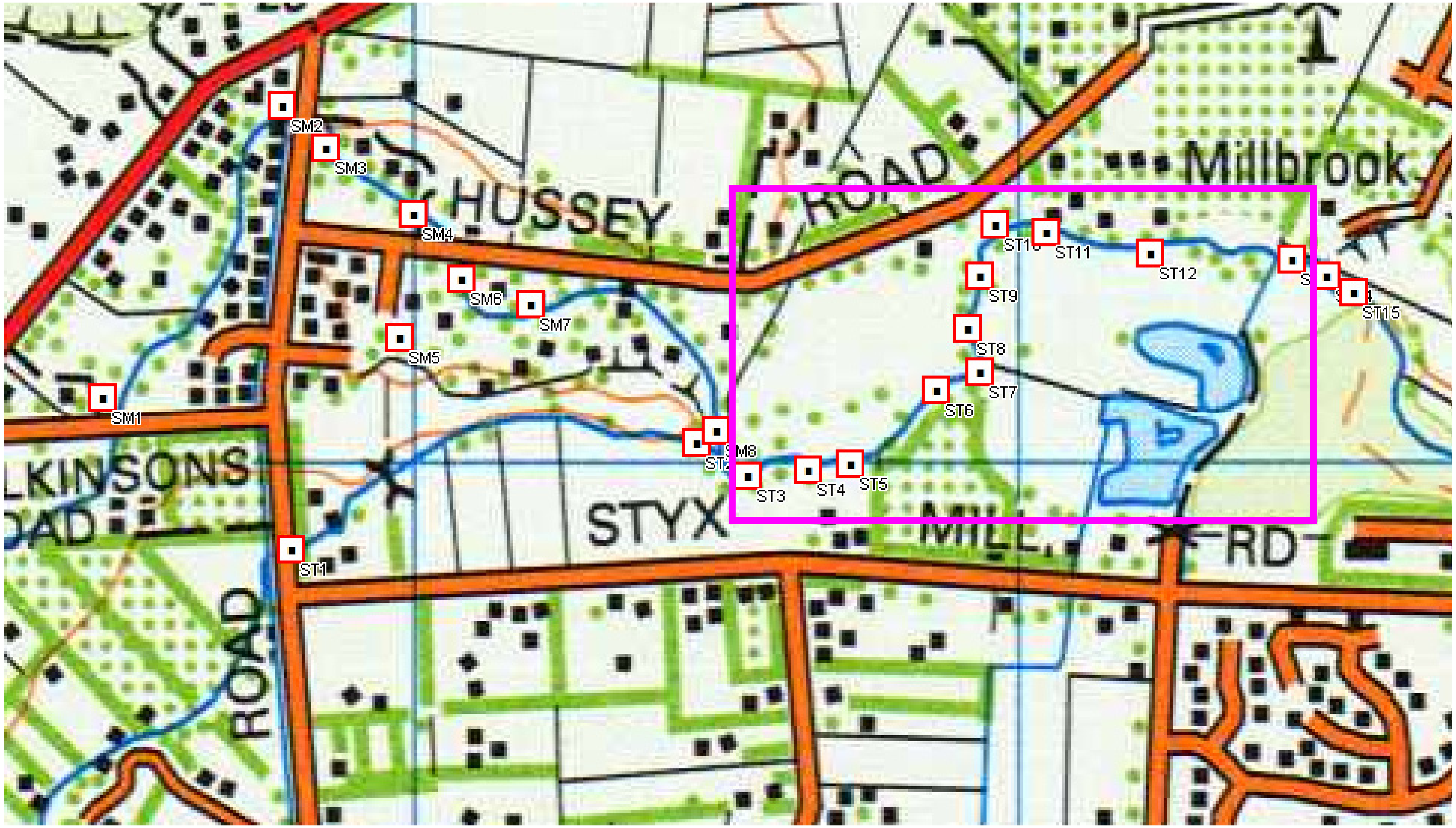

Figure 1: UStyx River showing site locations. Sites within the pink rectangle are located within the boundary of Styx Mill Conservation Reserve. Detailed descriptions of site locations and grid references can be found in Appendix 1.

Plate 1: Site St1. Styx River at Gardiners Road.

Plate 2: Site St2. Styx River out of Styx Mill reserve upstream of confluence point.

Plate 3: Site St3. Styx River out of reserve looking upstream to spring.

Plate 4: Spring located upstream of St3

Plate 5: Site St4. Styx river in reserve near dog park

Plate 6: Site St5 looking upstream.

Plate 7: Site St6

Plate 8: Site St7 looking upstream

Plate 9: Site St8. First bridge in Styx Mill Reserve

Plate 10: Site St9

Plate 11: Site St10

Plate 12: Site St11

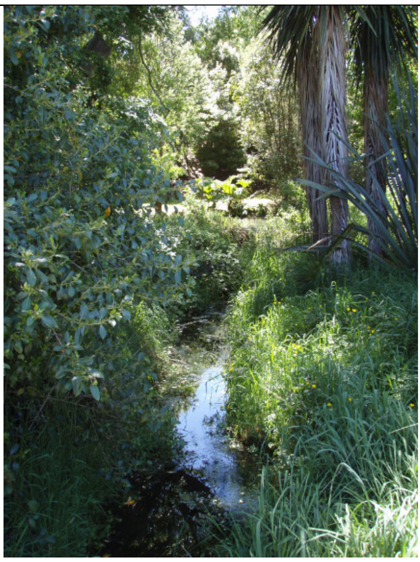

Plate 13: Farm drain

Plate 14: Site St12. Styx River after farm drain enters.

Plate 15: Site St13

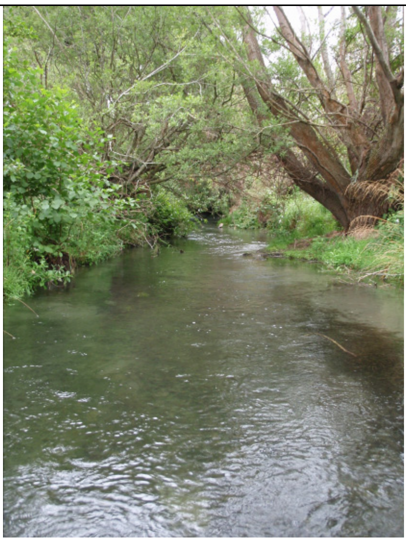

Plate 16: Site St14. In stream from Contemplation point

Plate 17: Site St15

Plate 18: Site Sm1. Smacks Creek at the crematorium

<table>
<tr>
<td>
Plate 19: Site Sm2. Smacks Creek at Timber yard</td>
<td>
Plate 20: Site Sm3. Smacks Creek over Gardiners Road from timber yard</td>
<td>
Plate 21: Site Sm4. Smacks Creek in aquatic centre</td>
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<tr>
<td>
Plate 22: Site Sm5. Smacks Creek in Springvale Gardens</td>
<td>
Plate 23: Site Sm6. Smacks Creek just outside Willowbank Wildlife Reserve</td>
<td>
Plate 24: Site Sm8. Smacks Creek between Styx Mill Reserve and Willowbank Wildlife Reserve before confluence point</td>
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Results:

Invertebrate taxon composition was similar between sites located in the Styx River within Styx Mill Conservation Reserve (sites St3-12) (Figure 2). In the Reserve, communities were dominated by *Deleatidium* (Ephemeroptera-mayflies), *Pycnocentria* and *Pycnocentrodes* (both Trichoptera-caddisflies) (Figures 2-6). No *Deleatidium* were found at site St14, located downstream from where water from the ponds in the reserve enters the Styx (Figure 3). Sites within the reserve had higher numbers of both *Pycnocentria* and *Pycnocentrodes* (Figures 4 and 5). Outside the reserve, both upstream and downstream (sites St1, 2 and 14), there was a noticeable change in community composition, with the sites largely dominated by *Potamopyrgus* snails (Figures 2 and 6). Styx Mill Reserve sites St3-11 were composed of over 80% EPT taxa (Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies)), and EPT taxa composition was similar over these sites (Figures 7 and 8).

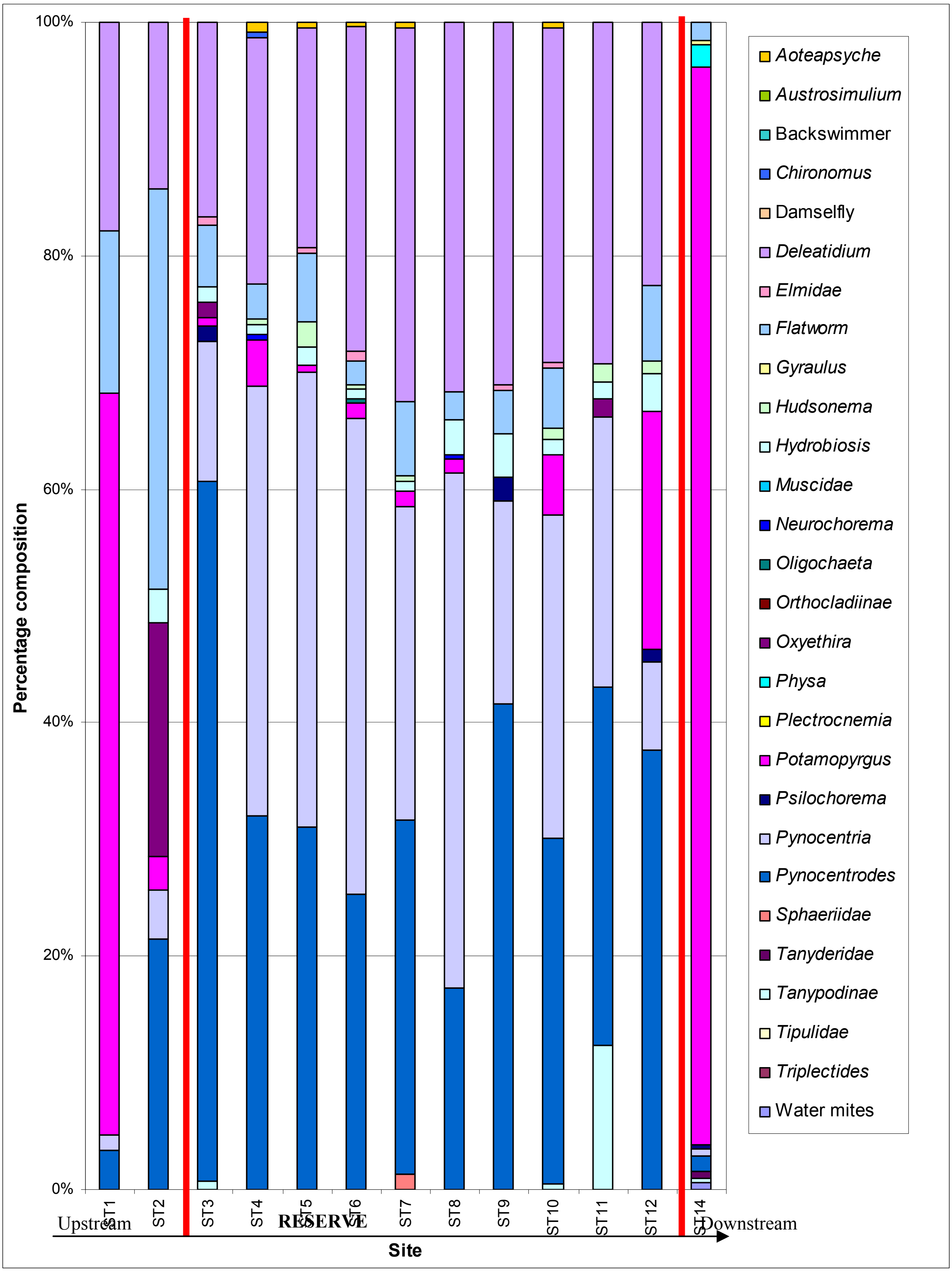
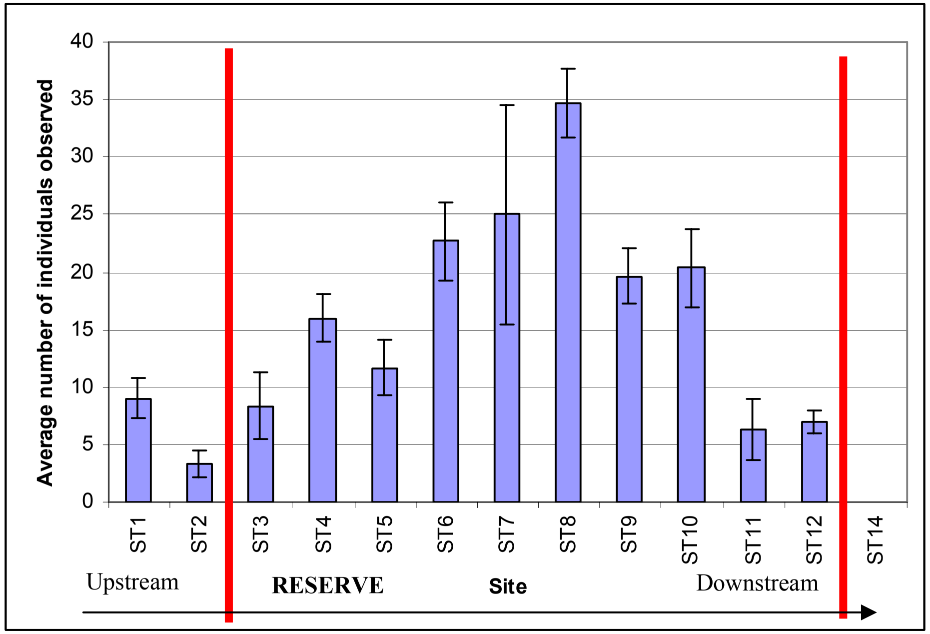


Figure 2: Taxon composition of sites in the Styx River, November 2007.

Note: This graph shows the proportions of species found in a sample. It does not reflect actual numbers of invertebrates found. For actual numbers see Figure 17.



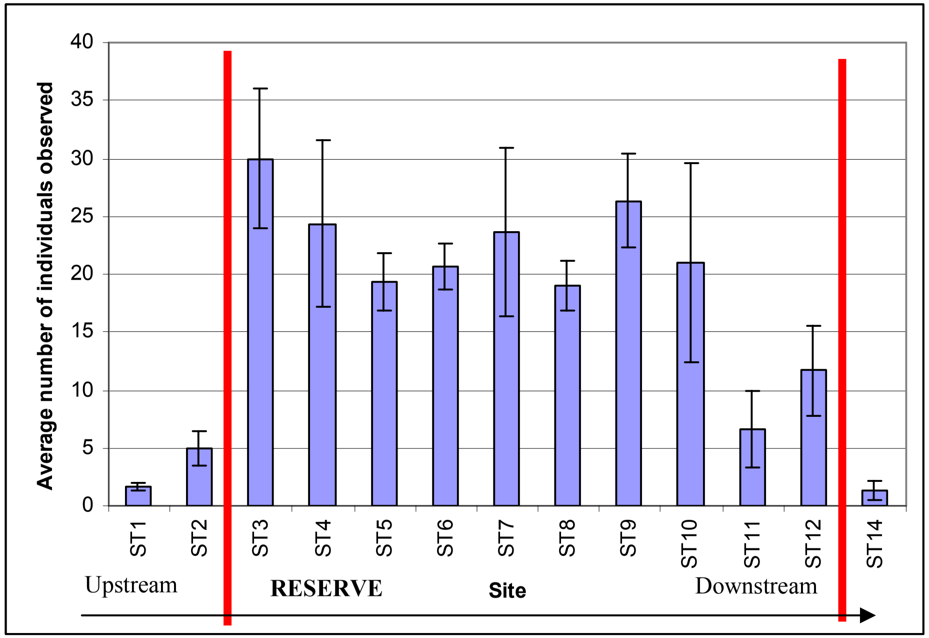
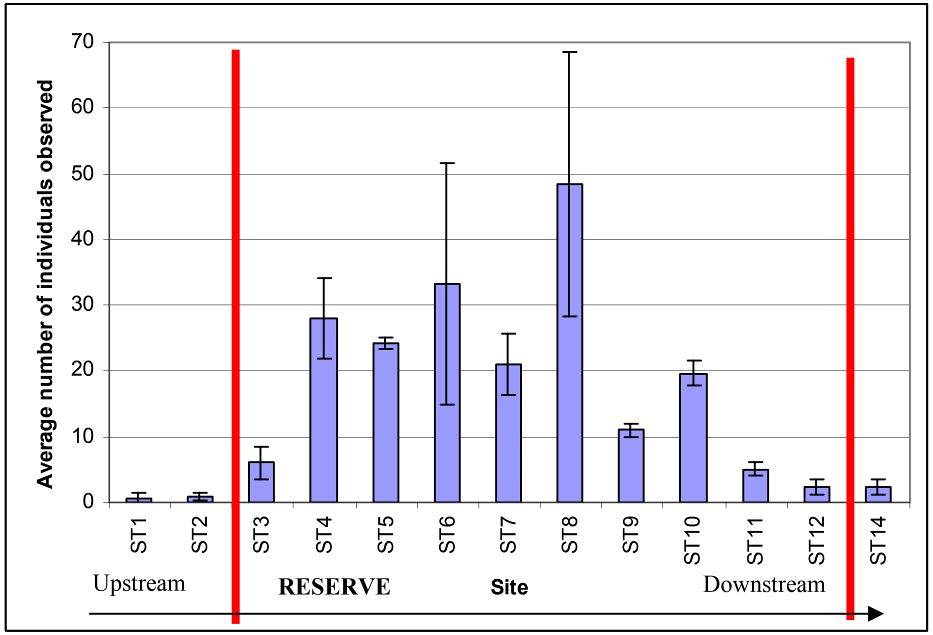


Figure 4: Average number of *Pycnocentrodes* found in the Styx River with error bars showing the standard error of the mean.



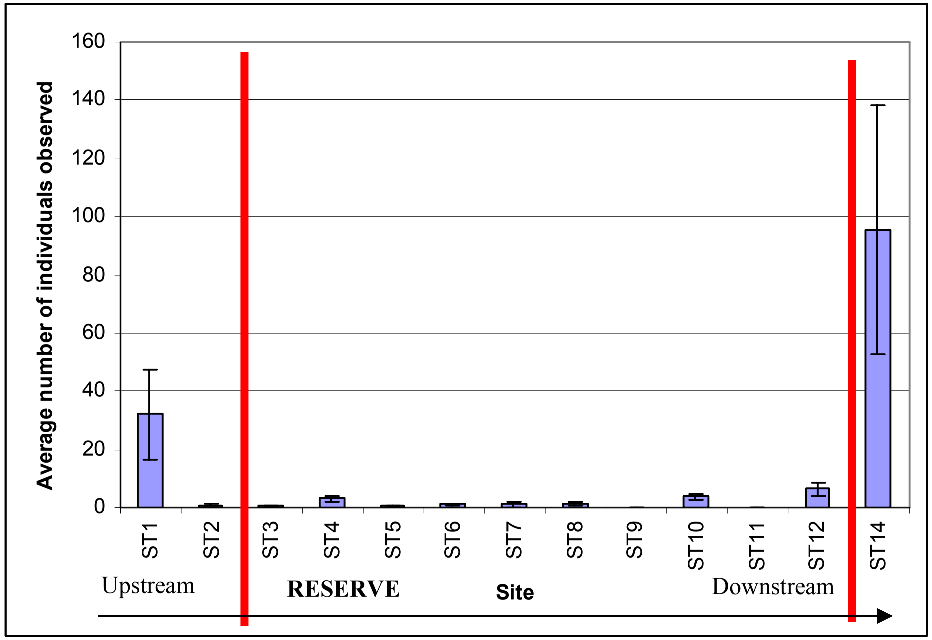


Figure 5: Average number of *Pycnocentria* found in the Styx River with error bars sl **Figure 6**: Average number of *Potamopyrgus* found in the Styx River with error bars showing the standard error of the mean.

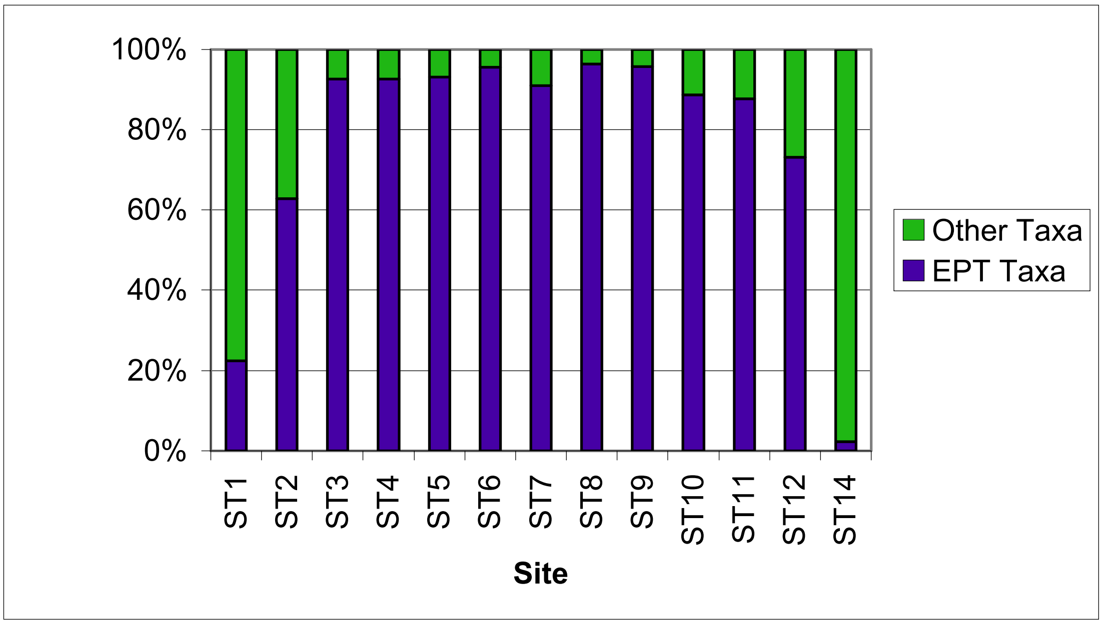


Figure 7: Proportion of EPT taxa compared with other taxa found in the Styx River. EPT taxa include species from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies).

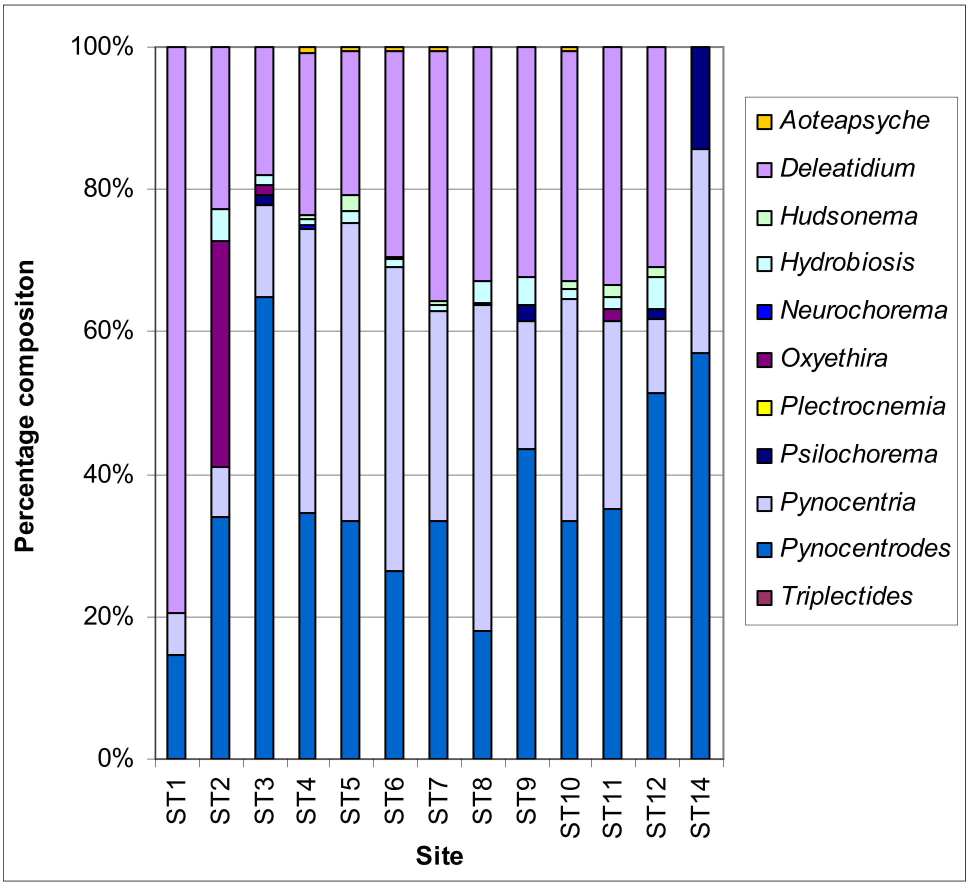


Figure 8: Proportion of genera of EPT taxa (Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies)) found in the Styx River.

Taxon composition was similar over all sites in Smacks Creek where communities were largely dominated by *Potamopyrgus* snails. Smacks Creek sites also had similar invertebrate composition to those sites in the Styx out of the reserve (sites St1, 2 and 14) (Figure 7). Invertebrate composition was highly variable within sites. This resulted in no significant difference in numbers of *Deleatidium, Pycnocentrodes, Pycnocentria* and *Potamopyrgus* being found between sites in Smacks Creek (Figures 10-13). All Smacks Creek sites had fewer than 50% EPT taxa (Figure 14). The proportion of EPT taxa varied greatly between the Styx and Smacks Creek (Figures 8 and 15). Smacks Creek sites tended to be dominated by *Oxyethira* (pursed caddises).

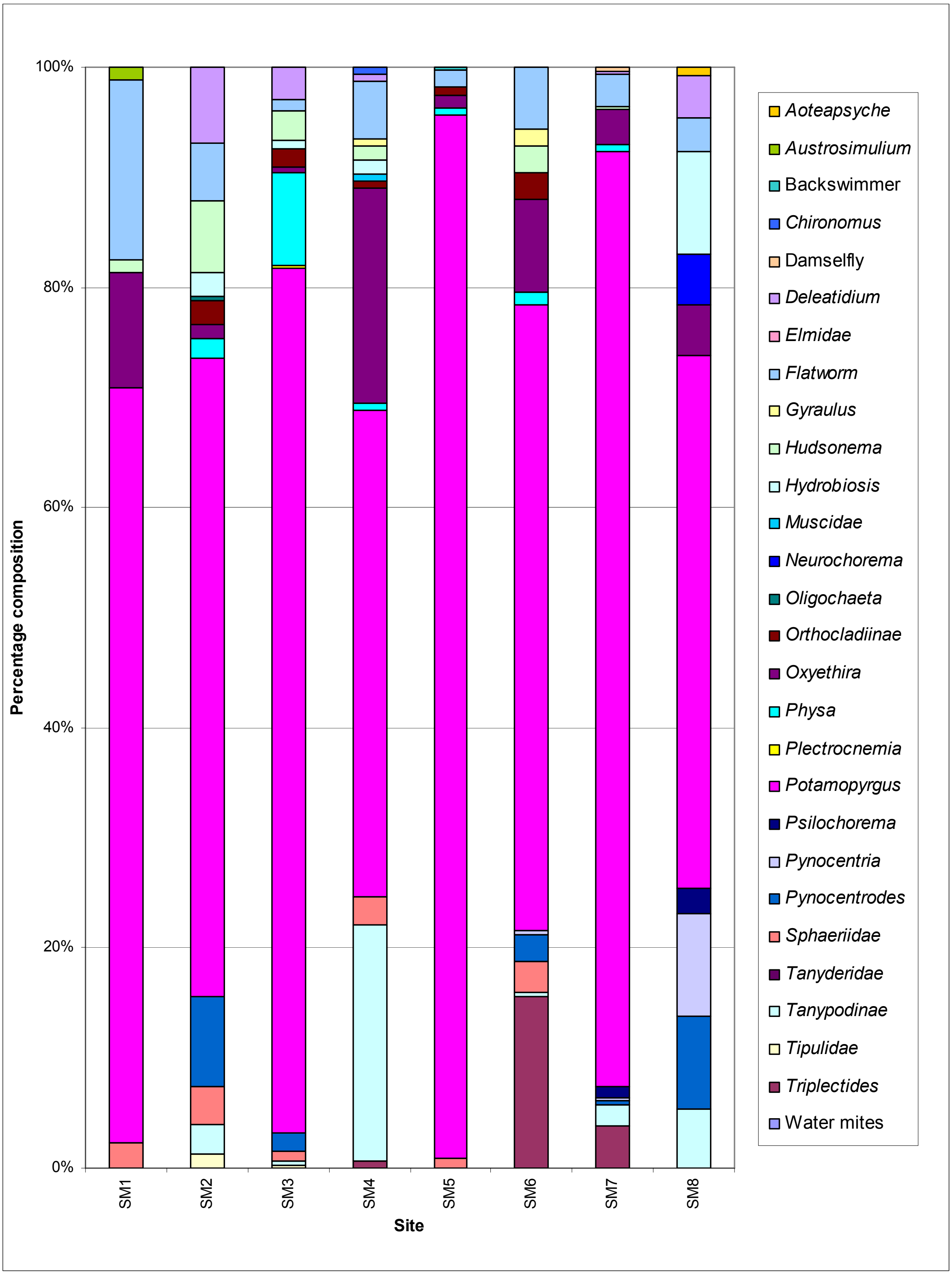


Figure 9: Taxon composition of sites in the Smacks Creek, November 2007.

Note: This graph shows the proportions of species found in a sample. It does not reflect actual numbers of invertebrates found. For actual numbers see Figure 17.

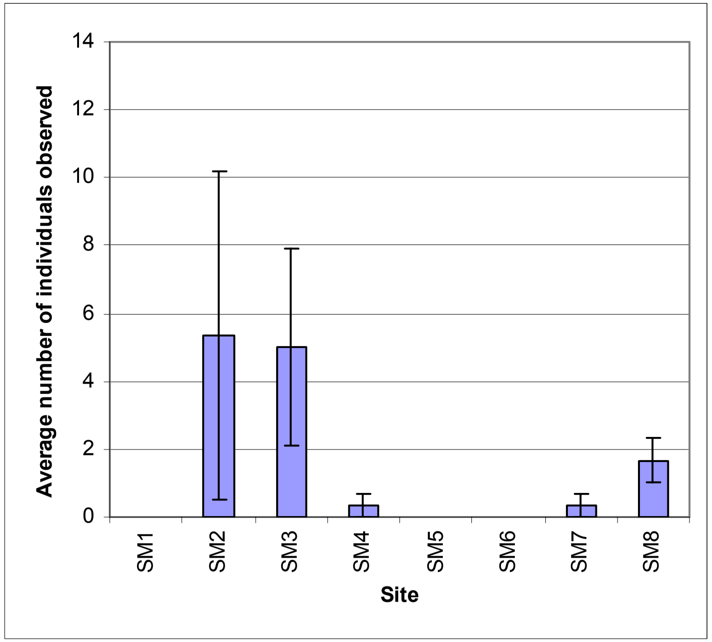


Figure 10: Average numbers of *Deleatidium* found in Smacks Creek with error bars showing the standard error of the mean.

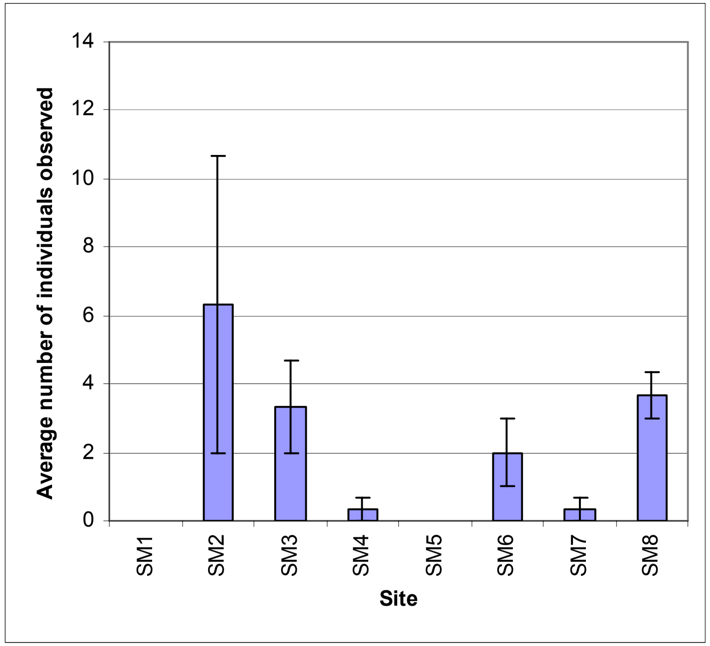


Figure 11: Average number of *Pycnocentrodes* found in Smacks Creek with error bars showing the standard error of the mean.

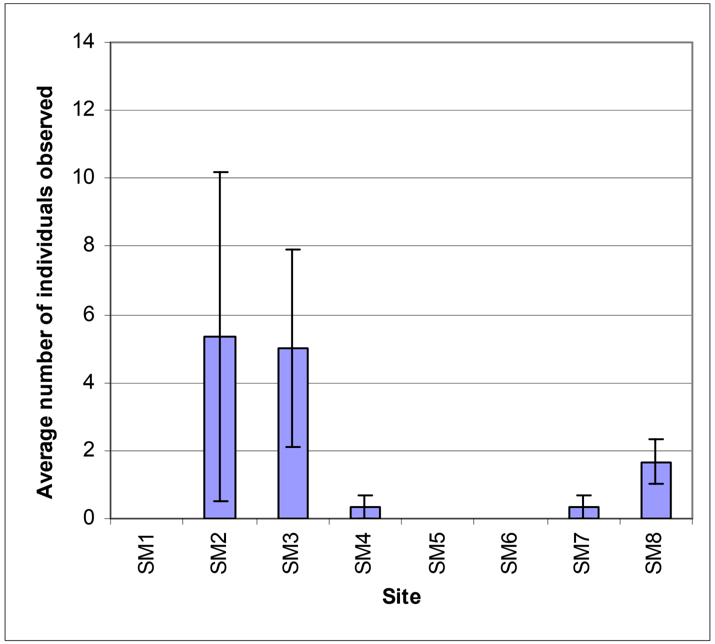


Figure 12: Average number of *Pycnocentria* found in Smacks Creek with error bars showing the standard error of the mean.

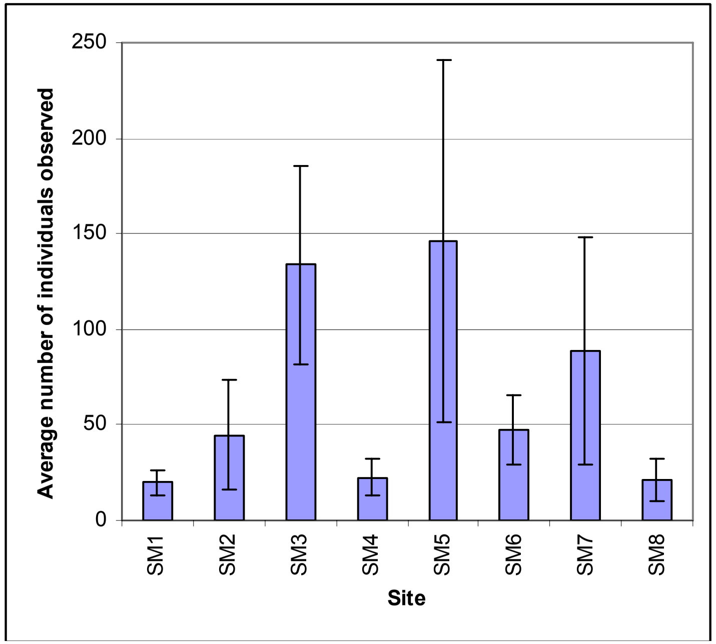


Figure 13: Average number of *Potamopyrgus* found in Smacks Creek with error bars showing the standard error of the mean.

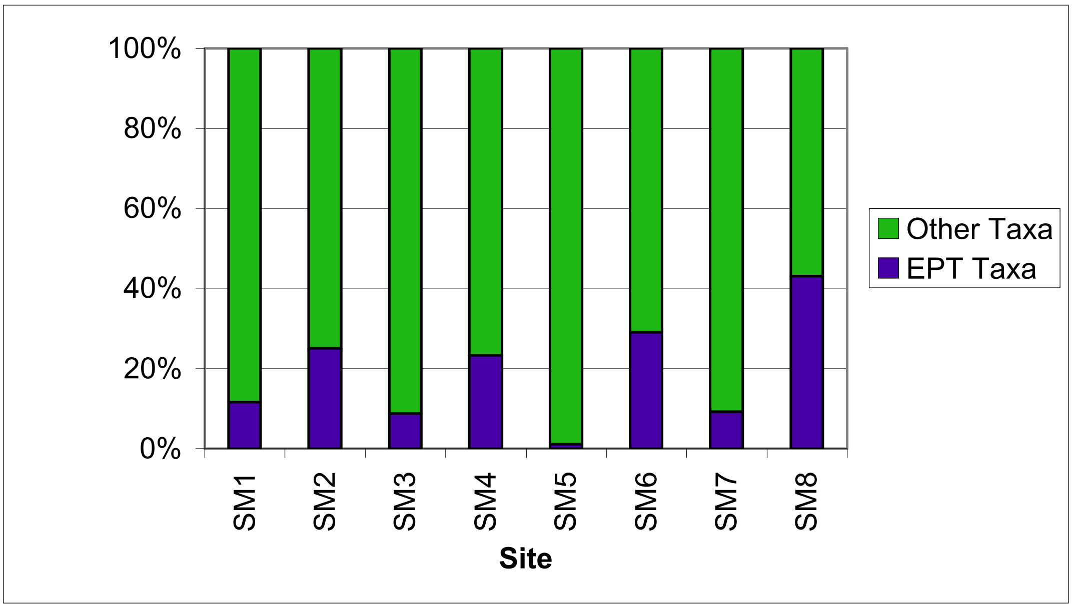


Figure 14: Proportion of EPT taxa compared with other taxa found in the Smacks Creek. EPT taxa include species from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies).

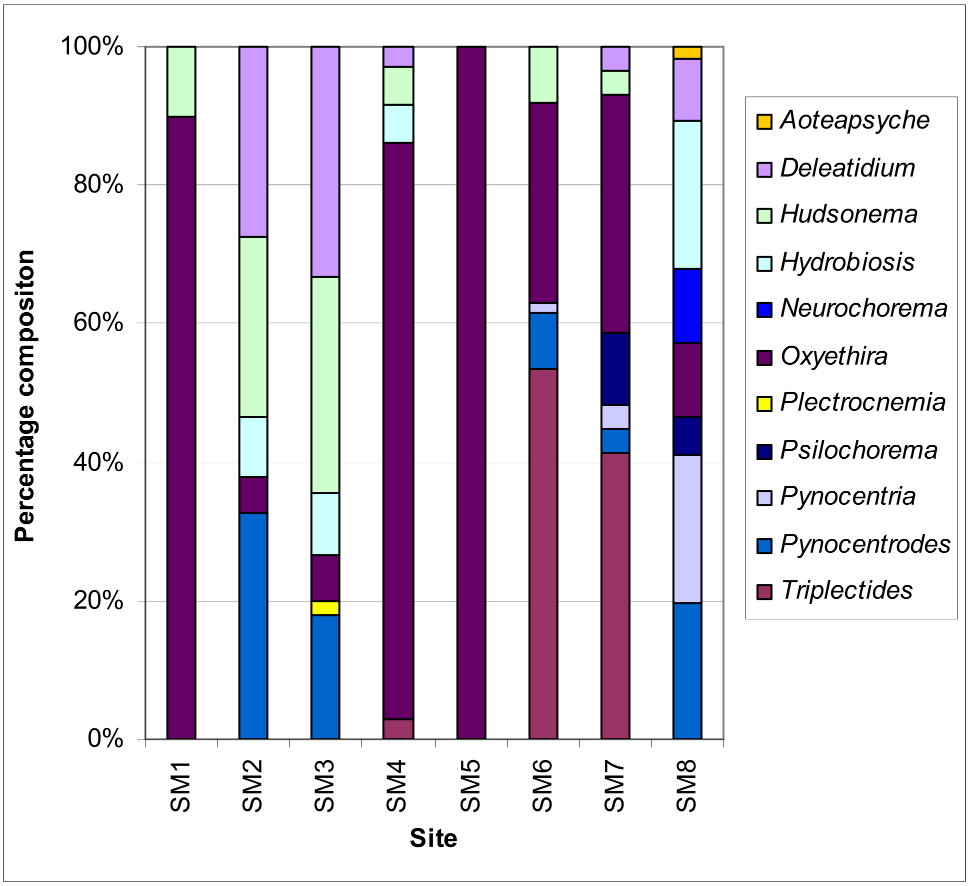


Figure 15: Proportion of genera of EPT taxa (Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies)) found in Smacks Creek.

The most diverse invertebrate community was at site Sm4 with 15 taxa. The least diverse site was site St1 with 6 taxa. An average of 12 taxa per site was observed at sites within Smacks Creek, whereas the Styx sites had an average of 9.4 (Figure 16).

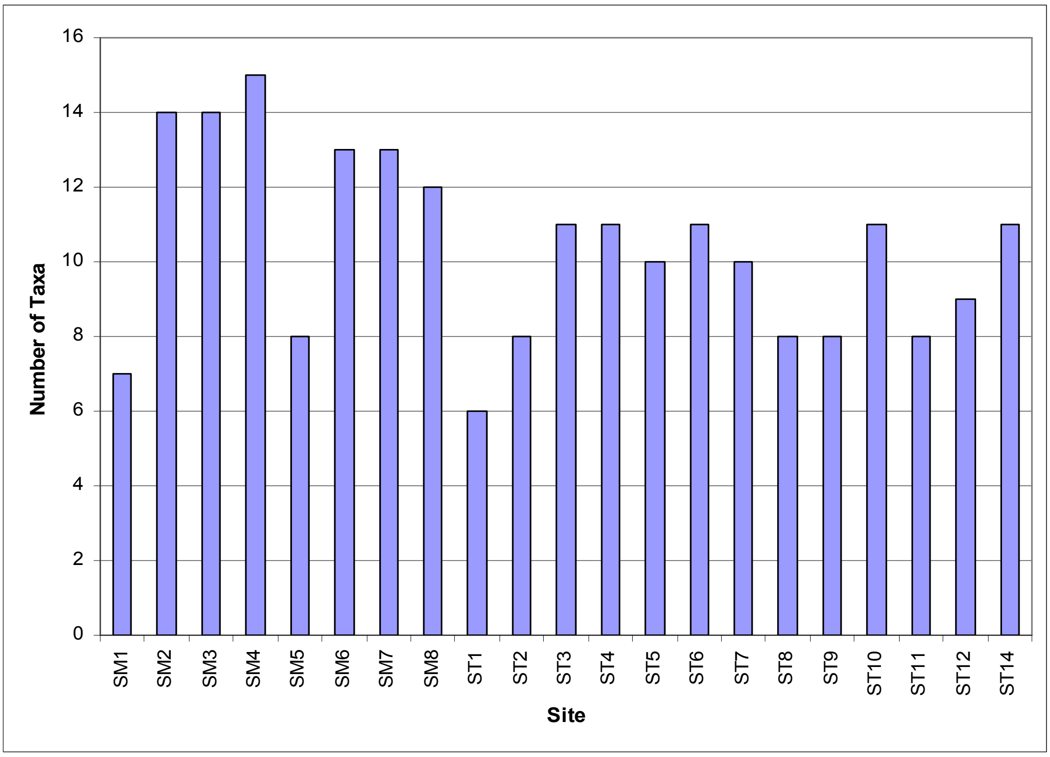


Figure 16: Number of taxa observed by site.

Due to the large variability in the number of individuals found between samples at the same site, no differences can be determined between each site (Figure 17).

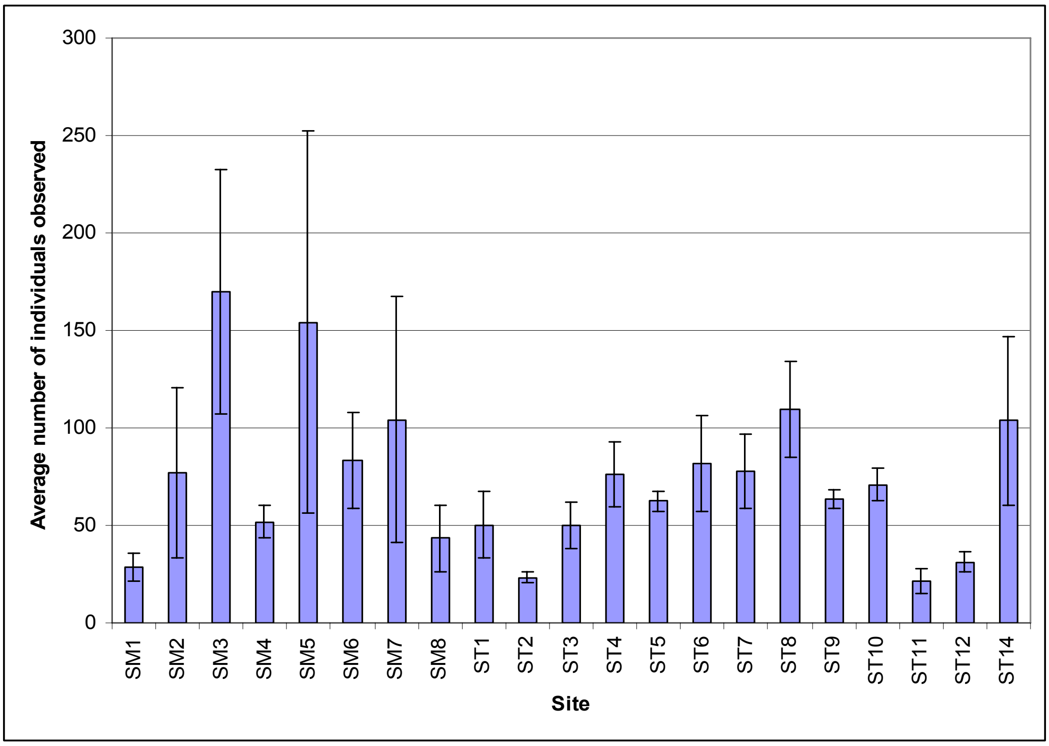


Figure 17: Average number of individuals observed by site.

Conductivity was similar at all sites, 80-120 uS/cm. Smacks site 8 had the highest conductivity, 140 uS/cm. The highest dissolved oxygen reading was recorded at Sm5 (Springvale Gardens) with 11.69 mg/L or 120.3%. Temperature was relatively stable over all sites. The highest temperature was recorded at Styx site 14 with 17.3 ^{o}C. Smacks Creek sites were generally shallower, narrower and had less flow than sites located in the Styx River (Table 1).

Table 1: Physical variables tested in the Styx River and Smacks Creek, November 2007 (measured on the day of invertebrate sampling at each site).

Site	Conductivity (uS/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% sat)	Temperature (^oC)	Width (m)	Depth (m)	Flow (m^3/s)
Sm1	90	3.01	29.2	14	2.5	0.11	-
Sm2	90	8.53	88.3	17	1.75	0.13	0.035
Sm3	100	8.37	82.9	14.9	2	0.08	0.060
Sm4	110	6.13	59.3	13.8	2.5	0.13	0.116
Sm5	130	11.69	120.3	16.8			
Sm6	110	5.6	54.3	14	3.5	0.22	-
Sm7	110	6.18	60	13.6			
Sm8	140	6.42	65.5	15.3	1.5	0.21	0.270
St1	110	5.88	57.8	13.7	3.23	0.24	0.340
St2	120	7.15	70.7	13.8	3.25	0.41	1.047
Spring		7.09	70.2	13.9			
St3	110	6.98	69.7	14.3	3.5	0.43	0.770
St4	117.3	7.66	72.0	14.4	4.82	0.56	0.820
St5	90	7.83	81.7	16.7	3.4	0.41	0.722
St6	118.8	8	75.3	12.4	3.43	0.34	0.653
St7	80	7.96	80.9	15.5	5.08	0.38	0.9997
St8	118.4	8.08	75.9	12.3	5.8	0.33	0.974
St9	90	7.87	79.0	15	4.2	0.28	0.739
St10	118.1	8.3	82.0	14.2	4.17	0.47	0.814
St11	117.8	8.12	82.9	15.8	5.8	0.47	0.7999
Farm drain	105	0.36	3.5	13.7 or 18.2*			
St12	117	8.3	82.0				
St14	126.8	9.75	102.5	17.3			

Note: sites St13 and St15 were not established at this time.

* conductivity and dissolved oxygen probes gave different readings for temperature on this date

After analysis of the November 2007 results, further sampling was carried out in the Styx in January 2008. Two established sites, St12 and 14 were resampled and two new sites, St13 (between St12 and 14) and St15 (downstream from St14) were sampled. Site St13 had a similar composition of invertebrates to other Styx sites within the reserve. Site St15 had less a quarter of the amount of snails that were found at site St14, and was dominated by *Aoteapsyche, Pycnocentria, Pycnocentrodes,* and *Deleatidium*.

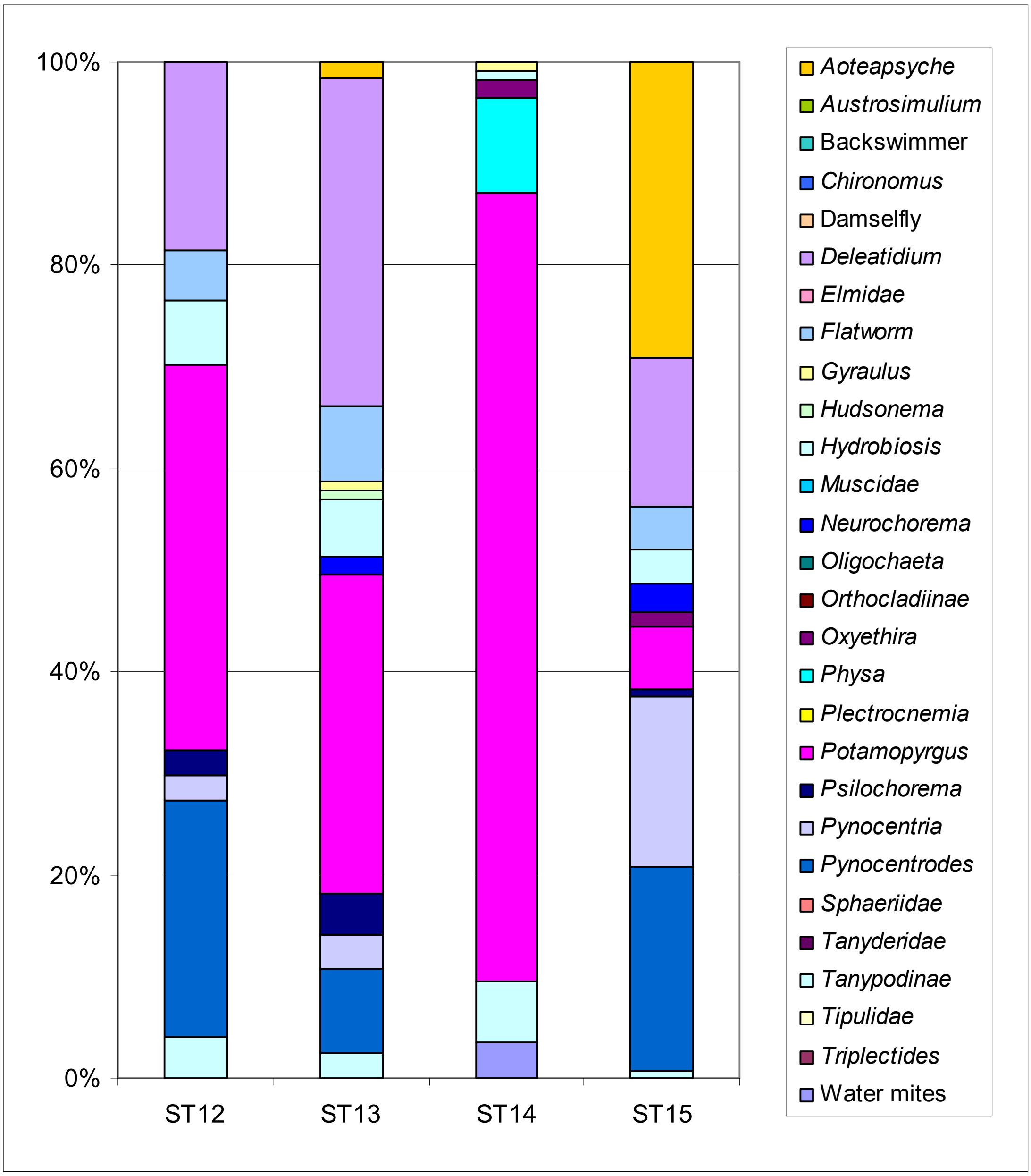


Figure 18: Proportion of taxa at selected Styx River Sites, January 2008.

In January 2008, physical variables were retested at selected sites to establish whether seasonality would have an impact on readings carried out at newly established sites. Readings taken in November 2007 were similar to those taken in January (Table 2). The ponds in Styx Mill Reserve and site St14 had high conductivities, dissolved oxygen, temperatures and pH (Table 2).

Table 2: Physical variables tested at selected sites in the Styx River, January 2008.

Site	Conductivity (uS/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% sat)	Temperature (oC)	pH
Sm1	130	4.55	45.9	15.8	6.9
Sm3	120	7.86	79	15.6	7
Sm5	150	16.91	178	17.8	6.9
Sm6	120	5.55	56.6	16.3	7.3
St1	120	6.19	59.2	13.3	7
St5	120	8	77.9	14.2	7
St6	120	8.7	79.6	14.2	7.1
St8	120	8.32	81.3	14.4	7.1
St10	120	8.43	82.1	14.2	6.9
Farm drain	140	0.585	4	14.7	7
St12	120	8.31	79.9	13.6	7.2
St13	120	8.48	81.8	13.8	7
Ponds	150	10.62	112.2	18	8.1
St14	150	9.9	104.8	18.2	7.9
St15	130	8.64	84.3	14.3	6.7

Sediment mapping in Styx Mill Conservation Reserve found sediment was deepest at site St5 with 0.083 m. Sites St10 and St11 had around 0.07 m present. Sites St6-St9 had very little sediment accumulation. Water was deepest at site St4, 0.558 m, and shallowest at site St9, 0.283 m (Figure 19).

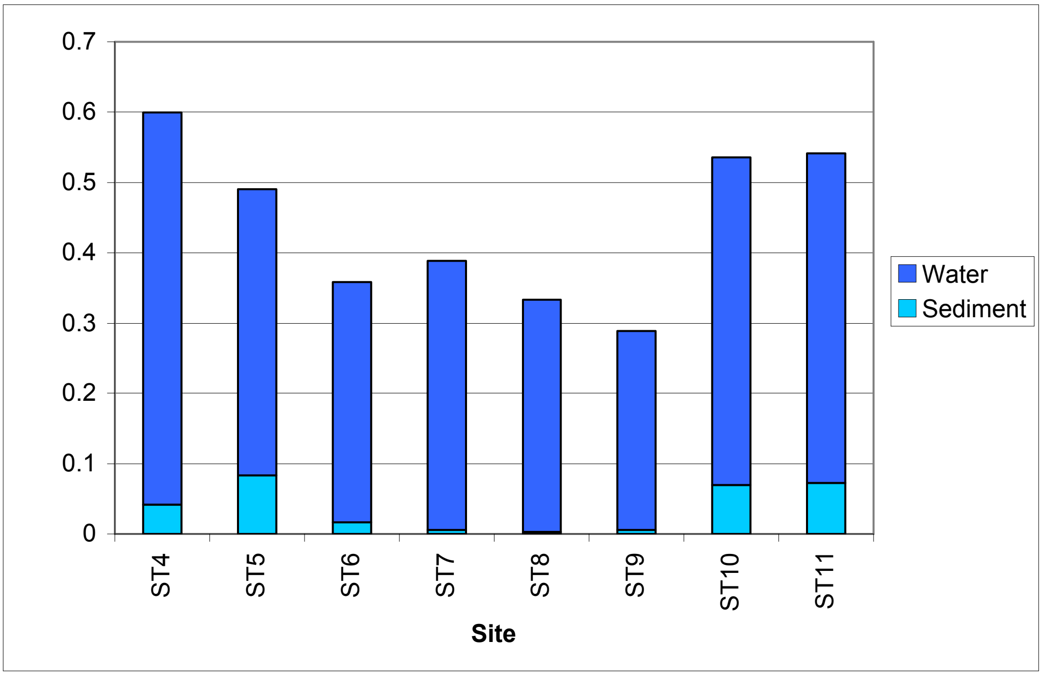


Figure 19: Water and sediment depth at Styx River sites within Styx Mill Conservation Reserve, November 2007

Discussion

Species composition was similar between the sites within Styx Mill Conservation Reserve, with sites largely dominated by EPT taxa including *Pycnocentria, Pycnocentrodes* and *Deleatidium.* EPT taxa are often used as general indicators of water quality due to their intolerance of polluted waters. The Macroinvertebrate Community Index (MCI) developed by Stark is widely used as a broad indicator of water quality (Winterbourn *et al.* 2006). Invertebrates are ranked on a scale from 1 to 10, with 1 being the most tolerant and 10 being the most sensitive. This index gives *Pycnocentria* a score of 7*, Pycnocentrodes* 5 and *Deleatidium* 8 (Winterbourn *et al.* 2006). These values imply that the majority of species found within the reserve are relatively sensitive species, suggesting reasonable water quality and habitat.

A factor that may cause the reserve sites to have similar species composition is the similar nature of the sites (in terms of verge and stream vegetation and substrate). An important characteristic of the sites in the reserve is the verge vegetation. Vegetation cover from riparian planting is important because it provides shade, regulates the temperature in the stream and adds organic matter used by invertebrates as food (Quinn *et al.* 1997).

Species composition of sites in the Styx River, both upstream and downstream of Styx Mill Conservation Reserve, was dominated by *Potamopyrgus* snails. These snails score 4 on the MCI, indicating that they are more tolerant of poor habitat and water quality (Winterbourn *et al.* 2006).

A spring feeds the Styx River on the upstream boundary of Styx Mill Conservation Reserve. This spring may be important because it increases the flow of the river. This increased flow allows more sediment to be held in suspension rather than being deposited on the riverbed (Taylor *et al.* 2000). The river flow peaked at site St7, and the flow began to decline after this point. This may be part of the natural flow and sedimentation pattern in the reserve, where there is a transport reach leading up to this site, and a deposition reach following it (personal communication: Mary Beech, Environment Canterbury, 2008).

The farm drain and ponds entering the Styx in the lower reserve potentially affect water quality in the river. They may have been the cause of the temperature and pH increases observed downstream because pH and temperature were higher at these sites. A possibility is that these increases affect site St14, but the impact of the water from the ponds entering the Styx is temporary, since 50 m downstream at site St15, temperature, conductivity and pH were reduced to values similar to other reserve sites. Furthermore, the effect on invertebrate communities also appears to be temporary because site St14 is dominated largely by *Potamopyrgus* snails, but site St15 had much fewer snails and was dominated by *Aoteapsyche, Pycnocentria, Pycnocentrodes,* and *Deleatidium.* There is a need for further invertebrate and water quality sampling to understand the impacts of farm drains and the ponds entering the Styx.

Smacks Creek had similar invertebrate composition between sites, and was dominated by *Potamopyrgus* snails, similar to those Styx River sites out of the reserve. EPT taxa showed high percentages of *Oxyethira* with a MCI score of 2 (Winterbourn *et al.* 2006). Both *Potamopyrgus* and *Oxyethira* have low MCI scores implying that they are tolerant species, suggesting poor water quality and a lack of suitable habitat in Smacks Creek.

Smacks Creek is generally shallower, narrower and has a lower flow rate than sites in the Styx River. The sites in Smacks Creek were variable in terms of verge vegetation, stream substrate and macrophyte cover. No continuous vegetation cover is present on the riparian margins of Smacks Creek. The timber yard on Gardiners Road, and Willowbank Wildlife Reserve both have potential impacts on water quality in Smacks Creek. Due to the wood chips entering the stream at the timber yard, the biological oxygen demand of the water is increased. This is because the organic matter entering the stream causes bacteria to multiply to break it down. In this breakdown process bacteria use oxygen, theoretically reducing the availability for fish and invertebrates in the environment. Inside Willowbank Wildlife Reserve, Smacks Creek has been extensively modified into large stagnant pools to provide habitat for tame eels and waterfowl. This causes an increase in temperature, as water temperature is several degrees higher when it leaves Willowbank. The impact of animal effluent from this

Wildlife Reserve entering the river may also be significant in lowering the water quality.

The high dissolved oxygen readings observed at Springvale Gardens (Sm5) and in the ponds within the reserve could be attributed to aquatic macrophytes photosynthesising. This process leads to the production of oxygen. Due to the lack of flow at these two sites this oxygen is not lost to the surrounding environment causing the high dissolved oxygen readings found.

Sites within Smacks Creek had more diverse communities than those in the Styx River despite the apparently poorer water quality. Smacks Creek sites had an average of 12 species per site, compared with 9.4 species at sites in the Styx. This could be due to the sites having more diverse habitats with a variety of different substrates and that there was more food present from algae, wood and bacteria. Though the Smacks Creek sites had more taxa than sites in the Styx River, fewer sensitive species were found. Robb (1992) found that Smacks Creek sites supported an average of 20.5 taxa whereas Styx only supported 14.9 (Taylor *et al.* 2000). Although our study found fewer species, the overall ratio of numbers of taxa observed between the Smacks Creek and the Styx was similar to that observed by Robb (1992).

Several actions could be taken to improve the quality of invertebrate species found in Smacks Creek.

Algal growth in Smacks Creek is also a problem in some areas, especially site Sm1 (crematorium). An increase in flow is needed to flush these algae through the river system and to prevent further growth. Flow would be impacted if people were extracting water from the stream. Perhaps there is a need for stricter control of how much water can be taken, especially in periods of low flow. Historical records of flow and resource consents for surrounding water could be examined to establish patterns that have been and are occurring. Maps indicate springs feeding the Styx River used to be located in Nunweek Park, but presently the most upstream spring is located between Gardiners and Sawyers Arms Roads. It is important to establish whether the river is receding or if this is a seasonal effect, and whether flow into Styx Mill Conservation Reserve is decreasing over time.

Native plants could be planted along the riparian zone to increase shade in the stream. Perhaps more intensive research on terrestrial and aquatic invertebrates in relation to type and amount of riparian vegetation in Styx Mill Conservation Reserve could be undertaken. This would result in further understanding about what sort of riparian planting and shade cover supports the "best" communities. This knowledge could then be used to more extensively replant riparian zones in optimum cover for invertebrate diversity. Establishing this planting would minimise bank erosion and reduce soil runoff reducing the sediment loads in the stream. Plantings would also provide shade, which would regulate temperature and add organic matter, providing food for invertebrate species.

The full impacts of the timberyard and Willowbank Wildlife Reserve need to be examined and if necessary, changes could be made to reduce these impacts. The biological oxygen demand of water could be tested upstream, at and downstream of the timber yard to investigate the effect of woodchips entering the river. Bacterial counts could be undertaken upstream and downstream of Willowbank Wildlife Reserve to determine the impacts of animal wastes entering the stream. Flow could be increased through Willowbank Wildlife Reserve to reduce pooling and the impacts that it has on water temperature.

Conclusions

Community composition of sites in Styx Mill Conservation Reserve were similar, dominated by more sensitive species including *Deleatidium* (mayflies), *Pycnocentria* and *Pycnocentrodes* (both caddisflies). The uniformity shown between these sites could be attributed to the similar nature of the sites. Community composition of sites in the Styx River both upstream and downstream of the reserve and sites in Smacks Creek were dominated by *Potamopyrgus* snails. This may be due to the lack of shade and the silty nature of the sites.

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Skills and Knowledge gained from the research

I have found the Lincoln University summer research scholarship useful for gaining practical research experience. I found it particularly advantageous that I could create my own project and follow it from start to finish, focussing on what I considered to be interesting. The flexibility of the project also allowed me to change my plans undertaking further sampling where necessary, assisting me in my ability to manage my time to achieve what was necessary. This research opportunity has allowed me to enhance my knowledge of freshwater invertebrate sampling and identification, which could prove to be useful experience as I continue in my studies.

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Appendix 1: Sampling site locations and grid references.

Site Name	Site Location	Easting	Northing
St-1	Gardiners Road culvert	2476798	5748853
St-2	Out of Styx Mill reserve upstream of Styx/Smacks confluence	2477480	5749039
St-3	Out of Styx Mill reserve downstream of confluence by spring	2477558	5748944
St-4	Upstream in Styx Mill reserve near dog park	2477654	5748984
St-5		2477725	5748994
St-6		2477867	5749117
St-7		2477940	5749148
St-8	First bridge in Styx Mill reserve	2477920	5749220
St-9		2477941	5749307
St-10		2477964	5749392
St-11		2478050	5749380
St-12	After farm drain enters	2478222	5749346
St-13		2478458	5749334
St-14	Contemplation point in water from ponds	2478515	5749308
St-15	Just downstream of contemplation point in Styx	2478546	5749281
Sm-1	Crematorium	2476485	5749104
Sm-2	Timber yard	2476783	5749590
Sm-3	Over road from timber yard	2476820	5749568
Sm-4	In aquatic centre	2476999	5749410
Sm-5	Springvale Gardens Reserve with spring entering Willowbank Wildlife Reserve	2476977	5749206
Sm-6	Upstream of Willowbank Wildlife Reserve by car park exit	2477081	5749302
Sm-7	Inside Willowbank Wildlife Reserve	2477195	5749260
Sm-8	Between Willowbank Wildlife Reserve and Styx Mill Reserve before Styx/Smacks confluence	2477503	5749049