# A Delicate Balance: Aquatic-Terrestrial Invertebrate Flux Across a Forested Riparian Buffer Gradient


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## Background

**Aquatic and Terrestrial Invertebrates as a Food Source**

- Allen's paradox– inadequate aquatic macroinvertebrate biomass to support fish community→ terrestrial subsidy compensates (Baxter 2005)
    - Terrestrial subsidies have greater biomass than aquatic– more energetically favorable for fish (Baxter 2005)
- Brook trout aquatic invertebrate consumption depends on availability of aquatic invertebrates, not terrestrial subsidy availability→ importance of studying *in situ* production (Wilson 2014)
- Benthic aquatic macroinvertebrates decline in summer and autumn, when terrestrial stream inputs peak (Baxter 2005)
- Brook trout size class influences extent to which terrestrial subsidies may be used (Wilson 2014)

**Invertebrate Variation between Forested Riparian Buffers**

- Forested streams migrate less, stabilizing benthic habitat (Sweeney 2004)
- Pasture streams receive fewer terrestrial inputs than forest streams; more from winged invertebrates than wingless (Edwards & Huryn 1996)
- Spatial scale of riparian vegetation impacts on terrestrial inputs remains unclear (Baxter 2005)

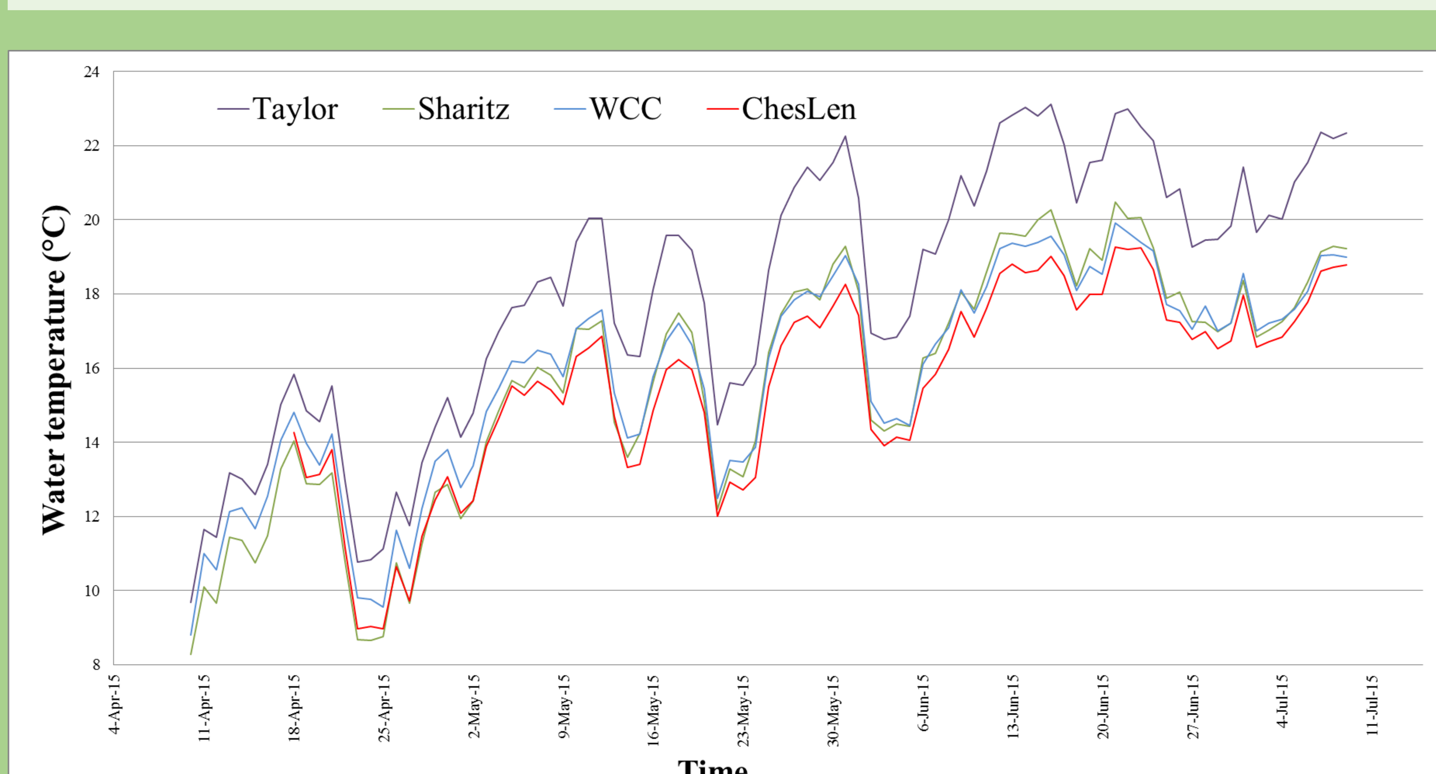


**Figure 2.** Temperature at all sites across sampling period

## Study Aim & Question

This study aims to assess the ability of forested riparian buffers to shape food availability for fish by providing habitat for macroinvertebrates and controlling terrestrial invertebrate input into streams.

**Question:** Does riparian vegetation condition influence aquatic and terrestrial invertebrate abundance, density, and size class distribution?

## Methods

This study was conducted in the Christina River Basin Watershed in southeastern Pennsylvania at four sites along a forested buffer gradient. Each site was sampled biweekly along four reaches, from April to June 2015. Temperature of each site was also recorded.

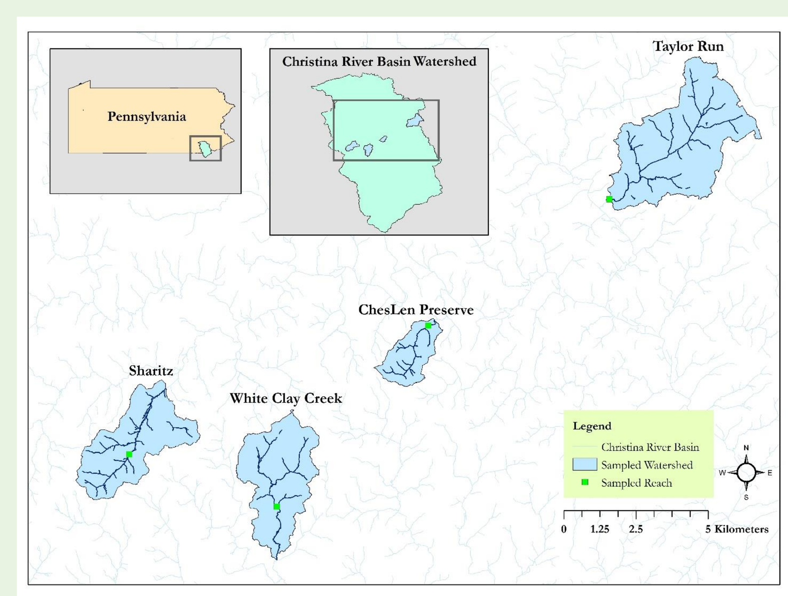


**Figure 1.** Four study sites within the Christina River Basin Watershed

**Terrestrial Invertebrates**

- Sticky traps placed facing away from stream
- Collection period: 48 hours

**Aquatic Invertebrates**

- Surber net
- Preserved in 95% ethanol
- Picked 1/8 subsamples until >100 bugs reached
- Hydropsychidae separated to measure:
    - Head capsule width and body length (using ImageJ)
    - Biomass (dried for 48 hours at 60°C)


**Figure 3.** Taylor Run, unforested meadow

**Figure 4.** Sharitz, recent tree planting & beginning restoration

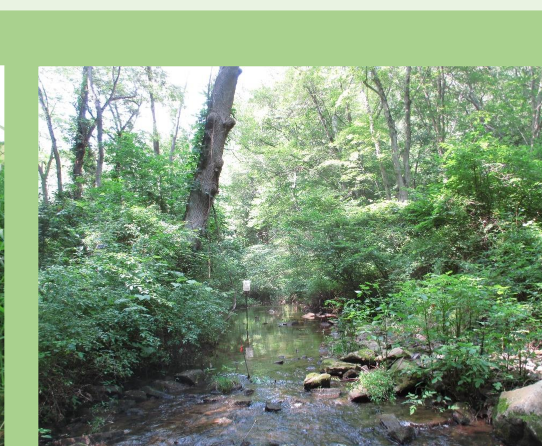

**Figure 5.** White Clay Creek (WCC), established forest restoration

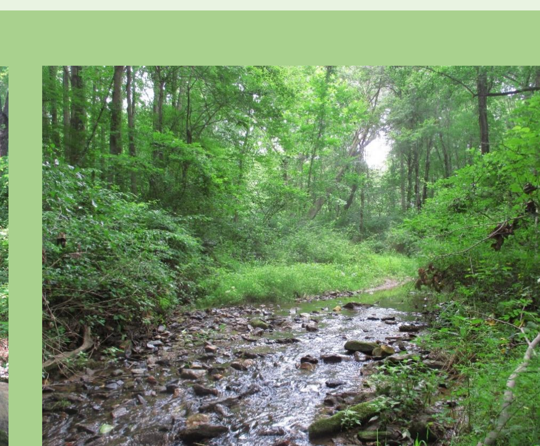

**Figure 6.** ChesLen Preserve, mature forest & brook trout reach

## Abundance

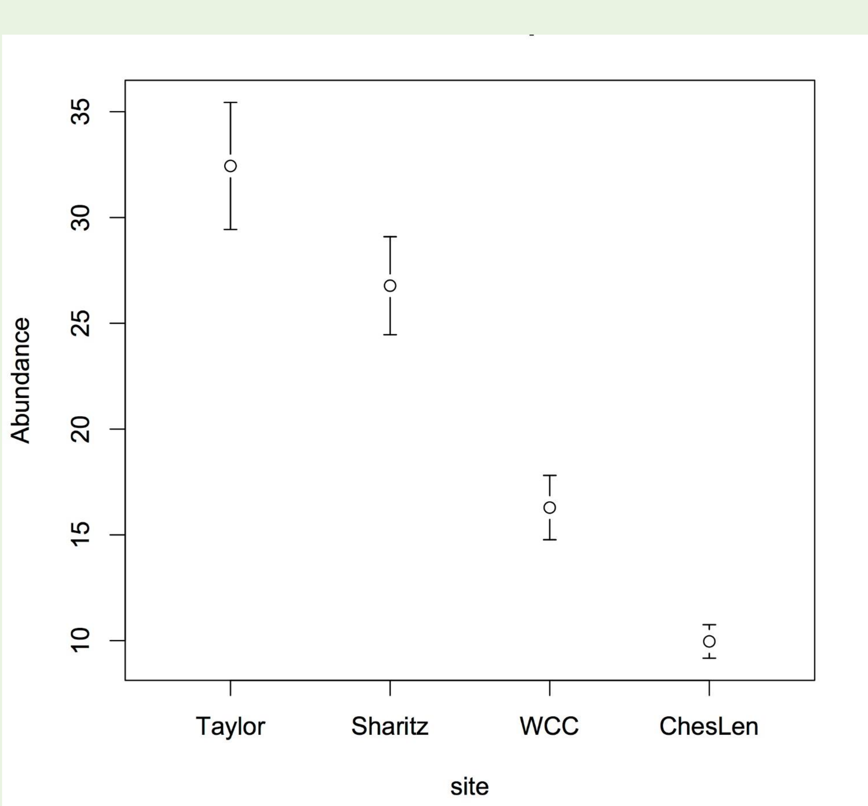


**Figure 7.** Terrestrial invertebrate abundance across all sites

## Density

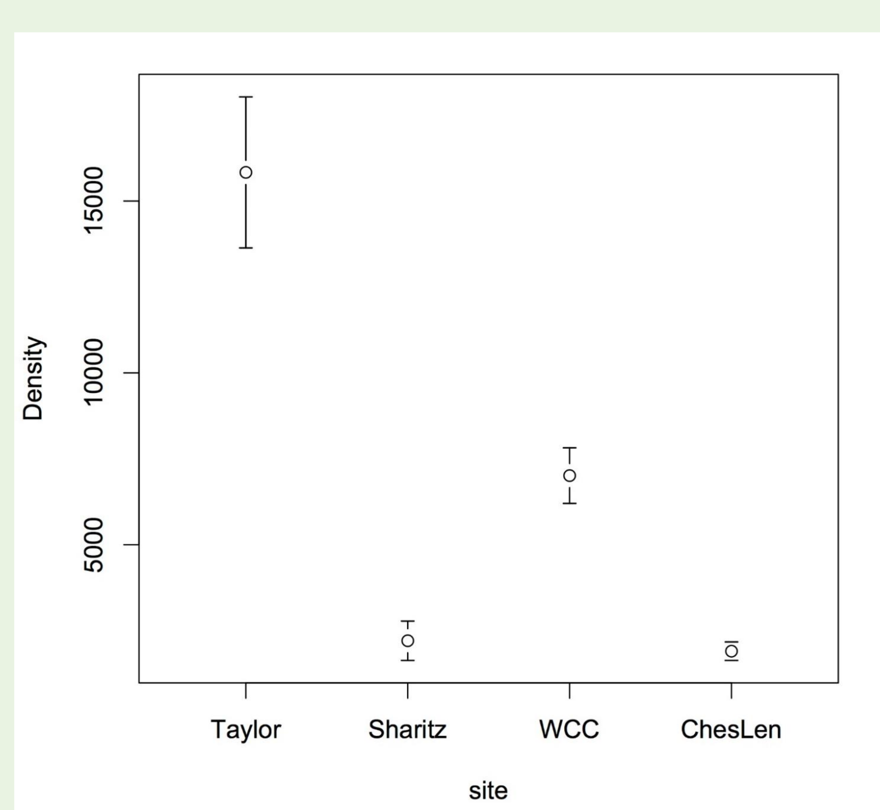


**Figure 8.** Aquatic macroinvertebrate density (per m$^2$) across all sites

## Size Class

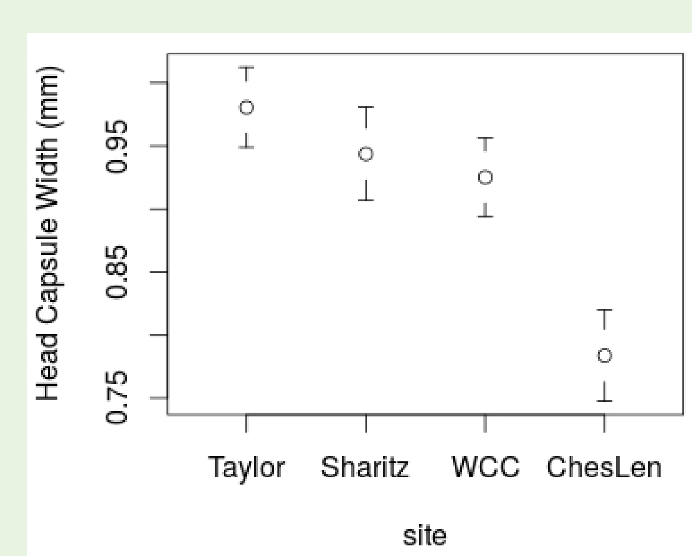


**Figure 9.** Average hydropsychid head capsule width (mm) across all sites

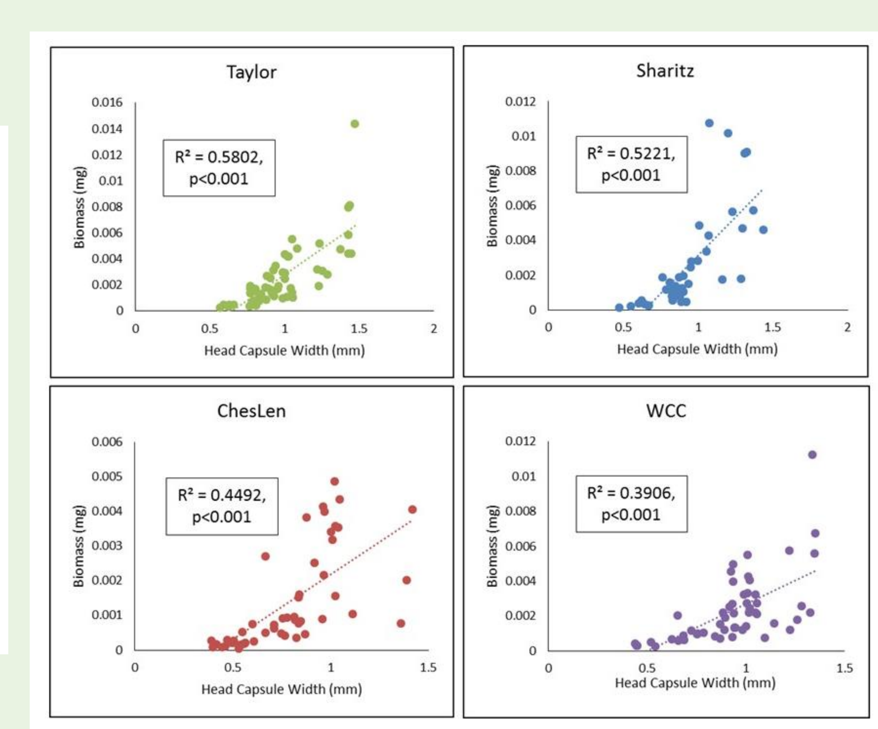


**Figure 10.** Regression of individual hydropsychid head capsule width (mm) against biomass (mg) at each site

## Discussion

**Terrestrial invertebrate assessment** shows decreasing abundance as forested riparian buffer increases (Fig. 7), contrasting with previous findings (Edwards & Huryn 1996) and highlighting the uncertainty of riparian vegetation impacts on terrestrial inputs. Furthermore, since the sticky traps were designed for winged invertebrates, our results do not accurately encompass the movement of the wingless terrestrial subsidy, which may compose a larger portion of the subsidy in forested areas. Additionally, from observation, the high density of woody riparian vegetation in the mature forest reach may act as a physical barrier to winged terrestrial invertebrates, resulting in lower sticky trap abundance in mature forests.

The unforested reach also holds the highest density of **aquatic macroinvertebrates** whereas the mature forest reach yields the lowest density (Fig. 8). However, we lack community composition and diversity analysis that may provide additional insight on the aquatic-terrestrial invertebrate balance within these ecosystems. These results may also be explained by temperature differences between the two reaches (Fig. 2) that cause variations in aquatic macroinvertebrate growth and timing of emergence.

**Hydrosychid size class analysis** reveals the smallest bugs in the mature forest reach compared to all other sites (Fig. 9). The unforested and mature forest reaches differ significantly from each other while the partially forested reaches fall in the middle and do not differ significantly from one another, exemplifying a transitioning phase between two ends of the reforestation spectrum.

**Looking Forward**

Further work is needed to explore the relationship between riparian area and other parameters that may influence stream biota such as temperature and water chemistry. A greater understanding of fish dietary habits is also necessary to bridge the gap between invertebrate fluxes and stream habitat in order to better understand how landscape scale change affects food webs and subsidies in stream ecosystems.

## Acknowledgements


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## References


Baxter, C.V., Fausch, K.D., & Saunder, W.C. (2005). Tangled webs: reciprocal flows of invertebrate prey link streams and riparian zones. *Freshwater Biology, 50*, 201-220. doi: 10.1111/j.1365-2427.2004.01328.x

Edwards, E.D., & Huryn, A.D. (1996). Effect of riparian land use on contributions of terrestrial invertebrates to streams. *Hydrobiologia, 37(1-3)*, 151-159. doi: 10.1007/BF00028516

Sweeney, B.W., Bott, T.L., Jackson, J.K., Kaplan, L.A., Newbold, J.D., Standley, L.J., …& Horwitz, R.J. (2004). Riparian deforestation, stream narrowing, and loss of stream ecosystem services. *Proceedings of the National Academy of Sciences (PNAS), 101*, 14132-14137. doi: 10.1073/pnas.0405895101

Wilson, M.K., Lowe, W.H., & Nislow, K.H. (2014). What predicts the use by brook trout (*Salvelinus fontinalis*) of terrestrial invertebrate subsidies in headwater streams? *Freshwater Biology, 59*, 187-199. doi: 10.1111/fwb.12257


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