

# SHORT-TERM RESPONSE OF THE BENTHIC MACROINVERTEBRATE COMMUNITY TO CATASTROPHIC FLOODING FROM TROPICAL STORM LEE IN CENTRAL PENNSYLVANIA

## Introduction

Headwater streams are subject to natural disturbances that can alter in-stream habitat and communities. Understanding how these populations recover and persist following disturbance is an important tenet of ecology that must be further examined as disturbance events become more frequent due to climate change.

Communities of benthic macroinvertebrates (BMI) have been shown to be severely depressed after extreme flooding, yet may recover very quickly (Elwood and Waters 1969; Hilsenhoff 1996). Hendricks et al. (1995) found that a 60 year flood event was only a short-term disturbance. Thorup (1970) showed that species richness returned to pre-flood levels in two months, and species relative abundance recovered in four months. Following Hurricane Agnes (a 500 year flood), Hoopes (1974) found four months post-flood that despite recovery of some BMI densities and populations, 7 of 13 BMI taxa were still depressed.

In headwater streams, extreme flooding events tend to act as cleansing mechanisms for invertebrate populations and physical habitat. During these events much of the fine sediment and decaying material in the stream is flushed out, thereby changing diversity and favoring species that prefer clean substrate or are stronger swimmers. Hoopes (1974) found a mixed response to flooding by mayflies, with faster, stronger swimmers being able to withstand scouring and flooding. Hilsenhoff (1996) found that the recovery is led by species that are most favored by changes in aquatic habitat created by geomorphic processes acting during extreme events.

In early September 2011, Tropical Storm Lee deposited over twenty inches of rain in the Loyalsock Creek drainage in Sullivan County, Pennsylvania. A catastrophic flood and debris flow occurred throughout the watershed on September 7 and 8, 2011 with peak flows (69,100 cfs) exceeding the previous record flow (55,800 cfs). We collected BMI monthly on 5 headwater streams within the flood affected watershed to determine short-term changes to BMI communities after catastrophic flooding. This study will determine how BMI communities have been affected by and recovers from the impacts of this catastrophic flooding.

## Methodology

- Pre-flood sampling at 5 sites (Figure 1) within Loyalsock Creek watershed (PA) were sampled for benthic macroinvertebrates between June 1 and July 11, 2011.
- September 5-8<sup>th</sup> Tropical Storm Lee deposited over 18 inches of rain locally.
- Post-flood samples collected at same 5 sites monthly for up to 24 months post flood (October 2011 to September 2013).
- Benthic macroinvertebrate samples were collected according to standard PA Department of Environmental Protection protocols (PDEP 2009).
- Composite of six kicks (1 m<sup>2</sup> area for 1 minute, depth of 10 cm) from riffle habitat in a 100 m stream reach.
- Organisms were picked from randomly selected grids in a 18" x 12" pan with 28 four-square inches grids until a 200-organism sub-sample (+/- 40 organisms) was obtained.
- Identified to family (QA/QC verified), will be taken to genera by certified taxonomist.
- Calculated total BMI density (#/m<sup>2</sup>), EPT density (#/m<sup>2</sup>), Total family richness, EPT family Richness, Shannon-Wiener diversity, % EPT, Dominant family, % dominant family, % Baetidae, % Heptageniidae, proportional Bray-Curtis Similarity.

## Study Sites

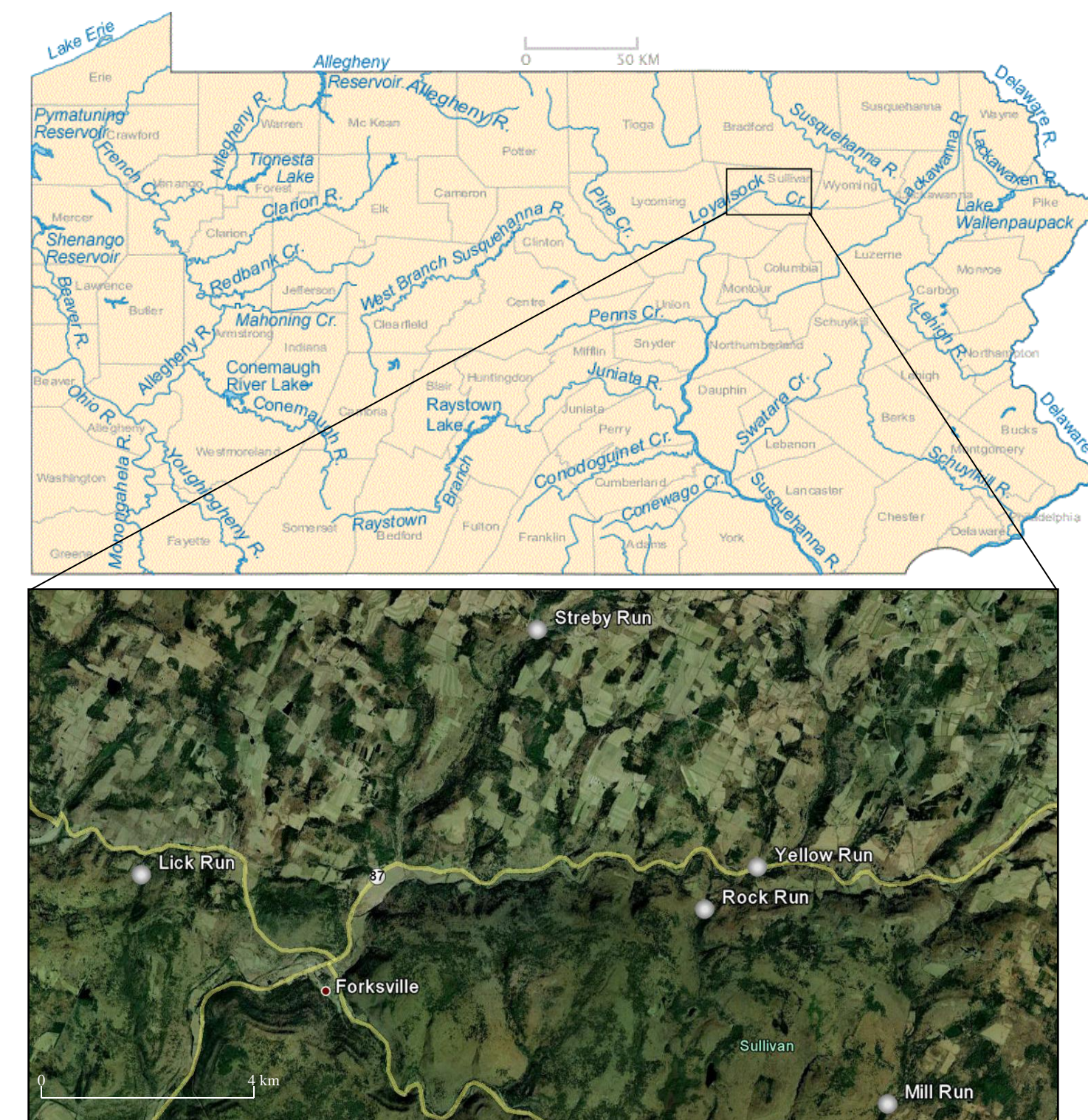


Figure 1. Map of study sites in Loyalsock Creek watershed.

Figure 2. Photo of Yellow Run study site.

## Results

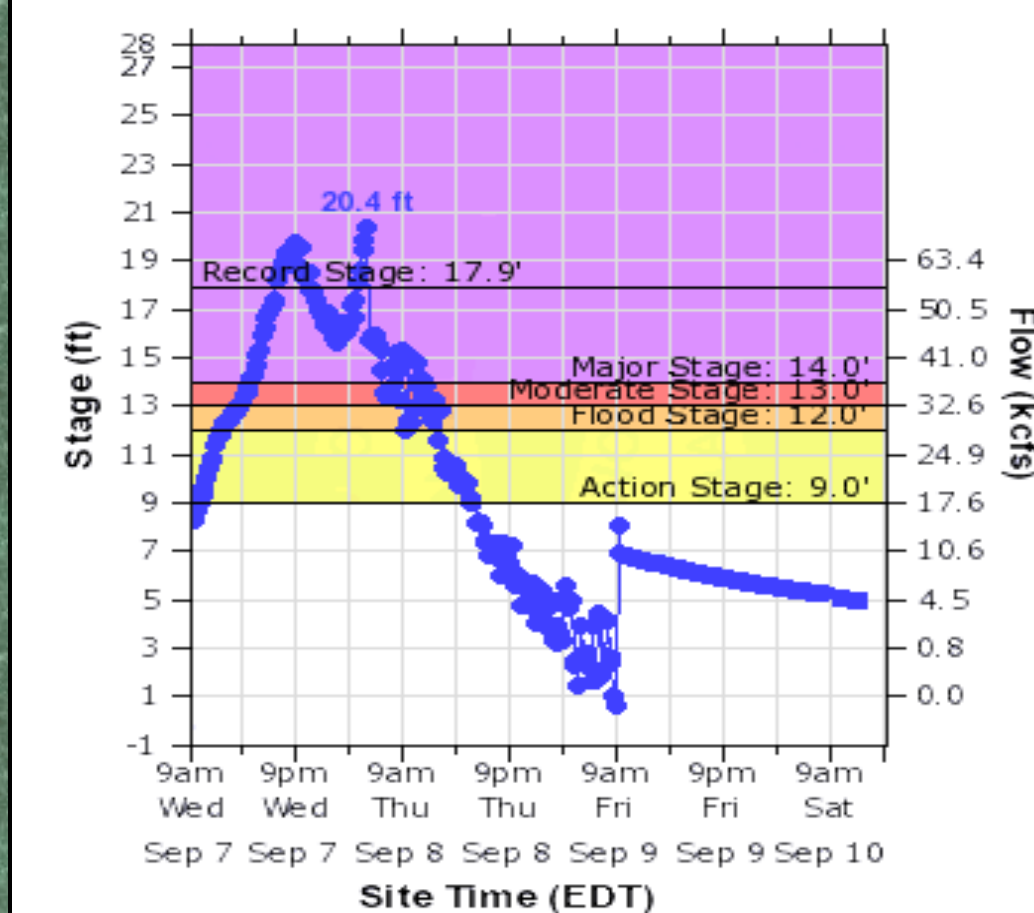


Figure 3. Gage height (ft) and daily discharge (cfs) of the USGS stream gage (01552000) at Loyalsock Creek in Loyalsockville, PA from September 3 to 10, 2011. Flood stage is 12 feet as denoted by red line. Discharge is estimated to have reached 69,000 cfs (NOAA data)

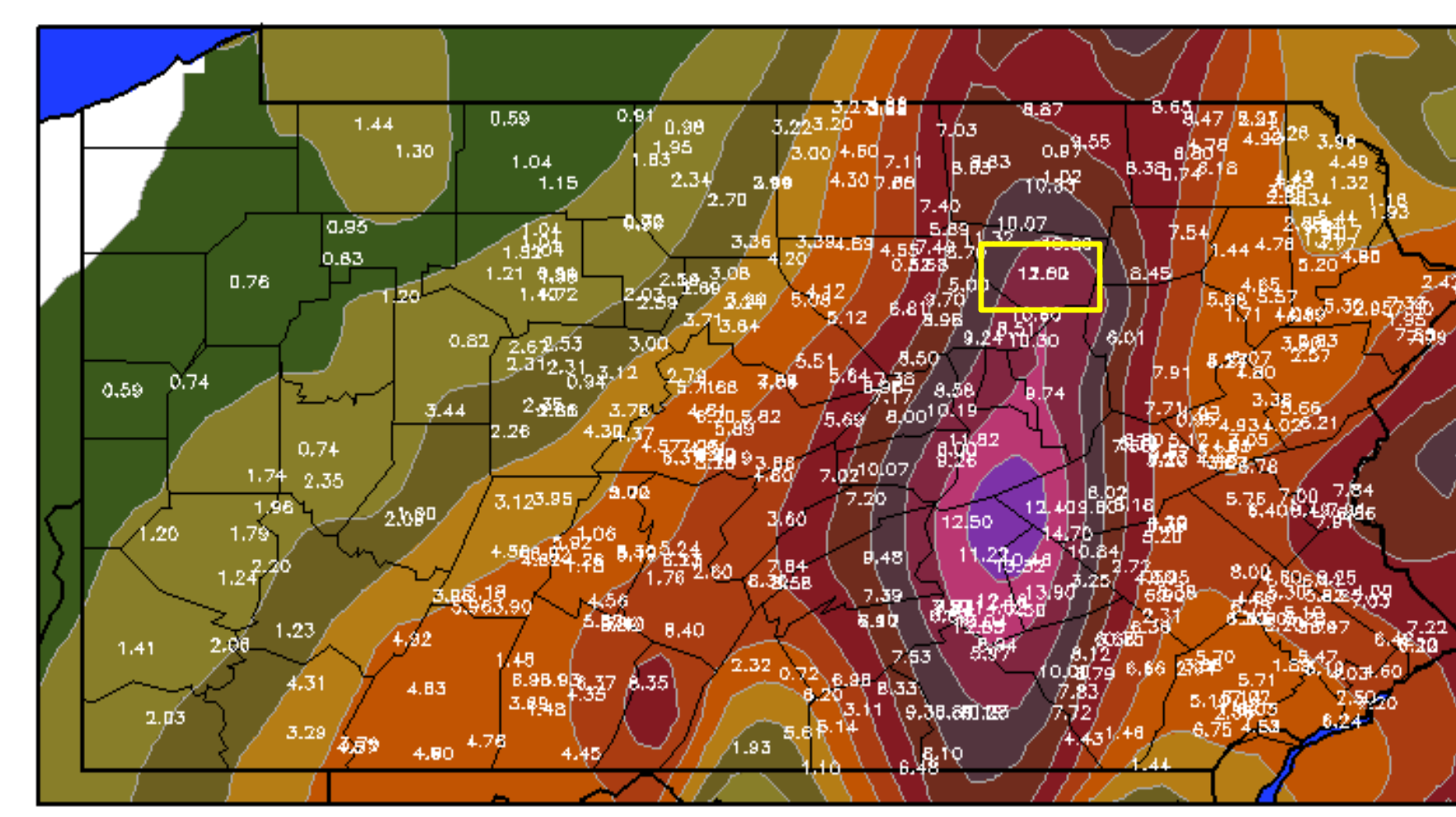


Figure 4. Total precipitation (in) in Pennsylvania from 7:00 am September 5, 2011 to 7:00am September 8, 2011. (NOAA data). Study area outlined in yellow.



Figure 5. Overhead view of flooding near the mouth of Loyalsock Creek. The normal creek bed is over 500m away from the green barns off to the bottom right. (Photo: Williamsport Sun Gazette)



Figure 6. Flooding on Loyalsock Creek destroyed the bridge over Rt. 973 in Loyalsockville, PA. The USGS stream gage at this site was disabled due to the record high flow. (Photo: PA State Police)

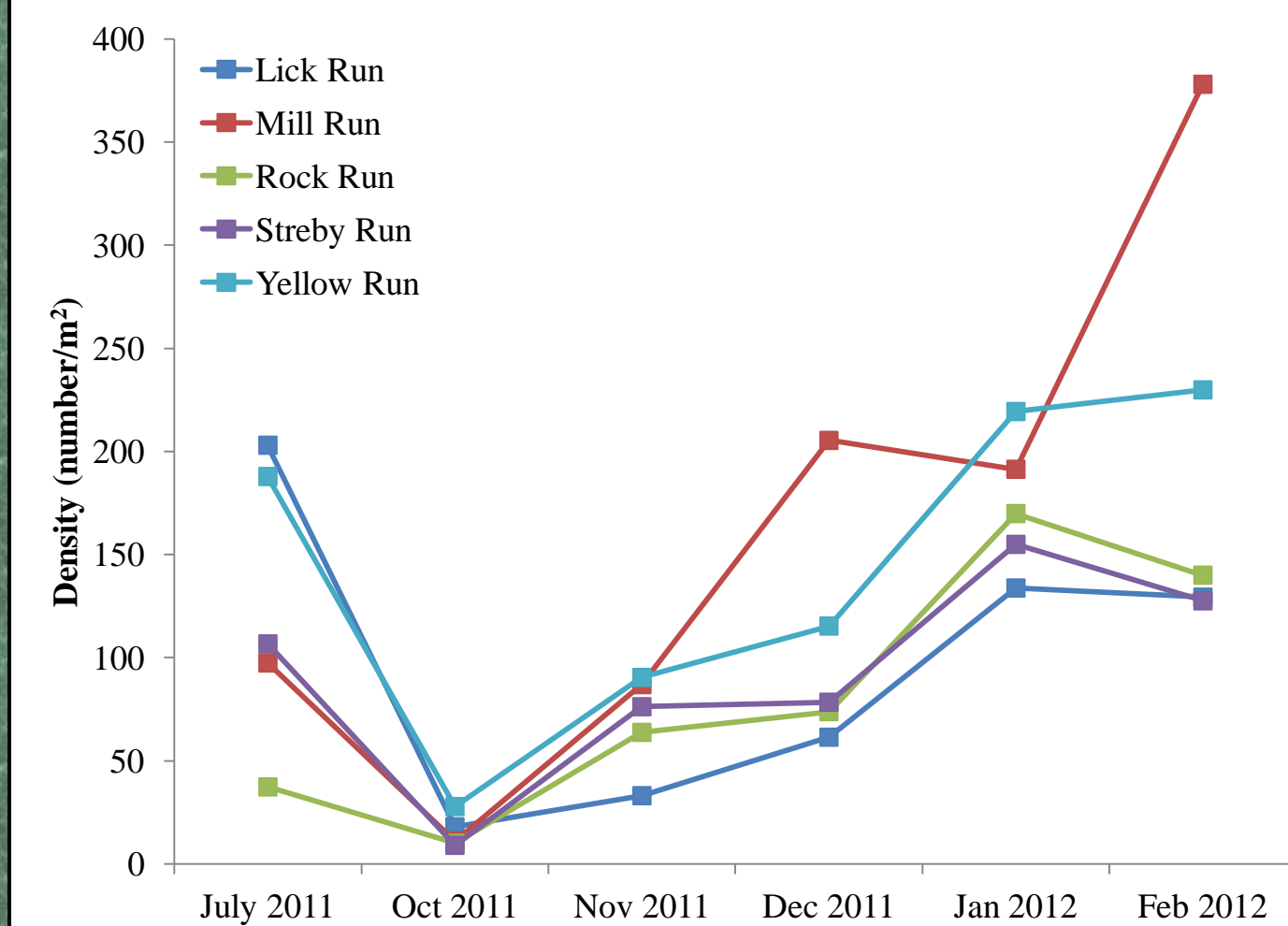


Figure 7. Density (number/m<sup>2</sup>) of all BMI at sample sites within Loyalsock Creek watershed. Flooding occurred September 2011.

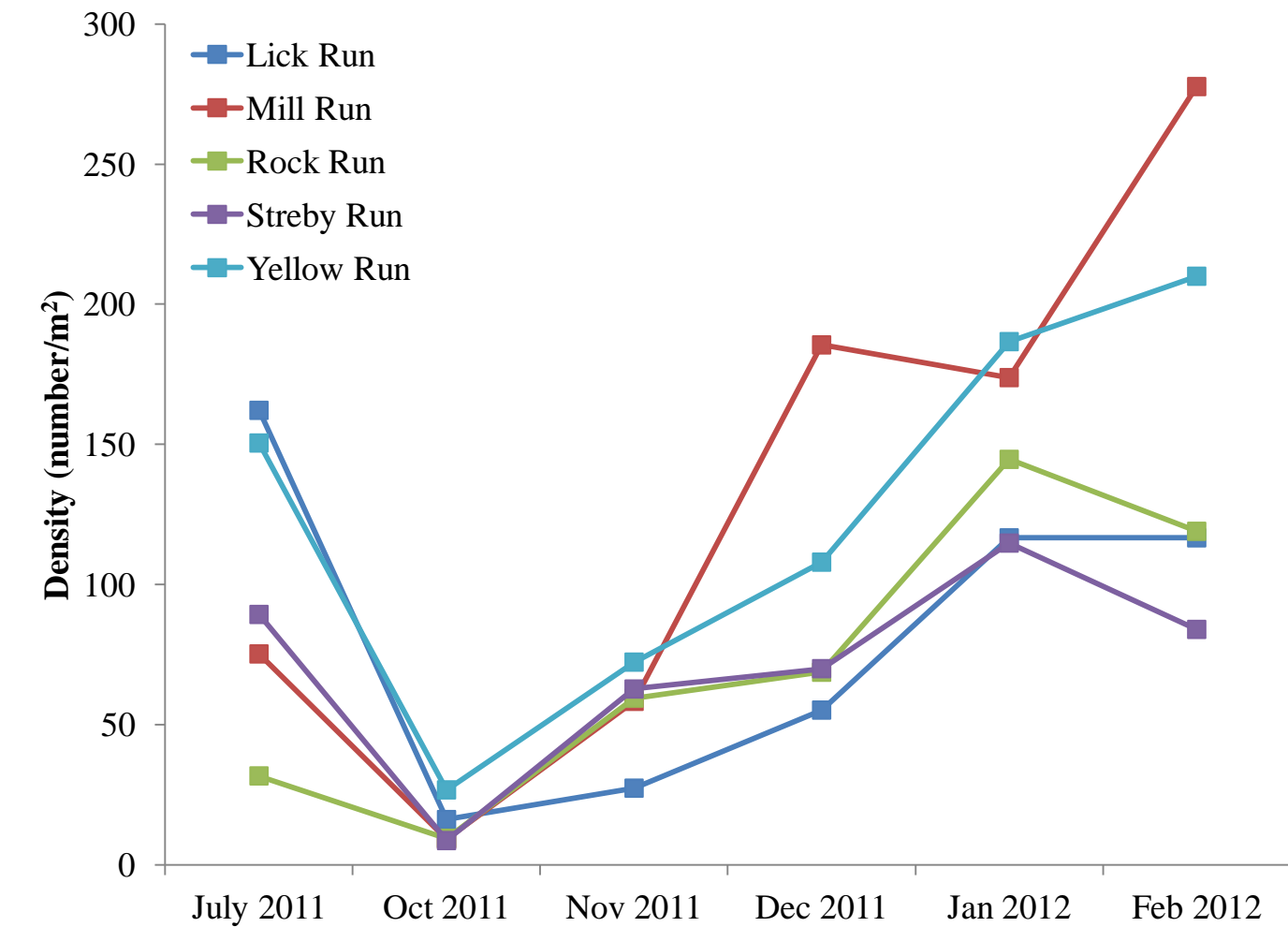


Figure 8. Density (number/m<sup>2</sup>) of EPT at sample sites within Loyalsock Creek watershed. Flooding occurred September 2011.

Table 1. Total family richness, EPT richness, Shannon-Wiener diversity at sample sites within Loyalsock Creek watershed.

Sites	July 2011	October 2011	November 2011	December 2011	January 2012	February 2012
<b>Total Family Richness</b>						
Lick Run	20	16	18	17	16	14
Mill Run	21	13	16	17	18	17
Rock Run	18	13	18	20	15	19
Strey Run	15	14	16	21	16	14
Yellow Run	18	14	11	17	15	16
<b>EPT Richness</b>						
Lick Run	15	12	15	14	13	11
Mill Run	15	9	12	14	15	13
Rock Run	13	12	15	16	12	15
Strey Run	12	12	14	15	13	12
Yellow Run	12	11	10	14	13	13
<b>Shannon-Wiener Diversity</b>						
Lick Run	2.540	2.472	2.446	1.641	2.325	1.746
Mill Run	2.488	2.190	2.212	2.247	2.364	2.126
Rock Run	2.286	1.964	1.991	2.050	1.866	2.084
Strey Run	2.064	2.173	2.176	2.304	2.062	1.803
Yellow Run	1.993	1.810	1.642	1.800	1.411	1.443

Table 2. Dominant family for each month at sample sites and the percentage of total abundance that the family represented.

Site	July 2011	October 2011	November 2011	December 2011	January 2012	February 2012
Lick Run	Baetidae 20.1%	Chloroperiidae 18.5%	Heptageniidae 25.6%	Heptageniidae 34.8%	Heptageniidae 30.2%	Heptageniidae 52.6%
Mill Run	Baetidae 25.1%	Leptophlebiidae 28.9%	Chironomidae 30.3%	Ephemerelellidae 23.9%	Ephemerelellidae 22.0%	Heptageniidae 26.5%
Rock Run	Heptageniidae 26.3%	Chloroperiidae 48.1%	Heptageniidae 41.7%	Heptageniidae 47.7%	Heptageniidae 45.0%	Heptageniidae 43.9%
Strey Run	Baetidae 35.0%	Chloroperiidae 26.5%	Heptageniidae 33.3%	Heptageniidae 27.3%	Heptageniidae 24.7%	Chironomidae 32.9%
Yellow Run	Baetidae 47.8%	Heptageniidae 45.8%	Heptageniidae 49.0%	Heptageniidae 53.8%	Heptageniidae 62.8%	Heptageniidae 64.0%

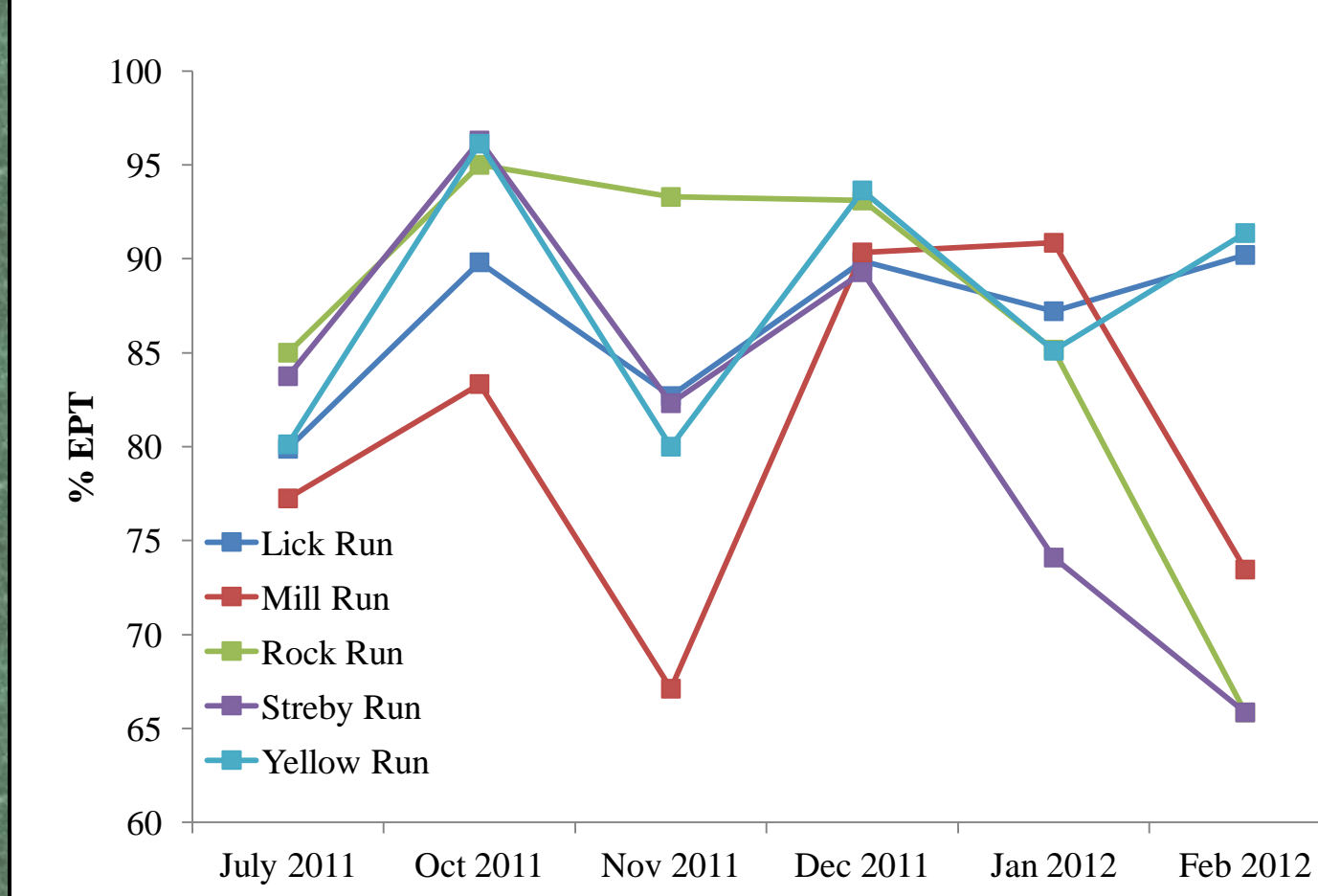


Figure 9. % EPT at sample sites within Loyalsock Creek

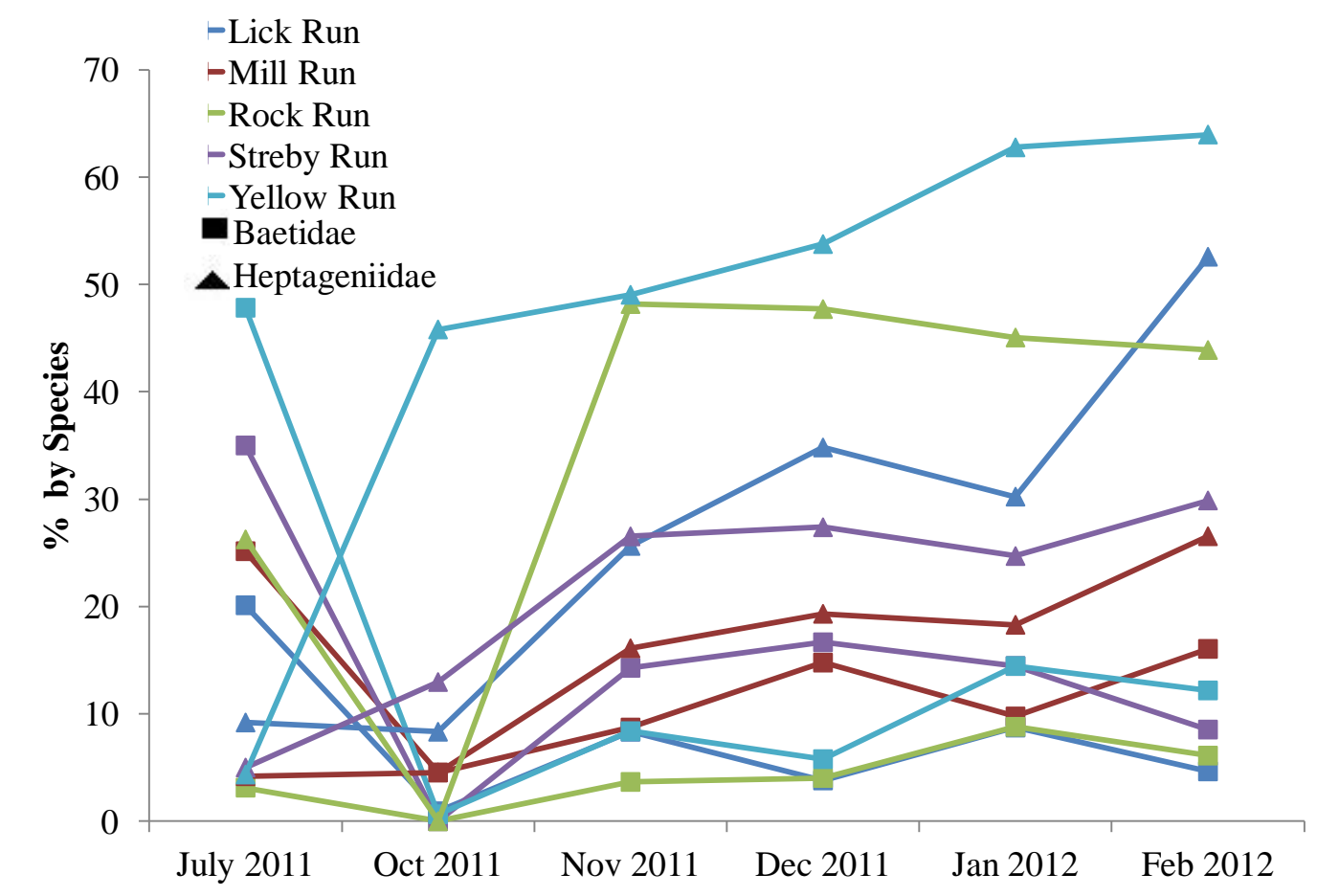
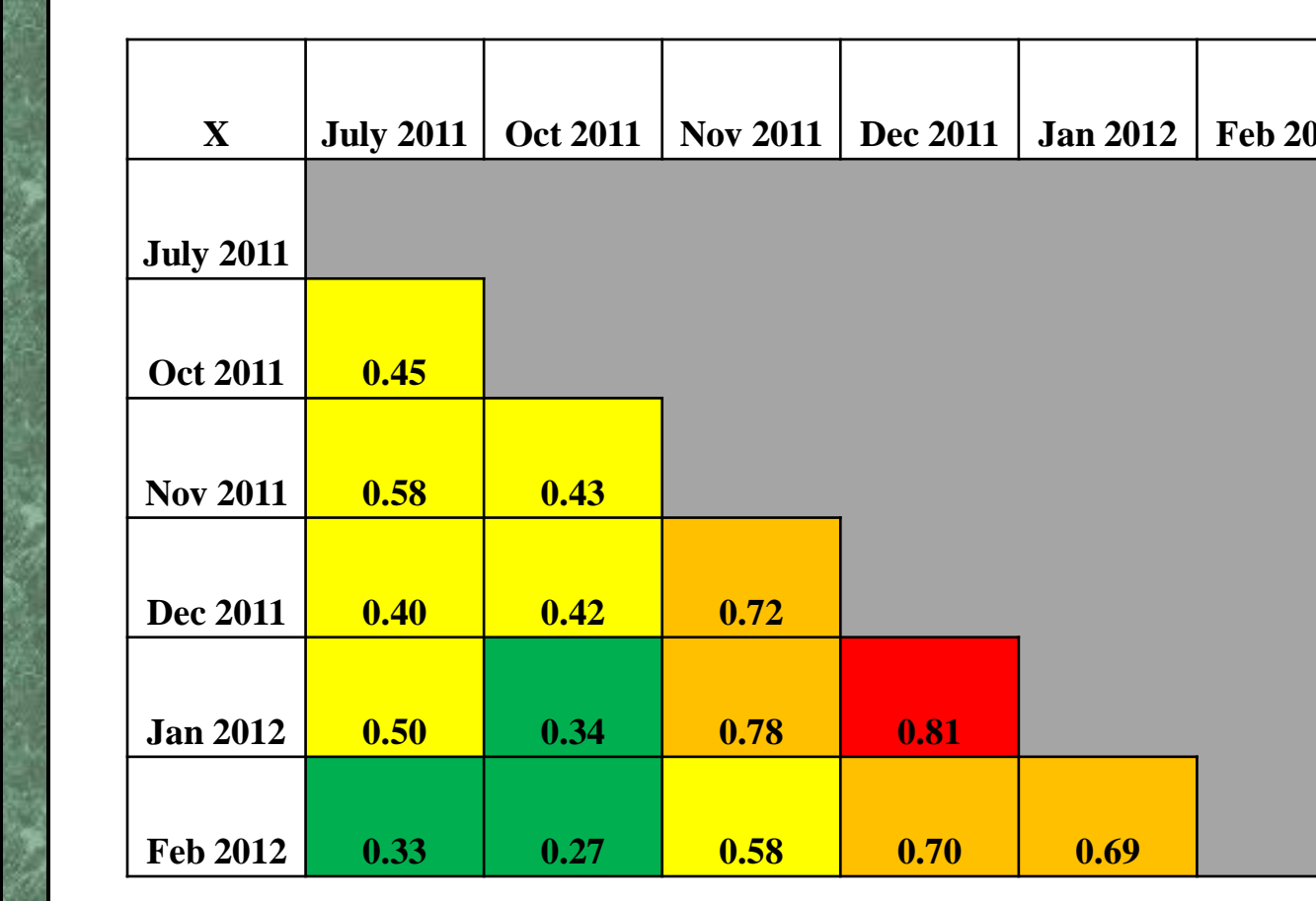
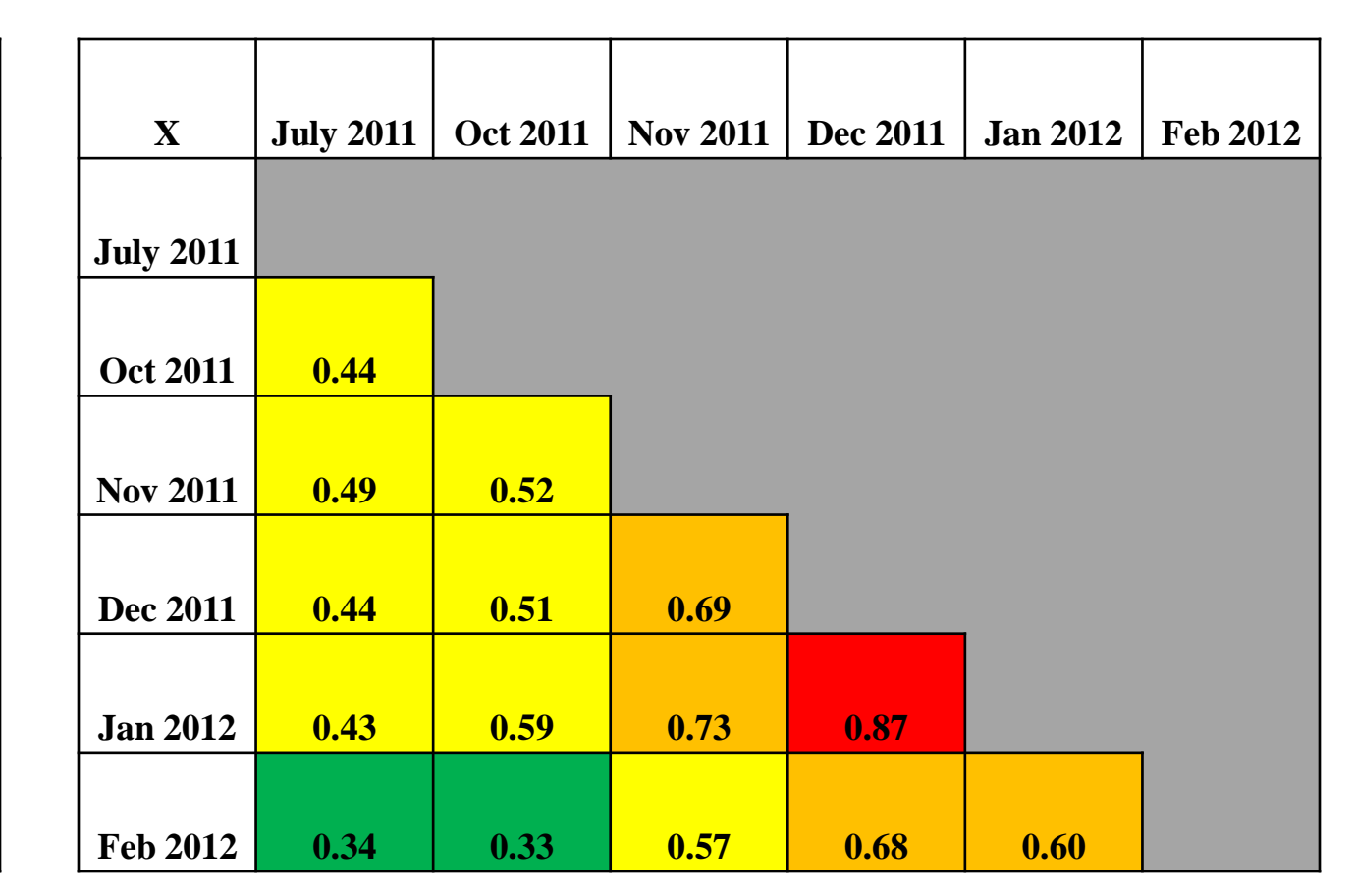


Figure 10. % Baetidae and % Heptageniidae at sample sites

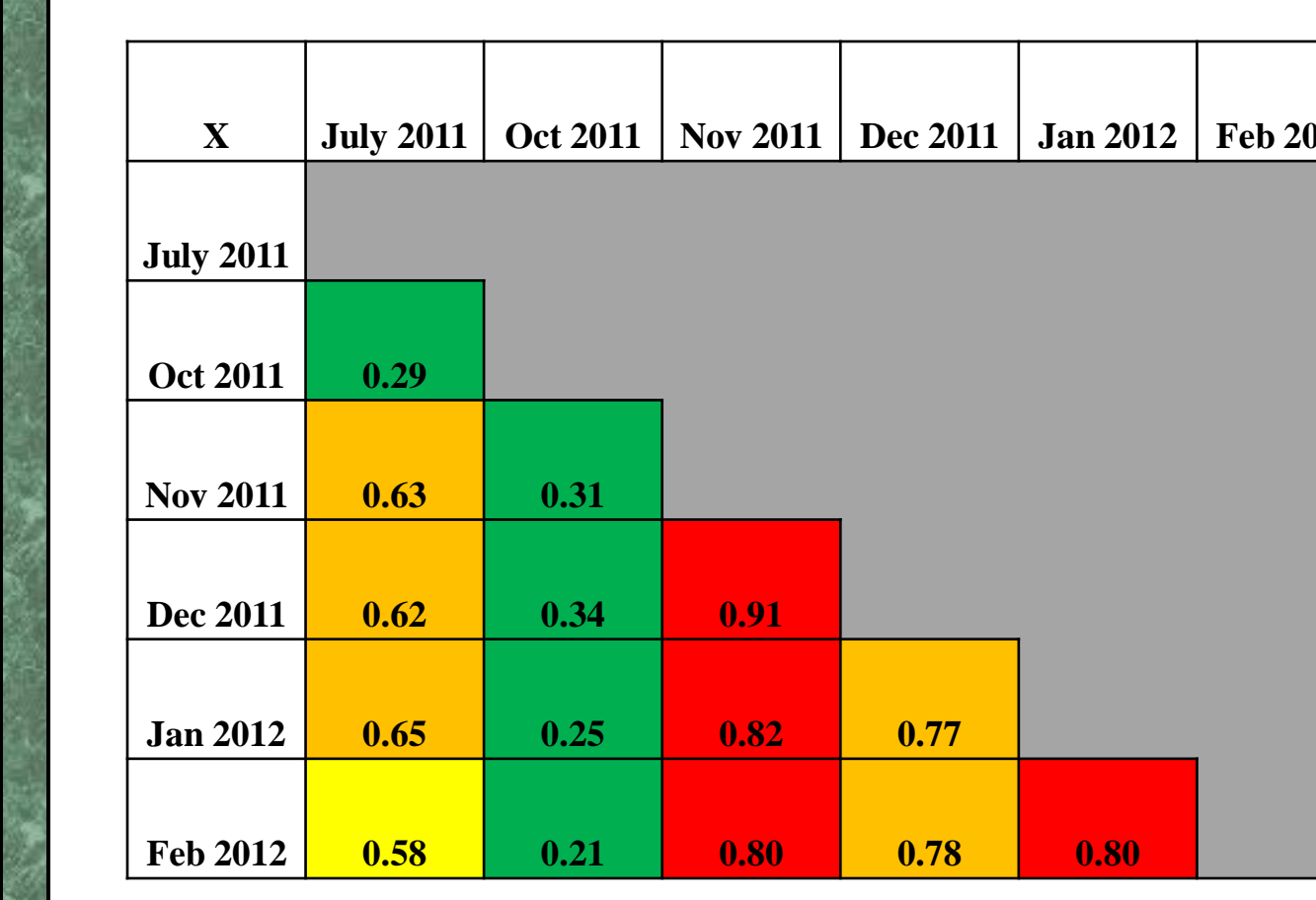
## Results



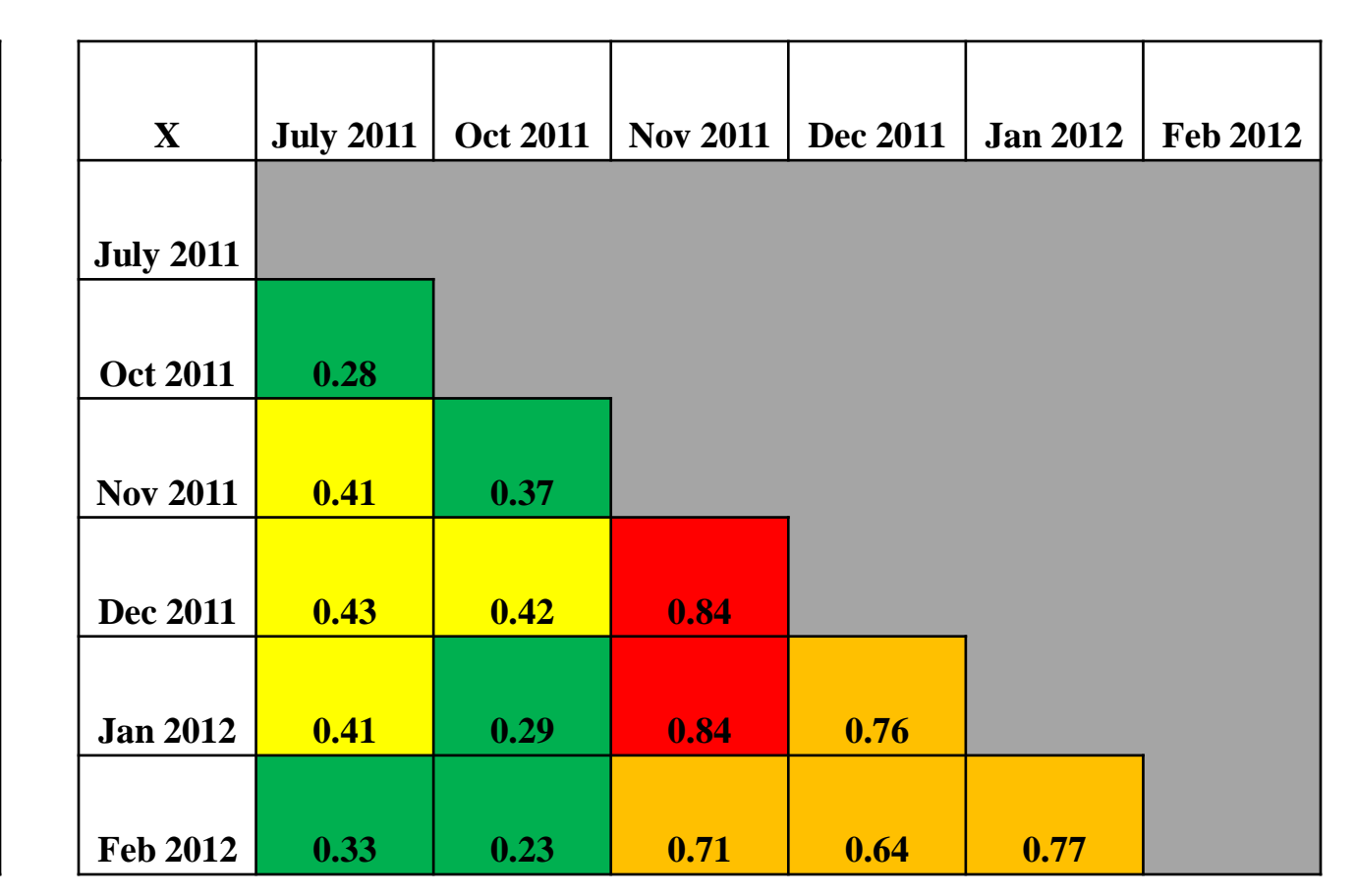
Lick Run



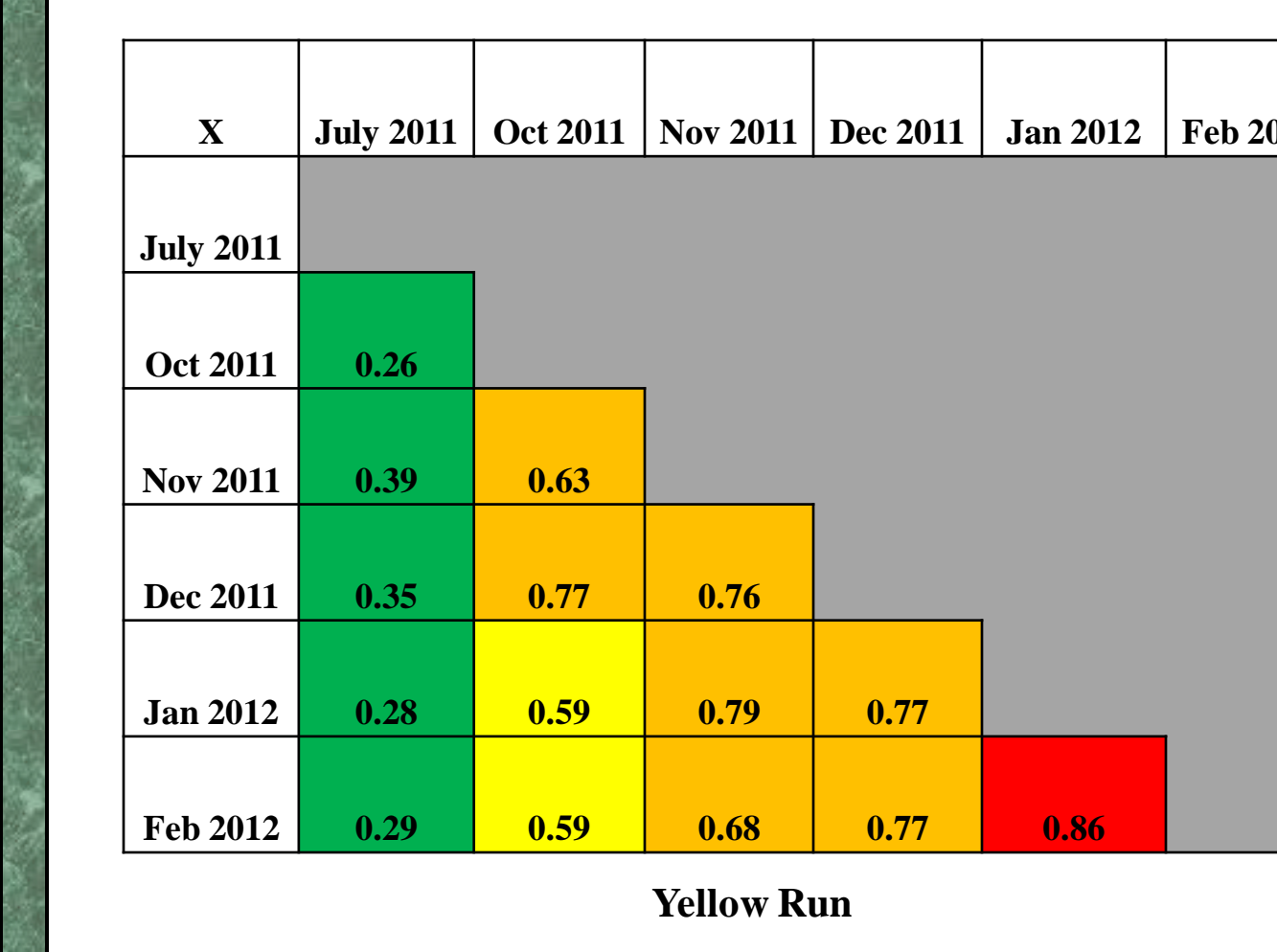
Mill Run



Rock Run



Strey Run



Yellow Run

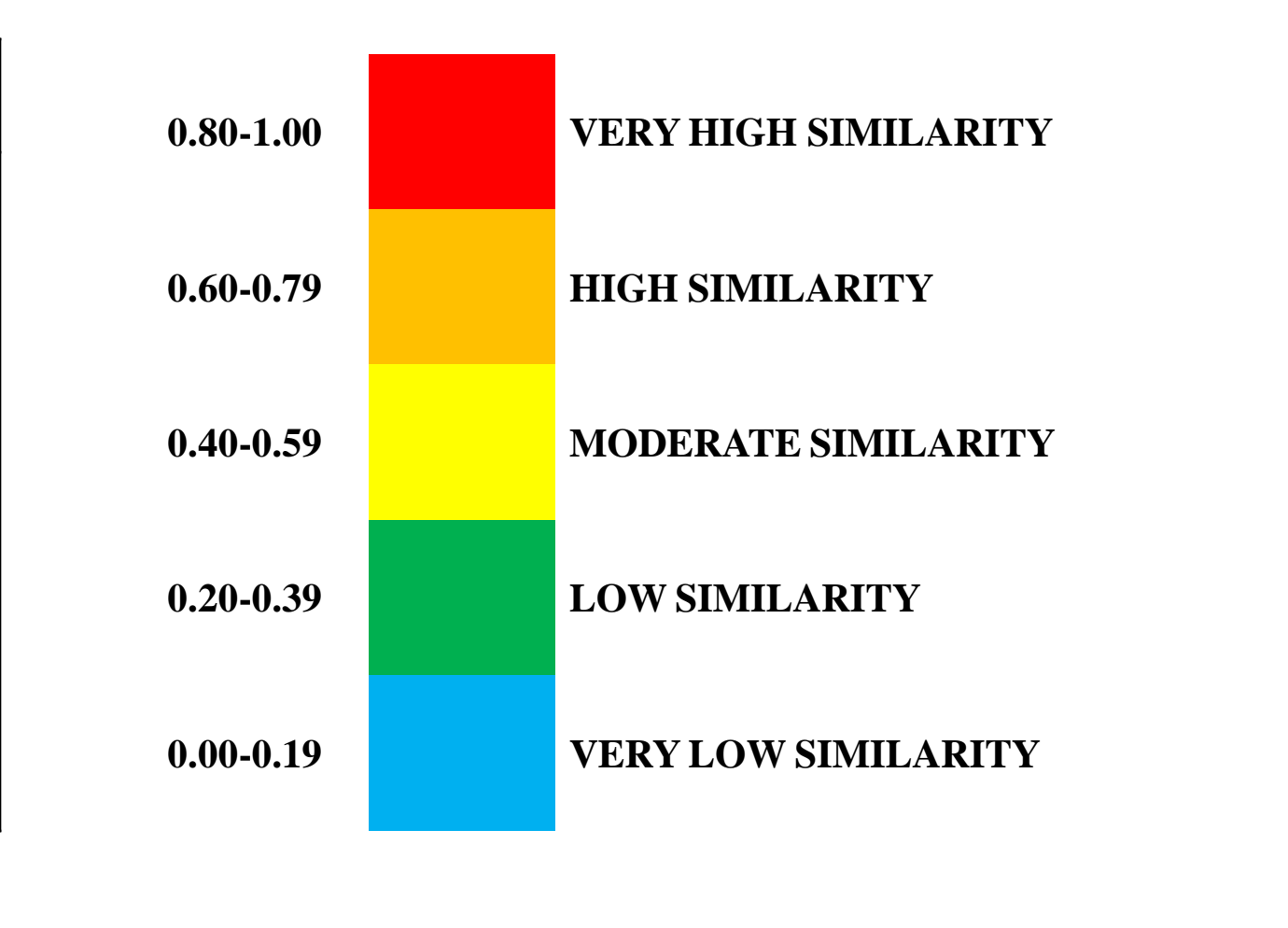


Figure 11. Proportional Bray-Curtis results for benthic macroinvertebrate families at the 5 study sites compared monthly. Pre flood samples are from July 2011.

## Conclusions

- > 50% decrease in density of BMI and EPT taxa ~ 1 month post flooding at all sites.
- 4 of 5 sites recovered to pre flood BMI and EPT density ~ 4 months post flooding. 1<sup>st</sup> order stream (Lick Run) was exception.
- Decrease in total BMI and EPT richness ~ 2 months post flooding at all sites.
- Decrease in diversity ~ 1 month post flood at 4 of 5 sites.
- Dominant organisms changed post flood: Baetidae dominant pre-flood, Heptageniidae were dominant post flood.
- 3 of 5 sites showed low BMI taxa similarity immediately post flood, 2 sites showed moderate similarity immediately post flood.
- 2 months post-flood, the monthly samples exhibited high similarity between species at most sites, and for the duration of samples.
- Future identification to genera level will allow determination of changes by functional group composition and by voltinism.

## References

• PDEP. 2009. A Benthic Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania. Pennsylvania Department of Environmental Protection.  
 • ELWOOD, J. W. AND T. F. WATERS. 1969. Effects of floods on food consumption and production rates of a stream brook trout population. Transactions of the American Fisheries Society 98:253-262.  
 • HENDRICKS, A.C., L.D. WILLIS, AND C. SNYDER. 1995. Impact of flooding on the densities of selected aquatic insects. Hydrobiologia 299: 241-247.  
 • HILSENHOFF, W.L. 1996. Effects of a catastrophic flood on the insect fauna of Otter Creek, Sauk County, Wisconsin. Transactions of the Wisconsin Academy of Science 84:103-110.  
 • HOOPEES, R.L. 1974. Flooding, as the result of Hurricane Agnes, and its effect on a macrobenthic community in an infertile headwater stream in central Pennsylvania. Limnology & Oceanography 19:853-857.  
 • THORUP, J. 1970. The influence of a short-termed flood on a springbrook community. Archiv far Hydrobiologie 66:447-457.

## Sponsors and Support

Susquehanna University, Susquehanna River Heartland Coalition for Environmental Studies, Foundation for Pennsylvania Watersheds, Degenstein Foundation