Examining terrestrial soil invertebrates to understand the impacts of climate change on the red-backed salamander (*Plethodon cinereus*)

Emily Mausteller, Michelle Gillette, Rachel Snyder and Tanya Matlaga, PhD; Susquehanna University, Department of Biology

INTRODUCTION

Climate change is predicted to cause a 2.8-4.3°C increase in air temperature and reduced snowfall in the northeast U.S. in the next 100 years. The impacts of climate change are relevant on local and regional scales (Hayhoe *et al*. 2008).

Eastern red-backed salamanders (Plethodon cinereus) are euryphagic, consuming a wide variety of food sources, but in general they prefer herbivores to detritivore and predator invertebrates (Homyack *et al*. 2010). There is conflicting evidence regarding the impact salamanders have on invertebrate abundance and ecosystem functioning (Homyack *et al.* 2010; Hocking and Babbitt 2014).

Snowfall insulates soil in winter, keeping it sufficiently warm for critical aspects of invertebrate life cycles (Templer *et al*. 2011). Salamanders also utilize insulated soil while burrowing up to 30 cm below the surface in winter (Taub 1961).

Climate change can lead to differences in the phenology and distribution of animal and plant species. Although invertebrate response to climate change is relatively unstudied, it is predicted that some species will go extinct and new species will evolve (Chown and Terblanche 2006; Parmesan 2006).

QUESTIONS AND HYPOTHESES

Will a reduced snowpack layer in winter affect soil invertebrate populations in a temperate deciduous forest?

Will certain invertebrate functional groups be more or less prone to population changes as a result of a reduced snowpack layer?

We hypothesize that the overall abundance and diversity of invertebrates in plots where snow has been removed will be reduced in comparison to control plots**.**

SPARCnet INVOLVEMENT

Our study is a secondary project of SPARCnet (Salamander Population and Adaptation Research Collaboration Network)

SPARCnet uses the eastern red-backed salamander (Plethodon cinereus) as a model species to examine how climatic change impacts terrestrial salamander populations (http://seansterrett.wix.com/sparcnet).

Figure 1. Eastern red-backed salamander (*Plethodon cinereus*)

STUDY SITE

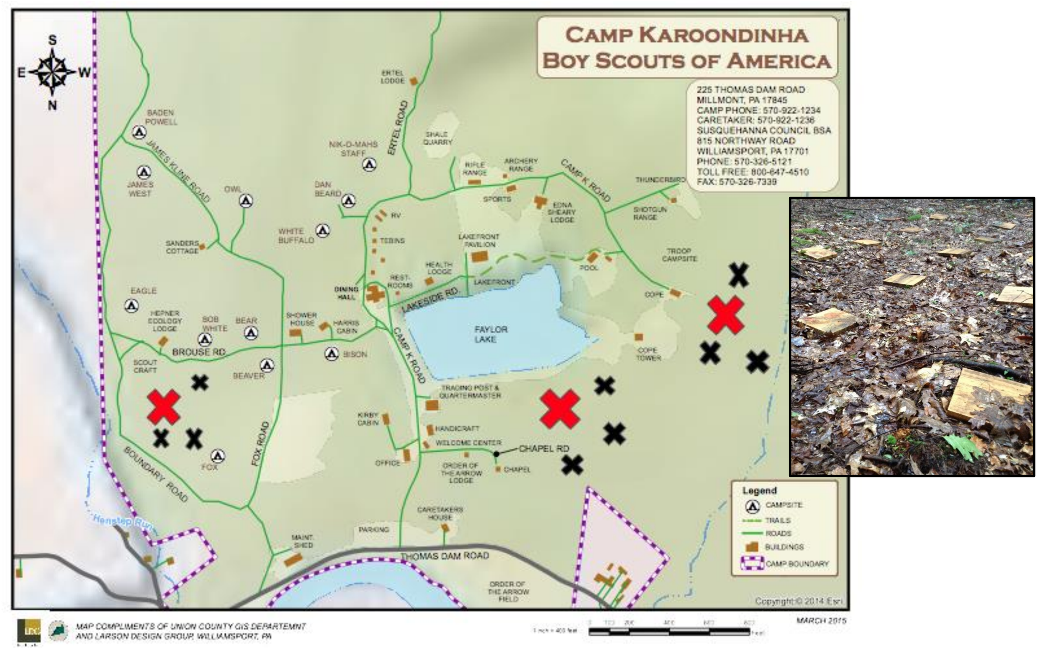

Figure 2. Boy Scout Camp Kardoondinha. Red X's indicate three study sites, black X's indicate replicate cover board array plots at each site.

METHODS

- Snow removed from one plot at each site (three plots total) (Fig. 2)
- Three PVC soil samples (Fig. 3) collected June 3, 2015 (spring sample) and October 20, 2015 (fall sample) in each plot
- Samples run through Berlese funnel system (Fig. 4)
- Samples quantified using a dissecting microscope and invertebrates identified to class/order level
- Data assessed for diversity, overall abundance, and abundance in three different functional groups (herbivores, detritivores, and predators) and variation between control and snow removal groups examined using ANOVA
  - Herbivores: Coleoptera larvae, Diptera larvae, Symphyla
  - Detritivores: Collembola, Acari (mites), Coleoptera, Diplopoda
  - Predators: Hymenoptera, Pseudoscorpionida, Araneae, Diptera, Chilopoda

Figure 3. PVC soil sampler

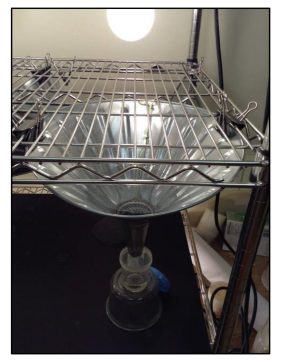

Figure 4. Berlese funnel set-up

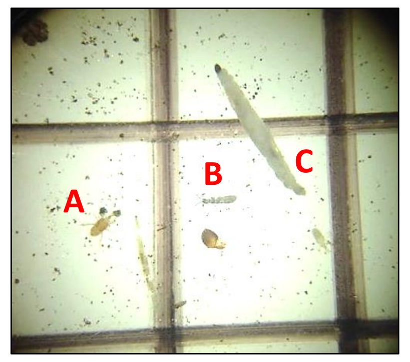

Figure 5. Invertebrates A: Acari, B: Collembola, C: Diptera larva

Gastric Lavage

- Extract stomach contents for identification
- Insert water-filled syringe into esophagus, water injected until contents are expelled (Fraser 1976, Homyack *et al*. 2010)
- Contents placed in 70% ethyl alcohol for preservation, identified in lab

Figure 6. Gastric lavage equipment

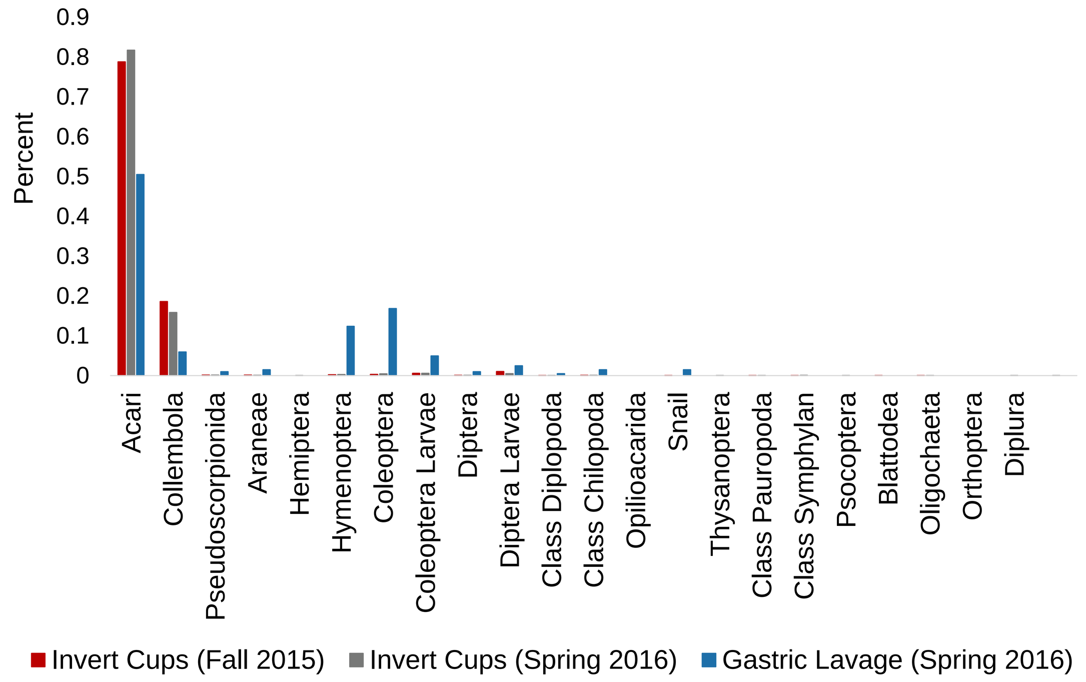

Figure 7. Invertebrate class presence in leaf litter samples (fall 2015 and spring 2016) and gastric lavage samples (spring 2016)

Massachusetts Site

- Samples obtained from SPARCnet site for future investigation
- Comparison of temperatures over snow season

RESULTS

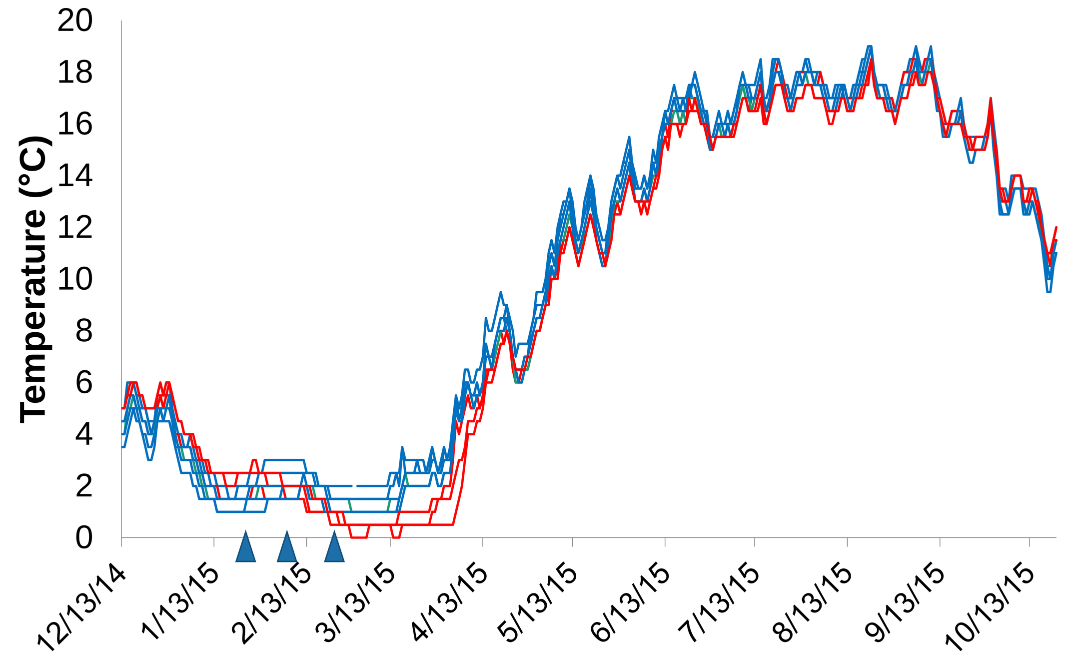

Figure 7. Minimum soil temperatures at 20 cm depth in each plot, recorded daily from 12/13/2014 to 10/22/2015 (control plots in blue and snow removal plots in red). Triangles represent approximate dates of snowfall events > 5 cm, when snow was removed from treatment plots.

- Snow events began in January, with the soil temperatures 1-2 ºC lower in snow removal plots until Mid-April when snow melted (Fig. 7)
- No significant differences in abundance or diversity of invertebrates between control and snow removal plots in spring or fall (Figs. 8 & 9)
- Data indicate seasonal variation in invertebrate abundance (Fig. 8)
- No differences in abundance of different functional groups between control and snow removal plots in spring or fall (Figs. 10 & 11)

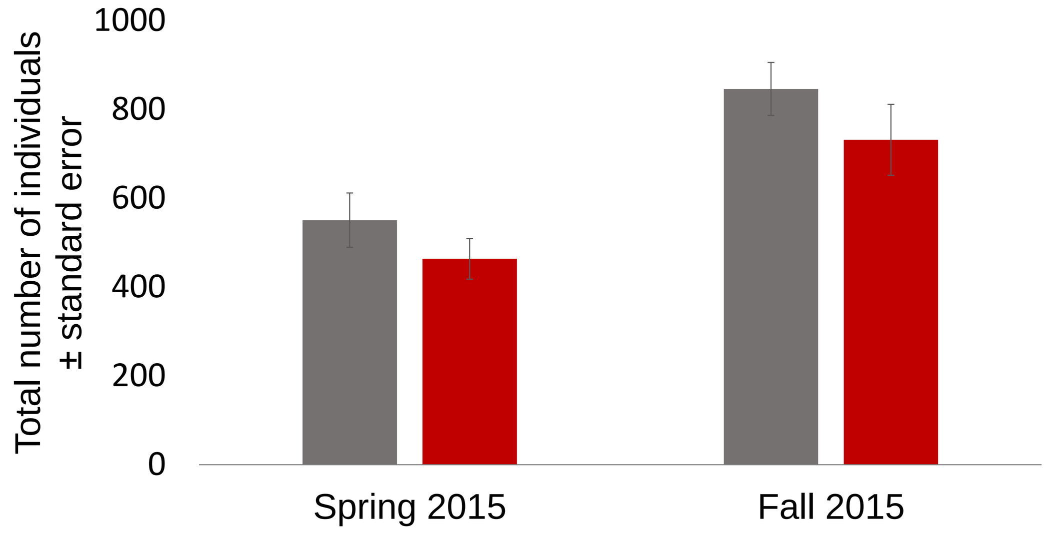

Figure 8. Total number of individuals present in spring and fall 2015 (control plots in gray and snow removal plots in red). (ANOVA: spring $F_{1,26}$= 0.566, p=0.460; fall $F_{1,26}$= 0.711, p=0.407)

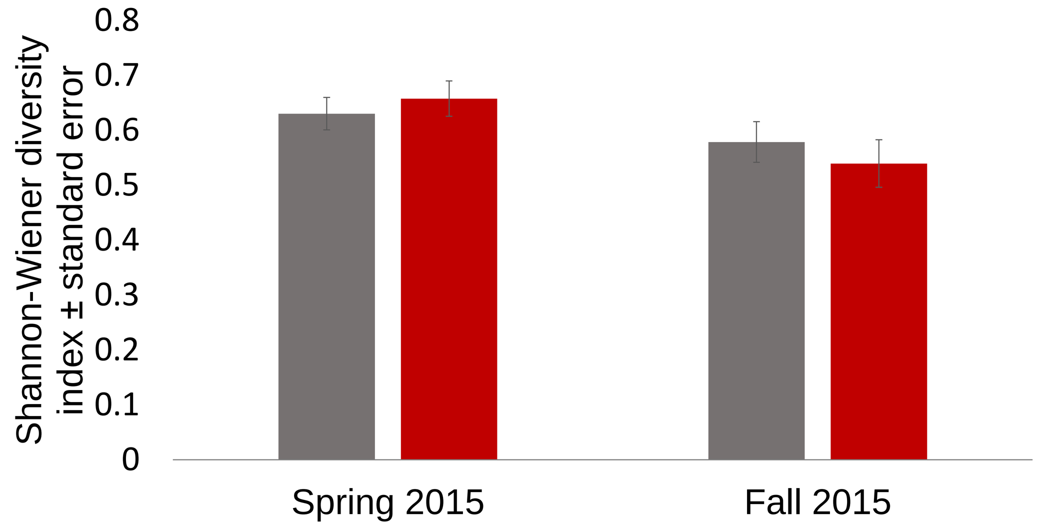

Figure 9. Shannon-Wiener diversity index for spring and fall 2015 (control plots in gray and snow removal plots in red). (ANOVA: spring $F_{1,26}$= 0.187, p=0.669; fall $F_{1,26}$=0.374, p=0.546)

RESULTS

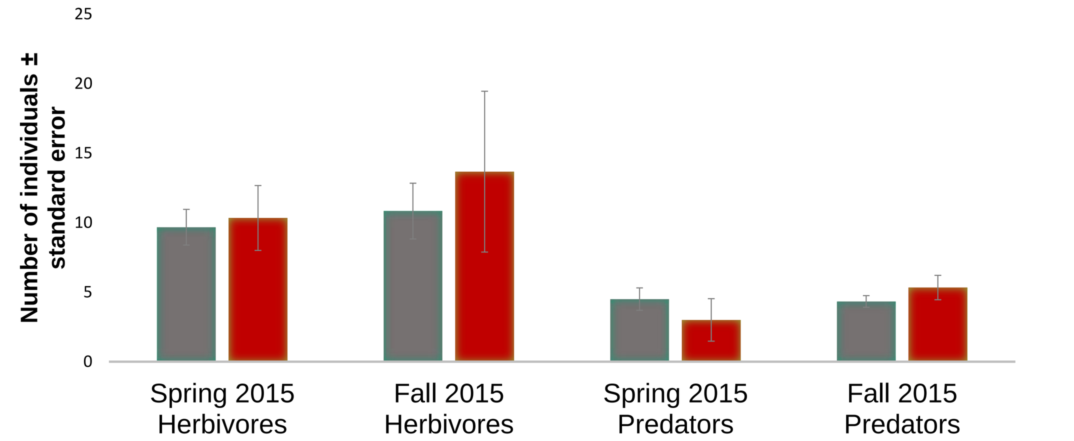

Figure 10. Herbivore and predator functional groups for spring and fall 2015 (control plots in blue and snow removal plots in red).

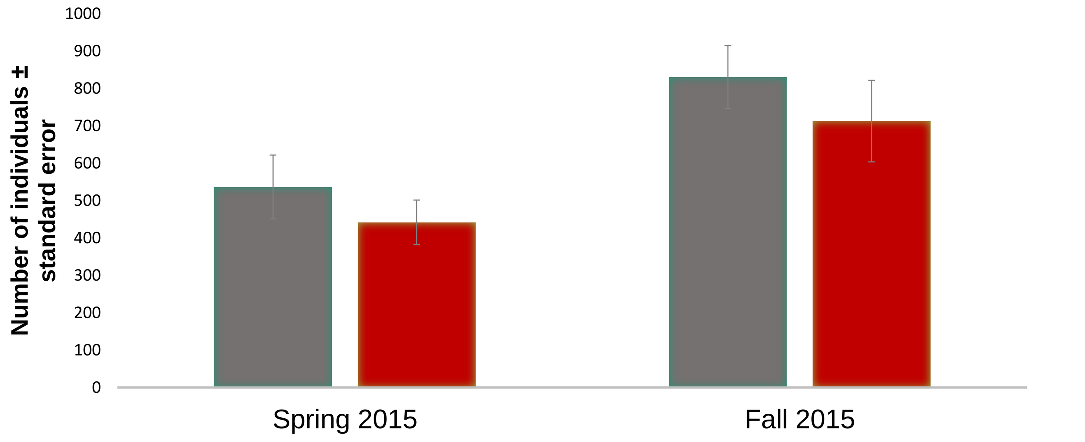

Figure 11. Detritivore functional group for spring and fall 2015 (control plots in blue and snow removal plots in red). (ANOVA: spring $F_{1,26}$= 0.696, p = 0.414; Fall: $F_{1,26}$= 0.791, p = 0.384).

CONCLUSIONS

Soil temperatures were lower during winter in snow removal plots compared to control plots, similar to results found by Templer *et al.* (2012).

Contrary to our hypothesis and the results of Templer *et al.* (2012), we found no significant differences in total abundance, abundance of functional groups or diversity of invertebrates in snow removal compared to control plots on either sampling date.

Invertebrates may not be sensitive to the level of soil temperature change we observed. A larger sample size and more sampling dates are necessary to continue examining our questions.

Invertebrate abundance increased in fall compared to spring, indicating population growth during the summer months.

A long-term study and larger sample size is needed to detect small changes in soil invertebrate populations as a result of climate change (Hayhoe *et al.* 2008). If additional research finds that invertebrate populations decline with climate change, we expect salamander populations to decline in a similar manner.

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