Monitoring the Wolves of the Forest Floor in Edmands Park with the Newton North High School

By Brooks Mathewson, M.F.S. - Ecologist/Educator/Photographer

***Note:** Tables referred to in this article and references can be found on NewtonConservators.org/newsletter.*

In the spring of 2016, I established a study of a population of eastern red-backed salamanders *(Plethodon cinereus)* in Edmands Park, also known as Cabot Woods, along with Tom Gwin, the head of the science department at Newton North High School, teachers Anndy Dannenberg and Shu-yee Chen, and four AP Biology classes.

The study was designed to acquire baseline data on the population size, age structure, distribution, and color-morph ratios of an ecologically important indicator species. It was also intended to provide the students with an opportunity to participate in research and to explore ecological concepts such as food webs, the carbon cycle, and climate change. Most importantly, it was our hope that the students would be encouraged to look more closely at the forests of Newton, and to have a greater appreciation for the numerous benefits that they provide.

The eastern-red backed salamander (Plethodon cinereus) is the most abundant vertebrate in healthy forests in the northeast with a biomass twice that of breeding birds.

Spending time in forests boosts the immune system, lowers blood pressure, reduces stress, improves mood, increases focus and energy levels, improves sleep, and can even accelerate recovery from surgery or illness (New York State - Department of Environmental Conservation).

Forests also provide ecological services including habitat for wildlife, clean air, clean water, and carbon sequestration. Ten to twenty percent of all carbon emissions in the United States are absorbed by our forests (Hite and Daley 2015). Along with a rapid conversion to clean energy and an overall reduction in energy consumption, the conservation of healthy forests is essential to reducing climate change.

Red-backed Salamanders as Bioindicators

Two thirds to three fourths of the carbon stored in forests is stored on the forest floor and in soils (Birdsey, R.A. 1992). Therefore, when we assess the health of our forests, it is imperative that we take a very close look beneath our feet. Red-backed salamanders are important indicators of the health of the forest floor and soils due to their widespread distribution, high densities, position in the middle of the food web, site fidelity, and sensitivity to environmental change (Welsh and Droege 2001). Unlike most species of amphibians who lay their eggs in water, red-backs spend their entire lives on land, laying their eggs in moist locations under rocks or logs. Free of the requirement to be within close proximity to aquatic habitat, red-backs have dispersed throughout forests and are often the most abundant vertebrate in them. Indeed, the biomass of red-backs has been found to be equivalent to small mammals and twice that of breeding birds (Burton and Likens 1975a, Mathewson 2009).

As top-level predators of the forest floor, red-backs prey on a great diversity of soil fauna, including larval and adult two-winged flies, larval and adult beetles, spiders, mites, ticks, collembolans, ants, nematodes, and other invertebrates (Burton 1976). Many of these prey play a critical role in soil decomposition by shredding leaves, greatly increasing the amount of surface area available for primary decomposers - bacteria and fungi. Red-backs keep populations of leaf shredders in check, thereby slowing down soil decomposition and keeping more carbon in the soil, some of which is immobilized and permanently added to the organic layer (Hairston 1987; Wyman 1998; Best and Welsh 2014). This has large implications for the global carbon budget as of course more carbon in the soil means less in the atmosphere (Wyman 1998).

As ectotherms, salamanders have low metabolic rates and are extremely efficient at converting the prey they consume into new biomass, fixing 60% of digested material into new tissue. To put this in perspective, birds, which are endothermic, only convert 2% of the food they ingest into new biomass (Burton and Likens 1975b).

Salamanders are also important prey for ground-foraging birds like the hermit thrush *(Catharus guttatus)* and American robin *(Turdus migratorius)*, snakes like the garter *(Thamnophis sirtalis)* and ringneck *(Diadophis punctatus)*, and small mammals (Coker 1931; Fenster and Fenster 1996; Arnold 1982; Uhler et al. 1939).

Since red-backs are non-migratory, changes in their populations can be directly linked to changes in the conditions of the forests in which they live (Welsh and Droege 2001). Some of the environmental conditions for which red-backs have been found to be good indicators include soil moisture (Heatwole 1962; Feder 1983), soil temperature (Bobka et al 1981), and soil pH (Frisbie and Wyman 1991; Wyman and Jancola 1992).

Methods of Monitoring Populations of Eastern Red-backed Salamanders

One way to assess changes in the size of populations of red-backs is by using mark-recapture studies in which individuals are captured, marked, released, and then recaptured. By determining the percentage of captured individuals that had been previously marked during each sampling round, it is possible to estimate population densities. Marking individuals with visual implant elastomers (harmless colored tags injected under the skin) is less invasive than the old method of toe clipping, but it is still labor intensive and requires a modest financial commitment.


PHOTO: BROOKS MATHEWSON

As predators of invertebrate fauna on the forest floor, red-backed salamanders often slow down soil decomposition and help to keep more carbon in the soil.

An alternative approach is to derive an index of relative abundance based on individuals counted on the surface of the soil. Surface counts can be conducted either under natural cover objects (NCOs) such as rocks, logs, and leaf litter or artificial cover objects (ACOs) such as cover boards. One major drawback to raw counts is that it is unknown what percentage of the population is being counted during each sampling session. Differences in counts from one sampling date to the next may be a reflection of a change in the probability of detecting an individual due to differences in environmental conditions rather than an actual change in the population. In addition, observers' sampling efforts or ability can vary significantly. That is why it is imperative to take sampling conditions as well as sampling effort into account when comparing raw count data. A major advantage of ACOs is that they limit between-observer variability, while also limiting disturbance to NCOs.


PHOTO: BROOKS MATHEWSON

Two color morphs, a striped and an unstriped or lead-backed morph (shown here), occur in most populations of red-backs including the one at Edmands Park.

Another way to monitor populations of red-backed salamanders is by tracking changes in the color-morph ratios of populations. Red-backed salamanders occur in two color morphs, an unstriped morph and a striped morph. Interestingly, the frequencies of color morphs in a population has been linked to differences in climate; higher percentages of the unstriped morph are found in drier, warmer sites (Lotter and Scott 1977). Further, as the climate has warmed the unstriped color morph has become more common throughout the species' range (Gibbs and Karraker 2006). Therefore, monitoring color morph ratios in a local population is a way to contribute to our understanding of how organisms are changing in the face of climate change.

Climate change is also believed to be playing a role in reducing the average adult body size of salamanders, including red-backs (Caruso et al. 2014). This change in body size is believed to be caused by a reduced metabolic efficiency due to changes in moisture and air temperature. By measuring red-backs, we can estimate how average body size might continue to change in the future. This body size information can also help us assess the age structure of a population.

Results from Edmands Park

The students, teachers and I searched for red-backs under NCOs on eight separate dates totaling six hundred and ninety minutes of search time in May and early June of 2016. Care was taken to not damage NCOs and to return them to their original location. The search effort was focused on the southern section of Edmands Park, as this area seems to receive the least traffic and overall seems to be the least disturbed. When red-backs were encountered, we recorded color morph and estimated size class based on the following categories - small: snout-to-vent length (SVL)

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under 30mm - believed to be first-of-the-year individuals hatched in the fall of 2015; intermediate: 30mm < SVL <= 35mm - believed to be juveniles, hatched in the fall of 2014 or possibly adults in their third year; and large: SVL > 35 mm - believed to be adults three years or older.

In addition, I installed an array of 50 ACOs made of one-inch thick, rough-cut hemlock boards in a grid in the southern section of Edmands Park on May 7th, 2016. The grid consisted of five rows of ten ACOs; each row was 1m apart and ACOs were placed 1m apart in each row. We used ACOs of two lengths, 12 and 18 inches; the width of the boards ranged from 8 to 11 inches. ACOs were checked three times in the spring and three times in the fall. When red-backs were encountered under ACOs, color morph and exact SVL and total length (TL) were measured. Temperature, relative humidity, and precipitation prior to sampling were also recorded for each sampling date.

Red-backs undergo direct development and do not have an aquatic larval stage. When young hatch after about six weeks of incubation, they resemble miniature adults.

A total of fifty-four red-backs were observed during NCO searches. The highest rate of observation was 16 red-backs/hour on May 6th. This sampling session was conducted in a light rain after six straight days of rain. The maximum number of red-backs found during one sampling session was 20 on May 18th (observation rate - 8.0 red-backs/hour) (Table 1). Given that only about a quarter of the park (albeit the quarter that seemed to be the best habitat for salamanders) was searched and that only 2% to 32% of a population is found on the surface of the soil at any one time depending on environmental conditions (Taub 1961), a reasonable estimate of the population size of red-backs at Edmands Park is likely between 150 and 250 individuals.

ACOs seldom yield observations of red-backs until they have weathered in the field for a few months, and not surprisingly three rounds of ACO monitoring in the spring yielded only one observation. Another round in the late summer yielded only one more. However, two rounds of ACO monitoring in October yielded fourteen observations of red-backs (Table 2). All but three observations were made under longer ACOs. The observation rate under ACOs in October (average rate: 0.14 salamanders/ACO; maximum rate: 0.20 salamanders/ACO) was similar to that of second-growth rural forests in north central Massachusetts in October (both average and maximum rate: 0.20 salamanders/ACO) (Mathewson unpublished thesis).

The estimated size class distribution of red-backs observed under NCOs was as follows: small: 16%, intermediate: 76%, and large: 8%. Under ACOs, the lone salamander observed in the spring was in the intermediate size class, while all fifteen individuals observed in the late summer and fall were in the largest size class. Part of the reason for the differences between the size class distributions is undoubtedly that the NCO searches were conducted in the spring and the ACO searches were conducted in the fall after the salamanders had had a chance to feed and grow all summer. However, the lack of intermediate size class observations under ACOs in the fall suggests that larger individuals are likely choosing these microhabitats preferentially, perhaps establishing territories around them and excluding smaller salamanders.

The unstriped color morph accounted for 56% of individuals observed under NCOs and 50% of observations under ACOs. These are larger percentages of unstriped morphs than in any previous published work from New England. In the closest study both in time and location to this one, conducted at the Arnold Arboretum in 2005, 40% of the population consisted of unstriped morphs (Mathewson 2007). The average percentage of unstriped morphs from eight populations in Massachusetts in 1977 was 18% with the highest being 33% in Boxford, MA (Lotter and Scott 1977). Our results, therefore, appear to be consistent with the overall trend of an increase in unstriped morphs (Gibbs and Karraker 2006).

Conclusions and Thoughts for the Future

Overall, I believe this study was valuable both educationally and in terms of the data we collected. The lectures I gave to students prior to data collection as well as in the field were well received. Numerous students inquired about how they might pursue a career in ecology, and everyone seemed very engaged and excited to be participating in research so close to their school.

In addition to continuing to work with the Newton North High School, there is also a tremendous opportunity to include elementary and middle schools in this study. Analysis of other aspects of the forest in Edmands Park would be extremely beneficial as well. Further, red-backs are found in a number of additional green spaces in Newton including Cold Spring Park, Hammond Pond Reservation, Webster Conservation Area, and Kennard Park. A network of longterm monitoring sites throughout Newton would be of great ecological and educational value. I will be presenting the results from this work at the Newton Free Library on January 18th, 2017, at 7:00 pm and would be excited to discuss these ideas further.

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In Tribute

The Newton Conservators was saddened to learn of the death of member Andrée Désirée Wilson of Newton Centre.

In addition to being an activist and conservationist, Andrée was a talented gardener who used her artist's eye to create beautiful gardens on the grounds of the home she shared with her husband, Richard. She had a special love for trees and historic irises and featured them in her gardens, which received a City of Newton Beautification Award in 2004.

The Wilsons worked with the Conservators to put a conservation restriction on their land to protect all but an envelope of land around the house from any development. There also is a path open to the public in perpetuity. Andrée welcomed neighborhood children to walk to school through her gardens, where a sign warns, "Beware of the Gardener. She talks."

Andrée and Richard were founding members of the Conservators. They donated a piece of their Newton Centre land to the city, and it's now the Wilson Conservation Area. Andrée also worked with the Conservators to preserve Webster Vale, which became the Charles Cohen Conservation Area (part of Webster Woods) when it was purchased by the city in 1972.

We will miss her strong spirit and her dedication to beauty and conservation.