Determining red eft (*Notophthalmus viridescens*) and red-backed salamander (*Plethodon cinereus)* populations in wooded areas of Robertson Athletic Complex, Allegheny College

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Abstract:

The red spotted newt (*Notophthalmus viridescens*) is a small amphibian that can be found throughout the United States, especially on the Eastern coast. The newt is an important predator in the food chain for both aquatic and terrestrial habitats. It is known for its toxicity in regards to being consumed by other animals, this being the reason why it is a predator more than it is prey. The expectations of this field work was to see the differences in population density in the three transect locations, and to use that data to assess how similar environments around Allegheny campus can provide improved habitat to these species. Using methods such as observation and the flipping of moveable natural cover items such as small logs and rocks, there was an overall population summary. Along with this there were site demographics taken such as temperature, soil moisture, leaf litter, and any visible stressor. Due to the timing of the data collection the only species found was the red-backed salamander (*Plethodon cinereus*). The salamander differs from the newt as it is smaller in size and it lives in terrestrial habitat only. The red-backed salamander is similar enough to the red-spotted newt that the objectives of this research are still applicable.

Introduction:

Ecosystems rely and thrive when there are a plethora of species, both flora and fauna. Ecosystems can be small or large and there can be multiple all within a small area. When thinking of biodiversity and how to manage and conserve biodiversity we often focus on a singular species or a set of species (such as amphibians as a whole). The truth is, to fully understand and sustainably conserve biodiversity there needs to be more thought on the ecosystems as a whole. If the focus shifted onto ecosystem management there would be a multitude of species benefiting within one habitat (Uchida, Blakey, et al., 2020).

Over 50% of wetlands in the United States had been lost since 1780, almost completely due to human activities such as draining, pollution, or hydrologic alterations (Strain, Turk, & Anderson, 2014). Amphibians are unique in needing three or more habitat types; wetland, terrestrial, wooded habitats to be specific. Such anthropogenic activities such as agriculture, logging, and others can affect not only the population of these species but also their migrational patterns (Gibbs, 1998; Chambers, 2008). Although many amphibians need an aquatic location to breed they are also seen to need a terrestrial habitat to

migrate, mature, find food, overwintering, and avoid predators (Porej, Micacchion, & Hetherington, 2002; Roe & Grayson, 2008). When both aquatic and terrestrial ecosystems are affected it can leave species under a lot of stress which can affect their population size.

There has been worldwide acknowledgement of the decline in amphibian populations, and a large factor is habitat destruction (Attum, Eason, & Cobbs, 2002). Amphibians' have permeable skin, aquatic breeding habits, and are smaller in size making it difficult for migration to different habitats. Many amphibian species have been found to return to the same breeding site season after season, meaning that if the favored site is destroyed the population of that species may be affected (Gill, 1979). Therefore, amphibians are at an increased disadvantage compared to other fauna when these lands are destroyed. Freshwater sources are being contaminated or are increasing in temperature (due to multiple reasons, some naturally occurring) which changes the pH balance. When this pH balance changes it can cause detrimental harm to amphibians, as their porous skin is susceptible to these changes. (Sherman & Van Munster, 2012; Rohr & Madison, 2003; Wise, Siex, et al., 1993).

The red spotted newt (*Notophthalmus viridescens*) is an amphibian found in highest densities on the eastern coast but can be found throughout the entirety of the United States. They are sized anywhere from 50.8mm to 127mm, this sizing changes throughout life stages. The newt has 4 life stages, the first is the egg where they are in aquatic habitat for three to five weeks. Then they transition into larvae for two to three months while still in the aquatic habitat, they are 25.4mm long and are a yellowish green coloring. Next is the most noticeable stage which is the juvenile or red eft, lasting for two to five years during this time they live on land only. The final life stage is the adult stage where the newt transitions from red to an olive color, and they may live up to 15 years (Johnson, Bowerman, et al., 2017; Carlson & Langkilde, 2016; Healy, 1975). Red-spotted newts can be named as an indicator species due to their sensitivity to pollutants or other habitat stressors, but more importantly they are also an indication of the total biodiversity of the ecosystem they are found in. Newts play a unique middle role in both the terrestrial and aquatic food chain (Strain, Turk & Anderson, 2014). They mostly eat micro and macro invertebrates and other amphibian eggs or larvae. When it comes to predators they have a few; frogs, snakes, turtles, praying mantis, and dragonflies (Carlson & Langkilde, 2016; Wrynn & Gall, 2019; Mebs, Yotsu-Yamashita, & Arakawa, 2016). The newt is known for its toxicity in regards to being consumed by other animals, although they live in aquatic areas where fish are, the fish are unable to fully consume them (Marion & Hay, 2011; Lutterschmidt, Fiorillo & Anderson, 2015). This toxicity is the reason why it is a predator more than its prey. The newt transitions from terrestrial to aquatic habitat throughout its life stages and to reproduce. Since newts have multiple habitats in their lives they are more susceptible to habitat stress that can affect their overall population in an area.

Red-backed salamanders (*Plethodon cinereus*) share many traits with the Red-spotted newt. The most obvious being their permeable skin and need for moisture (Jaeger, Gollmann, et al., 2016; Telfer & Laberge, 2013). Red-backed salamanders are the most abundant salamanders found in Eastern North American forests (Hocking, & Babbitt, 2014). These salamanders are smaller than the red-spotted newt as they vary between only 45mm to 90mm. The salamanders also differ from the newts as they spend all stages of their lives terrestrially (Jaeger, Gollmann, et al., 2016). Both species are indicator species to pollution and stressors in the environment. Red-backed salamanders have a low ability to tolerate toxins in the environment, when staying in these environments the toxins cause health issues (Johnson, Suski, & Bazar, 2007; Homyack, Haas, & Hopkins, 2010).

Urban biodiversity, and specifically biodiversity on college campuses, is an understudied topic. Although many institutions (owners of these properties) are shown to know that biodiversity can improve the local habitats they are also seen not making any active changes to help increase biodiversity (Orenstein, Troupin, et al., 2019; Bosci, Warren, et al., 2018). Due to colleges maintaining healthy property and being considered a protective space, they are an ideal location for experimentation with biodiversity conservation. They can be seen as mini cities as most campuses can be rather self sufficient, and also have a mix of natural habitat alongside urbanization (Harvey, Gange & Harvey, 2020). College campuses do not take actions to strengthen biodiversity on their campus. There is an upward trend of campuses that are utilizing their space to teach sustainability and ecology. Numerous things could be offered in a habitat that can improve biodiversity, including but not limited to “food and water sources, cover, places to raise young, sustainable lawn maintenance and landscaping, pesticide/herbicide use reduction, invasive species eradication, native plant species selection, water conservation, retention, and recycling, and climate change” (Bosci, Warren, et al., 2018). Being realistic there are common problems colleges face when attempting some of these projects. Funding, and time are often an issue but a bigger problem is the student turnover. Because of this turnover, outreach programs and education are vital for making these projects successful. Most campuses focus on community and social issues, if biodiversity is thought of at all it is most often placed into the grounds keeping part of the planning. By readjusting this to a more campus wide initiative, campuses can address more biodiversity issues without changing much of campus life (Orenstein, Troupin, et al., 2019).

Allegheny describes itself as “optimistic and creative actions” and how many of the college's sustainability projects have come from student ideas (“Sustainability at Allegheny College”). Allegheny can be placed into the mini city category as much of the college is self-sufficient. The campus has a variety of environment types on its property that can be utilized to increase the amount of biodiversity. Those types are grassy, low lying vegetation, and forested or canopy covered. Note that there is no

wetland or aquatic habitat on the campus besides a few narrow streams that can be found flowing after rainfall. Having these different environments is important as that can already improve the biodiversity of species found. Although we do have dense flora in some habitats there is still an overall clean look to these areas, as cover items such as tree debris seems to always be cleaned up. Ecosystems as a whole function better when there is more diversity of species, both biotic and abiotic (Turnball, Isbell, et al., 2016). Since Allegheny is located in an rural area there is already an advantage and increase in species seen, but no focus has been shown to the amphibian species, and that is reflected in their lack of campus habitat.

Allegheny College takes pride in the sustainable actions it has taken. If you go onto an Allegheny website it shows all of the sustainability efforts put forth yet this does not include wildlife conservation, biodiversity, or a landscaping plan based on native species. The closest you get to finding any data on these topics is from the Environmental Science department class research projects. The issue with not knowing what species live on the campus is that there is no way of knowing how healthy their habitats are. The red spotted newt and the red-backed salamander are important indicator species for terrestrial ecosystems, generally meaning that if they can be found in a habitat that the biodiversity can be thought to be healthy. The objective of this research is to gauge what improvements can be made to Allegheny properties as well as other colleges or parties looking into urban green spaces, specifically in assessing pollutants affecting woodland salamander habitat.

Methods:

Fieldwork was conducted at Robertson Athletic Complex. Each location had three transect sites (nine total sites); one location being the edge of the forest, another being near the trail edge, and the third being in dense forest. The edge of the forest site could be described as the transitional area from a densely wooded area into an open field. While the trail edge site could be described as the area directly off an inner forest trail that has full canopy cover and is inland from the forest edge. Finally, the dense forest site could be described as areas which had large standing trees that included a canopy coverage and was at least 20 meters inland from the closest trail. This data was collected after 12 PM each day for three hour time blocks. The data collection started October 26, 2021 and continued until November 25, 2021. There were three location sites, with three replicant transect sites at each location. Each transect was a fifteen meter by one point five meter area that was checked a minimum of three times each. Each transect was measured and flagged prior to any data collection dates.

Figure 1 *Map of transect locations at Robertson Athletic Complex*



Note: This map shows the location of each collection site at Robertson.

Data collected on each site's demographics consisted of; leaf litter depth, soil moisture and pH, types of cover items (such as but not limited to; fallen logs, tree branches, small rocks, etc), any additional amphibian species found, the hours since last precipitation, and also weather aspects such as temperature and current precipitation during the time of collection. The soil moisture and pH were detected using the Gobetter soil tester. The collection method being used was an initial observational sweep of the fifteen by one point five meter area. In addition to the initial sweep, naturally found cover items were lifted to observe what species (if any) were found underneath before placing it back to where it was originally found. Once a newt or salamander was located the population count was collected. If a red spotted newt eft was located a photo would have been taken, these would have been used for later analyses to determine if there were any juveniles repeatedly found, based on spot patterns. Fovea Pro software is a free program originally made for forensic image analysis. It has been used in other studies and was able to correctly identify eft newts (Davis & Grayson, 2008; Grayson, 2014).

All data collected from both species found as well as the sites was analyzed to show which site has the highest population through descriptive statistics. Comparisons were made between each site location and the total species population found at each site. Bar graphs were created to show population at each location as well as to show how population size changes with influx in weather conditions. An

ANOVA was also conducted to determine any significant differences among the total population from each transect among the repeated collection dates.

Results:

Twenty nine Red-backed salamanders were collected from October 31, 2021 to November 18, 2021 (Table 1). The temperature and precipitation varied throughout the data sampling dates which affected the total number of salamanders found (Table 2). Time constraints made it so that data collection was only done during the weather changes that naturally occur as the Fall transitions to Winter. Due to these weather and time constraints there was only one day of population data collection where all three transects were sampled (Figure 2). This collection date also had more optimal weather conditions as it was above fifteen degrees celsius, which has been noted in the above literature to be ideal temperature for salamander activity. Throughout the entire data collection process there was no accurate record of how many cover items were flipped throughout the collection period; only observations were made in regards to the types of cover items overturned. The most frequent moveable cover objects found at all three locations were small rocks, logs, and leaf litter. As data collection continued there were several large trees brought down by intense winds that landed on cover objects that had been previously counted and flipped. These large trees mostly affected the forest edge site, and by the end of the data collection period there were few items at this location that were able to be moved. The goal of the methods used in this research to assess the salamander population was to keep from interfering with the natural space where these species were found, therefore focusing on objects that were easily moved using slight force was an important factor. Observations also showed that out of all twenty nine red-backed salamanders there were twenty three of those found under a small log or piece of wood. There were only two salamanders located under rocks and four salamanders located around the base of a tree stump. The soil moisture and pH collected both fluctuated in the numbers representative of the data collection period. Soil moisture was seen to stay between one and four, but the equipment had no unit of measurement for these numbers. Both the dense forest location and the forest edge location had a steady pH of between seven and eight. The trail edge location on the other hand fluctuated slightly higher between six and eight. As stated above the soil moisture and pH was collected using a piece of Gobetter equipment, because of that it cannot be confirmed that the numbers provided by this equipment were accurate. A two factor ANOVA was done on the total population data collected among all locations and it was found that the P-value was 0.66. Therefore the hypothesis failed to be rejected and the conclusion is reached that there is no significant difference among populations found at each transect location.

Table 1 *Total Number of Red-backed Salamanders found at each transect.*

Transect Location	Total Salamanders Found
Trail Edge	12
Forest Edge	1
Dense Forest	16

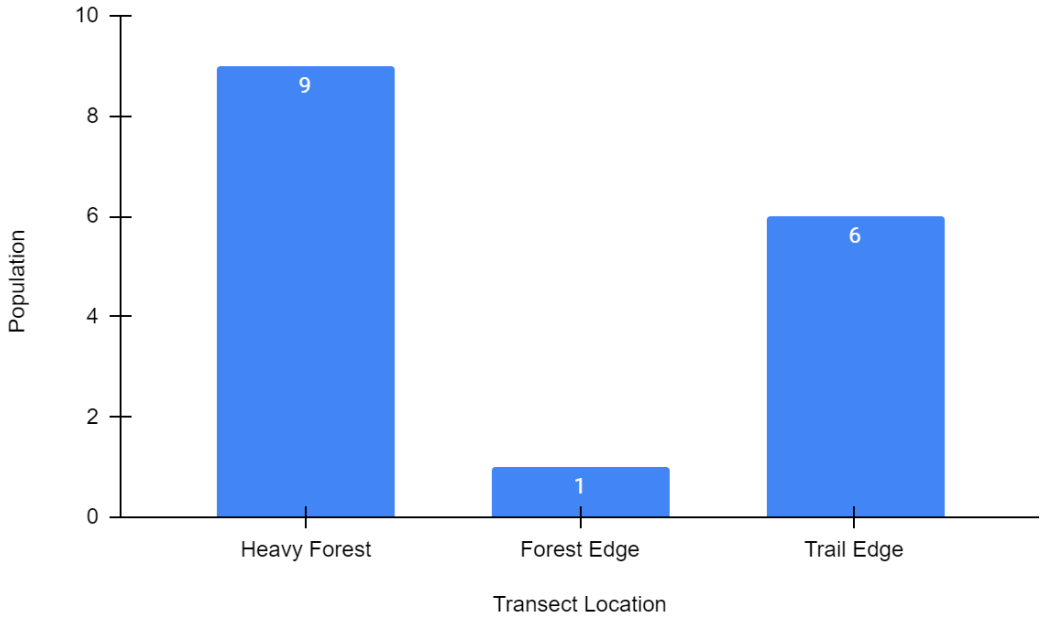
Note: This shows the sum of each transect across all sampling days, collected from October 31, 2021 to November 18, 2021 at Robertson Athletic Complex.

Table 2 *Relationship between temperature and number of salamanders found.*

Date	Temperature (C°)	Total salamanders found
Oct 31, 2022	9.4	6
Nov 6, 2022	6.1	4
Nov 11, 2022	17.2	16
Nov 18, 2022	5.6	3

Note: Table shows lowest average temperature (C°) of the day, and the salamander population sum for all three transects from October 31, 2021 to November 18, 2021 at Robertson Athletic Complex.

Figure 2 *Salamander collection from November 11, 2021*



Note: Salamander collections from all transects on November 11, 2021 at Robertson Athletic Complex. This was the only date all three locations were sampled together.

Discussions:

In natural ecosystems change is occurring at a constant fluidity, and the real field research parameters may not always be what was expected when originally planning. The original hypothesis of this research was dedicated to finding red-spotted newts, and assumed there would be other species found that shared the ecosystem. Upon data collection there were zero red-spotted newts found and in return there were 29 red-backed salamanders found. Finding species together in an ecosystem is to be expected as there may be thousands of species within one small transect but the complete lack thereof of the expected species was disappointing. As stated above amphibians as a group are a critical piece to an ecosystem's function, and healthy populations can reflect a healthy and stress free environment (Johnson, Bowerman, et al., 2017). Because there was a population of red-backed salamanders found at these locations it can still be indicated that the area is mostly free of stress and pollution.

The site location in which the population of red-backed salamanders were found agrees with other articles saying that they are most often found inhabiting areas without much human intervention and activity (Gibbs, 1998). The salamanders found in this research were most commonly at the dense forest and trail edge, with only a single salamander being found at the forest edge. Although the trail edge does harbor a medium amount of human and animal (such as dogs) activity it also offers specified boundaries, the trail that ran besides the transect was clearly marked and even had rope in certain areas to keep human activity from going off trail. Gibbs (1998) research specifically addresses how woodland amphibians do in fact occur in relationship to anthropogenic landscape features. Many species were found in this study, including both the red spotted newt and the red-backed salamander, they were both seen to be hindered by anthropogenic land markers such as roads or harsh forest edges but less so by open fields or gradient forest edges. This goes to show how human decision making can affect these species without a conscious thought. It is important to keep amphibians in mind when making decisions that could possibly hinder the population, fragment their habitat, or reduce the amount of prey found in the area.

All transects were observed to see obvious stressors such as pollutants, damage, large predators, human disturbance, etc all of which could hinder the ease of locating a population and have effects on its size (Marion & Hay, 2011; Graham & Wilcox, 2021; Park, Hempleman & Propper, 2001; Matthewson, 2014). Robertson is a high activity area as it has multifaceted uses and is openly available to the surrounding community of the campus and the city of Meadville. Each transect was different in the amount of canopy coverage as well as how much local activity there was, dense forest being the area expected to see the highest population of efts due to its lower human activity level and amount of anthropogenic barriers. As stated above in Figure 2, the population of red-backed salamanders found was

not evenly distributed amongst transect locations. The trail edge location showed the ability to have a higher population of salamanders in areas with high levels of human intervention. Interestingly, something that was repeatedly seen in these locations was the population of salamanders found around or specifically at the base of tree stumps. During the collection periods there were several salamanders repeatedly found around the base of a cut tree trunk, as seen in Figure 3 and 4. When researching background information this phenomenon was only mentioned in one article and gave no explanation for this behavior (Healy,1975). Other literature has stated that the salamanders are often found where there are small seasonal pools of water, like the collection of moisture around the base of the trunk, and where there are pre-existing holes or burrows (Piraccini, Cammarano, et al., 2016; Jaeger, Gollmann, et al., 2016). The reason for this is moisture (as stated) and also protection. Since newts and salamanders do not create their own burrows they use other species' work to evade stressful situations.

Figure 3 *Cut tree stump in heavy forest transect*



Note: This stump is located at the heavy forest transect location. The photo was taken during the November 6, 2021 collection date.

Figure 4 *Red-backed salamander found next to the base of the stump*



Note: The red circle shows the red-backed salamander that was next to the base of the cut tree stump. The photo was taken during the November 6, 2021 collection date.

It was not surprising that no red-spotted newts were found, time constraints meant that the seasons were changing and temperatures were continually fluctuating in a more decreasing manner. This helped contribute to the red-backed salamanders being found when the red-spotted newts were not, as stated above the salamander will deal with a lower temperature range than the newt will. There was a range in which the temperature was fluctuating during data collection, this range was between four degrees celsius at the lowest and eighteen degrees celsius at the highest. There were several days of frost during the collection period and upon the last day of collection there were a few red-backed salamanders that were found frozen. Red-backed salamanders do have a slightly lower temperature range than the red-spotted newt and so the rapid fluctuation of temperatures from below to above freezing had an obvious effect on the populations found (Homyack, Haas, Hopkins, 2010; Grayson, Bailey, & Wilbur, 2011).

Data collection in regards to these species habitats is crucial to accurately informing decision making when it comes to maintaining or creating more biodiverse ecosystems (Lee, Kahal, et al., 2021). Future research on the red-spotted newt should be done, especially on Alleghenys campus. Allegheny can benefit from the campus' size, and can utilize the research areas available to them as well as the students' involvement with sustainability practices. Research based upon this same hypothesis should be conducted

in the spring or summer rather than in the fall as temperatures cool. There was one day of data collection that had almost optimal weather conditions. This was the same day that the only salamander was found at the forest edge location. The red-backed salamanders could also benefit from further research, specifically looking at how their activity changes with temperature and what their realistic range is on Alleghenys campus. This research data shows the red-backed salamander has a higher ability to withstand rapid temperature changes, specifically with lowering temperatures, and creating a more concrete timeline can aid in the formation of suitable habitats. This further research can be used when taking into consideration the needs of these species, as well as how simple landscape accommodations can harbor an increase in the overall populations found on the college's campus.

Any and all land-use plans should be considerate of amphibians habitats, and specifically they should be looking at ways to improve already existing habitats or create new green spaces to increase campus biodiversity (Porej, Micacchion, & Hetherington, 2004). An important aspect of the observations during data collection that was echoed in other research was the access to natural cover items (Romano, Costa, et al., 2017). In locations with small to medium natural cover items such as logs, sticks, rocks, and thick leaf litter (like in the dense forest and trail edge transect sites) there is a higher population of salamanders found. Typically it is seen that college campuses, including Alleghenys campus, do not keep these cover items around its properties. Campuses usually look “clean”, kept, cohesive, and do not have the ecosystem properties that salamanders need. Another necessity to providing a complete habitat to amphibians is not only having the location itself but also providing an adequate prey base to improve the success of the amphibian populations. In the thought process of increasing amphibian populations on campus it might seem ridiculous to overlook their place in the food chain but it is extremely important. For amphibian populations to thrive they need to have ample amounts of prey already in their habitat, rather than being introduced as the only species in the ecosystem (Strain, Turk, & Anderson, 2014). If there was an increased focus on keeping these cover items as shelters and forage sites for these species as well as others, rather than a focus on aesthetic, biodiversity on campuses could blossom.

Amphibians such as the newt and the salamander take up a small portion of an entire ecosystem and yet they play a pivotal role in assessing the health of an ecosystem. Allegheny as a college campus is unique as it has its own small and fast tracked decision making system, this being a thing that slows many municipalities ability to act. Since Allegheny has a community that is understanding of eco-literacy and is committed to sustainability it has an opportunity to use its space to intentionally create habitats built for allowing amphibian populations to thrive. Doing small things such as monitoring campus species populations, enacting a biodiversity landscape team, sending a community survey, or even dedicating a green space to these species are just some of the actions that could be taken after the correct data assessment. The data collected on red-backed salamanders and Robertson athletic complex goes to show

that Allegheny is doing a good job at keeping the environment relatively healthy in those areas but the goal would be to expand this into other locations and even onto the main campus.

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