Environmental Preferences of the Oregon Forestsnail

by

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Abstract

Snails play crucial roles in forest ecosystems, aiding in soil creation, seed dispersal, and fungal spore distribution. The Oregon Forestsnail, imperiled in Canada, exhibits habitat preferences, notably favoring Stinging Nettle-rich environments. This study investigated environmental factors influencing snail presence in Colony Farm Regional Park, British Columbia. This study preformed searches and studies of a number of plots to find the number of snails and the environmental factors in those plots. Results showed a strong correlation between snail abundance and Stinging Nettle coverage, suggesting its importance as habitat. Relative humidity significantly impacts snail activity, with higher humidity correlated with increased snail presence. Soil moisture may influence snail behavior, with the difference in soil moisture during a drought potentially showing impacts on the number of snails found. Thatch thickness, while showing a positive trend, lacked significance in determining snail presence. These findings seek to inform conservation efforts, highlighting the significance of preserving moist habitats with abundant Stinging Nettle for the survival and expansion of Oregon Forestsnail populations.

Keywords: Oregon Forestsnail; Stinging Nettle; Humidity; Thatch Thickness

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Chapter 1. Introduction

1.1. Background.

Snails are critical animals for the forest floor, performing a number of ecologically important roles. These include assisting in the creation of soils by breaking down organic plant debris, seed dispersal (Gervais, 1996), and spreading fungus spores (Richter, 1980). The fungus in question is symbiotic with many tree species, forming networks to absorb minerals and water from the soil (Lua et al, 2023). Additionally, they serve as food for birds and animals living in the leaf litter with their shells serving as deposits of micronutrients, especially calcium (Oregon Forest Snail Best Management Practices Guidebook, 2018). Interest in snail conservation has been growing in recent years, with a notable example being the release of 5000 Polynesian Tree Snails (*Partula nodosa*) to the French Polynesian Islands of Tahiti and Moorea in 2023 (Kuta, 2023). These snails were extinct in the wild, and were bred in captivity for 30 years to get a large population ready for release, with smaller releases happening in earlier years.

The Oregon Forestsnail (*Allogona townsendiana*) is the largest land snail in British Columbia and is considered imperilled or critically imperilled in Canada, Provincially and Nationally (Recovery Plan for the Oregon Forestsnail, 2012). It can be distinguished from other snails in this area by its yellow-brown shell, with a thick white rim to the inside of the shell that flares outwards (Figure 1).

Figure 1. Pictures of Oregon Forestsnails, (Oregon Forest Snail Best Management Practices Guidebook, 2018).

Previous studies have suggested that the snails prefer to be in the presence of Stinging Nettle (*Urtica dioica*; Durrand, 2006). There are many reasons why they could prefer this plant to others, such as the stinging nature of the plant being an effective predator defense (Recovery Plan for the Oregon Forestsnail, 2012). Another possibility is due to the nutrient content of the plant (Oregon Forest Snail Best Management Practices Guidebook, 2018). It is well known that stinging nettle is very rich in nutrients, especially calcium (Diddana et al., 2021; Krawęcka et al. 2021). Snails need calcium to build their shells (Crowell, 1973; Çelik et al. 2024), and depriving them of calcium dramatically weakens them and their shells. As such, preferring to live around plants that are rich in calcium is a logical explanation for their correlation.

Oregon Forestsnails enter hibernation once the first frost hits, and they do so by burying themselves in the thatch, moss, and soil, typically 2-7 cm deep (Recovery Plan for the Oregon Forestsnail, 2012). The typical hibernation period is between November and February (Steensma et al., 2009), though they can enter hibernation as early as October and leave it as late as March. They also enter dormant states during high heat and low water conditions to preserve water (Cathcart et al. 2022). As such, they tend to be most active during the early morning before it gets hot and while there is still dew on plants.

This snail is only found in a range from Oregon, to Washington, and up to the lower latitudes of British Columbia and Vancouver Island (Figure 2). BC contains the most northern limit of its range, and most of that range is, unfortunately, in the Fraser Valley, one of the most urbanized and modified areas in BC (Figure 3). Construction, road building, farming, or general urbanization have removed most of the original forests and wetlands (Oregon Forest Snail Best Management Practices Guidebook, 2018). This is especially true of the low-lying areas near the river that were high enough to not be frequently flooded, but still moist enough for snail presence. This has resulted in many populations becoming cut off from one another (Recovery Plan for the Oregon Forestsnail, 2012) with limited to no travel between them. One such population can be found in the north-western section of Colony Farms Regional Park in Metro Vancouver.

Figure 2. Total Range of the Oregon Forestsnails in the US and Canada, from Oregon to British Columbia (COSEWIC, 2002)

1.2. Colony Farms Regional Park

Colony Farms (Colony Farm Community Gardens Website) was purchased by the BC government in 1904 to become a hospital for the mentally ill, along with a large amount of accompanying land to use as a farm. The land, which was originally floodplains, was cleared from 1904-1910, when it opened and expanded in 1918 with land on the other side of the river (Colony Farm Community Gardens). The farm was eventually closed in 1984 and reopened as a park in 1996. This begs an important question: how did the snails survive decades of farming at Colony Farm?

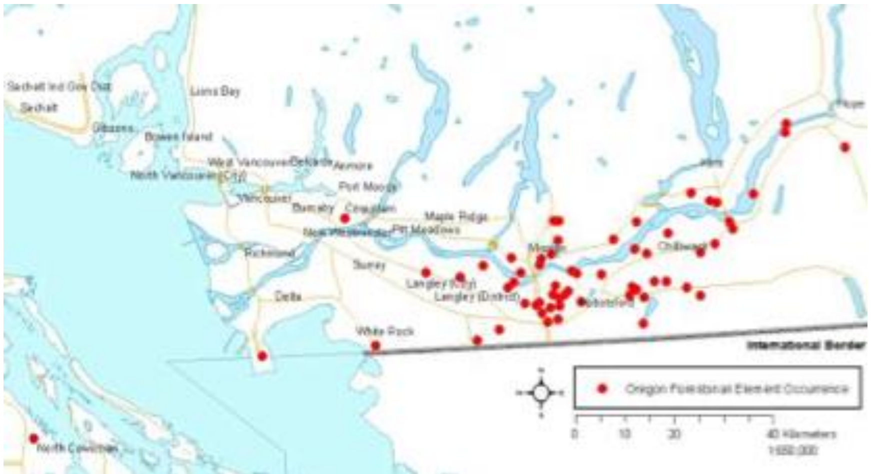

Figure 3. Range of the Oregon Forestsnails in the Fraser Valley and Vancouver Island, British Columbia.

There are two likely reasons as to how they survived. The first possibility is that a small number of them survived in a relatively protected spot that wasn't farmed, or they were introduced after the farming stopped. They may not have ever established themselves in the park before the floodplain was diked off for farming, as the frequent flooding of the area would likely have made the land difficult to live in for a terrestrial snail. Almost all the snail sightings have been around the parking lot (Figure 4; Cathcart et al, 2021). It is possible that after Colony Farms became a park, someone dumped garden waste from their vehicle, introducing the snails to the park. This could also be due to the fact that the parking lot is far from the river, meaning that area could have had a lower chance of being flooded.

Whatever the case, the fact remains that this population is largely centred on a single area and has not been found in other areas of the park. Or at least not in any noticeable numbers. Due to this fact, a single disruption could wipe out much of this population. Considering that the nearest population is just south of Burnaby Mountain Secondary School (Environment Canada, 2016), approximately 7 kilometres away, natural recolonization would be unlikely. Especially as those 7 kilometers is as the crow flies, across highways and residential areas. There are a number of possibilities as to why are only found in significant numbers there. Perhaps they haven't had the time to build their population and disperse to new locations. On the other hand, there may be some environmental factors preventing them from spreading. For example, this area is a copse of trees with many patches of stinging nettle, so perhaps this is just an area that has many ideal factors for them. Whatever the case may be, this is an ideal testing area with many areas with snails, and areas without them (Cathcart et al. 2021). Testing the difference between the sites in use and the ones that are not can tell a lot about the environmental factors they favour in this park.

In this park, they suffer from a few pressures on their population. They are preyed upon by a number of birds, garter snakes (*Thamnophis sirtalis*), and carnivorous Lancetooth snails (*Haplotrema vancouverense*), as well as other species. In addition, the current situation of the park results in many snails being run over by bikers or stepped on as they cross the trails, especially in the early mornings. Thus, increasing our understanding of the snails and their preferred conditions may allow us to modify the trails and the park, in general, to ensure the park is safe for them.

1.3. Study Parameters

As previously mentioned, these snails live amongst the leaf litter. As such, it could be expected that thatch thickness would be a good predictor for snail presence and number. After all, the snails are detritivores, and the thatch helps provide cover. Thick thatch would allow them to conceal themselves, as it is likely much easier to hide under leaves than it is for them to bury themselves in the soil to avoid predators and protect themselves from the elements. A previous study in Colony farms noted that the snails often disappeared in hot, dry weather and as such, noted that they were likely quite sensitive to humidity and would likely benefit from moist soils. In fact, the soil becoming wet may function as a signal for the snails hiding from the heat to emerge. As such, both soil humidity and relative humidity may be associated with their presence.

A study involving the mark and recapture of Oregon Forestsnails was done the previous year to see how far they travel. Future studies can build off the results of this research to help protect this critically imperiled species and to guide restoration actions.

Once this population is stable, it would allow us to move some snails to set up new subpopulations to enhance the metapopulation within Colony Farm and Lower Mainland of BC. It would reduce the risk of a single catastrophic event leading to the extirpation of the species from Colony Farm. This would also help inform local park planning to make alterations to the trails that allow snails to survive.

While we know a lot of generalities about the snails, we don't know the specifics. We know they like moisture (Hoffman et al. 2011; Randolph, 1973), but how much moisture? We suspect they like leaf litter for cover, but how much? This is what I set out to find. Given the habitat data gathered in previous studies (Durand, 2006; Steensma et al., 2009), I predict that there would be a strong positive correlation between the presence of the Oregon Forestsnail and stinging nettle, soil moisture, relative humidity, and thatch thickness.

Figure 4. The study sites used in 2022 to study the Oregon Forestsnail through mark-recapture and release program by Cathcart et al. (2022). Green Markers are sites with nettle, Red markers show locations where Oregon Forest snails were found.

Chapter 2. Methods

There were a few goals to be achieved by this research. Firstly, I continued the snail tag and release program done the previous year. I also made note of what habitat and environmental factors were present at each plot. As I was comparing where in the this populations range the snails were using, I designed it largely a Use vs Availability study, was well as a correlational study. I compared those resources that are available to those used disproportionally to their availability by the snails to identify site preferences. Due to the fact that the sheer number of potential variables (soil pH, soil compaction, etc.) makes testing all of them impossible, the study only analyzed vegetation species and cover, soil moisture, snail numbers, relative humidity, and thatch thickness.

I identified 64 individual 1-metre by 5-metre sample plots along the Mundy Creek Trail and the copse of trees near the parking lot along the Colony Farm Road Trail and identified percent cover of stinging nettle in Colony Farm Regional Park, Coquitlam, BC. Data collection started on May 25th and ended on October 3rd, 2023. As many plots as possible were done until they entered hibernation. The plots were originally done every 50 meters along the Mundy Creek Trail, on alternating sides of the trail. Each plot was 1 meter off the trail and 5 meters long, parallel to the trails. Soil moisture and relative humidity were gathered at the center of each plot, as was the percent cover of the vegetation.

To measure soil moisture and relative humidity, measurements were taken at the center of each plot, 0.5 meters away from the trail, and 2.5 meters away from either end of the plot. Relative humidity measurements were taken approximately an inch off the ground using a Kestrel model 3500, while soil moisture was measured with a Procheck using a Campbell Scientific 5TE Soil Sensor which measured the volumetric water content of soil in m^3 of water per m^3 of soil. The sensory probe was placed 5 cm into the ground, at the approximate depth the snails are expected to hide. Each site had its location described and GPS noted, with the GPS being enhanced by a “Bad Elf” GPS, which takes the latitude and longitude down to the 6th decimal. All sampling was done between 7:00 am in the morning and 1:30 pm, though this varied depending on field conditions.

Thatch thickness was checked at 3 places in each plot, once in the middle of the 1-metre x 1-metre plot on the ends and once in the middle of the center 1 meter x 1 meter plot. The 3 measurements were then averaged together to create a mean thatch thickness for the plot. That 1-m^2 plot at the center was also where the vegetation plot was located.

Vegetation was identified to species and the overlapping total percent cover of each species was recorded. Soil moisture and ground-level relative humidity were also measured at the center of that vegetation plot. Each sample plot was searched for approximately 3 minutes. After each snail was found, its location was marked with a flag and examined for previous markings. If it hadn't been previously marked, it was given a unique label using glue and returned to the site marked with the flag.

However, due to the drought causing the snails to be in hiding, the methods were adjusted. On this trail, data was gathered every 20 meters on alternating sides of the Colony Farms Road Trail until the end of the copse of trees. These data were also collected on the Mundy Creek Trail between March 6 and June 7. Similarly, these data were collected for the Colony Farms Road Trail between July 5 to July 7. However, for 25 of the 64 sites, these data were collected during unexpected drought periods. During the drought, snails seemed to go into hiding and then into a torpor. During this time, no snails were found in the plots, though data was still collected for drought conditions.

After this drought, all data collected in the summer was done during the days following a rainy day to ensure the snails were active. In the fall, the mornings were often foggy, resulting in there being plenty of dew and moisture for the snails. Five non-drought plots were done before the drought and methods shifted along the Mundy Creek trail. The sampling on the remaining 34 plots was done semi-randomly, as care was taken to avoid re-sampling the same sites as the drought periods. Mundy Creek Trail had 14 random sites, while 21 were done on the Colony Farms Road Trail.

All data was analyzed using RStudio (Version 2022.12.0+353) and each correlation was analyzed differently depending on what type of variables were being compared to one another. Snail presence and absence was binary, and when analyzed against non-binary factors like thatch thickness, a Wilcoxon Rank Test was used due to its ability to handle binary factors, and the fact that it doesn't require normal distribution in the data. Every variable that was measured was not normally distributed, and common forms of data transformation such as logarithmic transformation could not induce normality. For count data analysis, such as the total snails found vs thatch thickness, Spearmans Rank Correlation was used, as it too does not assume normally distributed data.

Additionally, I preformed T-tests comparing snail presence to other variables, as well as nettle presence to the number of snails found at the site. The T-Test does assume normality, which my variables lack. However, if the sample sizes are equal for each variable, the T-Test can still be robust, even when the data is not normally distributed (Zimmerman, 1987). As such, to make the sample sizes equal for the T-Test, a random number generator in R was used to select equal number of samples from the larger sample set.

Not all variables had the same number of data points due to equipment availability and changes in methods. Ground-level humidity was not gathered for the first 13 plots, after which ground-level humidity was recorded (n = 34). Similarly, soil moisture was measured after the first 23 sites (n = 37). The first 23 plots were measured during the first drought period. As such, many tests had differing degrees of freedom. The relative humidity tests did not include plots sampled during the drought, while the soil moisture tests did. For the T-Tests, due to the need for both variables needing to have the same sample size, these too had different n-values. The nettle coverage and thatch thickness T-Tests had 22 samples for each, nettle presence had 28 samples, relative humidity had 18 samples, and soil moisture had 36 samples.

Chapter 3. Results

3.1. Stinging Nettle

Overall, 231 snails were caught in 39 sample plots over a period of 6 months between May and October 2023. Most of those snails were found in small numbers, but there were a surprising number of sample plots that had more than 20 snails (Figure 5). Most snails were usually found in the first 60 seconds of surveying.

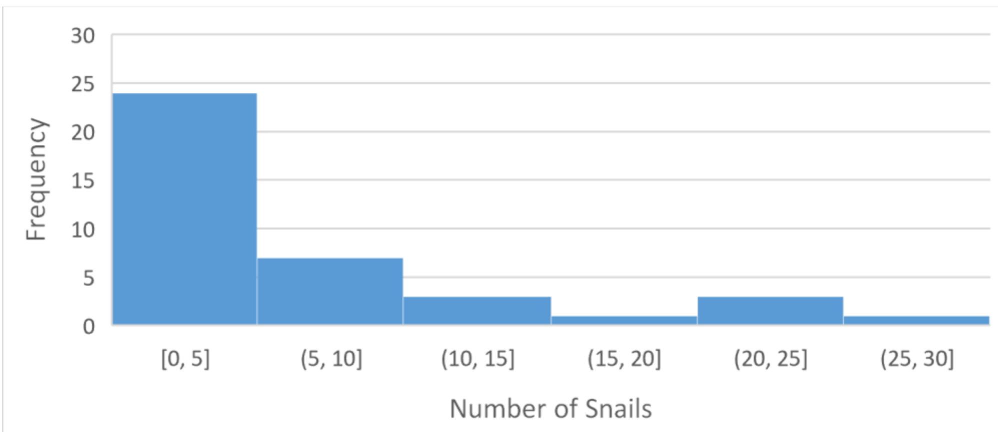

Figure 5. Frequency of snails found in each sample plot between May and October 2023 during the wet months (or spring and fall) at Colony Farm Regional Park, Coquitlam, BC.

There was a significant difference between the average (± SD) number of snails in plots with stinging nettle (8.1 ± 8.8) than plots without stinging nettle (2.2 ± 4.2; $W = 55.5$, p-value = 0.0002; Figure 6). In addition, 92% (± 5.4%) of plots with nettle also had snails compared to 35.7% (± 12.8%) of plots without nettle (Figure 7). Similarly, there was a significantly greater percent cover of nettle in plots with snails (34.5 ± 25.8) than in plots with no snails ((9.1 ± 15.27; t_{54}= -3.295 p=0.001742; Figure 8).

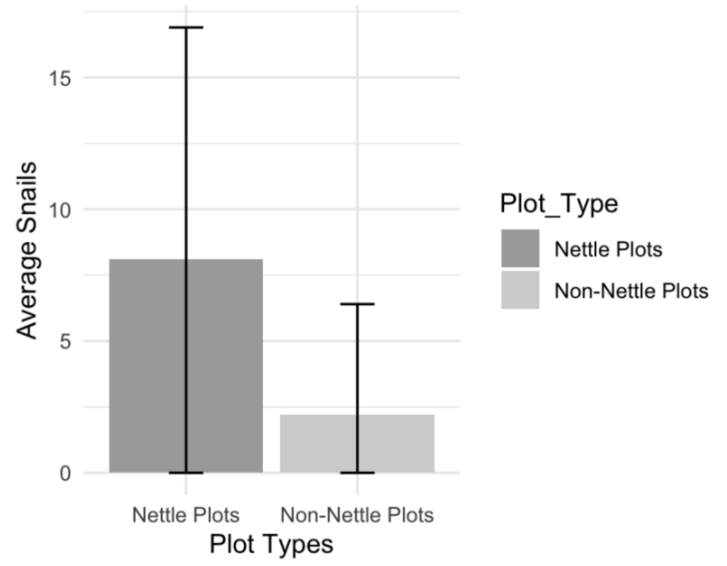

Figure 6. Average number of snails found per plot with (± 8.8) and without (± 4.2) stinging nettle at Colony Farm Regional Park (Coquitlam, BC) during the summer of 2023.

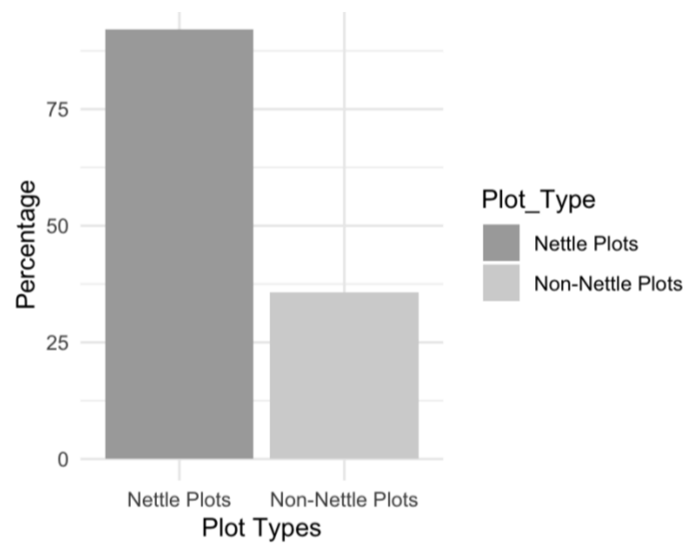

Figure 7. Percentage of plots with snails (± 5.4%) and without snails (± 12.8%) between Nettle plots and Non-Nettle plots in Colony Farms Regional Park.

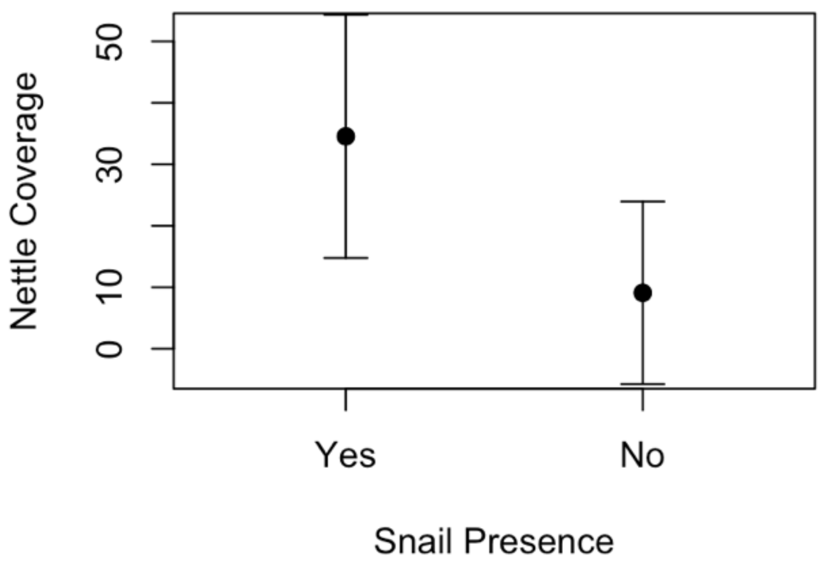

Figure 8. Means and 95% confidence intervals in stinging nettle coverage in plots that had snails and plots that didn't in Colony Farms Regional Park.

3.2. Relative Humidity

While relative humidity was shown to have an effect on the number of snails found at a sample plot (Figure 9), there was no sign that the humidity had any effect on the snails choosing one plot or another (Figure 10; Wilcoxon Rank Test, W = 122.5, p-value = 0.71). The fact that more snails show themselves in wet and moist times is in line with what was noticed in the field. There is a noticeable and significant increase in the number of snails being found at a site the higher the relative humidity is (Spearman's Rank Correlation, S = 10449, p-value = 7.039e-05).

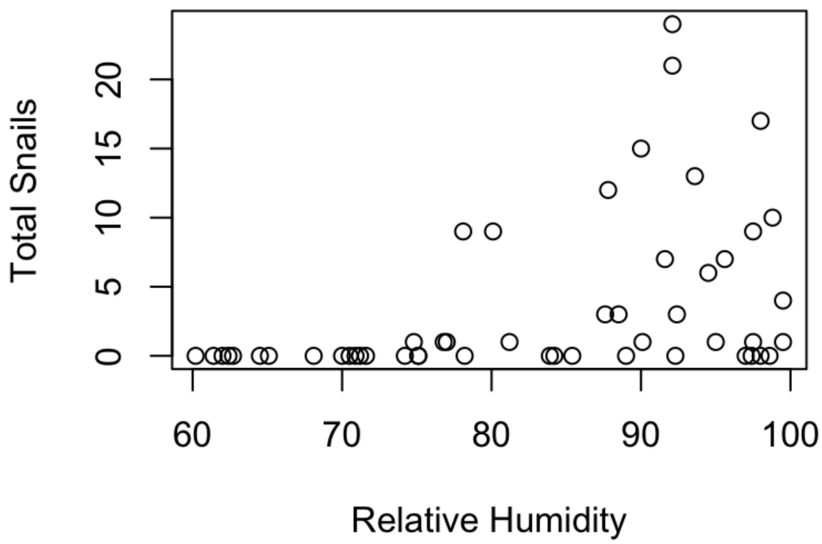

Figure 9. Number of snails found at certain levels of relative humidity in Colony Farms Regional Park.

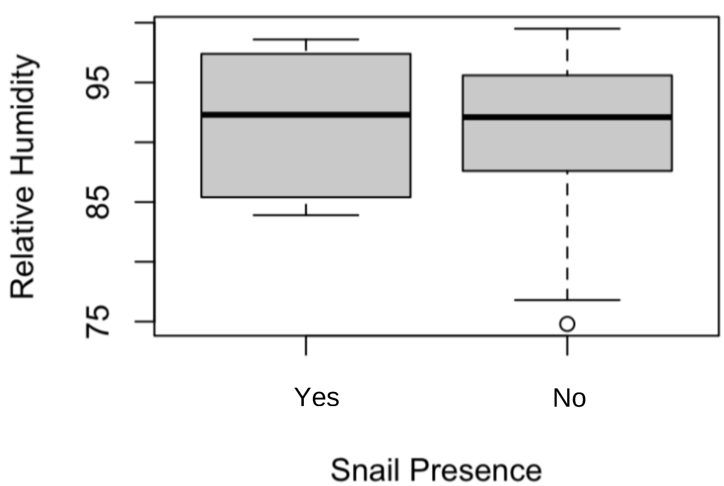

Figure 10. Relative humidity ranges at plots with and without snails found in Colony Farms Regional Park.

There was a highly significant relationship between the relative humidity and snail presence (t_{34}=-49.9, $p < 2.2 \times 10^{-16}$). Considering the overlap of 95% confidence intervals between snail presence (Mean=87.9 ± 8.6) and snail absence (91.8 ± 6.2; Figure 11), this does not seem likely. It also conflicts with the results of the non-parametric tests.

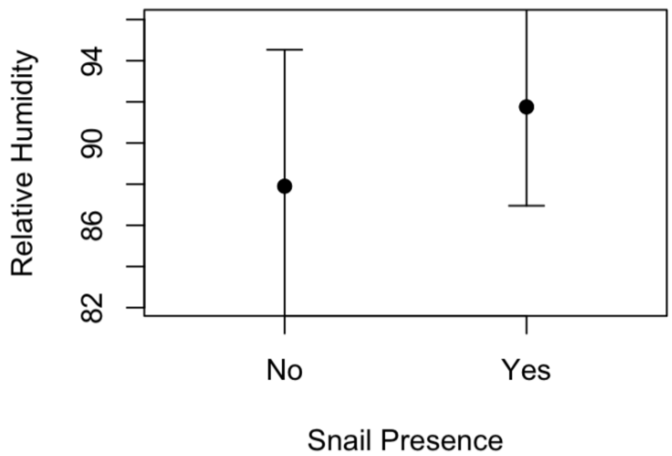

Figure 11. Mean and 95% confidence intervals for relative humidity vs snail presence for plots in Colony Farms Regional Park.

3.3. Soil Moisture

There was no noticeable effect of soil moisture on the presence of snails (Figure 12). While there is a general negative relationship between total snails and soil moisture, there is no statistically significant relationship (Spearmans Rank Correlation, S = 6307.2, p-value = 0.13) between the number of snails found and the soil moisture level (Figure 12). The nonparametric test and box plot seem to show some positive relationship between soil moisture and snail presence at a plot (Figure 13), but it is not significant (Wilcoxon Rank Test, W = 108.5, p-value = 0.06).

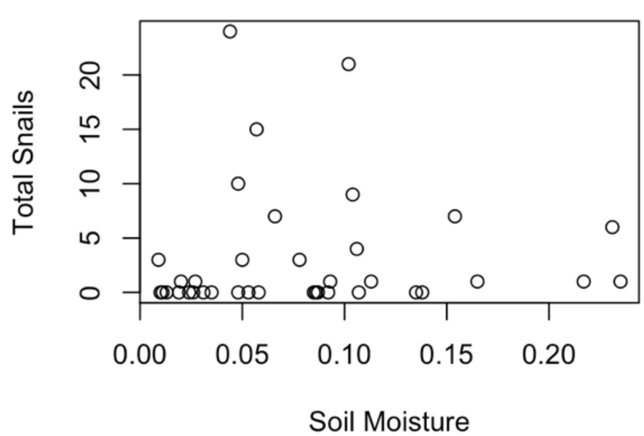

Figure 12. Total snails found at each plot compared to their soil moisture (m^3 of water per m^3 of soil) in Colony Farms Regional Park.

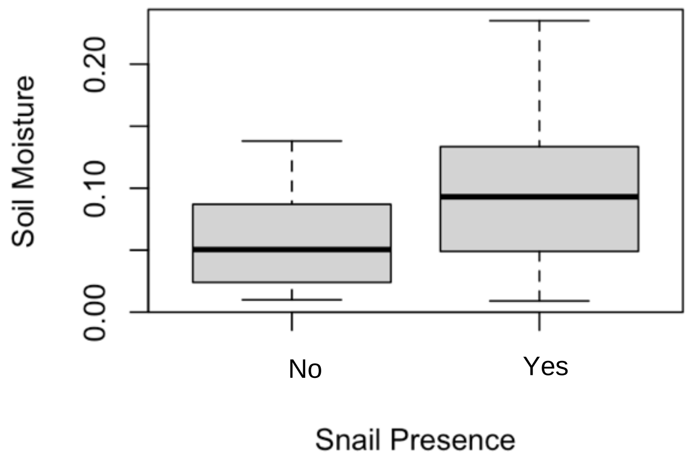

Figure 13. Soil moisture (m^3 of water per m^3 of soil) ranges at plots with and without snails.

There was a significant relationship between soil moisture and snail presence (0.104 ± 0.071) and absence (0.059 ± 0.042 ,t_{70}=4.9, p=5.616 x 10^{-6}; Figure 14). This supported by the fact that there is little overlap in their 95% confidence intervals. This is likely due to the fact that both drought and non-drought data were included in the measurements. As there were no snails found in the drought season, and the drought caused low soil moisture, this is really showing that snails were more likely to show themselves in with higher soil moisture. This doesn't mean that snails weren't on some of those plots, but they could have been hiding and not found.

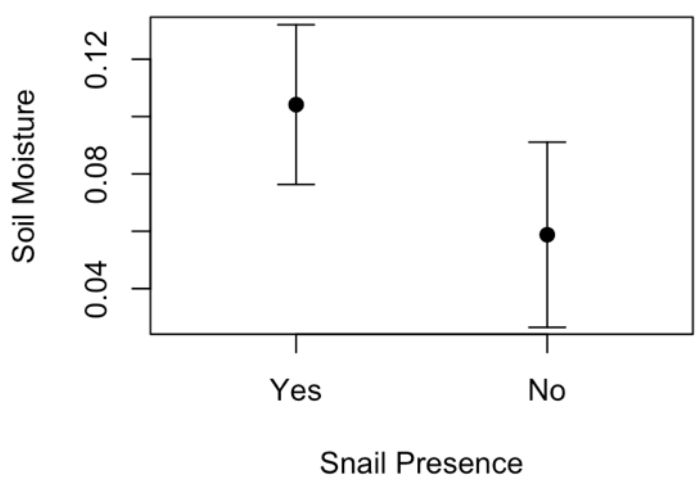

Figure 14. Mean and 95% confidence intervals for soil moisture (m^3 of water per m^3 of soil) in Colony Farms Regional Park.

3.4. Thatch Thickness

There appeared to be no significant difference (Spearman's Rank Correlation, S= 9243.2, p-value = 0.70) between the number of snails found at a site and how deep the thatch was (Figure 15). The general shape of the graph did suggest a negative trend, but it wasn't significant. Similarly, there was some indication of a positive relationship between thatch thickness and snail presence, but it wasn't significant (Wilcoxon Rank Sum, W = 101.5, p-value = 0.10; Figure 16).

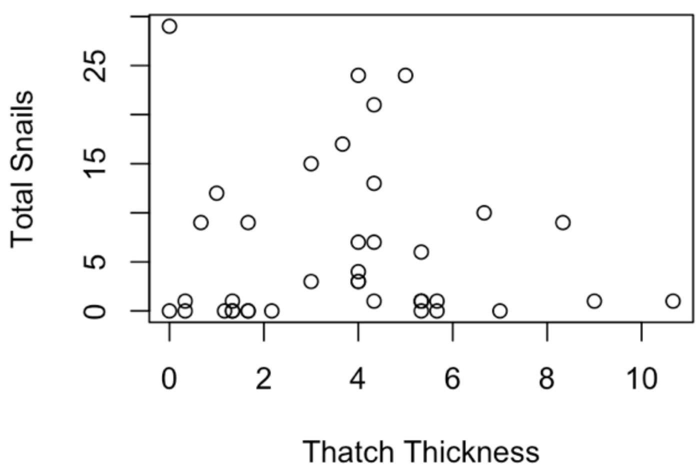

Figure 15. Total snails found at a plot compared to its average thatch thickness (cm) in Colony Farms Regional Park.

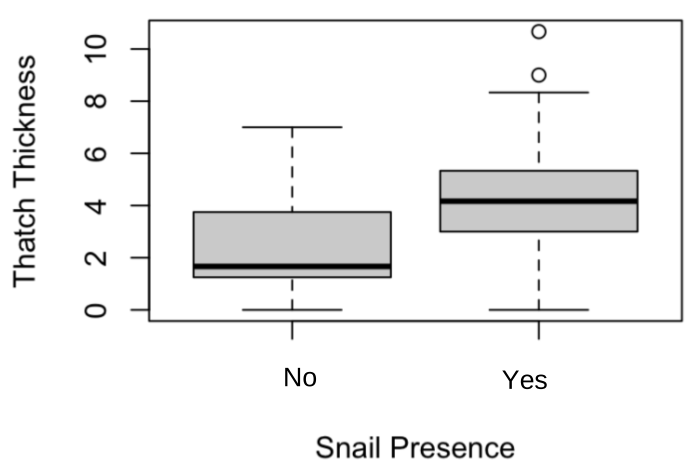

Figure 16. Average thatch thickness (cm) ranges at plots with and without snails in Colony Farms Regional Park.

The T-test, on the other hand, indicated that the positive relationship between thatch thickness and snail presence and absence was significant (t_{42}=-5.1, p=8.0 x 10^{-6}). However, there was significant overlap of the 95% intervals (Figure 17), which conflicts with this result. This also conflicted with the results of the non- parametric tests.

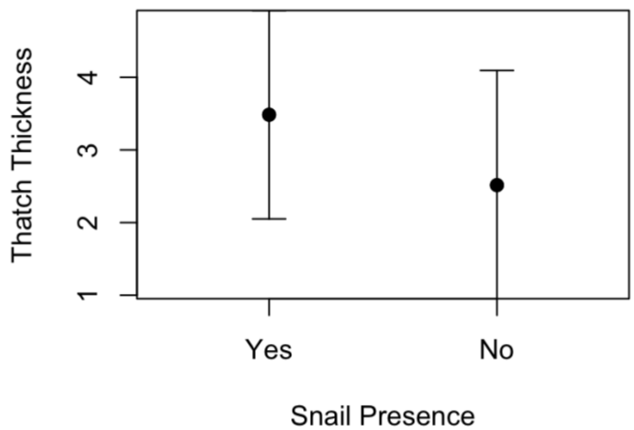

Figure 17. Mean and 95% confidence intervals for average thatch thickness (cm) vs snail presence for plots in Colony Farms Regional Park.

Chapter 4. Discussion

My results align with previous experiments that plots with nettle are strongly preferred by the snails to others, likely due to the aforementioned protection granted by the stinging nettles defenses and its high nutrient content of calcium. Considering that Oregon Forestsnails can eat the debris from the nettle, the nettle while it's still alive, and their slow travel speed, it's easy to see why they live around and on the plants. In addition, the standard deviation of the non-nettle sites was twice the mean. This showed a very diverse data set that was skewed to one side and had a few outliers. On two non-nettle plots one had 12 snails, and the other had 10. These plots, while they had no nettle in them, did have nettle nearby. In fact, these 2 plots had 22 of the 31 (71%) snails that were found on non-nettle sites. It is possible that the snails were simply traveling to the next patch of nettle through these non-nettle plots when they were found. Even if these two outliers were removed, it only supported the theory of nettle being important for the snails.

Other factors proved to be less clearly obvious. While data was gathered throughout the summer and into the fall, Oregon Forestsnails often did not come out during the summer due to the drought and high temperatures. This resulted in snail data only being gathered shortly after rainfalls, or during the fall when the morning fog and dew made it cool and moist enough for them to come out. During this drought period, no snails were found in any plots, though a few were found outside of them, although this was extremely rare. The ones that were found were noted to have placed a film of mucus over the opening to their shell, that hardened into a barrier. This is likely a measure to seal themselves in to prevent moisture loss. While sealed in, they seem to have placed themselves into a torpor to save energy while they wait for wetter conditions. This response to drier conditions should be studied in the future, especially as this could be the survival mechanism that allows them to endure climate change in the future.

Relative humidity seems to be a particularly useful parameter. The snails never showed themselves at any point when there was a relative humidity of less than 75%. Furthermore, they never consistently showed themselves in large numbers (greater than 10 snails in a 5-m^2 area) unless there was a relative humidity of 85% or higher. This may be a factor in other areas, but Colony Farms Regional Park is a wetland that used to be a floodplain, and frequently experiences fog and rain. It is a very lush area. The relative humidity never dropped below 60% in any of the ground-level readings, and never dropped below 75% unless it was during the drought times with no recent rain. At least, not between 7:00 am and 1:30 pm which is when the sampling took place. As such, relative humidity might be even more important in other areas of the Fraser Valley, where it might not be so moist. However, there was not enough data to show that the snails were picking individual plots within the park based on the ground level relative humidity. Despite that, I believe all future proposed habitats for establishing a new colony of Oregon Forestsnails should have their ground-level relative humidity monitored throughout the summers to ensure that the relative humidity is consistently high.

As measurements were taken of the area during the drought, and shortly after rainfall periods, it was expected that there would be some relation between soil moisture. The overall data suggested that there was a positive relationship between soil moisture and snail presence. However, that doesn't necessarily mean that snails were selecting certain areas due to how moist the soil was. As many of the plots that had no snails, and soil moisture was measured during the droughts, it is just as likely that this data simply showed that snails were less likely to be found when the soil was dry, not that the snails weren't there. They might have simply been in hiding during those times.

On the other hand, thatch thickness was less clear. Overall, thatch thickness showed a generally positive correlation between snail presence and thicker thatch, though not enough to be considered significant. This isn't an overly surprising result, as being able to hide themselves from the elements and predators is quite an advantage for survival. However, interestingly, the thatch seemed to indicate the possibility of a generally negative trend between the thatch thickness and the total number of snails present in the plot. There are a few possible explanations for this. Firstly, the snails may have difficulty traversing through especially thick thatch, with their rigid shells acting as a hindrance. Another possibility is that the thicker thatch actively hindered the ability to search for snails during the sampling.

Finding yellow-brown snails amongst dead leaf litter and fallen stems of stinging nettle is not an easy task. Considering that each plot had to be done in a reasonable amount of time, and not bias certain plots against others, a time limit of 3 minutes for snail searching was put into place. As such, while 3 minutes was more than enough time for most plots, the ones with especially thick thatch may have required more time for a truly thorough search. I would suggest that further studies into the effects of thatch thickness on snail presence and numbers be done in the future. Some potential studies include doing extremely detailed studies on plots, down to the complete removal of all thatch.

That was not the only limitation of this study. This was a study of a single isolated population in a single park. What was found in this study may not be fully useful for other populations of Oregon Forestsnails. In addition, this study focused only on where the adult snails were, due to the nature of the mark and recapture program. Young Oregon Forestsnails are difficult to properly identify, making finding and sampling them difficult (Oregon Forest Snail Best Management Practices Field Guide, 2018). Finding their eggs in this type of study is near impossible, as they tend to be buried in shallow burrows, and the eggs cannot be easily identifiable against the eggs of other snail species. It is not uncommon for species to use different habitats for different stages of their lives, and this study can only state what types of habitats the adults and juveniles were found in.

Overall, this study matched the studies of habitat requirements of Oregon Forestsnails by other groups, moist with lots of stinging nettle (Steensma et al., 2009; Durand, 2006).

With this data, I hope to better inform those who seek to preserve this species and potentially establish new populations in Colony Farms Regional Park and elsewhere in the Fraser Valley.

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