Comparing the Rate of Secondary Succession in a Raised Garden Bed and an in Ground Garden

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Abstract:
The objective of this study was to compare the rate of secondary succession in a raised garden bed and an in ground garden which was left empty since September. I predict that the raised garden bed would have a lower rate of secondary succession because of its physical structure which makes it hard for plants to disperse. To measure the rate of secondary succession, the two areas were divided into 3 plots and the number of species in each plot were counted to obtain an average species per plot. All the data was collected in one day. The analysis on the data using a two sample t-test ($p = 0.65 > \alpha = 0.05$) determined that there was no significant difference in the mean number of species in the ground garden (3.7) and the raised garden bed (4). Therefore, I am unable to reject the null hypothesis that there was no difference in means between the two areas. The results of the experiment were inconclusive on which area had a faster rate of secondary succession. I suggest future experiments with more data to explore the topic further because having knowledge in the trajectory in secondary succession can help us understand habitat restoration and will let us better plan restoration strategies.

Introduction:

Ecological succession is the process in which a biological community changes over time. There are two main types of ecological succession: primary and secondary. Primary succession occurs in areas where there is essentially no preexisting life or soil. This can include hardened lava flow or the bare rocky area left by a landslide. Secondary succession occurs in areas where previously existing plants are removed but there are still nutrients and soil to support new life (Thompson, 2018). A common example of this is when plants and animals reclaim an area cleared by a forest fire or a logged area of a forest. This experiment aimed to explore secondary succession on a small scale in my backyard. In my backyard, I have two separate spaces that are used for gardening fruits and vegetables during the spring and summer. One of the spaces is a raised garden bed which is elevated and is separated from the rest of the lawn. The second space is an in-ground garden which is at ground level and separated from the rest of the lawn by wooden planks. When fall time came, all the garden plants were removed and the spaces were left bare.

The purpose of this study is to compare the rate of secondary succession in the raised garden bed and the in ground garden. I hypothesize that the raised garden bed would have had a lower rate of secondary succession as measured by species richness compared to the in-ground garden because of its physical structure which makes it difficult for plants to disperse. The raised garden bed is elevated and the bottom of the bed is also separated from the rest of the lawn by a tarp like material. Due to these physical properties, it should be harder for other plants to reach the raised garden bed.

Secondary succession can be impacted by the chemical/physical properties of the soil such as clay composition and the topography of the area. However, these properties appear to be more important in later stages of secondary succession when larger shrubs and trees begin to appear (Robinson et al. 2015). Additionally, early successional plant types are fast growing, reproduce quickly, and can withstand harsh environments (Huston & Smith 1987). Therefore, this experiment focused on how the physical differences in the two garden areas would impact the dispersal of early successional plants and how it would affect secondary succession.

Plants can disperse by spreading seeds or through vegatative propagation. Vegetative propagation is a type of asexual reproduction where new plants grow off of a fragment of the parent or from reproductive structures like rhizomes or stolons (runners) (Sorensen & Garland, n.d.). Moss and clovers are examples of types of plants that can spread through vegetative propagation. The in ground garden would be accessible to these types of plants whereas the raised garden bed would only be accessible by airborne seeds.

Methods:

The data was collected on March 12, 2021 in Vancouver, BC. Assuming the garden areas were cleared out around September, there was approximately 7 months for secondary succession to occur. To compare which area had a faster rate of secondary succession, the species richness of the two areas were compared. To measure species richness, each area was measured and divided into 3 equal sized plots (figure 1). Each unique species of plant was counted for each plot and the species was identified using iNaturalist. For each species, a photo was taken on the iNaturalist app to identify the species. iNaturalist allows users to upload observations and the community of users can help identify the observations (figure 2).

Figure 1. Measuring and dividing the raised garden bed into 3 equally sized plots for data collection.

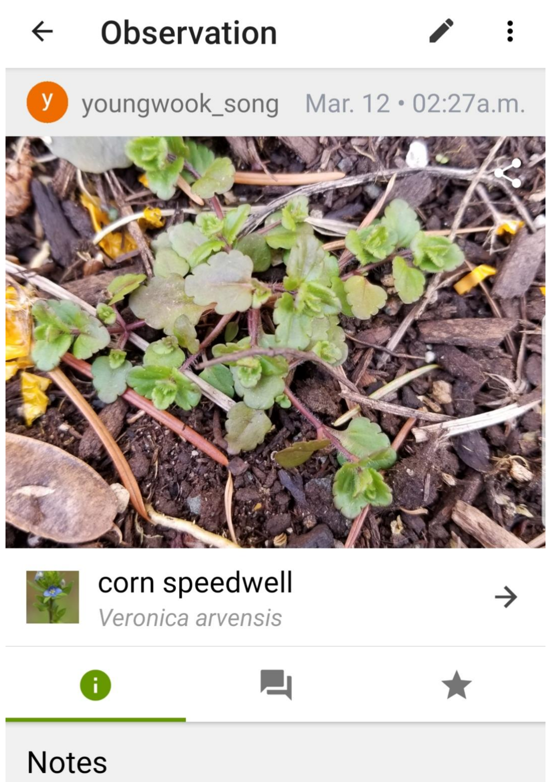

Figure 2. A plant from the raised garden bed identified as Veronica arvensis (common name corn speedwell) on the iNaturalist app.

Once the species richness data for each area was collected, the mean number of species for the two areas was graphed and a two sample t-test on excel was used to analyze the data.

Results:

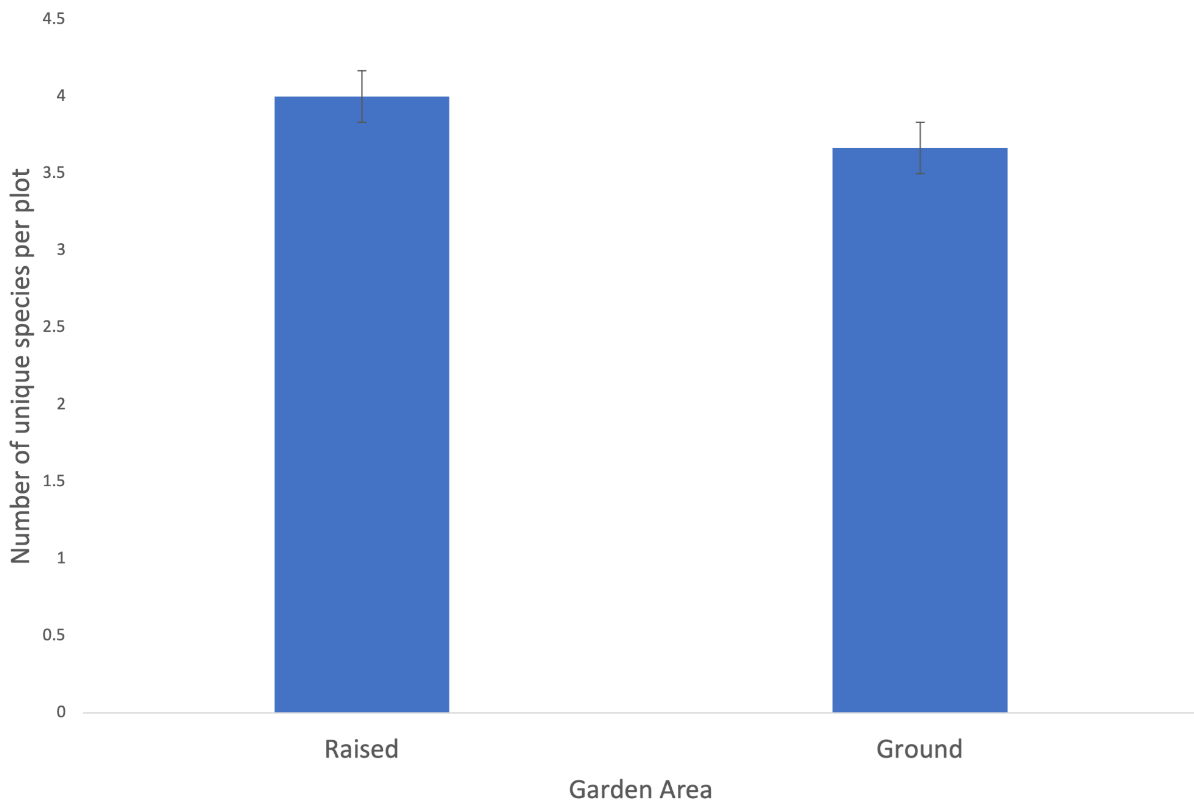

Figure 3. The mean number of species per plot for the raised garden bed and the in ground garden (n=3). The number of species per plot was used to measure species richness. Error bars represent standard error. p = 0.65, calculated from a two sample t-test.

Figure 3 shows the mean number of species per plot for each of the two garden areas. The number of species per plot was used to measure the species richness which was then used as a measure of secondary succession. The raised garden bed had an average of 4 species per plot and the ground garden had an average of 3.7 species per plot. The raised garden bed had a standard deviation of +/- 1 and the in ground garden bed had a standard deviation of +/- 0.57. From the two sample t-test, a p value of $0.65 > \alpha = 0.05$ was obtained. A significance level of 0.05 was chosen because a 95% confidence in the results is a conventionally accepted level of significance. From the obtained p value, there were no significant differences in the mean between the two areas and the null hypothesis that the two garden areas would have the same species richness can not be rejected.

Discussion:

The purpose of this study was to compare the rate of secondary succession in a raised garden bed and an in ground garden. From the p value obtained from the two sample t-test, the difference in means was not statistically significant and failed to reject the null hypothesis that the mean number of species in both areas are the same. Therefore, I can not provide support for the alternate hypothesis that the raised garden bed would have a lower rate of secondary succession compared to the in ground garden.

Rather than seeing a difference in species richness, a difference in the species composition was observed. The in ground garden had many types of plants capable of vegatative propagation whereas the raised garden bed had many types of plants which can only spread by seeds. For example, moss was the most abundant type of plant in the in-ground garden. On the other hand, the raised garden bed had a high abundance of plants from the mustard family which depend on seeds to disperse (Douglas et al. 1998). This difference in species composition does suggest that types of plants which primarily depend on vegetative propagation could not reach the raised garden bed and would need airborne seeds. Despite the differences in species composition, the differences in species richness was not significant. These results could be possibly explained by the fact that there was not enough data, variables other than the physical structure played a role, or it could just be that the physical differences between the two areas was not enough to create a diverging trajectory in secondary succession.

Due to the time of the data collection, the number of species in the areas were quite small, and this sample size could result in inaccurate results. The garden spaces were left alone since September and the data collection happened in March. The early stages of succession depend on the dispersal of early successional plants (Huston & Smith 1987), but during the fall and winter months, many of these species are less active or do not grow at all. In future experiments, it would be better to observe over a longer period of time, and during warmer months as well.

Furthermore, there were many limitations of the experiment. Natural ecosystems are complex and there would have been many factors other than the physical structure and location of the two gardens which would impact plant growth and dispersal. One noticeable observation made during the day of data collection was that the soil of the in ground garden appeared to be moist, whereas the raised garden bed was dry. This could have been a result of a difference in sunlight exposure for each area which also can impact plant growth. Many other studies looked at secondary succession on a large scale and looked into complex models taking into account other factors such as initial disturbance intensity, species composition, soil nutrients, and land topography (Turner et al, 1998). However, due to the time limitations and no access to equipment, the scope of the experiment was limited.

Human error could have occurred during the data collection. When counting the number of unique species, this was done by eye and there could have been mistakes. For example, two of the same species could have been identified differently or a different species could have been identified as the same species. Additionally, the species identification on iNaturalist can be unreliable because the identifications are often not done by professionals. For many of the species uploaded on to iNaturalist, the species was not identified.

While the present study failed to provide a conclusive comparison of a raised garden bed compared to an in ground garden, improvements to the study could provide better insight. Using species richness could be a misleading indicator because this does not take into account the relative abundances of each species. In future experiments, instead of only looking at the species richness, the total plant coverage can be looked at or the Shannon's index can be used to determine the species diversity.

Conclusion:

The results of this experiment found no significant difference in the mean number of species between the raised garden bed and the in-ground garden. The experiment failed to support the alternate hypothesis that the raised garden bed would have a lower rate of secondary succession compared to the in ground garden. However, future experiments done in warmer months taking into account factors other than species richness could provide better insight into factors affecting secondary succession which can help us better plan habitat restoration strategies.

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Appendix:

Appendix I.

	Raised Garden Bed (# of species)	In-ground Garden (# of species)
Plot 1	3	3
Plot 2	4	4
Plot 3	5	4

Appendix II.

Identified plants in the raised garden bed	**Identified plants in the in-ground garden**
corn speedwell	grasses
groundsels and allies	clovers
mustard family	moss
common dandelion	clovers
grasses	unidentified*
unidentified*	unidentified*
	unidentified*

Many plants were not specifically identified by the community on iNaturalist and given a broad identification such as “plants”*