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Ecology, Environment, and the Anthropocene
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Term Project

Proposal

My project focuses on the successional dynamics between terrestrial and aquatic ecosystems using several example studies. My project aims to demonstrate that despite their differences terrestrial and aquatic ecosystems share many factors that affect the successive process. My project will cover features that affect the succession process for terrestrial ecosystems and compare them to features that affect succession in aquatic ecosystems. Succession is the process in which an area is colonized by plants, which starts with small mosses lichens and or phytoplankton and leads to plants that are faster growing and sun loving and ends with more shade tolerant and slower growing plants. Succession also involves animals, as animals have been seen to have top down control on succession which is just as, if not more, influential as bottom up control. Succession is affected by a vast multitude of things beyond animal intervention. Temperature and rainfall also affect how "far" the successive process goes.

Terrestrial and aquatic ecosystems do have some similar factors that affect the successive process. Succession, in both aquatic and terrestrial ecosystems, can be controlled by either top down or bottom up means. Top down implies the effects of predators on animal and/or plant populations and how this affects the ecosystem. Bottom up implies the soil, climate and plants control the direction succession takes. Both of these control methods alter the direction and extent of the successive process. These can combine in controlling ecosystems, features like climate determine which plans can take root and predators determine which of those plants get to develop widely in that area.

Herbivore grazing plays a major role in shaping both aquatic and land based plants that develop during succession. Scientist, Oswald Schmitz performed a study in which he removed top predators from an old English field to see the effects the predators had in a top down control over the field's successional process. The removal of the predators irreversibly changed the successive process from top down to bottom up. With predators out of the way plants had free reign and were forced to compete more aggressively with one another for limited resources such as: space, sunlight and soil. We can clearly see that removing these predators has dramatically altered the terrestrial ecosystem that Schmitz was testing, proving the effect that herbivores had on the field's terrestrial succession [5].

For aquatic ecosystems scientist Mark Hixton tested herbivore grazing on coral reefs by caging algal blooms on coral to prevent fish from grazing on them and comparing their growth rates to the uncaged coral. Hixton found that the caged algae on coral, spared of aggressive fish grazing, developed through three stages: early, mid and late succession. This ability to grow and really develop was created because of the lack of predators for the caged test subjects. The uncaged algae did not nearly develop as far due to the aggressive fish grazing. This demonstrates that algae covered coral subjected to fish grazing develops less than algae covered coral removed from fish grazing. This implies that the herbivores, fish in this case, had a large effect on the successional development of the algae's development much like the findings in Schmitz experiment [4]. Here we see that despite their differences herbivores dramatically affect and alter both terrestrial and aquatic successive processes.

Likewise, soil also plays a large role in both aquatic and terrestrial succession. The availability and nutrition of soil as well as the relations of neighboring plants play important roles in terrestrial and aquatic succession. Scientist Test Van De Voorde studied the effects that soil had on succession in relation to available nutrients and plant relations. Van De Voorde discovered that the relationships between pre-existing plants and the soil effects can alter the order and species of plants that grow during the successive process. Van de Voorde notes that legacy effects of soil properties, both abiotic and biotic, tend to have major influence on plant community structures during later stages of succession. How much soil is available, which nutrients are in that soil and which plants are in the area are shown to determine the order and type of plants which proves that soil types have an effect on terrestrial succession processes [6].

Scientist Caitlin Crain studied and wrote about similar soil effects in marsh areas, which provide both terrestrial and aquatic qualities. Specifically Crain studied and compared relations between soil and early successive species in brackish, salt and oligohaline marshes. Crain found that oligohaline marshes have 24 times the seedbank, area of ground capable of holding seeds and not washing away, of salt marshes which allows them to have more seed availability and a tolerant model form of succession. Tolerant succession allows for more diversity as there is more competition since succession is not about pioneer species but instead about competitive special development. Brackish and saline marshes have vegetative runners, plants with horizontal budding roots, and tend towards facilitated succession, succession driven by early successional species typically known as pioneer species [2]. Both of these studies demonstrate the importance of soil in both terrestrial and aquatic environments. Soil helps determine the diversity of plants and the amount of competition. Soil is important for determining what can grow where and is a large part of bottom up successive control.

Many factors can affect succession but they don't all have to be "natural". Human intervention can have major effects on the successive process of both aquatic and terrestrial environments. Humans can alter the successive process by removing certain species which can change an entire successive environment such as the removal of predators in the field found in Schmitz article. Overfishing and harvesting has severely damaged many aquatic ecosystems and dramatically altered succession in those areas. The scientist Lisandro Benedetti-Cecchi studied the arising developments in a rocky shore environment after the removal of limpets, a type of snail. Benedetti-Cecchi found that limpets were preventing the monopolization of filamentous algae. The algae flourished in their absence taking over the rocky floor. Limpets allowed for the development of rissoella and rivularia bacterial colonies as well as barnacle colonies. These colonies suffered with the loss of the snails, especially inhibiting the development of rissoella colonies. This demonstrates that the removal of a predatory species, in this case the limpets, caused a shift in successional dynamics for this aquatic environment [1].

Scientist Lawrence Walker performed a similar land study where he removed the woody early successional plants from areas of recent landslides in Puerto Rico. Walker found that removing these species did allow for a surge in special development but ended up both hurting and helping succession. For example, removing the tree ferns and other early woody plants allowed other plants, like scrambling ferns to develop with the new access to sunlight and soil. However the ferns soon decreased forb and woody plant richness as they took over more and more ground. The removal of early woody plants and tree ferns decreased forb and special richness, as we saw with the ferns taking over, but promoted richness of later succession woody plants. This positively aided long term development [7]. These two examples show that human intervention in the way of removing a species can have a major impact on succession in both terrestrial and aquatic environments. The layout of both experiments shifted dramatically after humans removed limpets and woody plants respectively. We saw new species taking hold and rising to control the environment with the absence of the removed species. These slight shifts in power dynamics demonstrate the effects of sudden special removement in these ecosystems. This proves that human removal of species altered the successive process in both of these environments.

To consider all aspects of succession I have included one example of a mostly terrestrial successive influence: evaporation. George Fuller studied the effects of evaporation on terrestrial succession in the sand dunes of Lake Michigan. Fuller determined that evaporation is a major part of land succession because evaporation during the growing season can determine the growth of plants. The evaporation in the cottonwood dune area of the sand dunes of Lake Michigan causes xerophytic plants, plants which are can tolerate areas of low water and have good water storing abilities, and a lack of undergrowth. The evaporation in the pine forest exceeds the oak and beech tree areas due to the vernal mesophytic vegetation, plants that are not adapted to handle particularly wet or dry climates, surrounding it. In winter the deciduous forests evaporation rate exceeds the pines. These show that rates of evaporation, like climate and temperature, are important factors in the successive process. Evaporation is not nearly on this important a scale for aquatic systems since the majority of the plants remain submerged year round therefore making this mostly a terrestrial successive influencer [3].

I would like to incorporate the scientific ideas of the factors which affect both terrestrial and aquatic ecosystems as well as evaporation which only affects terrestrial systems. Soil type and nutrient availability affects succession in both terrestrial and aquatic ecosystems by regulating amount of competition and availability of nutrients necessary for certain plant growth. Herbivore grazing affects succession both terrestrial and aquatic ecosystems by providing top down control on plants and preventing species from developing too much or covering too much space. Species removal affects succession in both terrestrial and aquatic ecosystems by altering the layout of the ecosystem and allowing other species to fill the removed species position and change the structure of the ecosystem. Evaporation affects succession in terrestrial ecosystems by regulating the growth of plants through altering the availability of water.s

My creative work will take the form of several animated looping gifs which illustrate similar effects of the aforementioned factors on succession in both aquatic and terrestrial environments. Each land successive cycle will have a correlating aquatic successive cycle which shows the influence of one of the factors on the successive process. Each of the scientific ideas listed above, with the exception of evaporation, will have two separate animated cycles. One will be a terrestrial successive cycle the other will be an aquatic successive cycle. This will be done so that the viewer can see the effects of each factor on both types of ecosystem. For example there will be one terrestrial animation of cows in a field regulating plant growth as new shoots do not have time to bud and grasses cover most of the ground. Alongside it there will be an aquatic animation of damselfish feeding on algae formations in coral reefs and preventing algae from developing into later stages. Both will show how herbivores affect the successive process and allow the viewer to see the connections between the two different ecosystems. Evaporation will be the only exception as evaporation will only have a terrestrial animation seeing as it mostly affects land plants due to the submerged nature of most aquatic plants.

Bibliography

1) Benedetti-Cecchi, Lisandro. “Predicting Direct and Indirect Interactions during Succession in a Mid-Littoral Rocky Shore Assemblage.” *Ecological Monographs*, vol. 70, no. 1, 2000, pp. 45–72. *JSTOR*, JSTOR, www.jstor.org/stable/2657167.

This article contributed to the argument of the effect of human removal of species on the successive process. The experimental removal of limpets from the controlled environment and the resulting effects on colonies of rissoella, rivulaira and barnacles demonstrate the impact on the successive process for an aquatic ecosystem.

2) Crain, Caitlin Mullan, et al. “Secondary Succession Dynamics in Estuarine Marshes across Landscape-Scale Salinity Gradients.” *Ecology*, vol. 89, no. 10, 2008, pp. 2889–2899. *JSTOR*, JSTOR, www.jstor.org/stable/27650834.

This article contributed to the argument of the effects of soil properties on the successive process of aquatic, as well as terrestrial ecosystems. Marshes exhibit both aquatic and terrestrial qualities however in this case the article was used for an aquatic example. The differences in seed banks and the availability of nutrients affect the successive models in brackish, oligohaline and salt marshes. These findings support the idea that soil affects the successive process.

3) Fuller, George D. *Evaporation and Plant Succession*. Chicago, University of Chicago Press, 1912.

This book demonstrates the effects of evaporation on the successive process on terrestrial ecosystems. Lake Michigan sand dunes house many different forested areas. This book illustrates the differences in environments and the relation to evaporation. Evaporation is shown to affect which plants grow where due to the amount of available water and evaporation rates. This proves that evaporation affects the successive process.

4) Hixon, Mark A., and William N. Brostoff. “Succession and Herbivory: Effects of Differential Fish Grazing on Hawaiian Coral-Reef Algae.” *Ecological Monographs*, vol. 66, no. 1, 1996, pp. 67–90. *JSTOR*, JSTOR, www.jstor.org/stable/2963481.

This article demonstrates the effects of herbivores on the successive process in an aquatic environment. The herbivores grazing on the algae found in the controlled reef environment reveals that large grazing prevents algal development into mid and late stages of succession. The caged algaes, under no threat of grazing, were able to develop into late successive stages. This shows that the herbivores affect the successive process of the coral reef.

5) Schmitz, Oswald J., et al. "Alternative Dynamic Regimes and Trophic Control of Plant Succession." *Ecosystems*, vol. 9, no. 4, 2006, pp. 659–672. *JSTOR*, JSTOR, www.jstor.org/stable/25470368.

This article demonstrates the effects of grazing in terrestrial ecosystems, an old english field. We see this in the removal of top predators on the field which forces the plants into higher levels of competition. Soil amount and sunlight availability become the main concerns as the field dynamic shifts which shows the power the herbivores had on controlling the ecosystem. With their absence the entire layout of the field changes and new plants take over.

6) Van de Voorde, Tess F. J., et al. "Intra- and Interspecific Plant—Soil Interactions, Soil Legacies and Priority Effects during Old-Field Succession." *Journal of Ecology*, vol. 99, no. 4, 2011, pp. 945–953. *JSTOR*, JSTOR, www.jstor.org/stable/23027658.

This article demonstrates the effects of soil on a terrestrial ecosystem. The abiotic and biotic properties of the tested soil determined the order and prevalence of the plants that developed during succession. Neighboring plants and the amount of nutrients they absorbed also determined which plants could grow where. This shows soil's effect on succession in a terrestrial ecosystem.

7) Walker, Lawrence R., et al. "Early Successional Woody Plants Facilitate and Ferns Inhibit Forest Development on Puerto Rican Landslides." *Journal of Ecology*, vol. 98, no. 3, 2010, pp. 625–635. *JSTOR*, JSTOR, www.jstor.org/stable/40731842.

This article demonstrates the effect of species removal by humans on terrestrial ecosystems. The experiment involved removing early successional woody plants from landslide areas in Puerto Rico. The removal of plants both facilitated and inhibited forest development. They ultimately did change the successive process. Ferns spread and inhibited special richness by taking over a lot of the ground but they allowed the development of later succession trees which aided long term forest development which was ultimately beneficial. This demonstrates the effects that the species being removed had on the successive process as the structure changed allowing different parts of succession to play out and changing special richness.

Project Table

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| Soil type and nutrient availability affects succession in both terrestrial and aquatic ecosystems by regulating amount of competition and availability of nutrients necessary for certain plant growth. | This idea will be incorporated through two separate gifs, one of a terrestrial and one of an aquatic ecosystem. These will show soil's effect on succession by demonstrating available nutrients in the soil and having different plant types emerging in the gif depending on the soil type, space and nutrients. |
| Herbivore grazing affects succession both terrestrial and aquatic ecosystems by providing top down control on plants and preventing species from developing too much or covering too much space. | This idea will be incorporated through two separate gifs, one of a terrestrial and one of an aquatic ecosystem. Here the gifs will each show an example of ungrazed succession and them show the effects the predators have on the successive process and how they prevent other plants from growing or developing further. |
| Species removal affects succession in both terrestrial and aquatic ecosystems by altering the layout of the ecosystem and allowing other species to fill the removed species position and change their position in the ecosystem. | This idea will be incorporated through two separate gifs, one of a terrestrial and one of an aquatic ecosystem. In each gif the successive process will be shown with all present species. The gif will then loop and show what happens when the species is removed allowing the viewer to see how the successive process is altered. |
| Evaporation affects succession in terrestrial ecosystems by regulating the growth of plants by changing the availability of water. | This idea will be incorporated through a simple animation of a land successive system. Here there will be an area with different amounts of rainfall. The less rainfall will lead to a cottonwood like sand dune area, more rainfall will mimic ecosystems more like the hardwoods and pines. |