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Modeling the Effect of Post-Dispersal Seed Predation on Tropical Tree Species in Panama

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Abstract

Palm trees provide a unique opportunity to study what conditions optimize the probability that a seed will grow successfully. The seeds of palm trees, endocarps, are large and easy to locate. When they don't grow, predators leave marks on them that tell the story of their fate. The focus of my experiment is to determine how the current distribution pattern of parent palm trees in Panama Palm trees affects the the future distribution of seedlings. I have programmed a versatile model that takes the assumption that bruchid beetles are the sole predators acting on the seeds, and that these fall from the trees in an inverse logarithmic density pattern. The beetles are programmed to move to a random seed within an arbitrary distance of their start point. If no seeds are near enough to them, then they starve. I hypothesize that the beetles will decrease clumping within five generations.

Introduction

Population projection analysis can be used to determine the growth rate of a population. If the leading eigenvalue is greater than 1, then the population is in a state of growth at its equilibrium. If the leading eigenvalue is below 1, then the population is in a state of decline.

I chose to focus my simulations on Panama palm trees because:

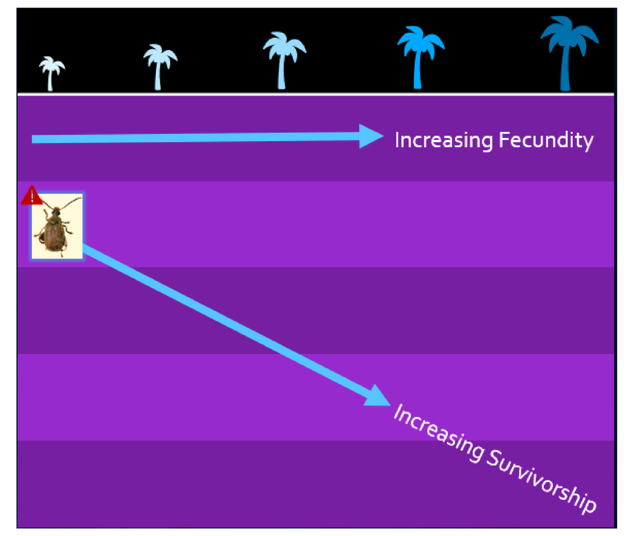
- The seeds retain scars from predation events, such as claw marks and emergence holes.
- Significant study of palms in Panama has given enough characterization about their predators to create complex simulations.

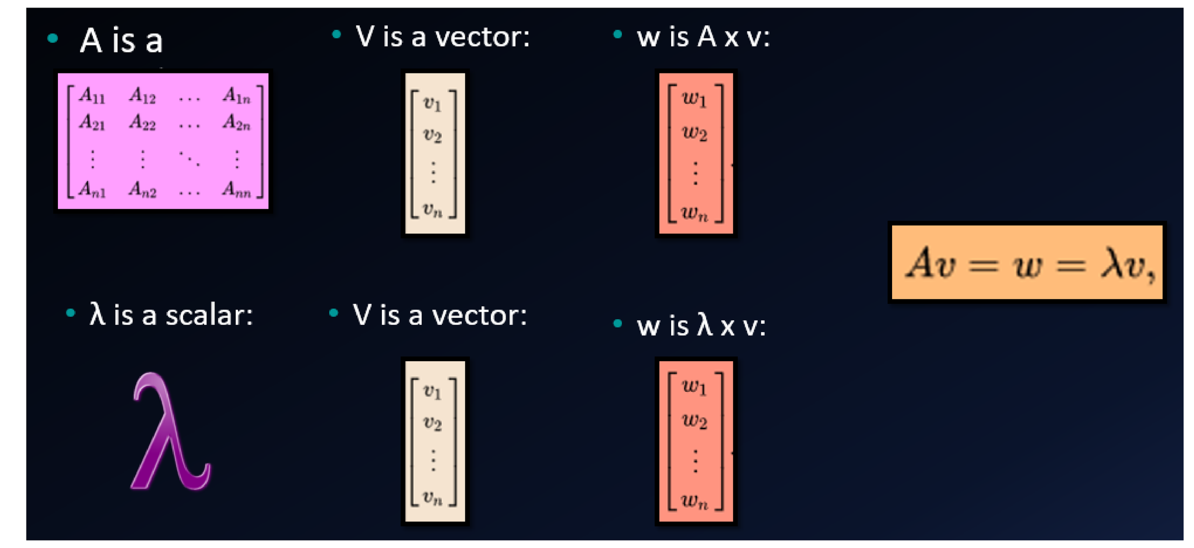
Population projection matrices rely on the assumption that survivorship and fecundity values for a population can be assumed to remain constant. This allows the age class distribution of a species to come to an equilibrium value. The growth rate that is observed is thus characterized as the growth rate for a species when the species is in stage class equilibrium

Specific Limitations working with tropical tree species:

- Age class Data is hard to come by for long-lived tropical species because trees in tropical environments to not produce seasonal growth rings.
- Stage Class matrixes must be calculated based on a size of an individual

Figure 1- Methods for Eigenvalue Calculations





User Interface: *This simulation can take input from the user that describes the dynamics of the existing population.*

Methods

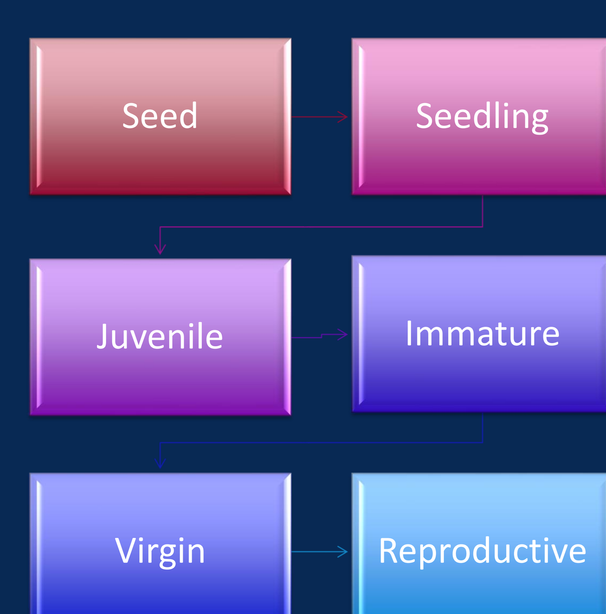
- Simulations of Beetle Predation in R statistical software
- Eigenvector & Eigenvalue analysis for Population Projection matrices
- Assumptions of Population Projection Matrices

1. Survivorship and Fecundity values are held constant
2. Stage classes based on size can be used
3. Density-independence

Results

- The model reports that the larger fragment (III) is more sensitive to predation than the smaller Fragment (I). (Figure 2)
- Populations crash if the seed predators kill more than 99% of the seeds
- Eigenvector Analysis shows that there is a 0.01% difference in the composition of the adult populations as a result of the different matrices

Figure 2 – *Population Projection Model*

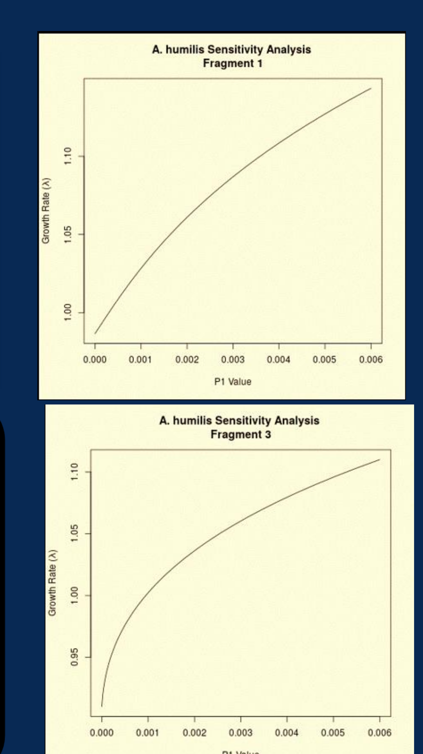


Fragment 1

Seed	Seedling	Juvenile	Immature	Virgin	Reproductive
0	0	0	0	0	667
X	0.81	0	0	0	0
0	0.19	0	0	0	0
0	0	0.99	0.44	0.08	0
0	0	0	0.33	0.92	0.20
0	0	0	0.11	0.001	0.80

Fragment

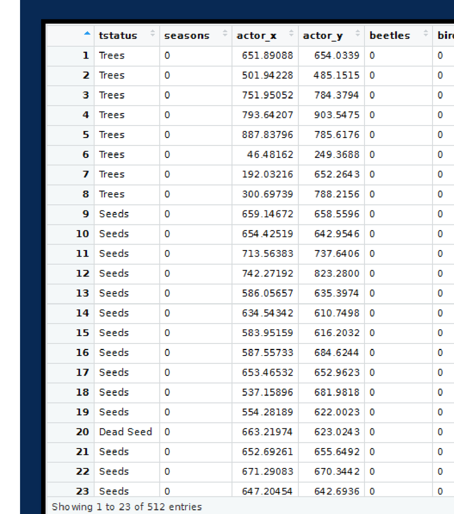
Seed	Seedling	Juvenile	Immature	Virgin	Reproductive
F1	F2	F3	F4	F5	F6
S1	To Seedling	0	0	0	0
0	S2	0	0	0	0
0	To Immature	S3	To Immature	To Immature	0
0	0	0	S4	To Virgin	0
0	0	0	To Reproductive	S5	S6



	Fragment 1		Fragment 3	
Survivorship	0.01%	1%	0.01%	1%
Seed	98.03%	95.50%	99.61%	96.65%
Seedling	0.05%	2.48%	0.03%	1.62%
Juvenile	0.01%	0.39%	~0.00%	0.08%
Immature	0.24%	0.61%	0.22%	1.47%
Virgin	1.52%	0.85%	~0.00%	~0.00%
Reproductive	0.15%	0.17%	0.14%	0.17%

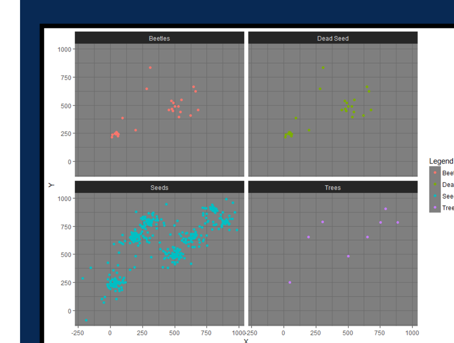
Stage Class matrices are based off of the stage class model created by Souza and Martins f

Figure 3 – Goals for Future Simulations of Tropical Spp.



X	Y
0.123	0.3
0.32	0.42
0.23	0.4
5.41	1.32
3.21	2.11

Storing location data in a Continuous model



X	O	O	O	O
O	O	X	X	O
O	X	O	O	X
X	O	O	O	O

Information storage in a discrete model

Program created using R Statistical Software: Using Discrete Space in future simulations

Future Projects

- Investigating the effect of adult tree density on the level of predation by Bruchid Beetles on BCI research station.
- Investigate the effect of additional columns on a population projection matrix model
- Use BCI time-series data to replicate these analysis with *Attalea butyracea* using my own age class matrix.

Citations:
1. Wright, S. J. (1983). The Dispersion of Eggs by a Bruchid Beetle among Scheelea Palm Seeds and the Effect of Distance to the Parent Palm. Ecology, 64(5), 1016–1021. https://doi.org/10.2307/1937808
2. Souza, A. F. & Martins, F. R. (2004). Population structure and dynamics of a neotropical palm in fire-impacted fragments of the Brazilian Atlantic Forest. *Biodiversity and Conservation, 13*: 1611-1632. Retrieved from: https://www.researchgate.net/publication/227158775_Population_structure_and_dynamics_of_a_Neotropical_palm_in_fire-impacted_fragments_of_the_Brazilian_Atlantic_Forest.

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