An Agent-Based Model of Santa Cruz Island Foxes Provides Evidence of an Allee Effect

Erin N. Bodine[1], Shelby M. Scott[1], and Anne Yust[2]

[1]Department of Mathematics & Computer Science
Rhodes College, Memphis, TN

[2]Department of Mathematics
Birmingham-Southern College, Birmingham, AL

Rhodes College
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Overview

The Island Fox

Island Foxes on 6 of 8 California Channel Islands
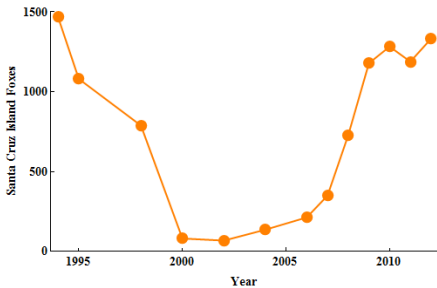

- Descendants of the grey fox

- Monogamous
- Territorial
- Conservation Status
  Critically Endangered in 2004
  Currently Near Threatened

Santa Cruz Island Foxes

Urocyon littoralis santacruzae
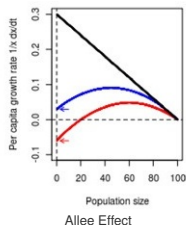

Decline & Recovery of the SC Island Fox

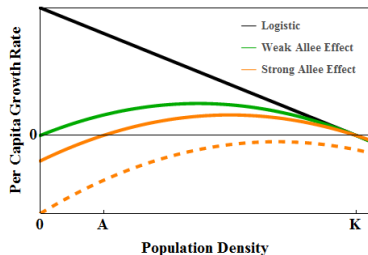Golden Eagle Predation

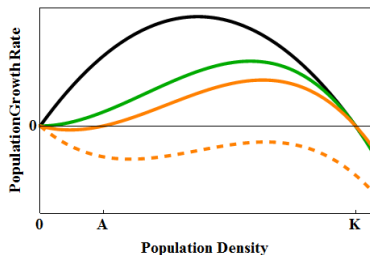Island Spotted Skunk Competition

Rabies & Canine Distemper Virus

Allee Effect

The Allee Effect

A biological theory which states that the fitness of an individual is positively correlated to its population density.

- **Component:** Individual Level effect
- **Demographic:** Population Level effect (*shown in the graphs above*)

Agent-Based Model (ABM)
Santa Cruz Island Fox Population

ABMs are a class of mathematical/computational models in which individuals (or agents) are **unique and autonomous entities** that can **interact with other indivduals and with their environment**.

- Simulate island foxes in space and time based on stochastic decisions
  - Movement
  - Establiment of territories
    Territory size: ~0.55 km²
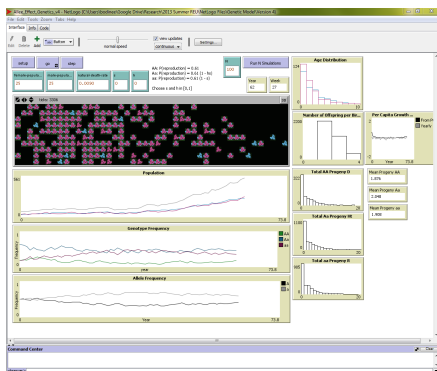   *Patch dimensions: 0.74km × 0.74km*
  - Breeding
    Mating success
    Fecundity
    Genetics
- Coded ABM in NetLogo

Agent-Based Model (ABM)
Santa Cruz Island Fox Population

Start simulation with 30 individuals (1:1 sex ratio), randomly selected ages, randomly placed (some placed in mated pairs). Run simulation 100 times.

Agent-Based Model (ABM)
Santa Cruz Island Fox Population

Start simulation with 20, 30, and 50 individuals (1:1 sex ratio), randomly selected ages, randomly placed (some placed in mated pairs). Run simulation 100 times.
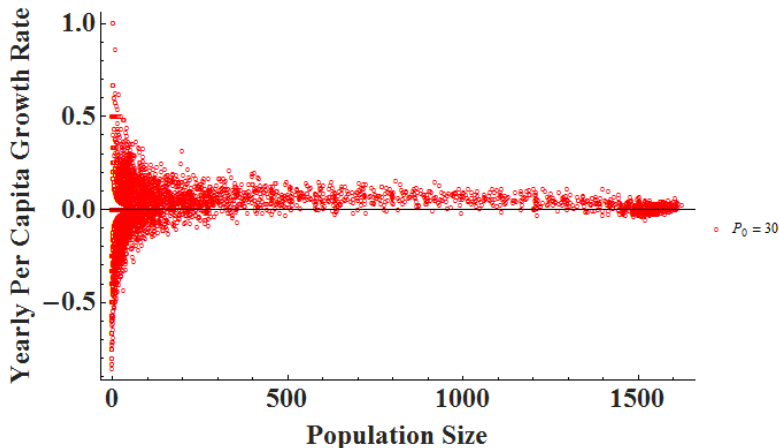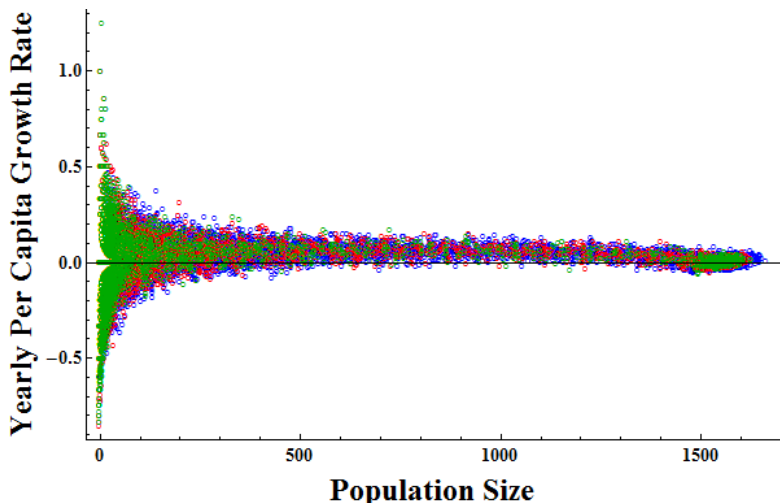
Agent-Based Model (ABM)
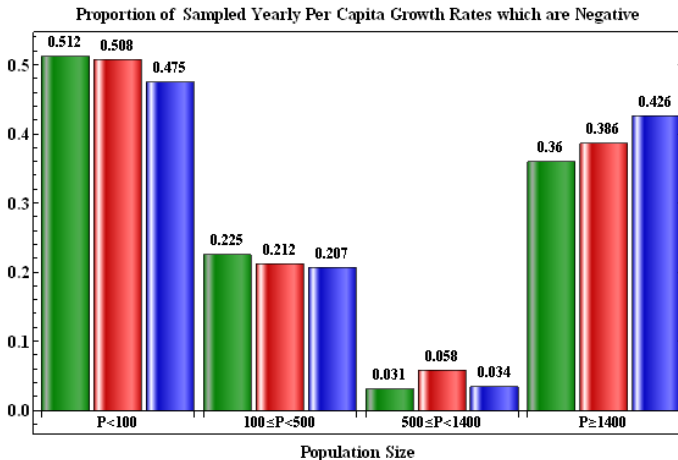
Santa Cruz Island Fox Population

Start simulation with 20, 30, and 50 individuals (1:1 sex ratio), randomly selected ages, randomly placed (some placed in mated pairs). Run simulation 100 times.

Proportion of Sampled Yearly Per Capita Growth Rates which are Negative

Population Size	P<100	100≤P<500	500≤P<1400	P≥1400
Green (20)	0.512	0.225	0.031	0.36
Red (30)	0.508	0.212	0.058	0.386
Blue (50)	0.475	0.207	0.034	0.426

Agent-Based Model (ABM)
Santa Cruz Island Fox Population

Introduce genetic component: Decrease in probability of successful mating occurs when a female carries a detrimental recessive allele
Tested two conditions:

- Only homozygous recessive genotypes cause decrease

- Homozygous recessive & heterozygous genotypes cause decrease

% of samples with negative yearly per capita growth rate for $P_t < 100$

	$P_0 = 20$	$P_0 = 30$	$P_0 = 50$
No Genetic Effect	52.5	48.9	48.7
Homozygous Recessive Only	53.5	52.0	52.9
Homozygous Recessive + Heterozygous	55.1	56.6	55.5

Conclusions

- In our stochastic ABM the Allee effect is manifest as an increased probability of having a negative yearly per capita growth rate at low population sizes

- The Allee effect was an emergent property of our Santa Cruz Island Fox ABM

- The Allee effect was exacerbated by
  - the presence of a detrimental recessive allele
  - lower initial population sizes

Future Work

- Incorporate other influences on fox population into the ABM
  Received a grant to work on incorporating golden eagle dynamics into the model over this summer

- Quantify the impact of the many factors in Santa Cruz Island fox decline
  Predation
  Competition
  Disease

Acknowledgements

Collaborators

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Rhodes College

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Birmingham-Southern College

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Birmingham-Southern College (student)