CIS 3130
Project Proposal

James Singaram
0758172

Oct. 27, 2020

## Introduction

The Isle Royale National Park in Michigan, USA has been the site of one of the longest running ecological studies ever conducted. Starting in 1959, moose and wolf population data has been collected and recorded. In the mid 2000s inbreeding caused a dramatic decrease in wolf populations. The wolves on Isle Royale are currently threatened with extinction, which would allow the moose population to grow unchecked and further destabilize the ecosystem. In order to counteract the effects of inbreeding and to help the wolf population rebound to healthy levels, humans must introduce foreign wolves to the island.

## Objectives

The wolf population must be restored to stable levels in order to stabilize the ecosystem. This can only be accomplished by introducing foreign wolves to the island. Increasing genetic diversity will counteract the negative impacts that inbreeding has had on the population.

The purpose of this model is to determine the number of wolves that must be introduced in order to return both wolf and moose populations to equilibrium. Introducing too many wolves will cause over-predation and deplenish the moose population. Introducing too few wolves will leave the wolf population susceptible to chance catastrophes and not sufficiently resolve inbreeding. In order to determine the optimal number of wolves to introduce, a computer simulation will be used.

## Data Collection

All of the parameters necessary to construct an accurate model can be extrapolated from population data for moose and wolves. The data that will be used comes from Peterson and Vucetich of the Michigan Technological University.

Growth rates and carrying capacities for moose and wolf populations are necessary to create the model. For the moose population the entire study sample will be utilized. Parameters for native, inbred wolves will be produced using data after inbreeding increased (2000-2018). Parameters for foreign, healthy wolves will use data prior to inbreeding (1959-1999). The wolf population's overall growth rate will be a weighted average based on the number of foreign wolves included in a given run of the simulation.

## Model Conceptualization

Ecological studies are conducted using models called Population Viability Analyses (PVA). A PVA simulates populations over time using growth rate, carrying capacity, and stochastic factors in order to make predictions regarding the population. Critical endangerment refers to a population declining by 80% within the next ten years or the next three generations (14 years in wolves, 9 years in moose). Because the initial wolf population is far below healthy, critical endangerment for wolves will be defined by the population falling below 10% of the carrying capacity.

The PVA will simulate the wolf and moose populations. The variable that changes between scenarios is the number of wolves introduced to the population at the start of each run. Each run functions similarly to a Bernoulli trial to determine whether a given scenario will result in a stable ecosystem over a period of 20 years, where stability is defined by no instances of critical endangerment in either species. The PVA is a discrete model that increments through time in one year periods. If either population becomes critically endangered then the trial will abort and report failure. If the trial reaches 20 years without this happening then it will report success.

The defining event for the model is the start of each new year. When this occurs moose population size will grow or shrink according to its growth rate and stochastic factors. If a function correlating wolf population to moose growth rate can be found then that will be added to the moose growth rate for a given year. If not then the moose population will be reduced by a number of individuals per wolf in the population based on. Next, the wolf population will be changed according to its growth rate and stochastic factors. If a function between wolf carrying capacity and moose population size can be found then the growth rate of the wolf population will depend on the moose population size.

The equation to determine population size, N, at time t+1 is given by:
$N_{t+1} = N_t * e\hat{}(r_{max}(1-N_t/K) + \theta + \psi)$, where:

- $N_t$ is the population size at time t
- $N_{t+1}$ is the population size at time t+1
- $r_{max}$ is the greatest observed growth rate for a population
- K is the carrying capacity of the species
- θ is a randomly determined impact on growth rate, based on historically observed variations in growth rate
- ψ is the impact of the wolf population on the moose population due to predation

In order to obtain the probability that both species will avoid critical endangerment within 0.5% of the actual value with a 99% confidence interval, each scenario needs to be run at least 66,358 times. This will be rounded up to 70,000 times to err on the side of caution.

$z_{\alpha/2} * \sqrt{(pq/n)} \leq 0.005$
$2.576 * \sqrt{((0.5)^2/n)} \leq 0.005$
$\sqrt{n} \geq (2.576 * \sqrt{(0.5)^2}) / 0.005$
$\sqrt{n} \geq 257.6$
$n \geq 66358$