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MODELLING THE SOUTHWESTERN ALBERTA GRIZZLY BEAR POPULATION USING ORDINARY DIFFERENTIAL EQUATIONS

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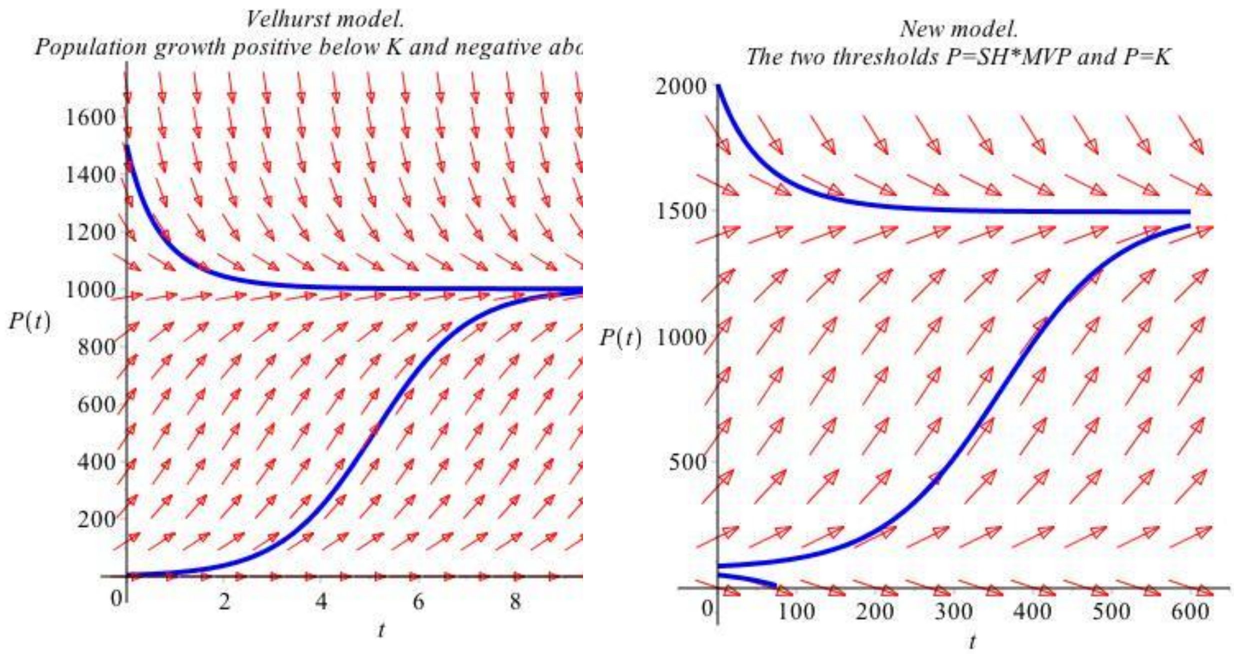
The Alberta grizzly bear population was listed as “threatened” by the Alberta Wildlife Association in 2010 [1]. This particular species is important, as it is an umbrella species for a variety of other animals. Our goal in this project was to create a model using ordinary differential equations, based on the logistic growth model, to determine whether the Southern Alberta grizzly bear population is recoverable. We aimed to calculate the rate at which the population was growing and its carrying capacity.

An adequate model for studying the grizzly bear population is the Verhulst's model, which is the classic Logistic Growth Model

$$\frac{dP}{dt} = rP\left(1 - \frac{P}{K}\right)$$

where r represents the intrinsic growth rate of the population, P is the population and K is the carrying capacity. The population reaches its threshold at P = 0 and P = K, where P = 0 is unstable equilibrium point and P = K is stable equilibrium point of the dynamical system.

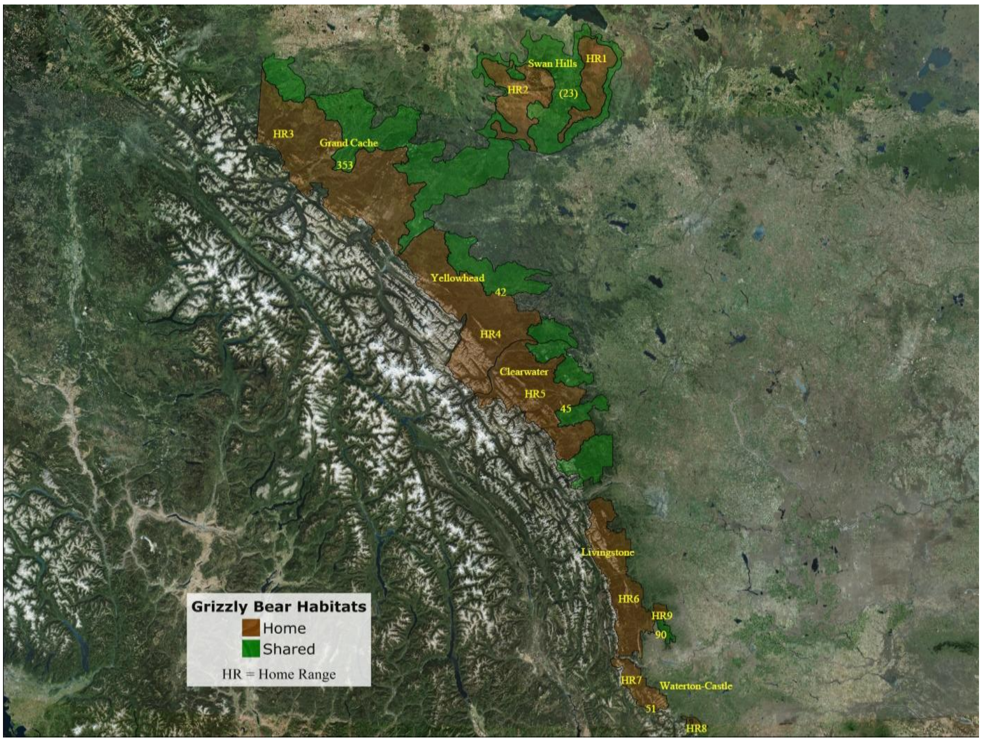


The traditional model still provides accurate values for r and K, but does not provide a realistic threshold value for survival. Based on the Verhulst model, we constructed a new model that more realistically depicts the threshold of the population:

$$\frac{dP}{dt} = r\left(\frac{P}{SH \cdot MVP} - 1\right)\left(1 - \frac{P}{K}\right).$$

SH represents the Safe Harbour, a new measuring function introduced by the Alberta Grizzly Bear Recovery Plan 2008–2013 [2], which speaks of the creation of Grizzly Bear Priority Areas in high quality habitat where there is a low risk of mortality; the Safe Harbour (SH) is a combination of high quality habitat and reduced risk. The MVP is referred to the Minimum Viable Population, a measure that species the necessary amount of individuals in order for the species to survive. While the threshold P = K is a stable equilibrium point of the dynamical system, the threshold P = SH · MVP is an unstable equilibrium point of the system. SH acts as a buffer zone for the MVP; it allows it to be depressed and then to rebound. Using SH as a buffer of the MVP we are able to predict, using an inverse problem, a realistic MVP based on an estimated fitness (EF, estimated value of the species' fitness) for a given population. The fitness of a species relates to «how good a particular genotype is at leaving offspring in the next generation relative to how good other genotypes are at it» [3]. We believe we bring something new in the field of Conservation Biology, as until now the MVP is estimated only by using computer simulations for Population Viability Analysis (PVA).

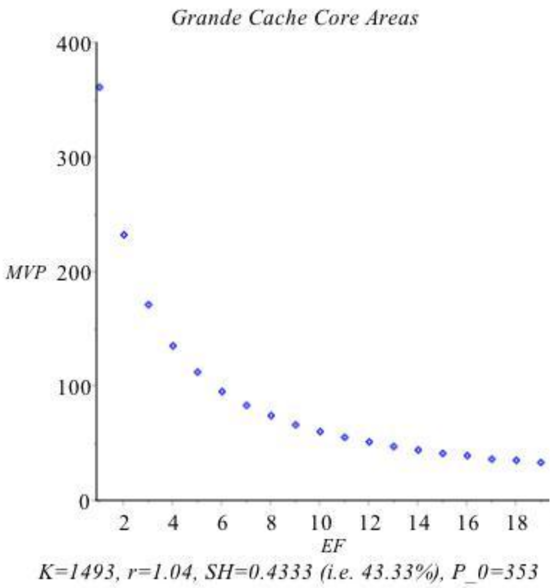
Our data was collected from areas of South Western Alberta. The populations we used can be seen in the following figure:

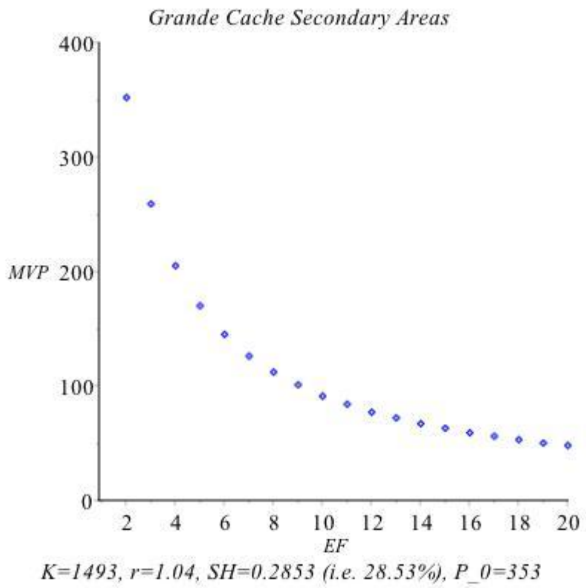


We calculated r using a combination of Leslie and Lefkovitch matrices. The result of our calculations was an r-value of 1.04798 which came in agreement with the given point estimate of 1.04 (0.99–1.09) by Garshelis et al ([8]). Using the Verhulst model with r representing the female rate of growth, we calculated the carrying capacity, K, and the female rate of growth, r, by using an exact method where populations from three consecutive years were plugged into the Verhulst model. Solving the resulting system of nonlinear equations we obtained relevant values for K and r.

We obtained a result of K = 1493. The r-value from these calculations was 0.23, which was in agreement with the estimations obtained in [1] (their estimation for the female rate of growth was close to the value of 0.24). This validated our calculation for K. In our research, due to limited available information for Safe Harbour, we focused on the Grande Cache Core and Secondary Areas (with respect to the Safe Harbor Index) when estimating the MVP.

For the Core Areas we acquired an MVP range of 361–31, which corresponds to an EF range of 1–20, and in the Secondary Areas we acquired an MVP range of 548–48, which corresponds to an EF range of 1–20. Based on our calculations, we could see the natural inverse relationship we were expecting between EF and MVP; as EF increases the required MVP decreases.





The initial female grizzly bear population in 2008 was 690. Due to our calculated range for the minimum viable population of 24–63, we can determine that the species is recoverable since 690 is significantly larger than 63. The initial population of 690 is well below the calculated carrying capacity of 1493. Thus, the population has not reached its maximum potential size and has the ability to continue growth.

Ultimately, based on our calculations, the threatened status given to Alberta grizzly bear population is not irreversible and the species has the ability to recover itself.

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