

The African Leopard in Kruger National Park

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INTRODUCTION

The African leopard weighs between 20 and 90 kilograms as an adult and is required to consume between 1.6 and 4.9 kilograms of meat per day in order to maintain body mass. Its main sources of prey fall between the 20 to 80-kilogram range and in that range lies the impala, which is by far its preferred prey. However, the leopard population has been steadily on the decline for a plethora of reasons. Since the impala population is largely stable, the danger to leopards is, somewhat, other predators, but most prominently poaching. "The leopard is likely the most persecuted large cat in the world." Mostly situated in southern Africa, the leopard is a top target for human trophy hunters for their valuable pelts. In the past 25 years, the African leopard population has decreased by more than 30%. The US government has recently said that the African leopard, in addition to all other species of leopards worldwide, qualify for 'endangered' status. That makes places like Kruger National Park all the more important, as they work incredibly hard to not only keep animals such as the white rhinoceros, lion, and elephant safe, but also, more importantly for our purposes, they try to keep the leopard safe on 19,485 km² of protected lands in northeast South Africa.

A nearby park (that has remained anonymous) has recently instituted technology, such as night vision drones and sensors, in an attempt to curb poaching, and, in 18 months, they have been able to cut it down by 96%! Though the nearby park is smaller, should similar steps be taken by Kruger National Park? If these steps are taken, what will happen to the leopard population? How will that affect the prey population, such as the impala? If Kruger National Park attempts to save money, how much should they evict poachers annually to ensure the survival of the leopard population by keeping it above the critically endangered list? We attempt to find the answers to these questions in this paper.

Scientists at Kruger National Park have done a great job of studying the African leopard. This paper will attempt to add onto the research done in Kruger National Park so that they can predict the distribution of leopard populations in different environments of poaching, and, thus, decide the best way forward to conserve the leopard populations.

MODEL DEVELOPMENT & METHODS

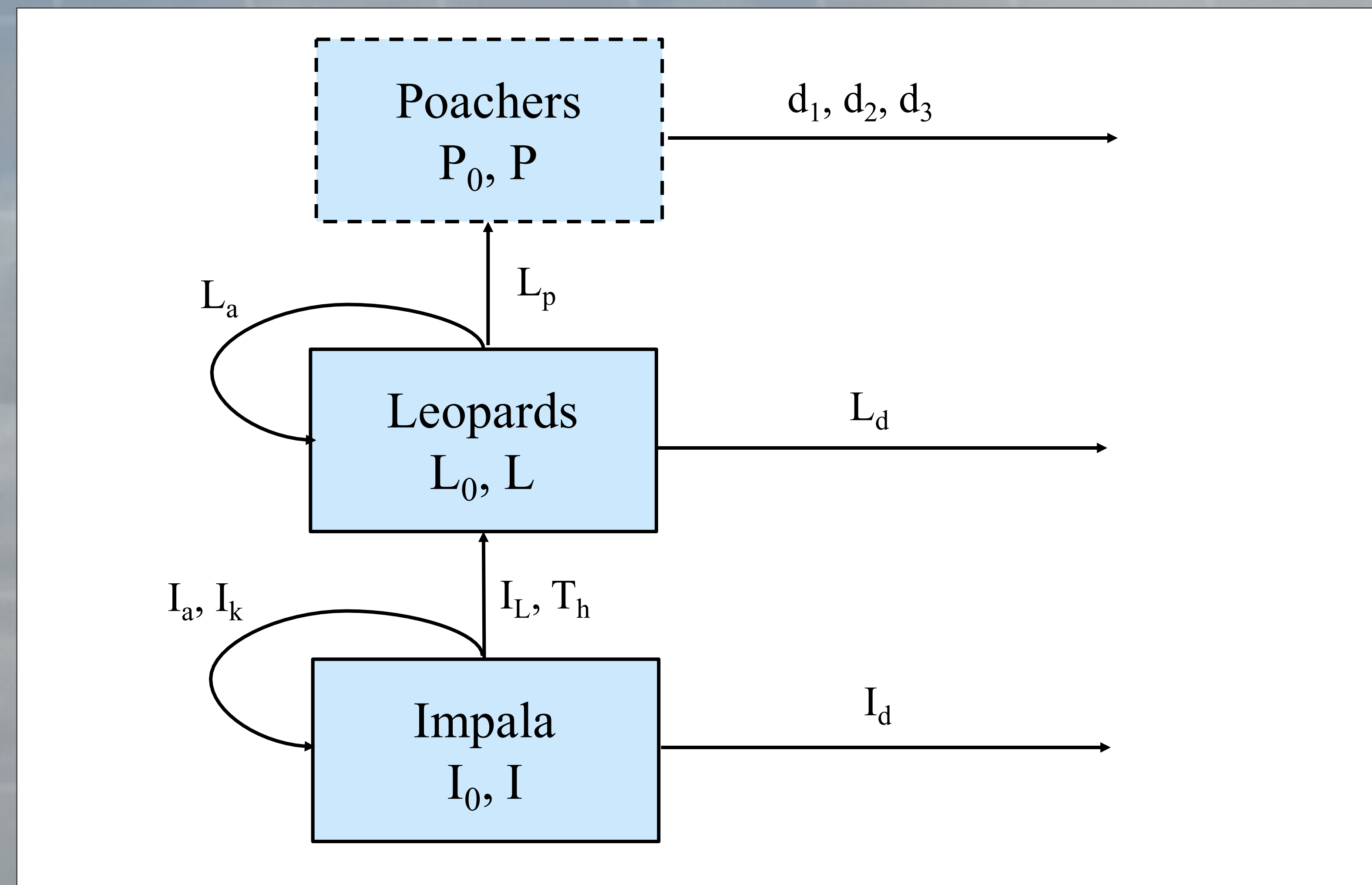
Along with the values of the coefficients we found for our equations through research, we also found the initial values for our animals and poachers. The number of leopards within Kruger National Park has been estimated a few times in the past decade or so, and all of these estimates have given the initial value of 1,000. For impalas, the Kruger National Park website estimated roughly 150,000 of them in the park. As for initial values of poachers, given that our leopards die from poaching at about 8% and roughly 80 leopards are killed in the park each year, we arrived at the value of roughly 1,000 poachers who go after leopards about 8% of the time.

We attempted to gauge the effect of eliminating poaching at different rates to find the results for the different courses of actions that Kruger National Park could take in regard to preserving the leopard population. Because of the size of Kruger, the changes in the smaller park would not be attainable. Nevertheless, we speculated that an annual decrease of 44% of poaching (roughly half of the rate of the smaller park), would be attainable. Finally, we looked for the lowest amount of annual poaching decrease that could sustain the African leopard.

We ran our model on MatLab with different starting parameters:

- **Experiment 1:** We run our code with no change in poaching (constant rate of 8% of leopards killed per year)
- **Experiment 2:** We account for potential maximum technological implementations that Kruger could put in place, resulting in a 44% decrease in poaching annually.
- **Experiment 3:** We look at specific values within our range of poaching eviction, or an annual percentage decrease in poaching (3% and 2%), to find the minimum steps needed to be taken by Kruger so that the leopard population does not become critically endangered. By using IUCN data, we use 250 for a restricted population.

BOX MODEL



EQUATIONS

The lines between the boxes within our box model represent a dynamic between their respective populations, and, using our research, the following equations represent these interactions and the changes in population each account for:

Leopard Growth

$$L' = k * \left(\frac{L_a * I_L}{1 + I_L * T_h * I_0} \right) * I * L - L_d * L - L_p * P$$

= natural leopard growth – natural leopard death – death due to poaching

Impala Growth

$$I' = I_a * I * \left(1 - \frac{I}{I_k} \right) - \left(\frac{L_a * I_L}{1 + I_L * T_h * I_0} \right) * I * L$$

= population growth limited by carrying capacity – death due to leopards

Poaching Change (this equation will differ for our different experiments)

$$P' = -P * d_n$$

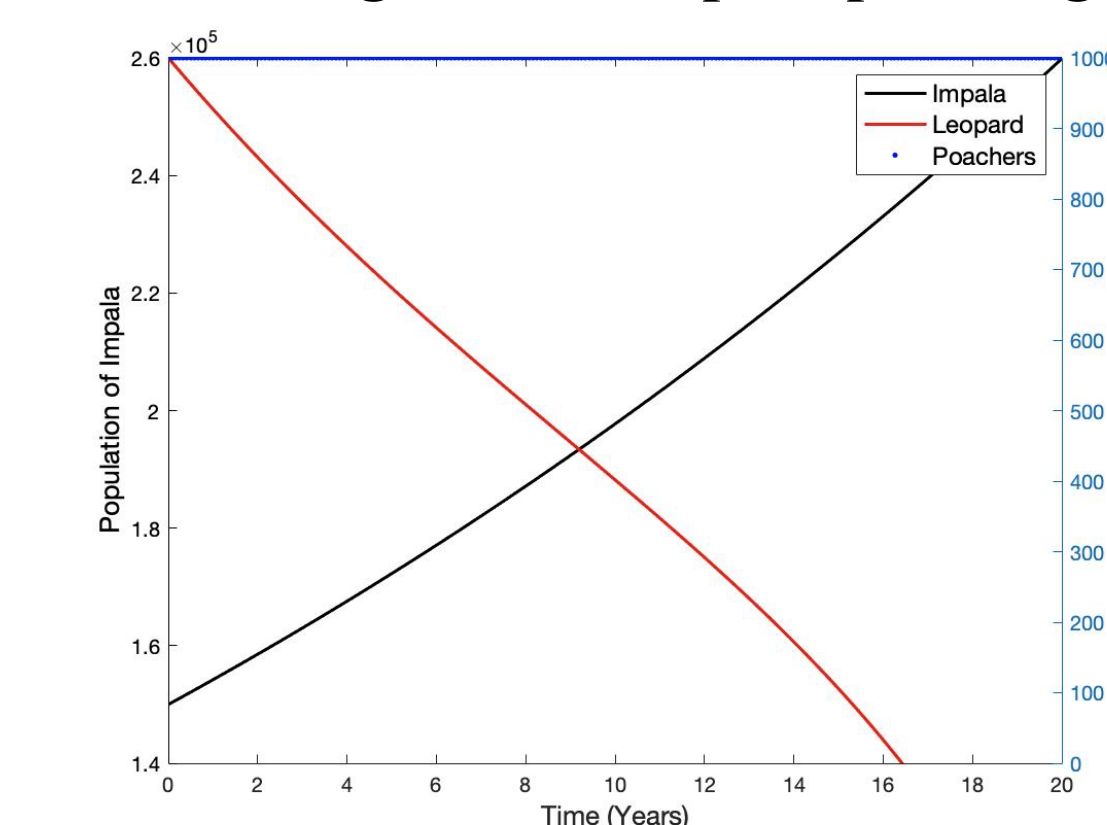
= – poaching eviction

REFERENCES

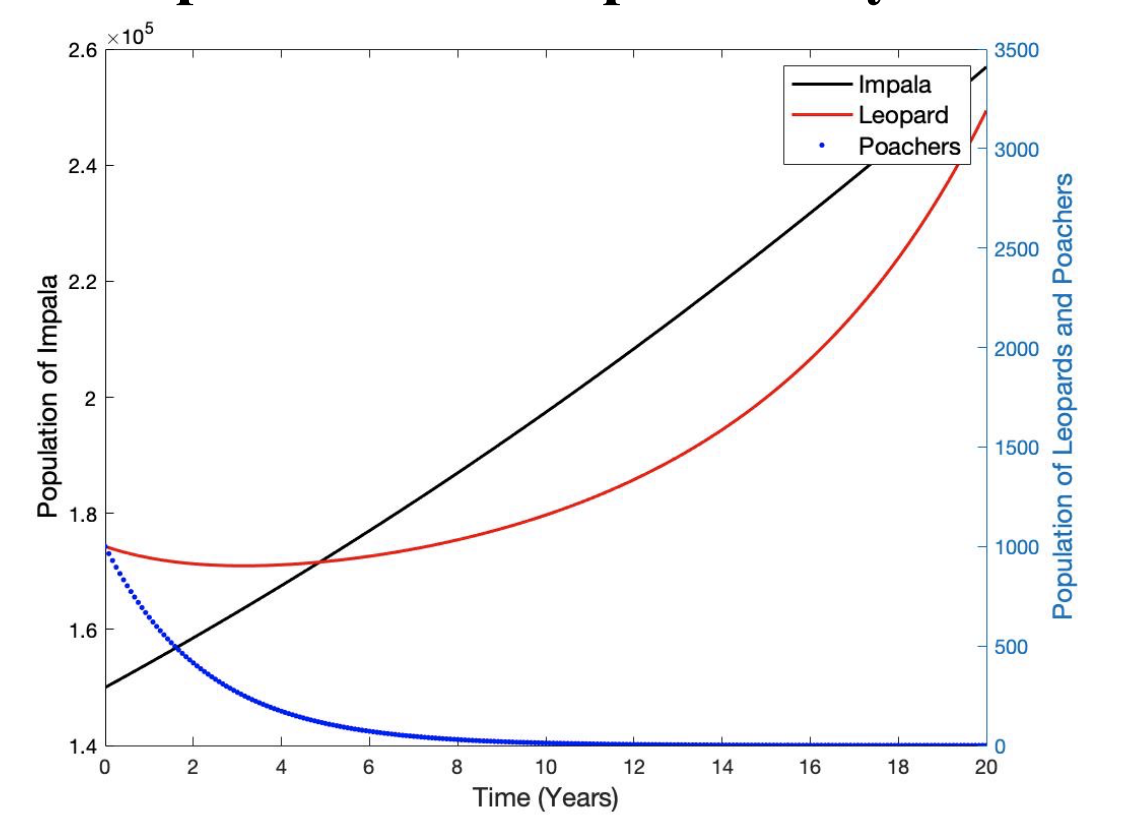
- "African Leopard." *SANBI*. www.sanbi.org/animal-of-the-week/african-leopard/.
- Bailey, Theodore. *The African Leopard: Ecology and Behavior of a Solitary Felid*. Columbia University Press, New York, New York, 1993.
- Bradford, Alina. "Facts About Impalas." *LiveScience*, Purch, 22 Oct. 2015. www.livescience.com/52557-impalas.html.
- Hamilton, P. H. (1976). *The Movements of Leopards in Tsavo National Park, Kenya as Determined by Radio-tracking* (Ph.D.). Nairobi: University of Nairobi.
- Hayward, M. W., P. Henschel, J. O'Brien, M. Hofmeyr, G. Balme, and G. I. H. Kerley. "Prey Preferences of the Leopard (*Panthera pardus*)." *Journal of Zoology* 270, no. 2 (2006): 298-313.
- Hogeback, Jonathan. "What Makes a Species Endangered?" *Encyclopedia Britannica*. Encyclopedia Britannica, Inc., www.britannica.com/story/what-makes-a-species-endangered.
- "Hunting in Greater Kruger National Park: SANParks & Mpumalanga Parks Board | PMG." *Parliamentary Monitoring Group*. www.pmg.org.za/committee-meeting/27072/.
- "Impala - The Most Populous Animal." *Kruger National Park Guide*. www.kruger-national-park-guide.com/impala.html.
- IUCN SSC Antelope Specialist Group. "*Aepyceros melampus*." *IUCN Red List of Threatened Species*.
- "Leopard | Panthera." *Panthera.org*. www.panthera.org/cat/leopard.
- "Leopard Poaching Statistics." *Poaching Facts*, 10 May 2019. www.poachingfacts.com/poaching-statistics/leopard-poaching-statistics/.
- Pozniak, Helena. "The Technology That Will Finally Stop Poachers." *Popular Mechanics*, 13 Dec. 2018. www.popularmechanics.com/science/animals/a25174825/technology-stops-poachers/.
- "Shocking Rise in Rhino Poaching Leads to Formation of New Unit." *Kruger National Park*. www.krugerpark.co.za/krugerpark-times-6-1-shocking-rise-in-rhino-poaching-25183.html.
- "South Africa." *South Africa Accommodation*. www.places.co.za/html/kruger_wildlife.html.
- "The Food Web." *Kruger National Park*. www.kruger-nationalpark.weebly.com/the-food-web.html.
- "Unearthing the Secrets of the Leopard Population at Londolozi_copy." *Kruger National Park*. www.krugerpark.co.za/krugerpark-times-2-17-londolozi-leopards-20757.html.

RESULTS

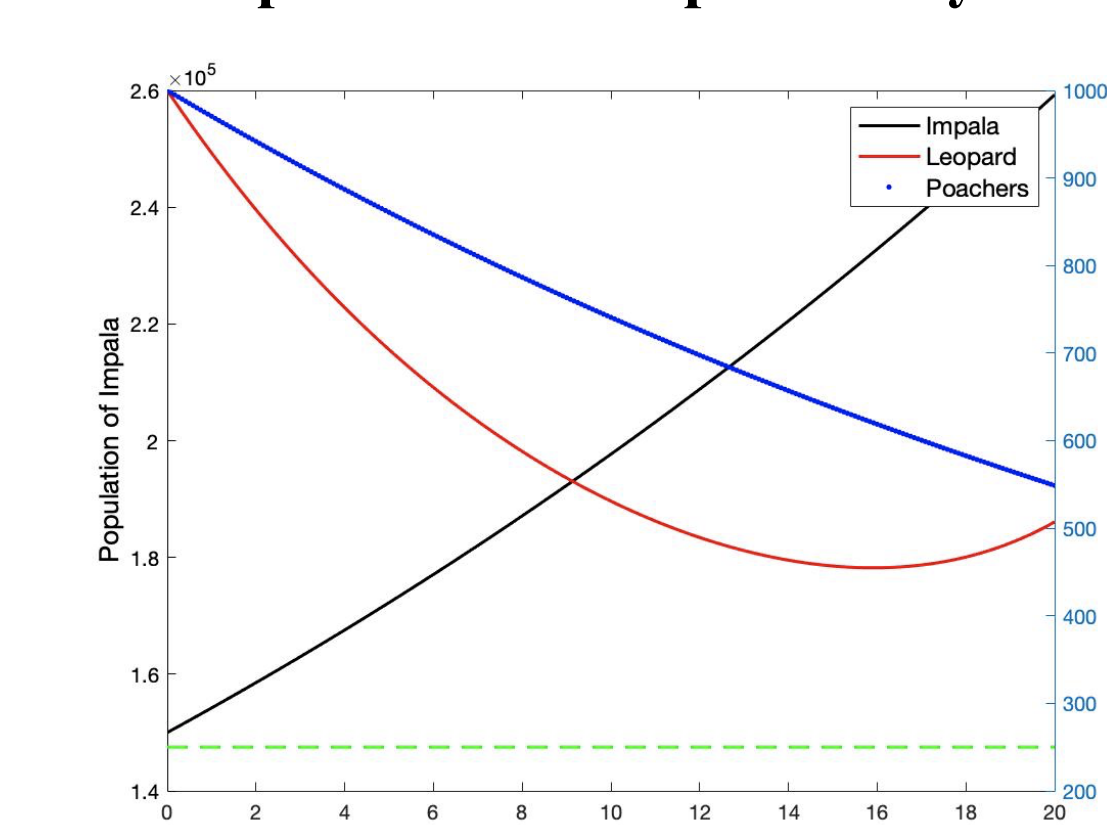
Kruger National Park does nothing to curb leopard poaching



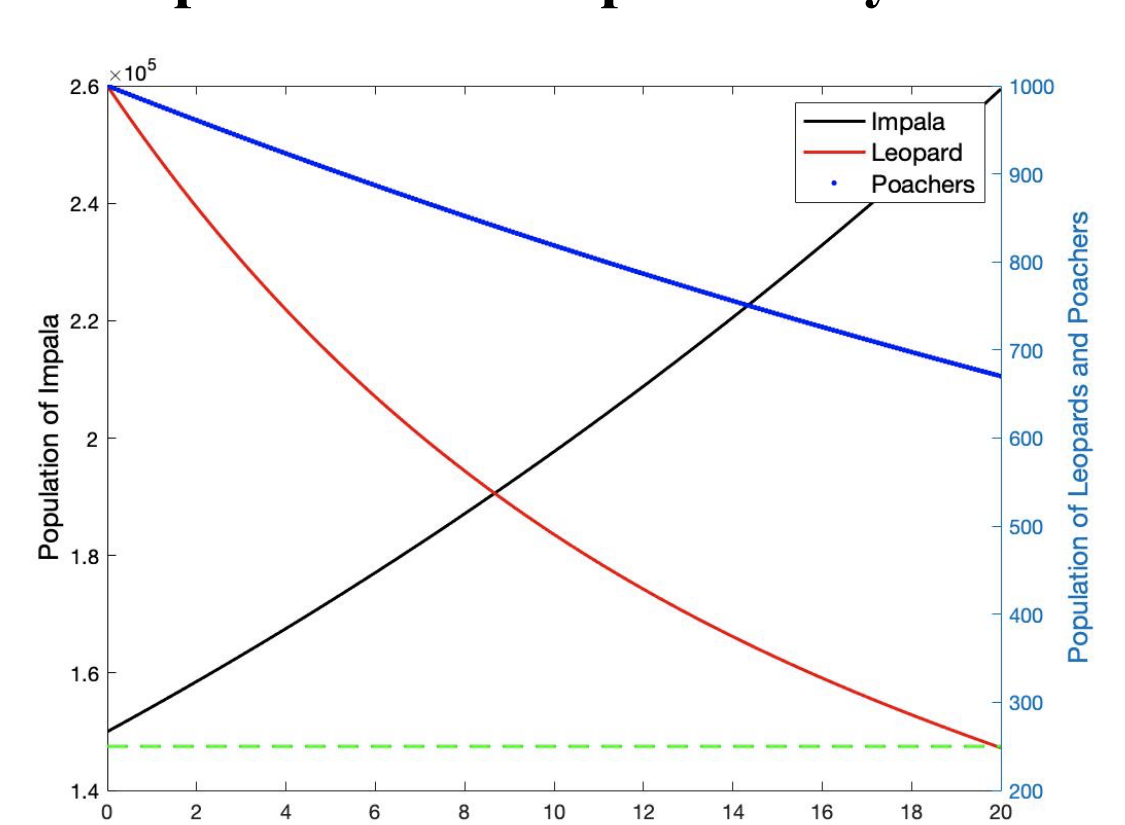
Effects of an effective decrease (44%) in poaching on the Leopard-Impala relationship over 20 years



Effects of a lighter (3%) decrease in poaching on the Leopard-Impala relationship over 20 years



Effects of a weak (2%) decrease in poaching on the Leopard-Impala relationship over 20 years



DISCUSSION

As we see in our results section, if Kruger National Park does nothing to curb leopard poaching, the leopard population will die out over the course of 16 years. However, we can see that the steps made in the anonymous smaller park to curb poaching can work to increase the leopard population within Kruger National Park. With an annual decrease of 44% of poaching (roughly half of the rate of the smaller park), the leopard population bounces back. Furthermore, we found that the Park can save some money (if needed) while also not eliminating the leopard population by implementing technology to evict only 3% of poachers per year to keep the leopard population above 250 since, according to the IUCN, "an endangered species is one that meets any one of the following criteria: ... a restricted population size less than 250 adults, or a statistical prediction that it will go extinct within the next 20 years." In all, our hypothesis was proven, in that, if Kruger National Park does nothing, the pervasiveness of poaching will eventually eliminate the leopard population, and if not enough is done to combat it, the population will decrease to an incredibly dangerous level.

FUTURE RESEARCH

Further research could answer a couple of questions that we have left unanswered. First, if after a long period of time poaching is decreased to such an extent that the leopards are safe and growing, could Kruger National Park sell permits to kill a handful of leopards per year for a high cost to supplement the initial costs of implementing technology at the front end? How high would the cost have to be and how many permits could they sell? Another point of further research could be adding in values to account for adults, cubs, and other predators. If we split the leopards on our box model into adults and cubs, we could more accurately model the death rates of leopards in different stages of their development. Finally, further research could add the effect that climate change will have upon the impala population. As the globe warms, the flora that the impala feed on will dwindle, leading to limited food and, thus, more prevalence of starvation. This, in turn, will affect the leopard population. Any of these changes could provide our research with even more information to send to Kruger National Park to inform them of these models.