Predators and Policies: Simulating the Impact of Hunting on Florida's Alligator Ecosystem

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PolymathJr2025

April 16, 2025

Project Description:

This project focuses on developing a mathematical model to analyze predator–prey dynamics centered on Florida alligators and their ecological role in wetland ecosystems. The study will investigate how key environmental factors—such as seasonal variations, temperature, and habitat conditions—and prey behaviors (for example, group defense mechanisms) influence alligator population dynamics. By simulating various scenarios, the project aims to assess the potential outcomes of different policy interventions, ranging from adjustments in hunting quotas to enhanced habitat conservation measures, with the goal of promoting sustainable populations and ensuring ecosystem balance.

Objectives:

- **Model Development:** Construct a modified predator–prey model—built on the Lotka–Volterra framework augmented with realistic influences—to simulate interactions between Florida alligators and their prey.
- **Data Integration:** Incorporate empirical data pertaining to environmental conditions and behavioral factors to enhance the model's fidelity.
- **Policy Impact Analysis:** Evaluate how adjustments in hunting regulations and conservation policies affect long-term population dynamics and ecosystem health.
- **Recommendations:** Develop policy refinement suggestions based on simulation outcomes to support effective wildlife management practices.

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Minimum Requirements

- Participants should have a solid foundation in linear algebra (completion of a course is required) and a basic understanding of ordinary differential equations (a formal course is not necessary; they can learn through instructional videos and hands-on research experience).
- At least two members must be proficient in Python programming.
- A strong enthusiasm and genuine interest in the field of mathematical modeling.

Skills that Students will Acquire:

- Mathematical Modeling: Formulating and solving models using ordinary differential equations, with a focus on various predator–prey interactions.
- Simulation Techniques: Implementing simulations to explore dynamic system behaviors.
- Bifurcation Analysis: Understanding and analyzing critical transitions in system dynamics, including Hopf and saddle-node bifurcations.
- Data Fitting Methods: Learning techniques for calibrating models using empirical data.
- Introduction to Machine Learning: Applying basic machine learning strategies—such as neural networks and regression models—to enhance model predictions and data analysis.

Data Sources

Students will use online sources documenting alligator population and hunting numbers in Florida. Although the population number is not clearly stated, the Conservation Commission does maintain a record of annual estimates (see "Alligator Data — FWC" on the Florida Fish and Wildlife Conservation Commission website). Pursuant to section 120.74 of the Florida Statutes, the Commission published its 2022 Agency Regulatory Plan ("2022 Agency Regulatory Plan," myfwc.com).

Online Videos and Resources:

- https://youtu.be/Ww4SOwqfJgI
- https://youtu.be/ASYKt0P7I9c

References

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[AE] Xie, J., Zhu, C. (2025). A study on a class of predator-prey models with Allee effect [Preprint]. arXiv.
https://arxiv.org/pdf/2503.23970.pdf