Judges' Commentary: The Outstanding Scrub Lizard Papers

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Introduction

The papers were assessed on

- the breadth and depth of the analysis on each portion of the posed problems,
- the validity and creativity in the proposed models, and
- the clarity and presentation of solutions.

Virtually all papers demonstrated a significant amount of work and thoughtful analysis by the team members. The judges were impressed with the quality of attentive research undertaken by the students on the science involving survival of scrub lizards and were pleased to see a variety of innovative attempts to solve the problems. Making sense of ecological factors affecting the scrub lizard population was essential for successful papers, but the heart of the contest problem was developing a mathematical model that might accurately determine the factors that could contribute to or detract from survival of the scrub lizards.

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The Problem

The Florida scrub lizard is a small, gray, or gray-brown lizard that lives throughout upland sandy areas in the Central and Atlantic coast regions of Florida. The Florida Committee on Rare and Endangered Plants classified the scrub lizard as endangered. The long-term survival of the Florida scrub lizard is dependent on preservation of the proper spatial configuration and size of scrub habitat patches.

The problem was written by Prof. Grant Hokit of the Dept. of Natural Sciences at Carroll College in Helena, Montana. He and his colleagues from the University of Florida have conducted extensive research on scrub lizards and their habitat, some of the results of which appear in this problem.

The Data

It is conjectured that fecundity and survival rates of the scrub lizard are related to the size and amount of open sandy area of a scrub patch where they live. Students were asked to deduce from small samples of data a pattern for fecundity and survival rates. The students were also provided the positions of scrub patches relative to one another and were asked to describe the impact of lizard migration on the survival rate of lizards in these patches. [Note: It is still not known why the scrub lizard migrates.]

The Science

Students with a background in ecology recognized that the plight of the scrub lizard is very similar to the plight of other endangered species. Research into the various factors that affect the habitat of the lizard was essential, because the maintenance of a livable habitat is just as important as the understanding of the impact that the habitat has on the survivability of the lizards. One of the problems posed related to the maintenance of the sandy areas by occasional controlled burning. After researching the habitat dynamics of the scrub lizards, students were asked to make recommendations to preserve the habitats and to discuss obstacles they might encounter to their recommendations.

Then came the students' understanding of reproductive rates within different age groups and the survivability of offspring, youths, and adults under different conditions. The term "fecundity" lent itself to more than one interpretation. The migration of juvenile lizards introduced a factor that complicated the population model.

The Model

The teams used a variety of modeling techniques. To estimate parameters such as fecundity and survival rates, some students extrapolated from the given data and some accessed additional data. To predict long-term survivability, some teams conducted simulations and others used Leslie matrices to determine which patches could sustain the lizards.

Interesting and viable probability models, as well as informative simulations, were used to analyze the migration of lizards from one patch to another. The geometry of the migration required complex modeling, taking into account the positions and sizes of patches relative to one another.

An essential part of the modeling process is clearly stating the underlying assumptions. It was enjoyable and informative when teams interpreted the results of the model with respect to the simplifying assumptions. Often, students believe that the judges know the correct answer and have absolute knowledge about the model development, so that there is no need to fill in the details of the modeling process. This belief is wrong—good papers must carefully provide these details.

Students wrestled with their responsibility to transform an ill-defined problem into a well-defined problem. The migration component of this problem provided only ideas, and the students had nearly a clean slate to begin the analysis. The motivation and dynamics for migration of scrub lizards is almost completely unknown. Therefore, the modeling process was limited to an empirical and not explicative model.

Other interesting perspectives on modeling were seen on papers that suggested burning schemes or other ways to keep the scrub patches from being overrun and uninhabitable for the lizards.

The Analysis

Analysis distinguished the Meritorious and Outstanding papers from the others, and the thoroughness with which that analysis was done distinguished the Outstanding papers from the Meritorious. Some teams used modeling that was less sophisticated but verified their model with simulations. This is acceptable as long as they describe their modeling process and show reasonable results.

Other teams used classic models, such as developing Leslie matrices for the patches and then basing their conclusions on the eigenvalues of the matrices. Many used the exponential distribution to describe the survival pattern of the lizards.

Presentation

There were great variations in the quality of the write-ups. Thoroughness is essential, and conciseness is necessary for the one-page summary. Some papers revealed great potential from the modeling perspective but were difficult to follow and therefore problematic to assess. Others developed good models but failed to interpret the models in the context of the issues raised.

On the other hand, some papers had page after page of well-written perspectives on the issues but failed to do adequate mathematical modeling. A qualitative approach must be accompanied with a quantitative analysis.

Failure to document sources properly kept papers from rising to the top. Papers that revealed a comprehensive review of available resources and documented where those resources were referenced showed intellectual maturity that was appreciated and valued by the judges.

Conclusion

Reading and judging the ICM papers was an enjoyable experience. It was clear that many students worked very hard on the project during the four-day period, and the judges were impressed. The interdisciplinary nature of this problem opens the door for creative solutions from many perspectives, and problems of this type enlighten students to the broader challenges associated with biodiversity and survival of endangered species.

About the Authors

Gary Krahn is the Head of the Department of Mathematical Sciences at the U.S. Military Academy at West Point. His interests include the study of generalized de Bruijn sequences for communication and coding applications. He enjoys his role as a judge and Associate Director of the ICM.

Marie Vanisko is in her 31st year of teaching undergraduate mathematics at Carroll College in Helena, Montana, and has been active in Project INTERMATH. She is interested in seeking out useful applications of mathematics to share with her students and in developing technology modules to enrich the mathematics classroom. Having served as a judge for the MCM for many years, she found it very interesting to judge the ICM for the first time this year.