INTRODUCTION / BACKGROUND

This case is based on several years of my personal research in Stearns County, Minnesota, and the data described is a product of the work of several undergraduate students at St. John's University, which partially funded this research. While I have slightly modified the data, the mistakes described really occurred and the populations are real. The case is designed to encourage students to think about plant population ecology from an actual research perspective. One of my motivations for developing this case has been my conviction that biology students spend too much time doing “canned” labs in which an outcome is expected within two to three hours and not enough time doing open-ended labs in which the outcome is unknown. True science is an attempt to find a better explanation for a phenomenon and all experienced scientists are profoundly aware of the challenge of exploring a phenomenon without knowing what the outcome will be as well as the difficulty of discerning what the correct explanation is.

Objectives

This case enables students to explore aspects of basic plant population ecology. It also forces students to think about research design. It attempts to simulate the process of doing science, through the gradual introduction of results using the interrupted case method.

CLASSROOM MANAGEMENT

The case can be used in an introductory biology or botany course, and can also be used with slight modifications in an upper-level plant ecology course. This case works very well as an interrupted case, where the instructor leads students through a discussion about the first part of the case before proceeding to hand out the next part. However, typically I use it as a group homework assignment, directing them to access the case on the Internet. By the time I use this case, my students are comfortable with the concept of group work outside of class and each group is well established. I give them the url for the first part, and tell them they should answer the questions on the page before going on to the next part. When you request that they do this, it may be helpful to remind them that many questions have many possible answers. In fact, the questions are not all answerable but are designed to help students understand the results and to think about the process of designing a research project. Typically, I assign this case less than a week before we discuss it and then spend one hour of class time discussing the case. I ask students in each group to sit together, and I call on different individual group members to explain their group’s answers. Some of the questions can be fairly quickly answered, such as questions 4 or 5, but with many of them I ask each group in turn to present their answers, and then summarize the class results on the blackboard. I ask each group to hand in their written answers and assign a grade to the group for the quality of their written answers and a second grade for the quality of their discussion. Again, this is my standard practice and by this point in the semester students are comfortable with this method of evaluation. If you are worried about uneven participation within a group, I suggest you use the method of having each person in the group anonymously grade each other at the end of the semester; students know they will be doing this, and generally I have found this method clearly identifies members who have not participated enough.
It is important that your students understand the general context of doing scientific investigations. They should be aware that scientists do not know the answers before they begin, that sometimes scientists make mistakes, and that many of these questions do not have a single “right” answer. At several points in the case there are good opportunities for discussing the scientific method. For example, questions 2 and 4 of Part II can be used as a springboard to discuss the role of funding agencies and the importance of designing a project that is feasible instead of a project that is perfect. Similarly, question 5 of Part III can be tied to the various components of a published paper and the overall role of speculation within science. Question 5 of Part IV directly addresses the role of managing mistakes within the process of doing research. One of the strategies that I have found quite successful in preparing students to think about the nature of scientific investigation is to discuss Lamarck’s concept of acquired traits. Lamarck’s idea that giraffes develop longer necks through stretching and subsequently transmit this trait to their offspring is, of course, incorrect, but it was not a stupid idea at the time, even though it is often erroneously presented as a really dumb idea.

**Blocks of Analysis**

We do not know much about this fascinating little cactus. Most of the research publications about it have examined its ability to survive very cold conditions. It dehydrates in the fall, which causes the pads to slump near the ground. The dehydration also means that the concentration of solutes within the cells increases. Together, the relative lack of water and the high solute concentrations apparently make it less likely for ice crystals to form across cell membranes, and the slumping habit may provide some protection from cold by making it more likely that the pads are hidden under the snow. We do know that *Opuntia fragilis* does not like to be wet over winter; winter rains or heavy wet snow will result in high winterkill. *Opuntia fragilis* has a very wide distribution, from Alberta to California and east to northwestern Illinois and northeast into eastern Ontario. Within the midwest it is quite rare, with fewer than 20 populations in each of the following states: Iowa, Minnesota, Wisconsin, Illinois, and Michigan. It does not enjoy hot weather, and disappears south of northern California to northern New Mexico.

**Answer Key**

Answers to the questions posed in the case study are provided in a separate answer key to the case. Those answers are password-protected. To access the answers for this case, go to the key. You will be prompted for a username and password. If you have not yet registered with us, you can see whether you are eligible for an account by reviewing our password policy and then apply online or write to answerkey@sciencecases.org.

**Follow-up**

As I described in the Classroom Management section above, I read and grade each group’s answers and separately grade the quality of each group’s discussion. This case does not lend itself well to a follow-up paper, but question 6 of Part IV can be assigned for a follow-up paper.

If you are interested, what did happen was that my wife and I decided to move to southwestern Indiana to take new academic positions. Jeremy Myrom and I published a paper about our findings about the population sizes in the *Journal of the Minnesota Academy of Science*. Jeremy went on to dental school, so the botanical world lost a promising new researcher, and I abandoned this particular research project because I didn't have enough funding to be able to afford travel back to Minnesota. However, my interest in *Opuntia fragilis* has remained. I am now a member of the Biology Department at Western Illinois University, and my graduate student Barbara Anderson and I are studying the only population of *Opuntia fragilis* in Illinois and have obtained a grant from the Illinois Endangered Species Board. We have a much larger sample size, have three years of data, and plan to collect more data. Barbara is close to finishing her master’s thesis about this population, after which
we plan to submit a manuscript about her findings to the *American Journal of Botany*. Interestingly, she has found that in our much larger population fruit set is still unlikely to happen. I’m planning to keep studying this population, and hope to be working with the population in Michigan soon.

*Addendum from the Author:* We now know that a form of self-incompatibility prevents sexual reproduction in the Midwest. Many plants have a mechanism to recognize pollen that they themselves produce. These self-pollen grains are then inhibited to prevent them from fertilizing any of the eggs. In effect, these plants have a mechanism to prevent having sex with themselves. In the Midwest, this mechanism inhibits all pollen from growing. Probably the genetic marker that is used has lost its genetic variability.

**References**


Mitich, Larry W. No date. Personal Communication.


