



CASE TEACHING NOTES for "Threats to Biodiversity: A Case Study of Hawaiian Birds"

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INTRODUCTION / BACKGROUND

This case was designed for the weekly, one-hour seminar component of introductory biology at Duke University. In addition to seminar, introductory biology students attend lecture and laboratory. Teaching assistant (TA)-mentors lead the 12-student seminars during which students engage in directed inquiry exercises. TA-mentors are instructed on how to teach a case in a preparatory meeting the week before the case is taught. In this meeting, TA-mentors complete the case as though they were students or review the main points of the case with the TA-mentor coordinator. In addition, they discuss possible ways to guide their students through the material.

This case study is designed to cover two seminar periods of the course. Topics covered in the lecture and lab components of the course prior to this case include community ecology, life history, resource allocation, population structure, population dynamics, species interactions, behavioral ecology, and hypothetical-deductive methods in scientific inquiry. This case also may be appropriate for upper level courses such as ecology, conservation biology, evolution, diversity, biology of social issues, or a non-majors biology course, and can be used with larger class sizes.

Objectives

- To learn the following about introduced species and how they threaten biodiversity:
 - what makes a certain introduced species more likely than another to become established in a new area;
 - how introduced species can directly and indirectly affect endemic species; and
 - why certain endemic species (e.g. Hawaiian birds) are particularly vulnerable to introduced species.
- To gain experience in data analysis and in how collaboration contributes to studying complex biological problems.

CLASSROOM MANAGEMENT / BLOCKS OF ANALYSIS

Week One: In-Class Exercise

Format:

1. Students read the Background Reading on ["Threats to Biodiversity"](#) prior to coming to class.
2. In-Class Exercise:

- a. Students complete questions 1-3. The purpose of this segment is two-fold. First, it illustrates the decline in biodiversity in Hawaii; secondly, it gets students thinking about introduced species as a factor which may contribute to this problem. Questions 1-3 can be completed in a large-group discussion led by you or in small groups of students. Note: After students finish question 1, inform them that the remainder of the exercise will focus on only one of the potential factors contributing to the decline of Hawaiian birds—introduced species.
- b. Divide students into three groups to work through question 4. Assign a different factor—bird size, nesting site, or incubation and fledging period—to each group. Groups generate a null and alternate hypothesis about how this factor affects the extent to which rats prey on birds. Alternatively, you may ask groups to form null and alternative hypotheses for all factors but to analyze the data for only one of those factors. Following hypothesis formation, groups evaluate their hypothesis with a set of data. Each group receives a different Table 2—either 2a, 2b, or 2c.
- c. Groups report to the entire class on whether or not the data they received supports their hypothesis. This also will give students the opportunity to learn about the other hypotheses that their peers addressed. Students should then collaborate to incorporate their results into a broad understanding of why birds might be at risk for rat predation. Instructors should facilitate this "collaboration time" to bring closure to and summarize the exercise and to emphasize and record on the board important points from the data.
- d. By the end of this session, the focus necessarily narrows—rats, ungulates, and birds in Hawaii. Ultimately, we want students to take away a more general message (see the [Objectives](#) above). Sometime during the wrap-up discussion, ask the students "Who cares?" Challenge them to begin thinking about how this case study relates to areas other than Hawaii and to the biodiversity crisis in general. Some points/questions that we have found useful for generating this discussion are listed below.
 - Pose the question "Who cares about biodiversity?" and have students debate their position on whether or not biodiversity should be conserved.
 - Discuss some of the ethical issues associated with biodiversity or general conservation issues.
 - Discuss how conserving biodiversity may allow us to find medications that will be vital to curing human disease (e.g., the Pacific Yew and taxol).
 - Use the following quote by Aldo Leopold, a well-known writer of natural history and conservation, as a discussion point:

If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

Ask students to respond to the question of how we should treat our ecosystem given the fact that we don't know for sure what may happen when we tamper with it.

- e. 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](#).

3. Take-Home Assignment:

- a. Distribute and discuss the take-home assignment for groups [1](#), [2](#), and [3](#). In this assignment, students examine one of three subtopics related to the introduction of ungulates to Hawaii:
 - i. how ungulates have impacted the habitat used by endemic birds;
 - ii. how ungulates facilitate the establishment and spread of other introduced species; or
 - iii. what characteristics of endemic birds make them sensitive to the effects of these introduced ungulates.

- b. Take-home assignment guidelines:
 - i. Each group works on one of the subtopics outside of class time.

 - ii. Groups use the list of references provided as the basis for their research (see [4d below](#)).

 - iii. Groups are expected to work together on this assignment to produce a group conclusion rather than individual conclusions from each member of the group. Each member of the group is expected to be prepared to present their findings to other groups in week two.

 - iv. *Optional writing assignment.* Students may be asked to present their conclusions from the take-home assignment in the form of a short (1- to 2-page) paper written by the group that is turned in at the end of class during Week 2. Writing a group paper may present some unique challenges to students. Some tips for collaborative writing include dividing the responsibility among group members for writing and editing. Instructors might suggest that students divide the labor such that one person writes an introduction, one person writes a paragraph to discuss specific data, and one person writes a conclusion. Or instructors may suggest that all students in a group discuss the information, one student writes the paper, and the other students take turns revising and editing this draft. No one method is best, but it is important to emphasize that all students should contribute equally to the final paper. Alternatively, asking each student to write a short paper also would work.

 - v. This assignment may be modified to decrease the amount of time spent outside of class. For example, students might be assigned only one or two review papers to read outside of class and a list of thought questions. The thought questions would be those listed in the take-home assignment. In Week 2, instructors would use questions 1-3 in the take-home assignment to guide their discussion of how introduced ungulates have impacted the habitat of endemic birds. Some good review papers for this iteration of the assignment include:
 - Scott, J.M., C.B. Kepler, C. van Riper III, and S.I. Fefer. 1988. Conservation of Hawaii's vanishing avifauna. *BioScience* 38(4):238-253.
 - Stone, C.P., and L.L. Loope. 1987. Reducing negative effects of introduced animals on native biotas in Hawaii: What is being done, what needs doing, and the role of national parks. *Environmental Conservation* 14:245-258.

- Vitousek, P.M., L.L. Loope, and C.P. Stone. 1987. Introduced species in Hawaii: Biological effects and opportunities for ecological research. *Trends in Ecology and Evolution* 2(7):224-227.

4. Additional Comments and Recommendations:

- a. Some instructors may find that students are dissatisfied by the results for [question 4](#) of the in-class exercise. In Part "a," students find a negative correlation between bird size and predation; however, there is no relationship between nest location and predation or nestling/fledging time and predation. This is a good place to emphasize some of the frustrations encountered by scientists when presented with inconclusive evidence. Some instructors may have their students speculate on potential experiments that could test their hypotheses or other data that might be helpful in determining what factors make birds more susceptible to predation.
- b. Instructors should note that not all of the data tables are complete. Since these data are generated from literature searches, not all of the information is available because studies on the life histories of these birds have not been conducted. These gaps in the data provide a good point of discussion with students. Have them speculate on why the data are incomplete. This may be an appropriate time to discuss how science is "done," the difficulties of collecting data in the field, and our knowledge of general natural histories of organisms.
- c. References for the take-home assignment are provided to students through the library reserve system. Papers are available in hard copies or as on-line PDF files.
- d. While the references provided for the take-home assignment are review articles, instructors should note the importance of teaching their students how to read the primary and review literature prior to this assignment. We accomplish this through a separate semester-long assignment in which students are expected to use the primary literature to develop a research proposal.

Week Two: Discussion of Take-Home Assignment

This session focuses on the results of the take-home assignment and serves to summarize some of the consequences of introduced species on the native biota.

Format:

1. Groups report their findings from the take-home assignment. There are multiple ways to do this, and instructors may find it helpful to explicitly write instructions for students on the board. Here are some ideas:
 - a. *The "Jigsaw Technique."* Groups send out representatives to other groups to hear their findings—the individual pieces of the puzzle. Representatives report back to their original group so that all groups have a complete understanding of each of the subtopics considered—a completed puzzle. Instructors circulate through groups to insure that all of the major points have been covered. Instructors might want to closely monitor the time that students spend (i) in other groups, (ii) reporting to their group, and (iii) in a class discussion. For example, one third of the class time may be allotted for each of the three activities.
 - b. *Group Presentations.* Groups take turns presenting their findings to the class as a whole. You could have them do this using overhead transparencies, a poster presentation, or at the

chalkboard. Note: If this option is chosen, be sure to allow time for questions.

2. Bring the case study to a conclusion by recapping observations from Week 1 and the take-home exercise. This is also a good opportunity to discuss with students the generality of the problem of introduced species.
3. Additional Comments and Recommendations:
 - a. Some instructors may want to use the end of this seminar to discuss issues related to biodiversity. For ideas about how to do this, see [2d](#) under Week 1, above.



REFERENCES

Suggested Background Reading for Instructors:

- Scott, J.M., C.B. Kepler, C. van Riper III, and S.I. Fefer. 1988. Conservation of Hawaii's vanishing avifauna. *BioScience* 38(4):238-253.
- Scott, J.M. 11/30/1999. Hawaii—Overview. <http://biology.usgs.gov/s+t/noframe/t283.htm>.
- Vitousek, P.M., L.L. Loope and C.P. Stone. 1987. Introduced species in Hawaii: Biological effects and opportunities for ecological research. *Trends in Ecology and Evolution* 2(7):224-227.

Summary of References for the Take-Home Assignment:

- Campbell, N.A., J.B. Reece, and L.G. Mitchel. Angiosperms and animals have shaped one another's evolution. In *Biology*, 5th ed. p 570. Menlo Park, CA: Benjamin/Cummings.

This reading describes the process of co-evolution using flowers and their pollinators as an example. The diversity of floral structures is explained in light of co-evolutionary processes between plants and the insects that pollinate them. The role of pollinator specificity is also discussed; some flowers have only one or two pollinators (as is the case with flowers that are pollinated by honeycreepers on the Hawaiian Islands) and others have multiple pollinators. This reading is from the text book that was used in the course in which this case was taught. Campbell *et. al.* is an introductory biology text book. This reading could be replaced with a similar one from any ecology or evolution text.

- Drost, C.A. and G.M. Fellers. 1999. Non-native animals on public lands. <http://biology.usgs.gov/s+t/noframe/x180.htm>.

This article is a general survey on non-native animals in the United States. The Hawaiian Islands are singled out for two reasons: (1) they are threatened by introduced ungulates and (2) they are extremely isolated. Feral pigs are discussed as a major threat to ecosystems in Hawaii because they dig up native plants and destroy habitat for native animals. These native organisms are also poorly adapted to compete with introduced predators, competitors, and diseases because they have been extremely isolated from mainland populations.

- Meffe, G.K., C.R. Carroll, and S.L. Pimm. 1997. The loss of plants and birds in Hawaii. In G.K. Meffe and C.R. Carroll (eds.), *Principles of Conservation Biology*, pp 257-258. Sunderland, MA: Sinauer Associates, Inc. Publishers.

This is a short, three-paragraph section that discusses characteristics of Hawaii's endemic avifauna that makes it susceptible to decline. Hawaiian honeycreepers are cited as examples of endemics that have a specialized relationship with the plants they pollinate. As the plants they pollinate become endangered (due to habitat destruction), the birds also become endangered since their beak morphology allows them to feed only on a narrow range of plants.

- Olson, S.L., and H.F. James. 1982. Fossil birds from the Hawaiian Islands: Evidence for wholesale extinction by man before western contact. *Science* 217:633-635.

This article cites fossil evidence that the number of endemic species was more than twice current numbers at the time of Polynesian settlement. It also shows that the distributions of extant species were greater prior to colonization than they are today. The colonization of the Polynesians corresponds to major declines in species, and it is suggested that introduced species (e.g., *Rattus exulans*) and habitat destruction led to the decline in species. Small, flightless birds and ground birds showed the greatest decline probably due to predation, and passerine birds declines probably corresponded to habitat destruction from agriculture.

- Scott, J.M. 11/30/1999. Hawaii—Overview.
<http://biology.usgs.gov/s+t/noframe/t283.htm>.

This article is an overview of the climate and geology of the Hawaiian Islands. It discusses how the isolation of this archipelago has led to a high number of endemic organisms. Data is presented on the loss of several species, with special note to birds, and cites introduced species as a major cause of decline in endemics. The article also cites ungulates as the single introduced group that has caused the greatest damage to Hawaiian endemics and discusses some steps that private and public organizations are taking to track endangered species. This article is very general, and only briefly mentions the above issues of endemism and ungulate introductions. It provides students with a general knowledge of the problem, but does not offer an in-depth discussion of the issues.

- Scott, J.M., C.P. Kepler, C. van Riper III, and S.I. Fefer. 1988. Conservation of Hawaii's vanishing avifauna. *BioScience* 38(4):238-253.

This article is a more in-depth analysis of how ungulates have affected Hawaii's avifauna. The authors review species declines in six major groups of birds (seabirds, endemic waterfowl, rails, stilts and herons, raptors, and perching birds) and the role of ungulates in this decline. Ungulates are cited as destroying habitat of these birds and facilitating the spread of other introduced species. In particular, stagnant pools of water often result where ungulates have routinely grazed and trampled an area. These water pools are ideal habitat for mosquitoes which carry avian malaria. The article closes with a discussion of management plans and recovery efforts for endangered species.

- Stone, C.P. Non-native land vertebrates. In C.P. Stone and D.B. Stone (eds.), *Conservation Biology in Hawaii*, pp 88-95. Honolulu: University of Hawaii Cooperative National Park Resources Studies Unit.

This article discusses the series of vertebrate introductions to Hawaii, including the introductions of ungulates, their effects on community structure, and how these domesticated animals soon became feral. The destruction to native birds' habitats by grazing and trampling is discussed, as are the effects of these activities on local watersheds. The article also discusses other introductions, such as birds, which brought with them avian malaria. Native birds are not immune to avian malaria, and its introduction (along with ample mosquito breeding pools created by ungulates) aided in the decimation of native birds. This article also discussed how introduced vertebrates can be managed to decrease the rate of species declines in Hawaii.

- Stone, C.P., and L.L. Loope. 1987. Reducing negative effects of introduced animals on native biotas in Hawaii: What is being done, what needs doing, and the role of national parks. *Environmental Conservation* 14:245-258.

This article discusses how the fauna of Hawaii slowly colonized the islands over thousands of years, and how this has led to extremely high endemism and explosive adaptive radiations on the islands. It then gives a historical account of Polynesian introductions of non-natives (e.g., rats, dogs, snails) and the subsequent decline of native birds. Post-colonial introductions of introduced vertebrates, including goats and pigs, are discussed in great detail. The decimation of local flora by these ungulates is detailed. Other species introductions relevant to the take-home assignment are avian introductions. Introduced birds may out-compete endemics for nectar resources. Also, introduced game birds provided a stable vector for avian malaria and caused a dramatic increase in the disease. Endemic birds have suffered serious declines due to avian malaria. Finally, introduced plants may out-complete local plants that provide nectar resources to endemic birds. The ability of these plants to out-compete endemics is due in part to introduced ungulates acting as seed dispersers and trampling the ground to provide seed beds for non-natives.

- Vitousek, P.M., L.L. Loope, and C.P. Stone. 1987. Introduced species in Hawaii: Biological effects and opportunities for ecological research. *Trends in Ecology and Evolution* 2(7):224-227.

This review focuses on the consequences of species introductions in the Hawaiian Islands. In particular, the effects of exotics on native birds and plants are discussed. The role of competition and facilitation between natives is discussed using introduced plants and birds as key examples. Introduced ungulates are mentioned as prime predators of native plants, and the decline of these plants is associated with the decline of birds species that depend upon them. The role of feral ungulates in dispersing non-native plant seeds is discussed as is their role in increasing soil erosion and altering nutrient availability. Introduced birds are cited as out-competing native birds and contributing to their decline.

- Warner, R.E. 1968. The role of introduced disease in the extinction of the endemic Hawaiian avifauna. *The Condor* 70:101-120.

This article examines the effect of introduced diseases, such as avian malaria and

birdpox, on Hawaii's indigenous avifauna. The mosquito that hosts avian malaria was introduced to Hawaii at the time of European settlement, and its population grew due to suitable breeding pools created by ungulates. Ungulates trample the ground, leaving exposed patches of ground that fill with water. These stagnant pools are excellent breeding habitat for mosquitos. Other introduced insects, such as hippoboscids, also host diseases that infect native avifauna. Finally, Warner found that native bird species are more susceptible to avian malaria and birdpox than are introduced bird species (e.g., domestic fowl).

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