Teaching Notes for Save the Turtles! And the Grizzlies? Or the Woodpeckers? Prioritizing Endangered Species Conservation

Dr. Judy Che-Castaldo, Dr. William Burnside, and Dr. Cynthia Wei
National Socio-Environmental Synthesis Center (SESYNC), Annapolis, MD

Abstract
This case study explores the complexities involved in endangered species management and provides an opportunity for students to perform an exercise in socio-environmental synthesis. Developed for introductory undergraduate courses in environmental studies or conservation biology, it contains suggested modifications for upper-level undergraduate and graduate courses. Students take the position of wildlife managers who must decide how best to allocate limited resources for conserving multiple threatened and endangered species. Students are provided with data on the ecological characteristics and socio-economic circumstances for a set of five species, and then work in small groups to develop conservation priority rankings based on those data. Students summarize their decisions in writing and in small-group presentations, and the case concludes with an instructor-led discussion of how actual conservation priorities are determined.

Objectives:
- Understand the concept of socio-environmental systems
- Recognize interactions between ecological and social factors in an environmental issue (recovery of endangered species)
- Synthesize natural and social science data
- Develop and compare ways to integrate different sources and types of data
- Apply synthesis results to make a management decision
- Be able to explain why it was important to consider interdisciplinary sources of data and how to reconcile conflicting information

Topical areas: Wildlife Conservation, Environmental Science, Socio-environmental Synthesis
Education level: Undergraduate lower division, Undergraduate upper division, Graduate
Type/method: Small Group, Student Presentations

[1]Photo credits:
Grizzly bear: USFWS photo. http://www.fws.gov/mountain-prairie/species/mammals/grizzly/
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Atlantic salmon: Photo by William Hartley, USFWS. http://www.nmfs.noaa.gov/pr/species/fish/atlanticsalmon.htm
Oahu tree snails: Photo by Steve Miller, USFWS. http://www.fws.gov/pacificislands/fauna/oahutreesnails.html
Kemp's Ridley sea turtle: Photo by Kim Bassos-Hull, Mote Marine Laboratory.
http://www.nmfs.noaa.gov/pr/species/turtles/kempsridley.htm#description

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Authors' Note:

This case has been used in a variety of courses from introductory to graduate levels. We think this case works best at the beginning of a course or module as an interactive way to introduce the challenges of considering and synthesizing different types of data, as well as the importance of including perspectives and data from multiple disciplines when addressing socio-environmental problems. The case works well as a way to initiate discussions about these important concepts; the depth of such discussions can be modified by instructors as appropriate for the audience. If you use this case, we would greatly appreciate a short email to let us know where and in what context you used it, along with any comments or constructive feedback. Please email Cynthia Wei at cwei@sesync.org.

Introduction/Background

Human population growth and the resulting increase in human activities have caused extensive changes to the natural environment, including degradation and reduction of wildlife habitat. Habitat loss is a major cause of species decline and has lowered the abundance of many species to near extinction. Invasive species, which may consume or compete with native species, is a growing problem as well. Efforts to protect native species and prevent their extinction have become a priority for conservation biologists and groups such as the International Union for the Conservation of Nature (IUCN). However, species conservation affects not only biodiversity but also the human populations that interact with the species. For example, local people may depend upon use of resources such as firewood in an endangered species' habitat, and protection of that habitat would eliminate this resource option. Thus, management of endangered species is a socio-environmental issue because conservation planning must consider not only the environmental requirements of the species, but also the human social systems that affect those species or will be affected by management actions.

In the United States, the Endangered Species Act (ESA) was enacted in 1973 to conserve species that are at risk of extinction and to manage their recovery. There are currently 1437 animal and plant species occurring in the United States that are listed under the Act as either threatened or endangered, the latter group being at greater risk. Due to the limited budget and large number of species requiring management, conservation budgets and efforts require prioritization. Because this is a socio-environmental issue, one way to prioritize is to focus efforts on species that are most at risk, have the greatest probability of recovery, and whose conservation would result in the least negative impacts on other human activities or interests. In this way, conservation prioritization requires a synthesis of relevant information from both the natural and social sciences.

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Synthesis, which literally means "to put together," is a holistic approach to science that combines information from different studies, data on different variables, or ideas from different fields. Considering this information together can provide original and unexpected insights. For example, synthesizing findings from genetics, paleontology, and other areas of biology enabled scientists to understand how evolution occurs. Socio-environmental synthesis is the use of this approach to study socio-environmental systems, defined as tightly linked social and biophysical subsystems that mutually influence one another. Considering how the size of a trout population in a lake (the biophysical system) varies with the density of lakeshore housing (a social variable) is one example. Applying ideas from sociology about social networks on the Internet to networks of interacting species in an ecosystem is another.

This case study provides an opportunity for students to learn about and perform an exercise in socio-environmental synthesis. It guides students to consider multiple factors that are important to conservation planning, and to determine how those data can be integrated to inform management decisions. Specifically, students are challenged to synthesize social and ecological data about five pre-selected threatened and endangered species in order to prioritize conservation efforts for the species. After an introduction to the overall problem, students are asked to rank the relative conservation priority for the five species based on individual factors alone, and then all ecological and social factors together. By focusing on a small set of species and a limited set of factors, this case study highlights the complex relationships and sometimes conflicting information that governmental agencies must consider when prioritizing conservation efforts and planning management actions.

This case is developed for introductory undergraduate environmental science or conservation biology courses (freshman- and sophomore-level), but may be modified for upper-level undergraduate or graduate courses as suggested in the Classroom Management-Teaching the Case section. The unmodified version of this exercise takes 2.25 -3.5 hrs. (can be broken up into multiple class periods), and most modifications will require longer class times.

Learning Goals
This case study will address the following Socio-Environmental Synthesis learning goals:
1. Ability to describe a socio-environmental system, including the ecological and social components and their interactions
2. Ability to identify disciplines and approaches relevant to the socio-environmental problem (*for Modification 1*)
3. Value different types of knowledge and understand the value of different knowledge sources
4. Ability to analyze and synthesize existing data
    • Understand the different kinds of data used by relevant disciplines in the natural and social sciences
    • Ability to integrate different types of data (interdisciplinary integration)

Learning Objectives
Through this case study, students will be able to:
1. Explain the coupled nature of social and natural systems in the context of endangered species conservation.

- Related activity: Students examine how the management decision of assigning conservation priority is part of a socio-environmental system: decisions are both based upon both ecological and social factors and in turn have social and ecological impacts.

2. Identify interactions between ecological and social factors in an environmental issue.
   - Related activity: Students discuss how ecological and social factors impact conservation priority, and discuss the difficulties of making decisions based on factors in isolation from each other.

3. Identify challenges in synthesizing natural and social science data.
   - Related activity: Students make their final ranking decisions by synthesizing multiple types of information, including ecological and social data.

4. Develop a way to integrate different sources and types of data in the context of this case.
   - Related activity: Students improve upon the suggested simplistic method for synthesis and develop their own methods to synthesize the provided data.

5. Apply synthesis results to make a management decision
   - Related activity: Students apply their synthesis results to rank the conservation priority for five threatened and endangered species.

6. Be able to explain why it is important to consider sources of data from multiple disciplines and sources and how to reconcile conflicting information.
   - Related activity: Students summarize their decision making process and final rankings in written reports and in small group presentations.

Classroom management

Summary

Introduction (15-25 mins).

- Before class, students are assigned readings that provide background information for the case study
- At the beginning of class, the instructor reviews major points from assigned readings (5min.)
- The instructor introduces the case, and students read the scenario handout describing their task of determining conservation priority for five species (5-10 min.).
- Instructor leads a discussion on types of data required to perform this task (5-10 min.)
- At this time, Instructors may also want to add a brief classroom assessment activity to quickly assess student thinking on the readings and/or as a pre-test to gauge student understanding of the issue prior to the activity. One suggestion is a minute paper: ask students to write a brief answer to the question: "What factors do you think are important to consider when prioritizing conservation efforts for different species?" This same question can be posed at the end of the activity with an additional request for students to reflect on what they've learned through the exercise.

Small Group Activity: Part 1 (1 hr. 15 mins- 1 hr. 40 mins.)

- Students are divided into teams, instructed to read the exercise, and then given four types of information one at a time: biological characteristics, intensity and type of threats, economic considerations, and socio-cultural values (10 mins.).

- Students examine each type of data individually, and assign a priority ranking to each species based on each factor (i.e., 1 = highest priority, 5 = lowest priority; 15-20 mins. per factor; 1-1 hr. 20 mins.).
  - Teams keep a written summary of their rankings and report their rankings to the class after each factor.
- Instructor leads teams to consider how the different factors might interact and discuss how this is a socio-environmental issue and requires synthesis (5-10 mins.) Instructors may opt to combine this discussion with the discussion in the next part.

Small Group Activity: Part 2 (50 mins.- 1 hr. 20 mins.)

- Teams are challenged to develop comprehensive priority rankings that consider all factors in combination (15-30 mins.).
  - Each team agrees upon a final ranking and writes a short report summarizing how they derived their rankings.
  - This should involve a discussion of how inclusion of multiple types of information changed the rankings, which factors were most important, and the implications for overall conservation effectiveness.
- Each team gives a brief presentation of their final rankings to explain their decisions (15-25 mins.).
- Instructor leads discussion and comparison of results among teams, reviews main conclusions, and contrasts with current approach used by USFWS (20-30 min.).

Total time: **2 hrs. 10 mins. - 3 hours 30 mins.**

Teaching the case

Prior to class, students are assigned the pre-class background readings listed below:

- Overview of the Endangered Species Program within the US Fish and Wildlife Service (USFWS): http://www.fws.gov/endangered/about/index.html
- ESA fact sheet from USFWS: http://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf
- Defenders of Wildlife fact sheet on economic benefits of conserving wildlife: http://www.defenders.org/sites/default/files/publications/bang-for-our-buck.pdf
- Political and economic aspects of the ESA, particularly critical habitat designation (identifies the various interested parties: landowners, developers, litigations, environmentalists): http://www.nytimes.com/2005/06/26/politics/26species.html?pagewanted=all&_r=0

At the beginning of class, the instructor should review the important points from the readings with students. For example:

- What is the Endangered Species Act? What protections does it provide the species?
- What is the role of the USFWS with regard to the Act?
- What are some relevant considerations when deciding how a species should be managed?
- Why would we need to prioritize species management?

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Next, the instructor introduces the scenario and the set of species that the students will focus on. Students are given a few minutes to read the scenario on their own. The species set was chosen to provide a range of conditions for each type of factor. They are:

1. Grizzly bear (*Ursus arctos horribilis*): charismatic but also directly threatened by humans
2. Red cockaded woodpeckers (*Picoides borealis*): endangered due to habitat specialization
3. Atlantic salmon (*Salmo salar*): threatened by commercial fishing
4. Oahu tree snails (*Achatinella spp.*): less well-known but highly endangered due to invasive species
5. Kemp's Ridley sea turtle (*Lepidochelys kempii*): mostly recovered though naturally rare

NOTE: Atlantic salmon and Kemp's Ridley sea turtle are marine species and actually managed by the National Marine Fisheries Service rather than USFWS

The instructor leads a brief discussion about the kinds of information the teams would want to have for prioritizing species conservation. Then s/he introduces the factors that they will be examining [For upper-level courses, see *Modification 1* in the Suggested Modifications section below]. Each factor will be presented as a fact sheet including information for all five species:

1. Biological characteristics: selected life history traits on range size, body size, life span, reproductive rates, and population trends
2. Intensity, type, and imminence of threats: including whether threats are historic, present, or predicted for the future
3. Economic considerations: industries affected by species conservation, estimated costs of conservation
4. Socio-cultural values: medicinal, recreational, cultural importance, and existence value of the species as well as social implications of management activities

[Taxonomic distinctiveness may be added as a fifth factor for upper level courses: see *Modification 2*. Students may be challenged to create the data sets instead of working with the ones we provide in this case: see *Modification 3*]

The instructor then divides students into teams of 3-4, and provides teams with the fact sheets for one factor at a time [See *Modification 4* for an alternate procedure that helps to illustrate the difficulty of considering factors in isolation]. Students assign conservation priority for the species set based on each factor, discussing why and how they derive their conclusions. The instructor should remind students to try to consider each factor alone (this is difficult to do, but the difficulty is part of the lesson). For example, why might one want to prioritize species that have larger range sizes? How important would it be to prioritize species whose management might have costly economic impacts? As a team, students should come to an agreement on the ranking based on each factor and write a brief explanation for why they ranked the species as they did. Students may be encouraged to create charts or figures to record their decisions. Teams repeat this process for each of the factors in the order they are assigned. When completed, teams will report their conclusions for each factor by recording it on a common spreadsheet or writing it up on a board. Instructors may choose to ask teams to report on their rankings at this point. Alternatively, reporting and discussion can be combined at the end (this is more time efficient). For younger students, instructors may want to pause for discussion and reporting of rankings after each factor to ensure that students are on the right track in terms of their approach to the exercise.

When all teams have discussed all factors individually, the instructor prompts students to consider how the different factors may interact, and how they might start to combine the information together. For example, ecological requirements (e.g. larger species have larger home ranges and therefore require more space) may interact with socio-economic constraints (e.g. cost of land preservation increases with the amount of land preserved; larger species tend to be more "charismatic" and garner more public support). This should lead to a discussion of how conservation prioritization is a socio-environmental issue and requires synthesis of seemingly disparate types of data. This step may be optional if students do not need prompting and have already started to discuss some of these interactions on their own.

Next, teams are challenged to develop comprehensive priority rankings that consider all factors in combination. The instructor may want to prompt students to start by summing up ranking scores for each species across factors and then ranking the species based on the sums (e.g., the lowest score would have highest priority). This is obviously a simplistic method, but it may provide a useful starting point for synthesis [To introduce a more sophisticated synthesis method, see *Modification 5*]. Students may then discuss whether this results in a satisfactory ranking, and if not, how can they adjust the process to reflect overall priority? Students should then discuss within their groups how the inclusion of multiple types of information changed the rankings, which factors they deemed most important, and their reasons. If they have some background in the subject, they may be able to discuss the implications of their rankings for overall conservation effectiveness. Each team should agree upon a final ranking and write a short report summarizing how they derived their rankings and conclusions from their discussion. This should include consideration of how integrating multiple types of information changed the rankings, which factors were most important, and the implications for overall conservation effectiveness.

Each team presents their final rankings, which are tallied on a white board or spreadsheet in front of the class as done with the rankings for the individual factors. Each team also gives a brief presentation to summarize their main conclusions and the difficulties they came across. The instructor leads a discussion with the whole class to conclude the case study. Some example discussion questions may include:
  • How did your team reach your final ranking decisions?
  • What was the reasoning behind your rankings? Did you create some sort of system or rules for considering all the factors in combination?
  • Was there one type of factor that seemed most important to your decisions? If not, why?
  • Were there specific factors or species for which you could not determine a final ranking?
  • What were the conflicting factors?
  • Did the conclusions vary based on which factor(s) a team considered first? [For *Modification 4*]

Finally, the instructor may present other relevant information to further the discussion and conclude the case. For example,
  • Discuss how this case involved a socio-environmental system: Prompt students to identify the social and the biophysical components of the system (e.g., the management decision and species survival) and how they influence each other.

- Briefly present how prioritization is currently done (see expected outcomes section below), and have students discuss how they might improve this based on the exercise and their conclusions.
- Present the actual reported expenditures on each species, as a reflection of how they are actually prioritized by the USFWS. Discuss how these compare to the students' rankings.

Additional background information

Under the Endangered Species Act, "endangered" species are those in danger of extinction throughout all or a significant portion of its range (ESA sec. 3(6)), whereas "threatened" species are those likely to become endangered within the foreseeable future (ESA sec. 3(20)). The ESA is implemented by two government agencies: the National Marine Fisheries Service manages the marine listed species, whereas the Fish and Wildlife Service manages the remaining 95% of listed species. These agencies carry out conservation activities that range from land protection and acquisition to active management, such as breeding programs and invasive species removal.

In the conservation community, the concept of "species triage" is controversial. While some proponents advocate for a more economically-focused approach to conserving species that prioritizes conservation efforts and funding to more efficiently use the pool of finite resources that exist, others are adamantly opposed to the idea. Opponents cite discomfort with "playing God" and worries that this approach will encourage people to give up too easily or provide a handy excuse to not do difficult things.

An interesting article that sums this controversy up well is *It's Time to Let Certain Animals Go Extinct*. This article in Outside Magazine describes the controversial species triage push by proponents such as Professor Leah Gerber of Arizona State University, https://www.outsideonline.com/2176276/its-time-choose-which-animals-we-let-go-extinct. Dr. Gerber's 2016 PNAS paper, *Conservation triage or injurious neglect in endangered species recovery*, can be found here: http://gerberlab.faculty.asu.edu/wordpress/wp-content/uploads/2011/10/PNAS-2016-Gerber-1525085113.pdf. These may be good articles to assign to students either in advance or after the case is implemented.

Expected outcomes

The case is designed not to yield a "correct" method for prioritizing the species. Rather, the intention is for students to develop and compare potential ranking systems, all of which may have advantages and disadvantages. The current method by which the US Fish and Wildlife Service prioritizes the conservation importance of listed species does not explicitly factor in social or cultural impacts (U.S. Government Accountability Office report 2005). For example, the priority ranking for developing and implementing recovery plans depends on the degree of threat, recovery potential, taxonomic distinctiveness, and whether there are conflicts with economic activity (yes or no, irrespective of specific conflicts) for each species.

However, if the budget spent on each species may be assumed to be related to actual prioritization (see table below), it would indicate that effort and budget are not allocated based on ecological considerations alone. The 'true' prioritization process and how spending decisions are made are undocumented and it is unclear whether they are standardized or consistent.

Reported spending on listed species in 2014 (USFWS 2014)	
Grizzly bear	$8,036,953 (+$1,052,651 on Experimental population)
Red cockaded woodpeckers	$28,091,150
Atlantic salmon	$8,621,892
Oahu tree snails	$626,181
Kemp's Ridley sea turtle	$5,636,214

https://www.fws.gov/Endangered/esa-library/index.html (accessed May 31, 2017)

Suggested modifications for upper-level courses

- *Modification 1:* Before providing teams with fact sheets, have students identify the key factors related to ranking conservation priority for species, and discuss what potential data they would need. Additionally, consider providing each team only the data that they request. In this case, the comparison of rankings among teams at the end of the lesson could then include discussion of the impacts of including or excluding specific types of data.
  - *Modification 1a*: Provide teams with fact sheets, but have students identify additional data that could potentially impact ranking decisions under each factor. This may be done at this point or at the end of the exercise.
  - *Modification 1b:* Allow teams to search for this additional information and incorporate the data they find into their ranking decisions.
- *Modification 2:* A fifth factor may be included into the synthesis: taxonomic distinctiveness (see supplementary handout at the end). This factor is explicitly included in the USFWS prioritization scheme, however it requires students to understand evolutionary relatedness and how to interpret basic phylogenies. In essence, this factor examines how many other species are closely related to the species in question, providing a measure of how unique or distinct it is from an evolutionary perspective. This will include the number of taxa at each of these classification levels for the focal species: Order, Family, and Genus. These data are included as a supplemental fact sheet. With this modification, the introduction should include a discussion of why taxonomic distinctiveness would be important to consider.
  - *Modification 2a*: For evolutionary biology courses, the instructor may provide phylogenetic tree information and have students determine the data needed to calculate taxonomic distinctiveness. Students may also discuss which taxonomic level might be best to examine distinctiveness (order, family, genus), or whether the three levels may be weighed equally
- *Modification 3:* If you also want students to wrestle with the challenges of finding relevant data, you can assign students the task of compiling fact sheets rather providing them. Each team may be given the task to compile a fact sheet for one factor for all species, or all factors for one species [A jig-saw case study]. This may work best as a take-home assignment.
- *Modification 4:* Instructor may assign a different order to each team for examining the four factors, so that some teams start with social factors and others with ecological factors. This would not allow for students to report their rankings after each factor, because teams would

have examined different factors. However, when the authors applied this modification, the students found that data from previously examined factors did influence their decisions, resulting in a useful discussion of how the factors are interrelated.

- *Modification 5:* Upper-level courses may be interested in applying a more sophisticated method of synthesis such as one described in Joseph et al. (2008). In this study, the authors proposed a systematic weighting scheme to prioritize species that simultaneously weights costs, benefits, and the likelihood of management success.
  - o *Modification 5a*: This may be a post-case study assignment, in which students read the article and compare the method with their exercise. This would include a discussion of the benefits of their method and what could be improved. For example, the authors do not include the social or cultural factors considered in our exercise - how could these be incorporated?
  - o *Modification 5b*: Students may be assigned to apply the authors' weighting method for the five focal species. This will require students to research data on the factors used by the authors for the species.
- *General modification:* Students may be tasked to assign proportions of a total budget to the species rather than a simple ranking of priority.

Assessment and Evaluation
While there are many classroom assessment techniques that could work well for this case, we describe here a few that we have tried.

Minute Paper:
The authors used this technique with a group of 17 undergraduate interns as a way to facilitate reflection on what the students learned through this case study, and as a way to assess student learning goal #6 (importance of considering multiple types of data from different disciplines)

Process: At the beginning of the activity, ask students to write on an index card their brief response to a question. We used the question: "What factors do you think are important to consider when making decisions about where to prioritize conservation efforts?" However, the wording of this led to responses that were not reflective or particularly informative. We suggest wording the question carefully to elicit more thoughtful descriptions. Perhaps adding the phrase "please explain why". This may require more than 1 minute.

At the end of the case, ask students to respond to the same question on the back of the index card, and ask them to compare their thinking to their response at the beginning.

Questionnaire/Survey:
The authors used this case study activity with a group of 13 undergraduate interns on June 6, 2013 and assessed the students' learning of the broad learning goals with a brief questionnaire consisting of four questions as shown here:
1. *Please describe and/or diagram how one of the endangered species you learned about today might be part of a socio-environmental system.*

- This question aims to assess student understanding of a socio-environmental system, and the coupled feedback dynamics between the parts of a system.
- Example response (partial understanding): "Salmon are part of a S-E system since they play a vital role in their ecosystem as they consume and regulate other species and are linked to humans since they are fished and eaten by people."
- We believe our original wording led to some confusion. We suggest the following instead: "Please describe and/or diagram a socio-environmental system involving one of the endangered species you learned about today; be sure to identify the parts of the system and the connections between them."

2. *In this exercise, how did considering data from both the natural and social sciences affect your results in comparison to considering factors in isolation?*
   - This question aims to assess student understanding the importance of synthesizing data across the natural and social sciences.
   - Example responses:
     o "The most difficult aspect of this activity was trying to consider each of the different categories independently. For example, it was very hard to rank the animals based on the socio-cultural value without also considering the economic value."
     o "The order in which we looked at factors tainted the next - the information we had received prior swayed our views each time."

3. *From this exercise, what did you do that might be considered "synthesis"?*
   - This question aims to assess student understanding of the process of synthesis.
   - Examples responses (strong understanding):
     o "I might consider synthesis as combining abstract and large data sets to generate an innovative idea."
     o "We had to look at data form 4 different categories and then figure out a way to incorporate each of the different pieces of information into one final priority system."
     o "Took many different types of data and organized them into a rating system…"
     o "Synthesis seems to be both the balance between the importance of the social and environmental factors in the system and the process of finding/achieving that balance."
   - "Examples responses (partial understanding):
     o "The main 'synthesis' for this exercise is the fact that we came together as a team and weighted the pros/cons of each species in order to obtain a ranking."

4. *What are three important points that you learned from this activity?*
   - Example responses:
     o "There is no one right or wrong answer; often the best solution is the 'least bad' one."
     o "It is really hard/impossible to quantify and standardize some aspects of nature that are so qualitative."
     o "It is incredibly helpful to bring together different perspectives - I come from a policy background, someone else in my group was a biologist, etc. This way, we could look at the problem from several different points of view, which was really helpful."
     o "It's often difficult to synthesize information (especially this kind) with missing data."
     o "People's values come into play when deciding what to assign funding importance."

References

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Supplementary Handout
TAXONOMIC DISTINCTIVENESS

The taxonomic distinctiveness of a species is another way of saying "evolutionary uniqueness." It may be measured as the number of species that are closely related (and therefore likely to be ecologically similar) to a focal species. This may be examined at different classification levels. For example, one could ask, "How many other species are in the same genus as the focal species, or how many other genera are in the same family as the focal species?" Below are the numbers of taxa that occurs at three classification levels (Order, Family, and Genus) for the five endangered species. Data are taken from the Catalog of Life (2013).

1. Grizzly bear (*Ursus arctos horribilis*): order Carnivora, 15 families; family Ursidae, 5 genera; genus *Ursus*, 4 species
2. Red cockaded woodpeckers (*Picoides borealis*): order Piciformes, 3 families; family Picidae, 29 genera; genus *Picoides*, 13 species
3. Atlantic salmon (*Salmo salar*): order Salmoniformes, 1 family; family Salmonidae, 10 genera; genus *Salmo*, 40 species
4. Oahu tree snails (*Achatinella spp.*): order Stylommatophora, 23 families; family Achatinellidae, 5 genera; genus *Achatinella*, 42 species (Thacker and Hadfield 2000)
5. Kemp's Ridley sea turtle (*Lepidochelys kempii*): order Testudines, 13 families; family Cheloniidae, 5 genera; genus *Lepidochelys*, 2 species

Modification: Students may want to incorporate these values quantitatively into their rankings by calculating a weighting value for each species based on the taxa numbers. One method to calculate a species weight would be from Joseph et al. (2008):
> take the inverse product of the taxa numbers at the three levels, then take the square root
> e.g., for Grizzly: $(1/(15*5*4))^{(1/2)} = 0.058$
> this method yields larger weight values for species with fewer closely related species

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