Questions for Reflection and Discussion – *updated 30 March 2020*

I have aimed to make the book as general as possible, but restoration is necessarily site-specific, as restoration strategies must be tailored to local biophysical and socioeconomic conditions. Therefore, many of the reflection and discussion questions ask the reader to think about and apply the concepts discussed in the chapter to a specific restoration project (i.e., case study), ideally one with which they are familiar. This may be challenging for those who are not familiar with individual restoration projects. If you are reading this book in a classroom setting, your class may want to choose one or a few restoration projects early on and use these examples as the basis of discussions with the entire class or in small groups. Alternately, individual students or groups could select and research a restoration project to reflect on throughout the class through discussions or written assignments. I do a mixture of both in my class. If you are reading the book individually and have interest in and/or experience with a specific restoration project, these questions give you an opportunity to apply the concepts to your project.

Local restoration projects are ideal for use with these questions, because readers can visit them and potentially talk to those in charge of the restoration project and with different stakeholders. Researching restoration projects elsewhere can also be helpful to provide a broader perspective on restoration; there are many restoration projects with extensive material available online through standard search engines and Google Scholar.

At the end of this document I also provide examples of two assignments my Restoration Ecology class does each year: a debate and a plan for a small local restoration project.

Chapter 1

1. Choose a local ecological restoration project you are familiar with and create a table that includes the different groups involved in the project and their motivations for participation.
2. Restoration is often expensive and commonly paid for by public funds. Think about a specific restoration project and justify committing resources to someone who is not supportive of the project. Consider the benefits to both the local community and society more broadly.

Chapter 2

1. Some restoration ecologists have said that we must accept that full restoration of some ecosystems is impossible, and it would be wiser to restore them to a novel state. What do you think of this statement? Is this a practical recognition of an unfortunate reality, or an abandonment of the principles of restoration ecology?

With respect to a specific restoration project:

2. What are some specific obstacles to restoring to a historical state?
3. Given these challenges, what would you recommend as a feasible restoration target for

this restoration project and why?

4. Both Higgs et al. (2014)[1] and Suding et al. (2015)[2] say that restoration ecologists should consider both the past and future when selecting a target for restoration. How would you incorporate both the past and future in selecting a restoration target for this project?

Chapter 3

With respect to a specific restoration project:

1. Make list of all the stakeholders you can think of, their primary goals for the project, and any concerns about the projects they might have. Can you think of ways to resolve some of the goals and concerns?
2. What information could you use to inform a reference model for this restoration project? How would you incorporate predicted future changes in the ecosystem in your reference model?
3. Make a list of the permits needed to implement the restoration project. Table 3.2 provides an example.

Skim one of the restoration design plans on the book website or one for a local projects and answer the following questions.

4. What did the plan do well? e.g., Were goals and measurable objectives clearly stated? Were the costs and who would pay for them specified? Was there a clear timeline.
5. What information was missing from the plan?
6. What did you learn by looking at the plan?

Chapter 4

With respect to a specific restoration project:

1. Draw out the adaptive management cycle and what it looks like (or could look like) for that project. What are some of the challenges to implementing an adaptive management approach in this case study?
2. Write out the following for that restoration project: (a) a general goal, (b) a few objectives associated with that goal, (c) the parameters you would monitor to evaluate whether the objectives have been met, (d) what you would use as a reference value for each parameter, and (e) how frequently and for how long you would monitor the project.
3. Are there specific parameters for which you recommend surveillance monitoring, and if so, why? If not, why not?
4. How would you disseminate the lessons learned from the project to a range of interested groups?

---

[1]Higgs, E, DA Falk, A Guerrini, M Hall, J Harris, RJ Hobbs, ST Jackson, JM Rhemtulla, and W Throop. 2014. "The changing role of history in restoration ecology." *Frontiers in Ecology and the Environment* 12:499-506.

[2]Suding, K, E Higgs, M Palmer, JB Callicott, CB Anderson, M Baker, JJ Gutrich, et al. 2015. "Committing to ecological restoration." *Science* 348:638-640.

Chapter 5

1. Why do larger habitat patches generally have a greater diversity of species?
2. What types of organisms might be distributed in a metapopulation structure?

With respect to your case study or a local ecosystem you are familiar with:

3. What type(s) of disturbance(s) has the ecosystem evolved with? What was the historic size, frequency, predictability, and intensity of the disturbance and how have those changed over time? What are some of the adaptations of the ecosystem to disturbance? What strategies could be employed to simulate the disturbance to restore the ecosystem?
4. Draw out the successional stages of ecosystem over time, identifying a few key species for each stage. Are there alternative stable states in this system?
5. Pick a species or group of species (e.g., birds) in your ecosystem and describe how they might be affected by abiotic factors/processes or biotic interactions at small, intermediate, and large spatial scales.
6. Given the biology of the target species/ecosystem and the constraints of the project, consider different options for how to best increase habitat connectivity.
7. What has been learned about the ecology of the system through the practice of restoration? How has this new information changed the way the ecosystem is managed or restored?

Chapter 6

1. Choose a local case study of a mine or another terrestrial area where human activities have altered the topography and cleared the vegetation. List a few different approaches that could be used to reduce erosion, and compare the strengths and weaknesses of those approaches.
2. Choose a local wetland or river system. Look up a map of the watershed and think about the sources of water into the system. If possible, look up a gauging station and the associated hydrograph (a figure illustrating the water depth or flow rate over time) for that wetland or river under different rainfall conditions. Otherwise draw the hydrograph you would anticipate for current conditions. Think about how humans have altered this system and discuss potential restoration strategies to restore the natural flow pattern.
3. Explain how restoring a river's sinuosity improves ecosystem services and habitat quality for flora and fauna.
4. Find a case study with photos of an effort to restore instream habitat or fish movement online. Discuss the strengths and weakness of the methods used, and suggest ways to improve the project.

Chapter 7

1. For soils that are low in nitrogen, discuss different approaches to increase biologically-available nitrogen and the pros and cons of each method.

2. Choose a local aquatic system (river, lake, or wetland) and draw a diagram of the various inputs and outputs of sediment, nitrogen, and phosphorus to and/or from the water body. Consider which strategies would be most practical to reduce anthropogenic inputs into the system.
3. Look up a case study of an aquatic system that was eutrophied by human actions. What were the consequences of eutrophication? What actions were taken to reduce eutrophication and were they effective?
4. Read Pilon-Smits and Freeman (2006)[3] and review which toxic cleanup methods can be used for different types of chemicals.

Chapter 8

1. Pick an invasive species of plant, animal, or disease and compile the following information: species name; native ecosystem and geographic distribution; region(s) where it is invasive; how it spreads; documented effects on native species, both negative and positive; removal techniques commonly used; and the efficacy of these techniques. If working in a classroom or group setting, compare approaches across species.
2. Pick a case study in which eradication or management of a nonnative invasive species has been controversial. Discuss the rationale for and concerns about controlling this species from the perspectives of at least three different stakeholders.
3. Most of the literature on invasive species focuses on preventing the spread of and reducing populations of nonnative invasive species, but restoration efforts also often aim to reduce the abundance of native invaders. What are the arguments for and against managing native invaders?

Chapter 9

1. It is much less expensive to assist the natural regeneration of plants than to actively seed or plant them. List some strategies that can be used to enhance natural successional processes.
2. What are some guidelines or best practices you would use for collecting seeds for restoration generally or for a specific project?
3. A common practice in restoration has been to collect material as locally as possible. Recently, there has been extensive debate about whether to collect locally, source vegetation from a range of locations so there is more genetic diversity and potential to adapt to climate change, or select a source population from a location that matches predicted future climate conditions. Which of these three strategies do you think makes the most sense generally or with respect to a specific case study?
4. Pick a specific restoration project that includes revegetation. What plant characteristics should be given the highest priority in selecting species? Where would you collect seeds from?
5. Review one of the many online manuals of best practices for seed collection and propagation and think about what new information you learned and how the

[3] Pilon-Smits, EA, and JL Freeman. 2006. "Environmental cleanup using plants: biotechnological advances and ecological considerations." *Frontiers in Ecology and the Environment* 4:203-210.

recommendations compare to those in the book and your case study. Some manuals include those of U. S. Bureau of Land Management Seeds of Success Program[4] and the Rancho Santa Ana (now California) Botanical Garden[5].

6. Compare several strategies for overcoming water or nutrient limitations and list the advantages and disadvantages of each strategy.

Chapter 10

1. Pick a species or group of fauna and list the specific ecological roles that it plays in ecosystem processes and therefore, recovery.
2. Look up a study or report on the effect of habitat restoration for certain faunal group (e.g., birds, mammals, reptiles, amphibians, fish, soil fauna, insects) or species. Which habitat or landscape factors were most important in determining the habitat quality for the target group or species? What were the key factors determining success or failure, according to the source you found?
3. Look up a study or report on faunal reintroduction or translocation. How long was the reintroduction or translocation monitored for and was it considered a success? What factors were attributed to the success or failure of the project?

If working in a classroom or group setting, compile and compare the answers to questions 1-3.

Chapter 11

1. Research the laws that affect restoration of a specific ecosystem type in a given region or country, and how those laws have been implemented.
2. For a local restoration project, either research or talk to project managers about the laws requiring the restoration, and how they affect the design of the project. What permits are or were required for the project?

If working in a classroom or group setting, compile and compare the answers to questions 1 & 2.

3. Compensatory mitigation and mitigation banking in particular have been criticized as making it easier to destroy habitat. Moreover, past reviews have indicated that the majority of mitigation projects do not adequately compensate for the loss of species and ecosystem services. Should compensatory mitigation be allowed? If it were not allowed, what might be the consequences?

[4]https://www.blm.gov/sites/blm.gov/files/uploads/SOS%20Protocol%202019.pdf
[5]https://upload-ssl.webflow.com/59613419dcbd9b40dceb57a6/5acd728da1daf8feb5427a0c_Seed%20Collecting%20and%20Storage%20Guidelines.pdf

Chapter 12

With respect to a case study or a local ecosystem you are familiar with:

1. What was/were the source(s) of funding for the project? Where does the funding fit in figure 12.1? What might have been other sources of funding and what would be the justification for those funds?
2. What reasons could be used to convince your local legislator to support spending public funds on this specific restoration project?
3. For this ecosystem type and region, think about the strategies that could be used to most effectively allocate limited funding at the regional scale.

If working in a classroom or group setting, compare approaches across questions 1-3.

Restoration Debate

Every year my restoration ecology students participate in a debate in discussion section (typically 18-22 students per section). It shows them that there are different options for restoring damaged ecosystems and that there is not one "right" way. It is always a popular activity. We have used different debate topics over the years. I include an example debate assignment below, along with a couple of alternative debates.

Debate Handout: Tamarisk removal and river restoration in the Western US

The invasive tree Tamarisk (*Tamarix* spp.) has invaded over one million hectares of riparian habitat in the Southwestern U.S., and is believed to cost between $280-450/hectare annually due to altered riparian flows and sedimentation (Case Study Tamarix Removal). It forms monocultures, outcompeting native riparian vegetation and transpiring large amounts of water. Despite these negative effects, there have been concerns about its removal because it provides habitat for the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus)* and because the removal of Tamarisk can cause erosion. Moreover, the appropriate method for removing Tamarisk is highly debated.

In class you will argue for one of three positions regarding riparian Tamarisk restoration (options 2 and 3 would be followed by native species planting):
(1) no Tamarisk control efforts,
(2) control of Tamarisk with herbicides and/or by mechanical means (e.g. bulldozing), and
(3) release of the beetle (*Diorhabda elongata*) as a biological control agent.

You should come to section on **[DATE]** prepared to argue for your management option with a clear understanding of your stance, the main arguments for your position, and evidence to back your position up. You should also have prepared arguments against the other teams' positions. Each student will be expected to speak at least once during the debate.

To help you prepare, the Tamarix Removal case study provides a good background to the topic. We have also provided a link to the 2008 special section on Tamarisk in the journal *Restoration Ecology* 16(1). **You are expected to find additional peer-reviewed articles on the topic to support your position.** Many articles are available on Web of Science.

The debate will be structured as follows:
1. Pre-Deliberation (5 minutes)
2. Round 1: Opening Statements defend argument (3 min. each team)
3. Round 2: Cross-examination / Rebuttal Statements (15-20 minute open forum)
4. Round 3: Closing Statements (2 min each team)

Feel free to "get into character" and have fun with this debate!

References:

Shafroth, Patrick B., et al. "Control of Tamarisk in the western United States: implications for water salvage, wildlife use, and riparian restoration." Environmental Management 35.3 (2005): 231-246.
Special 2008 section in *Restoration Ecology* Volume 16, Issue 1: Restoration in the context of *Tamarisk* spp. invasion and control along rivers in western North America; available online at http://onlinelibrary.wiley.com.oca.ucsc.edu/doi/10.1111/rec.2008.16.issue-1/issuetoc#group3

Topic 2: Restoring the Florida Snail Kite in the Everglades

In section, we will debate potential courses of action to restore the Florida snail kite in the Florida Everglades. Historically, the Florida Everglades ecosystem stretched over more than 10,000 km^2, but was dammed and drained in the early 20^{th} century for flood protection and to provide consistently available water for agriculture. These physical changes, along with the introduction of widespread invasive species, dramatically changed the appearance and function of the Everglades system. One of the most widespread and damaging of these invasive species is a species of invasive tree, *Melaleuca quinquenervia*. *M. quinquenervia* now covers over 1,800 km^2 in South Florida, forming dense monocultures that outcompete native vegetation, alter hydrology, and provide poor habitat for native animal species, such as the primary food source Florida snail kite (apple snails; *Pomacea* species).

The Florida snail kite is listed as an endangered species due to habitat loss and the decline of their prey species. In section you will argue for one of the following courses of action regarding the Florida snail kite:

1. No action – business as usual; allow snail kite prey (apple snails) to decline and potentially allow snail kites to go extinct
2. Alter water flow through the Everglades system by removing canals and dams to increase overland sheet flow and increasing the minimum annual delivery to the system, thereby improving the natural regeneration of apple snail habitat
3. Removal of invasive melaleuca trees through combined herbicide, biological control, and mechanical means, and the planting of marsh/wetland habitat suitable for apple snails following removal

Topic 3: Restoring the Brazilian Atlantic Forest

In section, we will debate the merits of a few approaches to restore the Brazilian Atlantic Forest (BAF). The BAF is a biodiversity hotspot that once covered 1.5 million km^2, but following 500 years of destruction post-European settlement only ~10% of forest remains in fragmented patches. In 2009, a coalition of 160 organizations, companies, and governments launched the Atlantic Forest Restoration Pact, which aims to restore 15 million ha (150,000 km^2) of degraded lands in the original area of the BAF by 2050. Recent studies indicate that 900,000 ha of restored forest have established between 2011 and 2015, a third of which were likely established via active restoration interventions.

In section, you will argue for one of the following courses of action regarding the Atlantic Forest:

1. Passive restoration or assisted natural regeneration
2. Planting native tree species only
3. Interplanting eucalypts and native species

Restoration Project Plan

Each year towards the end of my class I have my students write a short restoration plan for a small restoration project on the UC Santa Cruz campus. I talk with the campus planners to identify a project that they are working on and do not have a complete plan so the students see that it is a real project, though their plans on not sufficiently detailed to be used by the planning department. We work on a different project each year. I usually limit the project scope so they can address the primary issues in an ~1000-word essay, but I know other classes spend more time on class projects that are more detailed in scope. I am fortunate that the UC Santa Cruz campus has a great deal of undeveloped land, where there are always land management and restoration projects. For instructors teaching on campuses that do not have similar opportunities, I recommend talking to public or non-profit land managers nearby to discuss potential opportunities for a similar class project. I find it a valuable opportunity for students to synthesize and apply their knowledge.

Class project handout: Mitigation for the UCSC farm gas main relocation

Description: The UCSC Physical Planning, Development, and Operations office is planning to install an 8" gas pipeline through the UCSC Farm to replace the aging pipe infrastructure and realign the pipeline so it is away from the Farm and future developments. The pipeline will go through Inclusion Area D, an area that is considered suitable habitat for the California red-legged frog (*Rana draytonii,* CRLF) and the Ohlone tiger beetle (*Cicindela ohlone,* OTB), which are listed as threatened and endangered, respectively under the U.S. Endangered Species Act. Part of Inclusion Area D was designated as a habitat reserve for these species under a Habitat Conservation Plan for construction of Ranchview Terrace housing, so the campus has to ensure that construction does not reduce the habitat quality for these species. The project also passes through coastal prairie, which is a rare habitat type.

You have been hired as a consultant for UCSC to develop a plan for mitigating the impacts of the pipeline realignment that:

1. Minimizes negative impacts on habitat for the CRLF and the OTB.
2. Restores native coastal prairie.

Requirements for class: Attendance in class for the field visit on Feb. 28 is important. Please come with appropriate clothes and shoes to hike around the site. Each person must develop a plan for restoring this area. In your plan, you must justify the restoration strategies you propose using published references. Your plan should include (a) clear goal(s), (b) SMART objectives, (c) a timetable and (d) a monitoring plan. You do not need to discuss specific costs, but should consider that the campus has a limited budget. You should also note (e) what government agencies you will need to consult with on this project.

You should bring two-copies of a well-written draft of your plan to section on March 5 and the final version is due on March 9. The plan should be ~1000 words. Using bullet points for certain sections (e.g. objectives) is acceptable, and you may use sub-headings to organize your restoration plan.

A predesign study for this project and a copy of Stromberg et al. (2007) are available on the Canvas website in a folder entitled "resources for class project." You will need to find additional publications to help inform your plan.

Reference

Stromberg, MR, CM D'Antonio, TP Young, J Wirka, and PR Kephart. 2007. "California grassland restoration." In *California Grasslands*, edited by MR Stromberg, JD Corbin and CM D'Antonio, 254-280. Berkeley: University of California Press.

Project Example 2

Description: As part of the overall Stormwater & Drainage Master Plan of UCSC, the campus is aiming to reduce sedimentation problems in the Moore Creek West Fork Kresge Tributary. This land is part of the UCSC Campus Natural Reserve (CNR). The erosion in this drainage has resulted from two causes. First, development has increased the area with impervious surfaces, which in turn results in increased volume and duration of peak flows. Development prior to 2005 increased paved areas without mitigating for the increased runoff effects, whereas the Porter Apartments infill housing project (~10 years ago) was required to mitigate flows. Second, although bicycle traffic is illegal on CNR lands, bicycle traffic through this area is widespread, which has resulted in soil compaction and destruction of vegetation.

You have been hired as a consultant for UCSC to develop a plan for reducing peak flows and erosion, while improving the water quality of runoff from this drainage. During class on March 3, you will be shown the exact site to be restored. Three main issues must be addressed in your restoration plan:

1. Several areas of the drainage channel are downcutting as a result of prior high flows.
2. There are wide bike trails that are compacted and devoid of vegetation or litter cover.
3. These both result in extensive erosion during peak flows that negatively impacts water quality.