**Supplementary materials for**

**CHAPTER 9**

**of**

***The Biology and Conservation of Animal Populations***

**by John A. Vucetich**

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**A. SUMMARY AND POINTS OF DISCUSSION**

* Density-dependent population dynamics assumes what about a population’s supply of food (p. 206)? How is that assumption changed, when one considers predation dynamics?
* What is the brief timeline of historical developments in knowledge about modeling density-independent growth, density-dependent growth, and predation. (p. 207-208)?
* Chapter 9 indicates that the study of predation dynamics is often motivated by one of two basic questions. What are those questions?
* These are the Lotka-Volterra equations:
	+ *dN*/*dt* = *rN* – *aNP*
	+ *dP*/*dt* = *eaNP – mP*

Using the ideas represented by Figure 9.2, explain each part of these equations.

* The entire textbook is an explanation for how and why populations fluctuate in abundance. Inspired by pages 212-213, but in your own words, what are the main reasons why populations fluctuate in abundance?
* The Lotka-Volterra equations result in population cycles of predator and prey (Fig. 9.3). Why? (Hint: To answer this question, you cannot search for the one or two sentences in the book that provides an answer. Rather, the answer is conveyed throughout p. 209-214. You’ll need to study those pages, develop your own answer, and check it out with your instructor.)
* Summarize in your own words the main point of the section entitled, “*Coexistence is Delicate*” (p. 214-215).
* Shortly after the Lotka-Volterra equations were developed, a number of researchers aimed to assess those experiments in laboratory settings. The textbook describes three of these laboratory assessments. Describe each. That is, describe the experimental set-up, the result, and the *general* insight rising from each experiment.
* The general insights rising from those laboratory experiments have also been appreciated in wild populations of vertebrate organisms. Explain. (See p. 220-221).
* Above, you explained each part of the Lotka-Volterra equations. Each part can be described as some sort of ecological mechanism that can be studied on its own. This is the subject of pages 221-230. In this regard, what are the functional response and numerical response?
* *Per Capita Kill Rate*: In the Lotka-Volterra equations, the term *aN*, represents the per capita kill rate. That is, the number of prey killed per predator per unit time. This particular representation of the per capita kill rate can be represented as a function of *N*. In other words, *f*(*N*) = *aN*. As such one can make a graph with *N* on the x-axis and *aN* on the y-axis.

 Sketch the shape of this graph. Compare this graph with the ecological processes it is supposed to represent. What is realistic about this graph? What is the most unrealistic aspect of this graph?

* The Type II and Type III functional responses are intended to account for more realistic features of many ecological systems.
	+ What are the shapes of these functional responses?
	+ What more realistic features are they intended to represent?
	+ How does replacing a Type I functional response affect predator-prey dynamics, overall?
* What is the meaning and relevance of a ratio-dependent functional response?
* Describe in reasonable detail, how a functional response can be estimated for a wild population. (see p.223)
* What is the numerical response? Figure 9.9 is among the few examples of a well-documented numerical response. What is the relevance of observing that the *R2* of that relationship is only 0.18?
* What is the predation rate and how can it be calculated from the per capita kill rate? Would one expect the predation rate and per capita kill rate to be correlated? Explain.
* What is the significance of examining the relationship between the predation rate and per capita growth rate of the of the prey population? (Hint: see Figure 9.11)
* What is apparent competition? Illustrate your answer with an example.
* Chapter 9 shares two cases where systems with multiple species of predator were studied. Describe those cases. What *general* insight is gleaned from those cases?
* What is a trophic cascade? Summarize the evidence provided in the text for the existence of trophic cascades. Your summary should include caveats.
* Summarize the sections entitled, *Restoration of Large Predators* and *Predator Control*

**B. FURTHER READING**

Krebs, C. J., Boonstra, R., Boutin, S., & Sinclair, A. R. (2001). [What drives the 10-year cycle of snowshoe hares](https://academic.oup.com/bioscience/article/51/1/25/251849)? *BioScience*, *51*(1), 25-35.

O'Donoghue, M., Boutin, S., Krebs, C. J., & Hofer, E. J. (1997). [Numerical responses of coyotes and lynx to the snowshoe hare cycle](https://www.jstor.org/stable/3546526). *Oikos*, 150-162.

O’Donoghue, M., Boutin, S., Krebs, C. J., Zuleta, G., Murray, D. L., & Hofer, E. J. (1998). [Functional responses of coyotes and lynx to the snowshoe hare cycle](https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/0012-9658%281998%29079%5B1193%3AFROCAL%5D2.0.CO;2). *Ecology*, *79*(4), 1193-1208.

Vucetich, J. A., Smith, D. W., & Stahler, D. R. (2005). [Influence of harvest, climate and wolf predation on Yellowstone elk, 1961‐2004](https://nsojournals.onlinelibrary.wiley.com/doi/abs/10.1111/j.0030-1299.2005.14180.x). *Oikos*, *111*(2), 259-270.

Wittmer, H. U., Serrouya, R., Elbroch, L. M., & Marshall, A. J. (2013). [Conservation strategies for species affected by apparent competition](https://conbio.onlinelibrary.wiley.com/doi/abs/10.1111/cobi.12005). *Conservation Biology*, *27*(2), 254-260.

Alexander, M. E., Dick, J. T., Weyl, O. L., Robinson, T. B., & Richardson, D. M. (2014). [Existing and emerging high impact invasive species are characterized by higher functional responses than natives](https://royalsocietypublishing.org/doi/full/10.1098/rsbl.2013.0946). *Biology letters*, *10*(2), 20130946.

Kratina, P., Vos, M., Bateman, A., & Anholt, B. R. (2009). [Functional responses modified by predator density](https://link.springer.com/article/10.1007/s00442-008-1225-5). *Oecologia*, *159*, 425-433.

**C. Discussion Questions and Activities**

1. a) Suppose that a wildlife manager was confident about the value of hunting cougars because cougars prey on elk and humans who hunt elk wanted more elk for themselves. What would you say to this manager?

b) An advocate for wolf restoration says the most important reason to restore wolf populations to their former range is because wolves are essential for triggering trophic cascades that keep vegetation healthy.

* Would you say anything to temper this advocates reasoning?
* Are there other arguments for restoring wolf populations that might be more robust? (Hint: see 3rd full paragraph of p. 243)
* Consider addressing these issues by developing and assessing a formal argument (as explained in Chapter 4).

c) Suppose this same advocate was opposed to wolf hunting, because wolf hunting prevents wolves from performing their ecological functions, mainly limiting the abundance of large herbivores.

* Would you say anything to temper this advocates reasoning?
* Are there other arguments for opposing wolf hunting that might be more appropriate?
* Consider addressing these issues by developing and assessing a formal argument (as explained in Chapter 4).

d) Would it be reasonable for an advocate for wolves to claim, both (i) wolves need to be allowed to performing their ecological functions, mainly limiting the abundance of large herbivores and (ii) humans who hunt large herbivores should have no concern about wolves impacting hunters’ experience because wolves mainly kill old and sick prey that would die anyways?

1. Consider these materials:
2. A Youtube video, “[*How wolves change rivers*](https://www.youtube.com/watch?v=ysa5OBhXz-Q&t=202s)” that emphasizes – perhaps oversimplifies – the influence of wolves. Depictions like this are endorsed by a number of scientists.
3. This news article, “[*Scientists debunk myth that Yellowstone wolves changed entire ecosystem, flow of rivers*](https://www.accuweather.com/en/weather-news/scientists-debunk-myth-that-yellowstone-wolves-changed-entire-ecosystem-flow-of-rivers/349988)” featuring scientists who are concerned about oversimplifications about the effect of wolves.
4. The journal article written by other scientists who are also concerned about misrepresenting what they consider the true effect of wolves: Allen et al. 2017. [Can we save large carnivores without losing large carnivore science?.](https://www.sciencedirect.com/science/article/pii/S235224961730006X) *Food Webs*, *12*, 64-75.
5. This journal article is a direct response to Allen et al. (2017): Bruskotter et al. 2017. [The role of science in understanding (and saving) large carnivores: a response to Allen and colleagues](https://www.sciencedirect.com/science/article/pii/S2352249617300137). *Food webs*, *13*, 46-48.

What is your reaction to that set of materials? What is the best way to communicate – to the general public –the effect wolves have on the ecosystems they inhabit? That is, what is the most appropriate way to communicate complicated ideas about nature to an audience that cannot understand complicated messages? Would a more nuanced presentation to the public undermine the public’s interest to conserve predators?

1. Consider the theory and basic research pertaining to predation dynamics – by which I mean all ideas like those covered on pages 207-235 of the textbook. Now consider the real-world issues that conservation professionals face with respect to predation – including cases where predators are of conservation concern and other cases where prey seem to be adversely impacted by predators.

How exactly is theory and basic research on predators pertinent to solving real-world challenges pertaining to predation? Be specific. For example, of the material covered on pages 207-235, what are the five most important things that a conservation professional should know?

1. Predation research has been importantly motivated by this idea (p. 207):

[L]ife on Earth is diverse and abundant with myriad species where ever one looks. How do they all coexist, given how common predation is and the sketchy but persistent intuition that predation would seem to risk driving prey populations to extinction?

How would you answer this question?

1. The internet hosts a number of online calculators and spreadsheets featuring equations that model predator-prey dynamics. Here are a few:

<http://alexei.nfshost.com/PopEcol/lec10/fullmod.html>

<https://oceanservice.noaa.gov/education/marine-ecosystem-modeling-vr/predators-prey/activity-1.html>

<https://serc.carleton.edu/sp/ssac/national_parks/examples/14327.html>

<https://blog.uvm.edu/tdonovan-vtcfwru/files/2020/05/Donovan.and_.Weldon.2002.pdf>

Much can be learned by spending a little time at these sites.

Finally, the Excel file associated with this document has some exercises for you to try.