relation to the amount or ratio of available nutrients, or to time of year? (4) Do the same factors that favor increases in buffalo also influence other grazers? (5) Is there a relationship between abundance and richness of large mammals? (6) Is there a relationship between tree density and grass nutrient levels? (7) Are other factors, in addition to fire and elephants, important in determining whether a particular ecosystem in the region is woodland or grassland? (8) Do other regions of the world show ENSO related cycles? Each of these questions can be approached using a variety of observational and experimental methods.

Chapter 2

Thinking ecologically exercises

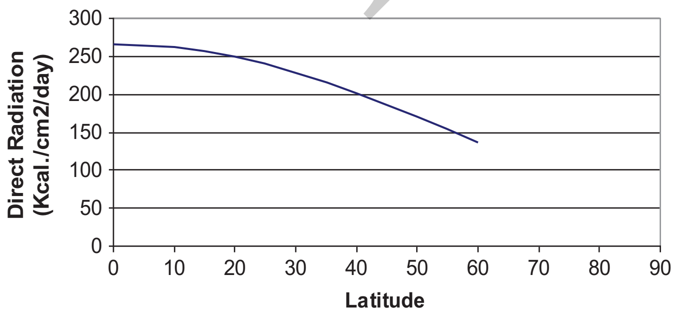
Thinking ecologically 2.1. John Buffo and his colleagues (1972) wanted to know how much direct radiation struck the Earth at different latitudes. Can you extrapolate from Table 2.1 an estimate of the direct radiation striking the North Pole over a one-year time period (See Deadhead 2.1)?

Thinking ecologically 2.2. What assumptions does this extrapolation make? How might you test whether these assumptions are valid?

Thinking ecologically 2.3. There were many different types of diatoms and chironomids at different depths of the Lake Yoa core. Modern African lakes vary in salinity and in the species composition of diatoms and chironomids, with lakes of similar salinity levels tending to have similar species composition. The researchers inferred salinity levels in the past 6000 years by comparing the species composition of the core with salinity levels and species composition of modern lakes. What assumptions does this inference make, and does it seem valid to you?

Thinking ecologically approaches

Thinking ecologically 2.1. The values in Table 2.1 follow a curve, depicted in the graph below.



By extending the curve through to the 90° line, we can estimate that the poles receive somewhere around 20 Kcal/cm^2/day. This extrapolation, however, assumes that the amount of solar radiation received by latitudes beyond 60° north or south follows the same pattern as the lower latitudes. As mentioned in Dealing with Data 2.1, this assumption may not be valid due to the nonstandard day/night cycle for higher latitudes.

Thinking ecologically 2.2. Erwin's major assumption was that linden trees contained a population of arthropods that was representative of other trees within the rainforest. Given the estimate of approximately 50,000 unique species of tree within the forest, this assumption could be subject to severe sampling error. For example linden trees may be more attractive to insects due to greater size, greater diversity of microhabitats or lower defenses than other tree species. Or, for a variety of reasons, linden trees may have a higher or lower proportion of beetles in its canopy. Researchers should survey arthropod species density living upon and within a wide range of rainforest trees to test whether this assumption was valid, overstated, or understated.

Thinking ecologically 2.3. The primary assumption made here is that the salinity preference of the reference species has not changed in the past 6,000 years. Given what we know about the rate of evolutionary change, this assumption seems very valid. There exist several ways to test the validity of this approach, such as a comparison of other salinity estimates for the same time period (oxygen isotope analysis of fossilized foraminiferan shells, for example) to the presence or absence of the diatoms and chironomids used in the Lake Yoa study. Such crosschecking increases the confidence of salinity estimates and helps prevent potential mistakes in data analysis.

Synthesis and application questions

1. The angle of the Earth's axis fluctuates between 22.5 and 24 degrees over a regular 41,000-year cycle. How do you think this periodic fluctuation would affect global temperature patterns?
2. There is a dispute among conservation biologists regarding whether fire suppression leads to larger fires. As it turns out, fire suppression has been practiced extensively in the USA, but only to a very small extent in Baja California, Mexico. Based on Figure 2.20, can you conclude that fire suppression has led to larger fires? Why or why not?
3. Use Figure 2.26 to calculate the turnover time for ocean water. Why is this value so much larger than the value for atmospheric water?
4. Reconsider Schindler and Fee's experimental design for Experimental Lake 226 and 227. Would the results be more convincing if the researchers had tried adding only carbon (C) to one lake, phosphorus (P) to a second lake, nitrogen (N) to a third lake, C and P to a fourth, C and N to a fifth, P and N to a sixth, and C, P, and N to a seventh lake? What would be the advantages to such a design, and in what way(s) would it be inferior to Schindler and Fee's experiments?
5. Do you think that mass spawning of coral will lead to an increase or decrease in oxygen levels in the reef? Explain your rationale.
6. The mangrove/sponge interaction (Ellison et al. 1996) is an example of a mutualism. Do you think that mutualisms should be more common in stressed biomes like mangroves, or in less-stressed biomes, like coral reefs? Explain your reasoning and suggest how you might go about answering this question.

Synthesis and application: possible answers

1. Presumably the differences between the seasons would increase as the tilt approaches 24°, and decrease as it approaches 22.5°. You would also expect that monsoons would wander further north and south as the angle increases.
2. This is difficult to measure, but the fires seem about the same size – perhaps the fires north of the border are a bit larger. This could raise the issue of whether recent policies to let fires burn are warranted. We must be careful with drawing this conclusion, however: this figure does not account for other factors which may influence the spread of large fires, such as weather patterns and human population density. Clearly we need to look at other regions, but it is likely that fire policy should probably be considered on a regional, rather than global, basis.
3. Approximately 3239 years. The ocean has a very low surface area to volume ratio, so evaporation rate is very low and thus the turnover time is very high.
4. The point here is that the design was not optimal, but that doing science involves making compromises between elegant experimental design vs. practicality and feasibility. Even if all combinations could be tested independently, you would then need to address the issue of replication – each combination should probably be done at least two and maybe three times. So elegance can get out of hand. You could also take the opportunity to raise questions about the ethics of adding nutrients into numerous lakes, given the ecosystem disruption such a manipulation is likely to cause. Finally, the curtain experiment should be discussed in the context of it being very sexy and that it raised public awareness of eutrophication and the influence of phosphates.
5. This could go either way. Increased production should increase O_2 levels, but if, as might be expected, there is lots of phytoplankton death, or if the or a substantial increase in waste created by any level of the food web, that will increase decomposition rates and might deplete O_2.
6. This, of course, raises a red flag about how you measure stresses in biomes. Assuming that can be done, you might expect mutualisms to be more common if conditions are more stressed (we discuss this in chapter 15). Presumably natural selection favors the evolution of mutualisms under more stressed conditions, because mutualisms help survival and reproductive success. A meta-analysis of mutualism frequency in relation to stress would address this question. Students won't learn about meta-analyses for several chapters, but they should be able to articulate that they could go through the literature to see how many mutualisms are reported in stressed biomes, and the clever ones will wonder how many interactions have actually been studied within these biomes.

Analyze the data questions

Analyze the data 1. Reconsider the data in Table 2.1. This time do a linear regression analysis of the data. If you entered the numbers properly, you will get a regression equation that looks something like this: direct solar radiation = 283048 – 2224 (latitude). If you plug in the value for the North Pole, your regression equation will estimate the direct solar radiation there. How does this estimate compare to your extrapolation estimate? Why is your extrapolation estimate likely to be more accurate than the value predicted by the linear regression equation?

Analyze the data 2. Refer back to Table 2.2. Graph the relationship between elevation and atmospheric pressure. What atmospheric pressure would you predict at 15 km? Did you use extrapolation or linear regression? Explain your choice.

Analyze the data answers

1. The regression analysis predicts 82888 cal/cm^2/day at the North Pole. This should be considerably higher than the student's previous extrapolation, because the relationship is clearly nonlinear, but instead curves downward as latitude increases. This also provides an opportunity for the instructor to explain to the students to be wary of using regression analysis to predict outside of the range of the data set.
2. This is definitely nonlinear, so the best approach would be extrapolation (or nonlinear regression, which we will not worry about). A reasonable extrapolation would be between 10–15 kPa)

Chapter 3

Thinking ecologically questions

Thinking ecologically 3.1. How does the mean beak depth of juveniles in Figure 3.7B compare to the mean beak depth of drought survivors (Figure 3.6B)? Given that drought survivors were the parents of the juveniles in 1978, would you expect the mean beak depth to be identical? Why or why not?

Thinking ecologically 3.2: Though natural selection favored shallow beaks after the El Niño of 1983, sexual selection might still favor large-beaked males. What types of data could you collect to understand the relative influence of natural selection and sexual selection in this population?

Thinking ecologically approaches

Thinking ecologically 3.1. The mean beak depth of juveniles born to survivors (ca. 9.7 mm) is lower than that of the survivors themselves (ca. 10.1 cm). Beak depth is influenced by factors other than strict genetics. Body size is a strong influence on beak depth, which can be a result of environmental pressures and juvenile nutrition. Chance could also play a role, as the population size of survivors decreased dramatically. This decrease in population would amplify the effects of random mating success and offspring survival. We should expect that the mean beak depth of juveniles born to drought survivors would increase from the pre-drought mean, but it would be unlikely to exactly match the mean beak depth of the parental generation due to non-genetic influences.