**Example Student Responses**

**Species Richness Estimates:**

**Team Data:**

 *Chao 1 (Plot-based Data):*

 S(n)= 4 Singletons= 1 Doubletons= 1

 Smax= 5

 *Chao 2 (Plot-based Data):*

 S(n)= 4 Singletons= 2 Doubletons= 1

 Smax= 6

 *Chao 2 (Plotless Data):*

 S(n)= 4 Singletons= 1 Doubletons= 1

 Smax= 5

**Class Data:**

 *Chao 1 (Plot-based Data):*

 S(n)= 16 Singletons= 2 Doubletons= 2

 Smax= 17

 *Chao 2 (Plot-based Data):*

 S(n)= 16 Singletons= 5 Doubletons= 2

 Smax= 19

 *Chao 2 (Plotless Data):*

 S(n)= 16 Singletons= 2 Doubletons= 2

 Smax= 16

Questions for further comment:

1) *How does your estimate of species richness change when you estimate it based on your entire class’s data versus only the data your team collected? ? Did other teams find species that were not present in your team’s plots? Would a guess of total richness just from your plots have anticipated these additional species? Did you have enough data in your team’s plots, or across all plots surveyed by the class to be confident of your estimate? Explain your answer.*

Estimates of species richness based only on team data severely underestimated species richness, as estimates of species richness derived from classwide data were approximately three times larger. Many species were detected by other teams that were not present in the plots or transects that we sampled. While it is likely that we did not successfully sample every species in the forest, all of the common species did appear to be well documented and I did not notice any additional species outside of our sampled areas during the course of the field study. So, while it is impossible to be completely sure, it is my opinion that this study produced estimates of the species richness of this forest that are unlikely to be off by more than 1-2 additional rare species.

2)*How many samples or plots do you think would be sufficient to reliably estimate local species richness? Explain your answer. (Assume that it is not practical to survey every tree.)*

This depends greatly on two factors: how accurate you want the estimates to be (and how much confidence you need in the accuracy of the estimates), and how the borders of the forest are determined. While I believe (as stated above) that our estimates of species richness within the section of forest that we sampled were relatively accurate and are sufficiently sampled by our existing data, adjacent forested areas that are dominated by pines likely include different sets of tree species than the hardwood forest we sampled. Thus, if that were considered to be a part of the same forest, or if we included the edges of the forest along the roads where additional invasive species were present, we would likely be underestimating the richness of the forest, and would require additional sites to adequately sample the larger forest. As both of those areas represent different environments (because of slope & facing for pine forests, and because of increased light and exposure at the forest edge), they might also be considered to be separate communities. Thus the issue may not primarily be the number of sites, but their placement with respect to what we consider to be the borders of the forest being sampled.

*3) Explain the difference between a sample and a census: What are the advantages and disadvantages of each?*

A census is when every single individual is sampled or observed. Thus, measures of species richness or diversity are totally accurate when based on a true census (assuming all species are identified correctly). However, this is rarely practical, either because there are too many individuals, because individuals move, or because there is not enough time to sample every single individual. A sample, in contrast, is a smaller set of individuals that does not include every individual in a larger population, but is taken to be representative of the larger population. However, samples may or may not be entirely reflective of a larger population. Some species may be easily overlooked, or missed entirely, plots may miss some microhabitats or species that occur only in a small portion of the area being sampled, and some sampling methods may not capture some species, particularly when sampling using traps that some species may avoid or escape from. Thus, while samples are typically much more practical than censuses, you can never be sure that they have captured all species or that they are totally representative of the entire forest. Estimates based on samples, therefore, must be treated with caution, and care must be taken to ensure that samples are as reflective of the larger population as possible.

*4) You have been commissioned to assess the species richness of trees throughout a highly diverse forest. The site includes a combination of old growth forest and young forest that was logged only 30 years ago, as well as a mixture of dry upland forest and forested bogs in the lowlands. How would you approach assessing the species richness of this site? What methods would you recommend and why? What concerns or potential problems do you foresee?*

It would be important to make certain that substantial sampling occurs both in the old growth and new growth sections of the forest, as well as in both the dry upland forest and the forested bogs. In many ways it might be more appropriate to calculate species richness differently for each habitat, as they are likely to differ. If it is desirable to calculate one overall estimate of species richness, however, care should be taken to ensure that enough trees have been sampled in each microhabitat to accurately represent the species richness within each one. Additionally, as the density of trees is likely to differ between the old and new growth forest (and possibly among upland and lowland areas as well) it would be important to either use plotless methods, or at least to calculate richness using Chao2 rather than Chao 1, as the number of species per plot it likely to differ throughout the forest. Thus, if a plot-based method is used, it might be wise to site additional plots in the portions of the forest with lower tree density to ensure that a sufficient number of individuals are sampled throughout all portions of the forest.

*5) Find a published peer-reviewed study that estimates the species richness of another taxonomic group or habitat such as forest birds, meadow wildflowers, or stream invertebrates? What challenges did that study face in identification, sampling, logistics, and so on, and how did the authors address those challenges? What are the key differences between their methodologies or concerns, and the ones you encountered in this assignment? What are the reasons for these differences? How do the habitat, taxa, and scale of the study affect the choices they made in the methodology of their assessment? Be sure to include proper citations for the paper you cite.*

 The paper I evaluated, “Patterns of ant species richness along elevational gradients in an arid ecosystem,” by Sanders et al. (2003), contrasted species richness of ants along three different sites along an elevational gradient in three different canyons throughout the Spring Mountains in the Mojave desert in Nevada. As ants are small and mobile, and would thus be difficult to survey using direct observations such as we used in our study, species richness was evaluated using pitfall traps that consisted of plastic cups buried so that the tops were flush with the surrounding soil, and then filled with water and propylene glycol. Additionally, this study required the development of species richness estimates for 43 different sites located along canyon walls that were often difficult to traverse. Thus, the authors showed particular concern for identifying the minimum number of traps that would provide estimates of species richness that were sufficient to make comparisons among the different locations along the elevational gradients within each canyon. To do this, the authors tested the number of species that were caught at one easily accessible site using a large number of traps, and utilized the species accumulation at that site to estimate the number of traps necessary for them to have confidence that they would catch at least 80% of species at each other site.

 Unlike our plots that were scattered throughout the forest, the authors sited their traps (12 per site) precisely 10 meters apart at each site, in a line perpendicular to the slope of the canyon. This was done to ensure that all traps were at the same elevation, as the intent was to evaluate differences in species richness at different elevations. Sites were placed every 100 meters in elevation at each of the three canyons being surveyed.

 Additionally, although the authors were measuring species richness, their intent was not necessarily to develop the most accurate estimates of the true richness at each location. Instead, the authors were more concerned with comparing relative richness across a large number of sites. Thus, they were less concerned with the possibility of missing rare species or trap-avoidant species, as long as the species richness estimates were analogous across all sites and robust enough to make meaningful comparisons. Thus, no attempt was made to estimate true species richness using statistical methods such as those devised by Chao.

If the intent were to ensure that the true richness of each site were estimated as completely as possible, it is clear additional effort would be made to estimate true species richness at each site, and that that additional traps would be needed at each site. It is also likely if estimation of true species richness at each site were of paramount importance in this study, traps of other types might also be useful in order to ensure that species that avoided pitfall traps were not missed.

 There was no discussion of practical difficulties in identifying the species of each ant, and so we assume that this presented no major problems to the authors.

Paper Cited:

Sanders NJ, Moss J, Wagner D (2003) Patterns of ant species richness along elevational gradients in an arid ecosystem. *Global Ecology and Biogeography,* **12**, 93-102.