American Museum of Natural History
Center for Biodiversity and Conservation
Network of Conservation Educators & Practitioners

What is Biodiversity? Analyzing Data to Compare and Conserve Spider Communities

Author(s): James P. Gibbs, Ian J. Harrison, and Jennifer Griffiths
Adapted by: Adriana Bravo and Ana L. Porzecanski

Source: *Lessons in Conservation*, Vol. 8, Issue 1, pp. 30–39

Published by: Network of Conservation Educators and Practitioners, Center for Biodiversity and Conservation, American Museum of Natural History

Stable URL: ncep.amnh.org/linc/

This article is featured in *Lessons in Conservation*, the official journal of the Network of Conservation Educators and Practitioners (NCEP). NCEP is a collaborative project of the American Museum of Natural History's Center for Biodiversity and Conservation (CBC) and a number of institutions and individuals around the world. *Lessons in Conservation* is designed to introduce NCEP teaching and learning resources (or "modules") to a broad audience. NCEP modules are designed for undergraduate and professional level education. These modules—and many more on a variety of conservation topics—are available for free download at our website, ncep.amnh.org.

To learn more about NCEP, visit our website: ncep.amnh.org.

What is Biodiversity? Analyzing Data to Compare and Conserve Spider Communities

James P. Gibbs,[1] Ian J. Harrison,[2] and Jennifer Griffiths[2]
Adapted by Adriana Bravo[2] and Ana L. Porzecanski[2]
[1]State University of New York College of Environmental Science and Forestry, Syracuse, NY, USA; [2]American Museum of Natural History, New York, NY, USA

ABSTRACT
In this exercise, students will classify and analyze data on spider communities to explore the concept of biological diversity and experience its application to decision-making in biological conservation. This exercise was adapted to further develop data analysis skills. Specifically, this exercise asks students to: 1) create an appropriate and informative graph, 2) interpret trends and patterns in the graph, 3) understand and correctly solve equations, and 4) make well-reasoned conclusions from data.

1. PART 1: INTRODUCTION

Spiders are a species-rich group of invertebrates that exploit a wide variety of niches in virtually all the Earth's biomes. Some species of spiders build elaborate webs that passively trap their prey whereas others are active predators that ambush or pursue their prey. While spiders are one type of invertebrate, they represent useful indicators of environmental change and community level diversity because they are taxonomically diverse, with species inhabiting a variety of ecological niches, and they are easy to catch.

2. PART 2: SORTING AND CLASSIFYING A SPIDER COLLECTION

1. In Appendix 1, you will find a spider collection from a forest patch in Africa ("Site 1"). The spiders were captured by a biologist traveling along transects through the patch, stroking a random series of 100 tree branches. All spiders that were dislodged and fell onto an outstretched sheet were collected and preserved in alcohol. They have since been spread out on a tray for you to examine (portrayed as illustrations in Appendix 1). The illustrations of the spiders are aligned in rows and columns so that, if desired, you can cut them out with scissors for sorting and identification.
2. Working in a group, the next task is for you to identify and sort the spiders. Your instructor will provide your group with a high-resolution paper copy to help you identify all the specimens in the collection. To classify the spiders, look for external characters that all members of a particular group of spiders have in common but that are not shared by other groups of spiders. For example, look for characteristics such as *leg length, relative size of body segments,* or *abdomen patterning and abdomen shape*.
3. Look for groups of morphologically indistinguishable spiders, and describe briefly the set of characters unique to each group. These "operational taxonomic units" that you define will be considered separate species. To assist you in classifying these organisms, a diagram of key external morphological characters of spiders is provided (Figure 1). Note that most spider identification depends on close examination of spider genitalia. For this exercise, however, we will be examining only general external morphological characteristics of different species.
4. Assign each species a working name, preferably something descriptive. For example, you might call a particular species "small, spotted abdomen" or "short legs, spiky abdomen." Just remember that the more useful names will be those that signify to you something unique about the species. You will use these data for Part 3 of the exercise. For your information, the species are also identified to the Family level in Appendix 2.
5. Complete Table 1 by listing each species, its distinguishing characteristics, the name you have

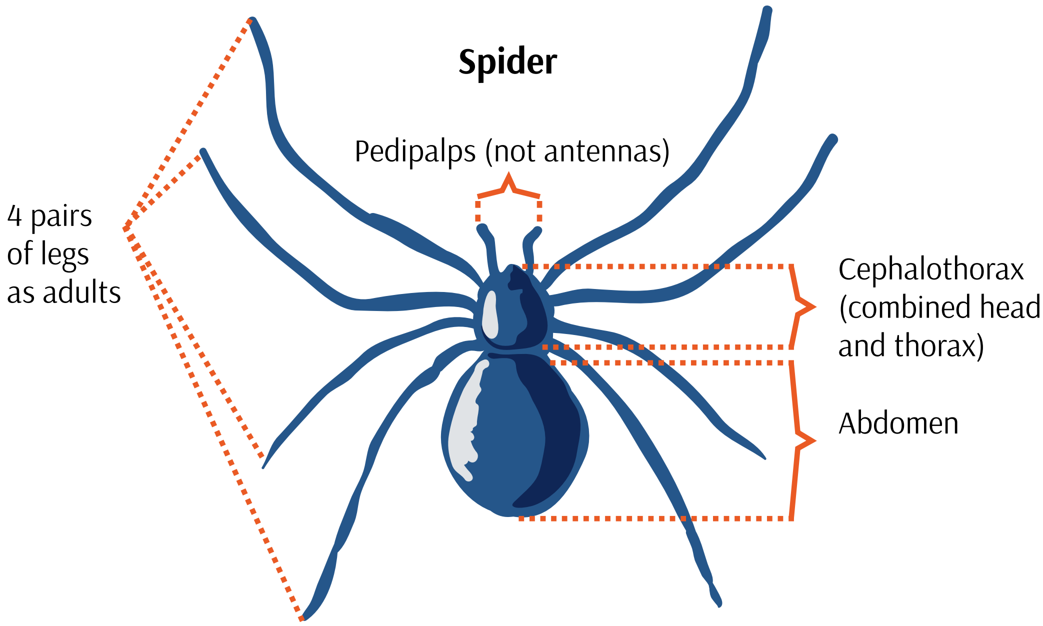


Figure 1. Basic external characteristics of spiders useful for identifying individuals to species. Illustration: Nadav Gazit.

applied to it, and the number of individuals of the species in this collection ("Site 1" in Appendix 1).

3. PART 3: ASSESSING THE COLLECTION

Next, working individually, you will investigate whether this collection adequately represents the true diversity of spiders in the forest patch at the time of collection. Were most of the species present sampled or were many likely missed? This is always an important question to ask to ensure that the sample was adequate and hence can be legitimately contrasted among sites in order to, for example, assign areas as low versus high diversity sites.

To do this, you will perform a simple—but informative—analysis that is standard practice for conservation biologists who do biodiversity surveys. This analysis involves constructing a so-called "species accumulation," or "collector's curve" (Colwell and Coddington 1994). These curves plot the cumulative number of species observed against the cumulative number of individuals

Table 1. Species name, characteristics, and number of individuals for Site 1 spider collection.

SPECIES NAME	DISTINGUISHING CHARACTERISTICS	NUMBER OF INDIVIDUALS

collected and classified. The slope of the species accumulation curve will decrease as more individuals are classified and as fewer species remain to be identified.

Using the spider collection from forest Site 1, create a graph using Figure 2 that depicts the species accumulation curve. The y-axis values are number of species observed.

1. What variable will go on the x-axis?

To construct the species accumulation curve for this spider collection, choose a specimen within the collection at random. This will be your first data point, such that x = 1 and y = 1, because after examining the first individual you have also identified one new species! Next move consistently in any direction to a new specimen and record whether it is a member of a new species. In this next step, x = 2, but y may remain as 1 if the next individual is not of a new species or it may change to 2 if the individual represents a new species different from individual Repeat this process until you have proceeded through all 50 specimens and construct the collector's curve from the data obtained (just plot y versus x).

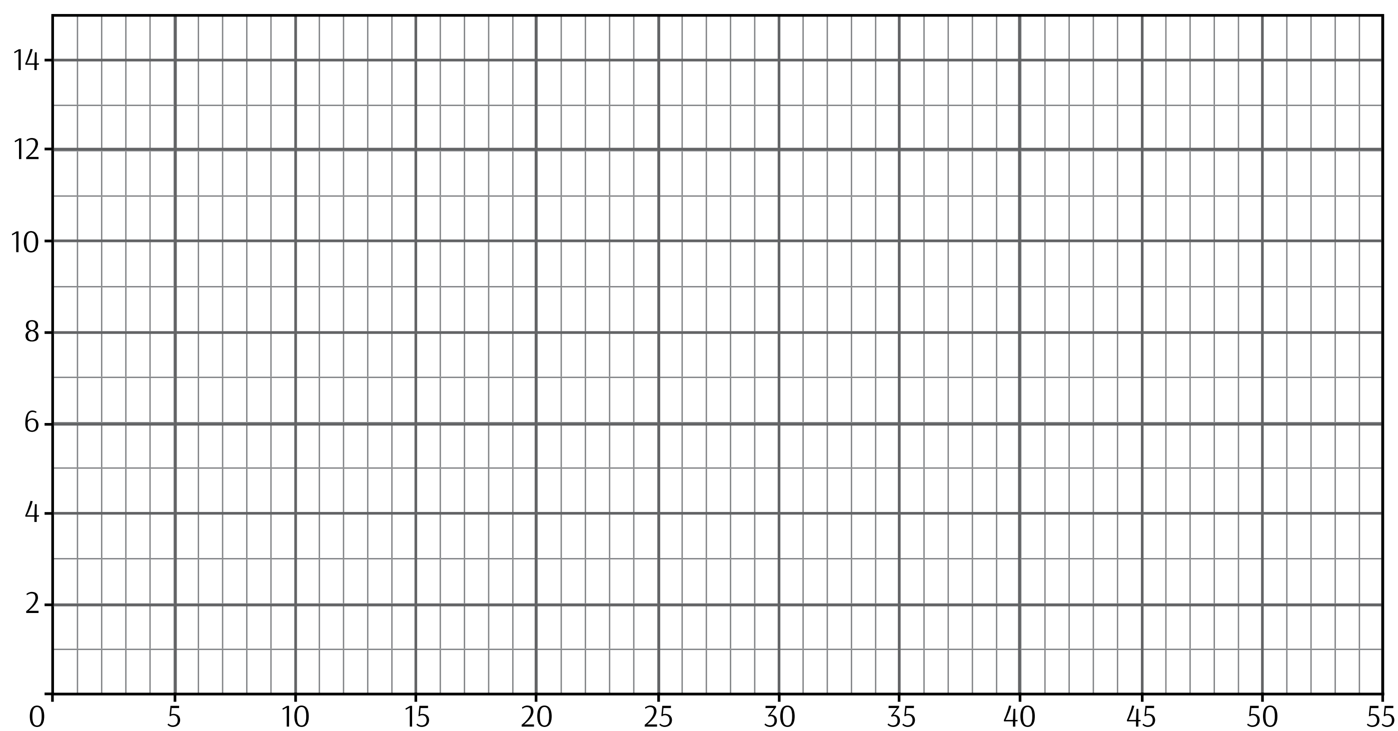
2. Draw your graph, label axes x and y and add a caption in the space provided in Figure 2.

As you will have seen, the species accumulation curve is an increasing function with a slope that will decrease as more individuals are classified and as fewer species remain to be identified. If sampling stops while the curve is still rapidly increasing, sampling is incomplete and many species likely remain undetected. Alternatively, if the slope of the collector's curve reaches zero (flattens out), sampling is likely adequate as few to no new species remain undetected.

Please answer the following questions:

3. Does the curve for forest Site 1 flatten out?
4. If so, after how many *individual spiders* have been collected? If not, is the curve still increasing?
5. Based on the shape of your species accumulation curve, do you feel this spider collection is an adequate representation of spider diversity at the site? *Please explain your answer.*

Figure 2. Caption:



Axis title:

Axis title:

4. PART 3: PRIORITIZING SITES FOR CONSERVATION BASED ON SPIDER DIVERSITY

4.1. Contrasting Spider Diversity Among Sites to Prioritize Conservation Efforts

Now you have data from five forest patches that contain different spider communities. If you had to make a recommendation, how would you rank these sites for protection and why? Through this assignment you will learn how to analyze the available data to answer this question.

The forest patches used to be connected as part of a much larger, continuous forest that was fragmented. A map of these forest patches, showing their size and proximity to each other, is shown in Figure 3.

Table 2 has detailed data on the species collected at each of the five spider communities. Although you only need species-level information for this exercise, the species have also been identified to family. More details about the families are provided in Appendix 2. Each cell in the table has the number of individuals (or specimens) of that particular species found in the collection from each patch.

You can now analyze these data further to generate different measures of community characteristics to help you to decide how to prioritize protection of the forest patches. Recall that you need to rank the patches in terms of where protection efforts should be applied, and you need to provide a rationale for your ranking.

You will find it most useful to base your decisions on four community characteristics:

- *species richness* within each forest patch
- *species diversity* within each forest patch
- number of endemic, or unique, species within each forest patch
- the similarity of spider communities between patches.

Species richness is simply the tally of different spider species that were identified in a forest patch. Check Table 1: do you already have this measure for each patch?

Species diversity is a more complex concept. It not only reflects the number of species present but also their relative abundances. This can reflect how balanced communities are in terms of how individuals are distributed across species. As a result, two communities may have precisely the same number of species, and hence species richness, but substantially different diversity measures if individuals in one community are skewed toward a few of the species whereas individuals are distributed more evenly in the other community.

To estimate *species diversity* we will use a standard index called:

Simpson Reciprocal Index = 1/*D*.

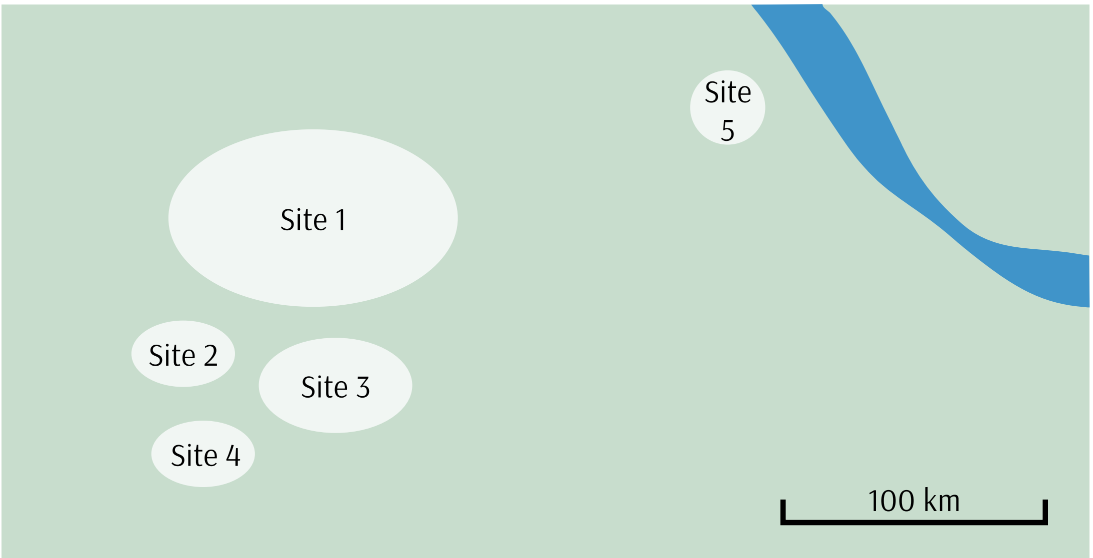


Figure 3. Map of five forest patches where spiders were collected.

Table 2. Species collected at each of the five forest patches, identified to family (see Appendix 2).

		SITE				
		1	2	3	4	5
FAMILY	**SPECIES**	**SPECIMENS**				
Araneidae	1	-	-	-	15	-
Araneidae	2	4	6	41	-	-
Araneidae	3	3	-	-	-	8
Araneidae	4	7	-	-	-	-
Araneidae	5	-	4	1	-	-
Araneidae	6	4	6	1	-	-
Araneidae	7	3	-	-	-	-
Araneidae	8	4	-	-	-	-
Araneidae	9	5	-	-	-	-
Araneidae	10	2	-	-	-	-
Clubionidae	11	-	-	-	7	-
Dysderidae	12	-	-	-	-	8
Eresidae	13	-	-	-	-	10
Gnaphosidae	14	3	6	1	-	-
Palpimanidae	15	-	5	1	-	8
Salticidae	16	-	-	-	7	-
Salticidae	17	-	-	-	7	-
Sicariidae	18	-	-	-	-	8
Theridiidae	19	3	4	2	7	8
Theridiidae	20	3	6	1	-	-
Theridiidae	21	5	8	1	-	-
Thomisidae	22	4	5	1	7	-
Total individuals collected		**50**	**50**	**50**	**50**	**50**
Total species identified		**13**	**9**	**9**	**6**	**6**

where $D = \sum p_i^2$ and p_i = the relative abundance of the i^{th} species in a site.

To obtain p_i, you need to convert the number of individuals to the proportion that each species represents of the total individuals captured at that site. For example, if you had a sample of 10 spiders from a site, and they belonged to two species, represented by five individuals each, then the relative abundance of each species is 5/10 = 0.5. Calculating relative abundance is equivalent to asking: what proportion of the total individuals (or specimens) captured belongs to this species?

For the same example of a sample of two species with five individuals each, then *species diversity*, or *Simpson's Reciprocal Index (1/D) =* $1 / [(0.5)^2 + (0.5)^2] = 2$.

The higher the value, the greater the diversity. The maximum value of species diversity is the total number of species in the sample, which is reached when all species contain an equal number of individuals. What is the spider species diversity of each forest patch? Use the worksheet in Table 3 to help you calculate species diversity and provide the values in the Diversity (1/*D*) row, for each site.

Table 3. Worksheet to aid species diversity calculations for each of the five sites.

SPECIES	SITE 1			SITE 2			SITE 3			SITE 4			SITE 5		
	specimens	p_i	p_i^2	specimens	p_i	p_i^2	specimens	p_i	p_i^2	specimens	p_i	p_i^2	specimens	p_i	p_i^2
1	-	0	0	-	0	0	-	0	0	15	0.3	0.09	-		
2	4	0.08	0.0064	6	0.12	0.0144	41			-			-		
3	3	0.06	0.0036	-			-			-			8		
4	7	0.14	0.0196	-			-			-			-		
5	-			4			1			-			-		
6	4			6			1			-			-		
7	3			-			-			-			-		
8	4			-			-			-			-		
9	5			-			-			-			-		
10	2			-			-			-			-		
11	-			-			-			7			-		
12	-			-			-			-			8		
13	-			-			-			-			10		
14	3			6			1			-			-		
15	-			5			1			-			8		
16	-			-			-			7			-		
17	-			-			-			7			-		
18	-			-			-			-			8		
19	3			4			2			7			8		
20	3			6			1			-			-		
21	5			8			1			-			-		
22	4			5			1			7			-		
D ($\sum p_i^2$)	-	-		-	-		-	-		-	-		-	-	
Diversity (1/D)	-	-		-	-		-	-		-	-		-	-	
Specimens	50			50			50			50			50		
Species	13			9			9			6			6		

In addition, note some sites have higher numbers of *endemic species*. Endemic species are those found *only* at a given site or area. Next, tally the number of endemic species per site in Table 4.

Finally, another important perspective in ranking sites is how similar or different the communities are from one another. We will use the simplest available measure of community similarity, that is, the *Jaccard coefficient of community similarity*, to compare all possible pairs of sites:

$$CC_J = c/S$$

where c is the number of species common to both communities and S is the total number of species present in the two communities. This provides us with a measure of how many species two given sites have in common. For example, if one site contains only 2 species and the other site 2 species, one of which is held in common by both sites, the total number of species present is 3 and the number shared is 1, so 1/3 = 0.33, or 33%.

This index ranges from 0 (when no species are found in common between communities) to 1 (when all species are found in both communities, i.e., the two communities contain the same species). You should calculate this index to compare each pair of sites separately, that is, compare Site 1 with Site 2, Site 1 with Site 3, etc. (Hint: there are a total of 10 comparisons). A worksheet is provided in Table 4. In addition, to compare all measures of diversity, transfer to this table the values you previously estimated for species richness, species diversity, and number of endemic species for each site.

4.2. Ranking Sites

Once you have finished these calculations, you can rank these five sites for protection and explain why.

Making an informed decision to rank these sites requires reconciling the concepts of diversity and distinctiveness (inverse of similarity). Your decision can be based on your estimates of species richness, diversity, and community similarity. However, once you have used those estimates you might also want to look at the spatial arrangement of the forest patches shown in Figure 3 and compare that to the species distributions given by the similarity among sites.

Next, taking this information into consideration please read and answer carefully the following questions:

6. A regional office of protected areas asks you to prioritize the conservation of the remnant forest patches shown in Figure 3. They specifically

Table 4. Endemic species per site.

	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
Number of endemic species					

Table 5. Worksheet for community similarity and comparison with other measures of diversity.

	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5
Site 1					
Site 2					
Site 3					
Site 4					
Site 5					
Richness	13	9	9	6	6
Diversity					
# Endemics					

ask you to provide two possible ranking options for protection (e.g., Site 1, Site 3, Site 2, Site 5, Site 4 from highest to lowest priority), and clearly explain the criteria used to make these rankings in Table 6. Note: remember to take into consideration *all* information available on biodiversity, distinctiveness, and geographic location of the patches. To facilitate making your decision, you can use Figure 4 as a worksheet, to summarize Table 4.

7. Describe what kind of additional information might change your recommendations with respect to *two* particular sites of your choice. Use *all* information available from the exercise.

REFERENCES

Colwell, R.K., and J.A. Coddington. 1994. Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society B 345:101–118.

Table 6. Sites ranked for protection.

RANKING OPTION	PRIORITY ORDER (e.g., SITE 1, SITE 2, SITE 5, SITE 4, SITE 3)	EXPLANATION OF CRITERION/CRITERIA USED
1		
2		

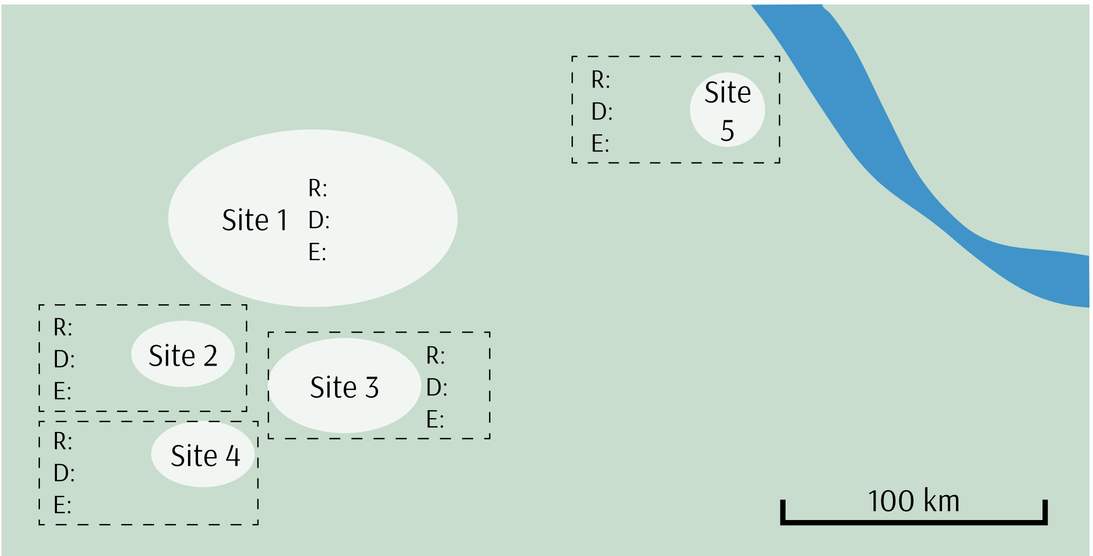
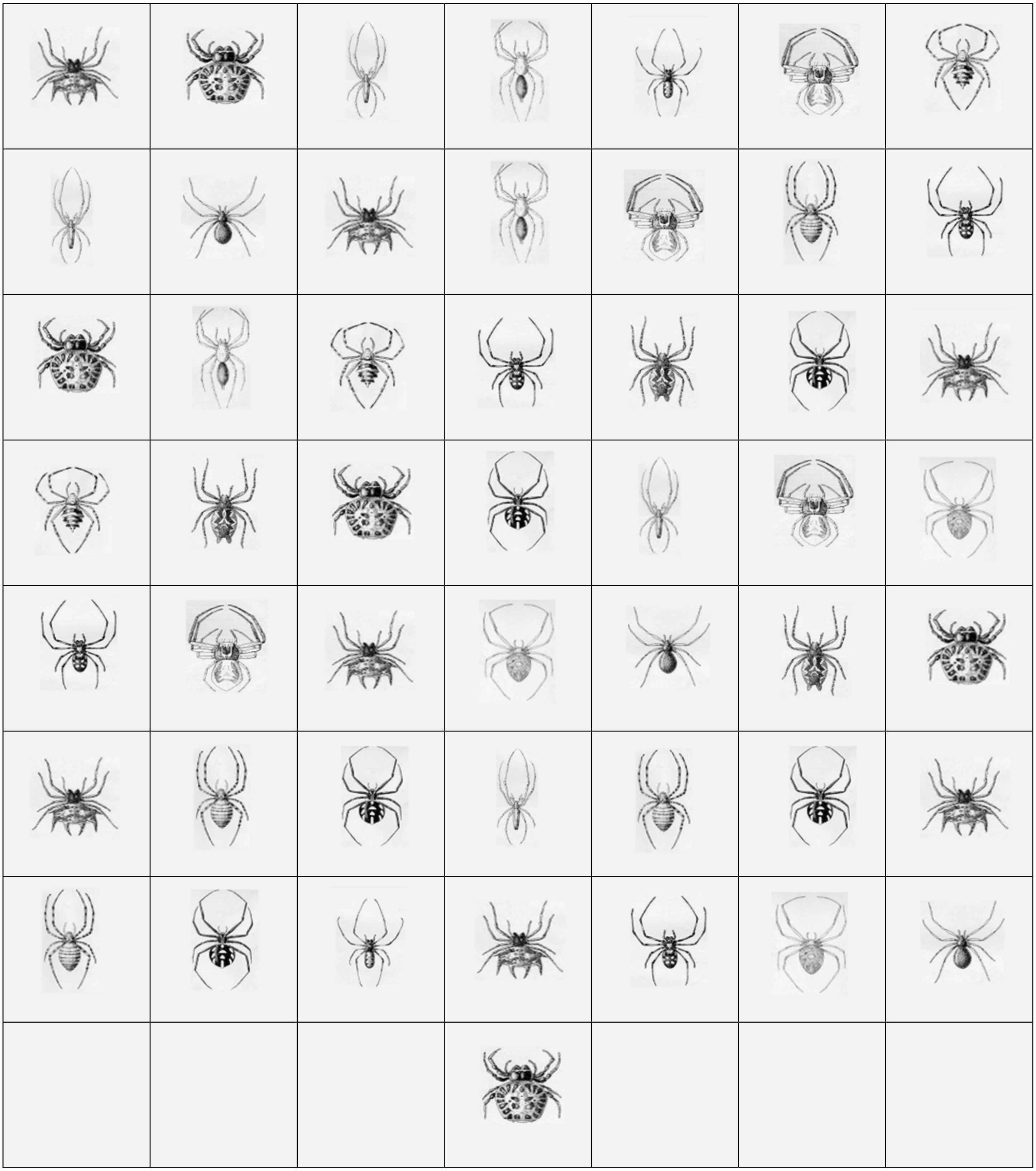


Figure 4. Worksheet showing the map of forest patches where spiders were collected. R = richness; D = diversity; E = number of endemics.

APPENDIX 1. SITE 1 SPIDER COLLECTION



APPENDIX 2. TAXONOMIC TABLE WITH SPECIES ORGANIZED BY FAMILY

Araneidae					
					
Clubionidae					
Dysderidae					
Eresidae					
Gnaphosidae					
Palpimanidae					
Salticidae					
Sicariidae					
Theridiidae					
Thomisidae