QUANTITATIVE FIELD ECOLOGY IN URBAN ENVIRONMENTS

BE AWARE THAT UPLOADING empty or completed LAB FILES to sharing websites (e.g. Course Hero, Study Blue) or other students constitutes academic dishonesty, and will be penalized.

OBJECTIVES

- develop hypotheses about abundance of nocturnal arthropods
- learn ecological assessment techniques: transects + pitfall traps + black lighting
- collect original scientific data
- use collaborative data collection and participate in a multi-functional team

INTRODUCTION

A. Background

This lab was inspired by a lab created by Dr. Susan Herrick (University of Connecticut), and developed as a collaboration between Dr. David Sadoway (Kwantlen Polytechnic University, Canada) and Dr. Nicola Plowes (Mesa Community College, USA) for the United Nations Sustainable Development Goals Open Pedagogy Fellowship.

This lab aligns with ***Goal 15: Life On Land : Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity, and, by 2020, protect and prevent the extinction of threatened species.***

The lab is a two-part assignment linking quantitative analysis of nocturnal arthropods (as ecosystem health barometers) [performed by Biology students] to an analysis of the conservation implications of urban planning [performed by Geography students].

B. The Science

It is common knowledge that different kinds of animals and plants are found in specific places. You would not find a spruce tree growing in the desert, nor would you find a saguaro cactus growing on the Alaskan tundra. However, the causes of many examples of animal and plant distributions are not so obvious.

A major focus of modern ecologists has been to identify the specific factors that affect the distribution and abundance of organisms. From this information, scientists can then test specific hypotheses regarding factors that influence what the scientists have observed. The multitude of factors that could potentially

determine why a particular species is found in one local and not another can be divided into two categories. The first category is the **physical requirements** of the organism. Spruce trees will not grow in the desert because they need more water to survive. As the physical parameters of habitats change due to climate change, we expect that the distribution and abundance of species will change as well.

The total requirements for an organism including food, temperature, moisture, sunlight etc. are called that organism's **ecological niche,** also known as the **realised niche**. Competition with other species, whether native, exotic, or invasive, can affect the distribution of an organism.

Ecologists monitor the abundance and distribution of different organisms using a variety of quantitative tools. Surveys, traps, transects, and museum records can help an ecologist to generate species lists and changes in abundance. Species richness indices (more later in the lab) provide succinct quantitative data that allow comparisons between different locations, and between the same locations over time - such as in Long Term Ecological Research sites (LTER). There is an LTER in Arizona, called the CAP LTER, which looks at a variety of different areas of research, from backyard bird abundance to the changes in soil nutrients, to changes in the abundance of ground dwelling arthropods since 1998 (Take a look at the trapping protocol, it's pretty easy!)

I. HOW DOES NOCTURNAL ARTHROPOD ABUNDANCE AND DIVERSITY VARY IN THE URBAN LANDSCAPE?

While there has been long term research in ground arthropods, there is a "gap" in the data regarding nocturnal, flying arthropods. YOU will help contribute, as a **citizen scientist**, to a body of data that can be used by Ecologists, Urban Planners, Geographers, and Conservation Biologists.

In this study we will be using a **light trap** with uniform size to quantify arthropod diversity in such a way that we can *compare between sites*. In the future, students will be able to compare sites *over time.* Geography students in Canada will be taking the data and analyzing it, to explore how features of the urban landscape (e.g. distance to natural areas, urban structure) correlate with abundance and diversity. They will be able to then make suggestions for informed policy decisions regarding urban planning and development.

The following video demonstrates the setup and data collection for a similar study performed in an ecology course in Connecticut.

Procedure:

Setup:

- Use a plain white sheet of fabric (a pillowcase, sheet, towel, or white t-shirt with no pattern is fine) and blue/green painter's tape (or similar) to create a sample plot that is 70cm X 70cm
- Tape the sheet of fabric directly under an outdoor porch light (as in the demonstration video).
- Starting at 3 hours after astronomical dusk, (time = 0) you will take a digital photograph of the light trap, and record data on the number of insects on the light trap. Data will be collected at 30 minute intervals, resulting in 5 data points.

- The data will be re-collected on a second evening.
- All data will be recorded both in this lab notebook, and will be transferred into shared folders for the collaborative, interdisciplinary analysis.

Data collection intervals:

1. collect data on two consecutive evenings
2. start data collection 3 hours after **astronomical dusk** (use Google to find what time that is in your zipcode on the dates you are collecting data).
3. collect data at the following hourly intervals: 0, 0.5, 1, 1.5, 2

Guide to size categorization:

Tiny = pencil tip size (x <0.5mm)
Small = rice grain (1cm > x >0.5mm)
Medium = Dime
Large = Nickel
XL = Quarter

Photographic guidelines

1. use a phone or digital camera
2. flash is ok
3. make sure that the image include the entire white sheet
4. put a copy of the image in your data table

Weather guidelines

1. go to https://www.weather.gov/
2. enter your zipcode to get the local weather
3. select "3 day history"
4. Choose the row of data that most closely corresponds with the time of your data collection for each date.

Data sharing process:

1. add a copy of each of your images to the IMAGE FOLDER - make sure that your image name has the following format:

   year_month_day_time_lat_long_Lastname

   e.g. ***2020_8_18_22:45_33.393_-111.872_Smith***

2. Enter your summary data into the collaborative data sheet. You will enter the data into the tabs that have your Instructor's name.
   a. For the Geographic data tab, you will have **2 rows of data** (one for each data collection day)
   b. For the Light trap data, **you will have 10 rows of data**.

c. Hint, you can use select/copy/paste to copy over data quickly, rather than entering each data point manually. Be conscientious of others- there may be other people trying to load data at the same time you are.

Data collection:

A. Geographic data (add to the tab **Geographic_InstructorName**)

State	County	Zip Code	Latitude	Longitude

Sample site: (circle the option that matches your data collection site)

Building Type	apartment (up to 3 levels) / multistory apartment (3+ levels) /townhouse/ single family home/ mobile home-rv
Locality	urban / rural-on farm /rural -in forest /rural - in desert

Weather data:

Date	Time	Time of astronomical dusk	Temperature F	Dewpoint F	Relative Humidity %	Wind direction	Wind speed MPH

B. Biological Data (Add to the tab **Light Trap _Instructor Name**)

Day 1 date:

	Summary of Arthropods observed					
Time (24hr)	#Tiny	#Small	#Medium	#Large	#XLarge	snapshot (color)

Day 2 date:

	Summary of Arthropods observed					
Time (24hr)	#Tiny	#Small	#Medium	#Large	#XLarge	snapshot (color)

Additional notes: (e.g. if you can identify a species, extraneous circumstances, interesting observations...

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II. DIVERSITY INDICES MEASURE RICHNESS AND EVENNESS

Ecologists use measures of abundance (how many individuals) and richness (how many taxa) to make qualitative comparisons between different locations, or in the same location over time. You will be learning how to quantify a small selection of the most frequently used indices.

MEASURES OF ABUNDANCE

A. **Species abundance** = number of individuals of a given species

B. **Relative species abundance** = abundance of one species / total abundance of all species

Evenness is a measure of similarity of the relative species abundances for the different species. In areas where the relative species abundances are very similar, the diversity is referred to as being **even**. If, on the other hand, there is one very common species (high relative abundance) and many rare species (low relative abundance), the diversity in the area is referred to as being **uneven**.

C. **Species density** = species abundance / area surveyed

Worked example for Measures of abundance:
Imagine you counted the numbers of plants, and identified the species found in a 5m X 5m quadrat.

Suppose each quadrat was $10m^2$

Plant Species	Quadrat 1	Quadrat 2
Creosote bush	4	3
Barrel cactus	5	7
Pincushion cactus	6	1

The **abundance** of creosote bushes in Quadrat 1 is 4.
The **relative abundance** of creosote bushes in Quadrat 1 is 4 / (4 + 5+ 6) = 0.27 (or 27%)
The **density** of creosote bushes in Quadrat 1 is 4 / (area of Quadrat 1 in m^2) = 0.4 bushes/ m^2

MEASURES OF DIVERSITY

A. **Species richness** = total number of species

The easiest way to assess an area is to count the number of species. This is called species richness and is the best way to compare areas of similar size and sampling effort. However, as described above, areas can have the same number of species, but one species being far more abundant. This is when you should use a diversity index that incorporates both species richness and evenness into one standardized measure.

B. **Shannon diversity index**

✓Watch this video showing how to calculate Shannon-Weiner Index

The Shannon index of diversity (sometimes called Shannon-Weiner) is a unit free measure of the diversity of a defined area. **The Shannon index combines the *number of species* and the *evenness* to generate a simple measure of diversity**. The index gives an answer from 0 – 4, values near 0 have areas of low diversity and areas with an index value close to 4 have high diversity. The appropriate way to use the Shannon index is to compare the relative diversity of areas that are similar in size and similarity.

The value you get at the end of the calculation is called the "H value" or "Index Number". Low diversity areas will have an H value closer to 0 whereas higher diversity areas will have values closer to 4.

The formula is $\mathbf{H = -\Sigma\, p_i \ln p_i}$

This means:
Σ = sum for all species. That means you will calculate the equation (pi* ln pi.) for each species and add the results together.

$\mathbf{p_i}$ = the proportion (relative abundance) of that species of all species. This is calculated using the number of individuals, not species. Add up the number of individuals for the species and divide it by the total number of individuals for all species. p_i = the proportion of species(i) of all species, e.g. ($p_{brittlebush}$ = brittlebush abundance/total abundance)

ln $\mathbf{p_i}$ = the natural log (or "ln") of the p_i value. If you don't have a calculator, you can use the Google calculator. If you use Google sheets, the formula is "=ln(value)".

(-)= We take the negative of the answer simply to turn the answer into a positive number. The raw answer to the equation will be negative because when you take the log of a proportion you get a negative number. The authors of the index felt it was more intuitive to turn the answer positive so that that high numbers refer to

higher diversity as opposed to the more negative number.

Worked example for Shannon Index:
Imagine you counted the numbers of plants, and identified the species found in a 5m X 5m quadrat.

Suppose each quadrat was $10m^2$

Plant Species	Quadrat 1	Quadrat 2
Creosote bush	4	3
Barrel cactus	5	7
Pincushion cactus	6	1

The next step is to calculate p_i and $\ln p_i$ for each species, in each different Quadrat

Quad 1:

Plant Species	# of individuals	p_i	$\ln p_i$	$p_i * \ln p_i$
Creosote bush	4	4/15 = **0.27**	ln(0.27) =-1.31	0.27 * -1.31 = -0.35
Barrel cactus	5	5/15 = **0.33**	ln(0.33)=-1.11	0.33 * -1.11= -0.37
Pincushion cactus	6	6/15 = **0.4**	ln(0.4)=-0.92	0.4 *-0.92 =-0.37
Total (N)	4+5+6 = **15**		$\sum p_i * \ln p_i$=	(-0.35) + (-0.37) + (-0.37
			Shannon Index for Quad 1=	-1 * -1.09 = **1.09**

✔Now it is your turn - using the same strategy as I did for Quad 1, find the Shannon Index for Quad 2.

Quad 2:

Plant Species	# of individuals	p_i	$\ln p_i$	$p_i * \ln p_i$
Creosote bush	3			
Barrel cactus	7			
Pincushion cactus	1			
Total (N)			$\sum p_i * \ln p_i =$	
			Shannon Index for Quad 2=	

✔Which Quadrat has higher diversity? _____

II. QUANTITATIVE EVALUATION OF YOUR DATA

1. **Post your <u>last</u> photo from day 1 in the space below:**

2. **Post your <u>last</u> photo from day 2 in the space below:**

3. **Estimate how many ***<u>different</u>* **<u>species</u> you have in each photo**. You can use the **morphospecies** concept to do this, in other words, if two arthropods *look* like they are the same, give them a "name" and count the number of that type from each photograph. For example "1- 1mm black beetle", "2 - 5cm moth with tiger striped wings". If a species is found on Day 1 not Day 2, simply put a "0" for that species on Day 2.

   Add rows as needed. Make sure to describe each morphospecies (rather than just "Species 1" etc).

Arthropod morphospecies	Day 1	Day 2
1-		
2-		
3-		

4. **Calculate the Shannon Diversity index for each day**. (add rows as needed, for each table (put

your cursor in the last species row, Right click, "Insert Row below")

DAY 1				
Arthropod	# of individuals	p_i	$\ln p_i$	$p_i * \ln p_i$
1				
2				
3				
Total (N)			$\sum p_i * \ln p_i =$	
			Shannon Index for Day 1=	

DAY 2				
Arthropod	# of individuals	p_i	$\ln p_i$	$p_i * \ln p_i$
1				
2				
3				
Total (N)			$\sum p_i * \ln p_i =$	
			Shannon Index for Day 2=	

5. **Which day did you have higher biological diversity?**

6. **Could you possibly explain the difference in diversity between the two days? (Think about abiotic variables)**

1. Remember to submit THIS completed document to Canvas for grading.

2. You MUST add your data to the collaborative data sheet, and your photographs to the folder for your lab to be counted as "Completed"