Ecological Methods & Experimentation

Ecology

• Study of ecological systems
  - Organisms interacting
  - Natural environment

• Structure: measurable condition
• Function: creates structure

• Goal: Understand HOW ecological systems function

Designing an Ecological Study

Exercise 1
Descriptive/Functional Hypotheses

- First test observations, then design controlled experiment

Scientific Method

- Deduction used in hypothesis falsification
  - Falsification: method in which we attempt to disprove parsimonious hypotheses logically
  - Form null hypothesis of no effect
  - Try to disprove null hypothesis using deduction
    - From null hypothesis, make prediction about what expect to find in data
    - If collect data that contradict these expectations (null is false), then we can reject null hypothesis

Scientific Method

- Test Hypothesis:
  - Formulate null hypothesis
  - Collect unbiased observational or experimental data
  - Perform statistical test of null hypothesis
  - Reject null and accept most parsimonious alternative hypothesis
    - or fail to reject null & reformulate hypothesis
**H₀: Null Hypotheses**

• H₀: the difference between 2 or more sets of data is not greater than expected by chance

• H₀: the data do not differ from a theoretical expectation

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**Example page 6**

• Plant species observed in 2 locations with different characteristics

• Is it genetic or environmental?

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**Experimental Design**

Exercise 3
Key Ideas in Manipulative Experiments

- Experimental unit
  - At what level are we applying the treatments? That is the experimental unit
- Replication
  - Must repeat the experiment (including each treatment) to reduce chance variation
- Repeated measure/pseudoreplication
  - Measures on same experimental unit over time

Key Ideas in Manipulative Experiments

- Controls
  - Controls are experimental units that are identical
  - Except in receiving treatment factor
  - Example: fertilizer spray
- Randomization
  - Randomized block, Latin square

Discussion

- What is the appropriate experiment unit for the experiment we’re conducting today?
Sampling Design

Variables
- Continuous - incremental variation, mass
- Discrete - count, # of eggs

Need operation definition for variable

Sampling units
- quadrats, volume, number, time

Sample Layout

Sample must represent population
- Random samples
- Stratified random sampling
- Systematic sampling

Number of samples
- 20-25 is minimum
- Statistically more like 35
Quantitative Description

Exercise 6

Central Tendency

• Mean, median
• Variance
  \[ \sigma^2 = \frac{\sum (x_i - \bar{x})^2}{n-1} \]
• Standard Deviation
  \[ s = \sqrt{\sigma^2} = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \]

Relevant Statistics

• Chi-square
  \[ \chi^2 = \sum \frac{(o-e)^2}{e} \]
• t-test
• ANalysis Of VAriance – ANOVA
• Correlation
• Regression
• MINITAB v14
Properties of Environments

- 2 types of environmental factors that affect distributions and abundances of organisms: Conditions and Resources

Acclimation Lab

Gammarus pseudolimnaeus

Conditions and Resources

- Condition - an abiotic environmental factor that varies in space and time
  - Examples: temperature, relative humidity, salinity, concentration of pollutants; also variety of hazards such as hurricanes and destructive storms
  - Organisms can modify conditions in their immediate environment
    - Relative humidity on ground underneath tree canopy will be different than relative humidity away from the tree
Conditions and Resources

• Resources - anything that can be consumed by an organism; anything which the amount of can be reduced by the activity of an organism
• Examples
  - Plants - water, minerals such as nitrogen and phosphorus, light, carbon dioxide, space, oxygen
  - Animals - water, food, oxygen, space

Conditions and Resources

• Important distinction
  - Conditions are not consumed or used up by an organism or made unavailable or less available to other organisms, while resources can be consumed or used up

Ecological Niche

• Summarizes tolerances of organisms to environmental conditions and their requirements for resources
• Niche - summary of a species’ tolerances and requirements; conditions under which a species is able to live, grow, and reproduce
Niche and Distribution

• If habitat or location has levels of conditions and resources that define species niche, then species can potentially live there.
• Whether actually does live and persist there depends on 2 further factors:
  - Must be able to reach or colonize location.
  - May be prevented from living there by actions of other species (e.g., competitors, predators).
• Allows distinction between fundamental and realized niche.

Fundamental and Realized Niche

• Fundamental niche – combination of conditions and resources that can allow species to maintain viable population if not adversely affected by other species.
• Realized niche – the more limited spectrum of conditions and resources that allow species to persist in habitat in presence of competitors, predators, etc.

![Diagram showing the relationship between fundamental and realized niche]
Acclimation to Conditions

• Today’s lab we will measure response of a population of aquatic organisms to gradients of temperature and light

• Popperian method of hypothesis falsification
  - Cannot prove hypotheses

Falsification Approach in Ecology

• Null Hypothesis: form of hypothesis that can try to falsify using logic of disproof
  - Null hypothesis is one of no difference or no change
  - If null is false accept most parsimonious alternative