



## ***Module 4: Drawing Conclusions From Data***

### 4.1 Observing Data versus Performing Experiments



### ***Observing Data vs Performing Experiments***

- ◆ Analyzing environmental data is often complicated by non-adherence to standard assumptions.
- ◆ Some issues that arise:
  - Rarely can experiments be carried out on the environment
  - It is difficult to “control” some variables while studying others

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## *Observing Data vs Performing Experiments*

- ◆ Some issues that arise:
  - There are many types of trends and patterns in nature at many different scales all happening simultaneously and these are not well understood by us
  - Laboratory scale experiments sometimes give different results than what is observed at a larger scale in nature
  - Standard distributions many not apply

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## *Observing Data vs Performing Experiments*

- ◆ Some issues that arise:
  - Data can be missing or not measurable (censored)
  - Data points close together in time or space are more alike than those further apart (autocorrelation)
- ◆ A few of these issues will be discussed in this module

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## *Observing Data vs Performing Experiments*

- ♦ Observation and experimentation are the basis of science
- ♦ Observation is passive while experimentation is active
- ♦ Experimentation involves purposefully changing some conditions in a controlled way and observing the result

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## *Observing Data vs Performing Experiments*

- ♦ In order to be certain that changing variable A will affect variable B in a certain way, it is necessary to change A and observe B (while holding everything else more or less constant)
- ♦ Other important considerations in experimentation are randomization, replication, and controls

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## *Observing Data vs Performing Experiments*

- ♦ Randomization involves making sure that sample units are randomly chosen to be measured or are randomly assigned to treatment groups
- ♦ This ensures that differences between sample units (on any number of unmeasured characteristics) will not interfere with observing the effect of the variable under study

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## *Observing Data vs Performing Experiments*

- ♦ If careful randomization is not used, unintentional bias can result:
  - A researcher unconsciously picks the unhealthiest specimens to measure for effects of environmental contamination because that agrees with his beliefs
  - A scientist with a new idea for treatment, unintentionally selects the healthiest lab mice to test it on

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## *Observing Data vs Performing Experiments*

- ♦ Replication involves doing the experiment multiple times or collecting multiple data points
- ♦ Without replication, we don't know how much variability is "normal" and so we can't tell if what we saw was natural variability or a real effect

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## *Observing Data vs Performing Experiments*

- ♦ Controls are sample units to which the treatment being studied is not given
- ♦ Controls allow us to see what would have happened to the population if we had left it alone
- ♦ Without controls, we must make a judgement about this issue and will have little assurance of its validity

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## *Observing Data vs Performing Experiments*

- ◆ The problem is that proper experimentation is rarely possible in the field of environmental science
- ◆ So, we often must rely on observational data
- ◆ If we observe A and B (and other things) and A and B change together, then A may cause B or vice versa or they may both be caused by C

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## *Observing Data vs Performing Experiments*

- ◆ We can do laboratory experiments to check on relationships
- ◆ We must also use our knowledge, experience, scientific theory, etc to make judgements about the environment

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## *Observing Data vs Performing Experiments*

- ◆ Be careful to:
  - Be a skeptic, double check
  - Make sure observed relationships make sense theoretically
  - Use experimentation where possible to validate observed relationships
  - Don't assume that if a relationship holds in the laboratory it will definitely hold in nature, you must observe it on that scale

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## *Observing Data vs Performing Experiments*

- ◆ Be careful to:
  - Make as few assumptions as possible regarding the data
  - Be as open minded as possible when analyzing the data, look at what the data is telling you
- ◆ In other words, being a good environmental statistician is being a good scientist

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