Brief Description of Ecology and Designing Successful Field Studies

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Bio 322: Experimental Field Ecology

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Ecology

- Ecology ***is not*** synonymous with environmentalism, natural history, or environmental science.
- Ecology **is** the study of the relations that living organisms have with respect to each other and their natural environment.

Environmentalism

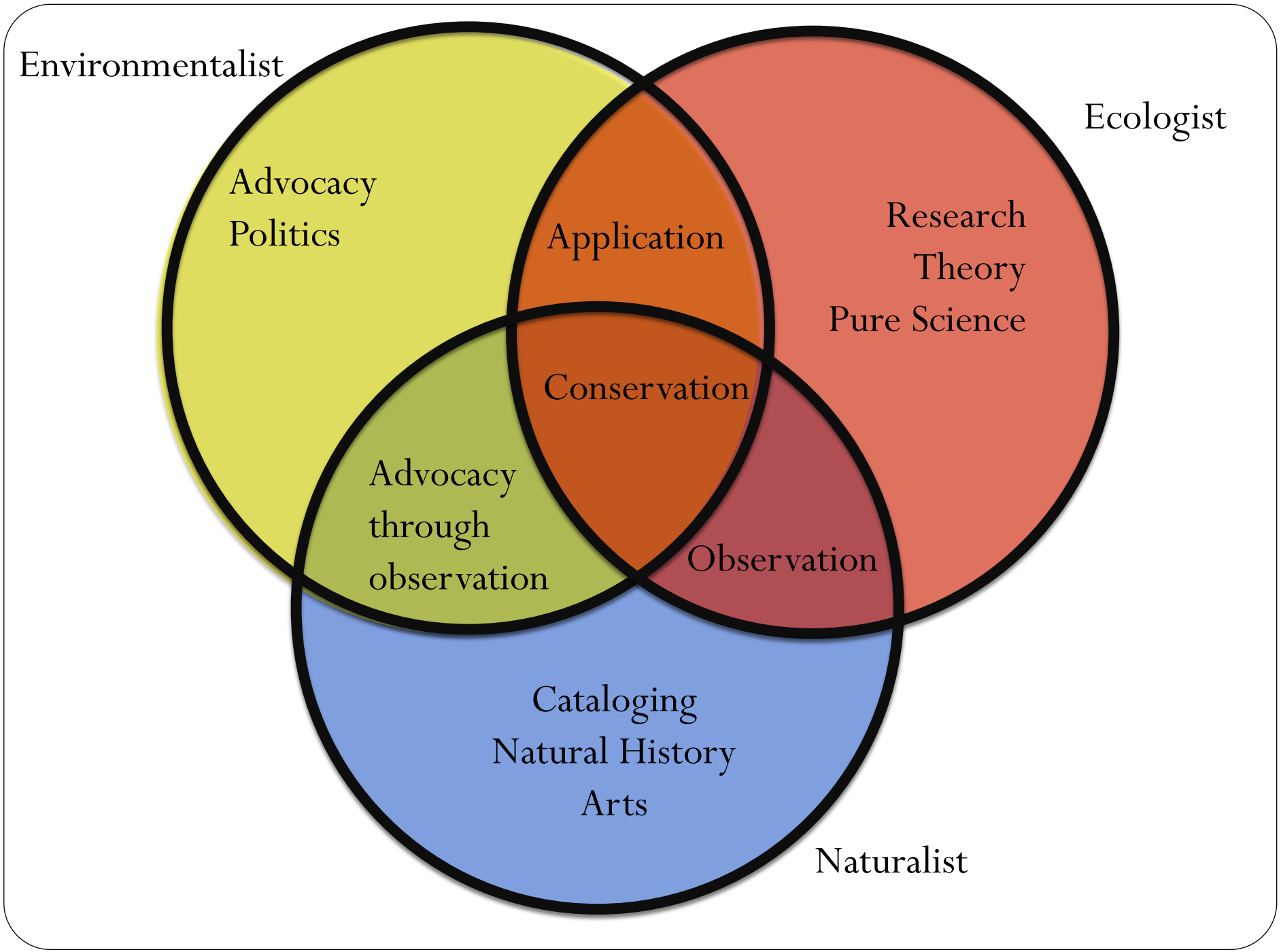
- Broad philosophy, ideology, and social movement concerning the environmental conservation and health of the environment.

Natural History

- Observational study of plants or animals.
  - Can also include photography, painting, and other art forms

Environmental Science

- Interdisciplinary field that includes ecology, physics, chemistry, biology, soil science, geology, atmospheric science, and geography.


Environmentalist
Advocacy
Politics
Ecologist
Research
Theory
Pure Science
Application
Conservation
Advocacy
through
observation
Observation
Cataloging
Natural History
Arts
Naturalist

What is the point of doing a study?

- Not as obvious as the question appears
- How and why questions seldom create a clear answer
  - "Experiments can do something for ecology that no other approach can do: establish cause and effect. But they don't tell you what questions to ask, or whether you are testing your questions appropriately" - *William Resetarits*

Informative Questions

- Are there spatial or temporal differences in variable Y?
  - Produces survey data
    - **NOT EXPERIMENTAL**
  - Starting point of most ecological studies
  - You cannot ask "how" until you ask "if"

Informative Questions

- Are there spatial or temporal differences in variable Y?
  - Has a simple null hypothesis
    - "Does this differ than random?"
  - Simple answer
    - "Yes" or "no"
  - Easily analyzed with ANOVA or regressions

Informative Questions

- What is the affect of factor X on the variable Y?
  - Answered by manipulative experiments
  - Usually associated with a p-value
    - Factor X does (not) influence variable Y, and the signal of Factor X is (not) greater than the "noise."

Informative Questions

- Are the measurements of variable Y consistent with the predictions of hypothesis H?
  - Does theory match data and vice versa?
    - Inductive: H is modified to fit data
    - Deductive: H is falsified and discarded if it does not fit the data
  - Can use experimental or observational data

Informative Questions

- Are the measurements of variable Y consistent with the predictions of hypothesis H?
  - Not an easy question to ask simply
    - Most hypothesis do not create simple falsifiable predictions
    - Hypothesis predictions are rarely unique
      - Cannot definitively test H using only data collected on Y

Informative Questions

- Using the measurements of variable Y, what is the best estimate of parameter Θ in model Z?
  - Can we take a measurement in Y and make a prediction how a population/community will react using a model?

The Control

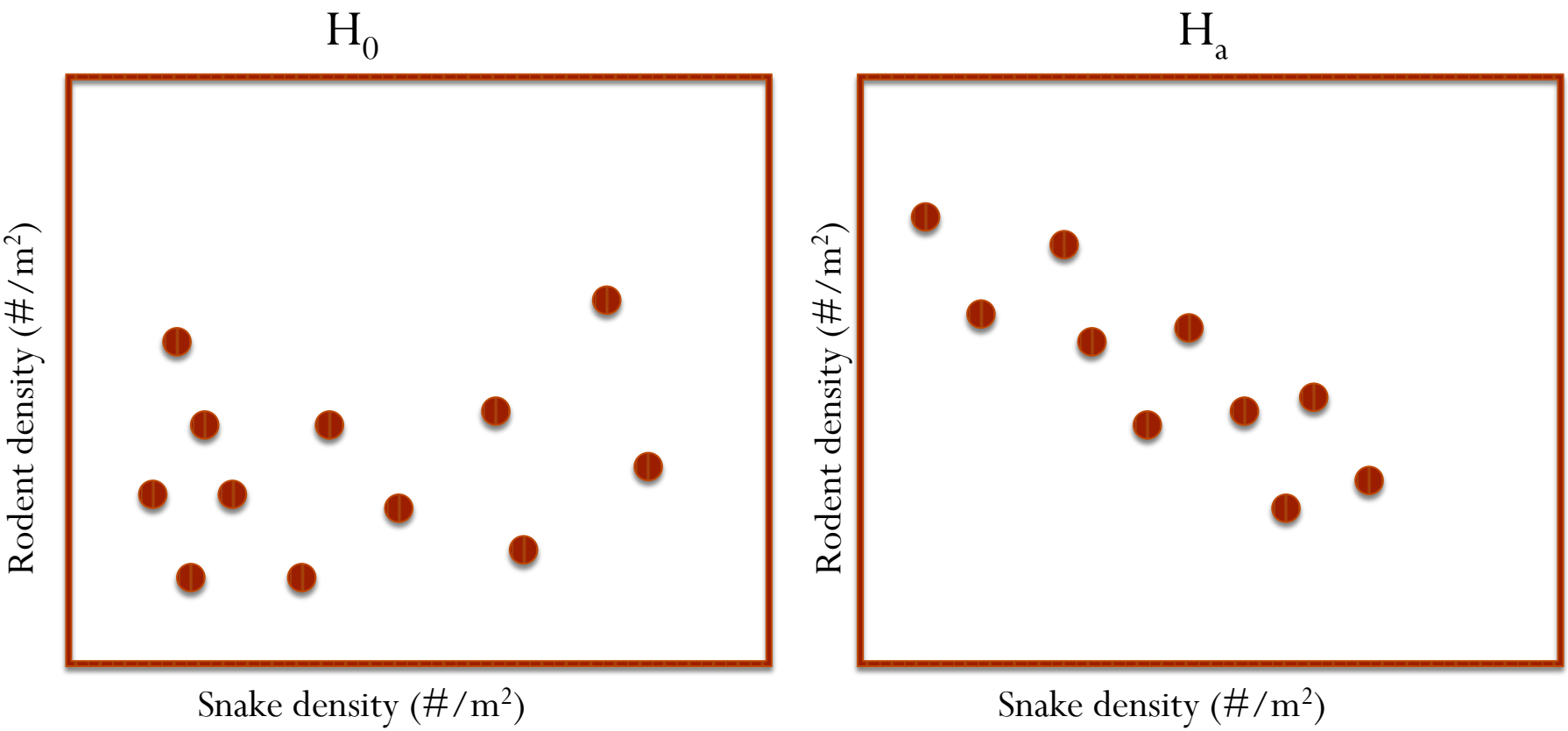
- It is a portion of the study that we do not alter
  - Attempt to hold constant
- What the system "should" look like
- What we compare our treatment to

Manipulative Experiments

- Manipulate one factor and then measure how one or more variables react
  - Tests for cause and effect
- Can be performed in the field or laboratory
- Test a hypothesis (H_a) against null hypothesis (H_0)

Manipulative Experiment

- Do snakes control small rodent populations?



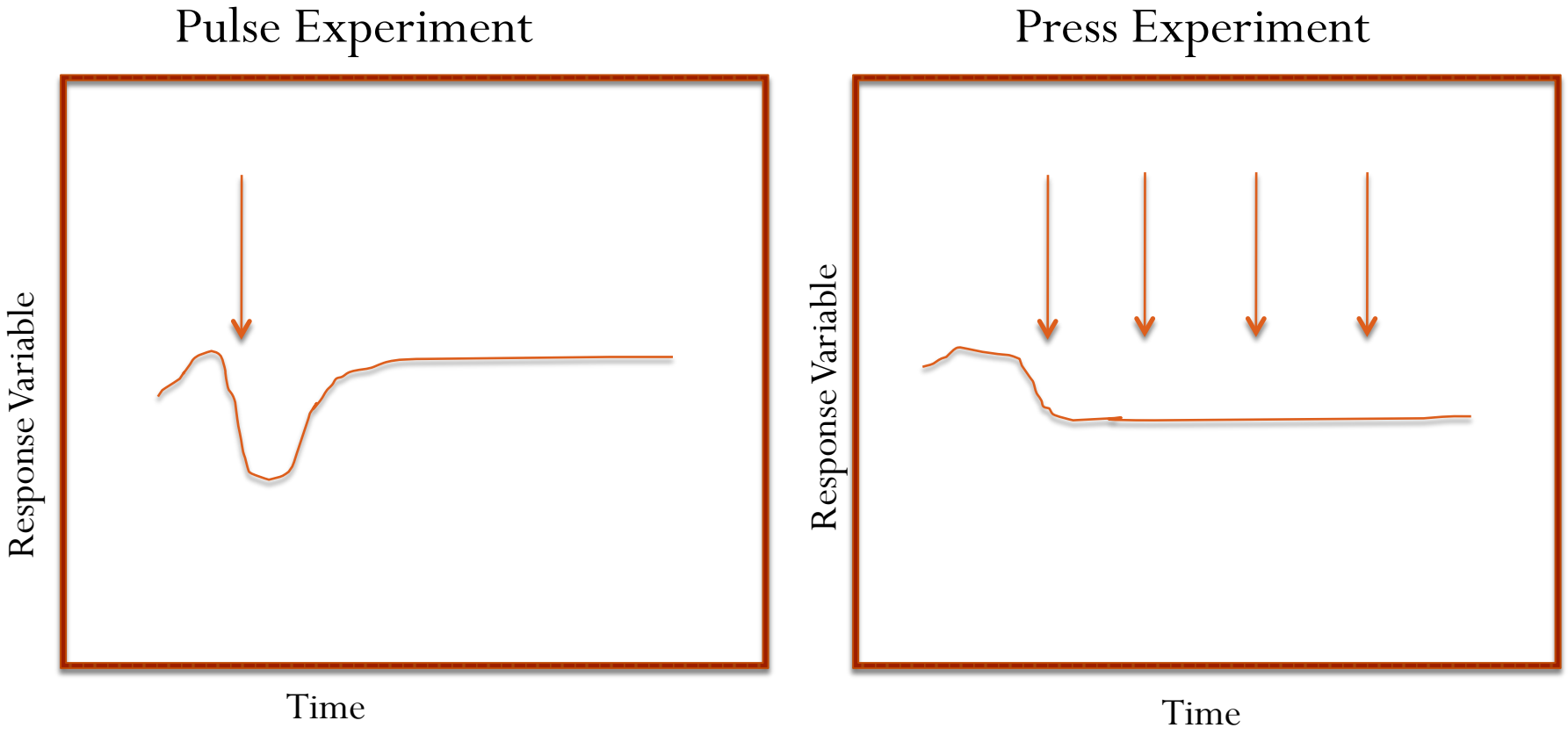
Press vs. Pulse

- Press
  - Treatment (X) is maintained through out the experiment
  - Measures resistance to constant environmental change
    - Low resistance = large response
    - High resistance = small response

Press vs. Pulse

- Pulse
  - Treatment is applied once at beginning and not re-applied
    - System is a allowed to "recover"
  - Measures resilience of the system to the treatment in a changing environment
    - Low resilience = long (if ever) recovery to control conditions
    - High resilience = quick return to control

Pulse vs. Press



Natural Experiments

- Not a "true" experiment
  - Observe differences in naturally occurring variance
  - No true control

Snapshot vs. Trajectory

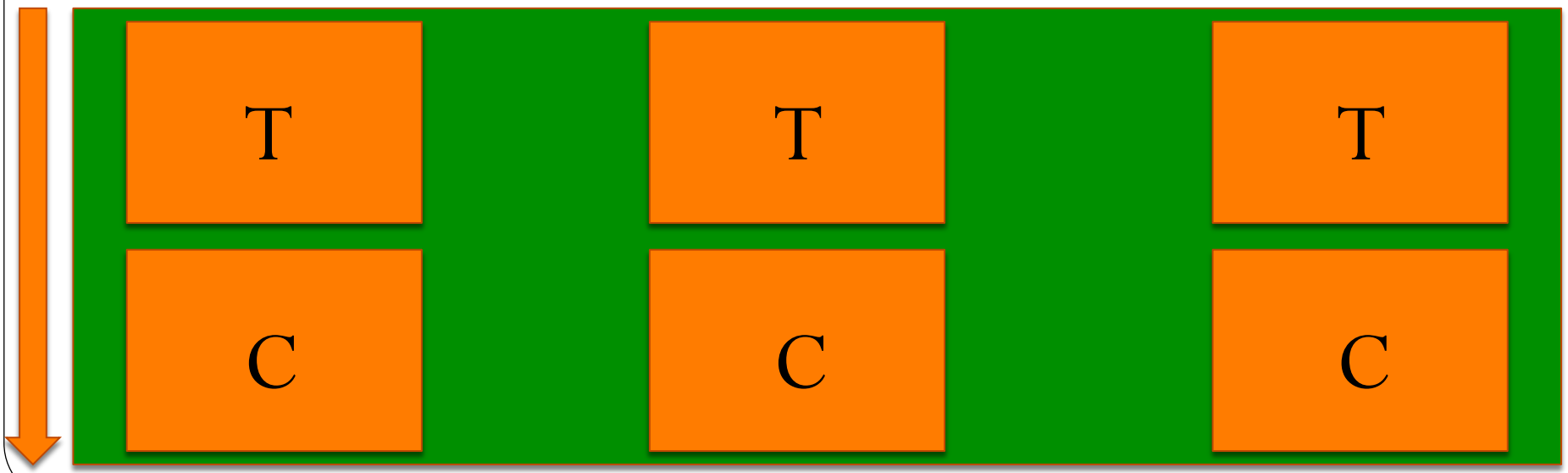
- Snapshot
  - Replicated in space
  - Multiple locations measured one time
  - Majority of ecological data are snapshots
    - Mainly due to funding and thesis/dissertation lengths
  - Advantage: replicates are statistically more independent
  - Disadvantage: No power of prediction

Snapshot vs. Trajectory

- Trajectory
  - Replicated in time
  - One location is measured multiple times
  - Some of the best data are trajectory
    - Long term experimental research
    - Best type of data for model building
  - Advantage: reveals how a system changes over time
  - Disadvantage: Limited to one system

Independence

- Do not want any of the replicates to influence another



Independence

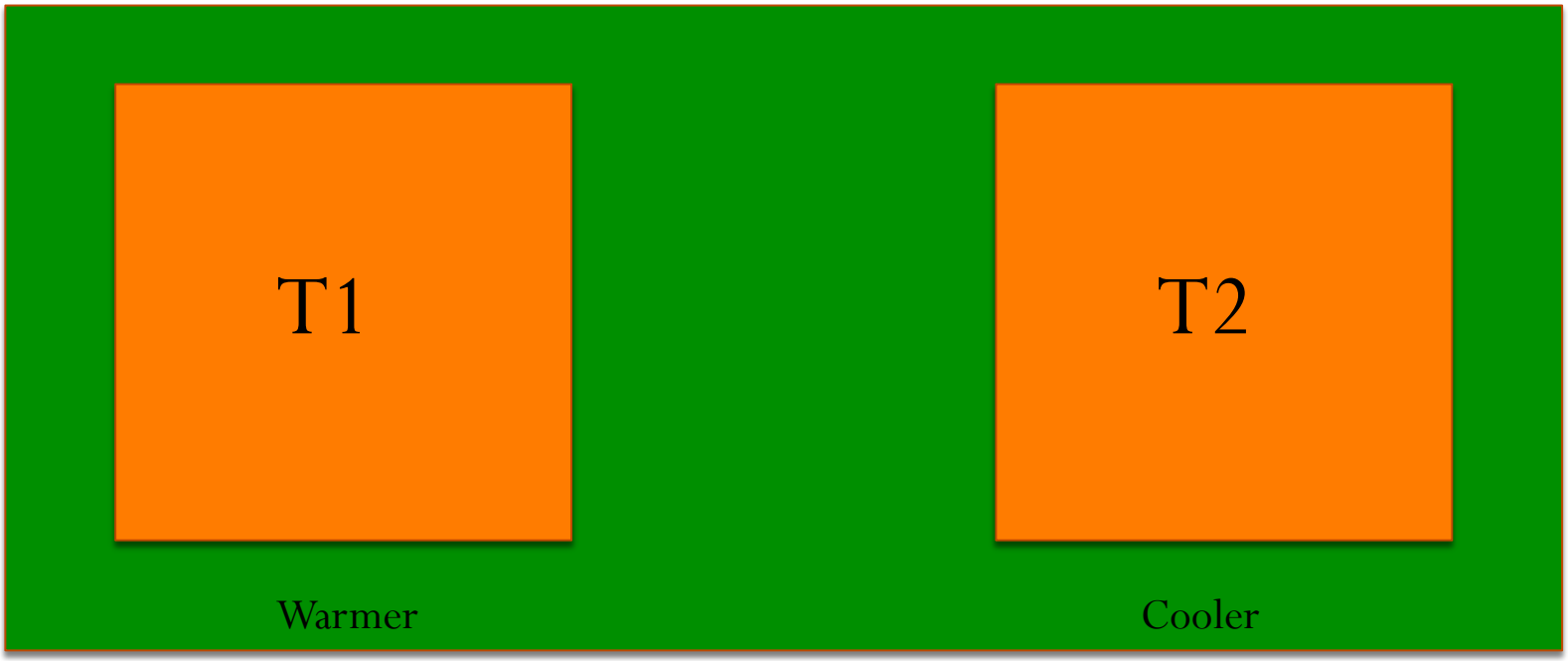
- Ideal World
  - Best defense is sufficient space and time between control and treatment
- Reality
  - Increased distance decreases homogeneity
    - Large distances can also create logistic problems
  - Small distance increases homogeneity but decreases independence

Independence

- Use common sense
- Pilot studies
- It is an issue that is often “ignored” by ecologists

Confounding Factors

- Factors in which the effects cannot be disentangled from one another



Confounding Factors

- Factors which effects cannot be disentangled from one another
- In reality, many factors are unmeasured or just unknown
  - Do the best we can
- In natural experiments we are just stuck with them

Replication and Randomization

- Attempt to minimize confounding factors and issues of non-independence

Replication

- How much?
  - Hardest question in ecology
  - Depends on the variance in the data and effect size
    - Hard to estimate
    - Often requires a pilot study

Replication

- Pilot studies
  - Generally not very feasible and potentially expensive
  - Field seasons are short
  - Grant money is small
- Generally we have to make an estimate based on previous work and discussions with colleagues

Replication

- First have to decide what can be afforded
  - Experiments take time, labor, and material
    - All = $$
  - The more time it takes to collect data the more variation due to time
- Consider the spatial scale of the experiment
  - Larger experiments are better but are harder to replicate

Replication

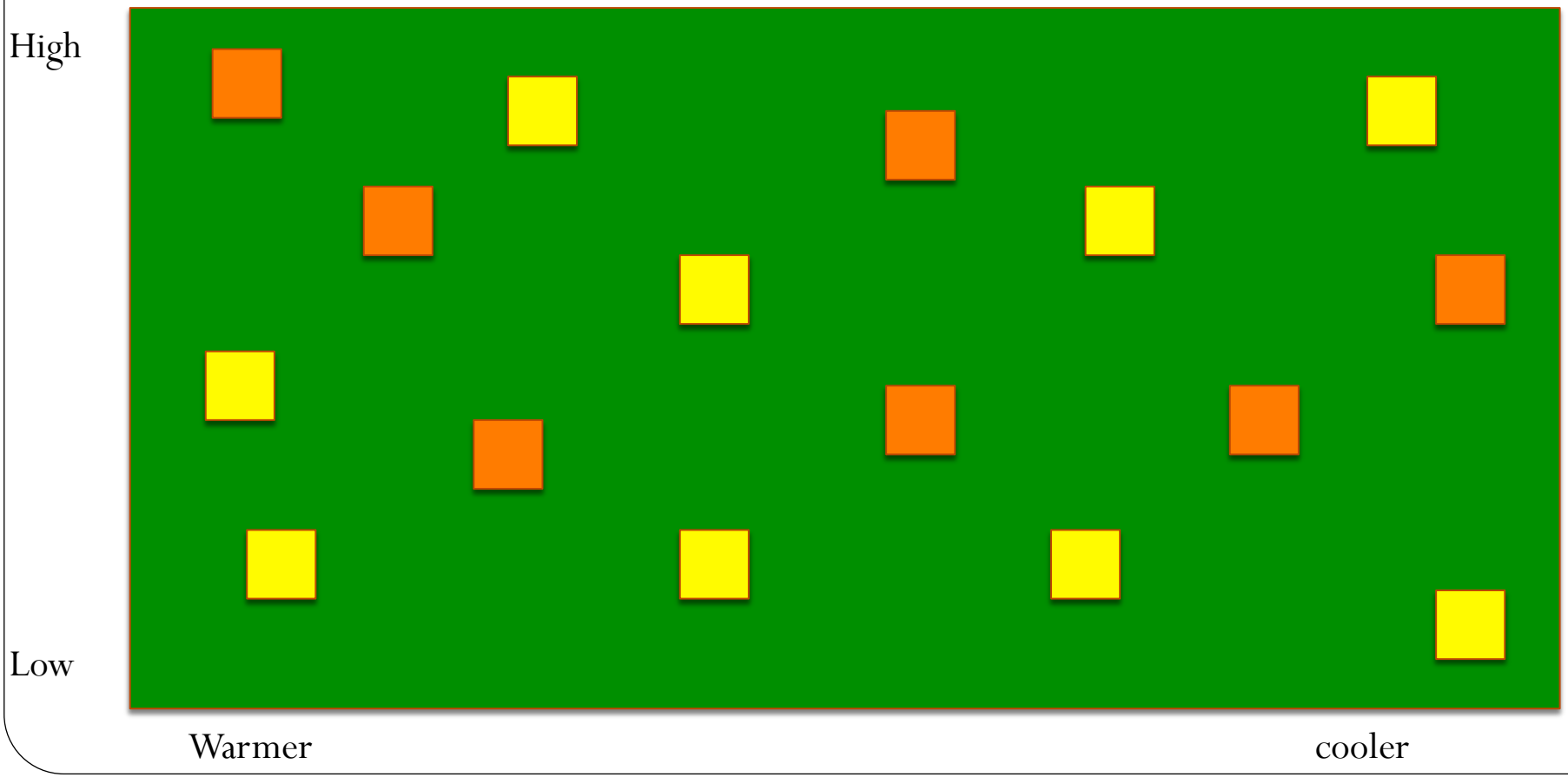
- Rule of 10
  - Perfect for small scale studies
  - Not based on anything other than experience
  - Always a good starting point
    - Things happen
    - Better to have too many than not enough

Replication

- Before-After, Control-Impact (BACI)
  - More suited for large scale experiments
  - Extensively collect data before and after treatment

Randomization

- Decrease confounding factors



Issues with Manipulative

- Hard to perform on large scale
  - Over 80% of field experiments performed on an area $<1\ m^2$
  - Replication is hard at large scale
  - Small scale results do not necessarily infer large scale processes

Issues with Manipulative

- Often restricted to small bodied and short lived organisms that are easy to manipulate
- Difficult to only change only one variable, and control for others
  - Confounding factors
- Standard designs are not realistic for field experiments
  - Species interactions

Issues with Natural

- Lack of confidence in the interpretation of results
  - 4 hypothesis could explain our rodent snake interaction

Issues with Natural

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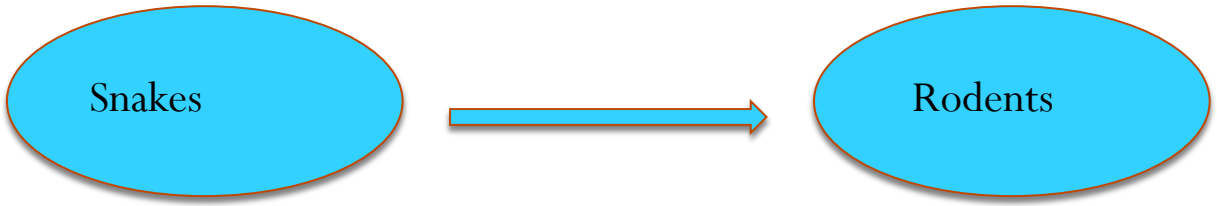

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Issues with Natural

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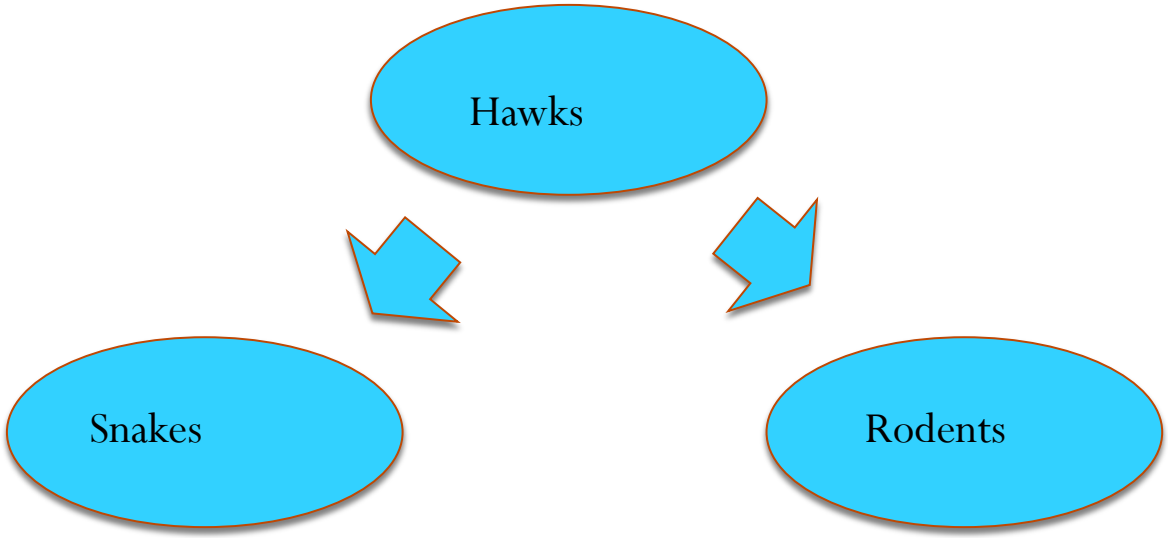

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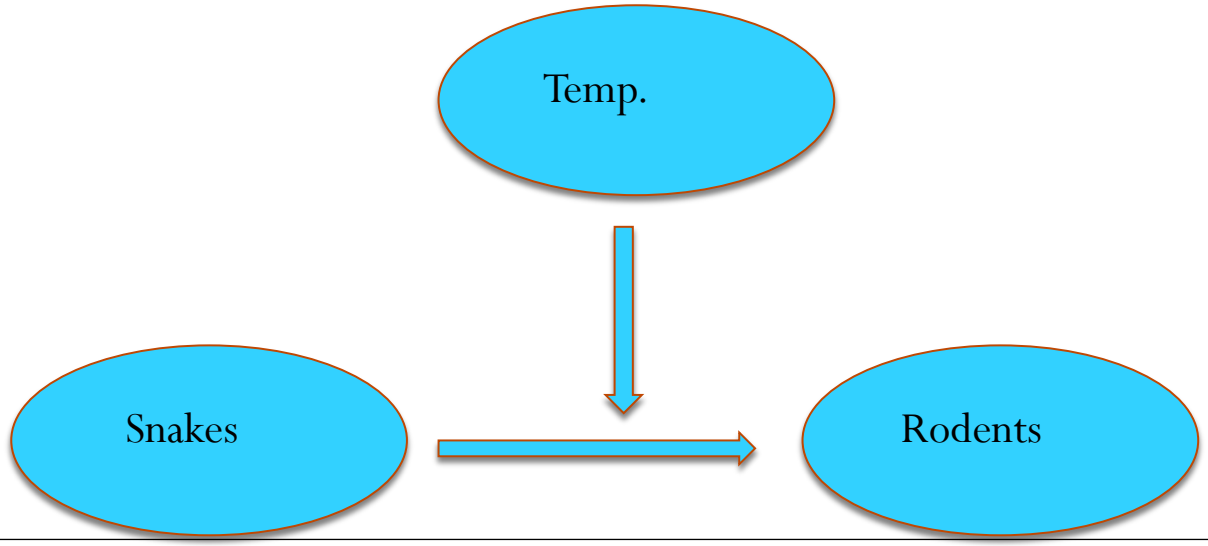
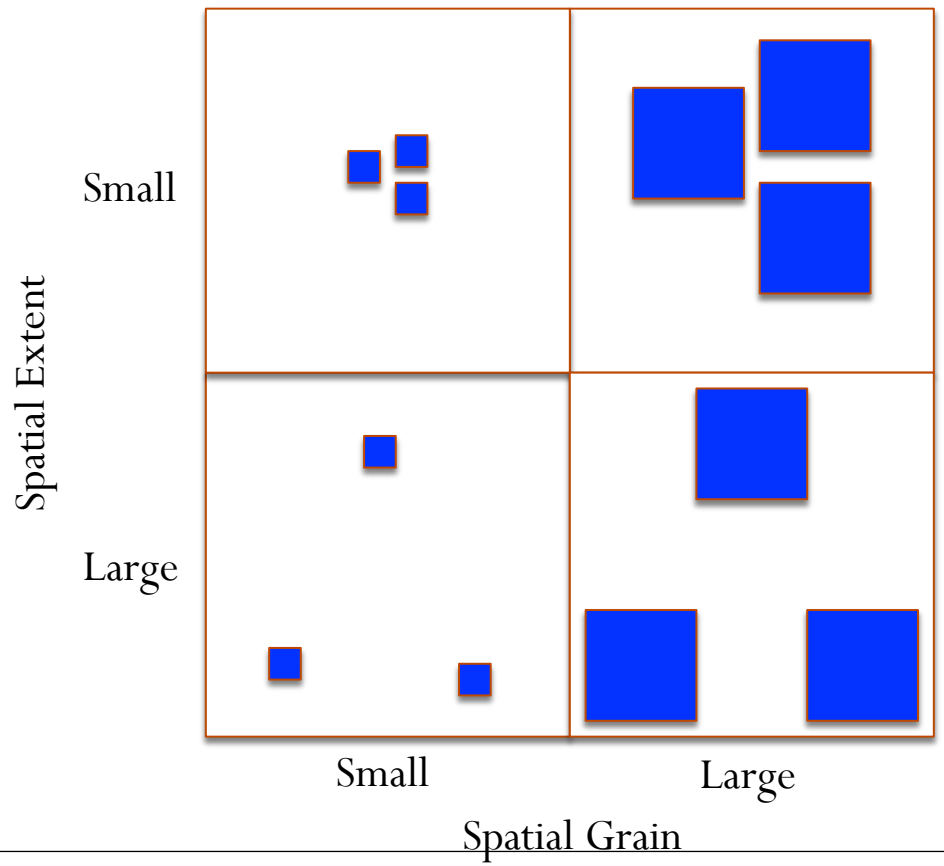


Designing an Experiment

- Is the study area large enough to ensure realistic results?
- What is the grain and extent of the study?
  - Grain = smallest unit of the study
  - Extent = total area encompassed by study area

Designing an Experiment

- "Best" is small grain with medium to large extent



Designing an Experiment

- Have appropriate controls been established to ensure the results only reflect variation in the factor of interest?
- Have all replications been manipulated the same way for the intended treatment?

Summary

- Clear Question
- Proper experiment design
  - Manipulative vs. natural
- Randomization and confounding factors
  - **Proper knowledge of ecology and nat. history of system**
- Established controls

Summary

- "Only by combining careful experimental design with long periods spent observing ecosystems and their inhabitants - what field researchers call 'muddy-boots biology'- can ecologists come up with truly meaningful results." - *Joseph Bernardo*