# CONCEPTUAL MODEL

Research Planning Workshop

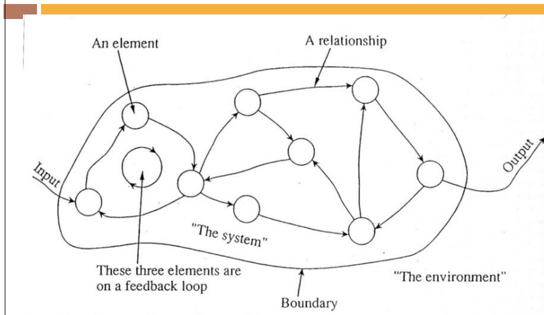
## Conceptual model

- A descriptive model or diagram that shows the key elements in the system of interest and the hypothesized relationships between them.

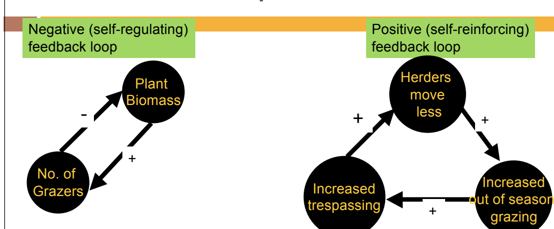
## Why make a conceptual model?

- Clarifies what is known and not known about the system.
- Goes beyond simple cause and effect to explore linkages and feedbacks in complex systems
- Key for:
  - Developing research hypotheses
  - Identifying variables to study
  - Interpreting research results
- **Essential for integrated interdisciplinary research**

## Basic components of a system



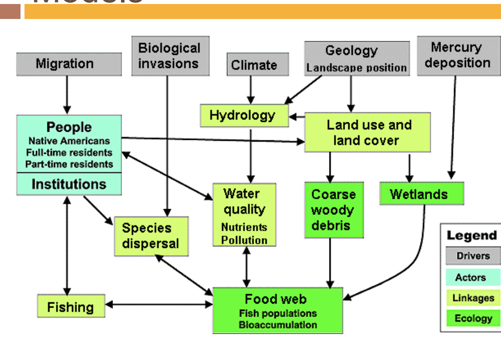

## Feedback loop

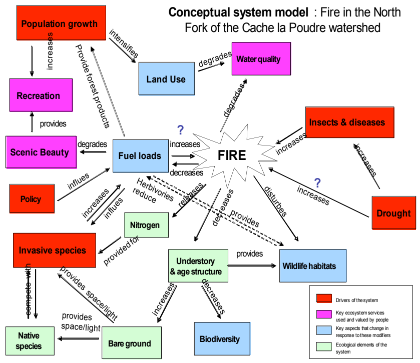


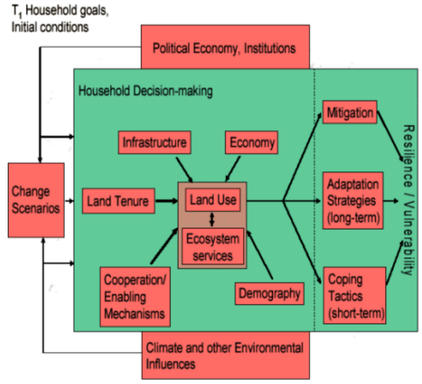

As grazers consume & reduce plant biomass, there is less food for the grazers and their population declines, releasing grazing pressure and allowing biomass to accumulate.

Herders move less due to lack of regulation and access to transportation, leading to increased out of season grazing, which leads to increased grazing of reserve pastures. Mobility declines as herders stay in one

## Examples of Conceptual Models

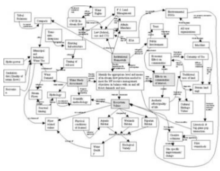





## Creating a Conceptual Model



## Guiding Questions for Conceptual Model

1. What are the boundaries of the system?
   - Start with a broad conception of the "system"—you can narrow your focus for on-the-ground actions later
   - Identify the focus question or statement that addresses the issue or situation you wish to map
     - Example: Does CBNRM increase resilience to climate change in rural Mongolia?

## Guiding Questions 2

2. What are the ecological elements of the system (i.e. biological and physical components)?
   - Examples: rivers & streams, wildlife and livestock populations, soils, plant communities

## Guiding Questions 3

3. What are the system processes and modifiers?
   - Examples:
     - Natural processes: seasonal flooding, grazing, wildlife migration
     - Human-induced processes: development & fragmentation, cultivation, hunting, water impoundment & release

## Guiding Questions 4

4. What are key aspects of the system that change in response to these processes?
    - Examples: species composition, pasture production, silt levels in river

## Guiding Questions 5

5. What are key processes that act as "drivers" of the system?
    - Examples: climate/weather, human population change, policy or economic change

## Guiding Questions 6

6. What are the key ecosystem services and resources used by and of concern to people in the area?
    - Examples: forage, water, medicinal plants, sacred places

## Try it!

- Write notes on your guiding questions
- Transfer key elements, processes, resources, etc to post-it notes
- Arrange post-its on paper and draw lines to show relationships among them
- Rearrange, discuss, be creative!

## Think About It

- Can you identify any feedback loops in your model?
    - Are they negative (regulating) or positive (reinforcing) feedbacks?
- Are some relationships in your model more important than others? Why? How can you represent these strong interactions?

## Identify Uncertainties

- Which system relationships are well understood?
- Which system relationships are more of a guess?
- What are the assumptions in your model?
- What are some uncertainties about future conditions that may affect the system?

## Developing Research Questions, Hypotheses & Data Statements

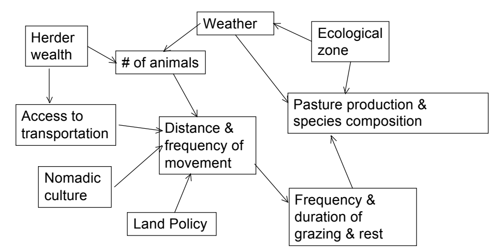
## Report Out on Model

- What are the known relationships?
- What are the unknown or uncertain relationships?
- Can these be phrased as research questions?
- Hypotheses?

## Brainstorm Research Questions

- Look at your model and write a list of questions based on the relationships depicted between elements in the model.

## Example




Research question 1: What factors are the best predictors of herder movements?
Research question 2: How does herder movement affect pasture conditions in different ecological zones?

Others???

## Develop a Hypothesis

- Remember, a good hypothesis:
  - Identifies the important variables
    - Independent (explanatory)
    - Dependent (outcome)
  - Is testable and falsifiable
  - Is short and clear

## Independent & Dependent Variables

- The factors you will measure to test your hypothesis
- A dependent variable is the outcome variable that is affected in the experiment or study.
- An independent variable is the explanatory variable that causes the effect. In an experiment, it is the variable that you change.

## Example

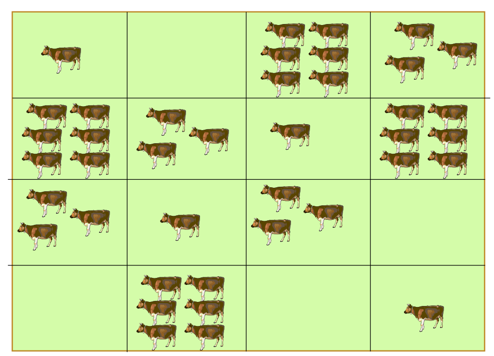
- Hypothesis: Adding **fertilizer** will increase **hay yield**.
- Fertilizer is the independent variable
- Hay yield is the dependent variable

## Testable and Falsifiable

- You can **disprove** or reject the hypothesis by performing an experiment, or collecting data in an observational study.
- Example:
  - Hypothesis: Adding fertilizer will increase hay yield.
  - We have a uniform hay field divided into treatment plots, and add fertilizer to 10 randomly selected plots, leaving 10 plots untreated.
  - If yield does not increase in the treated plots, our hypothesis is rejected.

## 2 Kinds of Experiments

1. Manipulative Experiments:
   - Change one thing, while holding all the rest constant (the same).
   - Example: In an ungrazed area, build fenced paddocks, and compare the diversity of species under no grazing to species diversity under low, medium, and high grazing.

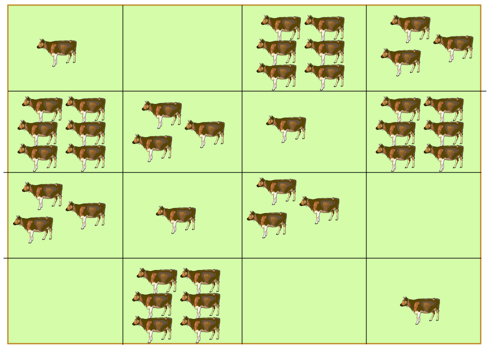


## 2 Kinds of Experiments

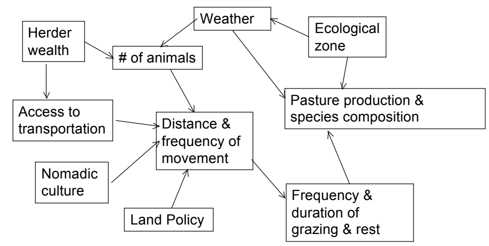
2. Observational Studies:
   - Not really an experiment, because the researcher cannot control the system.
   - Example: Measure species diversity in pastures under the forbidden grazing program and diversity in pastures not in the program.

## Experimental Design

- Treatments are <u>randomly</u> allocated
- Replication:
  - Each treatment is applied to 3 or more experimental units.
- Controls:
  - Treated areas are compared to non-treated “control” areas.
- Before & after measurements:
  - All experimental units are measured before the treatments are applied, as well as afterwards.



## Example




Hypothesis 1: Wealthy herders move farther and more often than poor herders.

What is the dependent variable? What is the independent variable?
Is this hypothesis testable? How would you test it?
What other hypotheses does this model suggest?

## Try it!

- Use your model to develop 3 testable hypotheses.
- Identify the dependent and independent variables.
- How would you test your hypotheses?

## Data statements

- A data statement is a description of the specific information you need to gather in order to evaluate whether your hypothesis is true or not.
- This statement should be a specific as possible.
- How will you measure the dependent and independent variables in your hypothesis?

## Example

- Hypothesis: Wealthy herders move farther and more often than poor herders.
- Independent variable = wealth.
- Data statement: Wealth will be determined by participatory wealth ranking of all herders in the study bag by at least 3 different herders of varying wealth levels and genders.

## Example

- Hypothesis: Wealthy herders move farther and more often than poor herders.
- Dependent variable 1= total distance moved over the past 3 years.
- Data statement: Distance moved will be determined by surveying herders in randomly selected households, and will be based on herders’ recollections of where and how far they moved.

## Try it!

- Write data statements for each of you hypotheses.
- Are there some variables that are difficult or impossible to measure?

## Introduction to Sampling

## Sampling is:

- The process of selecting a part of something with the intent of showing the quality, style, or nature of the whole.
- Providing information about part of a **population** in such a way that **inferences** about the whole population may be made.

## We sample because…

- Counting whole population is difficult or impossible
- Sampling can destroy objects of interest
- Sampling can give a more accurate estimate of the population than a census

## Goals of Sampling

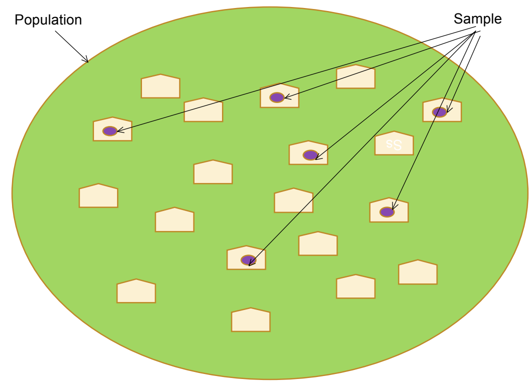
- Make reliable inferences about whole population by making measurements on a limited number of **sample units**.
- Determine an estimate of uncertainty associated with inferences.
- Minimize sample size while optimizing **accuracy** and **precision**.

## What is a population?

- **Statistical population:** the set of individual objects (**sample units**) about which you want to make inferences.
- Example:  The population of herders in Ikh Tamir Sum, Arkhangai, Mongolia (e.g. 567 households).

## What is a sample?

- A **sample** is the subset of individuals on which you have actually taken measurements.
- Example: 20 randomly selected herding households in Ikh Tamir Sum.




## Sample Unit

- The things that are measured.
- Examples:
  - An ecological plot
  - A herding household

## Accuracy, Bias & Precision

## Accuracy is

the closeness of a measured or computed value to its true value.

## Bias is

systematic distortion arising from a flaw in measurement or inappropriate method of sampling.

Example:

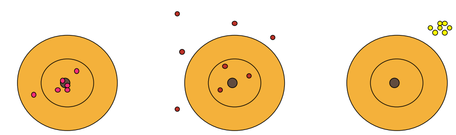
Surveying only households along the main road.

Sampling only plots within 200 meters of a well.

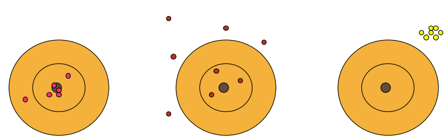
## Precision is

the closeness of repeated measures to the same quantity.

## Which is most accurate?



## Which is most precise?



## Sources of Error in Sampling

- **Nonsampling** (systematic) **errors**
- **Sampling** (random) **errors**

## Nonsampling (Systematic) Error

- Associated with human, not chance, mistakes
- Affects accuracy
- Cannot be estimated with statistics

## Nonsampling Error

Examples:

1. **Using biased selection rules**
2. Counting errors & boundary errors
3. Inconsistent application of protocols
4. Transcription & recording errors
5. Incorrect or inconsistent species identification

## Sampling Error

- Occurs by chance and is the result of sampling only a subset of the whole population
- Affects precision, not accuracy
- Can be estimated with statistics

## Two Types of Sampling Error

- **False-change error (Type I)**
  - E.g.: Research showed that wealthy herders moved farther, but they really did not (a false difference was detected).
- **Missed-change error (Type II)**
  - E.g.: Research showed no difference in the distance moved by wealthy and poor herders, when there really was a difference.

| | **NO DIFFERENCE** | **REAL DIFFERENCE** |
|---|---|---|
| **DIFFERENCE DETECTED** | False-change error (Type I) $\alpha$ | No error (Power) $1-\beta$ |
| **NO DIFFERENCE DETECTED** | No Error | Missed-change error (Type II) $\beta$ |

## Sampling Design Process

1. What is the population of interest?
2. What population attributes (variables) will be measured & how?
3. What is the appropriate sample unit?
4. **How will the sample units be placed or selected? (random, systematic)**
5. **How many sample units are needed?**

## Placement or selection of sampling units

2 requirements:

- **Randomness**: every sampling unit has an equal probability of being chosen
- **Interspersion**: sampling units representative of larger population

## Why is random sampling so important?

- If you don't choose sampling units at random, you might unintentionally choose them because they are:
  - Easier to get to or find
  - Similar to/different from other sampling units
  - Closer/farther from the population edge
- This results in bias - skewed and inaccurate estimates of the mean.

## Why is interspersion so important?

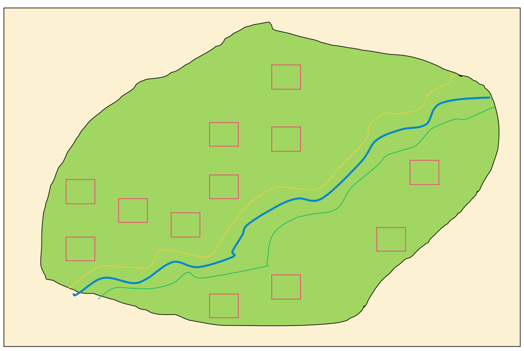
- If plots aren't interspersed throughout the sampling area, you may miss sample units that differ from the rest. For example, patches of pasture with different vegetation or households that are different from others.
- This results in incorrect estimates of the mean.

## Selection of sampling units

3 basic approaches:

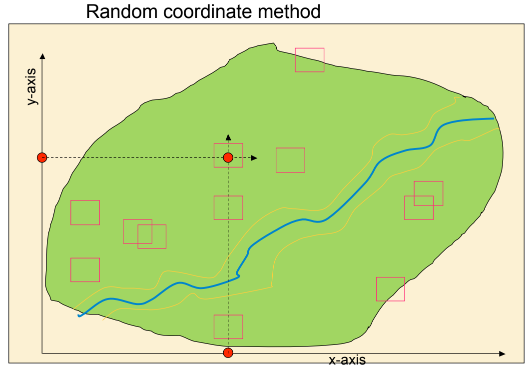
1. Simple random sampling
2. Stratified random sampling
3. Systematic sampling

Simple Random Sample – sampling units are simply randomly placed within sampling area



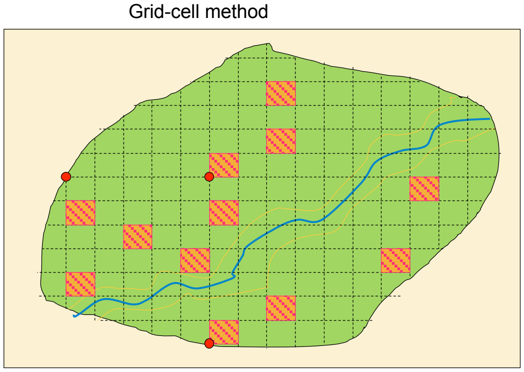
Simple Random Sample

Random coordinate method




Simple Random Sample

Grid-cell method



## Simple Random Sampling of Households

- Obtain list of all household within the study population (e.g. bag)
- Number each household on the list sequentially
- If there are 300 households, select the desired number of households (e.g. 25) randomly by chosing 25 random numbers below 300 from a random number table.

## Simple Random Sampling

**Advantages:**

- Simple statistical analysis

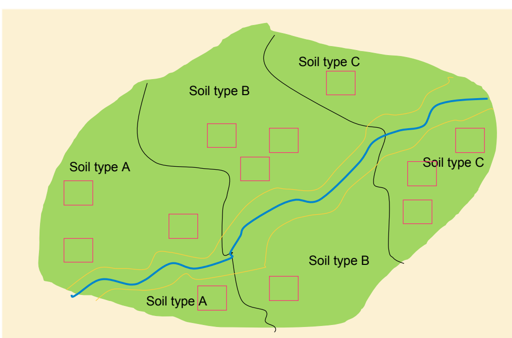
**Disadvantages:**

- By chance some areas may not be sampled (poor interspersion)
- Time-consuming and inefficient

## Stratified Random Sampling

- Target population divided into 2 or more subgroups (strata) that are:
  - Relatively homogeneous internally
  - Differ from each other
  - e.g., elevation, soil type, slope, aspect
  - e.g., household wealth

Stratified Random Sample




## Stratified Random Sampling of Households

- If household wealth is an important variable, you may want to stratify by wealth group.
- One method is to rank all households by wealth using participatory wealth ranking, and then to divide households into 3-4 wealth groups based on their ranks.
- Then randomly select an equal number of households from each wealth group.

## Stratified Random Sampling

**Advantages:**

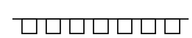
- Reduces variation among sampling units within strata
- More efficient
- Data can be interpreted separately or lumped

**Disadvantages:**

- Statistical analysis more complex
- May fail to sample some areas within each stratum (poor interspersion)

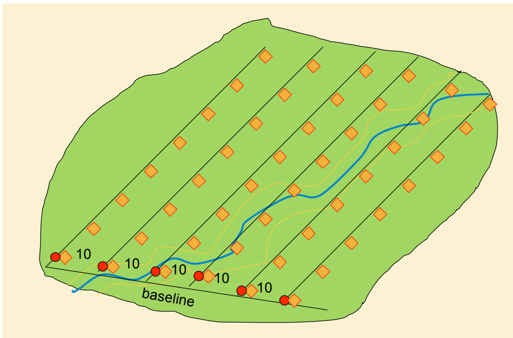
## Systematic Sampling

- **Randomly** selected start, then sampling units systematically placed
- Often points or quadrats systematically placed along a transect



- Transects systematically placed along a baseline

Systematic Sampling




## Systematic Sampling of Households

- Systematically select every 5th or 10th household on your list of households for sampling to achieve the desired sample size.

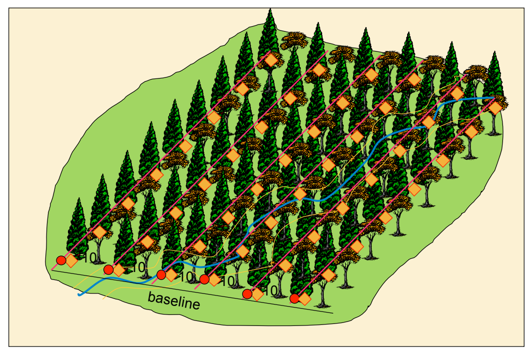
## Systematic Sampling

**Advantages:**
- Good interspersion
- Efficient
- Quadrats systematically placed along transect: get benefits of both shapes, ↑ accuracy & precision

**Disadvantages:**
- Biased if systematic layout coincides with an environmental or vegetation pattern

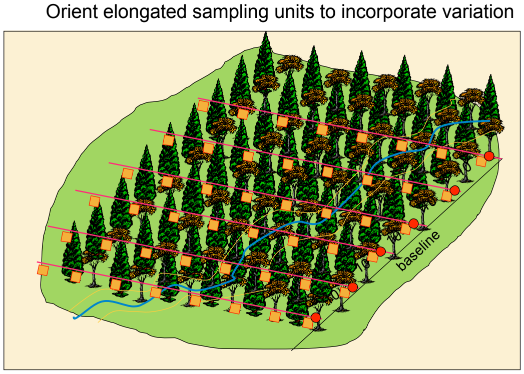
Systematic Sampling

Coincidence of systematic layout with pattern




Systematic Sampling

Orient elongated sampling units to incorporate variation




## Number of sampling units?

- **Sampling objectives:**
  - How small of a difference do you want to be able to detect?
  - What are acceptable false-change and missed-change error rates?
- **Variation in actual measurements**
  - Pilot sampling
  - Collect data from enough plots or households to obtain good estimate of standard deviation (sequential sampling)
- Precision increases with ↑ # of samples, up to about n=30

## Number of sampling units?

Formula for calculating sample size **for estimating population means or totals**:

$$N = \frac{Z_\alpha^2\, s^2}{d^2}$$

$Z_\alpha$ = Z-coefficient from Z table (with desired α)
s = sample standard deviation
d = half width of desired confidence interval around the actual population mean
(e.g., sample mean*(0.10) to be within 10% of true mean)

This assumes your estimates are correct and data are normally distributed.

## Example

- Pilot sample of herder movements has:
  Ave. distance moved = 15 km
  Standard deviation (s) = 3 km
  Desired false-change error rate = 0.10

$$N = \frac{(1.64)^\wedge 2 * (3)^\wedge 2}{(15 * 0.10)^\wedge 2} = \frac{2.89 * 9}{2.25} = \frac{26.01}{2.25} = 11.56$$

= measurements **12 households are needed**

## Developing A Sampling Plan

## Try it!

- Select one of your hypotheses
- What is your population?
- What is your sample unit?
- How will you select your sample units?
- How many sample units do you need?

## Introduction to Data Entry & Analysis

## Data entry

## Data analysis

- Quantitative data are numeric
  - Pasture yield in kg/ha
  - Distance moved in km
- Qualitative data are not expressed in numbers
  - Rangeland Health checklist
  - Interview transcripts and documents

## Data analysis

- Quantitative data analysis
  - Descriptive statistics
  - Inferential statistics
  - Modeling

## Data analysis

- Qualitative data analysis
  - Subjectively evaluates “perponderence of evidence” (rangeland health)
  - Code and analyze interview text
  - Narrative descriptions

Focus today is on Quantiative Analysis

## Quantitative Analysis

- **Descriptive statistics** describe the characteristics of the sample units in terms of the central tendency (average) and variation (standard deviation).
- **Inferential statistics** use data from the sample to draw conclusions about the population from which the sample was drawn. **To determine if two samples come from different populations, we need to use inferential statistics. <u>To test our hypotheses, we must use inferential statistics</u>**

## Hypothesis Testing

- To determine whether data from two samples are different, we must use inferential statistics.
- Example: To compare the difference between the distance moved by poor herders and wealthy herders.
- We CANNOT draw conclusions about differences or test our hypotheses with descriptive statistics.

## Hypothesis Testing

- Inferential statistics assume:
  - The data are normally distributed
  - The sample units are **independent** and were **randomly selected**

## Example

## Next Steps?

## Thank you!