

Citizen Science Learning About the World with Science



Chapter Goals:

After completing this chapter, volunteers should be able to:

- Describe the steps in the scientific process and understand that science is one way of learning about the world.
- Understand quantitative scientific research designs.
- Understand the concept of using samples and the importance of randomization in research.
- Identify a variety of data gathering methods.
- Explain the importance of accurately recording data and following protocol during field studies.
- Understand the benefits and shortfalls of using standardized research designs.

A Review of the Scientific Process

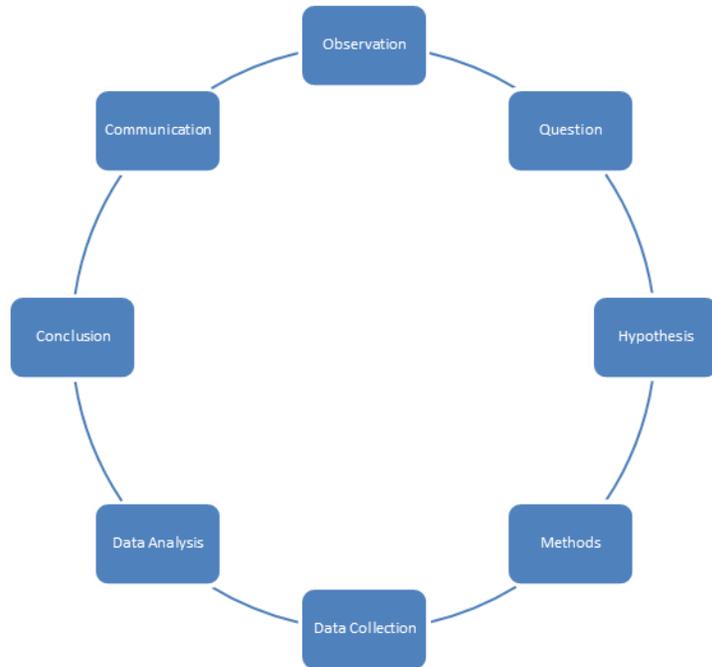
As a Citizen Scientist, you might find yourself collecting data as part of your volunteer work. Data collection is just one step in the important process of science. Sometimes, when we think of science, we think of the data collection phase, because it is when we are out in the field measuring things. It is often time consuming and labor intensive. Before data collection can occur, other very important steps must take place. Likewise, after the data are collected, important work remains. Chances are, no matter what your profession, you were taught the scientific process in school. Though it can be formal process, we practice it all the time in everyday life, unconsciously! Let us review the scientific process and see where data collection fits.

Observation

Nearly all scientific investigations start with observations made by people. “Observation” does not have to be done with our eyes. Using any of our senses, we can notice things around us. If you open your refrigerator one morning, and smell something...well, unique, you might instantly and without much thought, begin the scientific process. Your olfactory nerves just “observed” the smell of something rotten.

Question

The whole reason to initiate scientific process is to answer a question or solve a problem. Without a question or problem, why collect data? In our example, your question might be, “What is rotten in the fridge?” You might think of it as a problem, rather than a question, “There is something rotten in the fridge. That is a problem!”



8 Steps of the Scientific Process

Hypothesis

A hypothesis is an educated guess about the answer to your question or the solution to your problem. Based on other information or experience you have, you might have a good idea to answer to your question, but you are not entirely sure. You may be very sure of your answer. In order to convince others, the scientific process is necessary to show how you came to your conclusion using science. Standing in front of your refrigerator, you might think, “Oh, I bet it is the milk.” That is what you think is producing the smell, but you are not 100% positive.

Research Design and Methods

This step involves planning how you are going to test your hypothesis to see if you are right or wrong. Research designs and methods in scientific endeavors *can* be complicated. At this point, a researcher uses their question to determine whether to collect data quantitatively or qualitatively.

It is not the goal of research to confirm the hypothesis.

Most of this chapter is written with quantitative examples. Most likely, it is the type of science you will be helping with in the Idaho Master Naturalist Program. The term science is used broadly, encompassing many ways to gain knowledge. You might choose to open the milk first and smell it. If the milk is good then, systematically you check other containers.

Data Collection

This is when things are measured and counted. You see people collecting data all the time. Counting cars at an intersection, weighing birds at a banding station, counting white blood cells in a laboratory, or measuring dissolved oxygen in a stream are all examples of data collection. It is important in the data collection phase to follow precisely the methods the researcher decided upon in the previous step. To deviate from the methods will produce results that will not give accurate answers to the question posed. Collect your data the way you said you were going to....open that cap on the milk and take a whiff!

Data Analysis

Your analysis of the milk will not take long! You will know right away if your hypothesis was correct or not.

Sometimes data analysis is time consuming. Data usually needs to be entered into a database and statistical tests run to test the hypothesis.

Conclusion

The conclusion of research is determined in the data analysis step. The conclusion in our scenario is either the milk was the culprit or it was not the milk but the baked beans from the Fourth of July picnic....last year! It is important to remember that it is NOT the goal of research to confirm the hypothesis. It is as important to find results that do not support your hypothesis, as to find results that do support the hypothesis. To find out the stench is *not* coming from the milk is a great first step and will prevent you from dumping it down the drain. Sometimes, the conclusion is....well, inconclusive. What if you have checked the milk, thrown out the baked beans months ago, and every other item in the refrigerator looks and smells just fine. In this case, your hypothesis was not correct. You did not actually find the answer or solve the problem. However, you *did* find out what *was not* causing the smell. Research and science often create more questions than answers. Although frustrating to some, it can be exciting. The process begins again.

There you stand, refrigerator door open, looking at the food with no mold. You look around (observation). You ask more questions. You wonder about new problems. “I wonder what if it could be something outside the refrigerator.” Could the smell be coming from somewhere in the refrigerator I cannot see? (questions). The whole process continues.

Communication

Without communication of scientific results, the information gathered is only helpful to the researchers who performed the research. To maximize the benefit of research and results, one must communicate the results to another audience. It may be in the form of an article, in a scientific journal, written mostly for the use of other researchers and professionals in that field.

It could be a presentation at a conference. Research results are often used to make management decisions. Research results may be presented to policy makers, or managers. There are endless ways to communicate results. The important part is that some communication occurs. In our example, you might just tell your spouse, who walks into the kitchen, there is something that smells bad in the fridge and you know the milk is safe.

Science is a way of knowing, a process that perpetuates itself and adds to a collective body of knowledge to be shared by all. Some people think science is supposed to be value-free, objective, and free from human influence and opinion. Since humans do science, it is full of judgments, decisions, opinions, and interpretations. Remember, science is a human activity that is never completely free of bias.

Other Ways of Learning About the World

Science is just one way of knowing. In our society, science is held in high regard and respected. This was not always the case. Most natural resource agencies believe science is the best method to answer the kinds of questions they are asking.

In their book, *Research Methods: A Process of Inquiry*, Anthony Graziano and Michael Raulin outline six different ways of knowing (Graziano & Raulin, 2006, p.10). As you read these brief descriptions, try to think of an example in your own life using each of these methods.

- *Tenacity* - accepting knowledge as true because it has been accepted as true for so long.
- *Intuition* - accepting ideas because you have a “gut instinct.”
- *Authority* - accepting ideas because someone who you respect and has authority tells you it is true.
- *Rationalism* - using existing ideas and logic to arrive at valid ideas.
- *Empiricism* - making observations to gain knowledge.
- *Science* - Using rationalism to develop theories and using empiricism to test the theories to gain knowledge.

Different ways of knowing and perceiving the world are not to be deemed good or bad. They are just different. Conservation and natural resource management is a mix of ways of knowing. Often science is needed for decision-making, budgets, and actions by governments, policymaking, and influencing public opinion.

Consider a management decision based partially on public opinion. Public opinion might be gathered very scientifically, using the scientific process. Public opinion itself might be a reflection of people's intuition or tenacity.

The Idaho Master Naturalist Program strives to be a science-based program. The Citizen Science Track was designed specifically to help you participate in scientific projects. Knowledge can be gained to conserve Idaho's natural world. Your journal is a space where you can record not only your scientific pursuits, but also your experiences with other ways of knowing.

Examples of Common Research Questions

No matter what field of natural resource work in which you will be volunteering (forestry, ornithology, fisheries, plant ecology), there are some typical questions posed. Below is a list of five general categories into which many natural resource research questions will fit.

Biology

- *General* - What is the conservation status of species and their habitats?
- *Specific* - distribution (presence/absence), abundance, trends, threats, biodiversity hot spots, gaps in species protection, corridors and linkage zones?

Basic Wildlife Biology, Ecology, and Behavior

- *General* - What is it about a species that may determine or limit its population?
- *Specific* - Sex ratio, age ratio, age at first reproduction, gestation, litter/brood size, den/nest sites, mortality, home range size, dispersal capability, population dynamics, population genetics, social organization and structure, food habits, energetics, parasites and disease, intra- and interspecific interactions, courtship/breeding behavior?

Estimating Numbers in Populations

- *General* - How many individuals/populations do we need to conserve the species for survival or a human purpose (trees for paper, wildlife for hunting, and plants for medicine)?
- *Specific* - Indices of abundance, estimates of abundance and density, population modeling, population viability analysis.

Wildlife/Habitat Relationships

- *General* - What is the relationship between this species and its habitat?
- *Specific* - What habitats are used and for what purpose (food, denning, shelter), at what times of year, in what juxtaposition, how large an area, fragmentation, quality, foraging behavior?

Human Dimensions

- *General* - What does a population of people know, believe, want, and think about a particular subject? Who are the people in this population?
- *Specific* - Knowledge, beliefs, values, opinions, demographics?

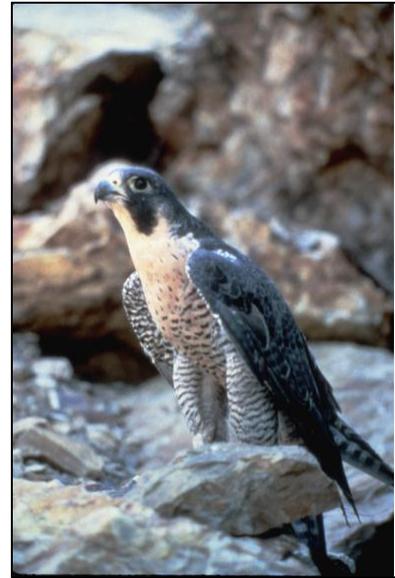
More about Questions-Choosing a Research Design

Now that you have reviewed the scientific process and have seen common categories of questions in natural resource conservation, you can see where data collection fits and how questions and problems drive the system. The question will dictate what research design will be implemented. In turn, that helps the researcher choose the methods and drives how data will be collected. The type of data collected determines the proper analysis steps.

Analysis of the data usually produces a conclusion. Each step helps a researcher decide what to do next. Below are examples of research questions about an animal. As you read the question, think about how each question would lead the researcher to choose *different* approaches and use *different* tools.

- How many Peregrine falcons are there in Idaho?
Estimating numbers in populations
- Where do Peregrine falcons nest?
Wildlife/habitat relationships
- Has the population of Peregrine falcons changed in the last 10 years?
Biology/trends
- What do Peregrine falcons need to survive?
Basic wildlife biology, ecology, and behavior

- What are the habits of Peregrine falcons when raising chicks?
Basic wildlife biology, ecology, and behavior
- How are Peregrine falcons affected by human presence?
Wildlife/habitat relationships
- Should Peregrine falcon eggs be collected by falconers?
Human dimensions, Biology
- Does the public know the conservation status of the Peregrine falcon?
Human dimensions/Communication
- Is this area appropriate habitat for Peregrine falcons?
Wildlife/habitat relationships



Peregrine Falcon © IDFG

The questions are endless. The design for the research will be decided based on the question. There are some general categories of research design that have varying levels of constraint. Constraint refers to the demands on the adequacy of the information you are collecting (Graziano and Raulin, 2006, p. 47) Previously, we discussed different ways of gaining knowledge (tenacity, intuition, authority, rationalism, empiricism, and science). Science is the way of knowing that requires the most demands on the adequacy of the information (Graziano & Raulin, 2006, p.14), However, within quantitative science designs, there is another continuum of constraint. Some scientific designs are more demanding than others. Again, judgment should not be made when comparing these research designs. Low and high levels of constraint do not coincide with bad and good science! Each level of constraint comes with positive and negative qualities.

The research design examples given below are quantitative designs. Qualitative designs will not be covered in this chapter.

Low Constraint Research

Naturalistic Observation

This type of research is defined by systematic recording of naturally occurring events, in their natural settings, by the researcher. The researcher's level of involvement with what is measured is usually low. The researcher may take measures not to be noticed and not to get in the way of what is being observed and recorded to

...to describe

assure events are taking place as they would if one was not there. These observations are later used to develop hypotheses about why the events took place. Jane Goodall is an example of a famous scientist who practiced this form of research. This design is usually chosen when the researcher want to observe, describe, or identify something.

Case Study Design

Case studies are used when a researcher wants to study something in depth. Case studies are bound by time and space. Something specific is studied, in a certain location, for an identified period. Multiple sources of information are usually used in a case study. For example, in SW Idaho, sport fishers are complaining that the American pelican population is reducing the quality of the local fishery on the Snake River. A case study might be appropriate.

...to identify a relationship or better understand a complex issue

Researchers can employ a variety of techniques to answer questions. A public opinion survey, a fish count, water quality testing, habitat monitoring, pelican banding, and a historical document search might be implemented to come to a conclusion about what effect pelicans are having on the fishery. The goals of a case study usually involve the need to describe or understand something in depth, or identify relationships that are occurring. Case studies are often a hodge-podge of high and low constraint research all directed toward answering one question or a set of questions about a phenomenon.

Higher Constraint Research

Correlational Design

A correlational study seeks to find a *correlation* or relationship between two variables and determine the strength of the relationship. Do not mistake this for cause and effect! The goal is not to find out if X causes Y. In a correlational designed study, causation cannot be claimed. Ice cream sales and the number of violent crimes committed in a city are correlated. There is a positive relationship between these two variables. As ice cream sales go increase, the number of violent crimes also increases. However, the sale of ice cream does not cause more crime that is violent. Rather, there is another variable that explains both levels of these variables, temperature. As the temperature increases in the summer, ice cream sales increase. As the temperature increases, violent crimes also increase. It is important to note the difference between correlation and causation. Do not to fall down the slippery slope of confusing them.

...to predict future scenarios

Just because science shows a *relationship* between two variables, it does not necessarily mean one causes the other. Only experimental and quasi-experimental research designs can determine cause and effect. Correlational research can be used to predict future events. If research shows a negative relationship between the amount of human disturbance and bald eagle reproductive success, we cannot say that increased human disturbance causes bald eagles to reproduce less. We can predict that if a new development is to be built near a river where bald eagles nest, their reproductive rate is likely to decrease.

Differential Design

Any research or science that measures the difference of a variable between two pre-existing groups is a differential design. The opinions about wolves in Idaho (the variable) could be compared between ranchers (group one) and Sierra Club members (group two). The fertility level (variable) of the Selkirk Grizzly bear population (group one) and the Yellowstone Grizzly population (group 2) could be compared. There are many kinds of differential designs. These types of research projects investigate at least one variable and measure it in two pre-existing groups.

...to compare two groups

Highest Constraint Research

Experimental Design

An experimental design is science done with the highest levels of constraint. The image of a scientist in a lab coat, measuring the different amounts of poison into hundreds of Petri dishes to find the “lethal dose” is an image of an experimental design. Experimental designs have two important qualities:

...to determine cause and effect

- All variables are controlled by the researcher.
- Groups that receive different amounts of the independent variable are chosen at random.

In our “mad scientist” example, the researcher has hundreds of Petri dishes prepared exactly the same way. Perhaps the researcher grew a plant in each Petri dish and the plants are genetically identical. They are all kept at the same exact temperature. They get the same amount of light. They get the same amount of movement and nutrition. All the variables have successfully been controlled. Then, different amounts of the independent variable (poison) are administered to groups of Petri dishes, including a control group, where no treatment of the independent variable

(poison) is given. How much poison each group of Petri dishes receives is controlled. Any difference in how the groups of plants in the Petri dishes react to the poison can be explained by the amount of poison given. Any difference seen in the plants after poison is added is due to the researcher's action, because all other variables were held constant. Cause and effect can be determined. Experimentally designed research is common in medicine and engineering, biology and chemistry. It is often not ethical or practical to control all the variables in natural resources and conservation.

Quasi-Experimental Designs

As the name implies, quasi-experimental designs are like experimental designs (Graziano and Raulin, p. 306). Often, the researcher has a little less control over some of the variables or groups that receive different levels of the independent variable were not randomly assigned. It would be difficult to grow two genetically identical forests in a laboratory, burn one forest and then compare amount of elk habitat in each forest after 5 years. In the real world, you could find two similar forests, burn one, and measure the amount of elk habitat in each forest after 5 years. The difference is that the two forests were not identical initially. They might have been very similar. The aspect might be just slightly different. There might be a better water source in one forest. One forest might have more recreation in it, or slightly different plant species. All of these things might affect the amount of elk habitat. If done properly and carefully, quasi-experimental research can conclude cause and effect relationships.

A final note on levels of constraint within science: After reading the descriptions of the quantitative research designs, note the higher the level of constraint research the further the investigation moves away from real life situations. Compare Jane Goodall, sitting quietly in a rainforest observing gorillas, taking copious notes (low constraint research), with the “mad scientist” in a sterile laboratory, delivering poison to plants in Petri dishes with a mechanical

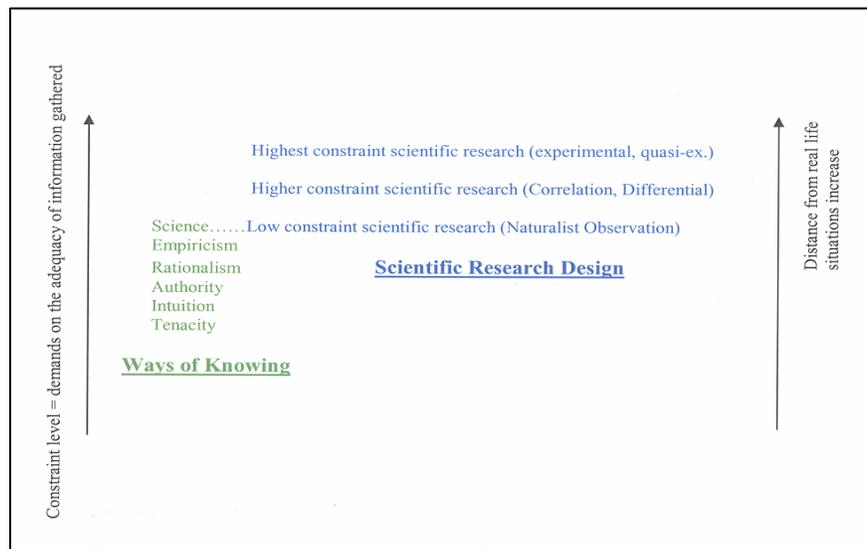


Figure 1: Various ways of knowing are listed in a column on the left, with science as the method that requires the greatest demand on the adequacy of information. Within science, there are different quantitative research designs with different constraint levels. Note the right arrow indicates the higher the constraint level in science, the further the research is from real world situations. Concepts used for this diagram from Graziano and Raulin, 2005.

eye dropper (high constraint research). The former example is without researcher intervention and is recording how the real world works (see Figure 1). The later example will help determine the powerful cause and effect relationship. When matched properly with the research question, all constraint-level research designs are appropriate.

Methods

Choosing how to collect data is to decide if and how to sample. Before discussing particular data collection methods, understanding the difference between census and sampling is important.

Ideally, if we want to know how many elk there are in Idaho, we would count all the elk. That would give us a precise number and it would be 100% accurate, because everyone was counted. This is a **census**. This would be next to impossible. Censuses are ideal, but rare. The United States Census is an attempt to do just that every 10 years. The Idaho Master Naturalist pre-program survey is another example of a census. Since there are not many IMNs, it is cost effective, time efficient and possible to ask each person the questions.

When a census is impossible, which is most of the time; we use samples to make inferences about populations. Not every park visitor across the state can be asked about state park use if the Director of Idaho State Parks and Recreation wants to know something about state park visitors. There is not the time, money, or resources to do so. It is not necessary. A sample number of visitors can be asked questions. In this case, the “population” is all state park visitors in Idaho in a given year. The people chosen to ask questions to are the sample. The results of the “sample” are analyzed and inferences can be made about this population, only if the sample is chosen correctly. Asking questions to only five people at Three Island Crossing State Park one day in May would not be a valid sample. A sampling plan must be developed to assure the samples will be representative of the whole population of state park visitors. Years could be spent learning the appropriate way to sample. What is important in science is samples can be used to make inferences about populations using statistics.

In citizen science work, you may be asked to measure something within a sample. Fortunately, you will not be asked to plan the research design, make inferences about the population or statistically analyze the data.

Figure 2 illustrates the use of samples. The researcher might have a question about a population. Imagine working with the Forest Service, near your town, to determine the percentage of forest cover that is tamarack trees. The “population” is the whole area you are studying... perhaps a whole hillside, or forest. The population is always well

***We use samples to
make inferences
about populations.***

defined and usually can be mapped. It would be too hard to go measure all the tamarack in the forest to determine how much canopy cover they provide in the forest. Instead, you will probably go collect information about tamarack in several sample locations. By using the data in your random samples, if enough samples are taken, the researcher can accurately infer how much canopy cover are tamarack trees within the entire population area.

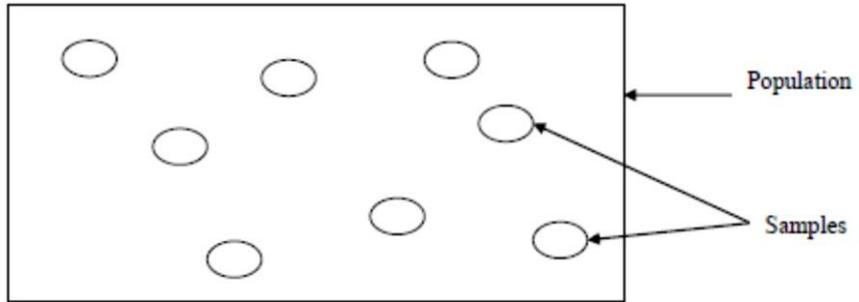


Figure 2: Samples are taken from a population. If samples are chosen randomly or systematically, represent the population, and enough samples are taken, inferences can be made about the population.

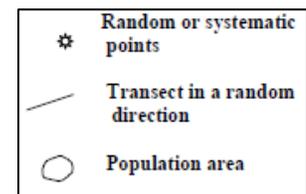
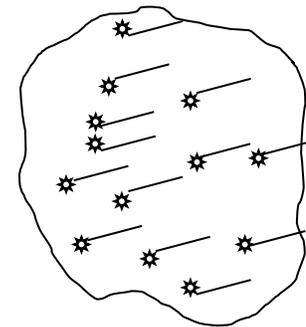
The samples must represent the population well to be able to make inferences about a population based on data collected only from samples. In the above example, we would not sample only tamarack along the prominent trail through the forest being studied. Trees along a trail might be different from trees elsewhere in the forest. Because tamarack trees might grow differently at the lower elevation, than at a higher elevation, we would not measure the canopy cover of tamarack trees in the lower elevations of the population (forest) being studied. Foresters know that tamarack trees grow very differently at the edge of a forest than in the middle of a forest. In order to make statements about the whole population in the end, samples really must be taken over all the population's area.

Samples must be representative of the population.

Transect

A transect is a common technique used in many disciplines including wildlife management, forestry, botany, soil science, and entomology, to name a few. Most of the time, a transect is a sample taken when it is too difficult to measure an entire population or area.

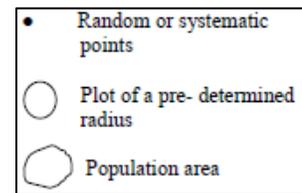
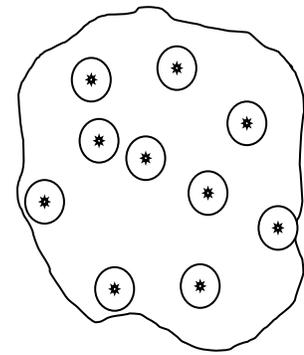
The transect counts or measures whatever is being studied, along random line segment (one sample) within a defined area (population). To find the relative abundance of different plants in the sagebrush-steppe community, the researcher would find a random point, within the population area, and stretch a tape measure in a random direction for 100 feet. Then, walking along the transect, the researcher would measure exactly how many inches of sagebrush, bitterbrush, rabbit



brush etc. was touching the tape. Many transects would be performed within the population area. The data would be entered and analyzed. Using statistics, the relative abundance of different plants in the sagebrush-steppe community could be inferred for the population.

Plot

A plot is much like a transect, but instead of a line, it is an area. Sometimes, a plot is a circle, radiating from a randomly chosen point in the study area. Sometimes, plots are square. A census of whatever is being studied is taken within each plot. A forester might want to know the abundance of downed and woody debris (DWD) in a forest in preparation for a prescribed burn. Plots are selected randomly and, within each plot, measured for how many and how large the DWD is. If plots are selected randomly, and enough are measured, a forester can make inferences about the population using the measurements from the plots (sample).



Sampling is used in nearly all natural resource disciplines. Once a sample location is found, there are many different ways to collect data. The following five natural resource disciplines and some typical data collecting methods for each are explained.

Common Methods in Plant Ecology

For plant ecology, many research questions are answered by using plots and transects. Measuring canopy cover, diversity, seral status (level of succession), and presence of weeds are commonly done with plots and transects. Measuring the plant structure of different layers of vegetation (grass, shrubs, and trees) is commonly performed with Robel Poles. These are large poles that a data collector props up at random points in a population area and record the visible number area of the pole.

Common Methods for Birds

A common way to use plots when collecting data on birds is a **call and response** survey. For this data collection method, a researcher will find a random point. Instead of counting something, a recording of a bird, for example an owl, is played. Then one listens for a pre-determined amount of time and records if a response is heard. The protocol may require several attempts at each random location.

Point counts are another way to use plots. A random point is found. The researcher records birds heard or seen for a given



About to be released, this Chestnut-sided warbler shows off her new leg band after being captured in a mist net. Photo by Jay Carlisle, Idaho Bird Observatory.

period of time at that point.

Mist netting is a common way to collect information on birds and bats. Mist nets are very thin nets that span from the ground to about 8 feet high. Usually, many nets are set up in a general area. Birds cannot see the net. They are caught in the delicate webbing when they fly into the net. Researchers quickly collect the birds, band them, weigh, sex, measure and identify the species before letting them go. Bats are not banded.

Common Methods for Mammals

Capture-mark-recapture methodology is used often in determining population estimates and mortality rates in small mammals. In this technique, a population is sampled at least twice. Each time, every unmarked animal is uniquely marked and previously marked animals are recorded. This methodology requires the data collectors to trap or somehow capture small mammals (live traps) and mark the individuals caught before releasing. Information about the mammals is recorded, such as sex, age, species, and weight.



Pygmy rabbit, Wendy Estes © 2005

Aerial surveys are commonly used to determine big game population levels and distribution. Often, it is not likely you will be able to see an animal to count it. Several methods require the researcher to count animal sign. **Snow track surveys, scat surveys, burrow surveys, and hair snag surveys** are all ways to determine if a species is present and in what quantity, without having to actually see the animal.

Common Methods for Fish

Electrofishing is the use of electricity to capture fish. Most typically, this involves using boats or backpack mounted units to sample water bodies. Generally, boats are used to sample shorelines along ponds, lakes, reservoirs, and large river systems. Backpack units are employed in small streams. Electro fishing is a sampling technique for sampling shallow waters. The vulnerability of fishes to electro fishing varies among species due to differences in anatomy and behavior. Species that inhabit shoreline habitat such as bass, minnows, and perch are most easily sampled by electro fishing. Fish size is also an important determinant of sampling efficiency using electro



Electrofishing in shallow water.
Photo courtesy, Friends of the Teton River,
<http://www.tetonwater.org>

fishing.

Generally, larger fish are more easily captured than smaller fish. Data analysis, using electro fishing gear, might include the development of population abundance information such as catch per unit effort, fish per unit area (e.g. adults/km), or size structure.

Direct underwater observation of fishes is a valuable tool in fisheries management. **Snorkeling** is employed where good visibility is available. A common application of underwater methods is estimating population abundance. Counts made by snorkelers can be used as estimates. Most typically, multiple snorkelers are used. The stream and river channel is divided. Each snorkeler keeps track of species and sizes observed. The area sampled is then measured and density estimates can be developed. Sometimes, multiple passes are done to refine the population estimate.

Netting - Passive capture gear involves the capture of fish by entanglement or entrapment in devices that are not actively moved. The use of nets and traps are widespread. They are most often used in still or slow moving waters. Entanglement devices capture fishes by holding them ensnared in a fabric mesh. Gill nets are entanglement gear. Entrapment gear captures fishes, which enter an enclosed area through one or more funnel or V-shaped openings. They cannot find a way out. One example of entrapment gear is a hoop net. These are used to sample fish in a wide range of habitats. Passive sampling gear, if employed in a standardized fashion, can be used to estimate catch per unit effort. Additional estimators are length-frequency (size structure) and age composition.

Common Methods for Human Dimensions

One of the easiest and most common ways to collect data about people is simply to watch them. **Observation** can be very insightful! A researcher might want to know how many people stop and read the new information board just installed at a state park. A data collector sits across the road from the information booth and counts the number of visitors that stop to look at the board and the number that do not. When collecting data about people, there are ethical considerations. Human dimensions researchers must pass rigorous ethical standards for approval by most universities and institutions. Some research projects, involving human subjects, do not require approval by the Human Assurances Committee like observing visitors at an information booth. Projects that need approval are reviewed to assure the rights of the participants, to check for unnecessary risks to the participants, and to ensure the participants gave informed consent.

Another common way to collect information about people is to ask them. **Face to face interviews** and **written questionnaires** are two of the most common techniques. This methodology requires a sampling plan, just like plots, transects, and snow track surveys. Data are entered into a statistical program to be analyzed like other quantitative data.

The Importance of Following Protocol when Collecting Data

No matter what methods are chosen, as a data collector, it is paramount to follow the protocol of the researchers. Any deviation from their directions or their chosen methods compromises their ability to answer their question with confidence. Methods can be right or wrong, good or bad, appropriate or not appropriate for a given research project. It is not your job as a data collector to make these judgments. It is your job to make sure the data are collected the way it was intended. **Validity** and **reliability** are constantly being strived for in science. One way researchers ensure validity is by choosing the right method for measuring. If you wanted to know how much you weigh, you would not choose to use a thermometer to measure your weight. You would choose a bathroom scale. This is an obvious example. Let us say a researcher had a question about the population distribution of a reptile. There are certain methods that would be better than others to answer this question. There are standard methods, used by other people that have been tried and tested.

Researchers train their data collectors to measure the same way to ensure reliability. Often, this is in a written format called a protocol. In the bathroom scale example, to be reliable, the scale would have to give the same weight each time you stepped on it. If you stepped on the scale three times in a row and got different readings, the scale would be valid, because it measures weight. It would not be reliable, because it measures the weight differently each time. In field research, there is always the fear that data collectors will not follow the protocol. Different people will measure things differently. There is always going to be some variation in how data is collected because humans performed the data collection. It is your job to follow the protocol as closely as you can. It is NEVER okay to make up data, omit data, or change data in any way. It is NEVER okay to make up your own way of collecting data.

As a data collector, you do not have the power to change protocol because of circumstances in the field (fatigue, bad weather, short staffed). You can communicate any data collection concerns to the researcher. Often, a method looks good on paper and just does not work in the field. You cannot change the methods. Certainly, in these cases, you can contact the researcher and explain the circumstances. They might be able to find another method of collecting the data that will be more appropriate.

Validity and reliability can be compromised when data collectors are not properly trained. If you feel you need more help understanding the protocol for data you have been asked to collect, do not hesitate to ask for help.

Standard Data Collection Methods

There are hundreds of different ways to collect data. Standard procedures have been adopted in most disciplines. By choosing to follow a standard research design, the researcher can compare results with others who have used the same procedure or with procedures done at an earlier time. This is a powerful ability in science. The downfall is that the standardized method might have big flaws. Let us look at an example. Breeding Bird Surveys (BBS) have been performed in the United States since 1966, using a standard method, to track the status and trends of North American bird populations.

“Each year during the height of the avian breeding season, June for most of the U.S. and Canada, participants skilled in avian identification collect bird population data along roadside survey routes. Each survey route is 24.5 miles long with stops at 0.5-mile intervals. At each stop, a 3-minute point count is conducted. During the count, every bird seen within a 0.25-mile radius or heard is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete. Over 4100 survey routes are located across the continental U.S. and Canada” (USGS, 2007).

Because everyone uses this standardized method across the country and over time, breeding bird populations can be compared to each other. Declines or increased can be detected. Standardization increased the reliability of the results. Reliability is consistency. However, the standardized method for breeding bird surveys is fundamentally flawed because birds are only looked for along roadways, not in random samples of the population area. In addition, determining distance of a birdcall is very difficult, even for seasoned birders. Other methods could be more valid. Even though the BBS has some flaws, it is still used widely and following the protocol is important.

This chapter was written to help you increase your knowledge and understanding of the scientific method. In addition, some concepts were present that will help you see your volunteer work as Citizen Scientists in a broader picture of quantitative scientific inquiry. Many concepts in this chapter are steps in the scientific process you will not be doing. However, it is important to understand the work performed before and after data collection. Feel free to ask questions about the details of the project you are working on because the better you understand the whole process of science, the better Citizen Scientist you will be.

Inventorying and Monitoring

It is important to note that data collection is not always done in the name of research. Often, data is collected for inventory and monitoring purposes. Inventory is usually done to find presence,

absence or abundance of a species in a specific location. It seems hard to believe that we do not have data like this for all species, but we do not. Many nongame animal and plant species in Idaho are not well studied. In order to “manage” a species, you first must know where it lives and in what quantities. An inventory gives us a snapshot in time, but provides no trend data. An inventory can be thought of as baseline data. We must first know where Pygmy Rabbits live in Idaho in order to protect them. Then, management actions can be taken and monitoring can occur to see if the management actions were effective. Monitoring serves to find trends over time and effects of management actions.

References and Credits

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