

Resource Allocation by Plants of the Sonoran Desert

Grade Level: Middle School, High School

Ecological Concepts: [Resource allocation](#), [Life history strategies](#)

Arizona Science Standards: Science as Inquiry; Life Science

Materials:

- 1) Seeds or seedlings of native plants
- 2) Pots and soil
- 3) Rulers
- 4) Water
- 5) Writing/drawing materials

BACKGROUND

Most [resources](#) are finite. Plants in the Sonoran Desert have access to almost unlimited light, but access to water and nutrients in the soil is not always sufficient for maximum growth. Therefore, plants "choose" how to allocate the available resources into growth of leaves, stems, roots, flowers, and seeds, and the production of defenses such as hairs on leaves, thorns, spines, or chemical substances to deter [herbivores](#). Resource allocation is an example of a trade off: with only so many resources available, a plant can't do everything maximally. It must trade off root growth in order to produce flowers and seeds for reproduction, for example.

According to ecological theory, given the resources available, the organism attempts to use those resources to maximize survival and reproduction. The life stage of the plant determines what part(s) of the plant grow the most, thus receiving the most resources at that time. How the resources are allocated within the plant to accomplish optimal growth and reproduction also varies with the average longevity of the species, the age it first reproduces, and how often it reproduces. Some plants live one year or season, reproduce and die, and others grow many years before reproducing and dying. These are both examples of [iteroparity](#). [Semelparity](#) is reproducing every year for more than one year. These aspects are part of the [life history](#) of the organism.

GUIDED INQUIRY

Initial Observation/Exploration Period: Explore and observe plant structures in the habitat. Look closely at plants of the same species, noting size and number of leaves, length and thickness of stems, and number of flowers and seeds, if present.

Group Discussion and Question Period: Why do plants of the same species vary in the size of their leaves? (Or number of flowers, number of seeds, etc.) Does location affect how a plant allocates resources? What causes plants to allocate resources to different parts of the plant?

Important aspects of guided inquiry are encouraging students to generate [multiple hypotheses](#), and letting students make decisions about what data are important and create their own data sheets. Keeping these ideas in mind, the sample in the box below illustrates how ONE OF MANY possible investigations around this topic might develop.

Sample Hypothesis: Let's use the question, "Why do plants of the same species vary in the number of their leaves?" Our hypothesis might be, "Some plants have more leaves because they have more resources available." Or, "A reduction in an essential resource will cause plants to allocate the available resource into growth of the most essential plant structures, depending on the life stage of the plant."

Sample Experiment Design: Grow plants from seed or start with seedlings purchased from a nursery. Fast-growing annual plants such as wildflowers would work well, or a shrub such as brittlebush, also a fairly fast grower. The **independent variable** is the resource to be tested. One possible resource to test is the amount of water. The **dependent variable** will be the measurements taken on the plants. There are several possibilities. For this example, we will use the number of leaves produced. If you work with purchased plant seedlings, be sure to count and record the number of leaves on each plant at the time of purchase, as you will have to subtract that number from the total number of leaves on each plant at the end of the experiment to get an accurate result.

Use at least eight plants of the same species for **replication**. Each plant is an **experimental unit**. **Control** variables such as soil, temperature, and light by planting all plants in either the same place in the habitat, or in the same size pots in the same place. If you plant in the habitat, the plants will need to be far enough apart, approximately one-half to one meter, to avoid overlap of plant growth. The **treatment** will be two levels of the resource, water. Half of the plants will receive one and one-half times the amount of water given to the other half. How much water you give each treatment group will depend upon what you select to plant, where you plant it, and what time of year it is. Plants placed in soil outdoors in the habitat will require more water than those planted in pots. Plants grown outdoors, whether in soil or in the ground, will require more water than those grown indoors. Plants will require more water during hot months and less during cool months.

The experiment will run until the plants have grown some leaves, then continue letting them grow for another three to six weeks. The total count of leaves will be the number of leaves present at the end of the experimental time period. Time until leaves appear will depend on the species chosen and the weather. Most Sonoran Desert wildflowers need to be planted in the late summer/early fall and will bloom in the spring (February-April). If you use seedling for this experiment, the experiment can begin as soon as seedlings are purchased and run for three to six weeks.

Sample Prediction: Plants receiving more water will produce more leaves than those receiving less water. You might want to make this experiment more interesting by adding the factor of time and keeping track of when new leaves appear on each plant. You then can add to your prediction that plants receiving more water will produce more leaves, and the leaves will appear sooner, than those plants receiving less water.

Record Results: Tag each leaf with a little bread bag tag with the date written on it to keep track of the leaf's appearance date. Record when the leaves appear as well as how many.

Sample Analysis of Data and Presentation: Make a **bar graph** with the treatment (low, high water amounts) on the horizontal axis and total number of leaves on each plant on the vertical axis. Calculate the **average** number of leaves for each treatment group. Graph the mean number on the vertical axis. Create **line graphs** of the number of leaves produced over time.

Discussion: Was your hypothesis supported? If yes, go on to test other hypotheses. If not, why not? What did happen? Why? This is a great opportunity to revise your hypothesis and do another test.

MORE:

(1) Middle School:

(a) Set up an experiment similar to the one described above. Measure the length of each leaf and its width at the widest part. Multiply the length and width to estimate leaf area. Take these measurements once per week for the three to six weeks. Graph leaf area changes over time.

(b) Explore the habitat for plants that have measurable physical characteristics such as leaves, stems, flowers or seeds. Randomly choose three plants of the same species and approximately the same size. Compare the size of leaves on the outer edge of the plant to those on the inside (that is, closer to the center of the plant). Measure leaf length and width; multiply the two numbers to get the surface area. Graph the average surface area of the inside leaves and outside leaves. This is a test of resource allocation within the same structure of the plant (in this case, the leaves), but differentiated by location on the plant, center versus edge.

(c) Set up an experiment similar to the one described above. As the plants grow, count the number of flowers, and the number of seeds in a random sample of flowers. Graph these measurements as averages over time on a **line graph** to see how resources are allocated to these parts of the plant

(d) Set up a similar experiment but test the effect of other plant resources (light, nitrogen).

(2) High School:

(a) Set up a similar experiment with twice as many plants. After the plants have reached a suitable size (approximately half-grown), dig up half of the plants in each treatment group and dry and weigh the roots, leaves and stems separately. Compare the average weights on a **bar graph** to see how resources have been allocated to growth in these parts of the plant. After the remaining plants have matured, flowered and set seed, dig them up, dry, and weigh as before.

(b) Look for plants of the same species in the habitat that are subjected to different conditions. For example, brittlebush plants in sunny versus shady spots. Compare flower number or seed production.