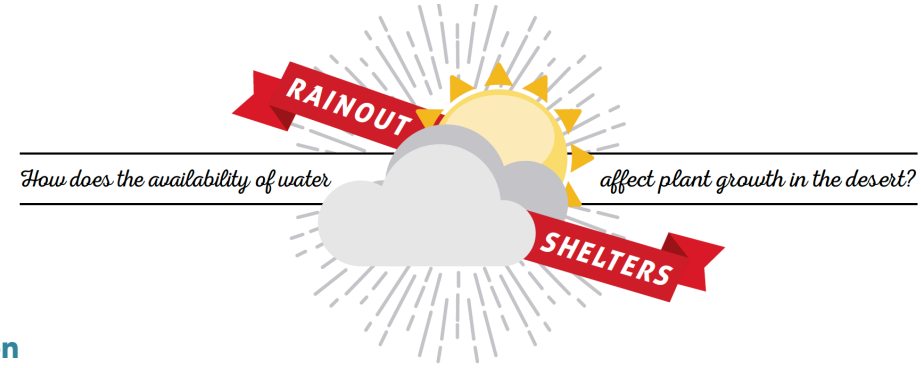


Description

Students analyze data from a desert field experiment to examine the effect of water availability on plant growth.

Grade Level

6 – 12

Objectives

Students will:

- Identify a research hypothesis
- Determine the independent and dependent variables in an experiment
- Interpret the results of an experiment and a graph
- Develop research questions and determine data needed to address them

Background

As climate change intensifies, climate scientists predict that many areas of the world, including the southwestern United States, will experience increased and prolonged periods of drought. Reduced rainfall will decrease the availability of water for plants and other organisms in these areas.

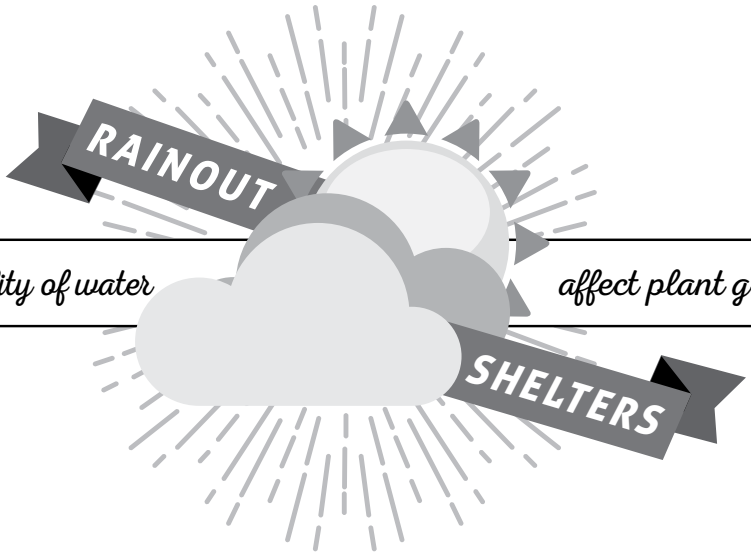
Ecologists from Arizona State University hypothesized about the effects of reduced water availability on plant growth. They developed a field experiment to test their hypothesis that involved installing plots in the Chihuahuan Desert and manipulating the amount of water received on the plots. Some plots received less than ambient rainfall because rain was partially blocked by structures called rainout shelters. Some plots received more than ambient rainfall through irrigation.

The researchers found that reducing the amount of water decreased plant growth. Adding more water increased plant growth, although the relationship was not linear because other limiting resources, such as nitrogen, affect plant growth as well. These results suggest that reduced water availability may have a negative effect on plant populations. In turn, decreases in primary producers could have broader impacts throughout food webs and ecosystems.

Procedures

1. Watch this short video about rainout shelters at the Chihuahuan Desert Nature Park: https://www.youtube.com/watch?v=PhFjgdvG0Iw
2. Take a few minutes to read the information on the first page of the handout beginning on the next page.
3. Make a prediction and review the data in the handout.
4. Answer the questions in the handout.

Name _____ Date _____



How does the availability of water affect plant growth in the desert?

Plants are amazing organisms. Through a process called photosynthesis, they are able to "fix" carbon dioxide and turn it into sugars that allow them to grow and reproduce. The growth of a plant is often measured by calculating the increase in the plant's biomass, which can include stems, roots, flowers and fruits.

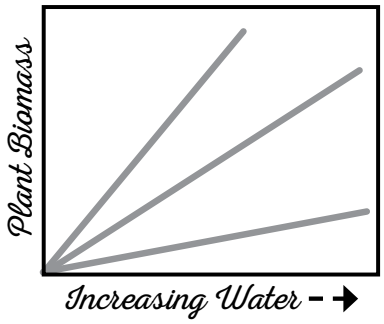
In order to grow, plants need light, nutrients, and water. Nitrogen is the nutrient most often limiting plant growth. In the Chihuahuan Desert, water also limits plant growth. The average annual rainfall at the research site in Las Cruces, New Mexico is 298 mm (11.7 inches). Many climate change models predict that the Chihuahuan Desert will receive less annual rainfall, with the largest decreases in the spring.

How does the availability of water affect desert plant growth and how might this change as annual rainfall decreases? Scientists at the Jornada Basin Long Term Ecological Research Program (LTER) are conducting a large experiment that helps answer this question and many more. They installed an Automated Rainfall Manipulation System with five types of plots: (1) rainout shelters that reduce rain on the plot by 80%, (2) rainout shelters that reduce rain on the plot by 50%, (3) controls, (4) irrigated plots that receive 50% more than ambient rainfall, and (5) irrigated plots that receive 80% more than ambient rainfall. Scientists then estimate plant biomass on each plot using measurements of plant species cover and the volume of shrubs.

Rainout shelter and irrigated plots

This experiment tests the effect of water availability on plant growth. If water is the **only** factor limiting plant growth, we expect plant biomass to increase linearly with increasing water (Figure 1). However, if nitrogen is also a limiting factor for plant growth, we expect plant biomass to level off at higher water availability, resulting in a plateau in the curve of the graph of biomass against water (Figure 2).

*Figure 1. Possible outcome #1 – three possible **linear** (straight line) relationships; as water increases, plant biomass increases.*



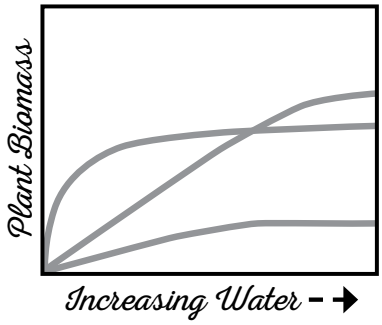


*Figure 2. Possible outcome #2 – three possible **nonlinear** relationships. At some water level, plant biomass levels off.*

PREDICTION

1. What do scientists predict they will see if both water and nitrogen are limiting? Find the prediction in the background information on page 1, and write it below.

DATA & ANALYSIS

1. Here are the data collected in the experiment. Calculate the mean biomass for each treatment and write it on the line to the right.

WATER MANIPULATION	AMOUNT OF WATER RECEIVED (MM)	BIOMASS (G/M^2 YR)
Rainout 80%	19	15.9
Rainout 80%	19	14.4
Rainout 80%	19	11.8
Rainout 80%	19	64.1
Rainout 80%	19	36.6
Rainout 50%	48	27.1
Rainout 50%	48	47.5
Rainout 50%	48	50.4
Rainout 50%	48	37.1
Rainout 50%	48	33.2
Control	95	61.1
Control	95	76.8
Control	95	57.8
Control	95	85.0
Control	95	49.1
Irrigation 50%	143	121.5
Irrigation 50%	143	74.6
Irrigation 50%	143	56.9
Irrigation 50%	143	99.7
Irrigation 50%	143	95.6
Irrigation 80%	171	60.8
Irrigation 80%	171	110.0
Irrigation 80%	171	94.3
Irrigation 80%	171	81.9
Irrigation 80%	171	84.2

Mean plant biomass on rainout 80% plots = _____

Mean plant biomass on rainout 50% plots = _____

Mean plant biomass on control plots = _____

Mean plant biomass on irrigation 50% plots = _____

Mean plant biomass on irrigation 80% plots = _____

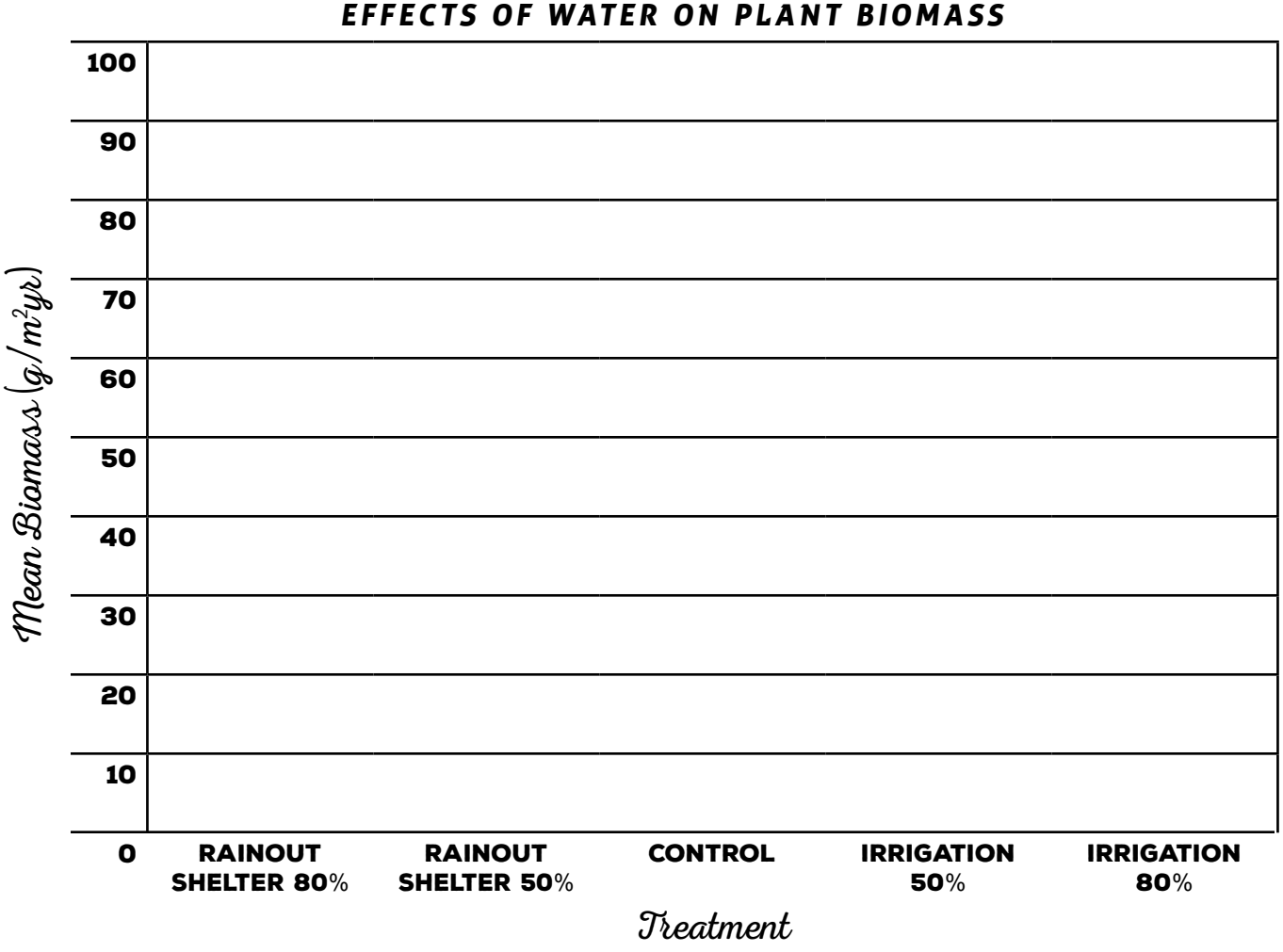
2. Which are the independent and dependent variables in this experiment?

Independent variable: _____
This is the variable that is not changed by the other variables measured in the experiment; independent variables are often manipulated by the researchers in an experiment.

Dependent variable: _____
This is the variable that may be changed by other variables; it is the response that is measured in the experiment.

3. Create a bar graph with the means from this experiment.

BAR GRAPH OF EXPERIMENTAL DATA MEANS



RESULTS & CONCLUSIONS

1. Circle the letter of the idea that is **most** supported by these data.

a. Based on the data, there appears to be a linear relationship between biomass and water (like in Figure 1 on page 1).

b. Based on the data, it appears that there is a nonlinear relationship between biomass and water; biomass levels off at higher water availability (like in Figure 2 on page 1).

2. Based on your answer to question #1, does is appear that water is the only limiting factor in this ecosystem across the range of different water treatments studied? Why or why not?

3. Science is an ongoing process. In the space below, write new questions you think should be investigated **related to this study**. What future data should be collected to answer your new questions?