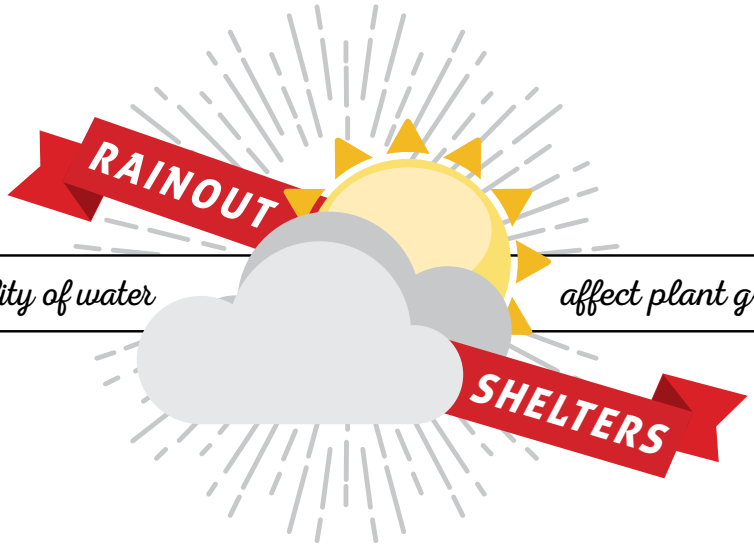

How does the availability of water affect plant growth in the desert?

DESCRIPTION

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

PHENOMENON

How do changes in precipitation affect desert 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

TIME
1 HOUR

COMMON CORE STATE STANDARDS

English Language Arts Standards » Science & Technical Subjects » Grade 6-8

CCSS.ELA-LITERACY.RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-LITERACY.RST.6-8.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

CCSS.ELA-LITERACY.RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

English Language Arts Standards » Science & Technical Subjects » Grade 9-10

CCSS.ELA-LITERACY.RST.9-10.1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

CCSS.ELA-LITERACY.RST.9-10.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.

CCSS.ELA-LITERACY.RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

English Language Arts Standards » Science & Technical Subjects » Grade 11-12

CCSS.ELA-LITERACY.RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

CCSS.ELA-LITERACY.RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Grade 6 » Statistics & Probability

CCSS.MATH.CONTENT.6.SP.B.5. Summarize numerical data sets in relation to their context, such as by: CCSS.MATH.CONTENT.6.SP.B.5.C. giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

High School: Statistics & Probability » Making Inferences & Justifying Conclusions

CCSS.MATH.CONTENT.HSS.IC.B.5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

NEXT GENERATION SCIENCE STANDARDS

Middle School Performance Expectations

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

NEXT GENERATION SCIENCE STANDARDS

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data (MS, HS) Constructing Explanations and Designing Solutions (MS, HS) Obtaining, Evaluating, and Communicating Information (MS) Engaging in Argument from Evidence (MS)	LS1.C Organization for Matter and Energy Flow in Organisms (MS) LS2.A Interdependent Relationships in Ecosystems (MS, HS)	Patterns (MS, HS) Cause and Effect (MS, HS)

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.

MATERIALS

- *Rainout Shelters* handout [1 per student]
- Calculators [1 per student]
- Optional: *Asombro Institute* informational video, short introduction to the rainout shelter study
- Computer and projector (if showing video)

PREPARATION

1. Set up a computer and projector to show the video if using. Open a web browser and prepare to show the *Asombro Institute* informational video (link below). This video includes students collecting data and then discussing rainout shelters, the equipment used in the focus experiment of this activity. It is helpful for students to visualize how the experiment was conducted. Showing the entire video is not necessary. https://www.youtube.com/watch?v=PhFjgdvG0Iw

PROCEDURES

This activity can be completed with varying levels of educator guidance. Students can complete the activity on their own or with direction. Modify these procedures to best suit the needs of students.

1. Optional: show the *Asombro Institute* informational video featuring rainout shelters and plant growth data collection.
2. Pass out a *Rainout Shelters* handout to each student.
3. Instruct students to read the Research Background on page 1 of the handout.
4. Once it seems like most students have had enough time to read the research background, discuss the Automated Rainfall Manipulation System (ARMS) study design. If the video was shown, discuss the additional treatments that were used on ARMS. The video features rainout shelters that reduce rain by 50% on the plots.
   a. Explain that the ARMS experiment included five treatments: 80% rainout, 50% rainout, control (no treatment), 50% increase in irrigation, and 80% increase in irrigation.
5. Discuss the two graphs at the bottom of page 1 of the handout

a. Figure 1 shows three options for linear (straight line) relationships between water and plant biomass. In other words, as water increases, plant biomass increases. If water is the only factor limiting plant growth, we expect that adding increasing amounts of water to plants would result in increasing plant biomass. The graph shows three possible scenarios for the rate of biomass increase in a linear relationship with increasing water.
b. Figure 2 shows three options for a nonlinear relationship between water and plant biomass. As water increases, plant biomass increases up to a point, and then it levels off. If water is not the only factor limiting plant growth, we expect plant biomass to plateau at higher water availability. In this scenario, other resources, such as nitrogen, limit plant growth, and simply adding more water will not increase plant biomass further. The graph shows three possible scenarios for the rate of biomass increase in a non-linear relationship with increasing water.

6. Guide students to answer the questions beginning on page 2 of the handout. After allowing time for students to answer, lead a discussion of each question.
   a. **Prediction Question 1**: locate the prediction in the background information on page 1 of the handout and write it.
   b. **Data and Analysis Question 1**: calculate the mean biomass for each treatment and record the answer on the blanks to the right of the table.
   c. **Data and Analysis Question 2**: identify the independent and dependent variables from the experiment and write them in the blanks.
   d. **Data and Analysis Question 3**: have students make a bar graph of the mean biomass for each treatment in the graph on page 3 of the handout.
   e. **Results and Conclusions Question 1**: determine whether there appears to be a linear relationship between biomass and water, and circle A or B accordingly.
   f. **Results and Conclusions Question 2**: decide whether it appears that water is the only limiting factor in this ecosystem and explain.
   g. **Results and Conclusions Question 3**: develop further research questions related to this study and identify the data needed to address them.
7. Wrap up with a discussion of the effects of water availability on plants and how decreasing plant populations may affect the local food web and Chihuahuan Desert ecosystem. Ask students what other effects reduced water availability could have on ecosystems throughout the Southwest [possible answers: declining plant populations, and primary consumer populations may also decrease, which could cause declines to populations of organisms throughout the food web/drier soil that is more susceptible to erosion/less water directly available for wildlife/more wildfires].

EXTENSIONS

1. Have students read a summary article (link below) about a long-term international study that investigated the ability of plants to tolerate drought conditions. Instruct students to write a paragraph that summarizes the findings and includes a prediction about how changes in water availability will affect plants and other organisms in your area.
   http://uanews.org/story/plants-adapt-drought-limits-are-looming-study-finds
   Original source:
   Ponce-Campos, GE, Moran, MS, Huete, A, Zhang, Y, Bresloff, C, Huxman, TE, Eamus, D, Bosch, DD, Buda, AR, Gunter, SA, Scalley, TH, Kitchen, SG, McClaran, MP, McNab, WH, Montoya, DS, Morgan, JA, Peters, DPC, Sadler, EJ, Seyfried, MS, Starks, PJ. 2013. Ecosystem resilience despite large-scale altered hydroclimatic conditions. Nature 494(7437): 349-352.

ADDITIONAL RESOURCES

Article with more information about the Automated Rainfall Manipulation System experiment:

Gherardi, L and Sala, OE. 2013. Automated rainfall manipulation system: A reliable and inexpensive tool for ecologists. Ecosphere 4(2): art 18, 1-10. Accessed online. 19 May 2015. <http://sala.lab.asu.edu/wordpress/wp-content/uploads/ARMS-reprint.pdf>.