

Activity #5

# Ecosystem Engineers III: Nitrogen Fixers

**Length:**

Two class periods with 5-6 week lab in between

**Prerequisite Activity:**

None.

**Objectives:**

- Identify how an invasive plant species might alter soil or other habitat conditions to affect the surrounding ecosystem.
- Explore how bacteria help certain plants harness airborne nitrogen.
- Formulate a hypothesis and design and conduct a lab to observe nitrogen accumulation in root nodes.
- Create a poster presentation of lab results.

**Vocabulary:**

Bacteria  
Biomass

Inoculate  
Nitrogen-fixing

Nodules  
Symbiotic

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## ● ● ● Class Period One: *Designing Labs, Nitrogen Fixers*

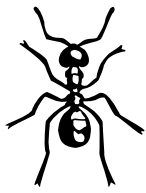
### In Advance

Order lab equipment: Rapitest Soil Test Kit and clover seeds inoculated with *Rhizobium leguminosarum* (1 packet), both available from Carolina Biological Supply Company at [www.carolina.com](http://www.carolina.com)

### Materials & Setup

*Group Discussion Series*

- 27 small pots
- Potting soil without fertilizer \*
- 1 packet clover seeds
- 1 packet clover seeds inoculated with *Rhizobium leguminosarum*\*\*
- Rapitest Soil Test Kit\*\*
- Nitrogen fertilizer
- Ruler
- Metric scale
- Teacher Background “Scientific Method Chart” p. 139 (You may want to display this with a projector)



\* Potting soil without fertilizer is ideal, but may be hard to find. If you are unable to find potting soil without fertilizer, establish with the class that all three test pots (no nitrogen added, nitrogen-fixing bacteria added, and nitrogen fertilizer added) will be starting with a baseline of nitrogen.

\*\*Available from Carolina Biological Supply Company at [www.carolina.com](http://www.carolina.com)

Note: Adult supervision required during use of nitrogen fertilizer.

*For each student:*

- Student Pages: “Nitrogen-Fixers: Friends or Foes?” p. 141 “Daily Data Sheet” p. 147 “Lab Report” p. 143, and “Lab Report Guidelines” p. 145.

## Instructions

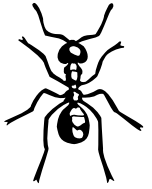
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- 1) Read the Student Page “Nitrogen-Fixers: Friends or Foes?” aloud in class.
- 2) Lead a discussion on the scientific method using Teacher Background “Scientific Method Chart.” Project or draw diagram on board.

*Question:* What are the steps of the scientific method?

*Answer:* The scientific method begins when you 1) ask a general question and 2) conduct some background research. Next, you 3) develop a hypothesis and 4) test the hypothesis in a controlled experiment. 5) Collect and analyze results. 6) Determine whether your hypothesis is true or false, based on your results. 7) Report your results and conclusion. If your hypothesis is false, you can begin the process again with a different hypothesis.

- 3) Pass out the Student Pages “Ecosystem Engineers Lab Report” and “Lab Report Guidelines.”
- 4) Tell students to develop a hypothesis to test (for example: seeds inoculated with *Rhizobium leguminosarum* will have 25 percent larger biomass after six weeks than non-inoculated seeds). Have them write out their hypothesis, materials, procedure (including what they intend to measure), and how they will compare their data to their control on their worksheet. Students can compete for whose hypothesis is the most accurate.
- 5) Have each student keep their own notes for their experiment because they will be putting together a poster at the end of their experiment. This experiment will be ongoing, with students watering/monitoring their seeds every other day for 5-6 weeks.
- 6) Make sure pots have holes in the bottom to allow the roots to “breathe.” Measure equal amounts of soil into each of the pots. Moisten the soil in each pot with the equal amounts of water.
- 7) Choose students to label nine pots “no nitrogen added,” nine pots “nitrogen fertilizer,” and nine pots “nitrogen-fixing bacteria.” Number the pots 1-9 in each set. In the pots labeled “no nitrogen added” and “nitrogen fertilizer,” plant 10 seeds from the regular clover packet. In the pots labeled “nitrogen-fixing bacteria” plant ten *Rhizobium leguminosarum*-inoculated clover seeds. Plant seeds according to seed packet instructions.



- 8) Set the pots near a window where they can access natural light, or beneath a timed light source that simulates natural light. Set a schedule for watering and recording data. Each student should take a turn or several turns.
- 9) Explain to students that when it is their turn to water, they are responsible for doing an effective job and recording data that the entire class will be using.

Pots labeled “No nitrogen added” and “*Rhizobium leguminosarum*” get regular water. Pots labeled “nitrogen fertilizer” get water and nitrogen fertilizer at the brand of fertilizer’s recommended concentration. (Note that they may not need to add fertilizer at each watering.) Soil should be kept moist. Depending on your classroom environment, you may have to water more or less frequently.

At each watering, have students measure the amount of nitrogen in the soil of each pot (use the Rapitest Soil Test Kit), number of seedlings per pot, and the height of two tallest seedlings per pot as they grow. They will record their data on three separate “Daily Data Sheets.” Tell them to list any changes they notice in the plants’ health in the “notes” section.

- 10) Clover will grow to maturity in 5–6 weeks. When clover plants are mature, proceed with experiment.
- 11) After the plants have matured, instruct students to carefully remove each plant from the soil and shake off any excess soil from the roots. Have them measure the total biomass of each plant on the scale and record data on worksheet.
- 12) As a class, compare the average nitrogen levels in each type of soil and the average biomass of the clover grown in each type of soil. Which type of soil had the highest levels of nitrogen? Which type of soil produced the greatest biomass of clover? Was there any noticeable difference in the health or appearance of the clover grown in the different soils?

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## ● ● ● Class Period One: Analyzing and Reporting on Results

### Materials & Set Up \_\_\_\_\_

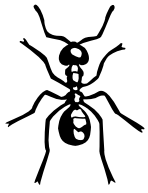
*For each student:*

- Graph paper or access to computer

### Instructions

- 1) After 5-6 weeks, collect the completed Student Page “Daily Data Sheets” from each group. Summarize the entire class’s data in charts and graphs. These charts and graphs can be drawn on graph paper or created as computer spreadsheets. Discuss why scientists calculate their results in a variety of ways, ie: using mean number and median.

For example, have students calculate the mean number of days it took seeds to germinate for both the variable and the control. Display germination time in a bar graph, with the x-axis having two categories (nitrogen added, no nitrogen) and the y-axis being the average number of days. Do the



same for seedling growth.

Determine the median days to germination and display in a table. Do the same for seedling growth.

Graph change in nitrogen levels (if any) over time.

- 2) Review the “Lab Report Guidelines” with the students. Have students complete their “Ecosystem Engineers Lab Report” based on the data gathered by the entire class.
- 3) The students will then make a poster to put on display for the class. The poster should include their hypothesis, a brief version of their procedure, and their results, including the graphs they made.
- 4) Place the posters on display in the classroom. Students whose hypotheses most closely matched the actual results can give a short 2-3 minute presentation on their research posters. Afterwards, the class can do a gallery walk, providing constructive and positive comments about each poster by writing it on a sticky note and placing it on the poster.
- 5) Have the students turn in their “Ecosystem Engineers Lab Report.”

## Journal Ideas

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- How do invasive species alter habitats and ecosystems? Name five ways.
- When people shop for landscaping plants, most look for exotic species that are hardy and fast growing. How might this be a problem for the native environment beyond the landscaped yard?
- Many native Hawaiian plants grow slowly and are conservative in their use of resources. Why might that be? How could these characteristics help a plant survive?

## Assessment Tools

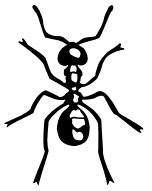
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- Daily data sheets
- Lab reports
- Posters
- Journal entries

## Further Enrichment

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- Build on this lab to explore the effects of nitrogen on non-native and native Hawaiian plants. In general, native Hawaiian plants do not maximize nitrogen as well as non-native, opportunistic species. In this six-to-eight week long experiment, students will monitor nine pots of ‘a‘ali‘i or ‘ōhi‘a seeds grown with nitrogen fertilizer, and nine pots grown without nitrogen fertilizer, comparing them to nine pots of grass seeds grown with nitrogen fertilizer and nine pots grown without nitrogen fertilizer. They will observe the effects of nitrogen on plant growth by recording days till germination and measuring the increase in biomass of each plant at the end of the experiment.



*Teacher Background*  
**Scientific Method Chart**

