

21 Lab, Experiment, and Field Report

Good science writing is rooted in good science—the careful study of phenomena through observation and experiment. Social scientists seek to understand human behavior and societies, whereas natural scientists investigate the physical world.

As a student, you may be asked to read science articles and to conduct scientific research in a range of courses. In classes, you may write literature reviews to summarize and assess what research has been done on an issue. In labs and in the field, you may perform experiments, gather data, and interpret results, and then share your insights with others.

This chapter will help you put your science research into writing—and your good writing into science.

Learning Outcomes

Read and evaluate science writing for logic and clarity.

Understand and follow the scientific method.

Utilize scientific style appropriately: objective tone, fitting use of passive voice.

Structure science writing using IMRAD: introduction, methods, results, and discussion.

Write an experiment or field report in APA or CSE style.



Audio



Video



Visually Speaking

▶ Review the photograph above. What does it suggest about science, the scientific method, and science writing?

Reading Science Writing



Web Link

In order to read and do science writing effectively, you need to understand certain principles of science. Follow the guidelines below.

Consider the rhetorical situation. ■■■

When reading a scientific article (scholarly or popular), consider the rhetorical situation. When doing your own writing, perform a similar analysis.

- **Purpose:** Typically, the goal is to report experimental and observational results. However, sometimes it is to summarize several studies on a topic so to disseminate scientific knowledge to a broad audience.
- **Audience:** Most readers are experts—scientists interested in the topic addressed, seeking to debate and build knowledge (typically in scholarly journals). Other readers may be laypeople—non-experts nevertheless interested in the topic (typically reading trade or popular magazines).
- **Topic:** Scientists study phenomena, seeking to understand, for example, the cause-effect forces at work. Virtually any natural or social phenomenon is a potential topic.

Consider science-writing strategies. ■■■

Sound science writing depends on these principles: the scientific method, the IMRAD format, and careful distinctions.

- **The Scientific Method:** Science focuses on measured observations aimed at understanding. Experiments are set up to test hypotheses about why things happen. However, experiments don't prove hypotheses correct: Experimental results can merely “agree with” or disprove a hypothesis. Overall, the method moves from observation to explanation as you do the following:

1. Observe something interesting (often while looking for something else).
2. Check whether other scientists have explained the same observation.
3. Summarize your observations and turn that generalization into a testable hypothesis—a working theory explaining the phenomenon.
4. Design research to test the hypothesis, paying attention to variables and controls.
5. Based on the results of your experiment, accept, reject, or modify your hypothesis.
6. Repeat steps 3 through 5 until you understand the phenomenon. Then write up your research so that others can respond to your work.

- **IMRAD Format:** To model scientific thinking, lab and field reports include an *introduction* establishing the problem, a *methods* section detailing procedures, a *results* section providing the data, and a *discussion* that interprets the data: IMRAD.

Experiment Report

In this report, student writers Dana Kleckner, Brittany Korver, Nicolette Storm, and Adam Verhoef share the results of an experiment in which they tested a hypothesis about the impact of an invasive plant species, Eastern Red Cedar, on Midwestern native species.

Outline

Introduction: allelopathy and Eastern Red Cedar hypothesis

Method: growing Black-Eyed Susans and Poppies in soil samples

Results: no significant differences between cedar and non-cedar soil samples

Discussion: Eastern Red Cedar does not negatively affect germination of native species.

The title contains key terms identifying the experiment's cause-effect focus.

The abstract summarizes the experiment and its findings.

The introduction offers background and surveys past research.

The Effects of the Eastern Red Cedar on Seedlings and Implications for Allelopathy

Abstract

The Eastern Red Cedar (*Juniperus virginiana*) is an invasive species that threatens native tall-grass prairies in much of the Midwest (Norris *et al* 2001). In an effort to learn more about its invasive characteristics, we decided to test for possible allelopathic properties. Allelopathy refers to the growth inhibition of one species by another species releasing toxins from its tissues (Simberloff 1995). In this study, the germination and survival of Black-Eyed Susans (*Rudbeckia hirta*) and Poppies (*Papaver orientale*) were examined. Seeds were planted in soil gathered from under three Eastern Red Cedar trees at Oak Grove State Park (Northwestern Iowa) and in soil from three non-cedar locations at this park. Germination and survival of the seedlings in controlled conditions were documented over thirty-two days. We found no significant difference between germination and survival proportions of the two seed types between the cedar and non-cedar soil. This led us to conclude that the Eastern Red Cedar does not negatively affect the germination and survival of the selected seed types.

Introduction

Several factors can give a plant dominance in an area. One of these factors is the production of allelopathic chemicals. Allelopathy is the secretion of chemicals by one plant that suppresses the growth of other nearby plants (Simberloff 1995). This phenomenon reduces competition for limited resources. One possible method of allelopathy is the secreting of chemicals through the roots, directly into the soil. The chemicals can also be stored in the leaves, flowers, fruits, and seeds, releasing chemicals into the soil as they decompose (Norris *et al* 2007).

These allelopathic properties are present in several invasive species, such as the Japanese Red Pine (Node *et al* 2003).

The writers identify the specific problem, explain the value of their research, and state their hypothesis.

The object in this experiment was to test for allelopathic capabilities of the Eastern Red Cedar (*Juniperus virginiana*). The Eastern Red Cedar is a pioneer invader in the Midwest, quickly populating disturbed land (Norris *et al* 2001). This invasion is problematic in certain areas of the Midwest, as it often changes the native ecology of the area it invades, namely tall-grass prairies (Norris *et al* 2001). In the effort to preserve native ecosystems, a correct understanding of the characteristics of invaders is useful. The knowledge of the allelopathic properties of this species could assist in preservation efforts.

We predicted that eastern red cedars are allelopathic and that the soil around cedar trees would have a negative effect on the germination and lifespan of other plants. We hypothesized that seeds planted in cedar soil would germinate at a lower frequency and have shorter life spans than those planted in non-cedar soil under the same conditions.

Methods

The writers detail the experimental procedure using precise terms and steps.

The experiment took place from March 19 to April 20, 2009 in the Northwestern College biology lab. Our professors collected soil from Oak Grove State Park near Hawarden, Iowa several months in advance. They gathered soil from three different locations under three different cedars trees and from three nearby non-cedar locations. They placed the soils under sun lamps to dry, and then stored the soil in plastic Ziplock bags.

To prepare for this experiment, two rows of evenly spaced holes were drilled into 18 potting trays for drainage. Each tray was labeled with the soil's location number and the soil type (cedar or non-cedar). From each specified location, soil was measured out equally and placed into the trays. In an effort to make the growing conditions realistic, any foreign plant roots, stems, etc. were left in the soil.

They explain choices made during the experiment.

Black-Eyed Susans (*Rudbeckia hirta*) and Poppies (*Papaver orientale*) were chosen because of their equal planting depth and equal time for seed germination. Two rows were planted in each tray with 10 evenly spaced Black-Eyed Susan seeds on one side and ten evenly spaced Poppy seeds on the other side (both were planted according to the directions on the packages).

On March 19, each tray was placed approximately 35cm. under sun lamps that ran on a 12hrs on/12hrs off cycle. Each day, the trays were watered and rotated so that they received an equal amount of light and warmth. When a seed

To keep the focus on actions rather than themselves as actors, the writers use passive voice (but mainly in the Methods section).

The results are stated in neutral, precise terms and portrayed in figures.

Figures effectively visualize the experimental data, and are properly titled, numbered, and captioned.

germinated, the date and the plant location in the tray were documented. If the plant died, the date of the death was recorded. Any foreign species that grew were left so as not to disturb the soil. On April 20, thirty-two days later, the data were compiled. The number of each species that germinated at each location and the number of days each plant survived were recorded.

Using Microsoft Excel, we first ran ANOVAs to see if there were any significant differences in germination rates among the three cedar soil sites or any significant difference in germination rates among the non-cedar sites. Then we ran paired t-tests on germination for each seed type between the cedar and non-cedar soils. To compare the percentage of surviving seedlings between cedar and non-cedar soils, we ran an ANOVA for each seed type.

Results

We found no significant differences related to location in germination of Black-Eyed Susan seeds (ANOVA: $F=2.71$, $F\text{-crit}=5.14$, $df=8$, $p\text{-value}=0.14$) (Fig.1) or Poppy seeds (ANOVA: $F=0.37$, $F\text{-crit}=5.14$, $df=8$, $p\text{-value}=0.7$) (Fig. 1) among the three cedar sites. We also found that there were no significant differences related to location in the germination of Black-Eyed Susans (ANOVA: $F=1.63$, $F\text{-crit}=5.14$, $df=8$, $p\text{-value}=0.27$) (Fig. 2) or Poppies (ANOVA: $F=0.31$, $F\text{-crit}=5.14$, $df=8$, $p\text{-value}=0.74$) (Fig. 2) among the three non-cedar sites. Knowing that there were no significant differences in germination among the sites, we condensed the data into four different groups: Black-Eyed Susan cedar, Black-Eyed Susan non-cedar, Poppy cedar, and Poppy non-cedar.

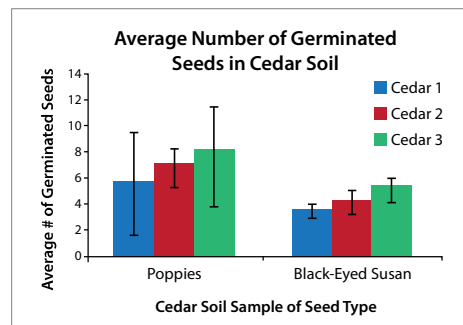


Figure 1. There is no significant difference in seed germination among the three cedar soils for Poppies ($p=.7$) or Black-Eyed Susans ($p=.14$). Bars represent standard deviation.

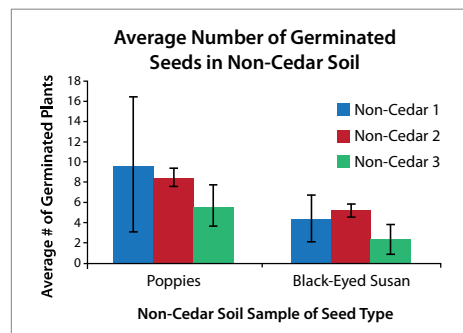


Figure 2. There is no significant difference in seed germination among the three non-cedar soils for Poppies ($p=.74$) or Black-Eyed Susans ($p=.27$). Bars represent standard deviation.

The two paired t-tests comparing seed germination in cedar soil versus non-cedar soil showed no significant differences in Black-Eyed Susan germination between the two soil types ($t=0.31$, $p=0.77$) (Fig.3) or in Poppy germination between the two soil types ($t=-0.78$, $p=0.46$) (Fig.3).

When comparing survivorship of the two seedling types in each soil, we defined surviving plants as those that lived for seven days or more. We ran ANOVAs and found that there was no significant difference between the proportion of seedlings that survived in cedar versus non-cedar soil for Black-Eyed Susans (ANOVA: $F=0.01$, $F\text{-crit}=4.49$, $df=1$, $p=0.92$) (Fig. 4) or for Poppies (ANOVA: $F=0.06$, $F\text{-crit}=4.49$, $df=1$, $p=0.82$) (Fig. 4).

Discussion

In this experiment, we sought to discover whether Eastern Red Cedar soil is allelopathic. We predicted that cedar soil was allelopathic and hypothesized that if our prediction were correct, seeds planted in non-cedar soil would show higher germination and higher survival. We tested for significant differences in soil sites, germination of the two seeds types between soil types, and survival percentages of the seed types between soil types. None of these tests yielded a significant difference.

The writers restate their purpose and hypothesis, and then interpret the results of their experiment.

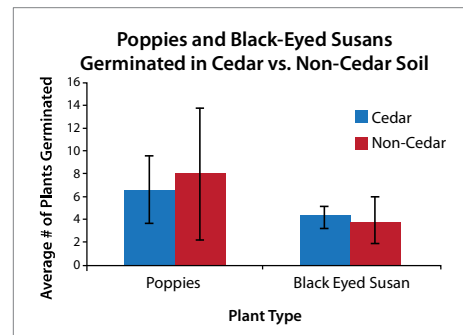


Figure 3. There is no significant difference in germination between cedar and non-cedar soil for Poppies ($p=.48$) or Black-Eyed Susans ($p=.77$). Bars represent standard deviation.

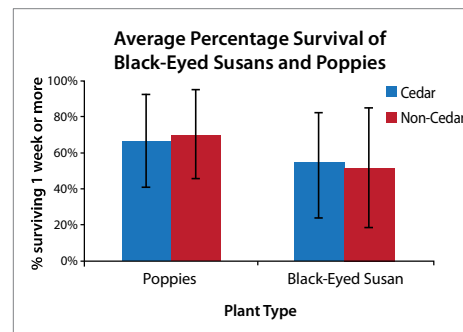


Figure 4. There is no significant difference in seedling survival between cedar and non-cedar soil for Poppies ($p=.82$) or Black-Eyed Susans ($p=.92$). Bars represent standard deviation.

11

12

13

If the Black-Eyed Susans and poppies are good representatives of typically affected plants, then Eastern Red Cedar soil appears not to reduce germination or survival. For those concerned with protecting native ecosystems from these invaders, the implications seem positive. An allelopathic invader would produce more damage than a non-allelopathic invader not only in the secretion of chemicals, but also in those chemicals remaining to harm desirable native species even if that invader is removed (Medley 2007).¹⁴

They consider the broader implications of their study.

However, even if cedars do not release allelopathic chemicals, a study conducted in the tall grass prairies of Kansas found that the Eastern Red Cedar increased the amount of above-ground biomass and surface-litter nitrogen pools that are linked to the conversion of grassland to forest (Norris *et al* 2007). Though this is not allelopathy, the invasive Eastern Red Cedar still changes the composition of the soil in a manner that could affect the growth of other plants (Norris *et al* 2007).¹⁵

Also, though the cedar soil appeared not to be allelopathic in our study, we are hesitant to make an assessment of the Eastern Red Cedar's affect on other plant types. Several factors may have confounded our non-allelopathic conclusion. The cedar's chemical may simply not be allelopathic to the types of plants we chose (Medley 2007). We purchased the seeds at a local Bomgaars store, and these seeds are domesticated strains. Domesticated strains may be more resistant to allelopathic chemicals and selected for high germination (Node 2003). If allelopathic chemicals are present, the chemicals may have been affected by the storage period and drying process and consequently have a different effect on seedlings (Norris *et al* 2001).¹⁶

The writers identify complicating factors and reflect on the experiment's method.

Though we doubt that chemicals affected the outcome of our study, we had several slight complications. In one of our planting boxes, more than ten poppies germinated. This was likely due to accidentally planting more than ten of the tiny seeds. In our statistics, we chose to count them all because excessive seeds were likely accidentally planted in other boxes as well. A recording complication occurred when some poppies germinated outside of their row in their container. The species type of some of the small seedlings was hard to distinguish as they were mixed together.¹⁷

If we repeated this experiment, we would change both materials and methods. We would grow separate seed types in separate containers so there would be no confusion as to the species. We would also be more attentive to the seeds during the planting process, so none would stick together and distort our data. To see if¹⁸

the drying process was a factor, in addition to planting in dried soil, we would plant in freshly gathered soil. Finally, we would use plant species that are actually threatened by possible cedar allelopathy instead of species to which this possibility is irrelevant in real life. A native tall grass may react much differently to cedar soil and would provide more interesting and relevant application.

Note: The references page is not shown. For more on documentation in the social sciences, see APA on pages 529–558. For more on documentation in the natural sciences, see CSE at councilscienceeditors.org.

Reading for Better Writing

Working by yourself or with a group, do the following:

1. Where do the writers discuss the experiment's purpose and value? Are their efforts convincing?
2. In the "Methods" section, what strategies do the writers use to ensure that the experiment can be repeated?
3. In the "Results" section, what is the relationship between the writers' statements and the four figures?
4. In the "Discussion" section, how do the writers interpret the experiment results? Are their interpretations and conclusions sound? Why or why not?



Field Report

In the following workplace report, a team of writers investigates the causes and effects of cockroach infestation in an apartment complex. In the study, they use their findings to recommend solutions.

SOMMERVILLE DEVELOPMENT CORPORATION

Date: September 20, 2010
To: Bert Richardson, VP of Tenant Relations
From: Hue Nguyen, Cherryhill Complex Manager
 Sandra Kao, Building Superintendent
 Roger Primgarr, Tenant Relations
 Juan Alexander, Tenant Representative
Subject: Investigation of Cockroach Infestation at 5690 Cherryhill

The subject line functions as a title.

The opening clarifies the study's purpose and goals.

During the month of July 2010, 26 tenants of the 400-unit building at 5690 Cherryhill informed the building superintendent that they had found cockroaches in their units. On August 8, the management-tenant committee authorized us to investigate these questions:

1. How extensive is the cockroach infestation?
2. How can the cockroach population best be controlled?

We monitored this problem from August 9 to September 8, 2010. This report contains a summary, an overview of our research methods, and findings, conclusions, and recommendations.

SUMMARY

The 5690 Cherryhill building has a moderate infestation of German cockroaches. Only an integrated control program can manage this infestation. Pesticide fumigations address only the symptoms, not the causes. We recommend that Sommerville adopt a comprehensive program that includes (1) education, (2) cooperation, (3) habitat modification, (4) treatment, and (5) ongoing monitoring.

The summary focuses on outcomes.

1

2

3

RESEARCH METHODS AND FINDINGS

Overview of Research

Research methods are described.

We researched the problem in the following ways:

1. Contacted the Department of Agriculture, the Ecology Action Center, and Ecological Agriculture Projects.
2. Consulted three exterminators.
3. Inspected the 5690 Cherryhill building, from ground to roof.
4. Placed pheromone traps in all units to monitor the cockroach population.

4

Results are categorized logically.

The Cockroach Population

Pheromone traps revealed German cockroaches, a common variety. Of the 400 units, 112 units (28 percent) showed roaches. Based on the numbers, the infestation is rated as moderate.

5

Findings are presented clearly and concisely.

The German Cockroach

Research shows that these roaches thrive in apartment buildings.

- Populations thrive when food, water, shelter, and migration routes are available. They prefer dark, humid conditions near food sources.
- The cockroach seeks shelter in spaces that allow its back and underside to remain in constant contact with a solid surface.

6

Methods of Control

Sources we consulted stressed the need for an integrated program of cockroach control involving sanitation, habitat modification, and non-toxic treatments that attack causes. Here are the facts:

- The German cockroach is immune to many chemicals.
- Roaches detect most pesticides before direct contact.
- Spot-spraying simply causes roaches to move to unsprayed units.
- Habitat modification through (1) eliminating food and water sources, (2) caulking cracks and crevices, (3) lowering humidity, and (4) increasing light and airflow makes life difficult for cockroaches.

7

CONCLUSIONS

Conclusions follow logically from the findings.

Based on our findings, we conclude the following:

1. A single method of treatment, especially chemical, will be ineffective.
2. A comprehensive program of sanitation, habitat modification, and nontoxic treatments will eliminate the German cockroach.

8

RECOMMENDATIONS

Recommendations apply what was learned in the study.

We recommend that Sommerville Development adopt an Integrated Program of Cockroach Prevention and Control for its 5690 Cherryhill building. Management would assign the following tasks to appropriate personnel: 9

Education: (1) Give tenants information on sanitation, prevention, and home remedies; and (2) hold tenant meetings to answer questions. 10

Habitat Modification: Revise the maintenance program and renovation schedule to give priority to the following: 11

- Apply residual insecticides before sealing cracks.
- Caulk cracks and crevices (baseboards, cupboards, pipes, sinks). Insert steel wool in large cavities (plumbing, electrical columns).
- Repair leaking pipes and faucets. Insulate pipes to eliminate condensation.
- Schedule weekly cleaning of common garbage areas.

Treatment: In addition to improving sanitation and prevention through education, attack the roach population through these methods: 12

- Use home remedies, traps, and hotels.
- Use borax or boric acid powder formulations as residual, relatively nontoxic pesticides.
- Use chemical controls on an emergency basis.
- Ensure safety by arranging for a Health Department representative to make unannounced visits to the building.

Monitoring: Monitor the cockroach population in the following ways: 13

1. Every six months, use traps to check on activity in all units.
2. Keep good records on the degree of occurrence, population density, and control methods used.

The closing stresses the value and benefits of the study.

We believe that this comprehensive program will solve the cockroach problem. We recommend that Sommerville adopt this program for 5690 Cherryhill and consider implementing it in all its buildings. 14

Reading for Better Writing

Working by yourself or with a group, answer these questions:

1. Examine the report's format and organizational strategies. How is this workplace report similar to and different from the experiment report in this chapter?
2. Describe the tone of the report. What does this tone accomplish?
3. This report depends extensively on cause-effect thinking. Where do the writers use cause-effect thinking, and how effective is it?

Writing Guidelines



Model

Planning

- 1. Review the lab manual and any handouts.** In most science courses, studies and experiments are assigned through textbooks, manuals, and handouts. Study those materials to understand what you must do and why. Read background information on the topic in textbooks and other sources.
- 2. Use a field or lab notebook.** Accurate, complete record keeping is crucial to doing good scientific research. Use the notebook to plan research, record what you do, collect data, make drawings, and reflect on results. For each notebook entry, record the date and your goal.
- 3. Plan and complete your study or experiment.** Do the following:
 - Develop your key research questions. If you are conducting an experiment (not just a study), then state your hypotheses and design procedures for testing them.
 - Gather the proper tools, equipment, and materials required.
 - Carefully conduct your tests and perform your observations.
 - Take copious notes, being especially careful to record data accurately, clearly, and completely. If helpful, use a data-collection sheet.

Drafting

- 4. Relying on your notebook, draft the report.** Study the data. Were results expected or unexpected? Which factors could explain those results? What further research might be necessary? Then draft the report in the sequence outlined below:
 - Methods:** Explain what you did to study the topic or test the hypothesis. Supply essential details, factors, and explanations. Be so clear that someone else could repeat the steps you took.
 - Results:** Using two strategies, present the data you collected. First, share data in graphical forms—as tables, line charts, bar graphs, photographs, and so on. While the correct design of graphics and the proper presentation of statistical data are beyond the scope of this book, follow this basic rule: Make your graphic independent of the written text by giving it a descriptive title, clear headings and labels, units of measurement, and footnotes. Readers should be able to study your graphics and see the “story” of your study. Second, draw attention to the major observations and key trends available in the data. However, do not interpret the data in your results or give your reactions to them.
 - Discussion:** Interpret the results by relating the data to your original questions and hypotheses, offering conclusions, and supporting each conclusion with details. Essentially, answer the question, “What does it all mean?” Explain which hypotheses were supported, and why. Also explore unexpected results, and suggest possible explanations. Conclude by reemphasizing the value of what you learned.

Introduction: Once you have mapped out the methods, results, and discussion, write an introduction that creates a framework for the report. Explain why you undertook the study, provide background information and any needed definitions, and raise your key questions and/or hypotheses.

Summary or abstract: If required, write a summary of your study's purpose, methods, results, and conclusions. An abstract is a one-paragraph summary that allows readers to (1) get the report in a nutshell and (2) determine whether or not to read the study.

Title: Develop a precise title that captures the “story” of your study. Worry less about the length of the title and more about its clarity.

Front and end matter: If required, add a title page, references page, and appendixes.

Revising

5. Improve the ideas, organization, and voice. Review your report, or ask a classmate or someone from the college's writing center to check the following:

- ___ **Ideas:** Does the report provide scientifically sound conclusions about accurate data related to a clear hypothesis or issue?
- ___ **Organization:** Is the traditional IMRAD structure followed effectively?
- ___ **Voice:** Is the tone objective and informed, but also inquisitive?

Editing

6. Edit and proofread the essay by checking for these conventions of science writing:

- ___ **Words:** The language is precise (not ambiguous), specific (not vague), and concise (not wordy); technical terms are defined as needed.
- ___ **Sentences:** Constructions flow smoothly, using the passive voice when needed to focus on the action and the receiver, not the actor. (See page 81.)
- ___ **Correctness:** The copy includes no errors in spelling, usage, punctuation, grammar, or mechanics. The writing follows the disciplinary conventions for capitalization, abbreviations, numbers, and symbols.
- ___ **Design:** The page design is correctly formatted and attractive, including presentation of graphics; information is properly documented.

Publishing

7. Prepare and share your report. Submit a polished report to your instructor. Also consider writing a relevant article, editorial, or blog post on the topic.