Classroom timeline and management tips

1 (45 minutes): **Teacher task:** View PowerPoint presentation about invasive species (see lecture at *www.collingelab.com/wp-content/uploads/2014/06/Litter-depth-experiment-lecture-2014.pdf*). **Student task:** Students use science notebooks to record observations from the presentation that indicate the need for an investigation.

Day 2 (45 minutes): **Student task:** Writing individually, have students state the purpose, background, and potential hypotheses. Then divide students into their long-term groups of three to. **Student and teacher tasks:** After grouping, have students discuss what they wrote and then report back to the class as a whole. Then regroup and discuss potential materials needed for the experiment before providing all students with a list of materials needed for the next day. Students can compare their materials list to the actual list

Day 3 (45 minutes): **Teacher task:** After a quick (10 minutes) recap of what was discussed previously, have students get in their groups and divide up group responsibilities. Each group will be responsible for preparing the soil and caring for, counting, and writing qualitative data for one treatment or pot (depending on size and number of classes). Students will be responsible for their pot or treatment for the entirety of the experiment. **Student task:** Students put the soil in the plots and place the pots of soil in a basin of water for 10 minutes to soak up the water. After the soil is wet, each group plants the 50 seeds per pot and covers the seeds with the appropriate amount of litter depending on the treatment (ensure litter depths are accurately measured). The trays of replicatescan be placed on a bench space that can be accessed for monitoring germination. The trays will remain in this location for the duration of the experiment.

Days 4–20 (10–15 minutes every second or third day): **Student task:** Students spend about 10–15 minutes per day counting seedlings, recording qualitative data in science notebooks, and discussing findings with their peers. Each student will benefit from the use of a magnifying glass during this stage of the investigation.

Day 21 (45 minutes): **Student task:** Student groups combine data of their treatment with the rest of the class. Spreadsheets are created and the data are graphed into a bar graph comparing the treatments and line graphs showing the changes to the seedlings over time. **Teacher task:** Using *NGSS* standard MS-ESS-3, ask students what type of graph they think would best represent the data. Also, once the data are plotted, have them interpret the data in their own words to show their mastery of the material.

Day 22 (45 minutes): **Student task:** Students discuss results in their small groups and write a conclusion that is supported with evidence from the data. **Teacher task:** Check in with students to see if their findings are the same as their hypotheses. Assure them that it is OK if the results differ from their hypotheses. This is an excellent learning tool to get them thinking of reasons why the results may or may not differ.

Days 23–25 (two to three 45-minute class periods): **Student task:** Students type lab reports. Graphs are inserted into the report and peer-editing commences.

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List of potential questions, hypotheses, and discussion points on the material.

Potential questions	Potential hypotheses	Associated discussion points
How does the increase of invasive litter depth affect native germination counts? *(Your most striking results will probably come from this question.)*	The greater the litter depth, the less germination will occur because of the physical barrier the invasive litter creates.	Why would a physical barrier stop germination? Does it inhibit light? Is it too heavy for the seeds to germinate through?
How does an increasing invasive litter depth affect native plant height?	The greater the litter depth, the shorter the native plant height because the physical barrier doesn't allow for upward movement.	If the invasives are bigger than the natives, are they squishing them? Is the litter-leaf structure difficult to push through? Does it look like the germinants are spindly and long, trying to find light?
How does increasing invasive litter depth affect native plant mass?	The thicker the invasive litter depth, the lower the native plant mass, because the physical barrier provides poor growing conditions.	Does the native leaf structure make it difficult for these plants to push through the litter layer?
How does increasing invasive litter depth alter leaf color?	The thicker the invasive litter depth, the lighter (and more yellow) the plant leaves will be because the litter layer doesn't let any light in and photosynthesis can't happen.	Plants need light for photosynthesis and the litter layer doesn't allow for any light. Why else are the germinants under the thicker litter layer lighter in color?

General outline and process of what should be included in each science notebook. All recorded information should be entered in this notebook to keep all written material in one location.

Setting up science notebooks

Teachers may choose to use science notebooks during this lesson. Headings and content, including the following, will help guide student inquiry:

Purpose: How can invasive plant litter affect germination and growth of a smaller-stature native species?

Background: Student notes and general summary of the plants being used.

Hypothesis: See potential questions and hypotheses.

Materials: Students can pick relevant materials from the supplies list.

Procedure: Students should develop a plan and keep detailed notes on variations from their plan over the course of the experiment.

Data/observations: A data/observations table should be kept over the course of the experiment.

Analysis: Students should visualize the data they collected. Spreadsheet software can be used to guide student thinking and analysis.

Conclusion: Students will also discuss why they think the germination numbers turned out the way they did and if this supported or did not support their original hypotheses. Students should be reassured that it is acceptable for the results to not support their hypothesis and to think critically about alternative explanations for their results.

Germinant-monitoring datasheet

This datasheet can be tailored to answer questions and observations specific to class size and students' chosen independent variables. For example, if there is a question about plant height across the variables, an additional column called "plant height (cm)" can be added.

Date	Treatment	Pot #*	Number of observed germinants	Ratio of germinants to seeds planted	Percent seeds germinated	Observation notes
	No litter	1				
	No litter	2				
	No litter	3				
	2 cm litter	4				
	2 cm litter	5				
	2 cm litter	6				
	7–9 cm	7				
	7–9 cm	8				
	7–9 cm	9				
*Each pot should have a unique identifier for monitoring ease, which can allow for students to have ownership over individual pots or trays.						

Possible extensions to the proposed litter-depth experiment

Extension	Student involvement
Repeat similar experiment with different litter types, seeds, or variables	Students can use different litter types, germinate different seed species, or alter the variables (e.g., watering levels/times).
Assign a unique invasive species of concern to individual students	Students can conduct research on the assigned species regarding its impact to the ecosystem and give a class presentation on their findings.
Public outreach	Students could prepare a letter to a local newspaper or public-service-announcement poster to raise invasive species awareness on a single invasive species or the general threat all invasive species pose on the environment.
Cross-curricular connection with social studies	Because humans are responsible for the introduction of invasive species, students can relate this to social studies concepts such as the trade and importation of potentially invasive species and what can be done to avoid this in the future.

Project rubric

Category	4	3	2	1
Journal/notebook	Clear, accurate, dated notes are taken regularly.	Dated, clear, accurate notes are taken occasionally.	Dated notes are taken occasionally, but accuracy of notes may be questionable.	Notes rarely taken or of little use.
Experimental design	Experimental design is a well-constructed test of the stated hypothesis.	Experimental design is adequate to test the hypothesis but leaves some unanswered questions.	Experimental design is relevant to the hypothesis but is not a complete test.	Experimental design is not relevant to the hypothesis.
Data	Professional-looking and accurate representation of the data in tables or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in tables or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in written form, but no graphs or tables are presented.	Data are not shown or are inaccurate.
Calculations	All calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results labeled appropriately.	No calculations are shown or results are inaccurate or mislabeled.
Analysis	The relationship between the variables is discussed and trends/patterns logically analyzed. Predictions are made about what might happen if part of the lab were changed or how the experimental design could be changed.	The relationship between the variables is discussed and trends/patterns logically analyzed.	The relationship between the variables is discussed, but no patterns, trends, or predictions are made based on the data.	The relationship between the variables is not discussed.
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report or shows little effort and reflection.
Appearance/ organization	Lab report is typed and uses headings and subheadings to visually organize the material.	Lab report is neatly handwritten and uses headings and subheadings to visually organize the material.	Lab report is neatly written or typed, but formatting does not help visually organize the material.	Lab report is handwritten and looks sloppy with cross-outs, multiple erasures, or tears and creases.