

Invasive Species

Name: _____ Hour _____ Date: _____

Date Packet is due: _____ Why late? _____ Score: _____
Day of Week Date If your project was late, describe why

Overview: in this unit, you will be learning about the Competition Exclusion Principle, ecological niches, and causes of extinction of living organisms as a result of the spread of invasive species.

Main Questions

- How does competition within a particular ecosystem role (or niche) affect the biodiversity of that ecosystem?
- How does the introduction of new species change the biodiversity, carrying capacity, and ecosystem services in a habitat?
- Why are some species more likely to become invasive than others?
- How does human activity affect the introduction and spread of invasive species?
- What can be done to slow or stop the spread of invasive species?

Weekly Schedule

Monday:

- Introduction to Invasive Species – Data Dive

Tuesday:

- Nutshell Video & Notes
- Class discussion & revisions of explanations

Wednesday:

- Option A: Invasive Species Prevalence Assessment (*outside*)
- Option B: Interview an Expert (*inside*)

Thursday:

- Review & Assessment

Friday:

- Weekly Reflection
- Career Connections – Peer Reviews of Resumes & Cover Letters

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Semester Schedule

Week 0: Introduction & Lab Safety

Atoms to Ecosystems

Week 1: Matter & Energy

Week 2: Cell Biology

Week 3: Biodiversity & Ecosystems

Week 4: Biodiversity & Habitats Lab

Week 5: Midterm Assessments

Causes of Extinction

Week 6: Extinction

Week 7: Habitat Loss

Week 8: Invasive Species

Week 9: Land & Water Pollution

Week 10: Atmospheric Pollution

Week 11: Overharvesting

Week 12: Midterm Assessments

Sustainable Societies

Week 13: Natural Resources Management

Week 14: Societies & Sustainability

Week 15: Individual Sustainability

Week 16: Personal Campaigns

Week 17: Personal Campaigns



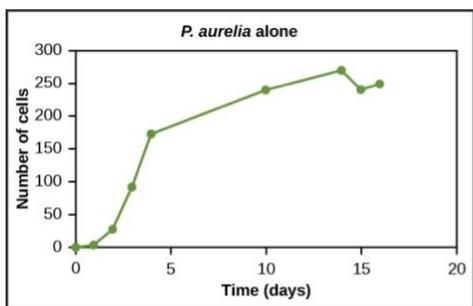
Day 1: Data Dive – Competition Exclusion Principle

Intro Video: <https://www.youtube.com/watch?v=QstJX8aR4ZM>

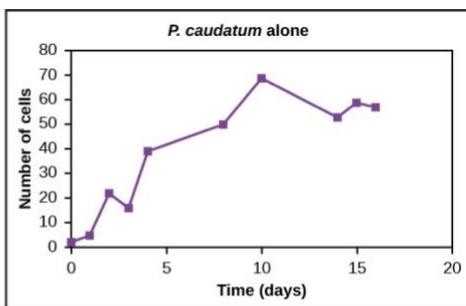
Overview: In this activity, your group will review data in order to identify patterns and trends that you will use to develop an explanatory model. You will then compare your observations and explanations to those of other groups in order to check your accuracy and refine your explanatory model.

Directions: look at the data provided below. Then use the data provided to you to answer the questions on the following page. If you are unsure about how to interpret the data, work with your group and seek help from your instructor if necessary. (Data sources: Gause, G. F. (1934). *The Struggle for Existence*. Courier Corporation; and MacArthur, R. (1958). *Population Ecology of Some Warblers of Northeastern Coniferous Forests*. *Ecology*, 39(4), 599-619. doi:10.2307/1931600)

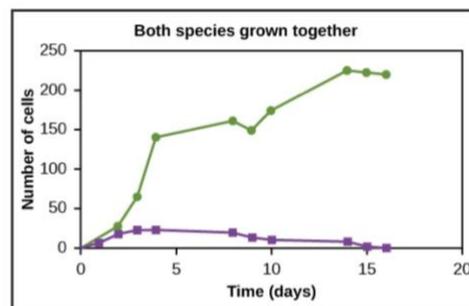
Summary of Research: the data from two studies are being presented below. In the first study (Gause, 1934), the researcher grew two species of single-celled organisms separately in a growth medium. The researcher then grew the two species of single-celled organisms together on the same growth medium and observed the differences in how each of their populations grew. The data is shown below.



(a)



(b)



(c)

Use a notebook, scratch paper, or a dry erase board to record your ideas and thoughts about the following questions. Be prepared to discuss these questions as a group and as a class.

1. Based on the data above, what are some conclusions that would be supported by this data?
 - a. How do you know that these conclusions are supported by this data?
 - b. What specifically suggests that your claims are accurate?

2. Based on these graphs, what can you presume about the impact of having two similar species existing in the same area?

I think that _____

In the second study (MacArthur, 1958), the researcher studied five species of warblers to determine where the individuals from each species were most likely to be found. The locations in which each species of warbler was most commonly found on the conifer trees of the studied forest is shown in the image to the right in orange.

Use a notebook, scratch paper, or a dry erase board to record your ideas and thoughts about the following questions. Be prepared to discuss these questions as a group and as a class.



3. Based on the data above, what are some conclusions that would be supported by this data?
 - a. How do you know that these conclusions are supported by this data?
 - b. What specifically suggests that your claims are accurate?
4. Why do you think that these birds were dispersed in this way? Provide a hypothesis below:

I think that _____

5. Biologists use a concept known as the **Competition Exclusion Principle (CEP)** to describe how similar species interact. This principle suggests that if two or more species who perform similar roles in an ecosystem are found in the same area, one species will outcompete the other species. This will cause the other species to go extinct in that area unless they can find another role to perform or find a different area in which to perform that role. In your groups, describe how the data and studies shown here relate to the Competition Exclusion Principle. Try to use specific examples from the data in your explanation.
6. In the 1948 MacArthur study, each of the warbler species occupied a different region of the tree. For the sake of this question, let's assume that each of the five species of warblers has a different predator. What might happen to the different warbler populations if the primary predator of the yellow-rumped warbler went extinct but the other four species of warbler were still affected by their respective predators?
7. An invasive species is usually a non-native species that is introduced into a new habitat. They displace other native species, reducing the biodiversity and function of that habitat. Examples of invasive species include Asian carp (a fish), buckthorn (a tree), and emerald ash borer (an insect). The invasive species typically performs a role similar to another species in that habitat. However, the introduced species usually lacks a predator and often has higher rates of reproduction, allowing it to reproduce faster than the native species that it displaces. How is this similar to the Competition Exclusion Principle?



Day 2: Notes & Discussion

Introduction & Directions: In this activity, you will begin by watching a short video about **invasive species**. This will help to clarify some of the questions you may have had yesterday. After the video, you will look at a short slideshow presentation that will provide you with specific information about this topic. Your instructor may decide to deliver the presentation as a classroom lecture or they may allow you to read the notes individually or in small groups (depending on your previous experience and capabilities with this content). After you have watched the video and finished with the slideshow, you will work in small teams to answer the questions listed below. You should take notes in a notebook, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. *Note: your instructor may assign your group to answer specific questions if time is limited.*

URL Links

YouTube Video: <https://www.youtube.com/watch?v=cu7cTOstOdQ>

Also consider: <https://www.youtube.com/watch?v=rPeg1tbBt0A>

Slideshow Presentation: https://www.factsnsf.org/uploads/1/4/0/9/14095127/2018-5-30_facts_invasive_species.pptx (or visit factsnsf.org and use the menu bar).

Discussion Questions:

1. What is an invasive species? Are *introduced species* the same as *invasive species*?
2. How do invasive species affect the biodiversity and carrying capacity of an ecosystem?
3. What is a niche in an ecosystem? How do invasive species change an ecosystem's niches?
4. Briefly summarize the Competition Exclusion Principle and explain how it relates to the impact of invasive species on an ecosystem.
5. Use the characteristics of invasive species to determine whether a species has the potential to become invasive.
6. Summarize how human activity, especially transportation and disturbances, enable invasive species to spread and become established.
7. Explain how the Invasion Curve relates to the effectiveness of human actions to control the spread of invasive species.
8. Summarize the four categories of management that can be used to prevent the spread of invasive species.
9. For a given ecosystem, select strategies that could be adopted to prevent the spread of invasive species in that particular habitat given its specific characteristics.

Be sure to revisit your explanations from the previous day's activity and add details or corrections as needed.



Day 3 – Option A: Invasive Species Risk Assessment

Overview: In this activity, you will be visiting a nearby habitat or portion of your school’s campus to assess whether or not invasive species are prevalent in this area.

Materials: published guides or internet printouts of invasive species that are currently affecting your area (your state’s department of natural resources would likely have resources available for this purpose).

Directions: Your instructor will provide you with details about the specific area you are visiting prior to leaving for this lab. You should complete the questions below and on the next page based on your observations of this particular ecosystem. Be prepared to discuss your findings and defend your conclusions using evidence during a whole-class discussion. If time is limited, your instructor may assign specific invasive species to your group.

1. Evidence: Do you see any evidence of invasive species affecting this area? Yes / Possibly / No

Which invasive species were you able to identify? _____

2. Habitat Disturbances: do you see any evidence of habitat disturbance occurring here as a result of these invasive species? Yes / Possibly / No What evidence supports this conclusion?

3. Niches: choose a particular invasive species: _____ . What niche is this species filling?

Example: a plant species would likely be a producer but could also provide pollen for insects if it has flowers.

4. Competition Exclusion Principle: do you see any evidence of the CEP occurring here as a result of invasive species? Yes / Possibly / No

What evidence supports this conclusion? _____



5. Invasive Characteristics: choose one of the invasive species that you found and list the species below:

Do you see any evidence of the following characteristics? Check the box for any characteristics that apply to this particular species:

- They grow rapidly and outcompete native species in a similar niche.
- They produce large numbers of seeds/offspring, and often at a young age.
- Their seeds/eggs can survive harsh conditions.
- They can travel long distances.
- They have few if any predators.
- Their native region has a climate similar to the affected habitat.
- They have multiple reproductive strategies.
- They have few, if any, specific needs.

6. Transportation & Disturbances: how do you think that this species became established? Discuss how human-caused transportation and/or disturbances may have affected the spread of this species in this area:

7. Recommendations: based on topics that you covered earlier this week, what are two ways in which the effects of these invasive species could be most easily minimized or reversed?

Recommendation #1: _____

How it could help: _____

Recommendation #2: _____

How it could help: _____

8. Final Assessment: How common is the prevalence of invasive species in this area? Rare/Moderate/Abundant

Why did you choose this? _____



Day 3 – Option B: Interview an Expert

Introduction: In this activity, you will have an opportunity to interview an individual with professional expertise in this week’s content topics. This activity will be reflective of *social science* research, or gathering, analyzing and interpreting information about human interactions. Often this work is conducted using *qualitative interviews*, which are interviews designed for research and data collection.

This activity will be divided into three parts:

1. **Part 1 – Planning:** After your instructor describes today’s guest speaker, your group will identify your research question using the prompts below. Your research question should pertain to the topics covered in class this week. Based on your research question, you will develop questions that might help you to gather information that can help you to answer your research question. Your instructor will ask your group to share your research question and interview questions prior to the interview and make sure that a variety of questions are ready.
2. **Part 2 – Interview:** Your instructor will facilitate the interview; they may choose to ask groups to ask their questions in a specific order (semi-structured approach), or they may choose to use an unstructured approach to the interview. Your group should record field notes during this time that you will use at the end of the hour to address your research question.
3. **Part 3 – Analysis & Debrief:** You will be provided with some time to consider the responses that they receive and reach a tentative conclusion about their research question based on this data.

Part 1 - Planning:

1. Briefly summarize the topics that were covered in class this week in one sentence: *This week in class,*

we studied _____

2. As a group, discuss what questions you still have about this week’s topics. Ideally, these questions should be open-ended (try to avoid Yes/No, Good/Bad, or Agree/Disagree kinds of questions). It can be helpful to use some of the following to start your questions: *Who, What, When, Why, How*

1. _____

2. _____

3. _____

Once you have developed three questions, ask for your instructor to provide you with some feedback.

3. From this list, choose a research question for your group and complete the prompt below:

Research Question: *We are unsure if* _____



4. Turn your research question into a hypothesis. What do you think is the answer to your research question given what you currently know?

We hypothesize that _____

5. What information could today's guest speaker provide that might help you to answer your question? Briefly describe how this individual's background and expertise is relevant to your research question:

6. Create three interview questions that you could ask this individual that may provide information related to your research question. Try to focus on their particular area of expertise as you craft your questions.

1. _____

2. _____

3. _____

7. Be prepared to briefly describe your research question and hypothesis, and how your interview questions will provide you with information that will help to address your research question.

Part 2 – Interview Field Notes

Use the space below to record some field notes as the guest speaker presents to the class. Record anything that you hear or observe that might be relevant to your research question. Note: you should also consider recording the guest speaker's responses to other group's questions if they are relevant to your own research question.



Part 3 – Analysis & Debrief (*your instructor may choose to use oral responses as well as or instead of written*)

What are your conclusions based on the guest speaker’s responses? Answer the questions below.

1. What was your hypothesis? _____

2. Does your data (your observations and field notes from your interview with the guest speaker) support or refute your hypothesis? Circle one: *Supports it* / *Refutes it* / *Not sure*

Explain: _____

3. Does your data adequately answer your research question? What are the limitations of your findings? Could *bias* or *representativeness* be a concern? (*Ask you instructor for guidance if needed*).

4. List two new questions that emerged as a result of your interview today:

1 _____

2 _____

5. If you were to continue this work, what kinds of investigations would you do next? Describe a potential research experiment that would be a suitable follow-up for today.



Day 4: Review & Assessment

Directions: you will begin by reviewing the unit objectives in your small groups. For each objective, rank it as a 1 (*completely unsure*), 2 (*somewhat unsure*), or 3 (*completely sure*) based on your comfort with that objective. After a few minutes of review, your instructor will lead a whole-class review. This is your chance to ask any questions you still might have about the concepts in this unit. Begin with anything you ranked as a “1”.

After you have completed the unit review, you will be taking an individual multiple choice quiz and/or a group short answer quiz. These quizzes may be graded in class to help you better understand the question and the correct answer.

Unit Objectives:

1. What is an invasive species? Are *introduced species* the same as *invasive species*?
2. How do invasive species affect the biodiversity and carrying capacity of an ecosystem?
3. What is a niche in an ecosystem? How do invasive species change an ecosystem’s niches?
4. Briefly summarize the Competition Exclusion Principle and explain how it relates to the impact of invasive species on an ecosystem.
5. Use the characteristics of invasive species to determine whether a species has the potential to become invasive.
6. Summarize how human activity, especially transportation and disturbances, enable invasive species to spread and become established.
7. Explain how the Invasion Curve relates to the effectiveness of human actions to control the spread of invasive species.
8. Summarize the four categories of management that can be used to prevent the spread of invasive species.
9. For a given ecosystem, select strategies that could be adopted to prevent the spread of invasive species in that particular habitat given its specific characteristics.

Day 5: Career Connections

Directions: Begin with a group and class discussion about the topics of this week. What is still unclear? What is still confusing? What seemed most important to remember? How does this relate to Natural Resources? How does this relate to your potential future career?

Then complete have students complete a peer review of a partner’s resume and cover letter. Students should use this feedback to create a revised version of these documents. Students should submit the original resume and cover letter as well as their revised version and their peer review critiques.



Invasive Species Individual Quiz

Name: _____ Hour _____ Date: _____ Score: _____ /

Directions: This quiz should be completed on an individual basis. A 3x5 notecard with handwritten notes can be used on this quiz.

- 1. Which of the following *best* describes an invasive species?**
 - a. Any species that exists in a location where it would not naturally be found.
 - b. A species that disrupts normal ecosystem function by displacing other species.
 - c. A species that is moved by human activity.
 - d. A species that cannot survive in habitats other than its own native habitat.

- 2. An invasive species would most likely _____ the carrying capacity of a habitat.**
 - a. Lower
 - b. Raise
 - c. Not affect

- 3. True or false: most introduced species become invasive species.**
 - a. True – when a species is moved to a new area, it almost always displaces the native species within its niche.
 - b. False – only native species can become invasive. Introduced species almost never survive in their new habitats.
 - c. True – introduced species and invasive species are both terms that describe the same thing.
 - d. False – only 10% of introduced species are able to become established and 1% become invasive, but those that do are capable of reducing biodiversity and ecosystem services.

- 4. Which of the following best describes a niche?**
 - a. Species that are dependent on very specific habitat conditions found only in a particular area.
 - b. The phenomenon where one species will eventually displace other species that perform a similar role in a location.
 - c. Species that don't have specific needs and can reproduce or acquire food using multiple strategies.
 - d. The role that a species plays in an ecosystem.

- 5. Which of the following best describes a habitat generalist?**
 - a. Species that are dependent on very specific habitat conditions found only in a particular area.
 - b. The phenomenon where one species will eventually displace other species that perform a similar role in a location.
 - c. Species that don't have specific needs and can reproduce or acquire food using multiple strategies.
 - d. The role that a species plays in an ecosystem.

- 6. Which of the following best describes the Competition Exclusion Principle?**
 - a. Species that are dependent on very specific habitat conditions found only in a particular area.
 - b. The phenomenon where one species will eventually displace other species that perform a similar role in a location.
 - c. Species that don't have specific needs and can reproduce or acquire food using multiple strategies.
 - d. The role that a species plays in an ecosystem.



7. How does the Competition Exclusion Principle relate to invasive species?

- a. CEP explains why so few introduced species become invasive; most native species are better adapted for their niches than species that evolved elsewhere.
- b. CEP suggests that if an invasive species is able to outcompete similar native species in its niche, the invasive species will eventually take over and displace the native species.
- c. If an invasive species lacks a predator, it is easier for it to outcompete the native species, and CEP suggests that it is not possible for both species to occupy that same niche over time.
- d. All of the above accurately explain how CEP relates to invasive species.

8. Which of the following is most likely to become invasive to the Midwest?

- a. A large tropical mammal that produces one or two offspring per year and can survive in most areas with year-round supplies of green grass.
- b. A flying insect from the Amazon that produces large numbers of eggs and is adapted to year-long warm weather.
- c. A flowering plant that is susceptible to frost and requires very specific soil conditions to thrive.
- d. A species of cactus that thrives in hot, sandy conditions and produces its first seeds after 20 years of growth.
- e. A plant from central Asia that is adapted to cold weather and produces large numbers of hardy seeds that stick to fur or clothing.

9. Which of the following is most likely to become invasive to Florida?

- a. A large tropical mammal that produces one or two offspring per year and can survive in most areas with year-round supplies of green grass.
- b. A flying insect from the Amazon that produces large numbers of eggs and is adapted to year-long warm weather.
- c. A flowering plant that is susceptible to frost and requires very specific soil conditions to thrive.
- d. A species of cactus that thrives in hot, sandy conditions and produces its first seeds after 20 years of growth.
- e. A plant from central Asia that is adapted to cold weather and produces large numbers of hardy seeds that stick to fur or clothing.

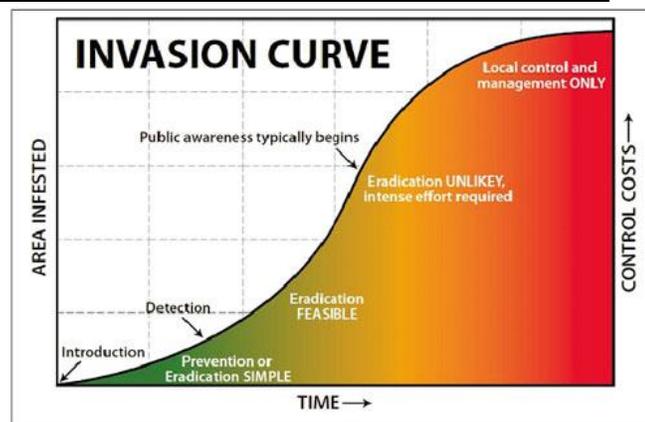
10. Summarize how the following types of human activity aid the spread of invasive species:

Transportation: _____

Disturbances: _____

11. Which of the following statements would be supported by the Invasion Curve (right)?

- a. Prevention is the most affordable and most effective strategy to stop the spread of invasive species.
- b. Public awareness of invasive species usually only occurs after prevention is no longer possible.
- c. The longer the public waits before fighting an invasive species, the more costly it becomes.
- d. By the time that the public is aware of an invasive species, it is nearly impossible to eliminate that species.
- e. All of the above are supported by the Invasion Curve





- 12. The use of herbicides to kill invasive species would be this kind of management strategy.**
a. Natural b. Nonchemical/Mechanical c. Biological d. Chemical
- 13. Physically removing invasive plants would be this kind of management strategy.**
a. Natural b. Nonchemical/Mechanical c. Biological d. Chemical
- 14. Increasing the numbers of predators of an invasive insect would be this kind of management strategy.**
a. Natural b. Nonchemical/Mechanical c. Biological d. Chemical
- 15. The fact that invasive fire ants are unable to spread to areas that freeze in winter reflects this kind of management strategy.**
a. Natural b. Nonchemical/Mechanical c. Biological d. Chemical
- 16. Building a new path or road through a forest would ___ the risk of invasive species because...**
a. Decrease the risk... it would increase the biomass production and biodiversity of that ecosystem.
b. Increase the risk ... it is a form of habitat disturbance and increases the risk of transporting new species to that area.
c. Not affect the risk ... invasive species cannot live on roads or heavily-used paths.
- 17. In the space below, list *and* describe three strategies that a school forest could use to prevent the introduction and spread of invasive species in that habitat.**

1. _____

2. _____

3. _____



3. Briefly summarize the Competition Exclusion Principle. Then use it to explain why invasive species threaten biodiversity and the carrying capacity of a habitat.

Writer's Name:

4. Choose a species native to North America that could have a high likelihood of becoming invasive on other continents. Then explain why you think this species could become invasive using some of the 8 characteristics common to invasive species.

Species: _____ Why it has a high chance of becoming invasive: _____

Writer's Name:

5. If you had to create a prevention plan to stop the introduction of more invasive species, what would be your top priorities? Include in your answer how humans enable the spread of invasive species and be sure these factors are included in your plan.

Top Priority: _____

Why? _____

Second Priority: _____

Why? _____

Writer's Name:



Appendix: Data Dives / Case Studies

Overview: Data Dives and Case Studies are exercises in which students are presented with data from experiments or scenarios, and are asked to identify trends and develop explanatory models in a process that is very similar to what actual scientists do on a regular basis.

Directions: Students should consider the data or scenario in their assigned groups. They should work with their group members to make sense of the information provided and try to determine the conclusions that can be drawn from it. Students may struggle with this, especially in their first attempts and particularly if your students have limited experience reading graphs and data tables. It may be necessary for you to project the data onto a large screen and guide students by explaining the steps that you would use to make sense of what is being reported. This may be difficult; just like explaining the steps of tying your shoes can be challenging because you rarely have to think about it, it can be exceptionally challenging for someone who is scientifically literate to identify the thought processes that they use to make sense of data. It may be helpful to jot down your ideas in advance and have them ready prior to the start of this class.

Students are likely to struggle to varying extents. That is ok! Be sure to float from group to group to assist. Be sure to remind group members to help each other out. It might ideal to assign groups with a mix of abilities. Encouraging struggling students to work with their better-prepared peers, and conversely, encouraging high performing students to advance their abilities by working with individuals with different skill sets helps to prepare students for the kinds of situations they will encounter in their careers and personal lives.

Plan to allow for about 15-20 minutes to introduce the activity and review how to interpret this information with your students. About a third to half of the class period should be reserved for allowing students to work in their individual groups. The remaining time should be reserved for intergroup or whole-class discussion so that students can engage in scientific debate and argumentation.

It would a good idea to remind students that the term *argumentation* is used differently between scientists and the general public. While argumentation generally has a negative connotation (such as a “heated argument”), argumentation among scientists is generally very good-natured and polite. The goal is not to “win” an argument but rather to expand the understanding of the phenomenon by all involved. Often scientists on opposing sides of an issue will both change their stance as a result of the improved understanding that results from engaging in argumentation. Similarly, students should not be trying to disprove each other or prove that they have the “right” answer. Rather, students should be examining the differences in their conclusions, the manner in which each conclusion was reached, and the similarities and agreements that exist among different conclusions.

Students may reach a conclusion that is not entirely supported by evidence. The temptation may be to point out errors in their reasoning. However, when students are struggling, they are also likely improving their abilities in evidence-based reasoning, which is one of the most important goals of this kind of instruction. Try to resist the urge to correct student errors; rather, try to probe their understanding and challenge them to re-examine the evidence to check the validity of their conclusions and the conclusions of other groups. Consider using the 9 Talk Moves (next page) to support productive classroom dialogue.

Remember – students should re-visit their explanations and models repeatedly over the course the week. If they don’t get it right on the first try, they will have more opportunities to do so.



Goals for Productive Discussions and Nine Talk Moves

Goal: Individual students share, expand and clarify their own thinking

1. Time to Think:

Partner Talk

Writing as Think Time

Wait Time

2. Say More: “Can you say more about that?” “What do you mean by that?” “Can you give an example?”

3. So, Are You Saying...?:

“So, let me see if I’ve got what you’re saying. Are you saying...?” (always leaving space for the original student to agree or disagree and say more)

Goal: Students listen carefully to one another

4. Who Can Rephrase or Repeat?

“Who can repeat what Javon just said or put it into their own words?” (After a partner talk) “What did your partner say?”

Goal: Students deepen their reasoning

5. Asking for Evidence or Reasoning:

“Why do you think that?” “What’s your evidence?” “How did you arrive at that conclusion?” “Is there anything in the text that made you think that?”

6. Challenge or Counterexample:

“Does it always work that way?” “How does that idea square with Sonia’s example?” “What if it had been a copper cube instead?”

Goal: Students think with others

7. Agree/Disagree and Why?:

“Do you agree/disagree? (And why?)” “Are you saying the same thing as Jelya or something different, and if it’s different, how is it different?” “What do people think about what Vannia said?”

“Does anyone want to respond to that idea?”

8. Add On:

“Who can add onto the idea that Jamal is building?”

“Can anyone take that suggestion and push it a little further?”

9. Explaining What Someone Else Means:

“Who can explain what Aisha means when she says that?” “Who thinks they could explain in their words why Simon came up with that answer?” “Why do you think he said that?”

Source: https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf



Appendix: Invasive Species Risk Assessment

Overview: In this activity, students will be assessing a habitat near your school to determine the prevalence of invasive species. For this exercise, this could include a non-landscaped area near your school's buildings (e.g. a grassy undeveloped area near some athletic fields could work well, as could a wooded area).

Materials: a local habitat; invasive species guides (contact your state department of natural resources; you'll need copies for each group).

Directions: the distance of the habitat from your classroom may limit the extent to which your students can complete all components of this lab. If your habitat is a considerable walking distance, you may opt to limit the number of species that your students assess. You can also use a more human-managed area of your school's campus that has identifiable invasive species.

Students should use their observations to answer the accompanying questions. Encourage students to use their class resources (particularly their notes) to work in teams to answer the lab questions. If time allows, it would be ideal to have students report their findings and conclusions and discuss the validity of their conclusions, as well as their level of confidence in their findings.

Be sure to remind students to dress appropriately and to be aware of the weather forecasts for the day of the activity. Make sure that administrators and parents are informed in advance; your school board or administrators may require permission slips to leave the school building. Make sure to take into account students with special needs and students with medical considerations (particularly those with stinging allergies). You should carry a cell phone or other means of communication while outside of the school building, and school administrators and secretaries should know how to reach you on this device.



Appendix: Interview an Expert

Introduction: In this activity, students will interview a member of your community with expertise in agriculture and/or sustainability. Examples could include DNR officials, university extension agents, etc. As an instructor, you will need to make arrangements for a guest speaker at least a week in advance (ideally sooner). Once you have found a volunteer who is willing to speak to your class, please inform them that this class activity is being designed to reflect how social scientists conduct research. Your guest speaker should know that students will be preparing research questions and hypotheses, and will be designing their interview questions to provide insights that may help them to address these questions in a manner similar to a social scientist.

This activity will be divided into three parts:

1. **Part 1 – Planning (15-20 min):**
 - a. Inform students of the guest speaker (or introduce them if they are there in person). Explain how their work pertains to this week's content.
 - b. Have student groups identify their research question using the prompts on the worksheet. Their research question should pertain to the topics covered in class this week. Remind students that questions should be thoughtful, insightful, and respectful. You should provide examples to students if they might struggle with this.
 - c. Have groups share your research question and interview questions prior to the interview and make sure that a variety of questions are ready.
2. **Part 2 – Interview (15-20 min):**
 - a. Serve as the facilitator of the interview. You may choose to ask groups to ask their questions in a specific order (semi-structured approach), or you may choose to use an unstructured approach to the interview.
 - b. Remind groups to record field notes during this time to use at the end of the hour to address their research question.
3. **Part 3 – Analysis & Debrief (10 min):**
 - a. Have students address their hypothesis using their observations and field notes. This can be either verbal, oral, or both depending on what you think will work best.

It is recommended that you introduce this activity to your students earlier in the week (e.g. Monday or Tuesday) so that they can begin to mentally prepare their research questions in advance. Make sure that your students avoid turning this activity into something that might feel accusatory or incriminating to the guest speaker. Emphasize that this should be a respectful exercise in finding information by asking thoughtful questions, not an opportunity to criticize an individual for their work.

The guest speaker can either appear in person or via an online platform such as Zoom or Skype. An in-person guest speaker tends to be more impactful but can be harder to arrange. You could also conduct the interview in advance and show a recording of the interview if needed (this activity may need more modification for this option). You may choose to ask an introductory question to model a proper approach for your students. Whether students ask their questions in a specific order or utilize a free-for-all approach to asking questions is up to you as the instructor. Time may run short, but if possible allow time at the end of class for debriefing and analysis (ideally at least 10 minutes). You might choose to have students answer the Analysis and Debrief questions orally rather than in writing to save time if that would be helpful. It is also an option to postpone the Analysis and Debrief to a later day.



Appendix: Review and Assessment

Introduction: In this section, we will discuss strategies to guide your students during review and assessment for a vocabulary-intensive unit.

While recent reforms to science education (as outlined by the NRC’s *K12 Framework* and NGSS) minimize the emphasis on having students learn vocabulary, we have found that we cannot completely eliminate vocabulary from ecological instruction for a number of reasons. Most importantly, we have found that in order for students to sufficiently engage in reasoning and sense-making about ecological phenomena, they need to have an appropriate language with which to develop explanations and solutions.

However, in the FACTS curriculum, we view vocabulary as a *means to an end* and not as a central objective to the curriculum. In other words, we don’t care very much whether students have memorized the definitions of terms, but whether they can accurately use those terms to describe and understand phenomena, and ultimately create evidence-based arguments, explanations, and solutions. We view vocabulary as part of a “sense-making toolkit” that enables students to organize their reasoning and argumentation.

As such, we recommend that you provide students with opportunities to practice mastering the vocabulary in this course while also recognizing that mastery of vocabulary is a secondary objective in these units. This means that assessing vocabulary can work as a formative assessment but is not ideal by itself as a summative assessment. The primary goal of this curriculum is to enable valid evidence-based reasoning and sense-making, and your summative assessments should reflect this.

There are a few strategies you might considering adopting to support these objectives:

- While multiple-choice assessments are provided in the weekly packets, we take the stance that these options should not be used by themselves as a final summative assessment.
 - o You might consider assigning this as optional homework, allowing students to use a 3x5 card with handwritten notes, and/or assigning completion points in lieu of scores based on the percent correct.
- Teachers have also created hybrids of the multiple choice and short answer assessments, selecting some questions from each option. Their experiences suggest that the multiple-choice assessments help to prepare students for the more intellectually rigorous short answer questions.
- You might also consider having a space on a chalkboard/dry-erase board for publicly posting course vocabulary or hanging a large sheet of paper and adding vocabulary and definitions if students start to struggle.
- Teachers have also used vocabulary practice as an option for a bell-ringer activity, using options such as short, ungraded online quizzes to start class.

You as the instructor are best positioned to decide what will be most effective for your classroom. Feel free to use or disregard these suggestions as you see fit. However, we do strongly recommend that you avoid positioning memorization of vocabulary as one of the primary objectives of this course, and instead emphasize valid reasoning and sense-making about ecological phenomena as your top priority.