CAUSAL LEARNING IN THE CLASSROOM (CLIC)

CURRICULUM MODULES

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OVERVIEW

The Causal Learning in the Classroom (CLIC) modules are designed to complement existing curricula in environmental ecosystems and climate change science. They are focused on the scientific content, principles, and habits of mind. The CLIC modules aim to augment students' learning by revealing to them patterns of thinking that impact their ability to perceive, attend to, and reason about the complex causal patterns embedded in science. They bring science content together with what we know about the nature of human cognition to 1) further what students understand and 2) help students realize why some of these concepts are hard for the public to understand and attend to. It invites students to think creatively about these challenges as they develop their own knowledge and create sustainable lives in our world.

There are two modules in the current set:

1. Becoming Global Thinkers: Thinking about Distant Causes and Effects
2. Becoming Responsible Individuals: Understanding Distributed Causality.

Each module is based upon research that has been carried out on how people think—both in the lab and in the classroom. It is designed to build upon affordances in students' knowledge, taking what they know from the everyday world and building deeper, more reflective understanding from it.

The CLIC modules also aim to increase sensitivity, ability and inclination to attend to complex causal patterns. By "sensitivity" we mean that students will be more likely to perceive and attend to each pattern. They will know how to detect it and will know the challenges involved in noticing it and actually turning their attention towards it. By "ability" we mean that they will understand how the pattern works, what is involved, and when it is likely to occur. Essentially, students will develop some techniques to help them to think about it well. By "inclination" we mean that students will understand why the patterns warrant attention—why we should care—and hopefully will be more inclined to see these patterns in their daily lives.

Each module contains four lessons that introduce the big ideas centered around complex causality. The lessons are also situated around climate change and environmental science content to encourage the further development and application of these concepts. Finally, the CLIC modules also include additional resources and extensions that teachers may wish to use to extend and reinforce the concepts. The lessons begin with background information for the teacher to help her/him better understand how people typically reason about the concept and understand its importance. Each lesson engages the students in an activity to help reveal and examine their current thinking and offer opportunities to challenge and deepen their thinking. A connection-making step asks them to consider opportunities to transfer the concepts. Side boxes with notes to the teacher highlight important ideas and offer extensions.

Why bother to teach these lessons? The habits of mind that are encouraged are those that the next generation will need to live together on Planet Earth.

INSTRUCTIONAL APPROACH

The activities in this module are best supported by a classroom culture that fits with the following suggested actions.

COLLABORATIVE LEARNING

- Help the students to help each other create a safe—nonjudgmental—environment. Doing their best thinking requires that they feel comfortable sharing their ideas. It also means that they do the thinking because they value it, and not just to impress someone else.
- Encourage students to take risks in their thinking and to test their ideas in a social context. No ideas should be shot down; instead, relevant evidence should be considered.

DEVELOPING NEW IDEAS

- Encourage students to think about and feel comfortable revising their thinking. We are exploring ideas that pull against our typical tendencies so, in many respects, these may be new ways of thinking. The purpose is to explore new ideas, and not to just get to the "right" answer.
- Emphasize developing understanding and the importance of transferring understanding to new contexts.
- Encourage students NOT to accept ideas just because someone else says that they are so. Students should change their ideas when they find that the evidence is convincing.

METACOGNITION

- Recognize that students come to class with general principles about how the world operates as a result of their own attempts to make sense of the world. Offer opportunities for them to reflect on their own thinking.
- Encourage students to think about their thinking—to try to be metacognitive. Being able to apply the ideas in the module in the real world necessitates being reflective and noticing opportunities in the moment. That involves being able to step back and ask yourself, "How am I thinking about this right now? In what other ways could I think about it?"

MODULE 1

BECOMING GLOBAL THINKERS: THINKING ABOUT DISTANT CAUSES AND EFFECTS

Overview: Thinking about Action at a Distance

Lesson 1: Action at a Distance: Thinking Across Spatial Gaps in Science

Lesson 2: Figuring Out the Connection Between Distant Causes and Effects

Lesson 3: Applications: A Watershed Case Study in Cambridge, MA

Lesson 4: Applications: How Can What I am Doing Here Hurt the Polar Bears?

MODULE 1
OVERVIEW:

THINKING ABOUT ACTION AT A DISTANCE

This first module focuses on the idea that causes and effects can be very far apart from one another, and that this makes it harder to reason about the causal relationship. Very young children expect causes and effects to touch each other in a physical sense. However, they also learn that there are certain kinds of causes, such as remote controls and web cams, that can make things happen without having to physically touch. By preschool, children are already beginning to recognize causes that can act at a distance from their effects.

Understanding action-at-a-distance and actually thinking about it explicitly are two different things. Often the causes of the effects fall outside of our attention span so we aren't aware of them. Even if someone makes us aware of them, it can be hard to keep them on our radar. We tend to focus on what is closest to us (spatially local) because it falls within our attentional space. It is also easier to notice local effects with distant causes rather than local causes with distant effects. For example, it's easier to backwards-map and figure out that pollution in a pond (an effect) might have come from fertilizer runoff (a more distant cause) than it is to predict all of the possible effects a tsunami might have around the world. This is because when we see something happen, we typically try to explain why it happened—we search for reasons. If there is not a possible local cause, then we may extend our search to more distant ones. On the other hand, if there is a plausible local explanation, we are likely to assume that it is the cause (whether or not it is) and not look further. When a local cause has a distant effect, we may be completely unaware of it.

Students bring a tendency to focus in spatially local ways to their science learning. This complicates a variety of understandings including how satellites work (students think that they have inertia that drives them rather than their path resulting from their forward movement and the gravitational attraction of the earth), how large watersheds and pond ecosystems extend well beyond the edges of the pond, and how events on one side of the globe, such as volcanic eruptions, can impact weather patterns a great distance away.

In learning about science and how to think like scientists, students need to realize the importance of thinking about action at a distance, and to see its relevance to the deep understanding of many topics. There are three ways that we can pay better attention to how causes close by can have effects far way:

1. By realizing that causes and effects can be distant from each other, we can push beyond looking locally and explicitly ask,
    - Is there something going on far away that is causing this?
    - Is there something happening here that is having distant effects?
    - Does this action cause effects far away?

MODULE 1
OVERVIEW:

THINKING ABOUT ACTION AT A DISTANCE

2. We can build an understanding of how different mechanisms work. For example, understanding that
   - fluids can move around, such as in global weather patterns (even if we can't see them),
   - the moon's gravitational pull impacts the water on Earth to create tides, or
   - remote controls can activate devices from a distance.
3. We can pay attention to the intermediate connections along the way and build a domino-like narrative of what is going on. For instance,
   - visualizing the rain over an extended area filling up small tributaries and those leading to bigger bodies of water and eventually those flowing into the Mississippi River and impacting the City of New Orleans, or
   - "connecting the dots" between decisions to buy inexpensive t-shirts in the USA, and the supply chain that reaches across continents to labor conditions in poorer nations to weak child labor laws in those places.

The lessons in this section use these three approaches to help students think about spatially distant causes and effects.

MODULE 1
LESSON 1:

ACTION AT A DISTANCE: THINKING ACROSS SPATIAL GAPS IN SCIENCE

BACKGROUND INFORMATION

This first lesson focuses on the idea that causes and effects can be very far apart from one another. This makes it harder to reason well about the causal relationship. Very young children expect causes and effects to touch each other in a physical sense. However, they also learn to realize that there are certain kinds of causes (e.g., remote controls, web cams, etc.) that can make things happen without having to physically touch. By preschool, children are already beginning to recognize causes that act at a distance from their effects.

ACTION-AT-A-DISTANCE
The idea that causes and effects can be separated in physical space (even by great distances).

SPATIALLY LOCAL
The cause and effect occur in close proximity, within the same location.

Understanding **action-at-a-distance** and explicitly thinking about it are two different things. Often the causes of the effects fall outside of our attention span so we aren't aware of them. If someone makes us aware of them, it is hard to keep them on our radar. We tend to focus on what is closest to us, or **spatially local**, because it falls within our attentional space. Students have a tendency to focus on spatially local ways in their science learning. The goal of this curriculum is to help students become more aware of action-at-a-distance. For some students, this lesson may represent the first time that they discuss the idea of cause and effect. Therefore, the lesson begins in a very basic way by introducing the concepts and asking them to generate examples from their experiences.

UNDERSTANDING GOALS

1. Causes and effects can be far apart.
2. We tend to notice causes and effects that are close together; it can be harder to pay attention to effects that are far away from their causes.
3. Science often involves paying attention to broad patterns and this often means attending to causes and effects that are very far apart.
4. Knowing the story behind how something happens can often help us connect causes and effects that are far apart.
5. We need to remind ourselves to consider distant causes and/or effects because it is so easy to forget.

See accompanying Power Point and Appendix for more resources!

MODULE 1
LESSON 1:

ACTION AT A DISTANCE: THINKING ACROSS SPATIAL GAPS IN SCIENCE

DEFINING A COMMON VOCABULARY: WHAT ARE CAUSES AND EFFECTS?

DISCUSSION

1. Engage the students in a discussion about what causes and effects are. Ask, "What is a cause?" List their ideas on the board. Common responses may include, "they make something happen," "they are the reason that an effect happens,"etc.
2. Then ask, "What is an effect?" Collect their ideas and write them on the board. Students will often respond by telling you, "the thing that the cause made happen." If they do, point out how difficult it is to talk about causes without talking about effects and vice versa. The concepts are linked to one another.

> It is common for students to offer examples of causes instead of definitions. If they do, put them in a separate list on the board and ask, "What makes all of these things 'causes'"?

3. Wrap up this part of the discussion by agreeing with the students on a working definition of "causes" and "effects." Explain that in the coming days they will be learning a lot more about how causes and effects behave, and that they will be using a wealth of knowledge that they have already collected in their everyday lives to help their learning.

CHALLENGE: If the students define a cause as something that "is followed by an effect" or an effect as something that "comes after a cause," challenge their thinking with some examples that are purely correlational so that even though one thing follows another, it is not caused by it. For instance, if they get sick after breakfast, it could mean that breakfast was the cause, but it might not be. It is possible that they would have gotten sick whether they ate breakfast or not.

REVEALING CURRENT THINKING: DO CAUSES AND EFFECTS NEED TO PHYSICALLY TOUCH EACH OTHER?

4. Pose the question to the students, "Do all causes and effects have to touch each other?"
   - Explain, "If I kick a ball, the cause and effect are right next to each other and they physically touch, but is that always the case?"
   - Write on the board, "Do causes and effects have to touch?" Tell them to take a minute to think about their answers. Ask students to think of evidence as they support their responses. You may use the handout in the appendix if it's helpful.

MODULE 1
LESSON 1:

ACTION AT A DISTANCE: THINKING ACROSS SPATIAL GAPS IN SCIENCE

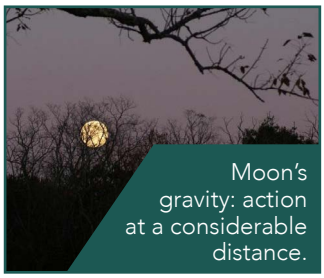
Give the students a minute to think about the question and their examples. Then collect a few responses. List these on the board or on chart paper. You will add to these in the next step, and you will also need this list for Lesson 2. Most students will say that they do not need to touch.

Common responses include magnets, shadows, remote controls, calling someone, using the phone, using the internet, and webcams. If students are struggling, you can show them this video of the moon's gravitational pull on the tidal waves: http://www.youtube.com/watch?v=l37ofe9haMU. See accompanying Powerpoint.

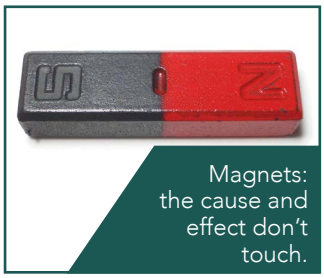
Then ask how far apart causes and effects can be. See if they can give one or two examples that are very far apart as well as one or two that are closer together.

RECASTING HOW THEY THINK ABOUT DISTANT CAUSES: EXTENDING THE CONCEPT

5. Have the students get into groups of two to three students. Give each group a large piece of chart paper and have them cluster their ideas to show causes that are really far apart (e.g., the moon's gravity pulling on the ocean water to make tides) as well as ones that are in the same place but don't touch (e.g., magnets). Have them brainstorm as many examples as they can think of.



Moon's gravity: action at a considerable distance.



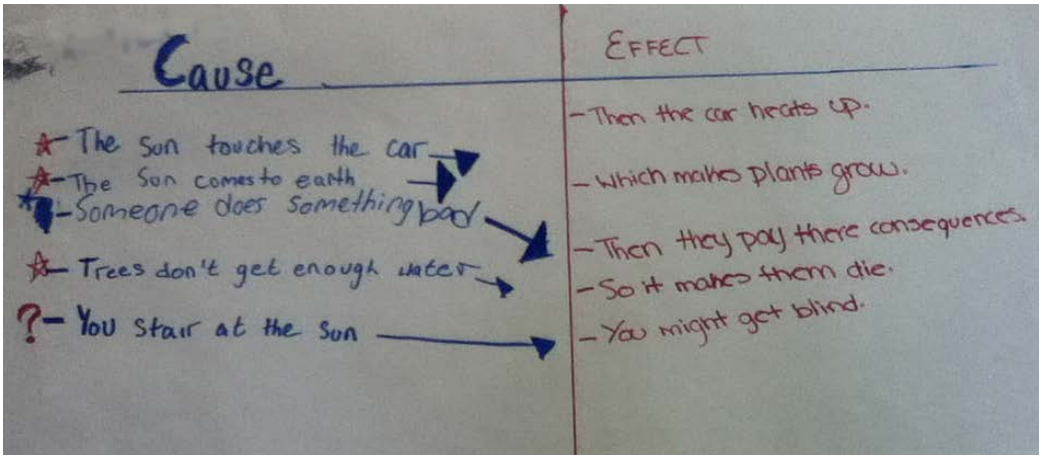
Magnets: the cause and effect don't touch.

- Give the groups at least 20 minutes to do their brainstorm. While they are working, circulate to talk with them about their thinking. Encourage them to think flexibly about different kinds of causes and effects. They should try to find ones from different categories (science, social interactions, visual patterns, etc.) Feel free to use the Thinking about Distant Causes and Effects handout that is attached in the appendix.

Remind the students that this is a brainstorm. Good brainstorming means that they should not filter their ideas at this point, but should put down everything that comes to mind. If they have questions about certain ideas, they could put a question mark or write their question next to it.

- As students push their thinking further, they often start to come up with a broader set of examples, for instance, being warmed from the sun, sending pictures on Facebook, getting a sunburn, texting someone far away and getting a message, greenhouse gases creating problems far from their source, and how the Japanese earthquake in 2011 caused garbage to float up on California beaches.
- After about 20-25 minutes, have the groups stop and reflect upon their brainstorm responses. Invite them to star or circle responses that they think are especially good examples of causes and effects that do not touch, and to add question marks to ones that they are unsure of.

Sample Student Poster



6. Have students post their brainstorm sheets around the room. Then invite the class to participate in a silent sharing. They should move around studying each chart with two questions in mind:
   - What is one new thing that they learned from other people's brainstorms that they did not think of in their group?
   - Do they see any big patterns in the thinking that the class has done? (Common responses include, "a lot of the answers use computers/technology in some way," "a lot of the answers involve social interactions," "some things in science just work that way—like getting energy from the sun.")
7. Come back together and discuss the patterns that they noticed. Capture these ideas somewhere in your classroom where they can see them and return to them in the coming weeks.

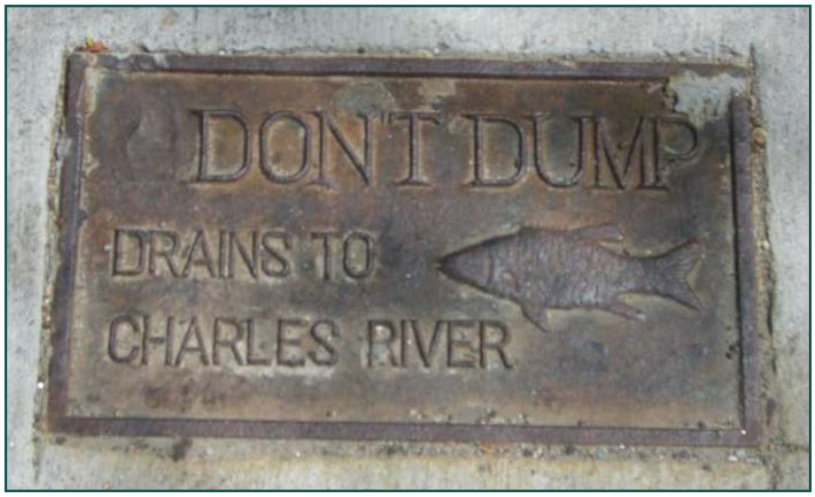
MODULE 1
LESSON 1:

ACTION AT A DISTANCE: THINKING ACROSS SPATIAL GAPS IN SCIENCE

REFLECTING UPON THE PATTERN: WHY IS IT SO HARD TO NOTICE CAUSES AND EFFECTS THAT ARE FAR AWAY FROM EACH OTHER?

8. Show the of the Fish Plaque from a street in the Cambridge/Boston area (see accompanying Powerpoint).
    - Ask, "What is the purpose of the plaque? Why is it needed?"
    - Guide the students toward the understanding that it is hard to pay attention to causes and effects that are separate in space and time. We tend to focus on what is in front of us at the moment. The plaque helps to address our human patterns of thinking. It turns out that the ability to filter out some information is important to our survival. If we paid attention to everything, we would be overwhelmed and unable to function, so we tend to narrow our focus.

Fish Plaque on Cambridge Street Corner



9. Show the image of the cap that reads, "Solar- powered." (see accompanying Powerpoint)
    - Discuss it. What do students think it means?
    - Do they agree or disagree?
    - What does it have to do with causes and effects that are "at a distance" from one another?

Students may or may not come to an agreement about this question in this lesson. In order to imagine how we are solar-powered, they need to think about the many intermediate steps that bring energy from the sun to us.

EXTENSION ACTIVITY

Have the students design an object or poster that gets people to realize that causes and effects can be far apart and that we have a hard time attending to them!

MODULE 1
LESSON 2:

FIGURING OUT THE CONNECTION BETWEEN DISTANT CAUSES AND EFFECTS

CAUSALITY
The relationship between something that happens or exists and the thing that causes it.

MECHANISM
A type of process or event—either physical, behavioral, or mental—that fuels an effect.

BACKGROUND INFORMATION

The purpose of this lesson is to raise the question of how people can know that distant causes and effects are related. It offers students two examples of distant causes and effects—one example that has a substantive mechanism that is fairly easy to see and trace, and one that has a more difficult to trace connection.

Research shows that when students can sketch the path between causes and effects that are distant from one another, they are able to link causes and effects that can be very far apart. Making those links involves knowing how things are connected and understanding how the **causal mechanisms** behind how something so far away can be linked to something so close by.

The first example looks at the flooding of New Orleans in the Spring of 2011. The winter of 2010 to 2011 had seen record snows. In addition, in April, there were two large storm systems that dumped record rainfall all along the Mississippi River watershed. By early May, the buildup of water from tributaries running into the Mississippi from both rain and melting snow began to swell the river to record levels. During these weeks officials anxiously monitored the build-up of water that was making its way towards the cities of New Orleans and Baton Rouge. The water flooded areas all along the river's path through the states of Illinois, Iowa, Missouri, Kentucky, Tennessee, Arkansas, Mississippi, and into Louisiana. In order to lessen the impact on cities downstream, officials had to open a spillway called the Morganza Spillway and flood portions of rural Lousiana. This decision was not without opposition. People living within the spillway flood zones lost their homes in order to avert a crisis that would have affected many more people farther downstream.

The second example looks at the March 2011 earthquake and related tsunami in Japan and the effects felt around the world. The quake occurred in the seas off the Northeastern coast of Japan. It was a magnitude 9.03 quake, one of the most powerful to ever have hit Japan, and one of the most powerful quakes in the history of record-keeping which began in the early 1900s. It triggered huge tsunami waves that were over 130 feet high and traveled as far as six miles inland in an area of Japan called Sendai. Nearly 16,000 people died, over 6,000 were injured and nearly 3,000 were unaccounted for. Over a million buildings were damaged, as well as roads, railway, and dams. Millions of households were left without electricity and water. The tsunami waves also caused nuclear accidents as reactors at the Fukushima Daiichi Nuclear Power Plant were damaged when their cooling systems failed. Residents in the vicinity of the plant were evacuated.

With the extreme devastation in Japan, much of the coverage was on the great tragedies unfolding there: the loss of life that occurred there, the radiation dangers, and loss of the infrastructure of daily life. However, there were also effects very far from the cause that, while not tragic or life-threatening, served as a reminder of how far causes can reach and that we are citizens of a global world.

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Tsunami warnings were issued in Hawaii, Oregon, Washington, coastal California, parts of Alaska, British Columbia, Canada and eventually the entire Pacific Ocean. Coastal areas on the Kuril Islands in Russia were evacuated. In Oregon and California, eight-foot waves hit some areas, damaging docks and harbors and causing approximately $10 million dollars in damage. The tsunami surge caused evacuations and boats to be banned from the water on Vancouver Island in Canada for twelve hours following when the waves hit. Some houses along the coast in Jayapura, Indonesia were destroyed; hospitals in Papua, New Guinea were damaged by waves; and nesting seabirds were killed on Midway Atoll, an island halfway between Japan and Hawaii. Buildings in Chile, Peru, and the Galapagos Islands were damaged and icebergs broke off of the Sulzberger Ice Shelf in Antarctica—over 8,000 miles away. The main piece of ice was as big as Manhattan. By April, wreckage from Japan started to wash up on distant shore lines.

Trace amounts of radiation from Japan were detected in the U.S. in Nevada and Colorado. In April, for instance, "trace amounts" of radiation from Fukushima were detected in Denver drinking water. Officials, however, concluded that radiation levels were "harmless." An EPA spokesman said in a statement, "To put this drinking water sample into context, an infant would have to drink nearly 7,000 liters of this water to receive a radiation dose equal to just one day's worth of natural background exposure" (Denver Post, 2011).

This second example is a more difficult case to analyze than the first one. The problems are not as easily visualized and it takes specific knowledge of how tsunamis, earthquakes, radiation, and ocean currents behave in order to predict possible distant outcomes. By contrasting it to the first case, the challenge of recognizing distant causes and effects will become clearer to the students.

In each example, the discussion focuses on thinking about possible mechanisms for how distant effects could occur, and on the intermediate connections that might help in reasoning about what happens.

UNDERSTANDING GOALS

1. Cause and effects can be far apart.
2. It can be hard to predict distant effects of causes unless you know how certain causes work.
3. Knowing the story behind how something happens can often help us connect causes and effects that are far apart.
4. Knowing how the problem occurs (such as in the first case where we think about the flow of water) can help us to connect distant causes and effects. It can be more difficult to connect distant causes and effects without specialized knowledge (such as weather patterns and movement of ocean water) as seen in the second case.
5. It is easier to reason from the perspective of effects to distant causes than distant causes to effects. For example, if you are at the "effect" end, you can follow the clues, so to speak. If you are at the "cause" end, you may never know what is happening because of your actions.

See accompanying Power Point and Appendix for videos and more resources!

MODULE 1
LESSON 2:

FIGURING OUT THE CONNECTION BETWEEN DISTANT CAUSES AND EFFECTS

Note to teacher: Depending on your schedule and the needs of the students, this lesson may be done in either one or two class sessions. If divided into two sessions, make sure that Case Study 1 is done on Day 1, and Case Study 2 is done on Day 2.

REFLECTING UPON WHAT HAS ALREADY BEEN LEARNED

1. Ask the students to mentally remind themselves of the thinking that they did in the last lesson. Invite them to take a minute or two of quiet reflection to recall the discussion and to look around the room to remind themselves of what was written on their posters.
2. After a few minutes, collect a few recollections and then explain that today they will look at two contrasting cases where causes and effects work at a distance. Afterwards, you will ask them to contrast the cases and consider in what ways they are similar and in what ways they are different.

CASE STUDY #1: THE FLOODING OF THE MISSISSIPPI RIVER

3. Project the image of the Mississippi River on a screen (see Powerpoint). Ask the students what they see. Gather as much information from them as you can about what it is.
   - Ask the students to follow it with their eyes and notice how long it is.
   - Have some of them trace it with their finger.
   - How many states does it go through?
   - Do they notice the smaller rivers and creeks leading into it? Have them trace some of those.
   - Fill in whatever information they don't have about where it is and any history of the river prior to 2011 that you would like to offer (see appendix for background information).

4. Ask students whether they know what happened to the Mississippi River in Spring of 2011. Gather whatever information they have and offer the rest (see pg.12):
   - Ask the students to focus on the northern portions of the river. As those begin to swell, what do they predict will happen downstream?
   - Have students trace the path of the water through the states of Illinois, Iowa, Missouri, Kentucky, Tennessee, Arkansas, Mississippi, and into Louisiana. What do they predict will happen as water all along the river gets higher and higher?
   - Have the students turn to a classmate and make predictions. Pass out a copy of the map to each group of students and ask them to use the map to draw on, make notes, and show what they think will happen.

READ MORE

The winter of 2010 to 2011 had seen record snows. In addition, in April, there were two large storm systems that dumped record rainfall all along the Mississippi River Watershed. By early May, the build-up of water from tributaries running into the Mississippi from both rain and melting snow began to swell the river to record levels.

MODULE 1
LESSON 2:

FIGURING OUT THE CONNECTION BETWEEN DISTANT CAUSES AND EFFECTS

WATERSHED

An area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay or ocean.

5. Draw the group back together and discuss their predictions. Make sure that they realize that the amount of water will increase substantially all the way down the river.
   - Trace for them how wide the **watershed** is. What does this predict for New Orleans and Baton Rouge, the cities that are at the Southern-most point, before the river reaches the ocean?
   - Connect back to the concept of causes and effects that are far apart. We don't typically think about far away snow and water as causing an issue. We tend to not worry about it because it's far away. What lessons do they think this story holds for people considering causes and effects that are far apart?

READ MORE

All that water that has traveled from far away will flow into and flood these cities. This was exactly what officials worried about as they watched the process occur over a couple of weeks.

During these weeks, officials anxiously monitored the build-up of water making its way towards the cities of New Orleans and Baton Rouge. You may wish to tell the story of Hurricane Katrina and what it did to New Orleans. The idea that New Orleans, which sits so low, would flood again was a highly sensitive issue.

In order to lessen the impact on cities downstream, officials opened a spillway called the Morganza Spillway to flood portions of rural Lousiana. This decision was not without opposition. People living within the spillway flood zones lost their homes in order to avert a crisis that would have affected many more people further downstream.

CASE STUDY #2: THE EARTHQUAKE AND TSUNAMI IN JAPAN

6. Explain that now you are going to turn to a different kind of case. Project the image of Japan onto the screen. Explain that the second example looks at the March 2011 earthquake and related tsunami in Japan and the effects felt around the world.

   Depending upon the age of the group, you can tell the story of what happened or show some video footage and fill in the details. If you show video footage, be sure to prescreen first. Footage on YouTube from a news organization that is clear and presents what happened in a matter-of-fact tone in a way that is unlikely to scare the students can be found at http://www.youtube.com/watch?v=SD p5tHmC2bk (see Powerpoint).

7. With the extreme devastation in Japan, much of the coverage was on the great tragedies unfolding there: the loss of life that occurred there, the radiation dangers, and loss of the infrastructure of daily life. But there were also effects very far from the cause, that while not tragic or life-threatening, served as a reminder of how far causes can reach and that we are citizens of a global world.

   Ask the students to turn to a partner and try to come up with three or four possible effects that might happen far from Japan. Encourage them to think in terms of the
   - impacts of nature,
   - economy,
   - social structures, such as power plants and buildings,
   - plant and animal life, etc.

   Circulate while the students are thinking to help them consider possible outcomes.

READ MORE

The quake occurred in the seas off the Northeastern coast of Japan. It was a magnitude 9.03 quake, one of the most powerful to ever have hit Japan and one of the most powerful quakes in the history of record-keeping which began in the early 1900s. It triggered huge tsunami waves that were over 130 feet high and traveled as far as six miles inland in an area of Japan called Sendai.

Nearly 16,000 people died, over 6,000 were injured and nearly 3,000 were unaccounted for. Over a million buildings were damaged, as well as roads, railway, and dams. Millions of households were left without electricity and water. The tsunami waves also caused nuclear accidents as reactors at the Fukushima Daiichi Nuclear Power Plant were damaged when their cooling systems failed. Residents in the vicinity of the plant were evacuated.

8. List their ideas on the board. See how many different ideas they can come up with.

   Share some of the outcomes that did occur:

   - The heightened waves from the tsunami hit far away in Hawaii, Oregon, Washington, coastal California, parts of Alaska, and British Columbia, Canada, and Coastal areas on the Kuril Islands in Russia were evacuated.
   - In Oregon and California, eight foot waves hit some areas, damaging docks and harbors and causing approximately $10 million dollars in damage.
   - Some houses along the coast in Jayapura, Indonesia were destroyed; hospitals in Papua, New Guinea were damaged by waves; and nesting seabirds were killed on Midway Atoll, an island halfway between Japan and Hawaii.
   - Buildings in Chile, Peru, and the Galapagos Islands were damaged and icebergs broke off of the Sulzberger Ice Shelf in Antarctica—over 8,000 miles away. The main piece of ice was a big as Manhattan.
   - By April, wreckage from Japan started to wash up on distant shore lines. Trace amounts of radiation from Japan were detected in water in the U.S. in Nevada and Colorado. Officials concluded that radiation levels were "harmless," however.
   - There were economic effects to car dealers in the United States. Do the students know why?

   Bring the example back to distant causes and effects. When we hear that there is an earthquake in Japan it may seem very far away. It is hard to imagine that somehow it could impact us.

COMPARING THE TWO CASES

9. Have the students partner up and think about the two cases.
   - Which case do they think it would be easier to detect distant causes and effects? Why?
   - Which one is harder? Why?

   Have them explain what information they have to rely on in each case. Then come back together as a group and discuss their ideas.

LESSON EXTENSION

Make sure to watch this video prior to showing it in class. Some students may be disturbed by what they see. Make sure to warn students and allot enough time for discussion at the end of the session so that you can address concerns and discuss ways to help the environment.

Watch this video about birds on Midway Island, North Pacific Ocean. Reiterate to students that this island is more than 2,000 miles from the nearest continent: http://www.upworthy.com/people-should-know-about-this-awful-thing-we-do-and-most-of-us-are-simply-unaware?g=2&c=upw1

Ask the following questions

- **How can the birds, which are more than 2,000 miles away from the nearest continent, be dying from pollution?**
- **How is pollution (a distant cause) connected to the birds' death (the effect)?**
- **Do you think that people who use water bottles are aware that animals could be choking on the lids? Do they intend for it to happen?**

MODULE 1
LESSON 3:

APPLICATIONS: A WATERSHED CASE STUDY IN CAMBRIDGE, MA

BACKGROUND INFORMATION

The purpose of this lesson is to have the students think about how action at a distance plays a role in ecological phenomena, and specifically to help them to realize the size of a watershed. While we tend to realize that our actions right next to a pond matter for the health of the pond, most people do not realize that watersheds are very large and that the systematic patterns of flow and movement can spread for many, many miles.

This lesson looks at a case study in Cambridge, MA, where town leaders decided to work with town leaders in a town 20 miles away, Lincoln, MA, to protect the upper watershed so that the City of Cambridge would have clean drinking water. Not everyone in town supported the purchase of a large tract of land west of the city, especially since much of it is forest, rather than reservoir. Town leaders, however, viewed this as an important decision for future generations. The lesson considers the ways in which Cambridge's water could be impacted by people's actions so far away. The lesson draws comparisons to other watershed maps and how startlingly large they are.

This lesson will probably take at least two class sessions to fully process.

UNDERSTANDING GOALS

1. Cause and effects can be far apart.
2. A watershed spreads over many miles.
3. Actions within the watershed can have an impact on the water quality many miles away.
4. It can be hard to encourage people to attend to and care about distant causes. They may not make the connection to their own situation.
5. Knowing the story behind how something happens can often help us connect causes and effects that are far apart.
6. In this particular case, knowing how the problem occurs, i.e. thinking about the flow of water, can help us to connect distant causes and effects.

MATERIALS

There are 9 PDFs associated with this lesson. Students can work together in a jigsaw format (see explanation), or read all of the articles independently.

- Articles 1-5 (in class jigsaw)
- Article 6 (homework, or part of jigsaw)
- Articles 7-9 (optional)

See accompanying Power Point and Appendix for articles, group worksheet, teacher reference sheet, and more resources!

MODULE 1
LESSON 3:

APPLICATIONS: A WATERSHED CASE STUDY IN CAMBRIDGE, MA

REFLECTING UPON WHAT HAS ALREADY BEEN LEARNED

1. Ask the students to mentally remind themselves of the thinking that they did in the recent lessons. Invite them to take a minute or two of quiet reflection to recall the discussion and to look around the room to remind themselves of what was discussed in earlier lessons. After a few minutes, you can collect a few recollections, or you can just begin to explain what they will work on next.

SETTING UP THE CASE STUDY

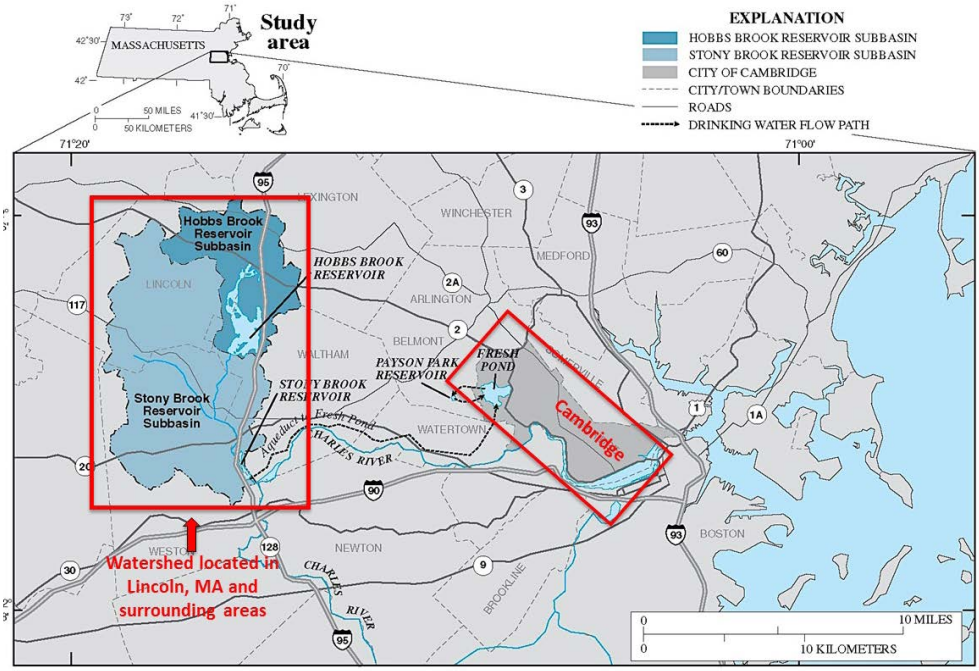
2. Explain to students that they will be working on a **Problem-Based Learning (PBL)** scenario that will help them better understand an issue faced by the City of Cambridge, MA. Hand out a copy of the PBL scenario (see appendix and below) and read it together in class.

PROBLEM-BASED LEARNING (PBL)
A type of learning based on real-world problems. It is centered on ill-structured, complex problems. Students identify questions involved in solving the problem and conduct the research necessary to solve it. The teacher takes on a coaching role.

CAMBRIDGE AND LINCOLN, MA: THE WATERSHED DEBATE

Imagine that you and your classmates are members of the citizen's advisory council in Cambridge, Massachusetts. You've been asked to evaluate the city's recent decision to purchase several acres of watershed land. A watershed is "an area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay, or ocean".[1] This particular watershed is located in the nearby town of Lincoln (about 12 miles away) and flows directly into the main drinking water source for Cambridge.

You understand the benefits of protecting the watershed—protecting the surrounding wildlife and the water you drink—but you're also concerned about the high cost needed to purchase it. Additionally, a developer wants to build homes on the watershed land. You need to make a decision soon. Should you buy the land to preserve the watershed, or let the developer build a mall and apartments on it?



1 http://water.epa.gov/type/oceb/fact1.cfm

3. As a warm up to the activity, before distributing any materials, take five minutes to let the students quickly brainstorm the pros and cons of buying the watershed land. Consider:
   - Why might Cambridge want to buy watershed land in Lincoln?
   - What are some good reasons not to buy the land?
   - What types of information would you want to know to make this decision?

   Capture a summary of the students' initial ideas on chart paper or in your own notes so they can be referenced later if relevant.

4. Explain to students that they will "jigsaw" the artifacts (newspaper clippings, maps, photos) that they will study in order to learn about what decisions the town was faced with, and what factors influenced what they ended up doing. Explain to students that you want them to gather the details from sources just the way that they would in the real world.

   Summaries of the articles are provided for your reference in the appendix.

   As students are reading, they may run into some challenging words. Glossaries are provided at the end of each article. Some terms you may want to discuss before handing out the readings include

   - Watershed
   - Reservoir
   - Acquisition
   - Tributary
   - Parcels
   - Zoning laws

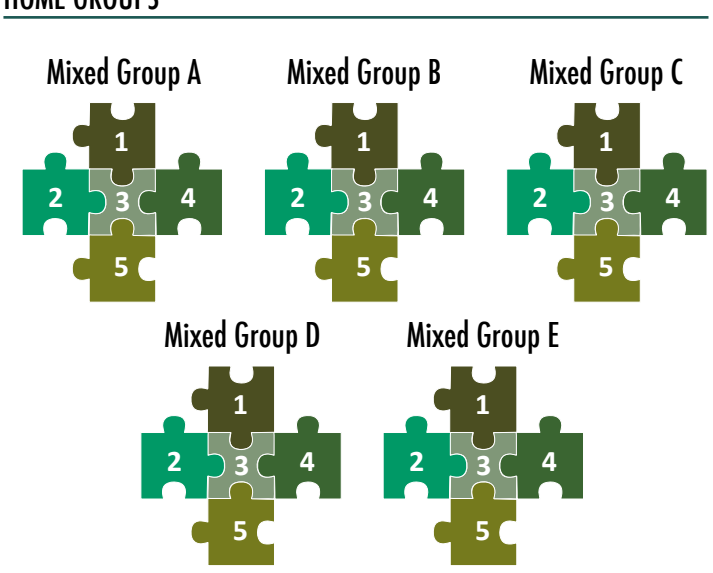
> Note to teacher: If the jigsaw arrangement does not work for your classroom, students can read all of the articles independently. Or, you can also invite them to first do some planning about how they will organize themselves and how they will collect and organize their information so that it will be available to them later. Will they divvy up the task (in a jigsaw arrangement) or will they all work together on each piece? Will they take notes? Where? (science journals? chart paper? etc.)

JIGSAW ACTIVITY

a. Divide students into five "home" group (each group should have 3-5 students).

   Each student in the "home group" is assigned a different article and is asked to read it independently and think about the guiding questions.

b. When students are done reading and filling out their corresponding article worksheet, have them leave their "home" groups and meet in "expert" groups.



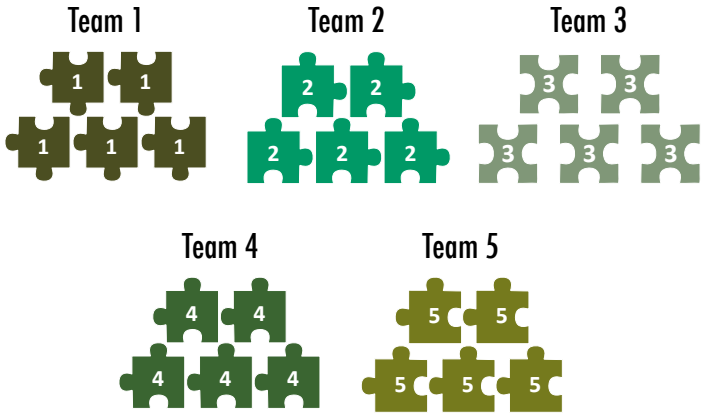
MODULE 1
LESSON 3:

APPLICATIONS: A WATERSHED CASE STUDY IN CAMBRIDGE, MA

Expert groups are comprised of students who have read the same article. Collectively, they discuss the material and brainstorm ways in which to present their understandings to the other members of their "home" group.

- Circulate and offer support to students while they are working.
- Try not to tell them what to do; instead help them make decisions that will serve their process well.

EXPERT GROUPS



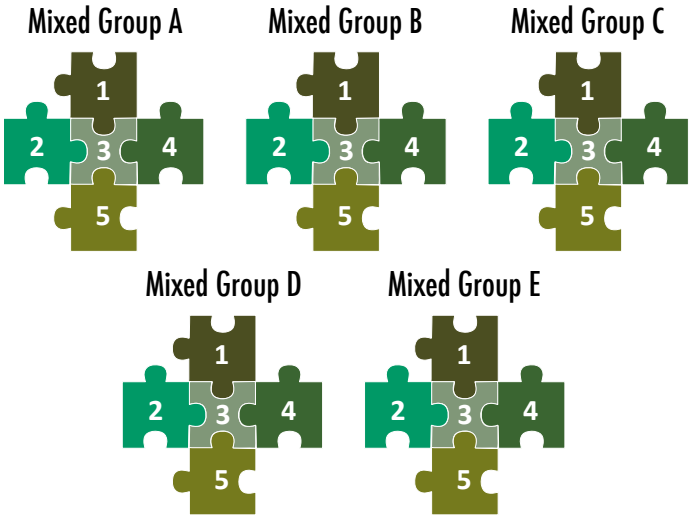
If students are getting very stuck, some important questions you can ask them to think deeply about are:

- Who owns the water?
- Where does the Cambridge drinking water come from?
- How far away is far enough to protect the Cambridge watershed?

c. Have students leave their "expert groups" and return to their "home" groups to teach their portion of the materials, and to learn from the other members of their "home" group.

It is fine to let students persist in a process that isn't working for a while to help them discover that it is not productive. However, given limited time, be sure to check back fairly soon to ask them how it is working and to encourage them to try a new tact. Give them at least 35 minutes to review the materials in the packet.

HOME GROUPS



MODULE 1
LESSON 3:

APPLICATIONS: A WATERSHED CASE STUDY IN CAMBRIDGE, MA

SOME OF WHAT THEY WILL LEARN FROM THE DOCUMENTS:

- The land is just west of Route 2 and includes fragile watershed.
- The Town of Lincoln has been trying to conserve it for many years.
- Cambridge has its own water system and is not part of the local Massachusetts Water Resources Authority (MWRA) that many local towns are.
- Cambridge has its own system because in the 1800s, it was forward- looking and bought land from Lexington, Weston, and Lincoln to provide water for its citizens.
- Cambridge owns much of the Hobbs Brook Watershed area, a large area of land west of the city.
- The owner of the land (Mr. DeNormandie) has argued that he will develop it if the town does not buy it.
- Mr. DeNormandie has been involved in issues in the town previous to this event. The students may question how well-liked he is.
- Other members of the DeNormandie family have been very generous to the town in the past.
- The Town of Lincoln donated additional conservation land (20 acres) that it already owned to the Cambridge parcel.
- Residents in the Town of Lincoln contributed approximately $300,000 to the preservation of the land. Some of this came from the town funds that were set aside for conservation land. Some of it came from local donations.
- There is not a lot of development in the area around the watershed.

Hobbs Brook Reservoir

forested watershed

CLASS DISCUSSION OF THE CASE

5. After groups have met in their expert and home groups, bring the entire class back together to review the case.
   - Make a list of information on the board. Divide the information up into categories that make sense. Some candidate ways to organize it include
     - ◊ "Questions"
     - ◊ "What We Know for Sure" (facts, for instance, how far Lincoln is from Cambridge)
     - ◊ "What We Think Might Be So" (observations, assumptions, and interpretations, for instance, "there is a lot of wildlife in the woods" or "if the land wasn't conserved, the owner might have developed it.")

Examples of Cambridge's needs: good schools, supporting the poor, flood support, etc.

6. After you have gathered as much information as possible, discuss what they think Cambridge should do.
   - As students give their opinions, ask for viewpoints that support or differ from the given viewpoint to encourage as much active processing as possible. If all the students immediately believe that they should buy the land, stress that $1.8 million dollars is a lot of money and Cambridge has lots of needs.
   - When students make a claim, ask them to back it up with evidence, if possible, and reasoning if they don't have evidence.
7. Ask the students what all of this has to do with distant causes and effects.
   - Why should it matter what people do in towns that are miles away from the City of Cambridge?
   - Project the images of watersheds. How big are they?
   - What are some of the kinds of problems that can occur?
   - Students may have noticed in the materials that some people in Cambridge want to start a farm on some of the watershed land that Cambridge owns in Lincoln. Is this a good idea? Why or why not?

POTENTIAL PROBLEMS: What are some of the kinds of problems that can occur? Students will think of pollution, but eutrophication is a much bigger issue. This is when so much fertilizer (phosphates and nitrates) end up in the water supply and encourage heavy plant growth, such as is seen in farm ponds. See the extension lesson on eutrophication in the appendix for more information.

8. To wrap up the case discussion, you can have the students vote on what to do, or you could have students write a letter to the Cambridge Tab expressing an opinion on what to do.
   - Finally, you probably will want to let them know what Cambridge did do (spent $1.6 million dollars and the town of Lincoln provided $200,000. Cambridge gave Lincoln the conservation rights (meaning that Cambridge cannot develop the land) and Cambridge owns the land.

LESSON EXTENSION

OPTION 1: Cambridge has a particular water system by which the land in Lincoln was a part of the Cambridge watershed. But how do other cities get water? Some cities

- **pump water directly from different parts of a watershed, including natural sources like lakes, rivers, or aquifers;**
- **build a structure, like a man-made reservoir, to collect water from natural sources; or**
- **purchase a share of a neighboring cities' supply.**

Do you know the source of your city or town drinking water? What if your community was faced with the concerns that Cambridge had regarding its water source? Based on where you live, would you make a similar decision? Why or why not?

OPTION 2: Ask the students to think about other cases where proactive thinking and planning ahead might be helpful in the case of distant causes and effects. When we intentionally think about possible links we can expand our view and frame the boundaries of what we should think about with a broader perspective. Can students think of instances where their own town may have had to deal with distant causes and effects in the recent past?

MODULE 1
LESSON 4

APPLICATIONS: HOW CAN WHAT I AM DOING HERE HURT THE POLAR BEARS?

BACKGROUND INFORMATION

This lesson is designed to complement curricula focused on climate change. The key message is that our actions can have an impact very far away and that very often we don't have a way of realizing that. This lesson introduces the idea that our actions contribute to greenhouse gases, which have effects in other parts of the world. It focuses on the melting ice in the arctic and the impacts on the polar bear. Many curricular resources have drawn attention to the plight of the polar bear. This tends to work especially well with elementary and middle school students because it offers a way to connect to what is happening and engages human feelings in trying to understand the plight of other organisms.

The message here is that while it can be hard to pay attention to how our actions affect creatures far away from us, as global citizens we must do so and we can make choices that help us do so. This lesson also highlights a car commercial from Nissan about the Nissan Leaf that features a polar bear who makes a very long trek to a suburban driveway to say thank you. It asks the students to analyze what it is that works about the commercial in terms with how it fits with human cognition and how hard it can be to keep distant effects in mind.

UNDERSTANDING GOALS

1. Cause and effects can be far apart.
2. It can be hard to encourage people to attend to and care about distant effects. They may not make the connection to their own situation.
3. Knowing the story behind how something happens can often help us connect cause and effects that are far apart.
4. Knowing how the problem occurs (i.e. thinking about the accumulation of carbon) can help us to connect distant causes and effects.
5. It is easier to reason from the perspective of effect to distant causes than distant causes to effects. If you are at the effect end, you can follow the clues, so to speak. If you are at the cause end, you may never know what is happening because of your actions.

See accompanying Power Point and Appendix for videos and more resources!

MODULE 1
LESSON 4

APPLICATIONS: HOW CAN WHAT I AM DOING HERE HURT THE POLAR BEARS?

REFLECTING UPON WHAT HAS ALREADY BEEN LEARNED

1. Ask the students to mentally remind themselves of the thinking that they did in the recent lessons. Invite them to take a minute or two of quiet reflection to recall the discussion and to look around the room to remind themselves of what was discussed in earlier lessons. After a few minutes, you can collect a few recollections, or you can just begin to explain what they will work on next.

FRAMING THE LESSON IN THE CONTEXT OF CLIMATE CHANGE

2. Remind the students of some of the basic ideas behind climate change. The following websites are great resources to use,
   - The EPA website: http://www.epa.gov/climatechange/basics/

     There is an excellent short video (2 min. 48 sec.) that introduces the main ideas: http://www.epa.gov/climatechange/students/index.html
   - Climate Literacy by the Climate Literacy Network: http://cleanet.org/cln/index.html
   - Climate Classroom Kids: http://climateclassroomkids.org/for-educators/

     See lessons on Climate 101 (especially the Polar Bears & the Arctic activities)

THINKING LIKE A COGNITIVE SCIENTIST

These materials all focus on getting kids to think like a scientist and that is incredibly important. However, it is also important to think like a cognitive scientist in order to figure out ways to keep climate change on our minds and help us to change our behaviors. We have to keep in mind that our actions here can have distant effects that we cannot see but that we must take into account.

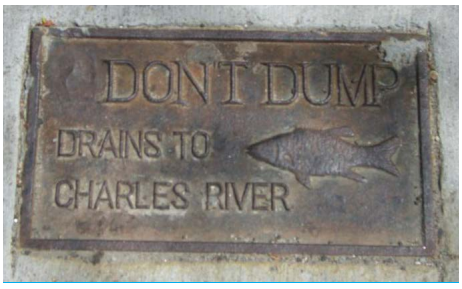
The earlier lessons in this unit focused on ways to realize that causes can have effects far away by focusing on the mechanisms that connect things. For example, by realizing where the water from the Mississippi will flow we can connect the domino-like narrative between events and the bigger story of what is happening. In this lesson, we think about the importance of remembering to ask:

- Does my action have a distant effect?
- Does a cause here make something happen far away?

Recall the fish plaque from the first lesson:

- What does it remind us?

It functions as a reminder that we need to think about distant effects even though we may not be able to see them.



MODULE 1
LESSON 4

APPLICATIONS: HOW CAN WHAT I AM DOING HERE HURT THE POLAR BEARS?

THINKING ABOUT VERY DISTANT EFFECTS

3. Ask students,
   - What happens when effects are very far away?
   - Thousands of miles away?
   - So far that we are unlikely to ever notice them?
   - How can we keep things on our minds when they are so far outside our attentional space?

   Explain that this is the problem that we are going to think about today.

4. Show the commercial about the Nissan Leaf: http://www.youtube.com/watch?v=9WxC1PtIvsY. (See accompanying Powerpoint)

   Have the students watch it once. Discuss what happens. Then ask them to watch it a second time and to think about why the car manufacturer created it.
   - What did the car manufacturer hope to accomplish?
   - Why is it important?

   Have students turn to a partner and come up with at least two reasons why the manufacturer made this kind of a commercial.

   After students have had a chance to consider the video with a partner, reconvene as a larger group to discuss it.

   - What impact did it have upon them?
   - How do they think it will affect others who watch it?
   - How did the car manufacturer deal with our tendency not to pay attention to distant effects?

LESSON EXTENSION

The students' generation will need to think about how to motivate people to consider "action at a distance," even when it is difficult to keep in mind. Laws are one way to encourage attention to distant effects. Another way is to develop creative reminders such as the fish plaque or apps. Another way is to find longer-term solutions by targeting key decision points such as what type of car you buy. This shifts the problem from reminding oneself not to drive so much to buying a car that is less harmful to the environment. Invite the students to choose one of the activities below or design their own.

OPTION #1: In 2009, President Obama declined to use the Endangered Species Act to control the growth of coal plants. Environmentalists were trying to make the case that coal plants impacted the habitat of polar bears and therefore the regulations associated with the Endangered Species Act should apply to their regulation. Consider two ways that you agree with the President's decision. Then consider two ways that you disagree with the President's decision. Write a letter to President Obama to tell him what you think about the decision and what he should do in the future. Try to be as compelling as possible by using evidence and what you know about action at a distance.

OPTION #2: Consider places where and times when people make decisions that involve distant effects without realizing it (as in the example of the fish plaque). Develop a clever way to remind them to think more broadly and to reconsider their actions. Try to create a design that could really be used. For instance, a Starbucks store had a sign that read "These napkins come from trees" to remind customers not to take more than they need. Look for ways to use your designs in your everyday life or around school.

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Aerial View of Fort Calhoun. By U.S. Army Corps of Engineers. Public domain.

Baseball Cap, Lesson 1 & Module 1 Resources: Blue Baseball Cap. By User:TexasRebel. Released to public domain.

Cambridge Watershed, Lesson 3 & Module 1 Resources: Map of the Cambridge Water Supply System. Adapted from Cambridge Water Department. Public domain.

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Satellite, Overview: The Warkworth Satellite Station. By User:sids1. Under CC BY 2.0.

APPENDIX

GLOSSARY
MODULE RESOURCES
SUPPLEMENTAL MATERIALS

MODULE 1 GLOSSARY

ACTION-AT-A-DISTANCE: The idea that causes and effects can be separated in physical space (even by great distances).

CAUSALITY: The relationship between something that happens or exists and the thing that causes it.

JIGSAW: Jigsaw is a cooperative learning strategy that enables each student to specialize in one aspect of a learning unit. Students do this by reading their assigned article and by meeting with other classmates who specialize in the same topic. They collectively master the material. Students then meet with other classmates who have mastered other aspects of the learning unit (e.g., other articles) and they collaboratively teach one another. Just as in a jigsaw puzzle, each piece--each student's part--is essential for the completion and full understanding of the final product.

MECHANISM: A type of process or event—either physical, behavioral, or mental—that fuels an effect.

PROBLEM-BASED: A type of learning based on real-world problems. It is centered on ill-structured, complex problems. Students identify questions involved in solving the problem and conduct the research necessary to solve it. The teacher takes on a coaching role.

SPATIALLY LOCAL: The cause and effect occur in close proximity, within the same location.

WATERSHED: An area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay or ocean.

MODULE 1 RESOURCES

LESSON 1 RESOURCES

- YouTube video of the moon's gravitational pull on the ocean. Used to demonstrate that causes and effects can be spaced far apart: http://www.youtube.com/watch?v=l37ofe9haMU

LESSON 2 RESOURCES

- YouTube video; news footage of the earthquake in March 2011 that triggered a tsunami on Japan: http://www.youtube.com/watch?v=SDp5tHmC2bk

LESSON 3 RESOURCES

- Coastal watershed factsheet from EPA; defines and describes features of a watershed: http://water.epa.gov/type/oceb/fact1.cfm
- Description of jigsaw learning strategy from Saskatoon Public Schools: http://olc.spsd.sk.ca/DE/PD/instr/strats/jigsaw/
- Description of jigsaw activity from Online Teaching Techniques by Anne Negus: http://edtech2.boisestate.edu/neguss/573/jigsawo.html
- Midway Island bird video: http://www.upworthy.com/people-should-know-about-this-awful-thing-we-do-and-most-of-us-are-simply-unaware

LESSON 4 RESOURCES

- EPA webpage that provides basic information about climate change: http://www.epa.gov/climatechange/basics/
- Additional material for educators incorporating Lesson 4 into a broader unit on climate change: http://climateclassroomkids.org/for-educators/
- Short video from EPA introducing the main ideas of climate change: http://www.epa.gov/climatechange/students/index.html
- YouTube video; Nissan Leaf commercial from September 2010 (Polar Bear Hug): http://www.youtube.com/watch?v=9WxC1PtIvsY

THINKING ABOUT DISTANT CAUSES AND EFFECTS

Name:

Date:

Try to think of examples where causes are very far apart from their effects. One example should come from your everyday life. The other example should come from science. Describe each example below. Then answer the questions.

Example #1: Everyday Life

Explain your example here.

Is it hard to know about the cause or the effect or both? Explain why.

Example #2: Science

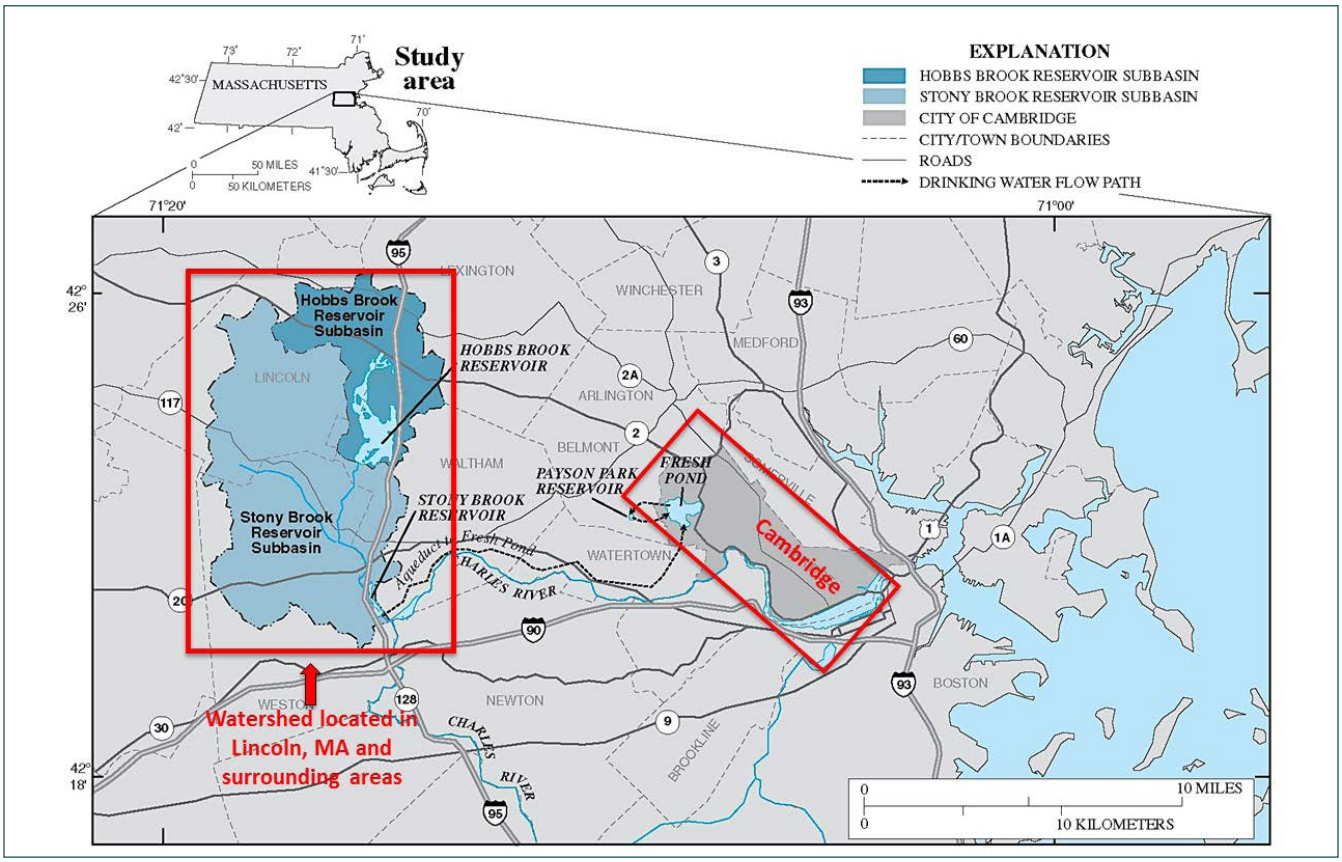
Explain your example here.

Is it hard to know about the cause or the effect or both? Explain why.

CAMBRIDGE AND LINCOLN, MA: THE WATERSHED DEBATE

Imagine that you and your classmates are members of the citizen's advisory council in Cambridge, Massachusetts. You've been asked to evaluate the city's recent decision to purchase several acres of watershed land. A watershed is "an area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay, or ocean". This particular watershed is located in the nearby town of Lincoln (about 12 miles away) and flows directly into the main drinking water source for Cambridge.

You understand the benefits of protecting the watershed—protecting the surrounding wildlife and the water you drink—but you're also concerned about the high cost needed to purchase it. Additionally, a developer wants to build homes on the watershed land. You need to make a decision soon. Should you buy the land to preserve the watershed, or let the developer build a mall and apartments on it?



ACTIVITY:

Your task is to review various materials concerning the facts and considerations leading up to Cambridge purchase of watershed land in Lincoln.

Do you think this was the right decision for Cambridge?

In your small groups, closely examine the evidence to understand what happened. Then, be prepared to share your rationale for why you think Cambridge should or should not have purchased the watershed land in Lincoln.

JIGSAW EXPLANATION

WHAT IS JIGSAW?
(adapted from Saskatoon Public Schools: http://olc.spsd.sk.ca/DE/PD/instr/strats/jigsaw/, and Online Teaching Techniques by Anne Negus: http://edtech2.boisestate.edu/neguss/573/jigsawo.html)

Jigsaw is a cooperative learning strategy that enables each student to specialize in one aspect of a learning unit. Students do this by reading their assigned article and by meeting with other classmates who specialize in the same topic. They collectively master the material. Students then meet with other classmates who have mastered other aspects of the learning unit (e.g., other articles) and they collaboratively teach one another.

Just as in a jigsaw puzzle, each piece--each student's part--is essential for the completion and full understanding of the final product.

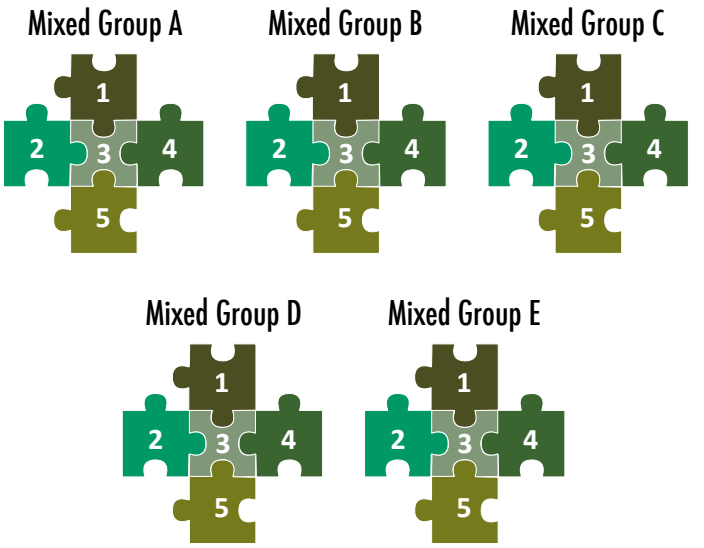
WHAT IS ITS PURPOSE?
Jigsaw learning allows students to be introduced to material and yet maintain a high level of personal responsibility.

The purpose of Jigsaw is to develop teamwork and cooperative learning skills within all students. In addition it helps develop a depth of knowledge not possible if the students were to try and learn all of the material on their own. Finally, because students are required to present their findings to the home group, Jigsaw learning will often disclose a student's own understanding of a concept as well as reveal any misunderstandings.

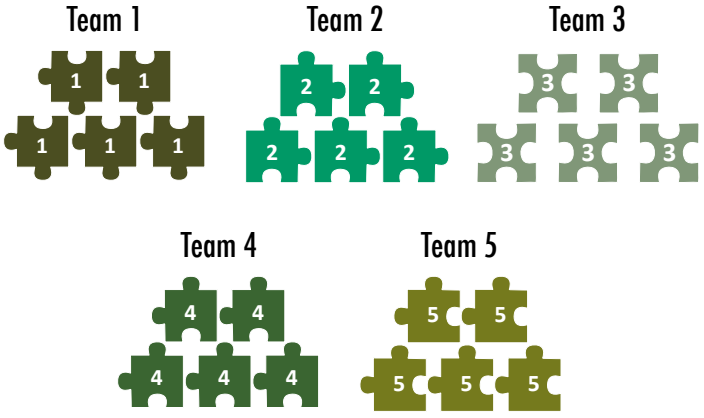
HOW CAN I DO IT?
In its simplest form, the Jigsaw instructional strategy is when

1. Each student is paired up into a "home" group (each group should have 3-5 students)
    - Each student is assigned a different article and is asked to read it independently and think about the guiding questions.
2. Students leave their "home" groups and meet in "expert" groups;
    - Expert groups are comprised of students who have read the same article. Collectively, they discuss the material and brainstorm ways in which to present their understandings to the other members of their "home" group.
3. Students then return to their "home" groups to teach their portion of the materials, and to learn from the other members of their "home" group.

HOME GROUPS



EXPERT GROUPS



Document # _____

Written Document Analysis Worksheet

1. TYPE OF DOCUMENT (Check one):
   - ☐ Newspaper article (paper or online)
   - ☐ Letter
   - ☐ Memorandum
   - ☐ Map
   - ☐ Email, phone text or online blog
   - ☐ Report or presentation

2. UNIQUE PHYSICAL CHARACTERISTICS OF DOCUMENT (Check one or more):
   - ☐ Typed
   - ☐ Handwritten
   - ☐ Has seals
   - ☐ Logo
   - ☐ Photographs or drawings
   - ☐ Other

3. DATE(S) OF THE DOCUMENT:

4. AUTHOR OR CREATOR OF THE DOCUMENT:

5. FOR WHAT AUDIENCE WAS THE DOCUMENT WRITTEN:

6. DOCUMENT INFORMATION (there are many possible ways to answer A-D):

   A. List three things the author said that you think are important.

   B. Why do you think this document was written?

   C. Write the answer to the document "Guiding Questions".
   (The questions are printed at the top of the first page of the document)

   D. Write a question to the author that is left unanswered by the document.

Adapted from worksheet developed by the Education Staff, National Archives and Records Administration, Washington, DC 20408

Guiding Questions: *What is Cambridge's hidden secret? Why is it important to the community?*

A Walk in Cambridge's Watershed

Posted by kmklinger on May 27, 2010.

By Karen Klinger

Standing on a knoll above a remnant of geological history, where a glacier moved mountains of rocks and gravel to the sea and flanked on both sides by a forest of tall trees, Chip Norton said that if not for the distant roar of a highway, you might think you were somewhere in the vast, verdant wilderness of Maine.

This was no wilderness, though, but a place so close-- and yet, in a way--so far from the dense, urban streets of Cambridge that no one not in the know might have guessed that it is actually a part of the city. Only minutes by car from Harvard Square, there are 1,200 acres of hiking trails, vernal pools, towering white pines and oaks, habitats for deer and a variety of other year-round wildlife, plus migrating birds and plants ranging from abundant blueberry bushes to mountain laurel, phlox, wild geranium and a red-coated lichen with the delightful name of "British soldiers."

It's a place families might want to go and explore on an afternoon. It is, after all, owned by the citizens and taxpayers of Cambridge.

If only they knew about it. But almost no one does. Not even a city council member, Sam Seidel, who told this writer in a conversation that he'd never been there and did not even know the public had access to it.

And that's too bad, because in just a short recent walk led by Norton, the watershed manager of the Cambridge Water Department, a small group marveled at the many toads they almost stepped on, the proliferation of berry bushes, the downhill sweep of rocks and boulders that he said were the remains of what a "glacier carried down here from New Hampshire" and stone walls built by Colonial-era farmers who cleared the property and eventually found the soil too thin and unproductive, with their descendants abandoning it and moving west toward more fertile land.

Thanks to the foresight of city leaders in the 19th century who bought land in Weston, Waltham, Lincoln and Lexington in what is now known as the "upper watershed," the city established its own water system with feeder reservoirs named Hobbs Brook and Stony Brook. People who are aware of the system are generally most familiar with Fresh Pond, a reservoir from which the city pumps up to 16 million gallons a day, but it is just a big holding tank--the actual source of the water is upstream in Hobbs Brook and Stony Brook.

When a pipe that ruptured earlier this month interrupted the safe water supply for 2.2 million people in the Greater Boston area who depend on the Massachusetts Water Resources Authority (MWRA), Cambridge was quite literally a tranquil oasis in a temporary urban desert. But the city, aware that even many Cantabrigians did not know they were not affected by the crisis, felt it had to put out an advisory to that effect on its cable TV channel.

With that precedent in mind, the city might want to do more to publicize the fact the hundreds of acres of watershed land it owns just a short trip away--even within bicycling distance--is a place that the public can, in fact, see where the water supply comes from while at the same time looking at hawks overhead, ducks and geese moving across the reservoirs and maybe getting a glimpse of the white-tailed deer that Norton said "are just everywhere." Not to mention the usual array of squirrels, coyotes, raccoons and groundhogs.

But for those who can't manage to get that far afield, the volunteer group Friends of Fresh Pond (which sponsored Norton's walk) has a full program of opportunities for getting out and enjoying pond-related activities in June, with bird walks, a plant photography workshop, a look at invasive plant identification and a Fresh Pond "walkabout" led by Norton, which will focus on the goals of an ecological restoration project.

Norton is scheduled to lead another walk through the upper watershed in July. Elizabeth Wylde, a leading force in the Friends of Fresh Pond and an avid gardener and botanist who helped guide the recent hike (Norton was often heard asking, "Elizabeth, what is this flower?") said she hoped for a good turnout so that the people of Cambridge can see just what a near-Eden they own, and so nearby.

To register for a tour or walkabout, send an email to fpr@cambridgema.gov or call 617-349-6489.

To see an artistic view of Cambridge's reservoir and watershed system, go to the second floor of the water treatment facility, where there is an eight foot by 16 foot mural created to scale in 1983 by painter Michelle Turre. To see a map of the watershed, including Hobbs Brook and Stony Brook reservoirs, go to:
http://www.cambridgema.gov/CityOfCambridge_Content/documents/Surface%20W...

For more information about programs sponsored by Friends of Fresh Ponds, go to:
http://friendsoffreshpond.org

Glossary of Words

Cantabrigian	A native or resident of Cambridge, Massachusetts
Geranium	A specific breed of red, white, pink, or purple flowers
Lichen	A fungus that grows with algae, resulting in an organism that forms a crustlike or branching growth on rocks or tree trunks
Near-Eden	A place close to pristine or abundant natural beauty
Phlox	A group of 67 species of perennial and annual plants in the family Polemoniaceae; found mostly in North America
Precedent	Happening at an earlier time, often a similar action or event
Proliferation	Growing or multiplying by rapidly producing
Restoration	The act or process of returning something to its original condition by repairing it, cleaning it, etc.
Tranquil oasis	A peaceful, fertile spot in a desert where water is found
Urban	Of or relating to a city
Verdant	Green with grass or other rich vegetation
Vernal pools	Temporary pools of water that provide habitat for distinctive plants and animals
Watershed	An area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay or ocean

WICKED LOCAL CAMBRIDGE
WITH NEWS FROM THE CAMBRIDGE CHRONICLE & TAB

Guiding Question: *Why does the City of Cambridge want to buy the land in Lincoln, MA?*

Cambridge scoops up Lincoln land

By Staff reports
Wicked Local Cambridge
Posted Jul 02, 2012 @ 08:35 AM

Cambridge —
$1,152,247

Purchase price of land the city will buy in Lincoln, Mass.

What is it: The city of Cambridge will purchase 53.6 acres of watershed land in Lincoln, MA, for $1,152,247 from the Community Preservation Act Open Space Reserve Fund, for the purposes of drinking water supply protection and land conservation.

Additional info: The land, referred to as the "DeNormandie Property," consists of a 53.6-acre, 2-parcel tract located adjacent to Route 2 in the town of Lincoln. According to a report from the Cambridge based environmental consulting firm, CDM Smith, the acquisition of the two DeNormandie parcels would contribute to the City of Cambridge's watershed protection program, with the overarching goal of ensuring that the watershed continues to be a source of high-quality drinking water to the City.

CDM Smith's report states, "although land acquisition is costly, it has been demonstrated to reduce treatment costs and provides significant long-term financial benefits." The report also states that land acquisition is one of the most effective ways to permanently protect drinking water supplies.

"The benefits of preserving undeveloped lands for water quality and ecosystem health are well documented," said the report.

What's next: Cambridge City Manager, Robert Healy presented the report to the city council at the June 18 meeting and the council adopted the order.

Glossary of Words

Tract	Land lot, a section of land
Watershed	An area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay or ocean

WICKED LOCAL CAMBRIDGE
WITH NEWS FROM THE CAMBRIDGE CHRONICLE & TAB

Guiding Question: *What is the City of Lincoln trying to raise money for? What will happen if they don't?*

Incorrect Thoughts: The clock is ticking

By Neil Feinberg/lincoln@wickedlocal.com
Wicked Local Lincoln
Posted Jul 31, 2012 @ 11:46 AM

Lincoln — Could this be the first time that Lincoln fails to find enough money for a conservation land acquisition? It would be unprecedented and it could happen next week. The clock is ticking and this deal could fall through come the end of this month. What deal? The deal to purchase that wooded lot on Rt. 2, aka the DeNormandie parcels.

That's right, the Rural Land Foundation (RLF) is fundraising to come up with the town's share ($360,000) of the $1.9 million cost, but it is still $77,000 short of its goal. With one week to go it may not have enough to acquire the 53-acre parcel from Boston real estate mogul and Lincoln native son, Philip DeNormandie. It's on the north side of Rt. 2, just before the Bedford Road interchange if you're heading west.

You'll be excused for not knowing what the heck I'm talking about; it is a pretty nondescript parcel that looks just like a bunch of trees and vines and bushes along the road. But behind that veneer, laced with wetlands galore, live all manner of wildlife. It's also a watershed area for the Cambridge reservoir. That's why the City of Cambridge is ponying up $1.6 of the $1.96 million cost. If the deal goes through, Cambridge will own the land for watershed protection purposes and Lincoln will hold a conservation restriction on the property to ensure its permanent protection.

Consider the alternatives: the RLF reports that the property has passed its perc test for a total of 11 house lots. That's 11 new houses with cars and trucks entering and exiting directly onto Rt. 2. Imagine the logistical nightmare of getting an ambulance, fire truck or police car to the property during an emergency. Say, aren't we about to build a new surface road on the other side of Rt. 2 so that cars on that side won't have to exit and enter directly on to Rt. 2 anymore? Even more frightening would be Philip's grand plan for that property, as he shared it with me in a moment of candor a few years ago. He'd like to put a high-rise on the property, tall enough to offer views of the Boston skyline. Wouldn't that be lovely?

Of course, Philip is familiar to many of us from his past actions on Weston Road in 2005-06 where he acquired the Fitts property at below market value without Charley Fitts' approval. After a long, protracted and, dare I say, bitter legal battle, Charley was ultimately evicted from the house he grew up and lived in. Philip had hoped to connect the Fitts property with his family's adjacent holdings, including DeNormandie Hill, the town's sledding mountain. His plan was foiled when Addison & Stacey Parks bought the multi-acre parcel around the Fitts house at auction, blocking access to the DeNormandie land from Weston Road.

Glossary of Words

Adjacent	Next to or adjoining something else
Candor	The quality of being open and honest in expression; frankness
Evicted	To expel someone from a property, especially with the support of the law
Foiled	To prevent (something considered wrong or undesirable) from succeeding
Galore	In large numbers or amounts
Market value	The current quoted price at which investors buy or sell a share of common stock or a bond at a given time
Mogul	A very rich or powerful person
Nondescript	Lacking distinctive or interesting features or characteristics
Perc test	Soils testing used to determine conditions and suitability of land for a sewage disposal system (septic system)
Protracted	Lasting for a long time or longer than expected or usual
Unprecedented	Never done or known before
Veneer	A decorative covering
Watershed	An area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay or ocean

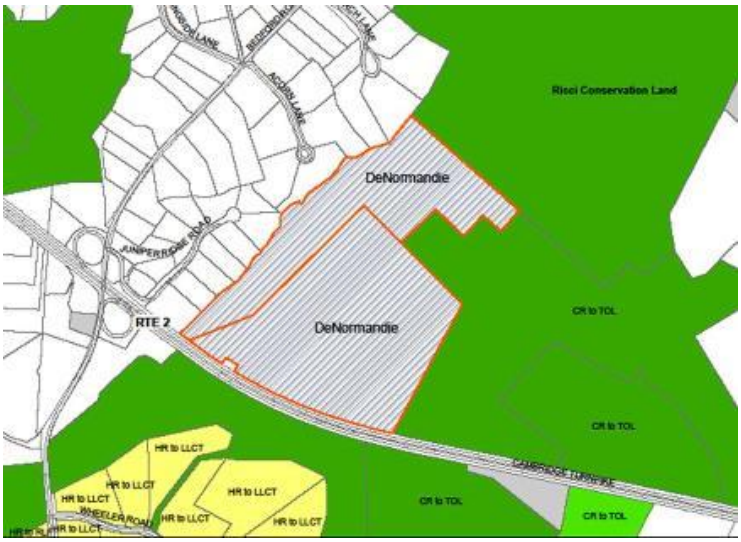
A partnership of the Lincoln Land Conservation Trust (LLCT)
and the Rural Land Foundation of Lincoln (RLF) to protect the rural character of Lincoln, Massachusetts through **land conservation**, **stewardship** and **education.**

4

Guiding Questions: *What is the City of Lincoln excited about? Why? What do they still need help with?*

DeNormandie Rte. 2 Parcels

THANK YOU FOR YOUR HELP!



We Did It!! We have raised enough funds to move forward with the acquisition.

THIS IS AN IMPORTANT PARCEL

Identified as Land of Conservation Interest on the Town's Open Space Plan this 53 acre parcel provides:

- WATERSHED PROTECTION
- WILDLIFE HABITAT
- SCENIC VISTAS
- OVER 300 CONTIGUOUS ACRES OF CONSERVATION LAND (INCLUDING RICCI AND D'ARRIGO)

DEVELOPMENT WOULD BE DETRIMENTAL TO LINCOLN

Land could support up to 11 house lots or, with a zoning change, large scale development similar to Rte 128 corridor. Potential impacts include:

- NOISE AND LIGHT POLLUTION
- TRAFFIC
- INCREASE IN DEMAND ON TOWN SERVICES
- DETERIORATION OF QUALITY TO SURROUNDING CONSERVATION LAND

CONSERVATION PLAN DETAILS
HELP PRESERVE NORTH LINCOLN'S LEGACY

The acquisition cost for the property is $1.96 million. The City of Cambridge has committed to be a major funding partner. The fundraising details are:

Total Cost of Acquisition:	$ 1,960,000
City of Cambridge:	$ 1,600,000
Lincoln CPA:	$ 100,000
Private Fundraising (To Date)	$ 255,000

Donations still accepted to cover related acquisition costs:

$ 5,000

To contribute, please fill print out and complete the pledge form and mail it to the Rural Land Foundation.

Should we reach our goal, your donation will be tax deductible.

PLEASE GIVE GENEROUSLY.

Subject site overlooking Route 2 facing southwest; photo: Alexander Olney

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Glossary of Words

Deterioration	The act or process of becoming worse
Detrimental	Causing damage or injury
Tax deductible	A reduction of the income subject to tax
Vista	A large and beautiful view of an area of land or water
Watershed	An area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay or ocean

WICKED LOCAL CAMBRIDGE
WITH NEWS FROM THE CAMBRIDGE CHRONICLE & TAB

Guiding Question: *Why is preservation of the Cambridge watershed a better solution for flood prevention than the flood storage?*

Letter: Solution to flooding 'inadequate'

Wicked Local Cambridge
Posted Sep 20, 2011 @ 11:56 AM

Cambridge—At the Sept. 7 meeting about Alewife flood storage in DCR parkland, Cambridge said the system it will build could handle two-year floods. As readers may know, there have been at least two 50-year floods there since 1996. Cambridge's solution will be grossly inadequate, the loss of parkland gratuitous.

Community Preservation Act (CPA) legislation allows for purchase of watershed lands. Cambridge has spent more than a million dollars of Community Preservation Act funds to buy watershed outside of the city, in Lincoln. I propose that instead of destroying Alewife, the city spend CPA funds to buy watershed in Cambridge, at Alewife, to deal with the torrents of water that will continue to flood there in future storms.

It should be possible for the city and the current property owner of a parking lot on Cambridge Park Drive to agree on flood storage under any future building there. The developer would retain air rights for such a building or buildings. The city would pay the developer for the easement and marginal increase in the costs of a foundation built over the flood storage.

The owner of the parking lot has been attuned to environmental issues and has previously installed a rain garden at Alewife property to deal with runoff from its buildings.

The city could reasonably pursue this option as an alternative to its imminent crime against the environment at Alewife. **-- Marilyn Wellons, Green Street**

Glossary of Words

Attuned	To cause (a person, company, etc.) to have a better understanding of what is needed or wanted by a particular person or group
Easement	A right to use property without owning it
Flood storage	A basin that temporarily store floodwaters during a flood
Gratuitous	Uncalled for; lacking good reason; unwarranted
Grossly	Very obviously or noticeably
Imminent	Happening very soon
Marginal increase	Pertains to cost, an additional amount needed in response to a change
Retain	To continue to have or use something
Torrents	Large amounts of water that moves very quickly in one direction
Two-year flood	A flood that has one in two (or 50%) chance of occurring in a given year; similarly, a 50-year flood has a one in fifty (or 2%) chance of occurring, and a 100-year flood has one in one-hundred (or 1%) chance of occurring
Watershed	An area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay or ocean

The New York Times

6

Guiding Questions: *This article explains a watershed controversy in New Jersey. What is the main problem? Does this change your perspective on the Cambridge watershed issue?*

In New Jersey, Development Conflicts With a Watershed

Richard Perry/The New York Times

Pete Rochelle, left, and Pete Hays want to build a golf course in Morris County, N.J., but a state law passed in 2004 to preserve the water supply has stalled their plans.

By KEN BELSON
Published: January 15, 2007

MORRISTOWN, N.J., Jan. 9 — By his own admission, Michael Natale is just a small-time homebuilder who wants to get back the nearly $3 million he paid for 112 acres of land in Sparta, about half an hour from here.

Michael Natale, left, a homebuilder, debated with Gary Oppenheimer, an environmentalist, at a public meeting over the Highlands.

The trouble is that less than a year after Mr. Natale bought the property in 2003, the state passed a sweeping law, the Highlands Water Protection and Planning Act, aimed at protecting the watershed in northern New Jersey.

And it turns out that Sparta, in Sussex County, is partly in the preservation area, where building has been severely curtailed, making it impossible for Mr. Natale to build 20 new houses on his land as he had planned.

"I'd move on if I could be compensated," Mr. Natale said last week at a public hearing to review the proposed Highlands Master Plan. "All I'm doing is running in place now."

Mr. Natale, who wore a shirt that said "Families Need Homes" at the hearing, is one of hundreds of thousands of New Jersey residents caught in this collision between water, money and politics — a familiar face-off being played out in other parts of the country. In deciding to preserve the watershed and the water supply, New Jersey lawmakers made choices that were bound to reduce the value of some privately held land.

The Highlands Council, a 15-member body created by the act, is now putting the final details on the development guidelines for the 859,000 acres in the area, which covers one-ninth of the state. The council has promised to compensate owners whose land has lost value from the rezoning through a program that allows them to trade their development rights, but so far, no redress program has been created and no money has been set aside.

Developers, farmers and large landholders said they were not opposed to protecting the environment but argued that they were being asked to shoulder a disproportionate share of the cost because they had the misfortune to buy their land before the act passed in 2004 and were now unfairly restricted in what they could do.

Preservation debates like this one are raging across the country as sprawling cities and suburbs gobble up more farmland, woodlands and water basins. But rarely have the stakes been as high as in New Jersey, the country's most densely populated state. Recent droughts have heightened the urgency for watershed protection, especially with the state expected to add 600,000 residents this decade.

"You won't find anything larger in proximity to a growing metropolitan area," said Robert J. Pirani, the director for environmental programs at the Regional Plan Association, a nonprofit group that studies development and transportation issues. "The Highlands are the fault line between the water supply and other critical infrastructure, and development and housing."

Other states like New York have been more aggressive than New Jersey in preserving their water supplies. Indeed, the debate over protecting the Highlands in New Jersey started a century ago but regulation had been put off repeatedly.

Lawmakers had dragged their feet partly because the Atlantic Highlands, which stretch into New York, Pennsylvania and Connecticut, are so vast. In New Jersey, the region supplies water to more than 5 million people, or 65 percent of the state's residents, as well as some of its biggest employers, including Merck and Prudential Financial.

Five towns are entirely in the preservation area, where development has been largely halted. Portions of 47 other towns, including Sparta, also fall in the preservation area. Another 36 towns are in the so-called planning area, where town government officials can choose whether to conform with the master plan. Many towns are grappling with new environmental standards that, in some cases, will require them to rewrite their zoning laws.

While more than half the land in the Highlands is already developed or protected under older environmental laws, developers, homeowners and environmentalists are struggling over the 300,000 acres that is still undeveloped or unprotected. Environmentalists who spoke here last week, some wearing stickers with phrases like "Got Water?", said the draft of the Highlands Master Plan released in November did not go far enough to preserve the land.

Indeed, thanks to exemptions in the current plan, about 50,000 more homes could go up in the Highlands, the Regional Plan Association said.

"Development, development and more development is no way to protect the water supply," said Mike Herson, Highlands issues coordinator for the New Jersey chapter of the Sierra Club. "We already live on top of the water supply in New Jersey."

Curtailing development, though, comes at a cost. Big builders also oppose the Highlands Act because it limits where they can build and could lead to fewer construction jobs. Still, those companies have the resources to find land elsewhere.

Individual landowners and independent developers like Mr. Natale, however, have far smaller financial margins for error. In some cases, they say, the zoning changes could drive them out of business.

Kurt Alstede, a member of the Highlands Council, is sympathetic to their plight and voted against the master plan because it did not do enough to compensate the landowners. "You can't expect people who have been here to bear the cost of changing the rules," he said. "The plan was thrust on them."

Until the council finds a way for landowners to recoup the development value on their property, they will have little recourse except to sell their property on the open market or to a conservation group — in all likelihood, for less than they paid for it. Some landowners are now talking about suing the state, arguing that the law is unconstitutional because it has so diminished their property value that it amounts to an uncompensated "taking."

The legal principles of eminent domain in cases where private land is taken outright by a state are relatively clear. But in the Highlands case, the state is not taking title to the land. As a result, courts are likely to rule that while some land prices may have fallen in the preservation area, property holders still retain some value, so the state is not obligated to repay them in full, according to Armando Carbonell, the chairman of the department of planning and urban form at the Lincoln Institute of Land Policy, a nonprofit research group in Cambridge, Mass.

The Highlands Council members regularly hear heartbreaking stories from landowners and admit that some people are bound to lose money as a result of the law.

"Anytime there's change and uncertainty, people are nervous," said Dante Di Pirro, the executive director of the Highlands Council.

But Mr. Di Pirro said the council hoped to establish a program that would allow property owners to transfer development credits from their land to builders elsewhere, like programs already in place in southern New Jersey and on Long Island, where the credits have become increasingly valuable. In the Pine Barrens on Long Island, for instance, some credits have jumped fivefold during the past decade, according to Ray Corwin of the Central Pine Barrens Commission.

There is no money yet to start such a program in the Highlands.

Even so, the act states that for the purposes of compensating landowners, property must be assessed at pre-act prices. But that is only a starting point for negotiations.

The Regional Plan Association estimates that New Jersey will need to find an additional $1 billion to pay for development rights and land acquisitions between now and 2014, a large amount in a state with big fiscal problems.

To help bridge that gap, the Sierra Club has suggested that residents outside the Highlands who get their water from the watershed — including those in Newark and elsewhere in northeastern New Jersey — pay a water tax to help compensate those affected by the rezoning.

In the meantime, Douglas Medaugh, who in 2000 bought 14.5 acres of land in Rockaway Township, which is partly in the preservation area, said he may be prohibited from breaking up his land into smaller plots to build a second home for his son.

“I’m not a polluter and I like clean water, too,” Mr. Medaugh said. “But I would think with 14.5 acres, I should be able to subdivide, too. My life is on hold.”

Glossary of Words

Compensate	To give money or something else of value to (someone) in return for something (such as work) or as payment for something lost, damaged, etc.
Eminent domain	The power to take private property for public use by a state
Exemption	Freedom from being required to do something that others are required to do
Fault line	An area of, or a boundary between, conflicting interests
Fiscal	Of or relating to money and especially to the money a government, business, or organization earns, spends, and owes
Fivefold	Five times as great or as many
Infrastructure	The underlying foundation or basic framework
Obligated	To be made to do something because the law requires it or because it is the right thing to do
Proximity	Nearness in space, time, or relationship
Recoup	To get back (money that has been spent, invested, lost, etc.)
Redress program	An arrangement designed to set right or compensate for a wrong or unfair situation
Re-zoning	The act of changing the zoning classifications of (a neighborhood or property, for example)
Watershed	An area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay or ocean

Guiding Questions: The Community Preservation Act Committee funds 3 initiatives. What are they and why are they important? In thinking about the Cambridge

Community Preservation Act Committee FY12 Allocations and Recommendations To the City Council

City of Cambridge

Adopted September 12, 2011

Community Preservation Act

The Community Preservation Act provides funding for:

1. AFFORDABLE HOUSING
2. HISTORIC PRESERVATION
3. OPEN SPACE


1. Affordable Housing


3. Open Space, such as watersheds

Do you think that funding should be provided for

-homes for people?
-preserving historic sites?

or

-protecting nature?

Why?

1. Continued Need for Affordable Housing

- There are more than **950 units** facing **expiring use restrictions** in the **next 10 years.**
- There are **14,642** households on CHA's **waiting list** for affordable **rental housing**.
- In order to afford the median market rent for a two-bedroom apartment in Cambridge, a **two-earner** household being paid Cambridge's **living wage** would **each** have to work more than **70 hours per week** to afford the rent.
- The median market price for **condominium** in Cambridge is more than **$424,000**, which would require an income of more than **$110,000** per year to purchase without a significant downpayment.

Median Market Rents – March 2011

1-bedroom	$2,000
2-bedroom	$2,650
3-bedroom	$3,000

Print Shop Condominiums
New construction of 24 affordable homeownership units sustainably built to LEED gold standards

1. CPA Housing Funds FY02-11: $81,360,000

Preservation of Affordable Housing	640 units
Acquisition/Creation of Rental Units	417 units
First-Time Homebuyer Units	+ 147 units
TOTAL	1,204 units

CPA funds committed to affordable housing have leveraged

more than $268 million

from other public and private funding sources

Putnam Green
40 affordable rental units under construction

2. Historic Preservation

Eligible Activities: preservation, rehabilitation or restoration of eligible historic resources

Eligible Historic Resources:

- Listed on or eligible for the Mass. Register of Historic Places
- Determined by the CHC to be significant in the history, archeology, architecture or culture of the city

Cambridge Projects:

- Preservation Grants for institutions and affordable housing
- Restoration of public buildings, landscapes and archives

The exterior of the Women's Educational Center at 46 Pleasant Street was restored in FY2011

3. CPA Open Space Funds FY11: Recent Accomplishments

Black's Nook Restoration Project within Fresh Pond Reservation

3. Recommended Use of FY12 CPA Open Space Funds: $960,000 (10%)

Watershed Protection and Landscape Stabilization – Adjacent to Fresh Pond Reservoir (Golf Course):	**$260,000**
Watershed Protection and Landscape Stabilization – Adjacent to Fresh Pond Reservoir (Glacken Slope):	**$350,000**
Watershed Protection – Adjacent to Fresh Pond Reservoir (Parkway Community Garden):	**$350,000**
+	
Total	**$960,000**

If you had to choose, what would you provide funding for any why.

-Homes for people?
-Preserving historic sites?

or

-Protecting nature?

8

Guiding Question: *This article details the history of the Cambridge water supply. What has changed? Why is it important to protect our water source?*

The Life Story of Cambridge Water

John F. Davis, President
Cambridge Water Board

Cambridge Massachusetts
December 1965

Early Years

Pure water was never a problem to the earliest settlers of Cambridge. A plentiful supply of pure water from such streams and springs as Menotomy River, Swamp Creek, Squaw Creek and Sachem Brook was utilized.

A Water Control Committee was appointed in 1700. Cattle were ordered pastured and watered at Charles River near the Watertown line. Refuse was dumped below the pasture. The Menotomy River was set aside for fishing and a weir constructed across it. Fish caught in the weir were divided among the settlers and the Indians.

The first Water Works Charter was granted to the Cambridgeport Aqueduct Company in April 1837, to bring water from springs on what is now Spring Hill in Somerville. The water flowed through wooden logs, and a limited amount was supplied to the lower Port for many years. Drinking water in other sections was obtained from wells. In some parts of the town of Cambridge, no houses were built because there was no well water to drink. Fire protection was nil. If a house caught on fire, it burned to the ground.

Cambridge, in 1846, had practically no sewerage system and very few private street lamps. Our highways at night were in darkness. The condition of the roads were wretched, and as for sidewalks, there were none. In the winter months, and in wet weather especially, transportation by horse and buggy was difficult and walking practically impossible…

Chester W. Kingsley, a member of the Water Board from 1865 to 1894, reported that a Charter was granted the Cambridge Water Works in 1852. In 1861, the Cambridge Water Works was empowered to purchase the Cambridgeport Aqueduct Company, and the City of Cambridge, in April 1865, purchased the rights of the Cambridge Water Works. Thus, all the Water Works in Cambridge became City property at a total cost of $291,000. This included the pumping station, Fresh Pond with all land surrounding it, approximately 200 acres, the reservoir on Reservoir Street with 12" pipe to Fresh Pond, and the distribution system. In 1885, a reservoir was constructed on Reservoir Street, the highest land in Cambridge.

This reservoir, constructed of planks, was 165 feet square by 10 ft. high, covered and of 2,000,000 gallons capacity. It was 73 feet above Fresh Pond and 2300 feet from the engine house at Fresh Pond.

In 1887, Cambridge was authorized to purchase land and to take the water of Stony Brook, and its tributaries in the Waltham and Weston area, with the added right to take land for building a dam and developing a storage basin. Thus, Cambridge acquired 22 square mile of watershed. The population of Cambridge was approximately 60,000 at this time…

Cambridge population in 1897 was about 87,500. At this time the facilities developed for its water resources were:

1. Fresh Pond of 1,500 million gallons capacity with land of 165 acres acquired in 1853.

2. Stony Brook Reservoir of 400 million gallons capacity with land of 71 acres acquired in 1887. Stony Brook was dammed at Waltham adjacent to Summer Street.

3. Hobbs Brook Reservoir with land acquired in 1892 from Waltham, Lincoln and Lexington of about 558 acres, excavated and bottom rock lined. Dams erected for Lower Hobbs at Winter Street, Waltham. For Upper Hobbs at Trapelo Road, Lincoln, a reservoir of 2,700 million gallons capacity had been created. When filled, this reservoir stood at an elevation of 183 feet above sea level.

4. Payson Park Reservoir erected on 163 acres of land acquired form Belmont. Payson Park Reservoir of 43 million gallons capacity stands 178 feet above City of Cambridge base, or about the level of Harvard Memorial Hall Tower. Thus, the head for Cambridge water lines was established at 178 feet at Payson Park Reservoir in 1898.

The total land area used by the Cambridge Water Department in this acquisition program was approximately 1,416 acres….

In 1923, the new Cambridge water purification plant was completed on the shores of Fresh Pond. It consisted of a dual underground settling basin 137 feet long by 96 feet wide and 16 feet deep; a new building of the Georgian type, two-story structure 223 feet long by 71 feet wide with central tower housing the water tank; the first story was of concrete, the second story faced with tapestry brick. The structure housed ten rapid sand filters with beds 24 feet by 20 feet by 9 feet deep; administration offices, laboratory, facilities for chemical treatment of water, engine pumps, etc.

This new water purification plant, or filter plant, was dedicated June 1923, by impressive services with Cambridge officials at Kingsley Park. This gave Cambridge the most up-to-date and largest water purification plant in New England. A steam driven Worthington Pump, of 20 million gallon capacity, was purchased and installed in 1930, which provided dual pumping facilities….

The Water Board, in 1932, installed a new pumping station and intakes at Fresh Pond, additional pipe capacity from Stony Brook, new filter beds at Fresh Pond and new mains in the distribution system. These works were required to meet the increasing industrial and population demands.

By act of the State Legislature, permission was granted in 1931 for a golf course on the shores of Fresh Pond. Cost was met by private subscription. Unemployed men were put to work building the golf course during the Depression. Professor Edwin H. Hall helped raise money. The earth removed during the construction of the purification plant in 1923 was used to fill in the low areas of the golf links.

In 1932, six new filter beds and a building were added making a total of sixteen beds for filtering 24 million gallons daily. The building and installation of two 7½ million gallon electric pumping units enabled an additional draw down of Fresh Pond.

A study of possible sources of pollution of the Cambridge water supply in Stony Brook and Hobbs Brook watershed was completed by Professor Whipple of Harvard and the State Director of Public Health, in 1934, which resulted in remedial action being taken during the succeeding years.

1942- 1963

In 1942, due to the increase in consumption of water, the City Manager appointed a committee, consisting of Professor Gordon M. Fair of Harvard University, Professor Thomas R. Camp of Massachusetts Institute of Technology and Mr. Frank P. Scully, to study the water situation of Cambridge…

The rainfall from 1937 to 1946 averaged 46.3". The maximum was in 1938 of 58.5"; the minimum was in 1941 of 32.2".

The water formerly flowing directly into Fresh Pond from Stony Brook is now partially diverted through a 42" pipe and enters the sedimentation basin of 1.5 million gallon capacity. Here alum is added to develop coagulation and to enhance sedimentation. The water then flows to the filter beds and passed through three feet of sand and gravel where the remaining suspended matter, caused by coagulation after chemical treatment, is removed. The water then passes over ripple plates in an aerator where gases, tastes and odors are removed. Before the water enters the clear water basin, chlorine is added in accordance with State Health requirement to insure the safety of the water. Finally, lime is added to restore alkalinity and to develop an anticorrosion control program. From the clear water basin, which has a capacity of four million gallons, the water is pumped to the Payson Park Reservoir for distribution to the consumers by gravity.

- Hobbs Reservoir man-made, 100 acres, watershed 7.5 square miles.
- Stony Brook water area 71 acres, watershed 17 square miles.
- Fresh Pond water area 166 acres, watershed one square mile…

The year 1950 marked the start of a program to improve the Cambridge Water system. The shortages of materials during the war and post-war years made it impossible to develop the improvement program at an earlier date. After years of study, under the guidance of Professor Howard M. Turner as President of the Cambridge Water Board, the expenditure of $1,5000,000 was approved by the City Council. This provided for a new pumping station, improvement and extensions for water treatment facilities at the filtration plant, work on the sedimentations basins,

flocculation chambers, valve chamber, also for a new maintenance general shop building and garage…

Water rates in Cambridge to users of Cambridge water were, in 1910, ten cents per 100 cubic feet, the lowest rate in the state. In 1949, the water rate was increased to thirteen cents per 100 cubic feet, and in 1957, the water rate was increased to sixteen cents per 100 cubic feet.

In 1959, the new liquid alum building was erected adjacent to the valve chambers building. Liquid alum is now delivered by truck and fed automatically to the flocculators.

The same year new, larger transformers were installed.

The citizens of Cambridge, at the November election in 1959, voted by a small margin to fluoridate Cambridge water. Dentists, physicians, engineers and people of authority considered fluoridated water a great health benefit to children's teeth up to age fifteen and of no detriment to other people's health. However, four years later, Cambridge citizens voted to remove fluoride form Cambridge water. Since February 1964, no fluoride had been added to Cambridge water…

North of the Fresh Pond Reservoir and adjacent to the golf links, a small pond know as Black's Nook had become unsightly and was the burial ground for tree stumps from the last hurricane. An active group of women in the City known as the Cambridge Garden Club initiated a project to clean up and develop this area. Many truck loads of stumps; dead trees and other foreign material were removed. The area was graded, loamed and seeded. Over one hundred new trees and shrubs were planted. The improvement developed in the area during the past two years is a credit to these fine women. Recently a reception to the Club was held on the grounds to commemorate their achievements.

1965-present

Water is today uppermost in everyone's mind. It is difficult for us to believe our supply of water no longer equals our demand. Rainfall is off seven inches since January 1, 1965, according to Metropolitan District Commission Director Harold J. Toole's report of July 1, 1965.

Lawns are brown, ponds and reservoirs are down. Rain has bee a scarce commodity for several years around Boston. This past summer, the use of water for sprinkling lawns, filling swimming pools, for air conditioning and even general use has been severely restricted.

The drought, the last two or three years, has taxed the Cambridge water supply. Fresh Pond is at its lowest level. Stony Brook, Lower and Upper Hobbs, which should be full during early summer, are approximately twenty feet below capacity. The Cambridge Water Department is obliged to draw a large part of its water from the Metropolitan (current MWRA) supply.

Due to the foresight of our predecessors, Cambridge is connected to the Metropolitan and can automatically secure water from the Metropolitan District Commission from three separate locations.

When you turn on your faucet in your home to get a drink of water, this water may have originated in several places: Hobbs Reservoir, Stony Brook, Quabbin or nearer home from rainfall at Payson Park or Fresh Pond. Wherever it originated, it is one of the world's purest and most potable drinks.

Mr. Toole, Director of the Metropolitan District Commission Water Division, said that homes and other users in the system, population of about 1,800,000 would continue to have water for well over two years, even if it did not rain at all.

This is despite the fact that Quabbin Reservoir is at its lowest level, 15½ feet below capacity, since its was filled in 1946. Quabbin is the largest fresh water reservoir in the eastern United States. It is a fenced-in area in North Central Massachusetts, ten miles wide and eighteen mile long. The water in Quabbin is impounded by Winsor Dam and Quabbin Dike. From these, water flows to the Metropolitan system.

The Cambridge Water Board, consisting of John F. Davis, George Fantini, Michael J. Mahoney, J. Carrell Morris and Timothy F. White, with Superintendent William H. McGuiness, Water Works Engineer John F. Glacken and advisor, Professor Richard C. Woodward, is awake to the problems of water shortage and maintaining good water for Cambridge. They are seeking every additional source of water, improving its distribution and conserving its use. Most of the water problems, according to experts who are studying the problems throughout the United States, are due partially to distribution. Waste is a major factor in the country's water resources problem and pollution of these resources deprives the citizenry of many sections of the country of their God given right. We need more planning more than we need more water.

With the increased per capita demand and the population growth, it is imperative that proper planning be developed to meet this increased need.

Glossary of Words

Alkalinity	The quality of containing an alkali (a substance that has a bitter taste and that forms a salt when mixed with an acid)
Alum	Any of various chemical compounds that are double sulfate salts. Alums are useful for a range of industrial processes. They are soluble in water, can crystallize, can be heated to liquefy, and can also become an amorphous powder.
Aqueduct	A pipe or channel that is used to bring water to an area
Anticorrosion	To prevent the chemical process of breaking apart and destroying (such as metal, an object, etc.)
Coagulation	The process of becoming thick and partly solid
Dammed	To be confined by a barrier; such as a body of water
Erected	Set or built straight up and down
Excavated	To be uncovered by digging away and removing the earth that covers it
Flocculation	The formation of lumpy or fluffy masses
Graded	To be leveled or smoothed to a desired slope
Imperative	Very important
Loamed	To filled or covered with loam, a soil mixture of sand, clay, silt, and organic matter
Nil	None at all
Predecessor	Something that comes before something else
Remedial	Done to correct or improve something; done to make something better
Watershed	An area in which water, sediments, and other dissolved materials drain to a common outlet such as a river, lake, bay or ocean
Weir	A low wall or dam built across a stream or river to raise the level of the water or to change the direction of its flow
Wretched	Very bad or unpleasant

Guiding Questions: Why does the City of Cambridge want to purchase the Cambridge Watershed? What might happen if they don't?

CITY OF CAMBRIDGE
MASSACHUSETTS
Water Department
250 Fresh Pond Parkway
Cambridge, MA 02138
617 349 4770
fax 617 349 6616

May 24, 2012

Mr. Robert W. Healy, City Manager
City Hall
795 Massachusetts Avenue
Cambridge, MA 02139

Subject: Land Acquisition Recommendation

Dear Mr. Healy,

The Cambridge Water Board has done an initial evaluation of two (2) parcels of land in the Cambridge Watershed for possible acquisition. Officials from the Town of Lincoln and the Lincoln Rural Land Foundation (RLF) contacted the Water Department and requested that Cambridge purchase the aforementioned undeveloped parcels, which they have identified as being environmentally sensitive and having a high potential for development.

The 53.6 acre DeNormandie properties (parcel ID# 30-3-0 and 30-6-0) in Lincoln, MA abut State Route 2 just west of Juniper Ridge Road in the Hobbs Brook headwaters region. The parcels surround approximately 1,800 feet of Hobbs Brook, the largest tributary to the Hobbs Brook Reservoir. Over 50% of the proposed land is DEP Surface Water Supply Protection Zone A, which is the first criterion used to prioritize land acquisition in the Cambridge Watershed. The resulting total land area protected would be approximately 74 acres because RLF has committed to donate an additional nearby 20 acre parcel (#30-8-0) to Cambridge.

The Water Board believes that the residential development of the parcels would be detrimental to the long-term integrity of the water supply. Therefore, the Board, by a unanimous vote at its public meeting on May 24, 2012, recommends that the City pursue acquiring these parcels by means of purchase or otherwise for the purpose of water supply protection and conservation.

This vote re-affirms the Water Board's vote of March 13, 2012 related to these parcels, while acknowledging the correction of the total acreage of the DeNormandie properties from 55.6 acres to the corrected 53.6 acres.

On behalf of the Board, Ann Roosevelt, President

cc. Mr. Richard C. Rossi, Deputy City Manager
Mr. Stephen Corda, P.E. Managing Director CWD
Mr. Chip Norton, Watershed Manager CWD
Water Board

Jennifer Wright
Conservation Commission Director

CITY OF CAMBRIDGE
CONSERVATION COMMISSION
344 Broadway
Cambridge, Massachusetts
02139

June 4, 2012

Mr. Richard C. Rossi, Deputy City Manager
Cambridge City Hall
795 Massachusetts Avenue
Cambridge, MA 02139

Re: Community Preservation Act – Open Space Funds
Land Acquisition in Lincoln, MA

Mr. Rossi:

On August 22, 2011, the Cambridge Conservation Commission reviewed a summary of the FY12 Community Preservation Act Open Space proposed projects at their public meeting. The proposed projects included land acquisition of the "DeNormandie Parcel" for watershed protection in Lincoln, MA. The Commission unanimously voted to support the proposed project.

Respectfully submitted for the Conservation Commission,

Jennifer Wright, Director

Telephone: 617. 349. 4680 *Facsimile: 617. 349. 4633*

CITY OF CAMBRIDGE • EXECUTIVE DEPARTMENT

Robert W. Healy, City Manager *Richard C. Rossi, Deputy City Manager*

To: Robert Healy, City Manager
From: Richard Rossi, Chair, Community Preservation Act Committee
Date: June 6, 2012
Re: Appropriation of CPA Open Space Reserve Funds For Purchase of DeNormandie Land in Lincoln, MA

The purpose of this memo is to summarize the meeting of the Community Preservation Act Committee on June 5, 2012 with regard to the City's recommendation to use CPA Open Space Reserve funds for the purchase of 53.6 acres of watershed land in Lincoln, MA.

The unanimous recommendation to purchase the property, made by the CPA Committee at its public meeting on June 5, 2012, followed a thoughtful discussion of the details and benefits of the purchase, which was based on an offer to sell the land made by the DeNormandie family and the Rural Land Foundation ("RLF"). The purchase of the parcels with Open Space Reserve funds will be supplemented by a $500,000 Drinking Water Supply Protection grant from the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) and a $300,000 contribution by the RLF. In addition, as part of this transaction, the RLF will contribute approximately 20 additional acres of watershed land in Lincoln, for a total of approximately 74 acres of sensitive watershed land, all of which will be protected from development by conservation restrictions. Both the Cambridge Water Board and the Conservation Commission voted in favor of this purchase and provided letters in support. Based on this input, the Committee recognized that the opportunity to purchase the parcels will enable the City to permanently protect this sensitive watershed property and to leverage the donation of an additional 20 acres of property owned by the RLF, for the same purpose.

Accordingly, on June 5, 2012 the CPA Committee voted unanimously to recommend to the City Manager that the CPA Open Space Reserve funds be appropriated as follows:

1. **Open Space Reserve ($1,152,247)**
   - $1,152,247 appropriated to purchase 53.6 acres of watershed land in Lincoln, MA, with the goal of drinking water supply protection and land conservation

Attendance at Community Preservation Act Committee Meeting: June 5, 2012

Committee Members Present:
Richard Rossi, CPA Committee Chair, Deputy City Manager
David Kale, Budget Director, Finance
Wyllis Bibbins, Member, Historical Commission
Gerald J. Clark, Cambridge Housing Authority

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Cambridge Watershed Case Study Articles				
#	**Article & Source**	**Summary**	**Guiding Question(s)**	**Tips**
1.	*A Walk in Cambridge's Watershed:* Cambridge Community Television	The busy city of Cambridge, MA, owns 1,200 acres of wilderness less than a few minutes drive away from its urban center. Most of Cambridge's residents are unaware that the city owns this land, which is part of a larger watershed that affects the river where Cambridge gets its water. The city government wants more of its citizens to know the source of their water and recognize its independence from the Greater Boston Area's water source, so it has organized a series of public activities in its wilderness to encourage this understanding and appreciation.	**Q:** What is Cambridge's hidden secret? Why is it important to the community? **A:** Cambridge's hidden secret is its 1,200 acres of wilderness. It is part of the larger watershed that affects the river where Cambridge gets its water.	Article 1 and 2 could be paired together so that the discussion could flow from the purpose to the value of public land.
2.	*Cambridge Scoops up Lincoln land:* Cambridge Chronicle	The city of Cambridge, MA, wants to preserve the quality of its drinking water by securing the watershed, the land that drains into the city's water source. Part of Cambridge's watershed is in the neighboring town of Lincoln, so Cambridge purchased 53.6 acres of land from Lincoln for $1,152,247. Even though protecting its watershed is expensive, the city of Cambridge will now spend less money on treating its water than it would have to spend if someone else owned this portion of the watershed.	**Q:** Why does the City of Cambridge want to buy the land in Lincoln, MA? **A:** The city of Cambridge wants to ensure that the water in the watershed continues to be high quality and lasting.	It might be helpful to contextualize $1.15 million dollars in terms how relatively expensive the land is. It might also be helpful to visualize how large 53.6 acres is to emphasize the expanse of a watershed.
3.	*Incorrect Thoughts: The Clock is Ticking:* Lincoln Journal	This opinion piece in a local online publication provides some background information about the deal to purchase the DeNormandie parcels. The author explains what the	**Q:** What is the City of Lincoln trying to raise money for? What will happen if they don't? **A:** Lincoln is trying to raise their share of the money needed to buy a plot of land that is	This article presents a local author's perspective on the land deal, and makes use of sarcastic language that may not be obvious to all of your students. Consider encouraging

		town of Lincoln is raising money for, and contrasts that option with the possibility that the land could be developed for residential or commercial use. The author clearly opposes this development.	part of the Cambridge watershed. If enough money is not raised, there are plans to develop houses or a high-rise building on the property.	students to pay careful attention to the author's tone as they think about which side of the argument he supports.
4.	*DeNormandie Rte 2 Fundraising:* www.lincolnconservation.org	This announcement was put forth on the website of a non-profit organization founded to protect rural land in Lincoln, MA. The page describes why the land is important, outlines the reasons why developing on this land would be problematic, and requests donations to help cover costs related to the land acquisition.	**Q:** What is the City of Lincoln excited about? Why? What do they still need help with? **A:** The City of Lincoln is excited that they have raised their share of the money needed to acquire the DeNormandie parcels. This is exciting because the land is an important part of the watershed and is home to a great deal of wildlife. Acquiring the land will prevent it from being damaged by developers. The town still needs $5,000 to cover the rest of the costs associated with the acquisition.	This piece presents a general, easy-to-read overview of the situation and demonstrates that the local citizens were being directly asked to provide financial support. It would be useful as a supplement to some of the longer readings describing the acquisition, especially for students who are having trouble identifying the main ideas.
5.	*Letter: Solution to flooding 'inadequate':* Wicked local	A citizen speaks out against the City of Cambridge's [then] current plans for flood storage at Alewife because it would be insufficient. The writer believes that in order to preserve Alewife, the city should spend its Community Preservation Act (CPA) funds to purchase watershed land instead.	**Q:** Why is preservation of the Cambridge watershed a better solution for flood prevention than the flood storage? **A:** Since past floods have shown that flooding will be greater than the flood storage system promises, it makes sense for Cambridge to buy watershed land for water to drain to.	• DCR = Department of Conservation and Recreation • This is a short article, and may be paired with another longer article.
6.	*In New Jersey, Development Conflicts with a Watershed:* New York Times	New Jersey's 2003 law to protect watershed land is preventing many property owners from developing on their own land. Due to the dense and	**Q:** This article explains a watershed controversy in New Jersey. What is the main problem? Does this change your perspective on the Cambridge watershed issue?	This is likely to be a challenging article for students, but it presents a very important aspect to the issue that the students are studying. This

		growing population as well as the frequency of droughts, it has become increasingly important to protect the water supply. Since the law restricts many individual landowners and small developers from building on their own property, a solution to compensate them is needed.	**A:** The main problem is that what the state has prioritized has many damaging results for people that owned the land before the law was passed. It is important to keep in mind what steps are taken to consider the interests of all parties involved.	may be read as homework, or done as a group activity. Article 6 uses a lot of legal and economic terms that will be too complicated for most students and are probably not critical. Can this be pared down?
		Optional Resources		
7.	*Community Preservation Act FY12 Allocations:* City of Cambridge	This Power Point (PPT), used for the City of Cambridge, identifies the three main initiatives that the city funds: affordable housing, historic preservation, and open space (e.g., watersheds). This PPT demonstrates that affordable housing is critical in the Cambridge area, but so is the preservation of open spaces and water. This PPT illustrates associated costs with each initiative.	**Q:** The Community Preservation Act Committee (CPAC) funds 3 initiatives. What are they and why are they important? In thinking about the Cambridge Watershed issue, which initiative do you think the city should spend money on? Why? **A:** CPAC funds affordable housing, historic preservation, and preservation of open spaces.	This is an optional resource. You can either lead the class with a discussion of how a city can allocate their funds, pair this resource with one of the other articles that students are reading, assign this as a separate reading, or omit it.
8.	*The Life Story of Cambridge Water:* John Davis, 1965	This article details the history of the Cambridge water supply. Starting in the 1700s until 1965, the article walks the reader through the different acquisitions of land that became part of the network of Cambridge water resources. It describes the challenges faced over the years in managing and maintaining the water supply and the investments that have been made to ensure that Cambridge water is of the best quality possible when it arrives at residents' homes. The article ends with a call by the author for continued planning and development to protect Cambridge water.	**Q:** This article details the history of the Cambridge water supply. What has changed? Why is it important to protect our water source? **A:** Encourage students to provide two or three main ideas from the article for each question posed above.	One of the hardest aspects of this article is that it is so heavy on chemical terminology. One way to scaffold this article is to tell students, "A lot of things have happened to the water you use every day during its path from the water supply to your faucet. Underline every phrase that describes something that happens to the Cambridge water during its journey (examples: chlorine is added, fluoride is removed, etc.)." You may also want students to create a timeline as they read the article to help them organize the

				dates and events. It may also be challenging for students to visualize the location of the different water sources (lands) that have been part of the Cambridge water supply over time. Make a map of the region accessible to students so they can refer to it before and during the reading. If not reading this article as a whole class, you might consider having students read this in pairs or groups to have students support one another in reading and comprehending the material in the article.
9.	*Cambridge Decisions:* City of Cambridge	This is a series of three memos written by City of Cambridge officials recommending that Community Preservation Act (CPA) Open Space Reserve funds be used to purchase Cambridge watershed land in Lincoln, MA. The letters report that both the Cambridge Water Board and the Conservation Commission voted unanimously in favor of this purchase to protect the environmentally sensitive land and the Cambridge water supply.	**Q:** Why does the City of Cambridge want to purchase the Cambridge Watershed? What might happen if they don't? **A:** • The DeNormandie properties have been identified as environmentally sensitive lands that need to be protected from development. • This land is part of the Cambridge watershed and contributes to the Cambridge water supply. • Residential development of this land would be detrimental to the long-term integrity of the water supply. In addition, it would endanger the environmental viability of the land.	Although concise and straightforward, the technical language may be challenging for some students. You may suggest that students underline the main takeaways from specific sentences or paragraphs as they read. Prior to reading the memos, it might help to briefly discuss with students the various city official and departments (e.g., CPA Committee, Cambridge Water Board, etc.) and their role in making these kinds of decisions. Background knowledge on the CPA and the Open Space Reserve funds may help put the memos in context.

MODULE 2

BECOMING RESPONSIBLE INDIVIDUALS: UNDERSTANDING DISTRIBUTED CAUSALITY

MODULE 2
OVERVIEW:

THINKING ABOUT DISTRIBUTED, DECENTRALIZED CAUSALITY

This second module focuses on the idea that the behaviors of groups and agents (or individuals) can result in collective outcomes. These outcomes are not always intended. In fact, because the intentions of each individual agent function at one level and the collective outcomes are at another, individuals may not even be aware of the outcomes. When they are, individuals may be surprised to see things happen that they never expected to happen.

Predicting collective outcomes can be hard for a number of reasons. It can be difficult to keep in mind the many different actions of many individuals and think about how they may add up and/or interact to lead to particular outcomes. It can also be difficult to observe the individual actions to imagine how they result in the collective effects. Some collective effects, such as clapping in an auditorium, are easy to see. The volume of the clapping swells as more and more individuals engage in the activity. **Accumulation** effects like these are additive (although they may also interact; for example, as one person claps more enthusiastically, others may as well). In some cases, they are contained in one space, and the physical connection between the action and the outcome are apparent. In other cases, the additive or interactive effects may not be easily discerned and the connection to the outcomes may not be obvious. The actors may also be spatially spread out. This is the case with climate change where multiple agents around the world collectively contribute to global warming. We can't directly see the connections between our actions and global warming. Furthermore, it is difficult to anticipate how some changes will interact with others in **feedback loops**—those with and without **spiraling**.

The diffuse and hidden nature of accumulating and/or interacting actions leading to certain outcomes contributes to our difficulties. Some phenomena have tipping points in which outcomes are triggered once accumulation reaches certain levels. This may be difficult to realize the impact of individual variables (for instance in cases such as pollution, carbon, and so forth). The additive features also complicate our reasoning. With pollution, for example, it doesn't seem like driving a few miles each day has much of an impact on the environment. However, when this seemingly small and insignificant action by one person is multiplied across thousands and millions of people, it can collectively contribute to a massive, negative outcome for our planet.

ACCUMULATION:
The effects of each of the contributing agents are simply additive: there is no interaction among agents. For example, the volume of clapping increases as more and more individuals engage in the activity.

FEEDBACK LOOPS:
A circle between entities in which they reinforce one another to continue the cyclic relationship. For example, cause (A) impacts the effect (B), which causes that effect (B) to impact the cause (A). There can be amplification or dampening that increases or decreases the level of each entity in the loop as explained below.

SPIRALING:
A process that involves amplifying or dampening feedback loops or interactive/synergistic components. For example, a cafeteria may get louder because each student is trying to talk over another student.

DETAILS ABOUT TERMINOLOGY

Distributed Causality and the concepts related to it have been studied by educational researchers. The literature makes certain distinctions in order to differentiate certain kinds of concepts and what they entail. In developing the curriculum we carefully analyzed the instructional challenges of teaching these concepts and how to make them easier for middle school students to understand. We have made deliberate choices in the terminology in the module and how we present it to students. In some cases, the terminology here departs from that used in the academic literature in order to better align with the instructional goals of the module. The paragraphs below outline these instructional design decisions in relation to terminology.

MODULE 2
OVERVIEW:

THINKING ABOUT DISTRIBUTED, DECENTRALIZED CAUSALITY

Distributed causality refers to instances where there are multiple agents engaged in a behavior and there is a collective outcome from those actions. These collective outcomes can be can be classified as one of three tiers: additive/accumulative tier, interaction tier, and synergistic tier. When agents accumulate together, such as people entering into a cafeteria, we consider this to be an additive model: each individual contributes to the size of the group. Sometimes, however, the agents interact. For example, when the individuals in the group of people in the cafeteria begin to talk, the result is above just adding one more person. The components of the group are interacting; we refer to these collective effects as part of the interaction tier. There are also, however, instances when the interactions between the agents interact—these are synergistic interactions. For example, in the cafeteria scenario, the noise may spiral and get even louder when people start to talk over one another in order to be heard. This synergistic tier begins to take on a life of its own. The people in the group do not directly control the outcome.

In summary, there are three different tiers of collective outcomes:

- **Additive/Accumulative Tier**: When a collective outcome is the result of a quantity of agents.
- **Interaction Tier**: When the agents interact (e.g., people start talking to one another) and the collective outcome is due to the quantity and interaction between the components.
- **Synergistic Tier**: When the interactions between agents interact (e.g., people speaking over one another in order to be heard) and the collective outcome is due to the quantity and interactions between components AND the interactions between those interactions (typically making the outcome non-linear and difficult to predict).

This curriculum utilizes the terms "collective" and "emergent" to refer broadly to outcomes at each of these tiers and to capture the idea that these outcomes can emerge from individual behaviors.[1] The module focuses less on the additive/accumulative tier, but it may be a great entry point for your students as they consider these concepts.

1 Some researchers reserve the term "emergent" only for what we refer to here as the synergistic tier. See, for instance, Chi et al., 2012. This research also uses the terms first and second level effects to refer to interactions (first level) and interacting interactions (second level). We use the term "emergent" more broadly because outcomes at all three tiers are often surprising to individuals and difficult to predict in many instances. We use synergy or interaction to talk about how these effects impact each other to add up to more than the sum of the parts.

MODULE 2
LESSON 1:

UNDERSTANDING DISTRIBUTED CAUSALITY: HOW IT ALL ADDS UP

BACKGROUND INFORMATION

The purpose of this initial lesson is to introduce aspects of the concept of distributed and decentralized causality (even though the terminology will not formally be introduced until Lesson 2). Middle-school students may realize that causes can be distributed and that they can have collective outcomes[2], but they may not have textured models for how to think about the ways that things add up and may also become interactive or synergistic. Students tend to be more familiar with accumulation models. For example, a student may think that a cafeteria gets louder because more kids come into the cafeteria and each student makes a certain amount of noise (accumulation) versus focusing on the idea that individual students may get louder because each person is trying to talk over another person (an interactive, collective phenomenon).

The lesson shares two examples of **distributed causality**: fire ants, and a termite computer simulation. By analyzing some of the behaviors of the organisms in each, it becomes clear that the behaviors have features of distributed causality. For instance, in the face of a flooding condition, thousands of fire ants can collaboratively assemble themselves into a raft in under two minutes—suggesting that the initiative for doing so is decentralized amongst the ants (and not that one ant is directing them)! Asking students to focus on the behaviors of ants and termites, as we do in this lesson, is a good way to help students to think about how individual behaviors can add up to a collective outcome. The ants can help students to think about how simple behaviors can result in synergistic interactions. When individuals aggregate, it can result in more than just a collection of the individuals if their behaviors or the outcomes of their behaviors result in a larger entity. Imagine trying to push your way through a crowd of people. If they are just a collection, it isn't that hard to get through, but if they lock arms and become a new unit, then it is nearly impossible. Traffic jams are like this—so are slime molds. In the following lesson, the ants and termites all follow a distinct set of lower level rules (go and grab onto the antennae and feet of another ant, etc.) that lead to the creation of a raft and termite mound. Individually, the ants and termites could not do this, but collectively they contribute to something much greater. This lesson explores agents' individual behaviors and how they can lead to collective outcomes.

The forms of interaction in this lesson are straightforward and fairly easy to talk about (e.g., termites collectively contributing to building a termite mound or the ants holding onto each other and creating a raft). These relatively easy examples of collective outcomes were chosen to pave the way for talking about more complex outcomes where the interactions are more difficult to discern.

DISTRIBUTED CAUSALITY
A form of causality in which the behaviors of multiple individuals (people or entities) add up and/or interact to result in an outcome. It has a "bottom-up," non-directed quality. Individuals may either intentionally or unintentionally work towards local and/or broad-level goals, such as seen in grassroots movements. The terms distributed and decentralized are often used interchangeably, although distributed emphasizes the "spread out" nature of the individuals.

DECENTRALIZED CAUSALITY
SEE DISTRIBUTED CAUSALITY.
Decentralized causality is often used in contrast to centralized causality where one agent directs the behaviors of other agents in a "top-down" manner.

COLLECTIVE OUTCOMES
The idea that the outcomes are the indirect, often unintended, result of the actions of many individual actors, and in some cases, the interactions or synergistic effects of those actions, rather than the direct result of a set of orchestrated, intended actions.

2 The term "emergent outcome" is also used to reference the collective outcome. However, as noted in the introduction, other researchers (e.g., Chi et al., 2012) reserve this term for second-level, synergistic effects. For the purposes of instruction, we use the term "collective outcome" and consider it to reflect various levels of population effects.

MODULE 2
LESSON 1:

UNDERSTANDING DISTRIBUTED CAUSALITY: HOW IT ALL ADDS UP

UNDERSTANDING GOALS

1. Distributed causes can have collective outcomes.
2. Highly organized outcomes can be the result of lower level interactions.
3. The outcomes of distributed behaviors can be much greater than the sum of the parts.

MATERIALS:

- Computer with internet access
- Capability to project online video on a large screen (e.g., overhead projector, Smartboard, television with HDMI cord to connect to a computer)
- StarLogo program (available at http://education.mit.edu/starlogo/)
  - It is critical that you download the program and familiarize yourself with it prior to the lesson.
  - Refer to Step #6 of this lesson procedure for specific StarLogo features that you will share with the students.
- Whiteboard, blackboard, or chart paper
- Copies of the Venn diagrams (enough for each student/group)
- Pencils or pens

Optional: Several color printouts of the termite mound (if you prefer to pass it around rather than project it on the overhead)

SYNERGISTIC
An interaction in which the outcome is greater than the sum of each individual effect. For instance, molecules of gases in the air bounce around off the walls of containers but they also bounce off of each other. This results in air pressure greater than the impact of individual molecules bouncing off of the container walls.

LOWER LEVEL RULES
Individual processes or behaviors that can result in a collective outcome. For example, students in a cafeteria may be getting louder because they are following a lower level rule of talking loud enough to be heard.

MODULE 2
LESSON 1:

UNDERSTANDING DISTRIBUTED CAUSALITY: HOW IT ALL ADDS UP

EXAMPLE #1: FIRE ANT RAFT

1. Tell the students that today they will closely examine and think about several interesting phenomena from science and nature. Tell students that you will first show a video about a fascinating pattern of behavior observed among a particular type of fire ant.

   - Before you show the video, ask students to make mental notes of surprising and interesting observations from the video. Tell students that they will have the opportunity to discuss their thoughts immediately after.
   - Show the Reuters video: http://www.reuters.com/video/2011/04/27/fire-ants-form-rafts-to-defy-floods?videoId=205675754 (see accompanying PowerPoint).
   - Prompt the students to share their observations by asking, "What did you find most interesting about that video?" During the discussion, encourage students to share direct observations, as well as any hypotheses they might have about the ants' behavior.

2. Next, play a second video that provides more detail about how fire ant rafts function.
   - Show the clip: http://www.youtube.com/watch?v=A042J0IDQK4 (see accompanying PowerPoint).
   - Again, ask students to notice surprising and interesting observations.

Note to teacher: As you facilitate the classroom discussion, gear students' understanding towards the concept that individual behaviors can result in a collective outcome. As much as possible, let the students come to this realization without just telling them.

3. On a large white board, piece of chart paper, or blackboard, collect student answers to some key questions:
   - What do the individual ants do to form a raft?
   - Why might individual ants do this?
   - What is the collective outcome of the individual ants' actions?
   - Is it possible for one ant to build a raft on his/her own? How do their combined behaviors help them survive?

   As relevant to the discussion, be sure to stress that the raft can form in under two minutes, and that the raft is "self-healing" should a hole form.

Note to teacher:
Either project the termite mound image on the overhead or, if you have printed copies, pass around the picture so they can see the detail of the physical structure.

EXAMPLE #2: TERMITE SIMULATION IN STARLOGO

4. Next, let the students know that they will observe a different example from nature. Using the provided image as a visual (see accompanying PowerPoint or appendix for image), explain that termites build mounds. Draw the students' attention to how sophisticated the castle is.
5. Explain to students that they will look at how the termites build their mounds using simulated technology called StarLogo.
    - StarLogo is a model that simulates one simplified aspect of termite behavior: mound building. The termites in this model follow a simple general rule: when a termite finds a wood chip, it picks it up, and sets it down next to another chip.
    - See StarLogo General Instructions in the appendix for detailed instructions on how to download and access this simulation. Please note that you will need to explore this simulation on your own before showing it to the class.
6. Project the StarLogo termites screen onto the white board. Explain the following basic information about how the simulation works.

OBJECT	DESCRIPTION
TURTLES	The little dot-like characters on the screen represent termites. In StarLogo they are known as "turtles;" these graphic creatures are the main inhabitants of the StarLogo world.
PATCHES	"Patches" are pieces of the world in which the turtles/termites live. Patches are not merely passive objects upon which the turtles/termites act; rather, like turtles, patches can execute StarLogo commands and can act on turtles and other patches. Patches are arranged in a grid with each patch corresponding to a square in the Graphics area. Each tan area is a wood chip.
OBSERVER	The observer "looks down" on the termites and patches from a bird's eye perspective, which makes it easier to watch both the individual actions and collective outcomes.

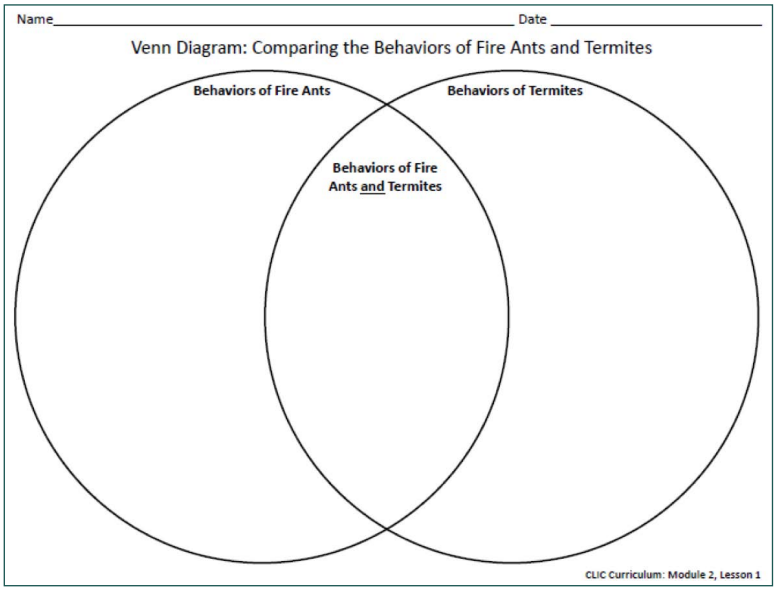
7. Play the StarLogo simulation for a few moments to help students get used to what the components are. Stop the simulation at various moments and point out the turtle and its various attributes, the patches, and the view of the observer.
    - Ask students to notice what the termites/"turtles" are doing.
    - Is there a connection between the ant mound and the "turtles" in StarLogo?
8. Restart the simulation and ask them to focus on a single termite for a couple of minutes and to think about what it is doing. Collect a few responses in a visible location. Then, tell the students that the termites follow a certain set of rules:
    - Each termite wanders randomly, until it finds a patch with a wood chip on it (based on the color of the patch), and without other termites on the patch.
    - When the termite finds an empty patch, it puts the chip down (it also changes shape, to indicate that it has picked the chip up and is now carrying it).
    - The termite then jumps around randomly until it finds an empty patch next to another chip, and then begins looking for another wood chip - which it does, again, by wandering randomly.
    - Once the termite finds another chip with no termites on the patch, this process is repeated.

9. Ask the students to predict what will happen if all of the termites continue to follow these rules. Collect their ideas on the chart paper or white board, then let the simulation play out in its entirety. Afterwards, in groups of 3-4 students, have them discuss:
   - What happened to the termites and the woodchips?
   - Why do they think it happened?
   - Was anything surprising about what happened?

Let them know in advance that you are going to collect headlines from each group. After they have discussed their ideas with their classmates for 5-10 minutes, collect 2-3 headline ideas from each group and track them on the board or chart paper.

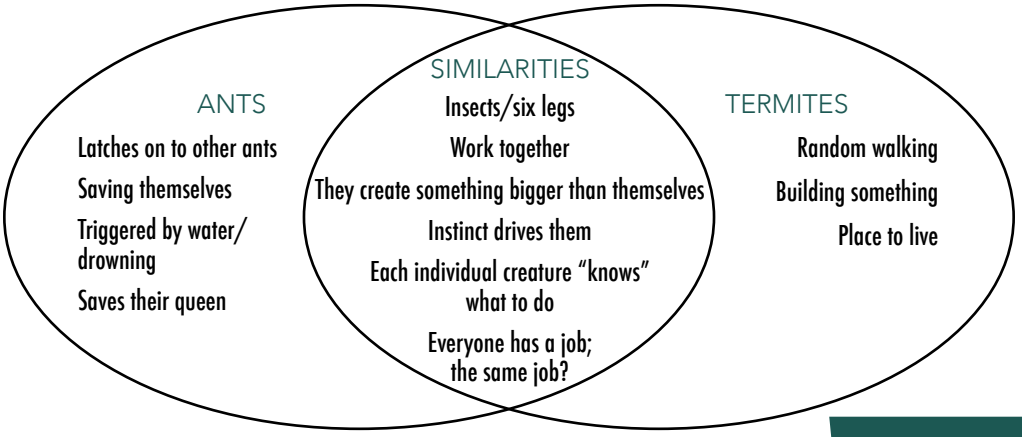
COMPARING SIMILARITIES ACROSS TWO EXAMPLES: FIRE ANTS AND TERMITES

10. Now that students have observed the termite simulation, ask the students to discuss the following questions about termite building behaviors in small groups for 10 minutes or so.
    - Did anything/anyone plan the design of the termite tower?
    - Did any termites control what happened?
    - If someone came upon a termite mound in the desert, how would he or she think that the mound was built?
    - Do you believe that this simulation shows how termites actually build mounds?
11. Show students an example of a Venn diagram and explain that they will fill it out by listing the similarities and differences between the behavior of termites and the behavior of fire ants (see the Venn diagram: Comparing the Behaviors of Fire Ants and Termites handout in the appendix).
    - Students may work with a classmate to fill in the Venn diagram.
    - Circulate as they work, providing assistance where needed.
    - Reiterate that students should think about the group and individual behaviors.
    - Emphasize that the similarities should go well beyond just appearances (e.g., the ants and termites are similar in color, etc.).



12. Project a Venn diagram on the wall and fill it in as a large class by collecting a few headlines from the small groups.
    - Focus on the "similarities" between the ants and termites.

    The resulting class diagram should contain some of the ideas below depending upon what the kids say and how they say it.



13. In closing, explain that during the next lesson the focus will be to discuss how these ideas connect to the science that they are learning. Tell the students that
    - In the examples they discussed today –the fire ant raft and the termite patches in the StarLogo program - they observed something called a **collective outcome**. This happens when many creatures/actors take certain actions at an individual level but the result is that they collectively create some larger pattern. The actions are distributed across many individuals but, taken together, a single, collective outcome emerges from the group's efforts.
    - In the ant example, each individual fire ant has the "instinct" to latch onto other nearby ants when they get in water –the collective outcome is that altogether they make an ant raft that protects them as a group.
    - In the StarLogo example, each termite follows certain pre-programmed rules about when they should pick up or put down chips they bump into—the collective outcome is that eventually the chips are all moved into large patches.
    - The ant raft and the wood chip patches are both created without a leader telling each ant or termite each thing to do in order to reach a certain goal.

Note to teacher: You may want to create a Word Wall and include collective outcome on the board so that students have it for reference.

CONNECTING FORWARD:
Let the students know that, in future lessons, they will discuss other sorts of collective outcomes. In the meanwhile, urge them to try to find other examples in the world that work like the termites and their mounds and the fire ants and their rafts. They will get a chance to share their ideas with everyone in the next class.

LESSON EXTENSION

You may want students to explore StarLogo on their own. If time permits, allow students to download the program onto computers and explore what happens when they change various variables.

MODULE 2
LESSON 2:

CONTRASTING CENTRALIZED & DECENTRALIZED CAUSALITY

BACKGROUND INFORMATION

This second lesson is designed to draw a stark contrast between **centralized** and **decentralized causality** in order to help students see the key differences. It also will help students realize that the outcomes of decentralized causality can be harder to predict than the outcomes of centralized causality. It invites them to engage in two activities– the "Lining Up Activity" and the "Follow the Rules Activity" – that both illustrate a form of distributed causality. These experiences should help students consider how the "lower level rules" that each individual student follows can give rise to the outcome.

The lesson starts with a review of the ideas from the first lesson, and then moves to analyzing a human example. This is important because one of the things that makes it difficult for students to make the leap from their own experience to distributed causality is the disconnect between their own intentions and the **population level** outcomes. It is common for students' experiences to be very focused on their own behaviors and goals as individuals (**agency based**). This can make it difficult for them to reason about their own individual actions and the collective, population-level outcome as part of the same set of phenomenon[3]—such as individual ants coming together to create a raft (see Lesson 1). This lesson attempts to connect their observations of non-human distributed causality to instances of how they can also be agents in distributed phenomena.

UNDERSTANDING GOALS

1. There are differences between centralized and decentralized causal patterns.
2. Centralized causality often results in easily traceable effects while decentralized causality often results in effects that are difficult to trace.
3. Decentralized causality and distributed causality refer to the same phenomenon.
4. Decentralization can often result in very efficient processing.
5. Decentralized causality can lead to difficult-to-predict outcomes. In the case of the termites, it was hard to predict what would happen.
6. Decentralized causality can involve many different kinds of actions, making it really hard to predict what the collective outcome will be.

MATERIALS:

- Videos (Internet connection or download)
- Index cards with a number (1-30, or number of students in class) with a large paper clip/clothes pin attached for each student to attach to shirt
- Chart with rules for emergence activity
- StarLogo program (Boids simulation)
- Copies of Connecting Forward sheet
- Chalk
- String

Note: You should arrange to use a large space for the "Follow the Rules" Activity.

CENTRALIZED CAUSALITY
A form of causality where one agent directs the behaviors of other agents in a "top-down" manner. Examples of centralized causality include a teacher assigning seats, a parent giving directions, etc.

DISTRIBUTED CAUSALITY
A form of causality in which the behaviors of multiple individuals (people or entities) add up and/or interact to result in an outcome. It has a "bottom-up," non-directed quality. Individuals may either intentionally or non-intentionally work towards local and/or broad-level goals, such as seen in grassroots movements. The terms distributed and decentralized are often used interchangeably, although distributed emphasizes the "spread out" nature of the individuals.

DECENTRALIZED CAUSALITY
See distributed causality. Decentralized causality is often used in contrast to centralized causality where one agent directs the behaviors of other agents in a "top-down" manner.

3 Wilensky, U., & Resnick, M. (1999). Thinking in levels: A dynamic systems approach to making sense of the world. Journal of Science Education and Technology, 8(1), 3-19.

MODULE 2
LESSON 2:

CONTRASTING CENTRALIZED & DECENTRALIZED CAUSALITY

Note to Teacher: Throughout this lesson we will be referencing "centralized" and "decentralized" causality. The examples are highlighted with these terms for your reference, but the concepts should not be addressed to the students until Step 7.

REFLECTING UPON WHAT HAS ALREADY BEEN LEARNED

1. Ask the students to get mentally ready by taking a minute to think back to what they did during the last lesson about the termites and the ants.
   - Ask them to recall two things about the termite simulation and then to share their two things with a classmate.
   - Collect and record some of the things that they remember on a chalkboard, whiteboard, or chart paper.

     While students are describing their ideas, organize their ideas into a three-column chart with the following sections:
     - INDIVIDUAL TERMITES: What individual termites do?
     - WHY THEY DO IT: Why do they do it?
     - COLLECTIVE OUTCOMES: What happens at the collective level? What features does the collective outcome have?

   Try to develop a good picture of what the termites do and the collective outcomes even if you need to add to what the students say. *Make sure that you have the following features:*
   - INDIVIDUAL TERMITES: Termites pick up wood chips until they bump into another one, then they put it down; they wander randomly.
   - WHY THEY DO IT: We don't know—perhaps instinct? Is there one termite that plans the castle/pile?
   - COLLECTIVE OUTCOMES: A pile of wood chips accumulates. This pile resembles and represents a termite castle.
2. Ask students if they found any examples in the world that work like the termite mound building. If so, have them share.
   - Possible examples include multiple cars contributing to global warming around the world, grassroots efforts, or even the formation of websites like Wikipedia (multiple people around the world contribute to the formation of this site by editing content).

EXAMPLE #1: THE HUMAN WAVE

3. Remind students that at the end of the last class we discussed the term "collective outcome."
   - Ask students if they remember the key parts of the definition (many actors behaving independently, but they collectively create some larger pattern, many times without even trying or knowing they are doing so).

LOWER LEVEL RULES
Individual processes or behaviors that can result in a collective outcome. For example, students in a cafeteria may be getting louder because they are following a lower level rule of talking loud enough to be heard.

AGENT BASED
A way of referring to actions and behaviors at the level of the individual actors. For example, one may perceive individual agents talking over one another in a noisy cafeteria (the overall noise is considered to be at the population level).

POPULATION LEVEL
A way of referring to the collective outcome of the actions and behaviors of individual agents, e.g. the loud noise in the cafeteria.

MODULE 2
LESSON 2:

CONTRASTING CENTRALIZED & DECENTRALIZED CAUSALITY

4. Tell the students that today they are going to look at an example of a collective outcome from the world of sports. Show students the video clip of the people at a football game.
   - The Wave at Michigan Stadium (The Big House) (2 min 57 sec): http://www.youtube.com/watch?v=_a_bI2Qzzi4
5. Ask students to think and discuss what they observed in the Michigan State video with a classmate.

   Ask them to consider:
   - **How does the wave happen?** At a certain time and at a certain speed, each of the 75,000 individual spectators in the stadium stands up after the person next to them stood.
   - **Is someone in control of it?** They all are; no one person is guiding what they do at a given moment.
   - **Why does it start?** It could be that something exciting happened in the game and a section of people started doing it, then others next to them followed along, etc.
   - **What makes it change direction?** In the Michigan State video, near segment 1:45, you see that the section of people wearing a lot of yellow did not seem to do the wave, so the individuals nearby started it in the other direction.
   - **What makes the wave crash in the Michigan State video?** Two waves were going in opposite directions, but people kept it going.
   - **Why does the wave stop in the Michigan State video?** Around segment 1:25, it gets really, really slow; people seem to be paying very close attention to the game. There is no rule that makes the wave stop, but the wave ends when enough people independently decide to stop participating.
   - **How does each individual's behavior play a role in the overall effect (the wave)?** Each person is a part of the wave. By standing up and raising their hands, everyone is collectively a part of the larger phenomenon.

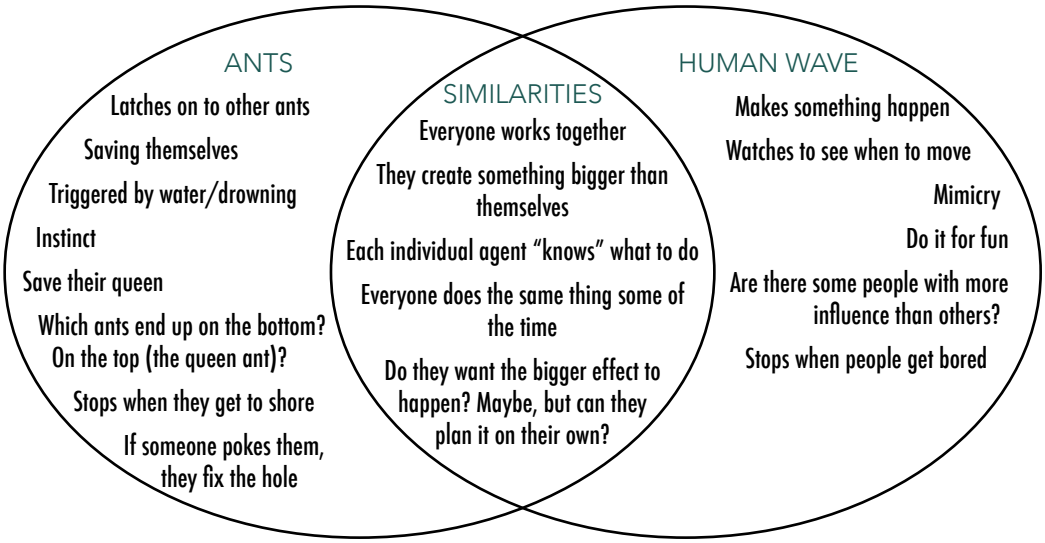
Note to teacher: If you have the time, you may wish to show an additional video: Rutgers Stadium Wave (54 sec), http://www.youtube.com/watch?v=3NxLh-3DdaE

6. After they have had time to process their observations of the wave, provide the students with Venn diagram sheets (see the Venn Diagram: Comparing the Behaviors of the Fire Ants and The Human Wave handout in the appendix). In pairs, they should work together to fill out a Venn diagram with human wave and fire ants.

Note to teacher: If you are running short on time, you can lead the completion of this Venn diagram as a whole class, or assign it for homework. If working as a whole class, give students a minute or two to collect their thoughts, then capture the student responses on a Venn diagram on an overhead, whiteboard/chalkboard, or chart paper. For this format, you would serve as the class scribe; allow the students to guide the discussion and development of the diagram.

MODULE 2
LESSON 2:

CONTRASTING CENTRALIZED & DECENTRALIZED CAUSALITY



EXAMPLE #2: LINING-UP ACTIVITY

7. Tell the students that everyone is going to participate in making a line using two very different approaches: first in a centralized and then in a decentralized manner.

   CENTRALIZED APPROACH
   Explain to students that when something happens in a centralized manner, usually one person is directing what happens. In this case it is the teacher. Examples of centralized approaches include a teacher assigning seats, a parent giving directions, etc.

   Note to teacher: You may want to add the terms "centralized causality" and "decentralized causality" to the word wall.

   Demonstrate a centralized approach:

   - Give each student a card with a number. They are to wear it.
   - As the teacher, tell them where to move so that they are all lined up.
   - Use a stopwatch[4] or clock to time how long it takes for them to be lined up by the teacher.

   Note to teacher: The enclosed PowerPoint has a video demonstration of this activity (the Knights video). This is to be used as a model for you, but the students should actually do the activity.

   DECENTRALIZED APPROACH
   Next, contrast the experience of being lined up by the teacher (centralized approach) to simply having them line themselves up (decentralized approach). Remind students that decentralized causality is when the behaviors of multiple individuals (people or entities) interact to result in an outcome. The ants, termites, and human wave are all examples of decentralized causality.

   - Collect, mix up and redistribute the number cards.
   - Students should line themselves up from least to greatest without talking.
   - Use the timer to keep track of how long it takes students to line up. It should be silent in the room while the students do this.

4 An online stopwatch you can use on your computer or project to the front of the class is available at http://www.online-stopwatch.com/full-screen-stopwatch/

MODULE 2
LESSON 2:

CONTRASTING CENTRALIZED & DECENTRALIZED CAUSALITY

CLASS DISCUSSION: CONNECTING TO DEFINITIONS OF CENTRALIZED AND DECENTRALIZED CAUSALITY

8. Discuss several questions about their experience:
    - What did they do to get themselves lined up?
    - How long did it take?

    Explore the ideas behind each activity by probing with some questions and comparing the first lining-up activity with the second:

    - Which approach went more smoothly– the teacher telling each person where to go, or the group lining itself up?
    - In each scenario, what made the process work better or worse?
    - Can you describe exactly how they ended up where they did?
    - What did you notice about the process?
    - How does it get complicated?
    - How easy was it to predict the outcome?

Note to teacher: A caveat to the demonstration is that once they have been lined up by the teacher, classes have a pretty good intuition about where their numbers should begin and end. What would be the impact if they didn't know this? What assumptions might they make?

9. Reiterate the terms centralized causality and decentralized causality and write them on the chalkboard.
    - Centralized means that there is top-down control, usually by one person, group, or organization (e.g., a teacher, the police, the governor, a queen bee, etc.)
    - Decentralized means that the control is spread out and often bottom-up (e.g., spread-out termites build a castle, ants each do what they need to do to make a raft, people all decide to stop buying hamburger meat because it has filler so the meat industry has to take the filler out because they can't sell the meat with it, etc.).

Note to teacher: Students usually find it easier to understand decentralized causes after centralized causes are explained. This is because many of their life experiences are rooted in centralized causes (e.g., being in school, rules made by parents, etc.). It can also be really hard to think about how decentralized causes produce certain outcomes, especially when agents are distributed around the world (for example, not everyone around the world thinks about how driving a car collectively contributes to pollution). Middle school students, however, are quite good at reasoning about some of the patterns, even though it may be challenging at first.

There are many collective outcomes that are the result of decentralized causal mechanisms!

- Sometimes things spread by contagion or "go viral" (e.g., YouTube videos)
- Individual interactions can just add up or they can increase, spiral, interact with other individuals to lead to new or changing outcomes, etc. (e.g., think about how the noise in a cafeteria escalates even when there are no new people coming into the cafeteria).
- It can be harder to think about what will happen when the individuals are spread out over different places or when things happen over time (e.g., climate change is like this).
- It can be really hard to predict what will happen when the actions of the individuals interact or increase (e.g., think about crowd psychology involving pushing and shoving during a Black Friday sale).

EXAMPLE #3: "FOLLOW THE RULES" ACTIVITY

10. Tell the students that in the previous activity you told the class what their goal was. This helped make it easier to predict the outcome. Ask the students to reflect on what would happen if the students were not told what the outcome was, but rather just followed a certain set of rules:
    - If you are about to crash into another person, turn around.
    - If you are far away from other people, head towards the nearest person, otherwise walk in the same direction as the person next to you.
    - When you get to an edge, turn around 180 degrees and walk towards the other edge.

    Ask students to predict what they think will happen when everyone follows these rules? Capture their thoughts on chart paper.

11. Find a large open area, like a gymnasium, or go outside (as arranged in advance of the lesson). For this to work, the students must stay in a limited area.
    - Students are to walk around inside of a bounded area (e.g., a very large circle or square marked with chalk or string) but they should always follow the rules listed above.

    You should put the rules up in an easily visible place and make sure that everyone understands them. Perhaps you might write them on chart paper if you have a place to post them during the exercise.

Note to teacher: If there is no place outside where they can do this, use the StarLogo software to run a simulation called Boids (see the StarLogo General Instructions in the appendix for instructions). Boids is a simulation of bird flocking behavior. Each bird follows some "lower level rules" about which direction to fly in and proximity to other birds, and the result is the larger pattern. In this model, the birds obey only three rules:

1. If you are about to crash into another bird, turn around.
2. If you are far away from other birds, head towards the nearest bird.
3. Otherwise, fly in the same direction as the bird next to you."?

Remind students what a turtle in StarLogo is: that their perspective is that they are vlooking down, that unlike in real life the turtles can walk off the sides of the screen and wrap around to the other side (i.e., if they go off the right side, they will reappear on the left side), etc. Ask the students to notice how the birds start to form groups as they fly across the screen. The birds were never told to form large groups (centralized causality) even though they may sometimes look like they are following a "leader." Ask students to think about why this may happen when each bird is following their own set of rules. http://education.mit.edu/starlogo/samples/boids.htm

12. At the end of the simulation, return to the classroom and discuss how easy or hard it was for them to predict the outcome and why.
    - Could they accurately anticipate what would happen?

As each classmate/bird individually follows the rules, a larger pattern of groups of students/birds forms. Make sure to reiterate that even though it may look like someone is directing the behavior, the larger pattern is really a result of individual agents acting according to particular rules.

Consider using simulation games like The Big Fish Little Fish game from the MIT Simulation Games website (http://education.mit.edu/pda/ifish.htm). It enables students to reason about the population and agent levels at the same time. Students can play it multiple times and see how the population effects are influenced by minor change in either the big or little fish behavior.

LESSON EXTENSION

Have the students work in pairs to generate at least three real-world examples of centralized causality and at least three examples of decentralized causality. In their decentralized examples, are they able to guess the outcome? See the *Connecting Forward: Examples of Centralized and Decentralized Causality* handout in the appendix.

MODULE 2
LESSON 3:

CONNECTING TO OUR INDIVIDUAL ROLE IN COLLECTIVE OUTCOMES

BACKGROUND INFORMATION

In this lesson students will learn to see the role that we, as individual agents, play in the emergence of a **collective outcome**. As a member of various communities – our families, neighborhoods, cities and the world – we each need to find ways to take responsibility for these collective outcomes, even when they don't feel like the direct result of our actions and when they don't directly impact us. In many situations, we have, but don't necessarily feel, a personal connection to the responsibility – these can include things like climate change or pollution.

This lesson considers that it can be difficult to feel a connection to collective outcomes for two reasons:

1. In the cases of a physical action, we may not have the broad "birds-eye view" (**population-level** view) of the outcome; and
2. The intent of our local actions is often misaligned with the broad outcome, meaning that what we intend to have happen individually may not align with what the actual outcomes at another level.

AGENT BASED
A way of referring to actions and behaviors at the level of the individual actors. For example, one may perceive individual agents talking over one another in a noisy cafeteria (the overall noise is considered to be at the population level).

POPULATION LEVEL
A way of referring to the collective outcome of the actions and behaviors of individual agents, e.g. the loud noise in the cafeteria.

COLLECTIVE OUTCOME
The idea that the outcomes are the indirect, often unintended, result of the actions of many individual actors, and in some cases, the interactions or synergistic effects of those actions, rather than the direct result of a set of orchestrated, intended actions.

UNDERSTANDING GOALS

- We often don't feel a personal connection to collective outcomes and so we may be less likely to take responsibility for them.
- Collective outcomes, such as climate change, may impact different groups of people differently.

MATERIALS:

- White board or chart paper
- Writing utensils
- Overhead projector, television, or large computer screen with internet access
- Paper and pencil to write notes

Optional: For Real World Example #3, you might collect a few of the students' empty chip bags or sandwich bags from lunch that day.

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CONNECTING BACK

1. Tell students to think back to the last lesson when they did the "Follow the Rules" activity in the gym/outside. Ask students to think back and ask themselves:
   - What do I remember most about the activity?
   - What was my individual role in the exercise?

   Write the questions on the board and give at least 60 seconds of "think time" for students to silently reflect on their prior experience. Then ask a few volunteers to briefly share their reflections with the whole group. Capture a brief summary of each response on a white board or piece of chart paper.

   Common responses may include: "I was watching my step to make sure I didn't go outside of the circle;" "I had to try to keep all of the rules straight in my head."

Note to teacher: This lesson contains 3 different examples of collective outcomes. If short on time, you can elect to cut the synchronized swimming clip, but ideally you should have students observe and think through all of them. The layering of these varied instances will help students more clearly grasp the deep underlying concept of the individual's role in collective outcomes.

Once some students have gotten a chance to answer, draw their attention to some general observations about the collective outcome. A variety of student responses may come up, but make sure that you also discuss the idea that, because we were so focused on following our individual level rules throughout the task, we may not have noticed the larger pattern forming.

EXAMPLE #1: UNIVERSITY MARCHING BAND AT FOOTBALL GAME

2. Tell the students that they will see a couple of examples of distributed causality from "a birds-eye view." Explain that by stepping back to pay very close attention to the actions of the individuals and the actions of the larger population pattern, we can better understand the individual's role in the outcome, and how the actions of one can feel really different from the collective actions of the group. This connection between the individual actions and the population-level outcome can be tough to notice, especially if you are one of the individuals, because you are focusing on your own role and do not see the entire formation.
   - On the overhead projector or computer screen, show the following online clip of a performance by the Ohio State University marching band.

     "Halftime Beach Boys 9-1-12" (7 min, 48 sec long; if short on time you just can play from 0:00 to 5:15. Note: there are some points when camera wiggles around a little bit)- http://www.youtube.com/watch?v=jrDNprWcwSA
     Also, see PowerPoint for video clip.

If there is time, invite a few students to share their overall reactions to watching the band performance.

Common responses include: "I've seen something like this before at a football game;" "I've never seen anything like this before in my life!"; "How did they do that?"

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OBSERVE AN INDIVIDUAL'S ACTIONS

3. Let the students know that you are going to re-watch just one brief 30-second section of the performance (there two options: a boy and girl walk toward each other at 3:15-3:50; OR a stick figure surfing across the field on a wave at 4:45 – 5:15).
    - In advance, tell them that during this time they should select and then focus closely on one individual band member. Ask students to track that one person and identify the types of actions, moves, or motions s/he person makes within that short time.
    - After they've watched the clip, collect their observations on a white board or chart paper, making a header for one column that says, **Individual Actions** (save room, another column will be added).

    Possible student responses could include: marching in place, holding/playing an instrument, walking forward/backwards/ to the side, walking in a line behind the person in front of them.

OBSERVE THE COLLECTIVE'S ACTIONS

4. After you have recorded those ideas, then play the exact same ~30 second clip that you just showed. This time, ask them to focus on the entire group.
    - Instead of looking at each individual person, ask students to identify the types of actions, moves, or motions that the collective group makes within that time.
    - After they've watched the clip, collect their observations on a white board or chart paper, making a header for another column titled **Collective Actions**—this should be adjacent to the Individual Actions column.

    Possible student responses could include: boy and girl walk toward each other, girl lifts up her foot, boy bends his knee, they tilt their heads near each other.

EXAMPLE #2: SYNCHRONIZED SWIMMING

5. Now, turn the class' attention from the marching band example to a synchronized swimming performance. Let the students know that, just as they did with the marching band, first you want them to focus their attention on the individual actions of one swimmer of their choosing (e.g., putting hands out, diving into the water, kicking in the air, stretching arm out to the left). Tell students to write down the actions they see so they can discuss them later.
    - Play the Russian Synchronized swimming performance from 2012: Russian team 2012 (3 min, 17 sec long) - http://www.youtube.com/watch?v=FtxdoVm6YfQ Also, see PowerPoint for video clip.

6. After you get to the 45-60 seconds mark in the video, briefly pause the clip and give students about 30 seconds to jot down their observations on scratch paper. Then, as you restart the clip, ask the students to shift their focus to looking at the collective movements of the swimmers as a unit (e.g., a ring rotating in a circle, a bunch of legs splashing down in the water). Again, after about 45-60 seconds, stop the video and give time for students to write down observations if they have not already done so.

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7. Ask students to share some of their observations in a small group of 3-4 students for about five minutes. Ask each person to keep comments very brief and specific so everyone gets a chance to share.

COMPARING EXAMPLES 1 & 2, POST DISCUSSION DEBRIEF

8. Explain to the students that, in both of these examples, the individual band and swim team members practiced both independently and together in order to work toward a particular collective outcome – a formation that is timed well and forms a cohesive picture from a distance. They have aligned intent—meaning that each individual acted with the intention of making something happen at the broader level (in this case, the "bird's-eye view level").

   Ask students to now think about collective outcomes that we don't intentionally work towards, such as pollution or global warming. Sometimes, even without knowing it, our behaviors build toward an overarching, collective outcome. For example, with environmental issues, there is often a "disconnect" between our individual behaviors or actions and seeing the effects of the population behavior. Yet, regardless of whether we attend to it or not and whether we intend it or not, our actions can still lead to a collective outcome.

EXAMPLE #3: THE PACIFIC OCEAN GYRE

9. Next tell the students that they will look at another example, but this time one that is related to the environment.
   - Ask the students, "Have you ever spent a day at the beach? Imagine you've just finished a picnic lunch with your family. When you're done you throw your trash in the trashcan, or maybe the wind unexpectedly catches your wrapper and it blows away. [Note: for added effect, you might have an old potato chip bag or baggie in hand]. You may not have realized it, but at that moment you have contributed to a collective outcome involving millions of individual people just like you."

10. Next, show students the Nightline video about pollution:
    - Nightline story from 2008 (5 min, 24 seconds long) - https://www.youtube.com/watch?v=8a4S23uXIcM
      Also, see PowerPoint for video clip.

Optional: In case you'd like to share additional information with the students, here is a related article that conveys the main points of the story. Landfill in the Sea – http://abcnews.go.com/Technology/story?id=4528488&page=1. See appendix for article.

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ANALYZING AN INSTANCE OF DISTRIBUTED CAUSALITY: WHERE DO THE SANDWICH BAGS GO?

11. Using the whiteboard, ask students to imagine 1-2 paths from their lunchbox to the Atlantic, Pacific or Indian Ocean gyre. The bag should have several (at least 3) "pit stops" along the way.

    Example: I was at the beach one summer day for a picnic. After I ate my sandwich I put my used sandwich bag in the trashcan nearby (1) but it was windy and it blew into the sand a few minutes after we left the shore. (2) Then, when the tide came in later that night, the bag was washed into the ocean. (3) After a long journey, it ended up in an ocean gyre along with millions of other sandwich bags.

12. After the individuals or pairs have had some time to think about some individual mechanisms that lead to the collective outcome, have some students share their stories. Spend some time facilitating a discussion about how hard it is to know the individual path of a lunch baggie, and how it can result in the pollution of the Atlantic, Pacific or Indian Ocean gyre. Reiterate that, as the various stories suggested, there are multiple pathways a lunch baggie can take, and that we may play a role in its pathway. Ask students,

    - How many different types of lunch baggie pathways did everyone come up with? Is it easy to know which pathway the lunch baggie will take? Why is it important to visualize the various paths if we cannot be certain which pathway the baggie will take?
    - When you see a lunch baggie on the street, how often do you imagine that it ends up in the ocean with thousands of other pieces of waste?
    - What happens when individual people all around the world drop their lunch baggies—where do they all go and how does it contribute to something larger (the collective outcome of ocean being polluted)?
    - Why might it be difficult for us to imagine our day-to-day actions playing a role in something much larger? What happens when people all over the world participate in day-to-day actions without realizing the broader outcomes? As an individual actor, what can we do to avoid pollution of the ocean?
    - How does this activity make you think about the choices you make? How can each one of us be a positive contributor to the health of the planet by making small changes?

CALL OUT

One of the most difficult parts of changing your behavior is anticipating the role that it plays in the broader outcome. We can develop the habit of trying to imagine collective outcomes as we take on individual actions. It involves asking questions like, "What if everyone (or at least a lot of people) did the same thing?" Or "What if I did something and lots of people responded in a certain way?" We won't always be able to make correct predictions given the complex interactions that lead to the outcomes, but sometimes we will!

CALL OUT

HOW DID THE TRASH GET TO THE ISLAND?

Ask students to recall the "bird video" in Module 1 (Extension Activity) if they watched it. Ask students how they think the trash got onto the island. Reiterate that although you may be paying attention to your own behaviors in a particular moment, the behaviors of each individual member of the collective are actually having a collective outcome (garbage gyre).

Some possible responses may include: Try to decrease your waste overall; Recycle cans, boxes, plastic grocery bags; Stop using plastic sandwich bags altogether--instead, use reusable (and later recyclable) containers to store food.

Tell the students that unlike the band and swimming troop, they weren't working toward a particular outcome when they used the sandwich baggie. Emphasize, however, that each of us contributed in a small way–along with many other people over many decades– to the creation of an oceanic garbage dump. This is the collective outcome from the choices of billions of individual people making thousands of choices per person about waste disposal.

You should be aware that even if you make major changes in your individual lifestyle, it may be unlikely that you will ever see a direct improvement in your own surroundings based on your individual decision. Making these choices are hard because they are often less convenient and do not offer an immediate, personal reward. However, it is important to adopt responsible behaviors because if many people begin to reduce the use of plastics, then over time we may slowly see a change in this collective outcome.

CALL OUT

OPTIONAL: If the students are interested in this topic, you can share a recent report that plastic waste may be circling back into the human food supply (see accompanying PowerPoint).

Plastic in mahi-mahi fish (3:59) - http://abcnews.go.com/GMA/JustOneThing/video/trash-found-fish-garbage-food-9735987

Ask students to consider how this may relate to the "bird video" that they explored in Module 1. How do we contribute, even if it's inadvertently, to the plastic found in the mahi-mahi fish? How can we all collectively contribute to a positive solution?

CONNECTING FORWARD

Ask the students to think about other collective outcomes that they are a part of. Ask students to think about groups to which they belong, for example: family, student body at school, neighborhood.

Before they begin, remind the students to keep in mind that

- Collective outcomes can happen through the tiny actions of multiple people;
- Effects can accumulate slowly over time;
- Often those contributing to collective outcomes are distributed; the people causing the outcome are not purposefully coordinating their behaviors;
- Those responsible for the outcome are not necessarily impacted by its effects.

Allow 1-2 minutes of individual brainstorming and think time to generate ideas before sharing with a partner.

MODULE 2
LESSON 4:

DISTRIBUTED RESPONSIBILITY & MORAL MUSICAL CHAIRS

BACKGROUND INFORMATION

In this last lesson of the module, students will play a game of "Moral Musical Chairs"[5]—a strategy that helps students to think objectively about the consequences of outcomes. It can help them understand the broad effects of collective outcomes. In this activity, students will consider a real-life scenario that impacts a community in Virginia Beach: beach erosion and beach nourishment. Beach erosion is when sand from a beach moves into offshore waters. This can be caused by rising sea levels (from melting polar caps) or from waves (both naturally occurring and ones caused by storms or watercraft devices). When beaches erode it jeopardizes recreational use, as well as places buildings, parking lots, and roads that are close to the beach in danger. One possible solution is beach nourishment, which is when sand is taken from various sources and is used to "refill" diminishing beach sites. While beach nourishment programs have many benefits, they are funded by the federal government with our tax dollars and are costly. Beaches may also need to be nourished on an on-going basis. Not all people agree with constantly having to replenish the beaches because there are many other programs that need to be funded and there are limited resources. The issue is complex, and there is no one right "answer" to the dilemma.

AGENT BASED
A way of referring to actions and behaviors at the level of the individual actors. For example, one may perceive individual agents talking over one another in a noisy cafeteria (the overall noise is considered to be at the population level).

POPULATION LEVEL
A way of referring to the collective outcome of the actions and behaviors of individual agents, e.g. the loud noise in the cafeteria.

COLLECTIVE OUTCOME
The idea that the outcomes are the indirect, often unintended, result of the actions of many individual actors, and in some cases, the interactions or synergistic effects of those actions, rather than the direct result of a set of orchestrated, intended actions.

In this Moral Musical Chairs activity, students will be assigned to a particular stakeholder position (e.g., business owner, army engineer, news analyst on climate change, Michigan farm family) and then asked to review primary materials and develop a particular perspective for a discussion. However, rather than simply arguing back and forth, midway through the activity they are asked to rotate around the chairs. By rotating chairs they are assigned a new role that was previously held by a different group of students—which encourages them to consider different perspectives.

Rather than solely attending to the solution that best serves his or her individual circumstances, Moral Musical Chairs urges learners to adopt multiple possible perspectives and try to work toward the best possible option for all individuals involved. This evaluative lens increases the likelihood that we will engage in solutions that are just for all–i.e., serving the greater good rather than simply the immediate and personal wants and needs of a few. Purposefully adopting different perspectives while separating oneself from your own situation can enable greater empathy for other's perspectives. Moral Musical Chairs therefore helps students acknowledge the joint responsibility of all community members for addressing a given situation particularly when it's easy to adopt an "it's not my responsibility" attitude. Moral Musical Chairs also helps students develop an ethically responsible attitude that acknowledges responsibility for outcomes in instances of distributed causality. It helps them consider the viewpoints of the stakeholders involved (such as in the Virginia Beach scenario) with the assumption that anyone could be in any given stakeholder role and that everyone is responsible for the outcome even if they are not affected by it.

From Kohlberg, L. (1981). The philosophy of moral development: Moral stages and the idea of justice.

MODULE 2
LESSON 4:

DISTRIBUTED RESPONSIBILITY & MORAL MUSICAL CHAIRS

When exploring these ideas with students, it is particularly important to ask students to think about how individual people may contribute to a larger outcome. It is also useful to ask students to consider how easy it is to dismiss the role they may have played in an outcome since the behavior, and therefore responsibility, may be distributed across a large number of agents. (For instance, in this case, increasingly intense storms fueled by climate change cause heavy beach erosion. The level of beach erosion that might have been expected in a century might occur in a decade.) It may be helpful to connect back to Lesson 3 and emphasize how we all may play an inadvertent role in an outcome, such as how we all may contribute in a small ways (along with many other people over many decades) to the creation of an oceanic garbage dump.

UNDERSTANDING GOALS

Students will understand that...

- **In order to effectively and critically evaluate an ethical quandary associated with the outcomes of distributed actions, one needs to think about the individual and population outcomes,**
- **Although multiple agents contribute to collective outcomes, the effects may impact some people more than others,**
- **Purposefully adopting different perspectives while separating yourself from your own situation can enable greater empathy for the wide spectrum of opinions and perspectives, and**
- **An ethically responsible approach includes acknowledging responsibility for outcomes in instances of distributed causality and considering the viewpoints of the stakeholders involved with the assumption that any of us could be in their position and that everyone is responsible for the outcome even if they are not affected by it.**

MATERIALS:

- Copies of guiding questions, either on paper, or projected on overhead that all can see
- Copy of blank notes page and "Stakeholder Group" summary sheet
- One per stakeholder group
- Pencils or pens
- Stakeholder nametags (can be clip-on, or string around the neck but should be durable)
- 4 chairs (or enough for 1 person from each small group if some duplicate groups)
- Radio/CD player/iPod with music files of your choice
- Speakers

Note to teacher: In preparing to lead this activity, you should listen to and read the NPR story regarding beach nourishment along the coasts of Virginia Beach. This is the basis for the materials and will give you the full background for this story in order to facilitate the students' discussion and debate.

http://www.npr.org/2013/01/30/170301306/debate-over-rebuilding-beaches-post-sandy-creates-waves (audio is 7 min, 46 sec long—see PowerPoint for audio file)

MODULE 2
LESSON 4:

DISTRIBUTED RESPONSIBILITY & MORAL MUSICAL CHAIRS

PREPARATION FOR DISCUSSION: "BEACH NOURISHMENT/ REPLENISHMENT" ON COASTS (VIRGINIA BEACH)—REBUILD OR RELOCATE?

1. Remind the students that over the past few lessons they have been discussing distributed causality and collective outcomes. Tell the students that today they are going to consider a real-world debate that connects what they have explored in previous small-scale examples (e.g., stadium wave, StarLogo, football band formations) to an important issue that affects people living in communities: beach erosion and beach nourishment along the east coast of the United States.

   Discuss the ideas of beach erosion and nourishment with your class. Explain that beach erosion is when sand from a beach moves into offshore waters. This can be caused by rising sea levels (from melting polar caps) or from waves (both naturally occurring and ones caused by storms or watercraft devices). When beaches erode it jeopardizes recreational use, as well as places buildings, parking lots, and roads that are close to the beach in danger. One possible solution is beach nourishment, which is when sand is taken from various sources and is used to "refill" diminishing beach sites. While beach nourishment programs have many benefits, they are funded by the federal government with our tax dollars and are costly. Beaches may also need to be nourished on an on-going basis. Not all people agree with constantly having to replenish the beaches because there are many other programs that need to be funded and there are limited resources.

   - Show students a "before and after" picture (see below, the appendix, and accompanying PowerPoint) of what beach nourishment looks like. This is an image of a beach in Cape May Point, New Jersey. Point out the differences in the images and explain to students that they will be exploring different perspectives about beach nourishment.

2. Divide your class into groups of 3-4 people. Explain to students that they will be reading about the different perspectives related to beach nourishment. Some people want to maintain beach nourishment programs while others do not.

   - Each group will take one of four stakeholder positions:
     i. Army Corps of Engineers
     ii. Virginia Beach Business Owners' Association
     iii. News Analyst on Climate Change
     iv. Michigan Farm Family

   More than one small group can represent the same stakeholder group. See Moral Musical Chairs Stakeholder Summaries in the appendix for an overview of each group.

   Note to teacher: Ask students if they know what a stakeholder is. A stakeholder is a person with an interest or concern in something.

   - Pass out the set of materials that explains each stakeholder position (see Stakeholder Articles in the appendix). These documents include general information about the beach nourishment situation, guiding questions, as well as the information that shapes the particular perspective of a given community member (e.g., scientific explanations, city data, interview synopses, and/or news articles).
   - Give students 15 minutes to read their documents and prepare with their groups. As they read and discuss, students should fill out the "Building Your Case" handout (see appendix). Students should understand the information about the issue, and then try to think of the most logical and compelling argument for their assigned perspective. Each team should work to develop a case for or against preserving the beaches.
   - Tell the students that they will come back together at the end of the class and each group will state their position and discuss the issue.
   - Explain to students that you will be circulating the room, and will be available to help clarify things as needed.

Important points to share with students before you begin:

- Students have 15 minutes to read and prepare with their groups. Start with "Guiding Questions for Small Group Discussion" found at the top of their "Stakeholder Groups" handout.
- Each group will have different types and amounts of information given to them.
- Encourage students to consider possible counter arguments that other groups might bring up about their reasoning.
- The "Building Your Case" handout will later be given to a different group at a later point in the lesson, so students should keep detailed notes.
- Another team member should prepare to represent the group's stance in a 60-second opening argument. They should summarize the main arguments and key evidence that helps to explain their group's position before the debate with the other stakeholder groups.

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SHARING PERSPECTIVES

3. At the end of the discussion time, have each group's representative go up to the front of the room and take a seat on behalf of the group they represent.
    - Give each student a nametag with the name of the stakeholder group they are representing (see appendix).
    - A representative from each group should stand up and, in roughly 60 seconds, share the group's thoughts from the completed sheet to support their stance.
    - After the group representative states their case, someone from a different group should take one minute to offer an opposing perspective.
4. When each representative has stated their view (and you've heard rebuttals for each), let the students know that they will now play a game called "Moral Musical Chairs."

MORAL MUSICAL CHAIRS AND GROUP DISCUSSION

5. In this game, each group will now assume a different stakeholder identity and think again about the Virginia Beach community dilemma.
    - Collect each nametag from the representatives of the groups.
    - Mix them up face down and place each one carefully on one of the chairs that have been rearranged into an inward facing circle, as in musical chairs.
    - In this case, unlike real musical chairs, there should be enough chairs for each person to have a seat when the music stops.
6. Tell the representatives that you are going to play some music, and they should walk around until the music stops and then sit down in the nearest chair. Explain to the class that because all of the nametags are mixed up, we don't know what identity each person will get. For example, if a stakeholder group was in favor of beach replenishment, this time they might get the exact same identity they had before, a different identity that is still in favor of replenishment, or an identity that is against replenishment.
    - Play music and have the students walk around the chairs until it stops.
    - The students should pick up and turn over the card to see their new stakeholder position.
    - Once each group has a stakeholder name card, a group who used to have that stakeholder group should give the new team the one page sheet and articles. Each group will then take that new information back to their group, discuss the new argument and ideas on that sheet and in the articles, and spend some time trying to make that case, even if it is opposing to their original one.
    - If some groups get the same group they had before, they should spend their time considering how it relates to the other perspectives they have heard, and if there is a way to reconcile the varying opinions.
    - Reiterate to students that in Moral Musical Chairs they should "become" the person listed on their nametag. They need to "take on" the other role and deeply

understand their perspective. The following questions/sentence starters may help students adopt a more empathetic role:

- ◊ Imagine yourself in this new role. Ask yourself, "How would I feel if I were in this situation?"
- ◊ It sounds like X (state stakeholder role) is experiencing Y's (restate their perspective). This must feel….

Note to teacher: If students are having trouble making connections, you might offer one of these points for them to consider:

- Reiterate that we all play a role in solving this dilemma, even though the effects may impact some people more than others.
- The local economy depends on tourism, which is affected by the quality of the beach.
- The cattle farm contributes to the amount of methane gas in the atmosphere, which affects global warming and the rising water levels in Virginia, even if they never travel there.
- Right now beach replenishment is less costly than repairing property damage from the rising tides. However, if we do not address climate change, the tides WILL rise slowly over time regardless of what we do on a particular beach.

CLOSING THOUGHTS

7. In the closing minutes of the class, ask each student to reflect individually on this experience. After thinking through each of the perspectives they considered or heard from, ask them to think of what might be the best possible option for Virginia Beach.

   Additional questions for reflection:

   - How did it feel to "become" another stakeholder and take on their perspective?
   - How was your new role similar or different to your original one?
   - How does this activity connect to the idea of distributed causality?
   - Can you think of other situations in which moral musical chairs could help with other types of decision-making? (Possible examples: deciding classroom rules, figuring out how to divide time to use playground equipment, choosing class activities, voting on rewards or incentives, etc.)
     Whenever a group decision is made, there is a possibility that not everyone will feel that they got what they wanted. A group decision affects everyone, but not everyone will be happy with the choice made. How does Moral Musical Chairs help students consider others' perspectives during decision-making that impacts the entire class?

   After 5-6 minutes of quiet think time, ask students to discuss with a partner. If there is time, you can allow a few students to briefly share their reflections with the whole class. Be sure to mention that while this strategy can help us to be more equitable in making decisions about the outcomes of distributed causality, particularly when those outcomes impact certain people differently, the Moral Musical Chairs exercise can also be used to better understand other's perspectives in many situations.

MODULE 2
EXTENSION ACTIVITY:

CONNECTIONS TO OTHER SCIENCE TOPICS: DISTRIBUTED CAUSALITY AND SLIME MOLDS

BACKGROUND INFORMATION

Students at this age realize that causes can be distributed and that they can have collective outcomes, but they may not yet have textured models for how to think about interactions or synergies. Instead, they seem to lean on accumulation models.

Slime molds can help students think about accumulations that become a larger entity or aggregate. Slime molds are an example of a synergistic organism composed of many smaller, individual organisms that come together to form a new entity, particularly when there is a shortage of food. They change shape, form, and function in order to produce a fruiting body that secretes spores. These spores eventually get distributed in a variety of ways (e.g., wind, animals, etc.), which allows the formation of new organisms to form.[6] In thinking about the slime molds, it is important to recognize that there needs to be some form of communication/interaction that allows the super-organism to form. The individual organisms act in different ways to lead to the success of the super-organism. They even make sacrifices for the group (the cells that make up the stalks of the fruiting bodies die) in order to allow the slime mold to continue to grow. The slime mold's behavior makes a nice analogy to dealing with problems like climate change. Encourage students to think about what we can learn from the slime mold's behavior that will make us more successful in addressing the impacts of how individual agents can contribute to a collective outcome.

UNDERSTANDING GOALS

Students will understand that...

- Sometimes decentralized, distributed organisms come together in ways that are very hard to predict because they act in synergistic ways: slime molds are an example because they become a super-organism.
- The individuals who make up the super-organism interact in complex and interesting ways to promote survival of the whole organism.
- We can study how these individuals interact to consider if there is anything that we can learn about dealing with distributed causal phenomenon (such as in world problems that impact us all, like climate change).

http://www.pbs.org/newshour/rundown/2012/04/the-sublime-slime-mold.html

MODULE 2
ADDITIONAL EXTENSION:

CONNECTIONS TO OTHER SCIENCE TOPICS: DISTRIBUTED CAUSALITY AND SLIME MOLDS

MATERIALS:

- Slime molds[7]
- Slime mold videos

  Why Study Slime Molds?
  www.youtube.com/watch?v=MlJ0ElcOAv8

  John Bonner's Slime Mold Movies
  http://www.princeton.edu/admission/multimedia/player/?id=2326

  Slime Mold Solving a Maze
  https://www.youtube.com/watch?feature=endscreen&NR=1&v=F3z_mdaQ5ac

LESSON SUGGESTIONS

1. Ask students to recall the various examples of distributed causality they explored in the previous lessons (e.g., ants, termites, StarLogo, etc.). Collect a few comments on what they remember about it.
2. Tell students that they will now consider a special case where organisms come together and become something that is unpredictable—they become more than just a group. Introduce Slime molds either through the above suggested videos, or the real thing. Make sure that the students understand that the individual organisms may play different roles—that not every individual is doing the same thing.
3. Facilitate a classroom discussion:
   - What do the individual organisms do to create a collective outcome?
   - How are the slime molds similar to some of the other examples we considered? How are they different? You may want to do a comparison of the slime molds and the ants with a Venn diagram, as in previous lessons.
4. Encourage students to think about climate change as a big challenge facing humans.
   - What lessons could we learn from the slime molds, ants, etc.?
   - How can individual people collectively contribute to something positive for our world?

7 Slime molds can be ordered in advance from Science Supply Houses. Be careful about how you care for your slime molds and don't assume that they will stay where you put them!

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IMAGE REFERENCES

Beach Replenishment Before and After, Lesson 4: Cape May Point, NJ. Used with permission from the U.S. Army Corps of Engineers.

Chairs, Lesson 4: Lawn Chairs. By Matthew Rogers. Under CC BY-NC 2.0.

Fire Ant Raft, Lesson 1: Fire Ants Cluster in Water. By User:Junglecat. Under CC BY-SA 3.0.

Marching Band Formation, Lesson 3: 2013 DCI World Championships. By Scutter. Under CC BY-NC-ND 2.0.

People Clapping, Module 2 Overview. Used with permission from Microsoft.

Slime Mold, Additional Extension Idea: Yellow Slime Mold. By User:KeresH. Under CC BY-SA 3.0.

Synchronized Swimming, Lesson 3: Team France 2013. By User:Pyb. Under CC BY-SA 3.0.

Termite Mound, Lesson 1: Termite Mound in Tanzania. By User:Krokodild. Public domain.

Traffic Jam, Module 2 Overview. Used with permission from Microsoft.

The Wave, Lesson 2: Hands. By Karen Blaha. Under CC BY-SA 2.0.

APPENDIX

MODULE 2 RESOURCES

GLOSSARY

MODULE RESOURCES

SUPPLEMENTAL MATERIALS

STARLOGO GENERAL INSTRUCTIONS

WHAT IS STARLOGO?

StarLogo 2.22 is a computer program designed to create models of systems. It simulates what happens at a population level when individual organisms interact in certain ways. You and your students will be manipulating the rules and interactions between agents and observing relationships.

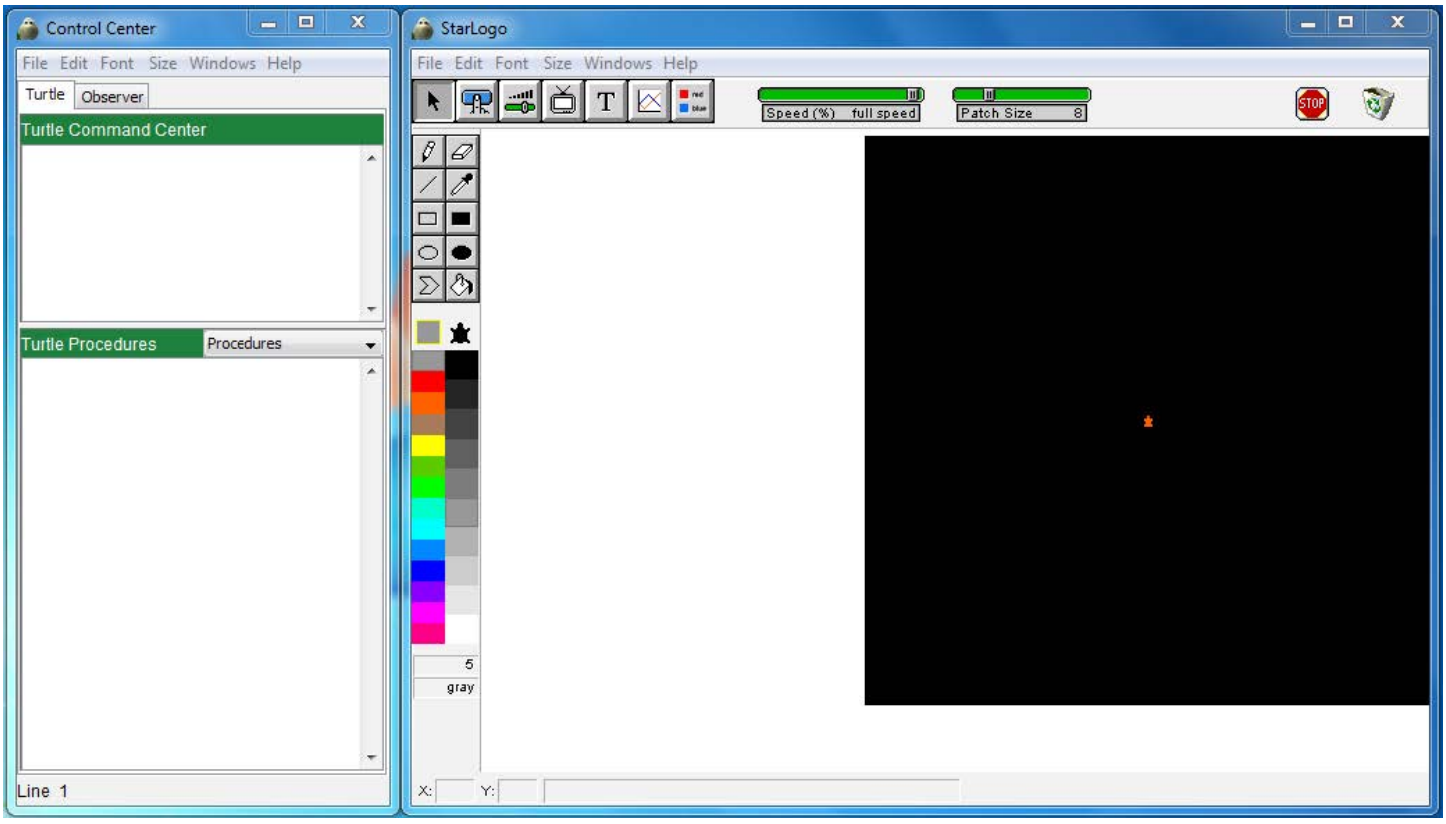
There are 2 simulations that will be used in the curriculum: the Termites and Boids simulations. The Termites Simulation (lesson 1) is inspired by the behavior of termites gathering wood chips into piles. The Boids Simulation (lesson 2) explores how the simple behaviors of individual birds combine to produce flocking.

DOWNLOADING STARLOGO

1. **Go to** http://education.mit.edu/starlogo/ to download StarLogo.
2. **Click** on the "download" icon found at the top green panel of the website.
3. **Select** your operating system (Windows, Macintosh, Unix, Other)
4. **Fill out** the StarLogo download questionnaire and click "Download StarLogo" at the bottom of the screen.
5. **Double-click** the file to start downloading the program on your computer.

ACCESSING STARLOGO SIMULATIONS

1. **Open** StarLogo. Your screen will look like this
2. **Click** on "File" and then "Open Project" and search for the "Termites" or "Boids" simulation found in the Support Files (located in the "Biology" folder—found within the "Sample Projects" folder) that were downloaded with StarLogo.



HAVING TROUBLE LOCATING THE SIMULATIONS?

WINDOWS 7 USERS

The version of Java included in the StarLogo 2.2 Windows version installer is not natively compatible with Windows 7. However, it works fine if you run it in Vista compatibility mode.

RUNNING WINDOWS 7 IN VISTA COMPATIBILITY MODE

1. Access Program Files (or wherever they installed StarLogo; Program Files would be default in Windows) through the Start Menu or My Computer.
2. Once you locate the StarLogo program, right click to see a short menu.
3. From this list, click "Properties," which brings up a window of settings.
4. By clicking the Compatibility tab, you will see a checkbox labeled, "Run this program in compatibility mode for:"
5. Confirm that the checkbox is clicked/checked, and using the dropdown menu select "Windows Vista."
6. StarLogo should run as intended, circumventing the need to change file names or download support material separately.

OR, TRY THIS…

The "any computer" version also works fine. If you want to use the Windows version not in compatibility mode, follow these instructions after running the installer:

1. Navigate to the folder where StarLogo was installed.
2. In that folder, open the folder named "Internal StarLogo Files.
3. You should see a folder named "jre". Rename it to "jre_old".
4. Start StarLogo normally, and contact us if it doesn't work.

OR, TRY THIS…

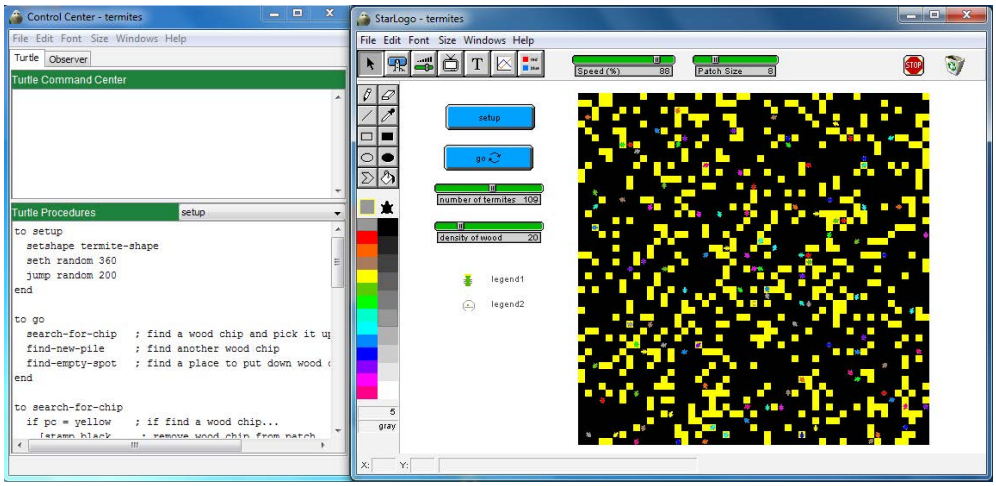
1. Return to the website (http://education.mit.edu/starlogo/)
2. Click on the "Open StarLogo" icon found on the top green panel.
3. Click the "Downloads" link.
4. Click the "Support Files" (sample projects, etc.) link.
5. Open the "Support Files" zip file on your desktop, click through the files until you find the "Sample Projects" folder, click on the Biology folder and drag and drop the "Termites" and "Boids" simulations to your desktop.
6. Return to the StarLogo program and Click "File Open" and search for the "Termites" or "Boids" simulation, which is now located on your desktop.

If you find a problem with StarLogo, please email bug-starlogo@media.mit.edu. There are several researchers working on StarLogo who can help you figure out what's wrong and how to fix it.

TERMITES SIMULATION

WHAT YOU SEE WHEN YOU OPEN THE TERMITES SIMULATION

- Click the "setup" button to set up the termites (red and other colors) and wood chips (yellow). Click the "go" button to start the simulation.
- The number slider controls the number of termites. (Note: Changes in the number slider do not take effect until the next setup.)
- The density slider controls the initial density of wood chips.



THE PROGRAM

The Termites simulation (lesson 1) is inspired by the behavior of termites gathering wood chips into piles. The termites follow a set of simple rules:

1. Each termite starts wandering randomly.
2. If it bumps into a wood chip, it picks the chip up, and continues to wander randomly.
3. When it bumps into another wood chip, it finds a nearby empty space and puts its wood chip down.

With these simple rules, the wood chips eventually end up in a single pile.

THINGS TO NOTICE:

As piles of wood chips begin to form, the piles are not "protected" in any way. That is, termites sometimes take chips away from existing piles. That strategy might seem counter-productive. But if the piles were "protected", you would end up with lots of little piles, not one big one.

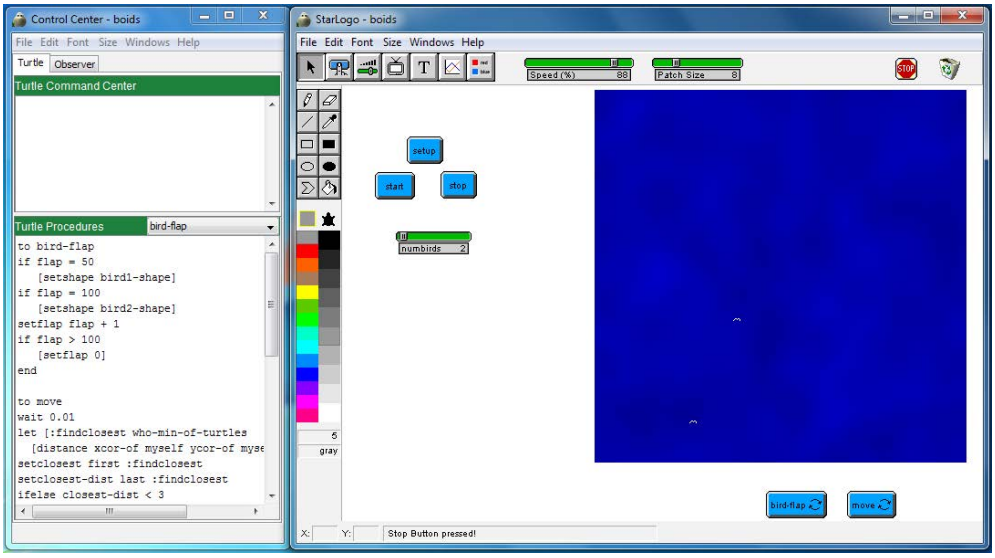
In general, the number of piles decreases with time. Why? Some piles disappear, when termites carry away all of the chips. And there is no way to start a new pile from scratch, since termites always put their wood chips near other wood chips. So the number of piles must decrease over time. (The only way a "new" pile starts is when an existing pile splits into two.)

This project is a good example of a DECENTRALIZED strategy. There is no termite in charge, and no special pre-designated site for the piles. Each termite follows a set of simple rules, but the colony as a whole accomplishes a rather sophisticated task.

BOIDS SIMULATION

WHAT YOU SEE WHEN YOU OPEN THE BOIDS SIMULATION

- Choose the number of birds that you would like with the "numbirds" slider.
- Click the "setup" button to reset the birds on the screen.
- Then click on "start" to start the simulation, and "stop" to stop the simulation.



THE PROGRAM

The Boids simulation (lesson 2) explores how the simple behaviors of individual birds combine to produce flocking. In this model, the birds obey only three rules:

1. If you are about to crash into another bird, turn around.
2. If you are far away from other birds, head towards the nearest bird.
3. Otherwise, fly in the same direction as the bird next to you.

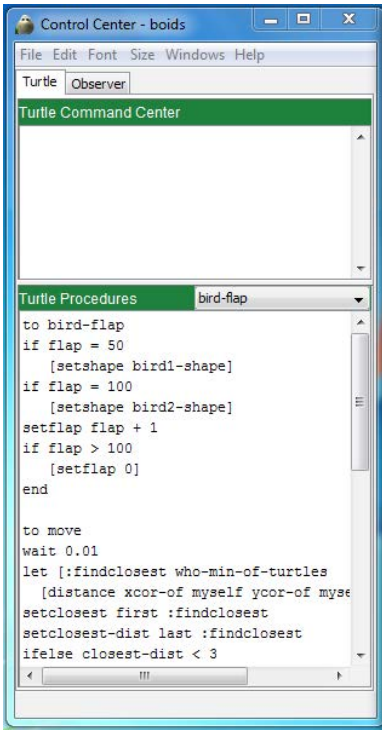
With these simple rules, the wood chips eventually end up in a single pile.

THINGS TO NOTICE:

Watch how the birds start to form groups of 2, 3, 4 and more as they fly across the screen. Even though these birds were never told explicitly to form large groups, they are joining together and they sometimes look like they are following a "leader".

OTHER STARLOGO NOTES

When you open the program, the Control Center also opens. This is where you can see the language used to program StarLogo. Notice that there are two tabs, one for the "turtles" (the termites, birds, etc.) and one for the observer. The Turtle Command Center is where the code is written that moves the turtles, and the Observer Command Center is where the code is written for the things that you and your students will be able to interact with. You do not need to add or remove anything. You DO need to leave the command center open. If you close it, the whole program will close.

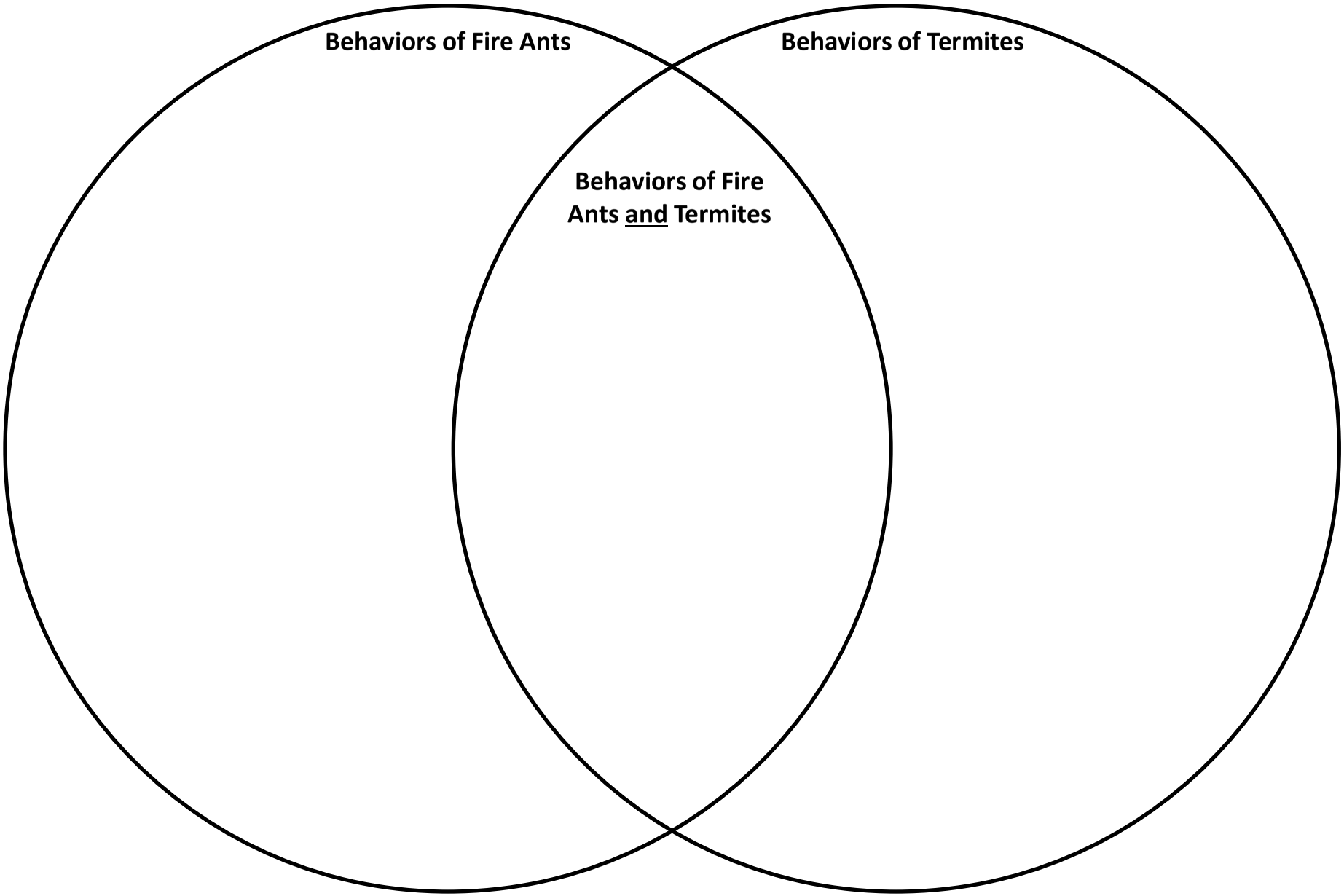


Notes to the teacher:

The version of StarLogo that you will be working with is the newest and it still has a few bugs. StarLogo has been known to freeze if a project is left running and your screensaver comes on. If you want to leave this simulation running for an extended period of time, it would be best to turn your screensaver off first.

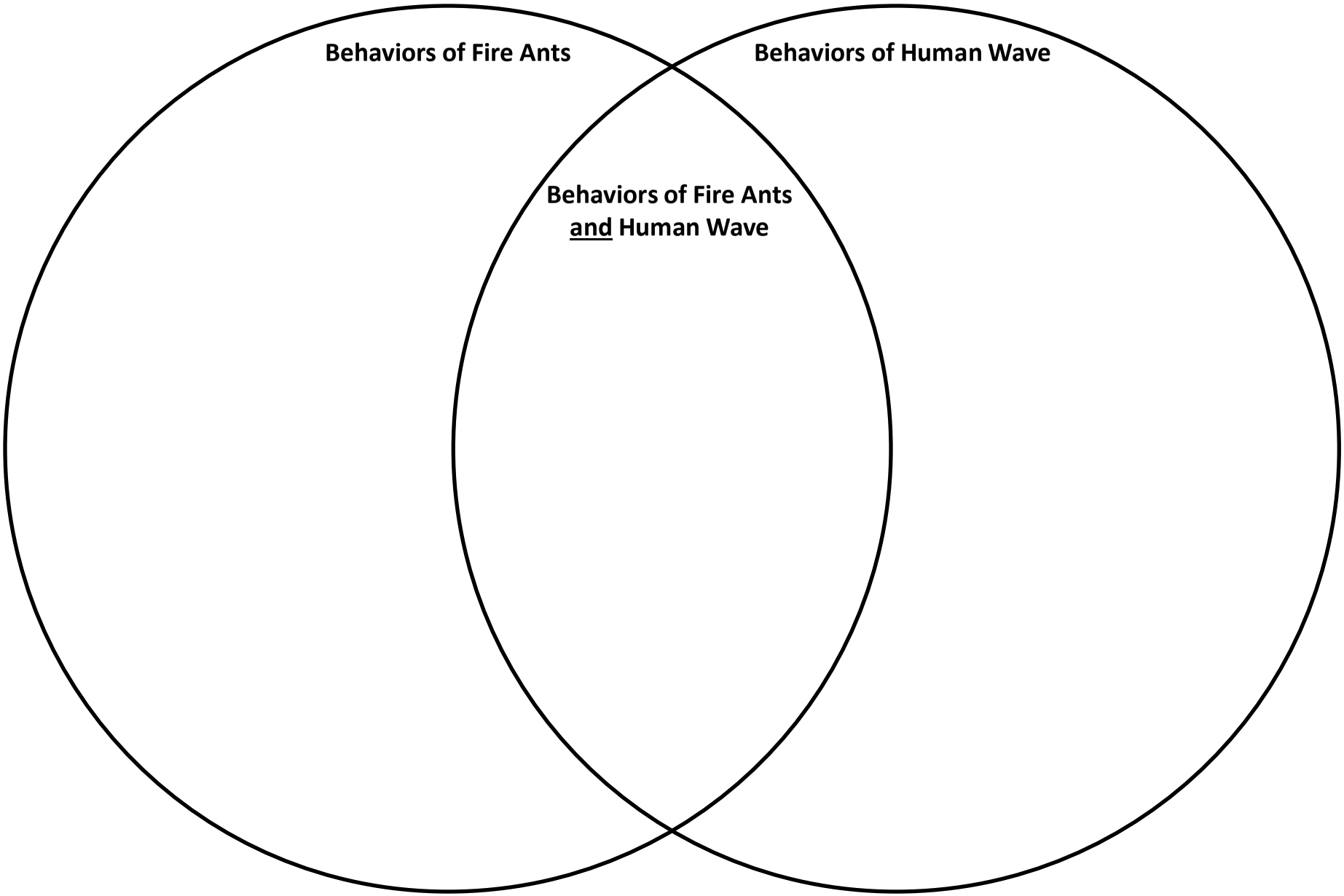
Name_____ Date _____

Venn Diagram: Comparing the Behaviors of Fire Ants and Termites



Name_____ Date _____

Venn Diagram: Comparing the Behaviors of Fire Ants and The Human Wave



NAME_____ DATE_____

CONNECTING FORWARD:
EXAMPLES OF CENTRALIZED AND DECENTRALIZED CAUSALITY

Where might you see examples of centralized causality? What about decentralized causality? Working with a partner, generate at least three examples of centralized causality and at least three examples of decentralized causality. In your decentralized examples, consider whether you can guess the outcome.

CENTRALIZED CAUSALITY:

1.

2.

3.

DECENTRALIZED CAUSALITY:

Can you predict the outcome? If so, what might it be like?

Can you predict the outcome? If so, what might it be like?

Can you predict the outcome? If so, what might it be like?

LANDFILL IN THE SEA

LONG BEACH, Calif., March 26, 2008
By BRIAN ROONEY via Nightline
http://abcnews.go.com/Technology/story?id=4528488&page=1&singlePage=trueCentralized Causality:

If by chance you are missing a basketball, you may be glad to know that it has been found in the Pacific Ocean.

It was there along with giant tangles of rope, sunken snack-food bags, a plastic six-pack ring and thousands upon thousands of plastic bags, billowing under the ocean surface like jellyfish.

And that's not all.

There is a floating garbage dump about the size of Africa created by Pacific currents now carrying refuse from North America, Asia and the islands, concentrating it into a swirl of flotsam estimated to contain 3.5 million tons of junk, 80 percent of which is plastic.

Charles Moore, founder of the Algalita Marine Research Foundation, is an independently wealthy man who decided to spend his life studying the ocean. Ten years ago he was credited with discovering The Great Pacific Garbage Patch, the oceanic dump of the Pacific Rim.

His organization is dedicated to restoring the marine environment. Among the many items he has pulled out of the water include: melted milk crates, a suitcase, fistfuls of toothbrushes, golf balls, glue sticks and brightly colored plastic umbrella handles.

"They are throwaway products," Moore said. "They are cheap now. An umbrella used to be something you might keep for a lifetime. Now an umbrella is for one storm."

Moore has focused his study on an area of the garbage patch that is twice the size of Texas, about a thousand miles from North America near the Hawaiian islands.

PLASTIC SOUP

Sailing his research catamaran named the Alguita, Moore and a small crew drag a trawling device through the garbage patch to study the content of ocean water.

They find what he describes as a "plastic soup." In some cases there is more plastic in the waters than plankton, the basic food organism of the ocean.

"It has some zooplankton. But overwhelmingly what we're seeing here are plastic particles," Moore said. "The ocean has become a plastic soup. This is the soup."

The problem with plastic in particular is that it doesn't quite float, and doesn't sink either. Sunlight and salt water slowly break it down until bags become shreds, and hard plastic breaks down into multi-colored chips.

"This is the new beach sand that we've seeing throughout the pacific islands," Moore said. "It's a sand made of plastic."

Mixed in with the plastic sand is a tiny bit of sand of volcanic origin and coral.

"Formerly we got sand by breaking down rock and coral. Now we're getting sand by breaking down plastic," he said.

Some of it comes from ships, some from fishing floats, and more still from Styrofoam buoys. But the majority of plastic garbage in the ocean comes from land: bottles and cups dropped in the street and washed by rain into the storm sewer, into the rivers and eventually into the ocean.

OCEAN'S FOOD WEB POLLUTED

"The ocean is downhill from everywhere," Moore said. "Things blow and drift into the ocean. They degrade into these particles and then become part of the ocean's load. And the consequences of this are currently unknown."

But some obvious consequences are known.

Moore and his crew have found jellyfish, fouled and caught in rope. Birds and sea life mistake the plastic for food. Bags that looks like jellyfish could choke turtles. Albatross chicks have been killed by a diet of plastic bits.

And then there's the question of what happens when the plastic breaks down even further.

"The bigger chips turn to smaller chips," Moore explained. "And we eventually get dust. Our concern is that this dust then goes to the molecular level and invades the entire food web in the ocean."

On a recent cruise in Long Beach Harbor, Moore and his crew used simple fishing nets to dredge up plastic waste headed out into the Pacific. He found container after container.

"Jerky. Plenty of jerky bags. Looks like a power bar. There's a granola bar," he said. "And the Ziploc baggies won't stop. Look at these Ziploc baggies one after the other. Baggies, baggies, baggies."

Moore said the amount of ocean trash is only increasing, which is a reflection of the increase in disposable packaging. He tracks the trends not at the store, but in the water.

A 'THROWAWAY' LIFESTYLE

"It's much easier to keep freshness in potato chips if you put a thin coating of metal on the inside of the bag. As soon as that started happening, we started finding these metalized chip bags out in the ocean," Moore said.

The Alguita returned from its most recent voyage with its rigging strung with found objects — Moore just hates to leave junk floating out there.

He turns his findings over to the SEA Lab in Redondo Beach, which analyzes the content and concentration of plastic in the water.

"No matter whether you're studying the surface, 10 meters, 30-meter samples or 100-meter samples, every sample that we've looked at in the pacific ocean has had plastic in it," said SEA Lab manager Gwen Lattin.

They even find what are called "nurdles," pellets of unmanufactured plastic spilled on factory lots and railway sidings that have washed out to the ocean.

"The levels are increasing, the amount of packaging is increasing, the throwaway concept of living is proliferating and it's showing up in the ocean," Moore said.

He offers no hope of cleaning it up. Straining the ocean for plastic would be beyond the budget of any country, and it might kill untold amounts of sea life in the process.

The solution, Moore says, is to stop the plastic at its source, stop it on land before it falls in the ocean. And in a plastic-wrapped and packaged world, he doesn't hold out much hope for that either.

MORAL MUSICAL CHAIRS STAKEHOLDER SUMMARIES

NO.	STAKEHOLDER	SUMMARY	POSITION	SUPPLEMENTAL RESOURCES
1	ARMY CORPS OF ENGINEERS	Over time, beaches lose sand due to natural events that cause erosion or sometimes due to man-made structures, such as dams that change the flow of sand. Since beaches provide invaluable benefits (e.g., natural habitats, storm protection, source for human recreation, economic stimulation) it is important to preserve them. The American Shore & Beach Preservation Association (ASBPA) has been working with lawmakers and other authorities to protect beaches and shores since 1928. A combination of measures is used to fight erosion, including land use regulations, removing or adding structures, and restoration by replacing lost sand.	This organization is for beach nourishment.	How beach erosion works (Scientific American): http://www.scientificamerican.com/article.cfm?id=what-causes-beach-erosion Beach nourishment basics (Bryn Mawr): http://www.brynmawr.edu/geology/geomorph/beachnourishmentinfo.html Details on the process: http://www2.gsu.edu/~mstnrhx/EnviroBio%20Projects/Beachfront/reclamation.html
2	VIRGINIA BEACH BUSINESS OWNERS ASSOCIATION	The City of Virginia Beach is at the center of a thriving region that is home to nearly 1.7 million residents and attracts millions of visitors every year. The business that is generated from tourism, building permits, and agricultural activities at Virginia Beach brings hundreds of millions of dollars for the city as well as the state.	This organization is for beach nourishment.	http://www.yesvirginiabeach.com/business-data/pages/demographics.aspx http://www.yesvirginiabeach.com/business-data/pages/economic-sectors.aspx http://www.yesvirginiabeach.com/news-publications/Documents/2013%20Community%20Profile.pdf
3	NEWS ANALYST INVESTIGATING CLIMATE CHANGE	The Intergovernmental Panel on Climate Change (IPCC), established by the United Nations, represents a body of scientists who study the causes of global warming. Reports issued by the IPCC confirm scientific findings that aside from natural changes in climate, greenhouse gases (GHGs) emitted by human activity are responsible for warming. Energy consumption, waste, and industrial processes generate gases that trap heat and warm the atmosphere. The emission of the primary greenhouse gas, carbon dioxide (CO2), has increased more than 20% since 1990.	This organization is against beach nourishment.	http://ocean.nationalgeographic.com/ocean/critical-issues-sea-level-rise/ http://saratogian.com/articles/2013/06/20/news/1d33c385-b244-4eac-bd33-f7420ce1ad31.txt http://www.wdde.org/45346-delaware-beach-replenishment http://www.wnyc.org/articles/wnyc-news/2013/jun/18/dumping-more-sand-most-expensive-beach-america/?utm_source=local&utm_media=treatment&utm_campaign=daMost&utm_content=damostviewed http://www.newsplex.com/news/headlines/Va-Seeks-Ways-to-Guard-against-Sea-Level-Rise-211689901.html?ref=901 http://environment.nationalgeographic.com/environment/global-warming/gw-causes/
4	MICHIGAN FAMILY CATTLE FARMERS	The farming industry has experienced a shift away from community- or family-based farms to corporate factory farms like Tyson and Dean Foods. The corporatization of agriculture has drastically changed food production methods and has resulted in the closure of many small family farms. Apart from the damages it has on local economies, factory farming remains controversial due to a number of dangerous practices including genetic modification, inhumane treatment of animals, and poor waste management.	This organization is against beach nourishment.	http://www.celdf.org/-1-49 http://www.thetimesherald.com/article/20130629/NEWS01/306290007

Army Corps of Engineers

News Analyst

Virginia Beach Business Owners Association

Michigan Family Farm

Building Your Case

Stakeholder group:

_____

In one sentence: Our position on beach replenishment is **for / against (circle one)** because

_____

List 3-4 key supporting facts and ideas supporting my position:

#1: _____

_____

#2: _____

_____

#3: _____

_____

#4: _____

_____

What if anything should the residents of the city of Virginia Beach do about beach erosion?

_____

_____

Stakeholder Group: Army Corps of Engineers

Guiding Questions:

What is the Army Corps of Engineers' position—should Virginia Beach continue beach replenishment or not?

What is your position on the issue—should Virginia Beach continue beach replenishment or not?

Background Information

- This organization executes beach replenishment each season.
- Beach replenishment costs $9 million dollars per year. It has been done every year for the past 49 years and is paid with federal tax dollars.
- There is a reported savings of $443 million dollars in prevented property damages during the past 11 years.

Read the featured article from the American Shore and Beach Preservation Association website (next page)

Why do beaches erode?

The simple answer is they do not have enough sand. However, the causes are different in different parts of the country.

- On the West Coast, beaches are sand-starved when river dams block the flow of sand. Eastern beaches often lack sand because inlets or navigation projects interrupt sand's along-shore movement.
- All beaches suffer from storms and other natural events that cause erosion. Things as disparate as storm-driven waves or a simple change in an offshore sandbar may cause one coastal area to lose sand while another gains.

Preserving our coastal economy

asbpa

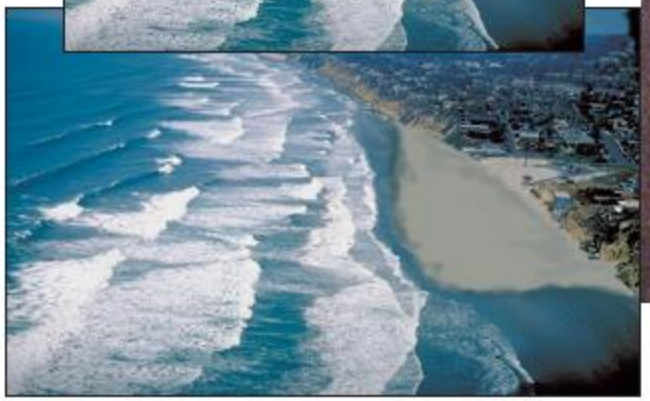
and ecology since 1926

Who is the ASBPA?

The American Shore & Beach Preservation Association is the nation's oldest organization promoting science-based policies for the protection of beaches and shores.

Since 1926, this national organization has worked with legislators and regulators to craft sound public policy to benefit shorelines across the country, while spearheading research efforts to better understand the dynamic processes at work along our coasts.

To learn more about beaches, visit the ASBPA's Web site at www.asbpa.org



Why beaches erode

. . . and what we can do about it

What can we do about it?

For decades, people have tried putting everything on the beach to stop erosion including the proverbial kitchen sink. During the 20th century, when coastal engineering and coastal geology came into their own, science played more of a role in fighting erosion.

Still, there is no one magical answer that works everywhere. Often, it takes a combination of solutions.

Land use regulations: While requiring coastal buildings to be set back and elevated doesn't slow erosion, it does lessen its impact on buildings. That's why most states have enacted special coastal land use regulations.

Abandonment: Wholesale retreat is not practical in many areas. But, in minimally populated areas with low property values, it may make sense to buy property and remove infrastructure.

Structures: There are two kinds that "draw the line" in the sand – literally. Seawalls run parallel to the shore to protect the property behind them. Unfortunately, they don't add sand to the system. Other structures (groins and jettys) run perpendicular to the shoreline and keep sand from moving down the beach. They can work well only when sand is already being added to the beach.

Beach restoration: Adding sand to the beach to replace what's been lost is the closest we've come to solving the problem. Coastal scientists have years of experience with beach restoration projects and have learned that adding sand in the right quantities, properly engineered and maintained, can make a beach last forever.

Why do we care about beaches?

Our beaches are an American treasure in terms of storm protection, recreation, the economy and the environment.

Recreation: Beaches are our longest national park, with more recreational use than all our national parks combined. Unlike many parks, however, beaches are accessible to metropolitan areas. Right now, public beach access must be provided in order for a beach project to receive any federal funding. That's a great motivation to keep our beaches accessible to everyone.

Storm protection: Studies show that a healthy beach protects the properties behind it – and the roads, buildings and sewer or water lines. That means fewer flood insurance claims and disaster assistance requests. It also means a lot less misery for coastal citizens.

Environment: When we lose the beach, we lose invaluable natural habitat. Sea turtles have difficulty nesting on an eroding beach, and those nests are more susceptible to predators. On a narrow or nonexistent beach, birds have no place to nest or feed. Unique beach ecosystems can be destroyed when there isn't enough sand to support them.

Economic: America's coast is a magnet for people who want to live and play on the beach. More than 50 percent of Americans live within 50 miles of the coast. Healthy beaches are a major draw for tourists from across the nation and the world, generating billions of dollars in revenues annually and creating thousands of jobs.

Stakeholder Group: Army Corps of Engineers

Glossary

abandonment	the act of giving up an interest or claim permanently
beach replenishment	also called beach nourishment; the replacement of sand that is lost through erosion with sand from a different source
disparate	different; unlike; not able to be compared
ecosystem	a community of living organisms together with their nonliving environment, as a system
erosion	a process in which soil, sand, and rock are removed and deposited elsewhere by forces like wind and water
groins, jettys/jetties	structures that prevent sand from moving down the shore
inlet	a narrow area of water leading into the land from an ocean or a river
proverbial kitchen sink	everything but the kitchen sink; it is a way of saying everything that can be conceived of

Stakeholder Group: Virginia Beach Business Owners' Association

Guiding Questions:

What is the Virginia Beach Business Owner's Association position—should Virginia Beach continue beach replenishment or not?

What is your position on the issue—should Virginia Beach continue beach replenishment or not?

Background Information

This group represents the resort and home owners in Virginia Beach – some members live out of state, others are year-round residents local to the area.

Businesses include the large hotels and resorts, as well as small business owners in the area.

Virginia Beach Demographics

- The Virginia Beach population is approximately 440,484 while the Virginia Beach Metropolitan Statistical Area (MSA) population is roughly 1,685,610.

There are several major economic sectors that help generate money for the region:

- In 2010, 5.5 million visitors stayed overnight in Virginia Beach (2.9 million stayed in hotels or motels) and 6.2 million more visitors traveled to Virginia Beach for day trips.
- That year, visitors spent $1.130 billion. This helped create 11,562 jobs and almost $95 million for the city and the state.
- Many construction companies are based in Virginia Beach but support projects along the East Coast and worldwide. In 2011, the total value of building permits approved in the City of Virginia Beach was $461 million.
- There are 172 farms in the city. The Virginia Beach agricultural community (production, fruit and vegetable farming, livestock programs, agri-tourism, wineries, and equestrian) generates more than $120 million per year. The city also has year-round farmers' markets, farm stands, and other markets and programs.

Source: http://www.yesvirginiabeach.com/

Stakeholder Group: Virginia Beach Business Owners' Association

Glossary

Equestrian	horseback riding
Metropolitan Statistical Area (MSA)	identifies a region with close economic ties throughout the area, even though it may not be legally considered as a single city or county

Stakeholder Group: News Analyst Researching Climate Change

Guiding Questions:

What is the News Analysts' position—should Virginia Beach continue beach replenishment or not?

What is your position on the issue—should Virginia Beach continue beach replenishment or not?

Background Information

Beach replenishment is costly to the federal government – some say we could just move back the shoreline instead of developing more properties there.

- In addition to Virginia Beach, this is happening in many other shorelines as well –the vast majority of expenses are subsidized by the federal government (e.g., Delaware, New York, other parts of Virginia's shoreline).
- Some beachfront cities are experimenting with alternative responses to rising seas – including improving storm water drainage systems, elevating homes, creating floodplains to divert rising waters.

"'Everything we do should be done with the assumption that the sea level's rising, and another [Hurricane] Sandy will come by in some number of years,' Orrin Pilkey, professor emeritus at Duke University, says. Pilkey has criticized federal beach nourishment for decades. And now, he says, studies show a warming planet is causing sea levels to rise even faster, especially in the mid-Atlantic. There's no avoiding it, he says." –NPR report

- This is an inevitable change to the coast over the next 100 years or so – the sea level IS going to rise no matter what efforts are made.
- Carbon Dioxide gas (CO_2) is the main contributor to global warming.

Read the featured National Geographic article (next page)

Sources: http://www.npr.org/2013/01/30/170301306/debate-over-rebuilding-beaches-post-sandy-creates-waves, http://ocean.nationalgeographic.com/ocean/critical-issues-sea-level-rise/, http://saratogian.com/articles/2013/06/20/news/1d33c385-b244-4eac-bd33-f7420ce1ad31.txt, http://www.newsplex.com/news/headlines/Va-Seeks-Ways-to-Guard-against-Sea-Level-Rise-211689901.html?ref=901

Causes of Global Warming

Photograph by Peter Essick

What Causes Global Warming?

Scientists have spent decades figuring out what is causing global warming. They've looked at the natural cycles and events that are known to influence climate. But the amount and pattern of warming that's been measured can't be explained by these factors alone. The only way to explain the pattern is to include the effect of greenhouse gases (GHGs) emitted by humans.

To bring all this information together, the United Nations formed a group of scientists called the Intergovernmental Panel on Climate Change, or IPCC. The IPCC meets every few years to review the latest scientific findings and write a report summarizing all that is known about global warming. Each report represents a consensus, or agreement, among hundreds of leading scientists.

One of the first things scientists learned is that there are several greenhouse gases responsible for warming, and humans emit them in a variety of ways. Most come from the combustion of fossil fuels in cars, factories and electricity production. The gas responsible for the most warming is carbon dioxide, also called CO2. Other contributors include methane released from landfills and agriculture (especially from the digestive systems of grazing animals), nitrous oxide from fertilizers, gases used for refrigeration and industrial processes, and the loss of forests that would otherwise store CO2.

This article excerpt explains the causes of global warming. Global warming is the rise of the average temperature of the Earth's climate. How might global warming relate to rising sea levels? How do rising sea levels relate to beach erosion?

Source: http://environment.nationalgeographic.com/environment/global-warming/gw-causes/

Stakeholder Group: News Analyst Researching Climate Change

Glossary

beach replenishment	also called beach nourishment; replacement of sand that is lost through erosion with sand from a different source
combustion	the process of burning
divert	to cause something to change course, or go elsewhere
floodplain	an area of land that lies next to a water source that becomes flooded
global warming	a continuing rise of average temperatures in Earth's climate
greenhouse gases (GHGs)	gases that absorbs infrared radiation, which means that they can trap and hold heat in the atmosphere
inevitable	unpreventable; sure to happen
storm water drainage	a system to remove excess water from roads, homes, and public spaces; includes gutters and sewers
subsidized	supported financially; a **subsidy** is the payment given by the supporter

Stakeholder Group: Cattle Farm Family in Michigan

Guiding Questions:

What is the Cattle Farm Family's position—should Virginia Beach continue beach replenishment or not?

What is your position on the issue—should Virginia Beach continue beach replenishment or not?

Background Information

- The Smith Family cattle farm has been running for three generations, but has made less money in recent years.
- The Smith farm has received $1 million in subsidy payments since 1995-2012, but recent federal legislation did not pass so those subsidies are in danger of being cut off completely.
- The Smith family has one child in college, and two more about to attend within the next two years.
- Their last vacation was 6 years ago, and they have never visited the state of Virginia before.
- The Smith farm is located almost 1,000 miles away from Virginia Beach.

Read the featured article about factory farms (next page)

Sources: http://www.thetimesherald.com/article/20130629/NEWS01/306290007

COMMUNITY ENVIRONMENTAL LEGAL DEFENSE FUND

Factory Farms

Communities across the country are facing the many problems associated with corporate control of agriculture. Called the ***corporatization of agriculture***, it means that fewer and fewer people (acting through corporations) are controlling more and more of the production of our food. These are corporate directors deciding to grow genetically-modified food, deciding to use mass production for "efficiency," deciding to use the land application of sewage sludge for fertilizer, and deciding to use chemicals, herbicides, and antibiotics in our food production.

The corporatization of agriculture also means that small, family farms have been closing at an alarming rate – 5 million since the 1930s. This has had a devastating effect on local economies and rural communities.

One of the symptoms of the corporatization of agriculture is factory farming. Today, four corporations control over 85% of beef packing in the United States. Two corporations – Tyson and Smithfield – control over half of pork production. Forty percent of milk production is controlled by Dean Foods. With this much of food production controlled by so few people, monolithic farming operations are now standard across the country.

The dangers of factory farming are well documented: inhumane treatment of animals; environmental harms to the water, soils, and air; and devastating economic consequences for rural communities that impact quality of life and the loss of family and small farms.

Furthermore, despite the claims of Big Ag, factory farms are not more efficient than smaller farms. Dairy farms have concentrated more and more cows into warehouse like conditions at a cost of 50,000 dairy farms closing down between 1997 – 2007; yet milk production levels remain the same. And as the pork industry has become more concentrated, we're raising the same number of hogs today as we were in 1950.

Source: http://www.celdf.org/-1-49

Stakeholder Group: Cattle Farm Family in Michigan

Glossary

antibiotics	substances used to kill bacteria that must be used carefully and properly
Big Ag	“big agriculture”; large farming corporations or businesses
corporatization	to be influenced by or become a large business
devastating	very destructive or damaging
federal legislation	the act of making and passing laws that affect the whole country
genetically-modified	altered at the genetic level to produce a desired characteristic
herbicides	chemicals used to kill weeds
inhumane	without compassion; cruel
monolithic	large, powerful, and indivisible
subsidy	the payment given by the supporter
sewage sludge	waste left over from sewage treatment processes