Lesson Title: What is the Living Breakwaters?

Unit: Living Breakwaters (LB) Curriculum: Restoration and Resilience in Raritan Bay
Chapter: Introduction the the Living Breakwaters

LESSON OVERVIEW

Grade: 6-8 Class Periods: 1-2 Setting: classroom Subject Area(s): science

Lesson Summary

Students close-read a rendering of the Living Breakwaters, making observations, drawing inferences, and posing questions about the image. Then they interpret SCAPE's graphic depicting the interrelated nature of three aspects of resilience: culture, risk reduction, and ecology. Students then prioritize what's most important to them, given a broad array of hypothetical uses for the shoreline and shallows of Raritan Bay. Finally, students concept-map their high-priority uses onto the SCAPE graphic that illustrates the interrelated three aspects of resilience.

Objective(s)

- Describe the Living Breakwaters project
- Define resilience in terms of three aspects: culture, risk reduction, and ecosystems
- Conceptually map relationships that specific uses of shorelines and shallows have to the abstracted three aspects of resilience

MATERIALS & RESOURCES

Supplies

- Removable tape - a supply for each group

Handouts

- *Sort items - shorelines and shallows should/not be a good place to…* - one complete set per student (see Preparation)
- Sort: rank these uses of shorelines and shallows -- one copy of the first page for each student, and one copy of the second page for each small group
- *Resilience graphic - 3 aspects - SCAPE* -- one per group

Lesson Materials

- *Living Breakwaters rendering - SCAPE* - to project
- *Resilience graphic - 3 aspects - SCAPE* - to project

Vocabulary

- **Landscape architecture** - the design of outdoor places to achieve specific goals. According to SCAPE Landscape Architecture's website, one design goal for the Living Breakwaters is to "reveal natural processes and create wildlife habitat, integrating natural systems with the human realm". SCAPE's work also includes City Planning and Urban Design, from "open space planning to stormwater management plans".

- **Resilience** - the ability of a system to recover from disruption. For example at the shoreline and in the shallows of Raritan Bay, a large storm can be a major disruption to the water flows and landforms, to people and society, and to local ecosystems. In response to a disruption, a system can be more *physically resilient* -- e.g. the water can subside, leaving behind less damage to the land and people and ecosystems. The system can be more *socially resilient* -- e.g. the people can support each other, and society can prepare better for large storms, so there is less damage to the land and people and ecosystems. And the system can be more *biologically resilient* -- e.g. the local ecosystems can survive the storm, and the organisms can help protect the land and support people's wellbeing. These three aspects of resilience are intertwined: risk reduction (physical), culture (social), and ecology (biological).

- **Risk reduction** - instead of trying to *prevent* a risky event, risk reduction is the effort to *reduce the risk* of that event. For example, you could completely prevent sexually transmitted infections (STIs) by preventing all people from having sex, ever. And/or you could reduce the risk of transmission of STIs by teaching people how to practice safer sex, and making sure everyone has the condoms and other supplies they need to practice safer sex, in case they do have sex. Another example is the risk of damage caused by storms. We can't stop a hurricane in its tracks. But because we know intense storms will come, one way we can make those storms *less risky* is to design our coastal cities so that the shorelines can flood without people getting hurt or losing their homes or businesses. For instance, in the long term, if we move homes and businesses further from the shore, and use the shoreline for things that can be flooded without being destroyed -- such as oyster reefs, eelgrass beds, and salt marshes -- then we can weather intense storms with *less risk* of harming people and society. And the Living Breakwaters is one way we can reduce the risk of intense storms right now.

- **Erode, erosion** - when water is moving, it can pick up and carry tiny objects with it. Usually those tiny objects are grains of sand or particles of mud. To talk about the mud and sand together, we say 'sediments'. When water is moving along land, it can pick up sediments from the land, and carry it far away. That process is called erosion.

  When water erodes land, it seems like part of the land is disappearing. Of course the sediments don't *disappear* like magic, but they can travel great distances, carried by water. When water carries sediments to another place, it is fair to say that the sediments *disappear from the place they started*. It would be even more accurate to say that the sediments are *transported* out of a certain system.

  Water constantly erodes land, pretty much everywhere that water is moving along land. Believe it or not, that means that all landforms are constantly changing.

  It's hard to believe because it can happen very slowly, much too slowly to see. But in some situations, erosion happens very quickly, and sometimes people are using the land that is eroding, and sometimes the people are using that land for something that they really care about, like their homes.

So erosion can be almost impossible to notice, or it can be a very noticeable problem for people, and it can be anything in between. In general we notice erosion when it happens quickly, and we don't notice erosion when it happens slowly.

Technically wind (moving air) can also erode land, in exactly the same way that moving water does. The main difference is that air erodes land even more slowly than water does, and so wind erosion is even harder to notice.

- **Deposit, deposition** - the word 'deposit' has so many meanings! To figure out what a person means when they say 'deposit', you need to know the context.

  If someone is talking about erosion, then deposition is the opposite of erosion. Deposition occurs when sediments drop out of water and settle to the bottom. That usually happens when the water slows down. Water can 'deposit' sediments, or leave the sand and mud behind. The water keeps moving, but the sediments stay in one place, where they were deposited.

  Deposition makes it seem like land is being created from water. Of course the sediments aren't being *created* like magic. They came from somewhere else, carried by water. And wherever those sediments came from, the land is eroding.

  The key is that sediments are *moving*. Erosion and deposition are like the beginning and end of a trip. A certain grain of sand starts somewhere, hitches a ride with the moving water, and ends up somewhere else. The starting point is eroding - losing sediments. The ending point is where the sediments wind up - where they get deposited.

  It's more common to hear people complaining about erosion, but people sometimes complain about deposition, too. The question about erosion is: do the sediments *stay* where people want? The question about deposition is: do the sediments *end up* where people want? It's almost the same question.

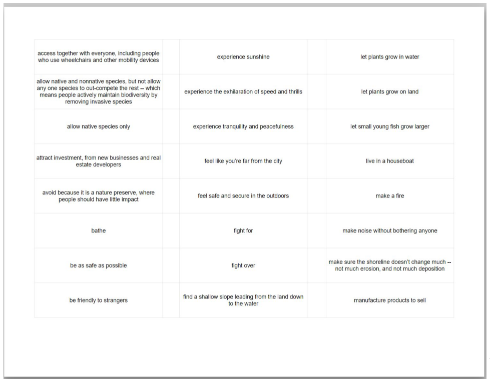
  For instance, Raritan Bay had amazing oyster reefs in the 19th century (and before that). Meanwhile, people were paving New York and New Jersey (and other places). Water moves a certain way over soil and plants, and it moves a different way over pavement. In general, water moves faster over pavement, so it carries more sediments, further, and faster over pavement.

  One idea is that once people paved enough of the land, a large enough rainstorm might have washed so much sediment off the land of New York and New Jersey, so quickly and directly into Raritan Bay, that a lot of the oysters might have suffocated under all that mud and sand. Clyde McKenzie talks about that idea in his article "A History of Oystering in Raritan Bay". You can read more in BOP's *Source Library: Raritan Bay Oyster Industry*

BEFORE YOU GET STARTED

Preparation

- To prepare the sort, print out the *sort items* in landscape format, one copy per student.



access together with everyone, including people who use wheelchairs and other mobility devices	experience sunshine	let plants grow in water
allow native and nonnative species, but not allow any one species to out-compete the rest -- which means people actively maintain biodiversity by removing invasive species	experience the exhilaration of speed and thrills	let plants grow on land
allow native species only	experience tranquility and peacefulness	let small young fish grow larger
attract investment, from new businesses and real estate developers	feel like you're far from the city	live in a houseboat
avoid because it is a nature preserve, where people should have little impact	feel safe and secure in the outdoors	make a fire
bathe	fight for	make noise without bothering anyone
be as safe as possible	fight over	make sure the shoreline doesn't change much -- not much erosion, and not much deposition
be friendly to strangers	find a shallow slope leading from the land down to the water	manufacture products to sell

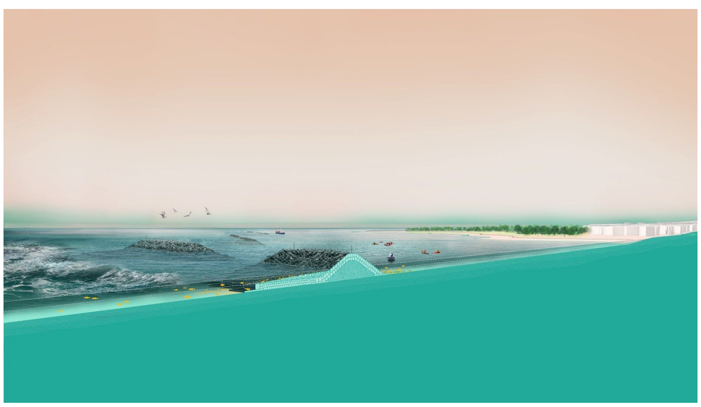
You can only print on one side of the page, because you will cut these out for students to manipulate at their desks.

    - For each student, cut out the set of 225 sort items (including two blanks, for students to fill in if they want), and put each complete set of 225 cutouts into its own envelope. Each student gets one envelope that contains all 225 items.

INSTRUCTION PLAN

Engage

1. Project the first slide from *Living Breakwaters rendering - SCAPE*.

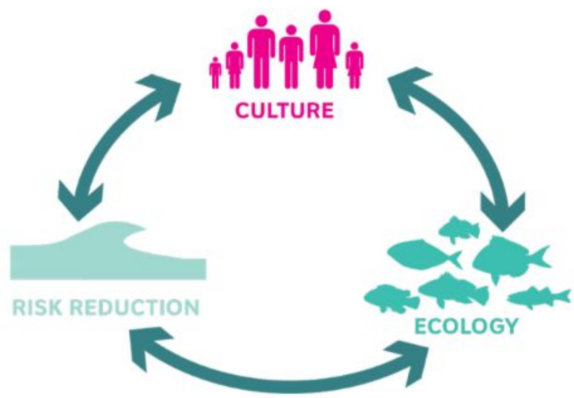


It shows an illustration of the Living Breakwaters drawn by SCAPE, the Landscape Architecture firm that designed the Living Breakwaters.

    - You can tell students: 'The Living Breakwaters will be in Raritan Bay, off the south shore of Staten Island' -- a place to be explored in detail in later lessons!

2. As they look at the rendering, repeatedly ask students: what do you notice?
    - Keep notes of their answers.

3. Project the *Resilience graphic - 3 aspects - SCAPE*



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and simultaneously provide the definition of the word resilience (see Vocabulary)-- or at least this much of it:

Resilience - the ability of a system to recover from disruption.

4. Explain: “this graphic describes SCAPE’s vision of the meaning of resilience for Raritan Bay.” Ask:
    - “What do you make of the three images? What do you think those images are trying to show? What could those images have to do with resilience?”
    - “What do you make of the three titles -- risk reduction, culture, and ecology? Why use those words with those pictures? What could those words have to do with resilience?”
    - “What do you make of the arrows? What is SCAPE telling us about resilience by including those arrows?”
    - “What does it mean that the graphic is more or less a circle? For example the same pictures and words and arrows could easily be drawn more like a triangle. Why might SCAPE have chosen a circular shape?”

Explore

1. One by one, project the rest of the slides from *Living Breakwaters rendering - SCAPE*, which show the same rendering but zoomed in on different areas.

2. Continue to ask students: “what do you notice?” And now also ask: “how could that thing that you point out relate to resilience? To culture, ecology, and/or risk reduction?”

3. If necessary, point out the following:
    - The Living Breakwaters structures are made from stones of different sizes.
    - They sit on the bottom of Raritan Bay, and they partly stick out of the water.
    - The waves are large on the offshore side of the structures, and the water is calm on the onshore side.
    - That will make a big difference for people during storms!
    - A wide variety of organisms live in and around the structures.

4. At appropriate moments, mention the following information, which cannot be seen in the rendering:

   - When students notice the different stones in the LB structures, or start talking about the critters living there, tell them:

     - The LB structures are designed to provide many different-sized crevices, and each crevice is a good place to hide (or in some cases to nest) for a different kind of critter, or a different size/age critter. That's one way that the Living Breakwaters support biodiversity.

     - In addition to all those stone crevices, the Living Breakwaters will also have concrete-and-metal parts, and live oysters, and those variations will add and greater variety of habitats for an even greater diversity of inhabitants.

       Note: A lot more is to come about those oyster reefs!

   - When the students notice the contrast between the big waves offshore of the structures, and the calm water onshore of the structures, add:

     - That's because the waves break on the structures, dissipating some of the waves' energy offshore. That protects the land and the shallowest areas of the bay from some of that wave energy.

     - You can see in the rendering that the water is moving more slowly on the onshore side of the structures, and there's more to the story:

       When water moves quickly, it picks up tiny bits of sand and mud. When it slows down, it drops that material.

       So by slowing down the water in specific places, the structures are also expected to help preserve the beaches you can see in the rendering.

       Over the years, those beaches have been washing away into the ocean (eroding).

       The Living Breakwaters is predicted to increase resilience in this additional way: by stabilizing the shoreline, so the beach doesn't disappear.

       - Optional: you might present this thought experiment: 'Suppose you don't care about the beach itself for whatever reason -- maybe you hate getting sand between your toes more than anything else in this world. And suppose all your friends and family and everyone you care about just happens to feel the same way. If no one ever goes down to the beach, and no one values the beach for its own sake, would you do just as well without it? Or does the beach contribute something to your community's resilience, just by being where it is?

- Some students will probably say: in that case the beach doesn't matter.
- And some may come up with different ideas, for example:
  - Look at the buildings in the rendering. With no beach, those buildings could fall down into the bay.
  - Look at the plants growing on the beach. Isn't it good to have plants?
  - What about the waves? Won't they hit very hard with no beach?
  - What about the people in boats? How can they get in and out of the water with their boats?

Explain

1. Say: "in this rendering, you noticed some of the ways that people can and should use the shoreline and shallows of Raritan Bay -- according to the folks at SCAPE Landscape Architecture. They have opinions about what should happen (and not happen) there. Now we will find out about *your* opinions."

2. Students complete the Sort: rank these uses of shorelines and shallows, using the *Sort items - shorelines and shallows should/not be a good place to…*

3. The class debriefs, and you can help point out:
   - Shared values
   - Points of disagreement
   - Uses of the shorelines and shallows that go well together (e.g. *a nature preserve* and *horseshoe crab habitat*)
   - Uses of the shorelines and shallows that cannot happen in the same place at the same time (e.g. *drive an all-terrain vehicle wherever you want* and *find a maritime forest*) -- so there is a tradeoff.

Elaborate

1. Each group has removable tape, a separate sheet of paper, and a printed copy of SCAPE's graphic showing the interrelated three aspects of resilience: risk reduction (physical conditions), culture (social conditions), and ecosystems (biological conditions).

2. Groups look at the graphic as a concept map, and map their top six priorities from the sort directly onto the graphic.

   - The three items they felt most strongly *should* happen at the shoreline and shallows of Raritan Bay

     AND

   - The three items they felt most strongly *should not* happen there

   For example:
   - An item you place right in the middle of the graphic is equally related to physical, social, and biological resilience.

    - Note: A student might put any item there! Our idea is that everything is interconnected. But of course students can disagree, and it's most lively when they disagree with and try to convince one another.

- An item you place halfway between Culture and Ecosystems is definitely part of social resilience and definitely part of biological resilience, but not as closely related to physical risk reduction.

    - Note: A student might put *go on an educational tour* there, and argue that education can increase social resilience, and when you go on a tour, you're probably learning about the ecosystem and how to help the animals, so that could increase ecosystem resilience. They might not see any connection between physical risk reduction and educational tours, and that's ok.
        - Perhaps later, in the discussion you lead in the Evaluate section, a classmate might come up with a connection, such as: 'the educational tour can also help people reduce their physical risk. For instance, maybe on the tour you learn your evacuation zone.' Or not. That's ok too.

- If you think your item has nothing whatsoever to do with resilience, put it on a different piece of paper.

    - Note: We don't have any examples in mind, but it's important to find out what your students are thinking does and does not relate to resilience.

    - Note: A student might place an item like *drive an all-terrain vehicle wherever you want* on that separate sheet of paper. It would be interesting to see if classmates come up with counter arguments during the discussion you will lead in the Evaluate section. For example, a student might make the case that driving all-terrain vehicles wherever you want sounds like fun, and fun brings people together, and those friends might help each other out in a crisis like a big storm, and that's social resilience. And they might argue that an all-terrain vehicle could come in handy after a storm, if the roads are messed up. And perhaps other classmates would raise concerns about greenhouse gases and the impact of the vehicle on the terrestrial ecosystems. This discussion can go in a lot of different directions!

Evaluate

1. Debrief as a class and encourage respectful disagreement and persuasion.

    - Some hypothetical points of disagreement are described in the notes within the previous section of the lesson, *Elaborate*.

2. Be sure to ask: which items do you think had nothing at all to do with resilience? Why not?

- Perhaps with further discussion, students may identify a connection to social, biological and/or physical resilience.

- Arguably every item in the sort has this kind of connection. But as long as students can articulate *some* intertwining of social, biological, and physical aspects of resilience, it is *not* important that they agree with us -- or with each other -- about individual items.

3. You could end the lesson here or, if you'd like to review, project the *Living Breakwaters rendering - SCAPE* once more. Ask:

    - What is one *risk reduction* aspect of resilience that you can see in this image -- something that reduces the risk of storms, by reducing wave energy and/or stabilizing the shoreline?

        - How does that thing affect people and society here?

          [for example, people can use small, human-powered boats because the water is calm]

        - How does it affect ecology in Raritan Bay?

          [for example, some plants or animals might need calmer waters, too]

    - What is one *cultural* aspect of resilience that you can see in this image -- something that strengthens relationships or social institutions (like governments), so people can recover more easily from a big disruption?

        - How does that thing affect ecology in Raritan Bay?

          [for example, people working together on the Floating Water Hub can also help maintain the oyster reefs on the Living Breakwaters]

        - How does that thing affect risk reduction in Raritan Bay?

          [for example, that boat probably emits greenhouse gases, and that makes climate change worse. On the other hand, those same people are probably learning about greenhouse gases and climate change, and they might go on to solve some of our problems with greenhouse gases and climate change in their careers.]

    - What is one *ecological* aspect of resilience that you can see in this image -- something that helps ecosystems recover from a big disruption?

        - How does that thing affect risk reduction in Raritan Bay?

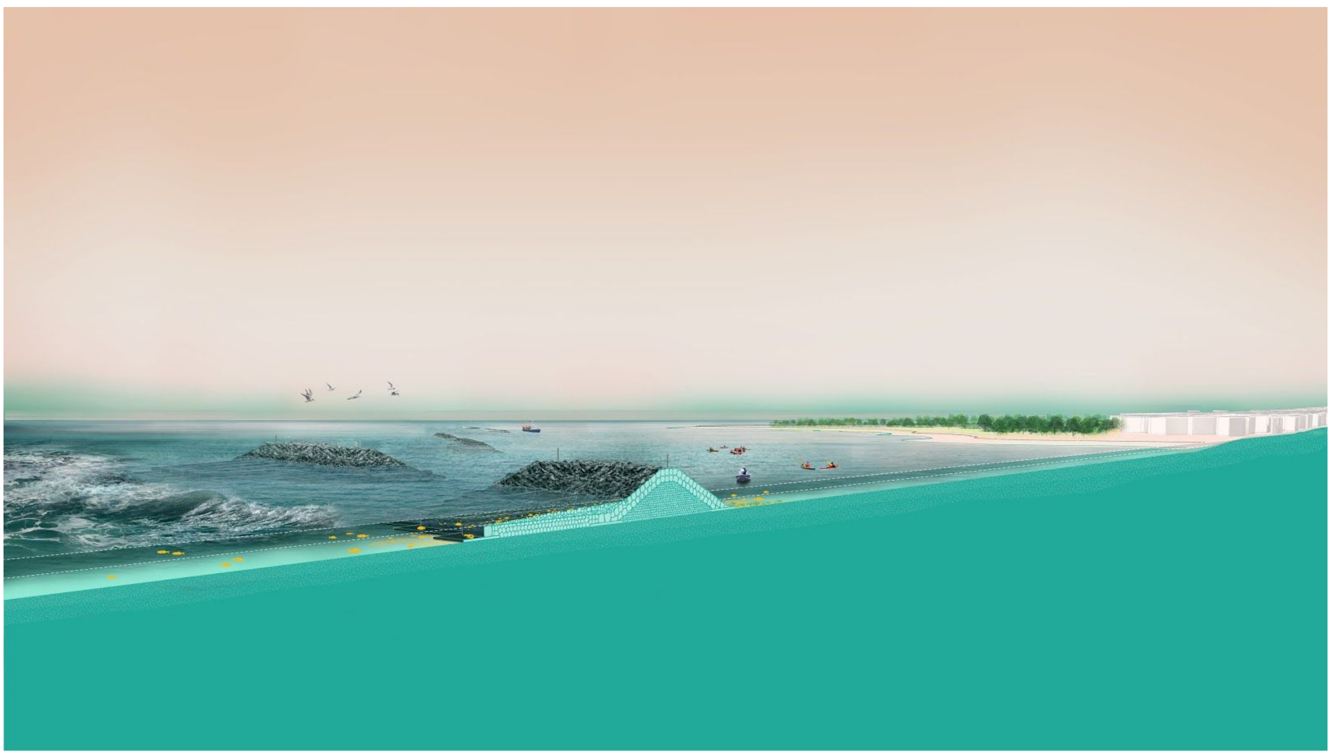
          [This is probably the hardest one because this one rendering doesn't emphasize it, and of course you could skip it. But one example could be the beginnings of an eelgrass meadow in the sediment that is accumulating on the onshore side of the structure. Big eelgrass meadows also slow down water currents. Of course oyster reefs do the same, but they are not visible in the rendering.]

- How does that thing affect cultural resilience in Raritan Bay?

  [for example, the more robust fish populations bring people out in boats to go fishing, where they can build relationships with others, and also learn more about the bay.]

FEATURED IMAGE

Featured image:



Featured image credit: rendering of the Living Breakwaters courtesy of SCAPE Landscape Architecture

Standards --

NYC Scope and Sequence Grade 5

Crosscutting Concepts

- A system can be described in terms of its components and their interactions. (5-LS2-1)

Science and Engineering Practices

- Develop a model to describe phenomena. (5-PS1-1), (5-LS2-1)
- Use models to describe phenomena. (5-PS3-1)

- critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). Support an argument with evidence, data, or a model.

Grade 5 Unit 2: Matter and Energy in Ecosystems -- How do matter and energy flow through ecosystems?

Disciplinary Core Idea

LS2.A: Interdependent Relationships in Ecosystems

- ... A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1)

NYC Scope and Sequence Science 6-8

Science and Engineering Practices

- Argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

Crosscutting Concepts

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)
- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4), (MS-LS2-5)
- Structures… can be visualized… and used to describe how their function depends on the shapes, composition, and relationships among their parts (MS-LS3-1)

Grade 6, Unit 3: Ecosystems -- Why does the Earth never run out of matter or energy?

Disciplinary Core Ideas organized by Performance Expectations

- MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
    - Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.
    - Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)
    - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)

- MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and protecting ecosystem stability.
    - Biodiversity describes the variety of species found in Earth's ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)
    - Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5)
    - Humans impact biodiversity both positively and negatively. (secondary to MS-LS2-5)

Science Addresses Questions About the Natural and Material World

- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)

NGSS High School standards

Disciplinary Core Ideas

- LS2.A Interdependent relationships within ecosystems
  ….The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem

- LS4.C Adaptation
  Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce….

Crosscutting Concepts

- Cause and effect
  In grades 9-12, students… recognize changes in systems may have various causes that may not have equal effects.

- Systems and system models
  In grades 9-12, students can... design systems to do specific tasks.

- Structure and function
  In grades 9-12, students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, [and] the way their components are shaped and used....

- Stability and change
  In grades 9-12, students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.

Science and Engineering Practices

- Developing and using models
  ...in 9-12 progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

    - Develop and/or use a model...to... predict phenomena, analyze systems, and/or solve problems.

- Constructing explanations (for science) and designing solutions (for engineering)
  ...in 9-12 progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
    - Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
    - Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
    - Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

- Engaging in argument from evidence
  ...in 9-12 progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.
    - Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.
    - Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
    - Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

- Obtaining, evaluating, and communicating information
  ...in 9-12 progresses to evaluating the validity and reliability of the claims, methods, and designs.
    - Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.
    - Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).