

## UNIT 2

# Energy & the ecosystem

Appendix

## 2.1 Who makes up this ecosystem? | Scavenger hunt

### Instructions

Groups working with the curriculum on site can use the Jones Beach: Home and Hotel, Diving Deep, and Pollinator Garden exhibits to complete the scavenger hunt, referring to the Map of Exhibits included in the Introduction to the Curriculum. Groups working off site can use an online biodiversity database like iNaturalist ([inaturalist.org](http://inaturalist.org)) to complete the activity.

#### Find a photoautotroph...

in the garden.

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on the beach or in the dunes.

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in the marsh.

\_\_\_\_\_

in the ocean.

#### Find a primary energy consumer...

in the garden.

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on the beach or in the dunes.

\_\_\_\_\_

in the marsh.

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in the ocean.

#### Find a secondary energy consumer and its food-source...

in the garden.

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on the beach or in the dunes.

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in the marsh.

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in the ocean.

#### Find a detritivore or scavenger...

on land.

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in the water.

#### Find two examples of pollinators and the plants they pollinate in the ecosystems of Jones Beach.

#### Find another example of symbiosis between organisms. What kind of symbiotic relationship is this?

#### Find three examples of animals that migrate to, from, or through the ecosystems of Jones Beach.

Compare and contrast abiotic factors in three of the ecosystems of Jones Beach.

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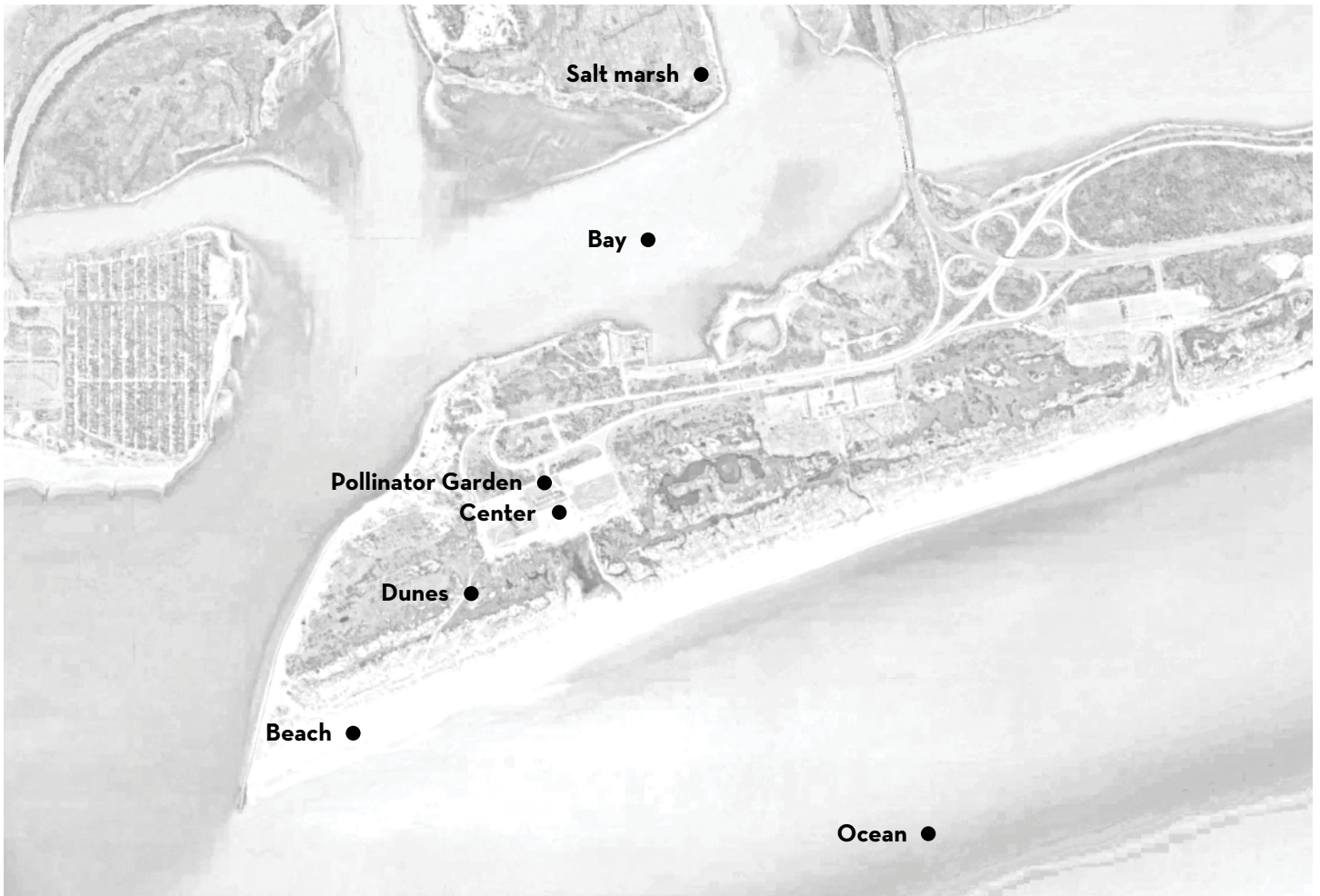
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During the discussion, map out the examples that the group identifies, and their relationships to one another, on the site map below.



## 2.1 Energy, organisms, and eating | Role play

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### Instructions

Read your assigned character profile and determine which other species you interact with, either as a source of energy or as a predator.

#### ABIOTIC FACTORS

*You provide solar energy, water, and nutrients. Your job is to distribute the building blocks of growth to the ecosystem's species.*

Start with 300 pennies.

#### Interactions

PRIMARY PRODUCER: Give 4 pennies.

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## 2.1 Energy, organisms, and eating | Role play

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### Instructions

Read your assigned character profile and determine which other species you interact with, either as a source of energy or as a predator.

#### CORDGRASS

*You are a primary producer. You transform solar energy into chemical energy through photosynthesis. Your seeds are spread by wind and water, so you do not need to be visited by pollinators in order to reproduce.*

Start with 2 pennies.

Survive round with 4+ pennies.

Die during round by losing all pennies.

#### Interactions

ABIOTIC FACTORS: Take 4 pennies.

PRIMARY CONSUMER: Give 2 pennies.

SECONDARY CONSUMER: Give 4 pennies.

## 2.1 Energy, organisms, and eating | Role play

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### Instructions

Read your assigned character profile and determine which other species you interact with, either as a source of energy or as a predator.

#### SEASIDE GOLDENROD

*You are a primary producer. You transform solar energy into chemical energy through photosynthesis. You are also a flowering plant, so you need to be visited by pollinators in order to reproduce.*

Start with 2 pennies, 3 pollen tickets.

Survive round with 4+ pennies and 2 pollen tickets.

Die during round by losing all pennies.

#### Interactions

ABIOTIC FACTORS: Take 4 pennies.

POLLINATOR: Give 2 pennies, exchange one ticket.

PRIMARY CONSUMER: Give 2 pennies.

SECONDARY CONSUMER: Give 4 pennies.

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## 2.1 Energy, organisms, and eating | Role play

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### Instructions

Read your assigned character profile and determine which other species you interact with, either as a source of energy or as a predator.

#### MONARCH BUTTERFLY

*You are a primary consumer. You obtain energy from primary producers. You are also a pollinator, so you can carry pollen between flowering plants (Seaside Goldenrod) to help them to reproduce and survive.*

Start with 6 pennies, 0 pollen tickets.

Survive round with 12+ pennies.

Die during round by being eaten.

#### Interactions

CORDGRASS: Take 2 pennies.

GOLDENROD: Take 2 pennies, exchange one pollen ticket if available. (Only carry one ticket at a time.)

SECONDARY CONSUMER: Potential predation. Flip a penny. Heads means you are eaten. Give consumer 1/10 of your pennies and leave ecosystem.

## 2.1 Energy, organisms, and eating | Role play

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### Instructions

Read your assigned character profile and determine which other species you interact with, either as a source of energy or as a predator.

#### DIAMONDBACK TERRAPIN

*You are a secondary consumer. You are omnivorous: you can obtain energy from Primary Producers or Primary Consumers.*

Start with 10 pennies.

Survive round with 20+ pennies.

Die during round by being eaten.

#### Interactions

PRIMARY PRODUCERS: Take 4 pennies.

PRIMARY CONSUMER: Potential predation. If prey has more than 10 pennies, flip a coin. Heads means predation is successful. Take 1/10 of prey's pennies.

TERTIARY CONSUMER: Potential predation. If prey has more than 10 pennies, flip a coin. Heads means you are eaten. Give consumer 1/10 of your pennies and leave ecosystem.

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## 2.1 Energy, organisms, and eating | Role play

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### Instructions

Read your assigned character profile and determine which other species you interact with, either as a source of energy or as a predator.

#### GREAT EGRET

*You are a tertiary consumer. You are carnivorous, and obtain energy by preying on Primary Consumers (insects) or Secondary Consumers (sparrows and terrapin turtles). You are a predator: watch and wait.*

Start with 20 pennies.

Survive round with 30+ pennies.

#### Interactions

PRIMARY & SECONDARY CONSUMERS: Potential predation. If prey has more than 10 pennies, flip a coin. Heads means predation is successful. Take 1/10 of prey's pennies.

## 2.1 The carbon cycle, photosynthesis, and fuels | Research and report

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Under normal circumstances, the vast majority of the cellular matter produced through photosynthesis is digested or decomposed, its chemical energy transformed into heat or work by animal bodies. But in Earth's early history, during the Pennsylvanian and Carboniferous Periods, large amounts of this matter accumulated in swamps and laid undisturbed for millions of years. Under conditions of intense pressure and heat, this matter transformed into the coal, oil, and gas that humans now describe as "fossil fuels." When fossil fuels are burned to provide power to machines, the ensuing chemical reaction is a mirror of that which occurs during digestion and decomposition – but its impact on the environment is much different.

### Instructions

Read and analyze the linked resource to formulate answers to the following questions:

**What is the carbon cycle? What is the chemical process of photosynthesis? What is the process of cellular respiration? What is the process of organic decay? What is the process of combustion?**

**How are hydrocarbons a part of the carbon cycle? What is the effect of fossil fuel combustion on this?**

**What does it mean to say that the carbon cycle is "fast" or "slow"?**

Then, use the Internet to research answers to the following questions:

**How does the chemical energy and combustion of fossil fuels relate to their origin as ancient photoautotrophs?**

**How are biofuels made from corn (ethanol) or algae similar to fossil fuels? How are they different?**

**What about these fuels makes them "sustainable"? In what ways are they "unsustainable"? What evidence and sources can back up these claims?**

### Source

NASA Earth Observatory | The Carbon Cycle

<https://earthobservatory.nasa.gov/features/CarbonCycle>

## 2.2 Ecosystem detectives | Investigation

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### Scenario

Citizen scientists have come to the New York State Department of Environmental Protection (DEP), with an alarming problem: In the last two years, their annual survey of Atlantic Blue Crabs in the Great South Bay has revealed a rapidly declining population. They fear that the crabs, a keystone species in the salt marsh ecosystem, are in danger of vanishing entirely.

Last week, the DEP called a meeting to try to get to the bottom of the matter. In attendance were councilors from the nearest town, Massapequa; representatives from the Long Island Blue Crab Fisheries Association; state fishery oversight officials; and the citizen scientists, who presented their findings. The meeting was inconclusive. State officials suggested that overfishing of crabs might have been to blame. Fisheries Association representatives argued that that was not the case, and that hard clams—a key source of food for the crabs—were being overfished instead. Or maybe the nearby town was responsible—Massapequa’s septic tanks have been known to overflow during storms. The councilors from Massapequa were offended at this suggestion. They argued that if pollution was to blame, the real culprit would be the cluster of auto body shops in the adjacent town, Amityville. The citizen scientists wondered if climate change might be to blame or if pesticides from nearby farms could be poisoning the water.

You are a group of investigators with the DEP. You must determine who is responsible for the declining population of Atlantic Blue Crabs. After the meeting, you collected what data you could from other citizen science efforts and government monitoring services about the conditions in the salt marsh, as well as a survey of the recent relevant research. You may draw a conclusion based on the data you have, or you have the option of running tests on water samples from three different sites around the marsh. (If you decide you want to “run tests,” just ask your teacher to give you the results.) If you determine that you do not have enough information to determine responsibility, instead determine what new data must be collected and propose a study design to obtain those results.

### Instructions

Review the resources in the data bank and discuss.

**Interpret each data set and abstract. What do they tell you, and what don’t they tell?**

**How do these different species and conditions relate to one another in the salt marsh? How are they vulnerable? What could be affecting each species?**

**Try diagramming a map of interdependence between species.**

**What do you hypothesize could be happening in the ecosystem, based on each data set?**

**Do any of the other data support or contradict these hypotheses?**

**Do you want to run tests on the sediment and water at these sites?**



## Blue Crab census

Surveyed annually, August 5

Year	Adult #	Juvenile #	Adult Avg. Length (mm)	Juvenile Avg. Length (mm)
2016	810	540	135	35
2017	872	563	131	34
2018	908	592	136	30
2019	760	350	128	34
2020	510	231	130	33

## Hard Clam census

Surveyed annually, July 25

Year	Number	Avg. Length (mm)
2016	1024	41
2017	996	36
2018	970	33
2019	902	26
2020	880	20

## Eelgrass census

Surveyed annually, August 1

Year	Acres
2016	2475
2017	2440
2018	2400
2019	2290
2020	2200

## Monarch Butterfly census

Surveyed annually, June 25

Year	Sightings per hour (10-week average)
2016	1024
2017	996
2018	970
2019	902
2020	880

## Town of Massapequa, NY

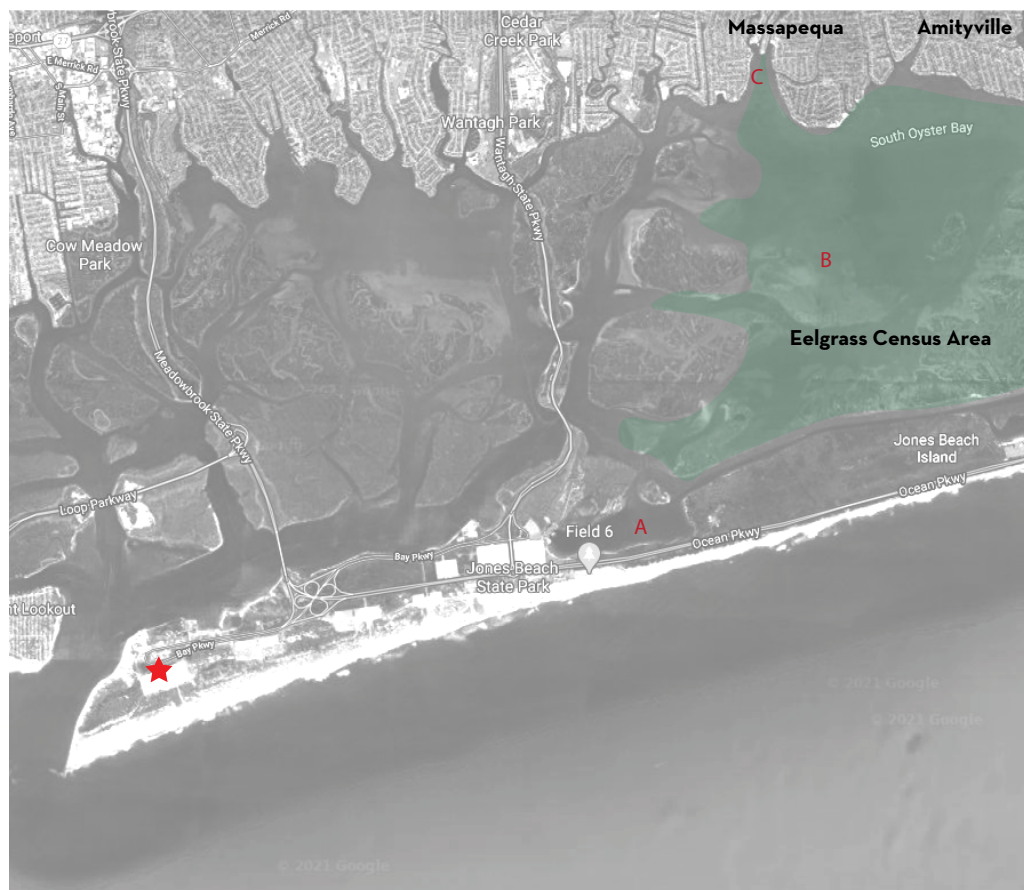
Year	Population
2016	21,702
2017	21,759
2018	21,861
2019	22,012
2020	23,120

## Local temperature, seasonal averages

Degrees Fahrenheit

Year	Fall	Winter	Spring	Summer
1981-2010 avg.	55	33.5	49.1	71
2015-2016	59	39.1	51.3	74.4
2016-2017	58	36.9	49.8	72.2
2017-2018	58.7	34.3	48.8	73.5
2018-2019	56.5	34.5	50.1	73.8
2019-2020	55.6	37.5	49.8	74.6

## Eelgrass census area



## **Recent research**

### **ABSTRACT 1: “Seagrasses in Crisis”**

Seagrasses are marine flowering plants that have been in existence for a very long time, but are threatened by anthropogenic environmental changes due to pressure from coastal human settlements. Seagrasses fix carbon, cycle nutrients, stabilize sediment, and provide habitat to numerous species. They are also early indicators of human impacts on coastal ecosystems. Throughout the world, large swaths of seagrass meadows have been lost as sediment and nutrient runoff, invasive species, development, commercial overfishing and overgrazing, algal blooms, and global warming infringe on these key ecosystems. The paper recommends a “targeted global conservation effort” to reduce nutrient and sediment runoff within coastal watersheds, along with educational programming to raise awareness about the importance of seagrasses.

### **ABSTRACT 2: “Hypoxia and acidification synergistically suppress growth, survival, and metamorphosis of marine bivalves.”**

Areas of low oxygen in coastal and open ocean ecosystems have grown in recent decades, and will continue to expand as the global climate warms. These low oxygen regions in the ocean are also acidified, containing larger quantities of carbon dioxide; as atmospheric carbon concentration increases, this condition intensifies. But little is known about how these dovetailing conditions affect sea life. This paper investigated the consequences of hypoxic (low oxygen) and acidified (high carbon) water on the development of young bivalves, including bay scallops, *Argopecten irradians*, and hard clams, *Mercenaria mercenaria*. For bay scallops, acidification reduced the survival of larvae, hypoxia suppressed growth and metamorphosis, both by more than 50 percent; when the stressors were combined, these negative impacts were amplified. For hard clams, hypoxia increased the larval mortality rate and acidification reduced growth, by more than 30 and 60 percent respectively. Clams that were exposed to only one stressor in their infancy showed resistance in later life stages, but clams that were exposed to both saw significantly increased mortality rates.

### **ABSTRACT 3: “No effect of acidification on the development of juvenile blue crabs”**

Exoskeletons, essential for the survival of marine invertebrates, are developed through a biomineralization process that could be impacted by increases in temperature and carbon dioxide concentration in ocean waters due to global climate change. This paper investigated the impact of increased water temperature and acidification on the development of exoskeletons among juvenile blue crab, *Callinectes Sapidus*, in the Chesapeake Bay. Light microscopy was used to measure thickness, and light spectrometry was used to measure the concentration of magnesium and calcium in the carapace. Increased temperature reduced the growth of the exoskeleton by 8.5 percent and reduced the mineral concentration by 2 percent. Increased acidification, however, increased the mineral concentration, suggesting a counteraction between temperature and carbon dioxide increases in water. Juvenile blue crabs exposed to higher temperatures and acidity may demonstrate a slight tradeoff between size and mineral concentration in the development of the exoskeleton.

#### **ABSTRACT 4: “Seagrasses and eutrophication”**

This paper summarizes existing research that indicates cultural eutrophication—the introduction of excess nitrogen and other nutrients to aquatic habitats through runoff due to human activity like farming and sewage treatment—as a major cause of seagrass die-off. We review what is known about the physiological mechanisms that underlies the relationship between nutrient over-enrichment and seagrass loss, as well as the recovery of seagrass meadows following nutrient reductions. The most common mechanism underlying seagrass loss due to eutrophication is the limit of sunlight reaching below the surface of water in the presence of algal blooms and phytoplankton overgrowth. Seagrass declines appears to be driven by indirect and feedback mechanisms as well, which means that die-offs tend to be sudden rather than gradual. High salinity, high temperature, and low light conditions appear to exacerbate negative effects from eutrophication for certain species, and impacts on species of organisms that support seagrass ecosystems (“ecosystem engineers”) also influence seagrass reductions. There are few examples of seagrass ecosystems recovering from eutrophication after nutrient reductions.

#### **ABSTRACT 5: “Restoration of Seagrasses Recovers Coastal Ecosystem Services”**

This paper examines the success of one of the only large-scale attempts to reverse the degradation of seagrass ecosystems through active restoration. Over 70 million seeds of eelgrass, *Zostera marina*, have been distributed into coastal lagoons in the mid-Atlantic region, recovering more than 3600 hectares of seagrass which are now home to healthy animal communities. The eelgrass meadows also sequester carbon and nitrogen and have supported the recovery of local bay scallop (*Argopecten irradians*) populations.

#### **ABSTRACT 6: Literature review of studies of factors driving the decline of Eastern Migratory North American Monarch Butterflies**

Recent large-scale declines in population for migratory Monarch Butterflies (*Danaus plexippus*) may be attributable to a range of underlying factors. This paper identifies and classifies according to current and anticipated impact five potential categories of threat. These include: change in abiotic environmental conditions; deforestation of overwintering habitats; exposure to herbicides, and insecticides; destruction of breeding habitat; and increase in predation, parasitism, and pathogens specific to the species. The wide geographical range of migrating butterflies suggests that factors are likely to interact and negative effects are likely to reinforce one another. However, the existing literature suggests that the loss of habitat for overwintering and breeding have the greatest impact on population decline now and in the future.

## Water quality test results

Variable	Normal range	Test Site A	Test Site B	Test Site C
Atrazine*	0 - 0.003 ppm	0	0.0034	0.004
Neonicotinoids**	0 - 0.005 ppm	0	0.006	0.01
Benzene***	0 - 0.005 ppm	0	0.0055	0.0065
Lead	0 - 0.015 ppm	0	0.005	0.013
Nitrate (NO <sub>3</sub> )	1 - 10 ppm	12	15	18
Dissolved Oxygen	6 - 12 mg/L-1	7.3	3.2	5.6
Acidity (pH)	7.5 - 8.2	7.7	6	7.3
Salinity	0.5 - 18 ppt	12	10	6
Radon****	0 - 0.4 pCi/L	0.32	0.32	0.34
Temperature (°F)	46.4 (historical seasonal average)	44	48	47.1

\* Atrazine is an herbicide widely used to control broadleaf and grassy weeds.

\*\* Neonicotinoids are a new class of insecticides with widespread use in veterinary medicine and crop production.

\*\*\* Benzene is a clear, colorless, highly flammable and volatile, liquid aromatic hydrocarbon found in crude oils and as a by-product of oil-refining processes.

\*\*\*\* Radon is a radioactive gas that forms naturally when radioactive elements uranium, thorium, or radium break down in rocks, soil, and groundwater.

## 2.2 Two frameworks for interdependence | Read and respond

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Why should we value the health of an ecosystem? Do we evaluate the worth of an ecosystem based on how much it supports human life? Or is there something inherently worthwhile in the continued functioning of the complex and dynamic systems of life? These questions matter because they shape our decisions about which ecosystems to protect and what resources to devote to their protection. In the attached texts, two different authors propose two different ways of thinking about the value of ecosystems.

### Instructions

Write a reading response summarizing, comparing, and evaluating the viewpoints presented in the two attached texts. Consider:

**What is the “ecosystem goods and services” framework?**

**What is the “economy of abundance” framework?**

**What do you agree with or disagree with about each?**

**What are the strengths and weaknesses of each framework?**

**Which one feels more familiar?**

**Which one do you think is more valuable, and why?**

**What factors might contribute to either one being more common than the other in societal conversations about ecosystems and the environment?**

### Sources

Robin Wall Kimmerer, “The Serviceberry: An Economy of Abundance.” *Emergence Magazine*. Published online, Dec. 10, 2020. Excerpted and available in full online

[www.emergencemagazine.org/story/the-serviceberry/](http://www.emergencemagazine.org/story/the-serviceberry/)

Thomas C. Brown, John C. Bergstrom, John B. Loomis, “Defining, Valuing and Providing Ecosystem Goods and Services.” *Natural Resources Journal*. Brown, T. et al. “Defining, valuing and providing ecosystem goods and services.” Volume 47 (2007) Page 329-376. Excerpted and available in full online

[www.fs.fed.us/rm/value/docs/defining\\_valuing\\_providing\\_ecosystem\\_services.pdf](http://www.fs.fed.us/rm/value/docs/defining_valuing_providing_ecosystem_services.pdf)

Robin Wall Kimmerer, “The Serviceberry: An Economy of Abundance.” *Emergence Magazine*. Published online, Dec. 10, 2020.

THE COOL BREATH of evening slips off the wooded hills, displacing the heat of the day, and with it come the birds, as eager for the cool as I am. They arrive in a flock of calls that sound like laughter, and I have to laugh back with the same delight. They are all around me, Cedar Waxwings and Catbirds and a flash of Bluebird iridescence. I have never felt such a kinship to my namesake, Robin, as in this moment when we are both stuffing our mouths with berries and chortling with happiness. The bushes are laden with fat clusters of red, blue, and wine purple, in every stage of ripeness, so many you can pick them by the handful. I’m glad I have a pail and wonder if the birds will be able to fly with their bellies as full as mine.

This abundance of berries feels like a pure gift from the land. I have not earned, paid for, nor labored for them. There is no mathematics of worthiness that reckons I deserve them in any way. And yet here they are—along with the sun and the air and the birds and the rain, gathering in the towers of cumulonimbi. You could call them natural resources or ecosystem services, but the Robins and I know them as gifts. We both sing gratitude with our mouths full.

Part of my delight comes from their unexpected presence. The local native Serviceberries, *Amelanchier arborea*, have small, hard fruits, which tend toward dryness, and only once in a while is there a tree with sweet offerings. The bounty in my bucket is a western species—*A. alnifolium*, known as Saskatoons—planted by my farmer neighbor, and this is their first bearing year, which they do with an enthusiasm that matches my own.

Saskatoon, Juneberry, Shadbush, Shadblow, Sugarplum, Sarvis, Serviceberry—these are among the many names for *Amelanchier*. Ethnobotanists know that the more names a plant has, the greater its cultural importance. The tree is beloved for its fruits, for medicinal use, and for the early froth of flowers that whiten woodland edges at the first hint of spring. Serviceberry is known as a calendar plant, so faithful is it to seasonal weather patterns. Its bloom is a sign that the ground has thawed and that the shad are running upstream—or at least it was back in the day, when rivers were clear and free enough to support their spawning. The derivation of the name “Service” from its relative *Sorbus* (also in the Rose Family) notwithstanding, the plant does provide myriad goods and services. Not only to humans but to many other citizens. It is a preferred browse of Deer and Moose, a vital source of early pollen for newly emerging insects, and host to a suite of butterfly larvae—like Tiger Swallowtails, Viceroy, Admirals, and Hairstreaks—and berry-feasting birds who rely on those calories in breeding season.

In Potawatomi, it is called Bozakmin, which is a superlative: the best of the berries. I agree with my ancestors on the rightness of that name. Imagine a fruit that tastes like a Blueberry crossed with the satisfying heft of an Apple, a touch of rosewater and a miniscule crunch of almond-flavored seeds. They taste like nothing a grocery store has to offer: wild, complex with a chemistry that your body recognizes as the real food it’s been waiting for.

For me, the most important part of the word Bozakmin is “min,” the root for “berry.” It appears in our Potawatomi words for Blueberry, Strawberry, Raspberry, even Apple, Maize, and Wild Rice. The revelation in that word is a treasure for me, because it is also the root word for “gift.” In naming the plants who shower us with goodness, we recognize that these are gifts from our plant relatives, manifestations of their generosity, care, and creativity. When we speak of these not as things or products or commodities, but as gifts, the whole relationship changes. I can’t help but gaze at them, cupped like jewels in my hand, and breathe out my gratitude.

In the presence of such gifts, gratitude is the intuitive first response. The gratitude flows toward our plant elders and radiates to the rain, to the sunshine, to the improbability of bushes spangled with morsels of sweetness in a world that can be bitter.

Gratitude is so much more than a polite thank you. It is the thread that connects us in a deep relationship, simultaneously physical and spiritual, as our bodies are fed and spirits nourished by the sense of belonging, which is the most vital of foods. Gratitude creates a sense of abundance, the knowing that you have what you need. In that climate of sufficiency, our hunger for more abates and we take only what we need, in respect for the generosity of the giver.

If our first response is gratitude, then our second is reciprocity: to give a gift in return. What could I give these plants in return for their generosity? It could be a direct response, like weeding or water or a song of thanks that sends appreciation out on the wind. Or indirect, like donating to my local land trust so that more habitat for the gift givers will be saved, or making art that invites others into the web of reciprocity.

Gratitude and reciprocity are the currency of a gift economy, and they have the remarkable property of multiplying with every exchange, their energy concentrating as they pass from hand to hand, a truly renewable resource. I accept the gift from the bush and then spread that gift with a dish of berries to my neighbor, who makes a pie to share with his friend, who feels so wealthy in food and friendship that he volunteers at the food pantry. You know how it goes.

To name the world as gift is to feel one's membership in the web of reciprocity. It makes you happy—and it makes you accountable. Conceiving of something as a gift changes your relationship to it in a profound way, even though the physical makeup of the “thing” has not changed. [...] A wooly knit hat that you purchase at the store will keep you warm regardless of its origin, but if it was hand knit by your favorite auntie, then you are in relationship to that “thing” in a very different way: you are responsible for it, and your gratitude has motive force in the world. You're likely to take much better care of the gift hat than the commodity hat, because it is knit of relationships. This is the power of gift thinking. I imagine if we acknowledged that everything we consume is the gift of Mother Earth, we would take better care of what we are given. Mistreating a gift has emotional and ethical gravity as well as ecological resonance.

How we think ripples out to how we behave. If we view these berries, or that coal or forest, as an object, as property, it can be exploited as a commodity in a market economy. We know the consequences of that.

Why then have we permitted the dominance of economic systems that commoditize everything? That create scarcity instead of abundance, that promote accumulation rather than sharing? We've surrendered our values to an economic system that actively harms what we love. I'm wondering how we fix that. And I'm not alone.

Because I'm a botanist, my fluency in the lexicon of berries may not easily extend to economics, so I wanted to revisit the conventional meaning of economics to compare it to my understanding of the gift economy of nature. What is economics for anyway? It turns out that answer depends a lot on who you ask. On their website, the American Economic Association says, “It's the study of scarcity, the study of how people use resources and respond to incentives.” My son-in-law teaches high school economics, and the first principle his students learn is that economics is about decision-making in the face of scarcity. Anything and everything in a market is implicitly defined as scarce. With scarcity as the main principle, the mindset that follows is based on commodification of goods and services.



I'm way past high school, but I'm not sure I grasp that thinking, so I fill a bowl with fresh Serviceberries for my friend and colleague, Dr. Valerie Luzadis. She is an appreciator of earthly gifts and a professor and past president of the US Society for Ecological Economics. Ecological economics is a growing economic theory that expands the conventional definition by working to integrate Earth's natural systems and human values. But it has not been standard practice to include these foundational elements—they are usually left out of the equation. Valerie prefers the definition that “economics is how we organize ourselves to sustain life and enhance its quality. It's a way of considering how we provide for ourselves.”

The words ecology and economy come from the same root, the Greek *oikos*, meaning “home” or “household”: i.e., the systems of relationship, the goods and services that keep us alive. The system of market economies that we're given as a default is hardly the only model out there. Anthropologists have observed and shared multiple cultural frameworks, colored by very different worldviews on “how we provide for ourselves,” including gift economies.

As the berries plunk into my bucket, I'm thinking about what I'll do with them all. I'll drop some off for friends and neighbors, and I'll certainly fill the freezer for Juneberry muffins in February. This “problem” of managing decisions about abundance reminds me of a report that linguist Daniel Everett wrote as he was learning from a hunter-gatherer community in the Brazilian rainforest. A hunter had brought home a sizable kill, far too much to be eaten by his family. The researcher asked how he would store the excess. Smoking and drying technologies were well known; storing was possible. The hunter was puzzled by the question—store the meat? Why would he do that? Instead, he sent out an invitation to a feast, and soon the neighboring families were gathered around his fire, until every last morsel was consumed. This seemed like maladaptive behavior to the anthropologist, who asked again: given the uncertainty of meat in the forest, why didn't he store the meat for himself, which is what the economic system of his home culture would predict.

“Store my meat? I store my meat in the belly of my brother,” replied the hunter.

I feel a great debt to this unnamed teacher for these words. There beats the heart of gift economies, an antecedent alternative to market economies, another way of “organizing ourselves to sustain life.” In a gift economy, wealth is understood as having enough to share, and the practice for dealing with abundance is to give it away. In fact, status is determined not by how much one accumulates, but by how much one gives away. The currency in a gift economy is relationship, which is expressed as gratitude, as interdependence and the ongoing cycles of reciprocity. A gift economy nurtures the community bonds which enhance mutual well-being; the economic unit is “we” rather than “I,” as all flourishing is mutual.

Anthropologists characterize gift economies as systems of exchange in which goods and services circulate without explicit expectations of direct compensation. Those who have give to those who don't, so that everyone in the system has what they need. It is not regulated from above, but derives from a collective sense of equity and accountability in response to the gifts of the Earth.

In his book *Sacred Economics*, Charles Eisenstein states: “Gifts cement the mystical realization of participation in something greater than oneself which, yet, is not separate from oneself. The axioms of rational self-interest change because the self has expanded to include something of the other.” If the community is flourishing, then all within it will partake of the same abundance—or shortage—that nature provides.

The currency of exchange is gratitude and relationship rather than money. It includes a system of social and moral agreements for indirect reciprocity. So, the hunter who shared the feast with you could well anticipate that you would share from a full fishnet or offer your labor in repairing a boat.

The natural world itself is understood as a gift and not as private property, as such there are ethical constraints on the accumulation of abundance that is not yours. Well known examples of gift economies include potlatches or the Kula ring cycle, in which gifts circulate in the group, solidifying bonds of relationship and redistributing wealth.

The question of abundance highlights the striking difference between the market economies which have come to dominate the globe and the ancient gift economies which preceded them. There are many examples of functioning gift economies—most in small societies of close relations, where community well-being is recognized as the “unit” of success—where the interest of “we” exceeds that of “I.” In this time when the economies have grown so large and impersonal that they extinguish rather than nurture community well-being, perhaps we should consider other ways to organize the exchange of goods and services which constitute an economy.

In a market economy, where the underlying principles are scarcity and maximizing return on investment, the meat is private property, accumulated for the well-being of the hunter or exchanged for currency. The greatest status and success comes from possession. Food security is assured by private accumulation.

In contrast, gift economies arise from the abundance of gifts from the Earth, which are owned by no one and therefore shared. Sharing engenders relationships of good will and bonds that ensure you will be invited to the feast when your neighbor is fortunate. Security is ensured by the nurturing of bonds of reciprocity. You can store meat in your own pantry or in the belly of your brother. Both have the result of keeping hunger at bay but with very different consequences for the people and for the land which provided that sustenance.

I haven't studied economics in decades, but as a plant ecologist, I've spent a lifetime asking the plants for their guidance on any number of issues; so I wondered what the Serviceberries had to say about the systems which create and distribute goods and services. What is their economic system? How do they respond to the issues of abundance and scarcity? Has their evolutionary process shaped them to be hoarders or sharers?

Let's ask the Saskatoons. These ten-foot-tall trees are the producers in this economy. Using the free raw materials of light, water, and air, they transmute these gifts into leaves and flowers and fruits. They store some energy as sugars in the making of their own bodies, but much of it is shared. Some of the abundance of spring rain and sun manifests in the form of flowers, which offer a feast for insects when it's cold and rainy. The insects return the favor by carrying pollen. Food is rarely in short supply for Saskatoons, but mobility is rare. Movement is a gift of the pollinators, but the energy needed to support buzzing around is scarce. So they create a relationship of exchange that benefits both.

In summer, when the boughs are laden, Serviceberry produces an abundance of sugar. Does it hoard that energy for itself? No, it invites the birds to a feast. Come my relatives, fill your bellies, say the Serviceberries. Are they not storing their meat in the bellies of their brothers and sisters—the Jays, the Thrashers, and the Robins?

Isn't this an economy? A system of distribution of goods and services that meets the needs of the community? The currency of this economic system is energy, which flows through it, and materials, which cycle among the producers and the consumers. It is a system for redistribution of wealth, an exchange of goods and services. Each member has an abundance of something, which they offer to others. The abundance of berries goes to the birds—for, what use does the tree have of berries other than as a way to make relationships with birds?

Eating too many berries has the same effect on birds as it does on people. Fuchsia splats decorate the fence posts. This of course is the whole point of berries—to make themselves so irresistible and plentiful that birds will come and feast, as we are doing this evening, and then distribute the seeds far and wide. Feasting has another benefit. Passage through a bird gut scarifies the seeds to stimulate germination. The birds provide services to the Serviceberries, who provide for them in return. The relationships created by the gift weave myriad relations between insects and microbes and root systems. The gift is multiplied with every giving, until it returns so rich and sweet that it burbles forth as the birdsong that wakes me in the morning. If the abundance had been hoarded, if Juneberries acted solely for their own benefit, the forest would be diminished.

Charles Eisenstein expresses that we have created a grotesque economy that grinds what is beautiful and unique into money, a currency that enables us to purchase things we don't really need while destroying what we do.

I think that the Serviceberries show us another model, one based upon reciprocity rather than accumulation, where wealth and security come from the quality of your relationships, not from the illusion of self-sufficiency. Without gift relationships with bees and birds, Serviceberries would disappear from the planet. Even if they hoarded abundance, perching atop the wealth ladder, they would not save themselves from the fate of extinction if their partners did not share in that abundance. Hoarding won't save us either. All flourishing is mutual.

As I watch the Robins and Cedar Waxwings fill their bellies, I see a gift economy in which abundance is stored “in the belly of my brother.” Supporting a thriving bird community is essential to the well-being of the Serviceberry and everyone else up the food chain. That seems especially important to an immobile, long-lived being like a tree, who can't run away from ruptured relationships. Thriving is possible only if you have nurtured strong bonds with your community.

Thomas C. Brown, John C. Bergstrom, John B. Loomis, “Defining, Valuing and Providing Ecosystem Goods and Services.” *Natural Resources Journal*. Brown, T. et al. “Defining, valuing and providing ecosystem goods and services.” Volume 47 (2007) Page 329-376. Excerpted and available in full online

## ABSTRACT

*Ecosystem services are the specific results of ecosystem processes that either directly sustain or enhance human life (as does natural protection from the sun’s harmful ultraviolet rays) or maintain the quality of ecosystem goods (as water purification maintains the quality of streamflow). “Ecosystem service” has come to represent several related topics ranging from the measurement to the marketing of ecosystem serviceflows. In this article we examine several of these topics by first clarifying the meaning of “ecosystem service” and then (1) placing ecosystem goods and services within an economic framework, emphasizing the role and limitations of substitutes; (2) summarizing the methods for valuation of ecosystem goods and services; and (3) reviewing the various approaches for their provision and financing.*

*Many ecosystem services and some ecosystem goods are received without monetary payment. The “marketing” of ecosystem goods and services is basically an effort to turn such recipients- –those who benefit without ownership – into buyers, thereby providing market signals that serve to help protect valuable goods and services. We review various formal arrangements for making this happen.*

“Ecosystem service” is the latest environmental buzzword. It appeals to ecologists, who have long recognized the many benefits derived from well-functioning ecosystems. It appeals to resource economists, who endeavor to measure the value to humans of natural resources. And it appeals to a host of others- public land managers and many private landholders included-who see opportunities for a more efficient and effective provision of basic environmental service flows. With all of this interest, “ecosystem service” has quickly come to represent several related topics, four of which are (1) the measurement of ecosystem service flows and the processes underlying those flows, (2) understanding the effect of those flows on human well-being, (3) valuation of the services, and (4) provision of the services. Despite the breadth of purview, “ecosystem service” brings a unique perspective to environmental dialog, one aimed at using economic tools to improve opportunities for reaching efficient levels of environmental protection.

Our purpose with this article is to summarize and bring some clarity to discussions of ecosystem services. We begin by explaining what “ecosystem service” means and how it fits within an economic context, emphasizing the fundamental contribution of ecosystem goods and services to human wellbeing, but also noting the importance of substitutes in considering the benefits and costs of protecting ecosystems. Next we review valuation of ecosystem goods and services. We then discuss provision and financing, focusing on the conditions that facilitate market exchange and on the various mechanisms that are now used to provide and protect ecosystem goods and services.

Ecologist Gretchen Daily offered the following answer to this question:

Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. They maintain biodiversity and the production of ecosystem goods, such as seafood, forage, timber, biomass fuels, natural fiber, and many pharmaceuticals, industrial products, and their precursors....In addition to the production of goods, ecosystem services are the actual life-support functions, such as cleansing, recycling, and renewal, and they confer many intangible aesthetic and cultural benefits as well.

Daily's definition makes an important distinction, between ecosystem services and ecosystem goods. Ecosystems goods are the generally tangible, material products that result from ecosystem processes, whereas ecosystem services are in most cases improvements in the condition or location of things of value. Daily explains that ecosystem services are generated by a "complex of natural cycles," from large-scale biogeochemical cycles, such as the movement of carbon through the living and physical environment, to the very small-scale life cycles of microorganisms.

[...]

Daily's definition makes another key point about ecosystem services: they "sustain and fulfill human life." The emphasis here is squarely on human well-being and is thus in keeping with an economic perspective. Some might say that such an anthropocentric focus is too limiting-that it devalues the importance of ecosystem structure and processes to species other than humans, or that it runs the risk of ignoring ecosystem processes that contribute to human welfare but are not yet recognized as doing so. Clearly a focus on ecosystem services may turn out, through hubris or ignorance, to have been shortsighted, but, on the other hand, this focus is a vast improvement over business as usual and provides an opening for even greater consideration of ecosystem processes as our understanding of the natural world improves.

[...]

### **Table 1. Ecosystem Goods & Services**

#### **Ecosystem goods**

Nonrenewable

Rocks and minerals

Fossil fuels

Renewable

Wildlife and fish (food, furs, viewing)

Plants (food, fiber, fuel, medicinal herbs)

Water

Air

Soils

Recreation, aesthetic (e.g., landscape beauty), and educational opportunities

#### **Ecosystem services**

Purification of air and water (detoxification and decomposition of wastes)

Translocation of nutrients

Maintenance and renewal of soil and soil fertility

Pollination of crops and natural vegetation

Dispersal of seeds

Maintenance of regional precipitation patterns  
Erosion control  
Maintenance of habitats for plants and animals  
Control of pests affecting plants or animals (including humans)  
Protection from the sun's harmful UV rays  
Partial stabilization of climate  
Moderation of temperature extremes and the force of winds and waves  
Mitigation of floods and droughts

[...]

From an economic perspective, things are of value if they are of utility to humans. Among the basic factors of production, ecosystem goods and services are unique in that they may be of either direct utility or indirect utility as they contribute to the production of produced goods and services that are in turn of direct utility. Ecosystem goods and services that are of direct utility include, for example, the air we breathe, natural temperatures, UV protection, and a landscape view. As seen above, all produced goods and services require some inputs of ecosystem goods and services.

[..]

The relative quantities of ecosystem goods and services, labor, and built capital that are required to produce a good or service are to some extent substitutable. To take farming as an example, a farmer may substitute capital (in the form of tractors and combines) for labor. Many ecosystem goods and services have similar substitutes in the form of built capital and produced goods and services. For example, considering ecosystem goods, mushrooms may be cultivated, and fir or pine timber for wooden studs may be replaced with iron manufactured into metal studs. Or, considering ecosystem services, the waste assimilation properties of natural watersheds can be replaced with a waste treatment plant (a form of built capital), and natural pest control can be replaced by pesticides. Of course, all of these produced substitutes require inputs including other ecosystem goods or services, but this does not negate the fact that substitutes generally exist

It is the nature of economic and population growth that some ecosystem goods and services become depleted and that humans use their technological prowess along with inputs including more plentiful ecosystem goods and services to produce new built capital and goods that compensate for such depletion. Of particular interest is whether the cost of producing substitutes for ecosystem goods and services exceeds the opportunity cost of protecting the original ecosystem goods and services. For example, healthy watersheds control the amount of sediment that enters stream drainage networks during precipitation events and perform natural waste assimilation, keeping costs low for downstream water treatment and delivery. The recent focus on ecosystem services has been in large part an effort to bring attention to the economic importance of natural ecosystems and to the fact that when ecosystems are degraded replacement of lost services, if possible, is often only feasible with more costly substitute investments of human and built capital and other ecosystem goods and services.

[...]

A further point, important when the benefits of environmental protection are being considered, is that ecosystems typically produce multiple ecosystem goods and services, many of which may be harmed if the ecosystem is degraded. For example, healthy watersheds not only protect water quality but also maintain aquatic habitats that are critical for fish and other organisms and for recreation. The degradation of a natural ecosystem may lead to a whole list of required replacements.

[...]

It is legitimate to ask, why bother to estimate the economic value of ecosystem goods and services? Surely it cannot be done perfectly, and even if it could, doesn't reducing the value of ecosystem goods and services to a monetary metric somehow downplay their real or full values? The answer to these questions is that decisions are commonly made about whether to protect or degrade ecosystem goods and services, and those decisions are more likely to be made in the best interests of the relevant publics if decision makers have comparable information about what is gained and what is lost if a certain policy option is chosen. Monetary estimates of the values of ecosystem goods or services, even if inexact, may be far better than a complete lack of such estimates, especially if the direction of the error in estimation — whether the value estimate is taken to be a lower bound or an upper bound of the actual value, for example- is known.

[...]

Many ecosystem services and some ecosystem goods are commonly received for free. For example, water users downstream of a forested area receive for free the water quality protection afforded by the forest, and farmers receive for free the waste assimilation provided by the stream into which their agricultural wastes drain. The marketing of ecosystem goods and services is basically an effort to turn such recipients - those who benefit without ownership-into buyers.<sup>41</sup> Some formal arrangement, like purchase, is needed to make this happen. Typically the sellers are landowners where the good or service originates or the public via its environmental laws.[...]

In the first case, we may want to protect an ecosystem good or service that is under the control of another party. For example, we may want to continue to enjoy the view of a local forest or have access to clean streamflow (which, let us imagine, would require averting the sediment produced by an upstream rancher who is letting his cattle graze along the stream). To assure the desired ecosystem protection in such situations, we have two basic options: buy the land or, less expensively, arrange to pay only for the ecosystem good or service we wish to enjoy (or for the management change needed to protect the good or service). Various arrangements are possible, including conservation easements and direct payments for an agreed management change. In the second case, individuals or firms who are enjoying access to the environment as a sink for their waste products may be forced to pay for that privilege if environmental laws restrict the right to pollute. Economic mechanisms include a cap-and-trade scheme and a direct pollution tax or other charge. In both of these cases the payments internalize externalities. In the former, beneficiaries of a positive externality begin paying for the benefit; in the latter, entities causing negative externalities begin paying for the harm they cause.

By internalizing externalities, payment provides signals that encourage behavior more accurately reflecting the full value of the resources at issue, thereby helping to ensure continued enjoyment of the ecosystem good or service.

## 2.3 Salt marshes near and far | Investigation

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### Instructions

Use the UN Environmental Program – World Conservation Monitoring Center’s Ocean Data Viewer to explore the distribution of salt marsh ecosystems across the globe. Consider:

**What do you notice about how this ecosystem is distributed?**

**Are there similarities?**

**What does the distribution suggest about the terrain and climate conditions of these ecosystems?**

Pick one salt marsh to focus on. Zoom in so you can see the details of the shoreline but still have a good density of marsh in view. Use Google Earth and Google Maps to navigate to your chosen marsh. Zoom in to the same scale.

**What do you notice?**

**What human developments are nearby? What other kinds of terrain do you notice nearby?**

Use Earth: An animated map of global wind and weather to collect climate information about both your chosen marsh and the marsh on the northern side of Jones Beach Island.

Gather the following data points. Gather data for the current date; 3 months, 6 months, and 9 months ago; and the same dates over the last five years.

**Temperature (Temp)**

**Wind Speed (Wind)**

**Relative humidity (RH)**

**Total 3-hour precipitation accumulation (3HPA)**

**Total cloud water (cloud cover) (TCW)**

**Air current direction**

**Ocean current direction**

Using the Global Biodiversity Information Facility, navigate to and zoom in on the same marsh area. Explore the species occurrences listed in the marsh.

Try to find species that occupy the same niche in the ecosystem that the species below occupy in the Jones Beach Island salt marsh:

**Great Egret (*Ardea alba*)**

**Saltmarsh Sparrow (*Ammospiza caudacuta*)**



**Monarch Butterfly** (*Danaus plexippus*)

**Eastern Mudsail** (*Ilyanassa obsoleta*)

**Hard Clam** (*Mercenaria mercenaria*)

Record both the common and Latin names of the species you find, if available.

Then, use Encyclopedia of Life to investigate these species further.

### **Where else can they be found?**

Use Google search and Google Scholar to investigate these species. (Try searching the organism's Latin name.)

**Is there any other information about their breeding, migration, or feeding habits would make them vulnerable to human impacts?**

**How are changing climate conditions likely to affect this species?**

If there is sufficient class time, repeat the investigative process for another marsh system. Once you've gathered your data, discuss these questions as a group:

**What is similar or different about the climate of the marsh(es) you investigated and that of the Jones Beach Island marsh?**

**What differences do you see between the species that populate these different ecosystems?**

**How do you think energy shapes these different ecosystems by determining climate conditions?**

**How do you expect that accelerated, anthropogenic climate change will impact these ecosystems?**

### **Sources**

UN Environmental Program - World Conservation Monitoring Center's Ocean Data Viewer

<https://data.unep-wcmc.org/>

Google Earth

<https://earth.google.com>

Google Maps

<https://maps.google.com>

Global Biodiversity Information Facility

<https://www.gbif.org/>

Encyclopedia of Life

<https://eol.org/>

Earth: An animated map of global wind and weather

<https://earth.nullschool.net/>

Note: Air and ocean current direction data is measured and reported in real time, but other data is drawn from global modeling systems, i.e., it is forecasted rather than measured.

More information about these resources can be found here:

<https://cleanet.org/resources/47829.html>

## 2.3 Invasive species, adaptation, and change | Research and report

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Ecosystems can become destabilized when “native” species – those that have originated in and adapted to a given habitat, with its distinctive climate conditions and terrain – are overtaken by invasive, nonnative species. *Phragmites australis* is a prime example of an invasive, nonnative species that has thrived in the tidal marshes of Long Island and the surrounding region in recent decades, at the expense of native species. But recent research has complicated the picture of *Phragmites* as an ecosystem villain, suggesting that *Phragmites* may be better suited to emerging climate conditions and better able to reduce the amount of carbon dioxide in the air, potentially limiting the effects of climate change. In this research activity, you must investigate *Phragmites australis* as a case study in nonnative species in a changing global climate system.

### Instructions

Use the Internet to research *Phragmites australis*. Focus on the following questions:

**What kind of plant is *Phragmites australis*? Where did it come from and how did it come to be in North America?**

**Why is *Phragmites australis* considered invasive? How does it spread and why is it hard to eradicate? What human impacts make marshes vulnerable to take-over by *Phragmites australis*?**

**What are the impacts of *Phragmites australis* on native marsh grass species? What are its impacts on other marsh species including fish, birds, and mollusks? Why is the spread of *Phragmites australis* a problem?**

Then, read and analyze the attached scientific abstracts. The abstracts are written in technical, scientific language. It is not essential to understand every word. Focus on the following questions, and use the Internet to supplement with additional research as needed:

**What question do the paper’s authors set out to investigate? What is their method for investigating the question? What are their findings?**

**In what way is *Phragmites australis* well-adapted to the changing climate? Why is this significant?**

**What is “blue carbon”? How do nonnative marsh grasses including *Phragmites australis* strengthen the ability of coastal vegetated habitats to sequester atmospheric carbon?**

**In what way is the story of *Phragmites australis* an example of how energy shapes the ecosystem?**

## Sources

Davidson, IC, Cott, GM, Devaney, JL, Simkanin, C. “Differential effects of biological invasions on coastal blue carbon: A global review and meta-analysis.” *Global Change Biology* 24: 5218– 5230. (2018). <https://doi.org/10.1111/gcb.14426>

### ABSTRACT

Human-caused shifts in carbon (C) cycling and biotic exchange are defining characteristics of the Anthropocene. In marine systems, saltmarsh, seagrass, and mangrove habitats—collectively known as “blue carbon” and coastal vegetated habitats (CVHs)—are a leading sequester of global C and increasingly impacted by exotic species invasions. There is growing interest in the effect of invasion by a diverse pool of exotic species on C storage and the implications for ecosystem-based management of these systems. In a global meta-analysis, we synthesized data from 104 papers that provided 345 comparisons of habitat-level response (plant and soil C storage) from paired invaded and uninvaded sites. We found an overall net effect of significantly higher C pools in invaded CVHs amounting to 40% (95% CI) higher C storage than uninvaded habitat, but effects differed among types of invaders. Elevated C storage was driven by blue C-forming plant invaders (saltmarsh grasses, seagrasses, and mangrove trees) that intensify biomass per unit area, extend and elevate coastal wetlands, and convert coastal mudflats into C-rich vegetated habitat. Introduced animal and structurally distinct primary producers had significant negative effects on C pools, driven by herbivory, trampling, and native species displacement. The role of invasion manifested differently among habitat types, with significant C storage increases in saltmarshes, decreases in seagrass, and no significant effect in mangroves. There were also counter-directional effects by the same species in different systems or locations, which underscores the importance of combining data mining with analyses of mean effect sizes in meta-analyses. Our study provides a quantitative basis for understanding differential effects of invasion on blue C habitats and will inform conservation strategies that need to balance management decisions involving invasion, C storage, and a range of other marine biodiversity and habitat functions in these coastal systems.

Mozdzer TJ, Megonigal JP. “Jack-and-Master Trait Responses to Elevated CO<sub>2</sub> and N: A Comparison of Native and Introduced *Phragmites australis*.” *PLOS ONE* 7(10): e42794 (2012). <https://doi.org/10.1371/journal.pone.0042794>

### ABSTRACT

Global change is predicted to promote plant invasions world-wide, reducing biodiversity and ecosystem function. Phenotypic plasticity may influence the ability of introduced plant species to invade and dominate extant communities. However, interpreting differences in plasticity can be confounded by phylogenetic differences in morphology and physiology. Here we present a novel case investigating the role of fitness trait values and phenotypic plasticity to global change factors between conspecific lineages of *Phragmites australis*. We hypothesized that due to observed differences in the competitive success of North American-native and Eurasian-introduced *P. australis* genotypes, Eurasian-introduced *P. australis* would exhibit greater fitness in response to global change factors. Plasticity and plant performance to ambient and predicted levels of carbon dioxide and nitrogen pollution were investigated to understand how invasion pressure may change in North America under a realistic global change scenario. We found that the introduced Eurasian genotype expressed

greater mean trait values in nearly every ecophysiological trait measured - aboveground and belowground - to elevated CO<sub>2</sub> and nitrogen, outperforming the native North American conspecific by a factor of two to three under every global change scenario. This response is consistent with “jack and master” phenotypic plasticity. We suggest that differences in plant nitrogen productivity, specific leaf area, belowground biomass allocation, and inherently higher relative growth rate are the plant traits that may enhance invasion of Eurasian *Phragmites* in North America. Given the high degree of genotypic variability within this species, and our limited number of genotypes, our results must be interpreted cautiously. Our study is the first to demonstrate the potential importance of jack-and-master phenotypic plasticity in plant invasions when facing imminent global change conditions. We suggest that jack-and-master invasive genotypes and/or species similar to introduced *P. australis* will have an increased ecological fitness, facilitating their invasion in both stressful and resource rich environments.