

Engineering for Ecological and Social Justice: What can pollinators teach us about designing healthier cities for humans and other species in the face of climate change?

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Time: ~5 (50 minute) class periods

Materials

- Easel Paper
- Glue stick
- Printed “cards” for building the systems model (in materials section)
- Red & Green whiteboard markers
- Red & Green markers (for optional small group modeling)
- Optional: materials to create pollinator corridors

Engineering for Ecological and Social Justice: Principles & Practices

Engineering for Ecological and Social Justice requires us to plan instruction that not only engages learners in engineering design practices, but also gets them to think critically about the field of engineering and related fields such as landscape architecture and city planning, and their impacts on communities and ecosystems. Critical engineering practices are more focused on understanding and exploring problems from multiple perspectives in order to see the full impact that engineering design solutions can have on ecosystems and communities. Many ecological and social problems emerge from the unintended consequences of design work.

When you engage in critical engineering with your students, frame instruction around the Framing questions and practices described below:

Engineering for Social and Ecological Framing Questions

Throughout this unit, you will have students revisit questions such as:

1. Who defined this engineering problem (who is it a problem for, inc more than human species and entities)?
2. What human actions and decisions created or contributed to this problem?
3. Who (including other species) has been most impacted by these decisions and how will you include these perspectives in defining and solving this problem?
4. How will your solution create a more just future or provide an example for others to imagine and design for this shared future?

Critical Engineering Practices for Designing for Ecological and Social Justice

This table contrasts traditional engineering design practices with more critical approaches. As students engage in learning throughout this unit, reframe engineering as a process of discovery, understanding and storytelling through artifact rather than simply solving problems. The more we explore problems from multiple perspectives (as in through story) the less likely engineers will produce inequities and

unintended consequences through their designs.

(adapted from Dunne & Raby, 2013)	
Traditional Engineering	Critical Speculative Engineering
Problem solving	Problem finding/ scoping/ understanding
Provides answers	Asks questions
Models as prototypes	Models as stories
Design as production	Design as Story
Design as solution	Design as a medium for thinking
In the service of clients and industry	In the service of society, community
Change the world to suit us	Change us to suit the world(s)
Consumer	Citizen
Centralized decision making	Distributed decision making

Core Practices of Engineering for Social and Ecological Justice

Follow these core practices as you adapt this unit for your own contexts or if you use this unit as a model for creating your own lessons for engineering for ecological and social justice.

1. Planning Instruction

This first stage of engineering for ecological and social justice (EESJ) focuses on planning for engagement with engineering practice that is grounded in students' everyday ways of knowing, interests, and experiences and anchored by a complex phenomenon that situates engineering in social, ecological, and historical contexts. All materials developed in this stage will be used in subsequent stages for planning day-to-day experiences for students across the arc of the unit. For example, in this unit we chose pollinator species declines and pollinator pathway corridors as anchoring phenomena for students to use multispecies perspective taking to explore solutions to a complex socio-ecological problem.

2. Eliciting Students' knowledges, interests, and experiences

The second stage of EESJ follows planning and engages your students in the co-construction of solutions for this unit (or adaptations and extensions to this unit). This stage of instruction involves eliciting students' everyday ideas, ways of knowing, interests, and experiences as foundations for equitable, student-centered instruction. Note that this written unit is only a model that you can and should adapt to build on your students' interests and identities and to engage your students in local, place-based learning. Eliciting and connecting to students ways of knowing should happen *throughout* the unit including during the process of identifying anchoring phenomena, understanding the problem as it relates to ecological and social justice, brainstorming and evaluating possible solutions and designing solutions for local and community contexts.

3. **Iterative Problem Scoping and Solving: Informing Approaches to Optimize Solutions to Problems**

In this phase, students engage in a set of practices to iteratively design solutions related to the anchoring phenomena. In the example from this unit, students use complex systems models called [causal-loop diagrams](#) to identify the social, ecological, historic, and technical variables related to pollinator health and designing place-based solutions to support long-term pollinator repopulation and survival. Most of this phase is focused on developing complex systems models in order to “problem scope.” Problem scoping is the practice of figuring out the problem that needs to be solved, and working through the details of the problem context. Problem scoping is a critical step towards creating socially and ecologically just design solutions as it engages students in taking on multiple perspectives before designing solutions. Perspective taking should include viewing the problem(s) and related solutions through multiple lenses including stakeholders, community members, and the other species impacted by design solutions. Students should continue to surface and draw on their everyday ways of knowing and prior interests and identities throughout the process of problem scoping and designing solutions; this is a central aspect of creating an equitable and inclusive learning space for students. The process of how youth engage in problem scoping and problem solving is as if not more important than the solutions that emerge from this stage. In this example unit, students are asked to think about how to create pollinator pathways and corridors that support both pollinator and community (human) health; they draw on their prior knowledge to consider the needs of humans and other species in their communities for now and in the future.

4. **Finalizing Designs, Taking Action, Re-Imagining Ecologically and Socially Just Futures for Humans and other species**

In this final stage of the instructional cycle, students select a final solution to implement or discuss with their communities. Solutions can include physical and place-based engineering work or can also be community meetings, design charrettes in which students get to share the stories of their design work and imagined futures.

NGSS Standards

DCIs

LS2.A: Interdependent Relationships in Ecosystem
LS2.C: Ecosystem Dynamics, Functioning, and Resilience
LS4.D: Biodiversity and Humans
ESS3.C: Human Impacts on Earth System
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions

Practices

Read this [STEM Teaching Tool](#) for an overview of how practices “Cascade” in the science and engineering classroom.

Defining problems
Developing and using models
Designing solutions
Engaging in argument from evidence
Obtaining evaluating and communicating information

CCCs

Cause and effect

Systems and systems models
Patterns
Structure and Function

PEs

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Unit Background & Overview

Overview of Engineering for Social and Ecological Justice

The Engineering for Equity and Justice Unit contests how engineering design is often instructionally presented as a socially neutral activity. Things get built to solve problems or satisfy desires. In this template and unit, instructional approaches are explored where students learn to relate engineering design to ecological systems and matters of social justice and power relations in society. Who benefits and who loses from engineering? Who decides what gets counted as engineering? How can we design solutions for more just and equitable human and more-than-human futures? Here, a recognition and concern for other species futures signal a moral concern for multispecies inhabitants and natural actors in ecological systems and a recognition of the entanglement between human and other species concerns in relation to survival, resurgence, and thriving.

Background Information

Humans are a part of natural systems. Like birds, beavers, pollinators, rivers, wind, and many other other species species, humans shape their environments over time. Cities and other urban areas are often considered biodiversity deserts that are separate from the natural world. However, many species have adapted to urban settings and this is especially true for insects and pollinating species. The way cities and the landscapes within cities are designed determines how viable urban areas can be for human and ecosystem health. Urban planners and community members can use engineering design practices to design cities and spaces within cities and other developed areas to take into account and increase pollinator habitat, secure the future of food production, create climate-resilient food and urban systems, and equitably distribute access to greenspace and urban food production.

Unit Overview

This complex anchoring phenomenon focuses on how human decision-making around engineering and city planning is often narrowly focused on a subset of human residents. Humans make decisions that ripple through systems. The humans, other species, and human-made aspects of the system are all interconnected. Adjusting one means that others will also change. Engineers, planners rarely consider nor plan for the other species that we share our neighborhoods with.

Although urban areas are a part of complex socio-ecological systems, access to resources is not equitably distributed across communities. Specifically, Black and Indigenous communities that have been impacted by redlining and other racialized urban planning practices have been denied

access to urban greenspaces such as canopy cover, parks, and urban gardens. The lack of investment and construction in greenspaces for predominantly Black and Indigenous communities also denies these communities the benefits and functions of such space, especially as it relates to impacts of the climate crisis including reducing the urban heat island effect, mitigating flooding, and securing health food and future food productivity. The impacts of racism and associated practices, such as redlining, have far-reaching impacts on both humans and other species and ecosystems.

Pollinators, including bees and other insects, are known to thrive in urban greenspaces and provide a case study for this unit where we ask, **“What can pollinators teach us about designing more just cities for humans and other species?”** The main threats facing pollinators are habitat loss and fragmentation. As native plants are replaced by roadways, lawns, crops, and non-native plants, pollinators lose the food and nesting sites that they depend on for survival. Pollinator species that migrate face additional challenges because the distance between suitable habitats is often too far for individuals of a species to travel or remaining patches of habitats are too small to support an entire migrating population.

Pollinators are important to human health and food justice. About two-thirds of commercial crops that feed the world are pollinated by insects or other animals. Pollination supports human nutrition and access to food. Consequently, a reduction in pollination means a reduction in food production globally with food scarcity disproportionately impacting under-resourced communities and peoples.

The climate crisis further compounds the impacts of declining pollinator populations, as it is already shifting species ranges and migratory patterns at unprecedented rates. In addition to species adapting synchronously to the rates of range shifts, human impacts of habitat fragmentation from suburban sprawl and roadways present further challenges for wildlife by impeding both natural and shifting migratory pathways. Engineers, landscape architects, ecologists, and communities are increasingly using wildlife corridors to create connectivity between fragmented habitats as one solution to support species migration across these fragmented habitats. Wildlife corridors can take on many forms which can include bridges and overpasses to help animals safely navigate roadways, tunnels, and culverts that allow fish to pass under or through infrastructure, fish ladders that allow fish to climb dams, and greenways that increase connectivity across landscapes. Studies have shown that creating and expanding community gardens to create “pollinator hotspots” is an effective and important way to support pollinator populations and creates connectivity corridors for migrating pollinator species. The greatest benefits of pollinator corridors occurred when gardens were planted in communities historically impacted by redlining and other racist zoning practices.

Additional Resources:

- Next City: [What Can pollinators Teach Us about Building Better Urban Ecosystems?](#)
- The Atlantic: [Tiny Pollinators Need Corridors Too](#)
- [How Community Gardens Help in the Fight for Food Justice](#)
- Washington Post: [Butterflies are vanishing out West. Scientists say climate change is to blame.](#)
- UW Interactive Map: [Where Species Will Move Under Climate Change](#)
- Lesson Plan: [Habitat Fragmentation and Wildlife Corridors](#) (pp. 2-3 only)
- Simulation: [What will climate feel like in 60 years?](#)

Driving Question: What can pollinators teach us about creating more connected, sustainable, and just landscapes?

Problem context around the driving question:

Habitat fragmentation is the leading cause of species decline and extinction, including pollinator species. However, the impacts of habitat fragmentation on humans and other species are not equally distributed. Predominantly Black and Indigenous communities are more vulnerable to the impacts of declining greenspace on human health and as it relates to climate-resilient cities. Additionally, other species are rarely considered in urban planning and development.

Planning for Instruction

HLP1: Planning for Instruction

Equitable and justice-centered instruction begins by creating a “porous” classroom in which student, family, and community ideas are invited into the classroom to shape instruction. This is a partnership approach to teaching, and teaching is grounded in an asset view of students and families; know that your students and their families have a lot to contribute to your lesson. Trust that you will be able to adapt your teaching and this lesson based on students’ emergent ideas. There are guides throughout the instructional sequence on how to do this.

In this lesson, we use a [self-documentation](#) tool in order to elicit and invite students’ outside knowledge into the classroom. An example self-doc is in the materials section—feel free to adapt this tool to reflect your students’ interests and questions based on classroom discussions.

2. Learn More about Systems Thinking Practices

Before starting this unit, become more familiar with the two systems thinking practices that students will use. The purpose of creating causal-loop/ systems diagrams is to surface the complexity of many contemporary science and engineering issues and to help learners see how the many factors that need to come into play when making decisions about human, other species, and ecosystem health, especially in the context of human impacts and human-caused climate change.

Begin by watching this video on [causal diagrams](#) (8 minutes). Next, read pp. 25 – 35 of the [Institute for Play Systems Modeling Guide](#). Read the activity/dimensions of systems thinking overviews without doing any of the reflection questions. There will be detailed instructions in the Instructional Sequence below for how to do this activity. Note that students will learn systems thinking practices by *doing* them. You do not need to pre-teach systems thinking before students engage in the activities.

3. Practice Creating Systems Models & Identify the Key Model Components for Students to Use in their Models

- a) **Begin by doing the Collect & Cluster activity** described/modeled on pp. 25- 27 of the [Institute for Play Systems Modeling Guide](#). In this activity, identify all of the components related to **supporting pollinator health**. Group the components together based on categories that you come up with. Below is a picture of our initial Collect & Cluster activity for this unit. As you can see in the photo, our larger categories were:

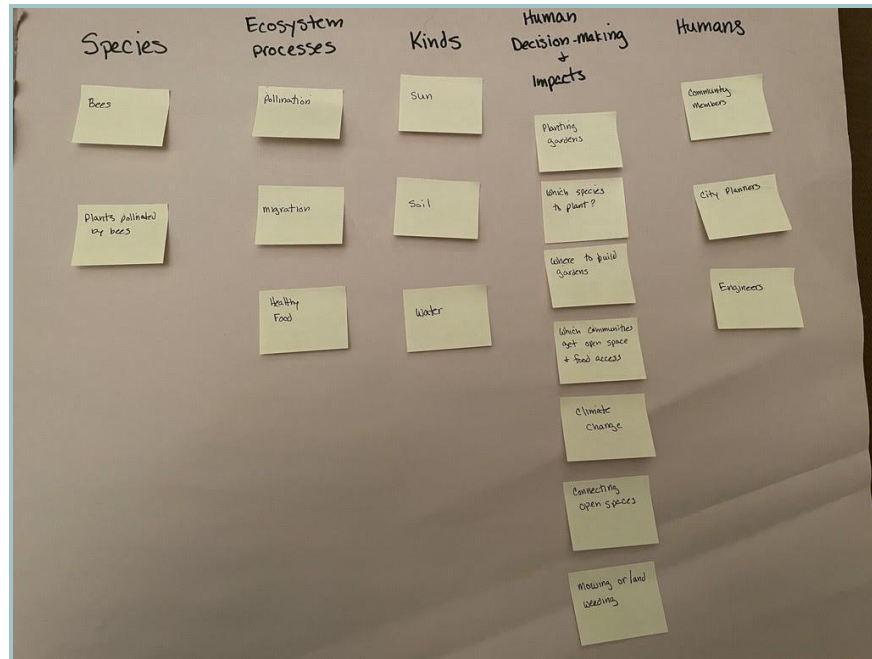
Species: Pollinators, plants pollinated by pollinators

Ecosystem Processes/Services: pollination, migration, health food

Kinds (lands, waters, etc.): sun, soil, water

Human Decision Making & Impacts: planting gardens, which plant species to plant, where to build gardens, which communities get open space and food access, climate change, connecting open space, mowing and weeding lawns

Humans: Community members, city planners, engineers



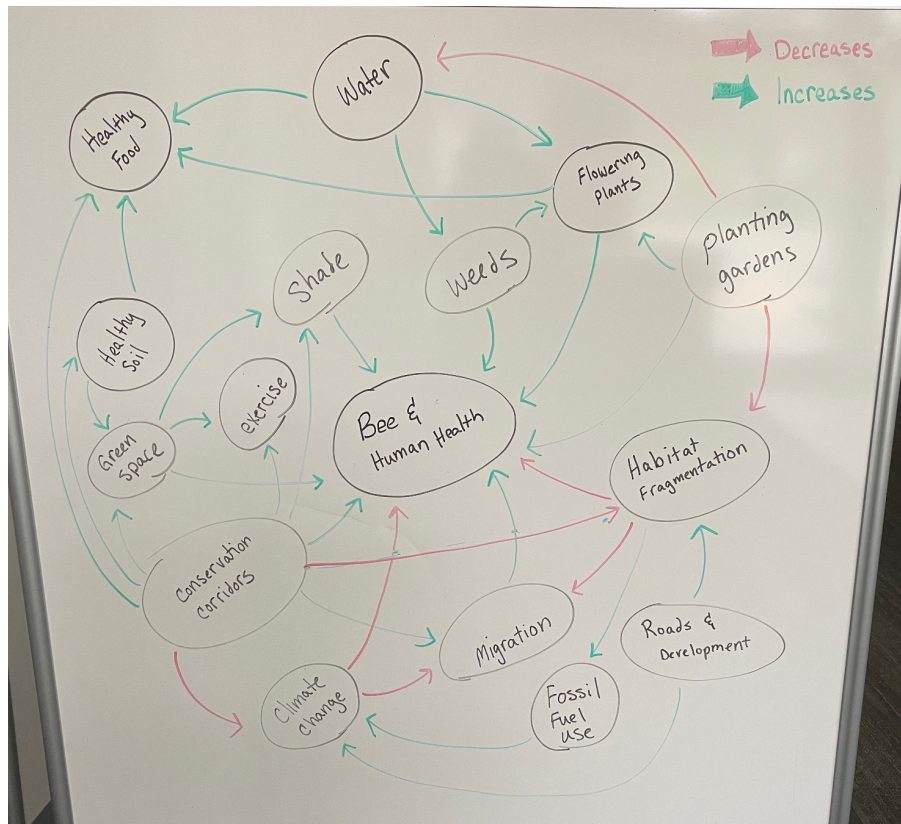
- b) **Next, build a systems model/ causal diagram** using these components and adding and taking away components as you think through your model. Note that as we moved from our Collect & Cluster set of components to our systems diagram, we ended up taking away a number of variables and adding many more. The Collect & Cluster is still a useful activity because you and your students may come back to many of the removed components as you get into the engineering problem-solving practices. For example, we did not include any of the components from the “humans” category in our system model, but they will be critical to think about when we talk about who designs wildlife corridors and for whom later in the unit.

Read pp. 29-35 of the [Institute for Play Systems Modeling Guide](#) to learn more about building systems models and understanding feedback loops. See our diagram below for an example diagram. Our final model components in this diagram are listed below. You can add or take away components based on your local context and students' interests. However, be sure to keep climate change, habitat fragmentation, human health, and migration in the core set. Also, make sure that you center your model around “Pollinator/Bee Health & Survival” Centering our problem solving and sensemaking around human and other species health and thriving is critical for equity and justice-centered approaches to problem-solving. Note that in the teacher materials section, there is a template of these variables (and blank boxes) for you to print and share with student groups.

Components in this model: Healthy Food, Soil, Human Health, Lack of open space in BIPOC communities, Roads & Development, Habitat Fragmentation, Fossil Fuel Use, Climate Change, Migration, Connection Open Spaces, Pollinator Populations Size, Pollination, Naive Plant Species, Healthy Garden Foods, Planting Gardens, Water Availability, Let Lawn and Weeds Grow

Connecting Components: As you read in the Systems Thinking Guide, making connections between model components is central to systems thinking and justice-centered decision-making. Placing human or other species health and thriving at the center of the model, orients problems solving to health and justice-centered solutions.

- **Use arrow directions to show how one component influences another.** You can use arrows going in the same or opposite directions between components. This is how feedback loops form.
- **Green Arrows- Indicate when one component INCREASES another** (i.e. burning fossil fuels increases effects of climate change)
- **Red Arrows- Indicate when one component DECREASES another** (i.e habitat fragmentation decreases pollinator population size)



4. Back pocket questions for the unit: These back pocket questions can help guide students' sensemaking around equity and justice-related issues as students construct their models and engage in

discussions and decision making based on their models. Example sensemaking is included below each question, however, students' ideas can go in many directions based on their own experiences, interests, and prior knowledge.

What human actions and decisions created or contributed to the phenomenon that you are studying?

- Habitat fragmentation occurred over time. It started with colonial settlers forcibly removing Indigenous peoples from their land. Land was then fragmented for agriculture and individual property. Dams, railways, and roads were eventually built to support settler communities.

Who had the power to make many of these decisions?

- Most decisions about large-scale infrastructure were made by governments, industry, and corporations in order to benefit large-scale production and economic growth at a cost to community rights.

Who (including other species) has been most impacted by these decisions?

- Habitat fragmentation is the leading cause of species decline across the world. It also threatens ecosystem processes including species migrations and pollination. The aggregation and industrialization of food and farming mean that humans and other species have less access to local, seasonal foods, and plants with major impacts on both human, other species, and ecosystem health.

What would a just future for humans and other species look like for this phenomenon?

- Humans and other species need green space, native species, and access to local food resources. A more just future sees cities as a part of the natural world, and cities and urban planning policies would create connectivity corridors supportive of healthy ecosystems for human and other species resurgence, and thriving.

Instructional Sequence

Driving Question: What can pollinators teach us about creating more connected, sustainable, and just landscapes?

Problem context around the driving question:

Habitat fragmentation is the leading cause of species decline and extinction, including pollinator species, like pollinators and butterflies. However, the impacts of habitat fragmentation on humans and other species are not equally distributed. Predominantly Black and Indigenous communities are more vulnerable to the impacts of declining greenspace on human health and as it relates to climate-resilient cities. Additionally, other species are rarely considered in urban planning and development.

HLP2 Eliciting Students' Prior Knowledge, Ideas, Interests, and Expertise

Day 1: Lesson Launch & Elicit students' prior knowledge about the topic

Purpose: The purpose of this lesson is to surface students' prior knowledge and ways of knowing about the role of pollinators in supporting human and ecosystem health, and the role of human decision-making in supporting the health of pollinator species, which in turn support human and ecosystem health.

- **Introduce the unit** by sharing the driving questions, What can pollinators teach us about creating more connected, sustainable, and just landscapes? Tell students that they are going to learn about how human impacts, like climate change and habitat fragmentation through roads and development are impacting pollinator species and that they are going to have an opportunity to work as conservation engineers to design solutions that support pollinator health and migrations as well as human health in their own neighborhoods.
- **Play the video**, Wild Science: [Timing is Everything: Bees, Flowers & Climate Change](#) (6 minutes). As students watch the video, ask them to take notes about the connections being made between climate change, pollinator health, and human health.
- **Engage students in a whole group discussion** around the following questions:
 - What have you heard about pollinator health and populations in the news? What do you already know?
 - Some students may have heard about bee colony collapse disorder. If this topic comes up, you can let students know that many scientists believe that pesticides are the cause of colony collapse and make connections that bees face many human-caused challenges that go beyond the video shown in class.
 - What do you know about the impacts of climate change on species? Is there anything that you are most concerned about?
 - Take notes of students' responses, and see if you can adapt your instruction to build on students' existing interests as it relates to climate impacts on species. For example, you can focus this unit on butterflies, birds, and other migratory species (e.g., bats, other insects besides butterflies).
 - How do you think humans can help species adapt to climate change?
- **Play the video**, [Pollinator Corridor Hives for Humanity](#) (~6 1/2 minutes), and have students take notes on the SOLUTIONS that Hives for Humanity is using to support pollinator health as well as human health.
- **Engage students in a whole group discussion**, around the question, How can supporting pollinators build better communities for humans and more-the-humans?
- **Introduce design challenge for this unit**: Tell students that they will be working in small teams of conservation engineers and landscape architects to design connectivity corridors to connect pollinator habitat across their neighborhood and possibly beyond. Remind students that pollinators need flowers to pollinate, and *also* need ways to travel between pollinator patches to support migration and movement across spaces.
- **Tell students that scientists and engineers are working on creating national and even international networks of pollinator corridors/pathways through various citizen science projects**. Two that you can share with the class are:
 - [Pollinator Pathway](#): "The Pollinator Pathway is 'about' looking at the earth as a massive design project. It is a challenge to connect the dots on fragmented landscapes and

building relationships around connectivity. The result is something like ecological judo: by the connecting landscape, we help offset the land use of big-scale agriculture and fragmentation caused by cities.”

- o [Homegrown National Parks](#): The Homegrown National Parks project is a grassroots call to action to restore biodiversity and ecosystem function by planting native plants and creating ecological networks, such as pollinator corridors (Note: that when you introduce a project like Homegrown National Parks, it is essential to share that the land we are on is Indigenous (not nation-state) land).
- **(Optional if time allows) In groups of 3-4 students, have students research the impacts of climate change on migratory species**, and then share their findings with the class. Students can share verbally or you can have students add their research into a shared document or on a whiteboard using sticky notes. This activity should only take about 10-15 minutes and you can skip this if you are nearing the end of the class period.
 - o Below are species that groups can focus on as well as other of their own interest. For example, instead of assigning a species, you can ask students groups to pick a species to find out if they are impacted by climate change. You can also create your own list of local species that students may be more familiar with.
 - Monarch Butterflies
 - White Sharks
 - Bird Migrations
 - Mule Deer
 - Bewick’s swans
 - Golden Eagles
 - Right Whales
- **Self-Documentation Activity:** Use/adapt the self-documentation activity in the resources section to invite students to share their knowledge of pollinator and garden habitat from their own neighborhoods with the class. Students will use their self-documentation tools when they design connectivity corridors, pollinator patches, and community gardens during their design challenge at the end of the unit. Note: even if students don’t complete or return a self-doc worksheet, they can still share their community and family knowledge about gardens, flowers, and connecting spaces in their own communities (Students should have 2 days to do their self-doc. These will be used in Day 3. If you want to give student more time, you can teach this lesson on a Friday).

Day 2: What does it take to support pollinator and human health in our neighborhoods in response to a changing climate?

- **Introduce this** lesson through a whole group discussion.
 - o Ask students, what do pollinators need to be healthy? How does supporting pollinator health also support human health?
 - o How can we design our neighborhoods, including cities, farmland, and suburbs to create healthier pollinator habitats?
 - Record students’ answers in a visible place in the classroom, such as the whiteboard.

- **Tell students to think back to videos from the prior lessons** and ask students how climate change is affecting pollinators.
 - Let students share and surface all ideas about the impacts of climate change on pollinator health and behavior.
- **Tell students that there are many factors that are impacting pollinator populations** and health. These include pesticide use, habitat fragmentation through road construction, development, suburban sprawl, and climate change. Let students know that they will be focusing on habitat fragmentation and climate change for this unit, but that pesticides are something they might keep in mind when they start their project work.
- **Tell students that Habitat Fragmentation is when continuous habitat like forest or prairie is divided into pieces due to human activity**, like building roads, creating farms, and development, that includes suburbs, rural communities, and cities.
 - Many students might not consider farmland fragmented habitat because it looks “natural.” However, the planting of large, single-crop farms is one of the biggest threats to wildlife due to the lack of plant biodiversity and native plants, the use of pesticides, and the harvesting of plants.
- **Tell students that habitat fragmentation is the leading cause of species loss globally**, and it is estimated that 70% of species decline is due to habitat fragmentation and loss due to human activities.
- **Show students this map of [global habitat fragmentation](#)**. Orient students towards how to read the map by showing the key of “Magnitude of Habitat Fragmentation” to the right. Point out that red indicates areas of a lot of fragmentation, meaning that the habitat is divided into small pieces across space. Ask students to share what they observe from this map, such as:
 - Where is habitat most fragmented?
 - Where is there low habitat fragmentation?
- **Share additional images of what habitat fragmentation looks like in different places**, reminding students that even “open space” can still be fragmented habitat if it doesn’t support species health and migration. Below are images of different types of habitat fragmentation.
 - [Agricultural land](#)
 - [Urban Fragmentation](#) (scroll for multiple images)
 - Note that habitats can be fragmented for humans as well. Policies such as redlining and commercial development have meant that Black, Indigenous, and Latinx communities have reduced access to fresh foods and open space. This is sometimes referred to as ‘food deserts’ and ‘food apartheid.’ Reduced access to open space also means that BIPOC and Latinx communities have great health impacts from climate & heat island effects, flooding, and poor air quality.
- **Show the Interactive Map: [Where Species Will Move Under Climate Change](#)** and ask students, How does habitat fragmentation make it harder for species to adapt to climate change?
 - Students should make connections that habitat fragmentation makes it harder for species to move to more suitable habitats in response to changing temperatures.
- **Break students into small groups** that they will continue to work in throughout this unit since the groups will build on their ideas from this initial activity in their final design work.

Hand out the student worksheet from the resources section of this unit. You can update the activity guide if you would like to add or change any of the resources.

- **In small groups, have students watch videos and view images of example connectivity corridors.** The Day 3 worksheet prompts students to record ideas and inspirations that they can apply to their future design work through these videos
- **After students have worked in small groups,** have each group share one idea about how conservation engineers and landscape architects are designing solutions to support species and human health in response to climate change.
- **Tell students that they will use these ideas as inspiration for their final design work in future lessons.**

HLP3: Iterative Problem Solving: Informing Approaches to Optimize Solutions to Problems

Day 3: Building Models from our Classroom and Neighborhood Explorations

- **In small groups share our neighborhood observations** from the self-documentation activity. Ask students to discuss the following questions:
 - o Where did we find healthy pollinator habitat?
 - o What can we do to create more and connect pollinator habitats in our neighborhoods?
 - o How can we support pollinators and also create spaces that support human and community health?

Note: even if students don't turn in a self-documentation assignment, they can still participate in this small group activity based on their prior knowledge and observations of their neighborhoods. Self-docs are meant to guide curriculum adaptation based on student and community knowledge. They are not intended to be used as traditional, graded homework assignments. Self-doc discussions should aim to surface and integrate diverse knowledges into class instruction and students' engineering design work.
- **Tell students they are going to use their neighborhood observations as well as their classroom learning from the last two lessons to build a systems model** of all of the components/variables that are important for supporting pollinator health in the face of habitat fragmentation and climate change.
- **Introduce the idea of systems thinking.** Tell students that systems thinking is an approach that scientists and engineers use to understand complex problems, like climate change and the impacts of climate change on species and Earth's systems.
- **Ask students, what comes to mind when you think of science investigations? What do scientists and engineers need to do to design a valid or reliable study?**
 - o Students might share ideas such as hypothesis testing, controlled experiments, variable testing, and others.

- o Use students' ideas to ground your teaching of systems thinking in their prior knowledge of what counts as science and engineering.
- o Typically, but not always, students come to science/engineering classrooms with the idea that “good” science is linear and controlled, and involves testing and reporting on only one variable at a time. Systems-based approaches to science are very much rooted in engineering and aim to surface that real-world and contemporary science is actually complex, includes multiple variables, is situated in social contexts (like communities), and is transdisciplinary meaning that it includes policymakers, community members, educators and diverse groups of engineers and scientists working together to solve problems.
- **Tell students that scientists and engineers construct systems models, sometimes called causal-loop diagrams, to understand all of the components including people, objects, actions, species, Earth’s systems, and more that are related in complex systems and phenomena.**
- **Play video about [Systems Thinking](#) (4 minutes).** As students watch the video, ask them to take notes about or consider how system thinking is different from how they have approached science and engineering investigations in the past. Tell students to consider all of the parts of the system need to support pollinator/pollinator health.
- **Tell students that they are going to create a systems model as a whole group and then will have an opportunity to create their own in small groups as part of their design work.** (Note: to save time, you can do only the whole group systems modeling activity and have students move right into design charettes. However, if you have time, it can be a powerful exercise for students to create their own causal-loop diagrams in small groups. Both large and whole group model construction should engage students in the NGSS practices of argumentation and constructing evidence-based explanations as they reason about which components to include and how they are connected to each other.)
- **Tell students groups to write down all of the components/variables** that they observed that relate to supporting pollinator, human, and community health in their neighborhoods from the classroom lessons and their self-documentation activity/ neighborhood observations.
- **Draw a large circle in the center of the white board and write, “Bee (or pollinator) Health & Survival”** in the center of the circle (See the diagram in the teacher planning section as an example).
- **Have students choose 3-5 key components they observed. Tell them to write those on sticky notes and post them to the front of the class.**
- **As part of a whole group discussion, read off the variables that students shared, and group similar variables together as in the Collect & Cluster activity described in the teacher planning section of this lesson.**
- **Choose your larger categories of components in this collect and cluster activity, and make those your system components.** Write them in large text on the board and draw a circle around each variable. Ask students if there are additional variables they would like to add.

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- Diagram illustrating the relationships between various factors and Bee & Human Health, categorized by impact (Decreases or Increases).
- Legend:**
- Red arrow: Decreases
 - Green arrow: Increases
- Factors and their impacts:**
- Water** (Central Node)
 - Increases: Flowering plants, Weeds
 - Decreases: Healthy Food, Healthy Soil, Green Space, Exercise, Conservation Corridors, Climate Change, Migration, Fossil Fuel Use, Roads & Development, Habitat Fragmentation
 - Flowering plants**
 - Decreases: Weeds
 - Increases: Bee & Human Health
 - Weeds**
 - Decreases: Bee & Human Health
 - Shale**
 - Increases: Bee & Human Health
 - Healthy Food**
 - Increases: Bee & Human Health
 - Healthy Soil**
 - Increases: Green Space
 - Green Space**
 - Increases: Exercise, Bee & Human Health
 - Exercise**
 - Increases: Bee & Human Health
 - Conservation Corridors**
 - Increases: Bee & Human Health, Migration
 - Decreases: Climate Change
 - Climate Change**
 - Decreases: Migration, Fossil Fuel Use, Roads & Development, Habitat Fragmentation
 - Migration**
 - Increases: Bee & Human Health
 - Fossil Fuel Use**
 - Increases: Roads & Development
 - Roads & Development**
 - Increases: Habitat Fragmentation
 - Habitat Fragmentation**
 - Decreases: Flowering plants, Weeds
 - Increases: Bee & Human Health

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Note: As with building the model, there are no right or wrong answers to these questions. Rather, they are ways to orient students' thinking toward the complexity of designing solutions for real-world contexts.

- **Exit Ticket:** Have each student write a short reflection on the opportunities and challenges of designing solutions for complex problems like supporting pollinator health. As part of the exit ticket, have students reflect on why it is important to prioritize multiple components at one time, such as pollinator health AND human health.
- **Leave this model on the board or in a visible space for students to refer back to.** If that isn't possible because of multiple class periods or space, you can also take a picture of the model and upload it to a shared drive/folder for students to view when doing their design work and/or optional small group systems models.

HLP 4: Creating Justice-Oriented Solutions: Redefining Designs, Taking Action, Re-Imagining Futures for Humans and other species

Days 4: Begin Design Work

- **Optional (add 1 day of instruction): In the same small groups from the Day 2 corridor video research activity, have student groups construct their own systems models.** If you add this activity, use the Day 4 worksheet in the resources section to print a set of components cards for groups to use. You and students can and should add additional components to this set.
 - Hand out one set of component cards, easel paper, glue stick, a red and green marker to each group, along with the directions (included with the Day 4 card set) to each group.
 - Tell students to decide on their component card selections and placements before gluing and drawing arrows! Tell students that it is okay if they change their minds during the modeling process - they can cross out and redraw arrows as much as they need to. The goal of this activity is to engage in complex systems discussions, not to create a perfect finished or even perfectly accurate model.
- **Remind students of the design challenge,** to design connectivity/pollinator corridors to support pollinator (and human) health in their own communities. You can remind students of the two ways scientists and engineers are doing this on a global and national scale. If students are interested, you can also engage them in community action projects or citizen science initiatives related to their design work.
 - [Pollinator Pathway:](#)
 - [Homegrown National Parks](#)
- **Introduce the design challenge as a Design Charette.** A design charrette is a collaborative session in which a group of designers drafts a solution to a design problem. Charettes serve as a way of quickly generating a design solution while integrating the aptitudes and interests of a diverse group of people.
 - The general idea of a charrette is to create an innovative atmosphere in which students can collaborate to generate visions for the future. In this case, students are creating visions for the futures of their own neighborhoods for ecological and human health.
 - The emphasis of charettes is on the *idea* not on the drawing. For this activity, students should focus on sketching rather than drawing their design solutions. Colors and details

should be limited and only substantial enough to communicate their solutions to the rest of the class.

- o For this reason, design charettes are quick activities and not lengthy projects. A charette can occur during part of a class period and ideally would not take more than one class period. Professional design charettes often take place over multiple sessions, but this one is designed for just one iteration.
- o You can read more about design charettes [here](#).
- **Have students come up with the criteria and constraints for their corridor designs** based on prior work and learning. Read this [STEM Teaching Tool: Students should generate criteria and constraints for engineering design problems - not just be provided with them](#) to guide you through this part of the lesson.
 - o **Criteria:** outcomes that each design solution needs to meet. In this case, the criteria should be related to supporting pollinator health in response to human impacts, including climate change and habitat fragmentation.
 - o **Constraints:** solutions should attend to equity and justice. In supporting pollinator health, it should also support human health, community health, and should place other species survival and health at the same level as human health.
Note that students can identify and define these criteria and constraints in ways that are personally meaningful to them, and that build on their prior knowledge and learning from earlier lessons in this unit and beyond.
Teacher Facilitation Note: As the facilitator of this discussion, you can remind students to attend to equity, justice, and human and other species health to guide the discussion and as the focus of this unit overall.
- **Hand out charette supplies to each group**, including easel paper and drawing materials. Encourage students to refer back to their notes and worksheets from prior lessons, especially on the pollinator pathway videos from Day 1, group corridor research from Day 2, and the systems models from Day 3.
- **Remind students to consider the complexity of the system for which they are designing a solution as part of their design work.** Tell students that they will be writing a claims-evidence-reasoning that connects their design work to the systems model after they are finished with their design work.
- **Have students work in small groups to create their designs.** As students work, circulate around the room, and use the back pocket questions to guide discussions with design teams.
 - o What human actions and decisions created or contributed to the decline of pollinator health in our neighborhoods?
 - o Who did the decision-making and for whom as it relates to habitat fragmentation and habitat loss in our neighborhoods?
 - o Who (including other species) has pollinator most impacted by these decisions?
 - o What would a just future for humans and other species look when we design connectivity corridors for pollinators in our neighborhoods?

Day 5: Finish Designs and Gallery Walk

- **Have students finish their design work.** It is okay for students to share incomplete designs if you are tight on time. A charette is intended to be a fast activity for sharing sketches and ideas,

so as long as students have enough to share ideas and generate discussions, they will have enough to participate in the gallery walk.

- **Give each student a gallery walk worksheet from the Resources Section to take notes during the gallery walk.**
- **Have students hang their design sketches around the room or have them lay them down on the floor or tables for the gallery walk.**
- **For the gallery walk, follow a ‘some stay, some stray’ model.** For the first round of gallery walks, have half of the design team stay to explain their design solution for connectivity corridors in their neighborhood to peers. For the second round of the gallery walk, have students switch roles.
 - Students should complete their gallery walk worksheet as they walk around and view peer’s design work.
 - Students should spend ~2 minutes with each sketch and group.
- Engage students in a whole group reflection about the variety of ideas shared during the charette and gallery walk.
 - Which ideas seemed most workable for their neighborhoods?
 - Which ideas do they think would be the most effective at supporting pollinator health in response to climate change and habitat loss?
 - Which ideas would be most effective at supporting human health?
 - Are there ways to integrate the best of these design solutions to create a future neighborhood that supports pollinator and human health in the face of climate change, development, and future human impacts?
- **Exit Ticket: Have each student write a CER based on their design work.**
 - **Claim:** How does their design support pollinator health in ways that also support human/community health in the face of climate change
 - **Evidence:** include 2-3 design features that support their claim
 - **Reasoning:** explain why these design features support pollinator/human/community health.

Optional Next steps: ‘take action’ in your own neighborhood/ schoolyard

- Encourage less mowing
- Plant flowers
- Create a community garden
- Map community gardens and plant wildflowers in between
- Use this as a launch to an investigation to see what types of habitats attract the most pollinators
- Participate in citizen science project such as
 - [Homegrown National Parks](#)
 - [Save Our Monarchs School Pollinator Garden Program](#)

Lesson Resources

Day 1 Lesson: Self Doc: What does our neighborhood like to a pollinator?

Directions: Take or draw pictures of your neighborhood from the perspective of a pollinator.

As a pollinator, where would you be able to forage (eat/pollinate) in your neighborhood?

Add images to the left column

Add a brief description/ caption for your image in the right column

How can you (a pollinator) travel from one habitat/food space to another in this neighborhood? What barriers are there that keep you from getting to a foraging habitat?

What can humans do to make your neighborhood healthier for pollinators and humans? (only a written response here)

Day 2 Lesson: Small Group Research on Connectivity Corridors

In small groups, explore some of the ways that conservation engineers and landscape architects are creating “connectivity corridors” or “pollinator corridors” to create pathways between fragmented habitats. These pathways help pollinators between habitat patches so they can find food and respond to changing landscapes due to climate change. Use these designs as inspiration for how you will approach our design challenge. Visit each site below and take notes on features that would work in your own neighborhoods. Later, you will incorporate these ideas into your own design work.

Video of Corridor/Greenway	Design Ideas for your Projects/ Neighborhoods
Habitat Biodiversity https://vimeo.com/195505962 (~3 mins)	
Science Bulletins: Habitat Corridors Benefit Isolated Plants https://youtu.be/2AfUcOnYWlo (~2 mins)	
B-Lines: How insect pathways can ensure the survival of pollinators and pollinating insects https://www.youtube.com/watch?v=OXUYZdfqg1Q&t=10s (~1 ½ mins)	
Dolores Street Pollinator Boulevard Community Planting Day https://vimeo.com/460659559 (~4 ½ mins)	

Day 4 Lesson: Systems Modeling Cards (Print and Cut one set for each group of students. Some cards are intentionally blank so teachers & students can add more ideas, especial model components with local relevance)

Directions: Draw **arrows** to connect the factors together and to the topic of focus (See example on next page for how to use arrows):

- Use **green arrows** → to show *increasing* relationships between variables.
- Use **red arrows** → to show *decreasing* relationships between variables

Healthy Food, Soil	Climate Change
Human Health	Species Migration
Lack of open/green space in BIPOC communities	Connection Open Spaces
Roads & Development	pollinator Populations Size
Habitat Fragmentation	Pollination
Fossil Fuel Use	Native Plant Species
Food Gardens for Community Health	Planting Gardens
Water Availability	Let Lawn and Weeds Grow

Gallery Walk Student Guide

As you view your classmates' designs, take notes about features that you think would work well in your own neighborhoods. You do not have to write in complete sentences. As you walk around the room, ask your peers questions about their design work, such as:

- What features of your design support pollinator health?
- What features support human health?
- How did you consider the impacts of climate change and future development in your design work?

Design Team Members	Write notes about features that you like about each design	Why would this design feature work for your community?

In the space below, write a CER about which aspects of your classmate's proposed designs you think would work in your own neighborhood or around your school. Use evidence shared by your classmate's during the gallery walk to support your claim.

Claim:

Evidence:

Reasoning:

