

SUSTAINABLE CITIES: NATURE-BASED SOLUTIONS IN URBAN DESIGN

Subject Area: Science – Biology, AP Environmental Science

Grade Levels: 9-12

Essential Question: What does sustainability mean in an urban context and how can we create nature-based solutions to solve urban challenges?

Purpose and Overview: This lesson is divided into four parts beginning with Part 1, an introduction to sustainability in the urban context. In this part, students describe their vision of a sustainable city, identify the challenges facing cities, and describe ecosystem services provided by nature. This sets the foundation for the other activities to follow.

In Part 2, students explore the ways in which humans have changed the environment. If students have computer access at home, this part of the lesson could be conducted as homework since the exploration takes place online. Sustainable cities are much more than places where humans and nature coexist productively – they are cities in which all people, regardless of their race, color, income and so on have equal access to a healthy environment in which they can flourish. In designing sustainable cities, planners must incorporate environmental justice ideals and more broadly – social justice.

In Part 3, students explore the concept of environmental justice and explore data and current events that illustrate instances where environmental injustices have occurred. Furthermore, this part of the lesson will guide them into finding resources that will help them become more involved in their communities.

Lastly in Part 4, students take an active role in mapping their communities and planning, designing, and proposing a project. Specific instructions for mapping impermeable surfaces and



designing natural areas using Google My Maps are included, but Part 4 provides the framework for other options as well.

Time:

- Part 1 – One 45-minute period
- Part 2 – One 45-minute period, or assigned as homework
- Part 3 – One to three 45-minute periods depending on how many activities are completed
- Part 4 – One week or more for design and proposal phases, if project is carried into completion, it could last the entire school year or become an after school club project depending on your school and resources

Materials:

Part 1

- Computer, Internet connection, projector for teacher
- Optional - Student devices (cell phone, tablet, computer, etc.)
- *Nature Works Everywhere* Video ***Sustainable Cities: Nature-Based Solutions in Urban Design***
<https://vimeo.com/153948280>
- Photocopies of the article “The 10 Cities that are Leading the Way in Urban Sustainability”
<http://www.fastcoexist.com/3016816/the-10-cities-that-are-leading-the-way-in-urban-sustainability>

Part 2

- Computer, Internet connection for students (If you don’t have computer access for students, you can project story map and share with students)
- “Welcome to the Anthropocene” story map <http://arcg.is/1uGgg6X>
- Copies of student handout “Investigating the Anthropocene” for each student
https://natureworkseverywhere.org/asset/resources/Anthropocene_Student_Handout.docx

Part 3

- Computer, Internet connection, projector for teacher
- Editorial cartoon found here: <http://www.tolerance.org/lesson/editorial-cartoons-povertyenvironmental-justice>
- Copies of each of the files below for each student or student group from the lesson linked below (<http://www.tolerance.org/supplement/environmental-justice-high-school>)
 - <http://www.tolerance.org/sites/default/files/general/air%20pollution%20map.pdf>
 - http://www.tolerance.org/sites/default/files/general/tt_biases%20in%20exposure.pdf
 - http://www.tolerance.org/sites/default/files/general/tt_effects_of_pollution.pdf
- Copies of contact list template for elected officials for each student
https://natureworkseverywhere.org/asset/resources/Contact_List_Student_Handout.docx
- Optional – computer and internet access for each student to explore the EJSscreen tool found here: <http://www.epa.gov/ejscreen>
- Optional – printed copies or online access for students to articles found here:
 - <http://www.npr.org/2016/02/01/465150617/flint-begins-the-long-process-of-fixing-its-water-problem>
 - <http://www.nytimes.com/interactive/2016/01/21/us/flint-lead-water-timeline.html>
 - http://www.nytimes.com/2016/01/22/us/a-question-of-environmental-racism-in-flint.html?_r=0

- <http://thehill.com/blogs/pundits-blog/energy-environment/266850-flint-water-crisis-is-classic-case-of-environmental>
- Optional – Storyboard template handout for each student
https://natureworkseverywhere.org/asset/resources/Storyboard_Student_Handout.docx

Part 4

- Computer, Internet connection for teacher and students
- Students must have a Gmail account with the address ending in @gmail.com
- Projector for teacher
- Access to Google My Maps https://www.google.com/maps/d/?hl=en_US&app=mp
- Copies of the My Maps instruction handouts for student (could also be shared online)
https://natureworkseverywhere.org/asset/resources/My_Maps_Handout.docx
- Jane Addams Middle School Project – Google My Map Example
https://www.google.com/maps/d/viewer?mid=zAEQwI2rdp_M.kQ3-vIGQH18
- Example project calculator for Jane Addams MS – Excel File:
https://natureworkseverywhere.org/asset/resources/Jane_Addams_MS_Project_Calculator.xlsx
- Nature Works Everywhere video and lesson **How Natural Areas Filter Water**
<https://www.natureworkseverywhere.org/resources/how-natural-areas-filter-water/>

Nature Works Everywhere Themes:



Sustainable cities make use of natural and permeable surfaces so that urban run-off can be filtered of pollutants.



Sustainable cities have transportation systems that work for everyone while keeping our air cleaner by reducing greenhouse gas emissions.



The buildings and vehicles in sustainable cities utilize energy efficient technologies that cut emissions and in turn improve air quality.



Urban design solutions use natural areas and permeable surfaces to help protect cities from flooding due to storm water run-off.

Objectives:

The student will...

- Define “sustainability” in the context of urban design.
- Investigate and describe the major issues facing urban areas.
- Define the ecosystem services that exist in urban areas and explain how these services can be utilized to support sustainable urban design.
- Describe and examine nature-based solutions.
- Define and investigate the social and environmental justice concerns that surround urban development issues.
- Explore environmental justice issues using real data and current events.
- Explore ways to become more involved in community issues.
- Identify how cities (including your home city) can be more sustainable.
- Identify and research local urban issues and develop, communicate, and execute a plan to mitigate some of them.

- Utilize Google My Maps to measure urban surfaces and calculate percent change between existing surfaces and proposed improvements.

Next Generation Science Standards:

Disciplinary Core Ideas:

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

Crosscutting Concepts:

- Cause and Effect
- Stability and Change

Science and Engineering Practices:

- Asking Questions and Defining Problems
- Constructing Explanations and Designing Solutions
- Analyzing and Interpreting Data

Performance Expectations:

High School

- HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including costs, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Common Core Standards – ELA Science and Technical Subjects:

Grades 9-10

- CCSS.ELA-LITERACY.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- CCSS.ELA-LITERACY.RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

Grades 11-12

- CCSS.ELA-LITERACY.RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- CCSS.ELA-LITERACY.RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

AP Environmental Science Topics:

- Land and Water Use
 - Other Land Use
 - Urban Land Development

- Land Conservation Options
- Sustainable Land Use Strategies

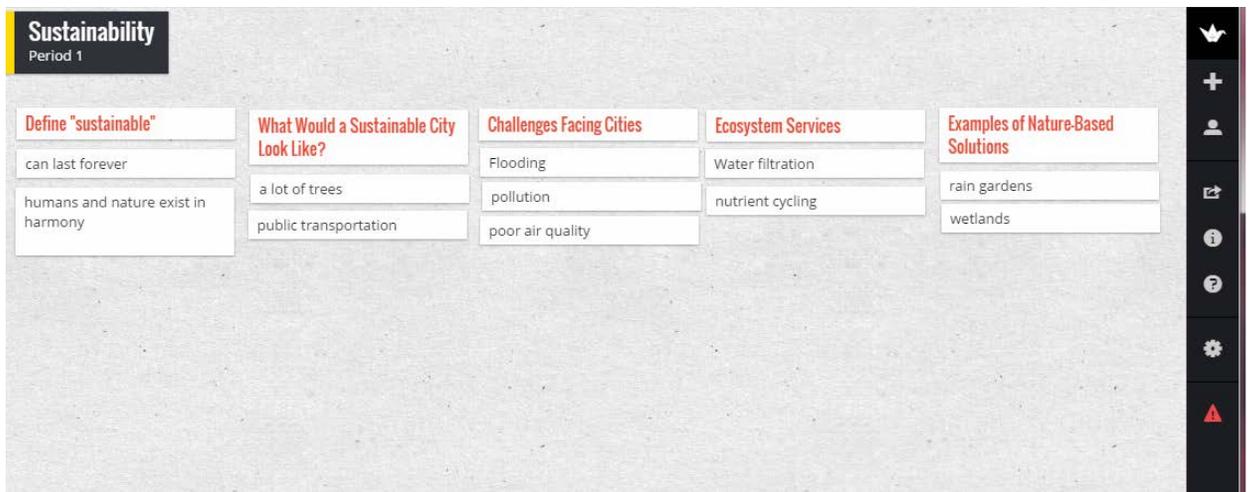
Vocabulary:

- **Anthropogenic:** Related to or resulting from the influence of humans.
- **Ecosystem services:** Services that nature provides for free. They are grouped into four categories including: supporting, provisioning, regulating, and cultural.
- **Environmental justice:** The fair treatment and meaningful involvement of people regardless of race, color, origin, or income with respect to the development, implementation, and enforcement of laws, regulations, and policies having to do with the environment.
- **Impervious:** Water cannot penetrate.
- **Nature-based solutions:** These types of solutions focusing on harnessing the power of nature, which exists for free, in order to help populations adapt to climate change, to mitigate the effects of climate change, protect ecosystem services, and increase resilience. These solutions help make development more sustainable while in turn protecting biodiversity and maintaining ecosystem services.
- **Permeable:** Water can penetrate.
- **Social justice:** The fair and just relationship between the individual and society, which includes societal institutions.
- **Sustainability:** Sustainability in an urban environment means to produce and maintain conditions where humans and nature can exist in productive harmony.

Part 1: LEARN - What does sustainable mean?

1. As an opening activity, have students state their definitions of “**sustainable**”. You can create a list on the board or if students have access to a device, they can populate a list using Padlet (<https://padlet.com/>) after you share the link to the Padlet. Alternatively you can have them create the list in a shared Google doc. An example of what this activity would look like in Padlet is below.

The [EPA describes that sustainability is based on one principle](#) that everything humans need for survival and well-being depends, either directly or indirectly on the natural environment. Creating sustainability in an urban environment means to produce and maintain conditions where humans and nature can exist in productive harmony.



2. Now have students apply their definitions of sustainability to living in a city. Ask them “**What would a sustainable city look like?**” and generate a list. You will use these lists throughout the lesson, it may be useful to refer to them and add where appropriate. Their answers will vary and are mostly based on opinion at this point. They can add to this list after watching a video and reading the article below. Encourage them to add to all lists if they think of something as you go along.
3. Next have students generate a list of some of the most common **challenges that cities face**. The list might include the following items:
 - Stormwater management, flooding, storm surge
 - Loss of natural areas and habitat (marshes, barrier islands, etc.)
 - Excessive heat, urban heat islands
 - Pollution, poor air quality
 - Disconnection from nature
 - Inadequate housing
 - Solid waste management, trash
 - Water quality

- Invasive species
 - Availability of healthy food
4. Now have students generate a list of things that nature provides for people or ways that people benefit from nature. These things are called “**ecosystem services**”. Ecosystem services are grouped into four categories: supporting, provisioning, regulating, and cultural. Examples are below. You can also project the chart found here (<https://freshwaterwatch.thewaterhub.org/sites/default/files/ecosystem-services-diagram.jpg>) when reviewing these services with students.
- Supporting: Nutrient cycling, primary production (plants), soil formation
 - Provisioning: Food, raw materials, water, medicine, energy, ornamental
 - Regulating: Carbon sequestration, decomposition, water purification, pest/disease control
 - Cultural: Inspiration, recreation, science, education
5. Show the *Nature Works Everywhere* **Sustainable Cities: Nature-Based Solutions in Urban Design** video at <https://vimeo.com/153948280>. While they are watching the video have them take notes on the projects shown in the video and describe how these solutions are nature-based. Have them define what it means to be “nature-based”. You can have them add their definitions to the lists on Padlet. Examples of nature-based solutions from the video include:
- Direct rainwater into gardens or wetlands, which absorb and clean water before it flow back into rivers
 - Mimic an upland forest to help filter water outflow
 - Mimic an ecosystem to help “process” materials that are in the system
 - Turn sewage into electricity, byproduct can be used as fertilizer
6. Next have students read the article “The 10 Cities That Are Leading the Way in Urban Sustainability” (<http://www.fastcoexist.com/3016816/the-10-cities-that-are-leading-the-way-in-urban-sustainability>) and summarize the characteristics that make these cities sustainable. They can add them to a final Padlet list called “**Sustainability Examples from Around the World.**” Examples from the article are below:
- Large and efficient urban transportation system
 - Energy efficient buildings
 - Carbon neutrality
 - Improved air quality due to cutting CO₂ emissions and air pollution
 - Containing urban sprawl
 - Green energy like wind projects
 - Improved landscaping and infrastructure in urban settlements
 - Adaptation and resilience plans
 - Waste management
 - Intelligent city infrastructure – real-time traffic data and electronic toll collection, which minimizes congestion

7. To wrap-up examine class lists that have been created:

- Definition of sustainability
- What would a sustainable city look like?
- Problems faced by cities
- Ecosystem services
- Examples of nature-based solutions
- Sustainability examples from around the world

Have students determine if the lists are comprehensive. If more items need to be added after the discussion, readings, and video – add them. Use these lists as guides for the rest of the lesson.

8. After students have both watched the video and read the article, have a class discussion and ask students the questions below. You may want to start a new Padlet specific to your city.

- What are some of the features that make these cities sustainable?
- How are these cities protecting their ecosystem services?
- Describe how ecosystem services and sustainability are connected.
- What are examples of sustainability in our own city?
- What might our city do better when it comes to sustainability?
- What are some issues that you think our city really struggles with when it comes to sustainability?
- List the things that people do that do not contribute to the sustainability of their city. If students are having trouble, you might prompt them by asking questions like – “if everyone in the world owned a gasoline powered car and drove it every day, would that be sustainable?”

9. Ask students to identify the items from the list in which they are most interested and try to identify which issues are faced by their community. This list will be the starting point for some of the activities that follow.

Part 2: EXPLORE - The Anthropocene - Investigating the Impact of Humans on the Earth

1. To provide context for how humans have shaped the Earth, have students explore the story map “Welcome to the Anthropocene” found here: <http://arcg.is/1uGgg6X>.
2. While students view this story map, have them answer the questions on the student handout found at the link below. A teacher answer key to this handout is on the next page.

https://natureworkseverywhere.org/asset/resources/Anthropocene_Student_Handout.docx

3. When students have completed viewing the story map, have a discussion with them. Pose the following questions:
 - Do you think that The Anthropocene is a good name for the present time period? Why or why not?
 - Describe the ways that humans are changing the Earth.
 - Which impacts seem easier to fix? Which impacts seem harder to fix?
 - Why are humans changing the Earth? Is it all bad? Are there good ways that we are changing the Earth?
 - What are the ways that you contribute to these changes?
 - Describe the things you would be willing to do to reduce your impact.
 - Discuss the ways that your city is trying to be more sustainable.

Investigating the “Anthropocene”

Student Handout -Teacher Answer Key

Go to <http://arcg.is/1uGgg6X> and explore the “Welcome to the Anthropocene” story map. Note that for many of the maps and images on the left side of the screen, you can click, drag and zoom to explore the maps in more detail. Where available, map legends are at the top of the screen.

1. What is the Anthropocene and how did it get its name?

It is an age shaped by human activity. It is named as such because humans have become the driving force behind many of the Earth's present day changes.

2. How are humans influencing the planet?

Population continues to increase – 7.2 billion people inhabit the Earth and that number is expected to rise to between 8.3 and 10.9 billion by 2050.

3. How much of the Earth's land surface (outside of ice sheets) is managed by humans? Describe how humans have modified the Earth's surface. Which areas (countries/continents) show the most “red”, which indicates a high level of human impact?

75% is managed by humans. Humans have modified the Earth's surface by mining, creating dams and dikes, farming, building roads and cities, and by logging. Some of the areas with the most impact are the eastern US, Europe, sub-Saharan Africa, Brazil, Central America, India, Eastern China, parts of Russian, Japan.

4. What percentage of the Earth's land is used for agriculture? Name three regions that have high agricultural productivity.

40% of Earth's land is used for agriculture. Northern India, parts of Europe, and the Midwestern US are three areas with high levels of agriculture. Parts of China and Indonesia also have significantly high levels of agriculture.

5. What percent of the Earth's forests have been lost? Name one county that appears to have the most significant deforestation by land area on the map.

50% of the world's forests have been lost. India appears to be largely deforested compared to other countries.

Investigating the “Anthropocene”

Student Handout - **Teacher Answer Key Continued**

6. How has biodiversity come under threat and how much of the world’s land are protected?

Extinction rates are now 100-1,000 times above normal levels. Only 10% of the world’s land area is protected.

7. On the map of protected lands, find an area or areas near you that are protected and click on them (they are green or blue in color). Write what the names of the areas.

Answers will vary.

8. For one of the protected areas near you – describe what makes the area unique (you may have to investigate this using the internet).

Answers will vary.

9. It’s not all bad! Humans have a lot of control over what happens next. Name at least two suggestions found in this story map for creating more sustainable cities.

Promoting pollution-free transportation through bike commuting, green rooftops to decrease the urban heat island effect, using desalination plants to turn brackish water into drinking water, solar-powered trash compactors, LED lighting, electric car charging stations.

10. How is your own city striving for sustainability? Can you find any examples of how your city and/or state are getting involved in this movement? Try to find 4-5 examples online and describe them here.

Answers will vary.

Part 3: EXPLORE - Social and Environmental Justice

Teacher Background

Social justice is the fair and just relation between the individual and society. The [Center for Economic and Social Justice](#) describes that “social justice is the virtue which guides us in creating...institutions. In turn, social institutions, when justly organized, provide us with access to what is good for the person...and in our associations with others. Social justice also imposes on each of us a personal responsibility to work with others to design and continually perfect our institutions as tools for personal and social development.” Social justice encompasses environmental justice – and together they are critical when examining the sustainability of cities. A sustainable city is not only a place where humans and nature can exist in productive harmony; it is a place where all people have equal access to resources and where all people have the same degree of protection from environmental hazards.

The EPA states that [environmental justice](#) is the fair treatment and meaningful involvement of all people regardless of race, color, origin, or income – in the development, implementation, and enforcement of environmental laws, regulations, and policies. Everyone should receive the same degree of protection from environmental and health hazards and should have equal-access to the decision-making process to have a healthy environment.

Suggested Flow:

1. For an opener, share with students the editorial cartoon found in the lesson “Using Editorial Cartoons to Teach Social Justice” (<http://www.tolerance.org/lesson/editorial-cartoons-povertyenvironmental-justice>). The cartoon depicts the disproportionate share of environmental problems that sometimes occur in areas with more poverty. The lesson associated with the cartoon provides a template that students could use while examining the cartoon. Share the cartoon and discuss the student analysis of the image (5-10 minutes).
2. To explore this issue in more detail, view the “Environmental Justice” lesson on Teaching Tolerance’s website (<http://www.tolerance.org/supplement/environmental-justice-high-school>). This activity will take about 45 minutes. In this lesson, students use maps and graphs to explore some instances of environmental injustice related to pollution in Connecticut and Massachusetts. Links to the maps and handouts used in the lesson are below for quick reference:
 - <http://www.tolerance.org/sites/default/files/general/air%20pollution%20map.pdf>
 - http://www.tolerance.org/sites/default/files/general/tt_biases%20in%20exposure.pdf
 - http://www.tolerance.org/sites/default/files/general/tt_effects_of_pollution.pdf
3. After students have examined the data in the lesson, have them describe environmental biases they may have observed in their cities and states. They can conduct a search on the

web to find if there are local organizations involved in addressing these issues and find out how to get involved.

4. Have students complete the “Make Your Voice Heard – Contact List” found here: https://natureworkseverywhere.org/asset/resources/Contact_List_Student_Handout.docx to record community groups that may be involved in advocacy and elected officials who could be contacted to show concern or support. It is important to remind students that becoming an informed citizen and participating in the democratic process are the first steps to transforming our world.
5. To take this activity a step further and explore a current event related to environmental injustice, have students read one or more of the articles below to gain background on the water crisis in Flint, Michigan and then following the instructions that follow to create a safe space for discussion.
 - Listen to the story on All Things Considered (8:00 min) and read the accompanying article: <http://www.npr.org/2016/02/01/465150617/flint-begins-the-long-process-of-fixing-its-water-problem>
 - Explore the timeline of events leading to the crisis: <http://www.nytimes.com/interactive/2016/01/21/us/flint-lead-water-timeline.html>
 - Articles about the crisis:
 - http://www.nytimes.com/2016/01/22/us/a-question-of-environmental-racism-in-flint.html?_r=0
 - <http://thehill.com/blogs/pundits-blog/energy-environment/266850-flint-water-crisis-is-classic-case-of-environmental>
6. Environmental justice and environmental racism may be controversial or emotional topics in your classroom. In order to have safe and productive discussions about the events in Flint and other environmental justice topics, you can help guide the discussion by focusing on the content and the facts contained in the resources. Guidelines for using discussion questions effectively can be found on the Center for Research on Learning and Teaching’s website (<http://www.crlt.umich.edu/node/956>).
7. While students are reading the articles above, have them consider the following questions and use these in a discussion following the readings:
 - What was the driver behind switching from Detroit’s water supply to the Flint River?
 - What problems associated with the water supply switch are described in the articles and timeline?
 - What surprised you about the information contained in the timeline?
 - How soon after the switch did residents notice a change in their drinking water?
 - How long did it take before any action was taken on the part of the local and state officials?
 - Do you think there are similar struggles in your communities? Describe them.
 - What are the challenges and barriers for communities to become more involved?
 - What resources might there be to become more involved? How would you find them?

Further Exploration:

- A. Have students create a tabbed story map about three of their local issues. They can use photo or video to document the problem and can provide a text description of the problem. After they have completed this lesson, they can add three more tabs with proposed nature-based design solutions that correspond to each problem they had previously identified. They can upload sketches or photos of similar design solutions in other cities to accompany their proposals.

Examples of award-winning story maps can be found here:

<http://www.esri.com/landing-pages/story-maps/contest-winners> to give you a sense of the variety of styles and uses.

If you chose to have students design a story map using Esri’s platform, you can go here to have them create accounts: <http://storymaps.arcgis.com/en/#>. They should choose the option to “create a free non-commercial public account to ArcGIS Online” which they will use to sign into the story map platform. The Story Map tutorial located here: <http://www.arcgis.com/home/item.html?id=d4a2705a8b224e71961404542ae94c6f> is a great resource that walks users through from account set-up through the story map building and sharing.

If you have students create a story map, it can be useful to have them storyboard out their map by on a three column chart where they type the text in the left column, images URLs or citation information, and URLs for clickable in text links to direct the reader to another website for more information on a topic. A storyboard template can be found here:

https://natureworkseverywhere.org/asset/resources/Storyboard_Student_Handout.docx

Story Map Text	Images with URLs or Citation Information	URLs for In-text Links

- B. For a more in depth local exploration of local issues, have students use the EPA’s EJSCREEN Tool (<http://www.epa.gov/ejscreen>) to explore national environmental indicator data and demographic indicators with a color coded map. EJSCREEN has the ability to generate reports for specific regions and can make comparisons between the state, the EPA region, and the nation. This is great tool for exploring your local environmental and demographic indicators simultaneously. These data could be a launching point for a more in depth investigation of the possible environmental justice issues in your area compared to the rest of the state or nation.

- C. Have students explore the Faces of the Grassroots Environmental Justice Video Contest winning videos at this link: <http://www3.epa.gov/environmentaljustice/events/video-contest.html>. An extension project could be to have students create their own environmental justice public service announcements or informational videos and/or multi-media presentations.
- D. Use the Teaching Tolerance lesson on the Gulf Oil Spill to explore more examples of environmental injustices: <http://www.tolerance.org/supplement/gulf-oil-spill-upper-grades>

Part 4: ACT - Use Google My Maps to Map the Community, Design, and Propose a Nature-Based Solutions Project

1. If you would like your students to do a community mapping project to determine community needs, check out Jane Goodall's Roots & Shoots guide to Community Mapping (<https://rootsandshoots.org/mapping>), which guides you through the entire process.
2. Students can use community mapping to tell the story of their city. They can look for the key features of sustainability listed in #3 below and assess where their city or community could use improvement. Community mapping is a great way to determine what enhancements can be made to make an area more sustainable. The outcomes of creating a community sustainability map might include the identification of areas where sustainable components already exist, community member interviews describing community needs, and proposed solutions that provide a design and vision for a city of the future where enhancements are made to increase the sustainability of the city.
3. In Part 1 of this lesson, students identified challenges that cities face, ecosystem services in cities, and features of a sustainable city. Go back to those lists that were created and compare the key features of urban sustainability listed below. Are all of these items included? Are there more to add? Use these lists as a guide to help students decide on a project where they can act on creating a sustainable city.

Key features of Urban Sustainability:

- a. Accessible public transport
- b. Walking and cycling are safe
- c. New construction is energy efficient
- d. Existing structures use energy-saving measures where appropriate
- e. Open space areas are present and safe, accessible
- f. Affordable housing is present
- g. Cultural and social resources available to all
- h. Waste is recycled whenever possible with a focus on re-use and reduction
- i. Renewable resources used where possible
- j. Healthy food choices are accessible to all
- k. Water management solutions are in place to address flooding and run-off
- l. Resources and services accessible to all (hospitals, libraries, etc.)

4. Given your subject area and the time allowed, students might only have time to work through the design and proposal phases of this project. But if time allows, the class may actually undertake the project at the school or in the community.
5. If you are looking for a specific project which your students can complete virtually and/or in their community, this next part of the lesson will guide you through a practical application of My Maps in Google (https://www.google.com/maps/d/?hl=en_US&app=mp) for designing and proposing a green urban design project to reduce impervious surfaces. The general flow of the project as described below could be applied to other urban design initiatives that might result from a basic community mapping as described in the [Roots and Shoots](#) guide above.
6. **Note that if your school is relatively new, it may not appear on My Maps, so it is important to check first to see if your school site can be mapped.** If not, you may wish to omit this part of the lesson or have your students choose another community location to improve.
7. In this lesson, students will use [My Maps](#) to find and measure impermeable surfaces in their community and propose solutions to reduce these surfaces or to mitigate their effects. You can set a percent change goal for students to reach and they must craft a proposal that meets that goal.
8. For an introduction to impervious surfaces, check out the Nature Works Everywhere lesson ***How Natural Areas Filter Water*** (<https://www.natureworkseverywhere.org/resources/how-natural-areas-filter-water/>) and corresponding video (<https://vimeo.com/77811268>). This lesson helps students understand the importance of natural surfaces versus impervious surfaces. Building off of that understanding, this activity allows students to investigate the surfaces around their school or area of choice and propose solutions for reducing impervious surfaces or reducing their impact. You may wish to show this video to kick-off the lesson.
9. If your students are already familiar with using Google documents and have their own Google/Gmail accounts, it will be fairly easy to conduct this activity. Students will need accounts that end with @gmail.com in order to login to My Maps. Accounts that are hosted by Google, but don't end in @gmail.com will not be able to login.
10. Using the features of Google Drive such as Google Documents, Sheets, and Slides are highly recommended as students can collaborate and share their final products easily.

11. The student handout located at:
https://natureworkseverywhere.org/asset/resources/My_Maps_Handout.docx provides instructions for using Google My Maps and for the calculations that will need to be conducted using either Google Sheets or Excel.
12. Assign students to small groups – these groups will work together on creating a proposal to improve an area around the school.
13. Start the lesson by taking students on a walking tour of the area around the school, including any rooftops if they are accessible. Have them make note of impervious surfaces. Depending on the type of building in which the school is located, you might have students count how many downspouts drain water from the building’s roof. Also have them take note of the existing green spaces like gardens and any other planted or grassy areas. While students are surveying the area, they should start brainstorming possible design solutions.
14. When you return inside have students work in groups to start mapping the impervious surfaces and existing green spaces by completing numbers 1-15 on the handout for both the impervious surfaces and existing green space.
15. Once students have mapped existing green space and impervious surfaces, they should start developing a plan of improvement. They can use the spreadsheet calculator here: https://natureworkseverywhere.org/asset/resources/Jane_Addams_MS_Project_Calculator.xlsx to do calculations in order to figure out by how much they will be increasing their permeable surface area. This is especially important if you have given them a goal.
16. They should work in their small groups to develop the plan and then add their proposed green spaces following the same instructions in 1-15 based on their calculations.
17. To provide inspiration, you may wish to show students how other schools have worked on similar projects. When they start to develop their proposal, they should search the internet for inspirational examples of their own to use to support their project proposal and presentation. A few examples of projects are below:
 - a. Da Vinci Rain Garden in Portland, OR https://www.youtube.com/watch?v=r_VoUIZHULM
<https://www.portlandoregon.gov/bes/article/78197>
 - b. Mount Tabor Middle School Rain Garden in Portland:
<http://artfulrainwaterdesign.psu.edu/project/mount-tabor-middle-school-rain-garden>
 - c. New York City Rooftop School Gardens
http://www.ryerson.ca/carrotcity/board_pages/rooftops/NYC_rooftop_school_gardens.html

18. Each group of students will likely have a different strategy. Students could present their proposals and the class could vote on the best proposal to bring forward to the school or community. You may also wish to include project budget guidelines. An example garden budget worksheet can be found here: <http://md.nutrition-education.org/tmp/GHHprogramplanning.pdf> but there are many more online.
19. Note that in My Maps, students can embed photos or movies into locations on their maps to help make their proposals more unique. For the proposed green spaces, they can upload a sketch or use a photo of a similar feature somewhere else. If you plan to have students present their proposals to the class, you can have them design a presentation using Google Slides.
20. If you plan to carry any of the proposals into reality, refer to this lesson on creating an Environmental Legacy at your school: <http://www.nature.org/about-us/careers/leaf/leaf-anthology-environmental-legacy-project-lesson.pdf>

Additional Resources:

If your students are interested in building rain gardens - there are more instructions at the links below. They could use the rain garden calculator to determine exactly how big their rain garden should be for the size of the building they are working around. This could be yet another math piece to add to their spreadsheets.

Students could use the rain garden calculator (below) to determine how many gallons of water a proposed rain garden would filter by using weather data for their location to find the average number of inches of rain per year.

- Rain Garden Handbook
<http://www.fairfaxcounty.gov/nvswcd/raingardenbk.pdf>
- Rain Garden Calculator
<http://raingardenalliance.org/right/calculator>
- Rain Gardens in the News
<http://www.king5.com/story/news/local/seattle/2015/09/21/the-roadside-rain-garden-why-seattle-is-going-green/72596410/>