

“Solutions-Oriented Learning” Storyline

HS- Urban Forestry: Designing the Urban Forest for Ecosystem Benefits

Storyline introduction and overview: This is a solutions-oriented storyline that leads students through a series of investigations to quantify and qualify the ecosystem and social benefits of an urban forest. At the end of the storyline, students will be able to design, evaluate and refine a chosen solution for urban forest ecosystem benefits.

Urban Forestry NGSS Learning Progression: The high school storyline is part of a larger learning progression that includes students mastering standards pre-K to 12th grade. Look at how the high school performance expectations fit in a continuum of learning for your student.

<p>Placemaking:</p> <p>Trees in an urban community provide many benefits as well present challenges to the community.</p>	<p>Anchoring phenomena:</p> <p>Trees are the cornerstone of the micro-environments that exist in urban settings.</p>	<p>Drawdown:</p> <p>Indigenous Peoples’ Forest Tenure</p> <p>Environmental Justice:</p> <p>Tree Equity in America’s Cities</p>
<p>Indigenous and other relevant cultural connections:</p> <p>Indigenous people: The First Scientists on the Land</p>	<p>NGSS PEs (progress towards):</p> <p>HS-LS2-7 Design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity.</p> <p>HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural, and environmental impacts.</p>	

Estimated time required to implement this storyline: 3-4 weeks

NGSS PEs:

HS-LS2-7 Design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

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HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural, and environmental impacts.

Science & Engineering Practice (SEP)	Disciplinary Core Idea (DCI)	Cross Cutting Concept (CCC)
<p>Constructing Explanations and Designing Solutions</p> <p>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.</p>	<p>For HS-LS2-7</p> <p>LS2.C: Ecosystem Dynamics, Functioning, and Resilience Moreover, anthropogenic changes (induced by human activity) in the environment — including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change — can disrupt an ecosystem and threaten the survival of some species.</p> <p>LS4.D: Biodiversity and Humans Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary) Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary) (Note: This Disciplinary Core Idea is also addressed by HSLS4-6.)</p> <p>ETS1.B: Developing Possible</p> <p>When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary)</p> <p>For HS-ETS1-3</p> <p>ETS1.B: Developing Possible Solutions When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.</p>	<p>Stability and Change Much of science deals with constructing explanations of how things change and how they remain stable.</p> <p>Connections to Engineering, Technology, and Applications of Science</p> <p>Influence of Science, Engineering, and Technology on Society and the Natural World</p> <p>New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.</p>

Materials:

Learning Session	Materials
5	Humidity: 1. Sling Psychrometers or two thermometers; one dry bulb and one wet bulb.

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	<p>2. Relative Humidity chart</p> <p>Wind:</p> <ol style="list-style-type: none"> 1. Paper or page in a notebook 2. String 3. Protractor (optional but handy to confirm angles) 4. Variety of weights such as paper clips, clothes pins, nails... <p>Sound:</p> <ol style="list-style-type: none"> 1. Anemometer or decibel meter app on cell phone or tablet <p>Soil Carbon:</p> <ol style="list-style-type: none"> 1. Butcher paper for drying soil 2. Screen door mesh 3. Propane barbeque or torch; or if available a kiln 4. Milligram scale <p>Diversity:</p> <ol style="list-style-type: none"> 1. Tape measure or string
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Learning Sessions

1.	Grounding Native Ways of Knowing:	Estimated time: Two 50 Minute periods
	<ol style="list-style-type: none"> 1. What past, present and future climate science decisions were made, are made, and will be made by indigenous cultures? Students discuss what it means to be a scientist on the land. 2. Students read the introduction to History of Science in Non-Western Traditions: Native America by Clara Sue Kidwell 3. After reading the Kidwell’s introduction, students revisit their discussion about what it means to be a scientist on the land. 4. Have their views changed? 5. There are six areas for your students to explore more deeply. Divide students into teams and have them explore an area and then present what they have learned about Indigenous People being the first scientists on the land. <ol style="list-style-type: none"> a. Culture and Environment b. Agriculture c. Environment Management 	

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- d. Medicine
- e. Astronomy
- f. Mathematics

[Traditional Ecological Knowledge](#), presented by the National Park Service, has over twenty current Indigenous explorations and practices of applying traditional indigenous knowledge to present ecological problems. Students can explore, discuss, and present on them.

To access information on how to reach out and build relationships with local tribes, visit the [OSPI Office of Native Education: Partnering with Tribes](#), and contact your district’s tribal liaison/Title VI coordinator.

To learn more about respecting and building upon Indigenous Peoples’ Rights visit the [Learning in Places website](#), a project led by Dr. Megan Bang then read Practice Brief #10: [Teaching STEM In Ways that Respect and Build Upon Indigenous Peoples' Rights](#) and Practice Brief #11: [Implementing Meaningful STEM Education with Indigenous Students & Families](#) published on the University of Washington’s [STEM Teaching Tools website](#)

Suggested activity for teachers and students: 3-2-1 research process

- Three new learnings about the Tribe most local to you
- Two questions that you still have about the Tribe most local to you
- One action you can commit to begin a partnership with the Tribe most local to you

To connect to native ways of knowing consider exploring the following ideas in connection with your local tribal nation by researching stories of the past and learn about current work and actions the Tribe is taking to mitigate, adapt to, and find solutions to a changing climate.

[Tribal Salmon Culture](#)

- [Importance of Salmon - Columbia River/Plateau | Teacher Resource](#)
- Internet Search: Spirit of the Trees: People of the Cedar (Northwest tribes)
- Internet Search: First People -- Why Trees Lose Their Leaves (a story of Pine and Maple)

2.	Phenomena: Trees are the cornerstone of the micro-environments that exist in urban settings.	Estimated time: 20 minutes
Students either go outside or explore their outdoors from inside to think about what trees are doing at this moment in the ecosystem.		

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3.	Pre-Assessment:	Estimated time: 40 minutes
HS-Urban Forestry: Designing the Urban Forest for Ecosystem Benefits Pre-Assessment HS-Urban Forestry: Designing the Urban Forest for Ecosystem Benefits Rubric		

4.	Guiding question: What are the characteristics of micro-environments? What micro-environments are observable?	Estimated time: 50 minutes
<p>Sit Spot</p> <ul style="list-style-type: none"> - Have students draw a map of their vicinity. Consider making sure the vicinity isn’t too large so as to inhibit exploration later. Have students do a gallery walk of their work so they can see what others included and didn’t include in their perception of their area. - As a class, norm the important elements to include in the map of your vicinity to study. After a map is drawn, such as on a white board, grid the map with the number of students in your class, or close to it. - Assign students to locations on the grid and have them bring a paper and pencil (science notebook preferred) to record observations based on the five senses as they sit and observe an area for a period of time. Have them rotate periodically to experience different places. Consider having students observe 2 or more places, gather them to discuss what they noticed, then observe more. - After having the opportunity to observe the different areas of your vicinity have students categorize the grid locations into generic areas of similar natural features/micro-climates, such as the different sides of a building, the presence of trees and vegetation, open areas of different types (asphalt, grass), natural features, landscaping etc... - NOTE: Observations are more varied on days with sunshine and wind as the contrast of shade and protected areas from wind show greater contrast in experience. It may not be possible to plant the weather, but if there is flexibility, consider the forecast. 		

5.	Guiding question: What measurable factors contribute	Estimated time:
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	to using urban forests as a solution to climate change?	Variable -- 50 Min per investigation
<p>Investigations</p> <p>Teacher Notes: Review Lesson 3. Introduce a variety of factors that trees contribute to minimizing the human impacts on urban communities. How can those be measured? Classes can be split up into groups who will measure different variables and then present to the class for faster results, or the class can rotate through each of the 5 investigations to provide more experience to more students. After completing the investigations, present and discuss the data and discuss the characteristics of different microclimates.</p> <p>Use water investigation:</p> <ol style="list-style-type: none"> 1. Students investigate how the presence of trees influences the humidity in a micro-environment. At the end of the investigation, students write a claim supported with their data as how measuring humidity can provide evidence of how trees decrease climate change. Humidity Investigation 2. Students investigate how the presence of trees minimizes the impact of wind in an urban community. At the end of the investigation, students write a claim supported by their data as to how by decreasing wind, trees are decreasing climate change. Wind Investigation 3. Students investigate how sound can be an INDIRECT or INDUCTIVE measurement of how trees provide benefits that are not easily measured such as air pollution, or well-being as a result of less traffic noise. Sound Investigation 4. Students investigate whether there is a correlation between diversity of an urban forest and the overall health of the urban community. Forest Diversity Investigation 5. Students investigate the role of soil in storing carbon captured by the trees. In this investigation, students measure the amount of soil carbon. At the end of the investigation, students make a claim supported by their data as to how trees increase soil carbon and therefore decrease carbon dioxide levels in the atmosphere. Soil Carbon Investigation 		

6.	Guiding question: What factors are considered in designing an urban forest?	Estimated time: 30-60 minutes
<ol style="list-style-type: none"> 1. iTree Design is a browser-based application that allows users to input a structure and tree location and determine average benefits. <ul style="list-style-type: none"> - Use Teaching with itree or the tutorial in the appendix to learn how to use the program. Introduce students to iTree Design OR have students use the resources to explore and learn how to use the application themselves. - Students play with the application either individually or in groups and explore how the changes in location, species of tree as well as time differences affects overall benefits. 		

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	<ul style="list-style-type: none"> - Use the scenario in the appendix titled “iTree Lesson Scenario” to challenge students to use iTree to make a recommendation of tree plantings or... - Ask students to propose two tree species plantings and location at a site of their choice, or at school. Have students compare and contrast the differences and make a recommendation based on specific criteria of their choice or yours based on local concerns such as stream protection, heat, etc. - Extension Option - Explore iTree Species - this application, similar to iTree Design, helps students select specific trees based on specific criteria. <p>2. Teachers: Invite an Urban Forest Guest Speaker (landscape architect, urban forester, urban biologist, Conservation District Land use planner, urban planner, Lands Council, social scientist, etc.) to meet with class virtually or in person to discuss career and evaluate the benefits and network of a healthy urban forest. Include Q & A time.</p>
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7.	Guiding question: What are the consequences of manipulating an ecosystem?	Estimated time: 90 minutes
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	<p>Manipulating microenvironments</p> <ol style="list-style-type: none"> 1. Use the graphic on the Biodiversity Factsheet under the sub section Goods and Services to jump start the discussion. Students discuss the question “Can micro-environments be ethically manipulated to benefit urban environments? What concerns surface regarding ethical and equitable manipulation of micro-environments in urban ecosystems?” 2. Many organisms engineer environments for their benefit and sometimes this impact surfaces new challenges when changes introduce complications. Students research and present examples of other species that manipulate the environment for their benefit and the consequences of these manipulations. 3. Planting trees in an urban environment may be a more thought-provoking topic than simply considering tree benefits over time. Residents in some neighborhoods may have experienced the challenge that managing urban trees now outweighs downstream benefits like sequestered carbon, energy savings, air quality, water infiltration, and general quality of life from decreased crime and increased property values. Students discuss the social factors involved in using urban forests as a solution to climate change.
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	<ol style="list-style-type: none"> 4. Use the following readings and search for networks in your community that could be developed to accommodate sustainable urban trees in a growth cycle. <ol style="list-style-type: none"> a. Bringing-new-life-fallen-urban-trees b. Reclaimed urban wood 5. Search your region for network partners that might benefit from a conversation about urban trees as a resource and invite stakeholders to an online poster presentation session and networking event or, if possible, seek funding and plan in-person networking with refreshments, time for students to share opportunities they have learned to develop urban trees as a sustainable resource.
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8.	Guiding question: What are the criteria and constraints to be considered in using urban forestry as a solution to climate change?	Estimated time: 90 minutes
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	<p>Scenario: SpoCanopy is a City of Spokane Urban Forestry program that collaborates with The Lands Council to ensure every person in every neighborhood in Spokane, Washington has access to trees and green space.. The following links reflect on the urban canopy solutions balancing some of the challenges culminating, similar to the SpoCanopy example, in a response to an urban forest challenge: Urban canopy- The Lands Council and Urban Forests and Climate Change</p> <p>Most are in agreement urban areas benefit from trees, but what are some of the challenges to the argument. An article from The Conversation raises some of the issues, and you may be able to think of more. Exploring multiple sides to an issue results in prepared dialog and better overall solutions.</p> <ol style="list-style-type: none"> 1. Students review Design Specifications for Tree Planting to see how the author used criteria and constraints in his design. 2. Students read the article from The Conversation Our-cities-need-more-trees-but-that-means-being-prepared-to-cut-some-down and create a list of challenges identified. Then, join in a group conversation with your learning team about these issues and see if your group can raise others. Do a little research for examples of these problems in other communities as well as resulting solutions. Now, assess your community for examples where one or more of the challenges is evident. 3. Reconvene your team of student scientists for a discussion about the validity of these challenges. Did your observations reveal the concerns are valid? If so, now, like SpoCanopy, your team can derive solutions to incorporate for urban forestry management in your community. 4. Whole class or in groups: Based on information gleaned throughout recent studies, students examine the existing terrain in their own neighborhood/community or (if real- 	
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	<p>life exploration is not possible) use online evaluative tools to find a location where an urban reforestation project may be used to solve real-life issues in the micro-environment.</p> <ol style="list-style-type: none"> a. For ideas of potential improvements: <ol style="list-style-type: none"> i. A Guide to Washington State's Urban Tree Canopy ii. I-tree is a great tool for this - whether planning for a “neighborhood” or a specific parcel of land. i-Tree Design <p>5. After determining potential solutions to mediate complications with urban forestry, meet with stakeholders, evaluate solutions, and refine potential methods to implement them. Publish the results: share these findings in a letter to the editor of your local paper, write a blog entry, submit an article to a local journal, make a poster to share with a local tree nursery, invite a panel of potential partners to join in a conversation about the challenges and potential network of service opportunities in your urban forest economy.</p>
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9.	Guiding Question: How can the overall environmental stability be improved in an area impacted by human activities?	Estimated time: Three 50 minute periods
	<p style="text-align: center;">Designing and Assessing Field-Based Solutions</p> <ol style="list-style-type: none"> 1. Students address a negative impact in an area in their local community by defining a local environmental or social issue that they would like to resolve using urban forestry; 2. Using scientific reasoning, students explain the proposed solutions to the issue. 3. Students describe and quantify the criteria for their solution. 4. Students evaluate their solution by rating the criteria (cost, safety, reliability, and overall impact on environmental stability). Students will justify their rating using information from their research. 5. Students refine their solution to improve one of the rating numbers from #4. <p>Pacific Education Institute’s Field Design: Engineering Design for Field-Based Applications Guide is an excellent resource to support this and similar projects. Additionally, in the guide appendix, you will find a Solutions Analysis tool students can use to evaluate possible options.</p>	

10.	Post -Assessment:	Estimated time: 40 minutes
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HS Urban Forestry: Designing the Urban Forest for Ecosystem Benefits Post-Assessment HS-Urban Forestry: Designing the Urban Forest for Ecosystem Benefits Rubric

11.	Possible next steps/off-ramps/actions: What are the consequences of manipulating an ecosystem?	
	<ul style="list-style-type: none"> • Write an effective grant proposal that includes the following elements: <ol style="list-style-type: none"> a. Short Overview b. Examination of a Need or Problem c. Description of your project d. Estimated Budget e. For info on grant writing check out the following sites: <ol style="list-style-type: none"> I. Planning and writing a grant II. Grants 101 3.) Get involved with an existing reforestation activity. With instructor approval and guardian authorization, students may participate in a pre-arranged volunteer project with a local organization/nonprofit. After participating in the project, students will provide signed proof of participation in the project. Student must also provide a written description of the activity that includes the following information: <ol style="list-style-type: none"> a. A description of the organization that facilitated the activity; b. Location of the activity; c. Improvement made to the existing space; d. What quantitative measures were improved by the project? 	

[OER Tracker](#)

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