NUTSHELL
In this lesson, students identify some of the benefits urban forests can provide. They will explore the connection between urban heat islands and urban forests and conduct their own heat island investigation on their school grounds. To conclude, students will participate in a game to help them review urban benefits and write a few paragraphs about their local urban forest.

ENDURING UNDERSTANDINGS
- The tree canopy retains stormwater, reduces heat island effects, absorbs pollutants, and provides wildlife habitat. These benefits are important and quantifiable. (Subconcept 6)
- Urban forests affect the physical and psychological health of human residents. (Subconcept 7)
- A healthy urban forest can provide economic benefits including reduced energy costs, reduced stormwater runoff, increased property values and jobs. (Subconcept 8)
- Urban forests help reduce the effects of climate change on communities.

ESSENTIAL QUESTIONS
- What are the ecological, economic, social and climate benefits of urban forests and tree canopies?
- How can urban forests play a role in reducing the impacts of climate change?

OBJECTIVES
Upon completion of this lesson, students will be able to:
- Describe benefits the tree canopy provides.
- Explain that urban forests affect the physical and psychological health of human residents.
- List the economic benefits of a healthy urban forest.
- Explain the important role of urban forests in climate mitigation or solutions.

SUBJECT AREAS
Language Arts, Social Studies, Science

LESSON/ACTIVITY TIME
Total Lesson Time: 150 minutes
Time Breakdown:
- Introduction   **TREES OR NO TREES**   30 minutes
- Activity 1   **WISCONSIN URBAN HEAT ISLANDS**   45 minutes (climate update)
- Activity 2   **INVESTIGATING LOCAL HEAT ISLANDS**   45-60 minutes (climate update)
- Conclusion   **NAME THAT BENEFIT**   30 minutes

MATERIALS:
FOR STUDENTS
- **Student Resource Sheets 1-2; *3 & 4* optional*, 5 & 6***
  https://docs.google.com/presentation/d/1gQ-fU20agx3LeIlArfHHWwUGlFJLzxC74BnIZ77x3JA/edit?usp=sharing
- Device for looking at online ArcGIS map *(optional)*
- Tools/Instruments for investigating local Heat Islands - Infrared Thermometers, Indoor/Outdoor Thermometers, etc. *(optional)*

FOR THE TEACHER:
- **Educator Resources 1 - 6**
  https://docs.google.com/presentation/d/1i_nC5kVAo-hbDhx6yJDVzPqS1_wIb1gBTXgM8JntIcU/edit?usp=sharing

VOCABULARY
Canopy: The leaves and branches of a tree or group of trees.
Carbon Sequestration: The capture and storage of carbon dioxide from the atmosphere into biotic (e.g., trees) or abiotic (e.g., coal) pools of carbon.
Evapotranspiration: The loss of water by evaporation from the soil surface and by transpiration from plants**.**
Forest: An ecosystem that is characterized by a dominance of tree cover and contains a variety of other organisms (e.g., other plants, animals).
Green Space: An area in a city, town, or village, containing mostly plants with few buildings, roads, or other structures.
Heat Island: The phenomenon that, because concrete and asphalt absorb and radiate heat, cities are five to nine degrees warmer than rural areas.
Runoff: Water that flows on the surface of the ground.
Urban Forest: A forest ecosystem that includes all the trees and other vegetation in and around a town, village, or city. Plants, people, and animals are part of the urban forest.

BACKGROUND
Canopy, or tree canopy, is a term used to describe the leaves and branches of a tree or group of trees. In an **urban forest**, tree canopy is important to the potential benefits the forest may provide. In general, the more area it covers and the denser the canopy, the more benefits the trees can provide. Although one tree is better than none, 100 are better still. Whether the benefits are from one tree or many trees, they are all still real and most can be quantified in some way. Often, forest benefits are divided into three categories: social, economic, and ecologic. It is difficult to divide the benefits that the urban forest canopy provides into these categories because so many benefits fall into more than one.

SOCIAL BENEFITS
Just as with a rural forest, an urban forest provides many benefits. Numerous studies have been done about the social and psychological benefits of "green" in urban environments. The findings of the studies make a strong case for the importance of urban forests.

A study done with children with Attention Deficit Disorder (ADD) found that children with ADD and ADHD showed milder symptoms and were better able to focus and concentrate after playing in natural, green settings, than in settings where concrete was predominant.

Urban public housing residents who lived in buildings without trees and grass nearby were asked about how they cope with major life issues. They reported more procrastination and assessed their issues as more severe than residents with green nearby. In another study, residents with green views reported that they used reasoning to resolve conflicts within their families rather than violence.

Urban areas with high levels of tree canopies have been shown to have less crimes than those with little or no tree canopy. This is true for both property crimes and violent crimes. While green space, in general, is better for mental health, areas with larger trees (higher levels of tree canopies) and more open space are considered safer than areas with a lot of small trees and shrubs.

In addition to these specific studies, access to nature also provides humans with other social benefits. Parks and other green spaces provide a space for people to play, walk, jog, birdwatch, or just sit quietly.

These activities are good for our physical health in a society that is increasingly sedentary. It is also good for our mental health by providing a place to unwind. Trees also reduce noise levels.

ECONOMIC BENEFITS

The economic benefits of urban forests are increasingly being documented. Economics often becomes the language used when it comes to urban forest management. Budgets of municipalities must cover an array of services, and the benefits of an urban ecosystem must often be proven to secure funding. A 2005 study that considered the costs and benefits of municipal forests in five U.S. cities, the researchers found that for every dollar spent, the benefits returned were worth from $1.37 to $3.09. A more recent study (2018) conducted by the Northeast-Midwest State Foresters Alliance Urban and Community Forestry Committee found that for every dollar generated in urban forestry in Wisconsin, another $0.63 was added to the state. In addition, for every job in urban forestry in Wisconsin, an additional 0.34 jobs were added to other economic sectors in Wisconsin. The total economic contribution of Urban forests in Wisconsin (2018) was $1.57 billion.

Trees save money through reduced energy costs. Cities create what is referred to as a **heat island**. The concrete, asphalt, buildings, and other surfaces absorb and hold heat from the sun. During hot summer days, cities can be five to nine degrees warmer than surrounding areas. Shading, evapotranspiration, and wind speed reduction provided by trees help conserve energy in buildings. A study conducted in Minneapolis, Minnesota, showed that trees placed in the proper location can reduce total heating and cooling costs by eight percent. The Urban Forestry Economic Analysis of Wisconsin completed by the Northeast-Midest State Foresters Alliance (2018) found that, "Urban trees can also mitigate electricity or fuel usage by cooling their surroundings during warm seasons or blocking winds during cold seasons. It is estimated the state's urban trees help avoid 500 million kwh of electricity usage, valued at $74.4 million, and 8 trillion btu of fuel usage, valued at $66.4 million."

Homeowners not only reduce costs of heating and cooling their homes, but increase the value of their property by planting trees. Research suggests that property value can increase three to seven percent when trees are present. Trees also make homes and neighborhoods more desirable places to live.

One economic benefit that urban trees can provide, but often don't, is one based on products. Municipalities and tree services across the country have come up with ways to use the wood that is cut from an urban forest. Products range from specialty furniture, to musical instruments, to lumber for park shelters, to artwork. These products from the wood of trees being removed could be used to defray the cost associated with the removal, making trees an even better investment.

ECOLOGIC BENEFITS

Benefits often fall into more than one category. Such is the case for energy savings. Not only does reducing energy consumption save money, it has ecological benefits as well. With reduced energy consumption comes reduced pollution. According to a publication by the USDAForest Service, urban forests provide four main air quality benefits:
- They absorb gaseous pollutants (e.g., ozone, nitrogen oxides, sulfur dioxide) through leaf surfaces.
- They intercept particulate matter (e.g., dust, ash, pollen, smoke).
  - They bind or dissolve water-soluble pollutants onto moist leaf surfaces.
  - They capture and store larger particulates on leaf surfaces which may be waxy, resinous, hairy, or scaly.

- ○ They also capture and store particulates on rough bark surfaces. •
- They capture carbon dioxide and release oxygen through photosynthesis.
- They transpire water and shade surfaces, which lowers air temperatures, thereby reducing ozone levels.

Water runoff from rainfall can be a challenge in cities. Most of the methods used for runoff control create a host of problems such as pollution, failure to recharge groundwater, and loss of wildlife. Trees have a positive impact on this problem. For example:

- Leaves and branch surfaces intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows.
- Roots create air spaces in soil and therefore increase the rate at which soil absorbs rainfall and the capacity of soil to store water. This reduces runoff.
- Tree canopies reduce soil erosion by diminishing the impact of raindrops on bare soil.
- Transpiration through tree leaves reduces soil moisture, increasing the soil's capacity to store rainfall.
- When runoff is reduced, the number of pollutants entering groundwater, rivers, and lakes decreases.

Reducing water runoff from storms with trees also falls into the economic benefit category. As water is slowed and absorbed or evaporated, it avoids being forced into a storm sewer. Less water entering the storm sewer system means less cost to treat it.

Don't forget that trees provide habitat for animals in urban areas, just as they do in rural forests. This increased wildlife presence makes a healthier ecosystem and certainly makes it a more interesting place for us to live.

PROCEDURE
INTRODUCTION - TREES OR NO TREES
1. Hand out **Student Resource 1**, **What's the Difference?** to each student. Give students a few minutes to jot down some of their notices about each image and the similarities and differences between the two images. As a group, discuss what some of the notices are *(Image A - street, stoplights, people, cars, buildings, signs, parking lots; Image B - street, trees, stoplights, a lot of cars, flower pots, person walking, people biking)* Discuss what the similarities they see in the images *(cars, streets, traffic lights, people, urban area/city, downtown, tall buildings and short buildings)* and the differences *(image B has a lot of trees and planters, image B has more cars, Image A has parking lots and parked cars and image B has moving cars).*
2. Have students partner up. Hand out **Student Resource 2, Let's Make a Match** to each pair of students (or have them turn their papers over if you have copied this as a double-sided sheet). Give students a few minutes to read each question and decide which answer they think is correct.
3. Discuss the answers as a class. For fun, have students use sign language to hold up a letter A or B before you reveal the correct answer.
   - 1 - A, trees help reduce noise; since picture A has no trees it will be louder there than in picture B
   - 2 - Without trees to shade the sidewalk, it gets hot. The shade of a tree helps reduce the sunlight hitting concrete and asphalt. That keeps the surface cooler so Willow doesn't hurt her feet.
   - 3 - B, Green space and trees make a more desirable neighborhood where people want to live.
   - 4 - A, Trees and other plants help slow the water that falls to the ground during a heavy rain. Also, where there is a tree, there is at least some soil. Soil can absorb the rain, while concrete or asphalt channels it into the stormwater system. Since image A doesn't have trees to slow water down, or soil to absorb water, water has to go into storm drains.
   - 5 - A or B, Trees help remove air pollution with their leaves. Air pollution contributes to asthma attacks so B is better in that case. However, trees produce pollen which can also contribute to asthma attacks in people who have allergies, so A might be better in that case.
   - 6 - A, When trees are used to shade a building, energy costs are reduced because the air conditioner doesn't have to run as much. Without trees it will be hotter in picture A.
   - 7 - B, People prefer to be outside where there are trees and flowers. When people are outside more they generally have better mental and physical health.
   - 8 - B. Trees (and even the flower planters) provide shelter and food for animals to live in the city.
   - 9 - B, Trees take in CO_2 through photosynthesis and store carbon in their trunks and roots.
   - 10 - B, Communities with a lot of trees may need to hire an urban forester and/or arborists to help care for the forest and trim trees that are old or damaged by weather events.

ACTIVITY 1–WISCONSIN URBAN HEAT ISLANDS - CLIMATE UPDATE

1. Introduce students to the concept of **urban heat islands**. Explain to them that urban heat islands occur when cities have a high concentration of asphalt, concrete, buildings and other surfaces that absorb and retain heat from the Sun's rays. This is called the urban heat island effect and it increases energy costs and consumption (for running air conditioners). It also increases the risk for heat-related illness and even death.

2. Tell students that according to the Wisconsin Initiative on Climate Change Impacts, the average annual temperatures in Wisconsin could increase by 2.5-7.5 degrees Fahrenheit by 2055. In addition, the number of days with temperatures of 90 and 100 degrees Fahrenheit are also expected to climb. Share the WICCI maps found on **Educator Resource 2 and 3, Projected Days Per Year With A Maximum Temperature Above 90/100°F**. Ask students what they observe in the 100° Map *(All areas in WI had 2 or fewer days with temperatures above 100°F from 1981-2010; About two-thirds of the state is projected to have 2-4 days above 100°F from 2041-2060)* Ask students what they observe in the 90°F Map *(Most areas of Wisconsin have fewer than 10 days with temperatures above 90° from 1981-2010; From 2041-2060 most areas have an increase in days above 100°F by at least 10 or 20 days; number of days with temperatures above 90°F is projected to increase almost everywhere throughout WI)* Ask students how this might impact people living in Wisconsin. *(more illnesses-especially for those who are weaker like younger children and the elderly, potentially more deaths as well).*
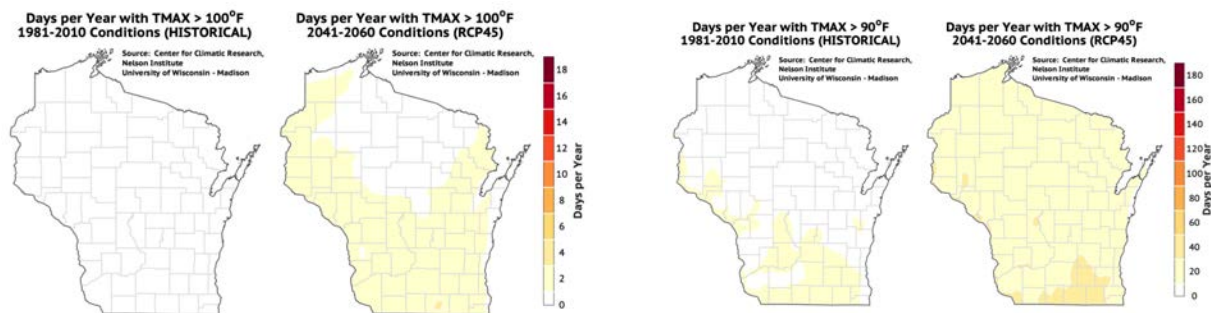
3. **OPTIONAL (but highly recommended)** Show students the "Extreme Heat - Climate Wisconsin" Video by PBS Wisconsin Education. The video can be found at this link: https://pbswisconsineducation.org/climate-wi-story/extreme-heat/ or in **Educator Resource 4, Extreme Heat - Climate Wisconsin**. Ask students if the video shows any additional ways people might be impacted by urban heat island effect in Wisconsin that they hadn't thought about. *(increased anxiety and frustrations/anger, discomfort, increased costs of air conditioning or other forms to cool).*

CASE STUDY: MILWAUKEE

4. Show students the Milwaukee Urban Heat Island Map. You can access it at this link: https://experience.arcgis.com/experience/2d6e905a42e645998d72a29466312af7 or in **Educator Resource 5, Milwaukee Urban Heat Island Map**. Explain to students that the map shows air temperature distribution throughout the city of Milwaukee on July 21-22, 2022 and that the data was collected by citizen scientists using car-mounted sensors as part of a project led by the Wisconsin Department of Natural Resources, Groundwork Milwaukee, and the Milwaukee Metropolitan Sewerage District. The image on the slide in **Educator Resource 5** shows the data from the morning. Click on the link to go to the actual map to see data for the afternoon and

evening as well. Ask students to make observations as you click from map to map (be sure to hide one view before looking at a new view). Encourage students to ask questions about what they observe. (Better yet, give students a copy of **Student Resource 3 & 4, Milwaukee Urban Heat Island Exploration** and have them complete this activity with a partner using the map on their own device. Encourage them to click on each layer multiple times and zoom in/out on the map as they examine it.) Ask students what the maximum temperatures were at each time of day. *(Morning - about 75°F, Afternoon - about 95°F, Evening about 88°F)* Ask students where the temperatures were the highest *(in the central part of the city)*. Ask the students where the temperatures were the lowest *(the further away from the city, usually the lower the temperatures).* Ask students what they notice about the amount of green (trees, plants, etc in the area surrounding the City of Milwaukee. *(The closer you get to Milwaukee, in general the less green space.* Turnoff all layers. Describe what color you see throughout most of Milwaukee - is it green space? *(no, looks more tan/brown, like buildings and roads with a little green throughout).* Tell students to zero their focus in on the larger green spaces within the City of Milwaukee. Turn the Afternoon Temperature layer on and off. Ask what they notice about the green spaces compared to the surrounding spaces *(they remain cooler - in many cases by5 °F or more)*. Ask students to share other observations they have.

5. Ask students what they think cities like the City of Milwaukee can do to **mitigate** (lessen) the impact of the Urban Heat Island Effect? *(Plant more trees - care for trees…larger trees have a larger canopy and can provide the most shade.)* Share that Trees are a climate solution and an Urban Forest benefit for this reason AND those discovered during the introductory activity.

CASE STUDY - LA CROSSE

6. Use this link to access Chloe Hilles article, *Urban heat islands identified in La Crosse neighborhoods due to lack of tree canopy, impervious surfaces*, posted in the La Crosse Tribune on July 19, 2023. Share it with students online or via print copies.
   https://lacrossetribune.com/news/local/urban-heat-islands-identified-in-la-crosse-neighborhoods-due-to-lack-of-tree-canopy-impervious/article_b8af251a-259d-11ee-a505-033b4a913d15.html

7. Share **Educator Resource 6, La Crosse Heat Islands** with students. Discuss how even though La Crosse is much smaller than Milwaukee and located on a river near forested bluffs, it still has areas within the city that experience the Urban heat island effect.

8. Read the article in the most suitable format for your class. LEAF recommends reading it aloud and discussing it along the way. Ask students to listen for answers to the following questions:

La Crosse Heat Island Map
Areas of the city with the least green space were reported to have temperatures up to 8 degrees warmer than other areas.

Lowest: 87.52°F
Highest: 95.5°F
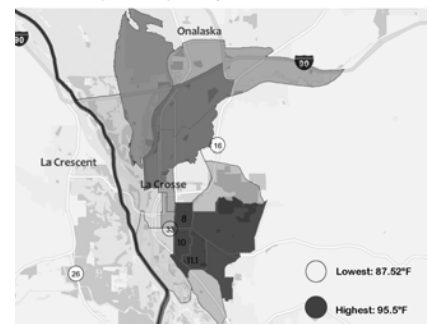
Sources: City of La Crosse Green Space Expansion, UW-Madison and the Census Bureau
Saskia Hatvany graphic, River Valley Media Group

   - What is the cause of the Urban Heat Islands in La Crosse? *(lack of tree canopy, excess impermeable - hard, built - surfaces; specifically near the Industrial district and Trane, and the Gunderson and Mayo hospital campuses)*
   - Who/Where are the vulnerable populations impacted most by La Crosse's Urban Heat Islands? *(minority and lower-income populations / Census tracts 8, 10, and 11.01 experience temperatures 10 degrees hotter than surrounding neighborhoods)*
   - What are recommended solutions and how do they help? *(Increasing urban vegetation including a tree canopy expansion planting trees - provide shade and increase evapotranspiration which cools the air; creating pocket parks - increase transpiration;*

green roof construction - increase transpiration; Increase albedo/paint surfaces white - reflects sunlight and reduces heat)

9. Ask students if urban heat islands can only happen in cities with large populations. *(no, they can be found anywhere there is a lack of tree canopy and a lot of impervious surfaces)*

ACTIVITY 2–EXPLORING LOCAL HEAT ISLANDS - CLIMATE UPDATES

1. Gather tools that students can use to determine if areas around the schoolyard are heat islands. The best tool, if available, is an Infrared Thermometer. Inexpensive infrared thermometers can be purchased locally or online through many vendors. They can also be checked out (for free) in the Energy Audit Kit from the Wisconsin Center for Environmental Education at this link: https://www.uwsp.edu/wcee/wcee/kits/energy-audit-kit/ . Other indoor/outdoor thermometers can be used, but may need to be placed and left in locations for a while so they register accurate temperatures (if you are using these thermometers, consider "planting" them in specific locations around the school your students may wish to test in advance of this activity). You can also tell students that they need to use their own senses to make observations. Consider the best procedure for allowing students to test any/all locations they think of while also making sure all students are safe and supervised.

2. Ask your students if they think there are any heat islands located around their school. *(yes - there can be large differences in areas commonly found near most school buildings)* Ask them if there are any (outdoor) locations they think would be cooler or more comfortable around their school. *(yes)* Tell them that during this activity, they are going to explore the area around the school for evidence of local heat islands and locations that are cooler. Explain the tools they will/won't have access to to complete the exploration.

3. Divide the class into groups of 2-4 students. Pass out copies of **Student Resource 5-6, Exploring Local Heat Islands,** to each student. Although students will work in groups, each student is responsible for their own learning and should complete their own sheet. Allow students about 10 minutes to complete **Student Resource 5**.

4. Ask students to think about the best way to record the data they will need to confirm/deny their hypothesis. Provide students with about 5 minutes to create data tables on **Student Resource 6.**

5. Take students outdoors to conduct the exploration. Students should make all necessary observations/collect all necessary data for each location and record it in their tables.

6. Once everyone is done collecting data, head back indoors - or to a good outdoor working location so students can analyze their data, record results and conclusions and think about what they have learned.

7. When everyone has finished the activity, discuss the results. Where did students expect to find heat islands? Why? Where did students anticipate it being cooler/more comfortable? Why? Were they able to collect significant data to prove/disprove their hypothesis? Explain why/why not. Were there factors that made testing/making observations challenging? Where were the local heat islands/cool locations? What do they think makes these areas hotter/cooler? Did they see connections between trees or impervious surfaces and heat islands? What did they learn?

EXTENSION

8. Compile student data and have them create a thermal map of the school grounds similar to the Milwaukee Urban Heat Island Map where red represents "hot" spots and blue/purple represents "cooler" locations with orange, yellow, and green being utilized for temperatures in the middle.

CONCLUSION - NAME THAT BENEFIT

1. Divide students into two teams . Tell them they will have 5 minutes to come up with as many benefits of Urban Forests as they can think of. The benefits can be ones discussed in the lesson today OR can be benefits that have not been discussed.

2. Tell students that there will be at least 10 rounds of the game (there are 14 words/phrases listed and some can be repeated - you could play 15 or more rounds) and they have to designate 10 people to participate. For each round, you will say a word or phrase that can be linked to an urban forest benefit. Their job is to think of an example of an urban forest benefit related to that word or phrase before the person from the other team does. The first person to raise their hand (or some other task - hit a buzzer, etc.) gets to answer the question. If they give a correct answer, their team gets a point. If they give an incorrect answer or fail to give an answer, the other team can steal the point by having a correct answer. The same benefit cannot be used more than once by students but the same words/phrases can be used more than once by the teacher. Continue the game until you complete all rounds and have covered many forest benefits. The team with the most points after the designated number of rounds wins.

   WORDS/PHRASES
   - Habitat
   - Heat
   - Rain
   - Pollution
   - Sound
   - Privacy
   - Jobs
   - Mental Health
   - Water Quality
   - Money
   - Physical Health
   - Crime / Violence
   - Soil
   - Light

3. Ask students to think about the urban forest in their community - ask them to write one paragraph describing the urban forest in their community and one paragraph about the specific benefits the urban forest in their community provides. Ask them to come up with at least one thing they would like to see the mayor, village president, town board, city council, etc. do to improve the quality of the urban forest in the community and at least one thing they, personally can do to care for or improve the quality of the urban forest in their community.

ADDITIONAL RESOURCES

LEAF

The lessons listed below, for the LEAF Wisconsin K-12 Forestry Education Lesson Guide, contain possible enhancements, extensions, or replacements for Urban Forest Lesson Guide: 5-8 Lesson 2.

- **UNIT 5-6 LESSON 5: WE ALL NEED TREES** Students learn about the values of forests and their impact on the environment by categorizing values and writing and producing a commercial. Use 5-6 Lesson 5 Activity and Conclusion after Urban Forest Lesson Guide: 5-8 Lesson 2 to broaden the idea of forest values for students. The lesson includes values outside urban forests.
  https://www3.uwsp.edu/cnr-ap/leaf/SiteAssets/Pages/5-6-Wisconsin-Forestry-Lesson-Guide/5-6L5.pdf
- **UNIT 5-6 FIELD ENHANCEMENT 1: WOOD'S WORTH** Students make their own tree scale sticks and use them to calculate the number of projects that can be made from individual trees. They also go on a scavenger hunt to explore many ways that forests are valuable. Use the Pre-activity, Introduction, and Activity 1 of 5-6 Field Enhancement 1 in any area with several trees with a 10-inch diameter or more. The lesson can be used as additional information about the economic benefit of rural trees for products. Activity 2 can be used if you have a wooded site.
  https://www3.uwsp.edu/cnr-ap/leaf/SiteAssets/Pages/5-6-Wisconsin-Forestry-Lesson-Guide/5-6FE1.pdf
- **UNIT 7-8 LESSON 5: MANY FORESTS, MANY VALUES, MANY REASONS** Students assess forest values and discover how forests shape the economy, environment, and society using games, story analysis, and brainstorming. Use 7-8 Lesson 5 as written or use the Introduction and choose activities as time allows to expand the value discussion in your class to the values of all forests.
  https://www3.uwsp.edu/cnr-ap/leaf/SiteAssets/Pages/7-8-Wisconsin-Forestry-Lesson-Guide/U78_L5.pdf

OTHER:

Article

- **The little-known physical and mental health benefits of urban trees** by Dana Nuccitelli, 28 Feb 2023, YALE Climate Connections an initiative of The Yale Center for Environmental Communication and Yale school of the Environment.
  https://yaleclimateconnections.org/2023/02/the-little-known-physical-and-mental-health-benefits-of-urban-trees/?utm_source=Weekly+News+from+Yale+Climate+Connections&utm_campaign=203df0c150-EMAIL_CAMPAIGN_2023_03_02_04_34&utm_medium=email&utm_term=0_e007cd04ee-c6e925287e-%5BLIST_EMAIL_ID%5D