



Fight for the Stars: Be a Knight for the Night ©

Grades 4 & 5

Lessons 1-7

Welcome!

This curriculum aims to teach students about light pollution. Students will learn about its causes, effects, and solutions as they dive into the past, present, and future of light pollution in our world. The rhythms for all forms of life, from animals to humans to plants, stem from the natural patterns of day and night, so when this is disrupted by artificial lights, there can be severe repercussions. There are simple actions such as shielding a light that can be taken to reduce light pollution, but many people have not received adequate information surrounding light pollution and its causes, effects, and solutions. Therefore, this curriculum aims to raise awareness by teaching students about light pollution. The majority of light pollution stems from the lack of knowledge about the things that are causing this problem.

My hope in creating this curriculum is that students, teachers, parents, advocates, etc. will have a concise place to learn and teach about light pollution. With every person who gains knowledge about light pollution, we are one step closer to seeing better and saving our stars!

Logo Note

The logo incorporates the knight from the game Chess that is referenced in this curriculum's name. This knight is meant to remind students that, similar to the game of Chess, advocating for the night sky and the stars takes strategy and knowledge, both of which students will gain from this curriculum. Through this curriculum, students will learn strategies to preserve and protect the night sky and all its benefits. Students will soon learn that fighting for the stars is worthwhile and fun!

Curriculum at a glance

This Fight for the Stars[©] curriculum aims to teach students around fourth and fifth grade about light pollution. Throughout these seven lessons, students will become knowledgeable about the effects of light pollution and the ways we can fix lights to reduce light pollution. The curriculum ends in a culminating activity which allows students the opportunity to become citizen scientists and take data on light pollution in their community using the Globe at Night program. By completing this curriculum, students will not only learn about light pollution but also have a tangible way to create beneficial change in their community.

Each lesson contains several different sections. Here is an overview of what to expect from each section.

- ★ Student Objectives
 - This section is a list of what students should gain from this lesson.
- ★ Activity
 - This section contains games and other activities for students to complete. On the Online Training portion of the txnsf.org website, you will find the Level 1 Downloadable Handout Packet. This packet contains any special documents you may need for these activities. The original links to any of these wonderful educational materials produced by others are documented here in this Curriculum. They have been downloaded and gathered in the packet for educational purposes only.
- ★ Demonstrations (Demos)
 - This section is a great way for students to learn through watching and doing rather than listening and talking. Most of these Demos are videos.
- ★ Key Discussion Phrases
 - This is the main section of each lesson where much of the formal learning happens. In this section, you will find potential talking points to spark conversation and teach your student(s) about that lesson's topics. Important phrases are **bolded**.
- ★ Extension of Learning and "Why is this important to me?"
 - This section lists ways you can incorporate this knowledge into other aspects of teaching. This could be other topics to talk about or an informal way to remind students of what they have learned. This section also includes ways you can make these lessons personal for your student(s) so that they realize that light pollution affects all aspects of our lives.

Each of these lessons has a corresponding video. These videos follow along with the lesson walkthroughs below. You can use these videos to help teach your student(s). You may be prompted to pause the video to contribute to the teaching, but the videos will take the load off you and teach (mostly) by themselves. These videos can be found at txnsf.org/online-learning/.

Standards Alignment

This curriculum is pertinent to the following TEKS (Texas Essential Knowledge and Skills):

- Science
 - 4.2.B The student is expected to: collect and record data by observing and measuring, using the metric system, and using descriptive words and numerals such as labeled drawings, writing, and concept maps
 - 4.2.E The student is expected to: perform repeated investigations to increase the reliability of results
 - 5.2.C The student is expected to: collect and record information using detailed observations and accurate measuring
 - 5.2.E The student is expected to: demonstrate that repeated investigations may increase the reliability of results
 - 5.3.A The student is expected to: analyze, evaluate, and critique scientific explanations by using evidence, logical reasoning, and experimental and observational testing
 - 5.9.A The student is expected to: observe the way organisms live and survive in their ecosystems by interacting with the living and nonliving components
 - 5.9.C The student is expected to: predict the effects of changes in ecosystems caused by living organisms, including humans, such as the overpopulation of grazers or the building of highways
- Language Arts
 - 4.1.A The student is expected to: listen actively, ask relevant questions to clarify information, and make pertinent comments
 - 4.1.D & 5.1.D The student is expected to: work collaboratively with others to develop a plan of shared responsibilities
 - 4.3.B & 5.3.B The student is expected to: use context within and beyond a sentence to determine the relevant meaning of unfamiliar words or multiple-meaning words
 - 4.6.D & 5.6.D The student is expected to: create mental images to deepen understanding
 - 4.6.E & 5.6.E The student is expected to: make connections to personal experiences, ideas in other texts, and society
 - 4.6.F & 5.6.F The student is expected to: make inferences and use evidence to support understanding
 - 4.6.H & 5.6.H The student is expected to: synthesize information to create new understanding
 - 4.7.F & 5.7.F The student is expected to: respond using newly acquired vocabulary as appropriate
 - 5.1.A The student is expected to: listen actively to interpret verbal and non-verbal messages, ask relevant questions, and make pertinent comments

- 5.13.A The student is expected to: generate and clarify questions on a topic for formal and informal inquiry
- History/Social Studies
 - 4.9 & 5.9 The student understands how people adapt to and modify their environment
 - 4.20 The student understands the impact of science and technology on life in Texas
 - 4.23 & 5.26 The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings
 - 5.23 The student understands the impact of science and technology on society in the United States
- Technology
 - 3-5.1.A The student is expected to: create original products using a variety of resources
 - 3-5.4.A The student is expected to: identify information regarding a problem and explain the steps toward the solution

This curriculum is pertinent to the following NGSS (Next Generation Science Standards):

- 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost
- 3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem

Light Pollution Curriculum Lessons Overview

Lesson 1: How humans have been connected to the night sky through the ages. What is this light pollution that is causing us to lose that connection?

Theme: Light pollution affects each of us.

Lesson 2: Ecological issues with light pollution.

Theme: The loss of the night sky affects our world (e.g. animals and plants) in a negative way.

Lesson 3: How does light pollution affect people?

Theme: Our bodies need naturally dark skies.

Lesson 4: Non-ecological problems and why this all matters.

Theme: Light pollution's effects on our whole world are important to pay attention to (glare, light trespass/private property rights, safety & security, saving money & energy).

Lesson 5: What causes light pollution and how can better lighting reduce it?

Theme: The root causes of light pollution are mostly fixable.

Lesson 6: How each of us can help. How do we encourage good lighting at home and/or in our community?

Theme: Using this knowledge, we can help to lessen this problem in our communities.

Lesson 7: Culminating activity (Globe at Night / Adopt a Street).

Theme: By completing this activity, you will be able to create real change in your community.

Student Objectives

- Students will read the book *Cassandra and the Night Sky* by Amy Jackson.
- Students will learn about naming conventions of constellations.
- Students will create their own constellation.
- Students will learn about human connection with the night sky over time and what that connection has inspired.
- Students will learn what light pollution is.
- Students will connect their own experiences with the night sky to light pollution.
- Students will observe a sunset/sunrise and think about their personal connection with it.
- Students will imagine the experiences of animals who are affected by light pollution.
- Students will learn about fireflies' process of finding a mate and how it may be affected by excess light.
- Students will learn about the growth and processes of plants like soybeans and trees and how they are affected by light pollution.
- Students will continue to expand their understanding of light pollution.
- Students will learn about the Circadian Rhythm.
- Students will learn about the ill effects of light in the blue wavelength.
- Students will learn about Melatonin.
- Students will connect blue light and Melatonin to investigate how our sleep is affected.
- Students will learn about light trespass and how it can affect humans.
- Students will observe the night to continue to connect with the night sky.
- Students will learn about glare.
- Students will discuss our feeling of safety paired with a false sense of security that glare and unshielded lights can provide.
- Students will continue to learn about light trespass and how and why to fix it.
- Students will begin to discuss how shielding a light can allow the owner to reduce the amount of light needed therefore saving money and energy.
- Students will design and create their own light shield to prevent glare and reduce light pollution.
- Students will learn about the Kirtland's Warbler.
- Students will play a game to imagine the Kirtland's Warbler's experience migrating and nesting while competing with light pollution and human impact.
- Students will continue to connect the ecological effects of light pollution with glare.

- Students will learn and practice how to categorize light fixtures as acceptable or unacceptable.
- Students will investigate how shielding, brightness, and color correlate to the type of light fixture and the type of light source.
- Students will learn the Five Principles for Responsible Outdoor Lighting and discuss how those principles can influence a light's effect on light pollution.
- Students will practice using the Five Principles to discover whether a light is acceptable or unacceptable and how it could be improved.
- Students will practice identifying a solution for a problematic light.
- Students will create, learn about, and practice how to use their sky chart.
- Students will be introduced to the Globe at Night program and their own involvement in the program.
- Students will learn how to take data on light pollution in their own community.
- Students will learn how they can extend their knowledge beyond this curriculum.

Lesson 1: Our Human Connection to the Night Sky

How humans have been connected to the night sky through the ages. What is this light pollution that is causing us to lose that connection?

Light pollution affects each of us.

Student Objectives

- Students will read the book *Cassandra and the Night Sky* by Amy Jackson.
- Students will learn about naming conventions of constellations.
- Students will create their own constellation.
- Students will learn about human connection with the night sky over time and what that connection has inspired.
- Students will learn what light pollution is.
- Students will connect their own experiences with the night sky to light pollution.
- Students will observe a sunset/sunrise and think about their personal connection with it.

Activity #1 Walk Through

This activity consists of the following steps

1. Read *Cassandra and the Night Sky* by Amy Jackson (or show video).
2. Discuss the origins of constellations.
3. Students create their own constellation of a non-fictional, modern day hero.

An introduction to the activity could look something like this: “When does your family tell stories? It could be at dinner or before you go to bed or maybe on the ride home. For a long time, people would tell stories in the moonlight under the stars. This was one way that people would connect to the night sky. Now, we’re going to read a story about the night sky!”

Cassandra and the Night Sky written by Amy Jackson tells the story of a greedy king who steals all the stars in the night sky. After growing up without stars, a princess named Cassandra becomes her kingdom’s hero and returns the stars to the night sky. This book demonstrates how important the stars are to our world and tells the story of some of the constellations through the heroine Cassandra. If you have access to this book, please read it to your students, but if not, Amy Jackson’s reading of *Cassandra and the Night Sky* can be found through this link:

<https://www.youtube.com/watch?v=9lXt7EdyfqM>.

Constellations are stars that seem to create recognizable patterns, pictures, people, or objects. Over time, constellations have been known by many different names and associations. One theme of naming and creating constellations throughout vast cultures and times has been to name constellations after heroes, such as our constellation Perseus found in the Northern sky named after the Greek hero.

For this activity, students may be split into groups or may work individually. Their task is to act as modern astronomers who are deciding to replace the old constellations based on modern heroes. Encourage students to think of non-fictional modern heroes, from celebrities to actors to sports stars to scientists to activists.

Hand out one of the star maps found at this link and also found in the Level 1 Downloadable Handout Packet accompanying the Fight for the Stars© videos: https://www-tc.pbs.org/seeinginthedark/pdfs/family_heros_charts.pdf. Remind students that their constellation does not need to look like a person; their constellation could be a symbol. For example, if a student chooses Serena Williams, they could find the outline of a tennis racket, or if a group chooses Beethoven, they may find the outline of a piano.

Encourage students to think outside of the box to connect our world with the night sky. Once students have created their modern constellations, let them share their constellations with the class, friends, or family and emphasize our world's connection to the stars and the night sky.

Key Discussion Phrases

“In that activity, we connected the stars to our modern heroes! Many, many people from all over the world, for many years, have looked up to the stars for inspiration! These people felt so connected to the stars that they created stories about them.”

“Humans have created artwork, songs, stories, and more to connect with the night sky. Now let's watch a video about how the night sky has affected the people in our world throughout history!”

The video can be found at this link: <https://youtu.be/8lvfBXdGjAM>.

“For thousands of years this connection between humans and the night sky and its stars has grown stronger. However, recently it has been getting harder and harder for us to see the stars at night. This is because of light pollution. Can anyone tell me what light pollution is? Think about what pollution is and what light is.”

“Light pollution is similar to trash pollution that you might have seen before! Trash pollution is when people put trash on the ground or somewhere else trash shouldn’t go instead of putting the trash in a trash can. Light pollution is just like this: when people put light where it isn’t needed, such as in a park that’s closed at night, they are creating light pollution! **Light pollution is when human made lights make the world filled with more light than it should be and pollute our night sky.** Also, these human-made lights put too much light where light isn’t needed or wanted. These artificial lights can be any outdoor light after dark, from street lamps to porch lights. When used wrong, these lights glow so bright that we aren’t able to see the stars as well.”

“Since we rely so much on artificial light after dark, we spend less time looking at stars and are slowly losing such a strong connection with the nighttime. The nighttime is very important! It’s a time when we get to rest, and important things happen in our brains and bodies while we sleep. At night, stars, planets, constellations, the moon, and more light up the sky. Have any of you been stargazing or looked at the moon? Is there anything special you have noticed at night?”

- Let a few students share experiences after dark to demonstrate connection.

“Now, imagine if you weren’t able to see the stars and planets because the lights around you were too bright! Luckily, as we go through these lessons, you will learn that there are many ways to help make our lights safer for us and for the night sky. This way, we will still be able to see the stars in a thousand years!”

Activity #2 Walk Through (Available in the Level 1 Downloadable Handout Packet)

Now that you have learned about constellations and the human connection with the night sky, you will get to go outside and experience the nighttime for yourself! If you are not able to go outside, find a window where you can see outside to do the activity. Student(s) should go outside with a responsible adult (or look outside) at sunset or sunrise to answer the following questions:

1. Can you see any stars, the moon, or planets?
2. Does the sun rise/set or is the Earth moving?
3. Why do you think we call it rising/setting?
4. What do you notice about the sky before and after sunrise/sunset?
5. What is your favorite part about being outside and looking up at the sky?

Extension of Learning and “Why is this important to me?”

- Two optional Junior Ranger activity sheets, A-Mazing Galaxy and Solar System Smarts and Planet Walk, are included in the Level 1 Downloadable Handout Packet.
- Discuss with students the rotation of the Earth and the orbit of Earth around the Sun as a follow up from the Sunrise/Sunset Activity. A helpful activity can be found at this link and is included as an optional activity in your Level 1 Downloadable Handout Packet:
https://astrosociety.org/file_download/inline/9048b9ee-9941-4ac7-8be6-eca1c88cc414.
- What is a star? Information about stars can be found here:
<https://science.nasa.gov/astrophysics/focus-areas/how-do-stars-form-and-evolve>. Students are innately curious, so teaching them about what a star is will fuel more curiosity when they look at the night sky.
- An activity follow up could take the form of talking about their answers to the questions. A discussion about what they saw and how they felt will create more of a connection with the night sky.
- If you are talking about a hero (e.g. scientist, celebrity) during another time, you could bring up the hero constellation activity to remind them of our important connection with the stars.

Lesson 2: Ecological Components

Ecological issues with light pollution.

The loss of the night sky affects our world (e.g. animals and plants) in a negative way.

Student Objectives

- Students will imagine the experiences of animals who are affected by light pollution.
- Students will learn about fireflies' process of finding a mate and how it may be affected by excess light.
- Students will learn about the growth and processes of plants like soybeans and trees and how they are affected by light pollution.
- Students will continue to expand their understanding of light pollution.

Key Discussion Phrases

“Close your eyes. Imagine you are a baby bird learning to fly and how to find your own food. It’s a warm summer and there’s lots of food! You and your bird siblings are learning so much from your parents. As the seasons start to change from Summer to Fall, the air starts to get a little cooler. Just before Fall approaches, it’s time for your first migration South to spend the winter in a warmer climate where there will be plenty of food. As you fly South, what guides your way? How do you know where to go? You use the sun, the moon, and the stars to find your way South.”

“Now open your eyes. What happens to those birds when the sky is not dark enough to see the moon and stars? What happens when manmade lights like streetlights are confused with stars? **The migration of birds, butterflies, and moths and the navigation of everything from sea turtles to dung beetles can be easily thrown off track because of distracting lights that animals confuse with the stars and moon.** To protect these animals, we need to turn off our lights and dim needed lights.”

“Have any of you been outside near a flashlight at night? You might have seen that many insects are attracted to your light. Sometimes, lights are left on all night. Whether it’s a porch light, a streetlight, or another light, moths and other insects could be attracted to a light for the entire night! Imagine if you spent your entire day looking at a light instead of doing important things like school and eating! **When insects spend**

their entire night attracted to a light, they do not have time to mate, lay eggs, and do other important things.”

“Okay, let’s review some! Can someone tell me what happens when a bug sees a light left on during the night?” (answers should be along the lines of the bug is attracted to it)

“That’s right! And what important things should those bugs be doing during the night?” (answers should be along the lines of pollinating and mating)

“Right again! Those bugs should be pollinating and reproducing, but instead they’re attracted to the light! When those bugs don’t mate, they don’t have babies, and their population shrinks! Not only is this bad for the bugs, but it also affects all of the animals that rely on bugs to eat. That means that owls, frogs, armadillos, and more wouldn’t have enough to eat! This is why it’s so important for each of us to turn off outdoor lights at night when we are not using them. That way, the bugs, owls, armadillos, and frogs will be so much happier! Frogs wait for darkness to call a mate or forage for food and take about 3 hours after lights are turned off to proceed with these natural life processes.”

“Another animal that is affected by our lights are fireflies/lightning bugs! North America has over 150 named species of fireflies. Each one will only mate with their own species. Each species has their own blinking pattern. What happens when our artificial lights are so bright they can not find each other?”

Activity #1 Walk Through

For this activity, you will need a room that can slowly become darker and a flashlight. This activity will demonstrate to your student(s) how much harder it is for fireflies to see each other’s flashes when there is light pollution. If your student(s) do not know what fireflies or lightning bugs are, please show a picture and explain that they flash their “tail lights” during the night, especially during the Summer.

First, it is important for students to understand why fireflies/lightning bugs flash. There are many, many different types of fireflies. Each of these kinds of fireflies have a different light rhythm. For example, one kind of firefly may light up for five seconds and rest for thirty seconds while another lights up for ten seconds and rests for ten seconds. These light rhythms are how fireflies find fireflies of the same type! You can demonstrate this to your student(s) by clapping a rhythm and asking them to repeat after you. This way, you and your student(s) can “find” each other like the fireflies.

Next, start with the lights on and use the flashlight to flash a rhythm. This can be as simple or as complicated as you want. It is better for you to face the flashlight so that they can not directly see the source of light. Continue showing them this rhythm as you slowly dim the lights. Ask students to clap the rhythm, so they can see that it is harder to identify when the lights are bright.

After the student(s) have come to the conclusion that it is easier to identify the rhythm with the lights turned off, connect this to the fireflies/lightning bugs. The student(s) should imagine themselves as the fireflies trying to find a firefly of the same kind. “Isn’t it easier for you to see the rhythm when it’s dark?” When there is light pollution, it is a lot harder for fireflies to see light rhythms! It’s important that humans turn off our lights so that the fireflies can find each other!

Key Discussion Phrases



Photo Courtesy Nebraska Extension Service

“In this picture, what do you notice about the field? Why do you think there are waves of green crops beside the ripe (brown) crops?”

“Well, **the crops in this picture grow based on the balance of daylight and darkness** around them. Because of those lights on the highway, the soybeans planted there think it is still summer. In the summer, the days are longer, so when the lights are left on all night, the plants think the days are longer, like in the Summer! The waves of green plants surrounding the lights are the areas of plants that the lights reached and made them think the days were longer. Because the plants never got enough darkness, they were never ready to be harvested! Trees are also affected by nearby lights. Think about a tree during Fall when it’s losing its leaves. A tree knows when to lose its leaves because the days begin to get shorter, and the night gets longer. So, when a tree is around a light during the night, it thinks that the days are longer, and the tree doesn’t lose its leaves! A tree needs to lose its leaves to save water and energy to survive the winter!”



Material Review // Activity #2 Walk Through



This activity will be used to physically demonstrate light pollution. It may be useful to review what light pollution is before going into the activity. For this activity, you will need a room that can be made dark and a flashlight such as one that can be found on a phone.

In a dark room, point the flashlight down at the ground. Show the student(s) that the flashlight allows them to see the ground. Then, look up at the ceiling, where the flashlight is lighting up the ceiling even though you are not pointing the flashlight up.

This activity can be compared to a streetlight or other outdoor light. These lights are meant to illuminate the space/ground below them, but end up spewing light up and around, creating the light pollution that disconnects us from the sky. To take this activity further, discuss how the flashlight could be fixed so that the light only lights the intended area and reduces light pollution.

Extension of Learning and “Why is this important to me?”

- When outside near a bird, ask students to recall what they remember about a bird’s migration and how it may be affected by light pollution.
- Encourage students to think about how an artificial light could affect or harm nearby animals and plants after dark.

- Ask students to consider: If light pollution affects animals and plants in these ways, how might light pollution affect us?

Lesson 3: Human Components

How does light pollution affect people?

Our bodies need naturally dark skies.

Student Objectives

- Students will learn about the Circadian Rhythm.
- Students will learn about the ill effects of light in the blue wavelength.
- Students will learn about Melatonin.
- Students will connect blue light and Melatonin to investigate how our sleep is affected.
- Students will learn about light trespass and how it can affect humans.
- Students will observe the night to continue to connect with the night sky.

Key Discussion Phrases

“What are your daily routines? What are things that you do every day?”

“Even though all of us do different things during our day, most of us do the same thing everyday... sleep at night and work and play during the day. Our bodies rely on the sun and the darkness to tell us what time it is. If our bodies see the sun above us, we know that it’s daytime, and when it gets dark, our bodies know that it’s time to go to sleep.

Our bodies use the sun and the darkness to keep a daily routine. The fancy name for this routine is called the Circadian Rhythm. This rhythm is how our bodies balance sleeping and being awake.”

Demo #1 Walk Through

In this demo, we will be discussing how bright artificial light, especially in the blue wavelength, disrupts our ability to sleep well. The demo can be found in Lesson 3’s corresponding video.

Key Discussion Phrases

“As we saw in the demo, most lights have blue light in them. Can someone recap what blue light is for me?”

“That’s right! Blue light is a kind of light that lots of light bulbs give off. Blue light is very bad for human health. It can confuse our Circadian Rhythm and confuse our bodies about what time it is. Phones and other electronics produce blue light. Because of this, phones or other lights can make our bodies think that it’s daytime when it’s really nighttime.”

“When we are surrounded by natural darkness, our bodies produce a chemical called Melatonin. **Melatonin helps us sleep and is what makes us feel well-rested.** How do you feel when you don’t get enough sleep? Do you feel grumpy and tired?”

“It doesn’t feel very good when you’re tired, right? That blue light we were talking about earlier can stop our bodies from making the chemicals we need to sleep well. That makes us feel very tired, and it is also harmful to our bodies. When our bodies don’t make enough Melatonin, it is harder for our bodies to fight diseases like cancer and obesity and can increase our likelihood to become depressed. Two ways we can be sure to get enough Melatonin is by reducing time on electronics before bed and limiting lights that give off blue light. We all want to stay healthy and get enough sleep! **It is important to get blue light from the sun during the day. It is just as important to keep the blue light away before we go to bed!**”

Demo #2 Walk Through

Now that we have learned about what blue light is and why it’s bad, we are going to explore how to keep that blue light out of our houses if there is a light outside their house. This demo can be found in Lesson 3’s corresponding video.

Activity Walk Through

(Nighttime Senses Observation Activity Available in the Level 1 Downloadable Handout Packet)

It’s important for your student(s) to realize how important natural darkness is to our health. Not only does the dark help us sleep, but it also protects us from illnesses and other unhealthy habits. For this activity, students should go outside with a responsible adult once it is dark (or look outside if they can not go outside). Students should turn off any artificial outdoor lighting that they have control of. Then, they should focus on the senses, answering the following questions to help them connect with the nighttime.

- Can you see the moon and the stars?
- What is the brightest thing you see?
- Close your eyes and listen. What do you hear?
- What can you smell?
- What can you feel using your sense of touch? Is there any wind?

- Does the air feel different at night than during the day?

Extension of Learning and “Why is this important to me?”

- Two optional Junior Ranger activity sheets, Deep-sky match and Scavenger hunt tic-tac-toe, and Smart Stargazing, are included in the Level 1 Downloadable Handout Packet.
- In this lesson, we juxtaposed daylight and darkness. Continue this by discussing the importance of sunlight (i.e. Vitamin D, circadian rhythm, etc.).
- Encourage students to spend time before bed only using warm temperature lights that emit less blue light.
- Discuss with students what they noticed during their nighttime observation. This will help them connect with the night sky.
- Continue the discussion of human health and diseases from lack of darkness.
- Discuss with your student(s) why the Moon looks different on different nights. This video can be very helpful for understanding this concept:
<https://www.youtube.com/watch?v=wz01pTvuMa0&list=LLVTrCP-E5zF-ug81Olv-qCA&index=231>.
- When spending time outside, talk to your student(s) about the importance of the sun and spending time outside. Then, compare that with the importance of spending time in the darkness (which isn't necessarily outside).

Lesson 4: Non-ecological Components

Non-ecological problems and why this all matters.

Light pollution's effects on our whole world are important to pay attention to (glare, light trespass/private property rights, safety & security, saving money & energy).

Student Objectives

- Students will learn about glare.
- Students will discuss our feeling of safety paired with a false sense of security that glare and unshielded lights can provide.
- Students will continue to learn about light trespass and how and why to fix it.
- Students will begin to discuss how shielding a light can allow the owner to reduce the amount of light needed therefore saving money and energy.
- Students will design and create their own light shield to prevent glare and reduce light pollution.

Demo Walk Through

Now that we know that light pollution is too much light where we don't want it and how light pollution affects us and plants and animals around us, it's time to learn about light pollution's non-ecological problems. This video is a demonstration of light pollution and one way to make the problem better. The demonstration can be found at this link:

<https://www.youtube.com/watch?v=XTjR4vef8JU&feature=youtu.be>

Key Discussion Phrases

"Thank you, Scott! That was a great demonstration. Now let's do a quick review. I want everyone to brainstorm three ways that light pollution negatively affects humans, plants, and animals. Take a couple minutes to think about three things we've learned in the past couple lessons. Then, I want you to share with me the three things you came up with."

"You came up with some great examples! In Scott's demonstration, what did he show us that adds to our understanding of light pollution? What did he do to make it better? What kind of light did that represent in our own lives? Where could you find that kind of light in our lives?"

“Exactly! Scott showed us a light that could be a streetlight in your neighborhood. And he made it look so much better by actually covering up the source of the light! Now Scott used a word for this: **glare**. Glare is what happens when a light directly hits your eyes. Imagine a bright light shining right into your eyes! Imagine how uncomfortable that light would make you! You would probably shut your eyes, right? Well, that light was creating glare. **When a light is so bright that it’s uncomfortable or distracting to look at, we say that light is creating glare.** That light is both uncomfortable and it’s limiting your ability to see other things around that light!”



“In picture #1, can you see the glare from that light? Can you imagine how hard it would be to see when that light is shining right into your eyes? Well, in picture #2, we can see that we weren’t able to see the man standing right in front of us because of the glare the light created! That glare is very dangerous because we need to be able to see around us to stay safe!”

“Have you ever been right beside someone who was yelling so loud it hurt your ears? Maybe it was your friends getting excited or someone who was angry. Maybe it was an alarm that kept going off. I bet that really frustrated you, right?”

“Now imagine instead of being frustrated and annoyed with a loud noise, you were being blasted with a bright light. Sometimes, lights don’t create glare, but they do give off too much light. A light that you don’t want to be around can annoy and frustrate you just as much as a noise that hurt your ears because it was so loud.”

“Outdoor lights that are too bright or are somewhere you don’t want them can be very irritating. Sometimes, neighbors have outdoor lights that shine so bright, it can light up your house as if your lights were on. Can you imagine an outdoor light so bright that it lights up your entire room? This is called light trespass, which we learned about in the last lesson. We can usually get rid of glare and light trespass by shielding our lights, just like Scott showed us! Let’s look at an example of this!”



“Look carefully at the two pictures above. Which picture do you like better? Look at the lights in each picture. In the second picture, the lights look a lot better, don’t they? Can someone tell me why that is?” (*student(s) should mention glare and/or unwanted lighting*)

“Exactly right! The lights in the first picture create a lot of glare! It would probably be uncomfortable to walk down this street. In the second picture, you can still see everything! When the lights are shielded and you get rid of the glare, you can see a lot better. Think about the pictures I showed before these. When the bright light was

shielded by the photographer's hand, we were able to see the man in the photo clearer. If we were walking in the dark and couldn't see in front of us because of a light's glare, we may trip on a rock or bump into someone else. It's so important to our safety to be able to see around us."

"We all agreed that when the town shielded their lights, they got rid of the glare AND made the street look so much better! When they got rid of the glare, they also got rid of the extra light that wasn't being used. Getting rid of the extra light means that light needs less energy. The light doesn't have to shine upwards anymore, so the light energy that used to shine up is not needed anymore. The energy that we save from shielding our lights also saves us money. So, **shielding our lights can help with four things: taking away the glare, lighting the street better, saving energy, AND saving money!!**"

"Think about the lamps you might have in your living room or bedroom. Can you see the lightbulb? You probably have a shade over them. This is just like the demonstration Scott showed us. The lights in your house would create severe glare if we didn't shade them. So, why don't we cover the lights outside too?"

Activity Walk Through

In the demonstration at the beginning of this lesson, Scott used a light shield to cover his light. When he used the light shield, he was able to use his streetlight even better than before! Not only was the light shining downward onto the pedestrian, but the light with the shield did not contribute near as much to the light pollution and sky glow of that area.

For this activity, you will need a couple flashlights similar to Scott's and paper, tape, string, and any other materials you want to give to your student(s) to create their own light shield. You can discuss with your student(s) what kind of shield would work best to cover your streetlights. If possible, create different scenarios for each light so that students are encouraged to create unique shields. One flashlight may be a streetlight like Scott's while another light is attached to a wall to represent an outdoor light on a house. Encourage your student(s) to be creative with their light shields to create the best possible light shield. Let them place their shields over to lights to see what kind of shield prevents light from going to unwanted places.

In this lesson's corresponding video (txnsf.org/online-learning/), you will find a video demonstrating this activity and potential light shields.

Extension of Learning and “Why is this important to me?”

- Use a flashlight to demonstrate glare and give them a personal experience to relate to.
- Point out lights that are shielded or unshielded and ask students to remind you of its significance.
- Remind students of the ecological effects of light pollution. When the non-ecological and ecological effects combine, it can severely harm humans, animals, and plants.

Lesson 5: Root Causes and Solutions

What causes light pollution and how can better lighting reduce it?

The root causes of light pollution are mostly fixable.

Student Objectives

- Students will learn about the Kirtland's Warbler.
- Students will play a game to imagine the Kirtland's Warbler's experience migrating and nesting while competing with light pollution and human impact.
- Students will continue to connect the ecological effects of light pollution with glare.
- Students will learn and practice how to categorize light fixtures as acceptable or unacceptable.

Activity #1 Walk Through

(Documents for this Activity are Available in the Level 1 Downloadable Handout Packet)

For this activity, students will play a board game about migration and how light pollution affects a bird's migration. Split your students into groups of around four players; depending on how many students you have, the amount and size of groups will vary. You will need the following materials for EACH group of students: printed versions of the board game, game pieces for each player (could be buttons, washers, etc.), migration and nesting cards, and one die. They are available in the Level 1 Activity Handout Packet and also at the listed internet links.

Link to the board game:

https://www.noao.edu/education/QLTkit/ACTIVITY_Documents/Animals/AnimalGame.pdf

Link to the migration and nesting cards:

https://www.noao.edu/education/QLTkit/ACTIVITY_Documents/Animals/AnimalGame_Cards.pdf

The Migration game follows the migration of the Kirtland's Warbler. Information on this bird can be found at this link:

https://www.noao.edu/education/QLTkit/ACTIVITY_Documents/Animals/KirtlandsWarbler_Facts.pdf. Introduces students to this bird may look something like this:

“We learned about a bird’s migration a few lessons ago. Can someone tell me something they know about a bird’s migration? This could be why they migrate, when migration happens, where they migrate, or something else.”

“We are going to learn about a special kind of bird called Kirtland’s warbler. The Kirtland’s warbler is an endangered species, which means that it is in danger of going extinct. There is lots of land in Michigan for these birds to create nests. This land has been helping the Kirtland’s warbler’s population grow! They are beautiful birds with blueish-gray and black backs and yellow breasts. Every year, the Kirtland’s warbler migrates from the Bahamas to Michigan to create nests and raise their baby birds. Once they are ready, they migrate back to the Bahamas. This journey can be dangerous for them! Sometimes birds accidentally run into buildings in a city. Sometimes, birds get confused when they see lights in a city. Now, we are going to divide up into groups and become the Kirtland’s warblers! Each of you will pretend to be a bird on its migration path and during its nesting season! When you are migrating, you might face some of these challenges. During the nesting season, you might get lucky, or you might have trouble finding a good place to nest. Are you ready to play?!”

The instructions to the game can be found at this link:

https://www.noao.edu/education/QLTkit/ACTIVITY_Documents/Animals/AnimalGame_Instructions.pdf

A very helpful video demonstrating how to play the game can be found at this link:

<https://www.youtube.com/watch?v=oLlvYDQ1qIQ&feature=youtu.be>

Key Discussion Phrases

“Did you enjoy getting to be a bird? We got to see the different problems that birds face when they migrate and nest. It can be very hard for Kirtland’s warblers to find the perfect place to build their nest. The Kirtland’s warbler needs at least 8 acres to build their nest and at least 30 acres to raise their babies. I bet that was really hard for you to find during your nesting season! It’s also very easy for the warblers to get confused by lots of lights. It must have been hard for you all to migrate through cities!”

“Think back to the last lesson. Can someone tell me one bad thing about glare?”

“Yes! And we aren’t the only ones affected by glare and lack of light shields. Birds like the Kirtland’s warbler can be really affected by glare. When we don’t shield our lights, it can stop the Kirtland’s warbler from getting to Michigan to lay their eggs!”

“We have learned so much about light pollution and its effects! You have done such a great job learning about what is affected by light pollution. Now, we are going to talk about what kind of lights give off that unwanted light that creates light pollution. We can put most lights into two categories: acceptable and unacceptable lights. Of course we would love for all our lights to be acceptable, but sometimes there are unacceptable lights. Last lesson, we learned about glare and light shields. Let’s use that knowledge to brainstorm what an acceptable light looks like. **Remember: The unacceptable lights are the lights that give off unwanted light and the acceptable lights are the lights that keep us safe, comfortable, and healthy.**”

Brainstorm with student(s) what acceptable vs. unacceptable lights look like.

Unacceptable lights are lights that give off excess light, contributes to light pollution, creates glare, gives off blue light, etc. Acceptable lights are shielded lights that shine only on the intended places, can be turned off when not in use, have a purpose, aren’t too bright, etc. Encourage student(s) to think about more ways to determine if a light is acceptable or unacceptable than simply shielding a light.

“Great job! One of the main ways light creates light pollution and glare is by not being shielded. An unacceptable light also affects humans, plants, and animals in a negative way. We have a handout called “Better Lights for Better Nights: Light Samples” (in the Level 1 Downloadable Handout Packet). Let’s use that to review what we’ve discussed.”

“Unacceptable lights create glare and are annoying to be around. Unacceptable lights give off light in places we don’t want, such as a light that gives off light upward. Unacceptable lights also give off blue light that is unhealthy for us. Acceptable lights are shielded so that it only puts light where we want it and are there for a reason. Acceptable lights do not create glare or increase light pollution.”

“Next lesson, we’re going to learn about more ways to improve unacceptable lights.”

Activity #2 Walk Through

(Lesson 5 Activity 2 Documents are Available in the Level 1 Downloadable Handout Packet)

Now that the student(s) understand what an acceptable light looks like, your group will play a sorting game. Students can either play individually or in groups of 2-5 students. Each student or group will receive the pictures of lights printed and cut out. They should then sort the pictures into two piles based on whether it is a shielded (acceptable) light or an unshielded (unacceptable) light. Mention to your student(s) that there are many ways to determine whether a light is acceptable; in this activity, however, we are

focusing on light shields as the differentiator because it is an obvious indicator of a light protecting the night from light pollution and glare.

The pictures to be sorted and the answers can be found in the Level 1 Downloadable Handout Packet.

Extension of Learning and “Why is this important to me?”

- Assign the sorting assignment as homework so that kids can practice identifying and categorizing lights on their own. Also, this will give them the chance to talk to their family about their outdoor lighting and practice good habits like turning off lights.
- Continue to prompt students to consider a bird’s migration when near a bird.
- Ask students to identify how an unacceptable/acceptable light might affect them or another creature near the light.
- When near a light outside, have a conversation with your student about what ways you could think about whether it is acceptable or unacceptable.

Lesson 6: What We Can Do

How each of us can help. How do we encourage good lighting at home and/or in our community?

Using this knowledge, we can help to lessen this problem in our communities.

Student Objectives

- Students will investigate how shielding, brightness, and color correlate to the type of light fixture and the type of light source.
- Students will learn the Five Principles for Responsible Outdoor Lighting and discuss how those principles can influence a light's effect on light pollution.
- Students will practice using the Five Principles to discover whether a light is acceptable or unacceptable and how it could be improved.
- Students will practice identifying a solution for a problematic light.

Demonstration Walk Through

In this demo, we will explore how much useful light shines where we need it from different types of light sources and different light fixtures. The light fixtures and bulbs will differ in shielding, brightness, and color. Refer to this lesson's video for the video of the demonstration.

Key Discussion Phrases

"We talked last lesson about categorizing our outdoor lights as acceptable or unacceptable lights. Can someone remind us the difference between an acceptable and an unacceptable light? Think about light shields, glare, light color, purpose, and brightness."

"Thank you for that reminder! Last lesson we talked about light shields and glare. These are two important ways we can choose if a light is acceptable or unacceptable. There are also other ways to choose too! In that demonstration we just watched, we saw how much of a difference something like directing a light where you want it can make. Controlling the brightness of a light and when a light is turned on is very important too."

"Now that we know which lights are the better ones that we should choose when we're replacing a light fixture and which lights are ones we don't want to choose, what do you

think we can do to change a light that's a poor choice into a light that helps us see better and doesn't create light pollution? Think about everything we've said about unacceptable lights, from glare to blue light to brightness. How can we make it better?" *Once you have discussed ways to make lights that are a poor choice better, you should show or hand out the "Five Principles for Responsible Outdoor Lighting" handout sheet. It is located in the Level 1 Activity Handout Packet under "Lesson 6 Discusson."*

Principle 1: "You came up with some great ideas!! Now let's condense all of that into five ways that we can possibly change a light that's a poor choice into a light that's a good choice. Can someone read the first way aloud?"

"This one is important. Would you put a lamp right next to another lamp in your living room? You probably wouldn't because that lamp wouldn't help light up the room. There wouldn't be a purpose for that lamp. Would it make sense to put a light in a park that is closed at nighttime? We wouldn't want to do that because no one would be able to use that light because the park is closed at night! Not only would that light not have a purpose, but it would also hurt the nature around it. **A light can only be an acceptable light if there is a clear purpose for it.** If a light isn't useful, then there is no point in keeping it. Can someone read the second principle aloud?"

Principle 2: "This is a great way to create an acceptable light! Shielding and directing a light reduces glare, which is uncomfortable and can be dangerous! We have to remember to shield our lights so that the light only goes where we want it to. One big cause of light pollution is unwanted light. When creating an acceptable light, it is important to think about where we want the light to go. We only want the light to go there. Can someone read the third principle aloud?"

Principle 3: "Think back to the demo we watched at the beginning of the lesson. Some lights are way brighter than others! We have to remember the purpose of that light when we decide how bright it will be. For example, a streetlight should be so much brighter than a porch light. If my porch light was as bright as a streetlight, I would be wasting so much light! Can someone read the fourth principle aloud?"

Principle 4: "Think about when you are getting ready for school. After you wake up, you brush your teeth, get dressed, eat breakfast, make sure your school supplies are all together, and more. When you leave your room for school, do you leave the light on? When no one is in your home, all of your lights are probably turned off. If you left the lights on, you would be wasting energy. The same thing is true for outdoor lights! It is important to light your path so you can see, but it would be wasteful to leave lights on

when no one is using them. There are even special outdoor light controls that make sure a light only turns on when someone comes near it. **Outdoor lights should be turned off when someone isn't using them.** Can someone read the last principle aloud?"

Principle 5: "Just like in the demonstration, the color of light matters a lot when thinking about the kind of light it gives off. Plants and animals expect to have the natural light of the moon and stars at night. Those give off a very warm color. So, we want our man made lights to be very warm colored too. Think about all of the animals that live outside our houses! There are deer, moths, lizards, squirrels, butterflies, birds, and so much more! All of these animals will be able to go where they want to, have a family, and be so much healthier if they are not around our man made bright white lights during the night!"

"Now that we have talked about five big ways we can turn a light that's a poor choice into a light that's a better choice, let's look at two real life examples!"



"This common light could create a lot of glare. What are the reasons why we might want to improve this light? Let's go through our five principles and decide how we could make this light an acceptable light!"

This light is a poor choice because the light is not directed in a certain direction. There are other ways that this light could be an unacceptable light depending on its surroundings (i.e. it may or may not serve a clear purpose). Ways this could become an acceptable light is by making sure it has a purpose, shielding the light, making sure the light is no brighter than it needs to be, turning off this light when not in use, and using a warmer colored light. One way to shield this light is to replace the glass with dark

colored glass. Another option is to shield the bulb with a metal bulb-shield. A third option is to replace it with a light more light this one:



“This is another light fixture that can cause light pollution depending on where it is installed! What are the reasons why it could be an unacceptable light? Let’s go through our five principles and decide the things we should look for in a new light to replace this light fixture!”

This light, as it is installed, is unacceptable because it is shining upwards and out, which creates a lot of glare. Also, the lights may be very bright and we can’t tell from the picture whether they are warm-colored or not. There are other ways that this light could be a poor choice depending on its surroundings (i.e. it may or may not serve a clear purpose). Things to look for in a light to replace this one is making sure there is a purpose, shielding the light so we can’t see the source of the light, making sure the light is no brighter than it needs to be, turning off this light when not in use, and using a warmer colored light.

“Now that we know how to change an unacceptable light into an acceptable light and have practiced it, let’s talk about how we can use this in our own lives! I want each of you to think about a specific outdoor light you know about. It could be an outdoor light near where you live, an outdoor light near school, a streetlight, or another outdoor light you have seen before. Once you have picked your light, figure out if that fixture was a poor choice for the location or if it’s an acceptable light at that location. If it is an unacceptable light, think about how you could change it to be an acceptable choice for that location using our five principles. If it is an acceptable light, think about what is good about it and how that could be done to other lights. Later today, I want each of you to tell someone who isn’t in this room about that light. Maybe you tell your parents or a sibling or a friend about how that light could be better or why it was an acceptable choice or a poor choice for that location.”

Activity Walk Through

(the Problem-Solution Matching Game and the Answer Sheet are both in the Level 1 Downloadable Handout Packet)

For this activity, each student should receive the printed version of the matching game handout. The handout has two columns: the problem column and the solution column. Students should draw a line from each problem to the solution that would solve that problem. There is one problem that matches up with each solution. This activity should get students thinking about how problems can be solved and how unacceptable lights can be turned into acceptable lights or what their replacement should look like.

To take this activity further, you can pick a light in the real world that is considered an unacceptable light. First, each student should draw out their design to replace that light using the five principles. Then, students can get in groups for a competition. They will select one of their designs for the group to create a physical replica of. Students can use paper, playdough, or other materials to physically create their group design. The design that applies all five principles and is most creative, functional, and safe wins!

Extension of Learning and “Why is this important to me?”

- This could be another time you have students design more effective lighting. Students could use materials such as paper and playdough to improve a light.
- Use lights to encourage students to practice using the Five Principles to brainstorm ideas to evaluate a light.
- Discuss with students the importance of evaluating a light. By evaluating a light, we are able to potentially lessen a light’s effect on humans, animals, plants, and light pollution.
- In this lesson, we talked about the different amount of light different light fixtures and bulbs produce. Discuss how the amount of light can affect our Melatonin production.

Lesson 7: Culminating Activity

Culminating activity (Globe at Night / Adopt a Street).

By completing this activity, you will be able to create real change in your community.

Student Objectives

- Students will create, learn about, and practice how to use their sky chart.
- Students will be introduced to the Globe at Night program and their own involvement in the program.
- Students will learn how to take data on light pollution in their own community.
- Students will learn how they can extend their knowledge beyond this curriculum.

Activity Walk Through

This activity walks you through how to create and use a sky chart to find the constellations students will find during their Globe at Night data collection. The instructions, called *IDA How to use a Sky & Telescope Sky Chart* can be found in the Level 1 Downloadable Handout Packet. You can print your sky chart at <https://skyandtelescope.org/interactive-sky-chart/>.

Key Discussion Phrases

“Now that we know how to use our sky charts to find constellations, we can learn how to use them to teach others about light pollution! It is so exciting that we know all about light pollution now, but there are still a lot of people who don’t know very much about light pollution. One way that we can help teach others is by taking data. If we all take data about how light pollution affects our community, then it will help scientists know more about how to help with this problem.”

“There is a great program that is going to help us take this data! This program is called Globe at Night. Globe at Night has regular citizens like you and me collect data about light pollution from all over the world. This data helps us better understand light pollution. We are getting the opportunity to become citizen scientists and help them take data! Are you ready to learn how to help?!”

“To take data, each of us is going to go outside after dark with a responsible adult once a month. When we go outside, we are going to use our sky charts to find a specific constellation. Then, we are going to answer a few questions about how well we can see that constellation. When we do this, Globe at Night will be able to know how much light pollution affects our community. If you want to go above and beyond, you could take multiple data points from different places along your street.” *You can use this link to find the date ranges for data collection for each month:*

<https://www.globeatnight.org/6-steps.php>. *Walk through this website with your student(s) starting with the dates and take them through how to gather data. If a group of students are interested in a larger project, the Adopt-A-Street is a great project for them to organize. Information about the Adopt-A-Street can be found at this link:* <https://www.globeatnight.org/aas2019.php>.

“By participating in Globe at Night’s international program, we are helping our world reduce light pollution. We also get to be scientists helping take data for a global project! I don’t know about you, but after learning about all the ways light pollution affects our world, I am ready to get out there and help! I challenge each and every one of you to help Globe at Night take data! We can all help change the world one data point at a time!”

“Let’s think about how much we have learned! We have learned about constellations, how we are affected by light pollution, glare, how to improve an unacceptable light, and so, so much more! We are ready to use what we’ve learned to help save our world! To celebrate how much we have learned, after you have completed the Fight for the Stars© lessons and collected data for the Globe at Night program, each of you has the opportunity to get the Dark Sky Patch!! You can put this patch on your backpack, a favorite hat or jacket, or another place to remind you about the importance of light pollution.” *Order your Dark Sky Patch from www.TxNSF.org in the "Patches and Online Learning" section.*

“Thank you for joining me! I hope you will all remember to Be a Knight for the Night. I’d like to leave you all with this quote by Sarah Williams: **“I have loved the stars too fondly to be fearful of the night.”**”

Extension of Learning and “Why is this important to me?”

- Walk students through an example of completing the Globe at Night program and using their star charts.
- Continue to discuss with students the importance of light pollution, how light pollution affects all living things, and how they can reduce light pollution.

- When observing a light, be sure to ask them about the Five Principles and how they would evaluate the light.
- Continue to assign Globe at Night data collection.
- Two optional Junior Ranger activity sheets, *Constellation Riddles* and *How Dark is the Sky?* are in the Level 1 Downloadable Handout Packet.

Conclusion Survey to fill out as a class

Thank you so much for following along with this curriculum and the corresponding videos. Hopefully you found these materials useful and helpful! To learn more about light pollution and what you can do, continue to browse txnsf.org.