



Name _____

Dark Skies

Inquiry Overview

In this inquiry, you will examine data from Globe at Night, a global citizen science project in which volunteers monitor night sky brightness and construct an argument about where in Arizona is the best place to stargaze based on the brightness of the night sky. You also have the option to record and contribute to Globe at Night data from your home.

Step 1: Stargazing

Reflect on your own or share with a family member:

- Have you ever been able to see stars really well? If so, where were you? What was it like at night?
- If this happened in a location other than where you currently live, how was that location similar to or different from where you live?
- If not, why do you think you haven't seen stars very well?

Step 2: Learn about the night sky

We will observe the night sky in different places in California.

- Watch this [video](#) of the night sky in different locations across California.
- While you watch, record what you notice and what you wonder.

Notice	Wonder
<i>Example: I notice very few stars in San Jose, CA.</i>	<i>Example: I wonder if the stars disappeared.</i>



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Gather more information about why stars are more visible in some places than others by reading the following article.

Light pollution is excess use of artificial light. Artificial light comes from man-made sources like street lamps, billboards, homes, and office buildings. Light pollution happens when these lights are too bright, when lights shine on an area where it is not needed or wanted, or when light reflects off of surfaces such as pavement or glass.

According to National Geographic, there is so much light pollution in some places that people can only see 0.05% of all visible stars (National Geographic, 2019). Light pollution tends to occur in areas with high population densities, like cities. Rural areas tend to have darker skies because they have fewer people using lights and fewer lights in general.

There are three main types of light pollution:

- **Glare** comes from bright lights that shine into people’s eyes and make it more difficult to see the dark sky, particularly for older adults.
- **Sky glow** happens when the night sky over a city cannot be seen because light pollution makes the sky brighter.
- **Light trespass** is when unwanted light shines from a light source to an area that it is not supposed to, such as light from a streetlight coming through a bedroom window where someone is sleeping.

As the amount of artificial light in an area increases, it can have negative effects on wildlife, human health, and energy use. Excess light poses a threat to nocturnal wildlife and can confuse animals who depend on light sources to make decisions, such as sea turtle hatchlings who depend on the light of the moon. It can also negatively affect people by disrupting sleep cycles. Lighting also uses one-fourth of electricity consumption worldwide. Excess lighting at night can contribute to wasting energy. Reducing excess light saves money, conserves energy, protects animals, and helps people.

Reflect:

Reflect on your own or share with a family member:

- Have you experienced light pollution in our community?
- Do we have a lot of light pollution here? What might be causing it?



- Why is light pollution an issue?
- Where do you think the best place to stargaze is around here?

Step 3: View the Light at Night map

Where is there more and less light at night around the world and in the United States?

Go to this map in FieldScope: [Light at Night map](#)

Reflect on your own or share with a family member:

- Where in the world is there the most and least amount of light at night?
- Where in the United States is there the most and least amount of light at night?

Technology Note: The FieldScope tool used in this activity requires Adobe Flash. Flash is compatible with Chromebooks, and popular browsers like Google Chrome, Firefox, and Safari used on laptops and desktop computers. Flash is not normally compatible with iPads or other tablets and mobile devices.



a. When accessing Flash on web browsers like Chrome, Firefox, or Safari, the browser may tell you that the Flash Player is not installed (*see image*). Most of the time it is already installed, and by clicking on the link to download it (*see the red circle highlighting this text*) the browser will then initiate loading the Flash Player.

- b. If you have an iPad or other tablet device, you can download the [Puffin browser](#), which is compatible with Adobe Flash; FieldScope should load normally when using the Puffin browser on iPads or other similar-sized tablet devices.



Step 4: Focus question

In the United States, there is less light at night in the western desert areas, especially Arizona. We would expect there to be very good stargazing in Arizona. In this inquiry, we will investigate:

Where in Arizona are the best places for stargazing?



Step 5: Read about Globe at Night Data Collection

We can predict the best places for stargazing by looking at light pollution data across Arizona. Read the information below about Globe at Night.



Globe at Night is an international citizen science project. Throughout the year, volunteers measure their night sky brightness and submit their observations to Globe at Night. This data collection can be done by anyone; volunteers can collect data one time or regularly throughout the year. Volunteers in 180 countries have contributed over 180,000 observations to the Globe at Night project over the course of more than ten years.

Globe at Night data are freely available and anyone can use them, including scientists, educators, and students, to answer specific and important research questions.

Sky darkness is measured by **limiting magnitude**. This is a measure of how well you can see specific constellations, or groups of stars, in the night sky.

To see an example of limiting magnitude for your area:

1. Look up your city or town's latitude [here](#).
2. Go to the Globe at Night [magnitude charts webpage](#).
3. Enter your city or town's approximate latitude.
4. Select a constellation to observe using the limiting magnitude charts associated with that constellation for levels from 0 to 7.

Then look at the [Globe at Night data collection protocol](#) to see the information that participants contribute when they make an observation.

Consider the following questions.

- **Who** collected the data?
- **When** did they collect the data?
- **What** data were collected? What was measured? How was it sampled?



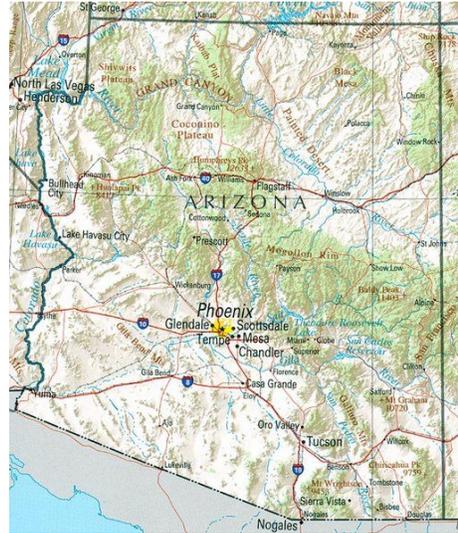
Step 6: Light pollution variability

Anyone can collect limiting magnitude measurements using magnitude charts you looked at above.

We can look at limiting magnitude in a few different places in Arizona to investigate the question: *What areas in Arizona are best for stargazing?*

Reflect on your own or share with a family member:

- Where would the darkest night skies in Arizona be? The lightest night skies? Why?
- Would limiting magnitude be the same across all city locations? Why or why not?



People have recorded the darkness of the sky across different parts of Arizona, including in parks and cities. We can look at histograms with data from a few places in Arizona to get a sense of the variation in darkness within a city or park location.

If you are not familiar with histograms, watch this [video](#).

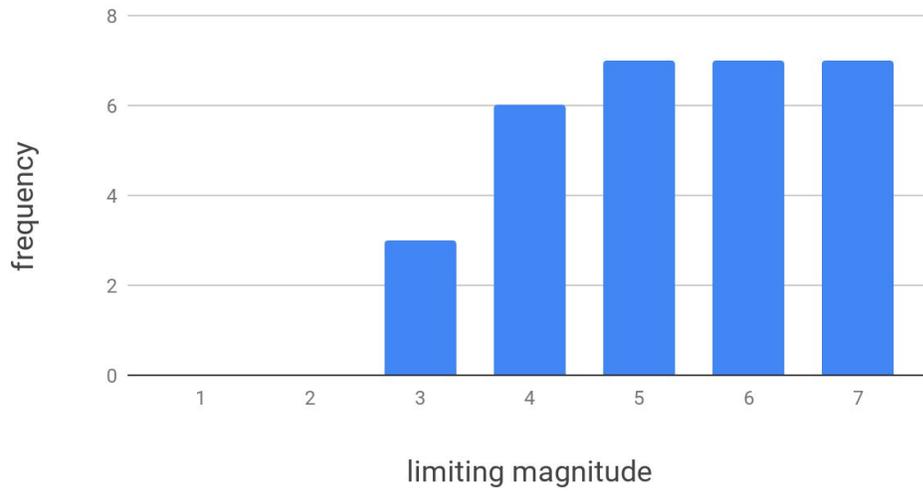
Step 7: Examine Graphs A-D.

Imagine members of the public contributed data about limiting magnitude in different parts of four different locations (some cities, some parks). Review the hypothetical histograms and record what each one would mean.

Location	Total number of observations	Average limiting magnitude	Range of limiting magnitude
Location A	30	5.3	3-7
Location B	30	4.0	1-7
Location C	30	4.0	1-7
Location D	30	4.0	2-6

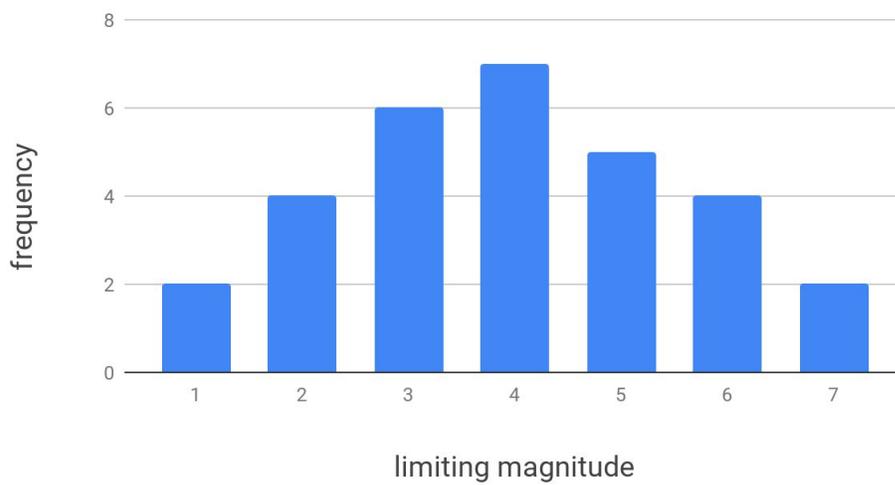


Location A



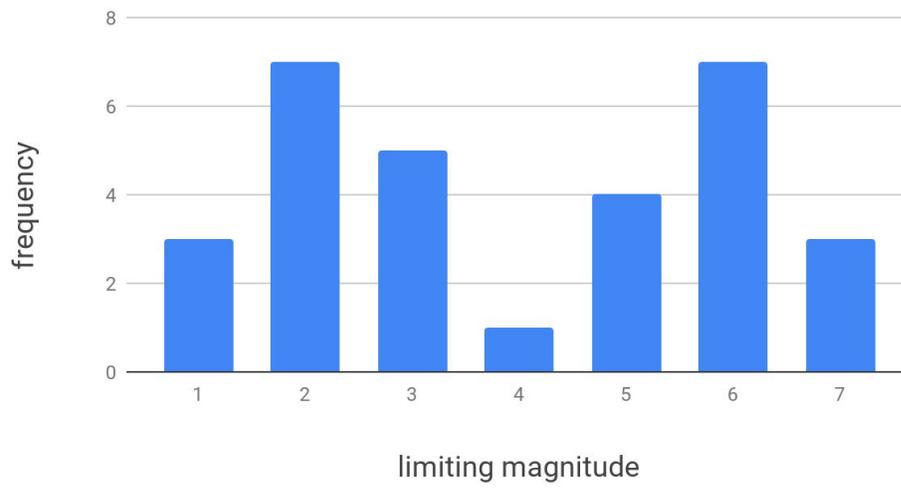
Example: This graph shows high limiting magnitudes. This means that the night sky is very dark.

Location B

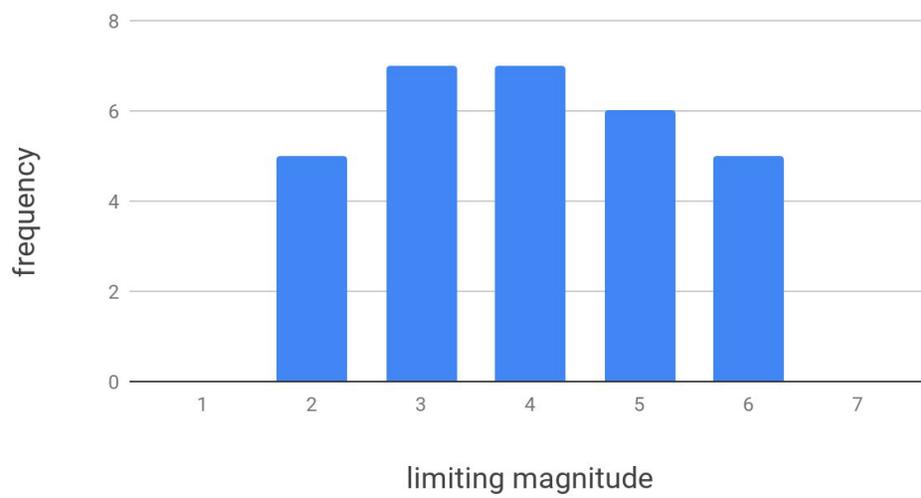




Location C



Location D





Step 8: Use the CCS strategy to investigate limiting magnitude data for four locations in Arizona.

We will use a mapping and graphing software called FieldScope to investigate Globe at Night limiting magnitude data for four locations in Arizona: Phoenix, Yuma, Flagstaff, and the Grand Canyon.

- Watch this short [video](#) to learn how to navigate FieldScope.

- Go to [this histogram](#) in FieldScope.

- Select “Graph Settings.” Change the number setting for the “Bins in Histogram” option from 20 to 8. Press “Save.”

- Analyze and interpret the data in each histogram.

- First, make CCS observations about the following three aspects of the online histograms:

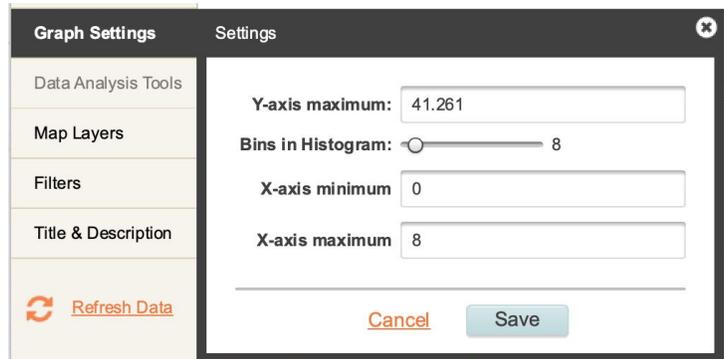
- What do you see in terms of:

- Central tendency: What is the mean or average limiting magnitude?
- Spread: What is the range or highest and lowest limiting magnitude values?
- Shape: What is the shape? Is it a normal curve, like Location B was? Is it skewed in one direction, like Location A was. Does it have two peaks, like Place C was?

- Second, interpret what these observations mean.

- Write “What it means” (or WIM) and then add your explanation next to the observation.

- As you explore the graph online, you can make CCS and WIM statements about the graph, the data table, and the map.





CCS: Central tendency, Spread, Shape	What it means
<i>Example: Flagstaff has an average limiting magnitude of 4.4. Phoenix has an average limiting magnitude of 3.3.</i>	<i>Example: Flagstaff is darker than Phoenix on average.</i>

Why do we see these patterns across cities?

- Why is there so much variability in all three cities?
- Why might Flagstaff be darker than Phoenix and Yuma?

Step 9: Prepare an argument.

Where is the best place for stargazing in Arizona?

Write your argument below and make sure to include the following key points.

- Make a **claim** that answers this question.
- What **evidence** did you use that supports your claim?
- Explain your **reasoning** and how the evidence supports your claim.
- How **certain** are you about your claim?



Step 10: Read about Flagstaff.

Why is the Flagstaff night sky darker than other Arizona cities?

Flagstaff is an International Dark Sky Place. International Dark Sky Places are part of a program to encourage cities and parks to adopt lighting policies that minimize light pollution and educate residents and visitors about the importance of dark skies. In 2019, there were over 115 International Dark Sky Places.



In 2001, Flagstaff became the first city designated as a Dark Sky Place. Residents, policy-makers, and two local observatories led Flagstaff in one of the world's first systematic efforts to reduce light pollution in their community. Their first outdoor lighting policy in 1958 outlawed using large searchlights in the city. Flagstaff has also adopted a zoning policy for light. The city is divided into four areas and each area has a different amount of light allowed at night. This zoning allows areas with a lot of development to have more outdoor lighting and natural areas to have less outdoor lighting.

Outdoor Lighting Basics

How can you help in your community? You can fix problematic outdoor lighting, teach community members about the importance of dark skies, and help your community adopt outdoor lighting policies.

From <https://www.darksky.org/our-work/lighting/lighting-for-citizens/lighting-basics/>

“To minimize the harmful effects of light pollution, outdoor lighting should:

- Only be on when needed
- Only light the area that needs it
- Be no brighter than necessary
- Minimize blue light emissions
- Point downward with a full shield.”

Outdoor Lighting Community Policy

From

<https://www.darksky.org/our-work/lighting/public-policy/lighting-ordinances/our-work/lighting/lighting-for-citizens/lighting-basics/>



While you might be able to fix your own lighting, you can also work to get your community to adopt an outdoor lighting ordinance, or codes that help cities develop good, safe outdoor lighting. A good ordinance will save money and increase safety.

Find out if your community has a lighting ordinance by contacting your local government. If they don't have a lighting policy, you can meet with a city staff member and ask them to develop a new policy. Examples of what might go in an outdoor lighting ordinance include:

- Using different lighting zones in the city, with some zones designed for natural environments and others designed for extensive development.
- Limiting how much light can be used for each property.
- Using outdoor lighting fixtures with good shields so light points down.

Step 11: Explore light pollution where you live.

Where is there light pollution in our city?

Visit <https://www.globeatnight.org/mapapp/>

- enter the name of your city and press “map it”
- enter a radius
- select a year
- select “generate map”

Observe the map and look for areas where there is high light pollution where you live.

Record your ideas below:

- What could we do to help reduce light pollution in our community?



Step 12 (Optional): Measure sky brightness at home

This activity involves going outside after dark. Only do this activity if it is safe to do so where you live.

Have a parent or guardian help you prepare to measure sky brightness at night.

- Find an appropriate local constellation to observe by following the steps on this website: <https://www.globeatnight.org/5-steps.php>.
- Use a star and constellation app to ensure that the constellation will be visible in your night sky. A few free or inexpensive guides, as of 2019, include:
 - Sky View Lite (free)
 - Night Sky
 - Star Walk - Explore the Sky
 - Sky Guide
- Once you select a local constellation, print a copy of the [Magnitude Chart](#) for each student with the settings activated for your constellation and latitude.

Prepare to measure sky brightness at home

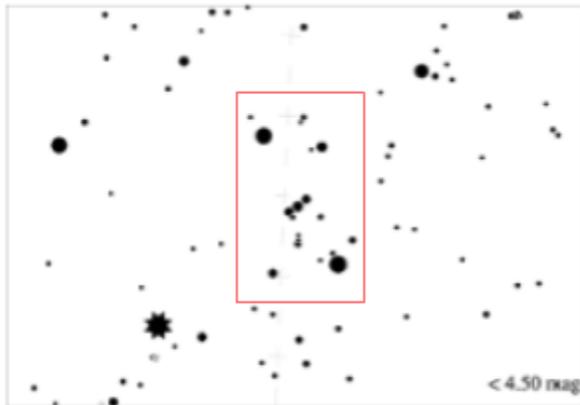
Practice determining limiting magnitude for the constellation Orion.

- Look at the two images below.
- Use the Magnitude Charts for the Constellation [Orion at 0](#) to determine what the limiting magnitude is.

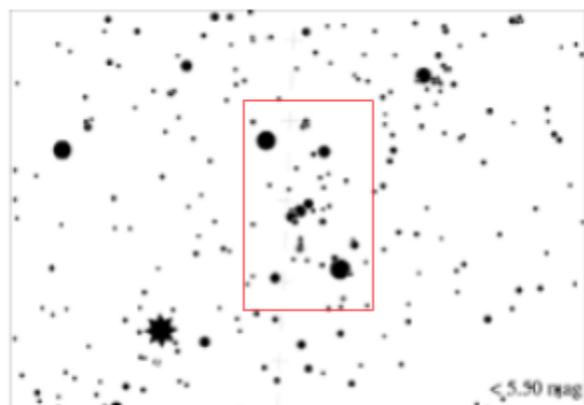




- The image on the left is about 4 and the image on the right is about 5. How did you do?



Magnitude 4 Chart



Magnitude 5 Chart

Measure Sky Brightness at Home

1. With a parent or guardian, download a star and constellation app onto a phone or tablet.

Here are a few free or inexpensive guides:

- Sky View Lite (free)
 - Night Sky
 - Star Walk - Explore the Sky
 - Sky Guide
2. Go outside more than one hour after sunset (8-10pm). Make sure the moon is not up.
 3. Use the star or constellation app to locate your constellation in the night sky.
 4. Let your eyes become used to the dark for 10 minutes before your observation.
 5. Match your observation to one of the 8 magnitude charts.
 6. Record:

1. When did you make your observations?

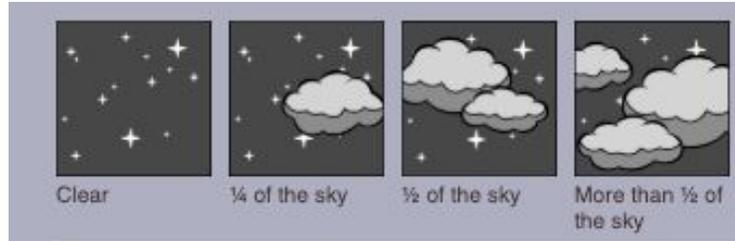
Observation Date: _____

Observation Time: _____

2. Where did you make your observations?: _____

3. How dark was the sky that night? (What was the limiting magnitude?)

4. What were sky conditions like that night?: _____



7. Enter your data on the [Globe at Night data entry website](#). If you are under 13, have your parent or guardian enter data with you. You have now contributed data to this larger citizen science project!