SAN DIEGO ZOO INSTITUTE FOR CONSERVATION RESEARCH

THE LIVING DESERT

DESERT MANAGERS GROUP

Conserving the Desert Tortoise

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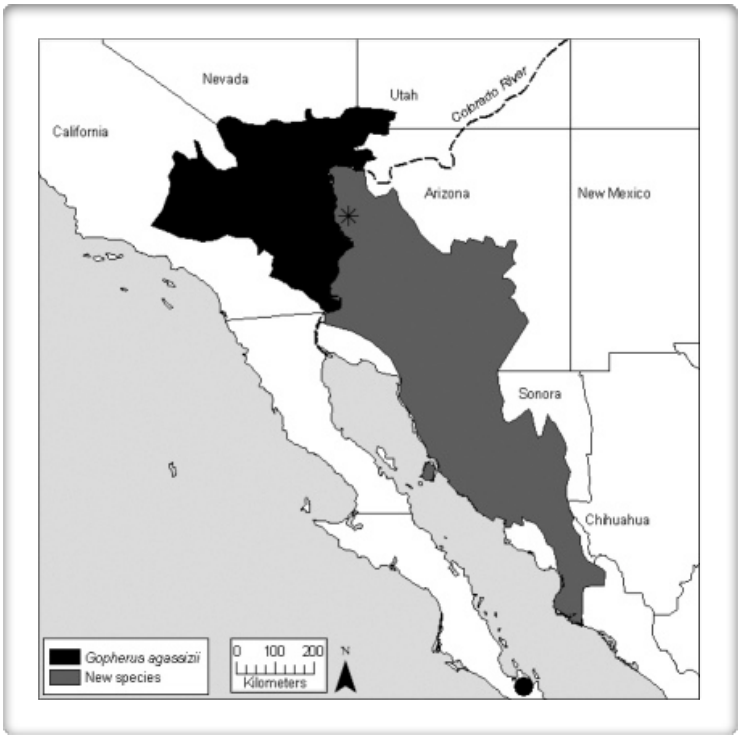
Desert Tortoise Overview

Habitat The desert tortoise (Gopherus agassizii) lives in the Mojave Desert. In the desert, there is not much rainfall and large fluctuations in temperature between the scorching summer and the freezing winter months. To deal with these temperature differences, the desert tortoise digs burrows in the ground. The tortoise uses these burrows as shelter from the sun in the summer and a place to hibernate in the winter. They lay their eggs in these burrows and utilize them as protection from predators. Other animals also use these burrows as shelter from harsh winter conditions and from predators. Desert tortoises also disperse seeds from the native desert plants that they eat, which in turn repopulates the desert ecosystem. Thanks to these key components in their niche, desert tortoises can be considered a keystone species of the desert ecosystem.



Evolution It has been argued for decades whether the populations of desert tortoises above and below the Colorado River are the same species. A study in 2011 showed conclusively through genetic evidence, that the tortoises in

Desert Tortoise Overview

these different locations are in fact different species. The species north and west of the Colorado River is Gopherus agassizii and the species located south and east of the Colorado River is Gopherus morafkai. This speciation was probably a result of physical separation and differences in environment. Some of the visible differences are shell shape, preferred habitat, and their egg laying season. Gopherus agassizii has a box-like, domed shell, and predominantly lives in valleys, digging its own burrows in the sand. They live mostly in the Mojave Desert around salt brush scrub, creosote bush scrub, desert scrub, and tree yucca woodland. They lay their eggs from April to mid-July, and are listed as threatened by the U.S. Fish and Wildlife Service. Gopherus morafkai on the other hand has a flatter, pear-shaped shell, and lives predominantly on slopes and rocky hillsides, burrowing under rock crevices. They live mostly in the Sonoran Desert around uplands, thorn scrub, and grasslands. They lay their eggs from June to early August and are not listed as threatened.

Social Interactions

The temperature of its egg during incubation determines the sex of a desert tortoise. Eggs with lower temperatures (26-30.6 C) become males and eggs with higher temperatures (32.8 – 35.3 C) become females. Life for a baby tortoise is difficult because their shell has not yet hardened, and they move slowly causing them to be vulnerable. During the active season males spar for the privilege of breeding, using their gular horn (part of the

Desert Tortoise Overview

plastron lying beneath the extended head) to hook other males and overturn them during aggressive interactions. When they fight, tortoises try to flip their opponent onto their back, and the one that gets tipped over loses, often dying from baking in the sun. Chin glands on a male serve as chemical and visual signals to other tortoises. Larger chin glands indicate that a tortoise has more testosterone therefore making it more sexually attractive to females. Males also bob their heads to get the attention of females. While mating, male tortoises are very rough to females until the female tortoises submit to their advances. Females will submit to their advances once the male has proven to be fit. This behavior ensures that their offspring will be strong. Females can store the sperm until laying conditions are favorable, eventually laying 2 to 14 eggs the size of Ping-Pong balls in a shallow nest that she digs near her burrow. The female does not stay to tend to her young, instead she leaves them to fend for themselves upon hatching.

Disease Desert tortoises are significantly affected by upper respiratory tract disease (URTD). URTD is a chronic, infectious disease responsible for population declines across the entire range of the desert tortoise. It is suspected that the disease arose in captivity, and spread to wild populations through the release of pet desert tortoises. It is caused by the infectious agents Mycoplasma agassizii and Mycoplasma testudineum. Another disease

Desert Tortoise Overview

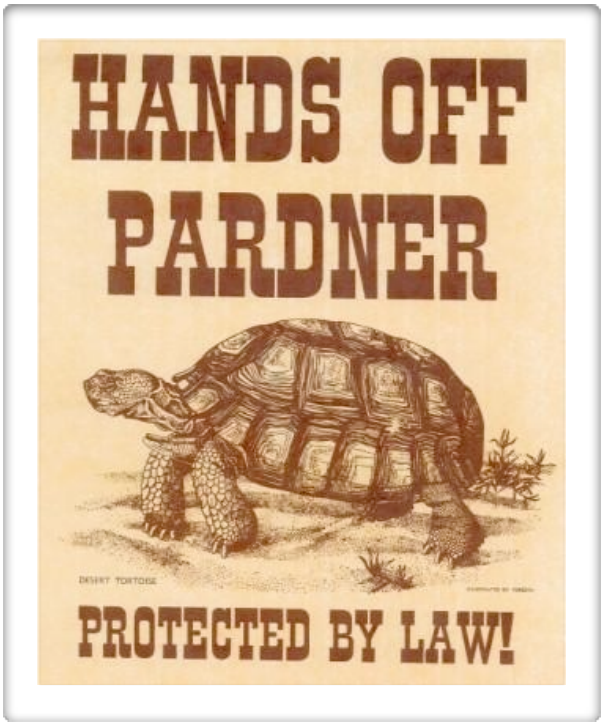
that has affected desert tortoise populations is Cutaneous dyskeratosis (CD), a shell disease that has unknown implications on the desert tortoise population. Not much is known about CD, but it is hypothesized to be either an autoimmune disease, the result of toxic chemicals, or possibly a nutrition deficiency disease.

Human Effects

Due to human development in their natural environment, desert tortoise populations in the wild have decreased significantly. Roads can be especially dangerous to tortoises since they are a relatively small species, and are easily run over by cars. Off-road vehicles often do not see tortoises before they are crushed. Before it was illegal, people visiting the desert would take wild desert tortoises home with them to be pets. It is not a good idea to do this because many of the people who picked them up were not prepared for proper desert tortoise care. Today, it is illegal to remove desert tortoises from their native habitat, but it is possible to adopt them through local turtle and tortoise clubs.

Conservation Efforts Since 1989, the US government has afforded federal protection to desert tortoises. In 2009, San Diego Zoo Global partnered with the U.S. Fish and Wildlife Service, the Bureau of Land Management, and the Nevada Department of Wildlife to operate the

Desert Tortoise Overview



Desert Tortoise Conservation Center (DTCC) to aid in the recovery of wild desert tortoise populations as well as the Mojave Desert ecosystem. The DTCC helps to teach the public about the desert tortoise through community outreach. At the DTCC, tortoises are put through a full health assessment before they are treated for any ailments. The tortoises that stay there are put into adult-sized pens which are predator-proof, so they can be content and live safely. Every year more tortoises are being released back into the wild from the DTCC, some with transmitters on them so that they can be tracked in the future to monitor their behavior back in the wild. For more information see the San Diego Zoo website at: http://animals.sandiegozoo.org/animals/desert-tortoise

If there are any missing or broken pieces in the kit, please contact the center you rented the kit from right away.

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Trunk Checklist

Permanent equipment	Qty.	Condition
GPS unit and cord	4	
Urolith	1	
Desert Tortoise Shells	1	
Tortoise USB	1	
Food Web Cards	1 bag	
Ecosystem Cards	Yellow folder	
Desert tortoise blogs/ fact sheets	Green folder	
GPS handouts	Red folder	
Case Files	Manilla folders	
“Desert Environment” bowls	2	
Green Marbles	2 bags	
Ping-Pong ball “eggs”	6	
Materials Binder	1	
Clipboard	4	

Consumable Supplies	Qty.	Storage
Student workbooks	Print one per student	USB drive

Lesson Sequence

Day	Activity	California State Standard	NGSS Practice
1H	Ecology	Biology - 6F	2
2H	GPS	Biology - 6B	3, 4, 6
3H	Disease	Biology - 10B, 10D	3, 4
4H	Population Genetics	Biology - 7D, 8B, 8C, 8D	2, 3, 5, 6
5H	Conservation	Biology - 6G	5, 7

Opening Activity

Desert Tortoise Roundtable

Theme/Concept:	Reflection on what students know about desert tortoises.
Goals:	To understand what students know, what they want to know and to help assess what students have learned.
Objectives: (Evidence of student learning)	Students will be able to: 1. List what they know about tortoise 2. List what they want to know about tortoise
Materials in Kit:	None
Materials provided by teacher:	White board, document cam, poster paper Markers for above materials
Materials on USB drive:	None

Opening Activity

Engage • 10 minutes

Description:

Create a chart that can be kept over the week as the students are learning. Add to this chart throughout the week. This can be a rubric to assess what students are learning.

This is a brainstorming activity to determine what students know, what they want to know, and what they learned. Explain to the students that they will be learning about the desert tortoise this week. Ask the students what they know about the tortoise. Write responses on the chart. Ask students what they want to know. Write responses on chart. Leave the third column blank. Encourage students to share their responses in full sentences.

An alternative to this activity is the creation of a concept map. The concept map should have main ideas in bubbles, and writing on the arrows between the concepts to explain the connections.

These activities are suggested for a full class, but can also be used as personal activities. If used as a full class it is suggested to do it on poster paper or a board that will not need to be erased over the duration of the week, so that it can be added to at the end of each day. If you do not have time to revise it each day as a class, maybe give each student a few sticky notes and ask them to add to the chart by writing it on a sticky note and putting it on the chart. If it is used as a personal activity, have each student put it on binder paper to be graded at the end of the unit.

Opening Activity

Sample Teacher Questions

- Do you think tortoises are turtles? How are they the same or different?
- Do you think that desert tortoises are big or small? Why?
- Have you seen a desert tortoise before? Does anyone have one as a pet?
- Where do they live? What do they eat?
- How do you think they reproduce?

Anticipation of Student work and common misconceptions

Misconceptions:

- Turtles and tortoises are the same thing so tortoises live in water
- That these tortoises are big like Galapagos tortoises
- You can take them home after a vacation in the desert
- That they are carnivores
- That they will live to be 100 years old in the Wild

Example 1: KWL Chart

What I know	What I want to Know	What I learned
They live in the desert.	What they eat?	
They are related to turtles	How old they get?	
They lay eggs	Can they swim?	
They are cold blooded		

1H: Ecology

Theme/Concept:	The Mojave desert is full of life, and each organism plays its role to sustain an ecosystem.
Goals:	Students will understand that the desert tortoise is a keystone species due to the fact that it burrows. Students will construct a food web, demonstrating the flow of energy in the ecosystem.
Objectives: (Evidence of student learning)	Students will be able to state that the desert tortoise is a keystone species. Construct a food web.
California State Standards	**Biology** 6f. Students know at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment
Next Generation Science Standards Practice	2. Developing and using models

1H: Ecology

Specific Background Info for Lesson
(Including definitions)

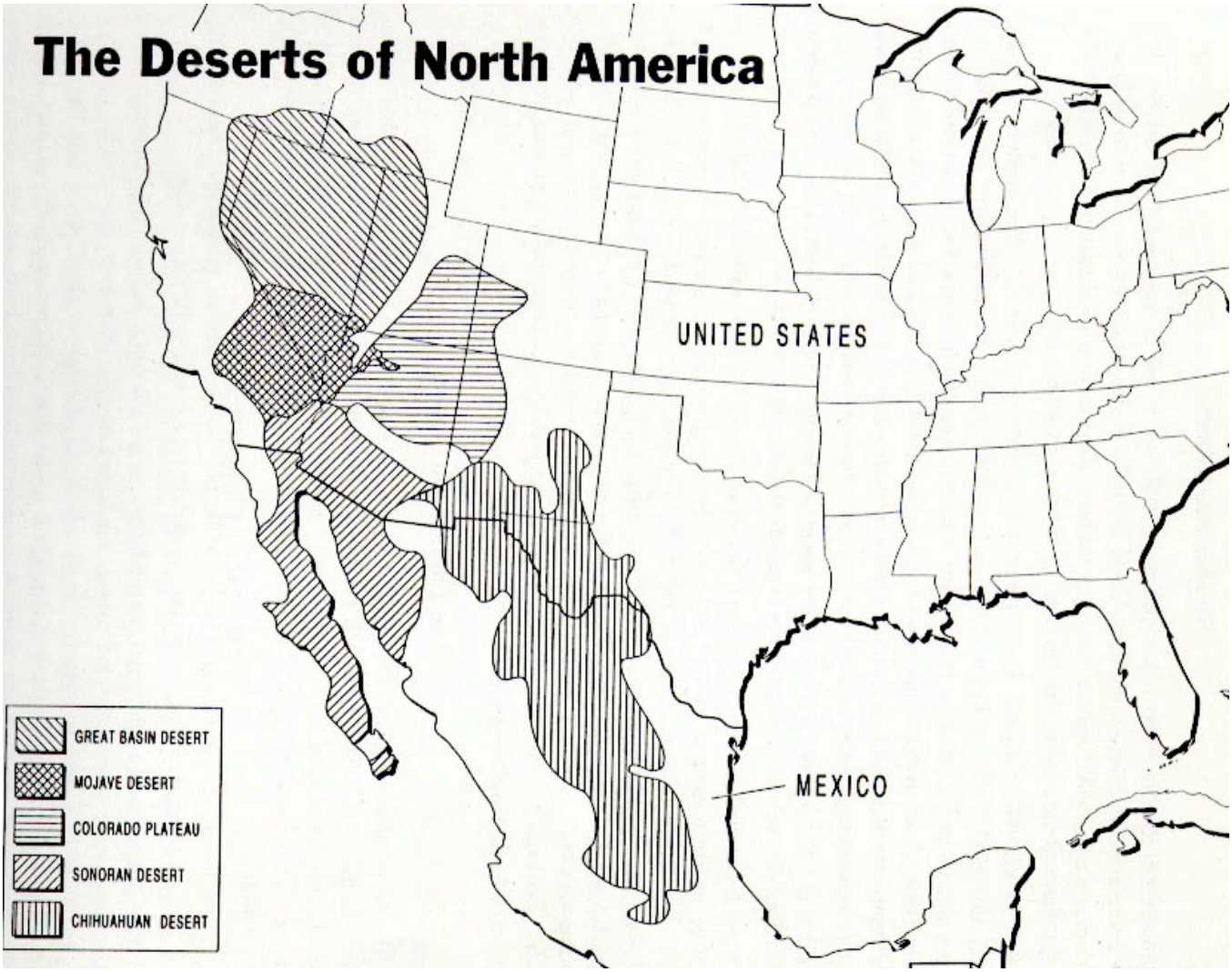
A food chain shows a chain of who-eats-who in an ecosystem. It also is a simple way of showing the flow of energy in the ecosystem. It consists of primary producers, primary consumers, secondary consumers, and tertiary consumers. When you link multiple food chains together, they become a food web. This system essentially shows all the organisms in the environment and at least one way how they interact.

When there is a species that the ecosystem relies on to function, it is called a keystone species. The keystone species of the Mojave Desert is the desert tortoise. This is because the desert tortoise digs burrows that other animals rely on. The desert tortoise uses burrows for protection from the harsh desert weather conditions as well as protection from predators. Other animals in the ecosystem such as mice and snakes use the burrows for the same reasons. If there were no desert tortoises to dig new burrows then there would eventually be a shortage of available space for the other animals in the ecosystem, creating competition that will lead to the demise of the ecosystem.

A limiting factor is something that prevents a population from growing uncontrollably. In the desert, for many animals it is a mix of food availability and water.

The Mojave Desert spans over parts of California, Nevada, Utah and Arizona. It displays typical basin and range topography, but spans from High Desert to Death Valley. The indicator species in the Mojave Desert are Joshua trees (Yucca brevifolia) which differentiates this desert from the surrounding areas. It gets less than 13 inches of rain a year (33 cm) and is between about 2,000 and 5,000 feet in elevation. The weather can range from 130 °F (54 °C) in the summer to below 0 °F (−18 °C) in the winter. There are many different plants and animals that live and interact in different parts of the desert based on topography. More information is available in the trunk.

1H: Ecology


The Deserts of North America
UNITED STATES
MEXICO
GREAT BASIN DESERT
MOJAVE DESERT
COLORADO PLATEAU
SONORAN DESERT
CHIHUAHUAN DESERT

1H: Ecology

Materials in Kit	Food Web Cards Ecosystem Cards (for homework)
Materials provided by teacher	Optional worksheet Optional notes White board/markers
Safety Requirements	
Materials on USB drive	• 1H PPT • 1H Notes • 1H Worksheet

1H: Ecology

Engage • 10 minutes
See KWL chart

Explore • 20 min

DESCRIPTION

Students will create their own food webs in small groups using a list of plants and animals.

GETTING READY

Locate all of the food web cards. Set them out and clear space on your board to draw a food web.

LEADING THE INVESTIGATION

1. Introduce the idea of a food chain.
2. Show an example of a food chain.
3. Have the students create food chains on their own using listed plants and animals.
4. Introduce the idea of a food web and how it is more complex, but illustrates the same ideas as the food chain.
5. In groups of four, have students come up and grab a handful of food web cards. Then, they must draw the connections between the cards.
6. Link together different parts of students' food webs from the groups and make a class model using the food web cards or writing it up on the board.
7. Talk about energy exchange and why it is important.

Sample Teacher Questions

- Which trophic level provides the most energy? Why?
- Which organism would have to eat the most to survive? Why? Which organism would have to eat the least?
- What would happen if you removed one of the species in the food web completely?
- How is the desert different from any other ecosystem? Is there anything more or less available?

1H: Ecology

Explain • 15 min

DESCRIPTION

The teacher will lecture on desert ecosystems and energy exchange in food webs.

Sample Teacher Question

- What ecosystem do we live in?
- What ecosystem does the desert tortoise live in?
- How/why are ecosystems different?
- What kind of scientists study ecosystems?
- How can you study different ecosystems?
- What different organisms live in the desert ecosystem?
- What is the niche of the desert tortoise?
- What other niches can you think of?
- How would the niche differ if the tortoise were to live somewhere else?

Evaluate • 3 min

DESCRIPTION

Each student will have to look up different parts of specific ecosystems. Assign each student to a specific ecosystem and part of the ecosystem that they have to look up. Then the next day in class you will put them all together to create a full picture of each ecosystem. In the yellow folder there are ecosystem cards with blank spaces for each component. Students will write in the portion they looked up for their homework in the blank spaces using a white board marker.

Ecosystems include: Coral reefs, wetlands, savanna, desert, chaparral, temperate grassland, temperate deciduous forest, coniferous forest, tundra

Components include: average temperature, annual precipitation, a common food chain or web, vegetation, elevation, primary consumers, carnivores, terrain, water depth

Sample Teacher Questions

- How does each ecosystem differ from the desert?
- Is there variation within each system? How?

1H: Ecology

Extend • 5 min

DESCRIPTION

Students will discuss the effect that humans have on the environment in the desert. This could include construction of roads and houses, depletion of water resources, and others. First, do a think-pair-share to give students a chance to think and rehearse what they want to share with the class, then have the class discuss the topic.

List a couple other possible extension Questions

- Are there any positive benefits to ecosystems that humans have?
- Why should we conserve different ecosystems? What effect would it have if humans completely destroyed or changed an ecosystem from what it originally was?
- What are the niches for other desert animals?

HOMEWORK

- Download GPS applications for students with smartphones. (Google Maps for Apple/Android. My Tracks for Android). See next lesson 2H for more details.
- (See above) Look up details for ecosystems

2H: GPS Tracking and Spatial Ecology

Theme/Concept:	Scientists use GPS units to study the range of animals in the wild. The data that they collect from these devices helps them build a picture of where these animals live.
Goals:	Students will understand how to use the technology of GPS units with computers. They will also be able to extend their knowledge of the computer technology to problem solve conservation problems.
Objectives: (Evidence of student learning)	Students will be able to Operate GPS units Write a conclusion sentence about conclusions they draw from given data Draw conclusions from data
California State Standards	Biology 6b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
Next Generation Science Standards Practice	3. Planning and carrying out investigations 4. Analyzing and interpreting data 6. Constructing explanations (S) and designing solutions (E)

2H: GPS Tracking and Spatial Ecology

Specific Background Info for Lesson
(Including definitions)

Spatial Ecology is the study of how animals use the area in which they live. The home range of any given animal is the area it occupies over the span of its life. Each individual has their own specific home range. The animal's home range must include habitable areas for the individual as well as sufficient food and water to survive. A major issue about relocating animals is that they are taken out of their home ranges. If an animal is taken out of its home range not only is it not familiar with the new environment, but it may need to move to a more adequately habitable area.

This activity opens with the students marking points on a GPS map which they think are useful for the daily life of a desert tortoise. To do this they either use GPS devices, or their smartphones (see note below**).

To use the GPS first turn it on. Then scroll the mark waypoint on the menu. Then add a note as to why the particular place is important, e.g.. where the tortoise would drink water. Then import the waypoints into Google Earth. Google Earth handouts are in the red folder.

You will need to download Google Earth to view the files that you download. A free download is available at earth.google.com. Once you download the files to Google Earth you can play with them to collect information about what path the GPS took. This information can be used with animals to explain where they live their daily lives, such as where they go to eat, where they sleep, where they hunt, etc.

In respect to the desert tortoise, students will solve a "conservation challenge" trying to figure out where it is best to release desert tortoises back into the wild in Nevada. The idea is to draw the conclusion that tortoises that do not move as much after their release were released into a more suitable habitat.

**If you feel comfortable allowing students to use their smartphones in class, there are some applications that do the same thing as the GPS units. The strongest application for Android would be MyTracks by Google. The strongest application for iPhone would be Google Maps, by using a workaround. Google Maps also works on the Android platform. Information on how to use these applications to do the activity is available in the "GPS on the Phone" powerpoint. It is suggested that they do this the night before and play with it a little.

2H: GPS Tracking and Spatial Ecology

Materials in Kit	GPS Units and Computer Cords Green folder with Blogs/research materials Red folder with GPS handouts
Materials provided by teacher	Download Google Earth (free)
Safety Requirements	GPS equipment is very expensive, handle with care. Students should be safe in hallways.
Materials on USB drive	• Worksheet 1 • Worksheet 2 • Download instructions for Google Earth • GPS Data for conservation challenges

2H: GPS Tracking and Spatial Ecology

*Note this lesson is designed to be more inquiry-based so it can take up to 2 days. It is written in option A and option B. Option A is more open inquiry and requires a trip to a computer lab or a class set of laptops, it is designed to be a 2 day activity. Option B is more guided and designed to have one classroom computer. It is designed to be a one day activity. There is no accompanied powerpoint with this lesson because it is more inquiry based, see specific background info for more info.

Warm UP: Go over previous day's homework

Option A

Engage • 10 min

DESCRIPTION

Ask Students the broad question "What do you need to conserve wild species?" They will give you a few answers. Then break it down into four categories on the board. Then the teacher will write down what the students say under each category on the board.

1) Manager [What qualities does a manager need to have?]
2) Conservation(ist) [What qualities does a conservationist need to have?]
3) Endangered Species [What does the conservationist need to know about the species?]
4) Wild [What factors need to be considered? What about if the conservationist wants to reintroduce the species back into the wild?]

Explore 1 • 40 min

DESCRIPTION

Students will create the home range of a tortoise using GPS.

GETTING READY

- Check to make sure that all the GPS units have batteries.
- Download Google Earth on class computers.
- Check to make sure that data points work on Google Earth
- Make copies of Worksheet 1 (optional)

2H: GPS Tracking and Spatial Ecology

LEADING THE INVESTIGATION

This investigation will have three "stations." Students will rotate between the three stations so that they will always have something to do, and everyone will have a chance to interact with the technology. Each station will take 10 minutes.

When all the students get a chance to work with the GPS units, do a debrief of the activity by asking some of the places that the students marked and why they marked them in a class discussion. Also give a chance for the students to share what they learned from the blogs and other research.

Station I: GPS
Separate the students into groups of two or three and have them go around the school grounds marking places which they think the desert tortoise would use in their daily life. This could be where they eat, sleep, drink, hibernate, lay their eggs, or dig their burrows. Each group will get 10 minutes to mark at least three waypoints. There are clipboards to use in the trunk for when they go out.

Station II: Summarize the blog
There are laminated blogs from the Desert Tortoise Conservation Center (DTCC) in the green folder. Students will write a 1-paragraph summary on at least one of the blogs. Encourage students to read more than one blog if they finish one.

Station III: Self-directed research
There are several information sheets (in the green folder) and books about the desert tortoise in the trunk. There is also a tortoise shell. Students should take notes and make observations using these materials.

Sample Teacher Questions

- Why was that place the best to get the resource that you chose?
- What kind of protection would that place provide?
- What time of year might the desert tortoise spend in that location?
- What was something interesting you learned from the blogs?
- How did you approach the independent research? What did you learn?

END DAY 1

2H: GPS Tracking and Spatial Ecology

Explore 2 • 30 min

DESCRIPTION

Students will use Google Earth to analyze GPS data.

GETTING READY

- Load the data from each GPS (A, B, C, D) in the computers
- Load conservation challenge data files (condors, pandas, desert tortoises) from USB drive onto the computer
- Make copies of worksheet 2 (suggested)

LEADING THE INVESTIGATION

- Have the students go to the computer lab and open Google Earth then load the data from the GPS unit that they used.
- Since the GPS will have been used multiple times (because it is taken out three times each period and multiple periods) each GPS will represent one individual.
- Using the instruction sheets in the red folder let the students play around with Google Earth for a few minutes.
- For half of the time have students play with their own data to get used to it.
- Then introduce the conservation challenge. Encourage the students to use the tools they used in analyzing their own data to analyze the conservation challenge data.
- Have students try it on their own before they work together to solve the challenge.

Explain • 10 min

DESCRIPTION

The teacher will debrief the use of GPS, emphasizing why it is a useful tool to researchers in the field.

Sample Teacher Questions

- What evidence do you have that one area is better than another?
- What methods did you use to come to this conclusion?
- Do agree with your classmates? What piece of evidence do you agree or disagree with and why?
- What would be the next steps after analyzing this data?

2H: GPS Tracking and Spatial Ecology

Evaluate/Extend • 10 min

DESCRIPTION

Students will write a paragraph with an introductory sentence, supporting sentence, and conclusion sentence, answering: "If you were a conservation biologist, what would you use the GPS to study and how?" (It doesn't have to be the desert tortoise.)

List a couple other possible extension Questions

- Update KWL chart
- Have a guest speaker from the SDZoo Institute for Conservation Research come and talk about how spatial ecology affects their work

Option B

Explore • 35 min

DESCRIPTION

Students will use GPS and Google Maps to analyze data.

GETTING READY

- Check to make sure that all the GPS units have batteries.
- Download Google Earth on class computer.
- Check to make sure that data points work on Google Earth.
- Make copies of Worksheet 1 (optional).
- Ask students to bring laptops to class if they have them, and download Google Earth.

LEADING THE INVESTIGATION

This investigation will have three "stations." Students will rotate between the three stations so that they will always have something to do, and everyone will have a chance to interact with the technology. Each station will take 10 minutes.

Once all the students had a chance to work with the GPS units, do a debrief of the activity by asking some of the places that the students marked and why they marked them in a class discussion. Also give a chance for the students to share what they learned from the blogs and other research.

2H: GPS Tracking and Spatial Ecology

Station I: GPS
Separate the students into groups of two or three and have them go around the school grounds marking places which they think the desert tortoise would use in their daily life. This could be where they eat, sleep, drink, hibernate, lay their eggs, or dig their burrows. Each group will get 10 minutes to mark at least 3 waypoints. There are clipboards to use in the trunk for when they go out.

Station II: Summarize the blog
There are laminated blogs from the Desert Tortoise Conservation Center (DTCC) from the San Diego Zoo in the green folder. Students will write a 1-paragraph summary on at least one of the blogs. Encourage students to read more than one blog if they finish one.

Station III: Self-directed research
There are several information sheets (in the green folder) and books about the desert tortoise in the trunk. There is also a tortoise shell. Students should take notes and make observations using these materials.

Sample Teacher Questions

- Why was that place the best to get the resource that you chose?
- What kind of protection would that place provide?
- What time of year might the desert tortoise spend in that location?
- What was something interesting you learned from the blogs?
- How did you approach the independent research? What did you learn?

Explain/Extend • 15 min

DESCRIPTION

Teacher will demonstrate using Google Earth by following the instructions in worksheet two, and solve the conservation challenge as a class. Students who brought their own laptops can load the maps on to their computers and do this on their own.

List a couple other possible extension Questions

- Update KWL chart
- Have a guest speaker from the SDZoo Institute for Conservation Research come and talk about how spatial ecology affects their work
- How else might GPS units be used to further conservation efforts?

3H: Disease

Theme/Concept:	Desert tortoises contract disease through contact with others, and can carry a disease without showing symptoms of being infected.
Goals:	Students will understand some of the techniques used to identify disease in desert tortoises and how or why they are used.
Objectives: (Evidence of student learning)	Students will be able to identify a diseased tortoise from a healthy one through scientific means. State that a tortoise does not need to show symptoms to be infected and/or carry a disease.
California State Standards	Biology 10b. Students know the role of antibodies in the body's response to infection. 10d. Students know there are important differences between bacteria and viruses with respect to their requirements for growth and replication, the body's primary defenses against bacterial and viral infections, and effective treatments of these infections.
Next Generation Science Standards Practice	3. Planning and carrying out investigations 4. Analyzing and interpreting data

3H: Disease

Materials in Kit	Urolith Case files (x5) Manilla folders
Materials provided by teacher	Optional notes/worksheet/exit slip
Safety Requirements	Handle Urolith with care, do not drop
Materials on USB drive	• 3H Presentation • 3H Notes • 3H Worksheet • 3H Exit Slip

3H: Disease

Specific Background Info for Lesson
(Including definitions)

Upper Respiratory Tract Disease (URTD) is a chronic infectious disease that developed in captive tortoises and spread to the wild. The URTD disease contributed to the rapid decline in wild desert tortoise population. It is characterized by mild to severe nasal discharge as well as lethargic behavior. It is common in many different types of tortoises. Because it is found in other types of tortoises, it is possible that the disease was introduced in captivity to a desert tortoise population and evolved to the bacteria Mycoplasma agassizii as we know it today. The other bacteria that is responsible for this disease is Pasturella testudinis.

Cutaneous dyskeratosis is an infectious disease characterized by shell lesions. The lesions first appear on the plastron and sometimes on the carapace and forelimbs. In advanced cases, exposed areas can become infected with bacteria, fungus, and exposed tissue and bone may become necrotic. It comes from an unknown source in the desert tortoise population first described as early as 1979. It is unknown how the disease is transmitted. Though there are hypotheses such as autoimmune diseases, exposure to toxic chemicals, or a deficiency disease.

Uroliths are a common problem in captive tortoises. They are analogous to kidney stones in humans. There are various causes of uroliths, the most common being dehydration and improper nutrition. Small stones can be eliminated from the bladder, but larger stones can grow enough to take up the entire bladder making water storage difficult for the tortoise. Larger uroliths must be removed through surgery. The traditional surgery involves cutting the lower shell of the tortoise, but there has been a new, less invasive technique developed at the San Diego Zoo Safari Park Hospital which only involves cutting the skin of the tortoise.

Fibrous osteodytrophy is a bone disease evidenced by a soft shell. It is usually caused by malnutrition from the lack of proper calcium to phosphorus ratio, sunlight, or both. This disease causes shell deformities, including raised, pyramid-like scutes on the upper-shell. Feeding tortoises fibrous plants and keeping them outdoors are a good way to help prevent this disease.

3H: Disease

Engage • 3 min

DESCRIPTION

Students will pass along a Urolith and answer probing questions about it.

Sample Teacher Questions

- What is this?
- Where do you think it came from?
- Why do you think that it had to be removed?

Explore • 27 min

DESCRIPTION

Students will use the information provided in case files to diagnose sick tortoises and come up with a solution to help heal the tortoises. Then the students will switch partners and share with another group what they learned. Lastly, there will be a class discussion about the different diseases and how they work.

LEADING THE INVESTIGATION

1. Break students into groups of 4 and give each group a case file
2. Have students read the file and conference about what may be wrong with the tortoise
3. Students will come up with a solution to treat the tortoise in their group.
4. Students will split their group up and then make new groups so that each member of the group will have a different case file
5. Students will share their case file and the solution with group members
6. Other group members give suggestions as to how they might approach the situation
7. One representative from each group shares with the class about the disease and what they would do to solve it

KEY

Case File 1: Fibrous osteodytrophy
Case File 2: URTD
Case File 3: Urolith
Case File 4: Cutaneous dyskeratosis
Case File 5: Healthy

Sample Teacher Questions

- How did you decide on this procedure? What is the procedure?
- Is there a more efficient way to treat this tortoise?
- Do you think that there is anything wrong with the tortoise at all?

- Would this disease likely occur in the wild?
- How do you think that the disease spread?
- How is the tortoise sick?

Explain • 15 min

DESCRIPTION

The teacher will go over techniques used by scientists to solve desert tortoise diseases.

Sample Teacher Questions

- How is this similar to what you came up with?
- How is it different?
- Would you want to work in one of these labs?

Evaluate/Extend • 5 min

DESCRIPTION

Students will write a short answer about the main way they can prevent the spread of disease in desert tortoises as well as other populations such as humans.

List a couple other possible extension Questions:

- Do you think that tortoise diseases could spread to humans? Why or why not?
- How do you think desert tortoises would overcome these diseases in the wild? Could they over come them?
- What kind of bacterial infections are there for humans?
- Could these diseases infect other reptiles? Would it be easier to infect other reptiles than to infect mammals?

4H: Population Genetics

Theme/Concept:	Populations in the wild can be estimated using math. Desert tortoise populations have drastically decreased in the last 30 years.
Goals:	Students will understand that desert tortoise populations have decreased and this creates problems for species survival.
Objectives: (Evidence of student learning)	Students will be able to Estimate population size using math Define the meaning of genetic drift
California State Standards	Biology 7d. Students know variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions. 8b. Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment. 8c. Students know the effects of genetic drift on the diversity of organisms in a population. 8d. Students know reproductive or geographic isolation affects speciation.
Next Generation Science Standards Practice	2. Developing and using models 3. Planning and carrying out investigations 5. Using mathematics and computational thinking 6. Constructing explanations (S) and designing solutions (E)

4H: Population Genetics

Specific Background Info for Lesson
(Including definitions)

This lesson is intended to be a guided inquiry lesson. Students will be given a question and all the tools they need to solve the problem. Once you give students a chance to brainstorm their own solutions, they should be introduced to the methods that scientists use, including the math that goes with them. In the experiment, students will have to estimate population size. Counting them 1-by-1 would take too much time and is often not plausible to catch all the individuals of a species in the wild. So to take an approximation of the population scientists use the catch and release technique. This technique involves catching animals, tagging them, and releasing them. Then the scientists will wait a certain amount of time then repeat the capture trials. They use math to approximate the population in a given environment. We will model this activity using marbles and dry erase markers. Each marble represents a desert tortoise. You should give students a chance to explore their own methodology before giving them the "shortcut" to how scientists account for populations in the wild.

Morafka's desert tortoise and Agassiz's desert tortoise are two different species in North America. Morafka's desert tortoise lives south and east of the Colorado River whereas Agassiz's desert tortoise lives to the north and west of the Colorado River. They are very similar, such as in habitat and diet. However, they differ in burrow location, shell shape, egg laying season, and molecular structure. Given that the Colorado River is the boundary that separates them, some think that this physical separation is what led to speciation.

The bottleneck effect is when there is a large decrease in population. It is a problem because the members of the new population now have less genetic diversity, thus making species survival more difficult. Genetic drift is when there is a change of allele frequencies. A population bottleneck can lead to genetic drift. Genetic drift eventually leads to speciation, or the creation of

new species. Speciation is characterized by reproductive isolation and/or physical isolation. As we saw above, the desert tortoise has undergone speciation. It can also occur when two populations have the same fundamental niche, but occupy different realized niches. This may also be the case when it comes to desert tortoises.

A survivorship curve shows the proportion of individuals in a population at particular ages. There are three types of survivorship curve. Type I represents large young and intermediate populations but a small older population, such as humans. Type II represents a gradual decline in population from young to old, such as squirrels. Finally, the type III survivorship curve has high mortality rates in the younger population, but a consistent death rate thereafter. The desert tortoise has a type III survivorship curve. This is because tortoise hatchlings are vulnerable to many different things. Once they leave the burrow they hatched in, their tortoise shells have not fully grown and hardened. This allows predators to easily grab them and eat them. The tortoises can also die of heat stroke and freezing due to harsh desert conditions. The bounce back of the tortoise population in the wild is taking a long time due to this model of survival. Not only do many of the young die, they also take years to reach sexual maturity, thus making conservation efforts even more essential to species survival.

4H: Population Genetics

Materials in Kit	(2) Bowls (2) Bags of marbles (6) Desert tortoise “eggs”
Materials provided by teacher	(Optional) Calculators
Safety Requirements	Small objects are choking hazards Glass beads may break, if they do, do not let kids handle broken pieces and dispose of them properly.
Materials on USB drive	• 4H Presentation • 4H Notes • 4H Worksheet

4H: Population Genetics

Engage • 5 min

DESCRIPTION

Students will play a game where they have to throw the "tortoise eggs" into a wooden bowl from across the classroom. The "tortoise eggs" are Ping Pong balls. Select a few students to try it out. Assuming they should not make their goal, but one might, this demonstrates that many tortoise eggs do not end up surviving to maturity. Ping Pong balls are the same size as desert tortoise eggs. Remember to replace the balls back into the trunk.

Sample Teacher Questions:

- What are some reasons that the eggs will not survive to adulthood?
- What does this mean for the desert tortoise population? Is it younger or older?
- Why do you think this gives the surviving tortoise population an advantage?

Explore • 25 min

DESCRIPTION

Students will use marbles to represent tortoises to compare estimated population size in 1980 versus today. This is also a good activity to show population bottlenecking and genetic drift.

GETTING READY

1. Pour the bag of marbles labeled 125 into one wooden bowl and the bag labeled 13 into the other wooden bowl.
2. Label the bowl with 125 marbles "About 50 years ago", and the bowl with 13 marbles "Present Day."
3. Check over the marbles to make sure that none of them have marker on them.

LEADING THE INVESTIGATION

1. Provide the students with background information about populations of desert tortoise in the Mojave Desert.
2. Split the class in half. Each half will get one bowl of "tortoises."
3. Present the students with the question "How many tortoises were in the Mojave Desert 50 years ago and how many are there today?" Explain what materials are available to them: calculator, dry erase marker, stop watch, etc.

4H: Population Genetics

4. For the first 5-10 minutes do not tell the students how to do the problem, and come up with solutions on their own.
5. Put this formula for catch and release on the board: **N=(M)(n)/R** [**N** represents the total population size to be estimated, **M** represents the number of individuals in the initial capture, **n** represents the number of individuals in the repeat capture, and **R** represents the number of marked recaptures]. Give students a hint that the dry erase markers might be helpful for the activity.
6. Actual procedure: students grab one large handful of marbles from the bowl, count them (**M**), and then mark them with the marker. They then add the newly marked marbles back into the bowl and mix the contents well. Students then grab a second large handful of marbles, count them (**n**), and then record how many of them are marked (**R**). Students then use the formula to estimate the population size. The whole procedure can be repeated multiple times to check for accuracy (NOTE: remind students to remove the marker from marbles between trials).
7. Come together and discuss how the two populations differ and why it is important.
8. Put away the 13 set of marbles, but keep the set of 125 out.
9. Tell them a story about the other desert tortoise: Morafka's desert tortoise. "A long long time ago there was only one kind of desert tortoise who wandered across North America. They stretched from Canada all the way down to Mexico. But as times changed, so did the environment. The Colorado River formed from a melting glacier, and one population was split into two."
10. Take a few handfuls of marbles from the full bowl and put it into the empty bowl.
11. Ask the students about what is happening, and what would happen to the population over long periods of time (such as thousands of years).

Sample Teacher Questions

- What method did you use to count the tortoises? Why did that work or not work?
- How many tortoises did you get in the end?
- How would this be different in the wild?

4H: Population Genetics

Explain • 10 min

DESCRIPTION

Debrief the activity by explaining about population sampling, population genetics, and evolution.

Sample Teacher Questions

- What was your estimate?
- How did you get it?
- Would you do anything differently?
- What would happen to the genes of the tortoises if they were separated by a river?
- How did the river get there? Do you think they may have always been different species?

Evaluate • 5 min

DESCRIPTION

Students will write down the answer to the following question in a full sentence: "Why do scientists believe there are more than one kind of desert tortoise?"

Extend • 5 min

DESCRIPTION

Update the KWL chart using notes from the previous lessons.

List a couple other possible extension Questions

- Have a research scientist come in and talk about the surveys that they do in the field
- Develop a citizen science project where the kids can do the data collection on local species of plants or animals
- Explore phylogenetic trees on the internet and show how species have evolved over time

**Note: This lesson has two different versions, one which is half a lesson and one which is a full lesson. The half lesson is designed so that you can give a short unit quiz to sum up the lesson. For the half lesson skip the explore and just use the powerpoint before the quiz. For the full lesson include the explore portion.

5H: Conservation

Theme/Concept:	Desert tortoises are worthy of conservation efforts and you can help!
Goals:	Students will understand the effects that humans have had on the desert tortoise's environment as well as know the steps they can take to help conserve the desert tortoise.
Objectives: (Evidence of student learning)	Students will be able to state why conservation of desert tortoises and their environment is important and complete a quiz on the desert tortoise.
California State Standards	Biology 6g. Students know how to distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change.
Next Generation Science Standards Practice	5. Using mathematics and computational thinking 7. Engaging in argument from evidence

5H: Conservation

Materials in Kit	
Materials provided by teacher	(Optional) Calculators (Optional) Quiz (Optional) Notes
Safety Requirements	
Materials on USB drive	• 5H Presentation • 5H Notes • Unit Quiz

Specific Background Info for Lesson
(Including definitions)

Conservation education is one of the most important goals for San Diego Zoo Global. With the desert tortoise, we work mainly at the Desert Tortoise Conservation Center outside of Las Vegas. At the DTCC, there are tours given so that the community can learn about desert tortoises. Research also takes place at the center on pressing issues such as the effect of the upper respiratory tract disease as well as the current desert tortoise population in the Mojave Desert. It is also a safe haven where tortoises can be dropped off if their owners can no longer take care of them. The DTCC is working hard to reintroduce healthy tortoises back into the wild to reestablish the population that was lost.

5H: Conservation

Explore/Explain • 30 min

DESCRIPTION

Students will use data given to find out how fast the desert tortoise population has declined. Then they will try to figure out why, and how they can help preserve desert tortoise populations.

GETTING READY

1. Divide students into groups of four or five. Make sure to have a student that is stronger in math in each group.
2. Write the following on the board, or use the powerpoint

Decade	Population Density
1950s	250 tortoises/mi^2
1980s	200 tortoises/mi^2
1990s	90 tortoises/mi^2
2000s	10 tortoises/mi^2
2010s	5 tortoises/mi^2

Available environment: 8,000 mi^2

Leading the Investigation:

1. Students in small groups will have to answer the question "If the desert tortoise populations continue to decline, when will they go extinct?"
2. Instruct the students to use math to figure out when the tortoise would go extinct if we do not step in to help their population. Perhaps they could draw a graph, or create an equation. They could figure out the approximate number of tortoises in the wild, and what percentage is lost between each decade. This is a math modeling problem, so hopefully students will come up with various answers.
3. After students come up with their solutions, ask them to share to the class, what they came up with and how they came up with it. Give the other students an opportunity to agree or disagree with them, and ask them to justify why.
4. Then show the powerpoint, telling the students what exactly is leading to the decrease in population.
5. Before getting to the portion about how they can help, have the students brainstorm ways to help conservation efforts.

Evaluate • 30 min

DESCRIPTION

There is a short unit quiz with 15 multiple choice questions and 2 short answer questions.

Extend • 5 min

DESCRIPTION

Have students revisit the KWL chart one last time. Make sure that all the "Want to know" questions are answered.

List a couple other possible extension Questions

- Can you explain what you have done in the past and how it differs from what you will do in the future? Why?
- Now that you know a little about desert tortoises, what more is there to learn? Is there anything else you want to know?
- If you had your own pet desert tortoise, what would it need to survive?