



DNA DETECTIVES

PROTECTING ENDANGERED SPECIES

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Grade Level
High School

Subject Area
Biology & Environmental Science

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Activity Title: DNA Detectives: Protecting Endangered Species

Focus: Protecting endangered species using genetics and conservation techniques.

Grade Level: High School Environmental Science/Biology

VA Science Standards:

BIO.5- The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include:

- a. genetic variation;
- b. use, limitations, and misuse of genetic information; and
- c. exploration of the impact of DNA technologies.

BIO.7- The student will investigate and understand how populations change through time. Key concepts include:

- d. how genetic variation, reproductive strategies, and environmental pressures impact the survival of populations;
- e. how natural selection leads to adaptations;

BIO.8- The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include:

- f. the effects of natural events and human activities on ecosystems;

Learning Objectives/Outcomes:

1. Students will define terms related to the Endangered Species Act, conservation, and genetics.
2. Students will solve a puzzle using the definition of terms to reveal a genetic sequence.
3. Students will explore the NCBI BLAST website and use their genetic sequence to identify their endangered species.
4. Students will research information about an endangered species.
5. Students will work in groups to summarize and discuss why their species is endangered and develop a conservation plan.
6. Students will compose a formal report to the U.S. Fish and Wildlife Service (USFWS) using research about their species to explain why their species is endangered and design a conservation plan to protect their species.

Total Length of Time Required for Lesson: 90-minute class period

Vocabulary:

Endangered Species Act – U.S. Law passed by Congress in 1973 which protects threatened and endangered species and the habitat in which they live.

Species – “any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.” Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884)

Endangered – “species is in danger of extinction through-out all or a significant portion of its range.” Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884)

Threatened – “species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.” Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884)

Conservation – “to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary.” Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884)

Natural resources – plants, wildlife, minerals, soil, water, and air.

Biodiversity – the variety of flora and fauna that live in an environment.

Genetics – the study of heredity, or the passing of genetic characteristics from parents to offspring.

Adaptation – a change in physical, genetic, or behavioral attributes that allow an organism or species to be better suited for their environment.

Inbreeding – when individuals related to one another produce offspring together.

Bottlenecking – a sharp reduction in size of a population due to environmental or anthropogenic events.

Anthropogenic factors – human related activity, like pollution.

Background Information:

Endangered Species Act

In 1973, Congress passed the Endangered Species Act (ESA). This act is jointly administered by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). As the strongest U.S. conservation law, the ESA provides protection and establishes conservation for threatened and endangered species and the habitats in which they live. As of 2019, 2,054 species are listed as endangered worldwide. Under the ESA, an endangered species is “a species is in danger of extinction throughout all or a significant portion of its range” and a threatened species is “a species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.” Even though the ESA is administered by USFWS and NMFS, the protection of endangered and threatened species is also dependent upon multiple stakeholders like state agencies and private landowners.

Conservation

Conservation is the act of protecting the land and all living things within it through sustainable use, so that the natural resources can persist for many generations. Natural resources include things like plants, wildlife, minerals, soil, water, and air. Conservation requires developing management plans to help protect these resources. These management plans can include actions like law enforcement, habitat protection and maintenance, trapping and relocating animals, restricting take, and research. Major issues associated with a decline in biodiversity include climate change, invasive species, habitat destruction, overexploitation, and pollution. Many of these issues are caused by anthropogenic factors, or actions related to human activity.

Genetics

Genetics is the study of heredity, or the passing of genetic characteristics from parents to offspring. As scientists, we can use concepts related to genetics and genetic diversity to help solve problems related to biodiversity and the conservation of species. If a species has genetic diversity and is able to adapt or show change in physiological, genetic, or behavioral attributes, that species will be better suited for an ever-changing environment. Certain issues that can be solved by looking at the genetics of an individual or species can be things like inbreeding, when individuals related to one another produce offspring together. This could be an indication that the population size is low, or that a population may be isolated from others which would result in a loss of genetic diversity because the populations are unable to share genetic characteristics. Bottlenecking, or the sharp reduction in population size can also have negative effects on the success of a population because genetic diversity would be limited with a decreasing genetic pool of individuals.

Student Handouts & Key:

1. Key for Definition Worksheet (Appendix 1)
2. Fill-in-the-blank Definition Worksheet 1, 2, 3 & 4 (Appendix 2-5)
3. Species Background Information Worksheet 1, 2, 3 & 4 (Appendix 6-9)
4. Background Information Fill-in-the-blank Worksheet (Appendix 10)
5. Formal Report Template for USFWS (Appendix 11)

Materials & Supplies:

1. Handouts listed above
2. Computer(s) with internet access for NCBI BLAST website

Classroom Set-up:

1. Work individually at desks for the first handout
Example for a 20-student classroom: Create 5 sets of the Fill-in-the-blank Definition Worksheets (Appendix 2-5) and distribute one worksheet per student. This will later identify the student groups for the second part of the activity.
2. Have computer(s) for use by students
3. Have students work in groups for discussion and writing of report
Example for a 20-student classroom: Based on their answer from the Fill-in-the-blank Definition Worksheet, give each student the appropriate copy of the Species Background Information Worksheet (Appendix 6-9) and a copy of the Background Information Fill-in-the-blank Worksheet (Appendix 10). Group the students based on their endangered species.

ProcedureEngagement – 10 minutes

This lesson plan starts with a news article about someone that was sent to prison because they were poaching loggerhead sea turtle eggs. This is a great introduction to the material on endangered species, conservation, and genetics. Use this as an opportunity to engage the students by having them take part in a similar story. For this lesson, your students will be U.S. Fish and Wildlife biologists. They will be tasked with figuring out which endangered or threatened species they have by identifying a genetic sequence unique to their species. The students will then have to research why their species is endangered or threatened and write a formal report of their findings to the U.S. Department of the Interior.

Exploration – 20 minutes

After the storyline has been introduced, the powerpoint provided with this lesson plan can be used to explain common concepts related to the Endangered Species Act, conservation management, and genetics. The background information for these topics will be written in the notes section of the powerpoint. These notes can be used as a guide during the lecture. The goal of the powerpoint is to illustrate the importance of conserving our natural resources for sustainable use and how genetics can play a role in the conservation of species. The definitions will be bolded throughout the powerpoint. Make sure to highlight these because they will be used in the fill-in-the-blank definition worksheet.

Explanation- 20 minutes

Once the powerpoint has been given, the students will then work independently on the Fill-in-the-blank Definition Worksheet. This worksheet serves as an opportunity for students to show their understanding of the material. Students will use the word bank to match a word to its corresponding definition. There are bolded boxes throughout the activity that will reveal a genetic sequence. After students have completed the worksheet, they will decipher their code from the sequence key to reveal a 30-letter sequence. This sequence can then be entered into the NCBI BLAST public database to reveal their

endangered species. Directions for NCBI BLAST website can be found in the powerpoint or online at:
<https://www.ncbi.nlm.nih.gov/home/about/mission/> &
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2447716/pdf/gkn201.pdf>

This activity has a teacher key (Appendix 1) and 4 versions that correspond to 4 different endangered species: North Atlantic Right Whale, Atlantic Sturgeon, Rufa Red Knot, Leatherback Sea Turtle (Appendix 2-5). There are 4 versions of this assignment because after the student completes this worksheet independently, all students that have identified the same endangered species will then work in groups.

Elaboration- 15 minutes

Once the students have identified their endangered species, they will confirm their answer with their teacher. Once they have correctly identified their species, the students will then receive a corresponding species background information worksheet (Appendix 6-9) and background information fill-in-the-blank worksheet (Appendix 10) from their teacher. Once all students have finished identifying their species, they can then form groups with students that have the same endangered species. Students in groups will review the background information sheet together and then discuss what they have learned about their species and complete the fill-in-the-blank worksheet. This portion of the lesson can be an opportunity for students to extend their understanding by evaluating why their species is listed as endangered and what conservation management actions can be taken to help de-list their species from endangered to least concern. Each group can then present their findings to the class and students can compare and contrast their proposed conservation management actions.

Assessment

Evaluation- 25 minutes (optional take-home assignment)

At the conclusion of the lesson, students' success will be measured through the process of writing a formal report to U.S. Fish and Wildlife Service (Appendix 11). This can be an individual assignment at the end of the lesson, or an optional take-home assignment. To complete this report, students can use the information they recorded in the Background Information Fill-in-the-blank Worksheet. There will be a handout that goes over the format of the report as well as bullet points suggesting things to discuss and defend related to their proposed conservation management actions.

References

- USFWS endangered and threatened species in Virginia
<https://www.fws.gov/endangered/map/va-info.html>
- Leatherback Sea Turtle info
<https://www.fws.gov/northflorida/SeaTurtles/Turtle%20Factsheets/leatherback-sea-turtle.htm>
- Atlantic sturgeon info
<https://www.fisheries.noaa.gov/species/atlantic-sturgeon>
- ESA background
<https://www.fws.gov/southeast/endangered-species-act/>
- Rufa Red Knot info
<https://fws.gov/northeast/red-knot/>
- Right Whale info
<https://www.fisheries.noaa.gov/species/north-atlantic-right-whale>
- NCBI BLAST info
<https://www.ncbi.nlm.nih.gov/home/about/mission/> &
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2447716/pdf/gkn201.pdf>
- USFWS Northeast Fisheries Center, Population Ecology Lab info
<https://www.fws.gov/northeast/fisherycenter/index.html>
- Egg Poaching case
https://www.fws.gov/news/ShowNews.cfm?ref=twice-convicted-turtle-egg-thief-sentenced-to-21-months-in-prison-&_ID=35285
- ESA fact sheet
https://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf
- Conservation
<https://www.nationalgeographic.org/encyclopedia/conservation/>
- Genetics
<https://www.ncbi.nlm.nih.gov/books/NBK224405/>
- Genetics and Conservation- Textbook: Biology the Dynamics of Life by Glencoe
- Chapter 5 (Biological Diversity and Conservation)
<http://www.glencoe.com/sec/science/ose/bdol2005/ca/docs/chap05.pdf>
- Chapter 10 (Mendel's Law of Heredity – Punnet Squares, Meiosis)
<http://glencoe.com/sec/science/ose/bdol2005/ca/docs/chap10.pdf>
- Formal Report Ideas
http://www.fws.gov/Midwest/endangered/section7/ba_guide.html
- ESA fact sheet
- https://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf
- ESA
Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884)

Appendix 1

Fill-in-the-Blank Definitions

Name: TEACHER KEY

Directions: Fill in the correct definitions for each number. Once all the words have been matched, look for the genetic DNA sequence hidden in your answers. The sequence will be revealed by writing out each letter from the bolded boxes (starting with definition 1). Once you have your DNA sequence, match it with the key at the bottom of this worksheet. Once you've identified your full 30-unit sequence, enter it in the NCBI Blast database to reveal your endangered species. Pick up the corresponding research sheet for your endangered species.

ENDANGERED SPECIES ACT

1. US Law passed by Congress in 1973 which protects threatened and endangered species and the habitats in which they live.

SPECIES

2. "any sub-species of fish or wildlife or plants, and any distinct population segment of any species or vertebrate fish or wildlife which interbreeds when mature."

ENDANGERED

3. "species is in danger of extinction throughout all or a significant portion of its range."

THREATENED

4. "species is likely to become endangered within the foreseeable future throughout all of a significant portion of its range."

CONSERVATION

5. "to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary."

NATURAL RESOURCES

6. plants, wildlife, minerals, soil, water, and air.

BIODIVERSITY

7. the variety of flora and fauna that live in an environment.

Appendix 1

GENETICS

8. the study of heredity, or the passing of genetic characteristics from parents to offspring.

ADAPTATION

9. a change in physical, genetic, or behavioral attributes that allow an organism or species to be better suited for their environment.

INBREEDING

10. when individuals related to one another produce offspring together.

BOTTLENECKING

11. a sharp reduction in size of a population due to environmental or anthropogenic events.

ANTHROPOGENIC FACTORS

12. human related activity, like pollution.

Word Bank:

Genetics	Biodiversity	Conservation	Threatened
Species	Anthropogenic factors	Natural Resources	Endangered Species Act
Adaptation	Inbreeding	Endangered	Bottlenecking

Code:

Sequence Key:

Code 30-letter Genetic Sequence for BLAST

tatccatctg= tatccatctg actaccacta ccaactacat (Group 2- Leatherback Sea Turtle)

ttttaagcat= attgggctaa ttttaagcat agcatgattt (Group 3- Atlantic Sturgeon)

ccagttcgtt= ccagttcgtt aaccacgct aagcaatcaa (Group 1- North Atlantic Right Whale)

acgtgagcta= ctgaggaaat acgtgagcta cggtcgggct (Group 4- Rufa Red Knot)

NCBI Blast Directions:

1. Go to the homepage: <https://www.blast.ncbi.nlm.nih.gov> and click the Nucleotide BLAST option
2. Enter in your 30-letter genetic sequence into the top left box.
3. Hit the BLAST button in the bottom left corner once the sequence is entered.

Appendix 4

8. when individuals related to one another produce offspring together.

9. a sharp reduction in size of a population due to environmental or anthropogenic events.

10. “species is in danger of extinction throughout all or a significant portion of its range.”

11. plants, wildlife, minerals, soil, water, and air.

12. a change in physical, genetic, or behavioral attributes that allow an organism or species to be better suited for their environment.

Word Bank:

Genetics	Biodiversity	Conservation	Threatened
Species	Anthropogenic factors	Natural Resources	Endangered Species Act
Adaptation	Inbreeding	Endangered	Bottlenecking

Code:

Code Match: 30-letter Genetic Sequence for BLAST:
 tatccatctg = tatccatctg actaccacta ccactacat
 tttaagcat = attgggctaa tttaagcat agcatgatt
 ccagtcggt = ccagtcggt aaccacgct aagcaatcaa
 acgtgagcta = ctgaggaaat acgtgagcta cggtcgggct

NCBI BLAST Directions:

1. Go to the homepage: <https://www.blast.ncbi.nlm.nih.gov> and click Nucleotide BLAST option.
2. Enter in your 30-letter genetic sequence into the top left box.
3. Hit the BLAST button in the bottom left corner once the sequence is entered.

Appendix 5

8. when individuals related to one another produce offspring together.

9. the study of heredity, or the passing of genetic characteristics from parents to offspring.

10. plants, wildlife, minerals, soil, water, and air.

11. human related activity, like pollution.

12. “species is likely to become endangered within the foreseeable future throughout all of a significant portion of its range.”

Word Bank:

Genetics	Biodiversity	Conservation	Threatened
Species	Anthropogenic factors	Natural Resources	Endangered Species Act
Adaptation	Inbreeding	Endangered	Bottlenecking

Code:

Code Match: 30-letter Genetic Sequence for BLAST:
 tatccatctg = tatccatctg actaccacta ccactacat
 tttaagcat = attgggctaa tttaagcat agcatgatt
 ccagtcggt = ccagtcggt aaccacgct aagcaatcaa
 acgtgagcta = ctgaggaaat acgtgagcta cggtcgggct

NCBI BLAST Directions:

1. Go to the homepage: <https://www.blast.ncbi.nlm.nih.gov> and click Nucleotide BLAST option.
2. Enter in your 30-letter genetic sequence into the top left box.
3. Hit the BLAST button in the bottom left corner once the sequence is entered.

Appendix 6

Species Background Information (1)

Name: _____



"2004: Right Whale and Young Calf" by Georgia Wildlife Resources Division is licensed under CC BY-NC-SA 2.0

Scientific name:

Eubalaena glacialis

Common name:

North Atlantic Right Whale

Current ESA status:

Endangered

Year protection started:

1970

Lifespan:

40 – 70 years old

Habitat Range:

Atlantic coastal waters

Diet:

Zooplankton

Reproduction:

A female reproduces every 6-10 years.

North Atlantic Right Whales are very social and will socialize at the water's surface. This species also communicates using low-frequency vibrations. North Atlantic Right Whales are known to migrate long distances from feeding grounds to nursery areas for their young.

North Atlantic Right Whales are one of the most endangered large whale species in the world. This species is a baleen whale, using their baleen to comb through the water for zooplankton. In the 1890s commercial whalers started hunting this species, almost bringing them to the point of extinction.

Current threats to North Atlantic Right Whales are entanglement in fishing gear. Entanglement in fishing gear can cause stress and injure a whale, which could lead to death. This species is also vulnerable to interactions with ships. This species migration routes brings them close to ports, where they could be hit by passing ships. Lastly, this species is also affected by ocean noise. Because North Atlantic Right Whales are a vocal species, their communication can be interrupted by other noise pollution.

Source: <https://www.fisheries.noaa.gov/species/north-atlantic-right-whale>

Appendix 7

Species Background Information (2)

Name: _____



"Sea Turtle" by AntoinetteDubey is licensed under [CC BY 2.0](https://creativecommons.org/licenses/by/2.0/).

Scientific name:

Dermochelys coriacea

Common name:

Leatherback Sea Turtle

Current ESA status:

Endangered

Year protection started:

1970

Lifespan:

30 years old

Habitat Range:

Open ocean

Diet:

Jellyfish, squid, fish, seaweed

Reproduction:

Nest 5-7 times per season (March – July).

Nest every 2-3 years.

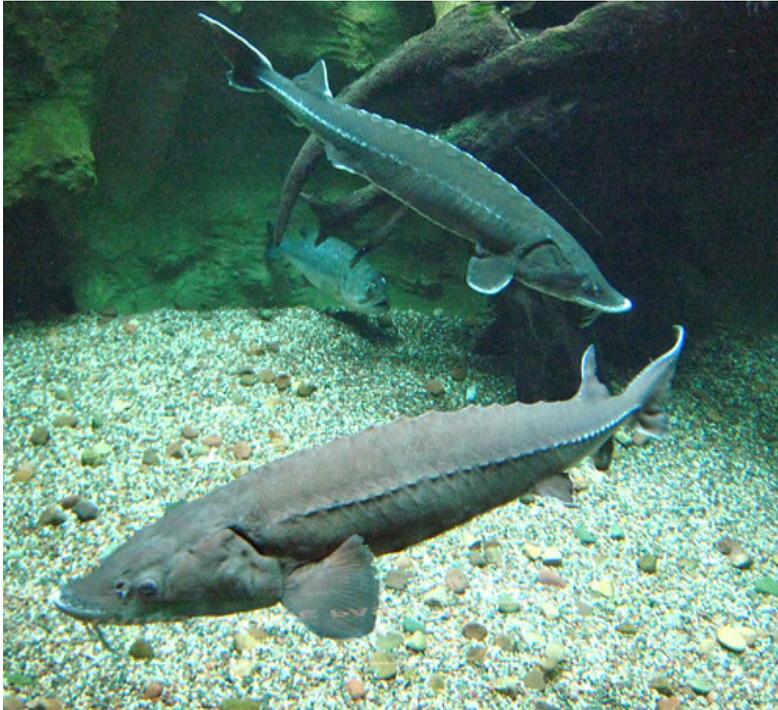
The Leatherback Sea Turtle is the most open ocean living sea turtle. This species is distributed worldwide in the Atlantic, Pacific, and Indian oceans. In the North Atlantic, there is an estimated 34,000 – 94,000 adult Leatherback Sea Turtles.

Leatherback Sea Turtle populations have been in decline. Nesting has been reduced in areas along the Pacific coast of Mexico, Costa Rica, and Malaysia. Current threats to Leatherback Sea Turtles are related to human use of their eggs and meat. This species is also threatened by bycatch from commercial fisheries. Other threats to this species include habitat loss due to housing developments on the coast. The housing developments cause light and noise pollution that disrupts nesting behavior of Leatherback Sea Turtle hatchlings. Leatherback Sea Turtles are also affected by marine debris and pollution.

Source: <https://www.fws.gov/northflorida/SeaTurtles/Turtle%20Factsheets/leatherback-sea-turtle.htm>

Appendix 8
Species Background Information (3)

Name: _____



"Shedd Aquarium" by swimfinfan is licensed under CC BY-SA 2.0.

Scientific name:

Acipenser oxyrinchus

Common name:

Atlantic Sturgeon

Current ESA status:

Endangered

Year protection started:

2012

Lifespan:

30 - 60 years old

Habitat Range:

Canadian and US Atlantic Coast

Diet:

Crustaceans, Mollusks, Worms

Reproduction:

Reproduce every 2 – 3 years.

Atlantic Sturgeon are an anadromous fish species. This means that they are born in freshwater, but migrate to the ocean to mature then come back to freshwater to reproduce. Most Atlantic Sturgeon will return to their birthplace to reproduce. This species is slow-growing and matures late in life.

Atlantic Sturgeon used to have large populations, but they have declined due to overfishing and habitat loss. In the 1800s this species was fished for their eggs, which were used in the caviar industry. By the 1900s the Atlantic Sturgeon population declined drastically.

Current threats to Atlantic Sturgeon include bycatch from other commercial fisheries. This species is also affected by habitat loss. This is primarily due to human activities like dredging, building dams, and pollution. Dams have become a major issue for species that require migrating from river to the ocean and back because they block fish from being able to move freely.

Source: - <https://www.fisheries.noaa.gov/species/atlantic-sturgeon>

Appendix 9
Species Background Information (4)

Name: _____



"Red Knot" by K Schneider is licensed under CC BY-NC 2.0

Scientific name:
Calidris canutus rufa

Common name:
Rufa Red Knot

Current ESA status:
Threatened

Year protection started:
2014

Lifespan:
10-13 years old

Habitat Range:
Eastern United States

Diet:
Seeds, Beetles, Worms

Reproduction:
Eggs are laid in June and July, with
4 eggs per nest.

The subspecies Rufa Red Knot are extraordinary travelers. They complete one of the longest migrations from the Canadian Arctic to winter in Brazil. During this long migration, this species will stop along the US Atlantic coast looking for food supply.

Abundance of this subspecies has been in recent decline since to 2000s. One of the major threats to this species is lack of habitat and food supply during the long migration. An interesting source of food comes from horseshoe crab eggs. Horseshoe crab populations have also been in decline along the US Atlantic coast, which now threatens the Rufa Red Knot populations as well.

Other threats to this species include human disturbances. Some examples of this are housing developments, dredging beaches, and noise pollution. Sea level rise caused by climate change also threatens this species by taking away habitat used for resting during long migrations.

Source: <https://fws.gov/northeast/red-knot/>

Appendix 10

Background Information Fill-in-the-blank

Name: _____

Directions: Use this sheet to fill in background information about the biology and history of your species. This sheet can then be used to complete the Formal Report to USFWS.

What is your species (write the scientific and common name)?

What is the current state of your species (endangered or threatened)?

List some biological facts about your species (How long does your species live?, Where is your species found?, etc.).

List current threats to your species, like anthropogenic factors.

What are some conservation actions we can take to help protect your species?

Appendix 11



United States Department of the Interior U.S. Fish and Wildlife Service



Date: [Month Day Year]

To: [Teacher Name], U.S. Fish and Wildlife Field Supervisor

From: [Student Name], U.S. Fish and Wildlife Biologist

Subject: [Species Name], Endangered Species Report

Body:

Things to consider:

- Provide background information about biology of species.
- The current state of species (endangered or threatened).
- What has caused species to be listed as endangered.
- Recommendations on actions to help conserve and protect species.
- How those recommendations be implemented.
- Think about how you could monitor or evaluate changes in species conservation status.

Sincerely,

[Student Name]
U.S. Fish and Wildlife Biologist