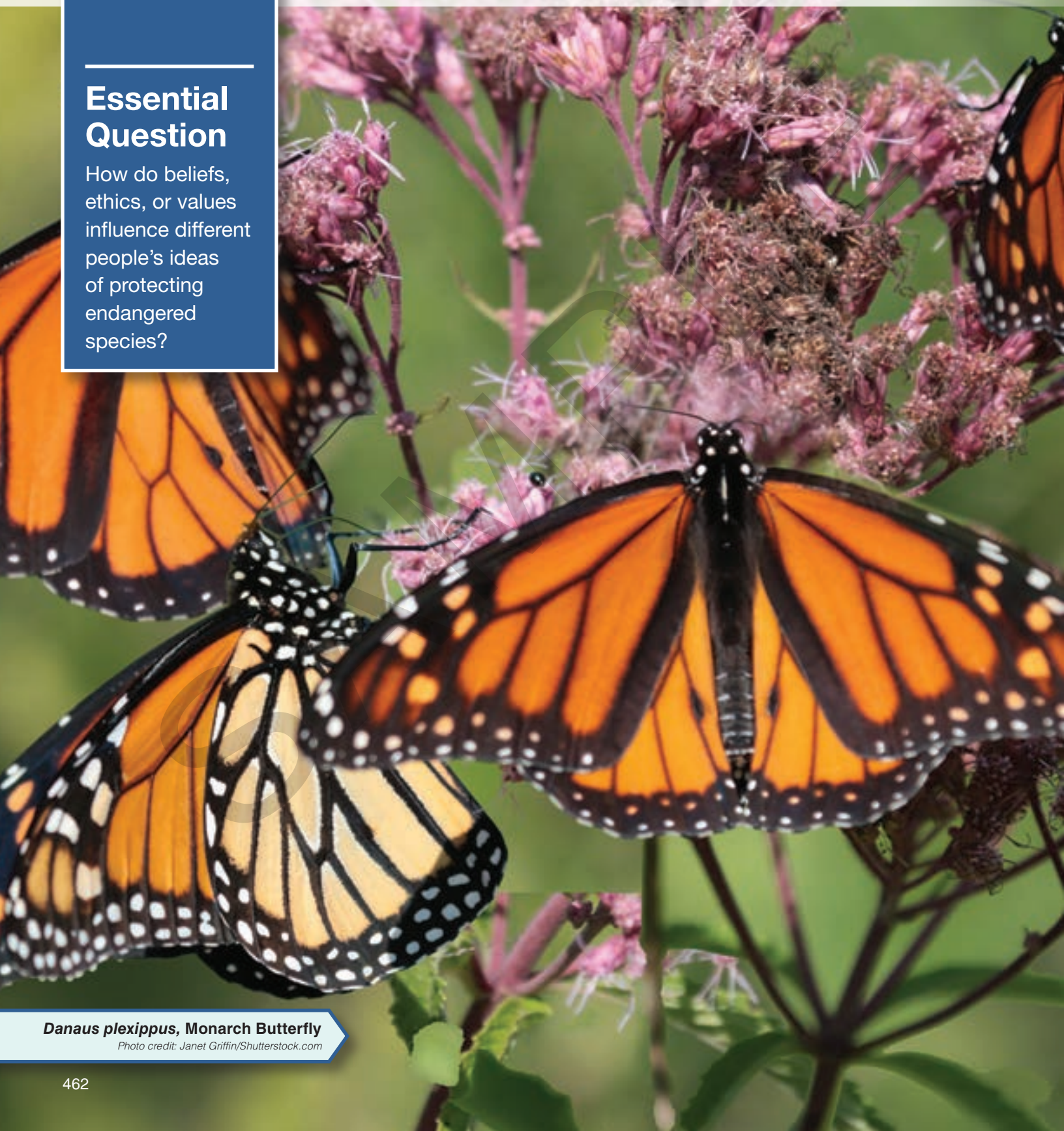
CHAPTER

19

Endangered Species

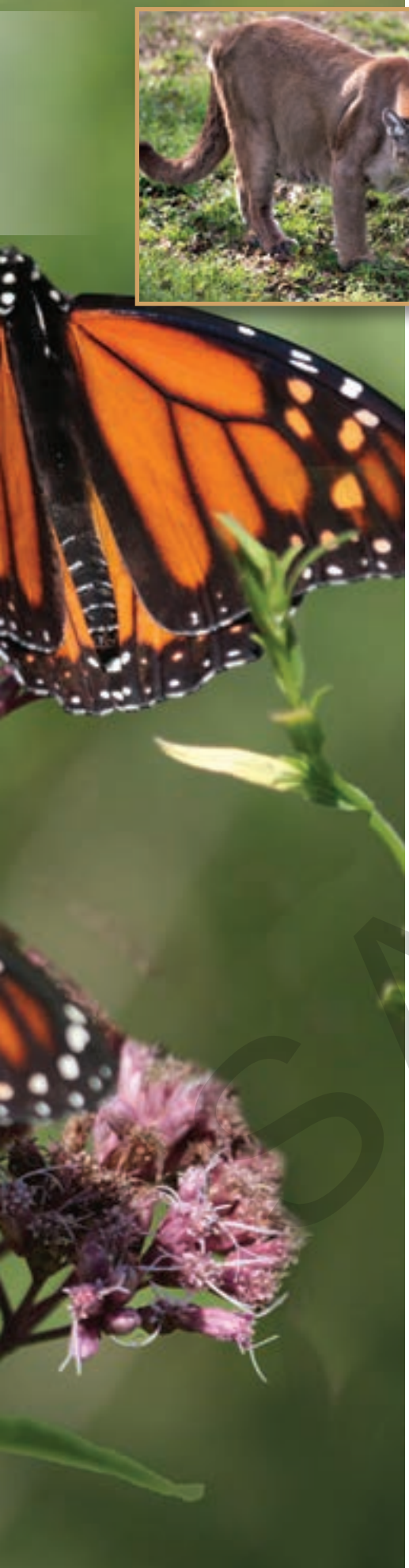
Essential Question

How do beliefs, ethics, or values influence different people's ideas of protecting endangered species?



***Danaus plexippus,* Monarch Butterfly**

Photo credit: Janet Griffin/Shutterstock.com



LEARNING OUTCOMES

After studying this chapter, you should be able to:

- Understand and explain the terminology used to describe the status of plant and animal species on the IUCN Red List of Threatened Species™.
- Understand and explain the terminology used to describe the status of plant and animal species on the US Federal Lists of Endangered Species.
- Assess causes of extinction and describe how those causes relate to loss of biodiversity.
- Explain the methods and technology used to assess wildlife species and their habitats.
- Determine strategies for preventing the loss of species and biodiversity including recover and restore efforts, captive breeding programs, and initiating a species survival plan.

KEY TERMS

background extinction rate
bioindicators
captive breeding program
complete count
critically endangered species (CR)
DNA barcode
DNA barcoding
endangered species (EN)
ex situ conservation
extinct
extinct in the wild species (EW)
extinct species (EX)
extirpation
generalized species
highly specialized species
incomplete count
indirect count
IUCN Red List of Threatened Species
least concern species (LC)
mass extinction
near threatened species (NT)
pandemic disease
quadrat
quadrat analysis
remote sensing
species survival plan (SSP)
threatened species
total count
transect line
vulnerable species (VU)
zoonotic disease

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Before You Read

Choose three animals on IUCN Red List. What do they have in common? What do you know about the history of these animals? Research the animals and learn about their history and status. Use this information to contribute to class discussions.

Did You Know?

The IUCN's current members include more than 1400 nongovernmental organizations. More than 16,000 experts volunteer in over 160 countries to perform research and assessments of the state of the world's natural resources.

Introduction

A species that is ***extinct*** is a species that is no longer living. Species extinction occurs naturally at a ***background extinction rate*** of about one to five species per year. These background extinctions are due to normal environmental changes, such as a volcanic eruption or increased competition and failure to adapt. This low rate of extinction allows other species in an ecosystem to adapt to the changes that occur when an organism is removed from an ecosystem. Today, however, scientists estimate the extinction rate is thousands of times the background rate and we are losing approximately 1000 species each year. This rate will increase as species disappear because each species' extinction has the potential to lead to the extinction of others.

Almost every species currently in danger of extinction is threatened because of our actions, primarily the destruction of habitats. Global climate change and the introduction of invasive species are also key factors. In this chapter, we will discuss how threatened species are classified, causes of species extinction, and efforts used to slow the extinction rate.

International Union for Conservation of Nature

The *International Union for Conservation of Nature (IUCN)* is an environmental organization dedicated to global conservation. The IUCN works with private, public, and nongovernmental organizations to develop ways in which conservation and sustainable development can take place together. In 1948, the initial goal of the IUCN was to examine how human activities affected the environment. In the 1960s and 1970s, the IUCN focused on the protection of

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Figure 19-1. Gee's Golden Langur, *Trachypithecus geei*, is native to Bhutan and northeastern India. There are currently 6000 to 6500 mature individuals, but the population has become severely fragmented, and the population is decreasing. The species is listed as Endangered on the IUCN Red List.

species and habitats that were necessary for their survival. In 1964, the IUCN established the ***IUCN Red List of Threatened Species***™, **Figure 19-1**. The IUCN Red List currently includes more than 134,000, including 37,480 which are threatened with extinction.

IUCN Animal Classification

The IUCN developed a system with nine classifications to help categorize species at high risk of global extinction. The IUCN Red List and the IUCN's system of classification is used by wildlife departments, government agencies, natural resource planners, and many other organizations and individuals involved in protecting endangered species and maintaining biodiversity.

- ***Extinct species (EX)*** are those with no living specimens.
- ***Extinct in the wild species (EW)*** are those with some specimens living in captivity but with no specimens living in the wild.
- ***Critically endangered species (CR)*** are species facing an extremely high risk of becoming extinct.
- ***Endangered species (EN)*** are those facing a high risk of extinction in the wild, **Figure 19-2A**.
- ***Vulnerable species (VU)*** are those likely to become endangered unless action is taken to identify and correct factors that will likely lead to its demise.
- ***Near threatened species (NT)*** are wildlife species that may face population decline in the future and should be monitored for changes, **Figure 19-2B**.
- Species labeled as ***least concern species (LC)*** are wildlife species that are doing well and have no cause for concern, **Figure 19-2C**.
- *Data deficient (DD)* identifies when there is inadequate information on abundance or distribution to make an assessment about a species' status.
- The final category is *not evaluated*.

A Photograph by Susan Berescik

B Photograph by Susan Berescik

C Photograph by Susan Berescik

Figure 19-2. A—The Utah prairie dog (*Cynomys parvidens*) is currently listed as endangered (EN) on the Red List. B—The American bison (*Bison bison*) is listed as near threatened (NT) on the Red List and as endangered on the US Federal List due to loss of genetic diversity. C—The nine-banded armadillo (*Dasypus novemcinctus*) is listed as least concern (LC) on the Red List.

IUCN Species Criteria

The criteria used to determine if a species is vulnerable, endangered, or critically endangered are population reduction rate, geographic range, population size, population restrictions, and probability of extinction.

Thinking Critically

Should our national government spend resources to save native plant species? Explain your answer.

The US Federal Lists of Endangered Species

The US Fish & Wildlife Service also publishes Federal Lists of Endangered Species that identify species as either endangered or threatened. According to the USFWS, a species identified as ***endangered*** is one that is in danger of extinction throughout all or a significant portion of its range. If a species is listed as ***threatened***, it is one that is likely to become endangered in the foreseeable future throughout all or a significant portion of its range. A species must be added to the federal lists of threatened and endangered wildlife and plants before it can receive protection by the Endangered Species Act (ESA), **Figure 19-3**.

Species Criteria

A species is added to the list when it is determined to be an endangered or threatened species because of the following factors:

- The present or threatened destruction, modification, or curtailment of its habitat or range

Career Connection

Paleobiologist

Paleontology is the scientific study of the life of past geological periods as learned from studying fossil remains. Paleobiology is a branch of paleontology in which the biology of fossil organisms is examined. It is a combination of life science biology using the methods of Earth science paleontology. A paleobiologist uses field research of current plants and animals, as well as that of fossilized remains to learn about evolution. Paleobiologists are studying evolution on a molecular level and have successfully extracted DNA and RNA samples of ancient plants and animals.

Paleobiologists must be willing to travel and spend months working wherever fossils or other resources are found. As with most biologists' work, paleobiologists also perform lab research. They may teach in universities, gather grant funding, and contribute to professional journals. They need to be willing to work in all settings and must also be self-starters to continue to gain funding for future work.

Education required: A bachelor's degree in biology is a great beginning, but to be successful in this career field, a PhD is required. It is suggested to study geology, Earth science, archeology, microbiology, paleontology, or paleobiology or a combination of these sciences to prepare for this career. The median salary for a paleobiologist is $94,000, with the potential to earn over $200,000 annually.

US Fish and Wildlife Service List of Endangered Species

Populations[1] and Recovery Plans[2] (April 2023)

	United States[3]			Foreign			Total Listings (US and Foreign)	US Listings with Active Recovery Plans[2]
Group	Endangered	Threatened	Total Listings	Endangered	Threatened	Total Listings		
Amphibians	23	16	39	8	1	9	48	28
Annelid Worms	0	0	0	0	0	0	0	0
Arachnids	11	0	11	5	0	5	16	11
Birds	77	23	100	217	22	239	339	90
Clams	77	18	95	2	0	2	97	77
Corals	0	7	7	3	15	18	25	0
Crustaceans	25	5	30	0	0	0	30	23
Fishes	94	78	172	27	9	36	208	108
Flatworms and Roundworms	0	0	0	0	0	0	0	0
Hydroids	0	0	0	0	0	0	0	0
Insects	75	17	92	4	0	4	96	69
Mammals	67	29	96	262	23	285	381	64
Millipedes	0	0	0	0	0	0	0	0
Reptiles	17	29	46	70	25	95	141	41
Snails	38	13	51	1	1	2	53	43
Sponges	0	0	0	0	0	0	0	0
Animal Totals	**504**	**235**	**739**	**599**	**96**	**695**	**1434**	**554**
Plant Totals	766	172	938	1	2	3	941	834
Grand Totals	1270	407	1677	600	98	698	2375	1388

[1]A listing has an E or a T in the "status" column of the tables in 50 CFR 17.11(h) or 50 CFR 17.12(h) (the "List of Endangered and Threatened Wildlife and Plants").
Note: Listings with status "Similarity of Appearance" are not included in the totals.
23 animal species (15 in the United States[3] and 8 Foreign) are counted more than once in the above table, primarily because these animals have distinct population segments (each with its own individual listing status).
[2]There are a total of 653 distinct active (Draft and Final) recovery plans. Some recovery plans cover more than one species, and a few species have separate plans covering different parts of their ranges. This count includes only plans generated by the USFWS (or jointly by the USFWS and NMFS), and only listed species that occur in the United States.
[3]United States listings include those populations in which the United States shares jurisdiction with another nation.

US Fish and Wildlife Service (USFWS), ECOS (2023)

Figure 19-3. The US Fish and Wildlife Service provides complete listings of each group on their website.

- Overuse for commercial, recreational, scientific, or educational purposes
- Disease or predation
- The inadequacy of existing regulatory mechanisms
- Other natural or manmade factors affecting its survival

Did You Know?

It is estimated that more than 90% of all living creatures have gone extinct over the course of history.

Why Do Species Become Extinct?

Some species become extinct because of natural background extinctions. However, the vast majority of extinctions or endangerment since the evolution of human beings (*Homo sapiens*) are caused by humans, primarily by the following:

- Habitat loss, degradation, and fragmentation
- Introduction of invasive species
- Overharvesting (hunting, fishing, harvesting), **Figure 19-4A**
- Loss of genetic variation, **Figure 19-4B**
- Unsustainable human population growth
- Climate change

Habitat Loss, Degradation, and Fragmentation

Habitat loss or degradation is the primary cause of species endangerment or loss. Habitat loss results when a habitat is removed completely, such as filling in a wetland to construct a subdivision, or changed in a way that it cannot support its inhabitants. The wetland's inhabitants must seek a new habitat or face extirpation. ***Extirpation*** occurs when a species is locally extinct and no longer found in an area it used to inhabit but is still found elsewhere.

Habitat Degradation

Habitat degradation changes the area in such a way that it can no longer meet the needs of its inhabitants. Degradation may be caused by factors such as pollution in the soil, water, or air, a change in water flow, or the killing or removal of a key species. Light pollution and noise pollution have also been shown as detrimental to habitat health.

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Figure 19-4. A—The last dodo bird was sighted in the late 1690s on its native island, Mauritius. Although the bird was hunted by sailors, it was more likely the pigs, rats, and dogs they introduced to the island that ate the dodo eggs and killed the birds. B—The last mainland (Siberia) wooly mammoths died due to climate change and human hunters. Experts say that wooly mammoths remaining on two small islands died due to genetic decline. As the genetic variation dwindled, undesirable mutations were no longer purged from the gene pool. *What implications might this theory have on dwindling populations of endangered species?*

Habitat Fragmentation

Habitat fragmentation is the division of a large, continuous habitat into smaller, disconnected pieces. These actions separate feeding grounds, affect migration patterns, and reduce the living space for many animals. Species often become isolated in each area and may experience genetic mutations over time that enable survival. However, if the species cannot adapt, the isolation may cause its decline or extinction. For example, dams constructed to establish reservoirs or generate power make it difficult for migrating fish to travel to their spawning areas. This type of restriction leads to population decline and may result in the loss of genetic diversity within a species, which may eventually cause its extinction.

In some cases, the fragmentation presents additional hazards for animals as they must cross busy roads and contend with fast-moving vehicles. In Australia, for example, as urbanization and deforestation reduce the koala's habitat, the koalas are forced to cross roads to reach separated parts of their habitat. According to the Department of Environment and Heritage Protection in Australia, about 300 koalas are killed on the roads in Queensland each year.

Thinking Critically

What immediate effect does deforestation have on the water cycle?

Invasive Species

The introduction of an invasive species commonly causes habitat destruction and degradation. Invasive species typically have few predators, develop rapidly with a short reproduction cycle, and quickly acclimate to the new environment. Native species typically cannot defend themselves or compete with aggressive invasive species. Many North American trees, for example, have succumbed to attack from the invasive, Asian longhorn beetle. See **Figure 19-5**. Many native species are also susceptible to predation and to disease introduced through the invasive species.

Thinking Critically

Would a South American piranha survive in the Great Lakes? Would it pose a threat to the ecosystem? Explain your answer.

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Figure 19-5. Invasive species in the United States include the Asian longhorned beetle (*Anoplophora glabripennis*), cogon grass (*Imperata cylindrical*), and the European starling (*Sturnus vulgaris*). *What effect has each of these species had on the environment and our native species?*

STEM Connection

A Sixth Mass Extinction

A ***mass extinction*** is a period during which a large number of species become extinct. It has been determined that mass extinctions, which are caused by major ecological changes, have occurred five times on Earth. Experts explain that the sixth mass extinction, which we are currently witnessing, is not caused by natural evolutionary forces; it is caused by human beings. The sixth extinction is also referred to as the Anthropocene extinction or the Holocene extinction.

According to the Center for Health and the Global Environment, we are losing approximately 1000 species each year, many of which have not been identified. This is much more than losses caused by the natural evolutionary process, which is the loss of approximately one to five plant and/or animal species each year. This great loss of biodiversity is the result of human activities, including habitat loss, the introduction of invasive species and disease, and global climate change. Sadly, many scientists believe that in the next five centuries, nearly 75% of all life forms on Earth may become extinct.

Consider This

1. Do you agree or disagree that we are experiencing a sixth mass extinction? Explain your answer.
2. Which species do you think will survive the next five centuries?
3. How will the species that survive change to ensure they continue to survive?

The Loss of Genetic Variation

As populations decline, the genetic variation available also declines. The genetic variation of new generations of organisms within the population becomes limited to the point that all members are closely related. Organisms that inbreed leave the species vulnerable to genetic mutations, lessen their disease resistance, and often develop physical disabilities. Members of the current cheetah population (*Acinonyx jubatus*), for example, have little genetic variation because of a minor mass extinction that occurred about 11,000 years ago. Over 90% of the cheetah population was lost and the cheetahs that survived and reproduced have little genetic variation, **Figure 19-6**.

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Figure 19-6. The limited genetic pool may be the ultimate cause of the cheetah's extinction. Excessive inbreeding may one day eliminate the cheetah's ability to birth healthy offspring.

High Specialization

An organism that is ***highly specialized*** eats a particular food and lives in a limited or exclusive area. (A species is referred to as ***generalized*** when it can exist in a wide range of conditions.) These animals are more vulnerable to extinction because they cannot adapt to sudden and extreme changes of their environment. The koala (*Phascolarctos cinereus*), for example, is a marsupial herbivore that is native to Australia. The koala feeds selectively on the leaves of certain eucalyptus trees that grow in the eucalypt forests and woodlands, **Figure 19-7**. Each koala has a home range that consists of multiple trees, or its *home trees*. Koalas typically do not stray into other home ranges unless they are breeding. When eucalyptus trees are felled or consumed by forest fire, koalas lose their home range. As koalas do not share home ranges, homeless koalas will perish unless they find an area with uninhabited trees. Koalas forced to live near humans are often attacked by dogs or hit by vehicles.

With such a limited diet and range, any changes to the koala's habitat will affect the species. The koala is listed as vulnerable on the IUCN Red List and may soon become endangered with the high rate of deforestation occurring in Australia.

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Figure 19-7. Koalas eat eucalyptus leaves as the main component of their diet. Their teeth and stomachs are highly specialized to digest this leaf matter which is poisonous to most animals. Koalas sleep for extended periods to conserve energy as their bodies digest the eucalyptus leaves that contain little nutritive value.

Disease

All living organisms are vulnerable to disease that can result in problems ranging from stunted growth and development to reproductive failures or death. An individual occurrence of a disease, such as canine distemper, may be limited to one animal or it may be the indication of a widespread problem, **Figure 19-8**. Canine distemper is a highly contagious viral disease that causes breathing difficulty, diarrhea leading to dehydration, and neurological impairments leading to death. Young or unhealthy animals will likely die if they contract the disease.

Canine distemper is rare in pets due to vaccinations; however, a wild animal with the disease can easily spread it to other wild animals. In addition, canine distemper is not limited to canines and can infect other species, including raccoons, kinkajous, red pandas, black bear, skunks, ferrets, mink, lions, tigers, and many other animals susceptible to this type of distemper virus. Diseases that infect wildlife include rabies, chronic wasting disease in deer, and bacterial wilt in plants. Note that some wildlife diseases can be transferred to humans. Wildlife diseases that can infect human beings are referred to as ***zoonotic diseases***. Diseases that have spread or are spreading to large areas and other continents are referred to as ***pandemic diseases***.

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Figure 19-8. This grey fox is in the final throws of canine distemper, a disease which is transmissible among many species of animals.

Did You Know?

Elephants have the longest gestation period of all mammals. An elephant's gestation is about 22 months or 640 to 660 days.

Reproduction Rate

Reproduction rates can be a contributing factor to a species' extinction, especially when there is a low number of specimens available for breeding. In some species, such as domesticated cats (*Felis catus*), the reproduction rate is high because the females can carry offspring at an early age (4 to 6 months old), have a short gestation period (58 to 67 days), and can have large litters that are weaned quickly (4 to 6 weeks). Other species, such as dolphins, have low reproduction rates because it takes 5 to 13 years for the female to reach maturity and they have long gestation periods (12 months). Dolphins nurse their young for about two years and are unlikely to have more than one calf at a time. See **Figure 19-9**.

The long span of time required for maturity and gestation in some species builds a population slowly. If members of the population are dying quickly because of disease, habitat loss, or overhunting, the species cannot reproduce quickly enough to sustain the population.

Minimum Viable Population

The minimum viable population (MVP) of a species is the lowest number of individuals needed for the species to survive in the wild. Scientists have attempted to establish an MVP that can be applied to numerous species but research indicates that the MVP estimate differs among species because of factors such as different habitat requirements and reproductive rates. One factor that applies to different species is that the MVP must be high enough to prevent inbreeding and maintain genetic diversity.

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Figure 19-9. Domestic cats often have large litters that can be weaned by six weeks. Dolphins, however, typically have one cub that they nurse for around two years. *How does a longer gestation period affect an endangered species?*

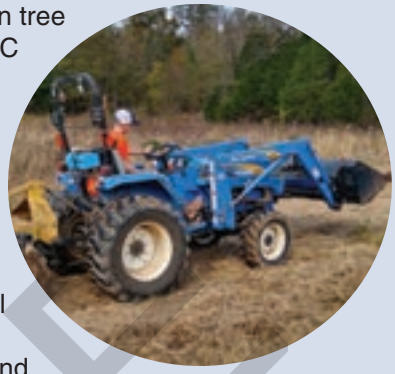
SAE for ALL Profile

Luke Burris, Wildlife Conservation

Luke Burris is an agriculture student in Cabarrus County in North Carolina. As a young FFA member, Luke determined the best opportunity for his SAE was to build on his interests in wildlife, and to assist in maintaining 40 acres following the Wildlife Conservation Agreement with the North Carolina Wildlife Resources Commission.

According to the Wildlife Conservation Agreement, the goals of the SAE were to establish areas for wildlife habitat, provide supplemental food, and control erosion of the land. Approximately two acres of the wildlife acreage needed seeding for wildlife feed plots. Five additional acres were dedicated to native seedling trees for habitat and woodland restoration. Further, the Little Bear Creek ran across the land and its riparian buffer needed to be restored with native trees and shrubs. Luke set aside $500 for these project expenses. Additional habitat was provided with wood duck boxes that were created and cleaned out.

Luke's initial project management required four months of planning, preparation, and planting. His challenges included the ground being too wet for planting and delays in tree seedlings from the NC Forest Service.



Luke Burris

After the initial work, Luke wanted to learn more about the impact of the food sources and habitat for wildlife. He fenced off a small portion of the area to monitor the food and habitat where no wildlife could graze or live.

Through his SAE, Luke learned that wildlife conservation is hard work and requires a lot of preparation, yet the work is fun and rewarding. He also learned the value of cooperating with the weather to plant trees. Now that the wildlife food sources and habitat are established, they still require work to be maintained to proper health.

- What are you willing to work hard for to ensure success?
- How must you cooperate with the weather and nature in your SAE?
- If you were to plan a habitat restoration, what would the plan include?

Extinct Animals

The Passenger Pigeon

The passenger pigeon (*Ectopistes migratorius*) was once the most abundant bird in North America. A single flock, which could have a million or more birds, would darken the sky as they flew over towns. In the mid- to late 1890s, wild flock sizes plummeted, and birds numbered in the dozens rather than the hundreds of millions.

Commercial harvesting and the national expansion of the telegraph and railroad were the beginning of the pigeon's extinction. The railroad made it easier for sportsmen to follow flocks around the country and reach nesting sites. Hunters disrupted nesting grounds and harvested squabs and eggs as delicacies. The birds were killed with cruel methods, including asphyxiation with burning sulfur and poisoning with whisky-soaked corn. They were killed faster than they could reproduce.

It is not known why the few thousands of remaining birds could not repopulate. Their scattered distribution may have interfered with their breeding abilities. There had been no effort to save the passenger pigeon, and in 1914, the last of the species, a female named Martha, died in the Cincinnati Zoo.

1. Which acts of Congress to protect birds were passed between 1900 and 1918? What does each act protect?
2. How would you use the passenger pigeon's story to educate people?
3. Project Revive & Restore is dedicated to resurrecting extinct animals through the manipulation of genetic coding. If the program were successful, how would the reintroduction of an extinct species affect the environment?
4. How would the reintroduction of an extinct species compare to the introduction of an invasive species?
5. How did the dickcissel, a sparrow-like migrant bird, almost become extinct? How was the species saved?

> "Restoring nature to its natural state is a cause beyond party and beyond factions. It has become a common cause of all the people of this country."
> —**Richard Nixon**, US President

Overhunting and Overfishing

As evident by the near extinction of the American bison from hunting, removing too many animals from an environment can quickly lead to a species' extinction unless efforts are made to protect the species. Overhunting or overfishing reduces the number of breeding animals and reduces the genetic variation among the remaining animals. These factors make it difficult for the species to repopulate and will likely lead to genetic defects in offspring. See **Figure 19-10**.

The passenger pigeon (*Ectopistes migratorius*) is an example of overhunting leading to extinction. The passenger pigeon, numbering in the billions, was once a plentiful and popular food source for North Americans in the 1800s. The birds were hunted until no passenger pigeons were found in the wild. There were no efforts made to protect the birds and attempts to breed them in captivity were unsuccessful. The last known specimen died at the Cincinnati Zoological Garden in 1914.

Biodiversity and Ecological Health

Biodiversity is the variety of organisms living in an ecosystem. Scientists have long theorized that biodiversity is critical to the ability of an ecosystem to provide benefits, such as oxygen production, nutrients for the soil, and clean water. A diverse ecosystem is one in which each species receives services needed from other species to ensure mutual survival. Recent studies conducted by the USGS have proven that it is not possible to have a sustainable, productive ecosystem without biodiversity in the landscape.

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Figure 19-10. The muskox (*Ovibos moschatus*), hunted for its hide, nearly became extinct in the 1930s due to overhunting and the American crocodile (*Crocodylus acutus*), hunted for its skin, was close to extinction in the late 1960s. Hunting regulations and the Endangered Species Act have helped increase populations of both species in the wild.

Wildlife Data Collection

An accurate accounting of a species living in the wild must be taken to determine if a population is at risk. Methods used to identify, track, and count the individuals include DNA barcoding, remote sensing, and quadrat analysis.

DNA Barcoding

DNA barcoding is a research tool used to identify known species by comparing their barcode DNA sequences to reference sequences in public data bases. The ***DNA barcodes*** are created by extracting DNA from a small tissue sample and mapping a short DNA sequence from a specific part of the genome. DNA barcoding helps researchers determine if a species is potentially new to science and to study ecological and evolutionary changes.

The mission of the International Barcode of Life (iBOL) project, based in Ontario, Canada, is to globally unite DNA barcoding research and to help monitor biodiversity worldwide. Researchers in the iBOL project are also working on applying DNA barcoding to real world problems, such as conservation, disease control, ecosystem monitoring, and forensics. To date, the iBOL barcode library contains over 5.3 million DNA barcodes for 580,000 species.

Remote Sensing

Remote sensing is a method of collecting information about organisms or environments from a distance using aircraft, satellites, or UAVs/drones (unmanned aerial vehicles), **Figure 19-11**. Remote sensing is used by many agencies and in most science disciplines to gather information that might otherwise be difficult or dangerous to obtain, including the following:

- Monitor or count animal populations in remote areas
- Track migration patterns over long distances
- Map forest fires from an aerial view
- Track changes in forests and grasslands
- Track the spread of urbanization
- Identify temperature changes in the ocean
- Monitor light pollution or levels of atmospheric gases

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Figure 19-11. Penguin tagging allows scientists to determine migration patterns and population sizes. This satellite tagging device is connected to a gentoo penguin (Pygoscelis papua) and relays information on penguin behaviors in the Falkland Islands. *Has tagging had any negative effects on penguins?*

Animal Monitoring and Tracking Technology

Animals may be monitored for research or game management or to assess progress and recovery of a species' population. One traditional method of counting animals in a population is through direct observation *in situ*. This method requires researchers on the ground to manually count the animals. This method is useful, but specimens may be easily overlooked or counted more than once. Researchers may also look for tracks and excrement to identify an animal's presence in an area.

Emily Barker/Shutterstock.com

Figure 19-12. Some wildlife organizations have sport fisherman tag certain species of fish to help extend their studies at little or no cost. Anglers are provided with tagging equipment and contact information to report captures, tagging, and recaptures.

Live trapping is also a physical observation method that requires researchers to be on the ground in the species' environment. The traps used in live trapping catch and hold the animal without causing them physical harm. Unfortunately, some species suffer more in live traps than others and some have higher accidental mortality rates with live traps. Animals may freeze, overheat, starve, or become overstressed. The captured animals are marked and released after data is collected. This is referred to as the *mark-recapture* technique. The mark-recapture technique requires capturing, marking, releasing, and recapturing animals during repeated samplings, **Figure 19-12**.

Advances in technology, such as remote sensing, have made it possible to track animals without physically entering their environment once the specimens have been collared or tagged. Tracking devices used with animals include satellite or GPS tracking collars, leg bands, tags, data loggers, and attached or implanted tracking devices. A tracking device, such as a traditional metal leg band, may be detrimental if it is obtrusive and interferes with their natural activities. Metal bands or collars, for example, can snag on vegetation or wear on fur or feathers. Newer technologies, such as implanted microchips, may make it easier for researchers to track an animal without recapturing it to collect data. See **Figure 19-13**.

Thinking Critically

Has the revitalization of the Florida Everglades increased the wading bird populations in Florida? Explain your answer.

Did You Know?

Researchers are attaching small external cameras to animals to view the animal's actions from the animal's point of view. Search online for television series featuring cheetahs, meerkats, and other animals.

Bob Hilscher/Shutterstock.com

Figure 19-13. Migratory butterflies and insects are marked with paper tags to help researchers gather information on their flight pathways and areas where they rest. The tag on this butterfly weighs about 2% of the monarch's body weight. *Would you be able to carry something constantly that was 2% of your own body weight?*

Quadrat Analysis

A ***quadrat*** is a frame (traditionally square) used in assessing animal or plant populations in a given area. ***Quadrat analysis*** is a method used to estimate a species population and determine its distribution over a random area using a set of similar quadrats (shapes). See **Figure 19-14**. Once data is gathered from multiple quadrats, the scientist can estimate the number and kind of species found in the larger total area. The same quadrats can be used over a series of years to monitor the presence or population of a species. This technique is not useful for studying fast-moving species because they will not remain in the quadrats. Quadrat analysis can be performed using mark-recapture, total counts, incomplete counts, and indirect counts.

Thinking Critically

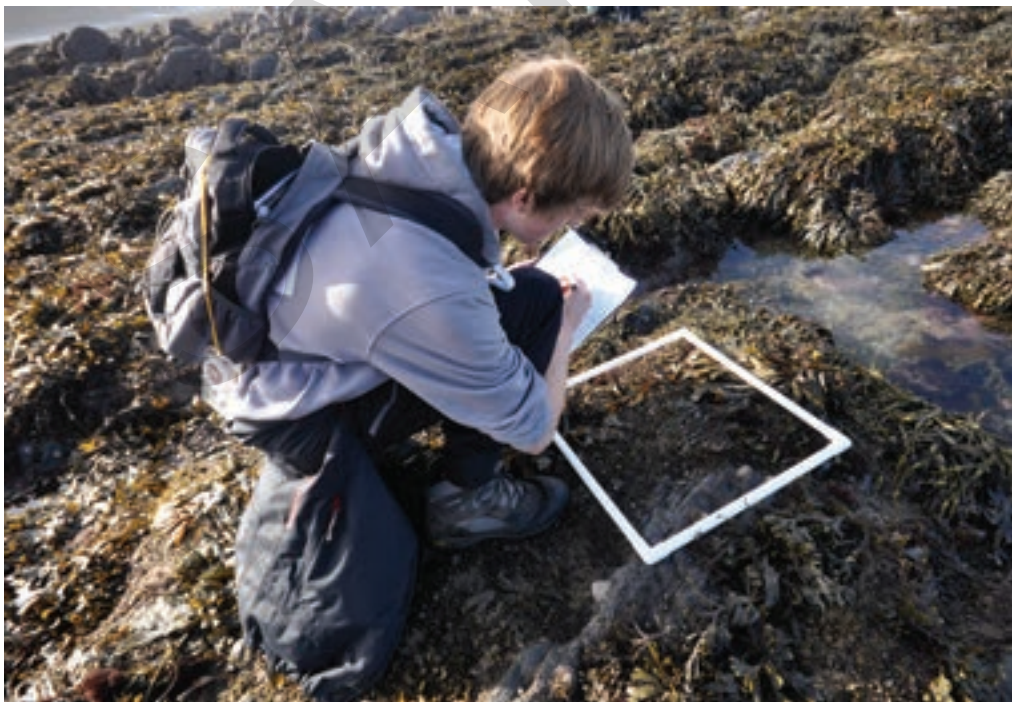
What disadvantages are there to quadrat analysis? How might errors be introduced to a quadrat study?

Mark-Recapture

As explained earlier, the mark-recapture technique requires capturing, marking, releasing, and recapturing animals during repeated samplings. Mark-recapture is advantageous because an accurate count does not depend on the assessment of the amount of habitat. The disadvantage is that it does require capturing a large portion of the population.

Total Counts

Every member of a species in an area is counted when the ***total count*** or ***complete count*** method is used. This method is best used with animals that stay in the open, such as waterfowl or beach-dwelling seals. In a total count process, animals must be flushed out of hiding so that each individual can be counted. The process is labor intensive and expensive to perform. Aerial photography can also be used to perform total counts.



Samib123/Shutterstock.com

Figure 19-14. A small frame may be moved around an area to perform counts on small organisms. This student maps the locations of each quadrat he studies and compiles the information.

Ivan Godal/Shutterstock.com

Figure 19-15. The wood grouse or western capercaillie (*Tetrao urogallus*) is often counted during mating season. Researchers can use a transect line through the breeding area to obtain accurate numbers.

Incomplete Counts

Incomplete counts are counts are done in specified areas, typically in quadrats, that use the average of specimens counted in multiple areas. For larger species, such as deer, a large crew is needed to drive the animals from one side of the quadrat so they may be counted by stationary members on the other three sides of the quadrat. There must be sufficient drivers and observers for this method to be accurate. Booming ground counts, roadside counts, and strip censuses are also types of incomplete counts.

A booming ground is the area in which the male of certain grouse performs mating displays in which they make booming or drumming sounds with their wings. The counter determines a transect line through the representative area and records the distances along the line at which the birds are located. A ***transect line*** is a line that is marked at regular intervals and used to divide an area, **Figure 19-15**. The transect line may be indicated with a rope or measuring tape or determined visually with no actual markings. This process is repeated in multiple locations. The researcher would then determine the average of the combined counts. In a roadside count, a road is used as the transect line. Counts are made by observers from a slow-moving vehicle. A strip census is performed along a strip of land, such as the area along a road.

Additional methods may be used to conduct a transect survey. Counts may be made of each species found below the knots on a rope or markings on the measuring tape, found directly under the entire length of the line, or within a specified number of feet on either side of the line.

Thinking Critically

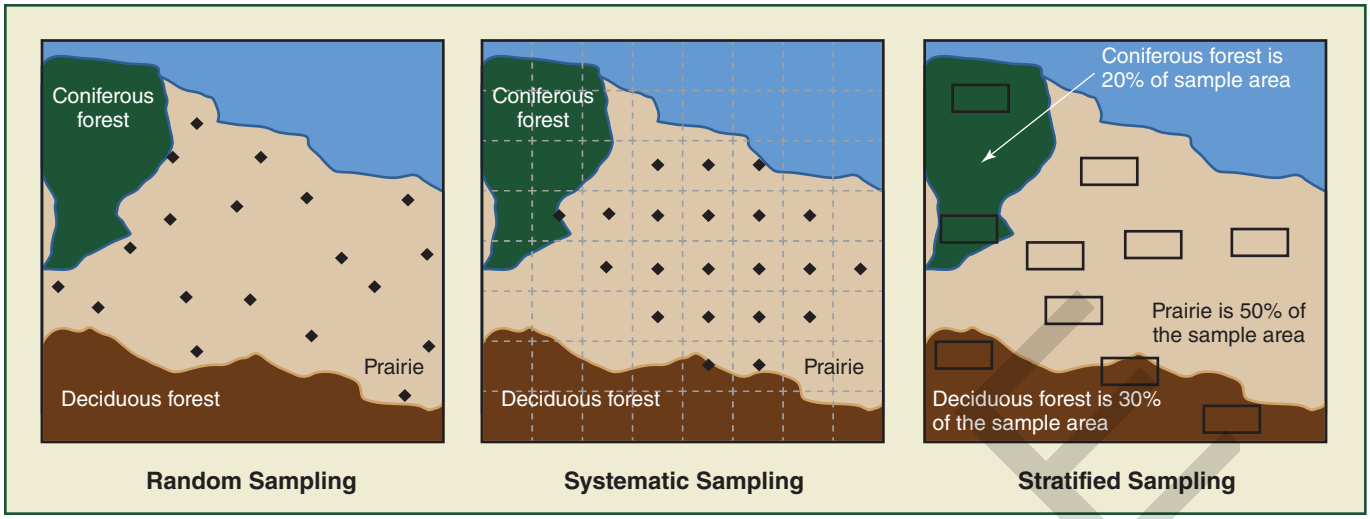
Should the President be allowed to withdraw environmental policies that have helped reestablish endangered species populations? Explain why or why not.

Indirect Counts

When performing an ***indirect count***, the researcher uses indirect signs of the species' presence and does not count the animals themselves. A scientist can determine the amount of scat, the number of constructed shelters, such as nests or burrows, damage to trees, marking or damage to the ground, and even listen for sounds of the animals to determine populations. When using indirect counts, the researcher must make assumptions about their estimation. If a researcher is counting scat, for example, he or she might assume that more scat in an area is a direct indication of more animals in the area when it may be the same animals defecating more in one area than another.

Random, Systematic, and Stratified Sampling

Quadrats may be randomly selected, systematically arranged, or stratified by some physical feature of the landscape, **Figure 19-16**. *Random sampling* is performed by randomly selecting and sampling small areas within the larger area. *Systematic sampling* involves sampling in a systematic way, such as on a grid system. The area is divided into even grids and then one sample is taken from each grid. *Stratified sampling* is accomplished by taking samples of an area according



Goodheart-Willcox Publisher

Figure 19-16. Random sampling, systematic sampling, and stratified sampling are three methods used by scientists to determine the population of a species in an area. In the stratified sampling diagram, all areas are sampled based on the total percentage of land that they cover in the sample area. One sample is taken per 10% of the total area. Five samples are taken from the prairie, for example, because it is 50% of the sample area.

to features that subdivide the overall area. If an area of prairie includes four different soil types, for example, samples are taken from each of the four soil types in proportion to the amount of area covered by each soil type.

Did You Know?

There are more than 500 species of salamanders. Many of these species can be found in the Southeastern United States.

Bioindicators

Bioindicators are species of microorganisms, insects, fungi, and plants whose presence or absence in an environment are used to assess the quality of an environment and how it changes. Bioindicators are very sensitive to the smallest amount of pollution in their environment. If the bioindicators in an area decline, show signs of disease, leave an area, or die in large numbers, there is an issue in the ecosystem that must be addressed. These issues can be related to anthropogenic stressors, such as chemical contamination, or natural stressors, such as drought or extreme weather changes.

Many species can be used as bioindicators, including frogs, toads, salmon, prairie dogs, grizzly bear, mosses, lichens, and water lilies. Amphibians, such as the salamander (*Urodela*), are common bioindicators because many species breathe through their lungs *and* skin, **Figure 19-17**. Salamanders are extremely vulnerable to environmental changes, including extreme temperature changes and poor water quality. Watching and counting populations of salamanders in a given area can be used to determine if there are environmental changes that may lead to negative impacts on other species.

Africa Studio/Shutterstock.com

Figure 19-17. The salamander has survived for more than 160 million years. Salamanders are common bioindicators species because they cannot tolerate poor water quality or extreme temperature changes.

Did You Know?

Female pandas have one 36-hour window of fertility each year.

Recover and Restore Efforts

Many zoos, wildlife reserves, botanic gardens, and other conservation organizations have ***captive breeding programs*** in which they attempt to raise animals or plants that have become rare in their native habitats. The term *rare* indicates that the population is uncommon or infrequently encountered. The goals of a captive breeding program are to create a stable, sizable, and healthy population and to reintroduce species into their natural habitats. For some species, a captive breeding program is the only chance it has to survive, **Figure 19-18**.

Bryan Faust/Shutterstock.com

Figure 19-18. A series of nature preserves in China protect the giant panda's (*Ailuropoda melanoleuca*) forested habitat. As with many endangered species, habitat destruction and fragmentation is the main contributing factor to their low numbers. There is a low success rate for mating in captive breeding programs, but these nature preserves may help pandas mate and birth offspring in the wild.

Captive Breeding Programs

The black-footed ferret (*Mustela nigripes*) of North America is a success story of captive breeding and reintroduction sponsored by the US Fish and Wildlife Service. The black-footed ferret is the only ferret species native to North America, **Figure 19-19**. The species once inhabited the central plains in the tens of thousands, hunting prairie dogs and small wildlife. Disease, such as the sylvatic plague from Asia, and habitat destruction by agriculture and development in the 1900s placed the species on the brink of extinction. There were only 18 remaining in captivity in 1986.

A captive breeding program began in 1987 to create a population that could be reintroduced to the wild. Participants of the captive breeding program include the National Black-footed Ferret

Figure 19-19. Black-footed ferrets were once considered a lost species. The captive breeding program sponsored by the US Fish and Wildlife Service has saved the animal from extinction.

Kerry Hargrove/Shutterstock.com

Conservation Center in northern Colorado, the National Zoo's Smithsonian Conservation Biology Institute, and zoological institutions in Colorado Springs, Phoenix, Louisville, and Toronto.

As of 2016, there were multiple populations in protected areas in several states, Canada, and Mexico. While the species is still endangered, the program may have saved them from extinction. One of the major challenges to their reintroduction is locating a continuous habitat with a large enough prairie dog population to support the ferrets. Additional species, such as the California condor, giant panda, Pacific fisher, and desert pupfish have benefited from such breeding programs, **Figure 19-20**.

James DeBoer/Shutterstock.com

Figure 19-20. The California condor (*Gymnogyps californianus*), which is the largest land bird in North America, was once clearly on its way to extinction. There were only about 22 known to exist in 1987 when the last free-flying birds were taken into captivity for breeding. Although the bird is still identified as critically endangered on the IUCN Red List, there were nearly 300 flying free in 2018 and more than 100 in captivity.

Species Survival Plan

Another method of helping wildlife at risk is a ***species survival plan (SSP)***. An SSP is an initiative by the Association of Zoos and Aquariums (AZA) to breed animals with the greatest amount of genetic diversity possible. Zoos breed animals through SSP partnerships and release the animals into the wild through captive breeding efforts. Some specimens may be kept in captivity as gene and seed banks. The concept of keeping animals in zoos and aquariums to artificially maintain a population in an SSP is known as ***ex situ conservation***, **Figure 19-21**.

Legislation

Governments also protect animals and plants and their habitats. Many acts of legislation have been passed to help protect habitats and the flora and fauna within them.

Puffin's Pictures/Shutterstock.com

Figure 19-21. This snow leopard (*Panthera uncia*) cub is the result of SSP partnership between two North American zoos. The snow leopard is a vulnerable species and an SSP based in Canada is working to improve genetics for the species.

Social Responsibility

Protecting Wildlife

Wildlife and humans interact on a daily basis around the world without harm, but damaging interactions often occur between wildlife and motor vehicles. In the United States nearly 1.5 million accidents happen each year with deer crossing roadways resulting in billions of dollars of insurance claims and damage. These interactions often lead to the death of the animal, destruction of the vehicle, and injuries or death of vehicle passengers. How can humans protect wildlife when roadways often fragment habitat?

In the effort to prevent vehicular accidents with wildlife both underpasses and ecobridge overpasses have been constructed. The idea for these passageways was inspired by the fish ladders constructed in the seventeenth-century to help fish move upstream in areas with dams. European countries began developing land crossings for animals in the 1950s to prevent wildlife and livestock from increasing traffic on roadways. In the 70 years since, thousands of ecobridges have been constructed on six continents. The largest ecobridge in the world is currently under construction in Los Angeles, California. This ecobridge will create a land bridge over the 10-lane 101 Highway. The intension of this bridge to protect mountain lions and other wildlife affected by urban expansion. It will help provide safe passage over the highway for wildlife to find food and new territories and hopefully reduce vehicular accidents with wildlife.

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- **The Lacey Act of 1900 and 2008.** It is unlawful to import, export, sell, trade, or use any fish, plant, or other wildlife listed in the act.
- **The Migratory Bird Treaty Act (MBTA) of 1918.** It is illegal to hunt, trap, or kill migratory birds as they move between the United States and Canada.
- **Migratory Bird Conservation Act of 1929.** Created the United States Migratory Bird Conservation Commission (MBCC) that approved purchase of open land or water areas by the US Fish and Wildlife Service to assist birds in migration.
- **Migratory Bird Hunting and Conservation Stamp Act (1934).** Anyone over 16 must purchase a stamp to hunt for waterfowl. The proceeds are used for wildlife conservation.
- **Marine Mammal Protection Act (MMPA) of 1972 and 1994.** Protects all marine mammals within United States' waters.
- **Endangered Species Act (ESA), 1973.** Works with both domestic and international conservation to prevent the killing of species listed as endangered or threatened. This act provides funds to conserve and protect species as well.
- **Wild Bird Conservation Act (WBCA) of 1992.** Requires special permits for the importation of wild bird species for zoos, recreation, or personal pets. This act is intended to protect birds at their point of origin.

Summary

- The IUCN Red List identifies animals as extinct species, extinct in the wild species, critically endangered species, endangered species, vulnerable species, near threatened species, and least concern species.
- The US Fish and Wildlife Service also identifies species as either endangered or threatened on the Federal Lists of Endangered Species.
- A species must be on the Federal Lists of Endangered Species to receive protection under the Endangered Species Act.
- The primary causes of extinction due to human activity include habitat loss, degradation, fragmentation, invasive species, overharvesting, loss of genetic variation, human population growth, and climate change.
- Habitat degradation may be caused by soil, water, or air pollution; a change in water flow; or the killing or removal of a key species.
- Habitat fragmentation is caused by human construction (dams, roads, and housing subdivisions) and the introduction of invasive species.
- Genetic variation declines as the population declines and organisms begin inbreeding. This leaves species vulnerable to mutations, lessens disease resistance, and may lead to physical disabilities developing.
- Overhunting or overfishing reduces the number of breeding animals and reduces the genetic variation among the remaining animals.
- Methods and technology used to assess wildlife species and habitats include DNA barcoding; remote sensing; quadrat analysis; mark-recapture; total counts; incomplete counts; indirect counts; random, systematic, and stratified sampling; and assessing bioindicators.
- Many zoos, wildlife reserves, botanic gardens, and other conservation organizations have captive breeding programs to raise animals or plants that have become rare in their native habitats.
- A species survival plan is an initiative by the Association of Zoos and Aquariums to share animals for breeding to spread genetic variation.
- The US government has developed legislation to prevent the import, export, and injury of species that are considered at risk. These laws are enforced by agencies such as the US Fish and Wildlife Service, US Forest Service, and National Park Service.

Chapter Review and Assessment

Vocabulary Review

Match the key terms from the chapter to the correct definition.

A. background extinction rate
B. bioindicators
C. critically endangered species (CR)
D. DNA barcode
E. endangered species (EN)
F. extinct in the wild species (EW)
G. extinct species (EX)
H. extirpation
I. generalized
J. highly specialized
K. incomplete count
L. indirect count
M. IUCN Red List of Threatened Species
N. least concern species (LC)
O. mass extinction
P. near threatened species (NT)
Q. quadrat
R. quadrat analysis
S. rare
T. remote sensing
U. species survival plan (SSP)
V. threatened species
W. total count
X. transect line
Y. vulnerable species (VU)
Z. zoonotic disease

1. A line that is marked at regular intervals and used to divide an area in which a species population will be counted.
2. A code created by extracting DNA from a small tissue sample and mapping a short DNA sequence from a specific part of the genome.
3. A frame (traditionally square) used in assessing animal or plant populations in a given area.
4. A list first published in 1964 that identifies species from around the world that are at risk.
5. A method used to estimate a species population and determine its distribution over a random area using a set of similar quadrats (shapes).
6. A time period in which a large number of species become extinct.
7. A species identified as having no living specimens.
8. A species identified by the IUCN as doing well and presenting no cause for concern or protection.
9. A species identified by the IUCN as facing an extremely high risk of becoming extinct.
10. Every member of a species in an area is counted for assessment purposes.
11. A species identified by the IUCN as having a high risk of becoming extinct and no longer living in the wild or in captivity.
12. The population of plants or animals is uncommon or infrequently encountered.
13. A species identified by the IUCN with a possibility of facing population decline in the future and should therefore be monitored.
14. Indicates when a species is locally extinct and no longer found in an area it used to inhabit but is still found elsewhere.
15. A species identified by the IUCN as likely to become endangered unless factors leading to its demise change.
16. The natural rate at which species extinction occurs.
17. A species identified by the IUCN as no longer living in the wild but with examples of the species living in captivity.
18. A species that can exist in a wide range of conditions.

19. A wildlife disease that can be transferred to human beings.
20. A wildlife population assessment method in which the researcher uses indirect signs of the species presence (scat, shelters, tree damage, ground damage) and does not count the animals themselves.
21. A wildlife population count performed in multiple areas in which some specimens may not be counted.
22. An initiative by the Association of Zoos and Aquariums (AZA) to breed animals with the greatest amount of genetic diversity possible.
23. An organism that eats a particular food and lives in a limited or exclusive area.
24. As per the USFWS, a species that is likely to become endangered in the foreseeable future throughout all or a significant portion of its range.
25. A method of collecting information about organisms or environments from a distance using aircraft, satellites, or UAVs/drones.
26. Species of microorganisms, insects, fungi and plants whose presence or absence in an environment are used to assess the quality of an environment and how it changes.

Know and Understand

Answer the following questions using the information provided in this chapter.

1. *True or False?* Today's extinction rate is lower than the natural background extinction rate.
   A. True
   B. False
2. Approximately how many species are identified on the IUCN Red List as endangered or nearing extinction at this time?
   A. 26
   B. 2600
   C. 26,000
   D. 260,000
3. Species facing an extremely high risk of becoming extinct are identified as _____.
   A. extinct in the wild
   B. endangered
   C. critically endangered
   D. near threatened
4. Species facing a high risk of extinction in the wild are listed as _____.
   A. extinct in the wild
   B. endangered
   C. critically endangered
   D. near threatened
5. Species that are likely to become endangered unless action is taken to identify and correct factors that will likely lead to its demise are listed as _____.
   A. vulnerable
   B. endangered
   C. least concern
   D. near threatened
6. *True or False?* If a species is likely to become endangered in the foreseeable future, it is listed as threatened on the US Federal List of Endangered Species.
   A. True
   B. False
7. Which of the following contribute to the endangerment of a species?
   A. Unsustainable human population growth
   B. Habitat loss, degradation, and fragmentation
   C. Introduction of invasive species
   D. All of the above.
8. Which of the following occurs when a species is locally extinct and no longer found in an area it once inhabited but is still found elsewhere?
   A. Extirpation
   B. Exasperation
   C. Extraction
   D. All of the above.
9. *True or False?* Invasive species have little to do with species extinction.
   A. True
   B. False

10. *True or False?* Organisms that inbreed leave the species vulnerable to genetic mutations.
    A. True
    B. False
11. Which of the following animals live on a specialized diet?
    A. Cheetahs
    B. Passenger pigeons
    C. Pandas and koalas
    D. All of the above.
12. *True or False?* Some wildlife diseases can spread to other species.
    A. True
    B. False
13. *True or False?* Species with long gestation periods produce offspring more often than those with shorter gestation.
    A. True
    B. False
14. Overhunting may lead to extinction because it _____.
    A. reduces the number of individuals
    B. reduces genetic variation
    C. reduces reproduction
    D. All of the above.
15. DNA barcoding serves multiple purposes, including _____.
    A. determining if the species is new to science
    B. reduces the overall health of a species
    C. eliminating genetic variation
    D. All of the above.
16. Remote sensing is used to _____.
    A. map forest fires
    B. track changes in forests
    C. track migration patterns
    D. All of the above.
17. Which of the following is a method of monitoring and tracking wildlife?
    A. Live trapping
    B. Mark-recapture
    C. GPS or satellite
    D. All of the above.
18. *True or False?* Live trapping has a higher accidental mortality rate than other forms of mark-recapture.
    A. True
    B. False
19. *True or False?* Mark-recapture requires an animal to be captured, sedated, marked, and set loose once again.
    A. True
    B. False
20. The tracking devices used to monitor animals that are considered the least detrimental and intrusive are _____.
    A. leg bands
    B. tags
    C. collars
    D. microchips
21. What type of frame is used to assess animal or plant populations in a given area?
    A. Static placement
    B. Quadrat
    C. Total count
    D. Square station
22. There are 25 students in your conservation class. Today, your teacher recorded that all 25 students were present. What type of count was taken during the attendance process?
    A. total count
    B. quadrat count
    C. complete count
    D. Both A and B.
23. A roadside count is considered a(n) _____.
    A. indirect count
    B. complete count
    C. total count
    D. incomplete count
24. *True or False?* A transect line is a line marked at regular intervals that is used to determine distance between members of a species.
    A. True
    B. False

25. Which of the following is not an indirect sign of a species used to perform an indirect count?
    A. Nests or burrows
    B. Flowers for pollination
    C. Damage to trees
    D. Scat quantities
26. Organisms that breathe through both their lungs and skin, are more susceptible to contaminants, and are considered one of the most sensitive bioindicator species are _____.
    A. frogs
    B. water lilies
    C. salamanders
    D. toads
27. *True or False?* Animals that are extinct in the wild have little chance of breeding in captivity and being reintroduced to the wild.
    A. True
    B. False
28. The Association of Zoos and Aquariums developed species survival plans with an ultimate goal of _____.
    A. collecting eggs and semen for future genetic crosses
    B. educating the public about the plight of endangered species
    C. releasing animals into the wild
    D. breeding animals to repopulate zoos and aquariums to prevent animals from being taken from the wild
29. The majority of early wildlife legislation was dedication to the protection of what types of animals?
    A. Birds
    B. Mammals
    C. Amphibians
    D. Reptiles
30. In the early 1900s, plume hunters killed migratory birds to harvest feathers for adorning hats and clothing. If hunters were to kill the birds and collect their feathers today, which congressional act would they be violating?
    A. Migratory Bird Hunting and Conservation Stamp Act of 1934
    B. Endangered Species Act of 1973
    C. Migratory Bird Treaty Act of 1918
    D. Marine Mammal Protection Act of 1972

Thinking Critically

1. Based on where you live, what species are rarer and which are of least concern or in overabundance? How can you determine if a species is rare or overly abundant without running formal experiments? Does your area have a hunting season? Discuss with your classmates to determine if you consider similar species as rare or abundant and why you felt that way.
2. Which plants and animals are endangered in your state? Make of list of species you think are on your state's list. Obtain a copy of your state's endangered species and compare your selections to those on your state's list.
3. Select a foreign country and research its laws pertaining to wildlife management and protection. Compare and contrast those laws with the ones discussed in this chapter. Are laws stricter in the country you researched or in the United States? How do the differences in law protect or harm at-risk wildlife? Be prepared to defend your position in writing.
4. Who petitions to provide protection for a species? How does a petition place a species on the federal government's endangered list? Research and report on the purpose, history, terminology, and challenges of the Endangered Species Act and current activities related to the Act.
5. Devise a strategy for preventing the loss of a species and biodiversity that takes into account the primary causes of species extinction from human activity.

STEM and Academic Activities

1. **Science.** Set up a study quadrat to research wildlife species at or near your school. What species of trees, shrubs, grasses, weeds, animals, and insects can you identify? If you do not see living species, what evidence do you have that wildlife has been present in the environment. What could be done to improve the habitat for plants and animals? Report your observations and counts and make comparisons between different study quadrats in your community.
2. **Technology.** Using aerial approaches to studying wildlife habitat minimizes human-animal interactions. Obtain a small scale drone or contact your local environmental protection agency and obtain aerial pictures of your community. Looking at the pictures, what areas would make good habitat for species and which are at risk? Come up with rationale to determine if your community is good for animals based on these pictures. Explain your reasoning.
3. **Engineering.** Engineering is extremely important in monitoring animal populations. There are tracking sensors small enough to place on butterfly wings. Research the history of animal sensors and see how these have changed over time. What is currently being done to make sensors longer lasting and less invasive?
4. **Math.** Data analysis is one of the keys to determining populations of wildlife. Design an experiment to calculate the population of individuals in your school. Mark a population at the beginning of the day and record the number of students marked. Then take a second sampling counting both the number of marked and unmarked individuals in the second sample.

$$P = \frac{M \times C}{R}$$

P = Total population

M = Number counted and marked in first sample

C = Total number counted in second sample

R = Number of marked population in the second sample only

Have multiple groups run this experiment at the same time. Each group should use different types of marks. Do any groups get close to the total school population? What can be done to make this method more accurate? Does it make a difference if you are researching older or younger wildlife?

5. **Social Studies.** A person is poaching when they hunt out-of-season or go over their limit. It is also killing protected animals, such as gorillas to sell their hands and feet, rhinos for their horn, elephants for their ivory, and tigers for their bones. Select a species that is commonly poached and research why it is killed, who is hunting the animal, and what is being done to prevent the wildlife loss. What can be done to change cultures to stop the poaching of endangered species?
6. **Language Arts.** Select a wildlife species that is endangered and look up wildlife poetry about that species. Select three poems and compare and contrast them in a short essay. Why is poetry a popular means for people to convey feelings about the loss of wildlife? Does the poetry that you found remind people to protect wildlife?

FFA and SAE for ALL Opportunities

1. **FFA.** Participate in the Environmental Science and Natural Resources Career Development Event. Make flash cards of the wildlife equipment, native species of wildlife, birds, reptiles, amphibians, fish, and the nonnative plants and animals. Use the flash cards to quiz the other students in your class about native and nonnative species of plant and animal wildlife for the contest.
2. **Immersion SAE.** Research careers involved in the Wildlife Production and Management SAE area and contact representatives of those careers to come and speak before the FFA chapter. Discuss opportunities for job shadowing for students interested in careers in wildlife.
3. **Immersion SAE.** Investigate the IUCN Red List and identify listed animals in your area that are at risk. What is causing their issue? Develop an agricultural communications project to promote how people can protect this species. Write a press release or make a radio announcement to promote the species. How can you get people involved and interested in protecting wildlife in your area?

Communicating about Natural Resources

1. **Reading and Speaking.** There are positives and negatives with captive breeding. Research the pros and cons of this issue and hold a debate in your class. Should biologists continue to breed in captivity? Does it help the animals? Research both successes and failures in captive breeding to add to your debate.
2. **Reading and Speaking.** Develop a campaign to save an animal from extinction. What media sources could you use? How would you develop communication to get your point across? What makes this animal worth saving when many other animals are also in peril? Develop fliers, websites, videos, and more to communicate to the public why this animal makes a difference and deserves to be protected.