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INDICATOR SPECIES REVEAL ENVIRONMENTAL HEALTH

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YOUNG REVIEWERS:

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AGE: 15

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When looking around outside, many people see reasons to worry about the environment. Often what they notice are the effects of pollution and climate change, which can be harmful to people, wildlife, and the ecosystems where they live. Understanding the condition of all living and non-living things in an ecosystem is important for maintaining a healthy environment. But collecting information on every element in an ecosystem takes time and effort and is not always possible. Luckily, the United States National Park Service scientists know that collecting data on the condition of one species, called an indicator species, can reveal a lot about the well-being of other species in an ecosystem. Based on what they learn from observing and studying indicator species, park managers can make decisions about restoring plants, using chemicals, and posting signs about fishing rules. In Indiana Dunes

National Park (Indiana, United States), researchers rely on frogs as indicator species.

INDICATOR SPECIES

Have you ever felt sick and used a thermometer to check whether you have a fever? A fever is an indicator that you are sick and a thermometer is a tool to help determine how sick you are. In the outdoors, certain animals and plants, called **indicator species**, can be used as environmental "thermometers." Researchers measure and monitor the health of indicator species to determine whether the environment where these special animals and plants live is healthy. Without indicator species, scientists must collect many more samples and conduct more tests. Tests and samples can cause disturbances in the environment. Also, when there is more work to do, scientists must find both the time and money to conduct that work (Figure 1).

INDICATOR SPECIES

An organism that helps scientists figure out the health of the environment.

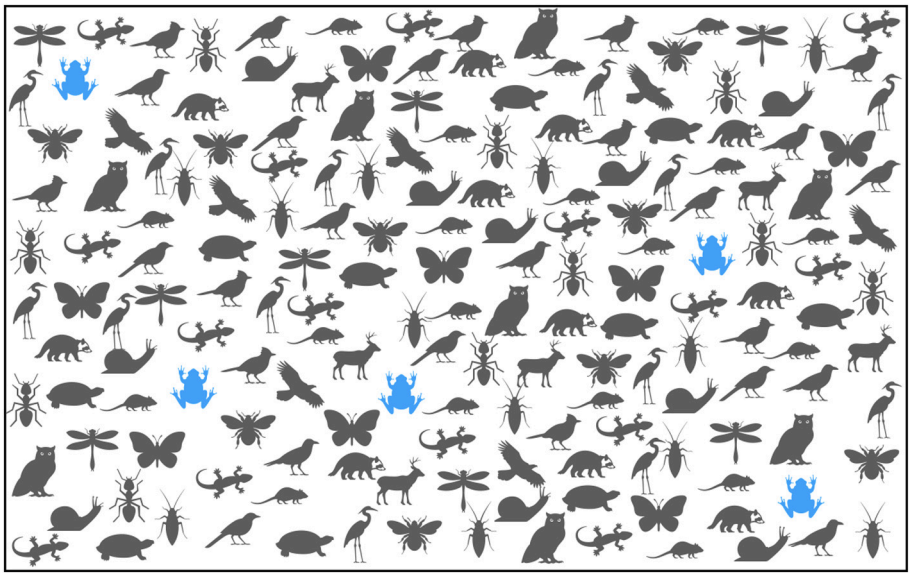

Figure 1

Would you rather count all the animals or just the frogs? If there are lots of frogs (the indicator species), then birds, fish, and insects will be present and likely be healthy, too. Fewer frogs indicate that other animals will also be absent or in poor health. (Image Credit: Nickolay Hristov).

WHAT DO INDICATOR SPECIES TELL US ABOUT THE ENVIRONMENT?

Indicator species can help researchers understand environmental conditions in a variety of ways. Here are two examples. To check on forest habitat quality, researchers look for red cockaded woodpeckers. These birds are picky about their nests. If the right combination of trees is not present, the woodpecker numbers drop. Fewer woodpeckers suggests it is time to pay attention to the health of the forest.

Common dragonflies living in ponds or wetlands are useful indicator species because they reveal a lot about pollution. **Mercury** is a nasty

MERCURY

A heavy metal contained in thermometers, electronics, and medicines. Mercury can be toxic in the environment.

toxin that affects reproduction and brain function in wildlife and people. Heavy metals like mercury travel on the wind from polluting factories and settle in ponds and soil. To gather data on mercury, U.S. national park rangers and students collected dragonflies in their **larval stage**[1] [1]. Yes, indicator species can be tiny in size. If you have ever scooped up water from a pond, you might have seen organisms smaller than a baby's fingernail. Some of these organisms are young dragonflies. Dragonfly larvae eat other insects. Because those insects once ate plants contaminated with mercury, anything that eats them, like dragonfly larvae, takes in that toxic metal. The toxic mercury levels in dragonflies then continue to build up in fish and other wildlife that eat those insects. Laboratory analysis of hundreds of dragonfly larvae provided scientists with information about mercury levels in ponds and wetlands across the nation. As a result, rangers and public health professionals know which spots should be monitored closely. Using dragonflies as an indicator species, scientists can track where mercury is or is not a threat to wildlife, and they can post signs to warn people about the risks of eating fish from certain areas.

Each indicator species gives researchers valuable clues. An excellent example is the long-term research on frogs in lands around the Chicago area (Illinois, United States), which includes Indiana Dunes National Park (Indiana, United States). Fish, frogs, salamanders, and dozens of plants—with fun names like duckweed and Pitcher's thistle—live there. In and near the park, researchers focus on two indicator species: green frogs and gray tree frogs. Both make great indicator species because they are super easy to find. They are noisy, so researchers know where to look for them. If these species hid all the time or were rare, they would not make good indicators. They would be much too hard to find, even in a healthy environment.

Frogs are fascinating because they spend the beginning of their lives in the water and then they move onto land. When they are babies, they move in the water like fish, and eat tiny plants called phytoplankton. When the tadpoles grow legs and move to land, they eat animals like worms and insects. Frogs are never safe from being eaten. In the water, they are a snack for snapping turtles and fish. When frogs are grown up, raccoons hunt them. The fact that frogs live in and out of water makes them awesome indicators because they can tell researchers about the environmental health of both land and water (Figure 2). When these frogs are abundant, their predators are well-fed and can have more healthy offspring too! If frog populations decrease, it is noticeable. Their predators have a tough time finding food and some of the flies and moths that frogs usually eat can increase in numbers and become even more of a problem for humans.

Another reason frogs make great indicator species is the fact that they have thin, moist skin that breathes. Their skin's unique structure lets water enter their bodies. Frogs are super sensitive. When in contact with polluted water, they will absorb harmful substances that are

TOXIN

A poison that causes a disease when present even at a very low quantity in the body.

[1] For more information, see https://www.nps.gov/articles/dragonfly-mercury-project.htm.

LARVAL STAGE

The immature form of an insect or other animal that goes through a transformation before adulthood.

Figure 2

Frogs make great indicator species because they live both on land and in the water. From birth to 12 weeks old, they can only live in the water. After 12 weeks, they can hop out of the water and enjoy living life on land and in the water. (Image Credit: Nickolay Hristov).

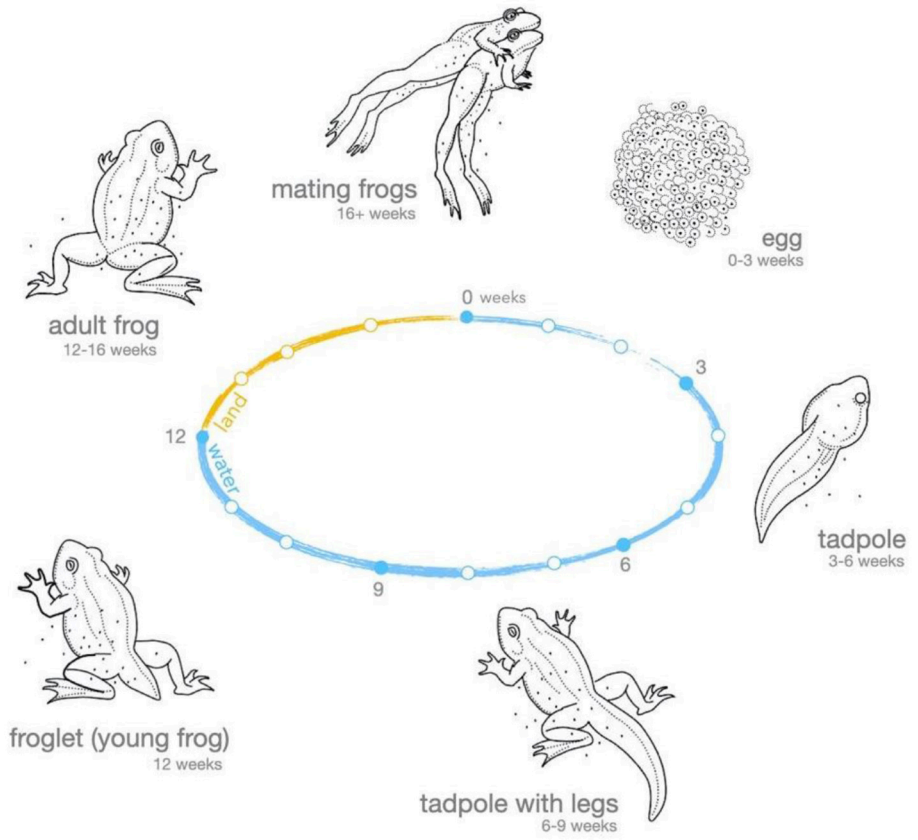

Figure 2

PESTICIDES

Substances used on plants to kill insects or other organisms harmful to the plant. Pesticides can have undesirable or unanticipated side effects on other plants and animals.

present in the ecosystem, such as **pesticides**, fertilizers, medicines, and toxic chemicals used in manufacturing. Conducting studies to measure pollutants in water is expensive and time consuming. So instead, researchers monitor the presence and health of frogs to determine if pollutants are a problem.

Researchers who are curious about the health of Indiana Dunes National Park study gray and green frogs to understand if the wetlands are healthy places for wildlife to eat and breed (Figure 3). Scientists do an annual count of the frogs. If the number of frogs is roughly the same from year to year, then the environment is stable. If the frog population numbers get smaller from one year to the next, then researchers discuss possible actions to make conditions more favorable for frogs. A decline in the population of these two frog species indicates that the health of other species living in the same habitat might be at risk.

HOW DO RESEARCHERS LOOK FOR INDICATOR SPECIES?

Scientists use three of the five senses to study indicator species: hearing, sight, and touch. The first thing scientists do to check the health of the wetlands of Indiana Dunes National Park is to listen for

Figure 3

Scientists look to frogs to indicate whether the environment is sick. If frogs are not doing well, then scientists can tell the environment is not doing well either. (Image Credit: Chris Tullar).

Figure 3

the sounds of gray tree frogs and green frogs. Once they hear their songs, they begin to locate the frogs by sight. They are looking for the bright, light green of the green frog and the striped gray of the gray tree frog. They look under dried leaves and next to tree roots to find them. The scientists catch the frogs using nets and quickly pick them up before they hop away.

We know frogs are very sensitive to chemicals. When researchers pick up frogs, they look for signs of chemical injury on each frog's skin. But researchers also look for clues that the frogs have absorbed chemicals through their skin. Often, pesticides run off from farms and surrounding land, ending up in the water. One pesticide, Atrazine, is used to kill weeds in corn fields. Increased Atrazine use causes more water contamination, which results in greater harm to frogs. Once pesticides are present in the water, frogs' biological traits can get messed up. Pesticides like Atrazine and chemicals like DDT disrupt the sexual development of frogs [2]. For example, male frogs will develop *both* male and female sex organs. Researchers have also noticed that male frogs exposed to chemicals have smaller vocal cords. Frogs with smaller vocal cords have a hard time making sounds to attract mates. If they cannot attract mates, they cannot reproduce. If researchers see a frog with strange organs, they suspect frogs in the area have been exposed to chemicals through their skin. Therefore, other species in the environment are likely suffering from unhealthy water, too. These are big problems for frogs and for the animals that

eat them. If frogs cannot mate, the number of frogs declines. Frogs must reproduce to keep their species alive. Without indicator species like frogs, researchers would have a much harder time finding out what is happening in the environment, and many more animals would suffer.

CONCLUSION

Indicator species are storytellers that researchers often rely on to determine the health of the environment. These important species save researchers time and money, draw attention to environmental problems, and provide managers with important information so they can start nursing the environment back to health. By being in the environment, calling out, and making themselves visible, indicator species help make a difference for not just their species, but for all the animals and plants that live with them. So, here is a big thank you to all the indicator species that are helping researchers as they try to protect the environment!

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AUTHOR DISCLAIMER

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. More information about iSWOOP is available at www.iSWOOPparks.com or contact Martha_Merson@terc.edu.

REFERENCES

1. Eagles-Smith, C. A., Willacker, J. J., Nelson, S. J., Flanagan Pritz, C. M., Krabbenhoft, D. P., Chen, C. Y., et al. 2020. A national-scale assessment of mercury bioaccumulation in United States National Parks using dragonfly larvae

as biosentinels through a citizen-science framework. *Environ. Sci. Technol.* 54:8779. doi: 10.1021/acs.est.0c01255
2. Sanders, R. 2010, March 1. Pesticide atrazine can turn male frogs into females. *Berkeley News*. Available online at: https://news.berkeley.edu/2010/03/01/frogs/.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

KAMARA, AGE: 15
My name is Kamara. I enjoy making long-rise bread on the weekends. This was my first time reviewing a scientific paper. It was really fun to be part of the problem solving process before publication.

SALENA, AGE: 15
My name is Salena and I love acting, playing music, and reading. I like science because it allows me to better understand the world around me.

AUTHORS

SOPHIE PHILLIPS
Sophie Phillips studies energy and environmental policy at the University of Delaware, U.S. She is also a Research Assistant for the Water Resource Center within the Biden School of Public Policy and Administration. As an undergraduate, she worked in the Robotics Discovery Lab, which is part of the University of

Delaware. Her research interests include wildlife conservation, environmental justice, and the connection between environmental history and race within the United States. Sophie inspired many people as Miss Delaware in 2021–2022 and plans to continue her public service either as a state representative or as a park ranger. *sophiekp@gmail.com

MARTHA MERSON

Martha Merson has co-led the project Interpreters and Scientists Working on Our Parks along with Hristov and Allen. Merson was never an outstanding science student, but she was curious about scientists' work. She has worked closely with scientists and park rangers to bring science stories to public audiences.

NICKOLAY I. HRISTOV

Nickolay I. Hristov is a scientist with interests in information and learning design and population dynamics. His research, done in tandem with Louise Allen, using LiDAR technology, has provided more accurate counts of clustering species like monarchs in Mexico and cave-dwelling bats in the south-central United States. Nick is a native Bulgarian and a huge fan of U.S. national parks.

LOUISE ALLEN

Louise Allen is a biologist and higher-ed administrator, formerly a zookeeper, with expertise in undergraduate mentoring. Her research has focused on anthropogenic impacts on behavior and stress in wildlife, including bats. She enjoys conducting research with park rangers and undergraduates on protected land.

ROBERT BRODMAN

Dr. Robert Brodman's research focuses on conservation of amphibians and reptiles, with questions ranging from ecology to animal behavior. He has developed undergraduate research programs centered on ecotoxicology studies investigating the impacts of herbicides, habitat restoration, and farming practices. His long-term studies in northwest Indiana have helped the National Park Service make decisions about wetland restoration projects and more. This video shows Dr. Robert Brodman walking through the wetlands of Indiana Dunes National Park. The video shows some of the animals that live there (`https://www.terc.edu/iswoop/collaborating-scientists/`).