

Meeting the *Standards* with Vanishing Frogs

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The purpose of this article is to explain how to introduce high school students to the issue of declining amphibian populations by reading the book, *Tracking the Vanishing Frogs: An Ecological Mystery* (Phillips 1994) and playing a game based on concepts introduced in this book. In this article we present a teaching/learning activity in which high school biology and environmental science students practice both reading comprehension and graphing skills, important skills stressed by recent educational reform efforts (NRC 1996). The *National Science Education Standards* suggest actively engaging students in inquiries that interest them and relate to current science topics (NRC 1996). The issue of global decline of frog populations has proven both interesting and important to our students. Engaging in the activities suggested in this article presents an opportunity to enhance students' understanding of possible outcomes of human disturbances in the natural environment, the interdependence of organisms, and the nature of scientific inquiry.

Background

Since the late 1980s, catastrophic frog, toad and salamander declines have been of great concern to scientists. In *Tracking the Vanishing Frogs*, Phillips (1994) recounts the decline of

various frog species from around the world. The Golden Toad has disappeared completely from the mountains of Monteverde, Costa Rica, its only known habitat. The gastric brooding frog in Australia has not been seen since 1981. Yellow-legged frogs and red-legged frogs are in trouble in California. Numbers of Yosemite toads, Cascade frogs, leopard frogs and western toads, once abundant in the Cascade Mountains, dropped precipitously in the 1980s and have not recovered. *Tracking the Vanishing Frogs* is an excellent text to use to introduce high school students to the issue of declining amphibians.

In *Nature* (2000) scientists report that we do indeed have reason to ask why frogs are in trouble. As humans, do we need to know what is causing the decline of amphibians? Can the problems responsible for declining amphibians affect humans? Are frogs ecological canaries or biological indicators for our environment? If so, what do we need to learn from the decline and what do we need to do to arrest it?

According to the Houlahan et al. (2000) analysis of 936 amphibian populations from around the world, at a global scale amphibians have declined over the past several decades and continue to do so. Moreover, they suggest that the most dramatic declines for amphibians occurred from 1960 to 1966, decades before herpetologists sounded the ecological alarm.

Ideas abound to account for the frog declines, including changes in local climate, acid precipitation, disease, parasites, environmental contamination, habitat loss and degradation due to direct human impacts, and increased UV irradiation (Houlahan et al. 2000; Pounds et al. 1997). Fungal infections are another possible cause of some declining frog populations.

A fungus that suffocates the animals by coating their undersides and legs has destroyed communities of frogs in Australia and Central America. It is possible that the fungus is spread by herpetologists (Kabbany 1999).

Agricultural chemicals may also be causing some of the declines. When scientists at Trent University in Ontario, Canada, exposed frog eggs and tadpoles to a common pesticide, they found that the frogs experienced high death rates and unusual growth and development patterns (Kabbany 1999).

Ultraviolet radiation causes DNA damage in frog eggs. The increase in UV radiation may be attributed to the depletion of stratospheric ozone (Blaustein et al. 1998).

Undoubtedly, there are other possible causes of local frog declines. As an example of habitat degradation due to direct human impact, the introduction of exotic species into wetland habitats has become prevalent. The introduction of exotic species reduces resources available to native amphibians. Nonnative trout have been released into mountain lakes in California where the yellow-legged frog population has declined. The nonnative trout have made a meal of the slowly developing yellow-legged frogs (Adams 1999).

Clearly, recent studies (Houlahan et al. 2000) provide evidence to support global amphibian population declines. Of the 936 populations of amphibians studied, 61 populations became extinct. Pounds and his colleagues (1997) who have studied amphibian populations in Costa Rica reported that they gathered data for five years expecting amphibian populations to rebound quickly. Unfortunately, amphibian populations have not rebounded; the amphibian fauna remains impoverished. The next section of this article discusses instructional strategies that teachers can use to make students aware of the issue of declining amphibians and the search for causes and implications of amphibian decline.

Instructional Strategies

One instructional strategy that we used in our classrooms was a Paideia-like seminar based on *Tracking the Vanishing Frogs*. This approach requires

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approximately one week of class discussion time (after students have read the book) if you are on a block schedule. First, we divided the class into groups of three, with each group responsible for one of the nine chapters in the book. Depending on class size, long chapters (5, 7 and 8) can be divided or short chapters (1 and 2) may be combined. After reading their chapters, students generated questions to guide the discussion of their assignments. We encouraged students to draft interesting questions that they thought their classmates would want to discuss. Students wrote questions on an overhead transparency before the actual discussion day so that the rest of the class had a chance to read the chapter and answer the questions. Students led the discussions of their chapters. We acted as facilitators and timekeepers, and occasionally interjected with supplemental materials or activities. We gave all students a loose-leaf binder where they kept all questions, answers, notes, and supplemental handouts for each chapter. At the end of our study, we used these notebooks to assess student achievement of learning objectives, for example:

- Students will show awareness of the issue of declining amphibians.
- Students will demonstrate understanding of the interdependence of frogs and other organisms in their environments.
- Students will demonstrate an understanding of the relationships between biotic and abiotic factors in ecosystems.
- Students will show awareness of the impacts of human activities (such as logging, riding 4-wheelers, and grazing cattle near rivers) on the environment.

Following the seminars, we played the game. In some semesters we were unable to read and discuss the entire book and thus opted to use just the *Frogs' Futures Game* with our students. This game is based on reading selections from chapter 9 of *Tracking the Vanishing Frogs* (Figure 1) and can be completed in one 90-minute class period. This game uses dice to represent the frogs. The game shows students how humans might contribute to an accelerated decline of various frog populations, how extinction may occur, and what might happen to frogs if appropriate conservation measures, such as the Endangered Species Act, are implemented. After we divide students into groups of three, they play four games as described below (Figure 2, Figure 3). Next, they collect and graph the data for

each game (Table 1, Figure 4). Students then compare data from the four different game situations to assess the effects of human activity on frog populations.

Teacher Information

Frogs' Futures Game: Survival or Extinction?

You will need the following materials for your class:

Materials (For Each Group)

- 1 sheet of graph paper
- 20 dice for each group (keep extra dice on hand as the populations of frogs sometime increase)
- 2 paper cup dice containers for each group (one labeled "living frogs" and one labeled "dead frogs")
- At least one copy of *Tracking the Vanishing Frogs* (All page numbers in the following games are referenced to the 1994 paperback edition of the book.)

You may want to begin by summarizing or reading the following italicized passage to your class:

Frogs. We do not think of them as cute and cuddly like the panda, dolphin, or wolf pup. However, some scientists believe that they may be nature's calling card, preempting an ecological catastrophe. The purpose of this activity is to identify how altered environmental conditions may lead to the accelerated decline of some frog species and how protecting a species may or may not help the species stabilize over time.

In this activity, you will play the Frogs' Futures Game in small groups. This game uses dice to represent frogs and represents how frogs may become extinct if something is not done to prevent their demise.

During this activity, students use dice to simulate the number of frogs that survive during a 10-year cycle. This game has been adapted to *Tracking the Vanishing Frogs*, but could be adapted with little effort to any book, which deals with endangered species. Reading assignments are incorporated into the game. Before each game the students read selections from the book (Figure 1), which give them a basis for that game. Alternatively, the teacher may read each of the selections asking students to focus on mental images that the descriptions convey.

After students have read the selection from *Tracking the Vanishing Frogs*

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Frogs' Futures Game

Selection 1. Humans in the Bog or Perfect Frogland.

Read pages 217-218. This selection gives students an idea of the perfect picture of frogland.

"The bog is hidden from the road where we park by a steep slope and a broad screen of trees. So my first view of it comes as we emerge from the shelter of trees. . . . a mix of large puddles surrounded by a wetland covered with shin-high bushes that resemble blueberry plants but aren't. Islands between the puddles on parts of the bog hold taller bushes and some spindly trees. The whole bog stretches about half a mile. As we approach it, our boots make powerful sucking sounds each time we pull our legs out of the wet earth.

The bog is teeming with life. . . . Hayes points to a hopping creature. "Toad behind you," he tells me.

. . . It believes, I am sure, that I am a predator and it is prey. I know that in some sense it is right. I have disturbed its peace, and I carry it to Hayes to mark, weigh and measure before I return it to its spot in the bog. I want it to survive, perhaps as much as it wants to survive. As I place it back in the shallow pool, I worry a bit while it sits still, adjusting to the water, before it bounces into hiding again." **Now have students play Game 1.**

Selection 2. Humans vs. Science.

Read pages 200-201. This gives an idea of how one person feels about the frogs. Is this a metaphor for the anger of others?

"This reserve is closed to most trucks and cars by a gate secured by a chain and lock. But it is open to pedestrians, and it is not unusual to see visitors hiking or jogging along the plateau's trails. So the man attracts no attention until he slows and asks Jennings what he has in the bags.

"Critters," Jennings responds pleasantly, anticipating the kind of gentle conversation that usually occurs when he encounters curious passersby in the field. Why, the man asks. Because he is studying them, Jennings answers. The man begins to pelt Jennings with a hail of questions: Why don't you leave the animals where they are? What right do you have to take them away? Leave them in the pond, he demands.

Jennings is stunned. Then, with the tone of a teacher guiding a student, he explains that the frogs will be returned to the pond. But the jogger isn't satisfied. "Why do you even do that? Why do you guys come in and mess with them? Why do I have to park out there and you get to park in here and mess with the animals?"

I am standing next to Hayes, and I see his jaw clench as he begins to breathe heavily. The jogger is yelling at Jennings, who watches the man benignly, waiting for a break in the argument. One of the volunteers tries to convince the man that the study will help the frogs. Suddenly Hayes moves closer to the jogger. "Listen," he demands as he points his finger at the man. Then Hayes explains again that the frogs will be returned.

. . . The group quietly watches the jogger until he is out of sight. Everywhere you go and study creatures, you disturb them, Hayes sighs. That is the trade-off for understanding them." **Now, have students play Game 2.**

Selection 3. Humans vs. Nature.

Read pages 209-210. Students read about what humans have done to harm the frog. This gives the idea of all humanity against nature.

"Human population growth is behind much of the habitat destruction. There are more than five and a half billion people in the world today. That number rises by 90 million each year. As

the number of people increases, the world's available land and resources shrink.

. . . Plants and creatures, including amphibians, are disappearing even before scientists have had a chance to discover and describe them. As long as that remains true, the amphibian scientists can feel confident their alarm wasn't premature. Indeed, it may have been too late for many amphibian species.

The amphibian declines, perhaps more than those of other animals, show just how vast and deep is the impact of even subtle habitat destruction. Many of the most notable amphibian declines have occurred in areas that people believed they had protected from environmental assault. This suggests that *pristine* is rarely still an accurate descriptive term for any wild area, even for protected national parks and preserves. They prove that building a fence around a swath of forest does not automatically protect it and its creatures from the environment beyond the forest. If nonnative fish are stocked in streams leading into the forest, if clouds polluted by acid or pesticides continue to roll over the forest, or if upstream dams change the waterflow through it, the creatures inside will be affected." **Now have students play Game 3.**

Selection 4. Government vs. Nature.

Read page 203. Now that frog populations are declining, in steps the Endangered Species Act. Is it too late?

"The Endangered Species Act has been under attack almost since the day it was adopted into law, in 1973. The act relies primarily on biological evidence to determine whether an animal is eligible for listing as either threatened or endangered. Depending on the level of its listing, any activity that would hurt the listed animal—from destroying habitat to owning or selling the animal—is prohibited. The act's principal critics are developers, logging companies, utilities, and other commercial interests who complain that complying with the act costs too much money, time, and jobs. The Secretary of the Interior can, in fact, waive the act for a species if it is causing 'undue economic hardship'.

In reality, the act has been neither as damaging as its critics claim nor as effective as its supporters would like. Few development projects have been stopped. Logging has continued in most forests, despite the presence of declining species. Many animals that deserve listing have died without notice." **Now have students play Game 4.**

Selection 5. The Natural World.

After Game 4, read pages 218-219. Understanding the importance of the frog may lead to an appreciation and understanding of the whole environment.

"Clouds gather in the sky as the day progresses. A grouse demonstrates its plungerlike call. A heron screams and rises from a distant bank and flies away. A woodpecker knocks a tree in the forest. A mallard swims to within feet of where Hayes works. The clouds continue to gather, and then, in the distance, lightning flashes. The lightning moves closer, and large raindrops begin to fall on us and the bog. The frogs continue to hop from the bushes into the ponds. Hayes continues to catch and weigh them. The rain falls harder and a thread of smoke on a distant hill, where a tree has been struck by the lightning, moves up into the sky. The frogs keep hopping.

It is quiet and still and noisy and chaotic at once. It is peaceful and turbulent. It is full of life, this bog, and these frogs are part of that life. This, I realize, is the way it is supposed to be. This is why frogs matter." **Now answer the discussion questions.**

Figure 1. Reading selections that precede each game.

Frogs' Futures Game Procedures & Rules

Each group begins with 20 healthy frogs, each represented by a single die. The numbers on the die represent events that occur during a frog's lifetime. You may use the following dice designations for each game or have students develop their own scenarios for the numbers on the die.

1. Roll all of the dice at one time. Each roll of all the dice represents a one-year period of time.
2. Roll the dice 10 times or you may let students determine a sufficient number of years to track the population changes. Keep track of the numbers of births and deaths of frogs for each year by recording the number of living frogs on the student data table for each game. Also, to avoid confusion, place the dead frogs in a cup labeled "dead," and the living frogs in a cup marked "living" ready for the next roll of the dice.

Figure 2. Procedures for playing the Frogs' Futures Game.

Game 1. Numbers on each die represent:

- 1 = death by starvation
- 2 = tadpole metamorphoses into a frog
- 3 = abundant food supply for 1 year
- 4 = tadpole metamorphoses into a frog
- 5 = eaten by a snake
- 6 = healthy habitat

Remove all 1s and 5s from the population. For each 2 or 4 add a die (frog) to the population. For each 3 or 6 leave the number of dice unchanged. Count the total number of dice and record this total on the student data table.

Game 2. Numbers on each die represent:

- 1 = death by starvation
- 2 = tadpole metamorphoses into a frog
- 3 = abundant food supply for 1 year
- 4 = habitat destroyed by filling in wetlands to build houses
- 5 = eaten by a snake
- 6 = successful amplexus

Remove all 1s, 4s and 5s from the populations. For each 2 add a die (frog) to the population. For each 3 and 6 leave the number of frogs unchanged. Count the total number of dice and record this total on the student data table.

Game 3. Numbers on each die represent:

- 1 = death by pollution-induced starvation
- 2 = tadpole metamorphoses into a frog
- 3 = habitat destroyed by filling in wetlands to build new houses
- 4 = habitat destroyed by building dams or canals for irrigation purposes
- 5 = eaten by an introduced species of snake or fish
- 6 = habitat destroyed by building new roads

Remove each 1,3,4,5 and 6. For each 2 add a frog. Count the total number of dice and record this total on the student data table.

Game 4. Numbers on each die represent:

- 1 = death by pollution-induced starvation
- 2 = tadpole metamorphoses into a frog
- 3 = habitat saved by using the Endangered Species Act
- 4 = habitat destroyed to build a new road
- 5 = eaten by an introduced species of snake or fish
- 6 = habitat destroyed by building dams or canals for irrigation purposes.

Remove each 1, 4, 5 and 6. For each 2 add a frog. For each 3, leave the number of frogs unchanged. Count the total number of dice and record this total on the student data table. Now, answer the questions about the game.

Figure 3. Game rules.

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Table 1. Game data table template and sample data table.

| Year | Game 1 perfect frogland | Game 2 humans vs. science | Game 3 humans vs. nature | Game 4 government vs. nature |
|------|----------------------------|------------------------------|-----------------------------|---------------------------------|
| 0 | 20 | 20 | 20 | 20 |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |

| Year | Game 1 perfect frogland | Game 2 humans vs. science | Game 3 humans vs. nature | Game 4 government vs. nature |
|------|----------------------------|------------------------------|-----------------------------|---------------------------------|
| 0 | 20 | 20 | 20 | 20 |
| 1 | 22 | 16 | 4 | 12 |
| 2 | 25 | 14 | 0 | 7 |
| 3 | 24 | 9 | | 8 |
| 4 | 32 | 6 | | 4 |
| 5 | 30 | 6 | | 3 |
| 6 | 25 | 9 | | 3 |
| 7 | 22 | 6 | | 3 |
| 8 | 20 | 6 | | 0 |
| 9 | 21 | 5 | | |
| 10 | 21 | 4 | | |
| 11 | | | | |

(Figure 1), they play the specified game (Figure 2, Figure 3). The data for each 10-year period game is recorded in the data table (Table 1). Then, the results for each of the four games can be graphed (Figure 4). Groups may graph their results on one sheet of graph paper, but should use different colors to represent each trial so that the trials are easy to distinguish. Finally, students answer the questions below.

Questions

1. Explain the results from your games. What happened to the frog population in each game? Explain why the number of frogs changed with each game.
2. If the frog population did not decline after habitat destruction, what might be the reason?

3. Based on research you find in the library about frog decline, what do you think is causing this mass declination around the world?
4. What do scientists think UV radiation has to do with frog declination?
5. Compare and contrast the scenarios you read and the dice game that followed. Rank them from best to worst with respect to frog survival and explain your rankings.
6. Why should we care about frogs?
7. What are the global implications of frog declines?
8. What are your solutions to the problem of declining frog populations?
9. Find at least one species of frog that has benefited from some eco-

logical disturbance quickly replacing native/endemic species (e.g. *Bufo marinus*, the cane toad). [There is an excellent video called *The Cane Toad* that is suitable for classroom use and makes a nice addition to a unit on amphibians.] Explain what happened to benefit the frog. How did it affect the environment?

Web Connections

The following web sites will provide you and your students with additional information about declining amphibian populations. Remember, however, that all Internet information should be verified from the source.

1. <http://www.frogs.org.au/>
The Victorian frog group's web

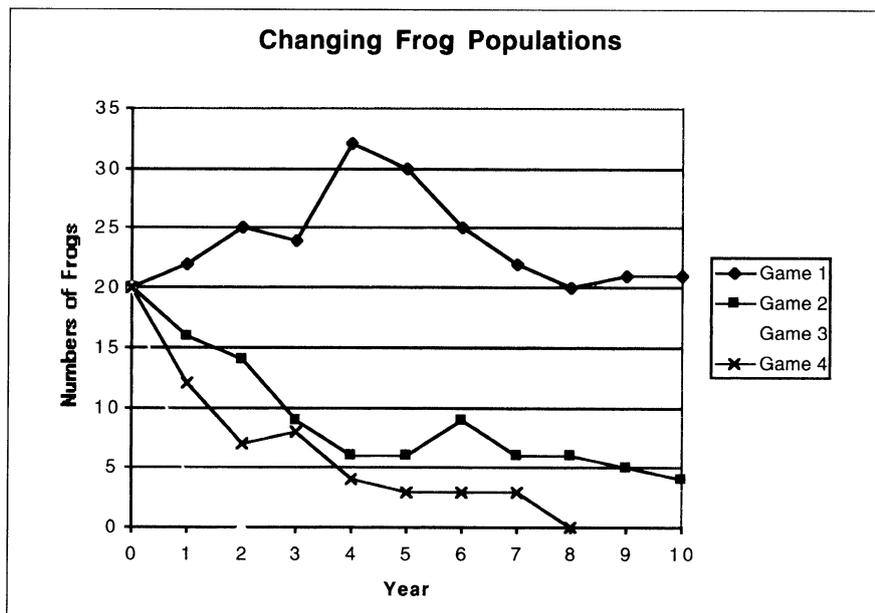


Figure 4. Sample graph.

- site includes a classification key for frogs of Victoria.
- <http://www.mncs.k12.mn.us/html/projects/frog/frog.html>
The Minnesota New Country School Frog Project's web site deals with the problem of deformed frogs in local ponds.
 - <http://www.cgee.hamline.edu/frog/index.html>
The web site for the Center for Global Environmental Education at Hamline University is a comprehensive site that includes lots of frog facts and information on frog declines. A PowerPoint® presentation on frogs has good pictures of frog malformations. This site also includes information on how students can become involved in the efforts to save frogs.
 - <http://www.im.nbs.gov/amphibs.htm>
The web site of the North American Monitoring Program contains technical information on frog surveys. This site also offers information on how to incorporate amphibian conservation in the classroom.

- http://www.aquarium.org/education/spotlight/disappearing_frogs
This web site offers a short, light-hearted fictional account of a frog that seeks the help of a detective in order to find its missing children. This site contains lots of factual information on frogs and the environmental conditions that negatively affect frogs. A short quiz is at the end of the program.
- <http://www.open.ac.uk/daptf>
The home page of the Declining Amphibian Populations Task Force gives a brief synopsis of the causes, importance and findings related to the decline of amphibian populations worldwide.
- <http://www.npsc.nbs.gov/narcam>
The web site for the North American Reporting Center for Amphibian Malformations (NARCAM).

Conclusion

Scientists do not know the specific causes of the declines of certain amphibian populations, but most scientists do agree that declining amphibian populations is indeed a problem. It is an enigma based on an interplay

of factors symptomatic of the general decline of environmental quality (Pelley 1998). We as teachers should do our part to make students aware of the environmental problems surrounding frog populations and what these difficulties may tell us about our future. The awareness we pass on to our students today may result in gains in awareness, knowledge and more informed stewardship.

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