

# The Basics of Biomagnification

## Introduction

### Purpose

To explore the effects pesticides can have on the environment and their influence on large predators.

### Time

30-40 minutes

### Materials

Hawk Mountain annual migration data  
Graph paper  
Calculators  
Pencils

### Skills

- Understanding pesticide use and its effects on the environment
- Recognizing complex food webs and the process of bioaccumulation
- Plotting data and constructing a line graph
- Making predictions and inferences using graphs.
- Gather and interpret data as fact, fiction or opinion.
- Reading and interpreting maps

You may have heard the word *pesticides*, but not know exactly what a pesticide is or what it is used for. Pesticides are used by millions of people each and every day to kill or eliminate unwanted pests. In this section, students will learn what effect too many pesticides can have on the environment and the plants and animals living there. We will explore how pesticides work their way into rivers and streams, through the food chain and into the bodies of large birds of prey and other predators in a process called biological magnification.

Rachel Carson, a Pennsylvania Biologist, helped pioneer the fight against damaging pesticides and opened the eyes of many people through her publication *Silent Spring* and Hawk Mountain Sanctuary founder Rosalie Edge noticed and discussed the destructive use of pesticides decades prior to Rachel Carson's work on *Silent Spring*. Students will learn the important role Hawk Mountain Sanctuary played in aiding Ms. Carson with her research and in making history. Students will also discuss the *use* and *mis-use* of pesticides in the environment and ways to safely eliminate and reduce pests.

By the end of this lesson students should be able to answer the following questions:

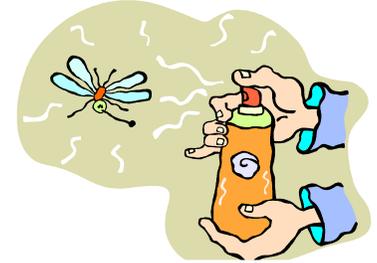
1. How do environmental contaminants make their way through the food chain?
2. Which animals have the highest risk of exposure to pesticides?
3. How and why did the pesticide DDT have an impact on the environment?



# The Basics of Biomagnification

## Teacher Background Information

Environmental concerns have been around for a long time and humans can be one of the biggest threats to the environment because we can quickly impact an otherwise healthy ecosystem. Besides habitat loss, one of the biggest environmental concerns in the past century is the *mis-use* of **pesticides**. Pesticides are any substances used to control unwanted or harmful living organisms, such as insects, fungi, plants, or bacteria. Most pesticides are sprayed on crops and other plants to protect them from the destruction caused by insects. Pesticides are used every day by millions of people throughout the world. In addition to their agricultural use, pesticides are often sprayed around homes, lawns, parks, gardens, golf courses, and other places where unwanted pests occur. Unfortunately, the same substances that destroy pests may also harm plants and other living organisms.



**Bioaccumulation** occurs when harmful substances or toxins build-up in the body tissues of organisms. Many of these toxic substances are pesticides or other environmental contaminants. When pesticides are applied to kill or control pests, they make their way into waterways and soil, slowly traveling through the food chain when insects, fish and small mammals consume them, this concentration within the food chain is referred to as **biological magnification**. Some pesticides do not decompose and retain their potency for a long time, lasting decades or longer in the environment. As a predator eats more and more contaminated prey items the concentration of the toxins builds in the animal's tissues. Scientists often measure the amount of pesticides found in the environment in *ppm* or *parts per million*. When toxins enter the environment only trace amounts are detected, or *parts per trillion*, but by the time the pesticides reach large predators they can be detected up to 20 ppm. Research shows levels above 4 ppm can be toxic to Osprey and other large predators. This process of increased concentration has occurred in several bird of prey species, including the Peregrine Falcon, Osprey and Bald Eagle.



Biomagnification within the food chain usually does not kill an animal directly, but may cause numerous long-term effects. Consequently harming raptors and other large predators. This is especially true if the animal has consumed large quantities of pesticides over a long period of time, as large predators typically outlive smaller ones and consume larger amounts of food over their lifetime.

Because of their vulnerability to environmental contaminants, raptors are recognized as barometers of the health of the environment. When the environment can no longer support raptor populations, the health of the environment itself is in jeopardy. One of the biggest threats to the survival of birds of prey during the late 1950s until the early 1970s was the reproductive failure that resulted from pesticide build-up in the body tissue of birds of prey. Consequently altering the bird's ability to absorb calcium. In other words, when the eggshell formed there was not enough calcium for it to develop properly. Then, when the eggs were incubated they were not strong enough to withstand the bird's weight and break, or ultimately fail to hatch because of a significant decrease in the number and size of pores within the eggshell. Birds of prey were hard hit as predators at the top of the food chain, because they consume many prey items over a long period of time. It is important to note the biggest problems with pesticides arise from their mis-use. Properly used pesticides can be very beneficial for controlling mosquito-borne illnesses and destruction caused by pests on crops or other plants.

## The Destruction of DDT

One of the most well-known and widespread pesticides is DDT. Prevalent in agriculture after WWII, it is an inexpensive and broad-spectrum pesticide that has been used to protect people from mosquito-borne illnesses, such as yellow-fever and malaria. Because of the mis-use of DDT, this pesticide caused the populations of many species of birds of prey to drop drastically during the 1950s and 1960s. Concerns about DDT came to light after the publication of Rachel Carson's book *Silent Spring*. The wide-spread use of DDT was banned in the United States in 1972. Unfortunately, the mis-use of DDT still occurs today in many countries throughout the world.

## Our National Symbol at Risk

There were a few factors leading to the decline of Bald Eagles. First of all, they are large predators, living 25 years or more. Together with their inability to reproduce until five years of age, and their preference to consume a diet of mostly fish, the eagle population was particularly devastated by the use of DDT during the 1950s - 1970s. Listed as an **endangered species** in 1967, the Bald Eagle was at an all-time low with only 417 breeding pairs recorded in the lower 48 states and was at risk for becoming **extirpated** within the lower 48 states. Many people believed each eagle they saw would be their last. However, due mostly to the ban on DDT, a successful breeding program, reintroduction efforts, and increased protection through the Endangered Species Act, the Bald Eagle population began to climb steadily. Its recovery is a remarkable journey made in a relatively short amount of time. Today, 40 years after DDT was banned, there are more than 10,000 nesting pairs of Bald Eagles in the lower 48 states and an estimated 20,000 pairs residing in Alaska. The species was *removed* from the Endangered Species List in 2007, though it is still protected through legislation such as the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act.



## What's the Alternative?

Environmental awareness, knowledge and education are the first steps towards environmental protection. Before taking action, one must learn what consequences and possible effects may occur to the environment or future generations. Some actions may not have an immediate impact on the environment, but may arise years or decades later, as in the case of DDT. As with all chemicals and pest-control measures, it is important to assess each on an individual basis then determine what benefits or detriments they pose. Many scientists now use broad-cast spraying of pests as a last resort because of the knowledge gained from the DDT era. We now know that many insects and pests are actually beneficial to our environment and help pollinate or play an important role in the food chain. Always consider alternative options to controlling pests in an undesirable location, rather than immediately destroying them. Next time you see an unwanted pest in your home or school, try to find out why it's there or how it got there and then take action to correct the problem.

# Women in Conservation

## Rosalie Edge

Often referred to as the first “true woman conservationist in North America,” Rosalie Edge made a difference in the conservation movement in the early part of the 20th century, years before other women were taking a stance on the environment. Rosalie Edge began the Emergency Conservation Committee and founded Hawk Mountain Sanctuary. She also helped establish Kings Canyon and Olympic National Parks and expand Yosemite and Sequoia National Parks. Read the brief biography (or portions of it) on Rosalie Edge “A Most Determined Lady” written by Peter Edge to learn more about this remarkable woman and her journey in the conservation movement.



## Rachel Carson



Her name is synonymous with the environment and conservation and with good reason. Rachel Carson, a biologist from Pennsylvania became famous for researching pesticide mis-use and writing *Silent Spring*. This book detailed the dangers occurring from the mis-use of pesticides and other environmental contaminants. Rachel Carson began researching and documenting what was causing many species of plants and animals to become sick and die and relied on Hawk Mountain Sanctuary’s count data to help make her case. Rachel Carson used annual Bald Eagle migration counts to provide evidence that the numbers of immature eagles were declining steadily during the 1950s.

Increasing awareness about raptors and their role in nature is important. Knowledge leads to action. Public involvement makes a difference. Rosalie Edge realized something had to be done about the shooting at Hawk Mountain and took action to set aside the area as a sanctuary and Rachel Carson spent many years researching a highly controversial subject that she was passionate about.

Whether by joining and supporting a conservation organization, writing a senator or congressman, or taking direct personal action in a special situation, every individual can help in the effort to conserve raptors and other wildlife.

**Try This:** Learn more about Rachel Carson and her important discoveries concerning DDT and other pesticides. Go to [www.rachelcarson.org](http://www.rachelcarson.org) and answer the following questions.

- Besides being an author, what other titles or occupations did she have?
- What year was *Silent Spring* published?
- What do you think the title *Silent Spring* refers to?
- List two other publications besides *Silent Spring* written by Carson.

## Extension:

Read *Rachel Carson: Pioneer of Ecology* by Kathleen V. Kudlinski. Photocopies of the text are available through Hawk Mountain. Ask each student to write a short paragraph about one of Carson’s accomplishments or a period of her life. Once the students have completed their paragraphs they should design a collage or picture depicting their work. Be sure students include one or two sentences about their topic and the year on their collage. Finally, have the students assemble the pictures into a Rachel Carson timeline. Invite other classes to view the timeline or share with the entire school.

## Activity: *Eagles, Eggs and Ecosystems*

Hawk Mountain Sanctuary has counted and recorded the number of migrating raptors since 1934. This long-term count of raptors has taught scientists a lot about the trends and migration patterns of birds of prey. Students will use information from Hawk Mountain Sanctuary's annual raptor migration to track the ups and downs of migrating Bald Eagles and learn what these numbers can teach us.

### Time:

2-40 minute sessions

### Materials:

Copy of Student Questions

Graph paper (1/student)

Copies of *Bald Eagle Migration Counts* (found on next page)

Pencils

Calculator (optional)

### Procedure:

1. Review the history of DDT with your students and its effect on the environment. Discuss the terms *threatened*, *endangered* and *extinct*.
2. Distribute graph paper and copies of the *Bald Eagle Migration Counts* to each student or group of students.
3. Decide the interval of data for the class to use (two, five, or seven years of data). Write the years on the board, so each chart is consistent. You may also choose to create a large chart on the board for your students.
4. Students should use the graph paper to design a chart and plot the data. Charts should include an appropriate title, axis labels, and a key or legend.

### Discussion:

Review the following questions as a class and make predictions about the count five or ten years from now. Besides DDT, what other factors may have led to the drastic drop in the number of migrating Bald Eagles during this period? How did changes in human behavior positively affect the survival of the Bald Eagle?

### Extension:

Historically, counts rise and fall over the years, and a short-term decline is not usually a concern. However, a decline over an extended period of time or for many consecutive years may indicate a much bigger problem.

- Research other species that were influenced by DDT in the past.
- Use Hawk Mountain records to determine if any other species are *currently* in a continued decline. Why do you think this might be the case? Which raptor species are on the rise?



### Do This:

You have learned a lot about the Bald Eagle and the effect of DDT on its populations, but DDT also devastated the population of the Peregrine Falcon.

- Read: *The Peregrine's Journey: A Story of Migration* by Madeleine Dunphy to learn about the lengthy migrations these birds endure and their amazing annual journey.
- Research your own city/town to determine if Peregrine Falcons can be found nesting near you.

## Bald Eagle Migration Counts from Hawk Mountain Sanctuary, 1934-2011\*

<b>Year</b>	<b>BAEA**</b>	<b>Year</b>	<b>BAEA</b>	<b>Year</b>	<b>BAEA</b>
1934	23	1963	21	1989	62
1935	65	1964	27	1990	76
1936	73	1965	36	1991	70
1937	31	1966	25	1992	91
1938	37	1967	30	1993	81
1939	64	1968	41	1994	80
1940	38	1969	30	1995	138
1941	50	1970	25	1996	120
1942	70	1971	14	1997	135
1946	69	1972	14	1998	172
1947	89	1973	17	1999	190
1948	79	1974	13	2000	173
1949	84	1975	19	2001	178
1950	116	1976	18	2002	230
1951	87	1977	19	2003	221
1952	91	1978	27	2004	216
1953	59	1979	16	2005	200
1954	65	1980	22	2006	202
1955	68	1981	28	2007	230
1956	53	1982	33	2008	245
1957	39	1983	24	2009	218
1958	41	1984	41	2010	406
1959	45	1985	37	2011	309
1960	23	1986	56	2012	?
1961	40	1987	65		
1962	35	1988	57		

\* No counts were conducted during 1943, 1944, and 1945

\*\*BAEA is the accepted abbreviation given by the American Ornithologists Union for the Bald Eagle

## Activity: *Back from the Brink*

The Bald Eagle population declined in the 1960s and 1970s for many reasons including habitat loss, shooting and exposure to DDT. However, the population has made a rapid comeback in recent years, and its numbers are steadily climbing in the lower 48 states. Students will interpret and use information presented on a map to answer questions and make predictions.

This activity should be conducted upon completion of *Activity: Eagles, Eggs and Ecosystems*.

### Time:

30 minutes

### Materials:

Copy of U.S. map and Student Questions

Colored pencils (3/student)

### Procedure:

1. Review with students the Teacher Background Information on DDT and its effect on the Bald Eagle population.
2. Give each student a copy of the US map and Student Questions.
3. Review the map briefly with the students. The map lists the number of breeding pairs of Bald Eagles per state. A *breeding pair* consists of two adult eagles. It does not include young, non-breeding eagles. The map was published in 2007 by the U.S. Fish and Wildlife Service and the data is from 2004 or later. It can be assumed that the population is currently greater than this map suggests.
4. Discuss with students which two states are missing from the map and reasons why they are omitted.
5. Answer the questions in the Student Journal and make appropriate predictions about the future of the nesting Bald Eagle population.

### Extension:

Scientists have spent years studying Bald Eagles and their nests. Conduct online research to learn more about Bald Eagles nesting in your state or at a river or lake near you. Why didn't the Bald Eagle population rebound more quickly? List a few factors limiting the growth of the Bald Eagle population. What kinds of species may have a more rapid population growth? Students can also research how scientists acquire population estimates of birds using the Christmas Bird Count. This national count occurs annually in December across the country and tallies the total number of many different bird species.

