In the modern, human-dominated world, a wide variety of pests threaten our environment, agriculture, and health, and must be controlled. Part of the strategy for controlling pests is the use of chemicals that kill or reduce the numbers of the pest.

While pesticides are important agents in pest control, they also can carry significant risks if not used carefully and strategically. We now know that some pesticides that were once widely used can be extremely dangerous to organisms other than the target pests.

Fifty years ago, a publication alerted the people of the world to potential dangers in pesticide use. This was the book, Silent Spring, written by Rachel Carson and published in 1962.
As a direct result of the publication of *Silent Spring*, practices of pesticide use were subjected to much more intense scrutiny and much has changed. Most observers say the changes have been for the better, but some suggest the impacts of *Silent Spring* have been negative.

Experience the exhibit, read the book.... and be the judge.
In an intense, some say alarmist tone, Silent Spring’s key theme is that humans are not separate from nature and natural systems, but are part of them. Carson argues that the best strategy for survival—of our crops, livestock, and the millions of species on Earth, including ourselves—is to understand the complex relationships in our environment and to change things as little as possible.

Published in 1962, Silent Spring documents the effects of pesticides on the natural environment and human and livestock health. It was first serialized in The New Yorker magazine and subsequently published in book form by Houghton Mifflin.

In Silent Spring, Rachel Carson explores several inter-related themes including:

- The impacts of pesticides on non-target organisms
- The toxicity of pesticides to human health
- The tendency of target pests to build up resistance to pesticides over time
- Alternatives to using pesticides, especially in broad-scale application

Carson discusses many different pesticides and uses numerous research studies or eye-witness accounts as evidence for pesticide impacts. Of the pesticides mentioned, DDT receives particular attention as it was very widely used to control insects at that time or era.

"If we are going to live so intimately with these chemicals... eating and drinking them... we had better know something about their nature and their power."

RACHEL CARSON
SILENT SPRING, PAGE 17 (2007 EDITION)

"It is our alarming misfortune that science has armed itself with the most modern and terrible weapons, and that in turning them against the insects it has also turned them against the earth."

RACHEL CARSON
SILENT SPRING, PAGE 297 (2007 EDITION)
Rachel Carson was born May 27, 1907, in Springdale, Pennsylvania. She showed promise as a writer at an early age, winning competitions at 10 years old. She also developed a strong love for nature. She joined the US Bureau of Fisheries - later to be the US Fish and Wildlife Service - as a part-time science writer in 1932, becoming full-time in 1936.

Carson became increasingly aware of the impacts of pesticides on the environment, and began writing *Silent Spring*. While writing the book she was battling breast cancer, which claimed her life less than two years after its publication, on April 14, 1964.

Carson attended Pennsylvania College for Women (now Chatham University), switching her major from English to biology. She then entered Johns Hopkins University to study marine ecology and completed her Master's degree but did not finish her PhD as she had to support her mother and siblings.

Over several years, she wrote three scientific yet lyrical books about the oceans: *Under the Sea-Wind*, *The Sea Around Us*, and *The Edge of the Sea*. *Silent Spring* was a critical and financial success, allowing her to devote herself to full-time writing.

*Over the Sea-Wind* was published in 1941.

*The Sea Around Us* was a critical and financial success, and she could subsequently afford to devote herself to full-time writing.

*The Edge of the Sea* was published in 1951, after her death in 1964.

Over several years, she wrote three scientific yet lyrical books about the oceans: *Under the Sea-Wind*, *The Sea Around Us*, and *The Edge of the Sea*. *Silent Spring* was a critical and financial success, allowing her to devote herself to full-time writing.

*The Edge of the Sea* was published in 1951, after her death in 1964.

*Te Sense of Wonder*, a short book for children, was published in 1965, after her death.
Pesticides can target any type of pest. There are four main types of pesticides:

- Herbicides (target plant pests)
- Fungicides (target fungal pests)
- Insecticides (target insects and other arthropod pests)
- Bactericides (target bacterial pests)

Other pesticides target worms, snails and slugs, rodents, and other animal pests. Some pesticides affect many organisms; others are more specific.

A pesticide is:

“any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm . . . The term includes substances intended for use as a plant growth regulator, or defoliants, . . .”

THE FOOD AND HEALTH ORGANIZATION
One thing is sure … things were different in the 1950s and early 1960s from what they are today.

When Silent Spring was published in 1962, there was no Internet, no mobile phones, and Apple’s first personal computer was more than 20 years in the future.

Manufacturing in America was thriving after the Second World War. The 1950s and 1960s saw the peak times for the US automobile industry, with more and larger cars being produced. Air travel became more common. This was a time of optimism on the homefront in the US but also of fear internationally. The Cold War was intensifying between the Western powers and the Soviet Union. The threat of nuclear weapons loomed large. In 1957, the Soviet Union launched the first satellite into space igniting the ‘space race’. Concerned by the Communist presence at its doors, the US staged the unsuccessful Bay of Pigs invasion of Cuba in 1961.

Common attitudes to the environment were also different then from those held by many today. There was limited perception of a ‘balance of nature’, where we regarded all processes of Planet Earth as interrelated, and where humans are but part of a complex system of natural forces that we can influence but not entirely control. Ecology was a term rarely used in public media.

From the 1930s to the 1950s, there was a growing belief that technology and engineering could resolve all the economic, health, and environmental challenges facing humanity. This prompted a rapidly expanding development and use of chemicals, including pesticides.

Companies like DuPont, Monsanto, American Cyanamid, and Dow grew rapidly.

DuPont adopted the slogan, “Better Things for Better Living...Through Chemistry” in 1935 and used it until 1982 when the “Through Chemistry” was deleted. The phrase “Better Living Through Chemistry” became widely applied as both an advocacy tool for chemical use, and, later, as an ironic criticism of this same chemical advocacy.

The publication of Silent Spring evoked a quick and powerful reaction from those interests that advocated strongly for pesticide use.

In particular, pesticide manufacturing companies regarded the book as a threat to commercial products for agriculture. A number of scientists, especially in agriculture, also criticized some of the case studies noted in the book or questioned the conclusions presented by Carson. The criticisms of Rachel Carson were at times caustic, and even today, some writers deride both the book and her motives in writing it.

WHAT WAS IT LIKE BACK THEN?
The effectiveness of DDT as a pesticide had resulted in its ever-growing application, often in large-scale and indiscriminate fashion. DDT was used in agriculture, for disease prevention, and around the home. At the same time, there was growing evidence that DDT and other toxins enter food chains where they become concentrated in organisms ranging from earthworms to vertebrates (like birds and mammals). There was also increasing evidence that some target pests were developing DDT resistance.

The Origin of DDT

DDT (or dichlorodiphenyltrichloroethane) is a synthetic chlorinated hydrocarbon. DDT was first synthesized in 1874, and its properties as a pesticide were discovered in 1939. It was used in World War II as an effective control of malaria mosquitoes and typhus-carrying body lice. A Swiss chemist, Paul Hermann Müller, won the 1948 Nobel Prize in medicine for sounding the effectiveness of DDT against insect pests that were causing (and spread) disease. DDT kills insects by over-activating nerve cells or neurons, causing the animal to go into spasms and then die.

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The Rise of DDT

By the 1950s, the effectiveness of DDT as a pesticide had resulted in its ever-growing application, often in large-scale and indiscriminate fashion. DDT was used in agriculture, for disease prevention, and around the home. At the same time, there was growing evidence that DDT and other toxins enter food chains where they become concentrated in organisms ranging from earthworms to vertebrates (like birds and mammals). There was also increasing evidence that some target pests were developing DDT resistance.

The Fall of DDT

Rachel Carson mentions many pesticides in *Silent Spring*, but for her, DDT was the “poster child” of the chemical industry—badly promoted, oversold, and underrecognized for its ecological effects. Public reaction to her book was instrumental in the banning of DDT in much of the world (1972 in the US). Many pesticides much more powerful than DDT have been developed, such as aldrithion, heptachlor, malathion, and many others. Progressively, many of these pesticides have also been banned. By the time DDT was banned in America, its use was in decline in this country. Chemical companies had released other pesticides that were soon to be more effective—and more profitable (the US patent on DDT expired at about the time *Silent Spring* was released).
Three months later, Rachel Carson died. There is no record that Rachel Carson and George Wallace ever met.
In Silent Spring, Rachel Carson refers to numerous case studies and examples of the negative impacts of pesticides. One prominent example is the case of the dying robins on the campus of Michigan State University.

Here is the story of Rachel Carson connects with that of an MSU faculty member, Professor George Wallace. Wallace, an ornithologist, and his graduate students John Mehner and Richard Bernard, collected birds—mostly robins—from MSU and surrounding suburbs from the mid-1950s into the 1960s. The birds were found either dead or dying in tremors. Tests on many of the birds’ carcasses revealed elevated levels of the pesticide, DDT.

In the late 1950s and 1960s, DDT was being sprayed by plane and from trucks at MSU and elsewhere in Lansing in an attempt to control Dutch Elm Disease.

Elms are a beautiful shade tree and MSU had over 5,000 elms on its campus. Dutch Elm Disease is caused by a fungus, which is spread by elm bark beetles that bore through the bark and move from tree to tree. DDT was being used to kill the beetle, in the hope of controlling the spread of the disease.

Wallace and his students’ studies revealed that DDT did not kill just the beetles. Because DDT does not quickly degrade, poison remained on the elm leaves when they dropped in fall to become compost in the soil. Some of the DDT probably fell directly onto the soil during spraying or was washed onto it by rain.

Soil and compost were ingested by earthworms, and the worms were eaten by American Robins and other birds. The DDT concentrated in the tissues of the birds, so a little DDT in an earthworm became a lot in a robin eating dozens of earthworms in a day.

Wallace and his students recorded over 80 species of birds, with various feeding modes, that showed symptoms of poisoning. In years to follow the publication of Silent Spring, other impacts of pesticides like DDT became better recognized.
America's national symbol—the Bald Eagle—was once headed towards extinction. It is likely that several factors contributed to its decline including habitat loss and hunting but pesticides were the major contributor. Many raptors (birds of prey) such as Bald Eagles, Ospreys, Peregrine Falcons, and others underwent dramatic population declines.

DDT used in agriculture and forestry was washed into rivers and lakes where it entered the food chains. The DDT or its breakdown product, DDE, accumulated in the tissues of fish and birds. At each level of the food chain, their concentrations increased, a process called biomagnification. When Bald Eagles ate fish with DDT, the pesticide was concentrated further in the eagles' tissues.

These high concentrations of DDT and DDE caused eggshell thinning and sterility, leading to widespread nesting failures. Egg numbers reduced and eggs broke in the nest. In 2007, the Bald Eagle was removed from the Endangered Species List. Populations of Ospreys, Peregrine Falcons, and Brown Pelicans have also recovered.

DDT was banned in the United States in 1972. Since then, the number of nesting Bald Eagles has increased dramatically. There are now more than 10,000 Bald Eagle nests in the lower 48 states, a twenty-fold increase over their low in the 1960s.

In 2007, the Bald Eagle was removed from the Endangered Species List. Populations of Ospreys, Peregrine Falcons, and Brown Pelicans have also recovered.

Some argue that the decline in raptors was not due to DDT and DDE, but the majority of environmental scientists and ornithologists regard the pesticides as the primary cause.
For each of us, as for the robin in Michigan or the salmon in the Miramichi, this is a problem of ecology, of interrelationships, of interdependence. We poison the caddis flies in a stream and the salmon runs dwindle and die. . . We spray our elms and the following springs are silent of robin song . . .

Rachel Carson
SILENT SPRING, PAGE 189 (2002 EDITION)
Silent Spring not only raised public awareness of how pesticides can cause unintentional impacts on non-target organisms, but also summarized growing evidence that insects and other pests can develop resistance to these toxins.

Resistance occurs when a few individuals in a pest population have a genetic mutation that makes them less sensitive to the toxin. These individuals survive the pesticide, breed, and convey the resistance gene to their offspring, and that the percentage of resistant individuals continues to grow. After many generations, most of the population may be resistant. This is an example of evolution in action. Widespread use of DDT in agriculture is one reason that insects such as mosquitoes built up resistance to the toxin.

Plant pests can also become resistant to herbicides. MSU researchers recently found that some horseweed in Michigan is now resistant to glyphosate (Roundup), the most widely used herbicide in America. This is the first confirmation of glyphosate-resistance in weeds in Michigan.

“...we thought we had some of the problems solved when we got such good results from the new insecticides. DDT...made medical history in 1943 and 1944 when an outbreak of typhus in Naples was controlled in a few weeks by its use. Entomologists hoped then that DDT could end all insect-borne diseases and even eradicate the house fly. In less than a decade, however, DDT was found to be a failure against the body louse in Korea, and...failed to control mosquitoes in some places.

In 1952 the house fly was no longer controlled in many places by any of the residual-type insecticides in use, and it seemed likely that other pests (those of agricultural, as well as medical, importance) in time would develop resistance.”

CHARLES F. BRANNAN, US SECRETARY OF AGRICULTURE
US DEPARTMENT OF AGRICULTURE YEARBOOK, 1952

TEN YEARS BEFORE THE PUBLICATION OF SILENT SPRING.
Some pesticides in current use, when applied as recommended, have little known impact on the environment and can achieve great benefits in controlling pests in agriculture and human health. Other pesticides, including many now banned in the US, had—and can still have—serious negative impacts on animals and plants that were not the intended targets.

Several aspects of pesticides influence how much danger they pose to the environment and human health, including:

- How toxic is the pesticide to a variety of organisms?
- How readily does the pesticide accumulate in living organisms?
- How persistent is the pesticide in the environment?
- How does the pesticide distribute in the environment?

Pesticides that kill or harm a wide range of organisms can pose greater risks than those that target a narrower range of pests.

Accumulation of a chemical in living organisms is called **bioaccumulation**. This can result in concentration of the chemical up the food chain, a process called biomagnification, resulting in higher order feeders (like large fish or birds of prey) being more affected by the chemical.

**Persistence** is the tendency of a chemical to remain stable in the environment. Some pesticides break down quickly, while others can be active for many months or years. Some pesticides can evaporate and be transported long distances in the air. Others are soluble in water and can readily move along rivers or through groundwater.
Biological control (or biocontrol) is the practice of using one species to control the population of another.

Four main types of biological control organisms can be used against pests:

- **Predators** prey on the pest
- **Parasitoids** have an immature stage that develops on or in the pest, eventually killing it
- **Pathogens** cause disease in pests
- **Weed eaters** consume weeds

Specialist feeders are preferred as biocontrol agents because they attack only the targeted pest. Generalist feeders may attack other non-pest species.

In *Silent Spring*, Rachel Carson advocates biological control as a superior method of controlling pests than pesticides in that there are fewer environmental side effects. She notes that some biological controls have achieved "brilliant success" (page 179, 2002 Edition). Is this always so?

Biological control is an area of increasing interest. There have been some great successes—also some disasters. An introduced species can become worse pest than the target. When successful, biological control can be sustaining, low cost, and has minimal side effects.
In the Vietnam War (1959–1975), a number of herbicides were used by the US against North Vietnam and Viet Cong forces. These included Agents Pink, Green, Purple, Blue, White, and Orange. Rachel Carson does not refer to these chemicals in *Silent Spring*, as their use only began in 1961.

**AGENT ORANGE!**

The best known and most widely used was Agent Orange. This herbicide was comprised of a mixture of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). Agent Orange was later found to be contaminated by dioxin, which has been called “possibly the most toxic molecule ever synthesized by man.”

Agent Orange and other herbicides were applied from the air to defoliate rainforests to give less cover to enemy troops, and to destroy crops to starve the enemy. Nearly 20,000,000 gallons were sprayed from 1962 to 1971. Resulting food shortages affected millions, mostly in South Vietnam.

**EFFECTS OF AGENT ORANGE!**

The chemicals also caused burns and disfigurement to human skin. Many newborns suffered physical and mental disabilities. Cancer rates increased, with dioxin the likely cause.

Not only the Vietnamese were affected. US and Allied war veterans who served in sprayed areas or handled the chemicals, showed increased rates of several types of cancer, and skin and respiratory disorders. Birth defects appeared higher in the children of returned veterans.

Large areas of forest were degraded, and then invaded by bamboo and other grasses. This persisted regrowth of the forest, thus changing the biodiversity and ecology for the long term.

The dioxin in Agent Orange is persistent, and can still be detected 40 years later.

Several countries have used Agent Orange in weed control and other industrial operations such as forest clearing for mining, and dam construction.

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In the 1930s, the Red Imported Fire Ant (Solenopsis invicta) was accidentally introduced to the US from Argentina, through the port of Mobile, Alabama. The ant quickly expanded its range throughout much of the south and southeast of the country. This ant has a painful sting, can damage some crops, and the colony mounds interfere with farm equipment.

In 1958, large areas of the USA were sprayed with the insecticides dieldrin and heptachlor in an attempt to destroy the fire ants. The widespread spraying temporarily reduced the population of the ant, but the insect rebounded and continued to extend its range. The ant colonies produce thousands of new queens that each can start a new colony, so missing just a few colonies means that the ant can regenerate its numbers very quickly.

While the ant was not controlled, livestock and wildlife, including birds, suffered from the toxins that affected the nervous system, often causing death. Thus the target pest was affected very little, but many other living things were badly impacted. The spraying for Red Imported Fire Ants ceased in the late 1960s.

The name invicta means undefeated. E.O. Wilson, one of the world’s most renowned entomologists, coined the term “Vietnam of Entomology”, for this failed campaign of eradication.
In *Silent Spring*, Rachel Carson cites many examples to demonstrate the negative impacts of pesticides. Critics have disputed her use of facts or her conclusions.

Science in the 1950s lacked the powerful analytical tools that scientists have today. Research subsequent to *Silent Spring* has strengthened our understanding of how pesticides operate and how they should be used.

The relationship between pesticides and human illness, including cancer, is still under investigation, as is the long-term impact of exposure. Future cases and effects difficult to predict. Overall, there is now strong support for the central message of her book—that pesticides should be used carefully, with consideration of all their impacts.

“Errors of fact (within *Silent Spring*) are so infrequent, trivial, and irrelevant to the main theme that it would be ungentle to dwell on them.”

LAMONT COLE
PROFESSOR OF ECOLOGY AT CORNELLE UNIVERSITY, N.Y.

SCIENTIFIC AMERICAN

Carson’s legacy is to remind us that we must exercise extreme caution in the use of these powerful chemical agents.

“It is not my contention that chemical insecticides must never be used. I do contend that we have put poisonous and biologically potent chemicals indiscriminately into the hands of persons largely or wholly ignorant of their potentials for harm.”

RACHEL CARSON
SILENT SPRING, PAGE 12 (2002 EDITION)
Silent Spring was an immediate success, and had almost immediate impact. It was placed on the New York Times best-seller list. Would the book have been so widely and enthusiastically received if it had been written in a different style?

Rachel Carson honed her writing skills over many years. Her work with US Fish and Wildlife Service was largely to translate science for a general audience.

The opening chapter of Silent Spring is titled, “A Fable for Tomorrow”, scarcely the introduction one might expect for a scientific book. Her writing is described as lyrical and poetic, and this style was targeted by some of her critics to suggest an unscientific approach to her analyses.

Ironically, Silent Spring is not as lyrical a book as her three works on the sea. Her tone in Silent Spring has been described by one supporter as “cool and furious”.

“It was a spring without voices.”

“...as crude a weapon as the cave man’s club, the chemical barrage has been hurled against the fabric of life....”

Is Carson’s writing style too emotive? Is it too romantic?

Read the book... and arrive at your own conclusion.

“...It was spring without voices.”

THE POWER OF THE WORD

I was a spring... without words.

Silent Spring
RACHEL CARSON
SILENT SPRING: PAGE 202 EDITION
Plenty!

Silent Spring became a best seller. It quickly influenced the thinking and attitudes of not only the general public but also of legislators, researchers, and government departments.

Soon after publication, President Kennedy directed his Science Advisory Committee to investigate Rachel Carson’s claims. Their vindication of Carson’s work led to strengthened regulation of chemical pesticides.

DDT was banned in the US in 1972—but it is still used in parts of the world. There are scientists and doctors who suggest DDT should be more widely used to control insect vectors of disease such as malaria that cause millions of human deaths each year.

Government agencies directed more funds towards research into the impacts of pesticides on the environment and human health.

The US Environmental Protection Agency was established in 1970 and continues to have a major focus on controlling and advising on the use of pesticides and other human-made toxins. The EPA has been called “the extended shadow of Silent Spring.”

Pesticide labels were required to carry more warnings (though these are often in fine print) and protective clothing and equipment were recommended for people using pesticides.

It is widely considered that Rachel Carson and Silent Spring were the inspiration for 20th century environmentalism. Many environmentalists—former Vice President Al Gore among them—were inspired by Rachel Carson.

Carson was posthumously awarded the Presidential Medal of Freedom by President Carter in 1980. She is featured on a 1981 Great Americans series 17¢ postage stamp, and on stamps from several other countries. Her name graces protected natural areas and bridges.

The New York University list of the 100 most important writings of the last century ranked Silent Spring as number 2 (beaten only by John Hersey’s Hiroshima, of 1946).

It was rated number 5 in the Modern Library List of the Best 20th-Century Nonfiction works and one of the 25 greatest science books of all time by Discover Magazine.

Rachel Carson died from cancer on April 14, 1964, and did not see many of the impacts of her book.
“We put DDT all over. … In the late fifties and early sixties … we had the catastrophe of the robins dying.”

GORDON GUERY
Recent studies by Cornell University suggest that the application of $10 billion dollars in pesticides each year in the US results in savings of $40 billion in crops. However, the studies also suggest that there are ‘hidden’ annual costs of more than $9 billion from these pesticides in impacts on public health, resistance development in pests, accidental crop losses, bird poisonings, and contamination of ground water.

So the tally sheet would indicate pesticides today do more economic good than harm in the US—but significant negative impact is still being done to human health and the environment. In some parts of the world where pesticide legislation is more lax or poorly enforced, the impacts are likely to be worse.

The message of Silent Spring—the need for caution in pesticide use and to consider all other options—is as relevant as ever.
Crops that have been genetically modified (GM) or engineered for pest and herbicide resistance are increasingly being developed and grown.

Recently some pests have developed resistance to Bt crops. The Cotton Bollworm (*Helicoverpa armigera*)—arguably the world’s worst agricultural pest—is showing resistance both to GM crops and to most chemical pesticides.

GM crops are more widely used in the United States than in most other parts of the world. Critics fear that GM crops may encourage the evolution of ‘super bugs’ with high resistance, that spliced genes may move up the food chain, and that there may be long-term livestock and human health impacts.

**Herbicide tolerant (HT) crops** are genetically modified to withstand herbicides better than the weeds, so heavier doses of herbicides can be used. HT varieties of soybeans and cotton are now extensively used.

**Pest-deterring (Bt) crops** are genetically modified to repel many insect pests. Genes from the bacterium *Bacillus thuringiensis* that are ‘spliced’ into the plant’s DNA cause the plant to make proteins toxic to insects. Bt varieties of corn and cotton have high usage in the USA.
Today there is a field called environmental ethics. This is defined as:

“The discipline in philosophy that studies the moral relationship of human beings to, and also the value and moral status of, the environment and its nonhuman contents.”

Silent Spring is not just about science; it is also about environmental ethics.

The argument Rachel Carson makes is that we not only harm ourselves if we misuse technology, but also that we humans do not have a right to devastate the natural world for our own ends.

“Who has decided—who has the right to decide—for the countless legions of people who were not consulted that the supreme value is a world without insects, even though it be also a sterile world ungraced by the curving wing of a bird in flight?”

RACHEL CARSON
SILENT SPRING, PAGE 127 (2002 EDITION)

There is growing interest in combining environmental ethics and environmental sciences, to recognize better that environmental management is more than understanding, controlling or modulating physical and natural processes. It is also about having a philosophical basis upon which decisions are made, and this basis should be an ethical one.

Michigan State University and Michigan Technological University have collaborated to establish a Conservation Ethics Group to facilitate dialogue between environmental scientists and ethicists. The CEG won the 2011 Phi Kappa Phi Excellence Award in interdisciplinary scholarship.

“In many ways, the entire 40 year-old field of environmental ethics is heir to her (Carson’s) work.”

DR. MICHAEL MILEN
HEAD OF THE MSU/MTU CONSERVATION ETHICS GROUP

“...who has the right to decide...”
WOMEN IN SCIENCE!

Rachel Carson has become a symbol for change in the status of women in science.

Some of Carson’s detractors emphasized her gender and her unmarried status, labeling her a “hysterical woman,” a “priestess of nature” and a “spinster.”

When changing her major from English to biology, Carson was warned that “there was no future for women in science apart from teaching in high schools or obscure colleges” and that “science was too rigorous a field for women.”

Graduate Women in Science (GWIS) is a national, interdisciplinary society of scientists and enthusiasts—both men and women—who encourage and support women to enter and achieve success in science. Pictured here are several GWIS members at MSU.

When Carson worked as a scientific writer at the US Fish and Wildlife Service, most of the female staff were secretarial.

Today, many women choose careers in the sciences, and in some cases, outnumber men in university courses. In 2011, at Michigan State University women comprised 55% of undergraduates in the College of Natural Science and College of Agriculture and Natural Resources; 57% of undergraduates in Lyman Briggs College (residential college of sciences); and 85% of undergraduates in the College of Veterinary Medicine. Of the 2011 total freshmen at MSU, 52.5% were women.
Silent Spring was published 50 years ago and still there is debate about the validity of Rachel Carson's documentation of pesticide effects and about the impacts the book has had on the use of pesticides in the US and around the world.
Most agriculture was organic before humans developed artificial fertilizers and pesticides in the 20th century.

Although the modern organic farming movement began in the 1940s, before *Silent Spring*, Rachel Carson’s book increased public interest in alternatives to chemical use.

**Fruits and vegetables accounted for 37 percent of U.S. organic food sales in 2008.**

While yields per acre of organic crops are generally lower than crops using artificial fertilizers and pesticides, there are benefits:

- Lower energy use per acre
- Less environmental impact
- Possible reduction in risks to human health

Organic food accounts for only 1–2% of total food sales worldwide, but it is the fastest-growing area of agriculture, increasing by 20% a year since the early 1990s.

**Organic foods are produced without synthetic pesticides and fertilizers, genetically modified organisms, irradiation, industrial solvents, or chemicals.**

World organic food sales increased from US $23 billion in 2002 to $52 billion in 2008.

Some estimates suggest future growth ranging from 10–50% annually depending on the country.

Future growth: 10–50%

Increasing by 20% a year

Organic farm acres for only 1–2% of total food sales worldwide, but it is the fastest-growing area of agriculture, increasing by 20% a year since the early 1990s.
Today, environmental and agricultural agencies advocate for managing pests using a combination of practices. This is called Integrated Pest Management (IPM). IPM operates on the principle that “an ounce of prevention is worth a pound of cure.”

Today, management of pests on the campus of MSU closely follows the principles of Integrated Pest Management.
Insect resistance to DDT was identified as early as 1955 in Africa, and by 1972 populations of 17 mosquito species worldwide had shown resistance to DDT. A World Health Organization study in 2000 in Vietnam suggested that non-DDT malaria control was significantly more effective than DDT use.

In light of questions about its persistence, growing resistance in insects, and safety, DDT has fallen out of favor around the world. It is banned in many countries.

Some estimates suggest that DDT has saved millions of human lives since 1945 by preventing diseases such as malaria, bubonic plague, sleeping sickness, and typhus.

However, DDT continues to be used in the fight against malaria in parts of the developing world by being sprayed on the inside walls of homes to repel insects. The World Health Organization (WHO) supports this strategy.

"One of the best tools we have against malaria is indoor residual house spraying. Of the dozen insecticides WHO [World Health Organization] has approved as safe for house spraying, the most effective is DDT."

R. Arata Kochi
Former Director of WHO's Malaria Program

The debate continues.

Advocates suggest that DDT restrictions should be loosened to allow more widespread use against malarial mosquitoes. This case emphasizes that malaria is a demonstrated killer (over 1 million people each year; mostly children) while the health effects of DDT on humans are far less certain. Studies show accumulation of DDT in the liver of personnel spraying DDT, but with no evident health effect; and there is some evidence linking this type of DDT with increases in breast cancer through exposure before puberty. The reported links between human illness and DDT continue to be subject to dispute.
At the time of writing of *Silent Spring*, environmental protection at the federal level of the United States was managed by several different agencies.

**Establishing the EPA**

President Kennedy instigated a major review of the allegations set down in *Silent Spring* but public concerns over environmental protection continued through the late 1960s. In 1970, President Nixon established the US Environmental Protection Agency (EPA) as a single, independent agency responsible for comprehensive regulation of environmental pollutants, including pesticides.

- The EPA is led by a Cabinet-rank Administrator who is appointed by the US President and approved by Congress. The Agency has approximately 17,000 employees including engineers, scientists, and lawyers.
- The EPA carries out environmental assessment, research, and education, and enforces national standards under federal environmental laws, in partnership with state, tribal, and local governments. EPA enforcement powers include fines, sanctions, and other measures.
- The Agency also works with industries, governments, and the public in a variety of voluntary pollution prevention and energy conservation programs.
- Today, pesticides in the USA are subject to over 100 health, safety and environmental tests.

Many believe that the establishment of the EPA was prompted by the increased public awareness of environmental pollutants due to the publication of *Silent Spring*.

**Criticism**

Some critics believe that the EPA has too much authority and can stifle economic development. In contrast, others criticize the EPA for not doing enough to control pollution.
When you see photographs of people applying pesticides in the 1940s and 1950s, what do you notice? Most obviously, they are not wearing any protective clothing.

Fifty years ago, most people applying pesticides for agriculture or human health had little or no training in how the pesticides should be used or how to keep themselves protected from possible adverse effects.

One of Rachel Carson’s key messages was that pesticides were being used in ignorance of their effects – on the environment and on human health.

Since the publication of Silent Spring, people have become much more careful in how they apply pesticides. There is greater awareness that even if a pesticide is designated as safe to use, it is only safe if it is applied according to the proper instructions. It is also better to be safe than sorry, so wearing protective clothing is advised for anyone applying pesticides in large quantities. People in the US who apply pesticides as part of their jobs must now be trained in how to use the chemicals safely.