

Science in Classics

经典中的科学

Rachel Carson (卡森)

Silent Spring (寂静的春天)

This lecture

1. Carson's *Silent Spring*
2. Limitation of reductionism (还原论)
3. Associative thinking
4. Reflection on biological control
5. Humans and Nature

Rachel Louise Carson

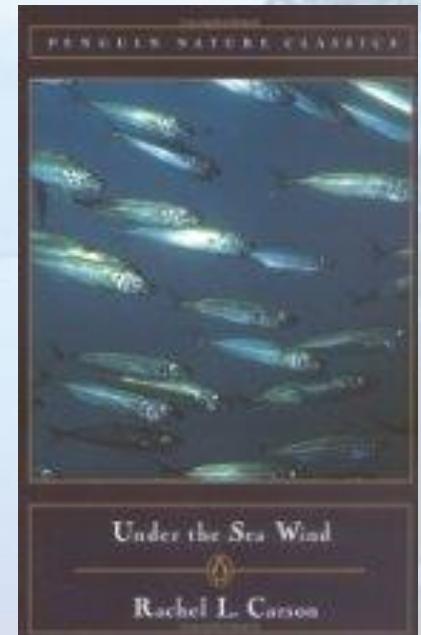
- May 27, 1907 – April 14, 1964
- U.S. Bureau of Fisheries
(美国鱼类及野生动物管理局)
aquatic biologist
- Full time nature writer



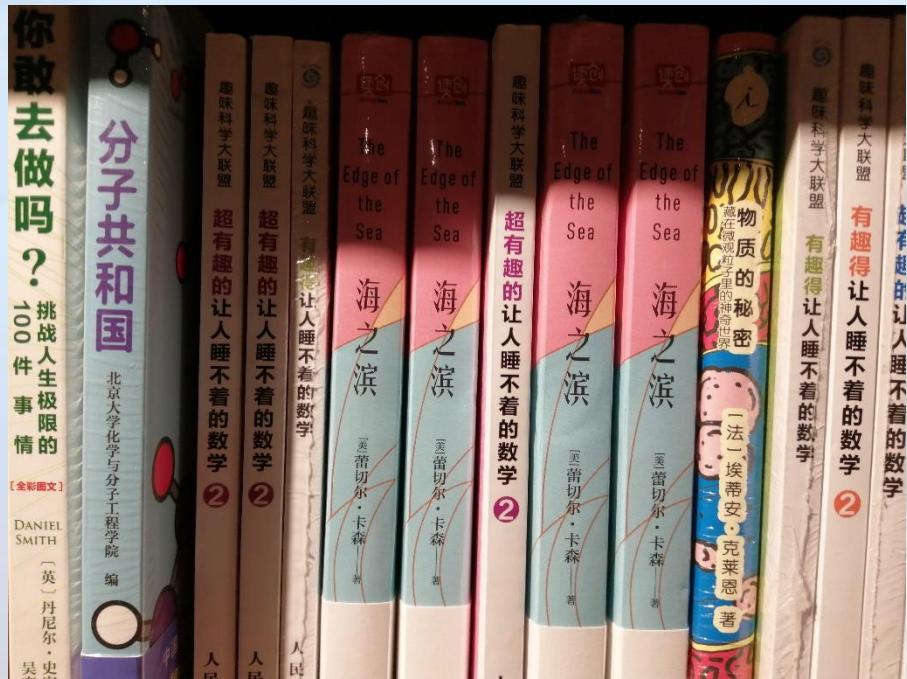
Carson's Fish & Wildlife Service employee photo, from *Wikipedia*

Publications

- *Under the Sea Wind* (1941)
 - Expansion of fisheries bureau brochure “*Undersea*”
 - Narrative of the ocean floor
- *The Sea Around Us* (1951)
 - Life history of the ocean
 - National Book Award 1952
- *The Edge of the Sea* (1955)
 - Coastal ecosystem



Book cover of *Under the Sea Wind*, Penguin Nature Classics edition, from Wikipedia



What to write next?

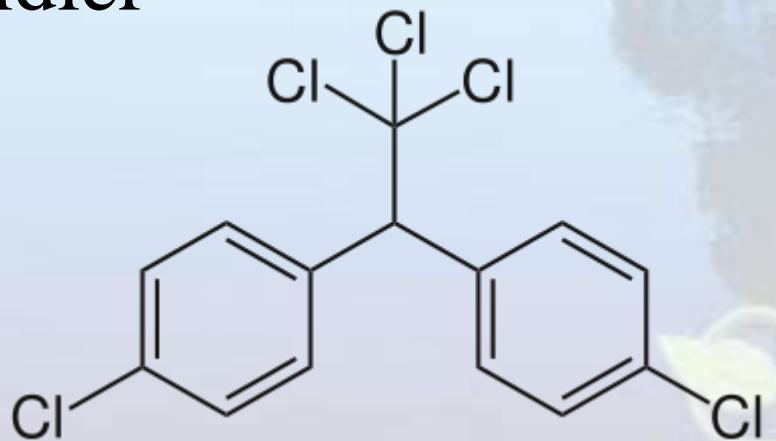
- Contract with publisher – book on evolution
- Julian Huxley: *Evolution in Action*
- The turning point: Olga Owens Huckins
 - *In a letter written in January 1958, Olga Owens Huckins told me of her own bitter experience of a small world made lifeless, and so brought my attention sharply back to a problem with which I had long been concerned.* ”
- *Silent Spring*

Silent Spring

- Published 1962
- Selected in:
 - Book-of-the-Month Club
 - Modern Library List of Best 20th-Century Nonfiction (#5)
 - *Discover Magazine*: 25 Greatest Science Books of All Time
 - *The American Reader: Words That Moved a Nation*

DDT (滴滴涕) as a pesticide (杀虫剂)

- Dichloro-Diphenyl-Trichloro-ethane
- Colourless, crystalline solid
- First synthesized in 1874 by Austrian chemist Othmar Zeidler



DDT

- In 1939, Swiss chemist Paul Hermann Müller discovered DDT can be used as an insecticide
- Effective against a wide variety of pests, including the common house fly, louse (虱), Colorado beetle, and mosquito



Paul Müller (1948
Nobel Prize in
Physiology or Medicine)

DDT

- World War II: successfully controlled typhus (斑疹伤寒) in Europe
- Postwar faith in science and human progress in America
- Agricultural use of DDT since 1945
- Worldwide malaria eradication program by WHO in 1955

General beliefs about pesticides

- Kills pests only
- Harmless to humans
- Protects crops and controls disease-carrying pests
- A **solution** to multiple problems

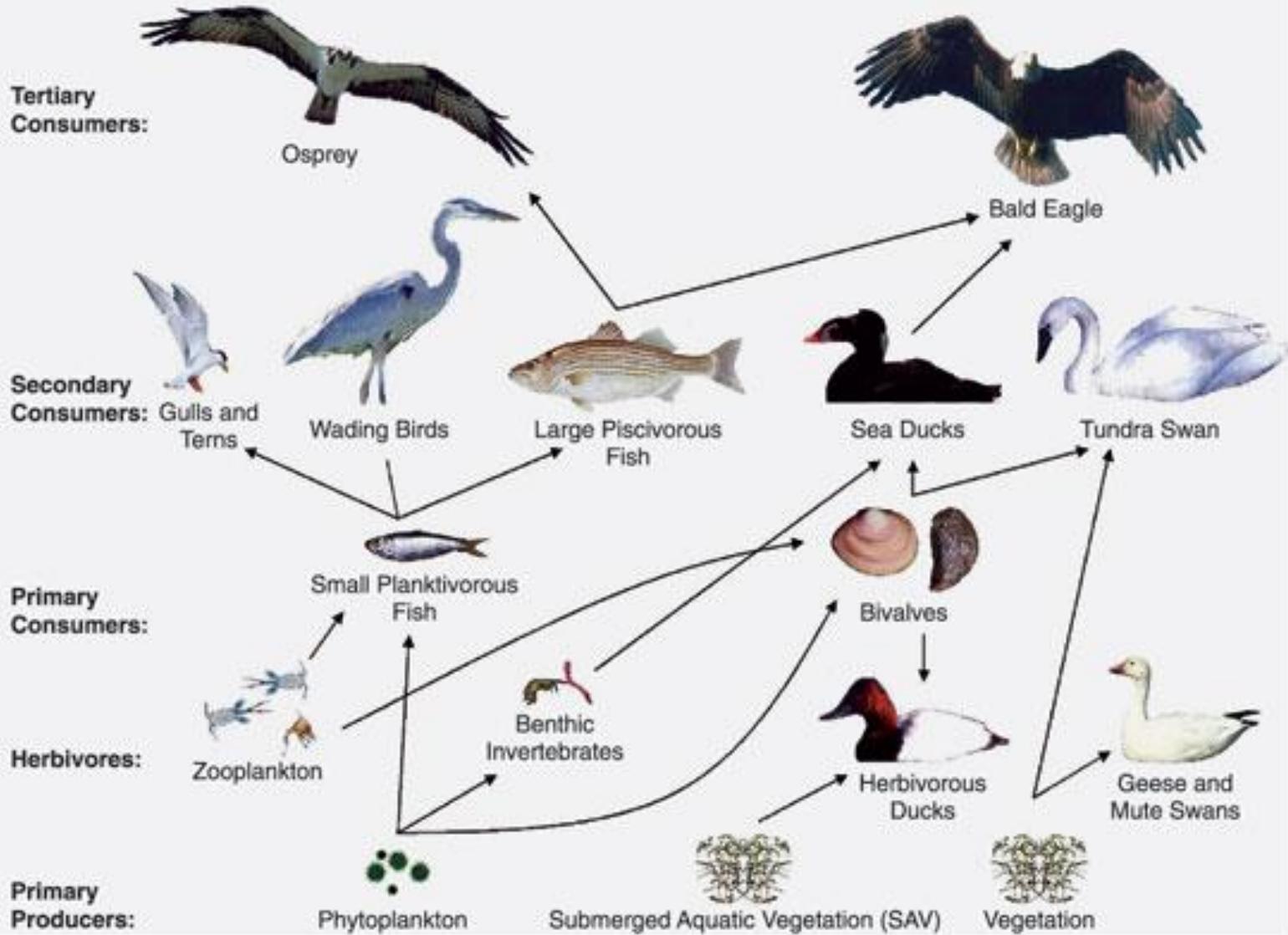
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DDT & Ecological Disaster

- Inter-relatedness of living organisms and their environment
- A food chain:
 - Plankton (浮游生物) → Fish → Crabs → Birds

Chesapeake Bay Waterbird Food Web



Biomagnification (生物放大作用)

- Biomagnification: concentration of poison along the food chain to lethal levels
- A case in California

	Pesticide Concentration (ppm)
Water	1/50
Plankton	5
Herbivore fish	40 – 300
Carnivore bird and fish	1600 and 2500 respectively

ppm: parts per million. An expression of proportion. 1 ppm is about 1 drop of water diluted to 50 liters, or 30 seconds in a year.

Health Hazards

- Direct poisoning
 - In animal tests:
 - 3 ppm of DDT inhibits heart muscle enzyme
 - 5 ppm of DDT causes liver cell necrosis (坏疽)
 - In humans:
 - Nerve system damage (23 ppm of DDT)
- Carcinogenicity
- Genetic damage

Pesticides make it worse

- Resistance
 - Natural selection
 - Pesticides → eliminate the weaker members of the pest
- Create new pests
 - Fire ant eradication program → crop loss



The sugarcane borer (甘蔗虫)

Reflection on reductionism (还原论)

... and our limitations

Reductionism

- Analytical thinking (= breaking down), a conviction that there are basic components and:
 - whole = components + interactions
 - (e.g. human body = organs + connections)
 - $\Gamma(\text{whole}) = \Gamma(\text{components}) + \Gamma(\text{interactions})$
- In such a reductionist view:
 - ecological system (es)
= environment (en) + species (sp) + interactions (int)
 - $\Gamma(\text{es}) = \Gamma(\text{en}) + \Gamma(\text{sp}) + \Gamma(\text{int})$

Γ : first letter of the Greek word for knowledge

Prediction

- To predict: consequences of use of chemicals
- Input: amount of chemicals (e.g. DDT)
- Calculation:
 - chemicals \Rightarrow effects on species +
 - chemicals \Rightarrow effects on the environment +
 - chemicals \Rightarrow effects on interactions
- Result: effects on the ecosystem

Limitation

- We don't have all the information about
 - chemicals \Rightarrow effects on species
 - chemicals \Rightarrow effects on the environment
 - chemicals \Rightarrow effects on interactions
- No accurate prediction.
- Limitation of a reductionist view (analytical thinking) on Nature.

If reductionism does not help ...



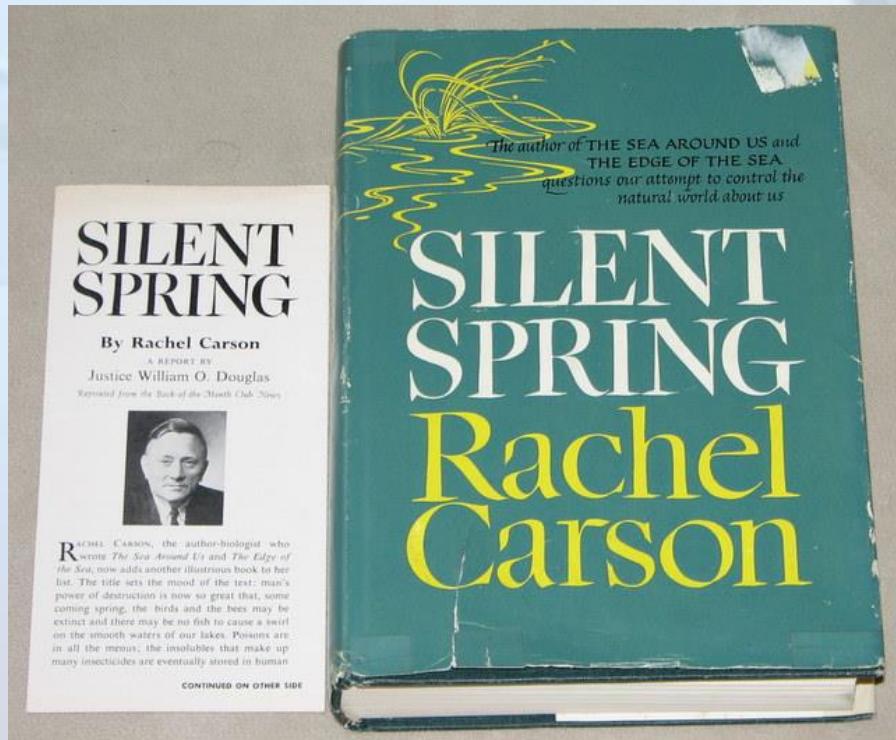
... what should we do?

This lecture

1. Carson's *Silent Spring*
2. Limitation of reductionism
3. **Associative thinking**
4. Reflection on biological control
5. Humans and Nature

Text

- Rachel Carson, *Silent Spring*
- Chapter 6: Earth's Green Mantle



The Book-of-the-Month edition of *Silent Spring*, from Wikipedia



CHAPTER 6

EARTH'S GREEN MANTLE

Water, soil, and the earth's green mantle of plants make up the world that supports the animal life of the earth. Although modern man seldom remembers the fact, he could not exist without the plants that harness the sun's energy and manufacture the basic foodstuffs he depends upon for life. Our attitude toward plants is a singularly narrow one. If we see any immediate utility in a plant we foster it. If for any reason we find presence undesirable or merely a matter of indifference, we may condemn it to destruction forthwith. Besides the various plants that are poisonous to man or his livestock, or crowd out food plants, many are marked for destruction merely because, according to our narrow view, they happen to be in the wrong place at the wrong time. Many others are destroyed merely because they happen to be associates of the unwanted plants.

1

Ignorance

The earth's vegetation is part of a web of life in which there are intimate and essential relations between plants and the earth, between plants and other plants, between plants and animals. Sometimes we have no choice but to disturb these relationships, but we should do so thoughtfully, with full awareness that what we do may have consequences remote in time and place. But no such humility marks

2

Arrogance



3 One of the most tragic examples of our unthinking bludgeoning of the landscape is to be seen in the sagebrush lands of the West, where a vast campaign is on to destroy the sage and to substitute grasslands. If ever an enterprise needed to be illuminated with a sense of the history and meaning of the landscape, it is this. For here the natural landscape is eloquent of the interplay of forces that have created it. It is spread before us like the pages of an open book in which we can read why the land is what it is, and why we should preserve its integrity. But the pages lie unread.

6 Along with the plants, animal life, too, was evolving in harmony with the searching requirements of the land. In time there were two as perfectly adjusted to their habitat as the sage. One was a mammal, the fleet and graceful pronghorn antelope. The other was a bird, the sage grouse—the “cock of the plains” of Lewis and Clark.



A herb, for cooking



On the rooftop of Hui Yeung Shing Building



Our limitation

The earth's vegetation is part of a web of life in which there are intimate and essential relations between plants and the earth, between plants and other plants, between plants and animals. Sometimes we have no choice but to disturb these relationships, but we should do so thoughtfully, with full awareness that what we do may have consequences remote in time and place. But no such humility marks

2

Arrogance

- Aim: to remove weeds
- Method: use of chemicals
- Limitation: even if we are not arrogant, we still cannot make any accurate prediction.

Alternatives?

- Chemicals: not a good solution
- Physical method
- Biological method

Carson's Solution

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The booming sales of chemical crabgrass killers are another example of how readily unsound methods catch on. There is a cheaper and better way to remove crabgrass than to attempt year after year to kill it out with chemicals. This is to give it competition of a kind it cannot survive, the competition of other grass. Crabgrass exists only in an unhealthy lawn. It is a symptom, not a disease in itself. By providing a fertile soil and giving the desired grasses a good start, it is possible to create an environment in which crabgrass cannot grow, for it requires open space in which it can start from seed year after year.

- Biological control (生物防治): Introduce natural enemies of the pest/weed
- e.g: Japanese beetle
 - Parasitic wasp (attack beetle grubs)
 - Milky spore (波林杆菌芽孢) disease

Associative thinking

- Already existing pattern(模式)/order(秩序):
 - environmental change (climate, introduced species, ...)⇒ natural selection ⇒ (new) equilibrium between and within species.
- Let the pattern/order occur again.
- Association:
 - a solution from Nature ⇔ a solution to a human problem

Other solid achievements show what can be done. Biological control has achieved some of its most spectacular successes in the area of curbing unwanted vegetation. Nature herself has met many of the problems that now beset us, and she has usually solved them in her own successful way. Where man has been intelligent enough to observe and to emulate Nature he, too, is often rewarded with success.

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59 In 1920 Australian entomologists were sent to North and South America to study insect enemies of the prickly pears in their native habitat. After trials of several species, 3 billion eggs of an Argentine moth were released in Australia in 1930. Seven years later the last dense growth of the prickly pear had been destroyed and the once uninhabitable areas reopened to settlement and grazing. The whole operation had cost less than a penny per acre. In contrast, the unsatisfactory attempts at chemical control in earlier years had cost about £10 per acre.

$$4046.86 \text{ m}^2$$

$$\approx 64 \text{ m} \times 64 \text{ m}$$

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Is biological control invincible?

not always ...

Humans vs. Nature

- Humans' impact on nature increases
- Types of pollutions
 - Physical: e.g. light, noise, radioactivity
 - Chemical: e.g. herbicides, DDT
 - Biological: (any?)
- When did we become aware of our impact?

Increasing Awareness

- Awareness of the need to protect ecosystem from pollution
- WWII: radioactive pollution
- *Silent Spring*: chemical pollution
- How about biological pollution?

- *Silent Spring* did not address biological pollution
- But a critic has found Carson indirectly promoted it:

...Carson discusses the use of spores of “milky disease” placed in the soil to kill the beetle larvae...Carson reveals with pleasure the fact that they infect at least 40 other species of beetles, but expresses no concern for environmental harm caused by such a broad-spectrum killer of native insects. To the contrary, on page 99 she attacks the use of pesticides because they “... are not selective poisons; they do not single out the one species of which we desire to be rid.” Evidently she felt that it was all right for bacteria to be broad spectrum poisons, but that pesticides must affect only a single target.

Will avoiding chemical pollution bring about another form of pollution?

Biological Pollution

- a new concept after *Silent Spring*

- Disturbance of the ecological balance by the accidental or deliberate introduction of a foreign organism, animal or plant species into an environment.

(Source: European Environment Agency)

Related Terms

- **Introduced species** (外来物种)
 - Organisms transported by human actions to areas beyond its natural geographical range
- **Invasive species** (入侵物种)
 - Organisms transported (directly or indirectly) by humans;
 - which successfully establish themselves in, and then overcome...native ecosystems.

(Source: The International Union for Conservation of Nature)

Kudzu / Japanese Arrowroot (葛根)

- Imported and widely planted
 - As crop
 - As ornamental plant
 - To reduce soil erosion
- Listed as “noxious weed” in 1997 in the US



Kudzu / Japanese Arrowroot

- Native range: China, Japan, Indonesia
- Introduced range: southern USA
- Invasive characteristics
 - Quick growth of ~1 foot per day
 - Grows well under wide range of conditions
 - Grows in most soil types



Kudzu / Japanese Arrowroot

- Impacts
 - Kills trees by climbing on them
 - Dense leaves growth blocks out sunlight
 - Chokes trees with its extensive vine
 - Breaks branches and uproots trees by its weight



The Red-eared Slider

- The most popular turtle in the pet trade
- Released into ponds by pet owners
- Released as religious act (放生)
- Native range
 - Eastern USA and Mexico



The Red-eared Slider

- Introduced range
 - Europe, Africa, South America, Asia
- Impact
 - Competition with indigenous species for
 - Food
 - Egg-laying sites
 - Basking places
- Advantages over native species
 - Higher fecundity (繁殖力)
 - Lower age at maturity
 - Larger adult size

100 Worst Invasive Species

100 OF THE WORLD'S WORST INVASIVE ALIEN SPECIES

MICRO-ORGANISM

avian malaria
banana bunchy top virus
rinderpest virus

(*Plasmodium relictum*)
(*Banana bunchy top virus*)
(*Rinderpest virus*)

MACRO-FUNGI

chestnut blight
crayfish plague
Dutch elm disease
frog chytrid fungus
phytophthora root rot

(*Cryphonectria parasitica*)
(*Aphanomyces astaci*)
(*Ophiostoma ulmi*)
(*Batrachochytrium dendrobatidis*)
(*Phytophthora cinnamomi*)

AQUATIC PLANT

caulerpa seaweed
common cord-grass
wakame seaweed
water hyacinth

(*Caulerpa taxifolia*)
(*Spartina anglica*)
(*Undaria pinnatifida*)
(*Eichhornia crassipes*)

LAND PLANT

African tulip tree
black wattle
Brazilian pepper tree
cogon grass
cluster pine
erect pricklypear
fire tree
giant reed
gorse
hiptage
Japanese knotweed
Kahili ginger
Koster's curse
kudzu
lantana
leafy spurge
leucaena
melaleuca
mesquite
miconia
mile-a-minute weed
mimosa
privet
pumpwood
purple loosestrife
quinine tree
shoebutton ardisia

(*Spathodea campanulata*)
(*Acacia mearnsii*)
(*Schinus terebinthifolius*)
(*Imperata cylindrica*)
(*Pinus pinaster*)
(*Opuntia stricta*)
(*Myrica faya*)
(*Arundo donax*)
(*Ulex europaeus*)
(*Hiptage benghalensis*)
(*Fallorgia japonica*)
(*Hedychium gardnerianum*)
(*Clidemia hirta*)
(*Pueraria montana* var. *lobata*)
(*Lantana camara*)
(*Euphorbia esula*)
(*Leucaena leucocephala*)
(*Melaleuca quinquenervia*)
(*Prosopis glandulosa*)
(*Miconia calvescens*)
(*Mikania micrantha*)
(*Mimosa pigra*)
(*Ligustrum robustum*)
(*Cecropia peltata*)
(*Lythrum salicaria*)
(*Cinchona pubescens*)
(*Ardisia elliptica*)

LAND PLANT (CONTINUED)

Siam weed
strawberry guava
tamarisk
wedelia
yellow Himalayan raspberry

(*Chromolaena odorata*)
(*Psidium cattleianum*)
(*Tamarix ramosissima*)
(*Sphagneticola trilobata*)
(*Rubus ellipticus*)

AQUATIC INVERTEBRATE

Chinese mitten crab
comb jelly
fish hook flea
golden apple snail
green crab
marine clam
Mediterranean mussel
Northern Pacific seastar
zebra mussel

(*Eriocheir sinensis*)
(*Mnemiopsis leidyi*)
(*Cercopagis pengoi*)
(*Pomacea canaliculata*)
(*Carcinus maenas*)
(*Potamocorbula amurensis*)
(*Mytilus galloprovincialis*)
(*Asterias amurensis*)
(*Dreissena polymorpha*)

LAND INVERTEBRATE

Argentine ant
Asian longhorned beetle
Asian tiger mosquito
big-headed ant
common malaria mosquito
common wasp
crazy ant
cypress aphid
flatworm
Formosan subterranean termite
giant African snail
gypsy moth
khapra beetle
little fire ant
red imported fire ant
rosy wolf snail
sweet potato whitefly

(*Linepithema humile*)
(*Anoplophora glabripennis*)
(*Aedes albopictus*)
(*Pheidole megacephala*)
(*Anopheles quadrimaculatus*)
(*Vespa vulgaris*)
(*Anoplolepis gracilipes*)
(*Cinara cupressii*)
(*Platydemus manokwari*)
(*Coptotermes formosanus shiraki*)
(*Achatina fulica*)
(*Lymantria dispar*)
(*Trogoderma granarium*)
(*Wasemannia auropunctata*)
(*Solenopsis invicta*)
(*Euglandina rosea*)
(*Bemisia tabaci*)

AMPHIBIAN

bullfrog
cane toad
Caribbean tree frog

(*Rana catesbeiana*)
(*Bufo marinus*)
(*Eleutherodactylus coqui*)

FISH

brown trout
carp
large-mouth bass

(*Salmo trutta*)
(*Cyprinus carpio*)
(*Micropterus salmoides*)

FISH (CONTINUED)

Mozambique tilapia
Nile perch
rainbow trout
walking catfish
Western mosquito fish

(*Oreochromis mossambicus*)
(*Lates niloticus*)
(*Oncorhynchus mykiss*)
(*Clarias batrachus*)
(*Gambusia affinis*)

BIRD

Indian myna bird
red-vented bulbul
starling

(*Acridotheres tristis*)
(*Pycnonotus cafer*)
(*Sturnus vulgaris*)

REPTILE

brown tree snake
red-eared slider

(*Boiga irregularis*)
(*Trachemys scripta*)

MAMMAL

brushtail possum
domestic cat
goat
grey squirrel
macaque monkey
mouse
nutria
pig
rabbit
red deer
red fox
ship rat
small Indian mongoose
stoat

(*Trichosurus vulpecula*)
(*Felis catus*)
(*Capra hircus*)
(*Sciurus carolinensis*)
(*Macaca fascicularis*)
(*Mus musculus*)
(*Myo castor copys*)
(*Sus scrofa*)
(*Oryctolagus cuniculus*)
(*Cervus elaphus*)
(*Vulpes vulpes*)
(*Rattus rattus*)
(*Herpestes javanicus*)
(*Mustela erminea*)

Species were selected for the list using two criteria: their serious impact on biological diversity and/or human activities, and their illustration of important issues of biological invasion. To ensure a wide variety of examples, only one species from each genus was selected. Absence from the list does not imply that a species poses a lesser threat.

Development of the 100 of the World's Worst Invasive Alien Species list has been made possible by the support of the Fondation d'Entreprise TOTAL (1998 - 2000).

For further information on these and other invasive alien species consult The Global Invasive Species Database:

www.iissg.org/database

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Core question

What impacts does manipulation of life bring?

What will be the 101st invasive species?



The 101st Invasive Species

- *Homo sapiens* – an invasive species?
- Invasive species definition
 - Organisms transported (directly or indirectly) by humans;
 - which successfully establish themselves in, and then overcome...native ecosystems.

The 101st Invasive Species

✓ Transported by humans

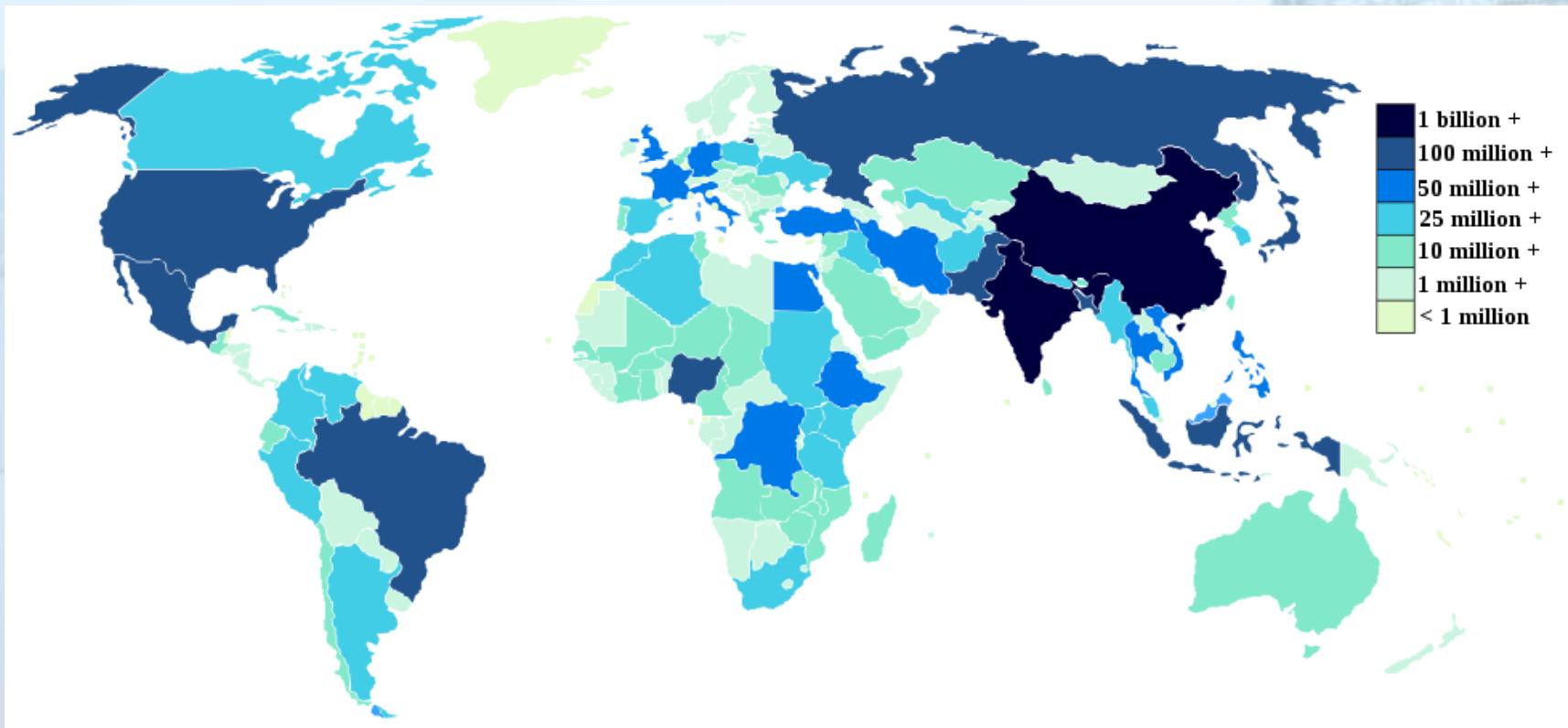
✓ Overcoming ecosystems

- Human activity has forced 869 species into extinction over past 500 years

✓ Successful establishment

- Humans live on all continents except Antarctica

The 101st Invasive Species



- “Man's attitude toward nature is today critically important simply because we have now acquired a fateful power to alter and destroy nature. But man is a part of nature, and his war against nature is inevitably a war against himself . . .”

- Rachel Carson

Silent Spring – Impact

- Investigation into the issue by the US President's Science Advisory Committee
- Campaign to ban DDT in the United States
- Environmental movement
- Presidential Medal of Freedom (1980)

Silent Spring – Criticism

- "If man were to follow the teachings of Miss Carson, we would return to the Dark Ages, and the insects and diseases and vermin would once again inherit the earth."

- Dr. Robert White-Stevens, biochemist

Silent Spring – Criticism

- A one-sided case
 - Quotes only isolated cases of bad effects of one or two pesticides, or pesticide misuse
- Exaggerating the dangers of DDT
 - Repeated studies showed no evidence that DDT increases cancer risk
- Indirectly worsening malaria (疟疾) as people avoid using DDT

Zika Virus



There's Now a Rapid Zika Test in the U.S.



CDC Director on Fighting Zika: 'There Is So Much That We Need to Do'



Brazilian Legislators Look to Increase Abortion Penalties in the Wake of Zika Outbreak



Zika Will Be 'Way Down' Before Brazil Summer Olympics, WHO Says



Zika Virus Linked to Paralysis Disorder in U.S., CDC Says



Zika's Rapid Spread Explained in 3 GIFs

Why Bringing Back DDT to Fight Zika Mosquitoes Could Backfire

Justin Worland @justinworland | Feb. 3, 2016



"It's a difficult question, and it's a very controversial question"



Less than a century since DDT was first sprayed, the spread of the [Zika virus](#) through mosquitoes has left [some wondering](#) whether regulators were too quick to move away from the chemical. But public health officials warn returning the controversial pesticide to use could do more harm than good in some places.

RECOMMENDED FOR YOU



Watch Taylor Swift Respond to Kanye West's Diss at Grammys

Carson's Legacy

- Public awareness to environmental issues
- Concept of ecosystem balance
- Question authority and policies

Thinking further...

- How can man be sure of all the impacts/consequences of his actions?
- If we cannot predict (precisely) what will happen, what shall guide our actions and decisions?

Question 1

- Does *Silent Spring* talk about DDT?
 - A. Yes.
 - B. No.

Question 1

- Does *Silent Spring* talk about DDT?
 - A. Yes.
 - B. No.

Question 2

- Does our selection (Chapter 6) talk about DDT?
 - A. Yes.
 - B. No.

Question 2

- Does our selection (Chapter 6) talk about DDT?
 - A. Yes.
 - **B. No.**

An elephant in the china cabinet

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“Once again we are walking in nature like an elephant in the china cabinet.”

So C. J. Briejèr, a Dutch scientist of rare understanding, sums up our use of weed killers. “In my opinion too much is taken for granted. We do not know whether all weeds in crops are harmful or whether some of them are useful,” says Dr. Briejèr.

大象在放了瓷器的陈列柜里



Miss/Mr. Wild Boar
on CU campus

(Photo taken by a
teacher on 21
February 2019
afternoon.)

What
should/shouldn't
we do with it?



Taken by a student on 31
January 2020



Will you welcome
Miss/Mr. Wild Boar?

End