On the Evolution of Radioecology--
and Why We Lost Ecology Along the Way

Thomas Hinton
Institute of Environmental Radioactivity
Fukushima University
Japan

International Union of Radioecology (IUR) Consensus Symposium

"Ecological impact of radiation on population and ecosystems"

Miami in 17-19 November 2015.

"Successful protection of the environment depends on the protection of natural populations, their dynamics, species interactions and contributions to ecosystem functioning. Ecosystem approaches are needed to support these protection goals"

IUR (International Union of radioecology) held a joint workshop with AERC (Association of Ecosystem Research Centers

Savannah River Ecology Laboratory (SREL) in South Carolina, USA, 2-5 October 2016.

Objective: the challenges of integrating ecosystem ecology into radioecology and risk assessment.

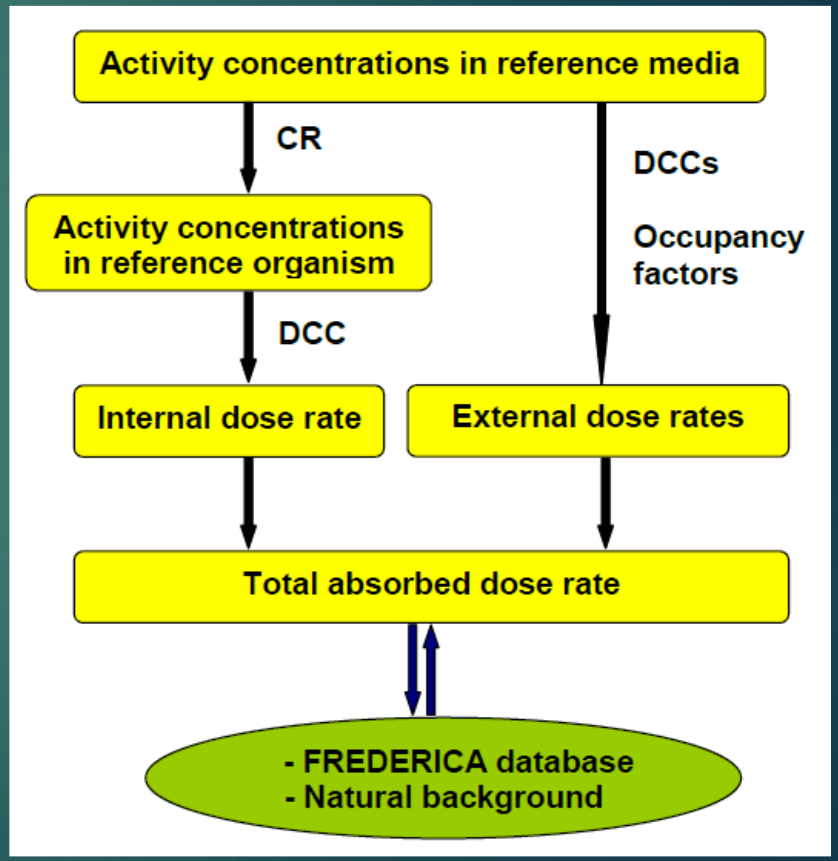
ICRP, Committee 5

Reference Organism Approach (RAPS)

1) 12 standardized organisms used as models to calculate exposure

2) Absorbed dose rates calculated using simple models based on measured or derived radioactivity concentration ratios

3) Risks assessment based on individual level endpoints (chromosome damage, morbidity, reproductive success, and mortality)

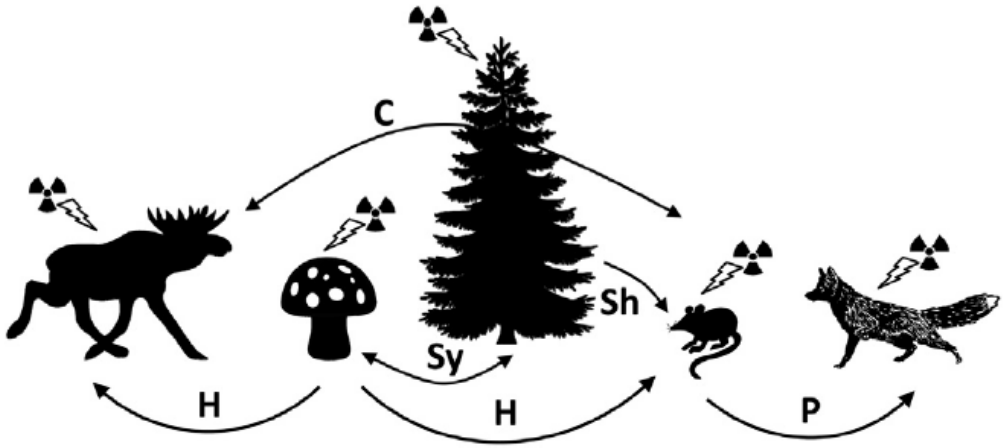


Pros and cons of the reference organism approach.

- Relatively simple, so convenient for risk assessment
- Maybe OK if they are the most sensitive and/or most exposed

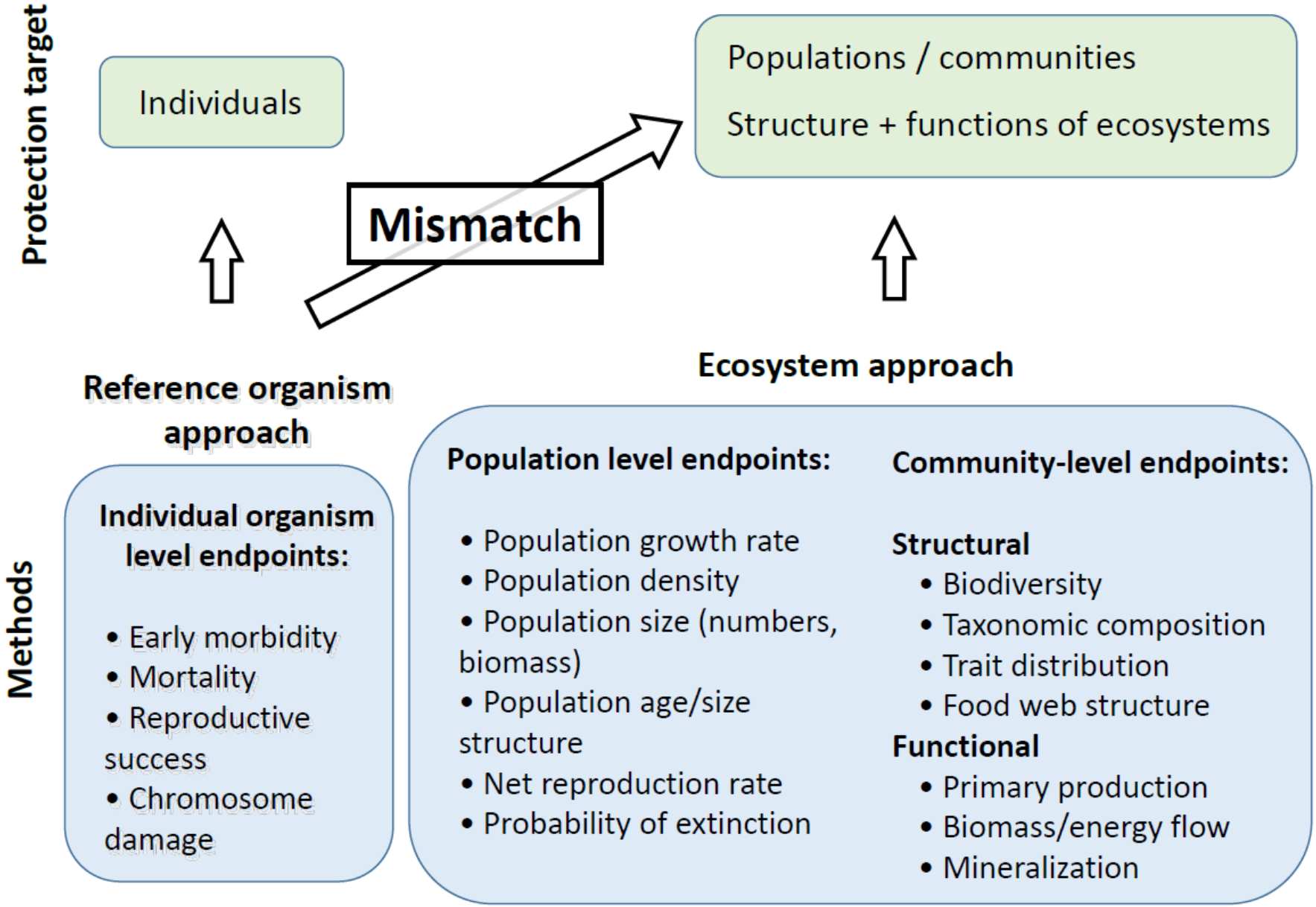
BUT

- The approach does not include ecological interactions
- There can be non-linear changes in ecosystem structure and function that cannot be predicted from effects on individual organisms.
- So this approach cannot guarantee the protection of all components of an ecosystem.



C = competition
P = predation
H = herbivory
Sy = symbiosis
Sh = shelter

Bradshaw et al (2014)



Bradshaw et al (2014)

Health Physics. 1965. Vol. 11

EFFECT OF ACUTE GAMMA RADIATION ON WILD OPOSSUM, GRAY FOX, RACCOON AND BOBCAT

FRANK B. GOLLEY, ERNEST L. RAUBER, ERIC L. MORGAN and JAMES H. JENKINS
Institute of Radiation Ecology, Department of Zoology and School of Forestry, University of Georgia, Athens, GA

FACTORS INFLUENCING THE ACCUMULATION OF FALLOUT 137Cs IN COLORADO MULE DEER

F. W. WHICKER, G. C. FARRIS, E. E. REMMENGA and A. H. DAHL
Department of Radiology and Radiation Biology, , Colorado State University, Fort Collins, Colorado

Health Physics. 1965. Vol. 11

RADIATION AND ANIMAL POPULATIONS: PROBLEMS, PROGRESS AND PROJECTIONS

NORMAN R. FRENCH
Laboratory of Nuclear Medicine and Radiation Biology, University of California at Los Angeles

Abstract-A review of recent literature indicates much progress since the 1961 Radioecology Symposium, and suggests the importance of measuring the functional efficiency of irradiated populations. Population ecology provides methods suitable for evaluating the performance of populations. Dosimetry in radiation studies is simplified by new microthermoluminescent dosimeters.…

EFFECTS OF RADIATION ON THE NATALITY, DENSITY AND BREEDING STRUCTURE OF A NATURAL POPULATION OF LIZARDS, *UTA STANSBURIANA*

DONALD W. TINKLE
Department of Biology, Texas Technological College, Lubbock, Texas

RADIATION DAMAGE TO FOREST SURROUNDING AN UNSHIELDED FAST REACTOR*

JOHN P. WITHERSPOON
Radiation Ecology Section, Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee

Health Physics. 1965. Vol. 11

A TROPHIC LEVEL EFFECT ON I37Cs CONCENTRATION*

ROBERT C. PENDLETON, CHARLES W. MAYS, RAY D. LLOYD and BRUCE W. CHURCH
University of Utah, Salt Lake City, Utah

INTERACTIONS OF GAMMA RADIATION AND OTHER ENVIRONMENTAL STRESSES UPON PINE SEEDS AND SEEDLINGS*

J. FRANK McCORMICK and ROBERT E. McJUNKIN
Department of Botany, University of North Carolina and University of Georgia Laboratory of Radiation Ecology

RADIATION EFFECTS ON PLANT POPULATIONS AND COMMUNITIES: RESEARCH STATUS AND POTENTIAL

ROBERT B. PLATT
Emory University, Atlanta, Georgia

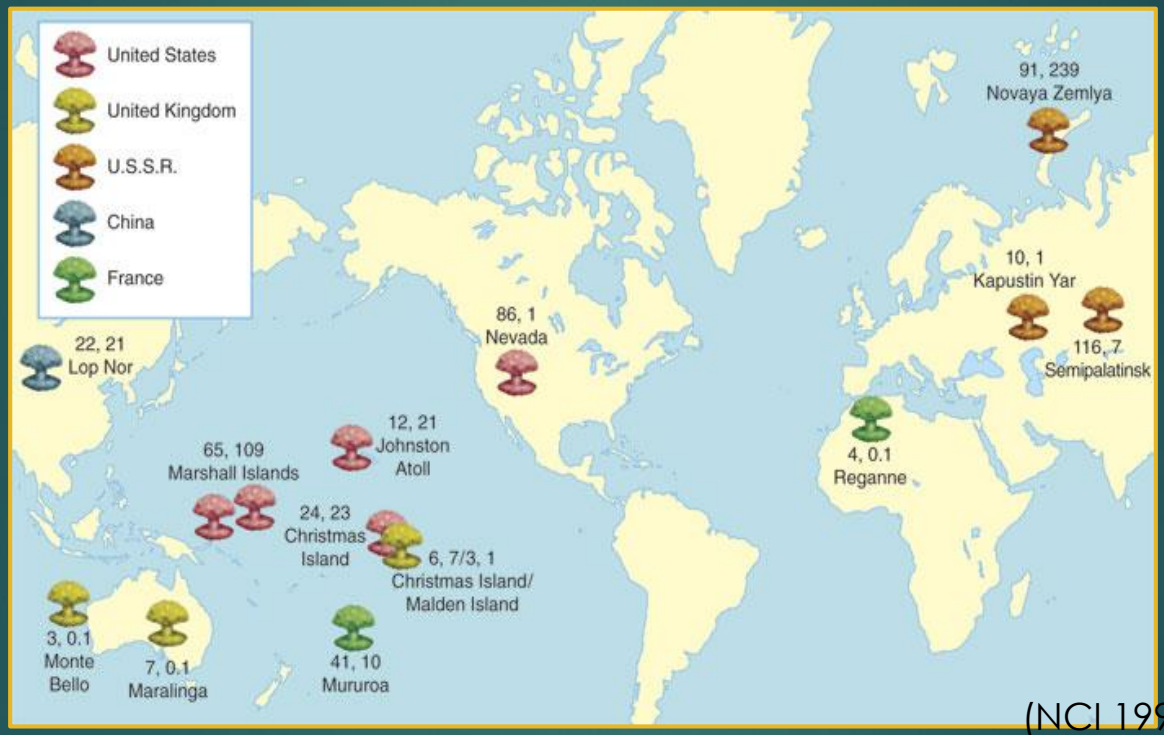
MINERAL CYCLING IN A DOUGLAS FIR FOREST STAND

HANS RIEKERK and STANLEY P. GESSEL
College of Forestry, University of Washington, Seattle, Washington

FEEDBACK BETWEEN RADIATION ECOLOGY AND GENERAL ECOLOGY

EUGENE P. ODUM
University of Georgia, Athens, Georgia

After Hiroshima and Nagasaki, the U.S. Atomic Energy Commission (AEC) continued to develop nuclear weapons…..Russia successfully tested their first weapon in 1949.

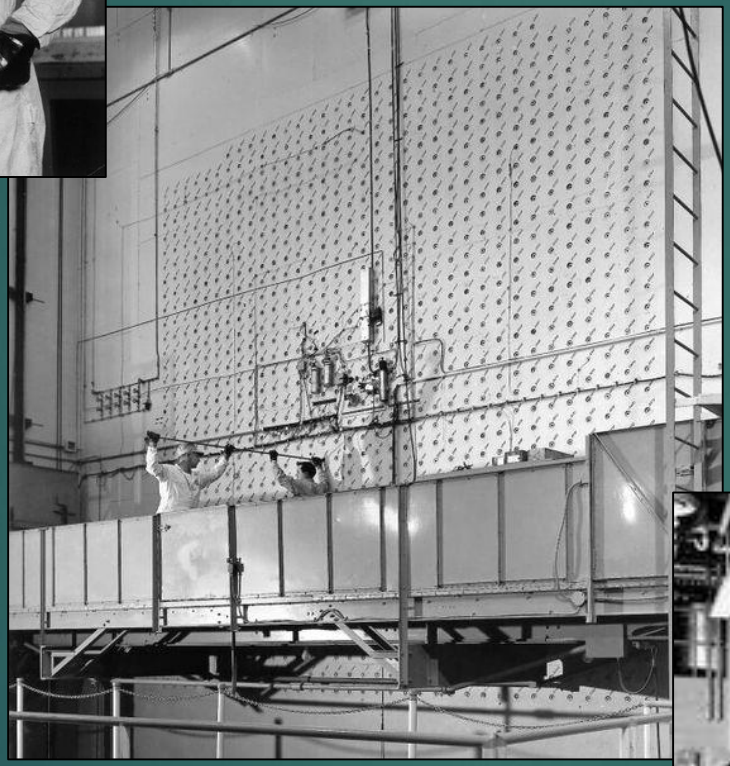


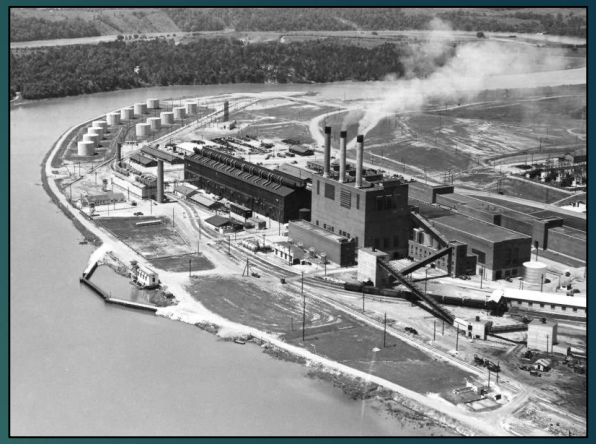
(NCI 1997)

From 1945 to 1980 more than 500 atmospheric tests were conducted

AEC's Factory Perspective of Radiation Safety

U cores into reactor

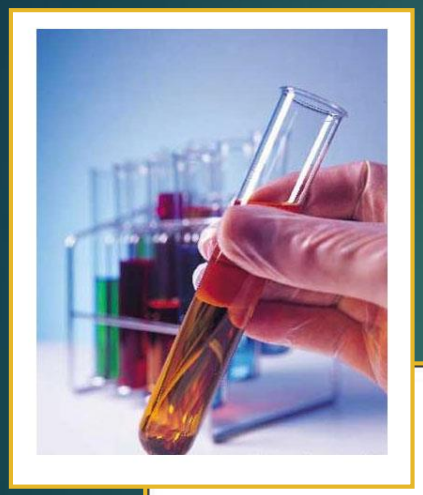




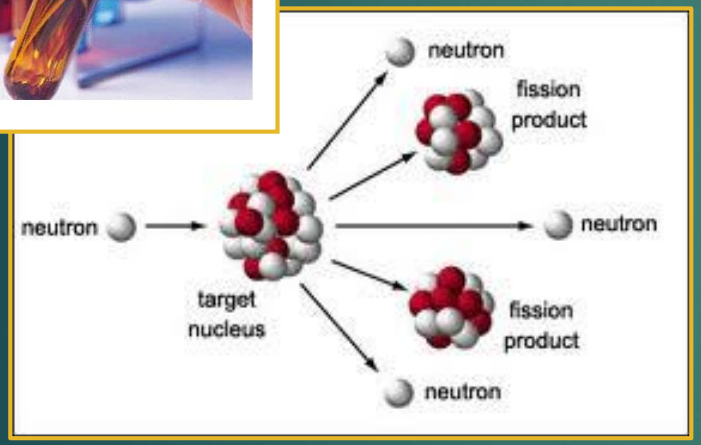
U enrichment, Oak Ridge, TN

remote handling

In the late 1940s and 1950s…



AEC scientists had a remarkable knowledge of nuclear physics and chemistry…

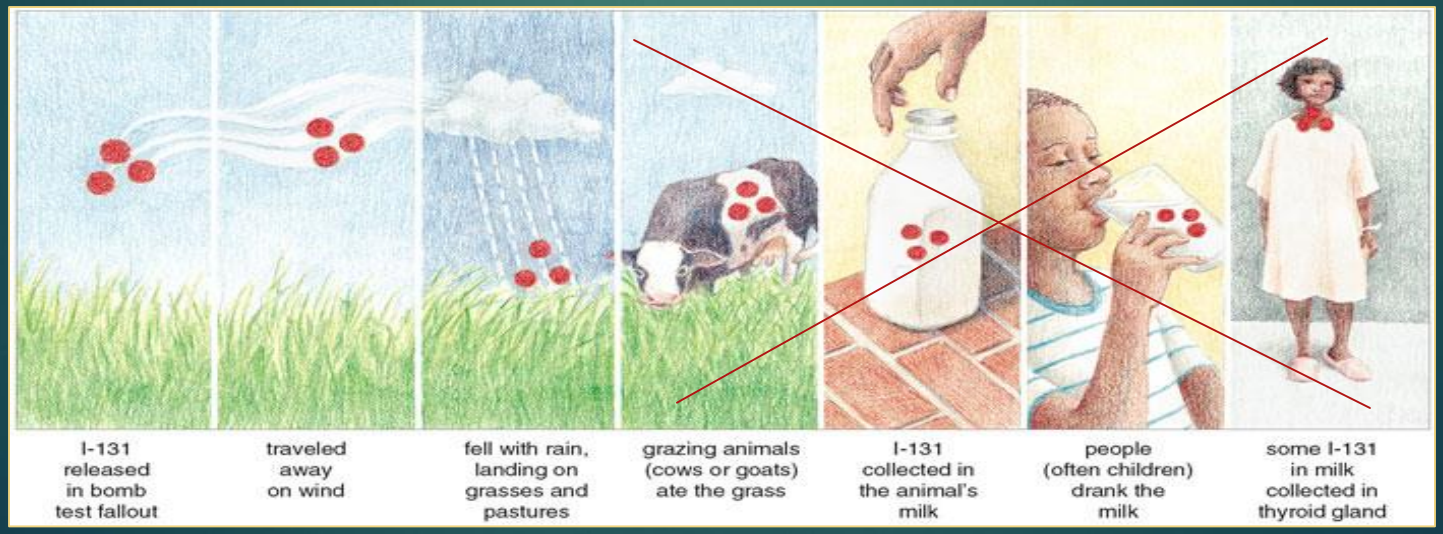


…and a remarkable lack of knowledge about the environment

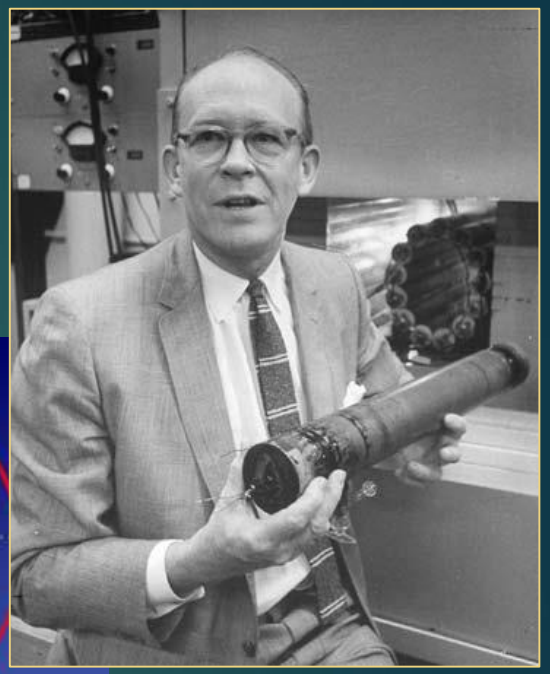
E. M. DeLourghrey, 2012, *The Myth of Isolates: Ecosystem Ecologies in the Nuclear Pacific*. Cultural Geographies.

The AEC view of fallout in early 1950s

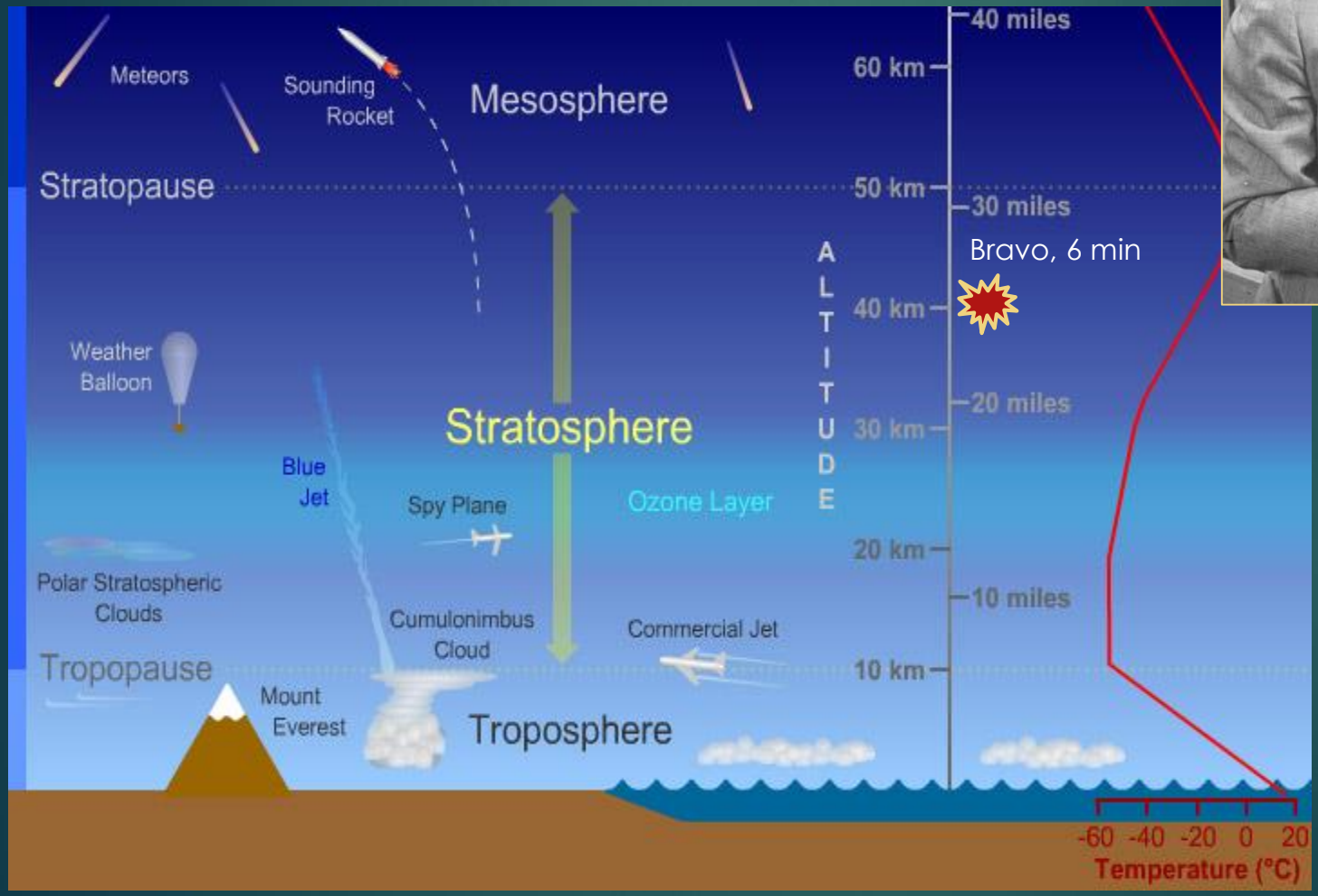
- exposure from external gamma radiation was the key risk from fallout
- the majority of the fallout would be contained within the boundaries of the test site
- internal exposure from environmental food chains was not important



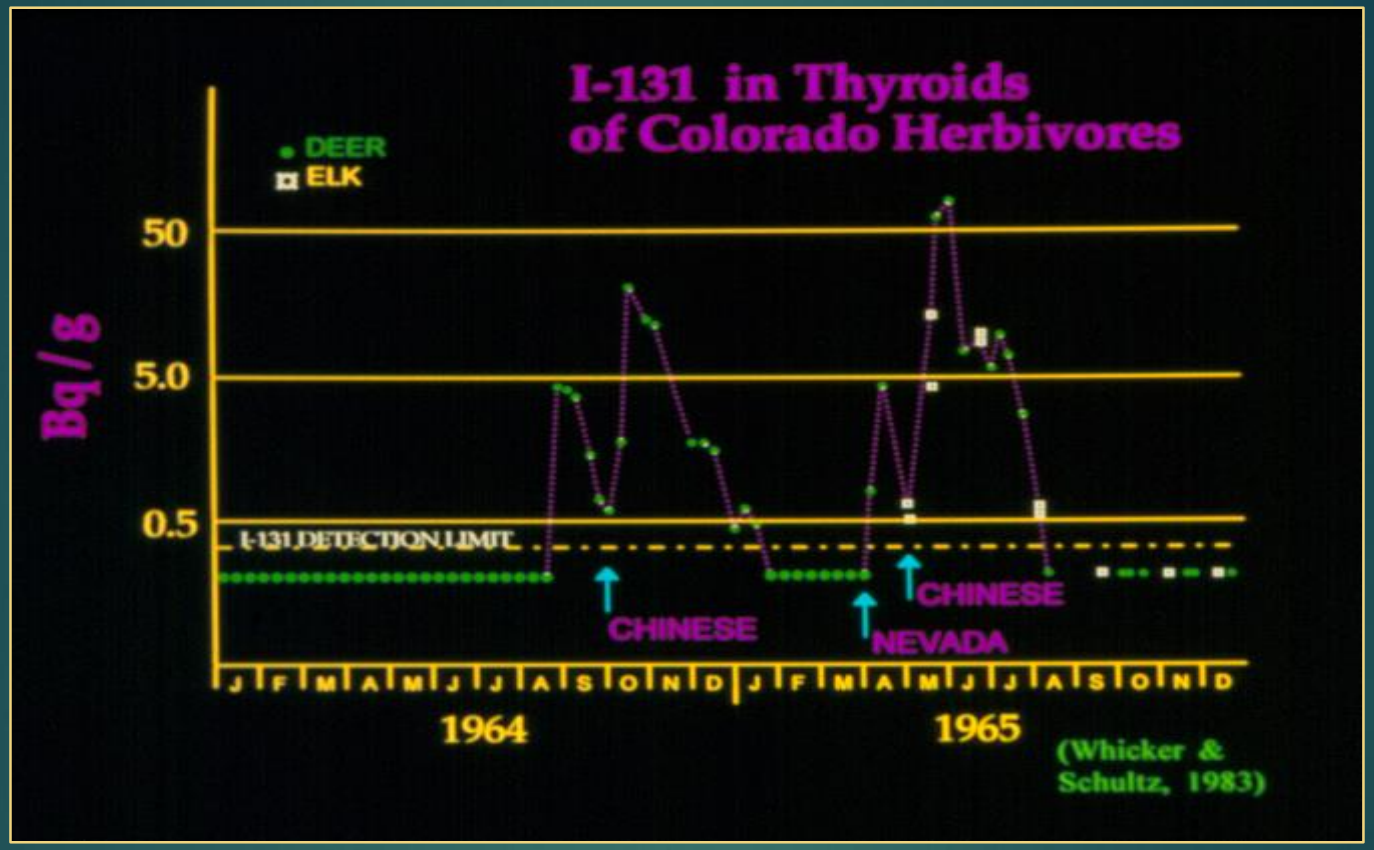
"Radiation from nuclear weapons tests would remain in the stratosphere for 10-12 years"



Dr. Libby, a commissioner with the AEC



Global transport and deposition of fallout



1951; Merrill Eisenbud, industrial hygienist at the AEC

Kodak: radiation was exposing film produced at their New York facility

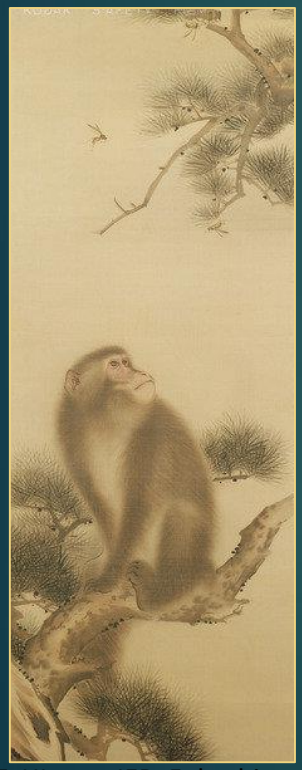
Medical Director at NTS: "You're crazy Merrill, I was out to Ground Zero, and there's no radiation out there, and you're telling me it's up in New York!"

AEC had no program to track offsite fallout further than 200 miles from the NTS

Variations in wind speed and direction with altitude causes fallout to spread over large areas. Trajectories of fallout shown for four altitudes, from a 43-kt test, detonated on April 25, 1953, at the NTS. Each dot indicates six hours. (NCI 1997)

The AEC view of fallout and the environment

- Not understanding the complex ways that environmental pathways altered fallout transport caused the AEC to dramatically underestimate its risks.

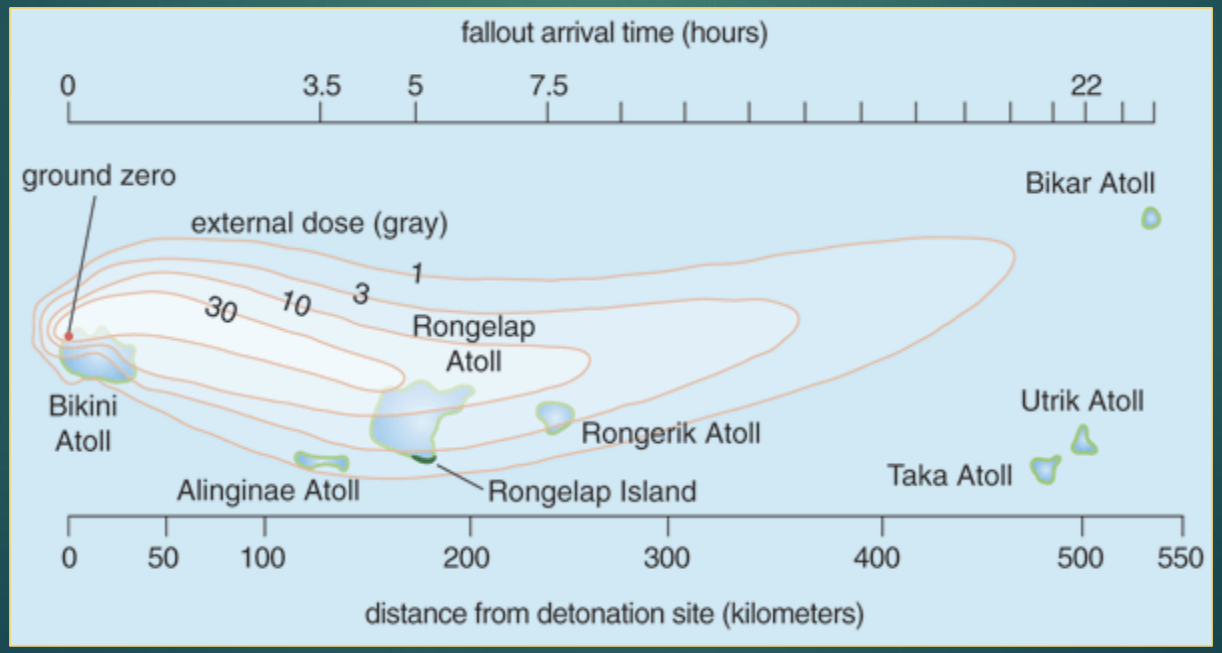


- Not considering environmental pathways was due in part to a more global "lack of appreciation that man [is] an integral part of his environment."

(J. Stannard, 1973)

Bravo Test on Bikini Atoll was called the worst radiological disaster in history (1 March 1954)

- 1000 times the force of Hiroshima and Nagasaki bombs
- yield underestimated
- resulted in widespread contamination of marine resources
- forced evacuation of Rongelap and Rongerik inhabitats



Bravo's extensive fallout catalyzed a worldwide outcry against weapons testing and forced the AEC to more thoroughly assess the radiation impact of its weapons program.

Officials measure radiation in tuna at Tsukiji fish market, Tokyo 1954

The *Lucky Dragon*

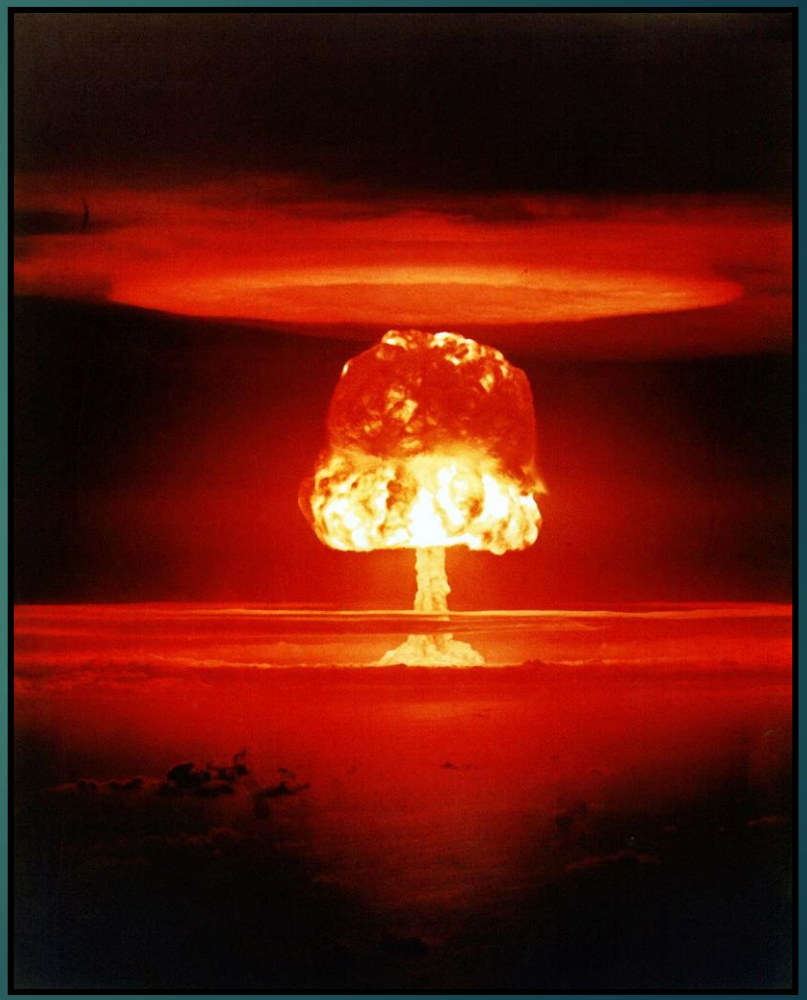
Crew of Japanese *Lucky Dragon* heavily contaminated, one member died from radiation exposures

Fallout became the first global environmental crisis

- Fallout problems enabled environmental scientists to enhance their status as experts

"The Age of Ecology began on the desert outside Alamogordo, New Mexico, on July 16, 1945, with a dazzling fireball of light and a swelling mushroom cloud of radioactive gas".

Donald Worster, *Nature's Economy*



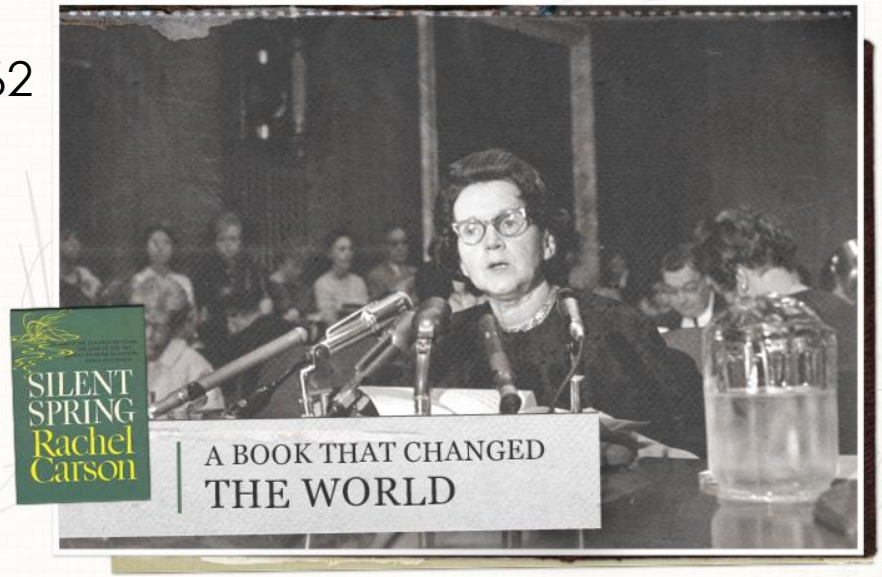
- 1957, U.S. Congress held special hearings on fallout to "try to compel the scientists to come forth with a satisfactory explanation of the radiation problem"

- 1957, the AEC created a special Environmental Studies Branch to deal specifically with the oceanographic, meteorological, and ecological aspects of radiation

- 1958, John Wolfe, an ecologist, became the Director of the AEC's Environmental Branch, and strongly emphasized large-scale, field-based experimental radioecology

1950 to 1965…the "Golden Age" of funding by the AEC

1962



many of the ideological, scientific, and social elements that made up environmental movement in the 1960s were forged in the widespread protests to nuclear fallout

'Silent Spring' Is Now Noisy Summer

Pesticides Industry Up in Arms Over a New Book

Rachel Carson Stirs Conflict—Producers Are Crying 'Foul'

By JOHN M. LEE

The $300,000,000 pesticides industry has been highly irritated by a quiet woman author whose previous works on science have been praised for the beauty and precision of the writing.

The author is Rachel Carson, whose "The Sea Around Us" and "The Edge of the Sea" were best sellers in 1951 and 1955. Miss Carson, trained as a marine biologist, wrote gracefully of sea and shore life.

In her latest work, however, Miss Carson is not so gentle, fending the use of their products. Meetings have been held in Washington and New York. Statements are being drafted and counter-attacks plotted.

A drowsy midsummer has suddenly been enlivened by the greatest uproar in the pesticides industry since the cranberry scare of 1959.

Miss Carson's new book is entitled "Silent Spring." The title is derived from an idealized situation in which Miss Carson envisions an imaginary town where chemical pollution has silenced "the voices of spring."

Oak Ridge Ecology Laboratory in 1956.
(Stanley Auerbach and Eugene Odum)

Radiation provided ecologists with an array of exotic new techniques for their research…..tracers!

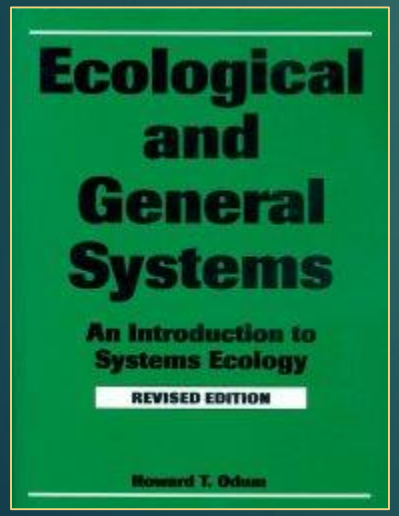
- for tracking the movement of animals and estimating population densities
- effects of stress on organisms
- 14C for dating
- radiosensitivities of species
- delineation of food webs
- a means of quantifying the rate of material and energy flow through ecosystems

Hagen, J. B. 1992. *An Entangled Bank: The Origins of Ecosystem Ecology.*

Measuring energy flow at the ecosystem level

Howard and Eugene Odum, Enewetak, 1954

- Odums' work on the irradiation of Enewetak's coral reefs was an ecosystem-level approach to quantify accumulations and transfers among ecosystem components
- provided ecologists with a model of a structured, self-regulating ecosystem and the first theorization of shared resource relationships in nature, which they termed 'mutualism.'



"Systems ecology emerged from the field of 'radiation ecology' in the Pacific Islands"

A. Brown. 2014. *No Promised Land: The Shared Legacy of the Castel Bravo Nuclear Test*

Dr. Howard T. Odum, right, University of Texas Institute of Marine Science director at Port Aransas, received the Ecological Society of America's George Mercer Award for 1956 from Dr. Logan Wilson, University president.

THE GEORGE MERCER AWARD FOR 1956

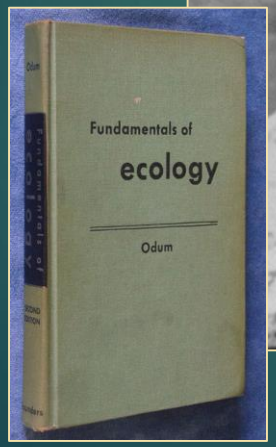
The George Mercer Award for 1956 was divided between two brothers—Dr. Eugene P. and Dr. Howard T. Odum—in recognition of their co-authorship of a paper judged outstanding by the Mercer Award Scrutineers, "Trophic structure and productivity of a windward coral reef community on Eniwetok Atoll", published in ECOLOGICAL MONOGRAPHS 25 (3): 291 - 320. 1955.

Eugene Odum's vision

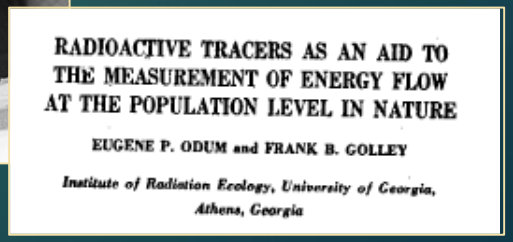
- At the First Atoms for Peace Conference in Geneva in **1955**, Odum stressed the importance of understanding the effects of radiation on higher levels of biological organisms—the population, community, and ecosystem levels.
- He also hinted at the importance of biogeochemical cycles in the context of the safe disposal of radioactive waste products.
- He laid out the scientific basis for the developing ecology program at the Savannah River site by calling for studies on the effects of radiation on trophic structure, productivity, and metabolic properties of ecosystems, emphasizing the comparison of contaminated and non-contaminated areas.
- This was state-of-the-art functional ecology with a new variable—radioactivity.

The ironic duality of radiation as a contaminant and as a scientific tool was recognized by Eugene Odum (1957)

"The atomic age can well provide the means of solving the very problems it creates…the use of radioactive tracers in the environment offers unlimited opportunities."



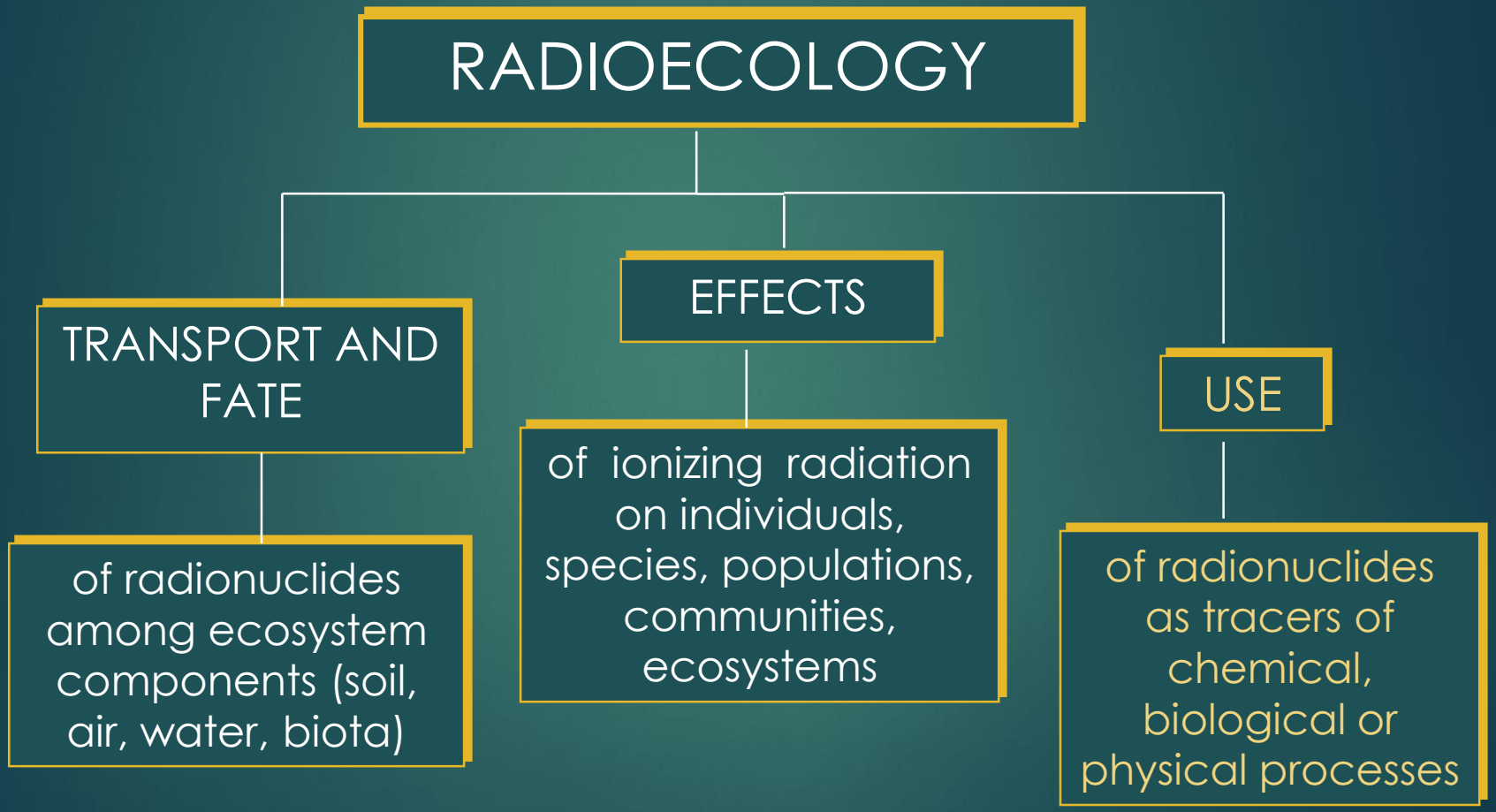
2nd edition, 1959


RADIOACTIVE TRACERS AS AN AID TO THE MEASUREMENT OF ENERGY FLOW AT THE POPULATION LEVEL IN NATURE

EUGENE P. ODUM and FRANK B. GOLLEY

Institute of Radiation Ecology, University of Georgia, Athens, Georgia

Radioecology emerged as a science when the environment was recognized as a factor in human exposure to fallout radiation



The Decline of Ecology in Radioecology

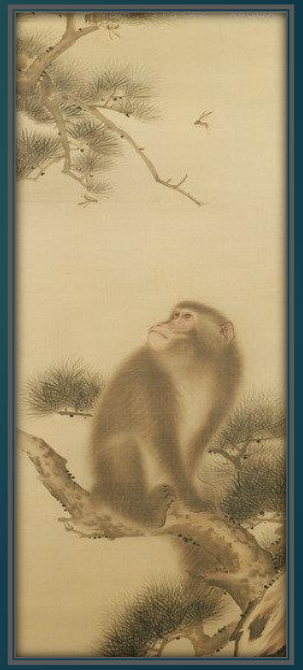
- The Limited Test Ban Treaty to stop atmospheric testing was signed by President Kennedy on October 5, 1963
- By the late 1960s, interests and funding for large-scale field radioecological research in the AEC began to wane.
- In 1974 the AEC changed to the Energy Research and Development Administration (ERDA) and then in 1977 changed to the Department of Energy (DOE)
- Safety concerns limited use of radioactive tracers in field studies …..so the strength of RE contributions to a larger science was greatly reduced

Funding agencies did not see a need for environmental effects research because of the long-standing paradigm for protecting plants and animals from radiation

If man is adequately protected, then so is the environment.

Explicit radiological limits are not needed for the biota. If dose limits are set to protect humans, then the environment is automatically protected as well.

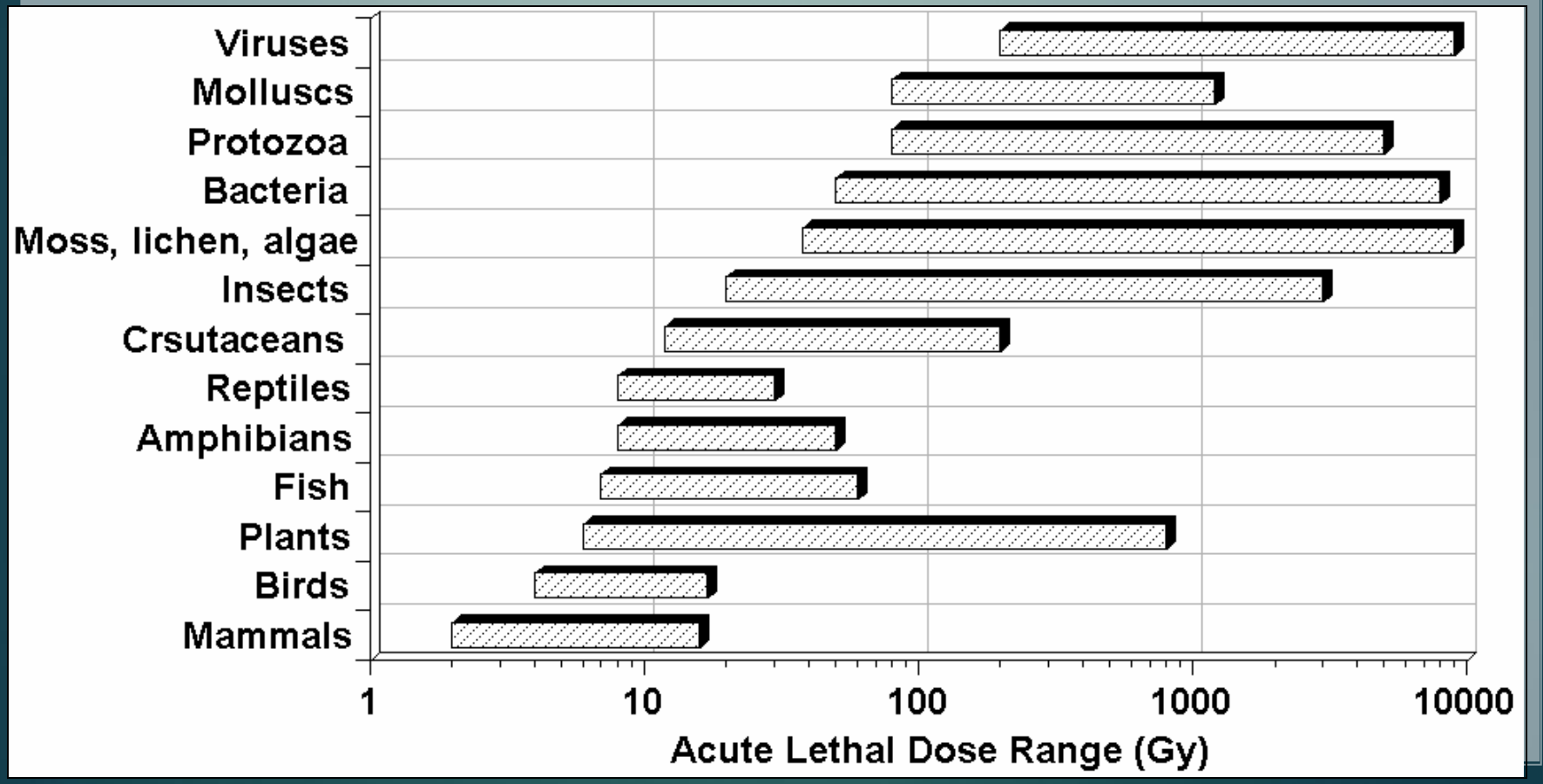
(ICRP 1977; ICRP 1991; IAEA 1992)



If we protect humans then all other things are protected as well....

Acute Lethal Dose Ranges

(Whicker and Schultz, 1982)



- Environment was recognized…but only as a pathway to human exposure,…….effects to the environment were not considered from a legal perspective

"The Commission concerns itself with mankind's environment only with regard to the transfer of radionuclides through the environment, since this directly affects the radiological protection of man."

ICRP
INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

ICRP 60, 1991

- No other contaminant has been managed from such a strong anthropocentric perspective

- Radiation is unique as an environmental contaminant, unlike all other pollutants on planet Earth

- Funding agencies prioritized other science topics and viewed knowledge of RE as being sufficient
- With major funding cuts, radioecology became very applied, with an emphasis on transport-fate model development
- Radioecology became separated from the broader discipline of ecology, with few ecologists participating in RE
- Chernobyl accident of 1986 revived RE in Europe, but not in the U.S.

2005

ICRP formed Committee-5 to develop an environmental protection system

ICRP founded in 1928, Committee-5 formed over 75 years later

ICRP
INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

….their methods, however, lack an ecosystems approach