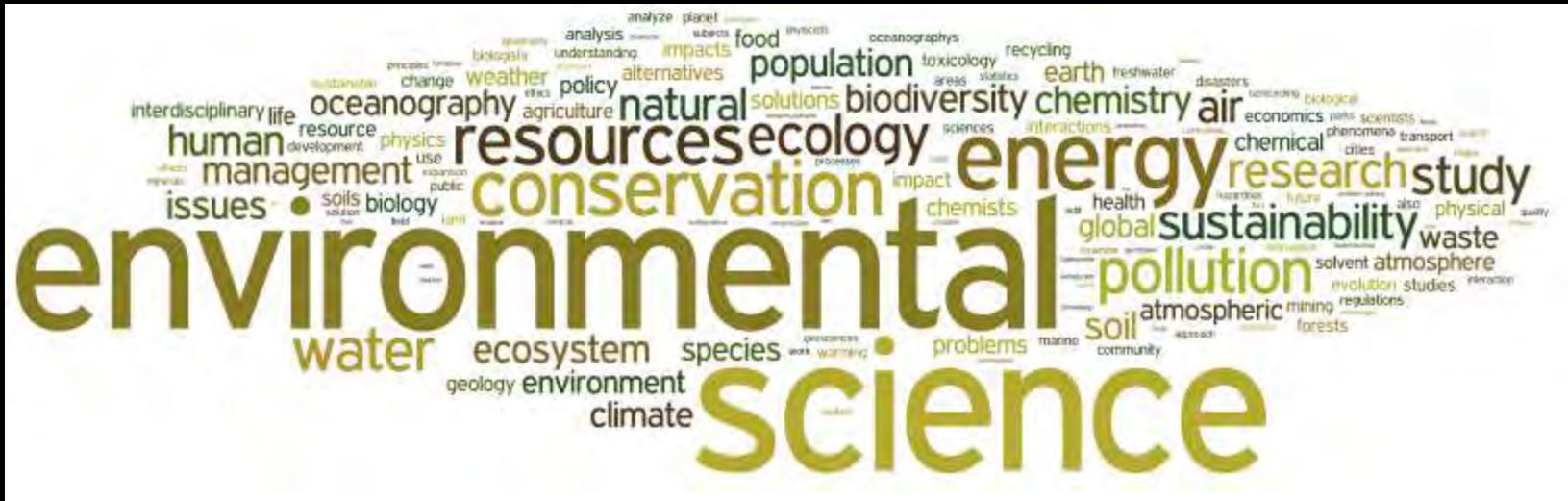


# American Environmental Science, Sustainability, and Human Nature

Kevin M. Anderson, Ph. D.  
Austin Water Center for Environmental Research

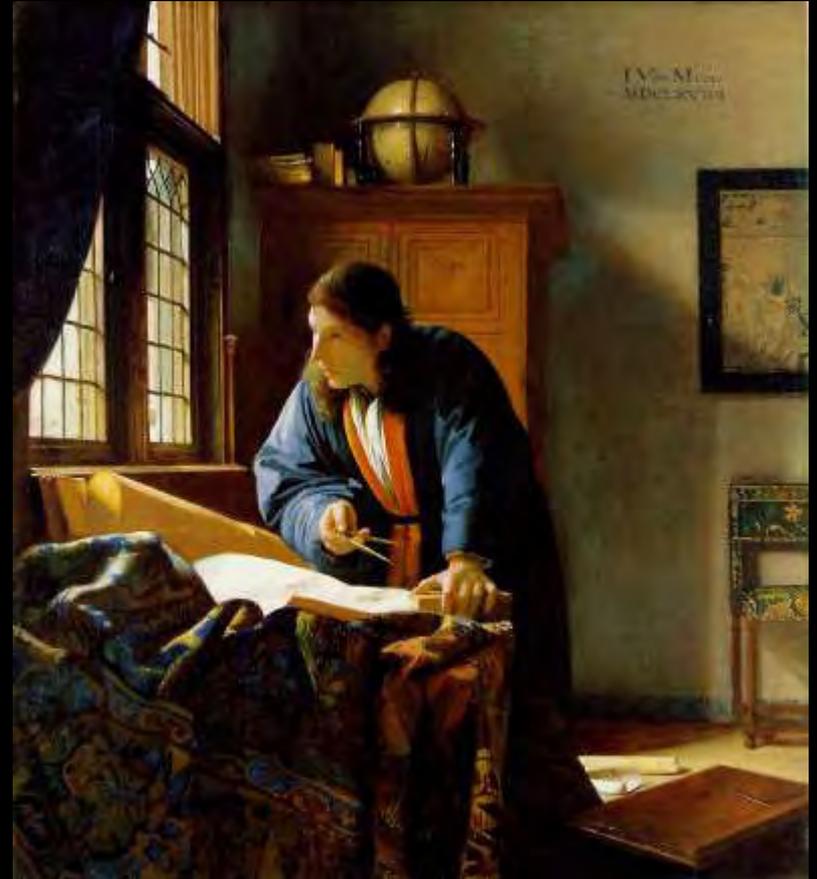




# Geography

A literal translation would be "to describe or write about the Earth".

As the bridge between the human and physical sciences, geography is divided into two main branches – human/cultural geography and physical geography.



Vermeer "The Geographer"  
1668–1669

# 18<sup>th</sup> and 19<sup>th</sup> Century Origins of Environmental Science



# Carrying Capacity and the Struggle for Existence

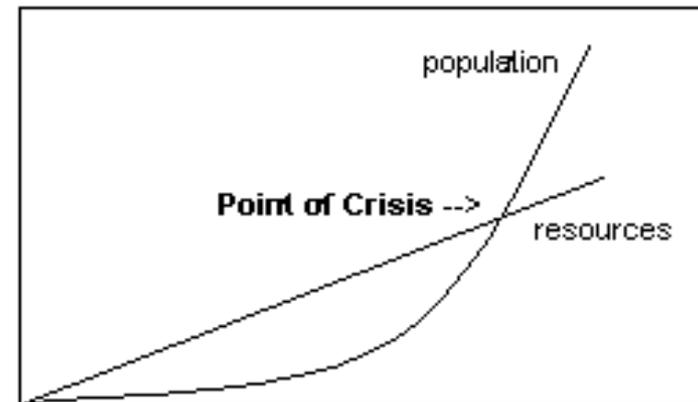
Thomas Malthus (1766-1834)

*An Essay on the Principle of Population* 1798

Believed that human populations would eventually be kept in check by famine, disease because populations grow exponentially, but food supply does not.

"This natural inequality of the two powers, of population, and of production of the earth, and that great law of our nature which must constantly keep their effects equal, form the great difficulty that appears to me insurmountable in the way to the perfectibility of society."

Darwin, *Origin of the Species* – "I should premise that I use the term Struggle for Existence in a large and metaphorical sense including dependence of one being on another and including (which is more important) not only the life of the individuals, but success in leaving progeny"



**Malthus' Basic Theory**



# Origins of Environmental Science

## Humboldtian Science - A vision of the unity of Nature

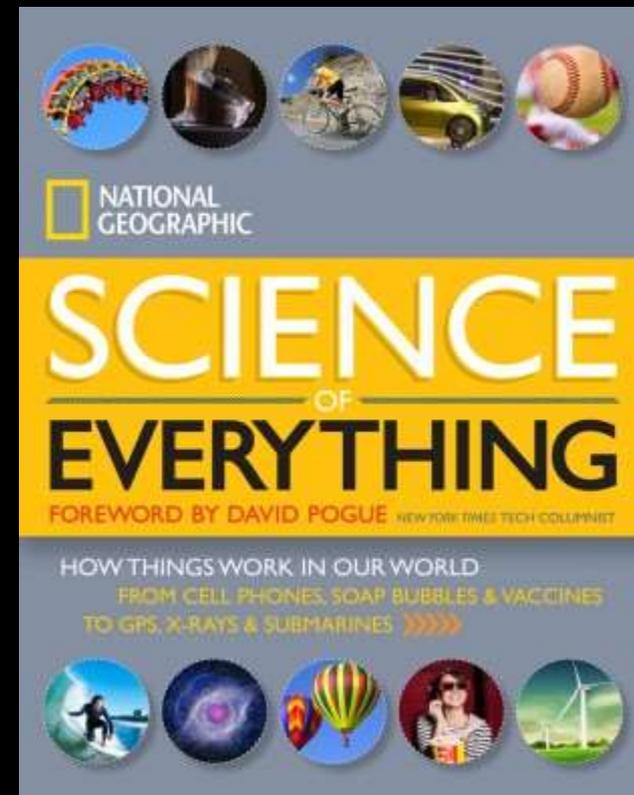
Alexander von Humboldt 1769 - 1859

*Unity in diversity, and of connection, resemblance, and order, among created things most dissimilar in their form, one fair harmonious whole...*

*Kosmos, 1845*

Between 1799 and 1804, Humboldt travelled extensively in Latin America, exploring and describing it. His description of the journey was written up and published in an enormous set of volumes over 21 years. Later, his five-volume work, *Kosmos* (1845), attempted to unify the various branches of scientific knowledge.

One concept that is central to Humboldtian science is that of a general equilibrium of forces. Humboldt, himself, explains, "The general equilibrium which reigns amongst disturbances and apparent turmoil, is the result of infinite number of mechanical forces and chemical attractions balancing each other out."





## George Perkins Marsh 1801 – 1882

American diplomat and philologist and “Prophet of Conservation”

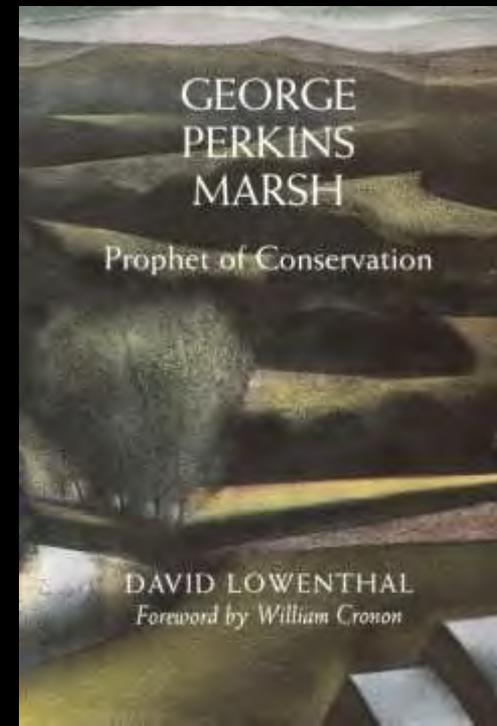
Marsh was born in Vermont, educated at Dartmouth College and taught Greek and Latin before becoming a lawyer and moving to Burlington, Vermont.

In 1839, he was elected to the U.S. House of Representatives and went to Washington, where he was a key figure in the establishment of the Smithsonian Institution.

Most known in his lifetime as a philologist. Knew 20 languages and wrote a history of the English language, championed Norse sagas.

Marsh began the diplomatic phase of his career in 1849, when he was appointed to serve as the Minister to the Court at Constantinople.

In 1861, Lincoln appointed him as ambassador to the Kingdom of Italy and he spent the rest of his life as ambassador in Italy.



## Physical Geography, Von Humboldt, and the Harmonies of Nature

Greatly influenced by reading Von Humboldt and other geographers to observe and compare Old World and New World environmental change.

It was during his time abroad that he saw the devastation caused by deforestation in Europe, and observed Europeans devising land management plans to remedy the damage.

He began to articulate his vision of how man could control his imprint on the natural world.

Marsh concluded that human activity could, and did, significantly alter the appearance and productivity of the landscape, and even the climate of our planet.

In his biography of Marsh, David Lowenthal writes that "History demonstrated that man was the architect of his own misfortunes; what the Old World had suffered, Marsh believed, might well become the fate of the New."



In 1864 Marsh published

## *Man and Nature, or, Physical Geography as Modified by Human Action*

This remarkable text engendered worldwide awareness of the ill-effects of human agency, along with efforts to repair the damage and conserve the fabric of nature. Most noteworthy was Marsh's stress on the unforeseen and unintended consequences, as well as the heedless greed, of technological enterprise.

Wallace Stegner "the rudest kick in the face that American initiative, optimism and carelessness had yet received.:

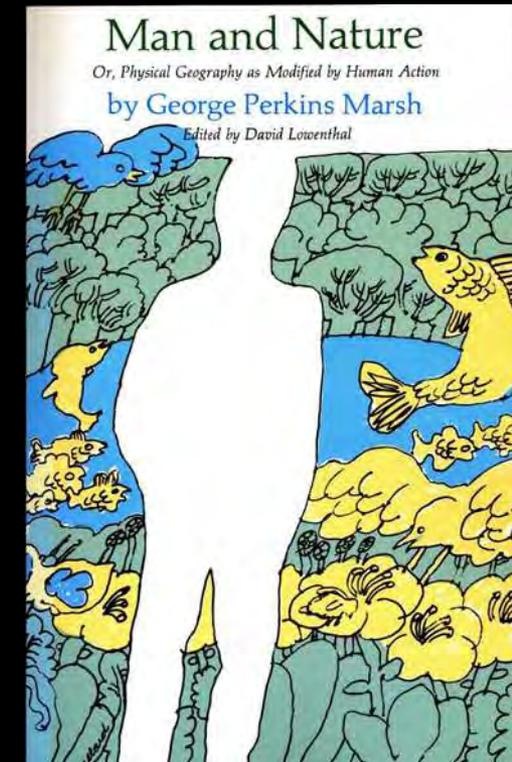
"Man is everywhere a disturbing agent. Wherever he plants his foot, the harmonies of nature are turned to discord"

"...Man, who even now finds scarce breathing room on this vast globe, cannot retire from the Old World to some yet undiscovered continent, and wait for the slow action of such causes to replace, by a new creation, the Eden he has wasted"

"Man has too long forgotten that the earth was given to him for usufruct alone, not for consumption, still less for profligate waste. Nature has provided against the absolute destruction of any of her elementary matter... But she has left it within the power of man irreparably to derange the combinations of inorganic matter and of organic life."



1864



## Two Key Insights from Marsh

### 1. Unintended Consequences

...even the best intentions do not ensure good environmental management. For as Marsh reiterated time and again, most human impacts are unintentional. “Vast as is the . . . magnitude and importance [of] intentional changes”, they are “insignificant in comparison with the contingent and unsought results which have flowed from them”.

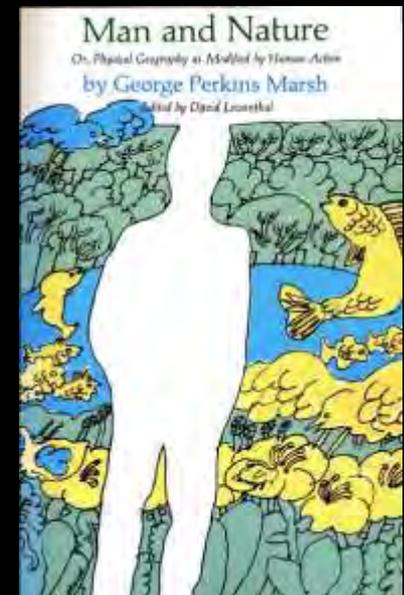
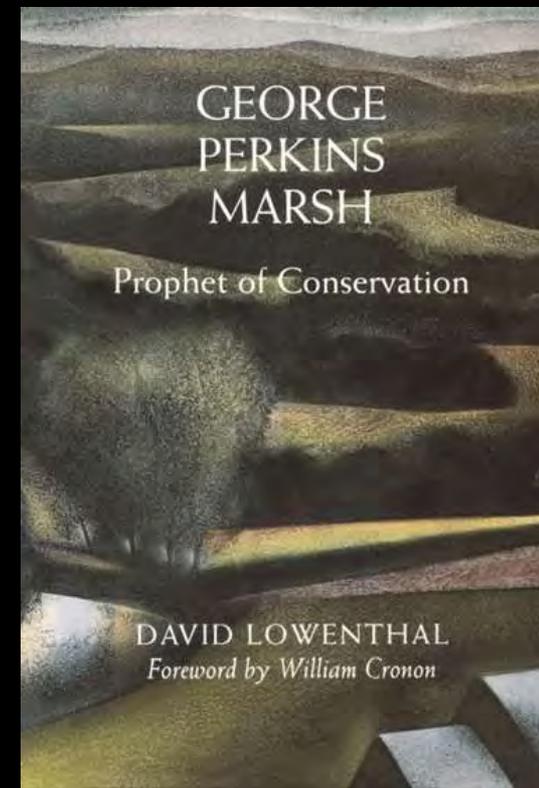
As human global impacts proliferate, their unsought, undesirable, perhaps lethal consequences can never be fully foreseen, let alone prevented.

### 2. Commitment to the Future

For all Marsh’s dire warnings, pragmatic optimism suffuses *Man and Nature*. Many of his insights and remedies were drawn from Europe, but his central themes—the need for reform, the faith in man’s powers—are characteristically American.

And they were interfused with another American trait—commitment to the future. The whole force of *Man and Nature* lies in its assumption that the welfare of future generations transcended immediate gains. Americans who disdained to practice a better husbandry for themselves should feel morally obliged to do so for their offspring.

Impact - Watershed protection through forestry management, 1876 Federal Forestry Commission, Arbor Day Movement



One Hundred Years later...  
Contemporary Environmental Science

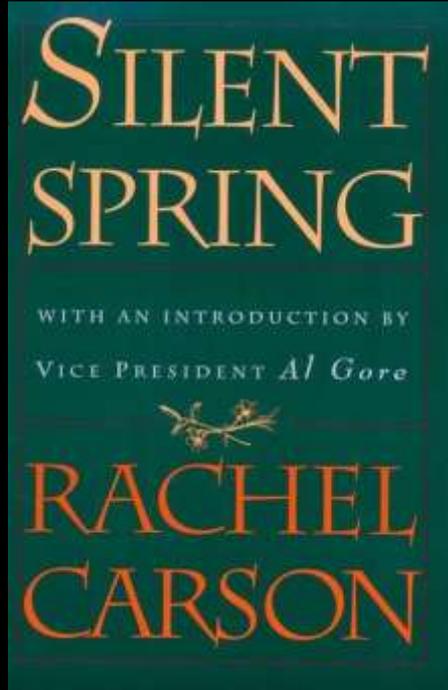
Rachel Carson 1907-1964

Aquatic Biology and Oceanography

The Sea Around Us (1951)

The Edge of the Sea (1955)

Silent Spring (1962)



"DDT is good for me-e-e!"

The great expectations held for DDT have been realized. During 1946, exhaustive scientific tests have shown that, when properly used, DDT kills a host of destructive insect pests, and is a benefactor of all humanity.

Pennsalt produces DDT and its products in all standard forms and is now one of the country's largest producers of this amazing insecticide. Today, everyone can enjoy added comfort, health and safety through the insect-killing powers of Pennsalt DDT products . . . and DDT is only one of Pennsalt's many chemical products which benefit industry, farm and home.

**GOOD FOR STEERS**—Beef grows sweeter nowadays . . . for it's a scientific fact that—compared to untreated cattle—beefsteers gain up to 20 pounds extra when protected from horn flies and many other pests with DDT insecticides.

**GOOD FOR THE HOME**—helps you to make healthier, more comfortable homes . . . protects your family from dangerous insect pests. Use Know-Out DDT Powder and Sprays as directed . . . then watch the bugs "bite the dust!"

**GOOD FOR DAIRIES**—Up to 20% more milk . . . more butter . . . more cheese . . . tests prove greater milk production when dairy cows are protected from the annoyance of many insects with DDT insecticides like Know-Out Stock and Barn Spray.

**GOOD FOR FRUITS**—Bigger apples, juicier fruits that are free from unsightly worms . . . all benefits resulting from DDT dusts and sprays.

**GOOD FOR ROW CROPS**—25 extra bushels of potatoes per acre . . . witness! DDT tests have shown crop increases like that! DDT dusts and sprays help truck farmers pass those gains along to you.

**KNOW FOR INDUSTRY**—Food processing plants, laundries, dry cleaning plants, hotels . . . dozens of industries gain effective bug control, more pleasant work conditions with Pennsalt DDT products.

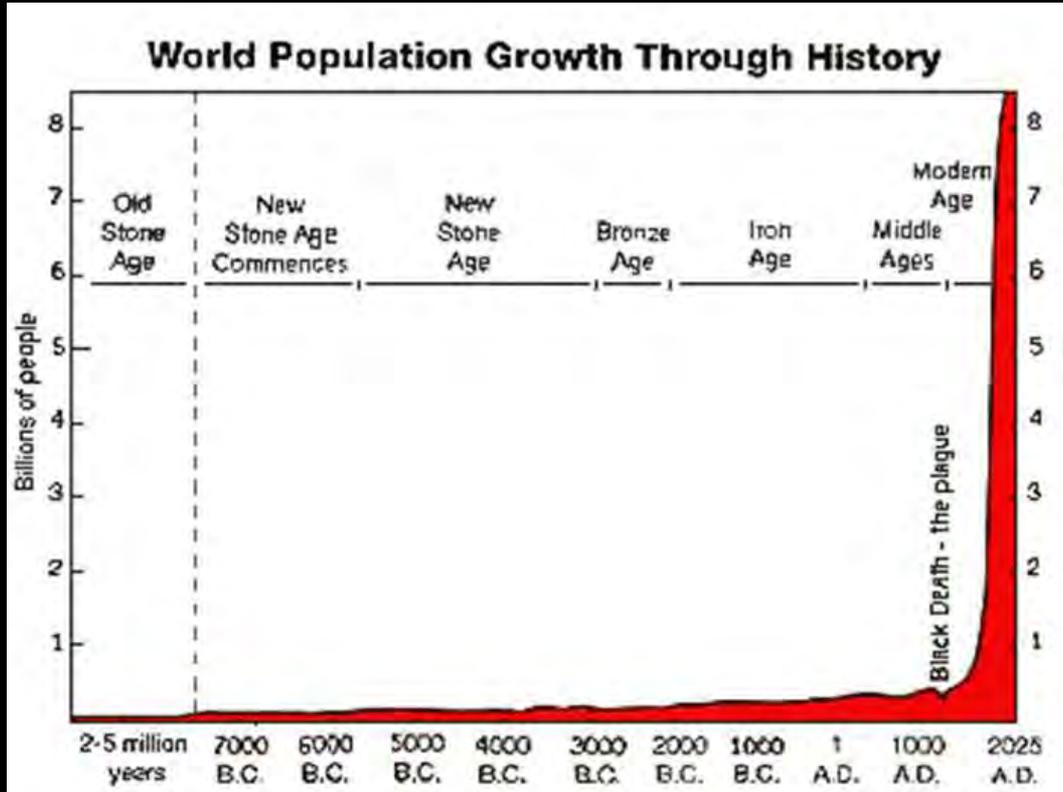
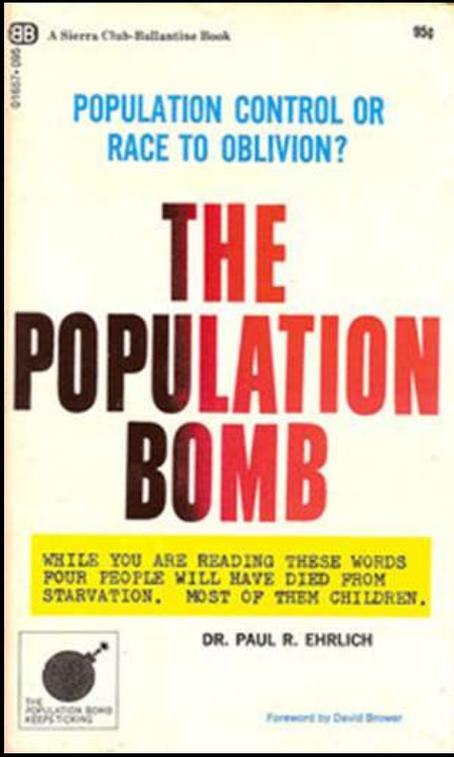
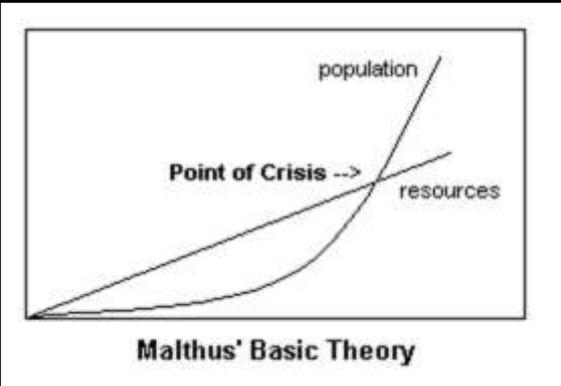
**PENN SALT**  
CHEMICALS  
87 Years' Service to Industry • Farm • Home  
PENNSYLVANIA SALT MANUFACTURING COMPANY  
WIDENER BUILDING, PHILADELPHIA 7, PA.

# Population

Paul Ehrlich b.1932

*The Population Bomb* 1968

Population Control – Neo-Malthusians



# The Commons and Population

Garrett Hardin 1915 -2003

The Tragedy of the Commons 1969

The population problem has no technical solution; it requires a fundamental extension in morality.

Hardin's parable involves a pasture "open to all."

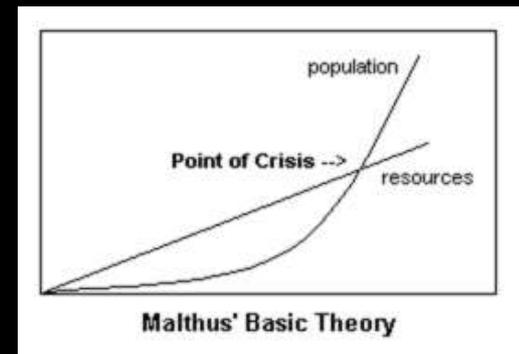
He asks us to imagine the grazing of animals on a common ground. Individuals are motivated to add to their flocks to increase personal wealth.

Yet, every animal added to the total degrades the commons a small amount. Although the degradation for each additional animal is small relative to the gain in wealth for the owner, if all owners follow this pattern the commons will ultimately be destroyed.

And, assuming rational actors, each owner adds to their flock:

"Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit - in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own interest in a society that believes in the freedom of the commons."

Under conditions of overpopulation, freedom in an unmanaged commons brings ruin to all.



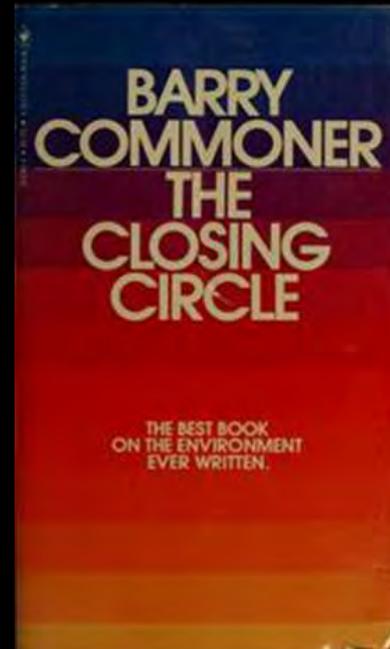
# The Environment and Sustainability

Barry Commoner 1917-2012

*The Closing Circle* 1971

Commoner's 4 Principles

1. Everything is connected to everything else.
2. Everything must go somewhere.
3. Nature knows best.
4. There is no such thing as a free lunch.



He had a long-running debate with Ehrlich and his followers, arguing that they were too focused on overpopulation as the source of environmental problems, and that their proposed solutions were politically unacceptable because of the coercion that they implied, and because the cost would fall disproportionately on the poor.

He believed that technological and, above all, social development would lead to a natural decrease in both population growth and environmental damage

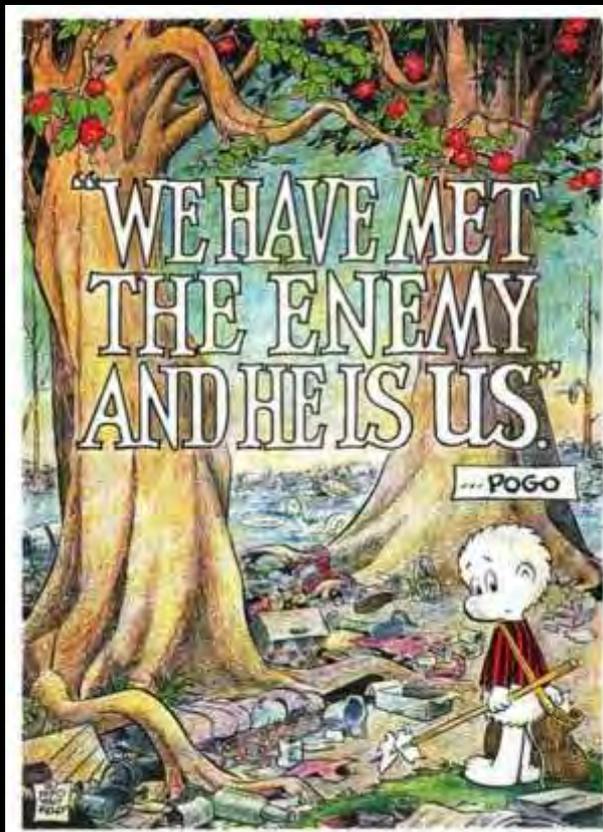
## The Environment and Mass Culture

Earth Day – April 22, 1970

The idea came to Earth Day founder Gaylord Nelson, then a U.S. Senator from Wisconsin, after witnessing the ravages of the 1969 massive oil spill in Santa Barbara, California.

Senator Nelson announced the idea for a “national teach-in on the environment” to the national media; persuaded Pete McCloskey, a conservation Republican Congressman, to serve as his co-chair; and recruited Denis Hayes as national coordinator. Hayes built a national staff of 85 to promote events across the land.

As a result, on the 22nd of April, 20 million Americans took to the streets, parks, and auditoriums to demonstrate for a healthy, sustainable environment in massive coast-to-coast rallies.



Walt Kelly's poster for the first Earth Day



# Sustainability Defined

*Our Common Future*, also known as the *Brundtland Report*, from the United Nations World Commission on Environment and Development was published in 1987.

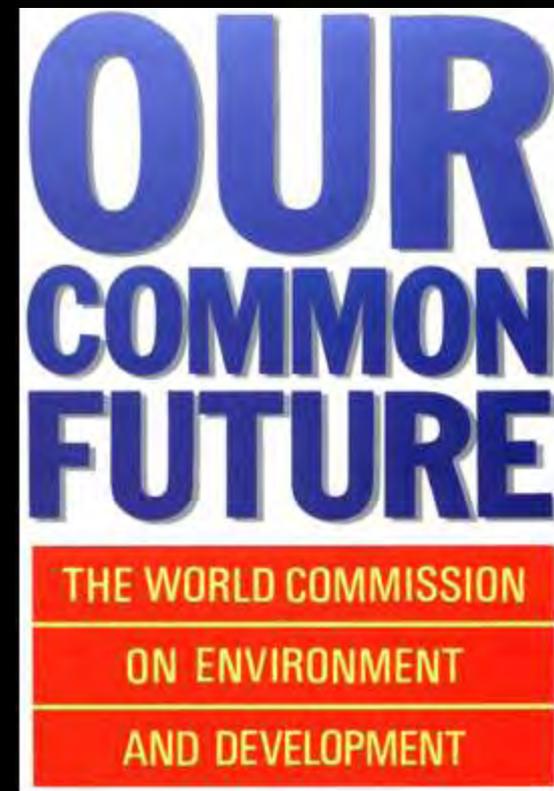
Sustainable development is defined in the report as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Environment – Economy – Equity

"In the middle of the 20th century, we saw our planet from space for the first time. Historians may eventually find that this vision had a greater impact on thought than did the Copernican revolution of the 16th century, which upset the human self-image by revealing that the Earth is not the centre of the universe.

From space, we see a small and fragile ball dominated not by human activity and edifice but by a pattern of clouds, oceans, greenery, and soils. Humanity's inability to fit its activities into that pattern is changing planetary systems, fundamentally. Many such changes are accompanied by life-threatening hazards.

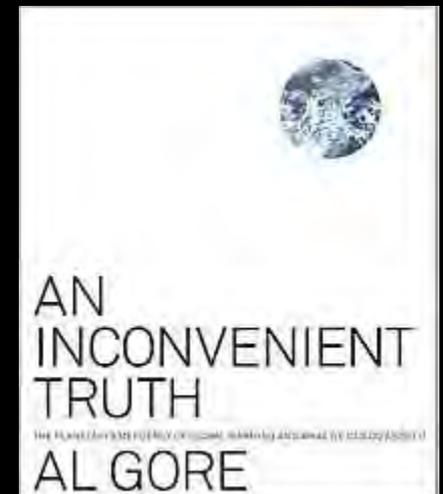
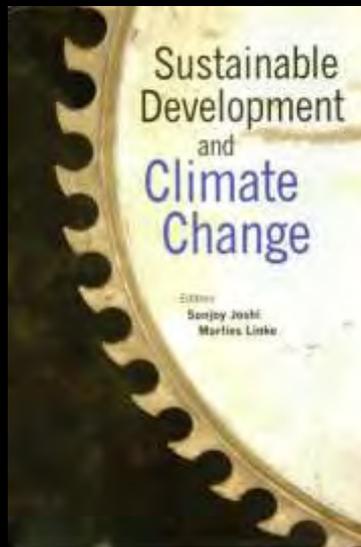
This new reality, from which there is no escape, must be recognized - and managed."



# YOU CONTROL CLIMATE CHANGE.



TURN DOWN. SWITCH OFF. RECYCLE. WALK. **CHANGE**



# Global Change and Nature

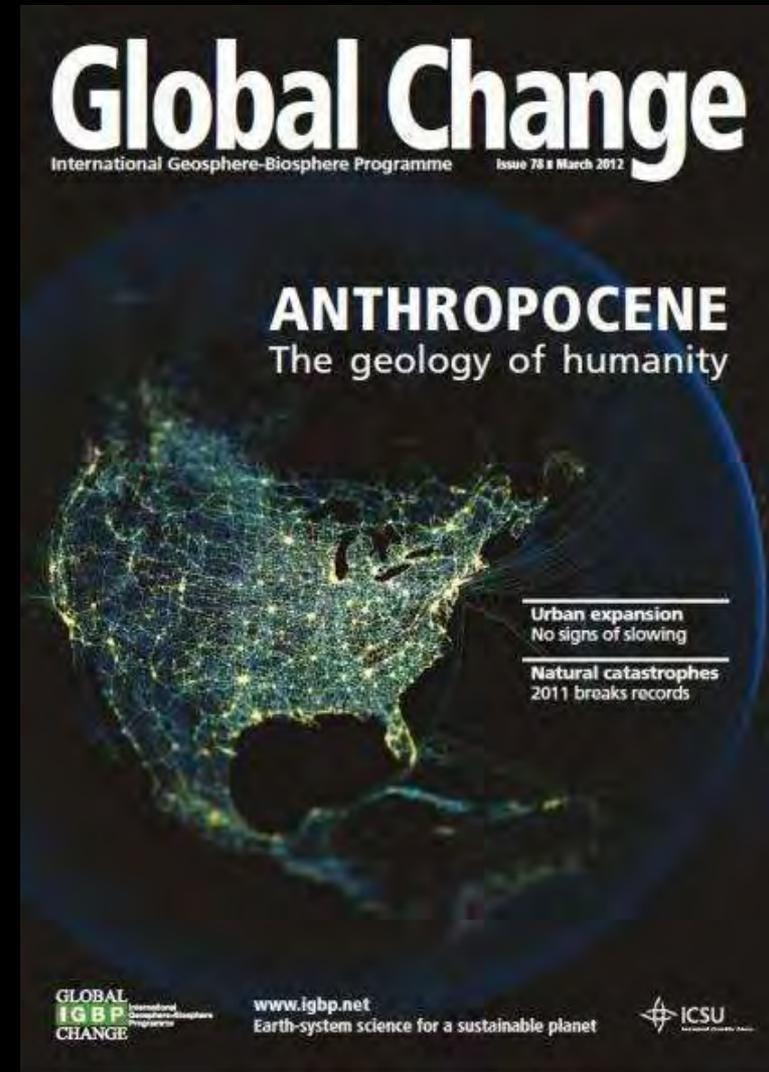
## Anthropocene – the Age of Humans

Nearly all humans live in anthropogenic landscapes, especially in urban, suburban and densely populated rural village landscapes.

Anthropogenic landscape transformation (land-use change) is one of the primary drivers of global changes in climate, biodiversity and biogeochemistry.

Ecological processes in anthropogenic landscapes differ profoundly from those of pristine and indirectly impacted ecosystems. These processes include species introduction and domestication, population management and harvest, the tillage transport and cover of soils by impervious structures, fossil fuel combustion, irrigation and the fertilization of ecosystems with nitrogen, phosphorus and other limiting nutrients.

Anthropogenic landscapes are highly fragmented fine-scale mosaics of managed and unmanaged landscape features with clearly defined boundaries such as buildings, roads, yards and agricultural plots.

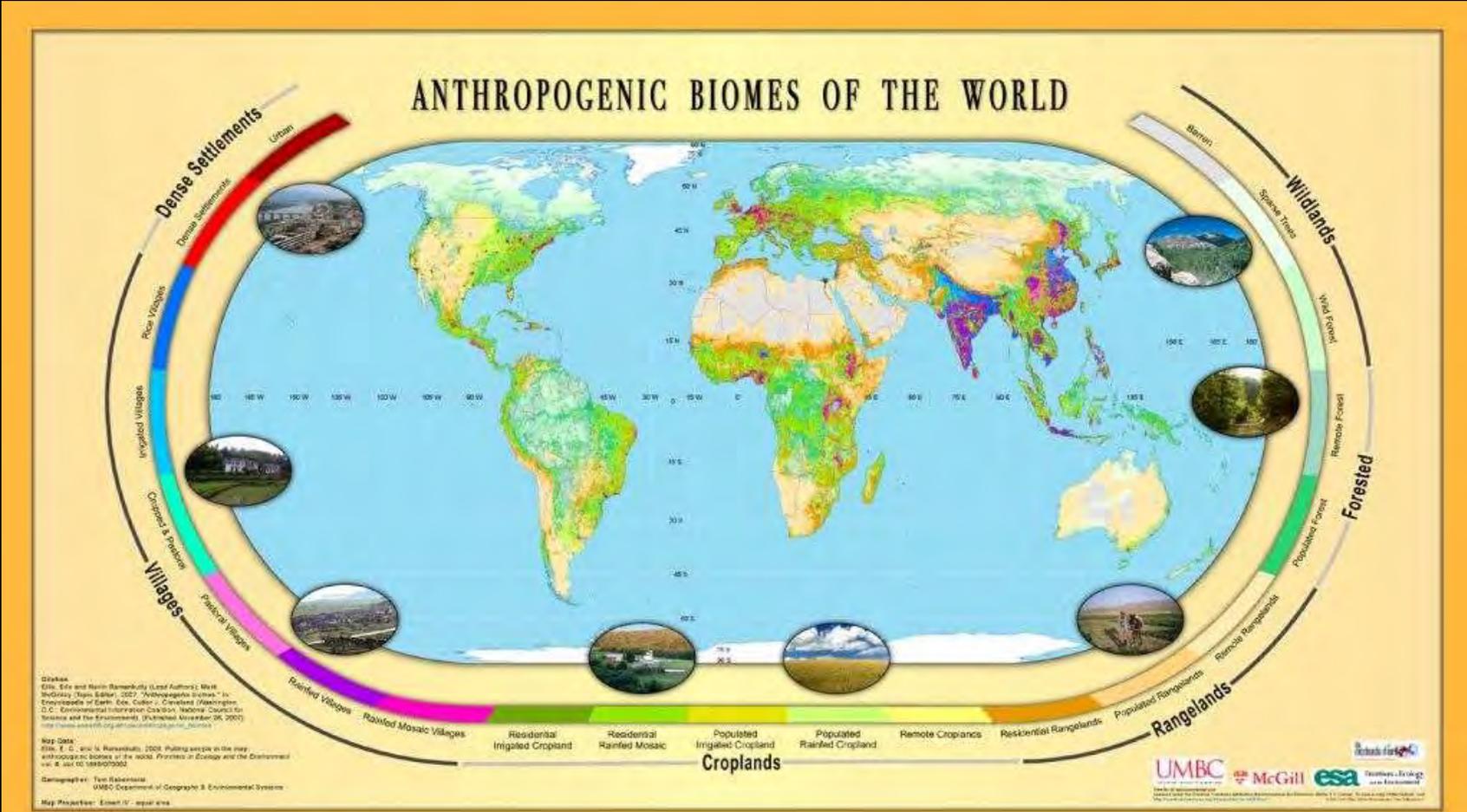


# Anthropogenic Landscapes, or "Human Landscapes"

<http://ecotope.org/> Dr. Erle Ellis

areas of Earth's terrestrial surface where direct human alteration of ecological patterns and processes is significant, ongoing, and directed toward servicing the needs of human populations for food, shelter and other resources and services including recreation and aesthetic needs.

Anthropogenic Biomes ("Anthromes"), describe the globally-significant types of anthropogenic landscapes.



## Human-Nature and the American Mind

“Anthropogenic biomes point to a necessary turnaround in ecological science and education, especially for North Americans.

Beginning with the first mention of ecology in school, the biosphere has long been depicted as being composed of natural biomes, perpetuating an outdated view of the world as ‘natural ecosystems with humans disturbing them’.

Anthropogenic biomes tell a completely different story, one of ‘human systems, with natural ecosystems embedded within them’. This is no minor change in the story we tell our children and each other. Yet it is necessary for sustainable management of the biosphere in the 21st century.” Erle Ellis





## New Nature - Novel Ecosystems

Assemblages of species in a given area that have not previously occurred.

Novel ecosystems are not under human management, but they are mostly the result of direct or indirect human activities.

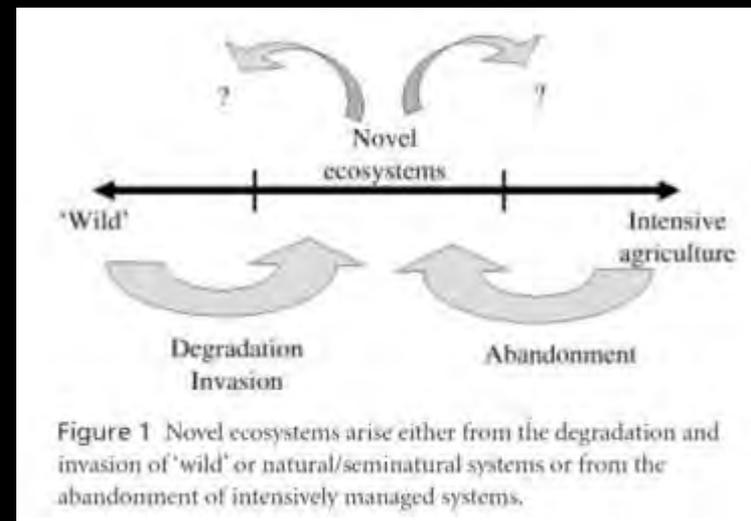
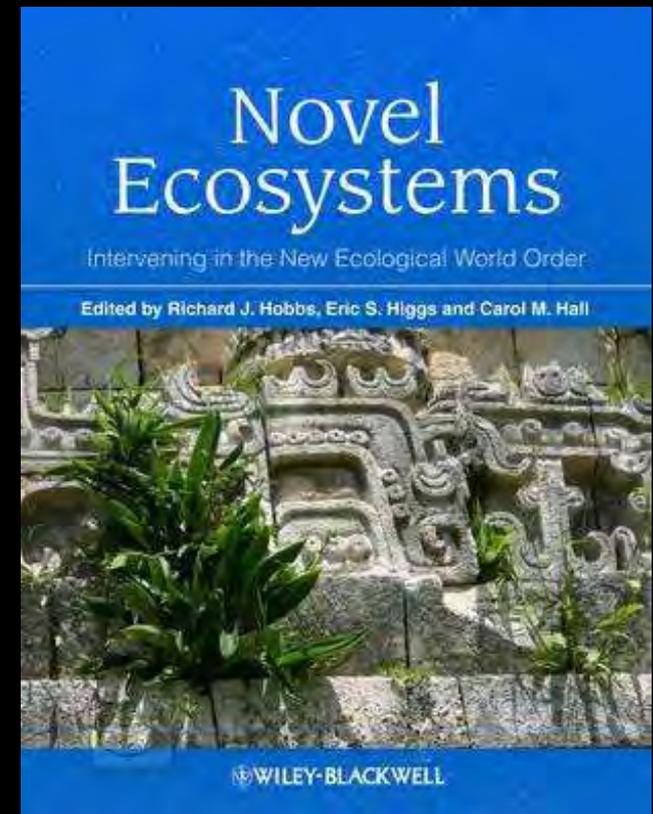
They lack natural analogs

Ecology (like evolution) has a strong historical dimension.

Pristine or near pristine ecosystems are historically and culturally important just like cathedrals and castles. Just like cathedrals and castles, they need to be preserved and restored as best they can.

Novel ecosystems are not really all that novel, except in their species composition.

We need to develop a new ecology that is not prejudiced by the human-nature dualism.



# A critique of the 'novel ecosystem' concept

Carolina Murcia<sup>1,2\*</sup>, James Aronson<sup>3,4\*</sup>, Gustavo H. Kattan<sup>5</sup>, David Moreno-Mateos<sup>3</sup>, Kingsley Dixon<sup>6,7</sup>, and Daniel Simberloff<sup>8</sup>

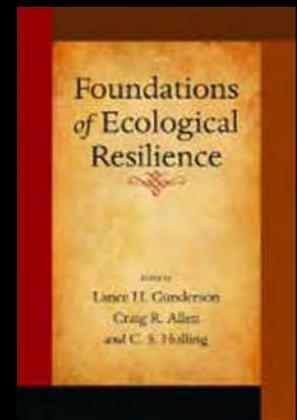
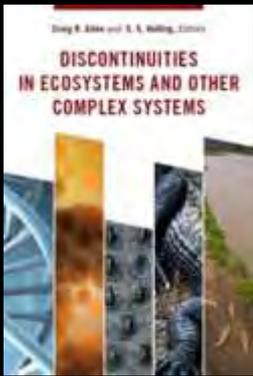
Trends in Ecology & Evolution xx (2014) 1–6

The 'novel ecosystem' concept has captured the attention of scientists, managers, and science journalists, and more recently of policymakers, before it has been subjected to the scrutiny and empirical validation inherent to science. Lack of rigorous scrutiny can lead to undesirable outcomes in ecosystem management, environmental law, and policy. Contrary to the contentions of its proponents, no explicit, irreversible ecological thresholds allow distinctions between 'novel ecosystems' and 'hybrid' or 'historic' ones. Further, there is no clear message as to what practitioners should do with a 'novel ecosystem'. In addition, ecosystems of many types are being conserved, or restored to trajectories within historical ranges of variation, despite severe degradation that could have led to their being pronounced 'novel'.

# New Myth of Nature

## Novel Ecosystems and Resilience Ecology

Holling, C.S. (1973). "Resilience and stability of ecological systems"



2005



2007



2009



2012

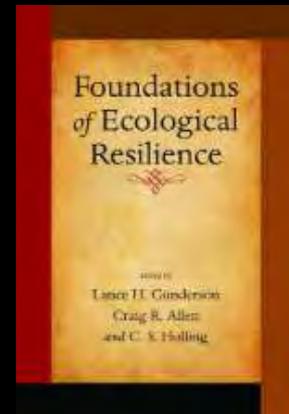
# Resilience and Adaptive Management

...the ability to absorb disturbances, to be changed and then to reorganize and still have the same identity (retain the same basic structure and ways of functioning).

As resilience declines the magnitude of a shock from which an ecosystem cannot recover gets smaller and smaller.

Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes.

A resilient ecosystem can withstand shocks and rebuild itself when necessary.



"Resilience" as applied to ecosystems has three defining characteristics:

- The amount of change the system can undergo and still retain the same controls on function and structure
- The degree to which the system is capable of self-organization
- The ability to build and increase the capacity for learning and adaptation

# Adaptive Cycle

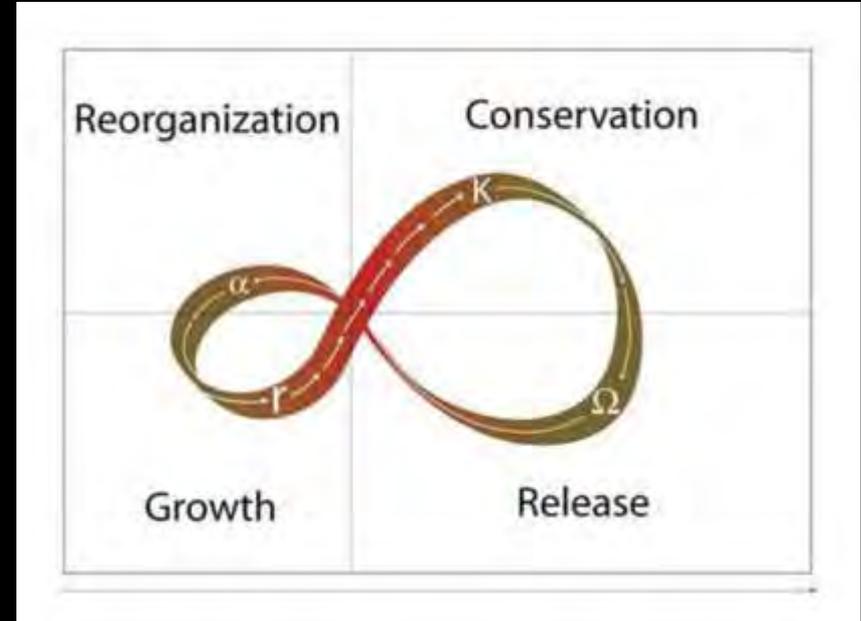
An adaptive cycle that alternates between long periods of aggregation and transformation of resources and shorter periods that create opportunities for innovation, is a fundamental unit for understanding complex systems from cells to ecosystems.

Growth - where species and systems grow and diversify to exploit new opportunities and develop entirely new ecological ways of being.

Conservation - where climax species are tightly connected and organized, and systems stabilize into mature, often hierarchically nested systems, where there is little or no room for innovation or growth.

Release (the “backside” of the mobius strip) - where mature systems destabilize and collapse, and become increasingly discontinuous and chaotic which opens the field for...

Reorganization – where systems return in completely new ways, which creates a new field of conditions and possibilities for the next growth phase



# Adaptive Cycle

An adaptive cycle that alternates between long periods of aggregation and transformation of resources and shorter periods that create opportunities for innovation, is a fundamental unit for understanding complex systems from cells to ecosystems.

# Adaptive Capacity

Systems with high adaptive capacity are able to re-configure themselves without significant declines in crucial functions in relation to primary productivity, nutrient and hydrological cycles.

A consequence of a loss of resilience, and therefore of adaptive capacity, is loss of opportunity, constrained options during periods of reorganization and renewal, an inability of the system to do different things.

And so the effect of the loss of resilience is for the social-ecological system to emerge from such a period along an undesirable trajectory.

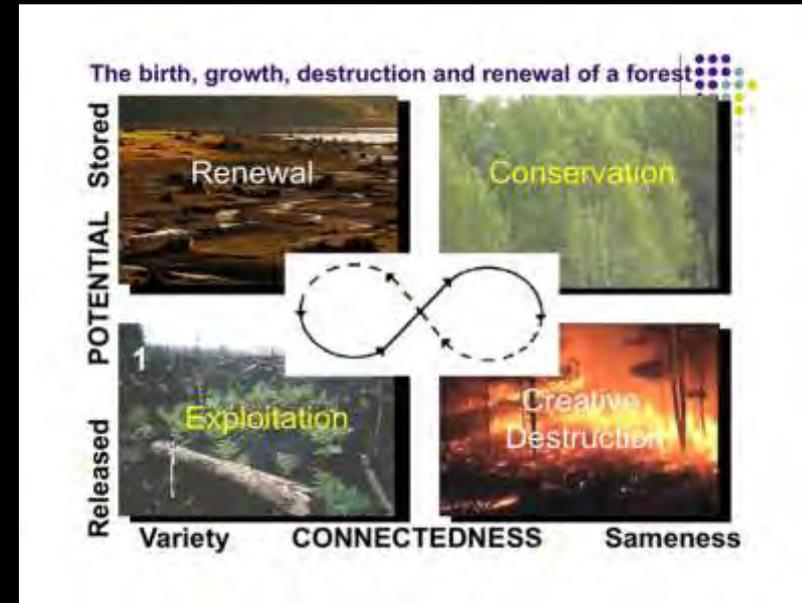
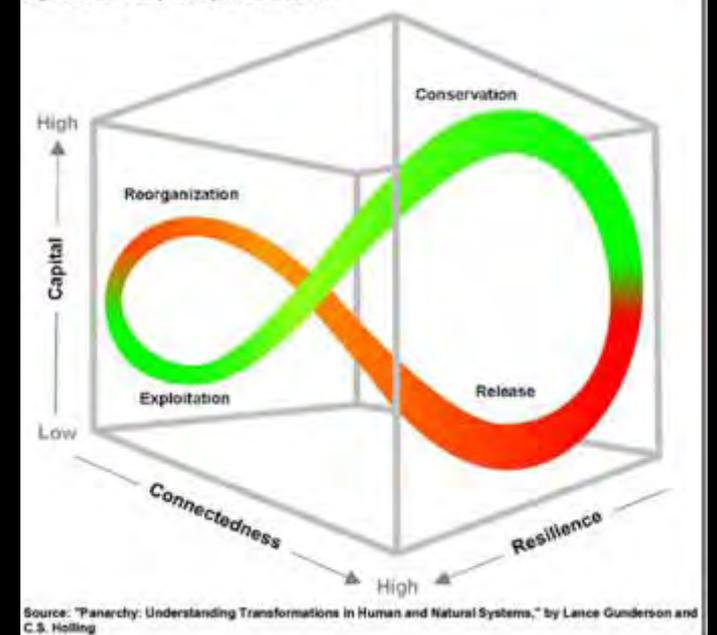


Figure 2. The Adaptive Cycle of Renewal



# Resilience, Environmental Science, and Socio-Ecological Systems

We define resilience, formally, as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks - and therefore the same identity.

The basic concepts are:

- non-linearity, alternate regimes and thresholds
- adaptive cycles
- multiple scales and cross-scale effects - "panarchy"
- adaptability
- transformability
- general versus specified resilience



<http://www.resalliance.org>



*research on resilience in social-ecological systems -  
a basis for sustainability*

