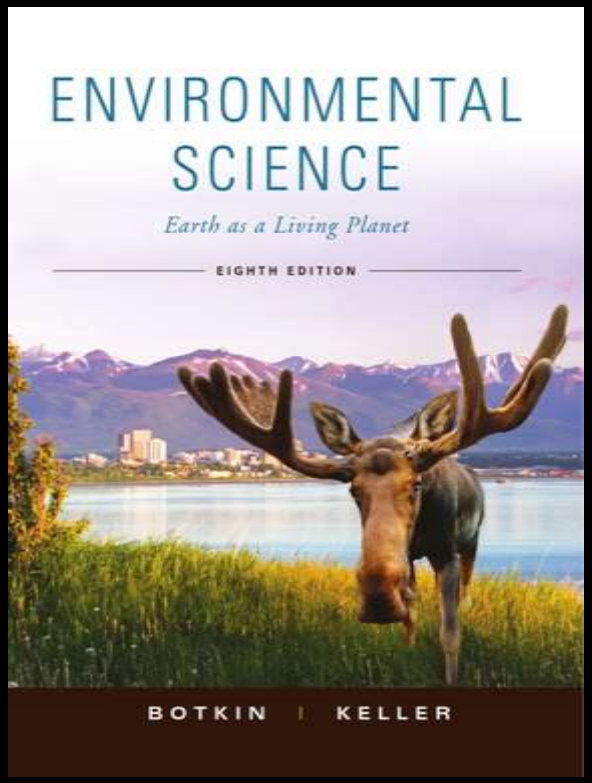
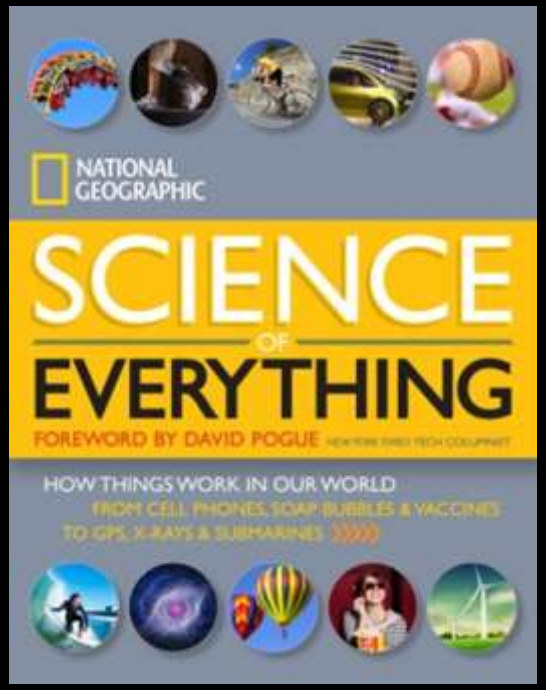
The Earth Managers: Balance, Resilience, and Environmental Science

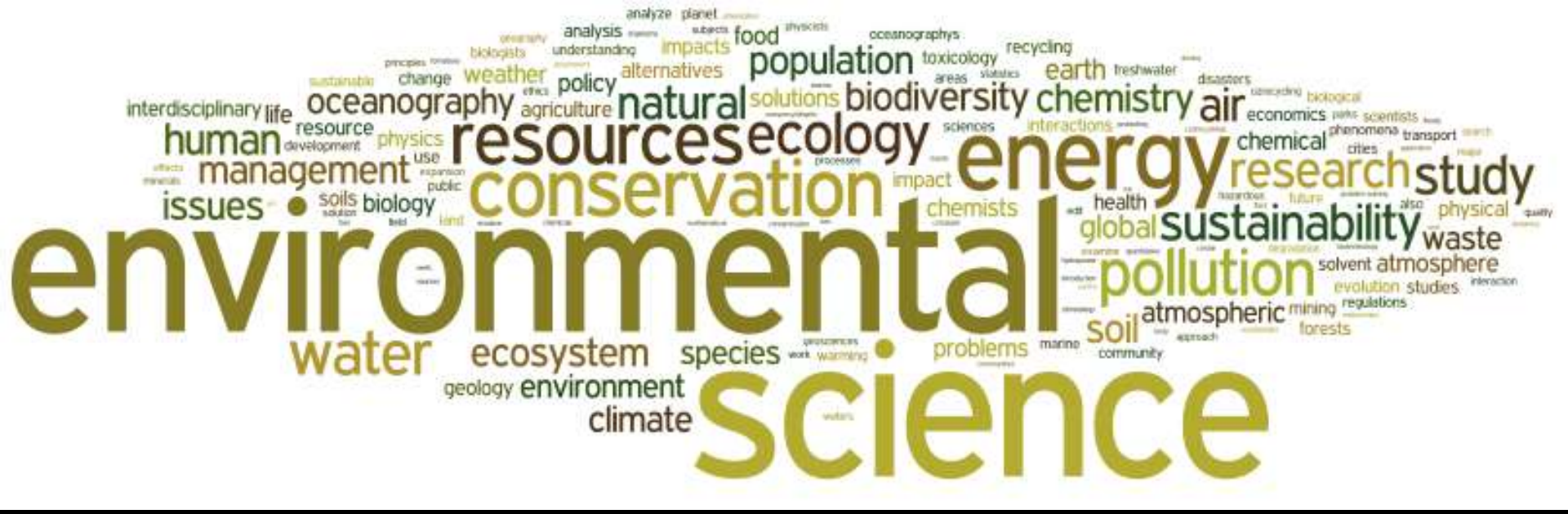
Kevin M. Anderson Ph.D.
Austin Water Center for Environmental Research





ResilienceAlliance

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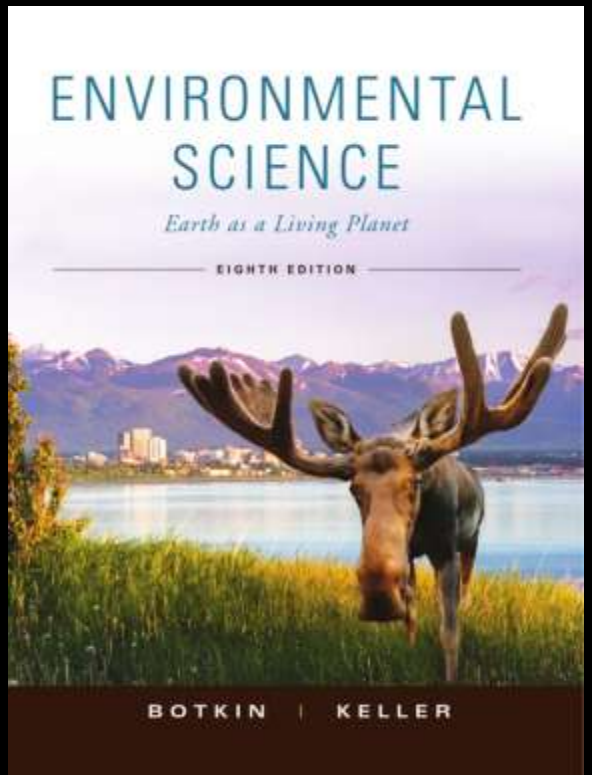
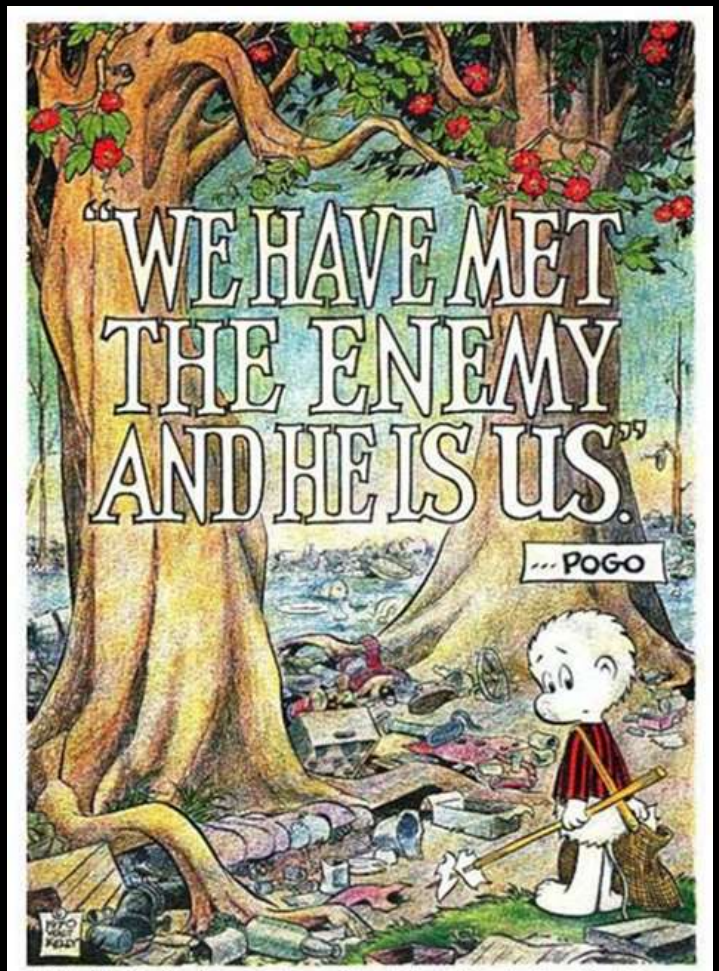
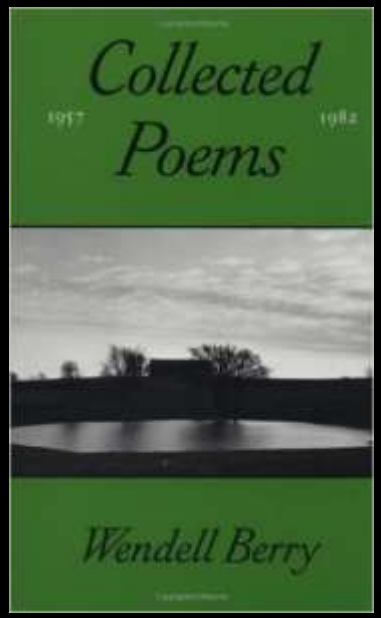

ENVIRONMENTAL
SCIENCE
Earth as a Living Planet
EIGHTH EDITION
BOTKIN | KELLER



Walt Kelly's poster for the first Earth Day

The Peace of Wild Things
Wendell Berry

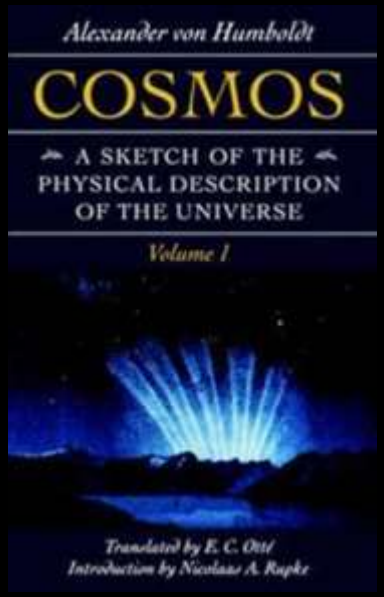
When despair grows in me
and I wake in the middle of the night at the least sound
in fear of what my life and my children's lives may be,
I go and lie down where the wood drake
rests in his beauty on the water, and the great heron feeds.
I come into the peace of wild things
who do not tax their lives with forethought
of grief. I come into the presence of still water.
And I feel above me the day-blind stars
waiting for their light. For a time
I rest in the grace of the world, and am free.



The Consolation of Nature

The earnest and solemn thoughts
awakened by a communion with Nature
intuitively arise from
a presentiment of the order and harmony
pervading the whole universe,
and from the contrast we draw
between the narrow limits of our own existence
and the image of infinity revealed on every side,
whether we look upward to the starry vault of heaven,
scan the far-stretching plain before us,
or seek to trace the dim horizon
across the vast expanse of ocean.

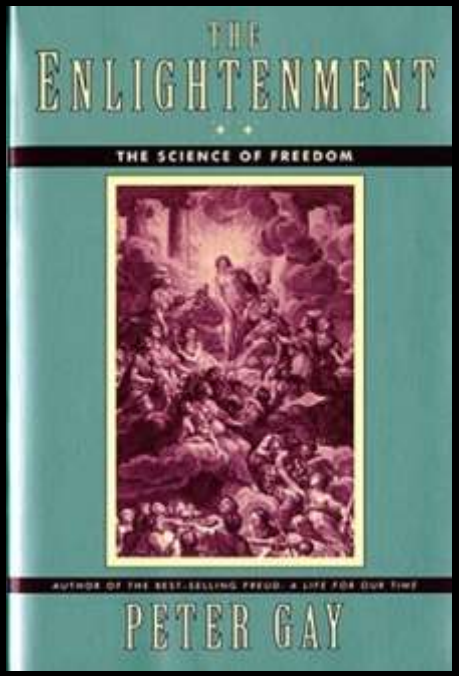
Cosmos 1:3



Alexander von Humboldt 1769-1859

The Enlightenment 1687-1800

- Revolutions in science, philosophy, and society swept away the medieval world-view
- Ideals of freedom and equality for all, founded, ostensibly, upon principles of human reason
- Culminates historically in the political upheaval of the French Revolution 1789-99, in which the traditional hierarchical political and social orders were overthrown



A Life of Political and Social Turmoil

1769 Born in Berlin – same year as Napoleon Bonaparte

1769-1799 American Revolution, French Revolution – Prussia ruled by Frederick the Great - Industrial Revolution

1800-1815 Napoleonic Era, Four Powers (Austria, Russia, Prussia, Britain)

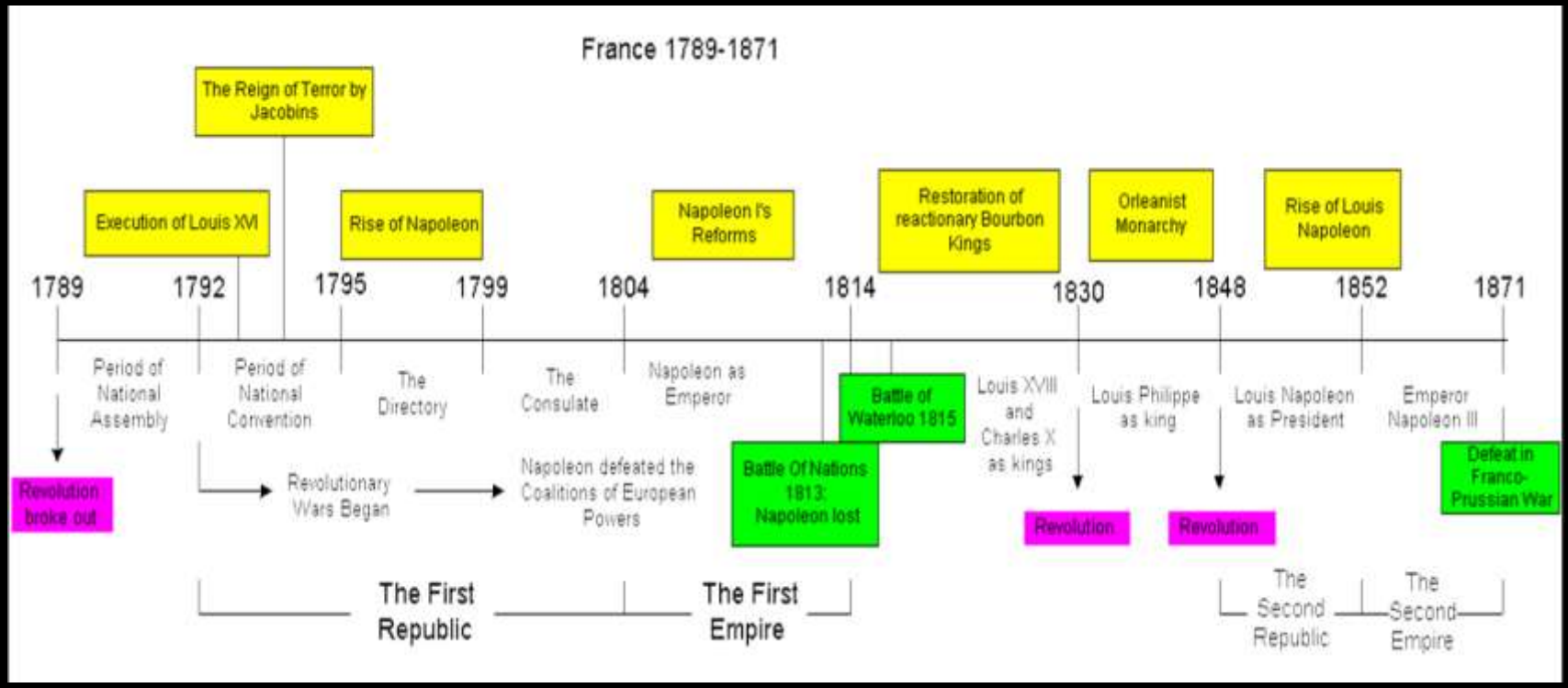
1808-1830 Simón Bolívar and War for Latin American Independence

1815-1840 Return of French Monarchy – Ultra-Royalist Revenge – 1830 Revolution crushed

1848 European Revolutions (Crushed or Compromised), Publication of *Communist Manifesto*

1852 Second French Empire

1859 Dies in Berlin the most famous "scientist" in the world but marginalized politically in Europe



“the sole survivor of an extinct race”

1805-1826	Lives in Paris – Scientific Center of the World
1827	Forced to return to Berlin
1829	Russian Expedition
1829	Brother Wilhelm’s wife, Caroline, dies
1835	His brother Wilhelm dies
1845	*Kosmos* Vol. 1 published
1859	Humboldt dies in Berlin
1862	Last volume of *Kosmos* published

Humboldt was a dissident who spoke out, loudly and persistently, against European imperialism and American slavery, and he was both honored and condemned as a dangerous man.

Popular adulation, professional reputation, and his dense network of high-placed friends protected him to some extent from Napoleon’s charges of espionage and, later, the insinuations of his enemies at the Berlin court.

He was increasingly muzzled during the reactionary years which saw European monarchies put down the Revolutions of 1830 and 1848. In both Paris and Berlin, his mail was routinely opened and his apartments periodically searched.

He withdrew into science, philosophy, and poetry, repressing and even destroying his writings of social protest.

In a letter to a friend 1849 -

“Like the bird perched above the foaming cataract, of which you have so sweetly sung – the last of the Atures – so am I now left the sole survivor of an extinct race.”

1831

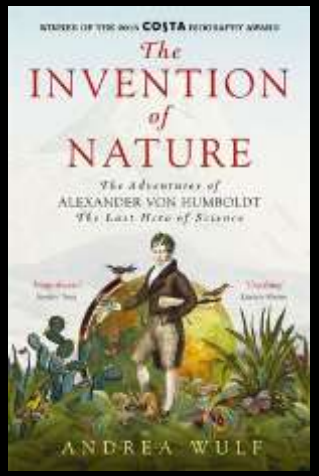
1855

“I am sad to say that at the age of eighty I am reduced to the banal hope that the noble and ardent desire for free institutions is maintained in the people and that, though from time to time it may appear to sleep, it is as eternal as the electromagnetic storm which sparkles in the sun.”

“’Nature is the domain of liberty,’ Humboldt said, because nature’s balance was created by diversity which might in turn be taken as a blueprint for political and moral truth. Everything, from the most unassuming moss or insect to elephants or towering oak trees, had its role, and together they made the whole. Humankind was just one small part.

Nature itself was a republic of freedom.”

Wulf *Invention of Nature*



Humboldtian Science - “Nature is the domain of liberty”

Cosmos: A Sketch of the Physical Description of the Universe

Humboldt’s five-volume opus Cosmos (1845-1862)

Cosmos “is the assemblage of all things in heaven and earth, the universality of created things constituting the perceptible world.”

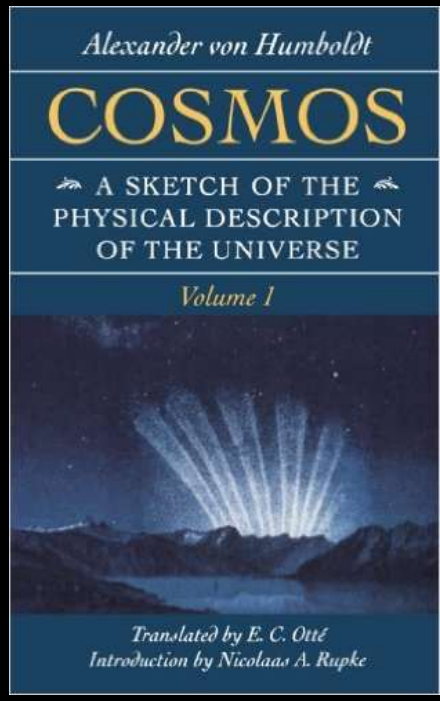
Cosmos signifies both the “order of the world, and adornment of this universal order.” Thus, there are two aspects of the Cosmos, the “order” and the “adornment.” To Humboldt, Cosmos is both ordered and beautiful through the human mind.

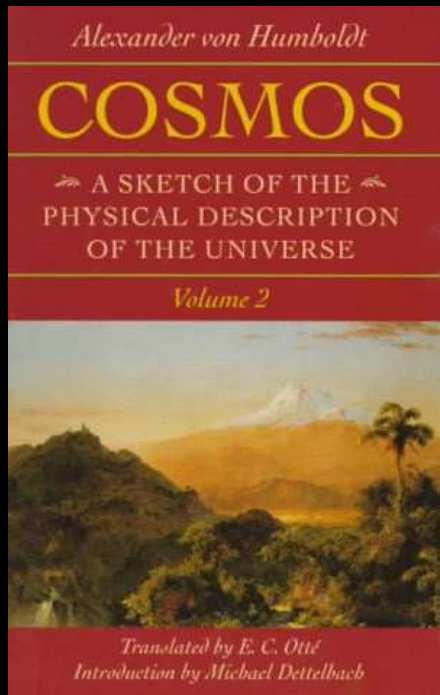
Cosmos was the scientific bestseller of the age. In 1845, the first edition of the first volume sold out in two months; by 1851, Humboldt estimated that eighty thousand copies had been shipped.

Humboldt’s aesthetic science has a deep moral and political direction

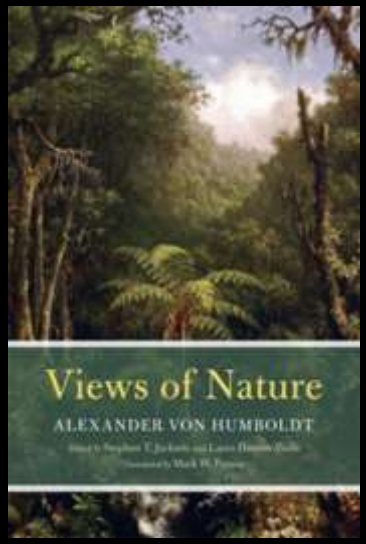
His narrative of the Cosmos becomes a narrative of the advances and setbacks experienced across history by this “powerful progressive movement” which “elevates and animates cosmical life,” for despotic governments, though they may prevail temporarily, must finally give way to liberty, equality, and the “fraternity” of humankind (*Cosmos* II: 199).

Humboldt blended an Enlightenment-derived certainty in the agency of reason, factuality, and precision with a Romantic’s enthusiasm for feeling and poetry.





“Nature is the domain of liberty”

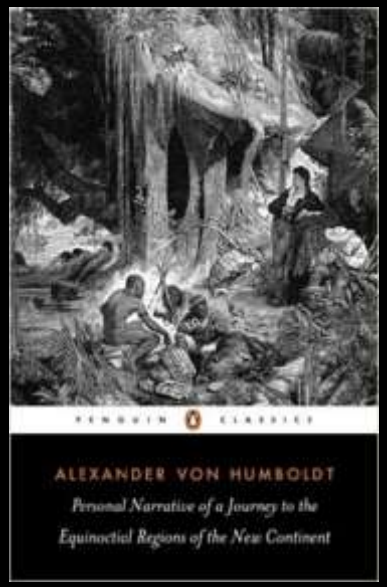


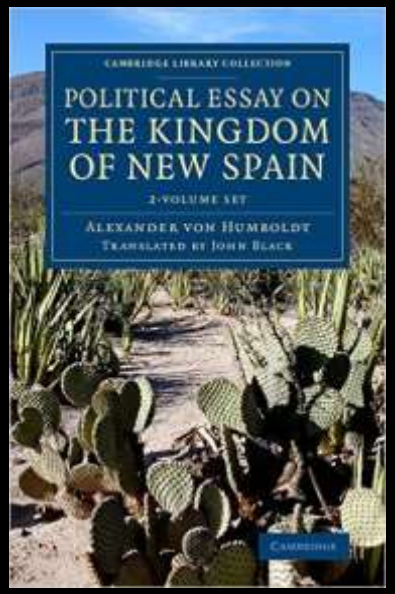
Views of Nature – Nature offers not only deep insights about the Cosmos but also solace and sanctuary from human failings without erasing humanity -

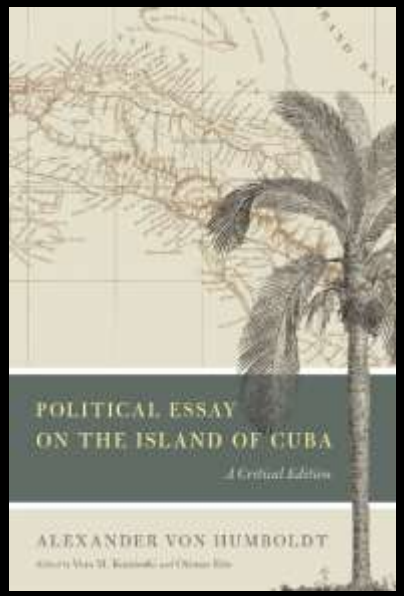
Political Essays – Vehemently anti-slavery, anti-racism – unity of human species
“All are alike designed for freedom”

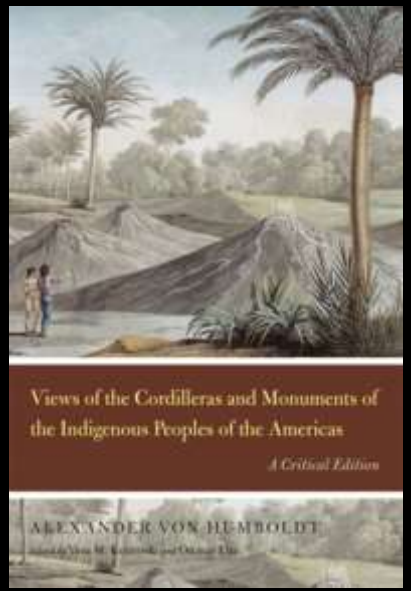
- Cultural Diversity – Celebrates the accomplishments of non-European cultures
- Internationalist – Science as a bridge between nations and cultures, and a means to promote understanding and peace

“The principle of individual and political freedom is implanted in the ineradicable conviction of the equal rights of one sole human race. Thus...mankind presents itself to our contemplation as one great fraternity and as one independent unity, striving for the attainment of one aim – the free development of moral vigor.”









Humboldtian Science – Science of Dynamic Change – “One fair harmonious whole”

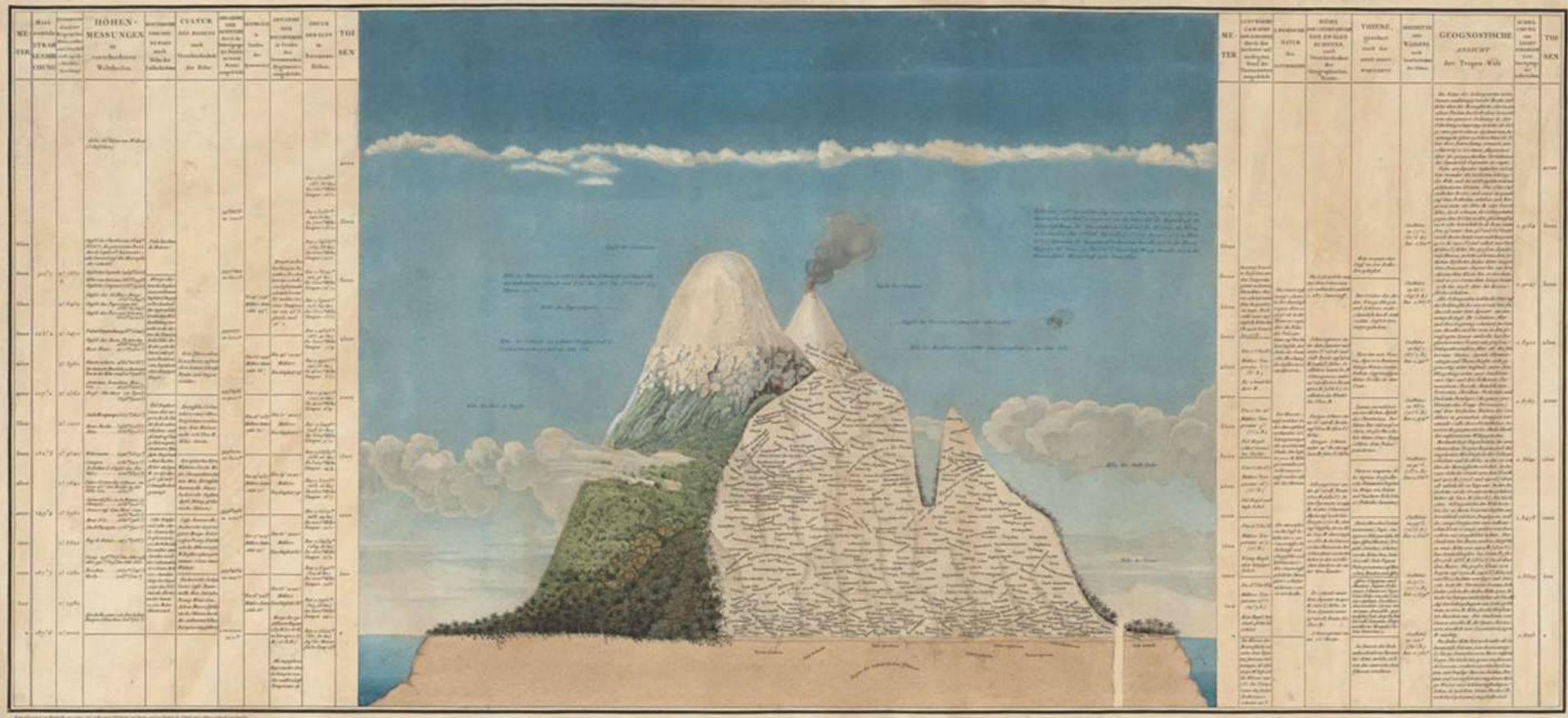
A Vision of the Harmony of Nature and Society
“Cosmos” referred to the universe as a “harmoniously ordered whole”

One concept that is central to Humboldtian science is that of a general equilibrium of forces amidst change.

Not balance and stability, but dynamic change

“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.”

“to recognize unity in the vast diversity of phenomena, and by the exercise of thought and the combination of observations, to discern the constancy of phenomena in the midst of apparent changes.”



Geographie der Pflanzen in den Tropen-Ländern;

ein Naturgemälde der Anden,

gegründet auf Beobachtungen und Messungen, welche vom 10ten Grade nördlicher bis zum 10ten Grade südlicher Breite angestellt worden sind, in den Jahren 1799 bis 1803.

von ALEXANDER VON HUMBOLDT und A. G. BONPLAND.

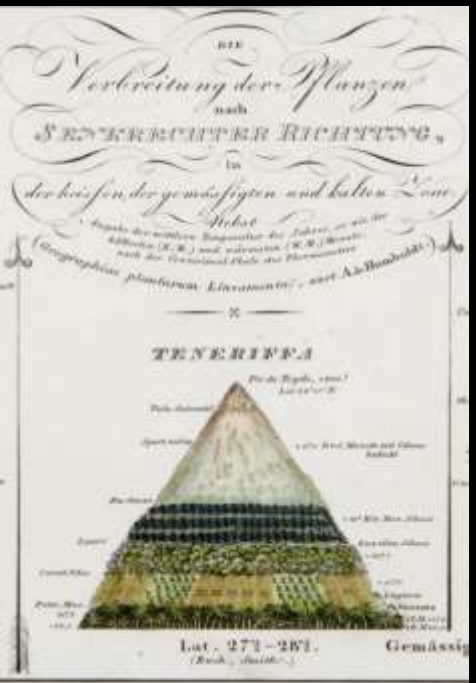
He created a dynamic picture of the universe that would continually grow and change as human conceptions of nature and the depth of human feeling about nature enlarge and deepen.

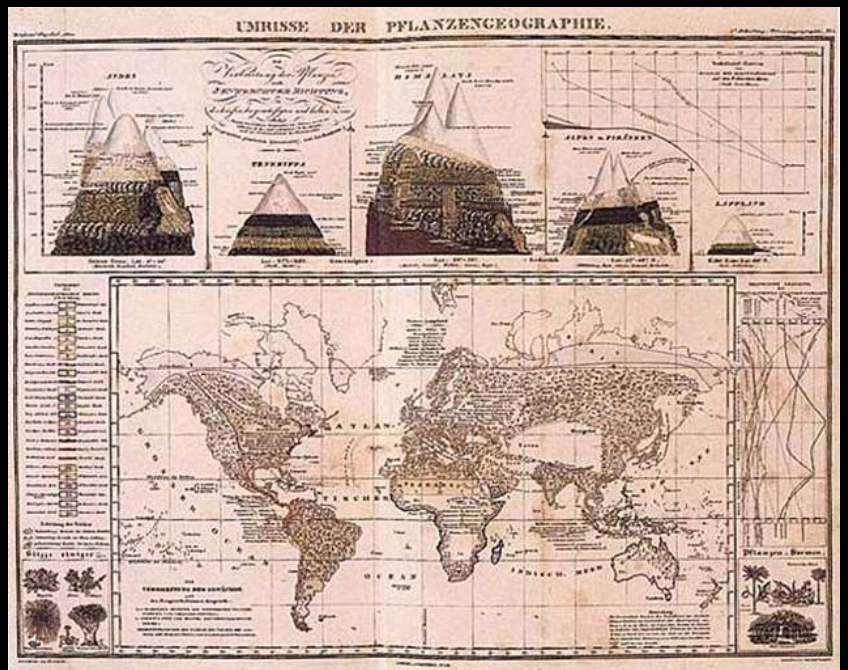
The Invention of Environmental Science

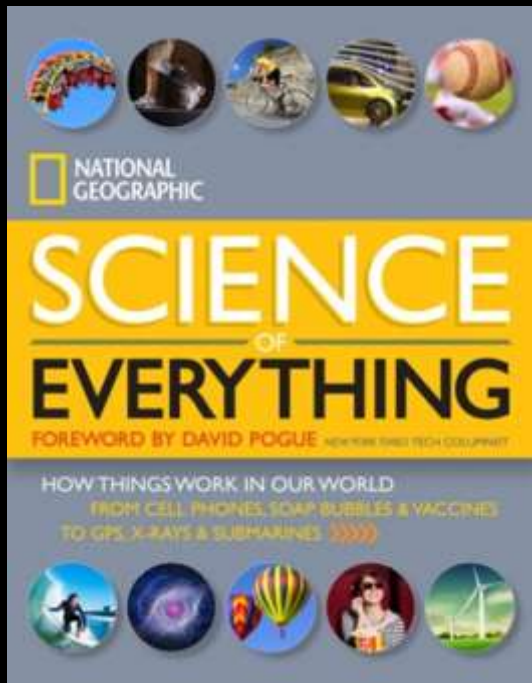
Humboldtian Physical Geography – An Environmental Science of a Systematic Dynamic Universe

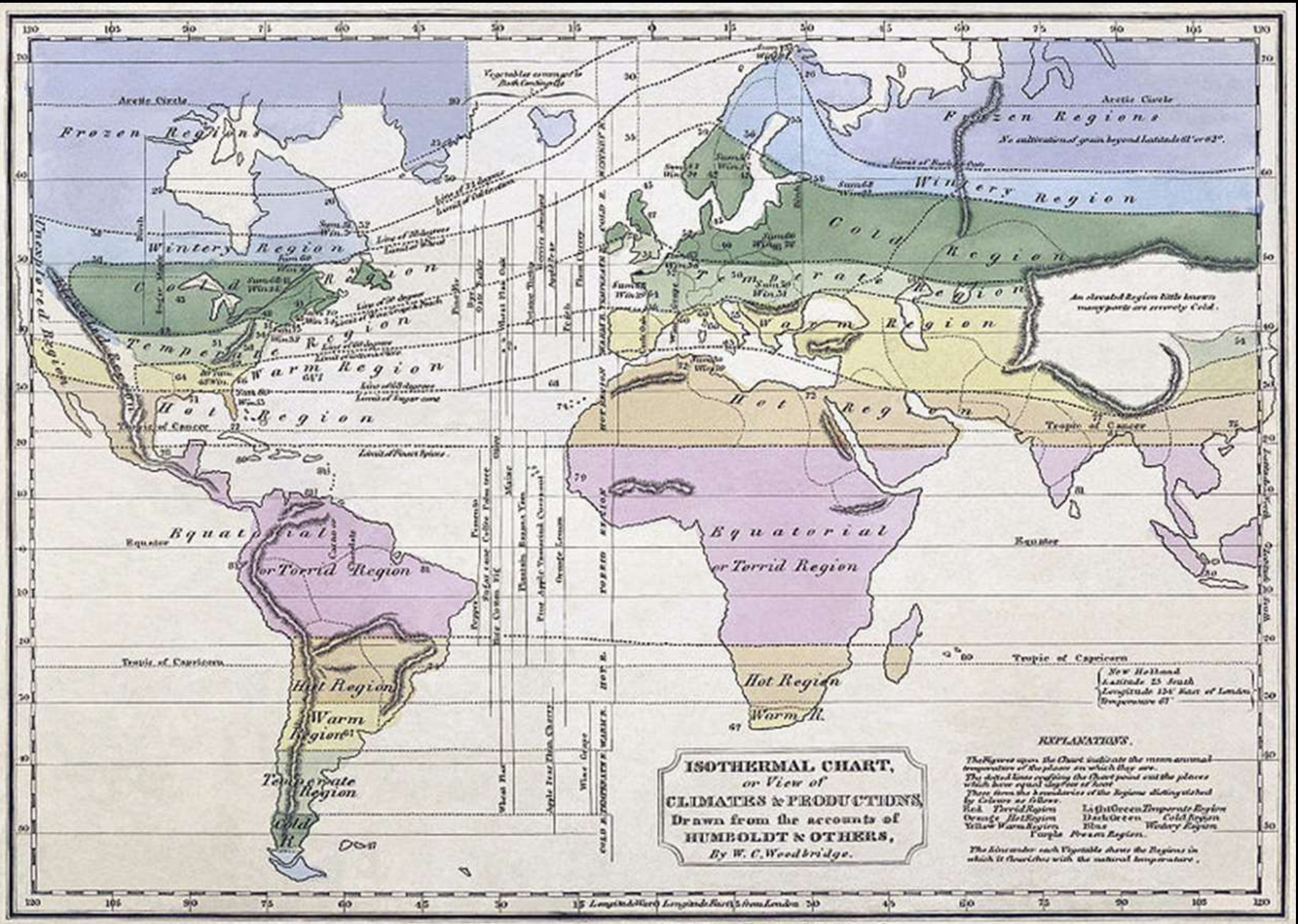
"the accurate measured study of widespread but interconnected real phenomena in order to find a definite law and a dynamic cause"

1. The Systematic Universe – Everything is connected
2. Nature - an inseparable organic whole, all parts of which were mutually interdependent, including humans.
3. Interconnections not just particulars - though he began first with particulars and moved towards generalizations, his objective was never simply to measure one kind of phenomenon in nature.
4. "In this great chain of cause and effects, no single fact can be considered in isolation"
5. Instead, his aim was to illustrate the manner in which the many phenomena of nature interact with each other at different places on the earth. Thus, he firmly believed that only by understanding the interconnections of phenomena could you evaluate any one of them.









Human Impacts on the Environment

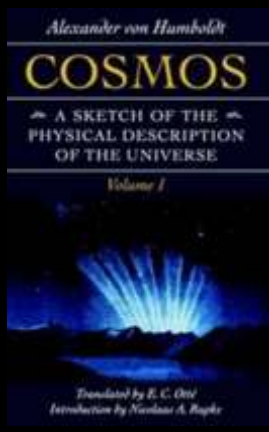
In his book *Central Asia*, Humboldt listed three ways in which the human species was even then affecting the climate:

"Through the destructions of forests, through the distribution of water (irrigation and drainage), and through the production of great masses of steam and gas at the industrial centers."

"The wants and restless activity of large communities of men gradually despoil the face of the Earth."

- Humans are part of nature
- Nature/Cosmos is bigger than us
- Most human impacts are unintended consequences
- Limits of human understanding of nature should encourage caution

Humboldt said it was the duty of scientists to examine the changeable elements in the "economy of nature" to understand human impacts.



Carrying Capacity and the Struggle for Existence

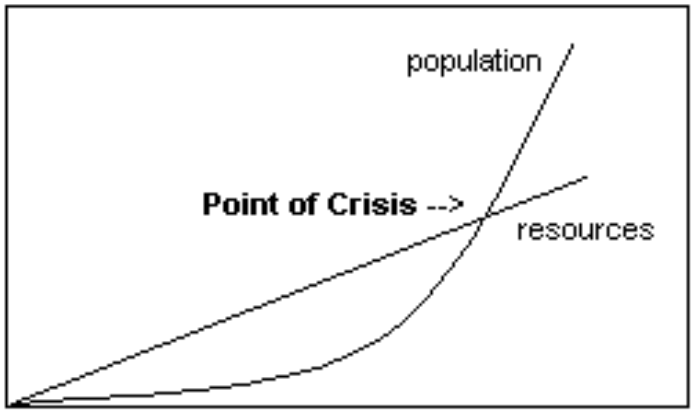
Thomas Malthus (1766-1834)

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."

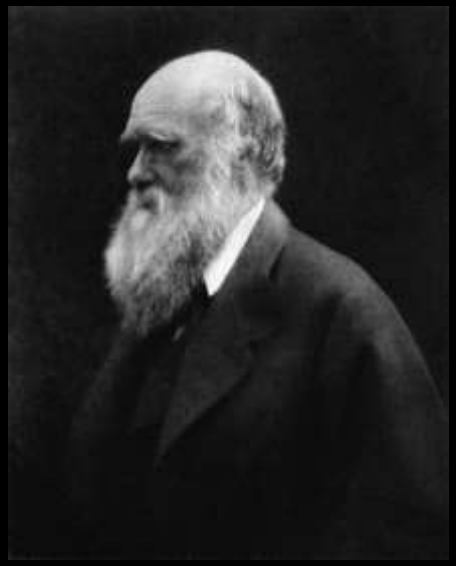
Darwin, *Origin of the Species* – "I should premise that I sue the term Struggle for Existence in a large and metaphorical sense including dependence of one being on another and including (which is more important) not only the life of the individuals, but success in leaving progeny"



Malthus' Basic Theory

Evolution and the Economy of Nature

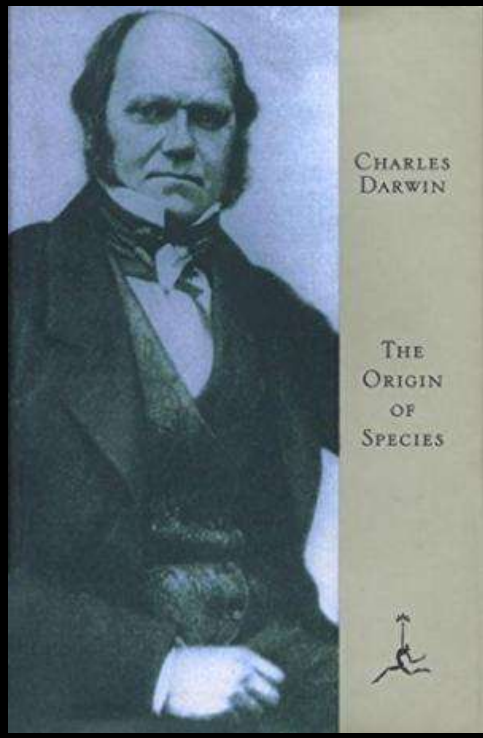
Charles Darwin 1809-1882



He established that all species of life have descended over time from common ancestry, and proposed the scientific theory that this branching pattern of evolution resulted from a process that he called natural selection in *On the Origin of the Species* (1859).

Darwin claims in the Origin that "all organic beings are striving, it may be said, to seize on each place in the economy of nature."

What was also new with Darwin is that the economy of nature began to be understood with conceptual tools borrowed from political economy. The division of labor, competition (“struggle” in Darwin’s words), trading, cost, the accumulation of innovations, the emergence of complex order from unintentional individual actions, the scarcity of resources and the geometric growth of populations are ideas borrowed from Adam Smith, Thomas Malthus, David Hume and other founders of modern economics.

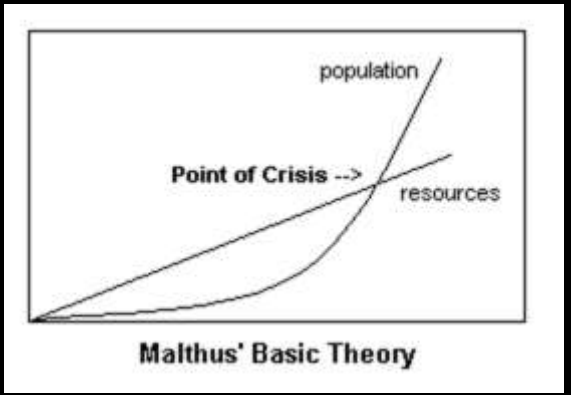


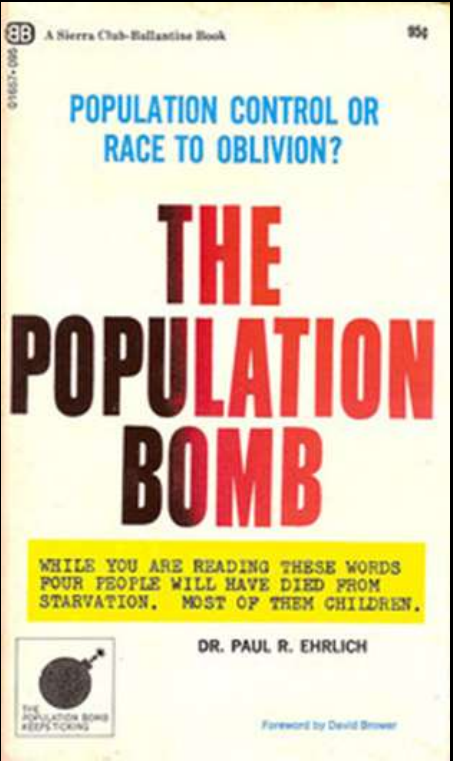
Population

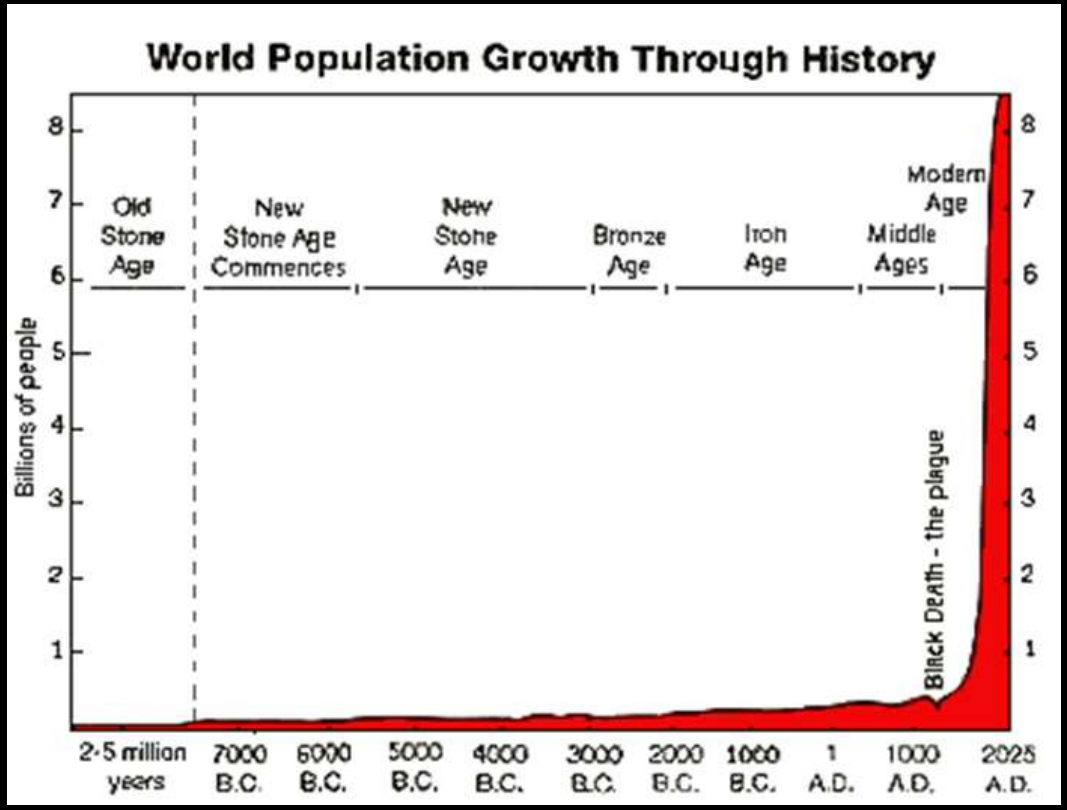
Paul Ehrlich b.1932

The Population Bomb 1968

Population Control – Neo-Malthusians





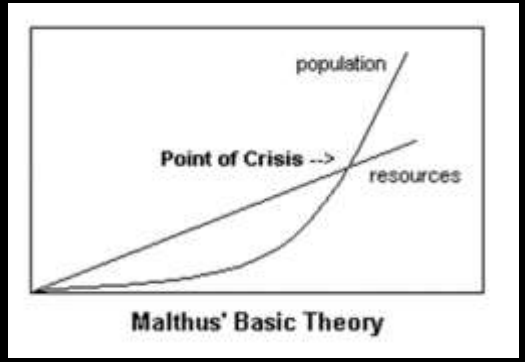


The Commons and Population

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.

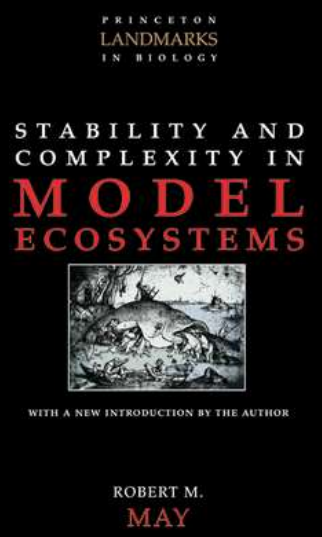


The “new ecology” post-Odum

No inherent stability

Robert May, *Stability and Complexity in Model Ecosystems* (1973)

- Mathematical models demonstrate that the more species there were, the more fragile was the system
- Chaos theory and complexity, “Confronted with disturbances beyond their normal experience” complex systems like rainforests tended to crumple.



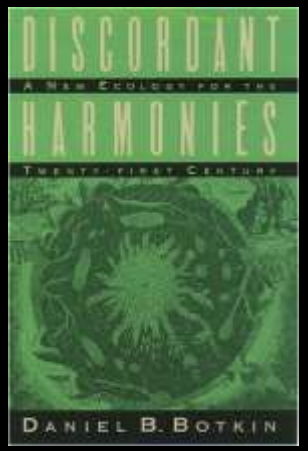
Instability of biodiversity and invasion biology

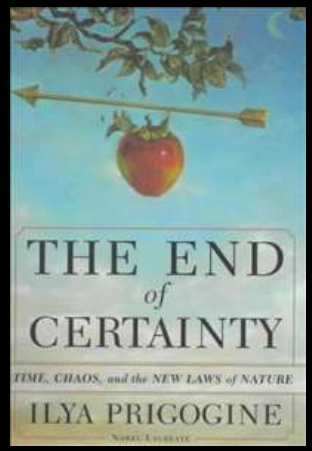
Daniel Botkin, *Discordant Harmonies: A New Ecology for the Twenty-first Century* (1990)

The new ecology emphasizes

- Disequilibria
- Instability
- Chaotic fluctuations

in ecosystems both “natural” and human impacted





If 20th-century ecology was marked by an infatuation with balance, then our era is one of disturbance, disruption, non-equilibrium, chaos, and randomness.

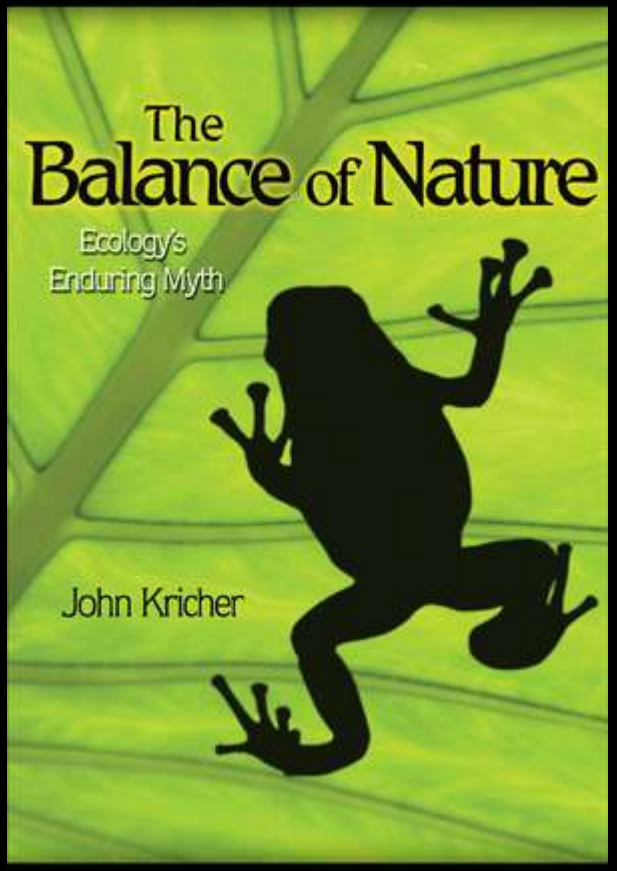
"The existence of a balance of nature has been a dominant part of Western philosophy since before Aristotle.

But the science of ecology and evolutionary biology together demonstrate that there is no balance of nature—not today and not at anytime in Earth's long history.

The paradigm is based on belief, not data; it has no scientific merit.

Nature is constantly in flux varying in scales of space and time, and most of that flux is due entirely to natural causes. At this time of extraordinary human influence on Earth's ecosystems and biota, I argue that it is essential for humanity to understand how evolution occurs and why ecology is far more dynamic than static."

Nothing Endures But Change
Heraclitus 540-480BC



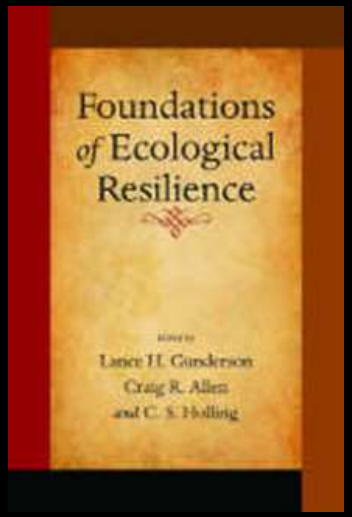
The New Ecology of Change - Ecological Resilience

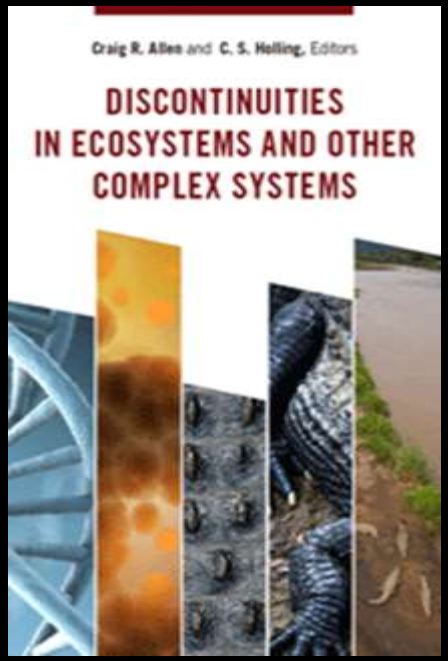
The general meaning of resilience, derived from its Latin roots 'to jump or leap back', is the ability to recover from or adjust easily to misfortune or change.

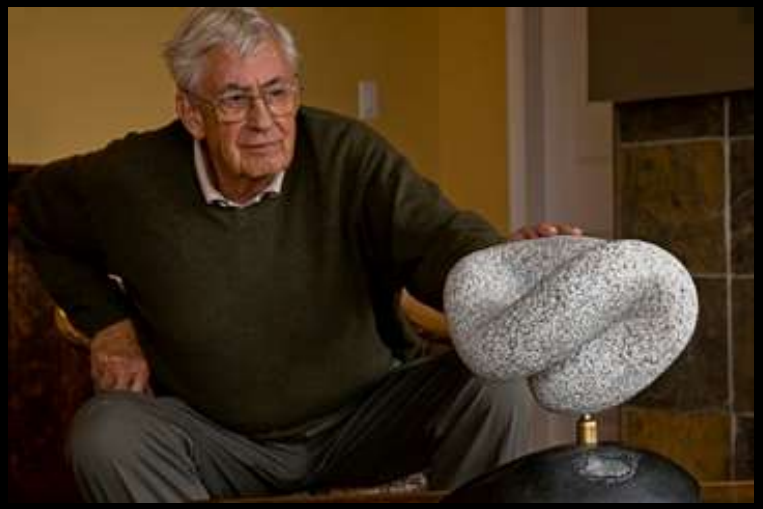
The concept of resilience in ecological systems was first introduced by the Canadian ecologist C.S. Holling in order to describe the persistence of natural systems in the face of changes in ecosystem variables due to natural or anthropogenic causes.

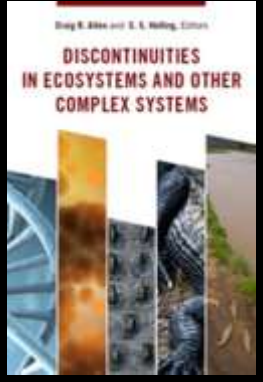
Holling argued that complex adaptive systems did not tend toward equilibria, but toward maximizing diversity over deeper evolutionary time.

Holling, C.S. (1973). "Resilience and stability of ecological systems". Annual Review of Ecology and Systematics 4: 1–23.

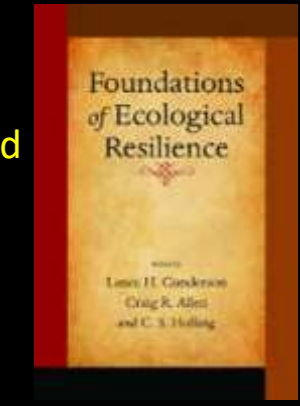








Resilience is...



…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.

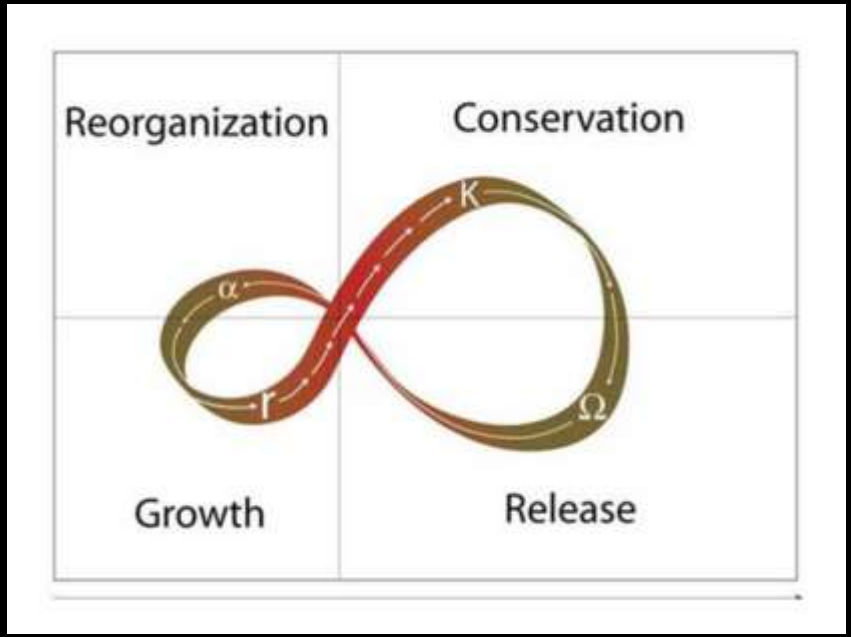
Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes.

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

2005 2007 2009 2012

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…

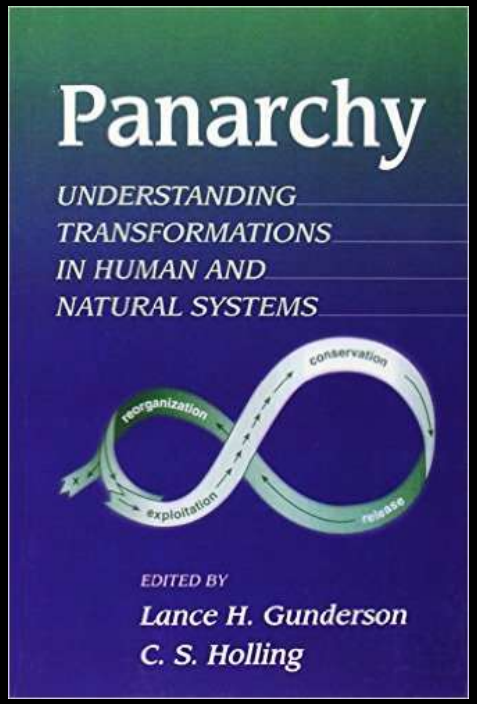
Reorganization – where systems return in completely new ways, which creates a new field of conditions and possibilities for the next growth phase

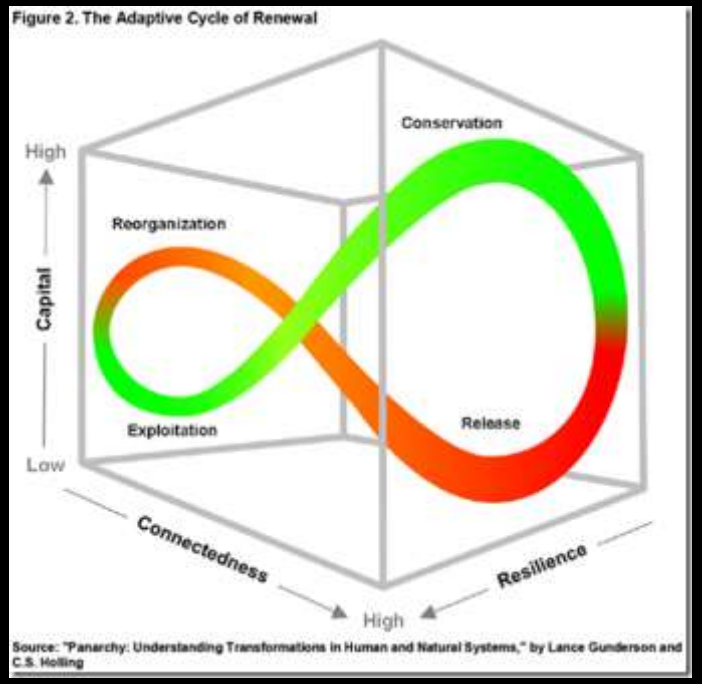
Adaptive Capacity and Social-Ecological Systems

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





Earth Managers

Resilience, Environmental Science, and Managing 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

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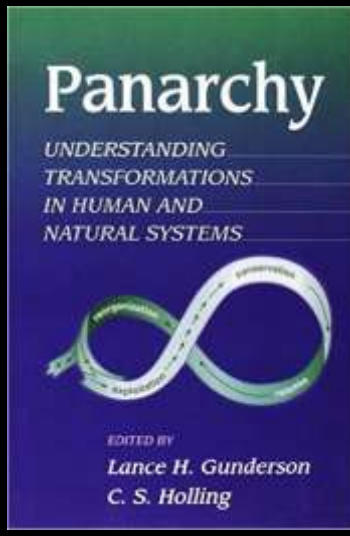


Resilience Alliance
research on resilience in social-ecological systems - a basis for sustainability

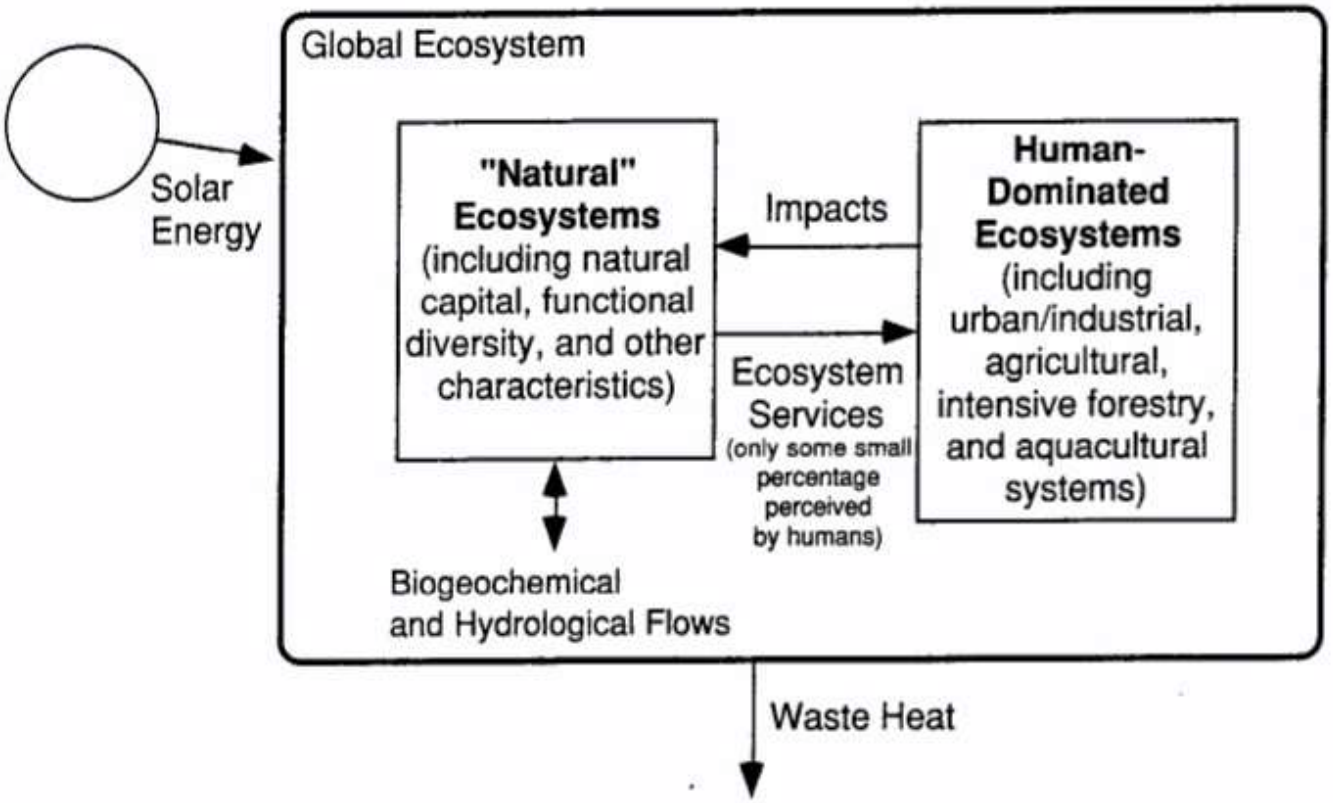
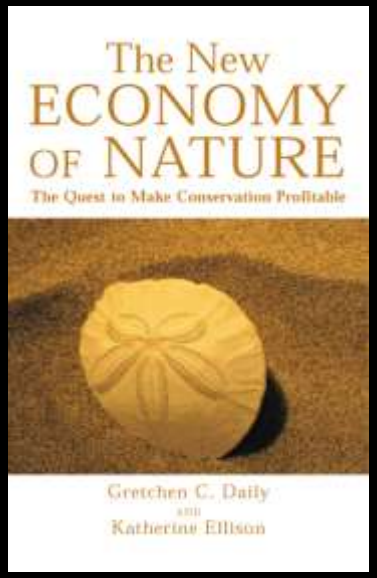


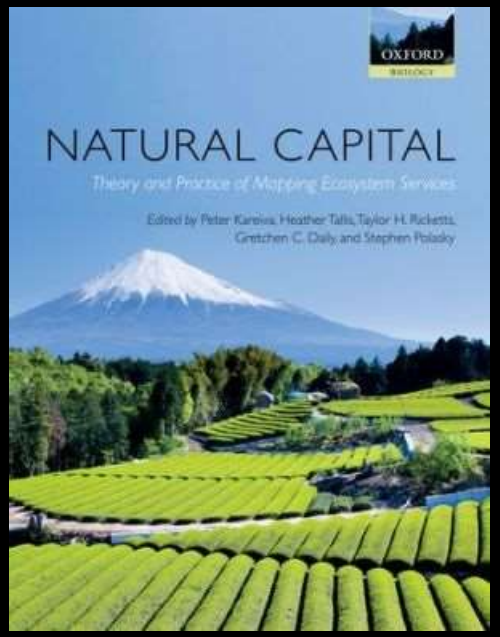
Figure 4.1. Human-dominated ecosystems are parts of the overall global system. Ecosystem services are essential for the development and well-being of human society, but only a fraction of this work is covered by market prices or perceived by humans.

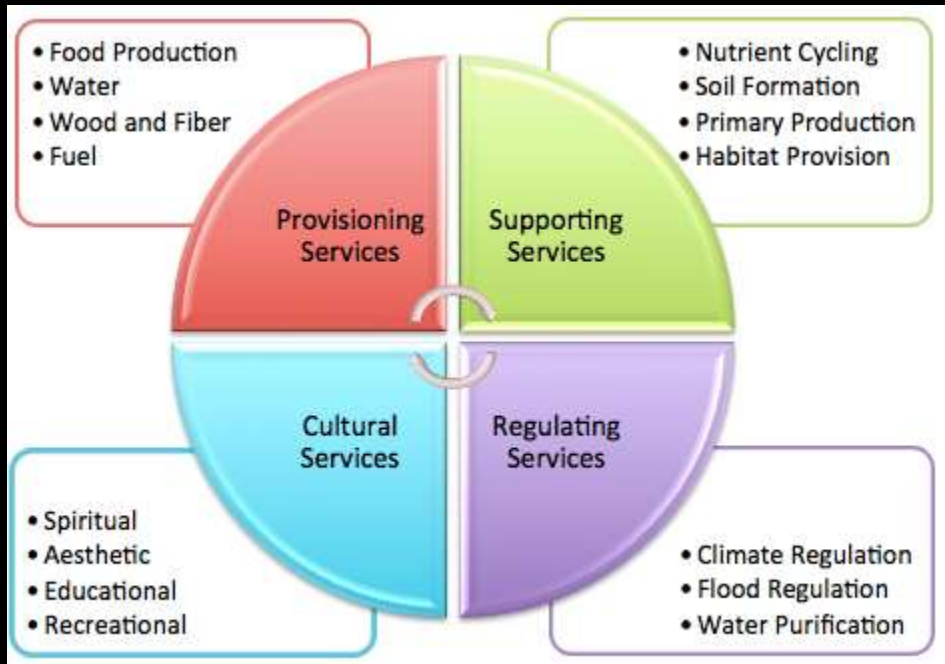
From Daily, *Nature's Services* 1997



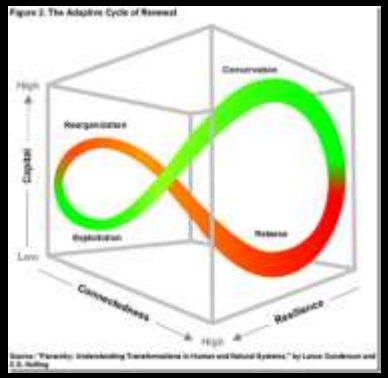
Ecosystem Services

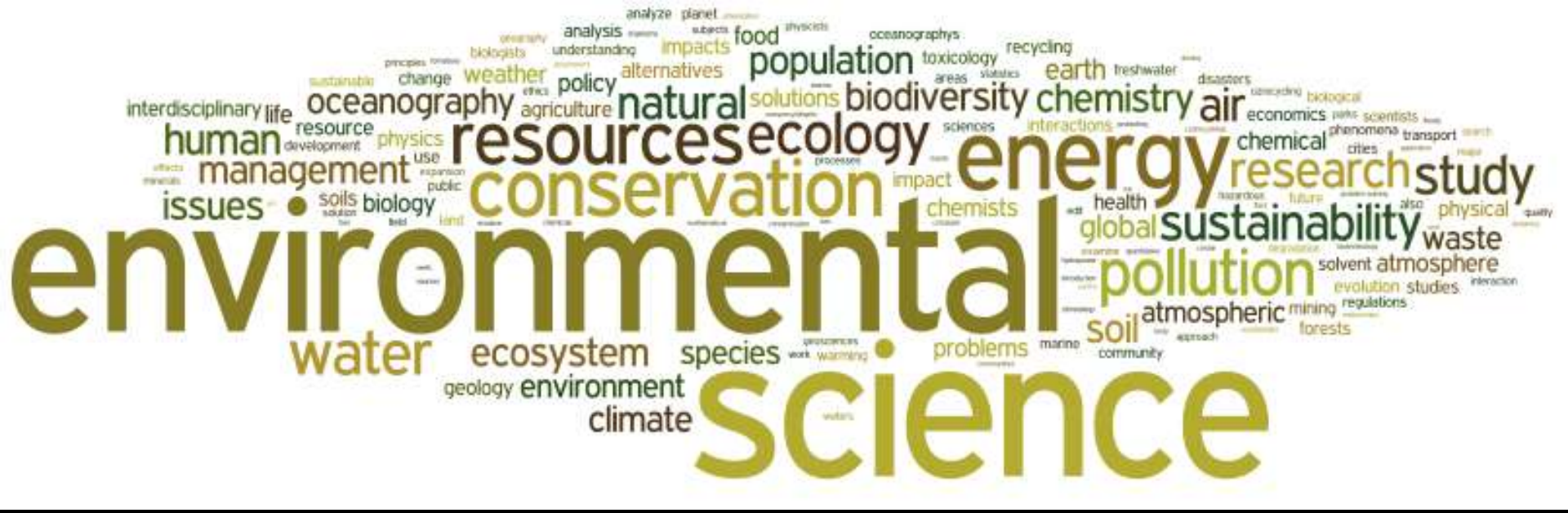
- Maintenance of atmosphere
- Protection from ultraviolet rays
- Regulation of climate
- Maintenance of genetic diversity
- Purification of air and water
- Detoxification and decomposition of wastes
- Generation of soil and renewal of soil fertility
- Pollination of vegetation
- Control of agricultural pests
- Dispersal of seeds
- Translocation of nutrients





Source: Millenium Ecosystem Assessment, 2005.

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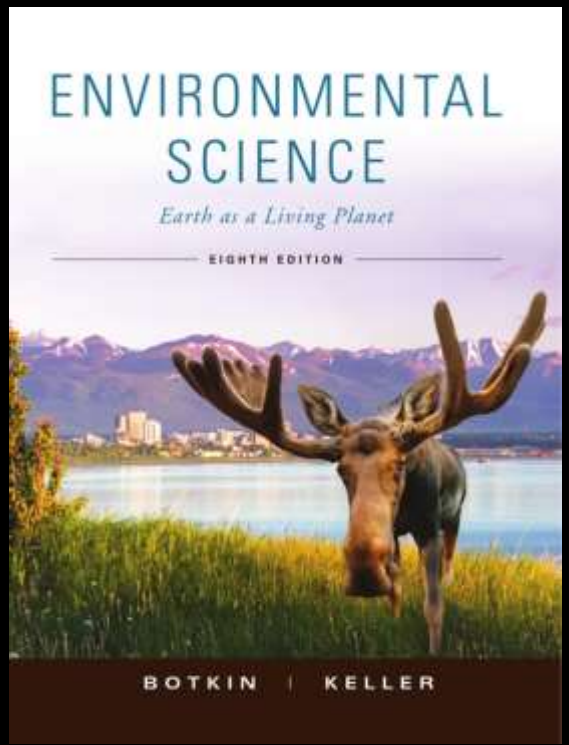
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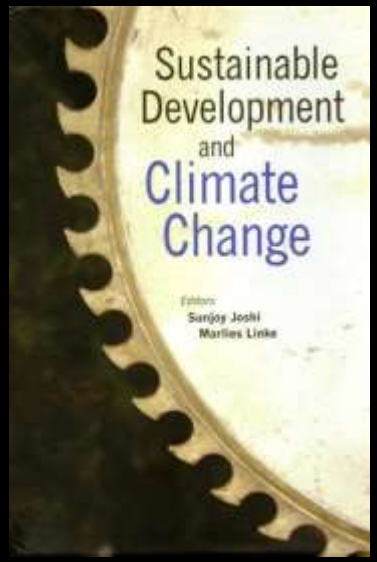

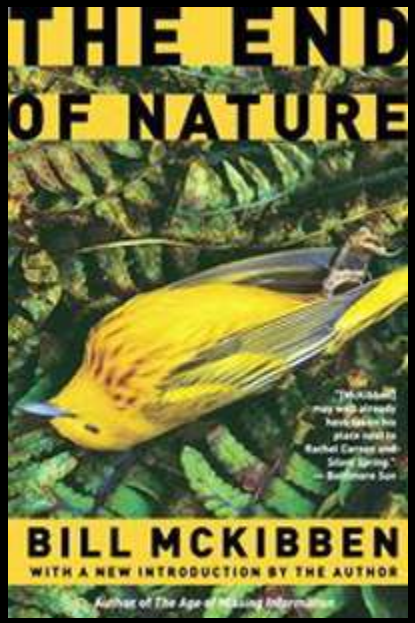

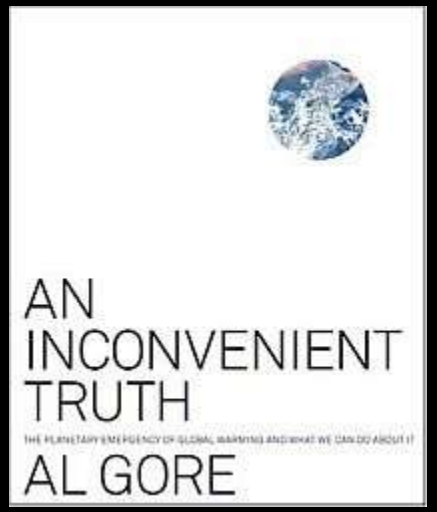

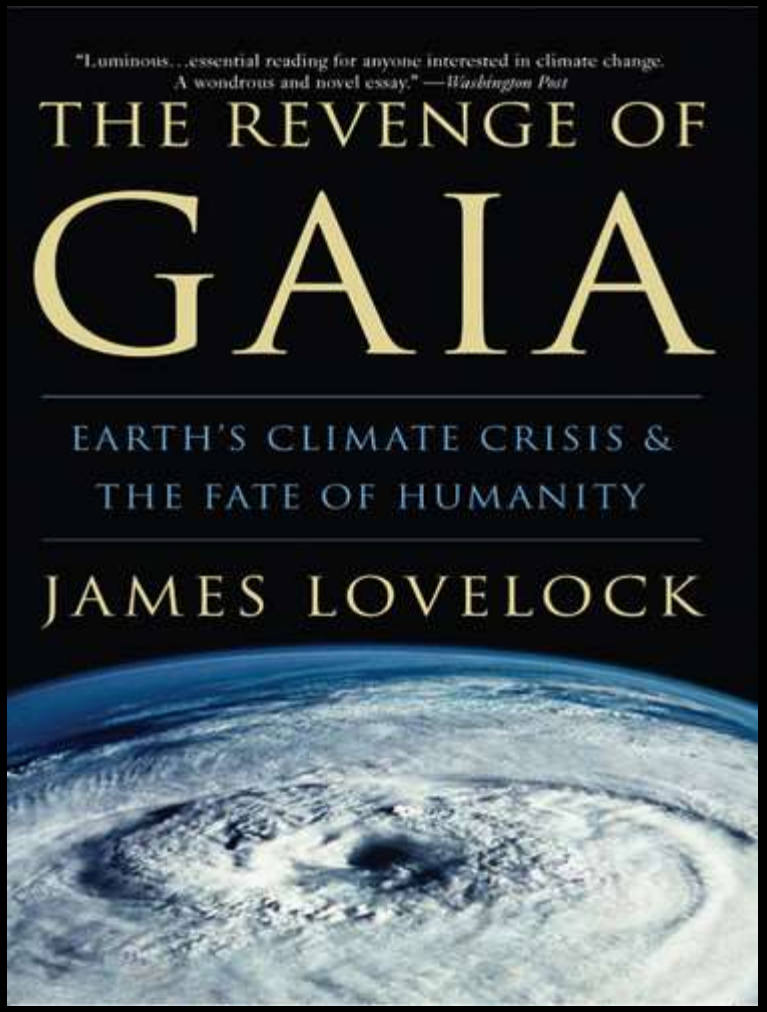
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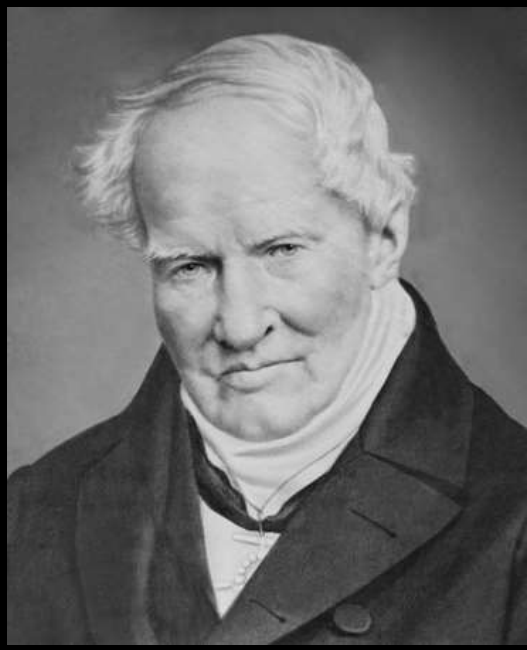
"Nature is the domain of liberty"

"Of all the birds of the Canary Islands, that which has the most heart-soothing song is unknown in Europe. It is the capirote, which no effort has succeeded in taming, so sacred to his soul is liberty. I have stood listening in admiration of his soft and melodius warbling, in a garden at Orotava; but I have never seen him sufficiently near to ascertain to what family he belongs"

The Universe is wider than our views of it

"The attempt perfectly to represent unity in diversity must…necessarily prove unsuccessful…If nature be illimitable in extent and contents, it likewise presents itself to the human intellect as a problem which cannot be grasped, and whose solution is impossible."




Applause