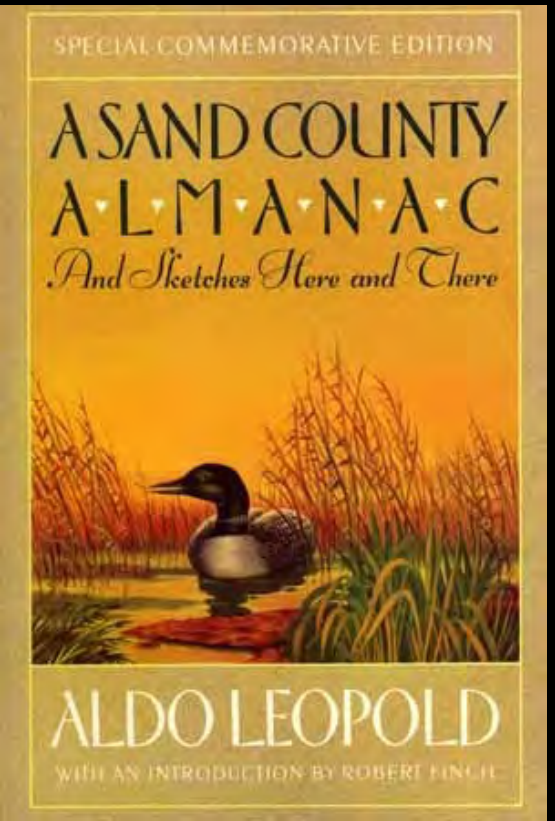
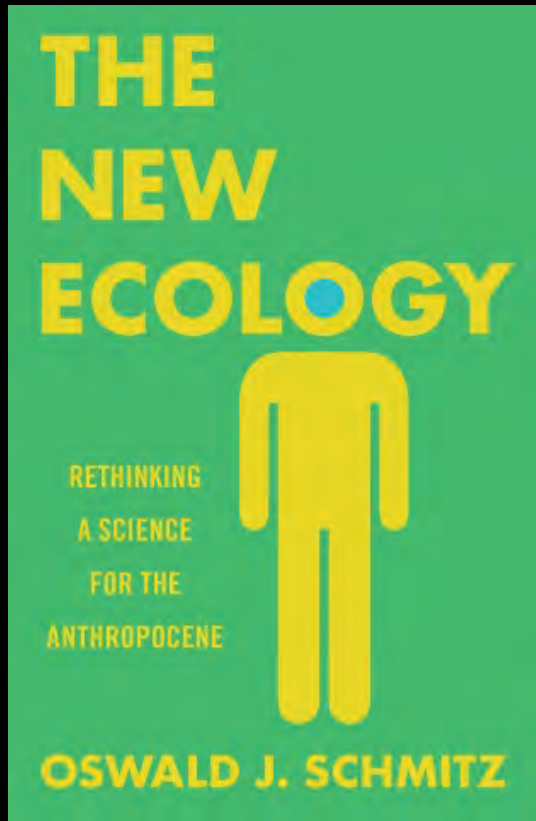
Center for Environmental Research at Hornsby Bend

Austin WATER

American Ecology: Stability, Integrity, and Leopold's Legacy

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

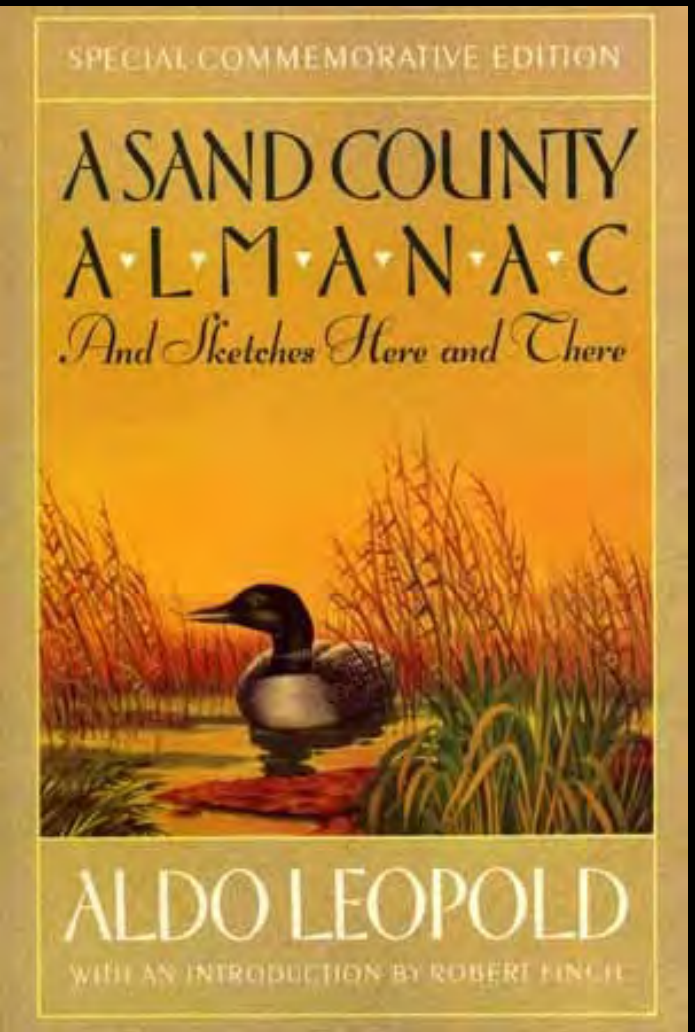




Ecology, Conservation, Restoring Rural Land

A Sand County Almanac (1949)

Aldo Leopold 1887-1948



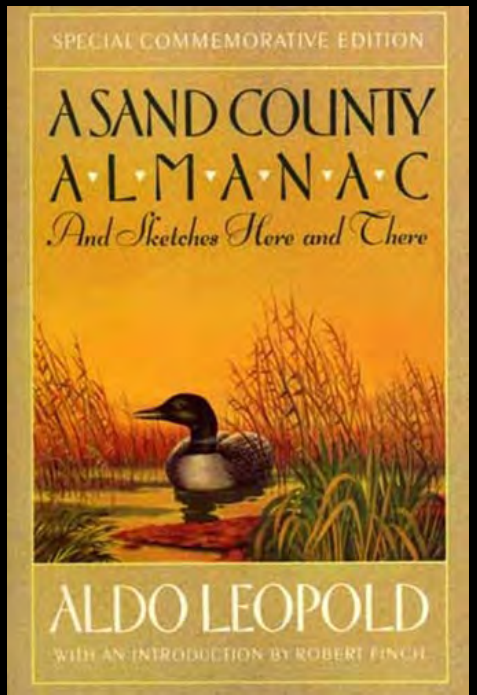
The Land Ethic – Aldo Leopold 1887-1948

The Ecological Basis for Environmental Ethics?

"A thing is right when it tends to preserve the **integrity, stability,** and **beauty** of the biotic community. It is wrong when it tends otherwise."

"The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land."

"…In short, a land ethic changes the role of Homo sapiens from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such."

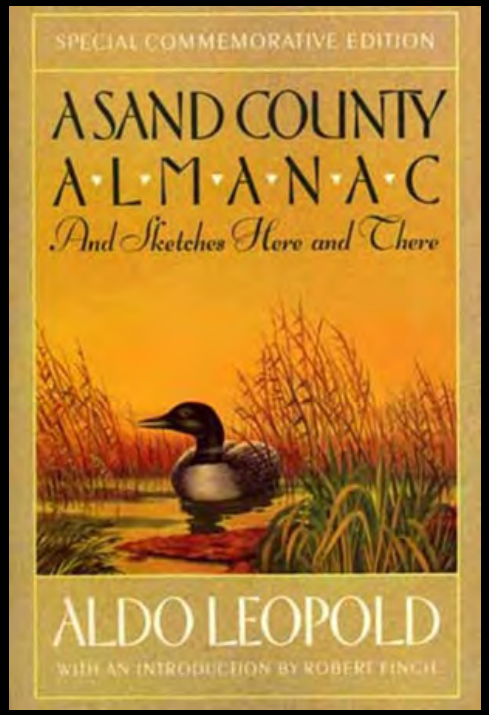


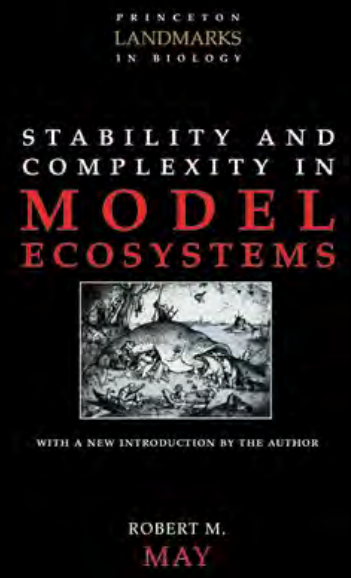
How does Nature Work?
Ecological Concept of Nature

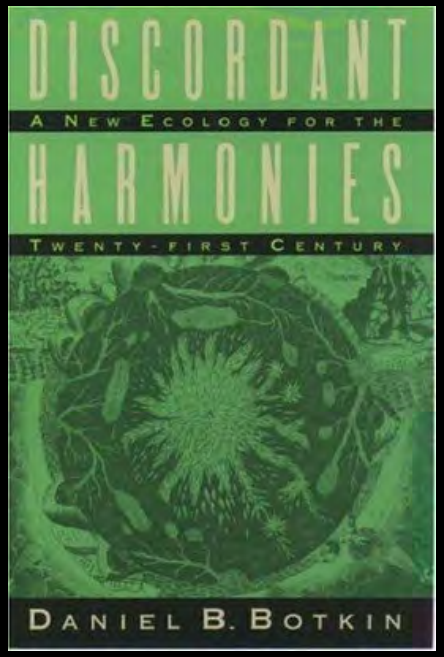
Stability
- Balance vs. Disequilibrium
- Harmony vs. Disharmony

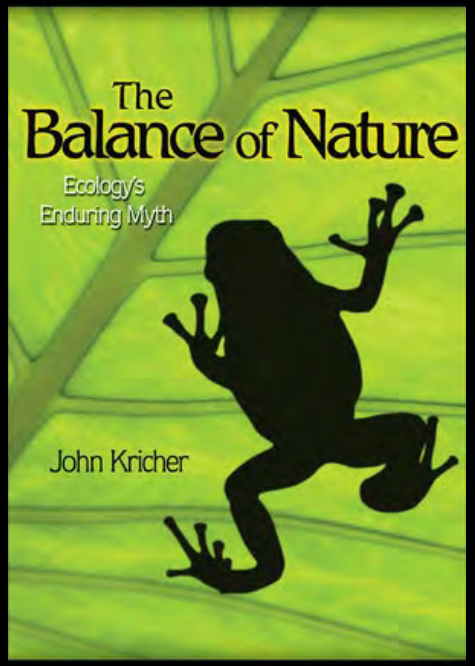
Integrity
- Permanence vs. Change

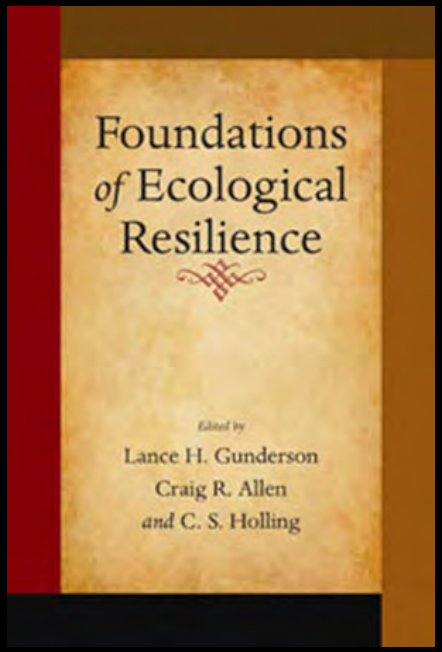
Beauty?

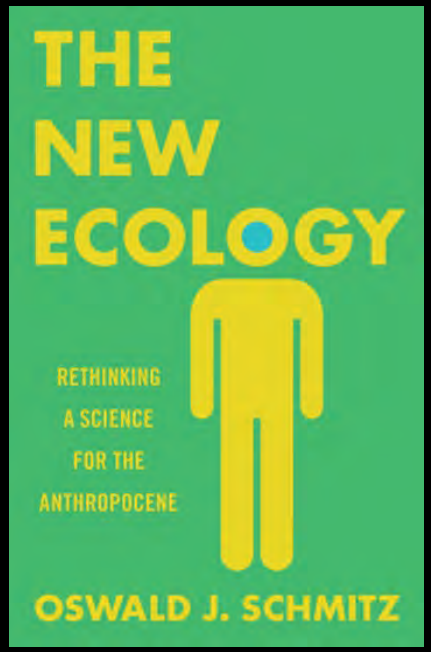












Aldo Leopold 1887-1948

Born in Iowa 1887 - Yale Forest School in 1909

1909 - Takes job with the U.S. Forest Service in Arizona and New Mexico.

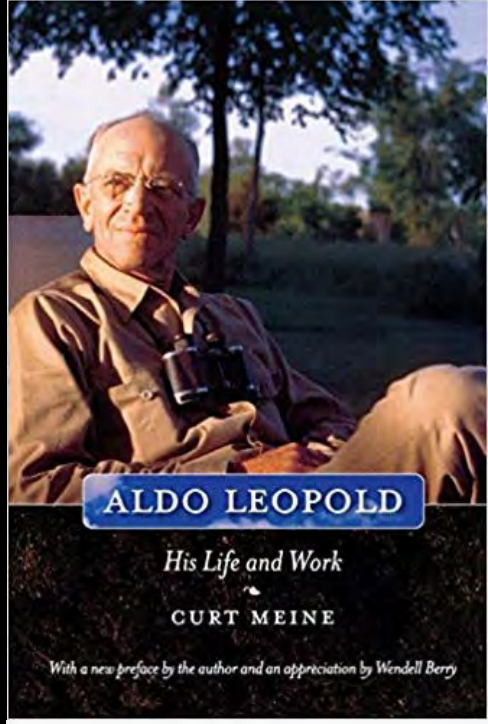
1911 - Promoted to supervisor for the Carson National Forest in New Mexico.

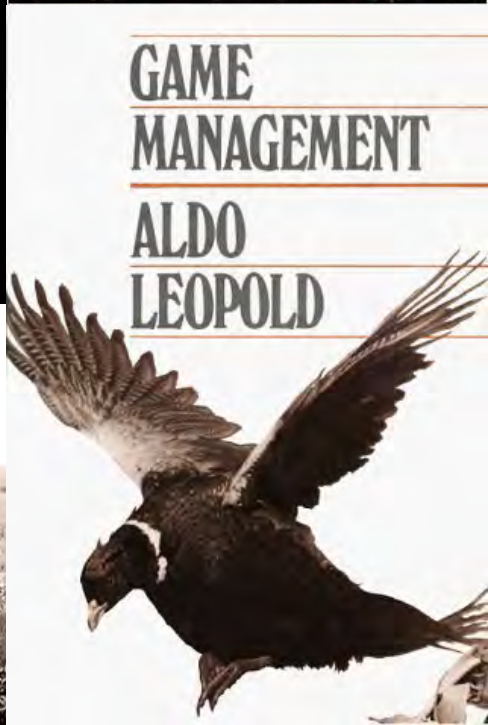
1922 - Proposal to manage the Gila National Forest as a wilderness area. The first official wilderness area in 1924.

1924 - Transfer to the U.S. Forest Products Laboratory in Madison, Wisconsin

1933 - Published the first textbook in the field of wildlife management.

1934 - Accepted a new chair position in game management for the University of Wisconsin





Restoring an Old Farm – Restoration Ecology

In 1935, he and his family initiated an ecological restoration experiment on a worn-out farm along the Wisconsin River - 80 acres in the sand country outside of Baraboo.

The once-forested region had been logged, swept by repeated fires, overgrazed by cows, and left barren.

"What more delightful avocation than to take a piece of land and by cautious experimentation to prove how it works. What more substantial service to conservation than to practice it on one's own land?"

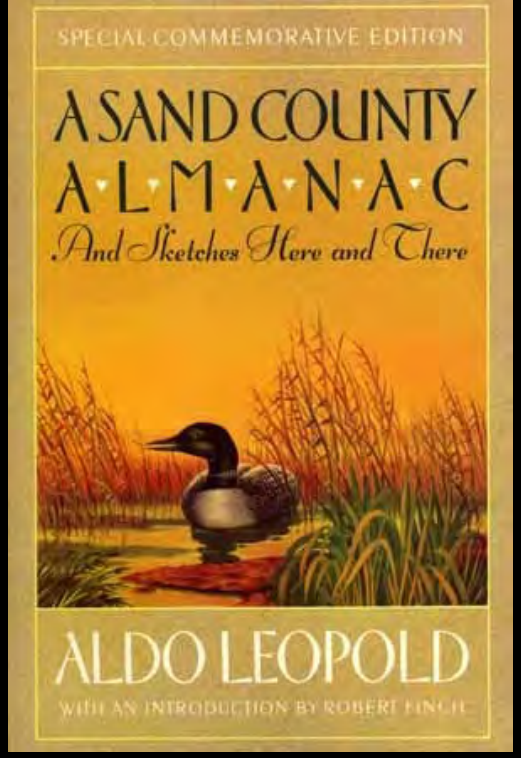
THE ALDO LEOPOLD FOUNDATION

A Sand County Almanac 1949

A few years before his death, Leopold conceived of a book, geared for general audiences, which would examine humanity's relationship to the natural world.

One week after receiving word that his manuscript would be published, Leopold died of a heart attack on April 21, 1948.

A year after his death, Leopold's collection of essays, *A Sand County Almanac*, was published.



Thinking like a mountain – How does Nature work?

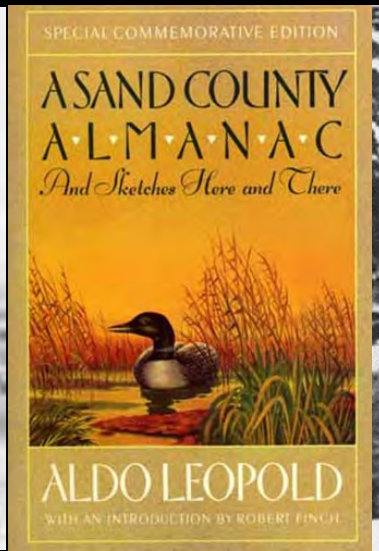
"A deep chesty bawl echoes from rimrock to rimrock, rolls down the mountain, and fades into the far blackness of the night…

Only the mountain has lived long enough to listen objectively to the howl of a wolf…

Only the ineducable tyro can fail to sense the presence or absence of wolves, or the fact that mountains have a secret opinion about them…

My own conviction on this score dates from the day I saw a wolf die…

In those days we had never heard of passing up a chance to kill a wolf. In a second we were pumping lead into the pack…"



Thinking like a mountain – A Fierce Green Fire

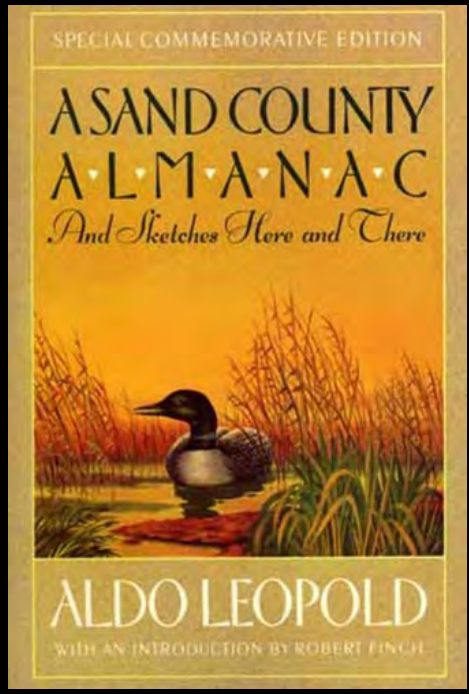
How does Nature work?

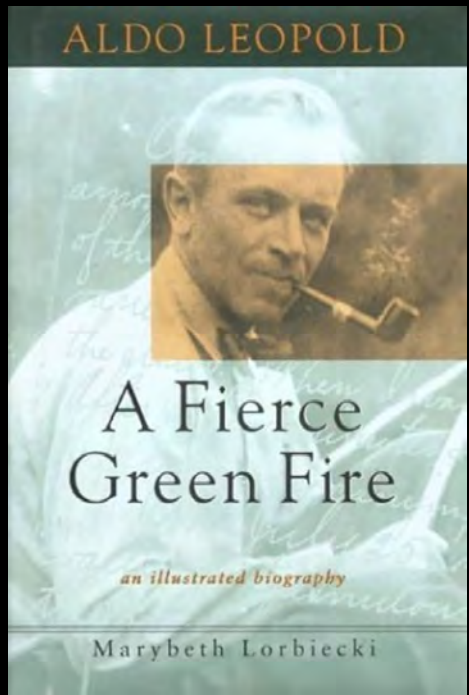
"We reached the old wolf in time to watch a fierce green fire dying in her eyes.

I realized then, and have known ever since, that there was something new to me in those eyes - something known only to her and to the mountain.

I was young then, and full of trigger-itch; I thought that because fewer wolves meant more deer, that no wolves would mean hunters' paradise.

But after seeing the green fire die, I sensed that neither the wolf nor the mountain agreed with such a view."





Thinking like a mountain - Ecological Vision of How Nature Works

"Since then I have lived to see state after state extirpate its wolves. I have watched the face of many a newly wolfless mountain, and seen the south-facing slopes wrinkle with a maze of new deer trails. I have seen every edible bush and seedling browsed, first to anemic desuetude, and then to death… ***I now suspect that just as a deer herd lives in mortal fear of its wolves, so does a mountain live in mortal fear of its deer***…

So also with cows. The cowman who cleans his range of wolves does not realize that he is taking over the wolf's job of trimming the herd to fit the range. ***He has not learned to think like a mountain***. Hence we have dustbowls, and rivers washing the future into the sea…Too much safety seems to yield only danger in the long run.

Perhaps this is behind Thoreau's dictum: In wildness is the salvation of the world. Perhaps this is the hidden meaning in the howl of the wolf, long known among mountains, but seldom perceived among men."

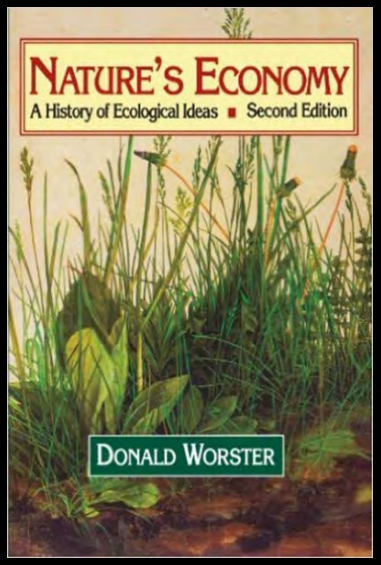
Nature's Economy - How does Nature work?

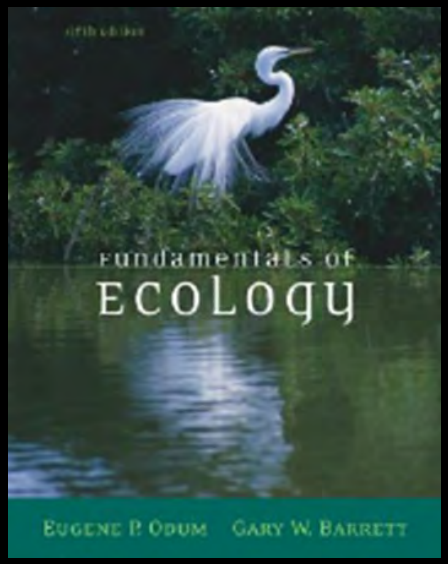
Stability

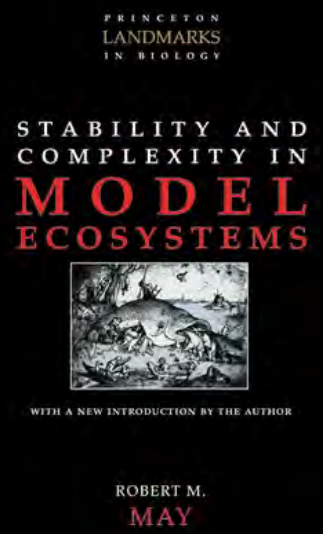
- Balance vs. Disequilibrium
- Harmony vs. Disharmony

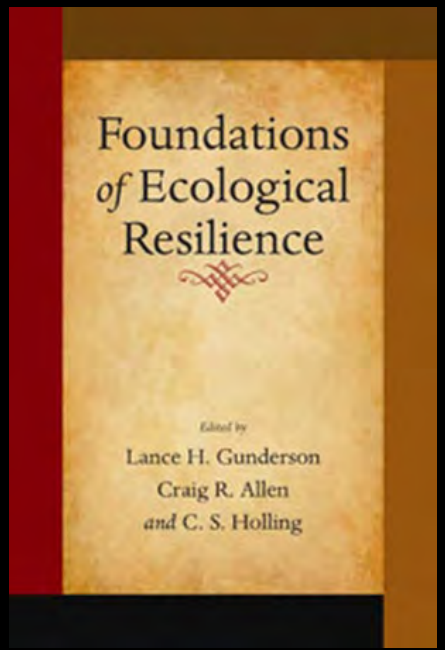
Integrity

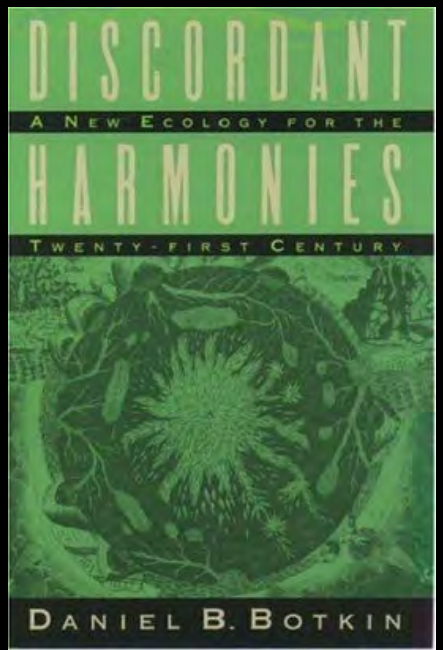
- Permanence vs. Change

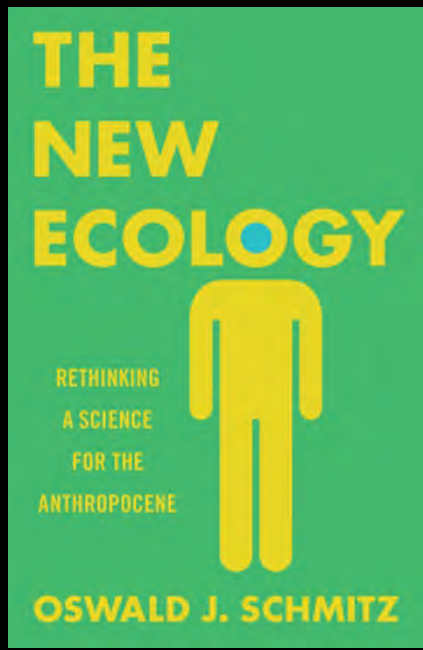








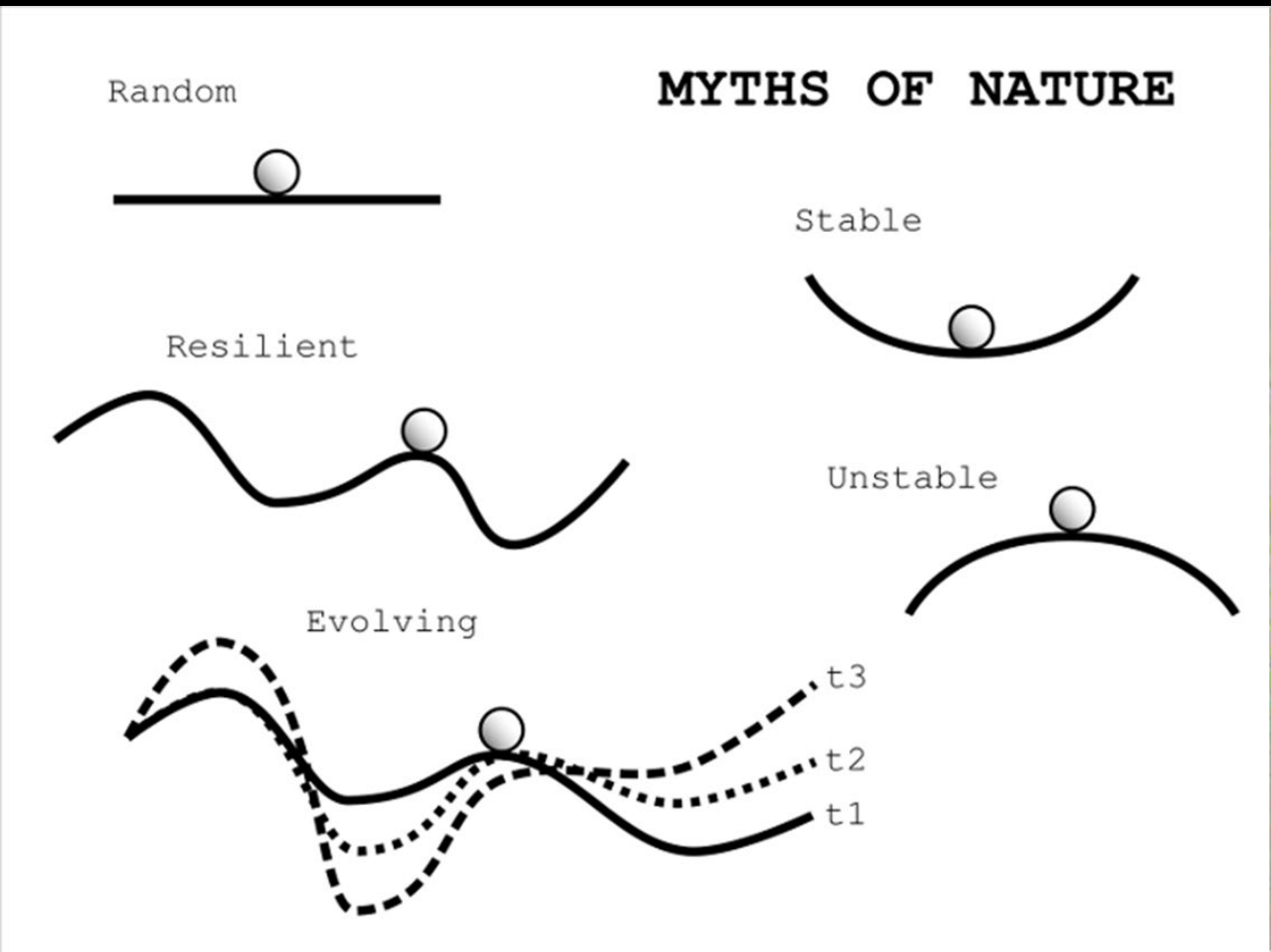


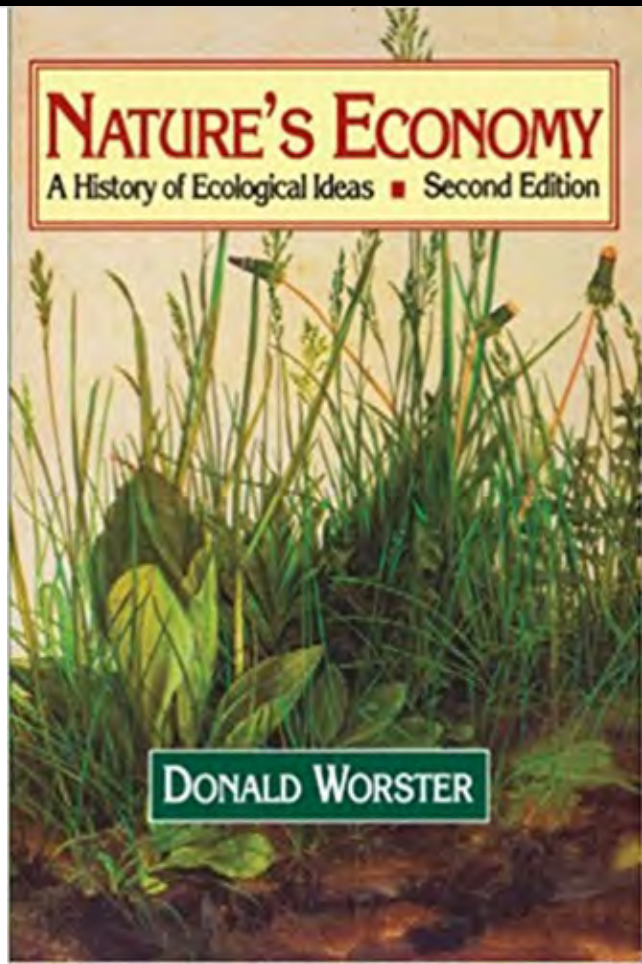


How Nature Works – Ecology's Myths (Narratives/Ideas) of Nature

"Every generation…writes its own description of the natural order, which generally reveals as much about human society and its changing concerns as it does about nature."

Nature's Economy, Donald Worster





How Does Nature Work? Permanence and Change

Heraclitus 540-480BC

"No man ever steps in the same river twice."

Everything Flows

Everything stays the same only by changing.

Nothing Endures But Change

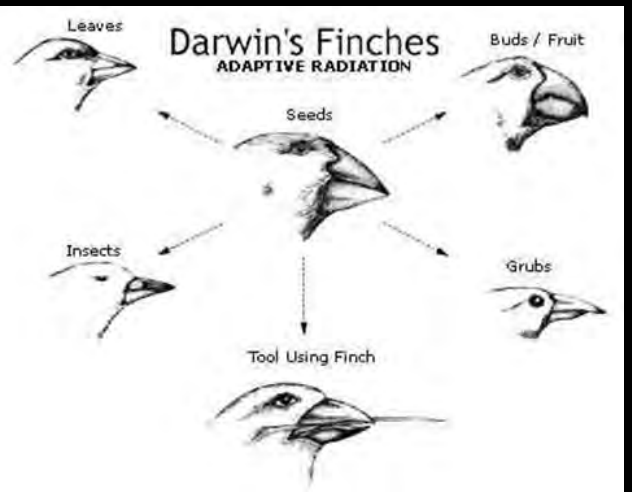
The Economy of Nature and Evolution
How Life Works – Biology

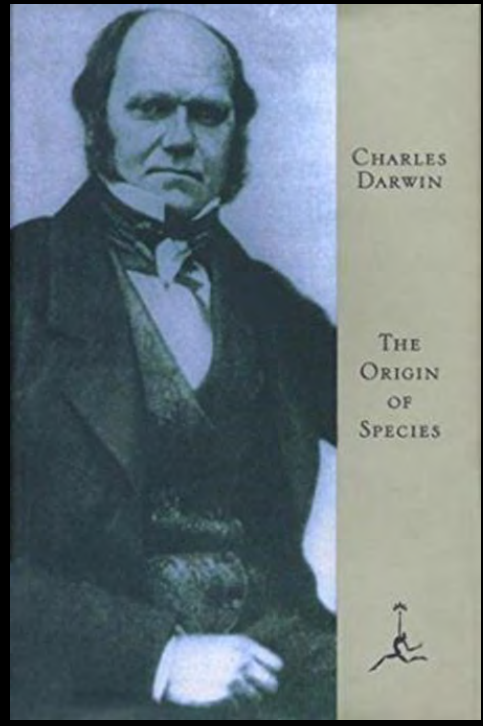
Darwin and the Economy of Nature – Structure and Change

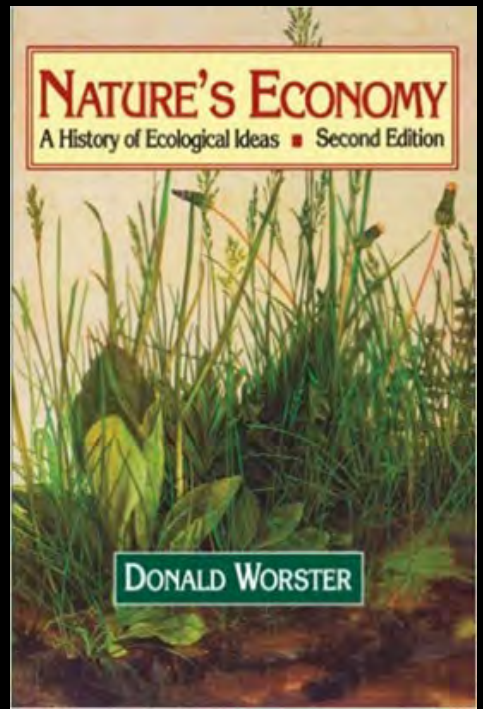
Structure - Darwin claims in *On the Origin of the Species* (1859) that "all organic beings are striving, it may be said, to seize on each place in **the economy of nature**."

"And it follows, I think, … that the varying offspring of each species will try (only few will succeed) to seize on as many and as diverse places in the economy of nature, as possible."

Change – "Each new variety or species, when formed will generally take the places of and so exterminate its less well-fitted parent."



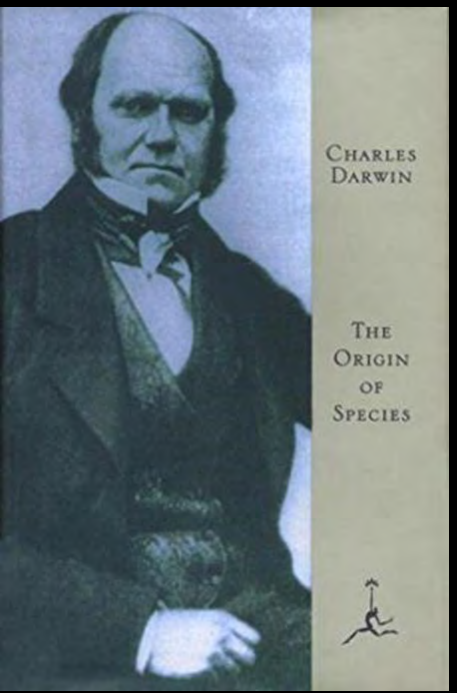


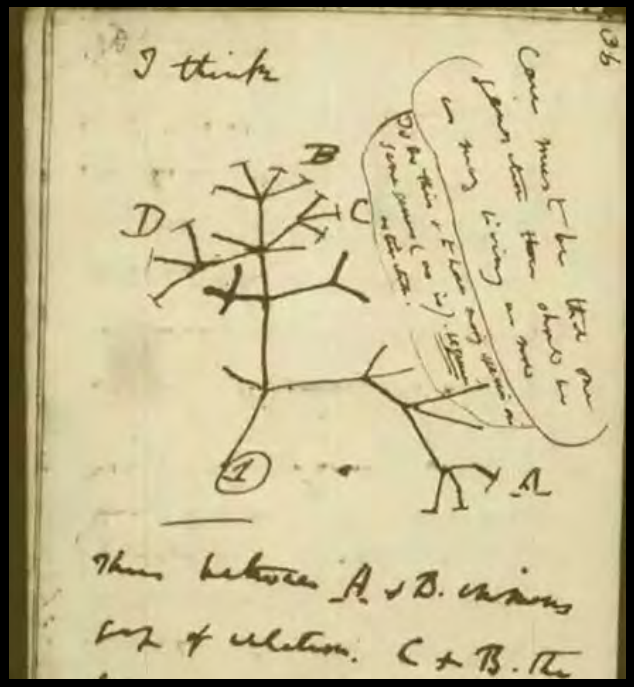


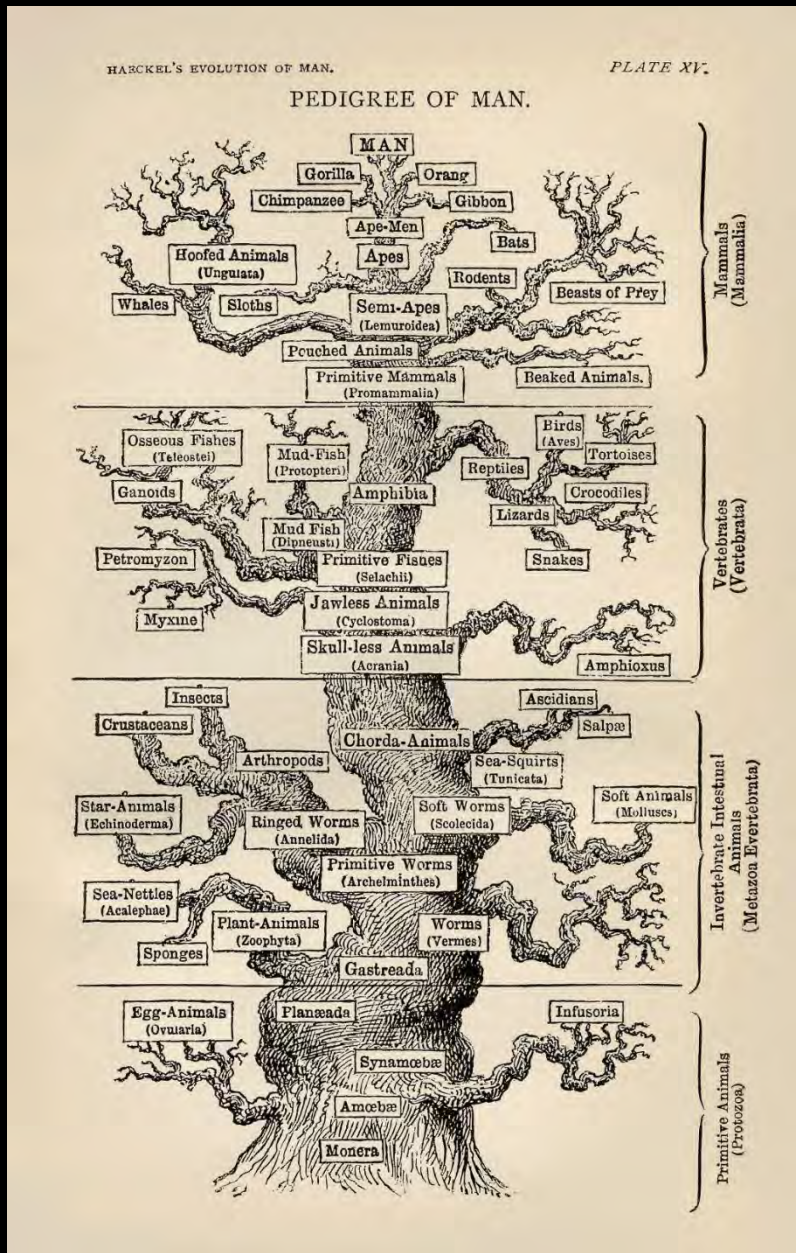
Structure and Change - The Tree of Life

"This, I believe, to be the origin of the classification or arrangement of all organic beings at all times.

These always seem to branch and sub-branch like a tree from a common trunk - the flourishing twigs destroying the less vigorous - the dead and lost branches rudely representing extinct genera and families"



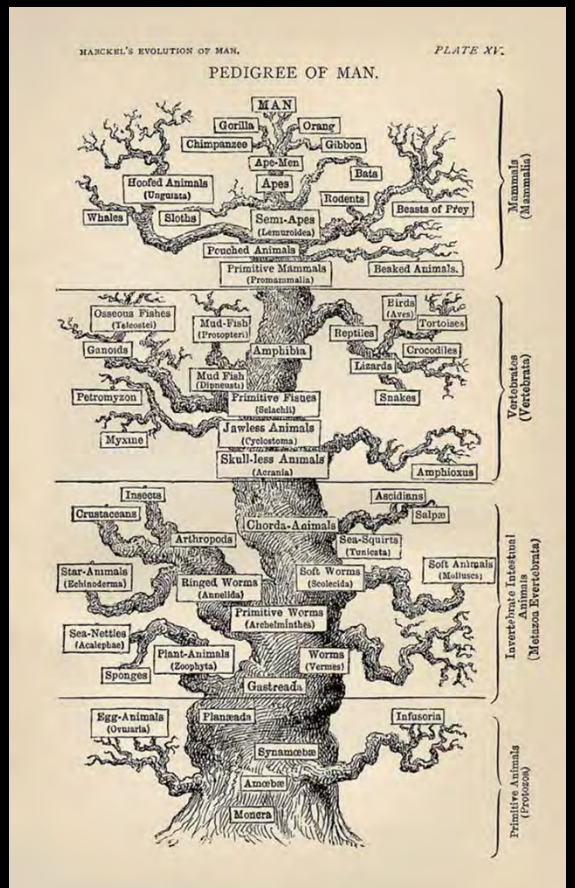


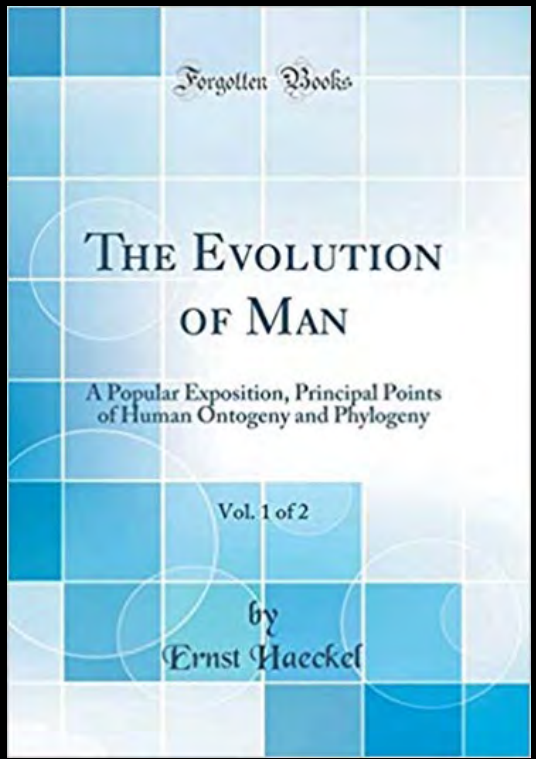


Naming a New Science - Ecology

Ernst Haeckel 1834–1919

German biologist inspired by Humboldt and Darwin described and named thousands of new species, mapped a genealogical tree relating all life forms, and coined many new terms for biology, including phylum, phylogeny, stem cell, protista…and the name of a new science – Ecology.



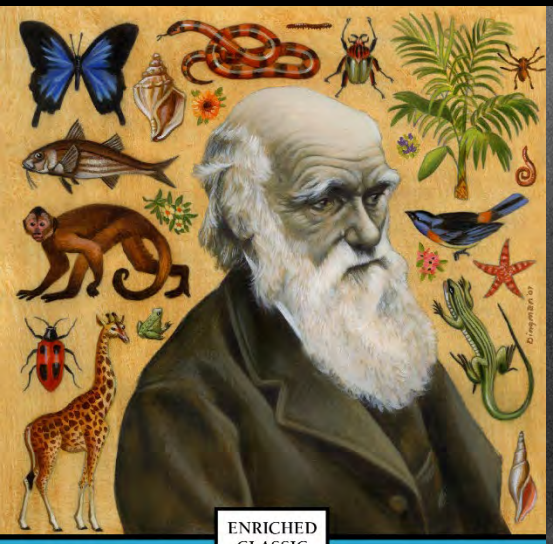


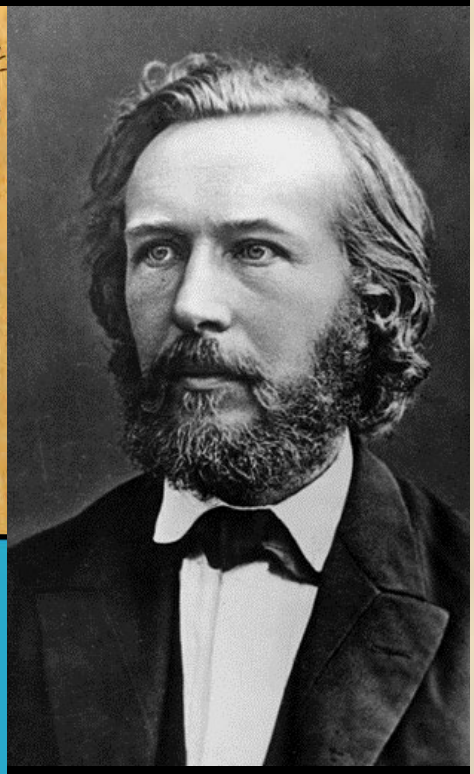
Haeckel and Darwin
Ecology and Biology

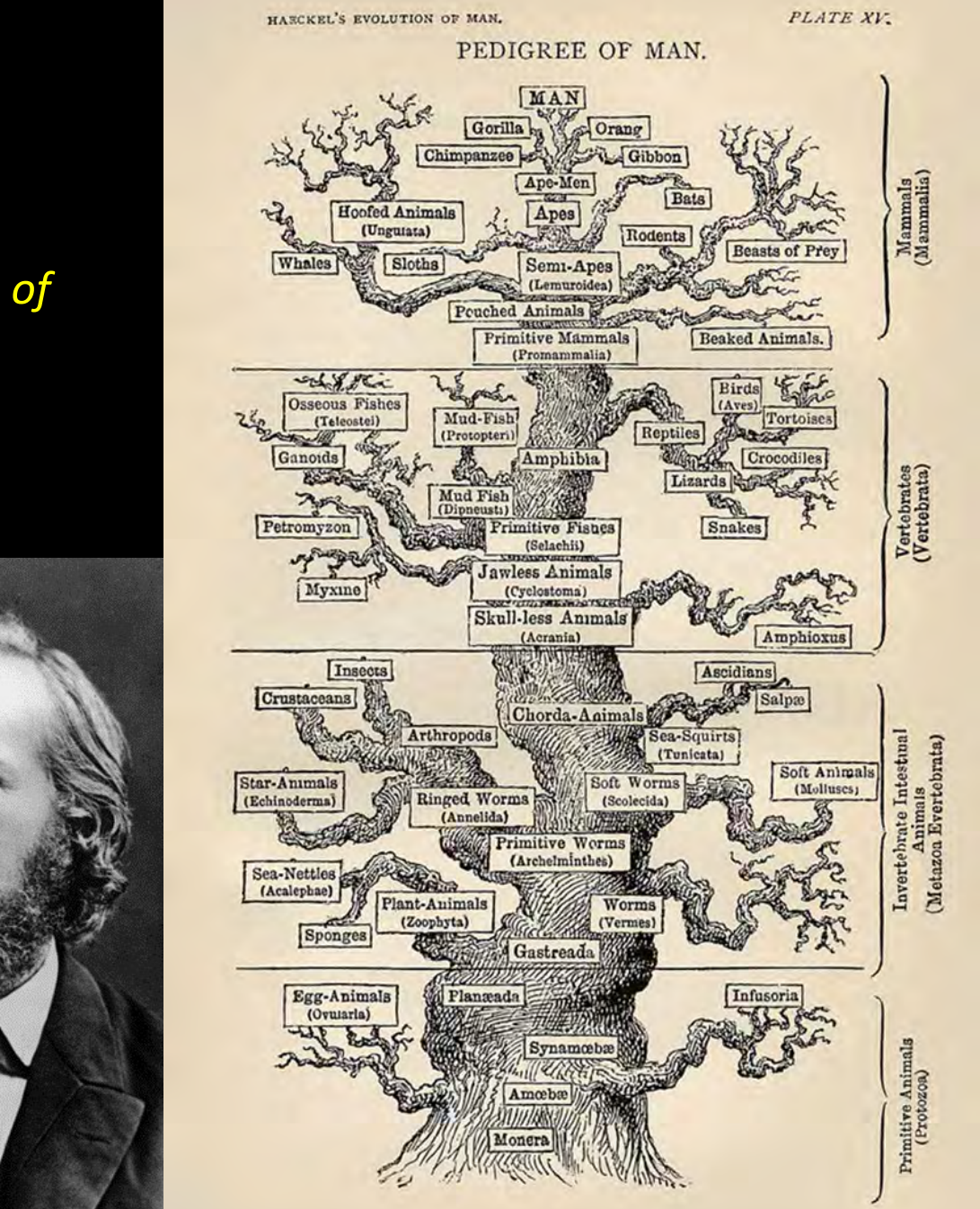
Biology - How Does Life Work?

- Darwin – Life Evolves
- *On the Origin of Species by Means of Natural Selection* (1859)

Ecology – How Does Nature Work?







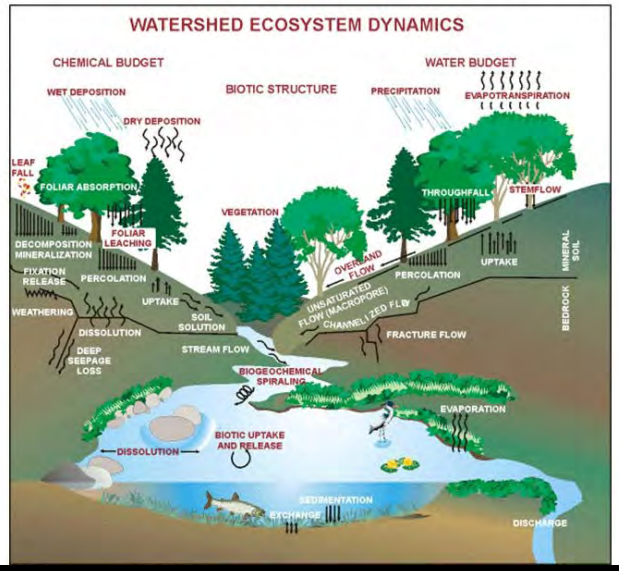
How Does Nature Work? 1866

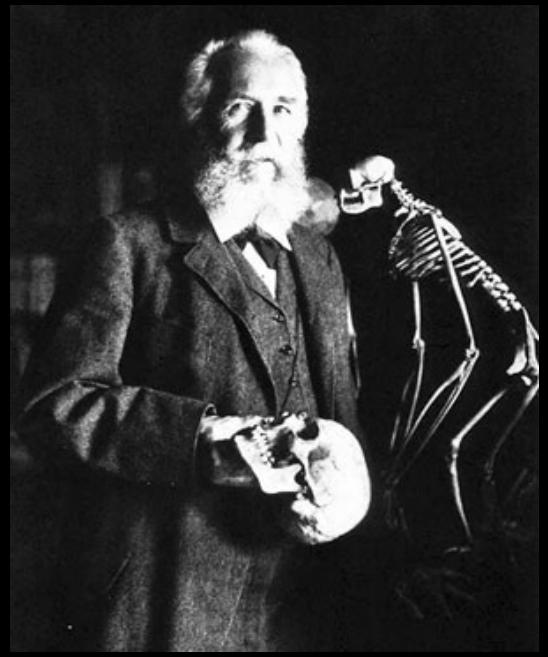
Ecology - The study of Life Systems [ecosystems] – the biotic and abiotic

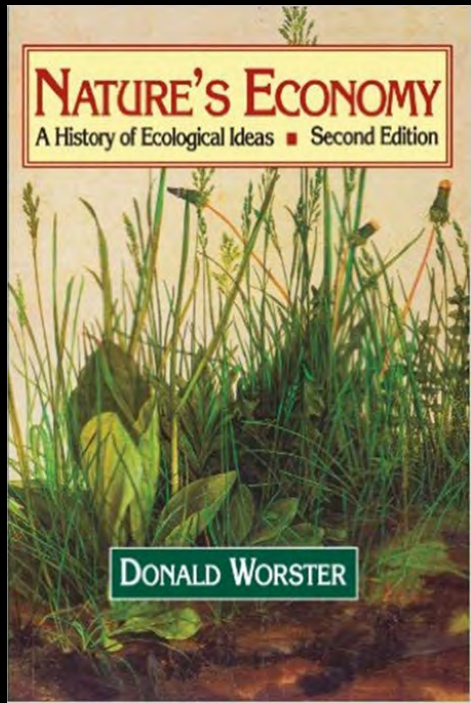
- In 1866, Haeckel coined the word “oekologie” for a science of the “relation of the animal both to its organic as well as its inorganic environment.”
- The word comes from the Greek oikos, meaning “household,” “home,” or “place to live.” Thus, ecology deals with the organism and its environment.

“By ecology we mean ***the body of knowledge concerning the economy of nature***… in a word, ***ecology is the study of all those complex interrelations referred to by Darwin as the conditions of the struggle for existence***.”

Ecosystem – Biotic and Abiotic





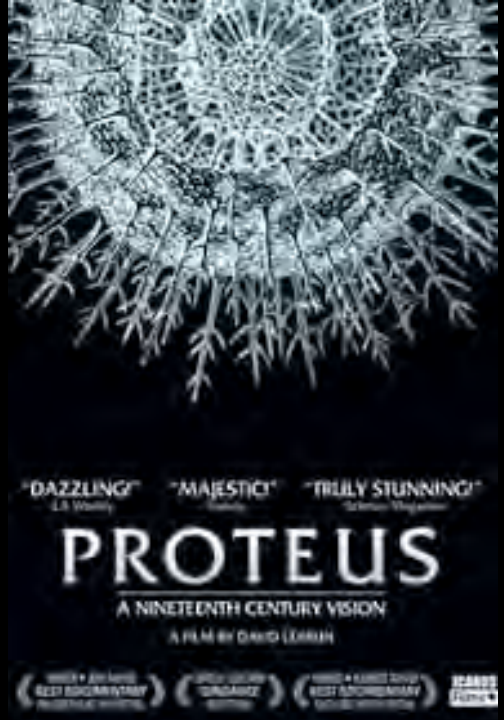


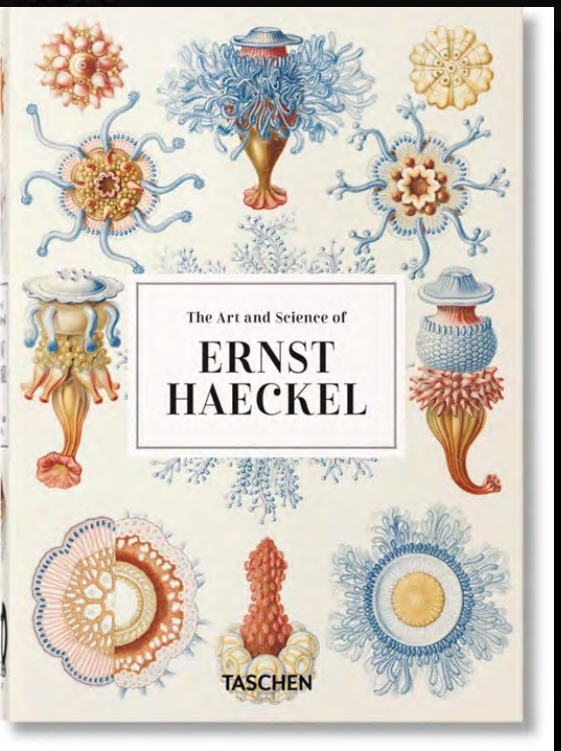
Permanence and Change – Integrity

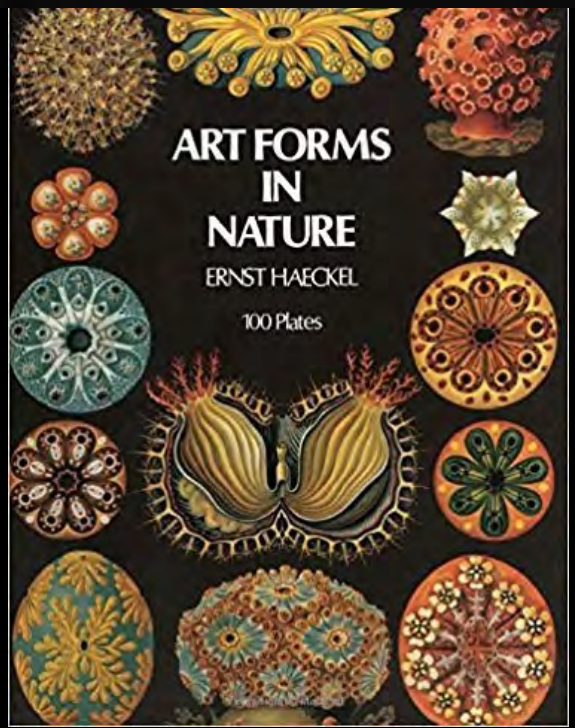
Ernst Haeckel

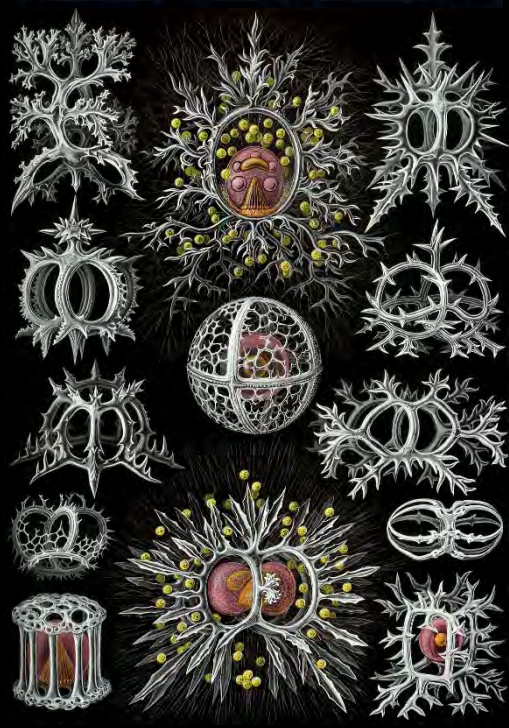
Nothing is constant but change! All existence is a perpetual flux of "being and becoming!" That is the broad lesson of the evolution of the world.

AZ QUOTES









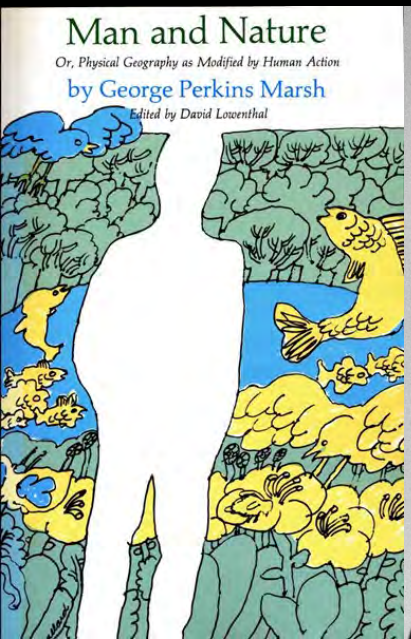
Permanence and Change – Integrity, Humans and Nature

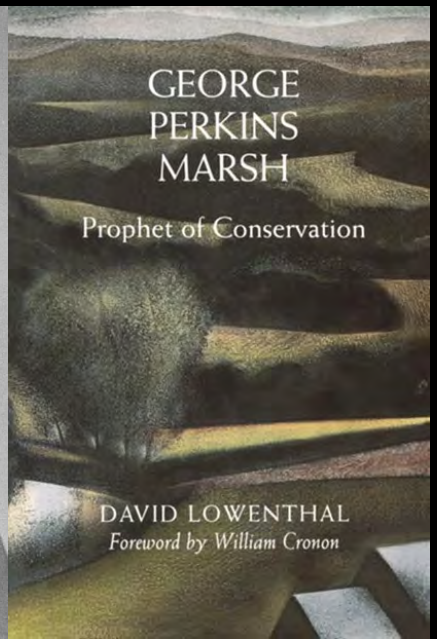
Man and Nature: Physical Geography as Modified by Human Action (1864)

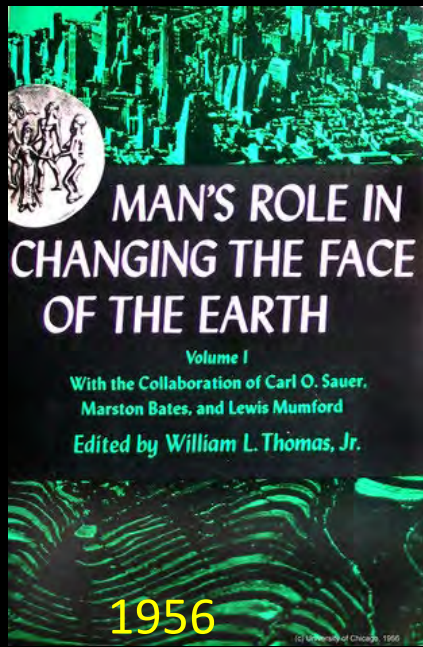
George Perkins Marsh 1801-1882

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

Stress on the ***unforeseen and unintended consequences***, as well as the heedless greed of technological enterprise.



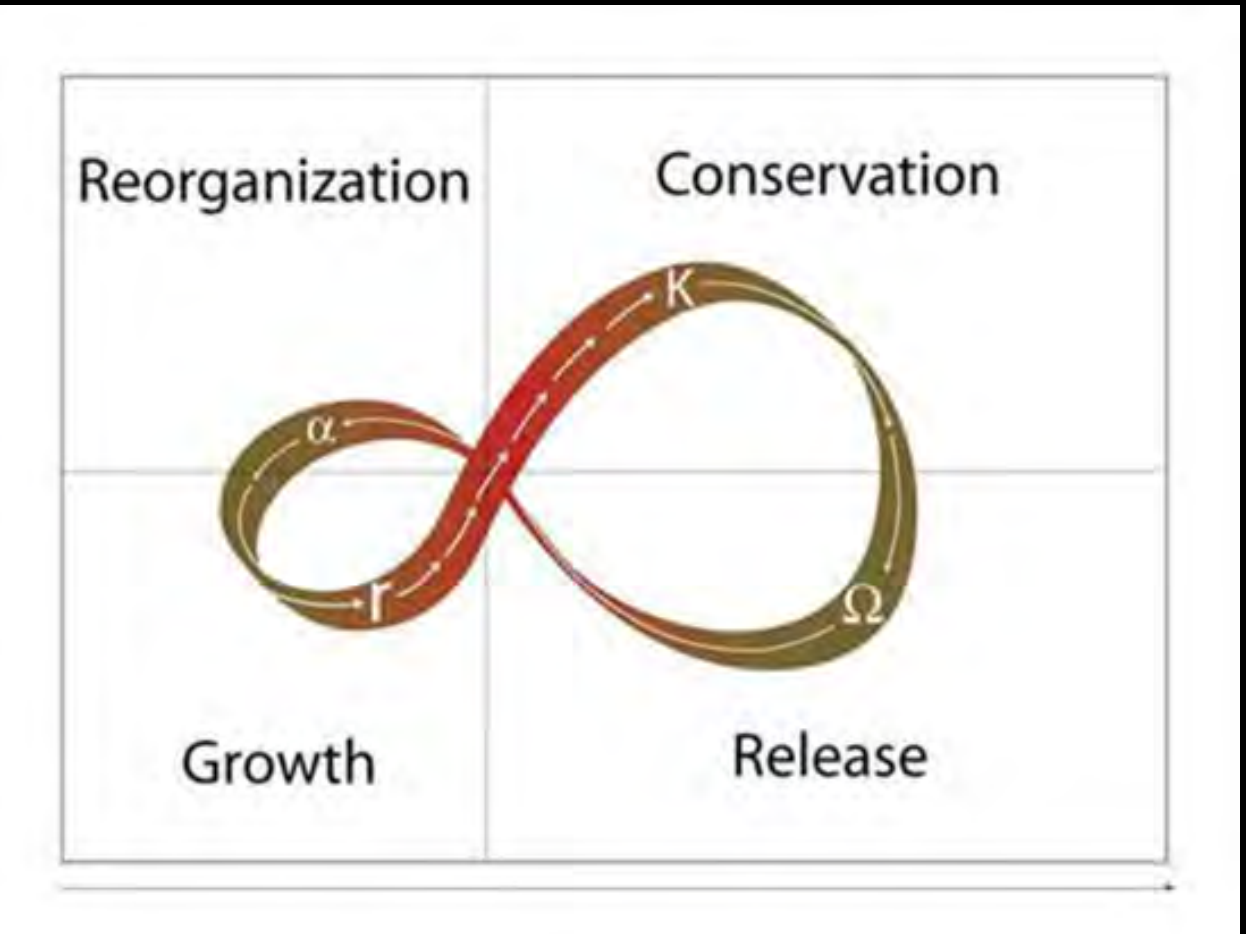


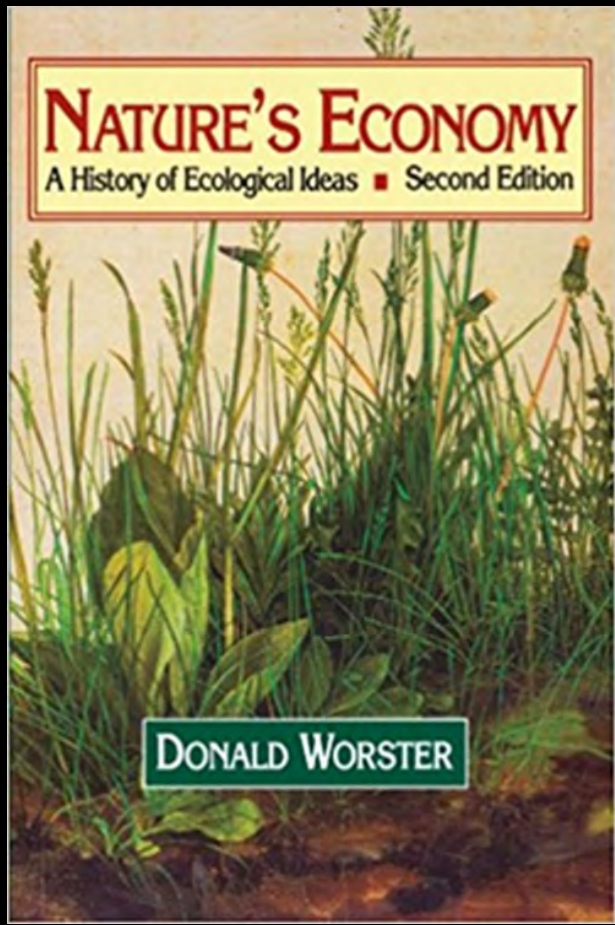


A History of Ecological Ideas 1900 - Present

Ideas/Myths/Narratives of Nature About How Nature Works?

A Story About Permanence and Change



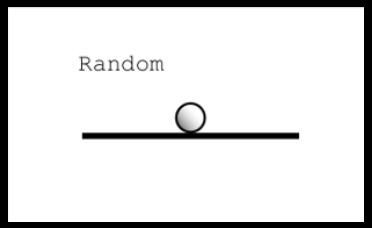


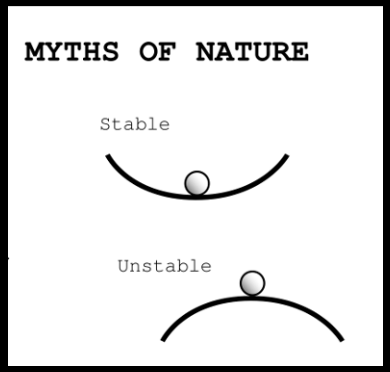
How Does Nature Work? – Succession and Stability

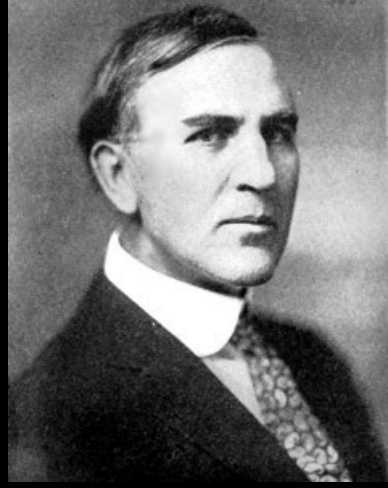
Frederic Clements 1874-1945

The Development and Structure of Vegetation (1904)

Plant Succession (1916)

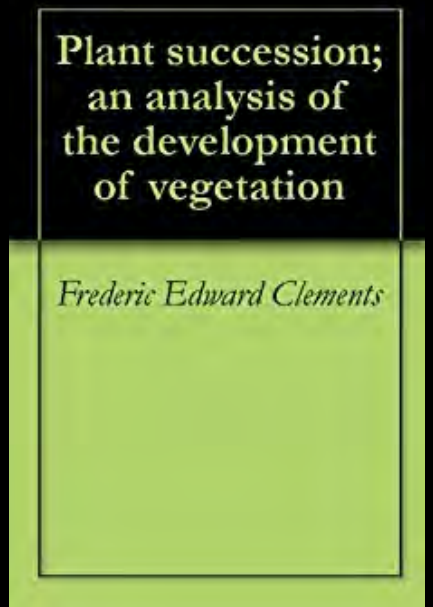


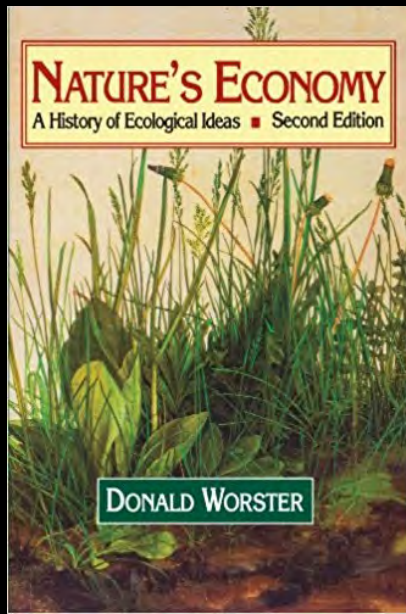




Structured change

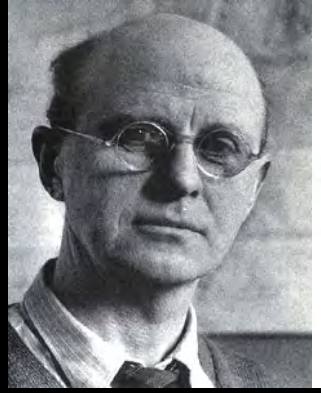
- Vegetation is dynamic
- Succession and climax stage
- Monoclimax – any region of Earth can have only one mature stage based on climate
- Assumes a natural state with ***no human interference – natural equilibrium***
- "Nature's course, he contended, is not an aimless wandering to and fro but a steady flow toward ***stability*** that can be exactly plotted by the scientist." Worster

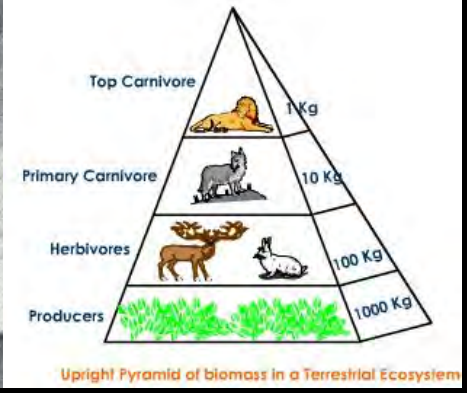




Stability, Trophic Levels, Invasion Ecology

Charles Elton 1900-1991

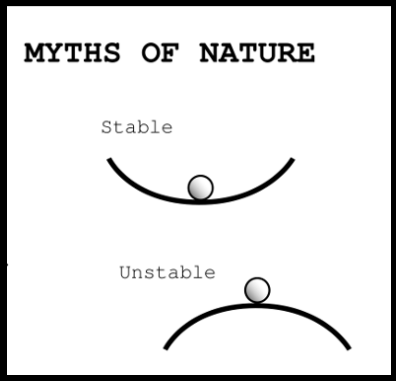




Animal Ecology (1927)

Stability

- **Community Structure** – an economy of nature
- Food chain, food web
- Plants = producers, Animals = consumers (reducers, decomposers)
- Niche – the status or occupation of an organism in a community
- ***One species to one niche*** (competition)

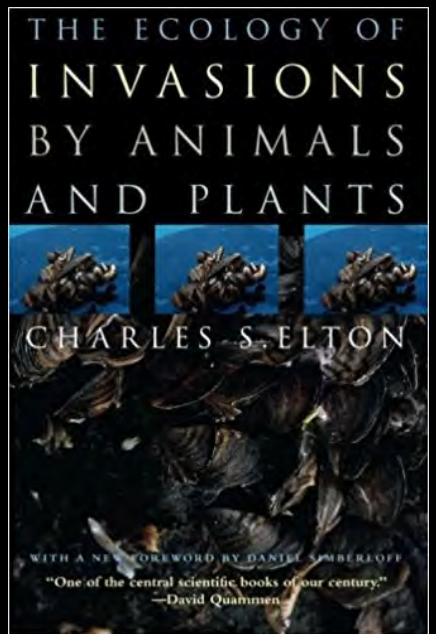


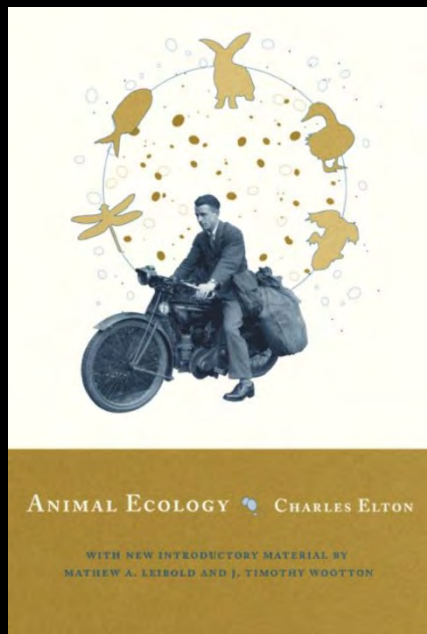
The Ecology of Invasions (1958)

Instability

Invasion Biology – Invasive Species

- DIH – the Diversity-Invasibility Hypothesis
- More Biodiversity Less Likely to be Invaded
- **Biodiversity = Stability** – All niches filled
- Disturbance is the prerequisite for invasion
- "Man is everywhere a disturbing agent"

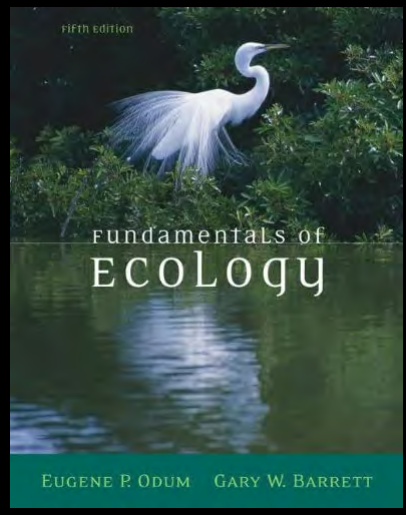


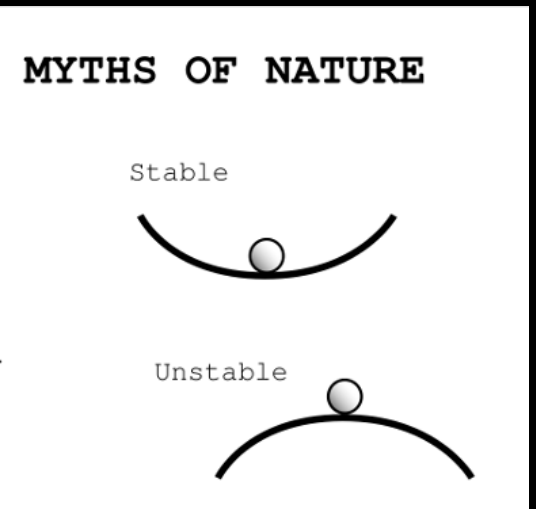


Ecosystem, Stability, and the Equilibrium Paradigm

Eugene Odum, *Fundamentals of Ecology* (1953)

- Stability - Nature is ***a series of balanced ecosystems*** – the basic functional unit of ecology, and so a need for a unified theory of the ecosystem [a pond, a watershed, a meadow]
- Steady State System - Rather than climax stage he used "***mature ecosystem***" – the ecosystem was often disturbed but fluctuated around a single ***homeostatic point = health = stability/equilibrium***
- Humans the Great Disrupters - the reference point is an "original" condition of a natural landscape





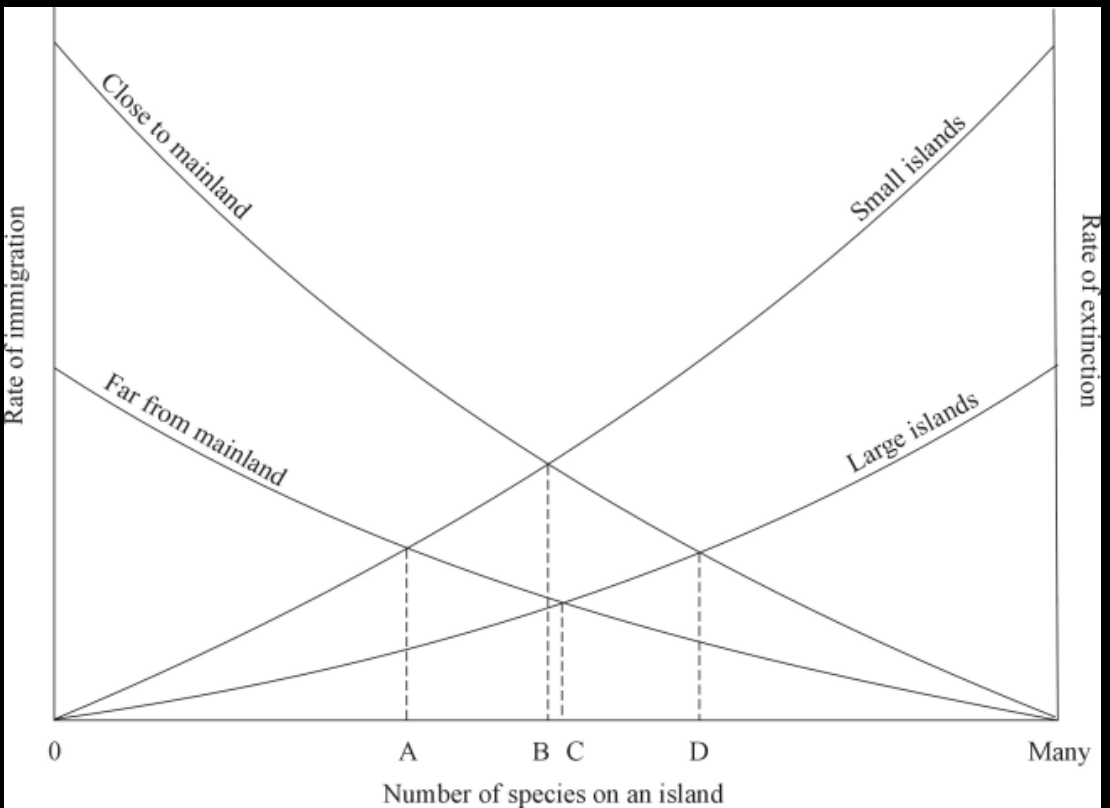
By the 1960s, these scientific beliefs are questioned…

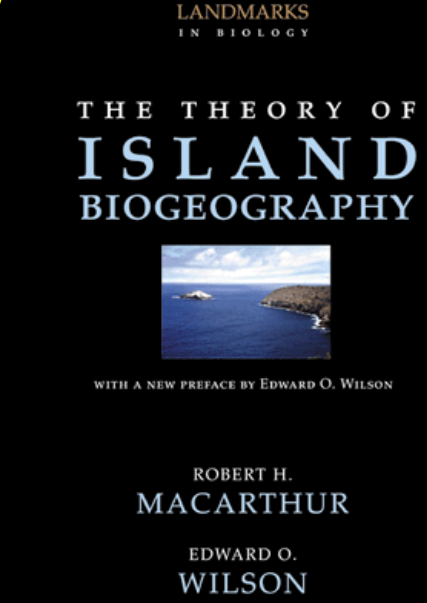
1. Is an ecosystem a reality or an abstraction?
2. Are ecosystems inherently stable?
3. How does disruption fit in?
4. How do the great disrupters – Humans - fit in?

How Does Nature Work? – Equilibrium and Biodiversity

The Theory of Island Biogeography (1967)
Robert MacArthur and Edward O. Wilson

- **Mathematical modeling reveals structure of change**
- Number of species always reaches ***an equilibrium point*** – species diversity does not continue to develop indefinitely
- New colonization must be matched by extinction
- Community structure focus rather than ecosystem

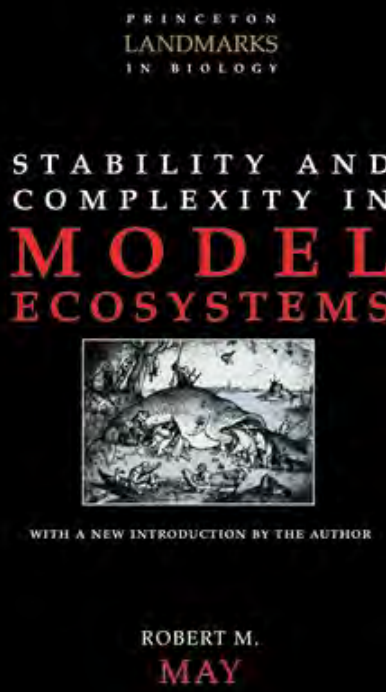




How Does Nature Work?
The New Ecology - No inherent stability

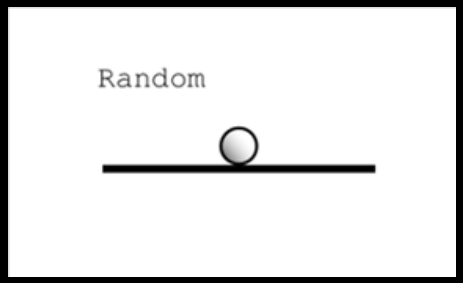
Robert May, *Stability and Complexity in Model Ecosystems* (1973)

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



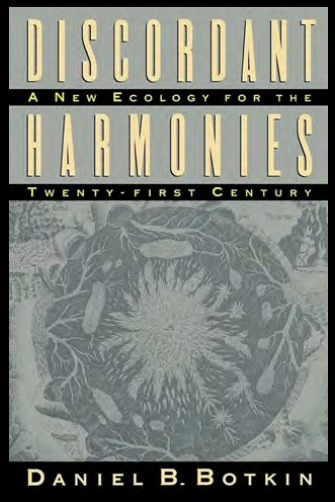
The new ecology emphasizes

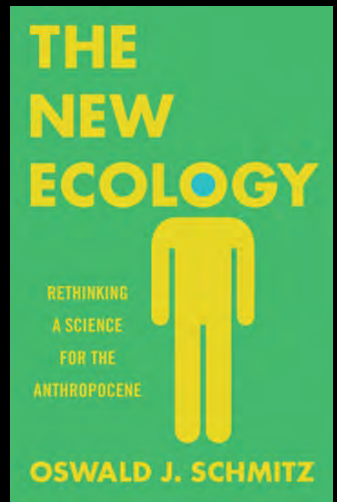
- ***Disequilibria***
- ***Instability***
- ***Chaotic fluctuations***



in ecosystems both "natural" and human impacted

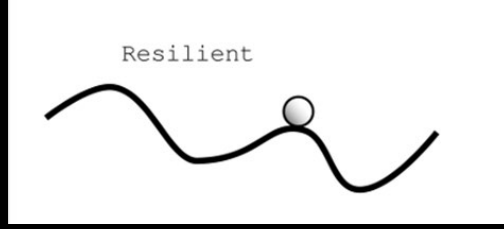
If 20th-century ecology was marked by an infatuation with balance, then our era is one of ***disturbance, disruption, non-equilibrium, chaos, and randomness***.
– Daniel Botkin, *Discordant Harmonies* (1990)





"Resilience and stability of ecological systems“ 1973

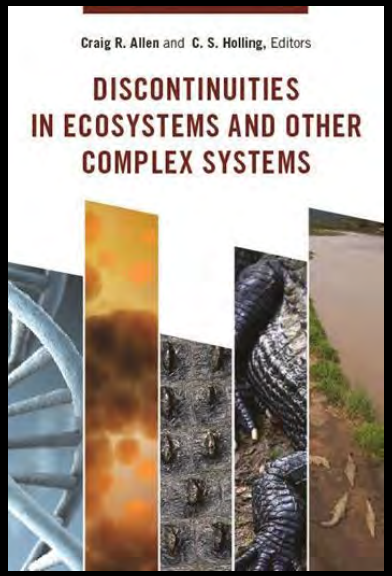
Balance and Disequilibrium - Permanence and Change

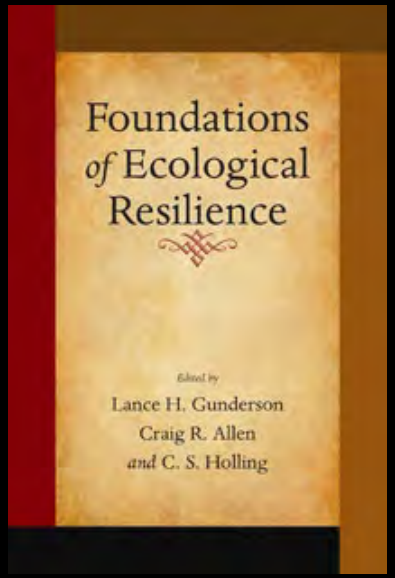


- **The concept of resilience** in ecological systems was first introduced by the Canadian ecologist C.S. Holling in order ***to describe the persistence of natural systems in the face of changes in ecosystem variables due to natural or anthropogenic causes***.
- **Resilience**, derived from its Latin roots 'to jump or leap back', is the ability to recover from or adjust easily to misfortune or change.
- Ecosystem resilience is **the capacity of an ecosystem to tolerate disturbance**.

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

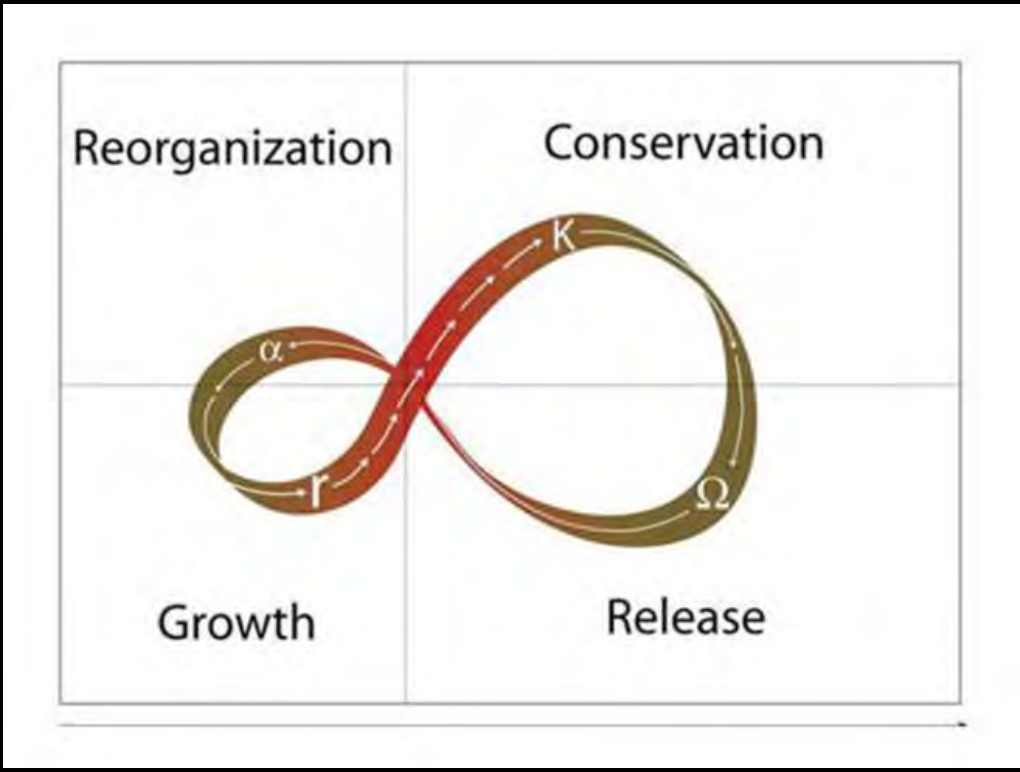
C.S. Holling 1930-2019



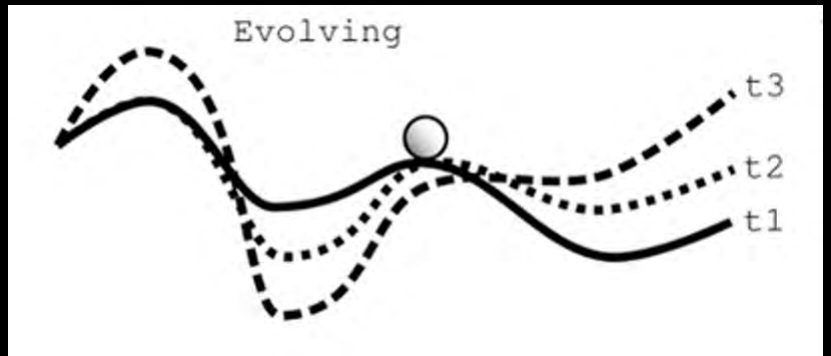


How Does Nature Work?
The Adaptive Cycle

- **Growth** - species and systems grow and diversify to exploit new opportunities and develop entirely new ecological ways of being.
- **Conservation** - species are tightly connected and organized, and systems "stabilize" into often hierarchically nested systems, where there is little or no room for innovation or growth.
- **Release** – where "mature" systems destabilize and collapse and become increasingly discontinuous and chaotic
- **Reorganization** – systems return in new ways, which creates a new field of conditions and possibilities for the next growth phase



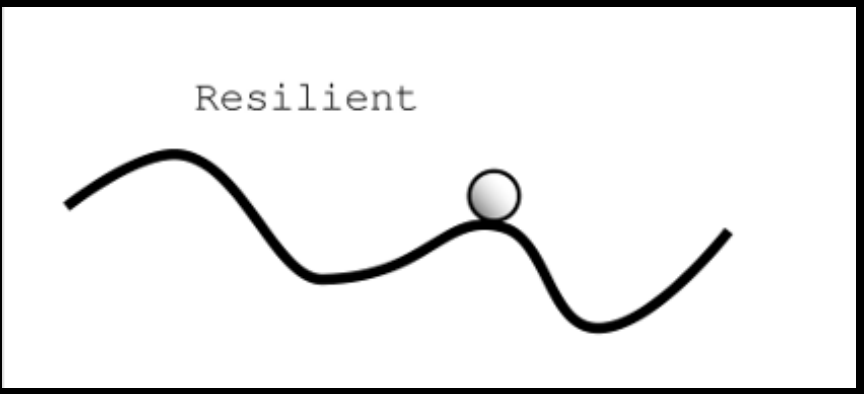
- **Incremental change** in the r and K phases, which are smooth and fairly predictable
- **Abrupt change** in the transitions from K through Ω and α

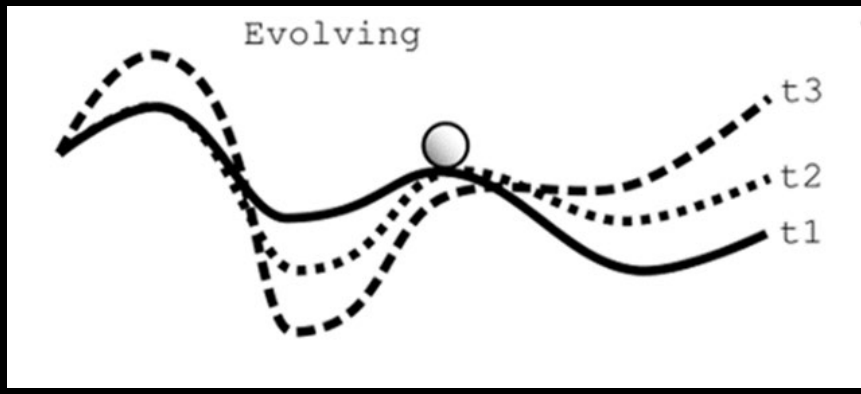


Resilience, Permanence, Change

Ecosystem Resilience - 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 without collapsing into a qualitatively different state that is controlled by a different set of processes).

- **As resilience declines the magnitude of a shock from which an ecosystem cannot recover gets smaller and smaller**.
- A resilient ecosystem can **withstand shocks and rebuild itself when necessary**.

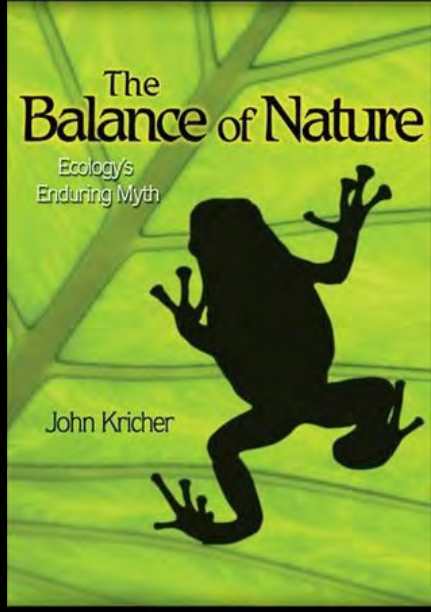




"Resilience" as applied to ecosystems has three defining characteristics:

- 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 = ***Evolve***

The Balance of Nature – The End of Stability?

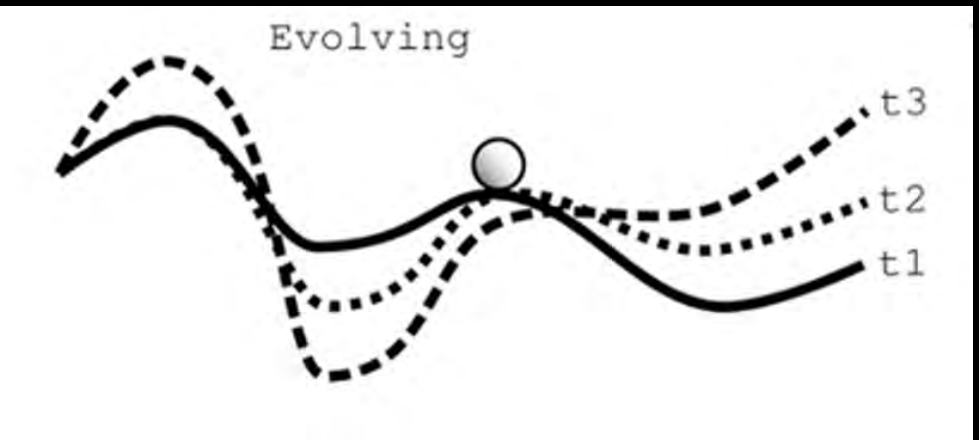


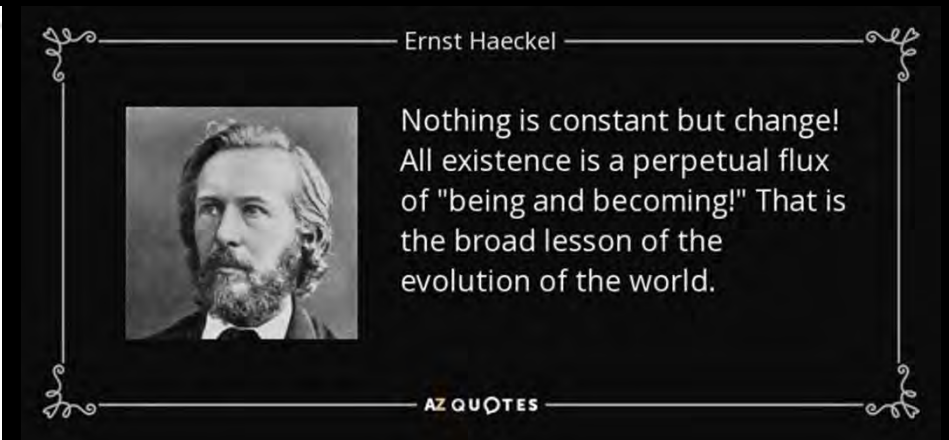
"The existence of a balance of nature has been a dominant part of Western philosophy since before Aristotle.

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***." - Kricher (2009)





How does Nature work?

Biotic Change - Integrity and Instability

New Nature - Novel Ecosystems

- Assemblages of species in a given area that have not previously occurred.
- They lack historically natural analogs
- Novel ecosystems are not really all that novel, except in their species composition.

The interplay between change and persistence

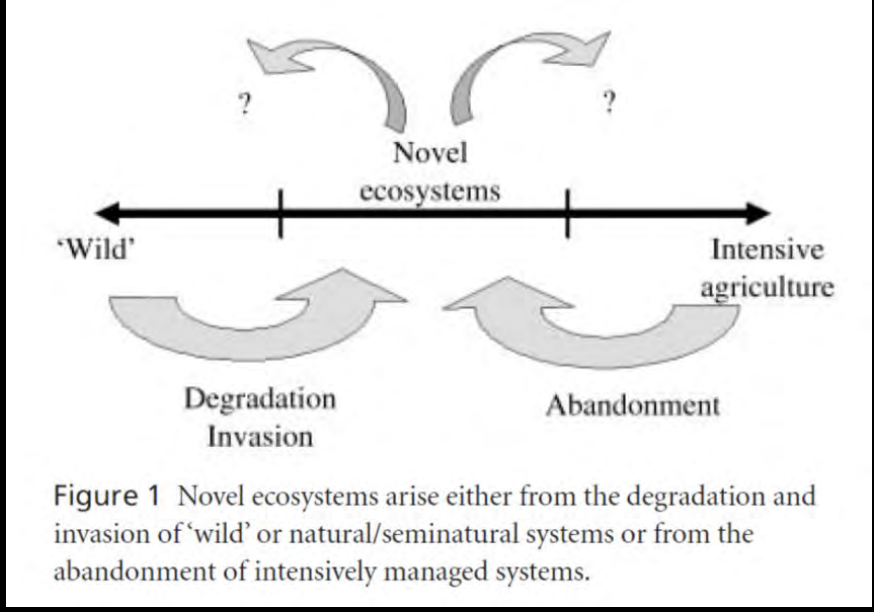
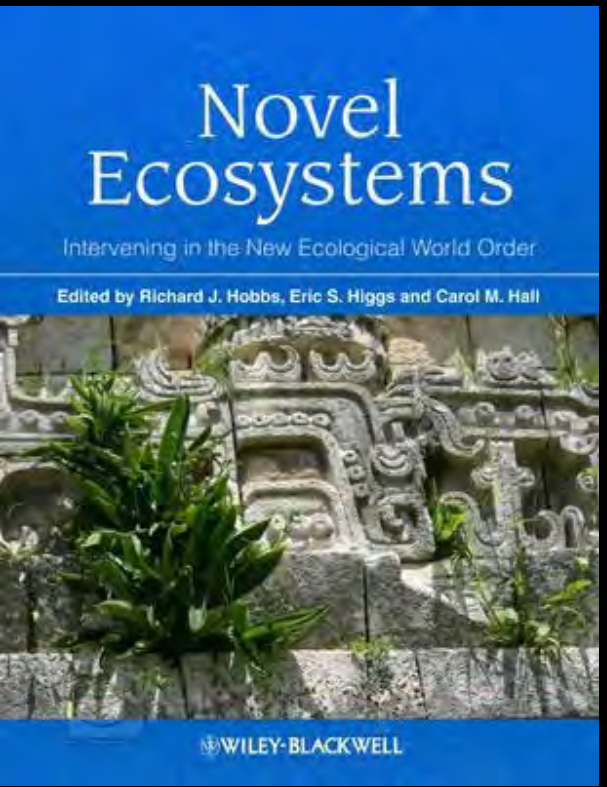
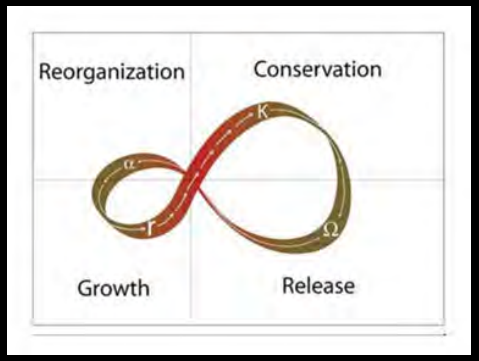
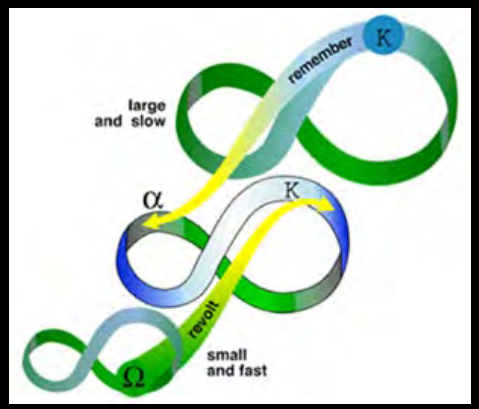
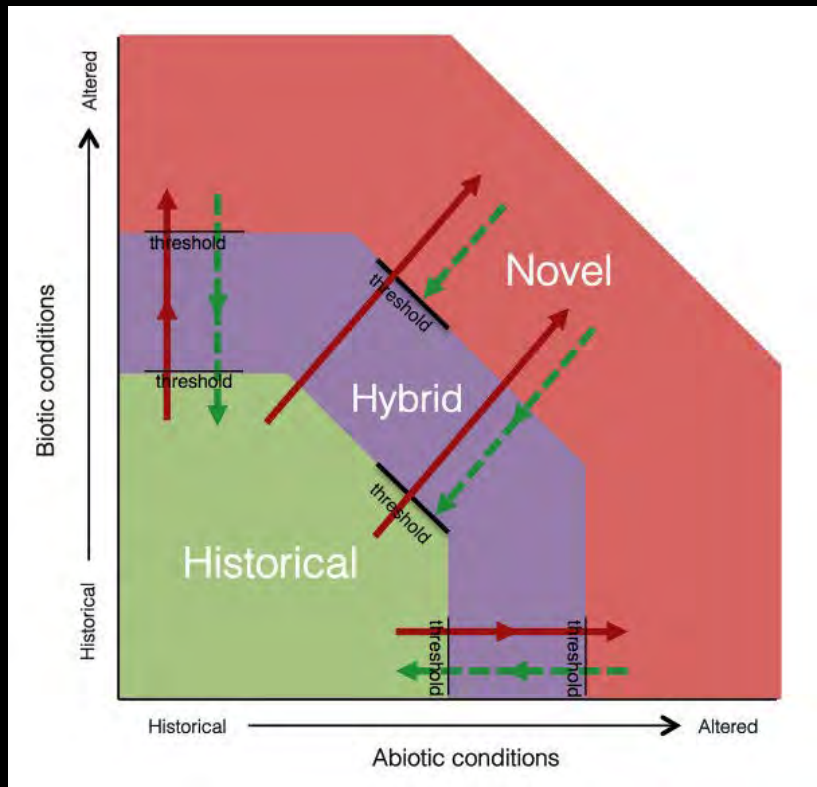


Figure 1 Novel ecosystems arise either from the degradation and invasion of 'wild' or natural/seminatural systems or from the abandonment of intensively managed systems.

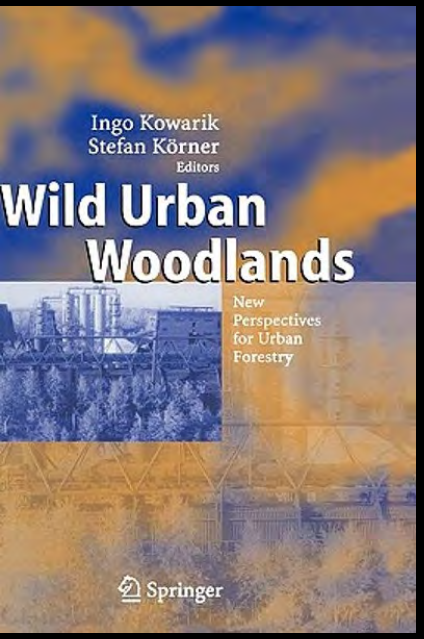




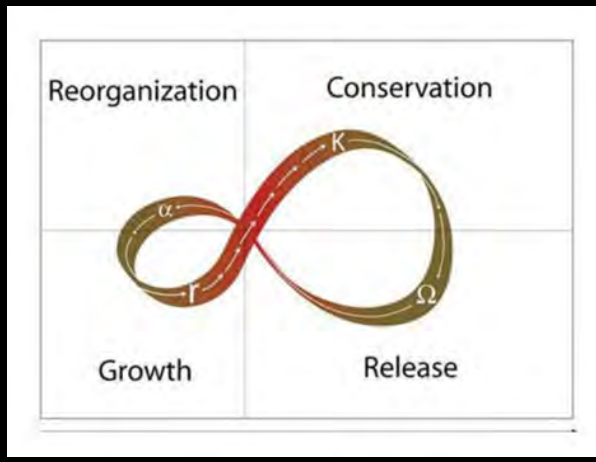




Wild Urban Woodlands – Waller Creek 7th Steet Bridge



2024



2005

2009

2012

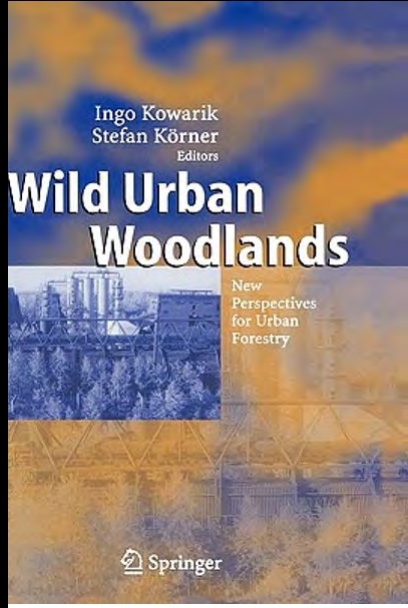
2017

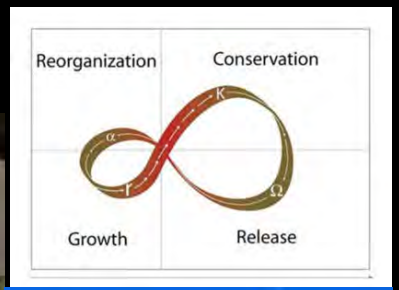
The New Ecology – How does Nature work?

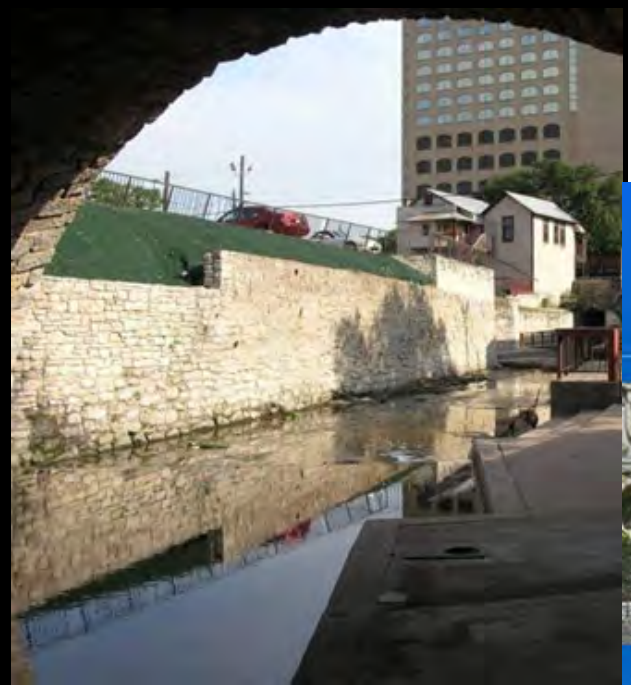
Permanence and Change = Process

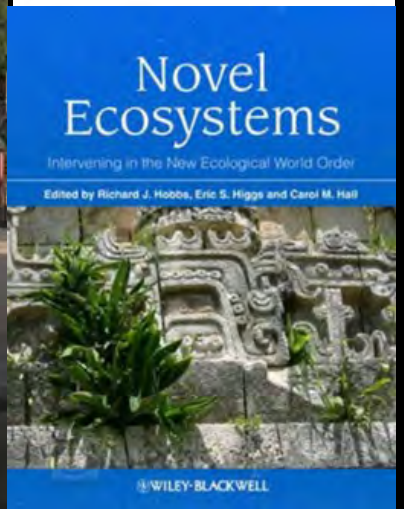
"**the reference point is not an original condition of a natural landscape**, but rather a condition defined based on the current site potential and the greatest possible degree of self-regulation.

From this perspective, therefore, **the natural capacity for *process*** is the central point, **not a particular, retrospectively determined and often idealized, *picture* of nature**."









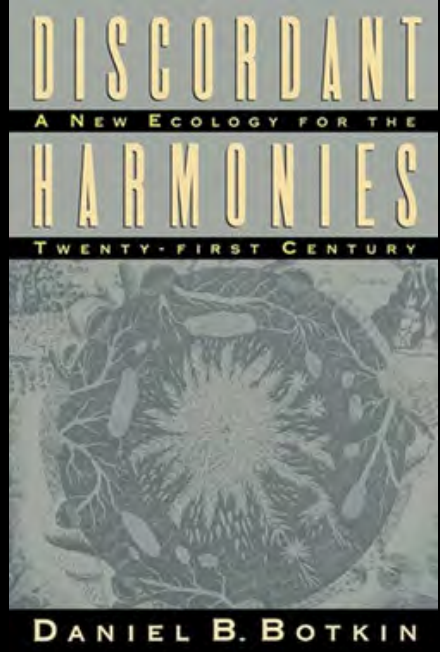
New Nature

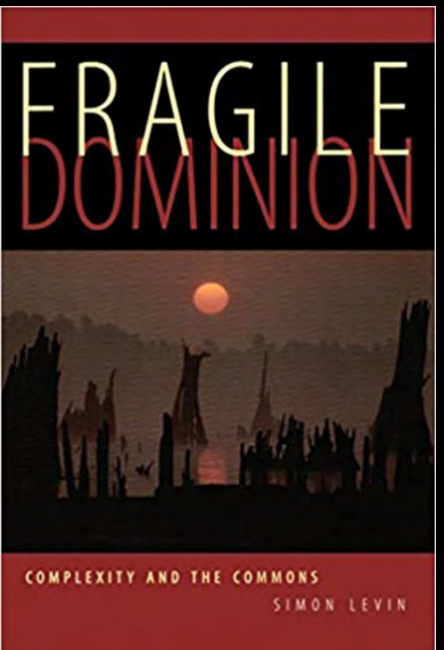
New Metaphors of Change and Permanence

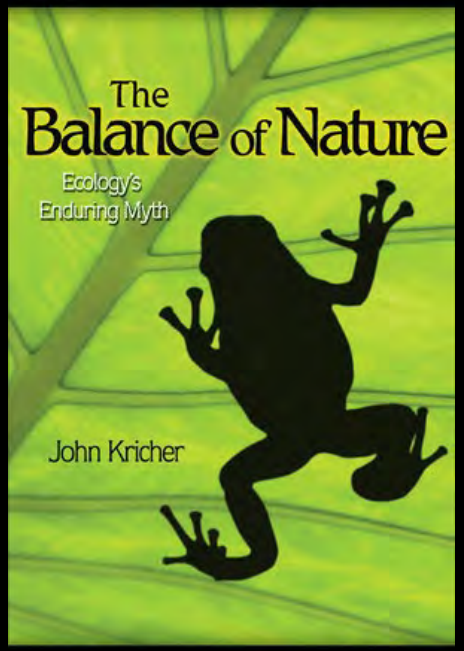
"Clearly, to abandon a belief in the constancy of undisturbed nature is psychologically uncomfortable…

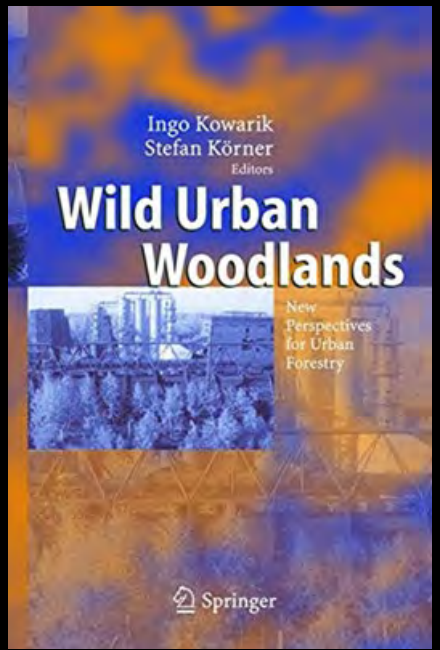
The way to achieve a harmony with nature is first **to break free of old metaphors and embrace new ones** so that we can lift the veils that prevent us from accepting what we observe, and then to make use of technology to study life and life-support systems as they are."

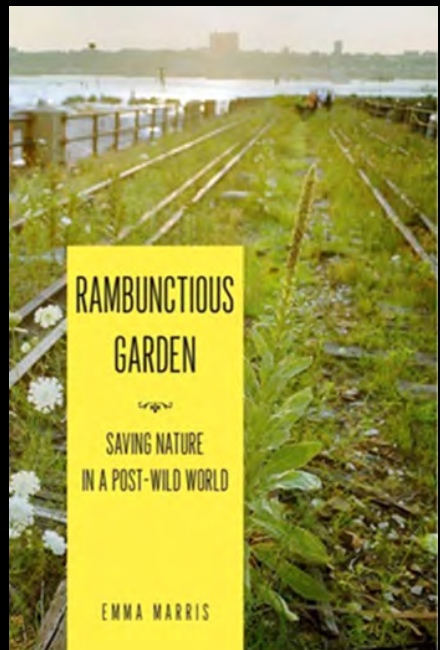
Botkin, *Discordant Harmonies*









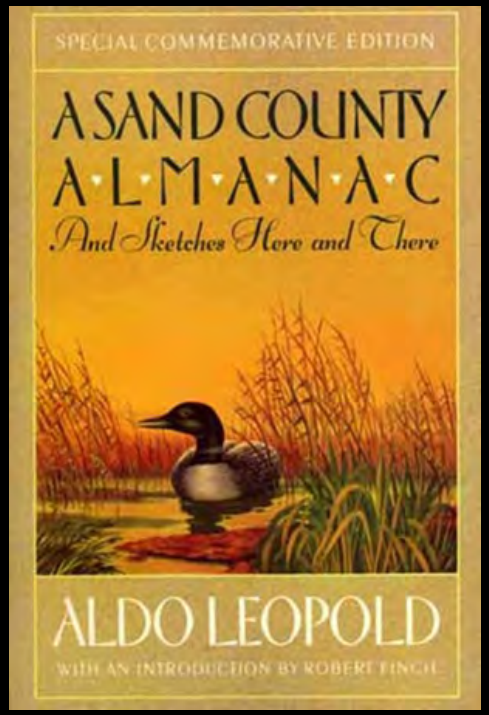


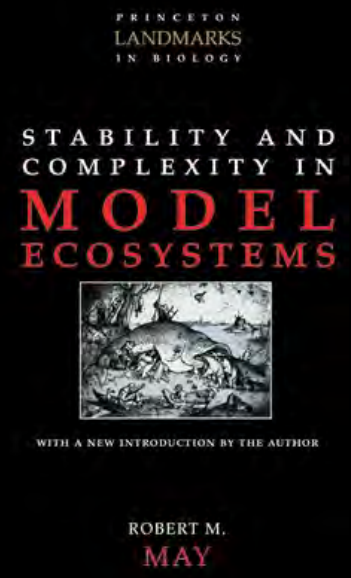
How does Nature Work?
Ecological Concept of Nature

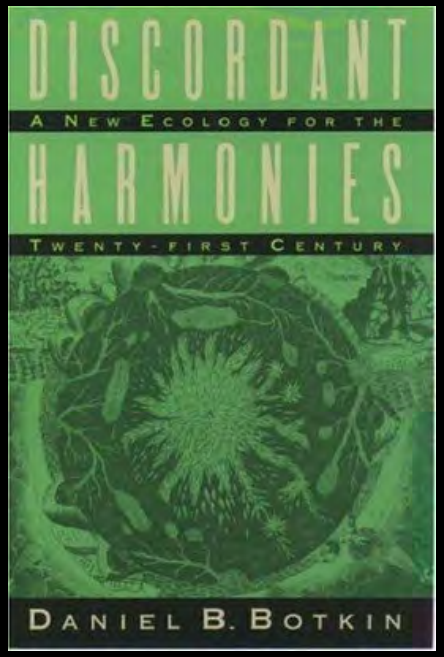
Stability
- Balance vs. Disequilibrium
- Harmony vs. Disharmony

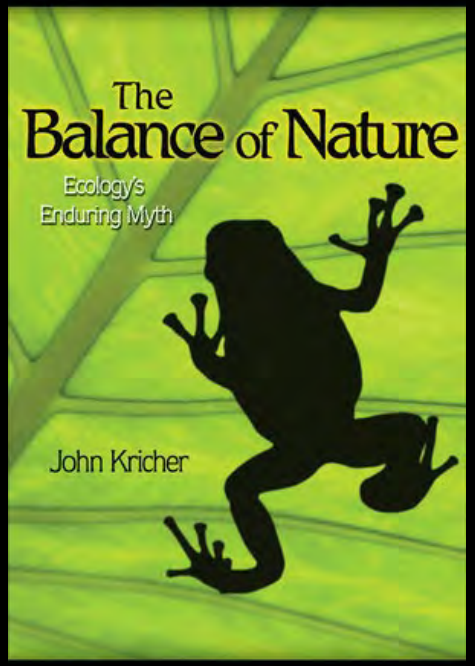
Integrity
- Permanence vs. Change

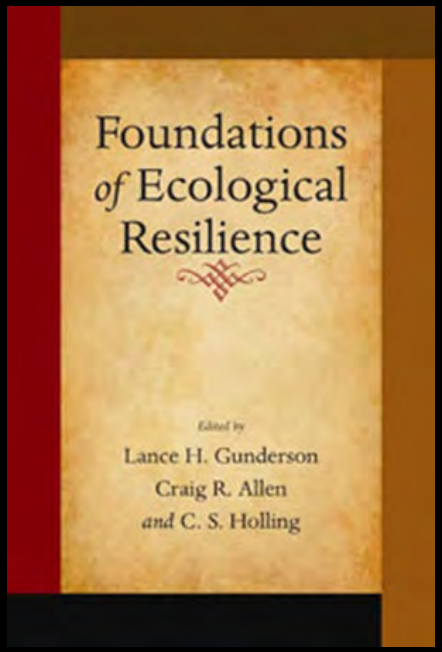
Beauty?

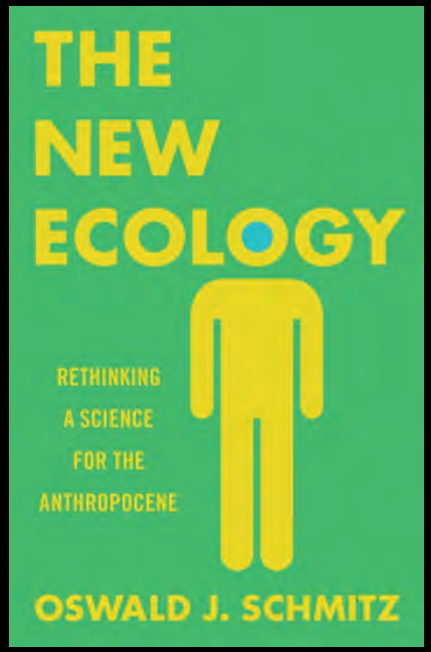












The Land Ethic – Integrity, Stability, Beauty

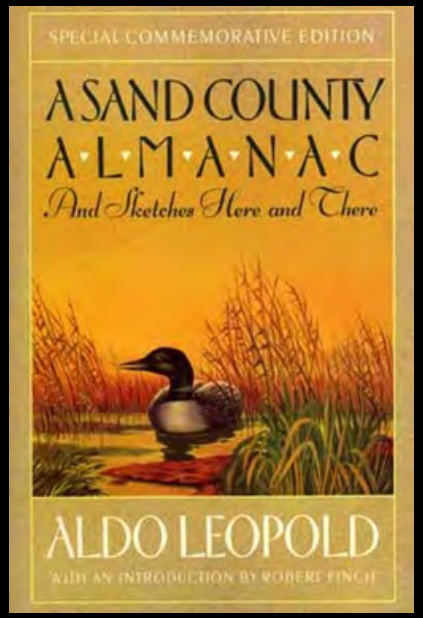
The Ecological Basis for Environmental Ethics?

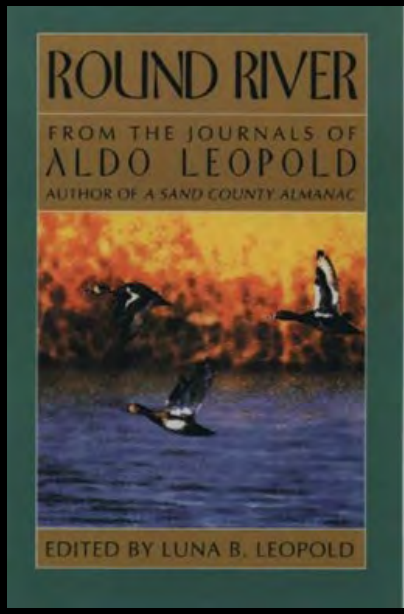
"A thing is right when it tends to preserve the ***integrity, stability, and beauty*** of the biotic community. It is wrong when it tends otherwise."

A Sand County Almanac 1948

Beauty?

Moral Sentiment





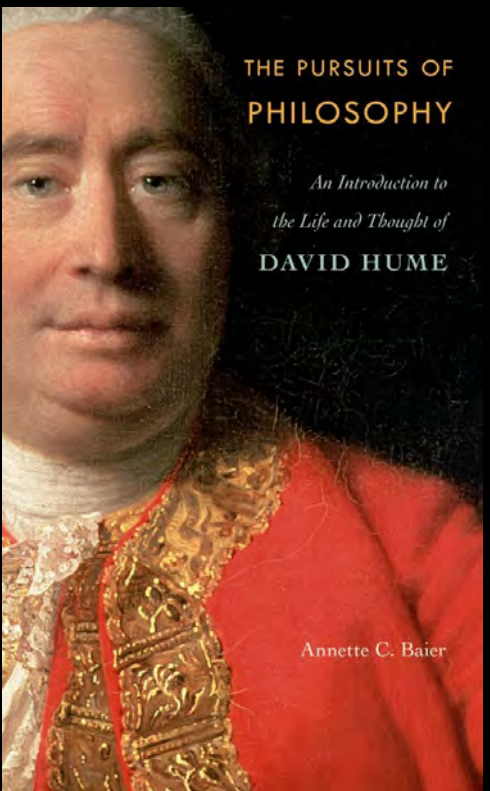
David Hume

Morals excite passions, and produce or prevent actions. Reason of itself is utterly impotent in this particular. The rules of morality, therefore, are not conclusions of our reason.

AZ QUOTES

Empiricism
David Hume (1711–1776)

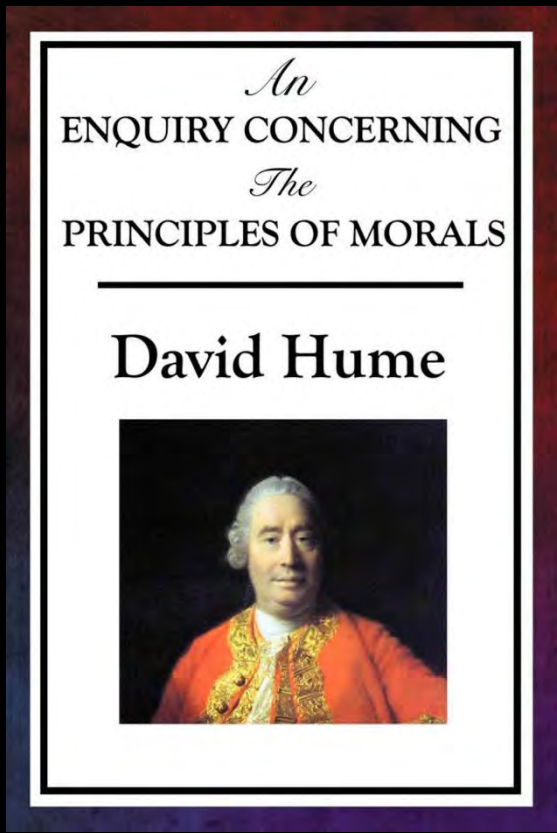
- Moral Sentiment
- Reason and Perception
- Beauty



“

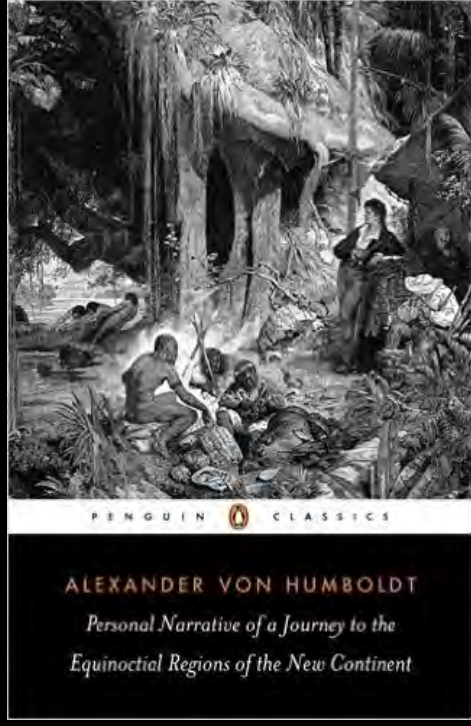
Beauty is no quality in things themselves: It exists merely in the mind which contemplates them; and each mind perceives a different beauty.

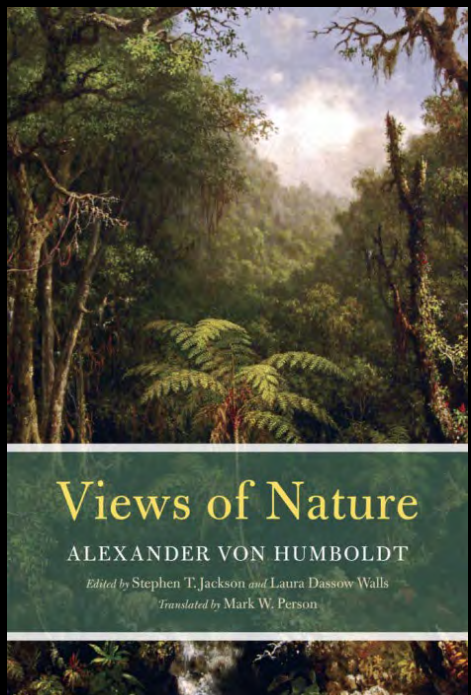
DAVID HUME



Science and Beauty

Alexander von Humboldt
(1769-1859)

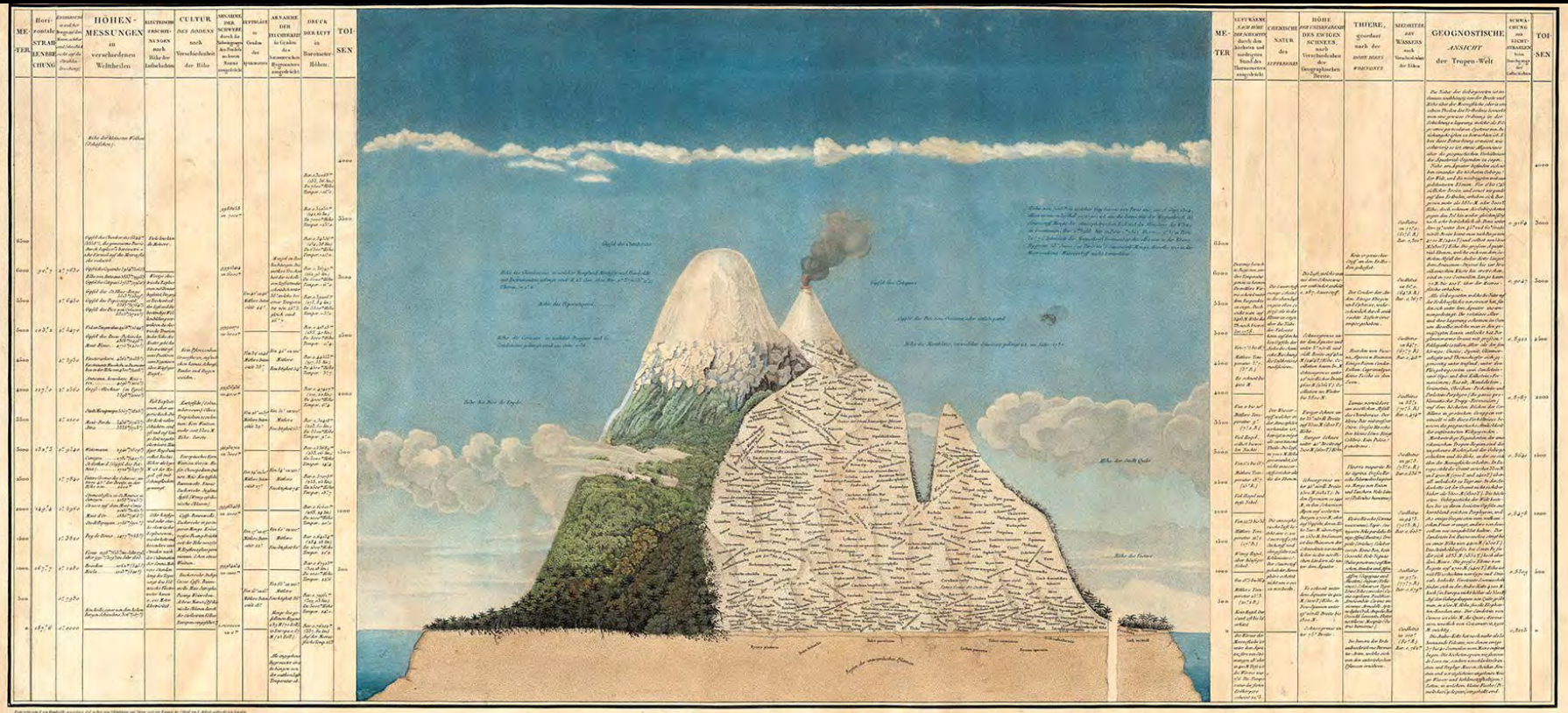




The Order of Nature

A New Vision of Nature – Unity in Variety

Nature is a system in which everything was connected



Geographie der Pflanzen in den Tropen-Ländern;

ein Naturgemälde der Anden,

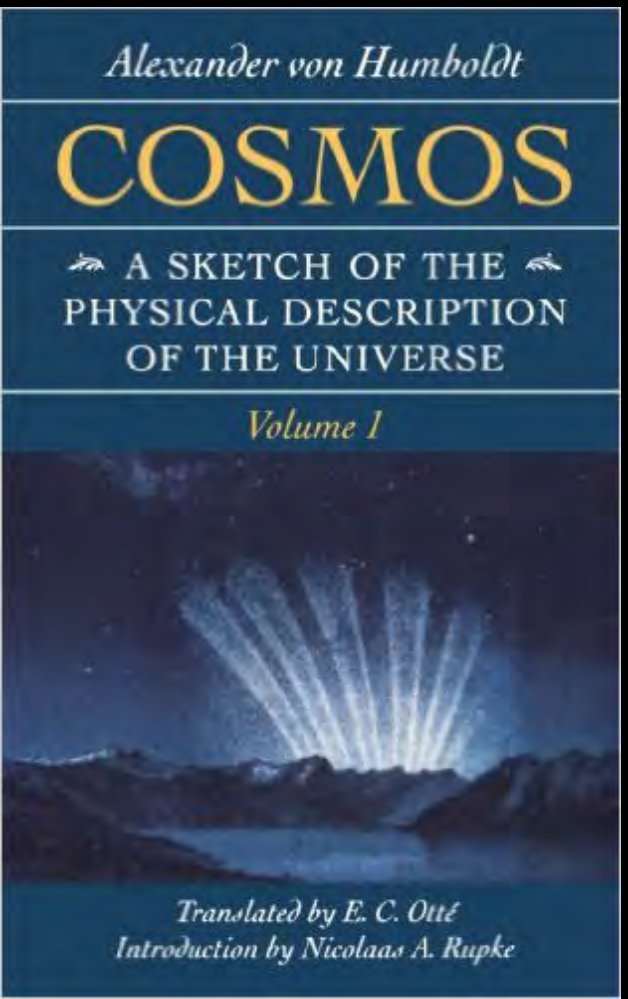
gegründet auf Beobachtungen und Messungen, welche vom 10ten Grade nördlicher bis zum 10ten Grade südlicher Breite angestellt worden sind, in den Jahren 1799 bis 1803.

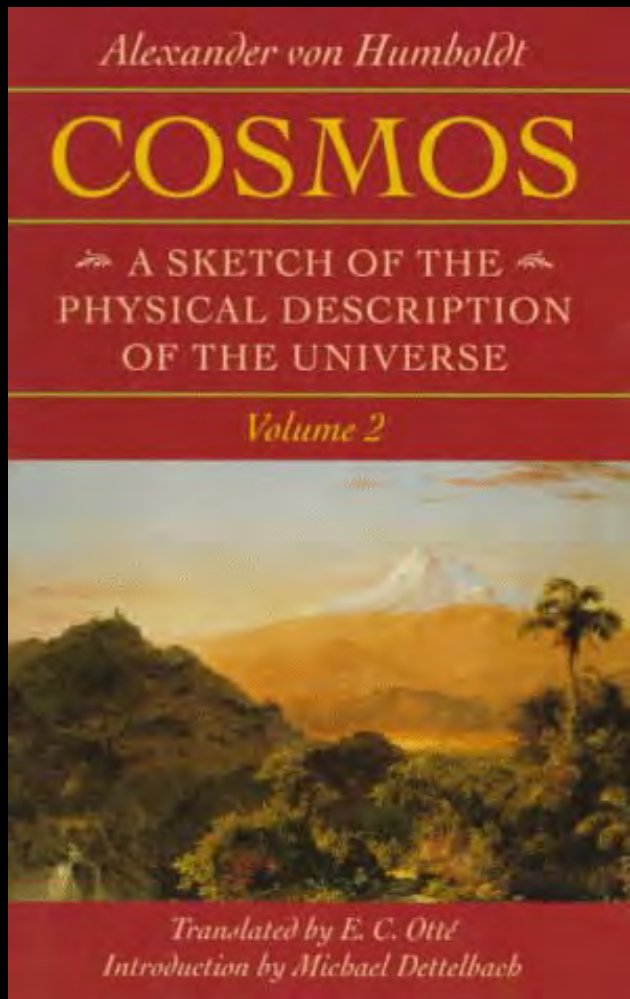
von ALEXANDER VON HUMBOLDT und A. G. BONPLAND.

Imaginative Understanding and Science

Cosmos: A Sketch of the Physical Description of the Universe

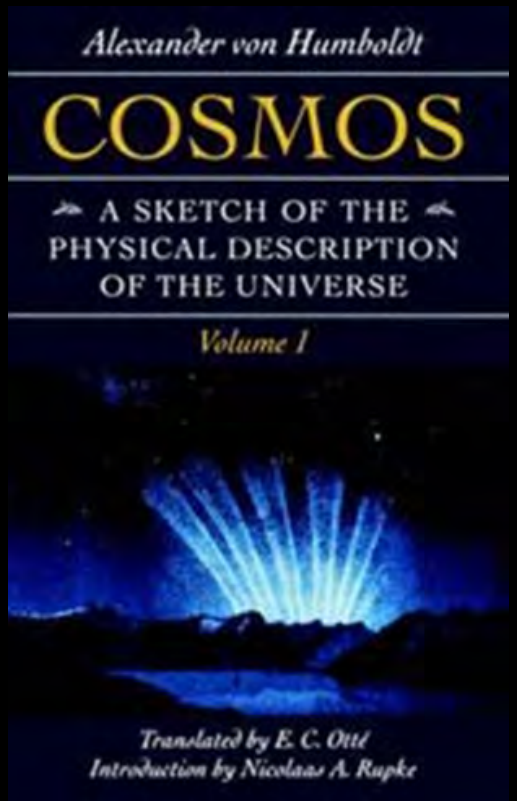
For Humboldt "Cosmos" signifies both
the "order of the world, and adornment of this universal order."

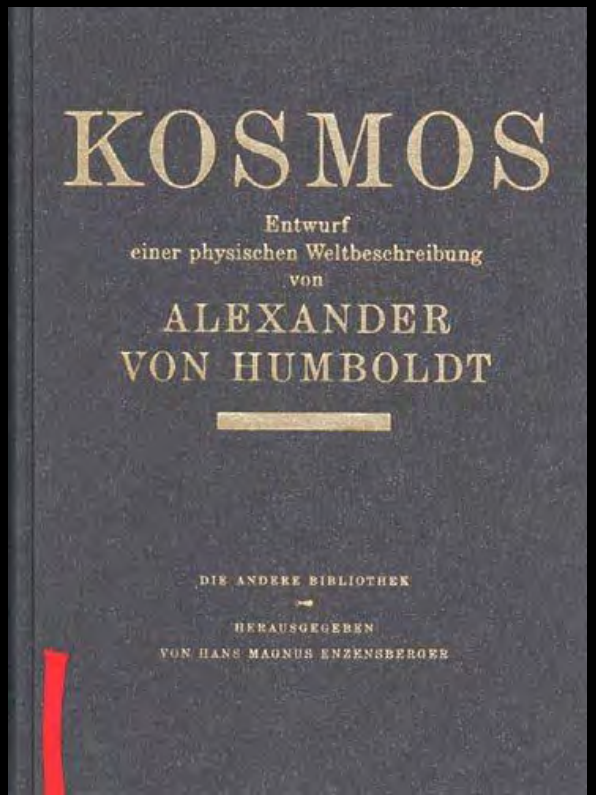


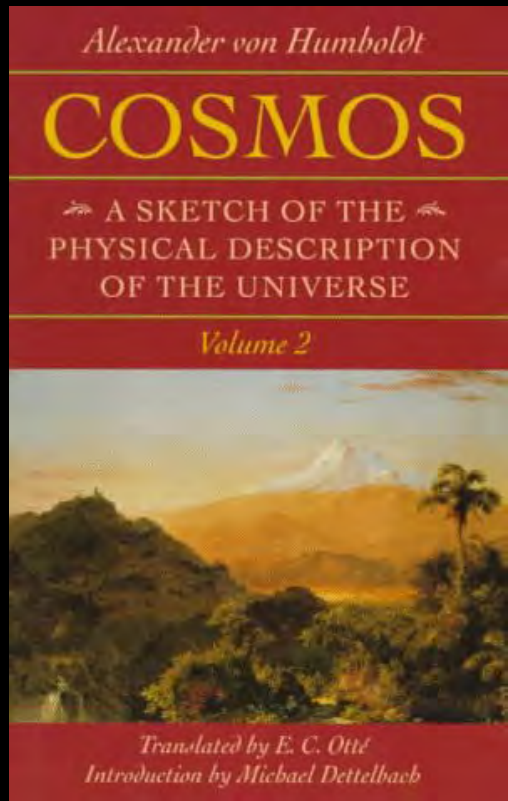


Imaginative Understanding and Science
Humboldt's Cosmos "Order and Adornment"

- Order refers to the observed fact that the physical universe, independently of humans, demonstrates regularities and patterns that we can define as laws.
- Adornment refers to human imaginative perception of beauty and wonder, which is also part of the universe.







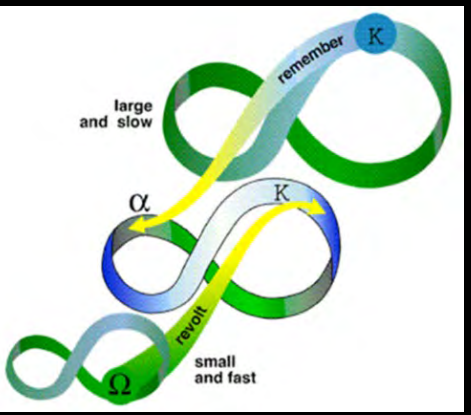
Humboldtian Cosmos - A Vision of the Unity of Nature

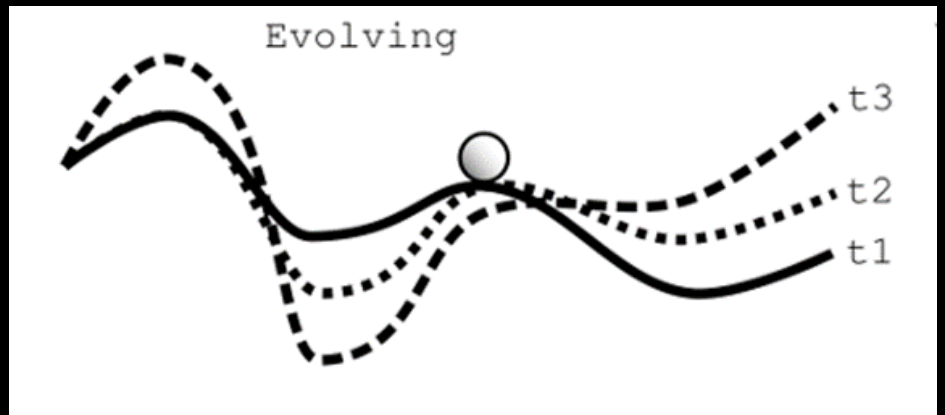
- The Cosmos is both ordered and beautiful.
- Nature and the human mind are a unity
- To know nature better is thus to know ourselves better, for knowledge is a deeply human project combining understanding and imagination.
- A dynamic picture of the universe that would continually grow and change as human conceptions of nature and the depth of human feeling about nature enlarge and deepen.

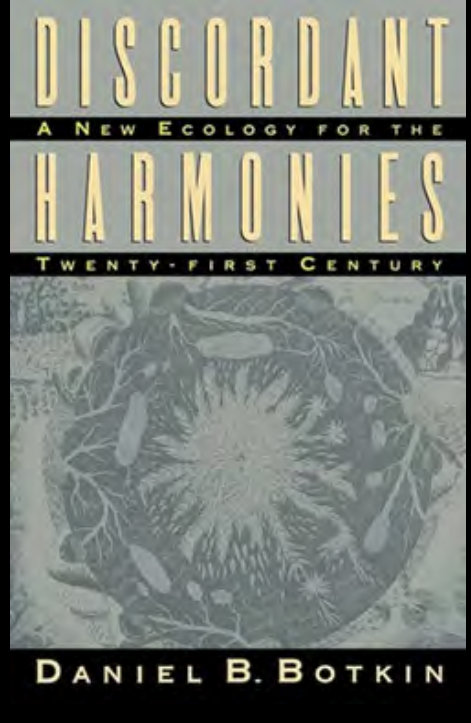
Discordant Harmonies - Prescriptions for New Nature

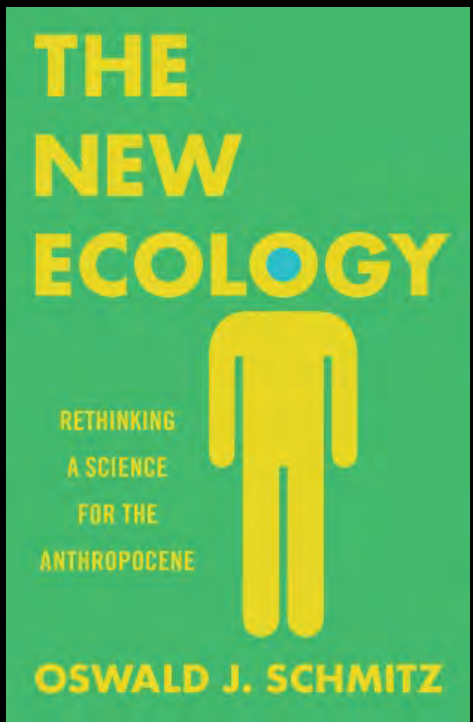
- "Begin to observe nature as it is, not as we imagine it to be."
- "Nature in the 21st Century will be a nature that we make; the question is the degree to which this molding will be intentional or unintentional, desirable or undesirable."
- "If nature in the twenty-first century will be a nature that we make, then the guide to action is:

1. our knowledge of living systems and our willingness to observe them for what they are,
2. our commitment to conserve natural areas,
3. to recognize the limits of our actions, and
4. to understand the roles of metaphor and myths in our perceptions of our surroundings." Botkin









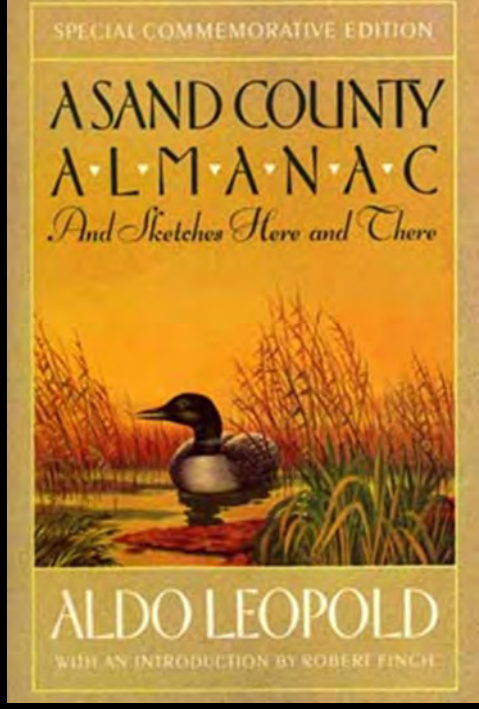
The First Precaution of Intelligent Tinkering – Aldo Leopold

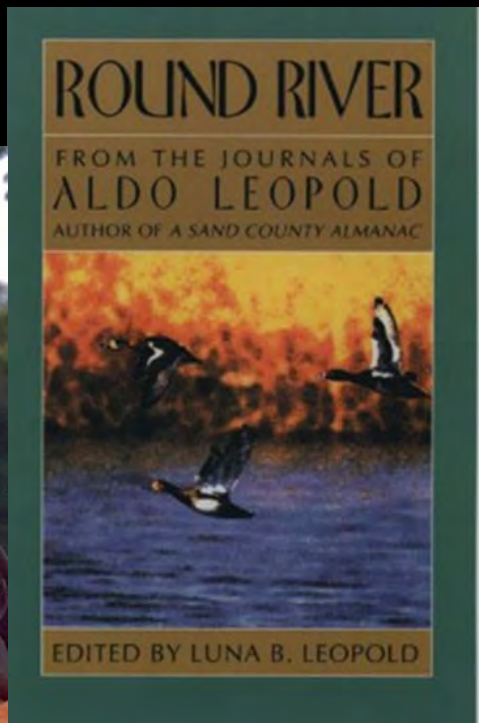
"The last word in ignorance is the man who says of an animal or plant, "What good is it?"

If the land mechanism as a whole is good, then every part is good, whether we understand it or not.

If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts?

To keep every cog and wheel is the first precaution of intelligent tinkering." — Aldo Leopold, Round River





Ecology – A Collective Wisdom of Biotic Navigation

"Ecology is an infant just learning to talk, and, like other infants, is engrossed with its own coinage of big words.

Its working days lie in the future.

Ecology is destined to become the lore of Round River, a belated attempt to convert our collective wisdom of biotic materials into a collective wisdom of biotic navigation.

This, in the last analysis, is conservation."

Aldo Leopold 1948