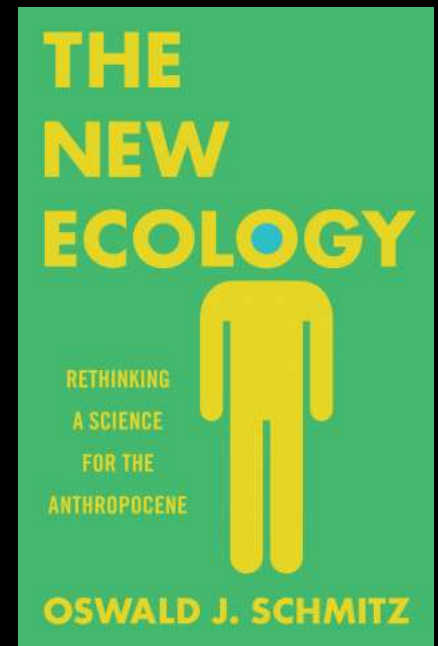
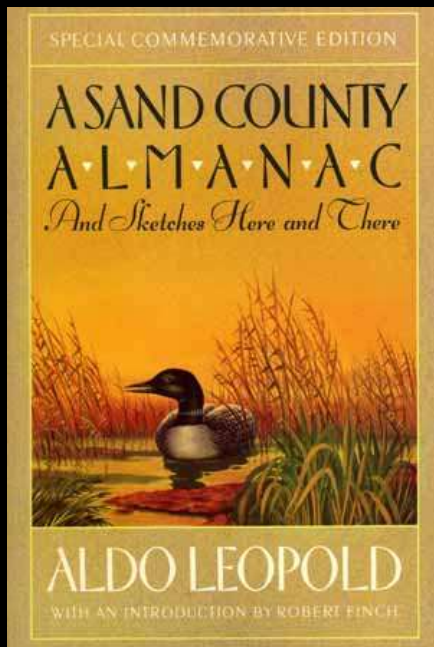




American Ecology: Stability, Integrity, and Leopold's Legacy

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



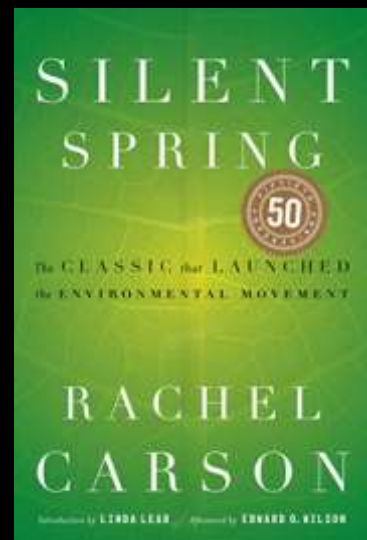
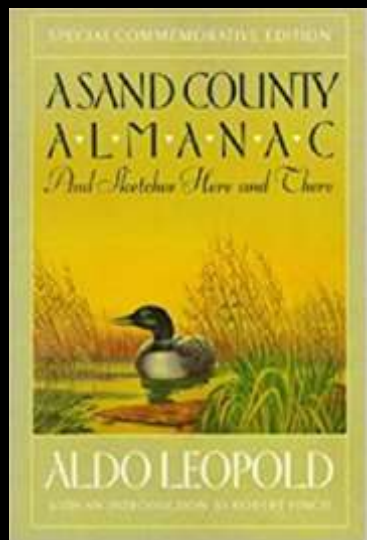
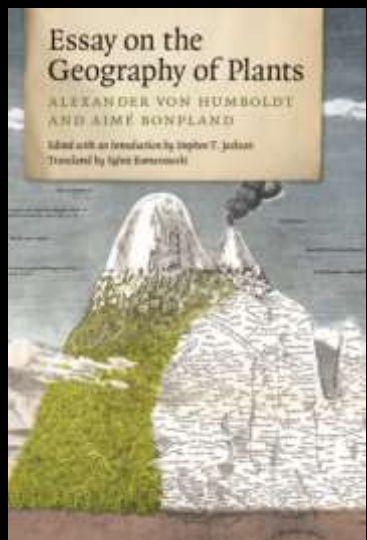
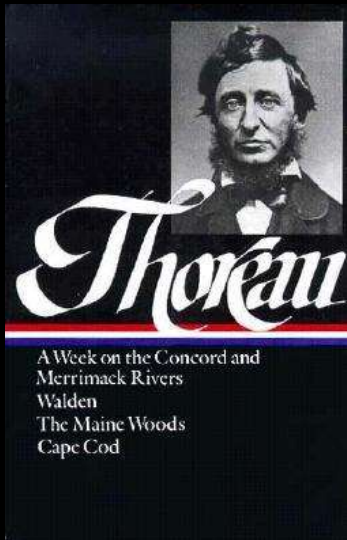
Science and American Nature

Natural History – description and classification of organisms

Biology – the study of Life – biotic world – How does Life work?

Ecology – the study of the biotic and abiotic worlds – How does Nature work?

Environmental Science - the multidisciplinary study of the environment – biogeochemical cycles – How does the Environment work?



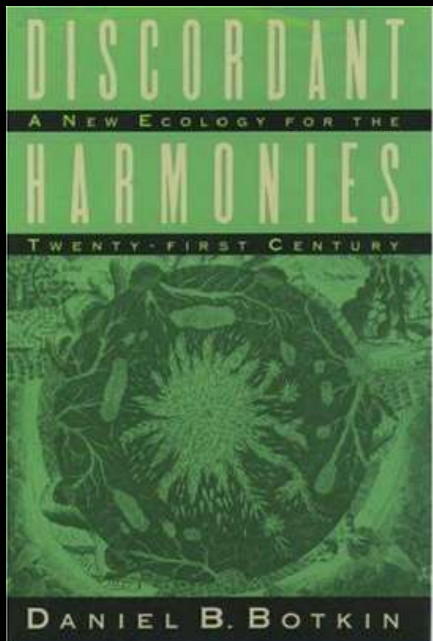
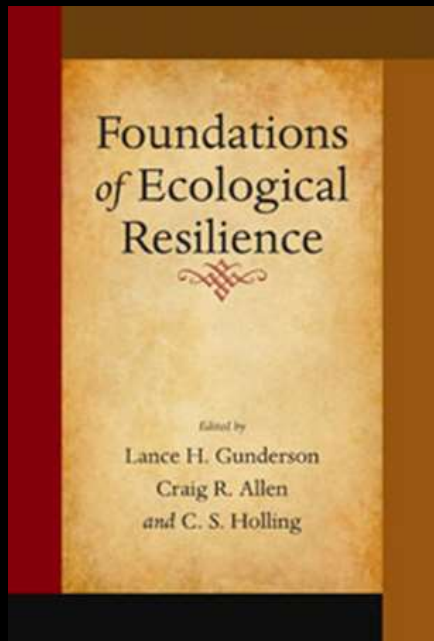
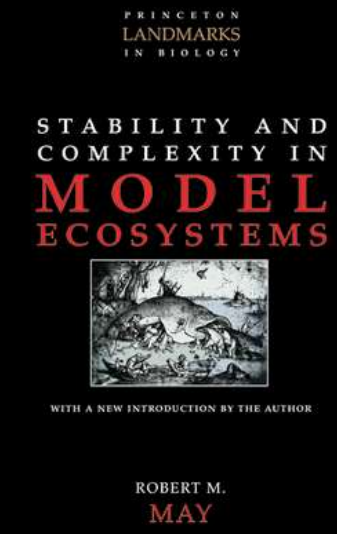
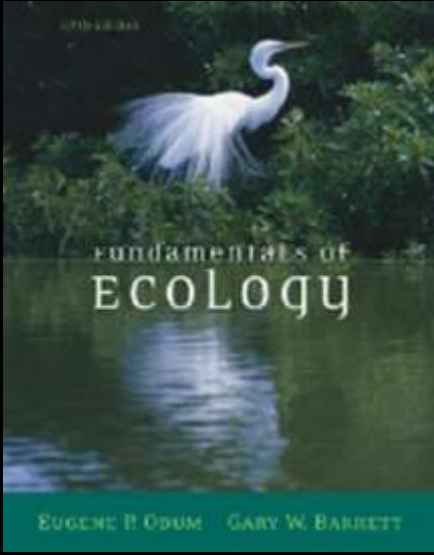
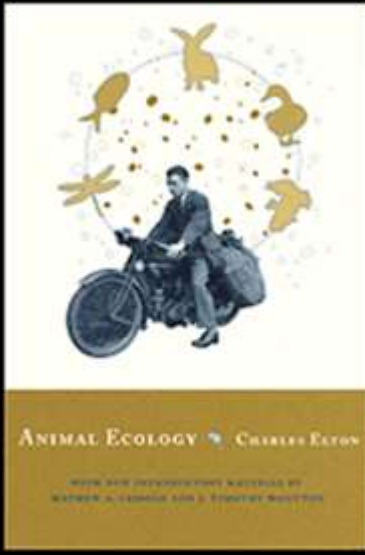
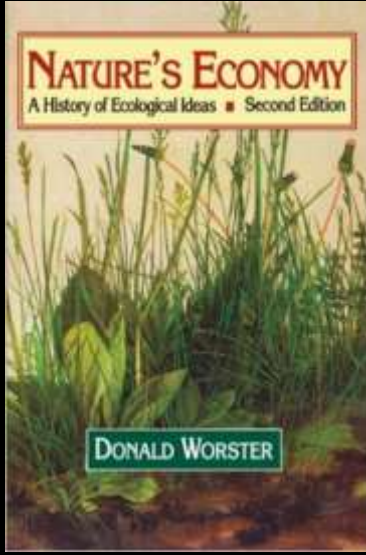
Nature's Economy - How does Nature work?

Stability

- Balance vs. Disequilibrium
- Harmony vs. Disharmony

Integrity

- Permanence vs. Change



Aldo Leopold 1887-1948

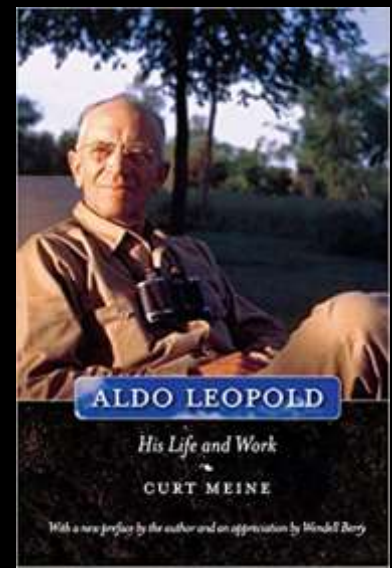
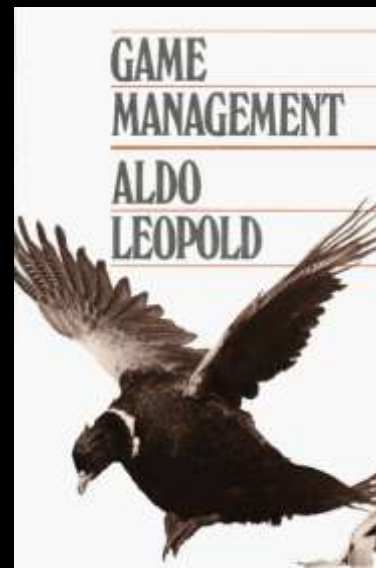
Born in Iowa, Leopold developed an interest in the natural world at an early age, spending hours observing, journaling, and sketching his surroundings.

After graduating from the Yale Forest School in 1909, he worked for the newly established U.S. Forest Service in Arizona and New Mexico.

By age 24, he had been promoted to the post of supervisor for the Carson National Forest in New Mexico. And in 1922, he was instrumental in developing the proposal to manage the Gila National Forest as a wilderness area. It became the country's first official wilderness area in 1924.

In 1924, he accepted transfer to the U.S. Forest Products Laboratory in Madison, Wisconsin, and became an associate director, and in 1933 published the first textbook in the field of wildlife management.

Later that year, he accepted a new chair position in game management – a first for the University of Wisconsin and the nation.



Restoring an Old Farm – Restoration Ecology

In 1935, he and his family initiated their own ecological restoration experiment on a worn-out farm along the Wisconsin River outside of Baraboo, WI.

He purchased 80 acres in the sand country of central Wisconsin. The once-forested region had been logged, swept by repeated fires, overgrazed by dairy 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

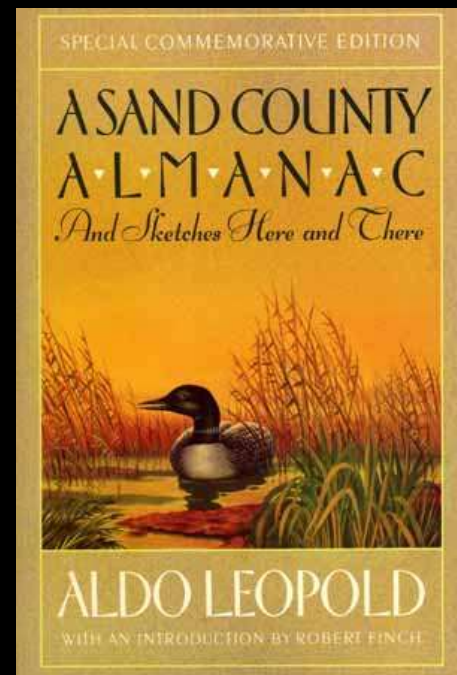


A Sand County Almanac 1949

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.

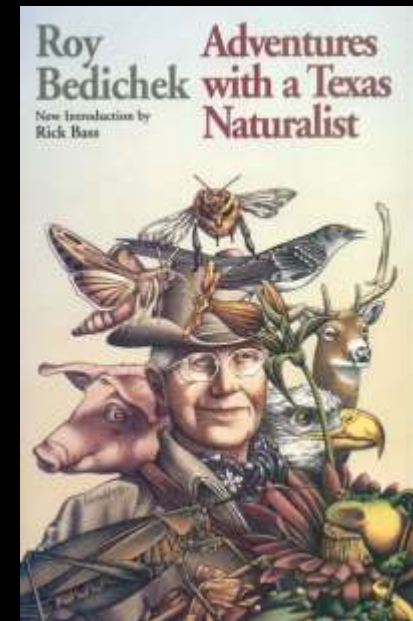
Unfortunately, just one week after receiving word that his manuscript would be published, Leopold died of a heart attack on April 21, 1948.

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



“Mutual dependence, solidarity, or community of interest is after all and generally nature's most distinctive characteristic. The sin of non-cooperation is severely penalized.”

1947 Roy Bedichek



Thinking like a mountain – A Fierce Green Fire

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...

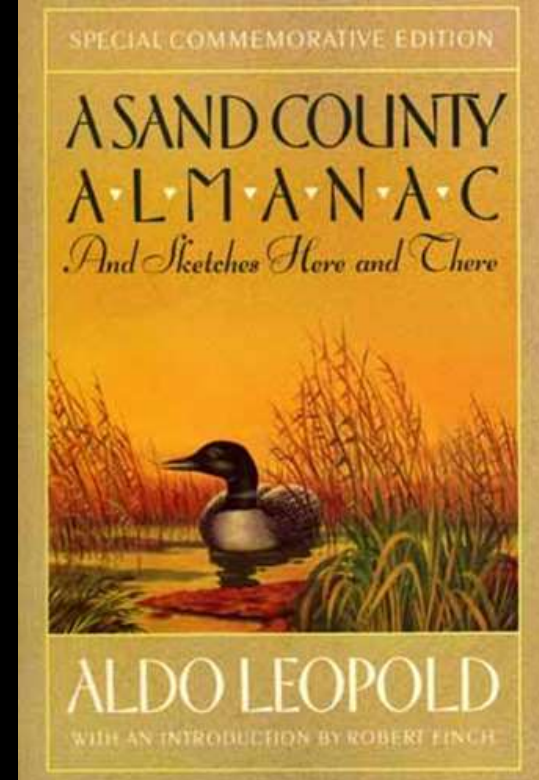
In those days we had never heard of passing up a chance to kill a wolf. In a second we were pumping lead into the pack...

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...

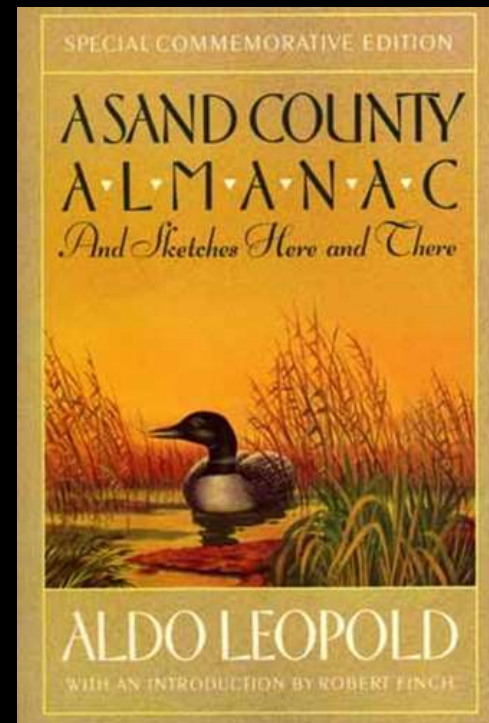
I now suspect that just as a deer herd lives in mortal fear of its wolves, so does a mountain live in mortal fear of its deer...

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.”



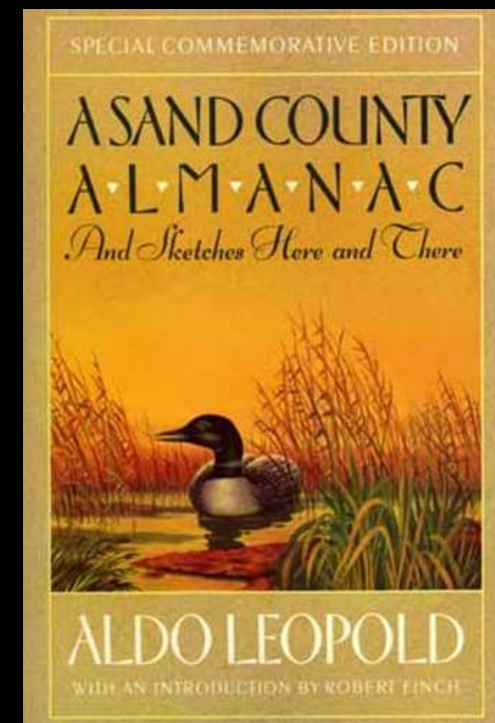
The Land Ethic – the Ecological basis for Environmental Ethics?

"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."



Nature's Economy - The History of the Science of Ecology

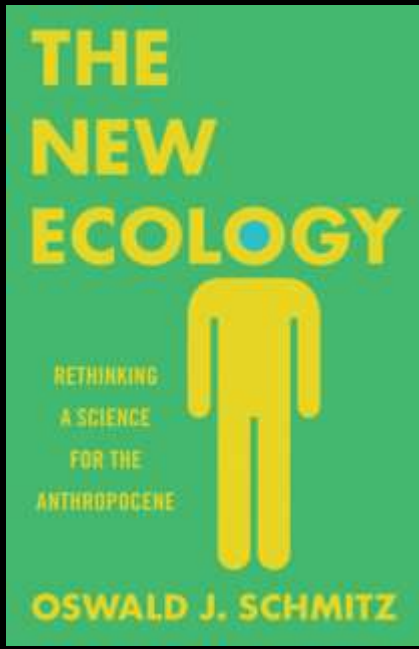
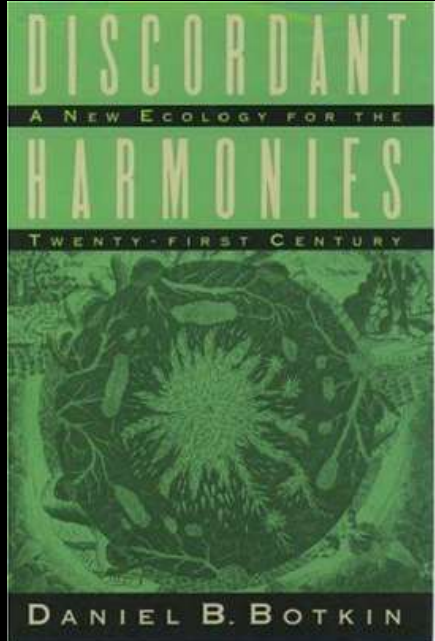
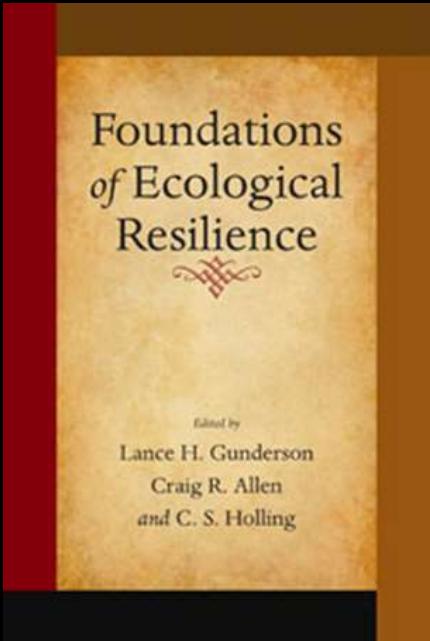
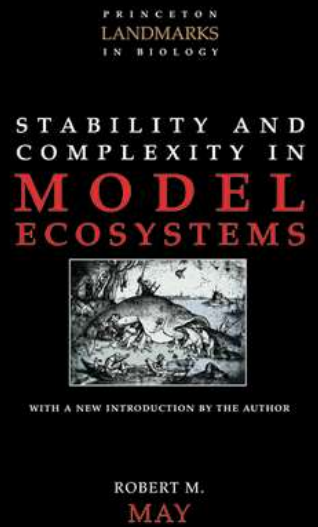
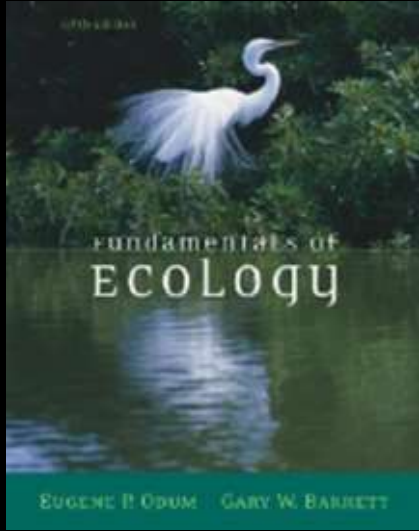
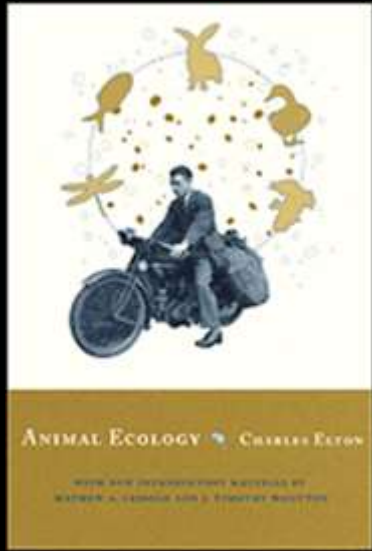
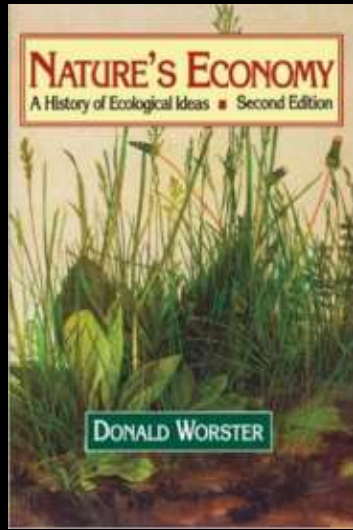
Stability

- Balance vs. Disequilibrium
- Harmony vs. Disharmony

Integrity

- Permanence vs. Change

The Economy of Nature



The Economy of Nature and Evolution

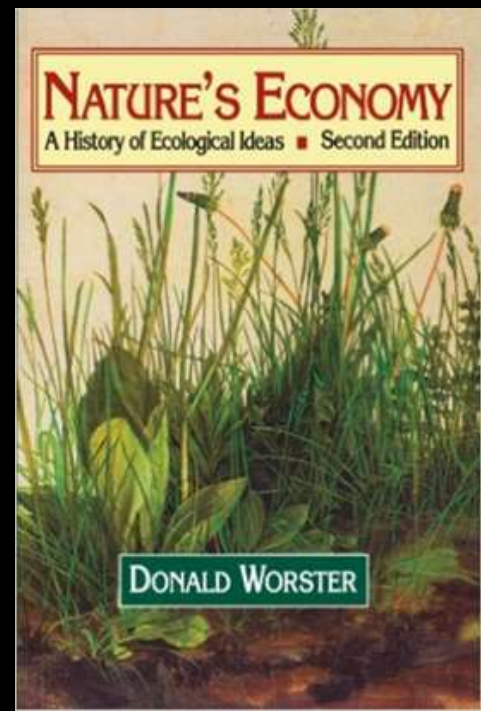
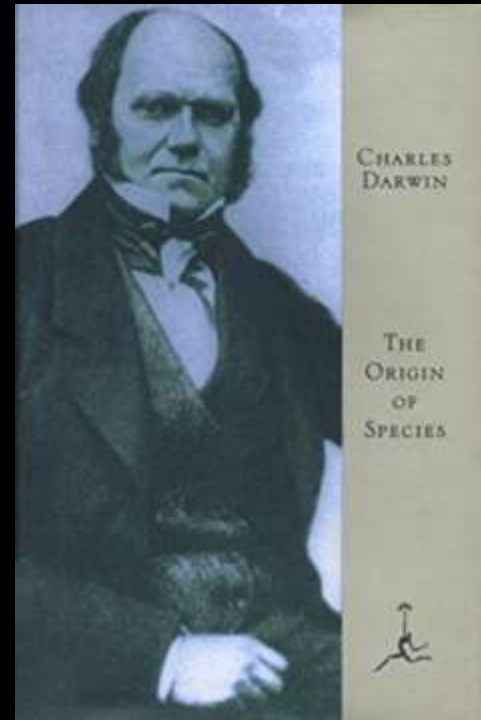
How Life Works – Biology

Charles 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."

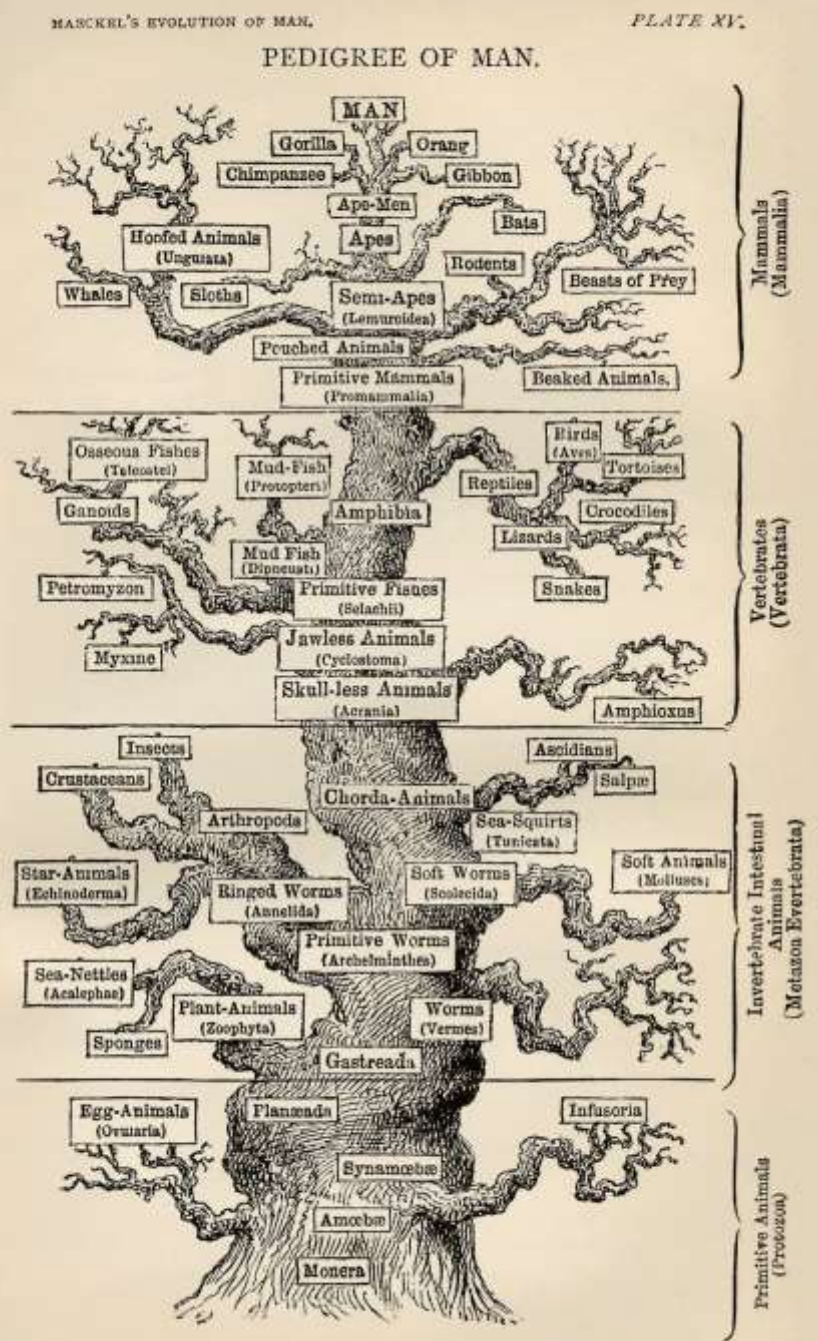
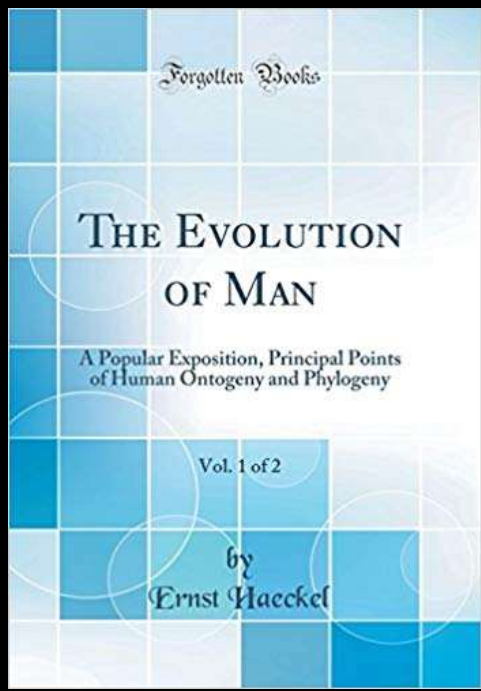
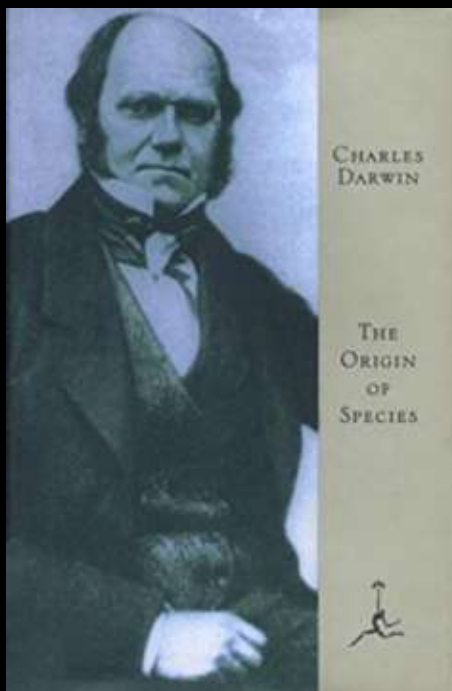


Structure and Change - The Tree of Life

Charles Darwin and the Economy 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”



Change – Humans as “Disturbing Agents” of the Economy of Nature

Man and Nature, or, Physical Geography as Modified by Human Action - George Perkins Marsh
Published 1864

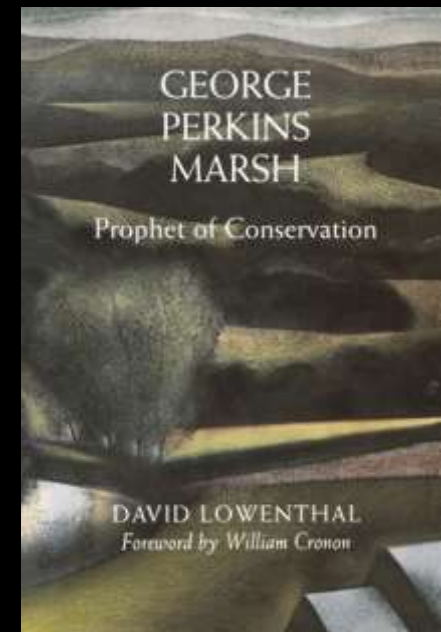
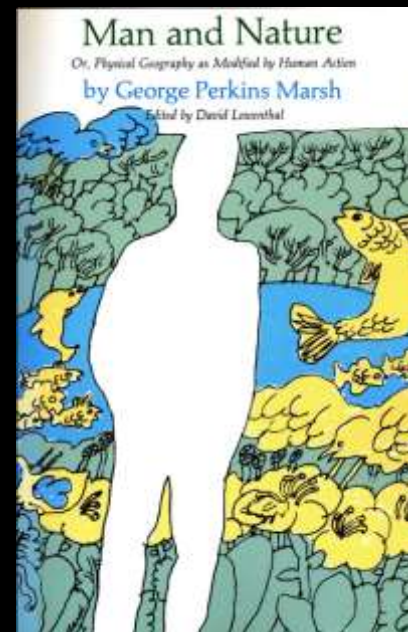
"Man is everywhere a disturbing agent.

Wherever he plants his foot, the harmonies of nature are turned to discord"

- 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."
- The book was instrumental in the creation of Adirondack Park in New York and the United States National Forest. Gifford Pinchot, first Chief of the United States Forest Service, called it "epoch making"



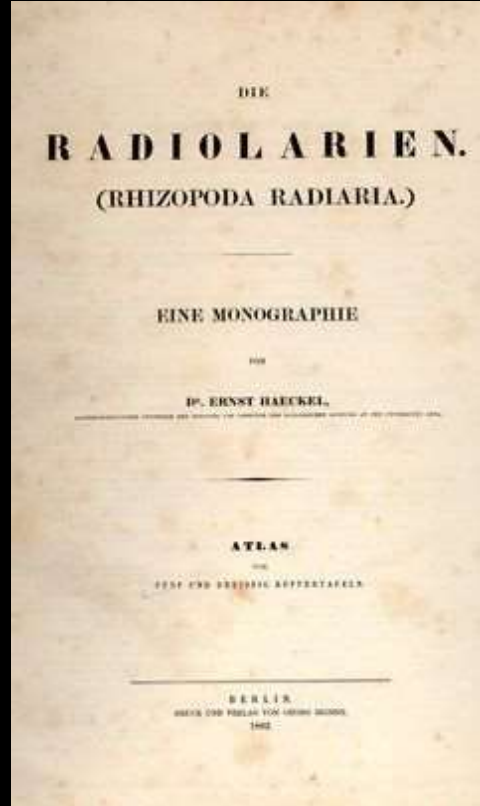
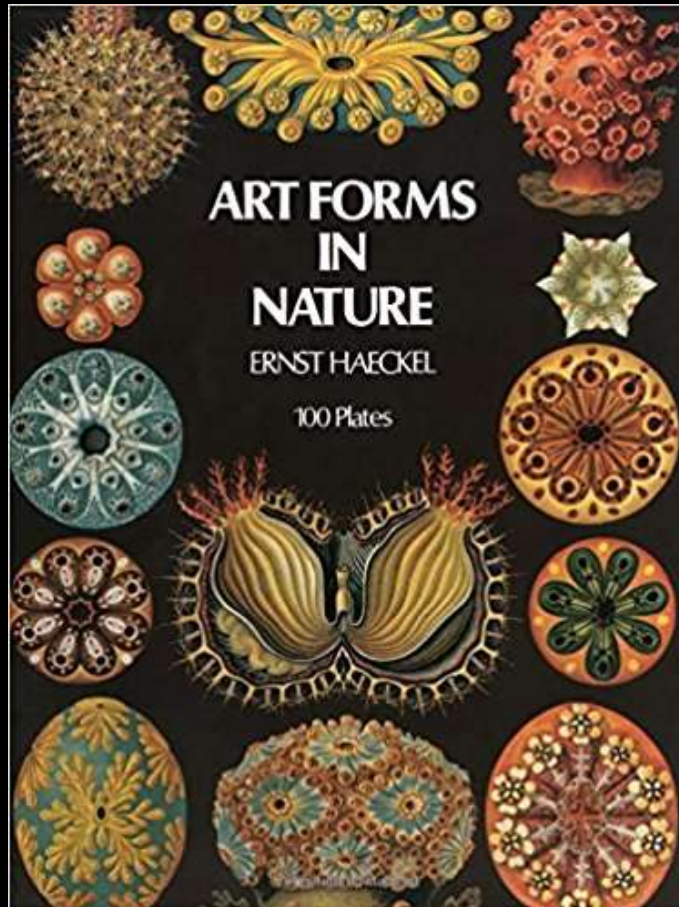
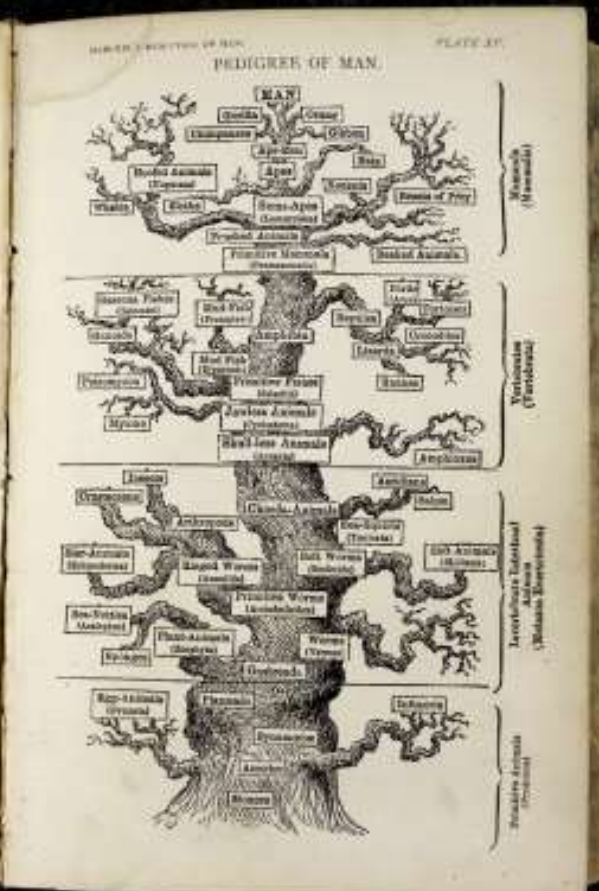
George Perkins Marsh
1801-1882



How Nature Works - Naming a new Science

Ernst Haeckel 1834–1919

A 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.

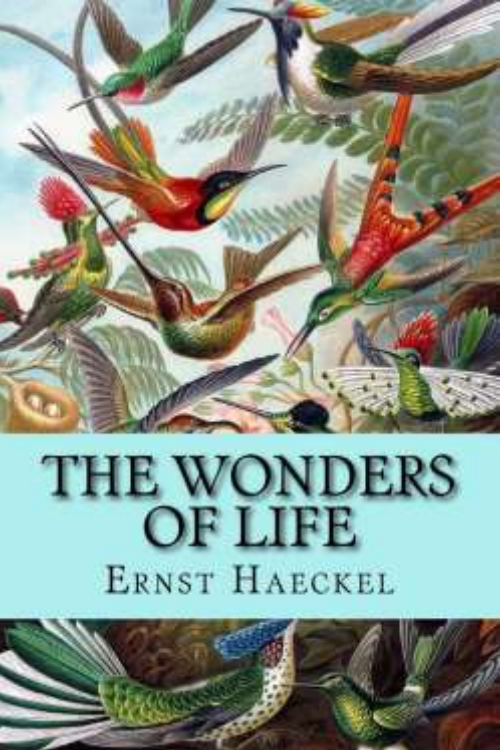
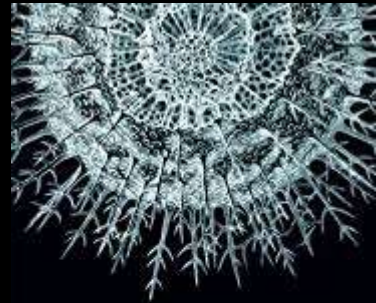


How Nature Works - Ecology - 1866

The Economy of Nature


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

The word comes from the Greek oikos, meaning “household,” “home,” or “place to live.” Thus, ecology deals with the organism and its environment.



How does Nature work? Stability or Change?

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.

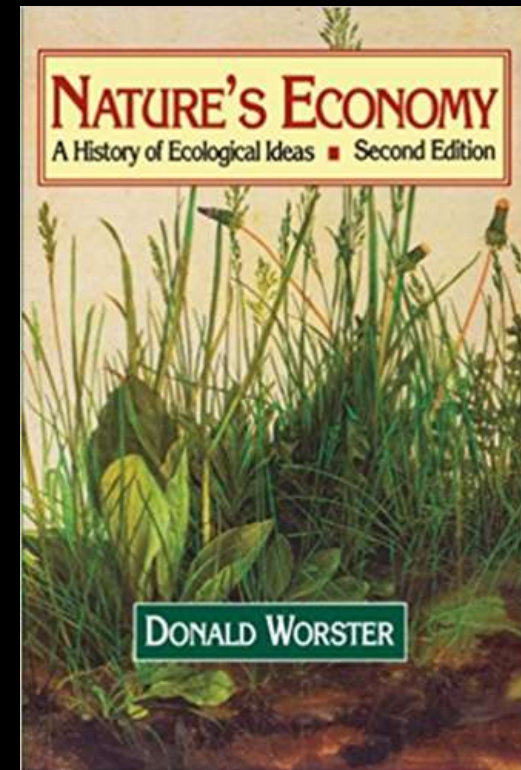
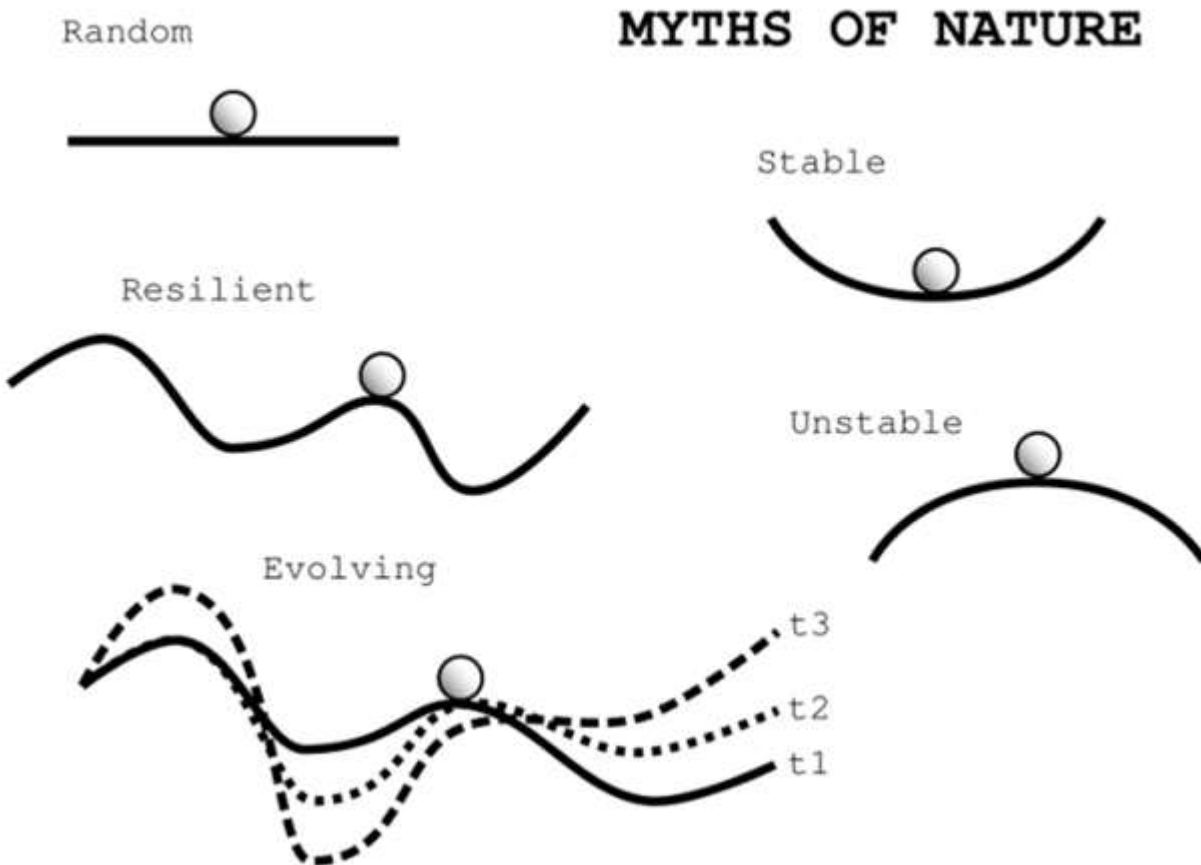
AZ QUOTES

20th and 21st Century Ecology

How Nature Works – Ecology's Myths 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.”

Donald Worster

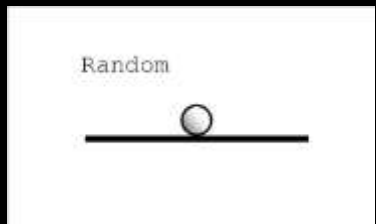
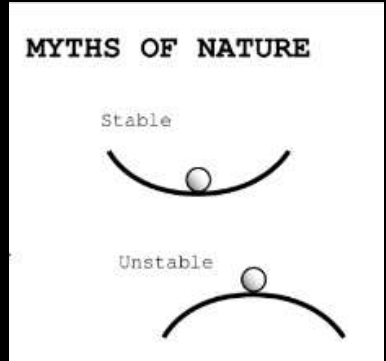


How Does Nature Work? – Stability, Equilibrium, and Succession

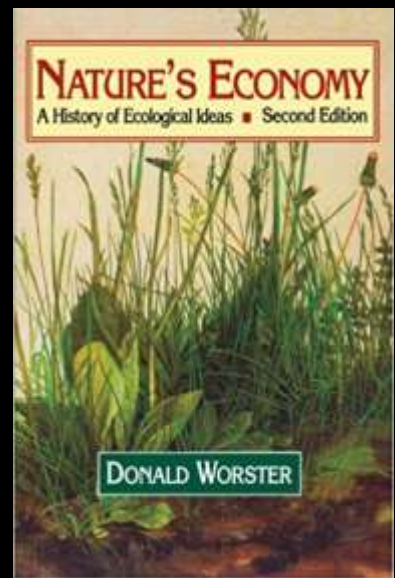
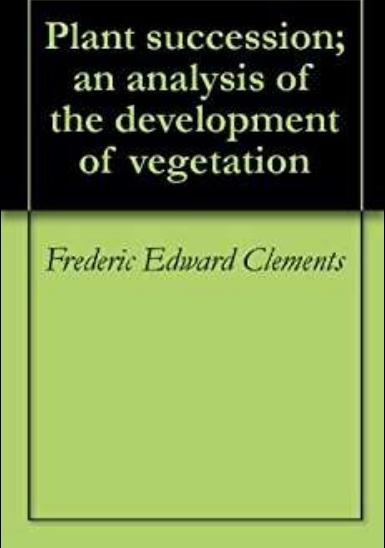
Frederic Clements 1874-1945

The Development and Structure of Vegetation (1904)

Plant Succession (1916)



- 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

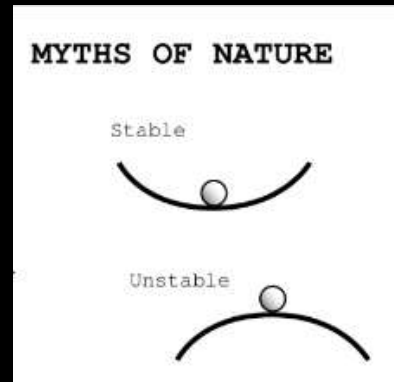
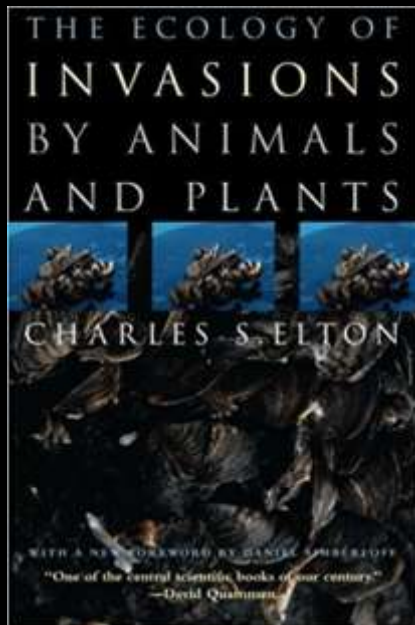
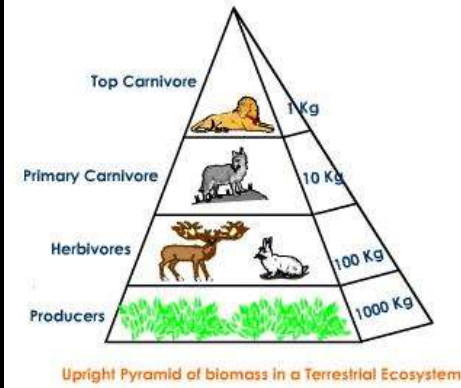


How Does Nature Work? – Integrity and Stability Food Web, Trophic Levels, Invasion Ecology

Charles Elton 1900-1991

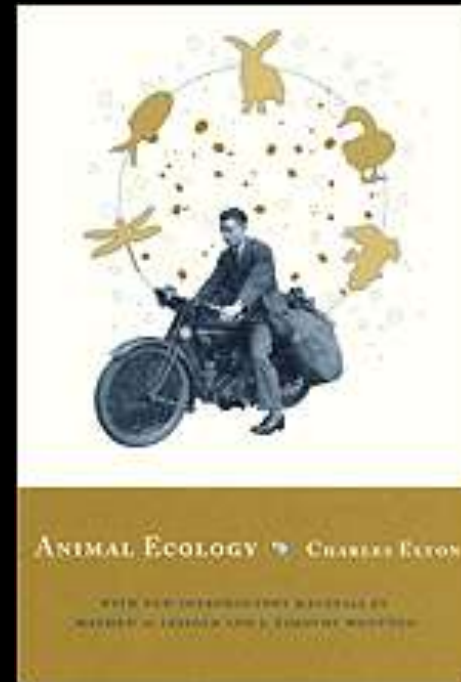
Animal Ecology (1927)

- 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)

- Invasion Biology – Invasive Species
- DIH – the Diversity-Invasibility Hypothesis
- More Biodiversity Less Likely to be Invaded
- (all niches filled)
- Disturbance is the prerequisite for invasion



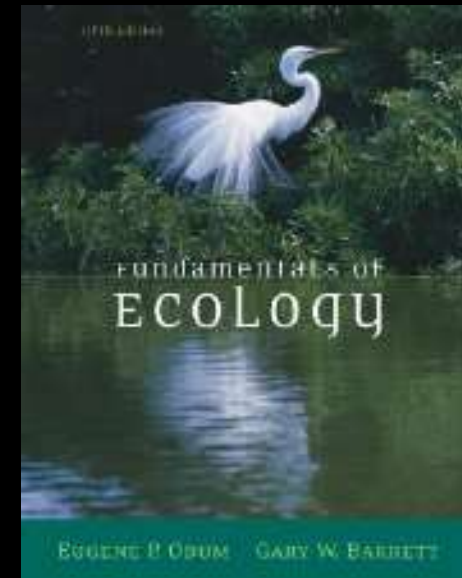
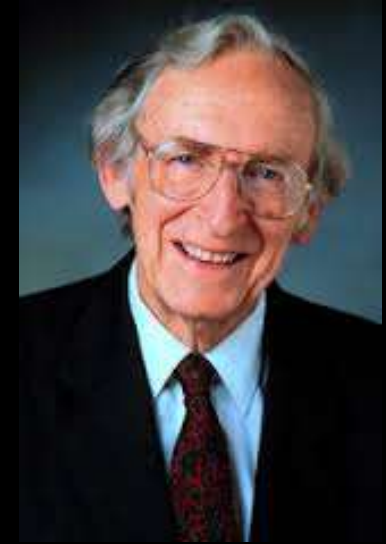
Ecosystem, Stability, and the Equilibrium Paradigm

Eugene Odum

Fundamentals of Ecology (1953)

- The law of organic nature is to bring order and harmony out of chaotic materials of existence
- 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]
- 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

By the 1960s, these scientific beliefs are questioned...



MYTHS OF NATURE

Stable



Unstable

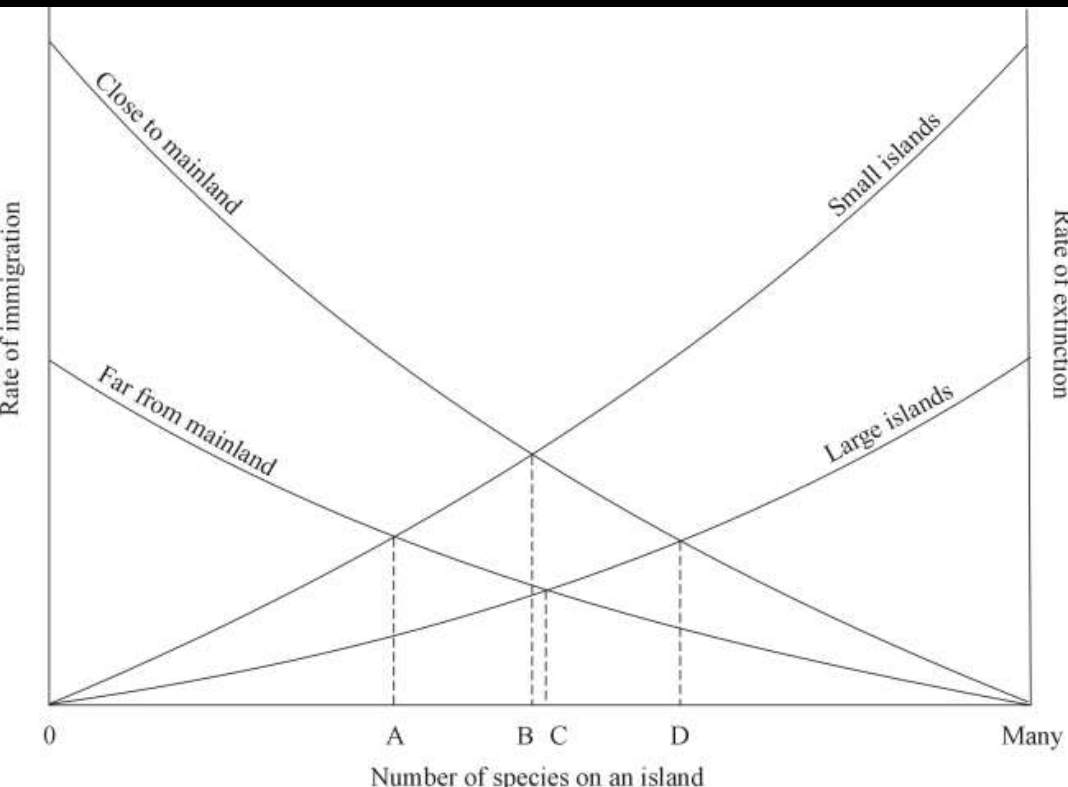


1. But is an ecosystem a reality or an abstraction?
2. Are ecosystems inherently stable?
3. How does disruption fit in?
4. How do the great disrupters – Humans - fit in?

How Does Nature Work? – Equilibrium and Biodiversity

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

- Mathematical modeling and islands
- The number of species represented on an island depends on size and location
- 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



PRINCETON
LANDMARKS
IN BIOLOGY

THE THEORY OF
ISLAND
BIOGEOGRAPHY



WITH A NEW PREFACE BY EDWARD O. WILSON

ROBERT H.
MACARTHUR

EDWARD O.
WILSON

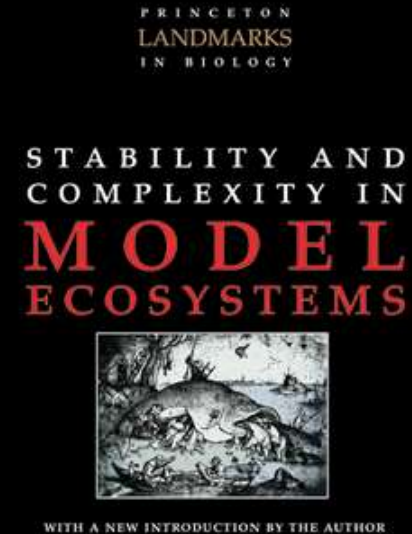
How Does Nature Work?

The New Ecology - No inherent stability

Robert May

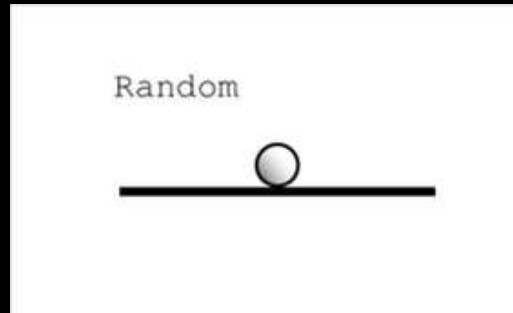
Stability and Complexity in Model Ecosystems (1973)

- 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

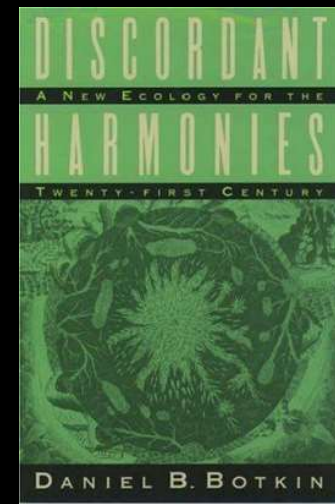
- Disequilibria
- Instability
- Chaotic fluctuations



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 1990



Harmony vs. Disharmony

The Balance of Nature: Ecology's Enduring Myth 2009

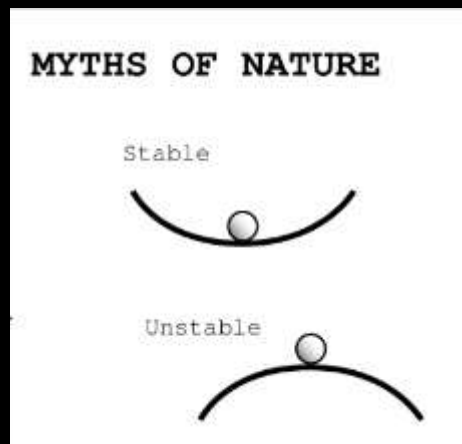
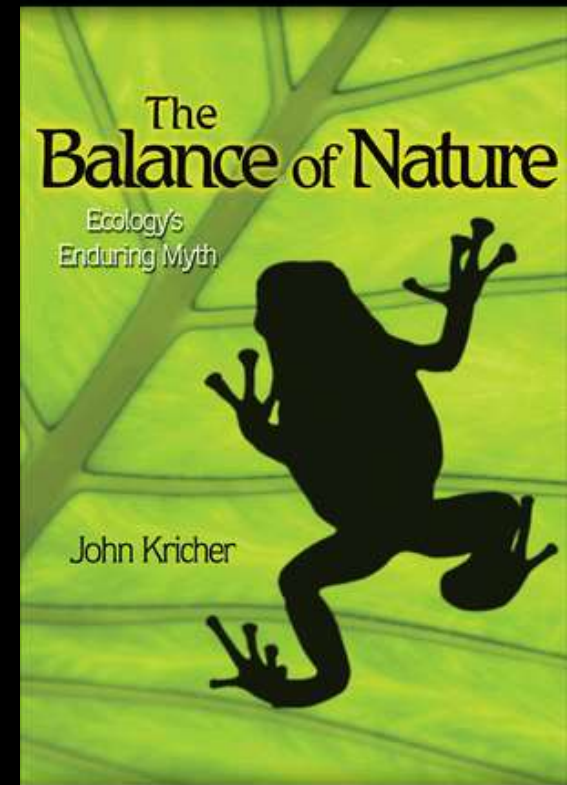
John Kricher

“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.”



The River of Change - Heraclitus 540-480BC

No man ever steps in the same river twice, for it's not the same river and he's not the same man.

Everything flows and nothing abides.

Nothing Endures But Change



How does Nature work?

Aldo Leopold and The Round River – A Metaphor for Ecology

"a river that flows into itself"

"One of the marvels of early Wisconsin was the Round River, a river that flowed into itself, and thus sped around and around in a never-ending circuit.

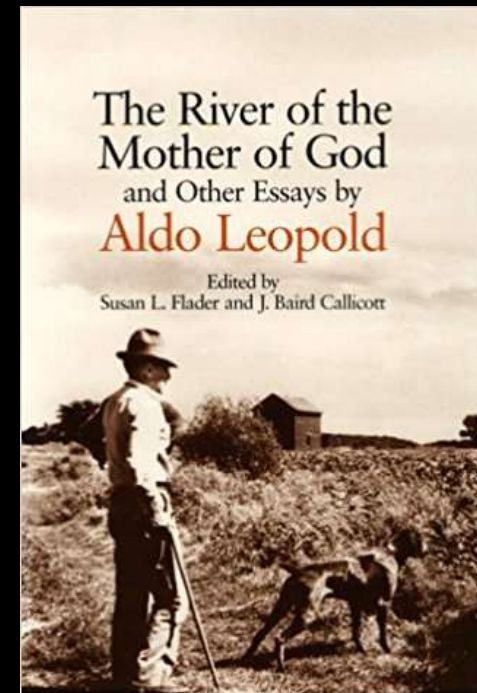
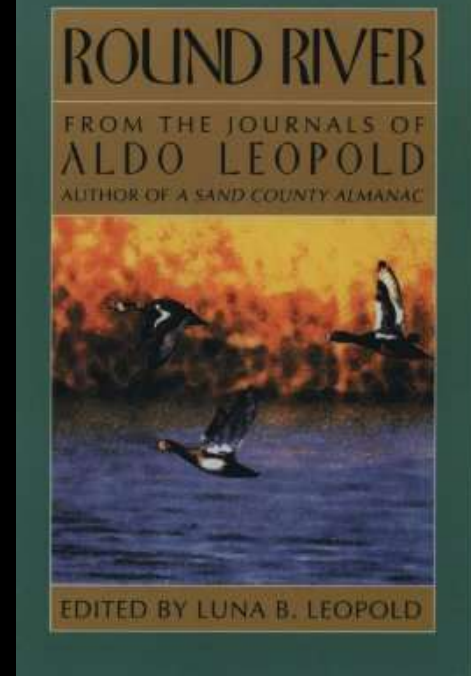
Wisconsin not only had a round river, Wisconsin is one.

The current is the stream of energy which flows out of the soil into plants, thence into animals, thence back into the soil in a never ending circuit of life.

In our educational system, the biotic continuum is seldom pictured to us as a stream.

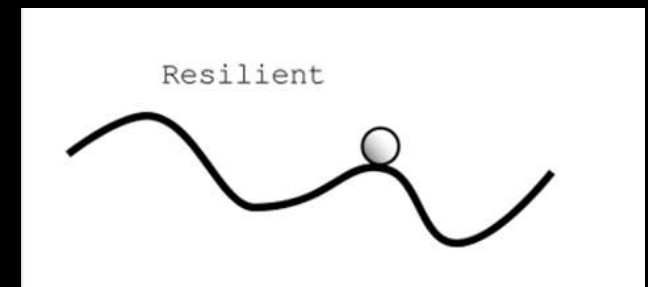
From our tenderest years we are fed with facts about the soils, floras, and faunas, that comprise the channel of Round River (biology), about their origins in time (geology and evolution), about the technique of exploiting them (agriculture and engineering).

But the concept of a current with droughts and freshets, backwaters and bars, is left to inference.



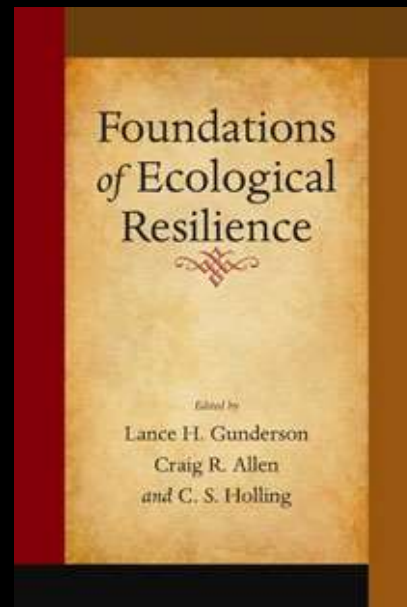
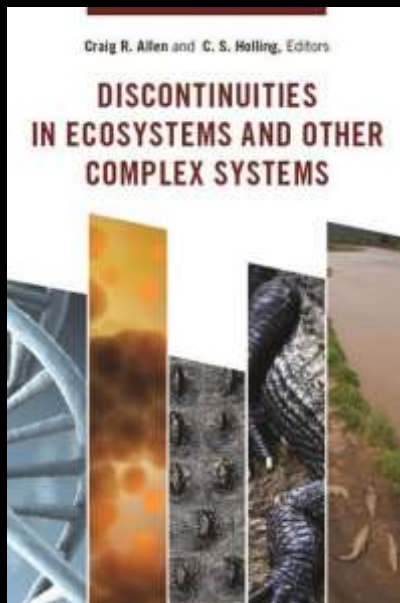
The New Ecology of Change - Ecological Resilience

Balance vs. Disequilibrium
Permanence vs. 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.
- 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.

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



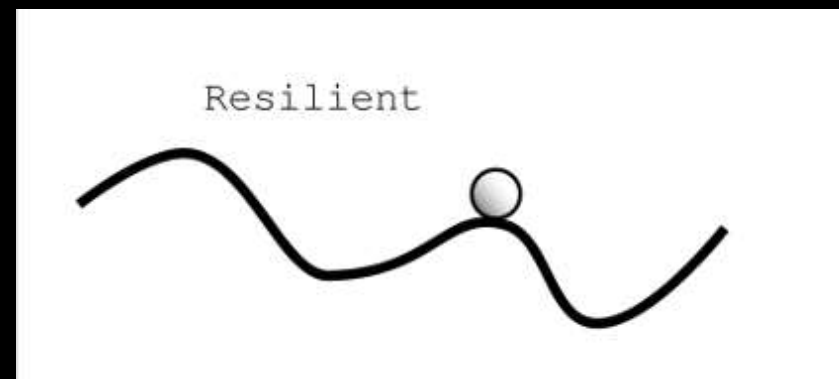
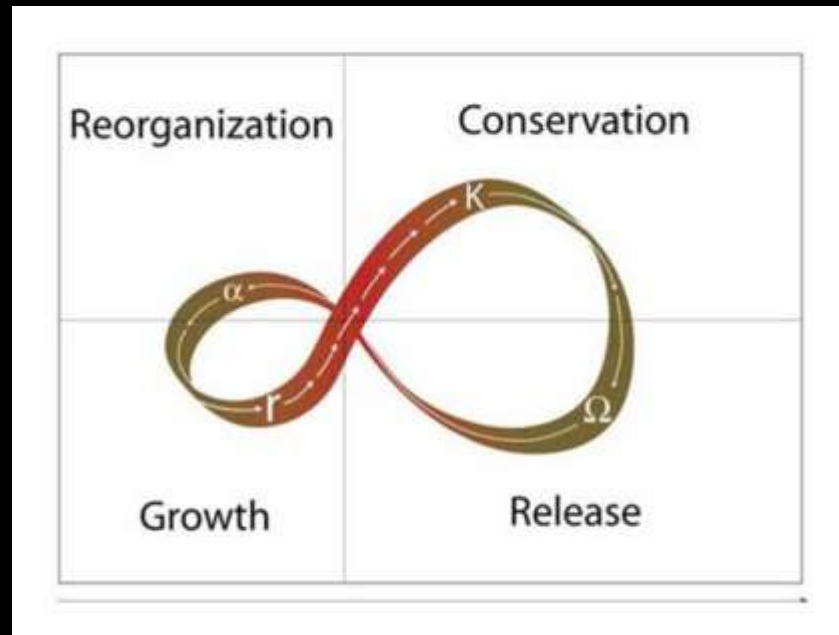
Structured Change – The Adaptive Cycle

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...

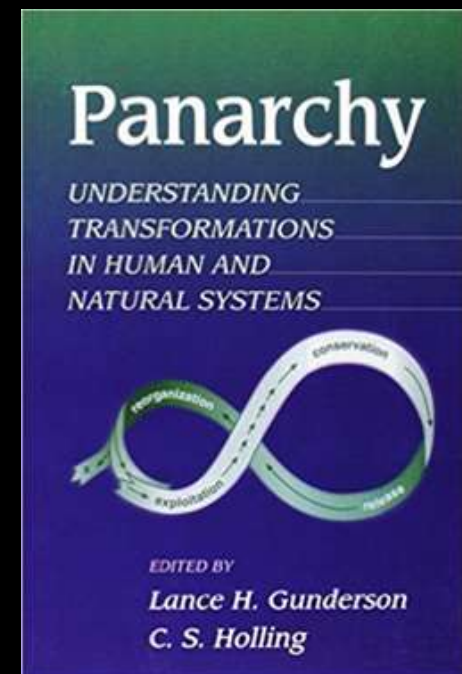
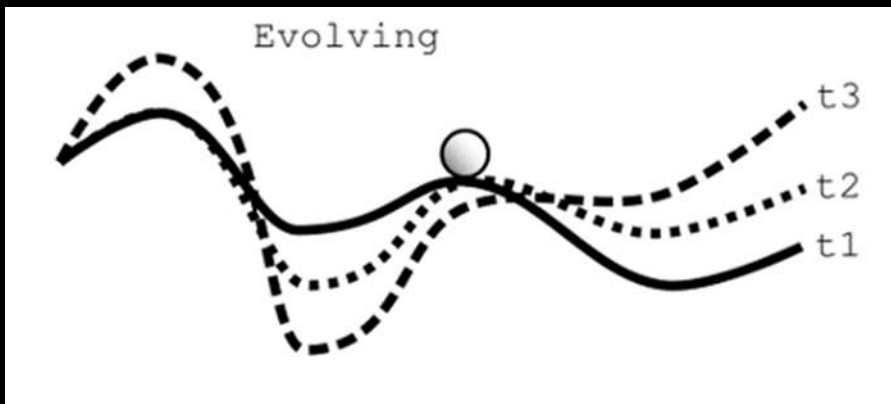
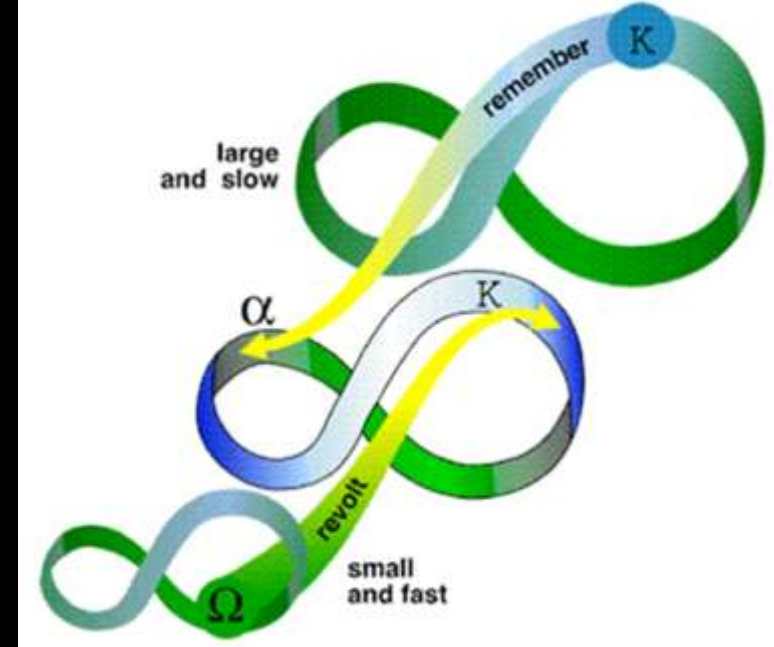
Reorganization – where systems return in completely new ways, which creates a new field of conditions and possibilities for the next growth phase



Resilience, Panarchy, and Adaptive Evolution

A Theory of Permanence and Change

- This interacting set of hierarchically structured scales has been termed a "panarchy"
- The panarchy framework connects adaptive cycles in a nested hierarchy. Ecological and social-ecological systems form nested sets of adaptive cycles. The larger, slower cycles generally constrain the smaller, faster ones and maintain system integrity
- 'Panarchy' is a term that "explains the evolving nature of complex adaptive systems" Human and Natural systems - Socioecological systems

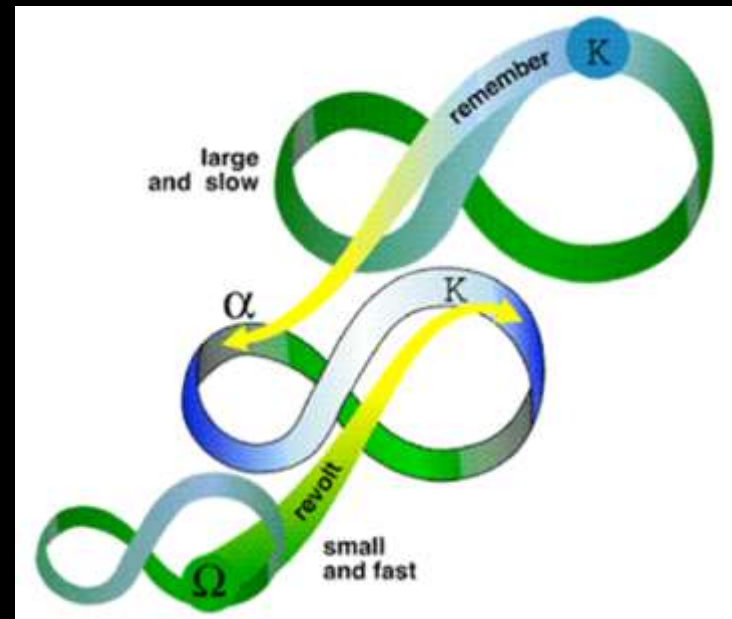
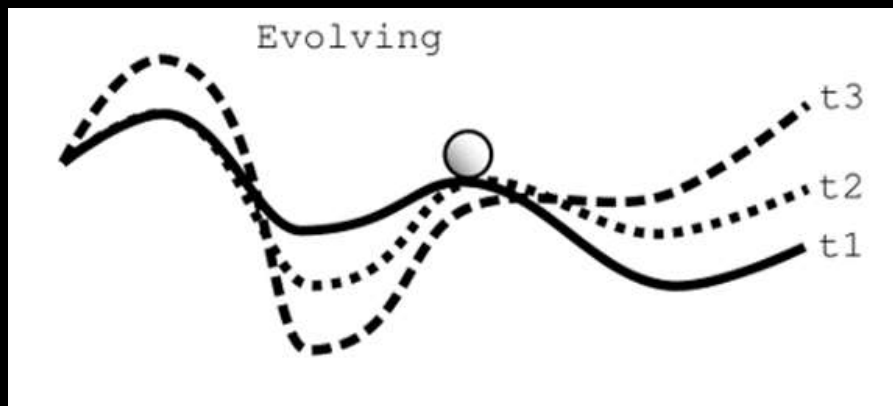
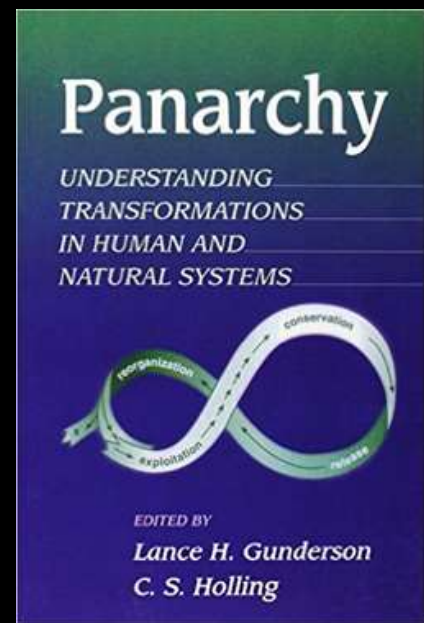


New Myth of Nature: Evolving Nature and Panarchy

A Myth of Permanence and Change

Unpredictable Change and Unintended Consequences

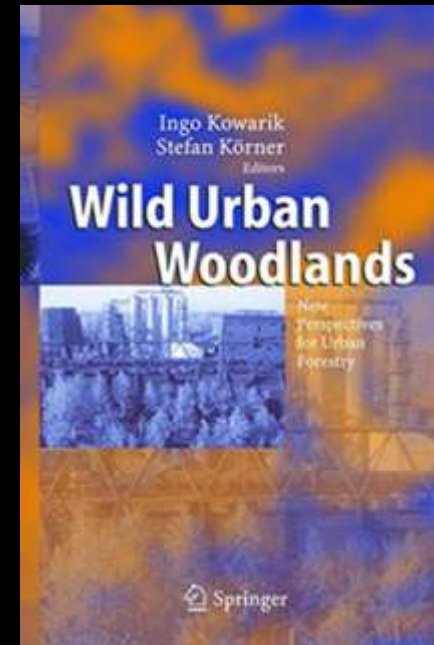
- Panarchy is a new narrative or myth of evolving nature, hinted at by the name of the Greek god of nature - Pan - whose persona also evokes an image of unpredictable change.
- Unintended consequences - Change is not always for the good - Pan has a destabilizing role that is captured in the word panic, directly derived from one facet of his paradoxical personality.



The New Ecology Permanence and Change

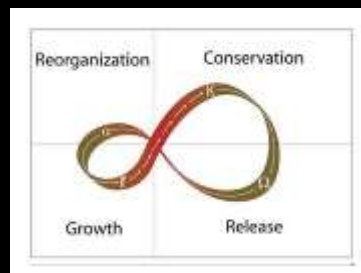
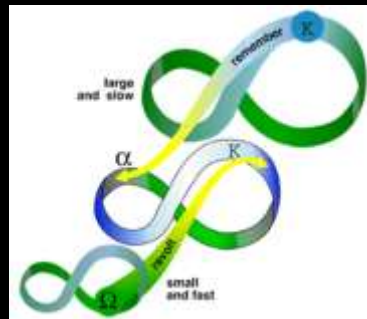
“the reference point is not an original condition of a natural landscape, but rather a condition defined based on the current site potential and the greatest possible degree of self-regulation.

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



2005

2017



New Nature

New Metaphors of Change and Permanence

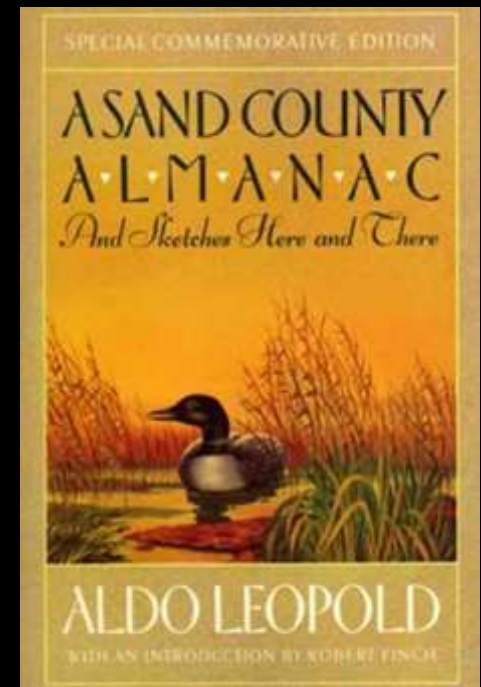
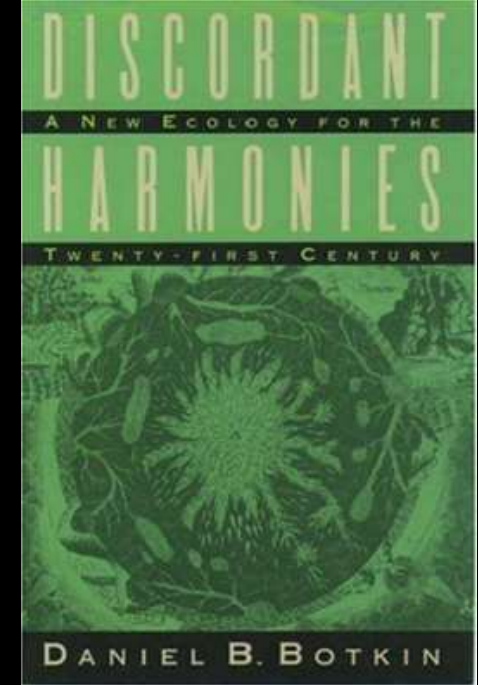
“Clearly, to abandon a belief in the constancy of undisturbed nature is psychologically uncomfortable...

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*

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

Aldo Leopold



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

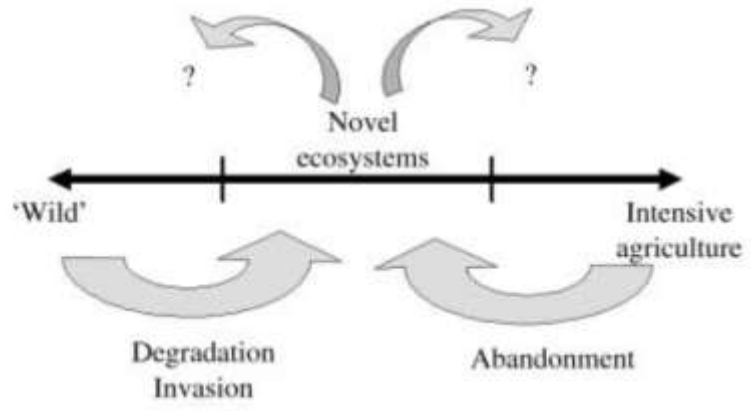
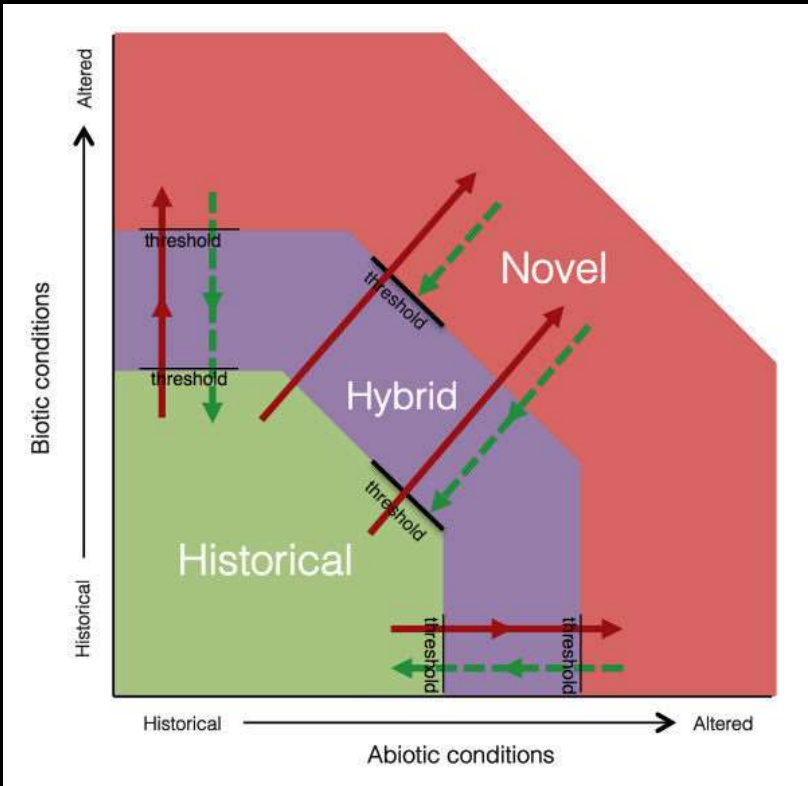
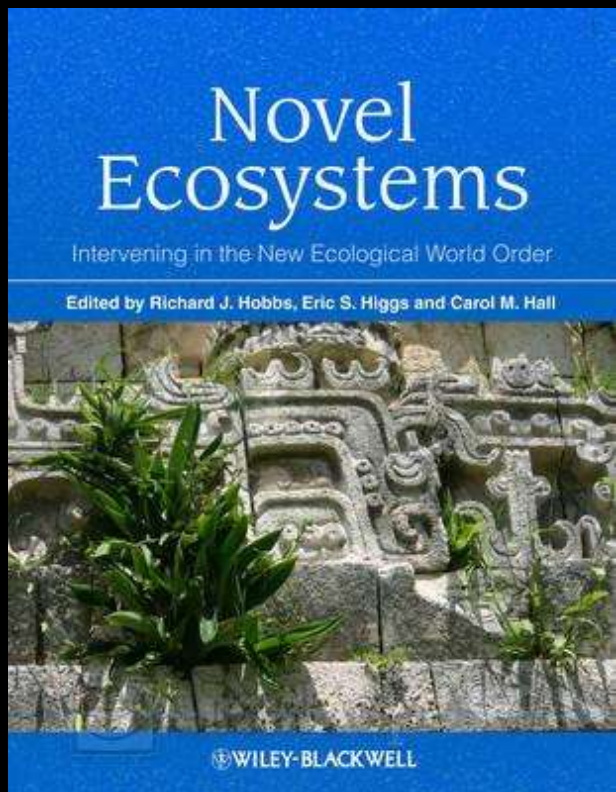


Figure 1 Novel ecosystems arise either from the degradation and invasion of 'wild' or natural/seminal systems or from the abandonment of intensively managed systems.

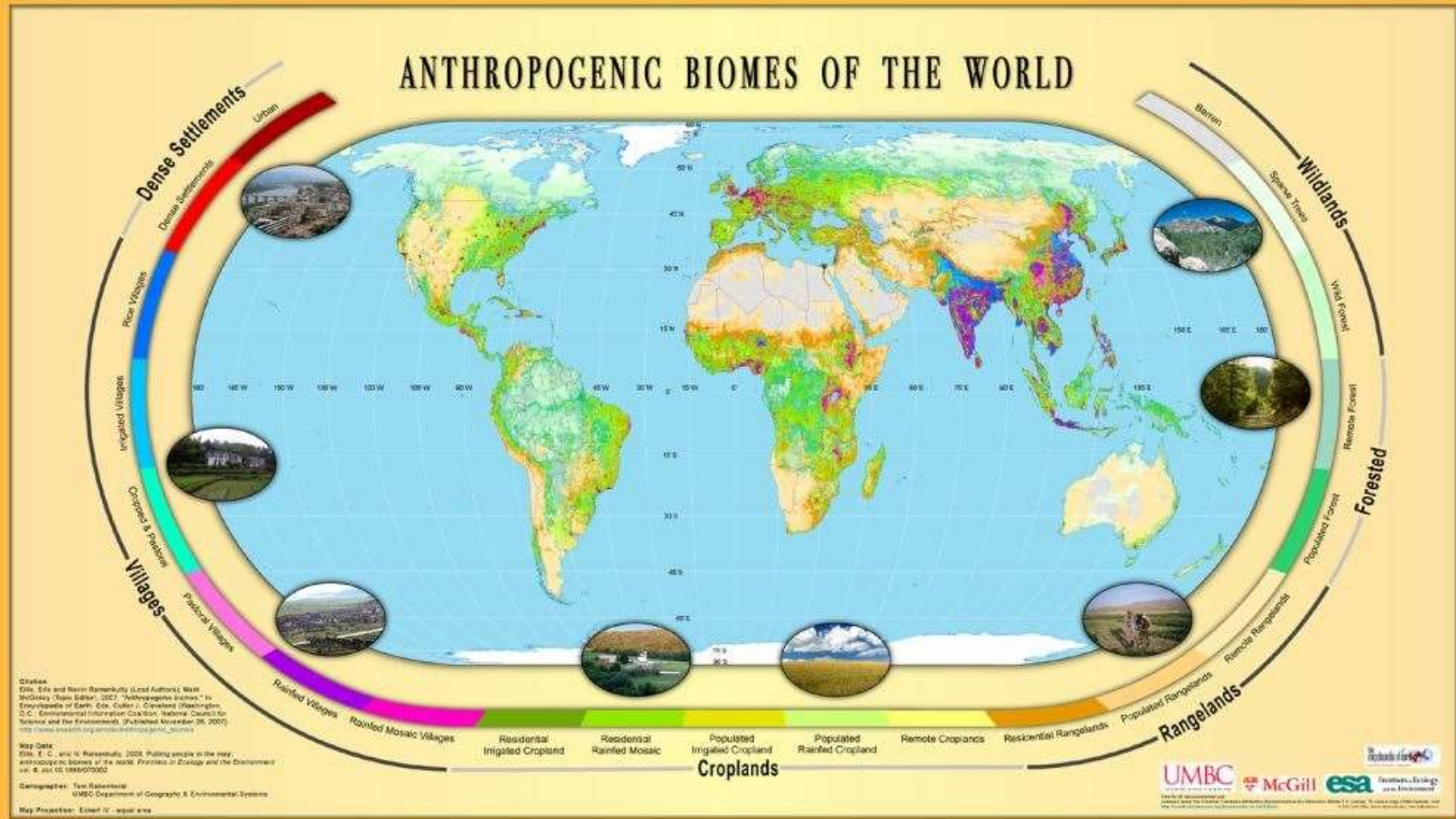


Envisioning the Changing Socioecological Earth Humans as part of Nature

Anthropogenic Landscapes, or "Human Landscapes"
<http://ecotope.org/> Dr. Erle Ellis

Anthropogenic Biomes ("Anthromes")

The globally-significant types of anthropogenic landscapes



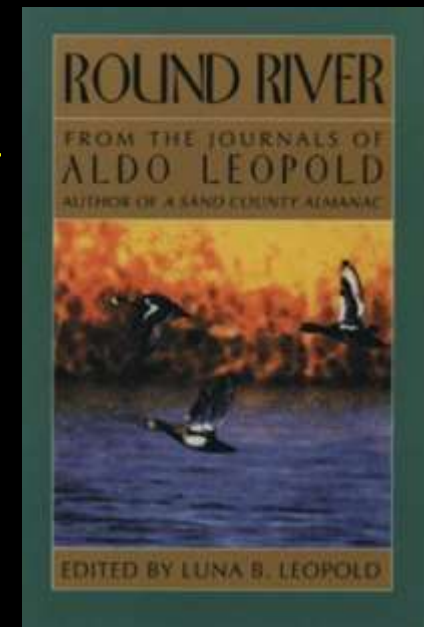
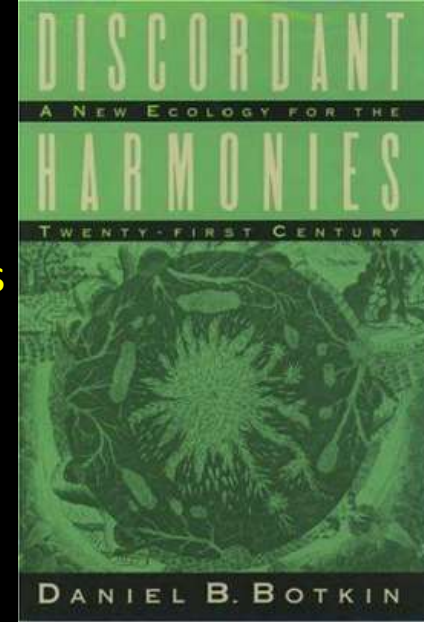
Discordant Harmonies – Daniel Botkin

The New Ecology and the Ecological basis for Environmental Ethics?

- 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.

“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



Biotic Navigation

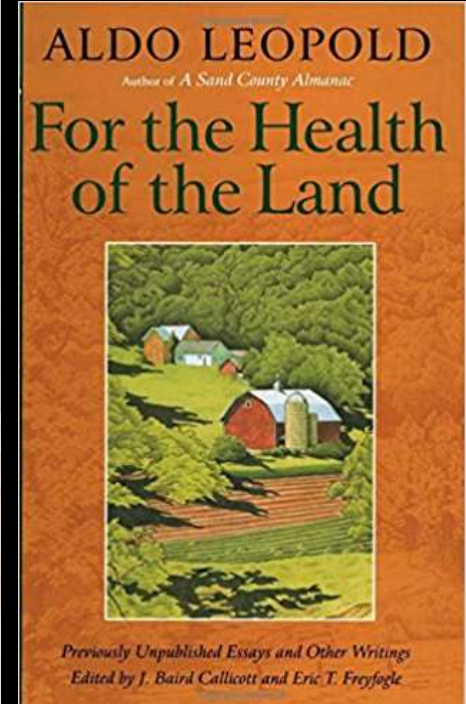
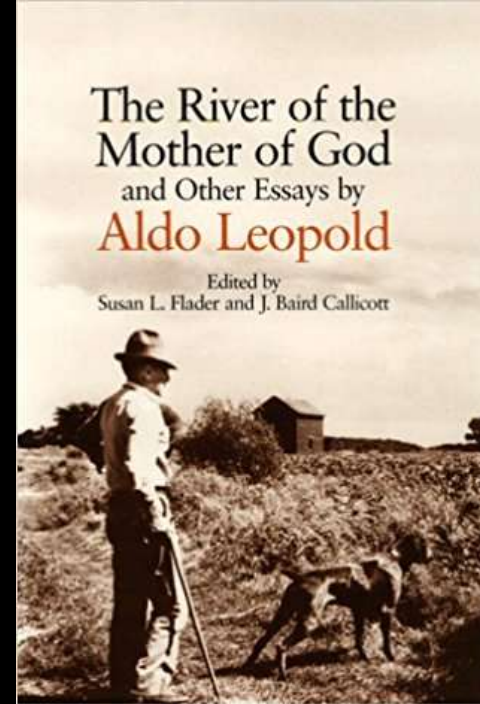
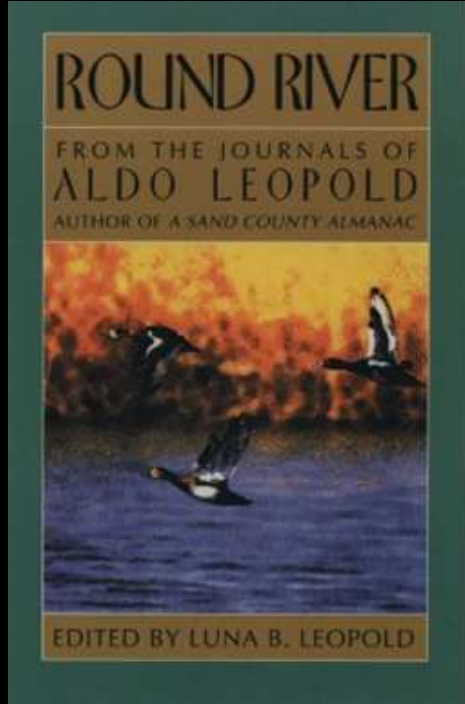
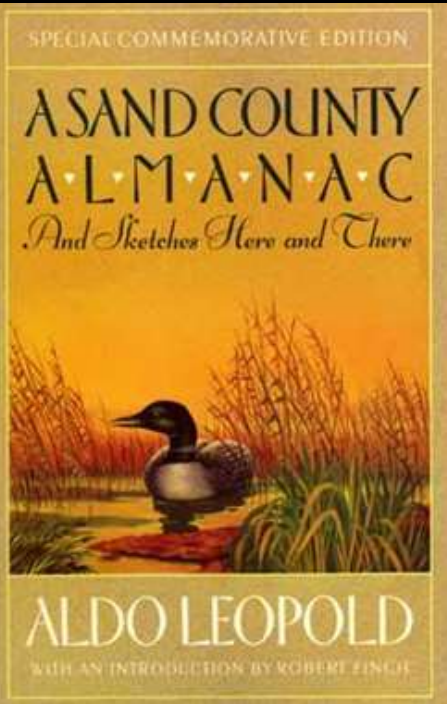
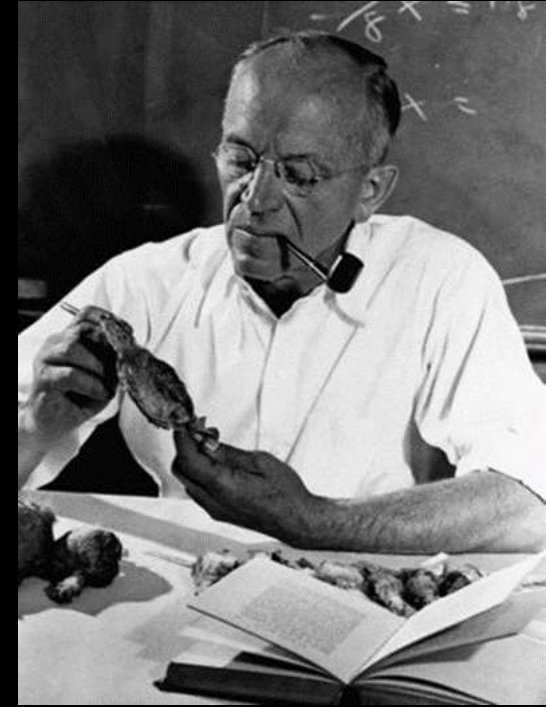
“Ecology is an infant just learning to talk, and, like other infants, is engrossed with its own coinage of big words.

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



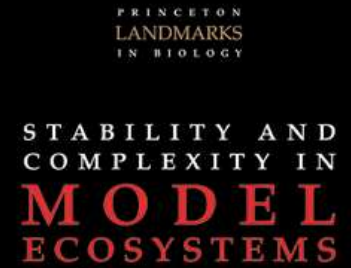
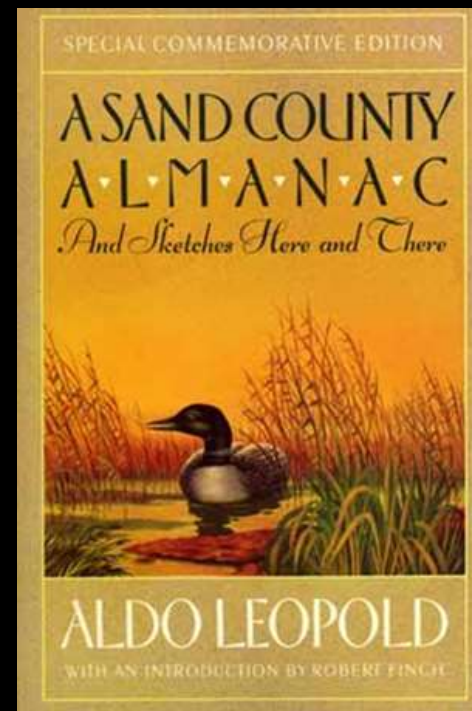
Stability

- Balance vs. Disequilibrium
- Harmony vs. Disharmony

Integrity

- Permanence vs. Change

Beauty?



WITH A NEW INTRODUCTION BY THE AUTHOR

ROBERT M.
MAY

