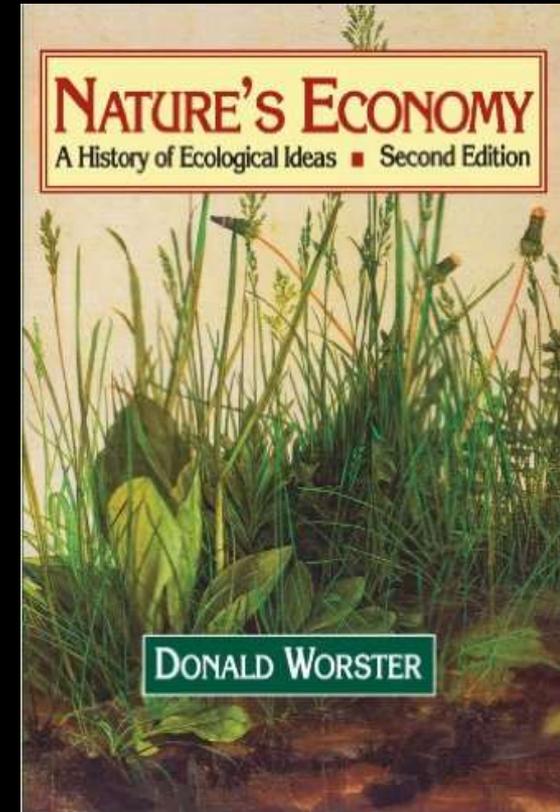
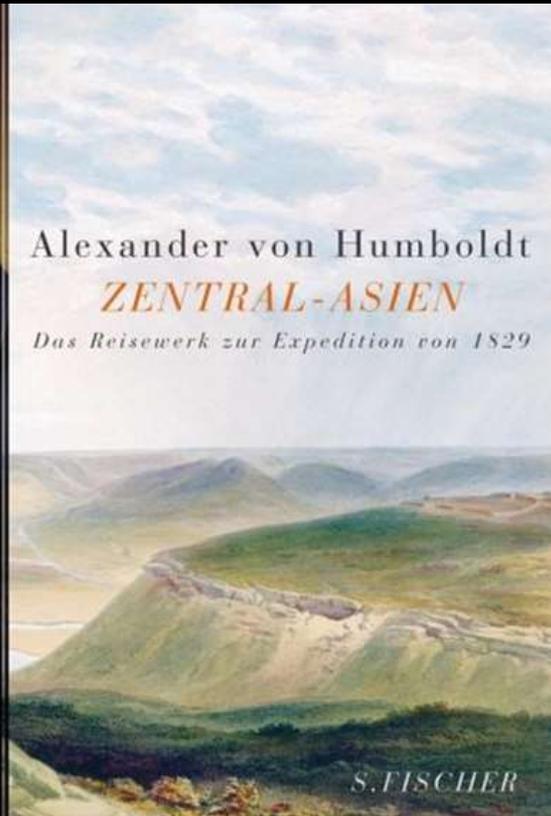


# The Economy of Nature: Ecology, Earth Science, and Biotic Navigation

Kevin M. Anderson Ph.D.

Austin Water Center for Environmental Research



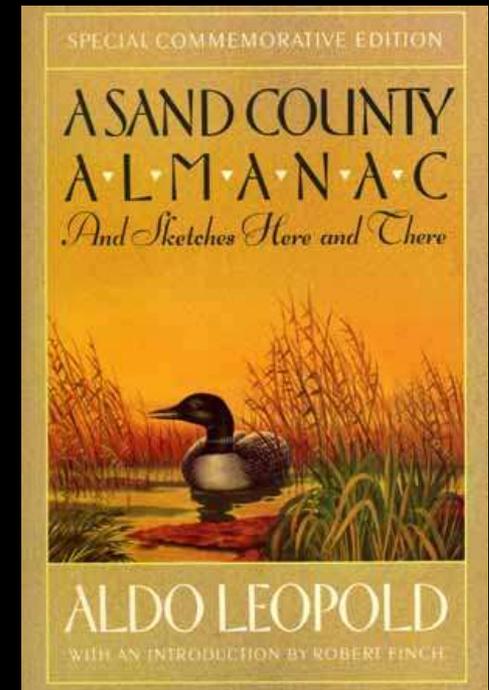
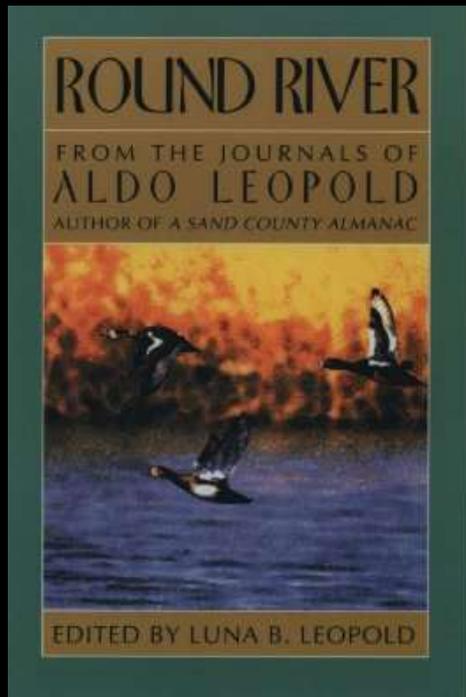
# The Economy of Nature

The Round River – Aldo Leopold

Metaphor for ecology

"a river that flows into itself"

Aldo Leopold 1887-1948



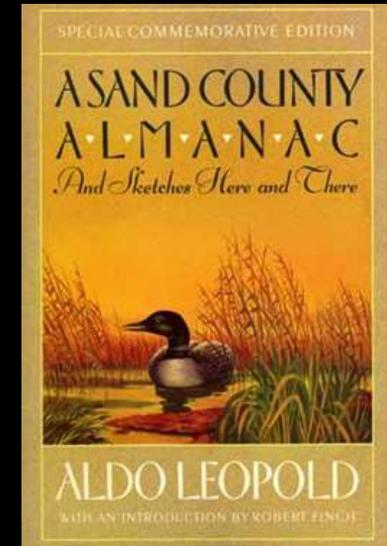
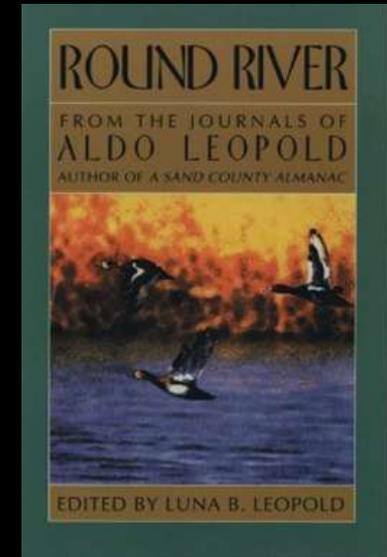
## Biotic Navigation

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.

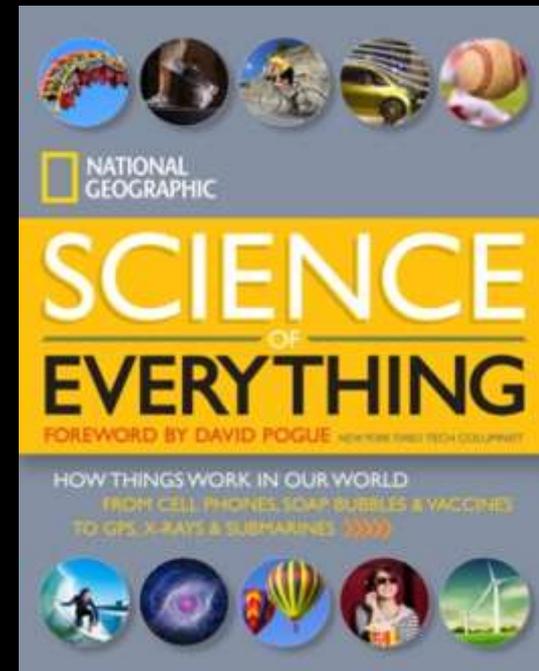
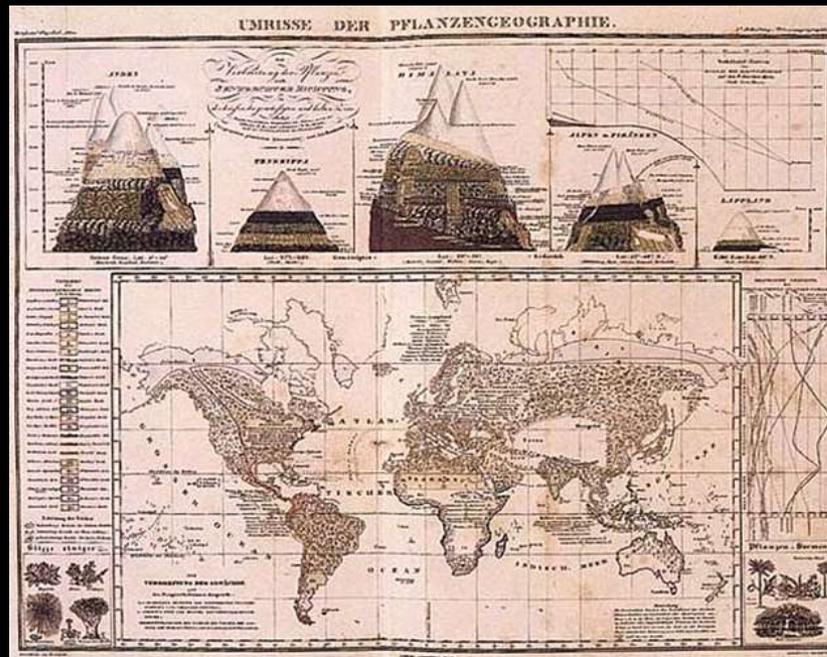
This, in the last analysis, is conservation.



# The Invention of Ecology

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

1. The Systematic Universe – Everything is connected
2. The earth as 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. “In this great chain of cause and effects, no single fact can be considered in isolation”
4. “the accurate measured study of widespread but interconnected real phenomena in order to find a definite law and a dynamic cause”
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.

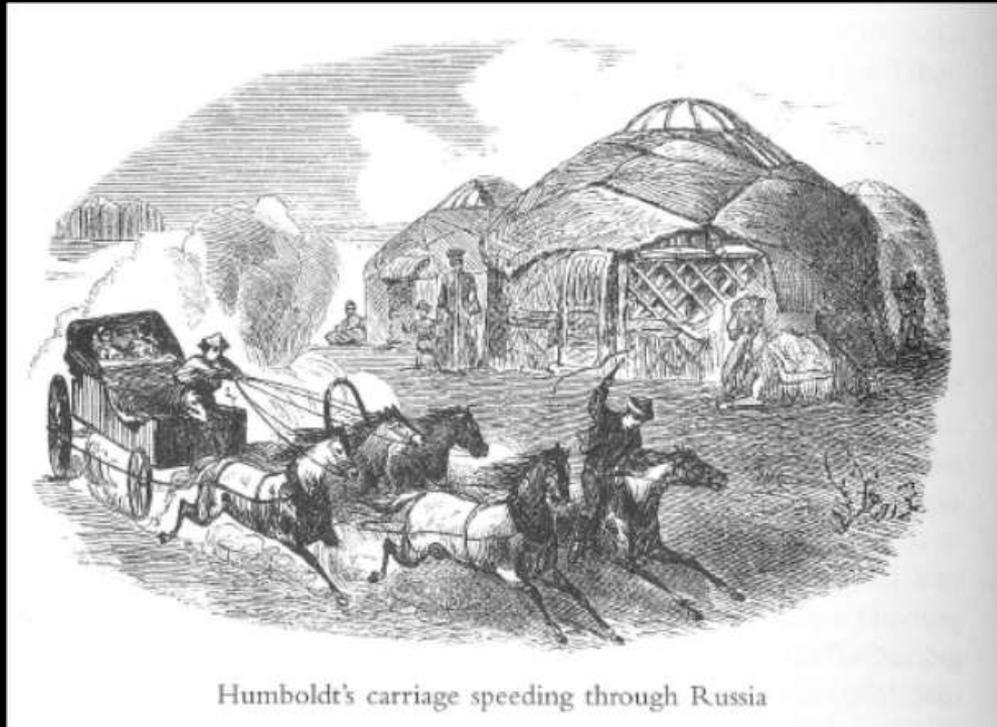


## Alexander von Humboldt in Russia: The 1829 expedition

In April 1829, Humboldt was invited to Russia to consult about the new metal called platinum discovered in the Ural Mountains and found an opportunity to realize his other grand dream: an expedition through Central Asia.

Knowing that diamonds were often found with gold and platinum deposits, Humboldt predicted that diamonds would be found there, too, and the Russian Government offered to fully fund his expedition to the Urals.

Humboldt would push past the Urals to reach the border of China.



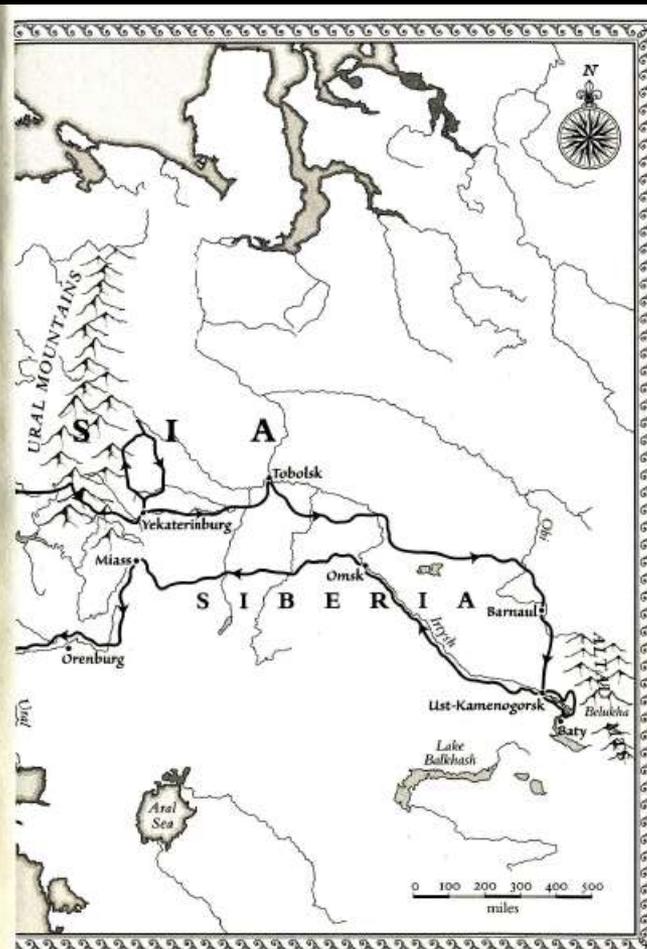
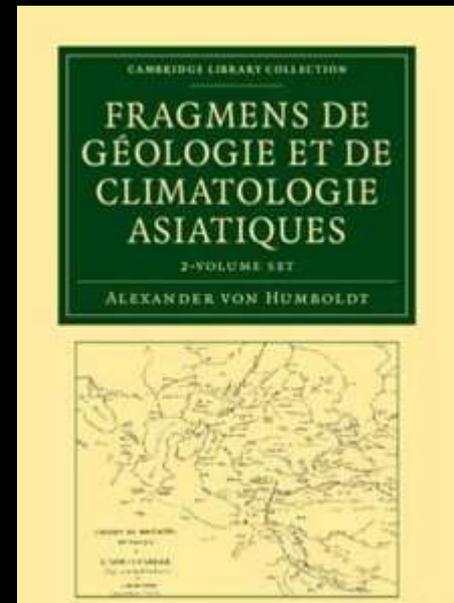
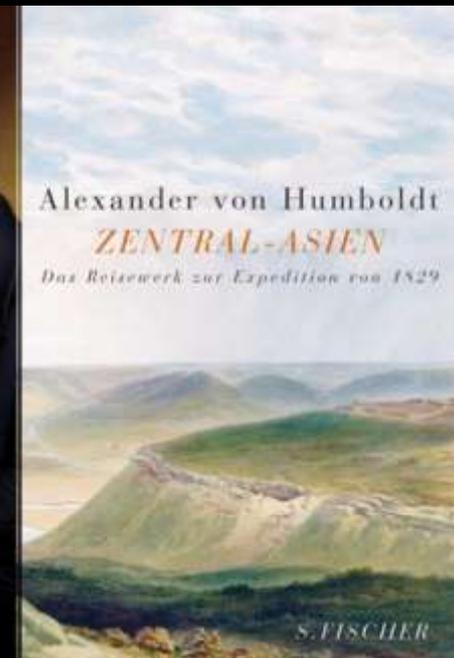
Humboldt's carriage speeding through Russia



## Alexander von Humboldt in Russia: the 1829 expedition

In a whirlwind of about six months' duration, the party covered approximately 9,700 miles (some by river), passed through 658 post-stations, and used more than 12,000 post-horses!

On arriving back in St. Petersburg, Humboldt learned that diamonds had been found in the Urals, the first diamonds found outside the tropics.

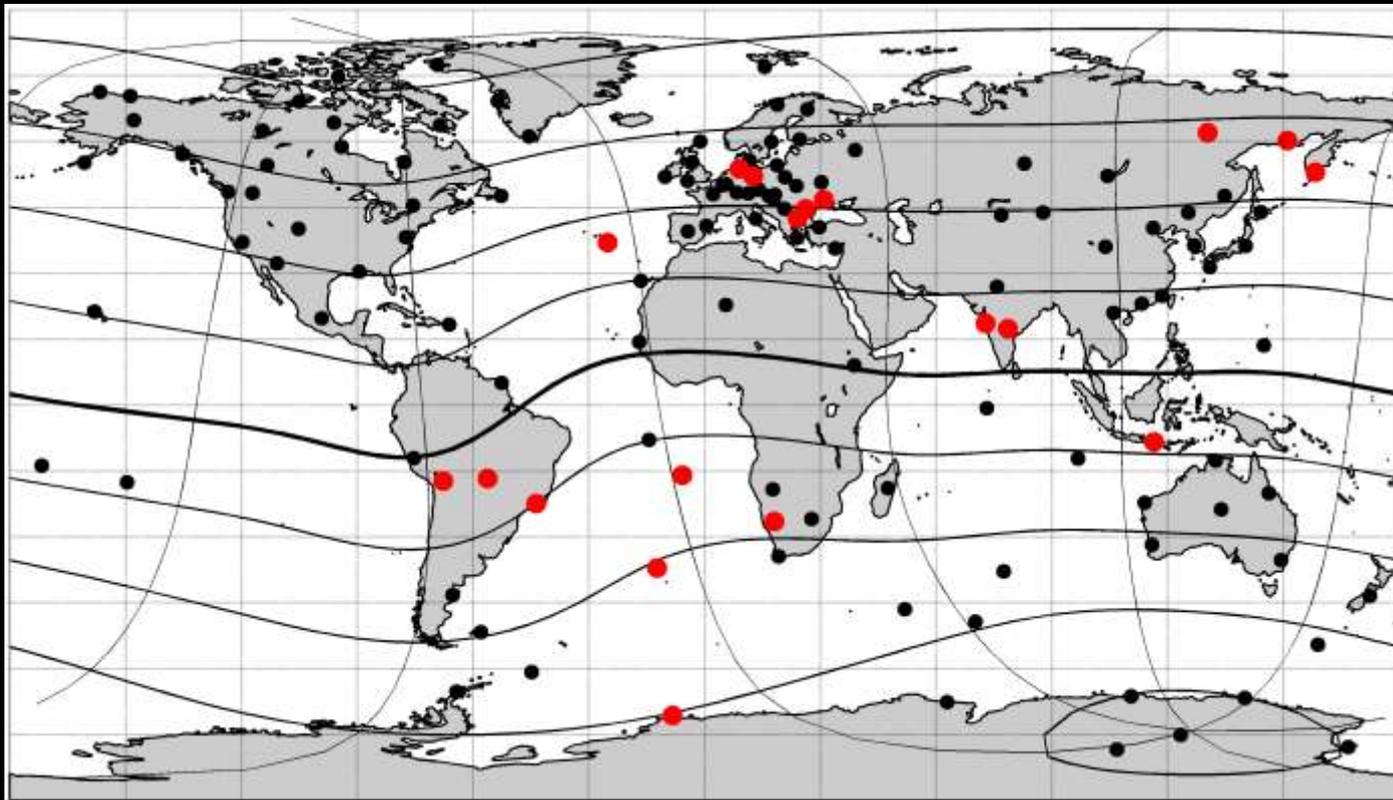


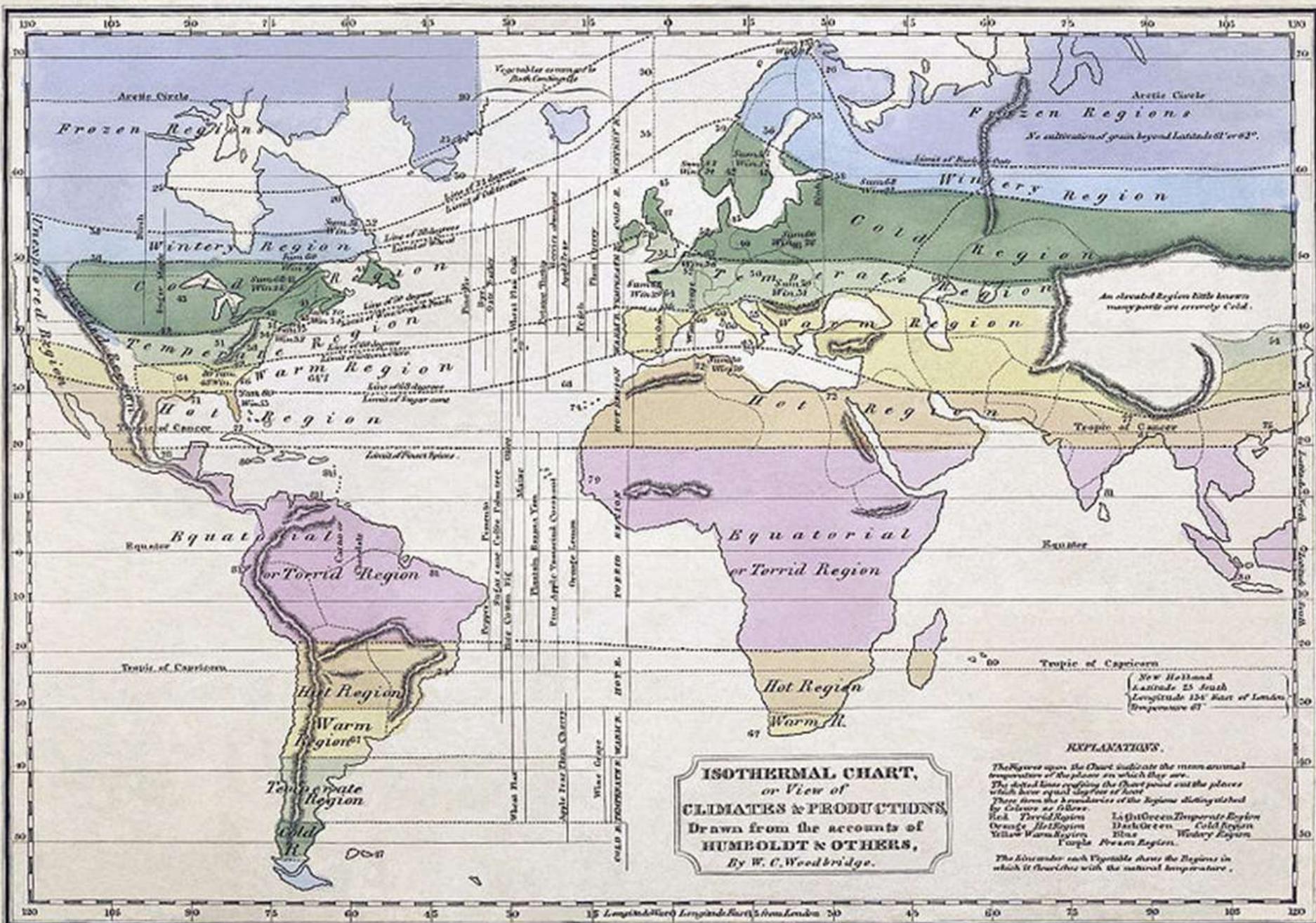
## Humboldtian Science – Global Network for Earth Science

Back in St. Petersburg by November 1829, Humboldt gives a speech for the Russian Imperial Academy of Sciences, in which he urged the establishing a chain of geomagnetic observation stations across the Russian Empire linking with a network around the globe.

The Czar agreed, creating stations from St. Petersburg to Alaska. These connected to stations in the US and Europe, and by 1839 the British had built them across the British Empire. Humboldt's dream was fulfilled as the observation stations collected geomagnetic and climate data on a global scale.

In the same speech, he urged climate study to understand the effects of the destruction of forests on climate which he first described in South America on his first great journey.





**ISOTHERMAL CHART,**  
*or View of*  
**CLIMATES & PRODUCTIONS,**  
 Drawn from the accounts of  
**HUMBOLDT & OTHERS,**  
*By W. C. Woodbridge.*

**EXPLANATIONS.**

The figures upon the Chart indicate the mean annual temperature of the places in which they are.  
 The dotted lines crossing the Chart point out the places which have equal lengths of day.

These form the boundaries of the Regions distinguished by Colors as follows:

Red	Torrid Region	Light Green	Temperate Region
Orange	Hot Region	Dark Green	Cold Region
Yellow	Warm Region	Blue	Wintery Region
Purple	Frozen Region		

The lines under each Vegetable show the Regions in which it flourishes with the natural temperature.

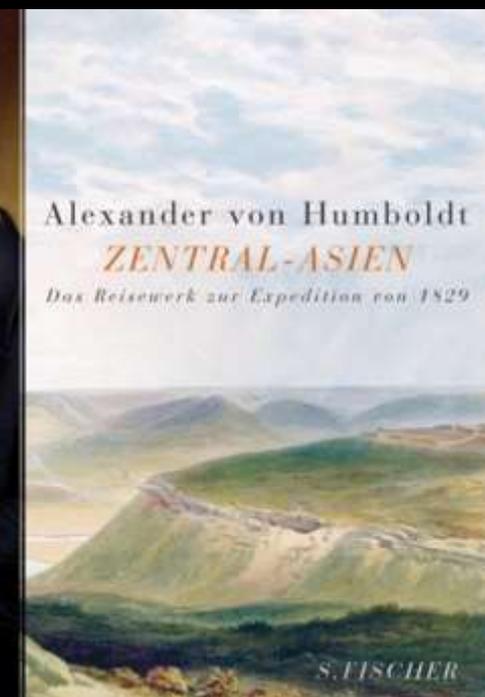
Printed according to an engraving the 15<sup>th</sup> day of January 1850 by William C. Woodbridge of the State of Connecticut.

## Humboldtian Science – The Economy of Nature and Human Impacts

Humboldt wrote that the “wants and restless activity of large communities of men gradually despoil the face of the Earth.” In his book on Central Asia (1844), he prophetically listed three ways in which the human species was even then affecting the climate:

“Through the destructions of forests, through the distribution of water, and through the production of great masses of steam and gas at the industrial centers.”

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



# The Economy of Nature

## Carl Linnaeus 1707 – 1778

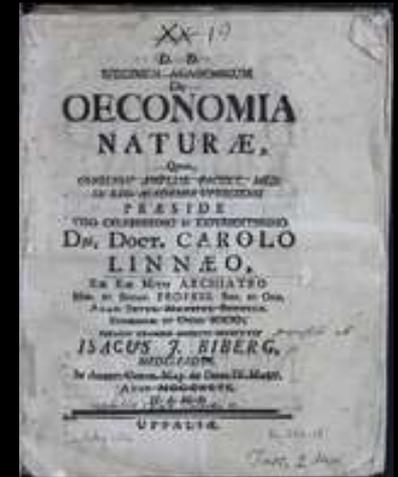
Swedish botanist, physician, and zoologist, who laid the foundations for the modern scheme of binomial nomenclature (*Genus species*).

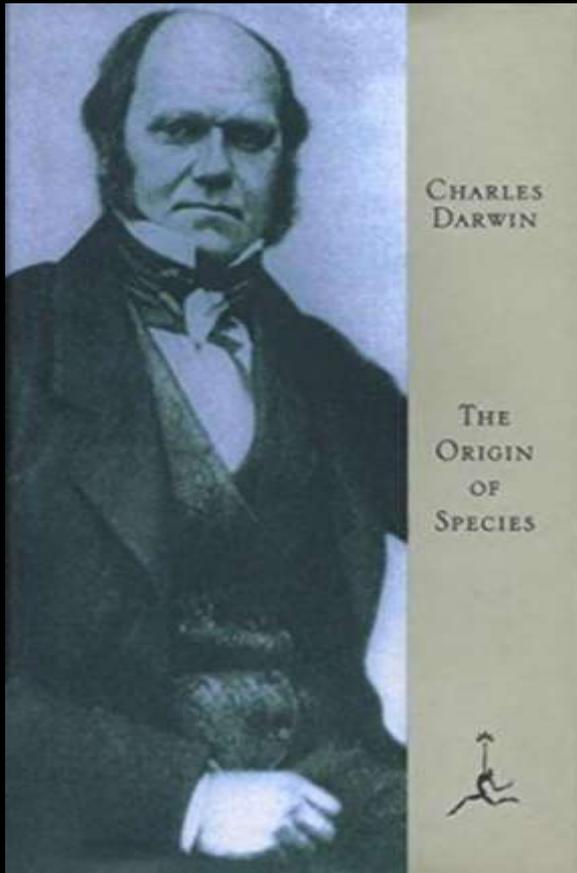
The first edition of *Systema Naturae* was printed in 1735. He then returned to Sweden, where he became professor of botany at Uppsala. In 1751 he publishes *The Economy of Nature*, [Transl. of *Oeconomia naturae*],

Linnaeus opened his *The Economy of Nature*, "We understand the all-wise disposition of the Creator in relation to natural things, by which they are fitted to produce general ends and reciprocal uses."

"an order of nature, that some animals should be, as it were, created only to be miserably butchered by others, it seems that his Providence not only aimed at sustaining, but also keeping a just proportion amongst all the species; and so prevent any one of them increasing too much, to the detriment of men, and other animals.

For if it be true, as it is most assuredly, that the surface of the earth can support only a certain number of inhabitants, they must all perish, if the same number were doubled or tripled."





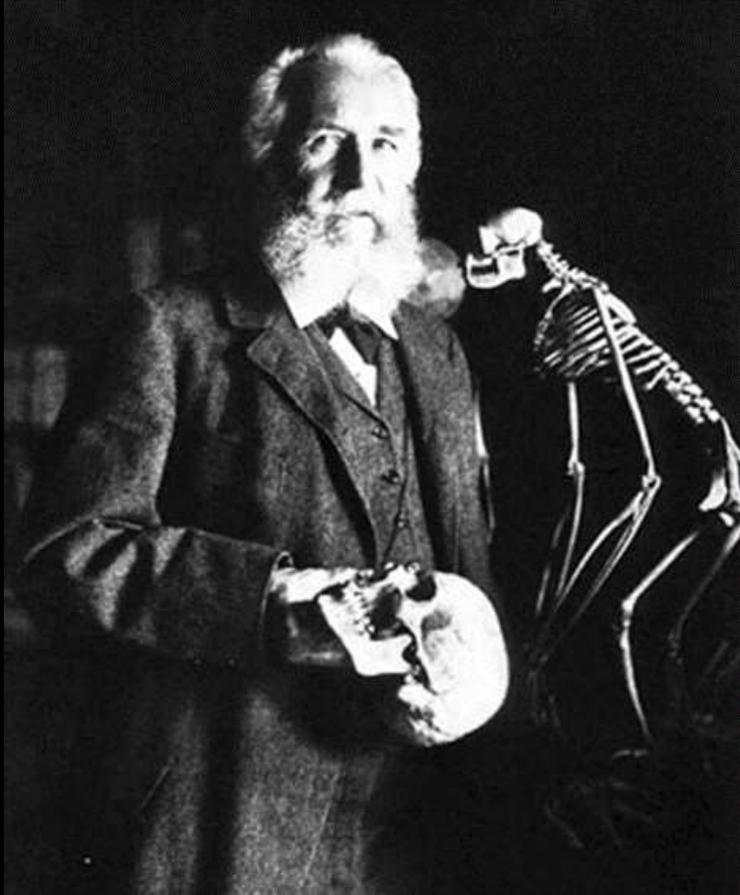
## Charles Darwin and the Economy of Nature

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

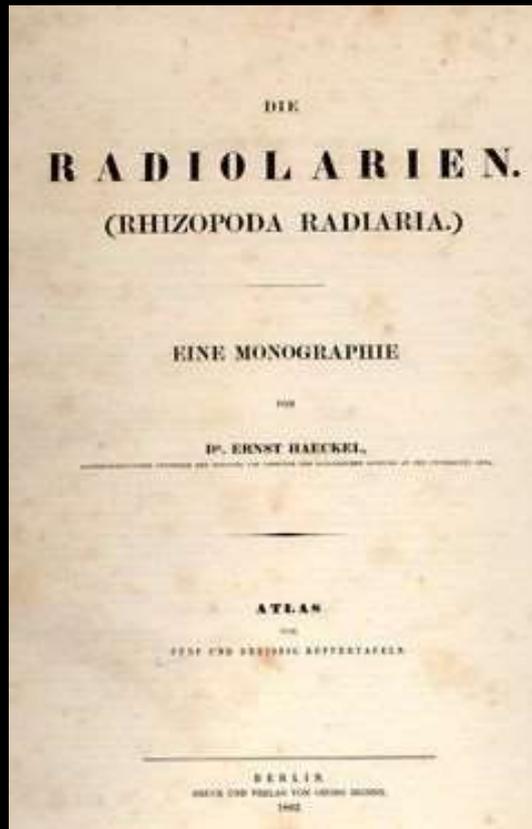
Order and Change over Time – Evolution of Life

## The Economy of Nature as Round River and Biotic Navigation



# 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.

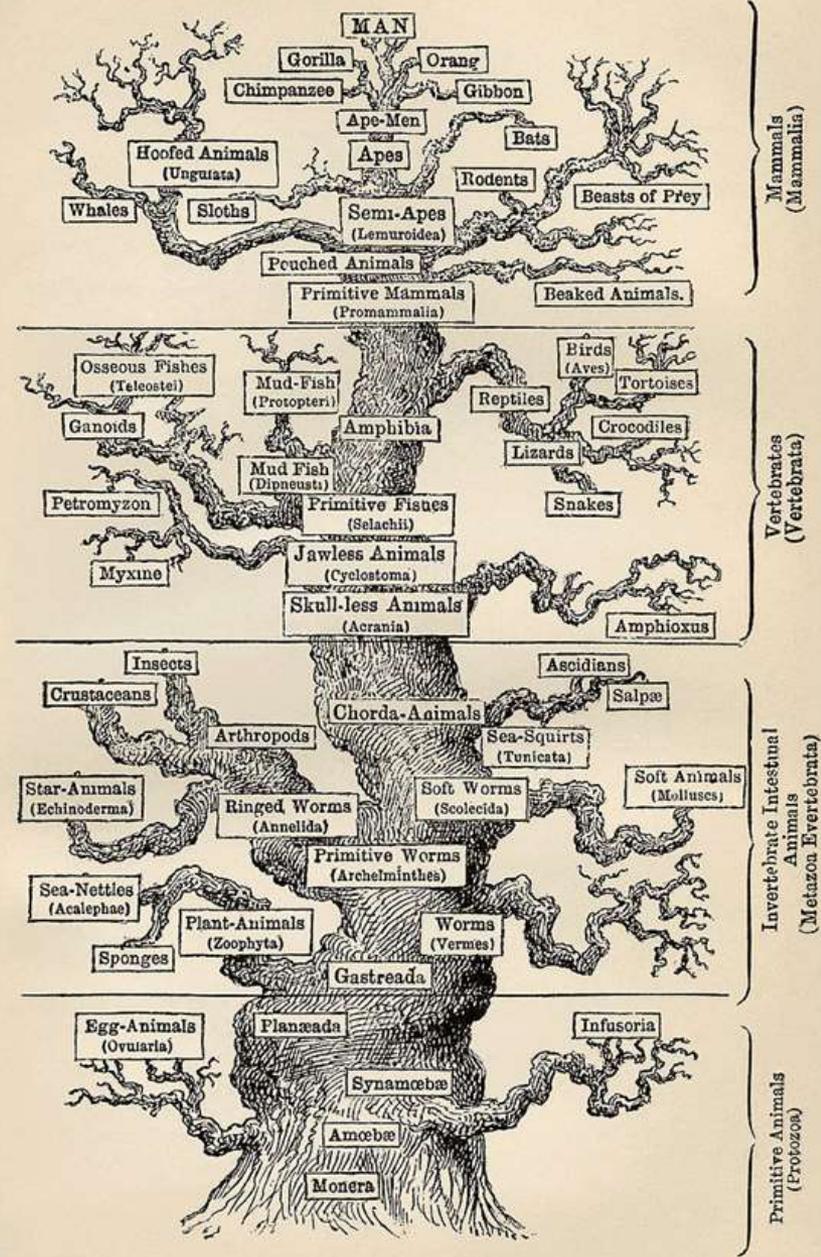


# Haeckel and Evolutionary Biology

Haeckel promoted and popularized Charles Darwin's work in Germany and developed the influential but no longer widely held recapitulation theory ("ontogeny recapitulates phylogeny") claiming that an individual organism's biological development, or ontogeny, parallels and summarises its species' evolutionary development, or phylogeny.



PEDIGREE OF MAN.

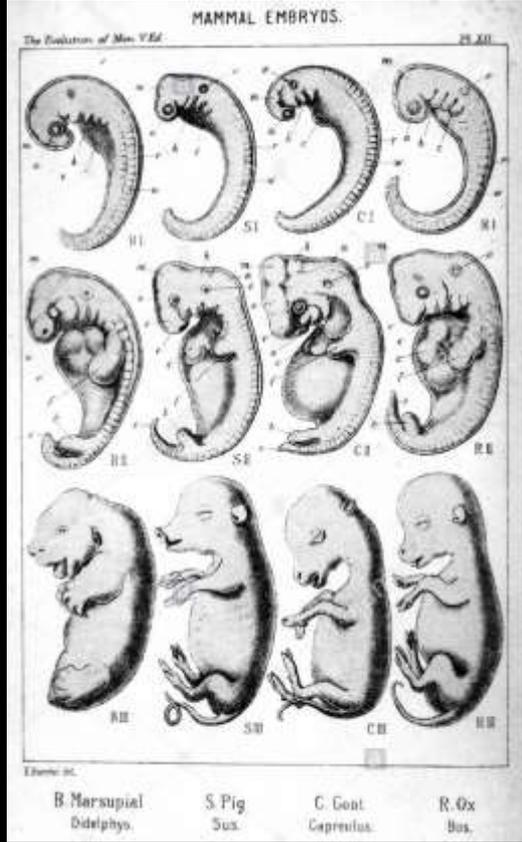


# Recapitulation Theory - "Ontogeny recapitulates phylogeny"

The notion later became simply known as the recapitulation theory. Ontogeny is the growth (size change) and development (shape change) of an individual organism; phylogeny is the evolutionary history of a species.

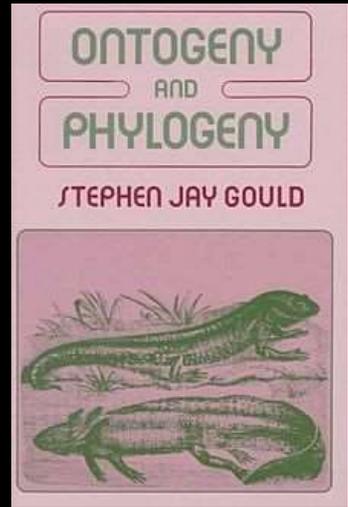
Haeckel claimed that the development of advanced species passes through stages represented by adult organisms of more primitive species. Otherwise put, each successive stage in the development of an individual represents one of the adult forms that appeared in its evolutionary history.

For example, Haeckel proposed that the pharyngeal grooves between the pharyngeal arches in the neck of the human embryo not only roughly resembled gill slits of fish, but directly represented an adult "fishlike" developmental stage, signifying a fishlike ancestor.



"In the course of individual development, inherited characters appear, in general, earlier than adaptive ones, and the earlier a certain character appears in ontogeny, the further back must lie in time when it was acquired by its ancestors."

Ernst Haeckel



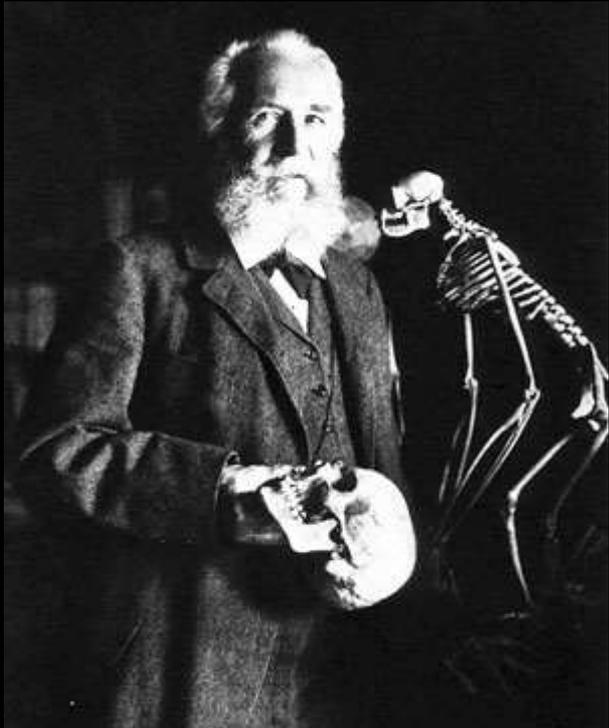
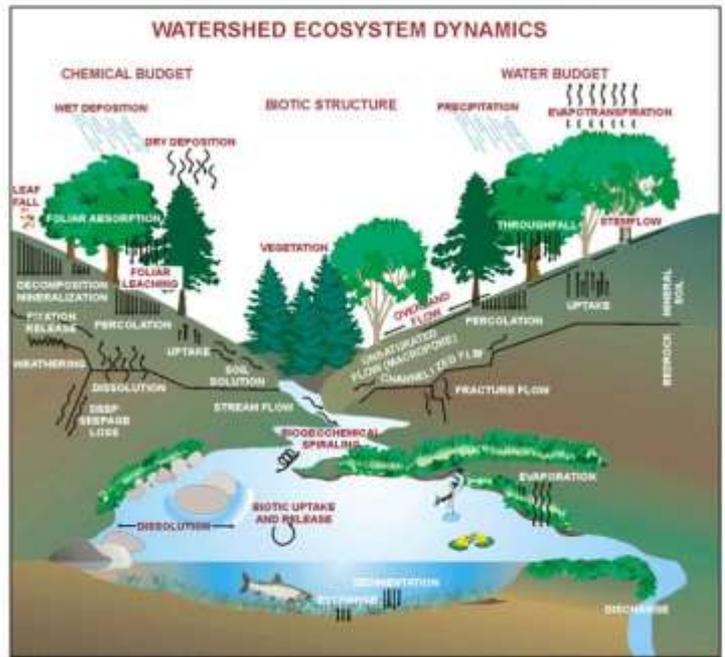
# Haeckel and Ecology – the study of Life Systems [ecosystems] – biotic and abiotic 1866

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—the investigation of the total relations of the animal both to the inorganic and to its organic environment; including, above all, its friendly and inimical relations with those animals and plants with which it comes directly or indirectly into contact—in a word, ecology is the study of all those complex interrelations referred to by Darwin as the conditions of the struggle for existence.”

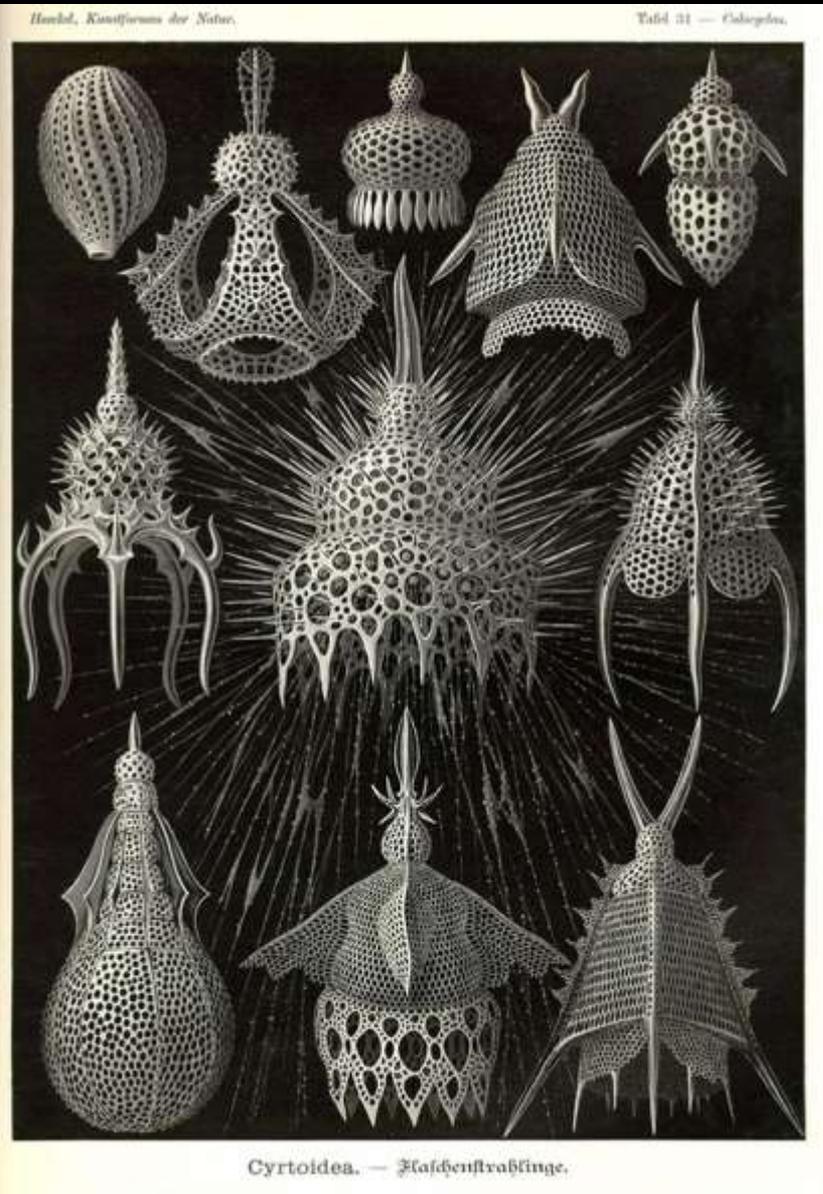
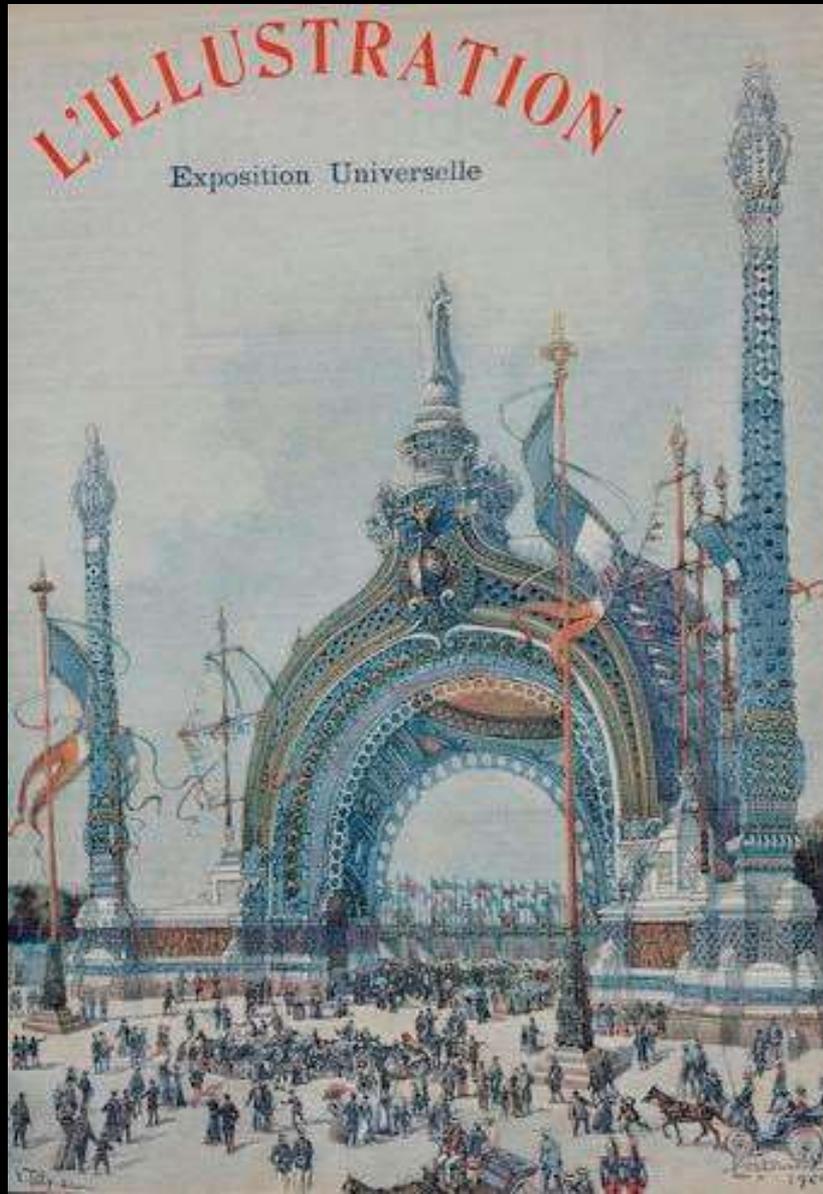
## Ecosystem – Biotic and Abiotic

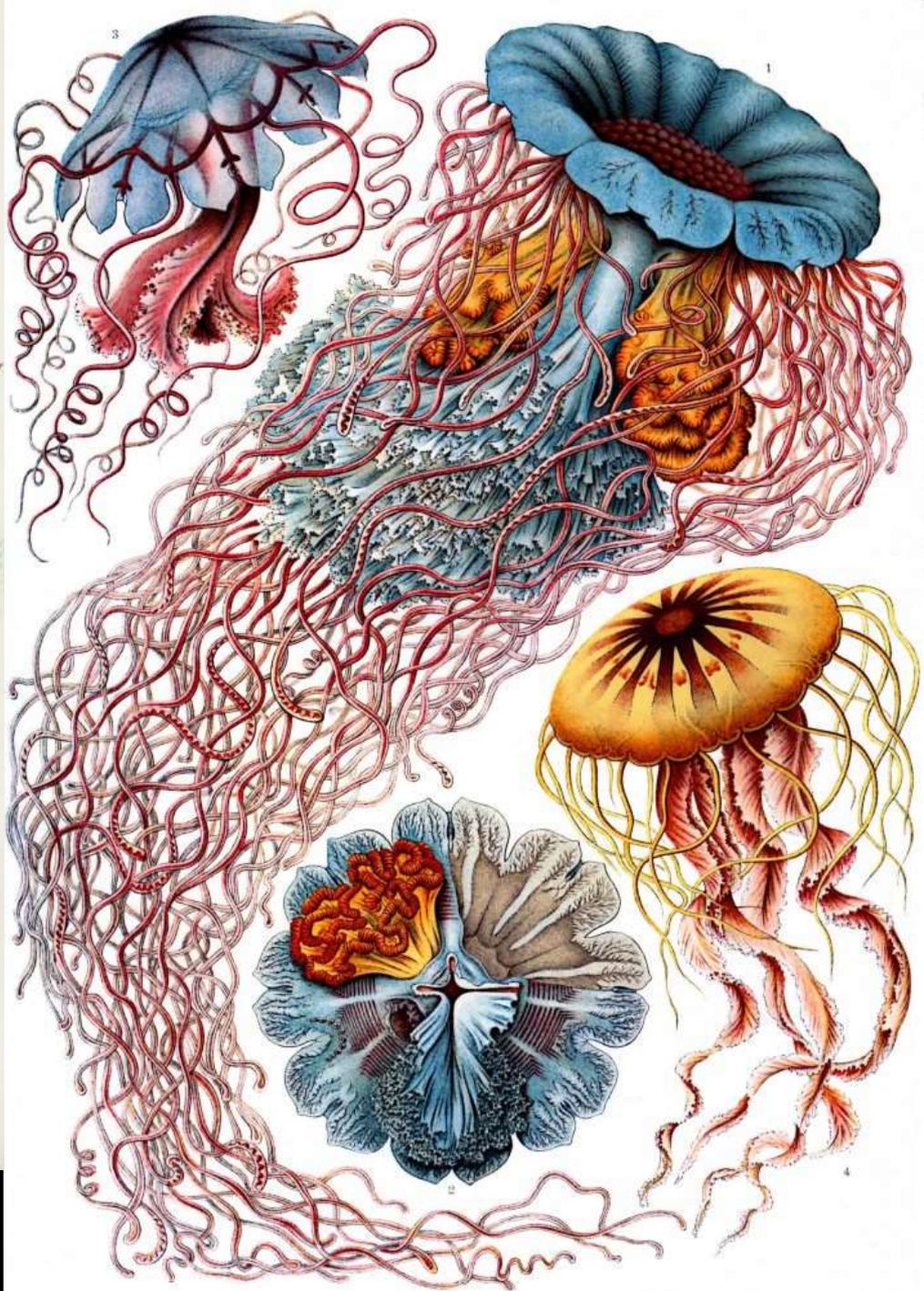
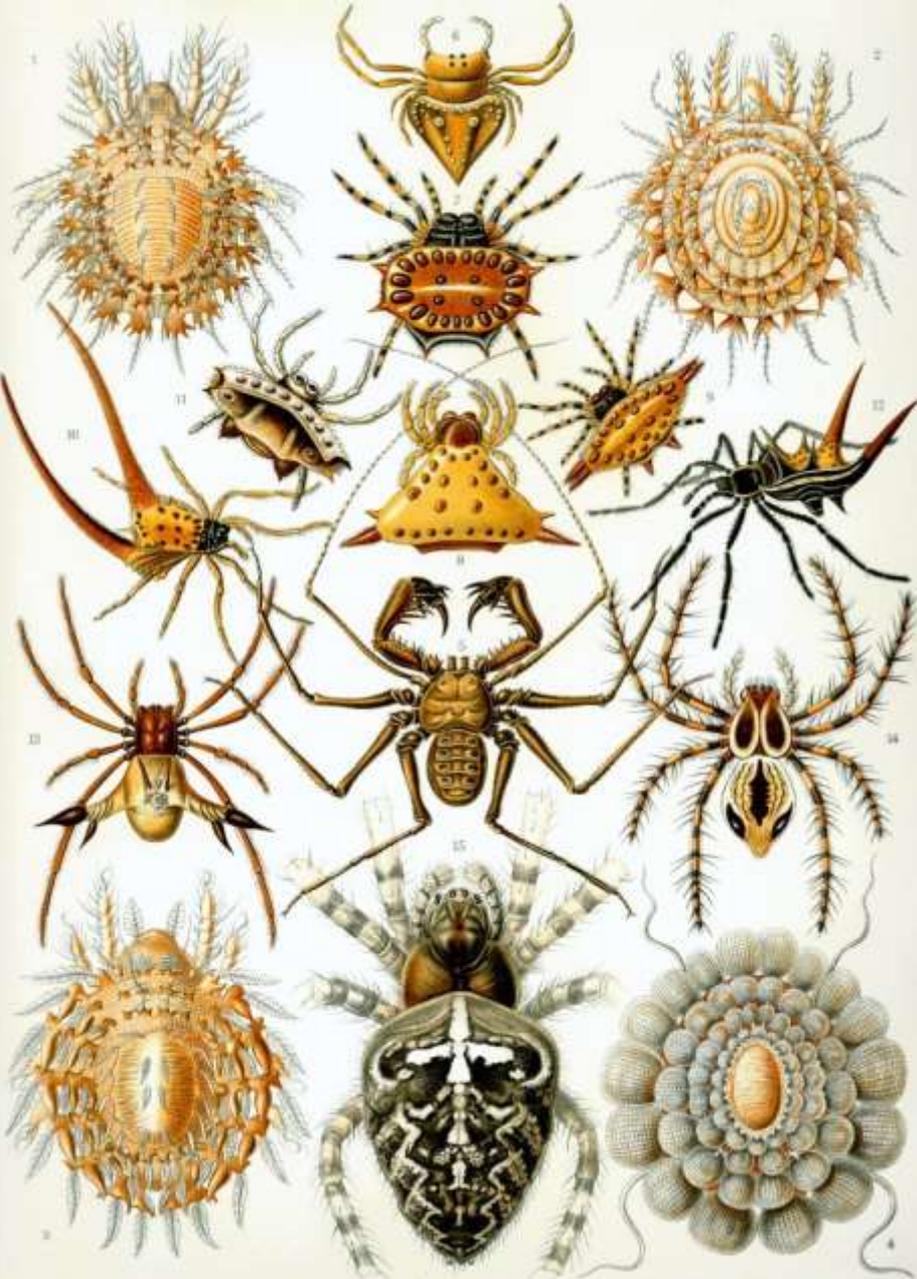


# Haeckel and Humboldtian Science

Kunstformen der Natur (1904) Art Forms of Nature

Porte Monumentale (Porte Binet) Exposition Universelle et Internationale de Paris 1900



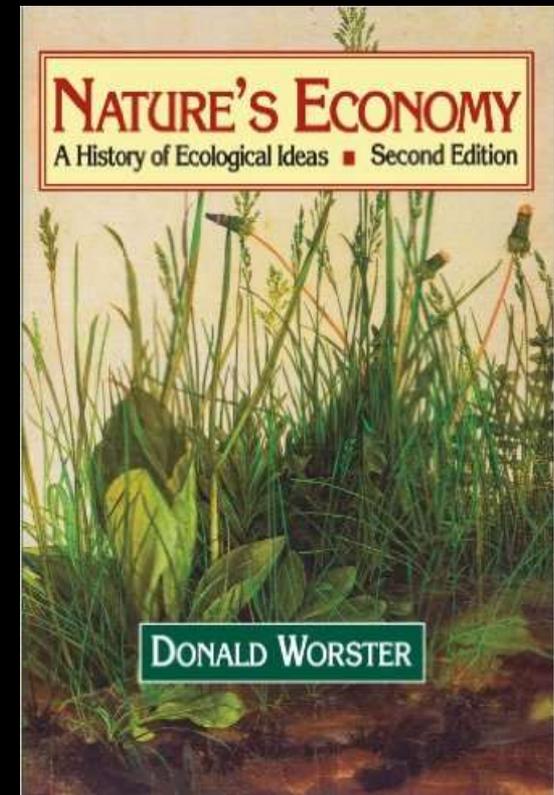
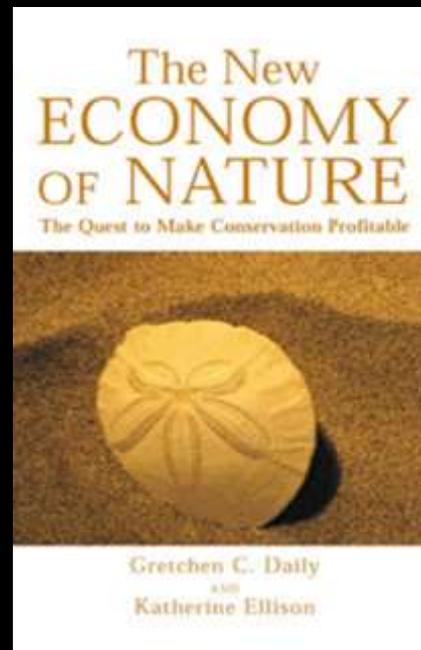
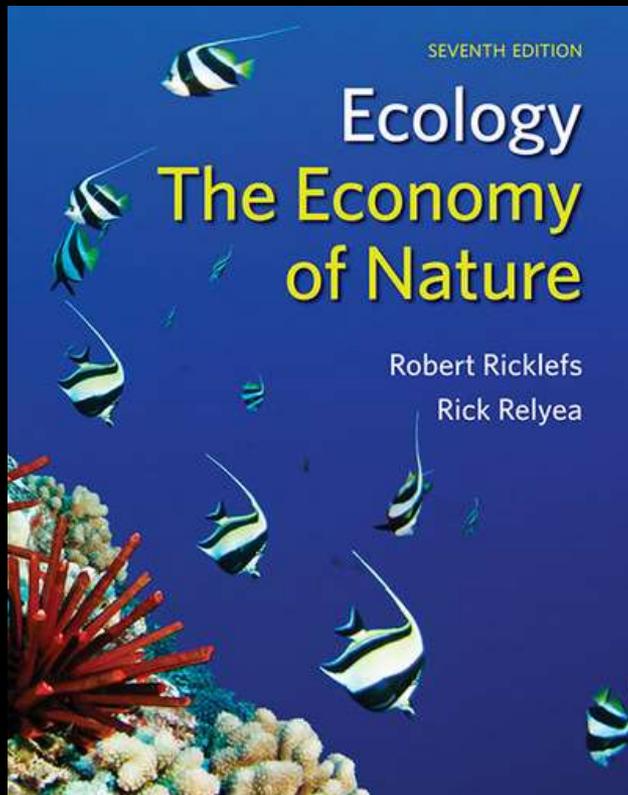


# Ecology as “biotic navigation”

## 20<sup>th</sup> and 21<sup>st</sup> Century Ecology – Science, Discourse, and Political Movements

- “the body of knowledge concerning the economy of nature (...) the study of all those complex interrelationships referred to by Darwin as the condition of the struggle for existence”
- “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.” Worster

### Order and Change - Conservation

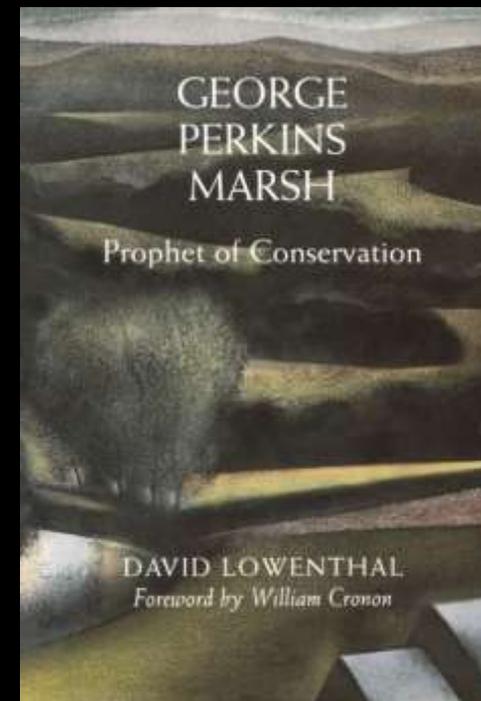


## Origins of Ecology as “biotic navigation”

George Perkins Marsh 1801 – 1882

American diplomat and philologist and “Prophet of Conservation”

- Greatly influenced by reading Humboldt to observe and compare Old World and New World environmental change.
- Humboldt was the “greatest of the priesthood of nature”
- Marsh was born in Vermont, educated at Dartmouth College and taught Greek and Latin before becoming a lawyer and moving to Burlington, Vermont.
- In 1839, he was elected to the U.S. House of Representatives and went to Washington, where he was a key figure in the establishment of the Smithsonian Institution.
- Most known in his lifetime as a philologist. Knew 20 languages and wrote a history of the English language, championed Norse sagas.
- Marsh began the diplomatic phase of his career in 1849, when he was appointed to serve as the Minister to the Court at Constantinople.
- In 1861, Lincoln appointed him as ambassador to the Kingdom of Italy and he spent the rest of his life as ambassador in Italy.

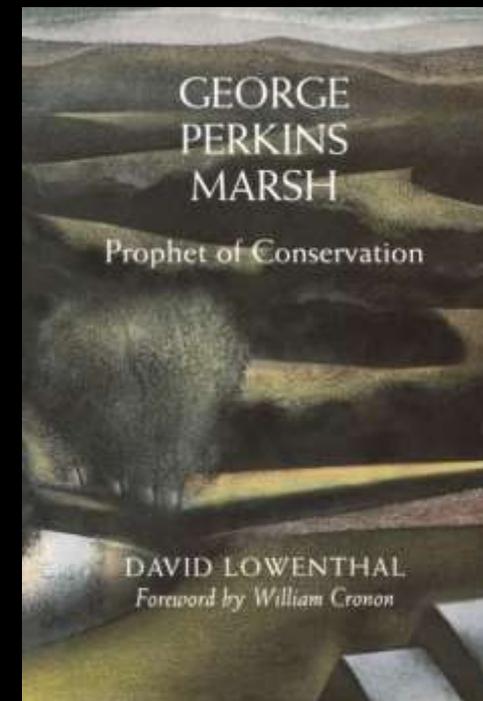


## Origins of Ecology as “biotic navigation”

George Perkins Marsh 1801 – 1882

American diplomat and philologist and “Prophet of Conservation”

- Marsh would go on to be the longest-serving chief of mission in U.S. history, serving as envoy for 21 years until his death at Italy in 1882.
- He is buried at the Protestant Cemetery in Rome



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

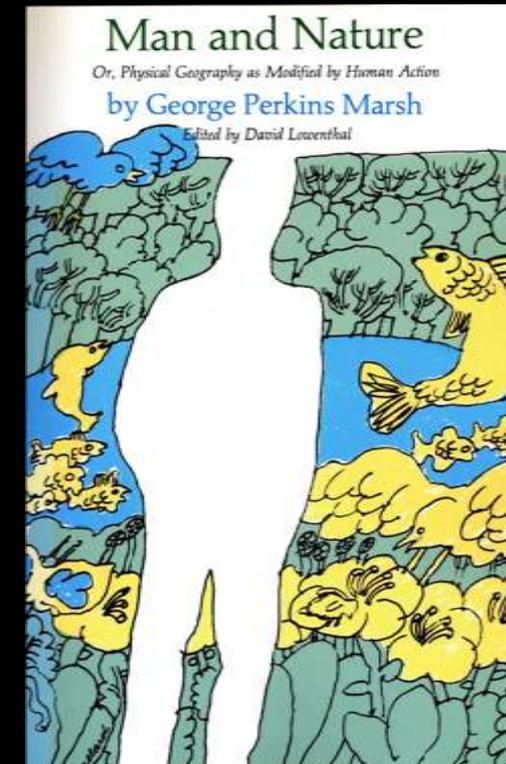
Published in 1864

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

- "Man is everywhere a disturbing agent. Wherever he plants his foot, the harmonies of nature are turned to discord"
- "...Man, who even now finds scarce breathing room on this vast globe, cannot retire from the Old World to some yet undiscovered continent, and wait for the slow action of such causes to replace, by a new creation, the Eden he has wasted"
- “Man has too long forgotten that the earth was given to him for usufruct alone, not for consumption, still less for profligate waste. Nature has provided against the absolute destruction of any of her elementary matter... But she has left it within the power of man irreparably to derange the combinations of inorganic matter and of organic life.”
- Marsh reframes Humboldt through Christian doctrine and American Natural Theology



1864



# American Natural Theology

Theology of Nature - Natural History as a Window into the Divine

Ordinary Americans asked and answered why phenomena occurred, oftentimes with theological reasoning, adding religious import to nature study and nationalist gloss.

Cotton Mather 1663 – 1728

*The Christian Philosopher. A Collection of the Best Discoveries in Nature, with Religious Improvements* (1721)

“Natural Philosophers” were not a threat to religion but when properly construed they presented evidence of God’s perfection.

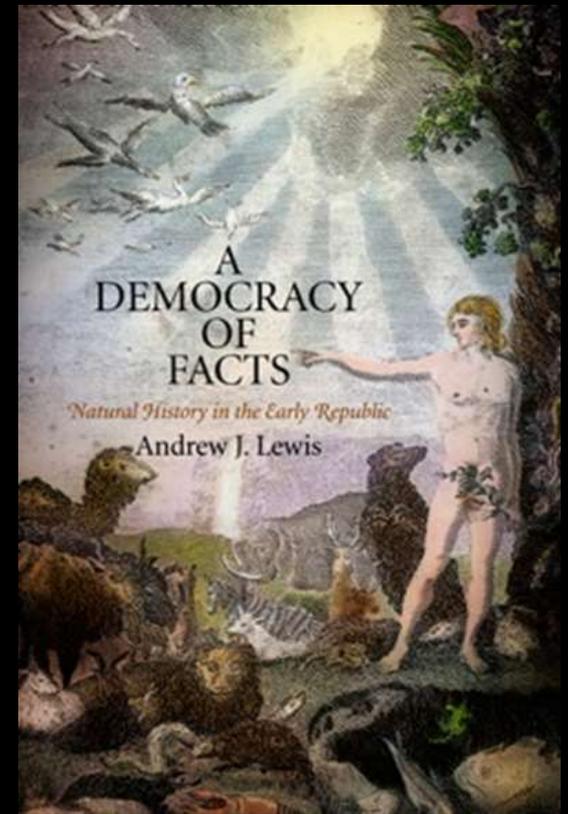
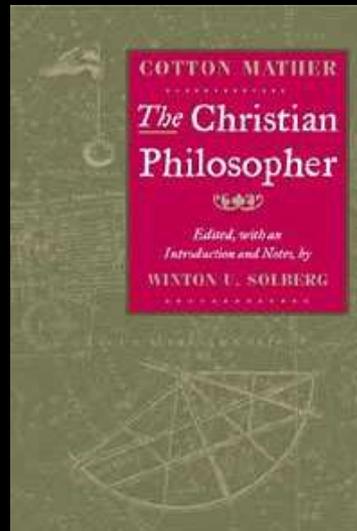


Image from  
*Natural History of the Bible*  
Thaddeus Mason Harris  
1793

# Two Key Humboldtian Insights from Marsh

## – Destruction and Reclamation

### 1. Unintended Consequences

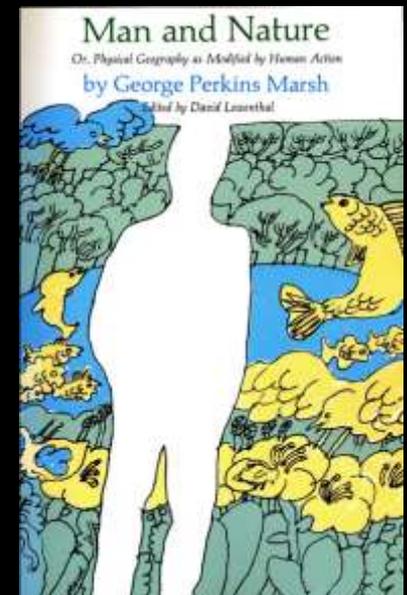
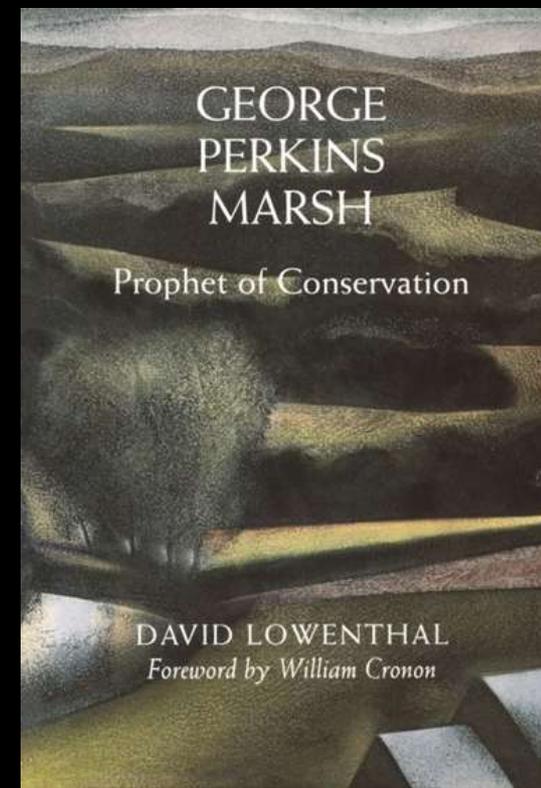
Most human impacts are unintentional. “Vast as is the . . . magnitude and importance [of] intentional changes”, they are “insignificant in comparison with the contingent and unsought results which have flowed from them”.

“The equation of animal and vegetable life is too complicated a problem for human intelligence to solve, and we can never know how wide a circle of disturbance we produce in the harmonies of nature when we throw the smallest pebble into the ocean of organic life.”

### 2. Commitment to the Future

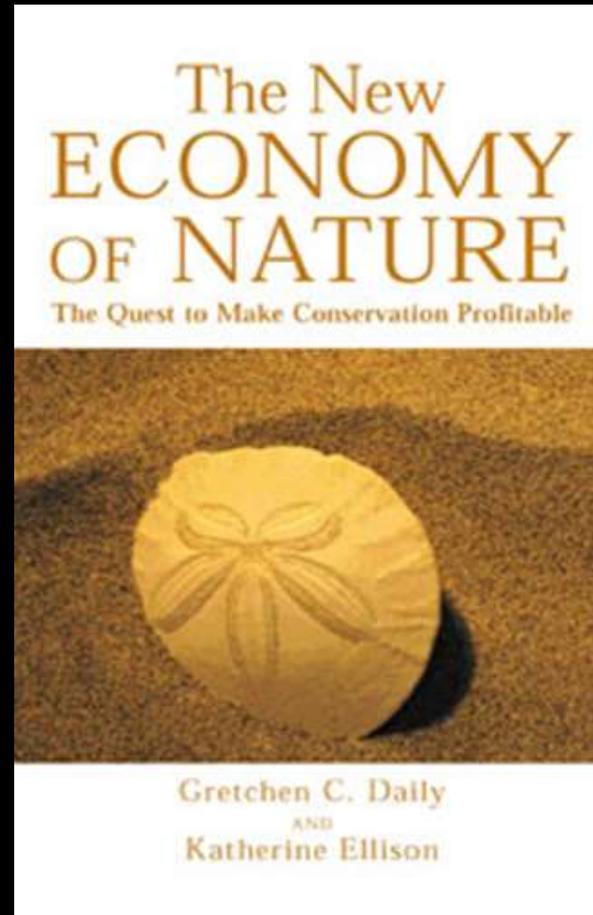
The whole force of *Man and Nature* lies in its assumption that the welfare of future generations transcended immediate gains. Americans who disdained to practice a better husbandry for themselves should feel morally obliged to do so for their offspring.

Conservation Impacts - It led to the passage of the 1873 Timber Culture Act, which encouraged settlers on the Great Plains to plant trees. It also prepared the ground for the 1891 Forest Reserves Act, which took much of its wording from Marsh and from Humboldt's earlier ideas.





# Biotic Navigation - From Humboldt to A New Economy of Nature



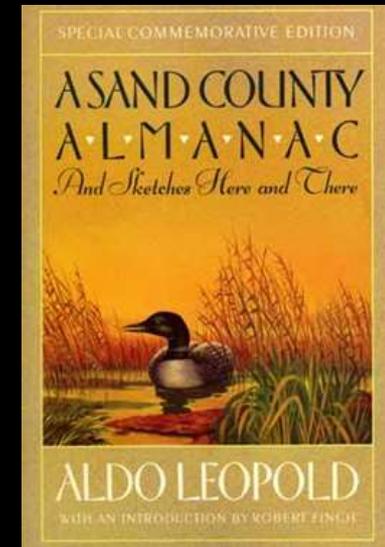
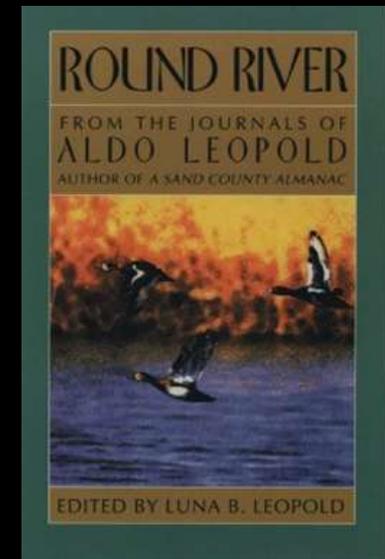
## Round River

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.

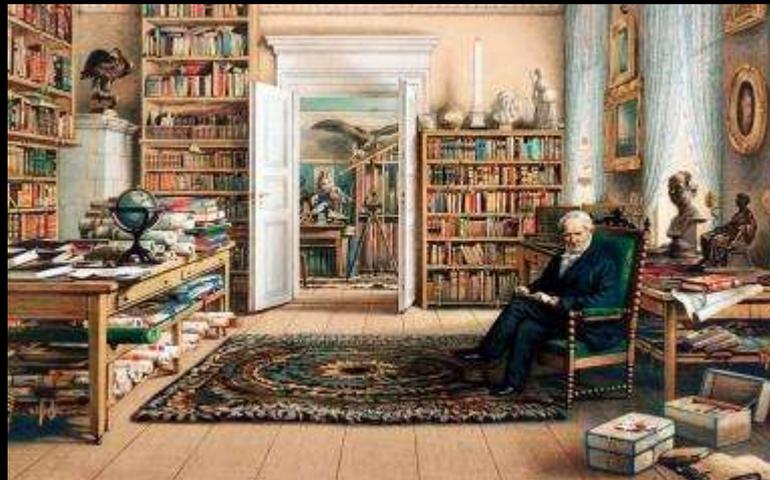
Ecology is destined to become the lore of Round River, a belated attempt to convert our collective wisdom of biotic materials into a collective wisdom of biotic navigation.

This, in the last analysis, is conservation.





Alexander von Humboldt 1769 – 1859



Applause



# Questions?



# Center for Environmental Research at Hornsby Bend

## The Discovery of Nature [April - September]

April – The Nature Collectors: New Lands, New Nature, and Ecological Imperialism

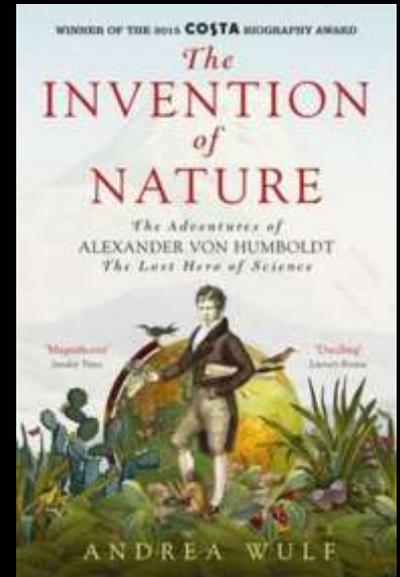
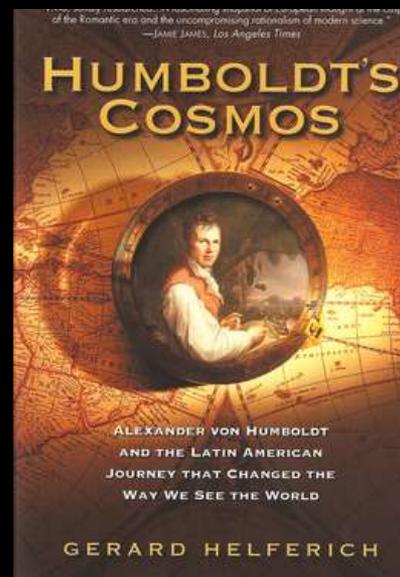
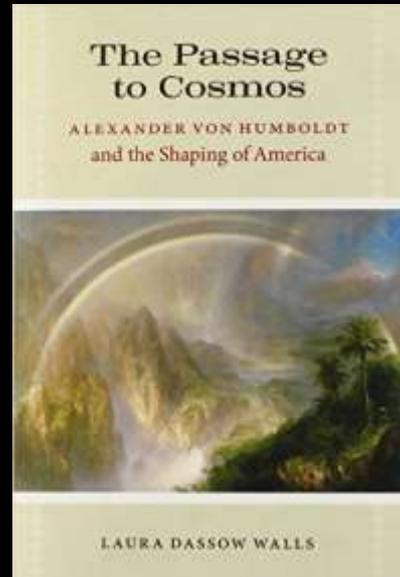
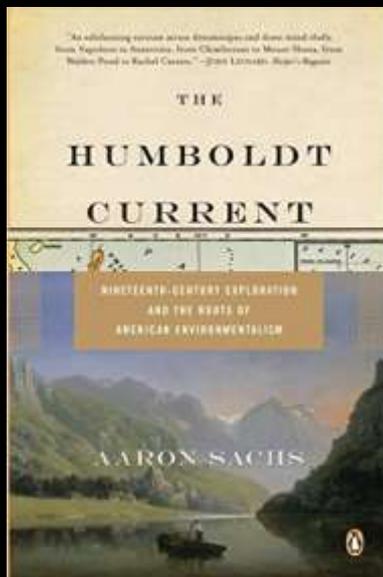
May – The Scientist of Nature: Alexander Von Humboldt and the Physical Description of the Earth

June – The Invention of Modern Nature: The Earth as a “Natural Whole”

July – The Romance of Nature: Science, Imagination, and the Poets of Nature

August – The Evolution of Nature: Von Humboldt, Darwin, and the Systematic Universe

September – The Economy of Nature: Ecology, Earth Science, and Biotic Navigation





# Center for Environmental Research at Hornsby Bend

## The End of Nature [October – December]

October – The Great Disruptors: Environmentalism and the Idea of American Nature

November – The Earth Managers: Balance, Resilience, and Environmental Science

December – The End of Nature: Permanence, Change, and the Anthropocene

