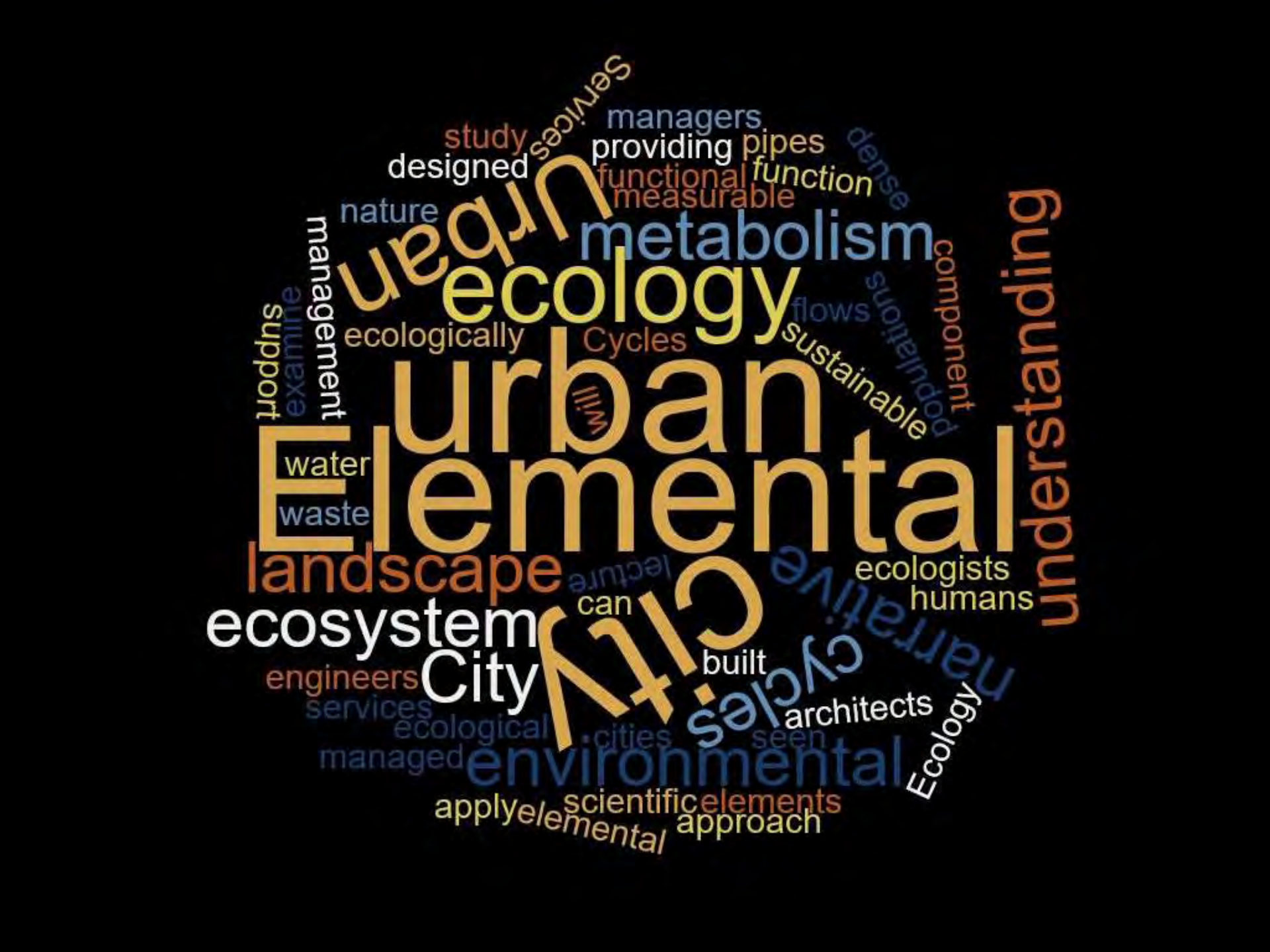

Elemental
urban
ecology
metabolism
Urban
City
landscape
ecosystem
City
environmental
understanding
natural
cycles
Ecology
water
waste
nature
designed
study
Services
managers
providing
pipes
functional
function
measurable
dense
management
support
examine
ecologically
Cycles
will
flows
sustainable
populations
component
ecologists
humans
can
lecture
built
engineers
services
ecological
managed
cities
seen
architects
apply
elemental
scientific
elements
approach

Center for Environmental Research at Hornsby Bend

Austin WATER

The CER Lunchtime Lectures 2017

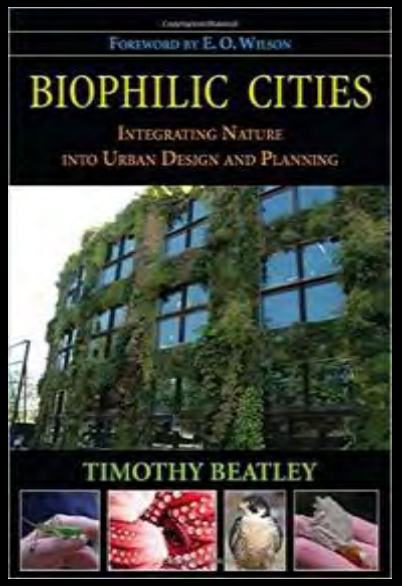
Understanding Urban Nature: Ecology, Culture, and the American City

Perspectives on Urban Nature

January	Varieties of Possibility: Perspectives on Nature and the City
February	Urban Wild: Wilderness, Wildness, and the American City
March	Urban Pastoral: Farms, Gardens, and Parkland in the City
April	The Elemental City: Cycles, Services, and Urban Ecology

The Nature of Cities – Urban Natural History and Ecology

May	Nature in the City: Urban Habitats and the Degradation Myth
June	The Aquatic City: The Ecology of Urban Waterways
July	The Terrestrial City: Greenspace and the Urban Forest
August	The Subterranean City: Soil and the Urban Microcosmos
September	The Aerial City: Urban Birds, Bats, and Denizens of the Sky



The Proper Place of Urban Nature

October	Nature Out of Place: Invasive Species, Novel Ecosystems, and Urban Ecology
November	Design with Nature: Urban Planning, Management, and the Sustainability Myth
December	Encounters with Urban Nature: Ecology, the City, and the Arts

Perspectives on Urban Nature and the American City

The Sacred and the Mundane

Wilderness and the City

Natural vs. Artificial

Pristine vs. Degraded

Native vs. Non-native

Invasive Non-native Species

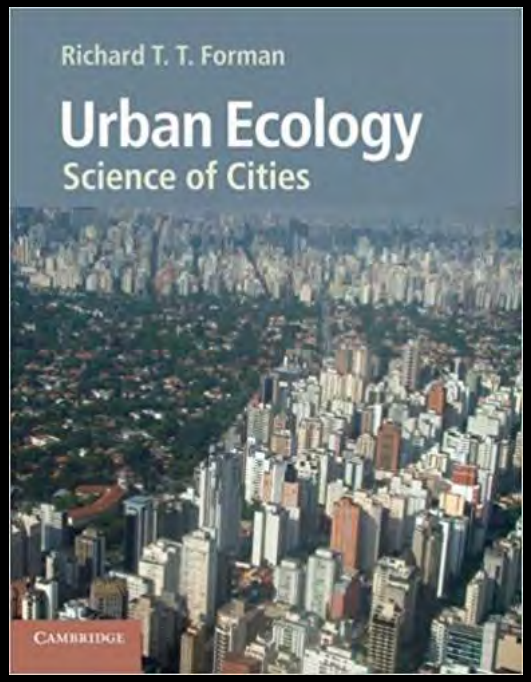
Once a rock dove, now the winged rat of the city

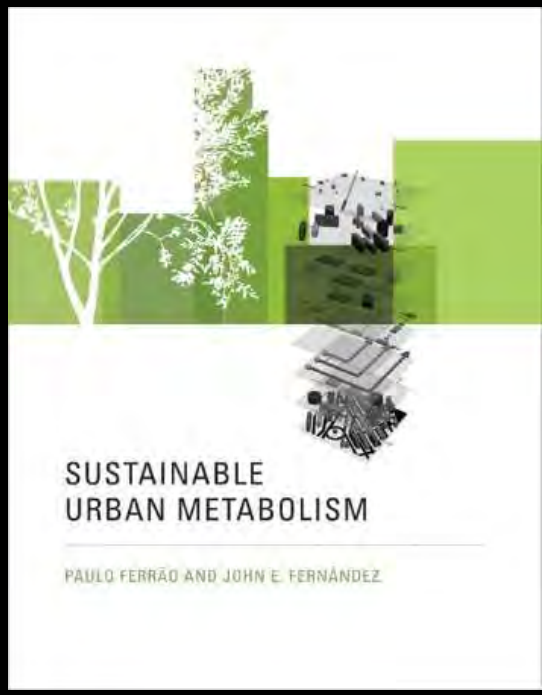
Non-native species and Biodiversity?

Center for Environmental Research at Hornsby Bend

Austin WATER

The Elemental City: Cycles, Services, and Urban Ecology





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

Varieties of Possibility: Perspectives on Nature and the City

Narratives of Urban Nature

Narrative of Redemptive Urban Nature – The Wild and The Pastoral

Narrative of Restorative Urban Nature

- Version 1 - Architecture and Urban Design/Planning
- Version 2 - Restoration Ecology and Conservation Biology

Narrative of Functional Nature - Ecology and the City

Urban Ecology

What is a City? An Ecosystem

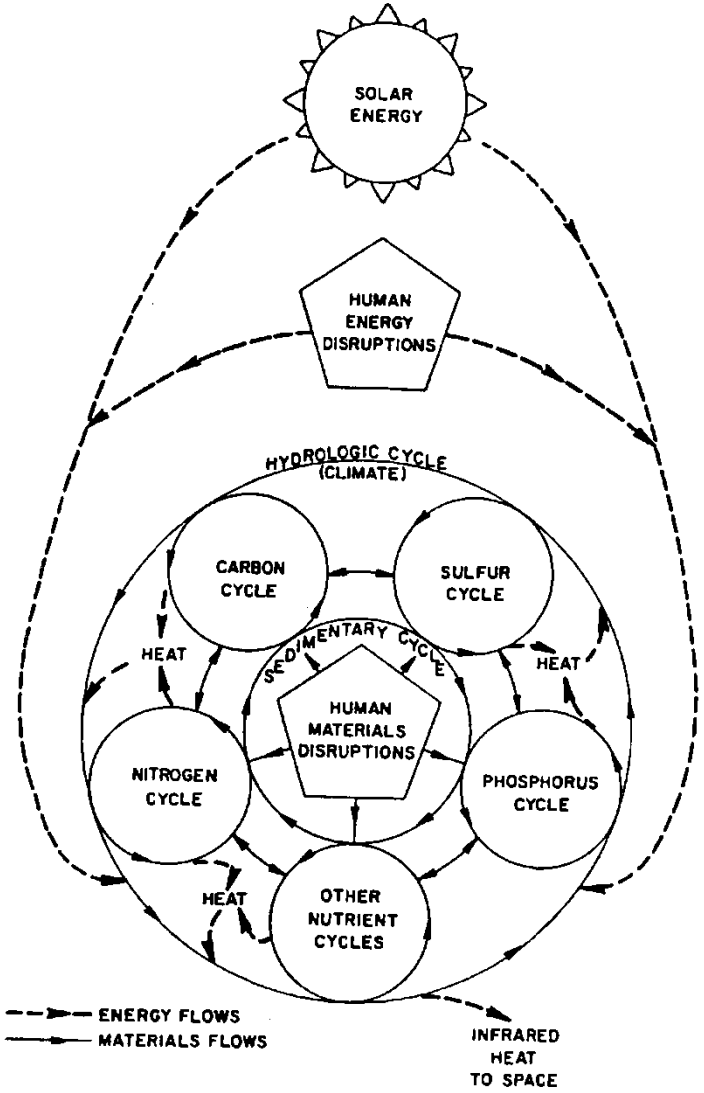


Figure 5.1. Climate and life are linked by a complex web of interconnected cycles. Life on earth depends on the cycling of nutrients through air, water, soil, and living things. The climate mediates the flow of materials through these global cycles. Solar energy degrades to heat at each stage of the cycling process and is eventually returned to space as infrared radiation. The composition of the earth's atmosphere regulates the radiative balance on earth between absorbed solar energy and emitted infrared energy, which, in turn, controls the climate.

Source: Schneider and Morton 1981.

Urban Ecology

The Elemental City

Ecosystem Cycles

[Biogeochemical Cycles]

- Water cycle
- Carbon cycle
- Nitrogen cycle
- Phosphorus cycle
- Other trace minerals and metals

Urban Colonial Nesting Mammals

Congress Avenue Bridge 1.5 -2 Million

Mexican Free-tailed Bats

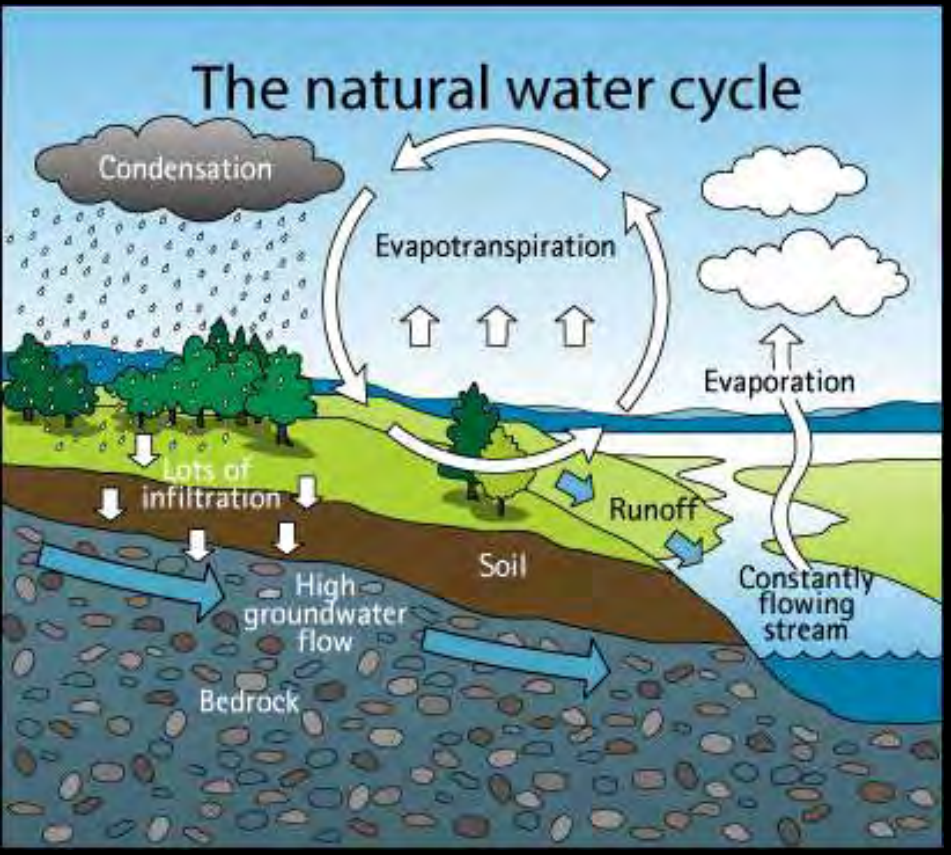
Rural Colonial Nesting Mammals

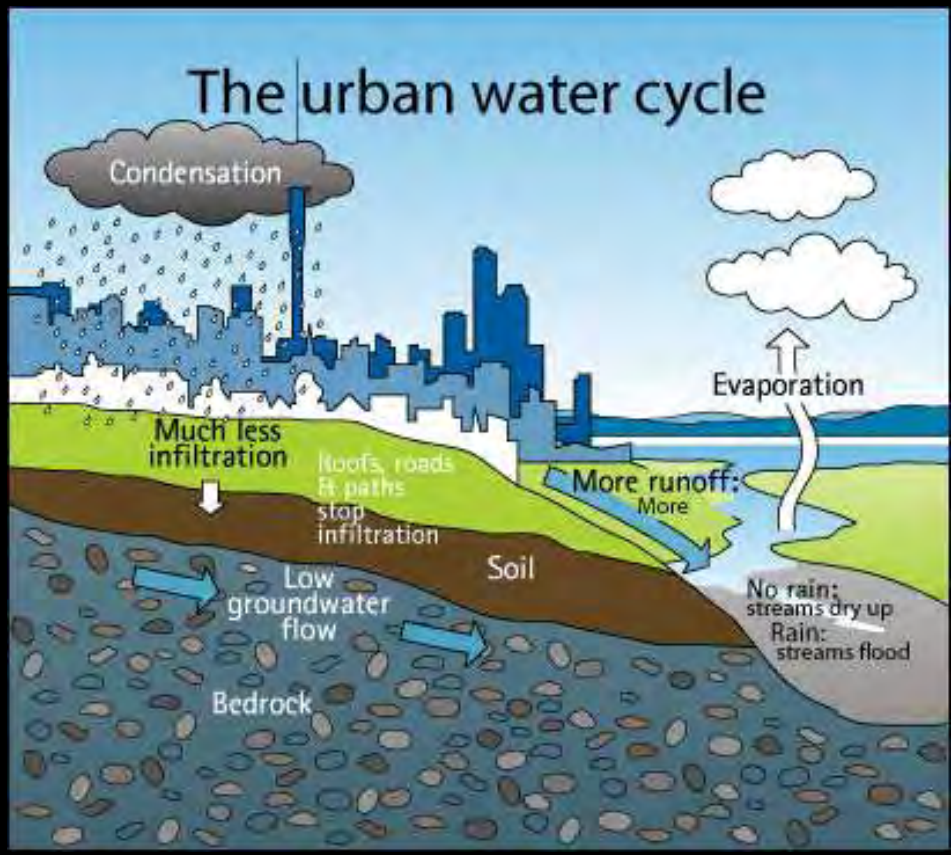
Black-Tailed Prairie Dog

Colonial Nesting Mammals

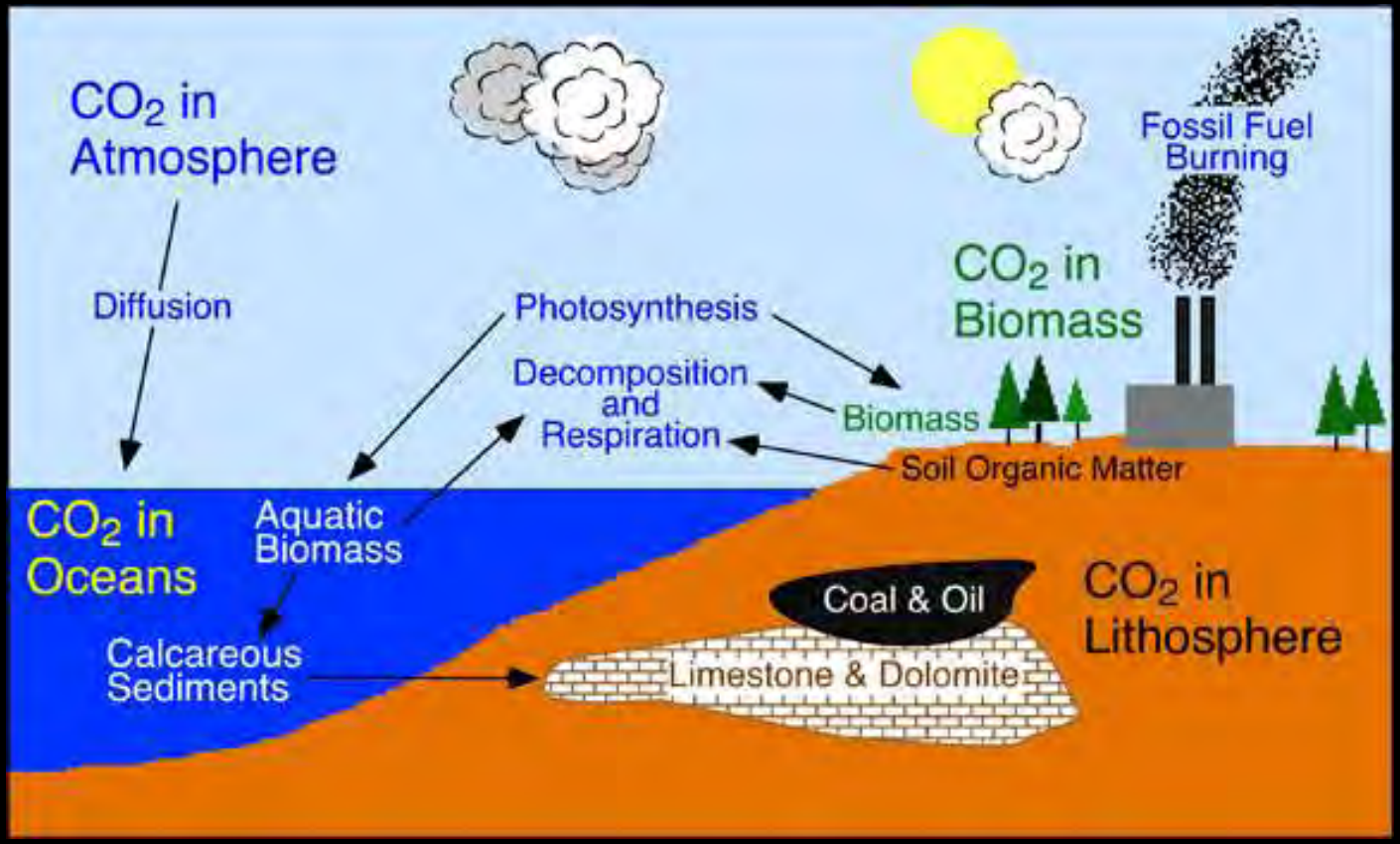
Elemental City

Socioecological

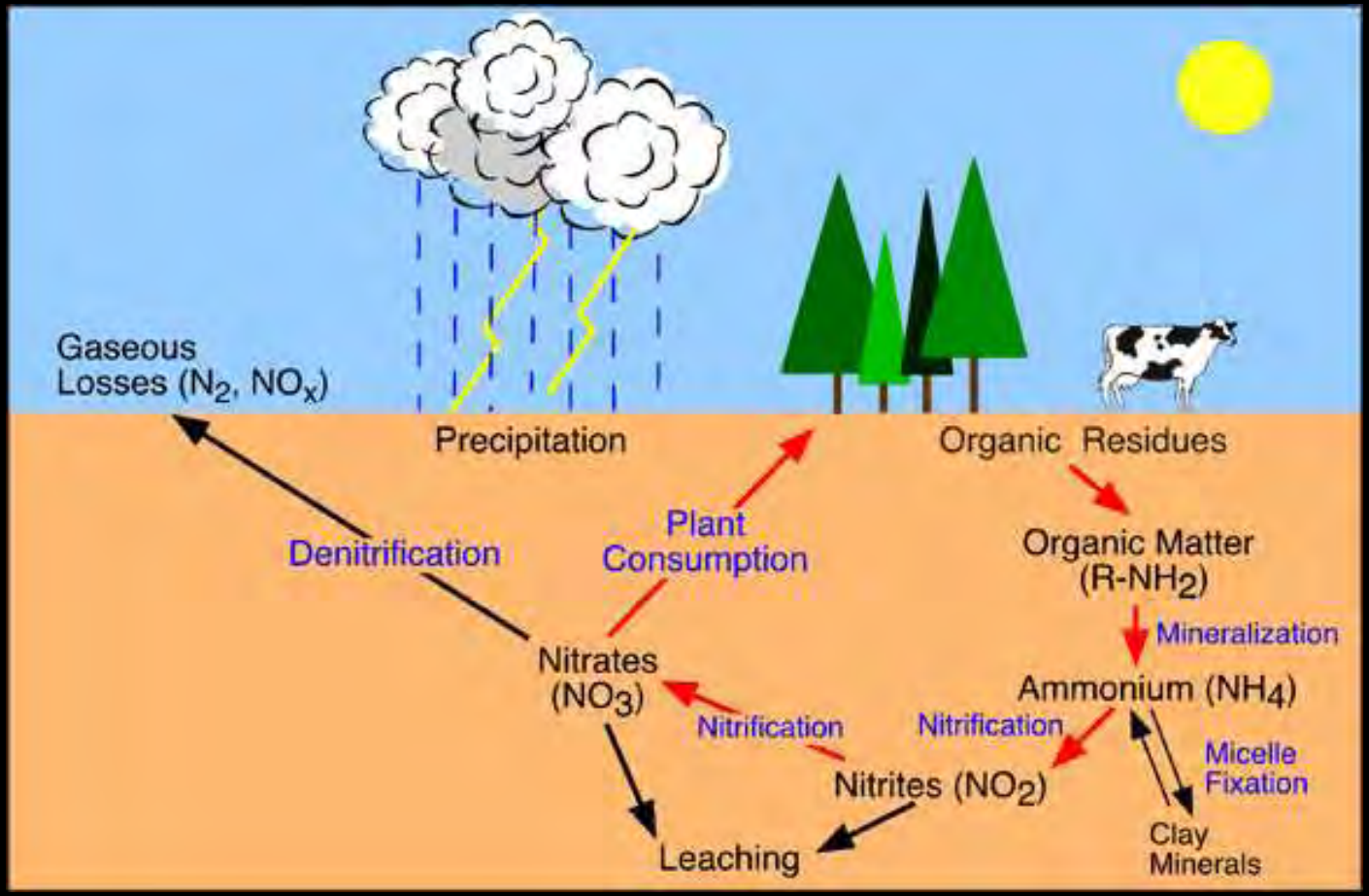

The natural water cycle
Condensation
Evapotranspiration
Evaporation
Lots of infiltration
Runoff
Soil
High groundwater flow
Constantly flowing stream
Bedrock


The urban water cycle
Condensation
Evaporation
Much less infiltration
(roofs, roads & paths stop infiltration)
More runoff:
More
Soil
Low groundwater flow
No rain: streams dry up
Rain: streams flood
Bedrock

The Carbon Cycle



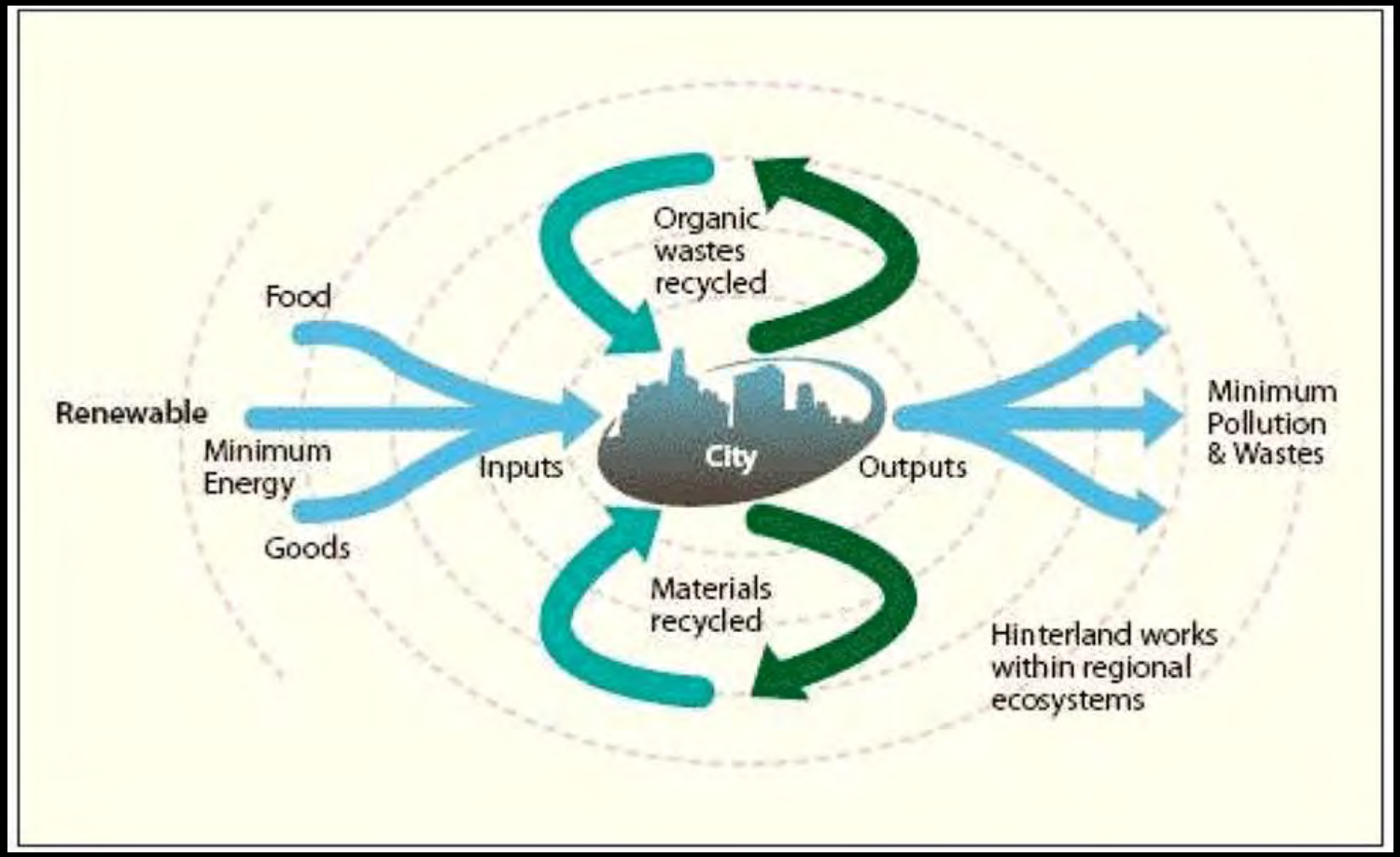
The Nitrogen Cycle



The Socioecological Elemental City

Urban Ecology

The ecology ‘in’ cities
or
The ecology ‘of’ cities



Narrative of Functional Nature
Ecology "and" the City

Ecological Narrative and "City as Organism" Metaphor

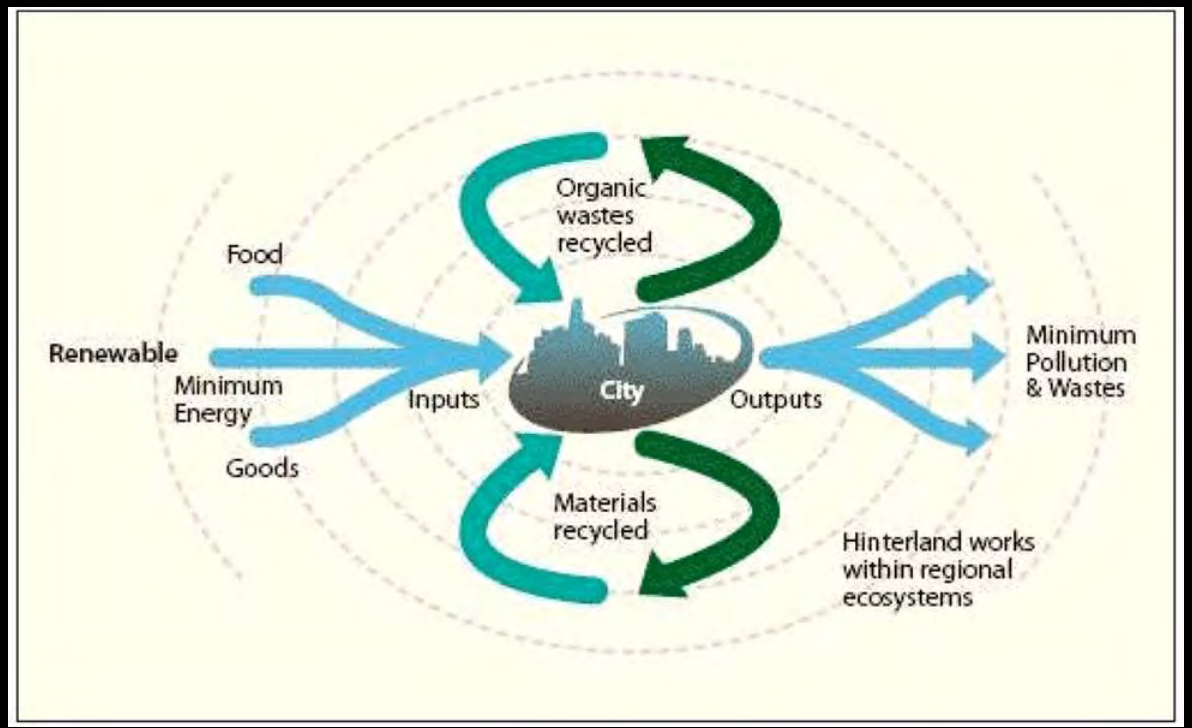
Version 1 – Engineering and Resource Management

- Version 2 - Urban Environmental History
- Version 3 - Urban Political Ecology

Ecology "in" and "of" a City

Version 4 – Science and Environmental Management - Urban Ecology

NATURE?



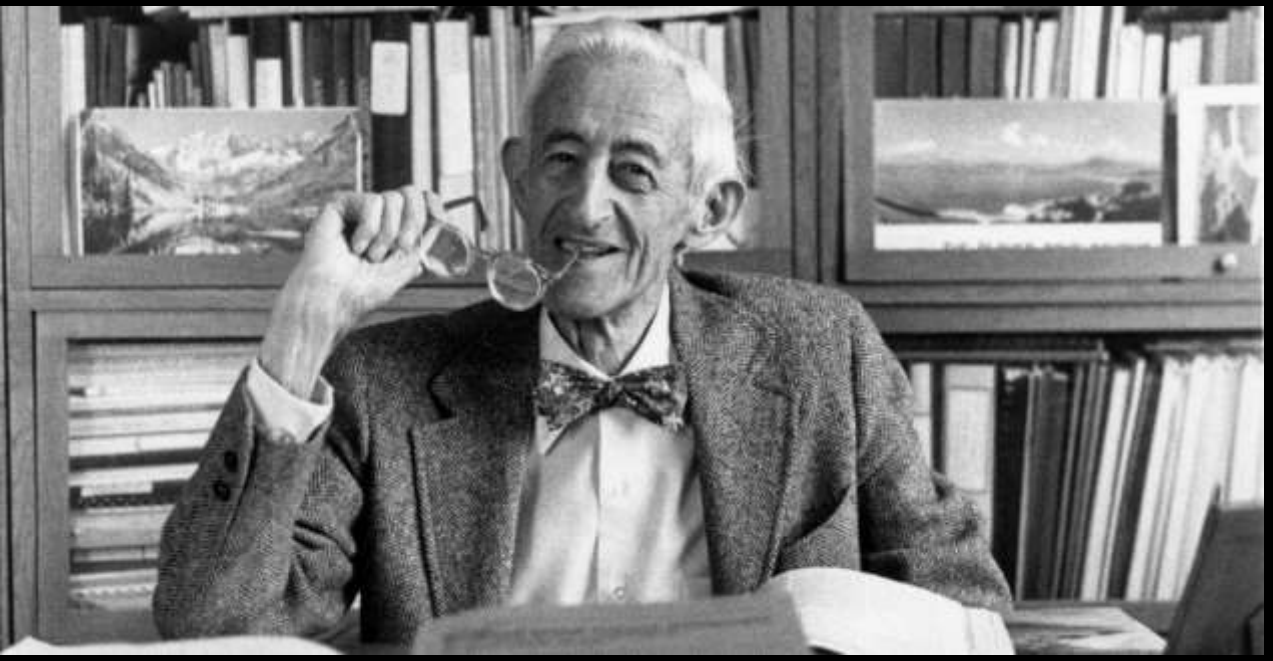
Narrative of Functional Nature

Version 1 – Engineering and Resource Management

Urban Metabolism

The metabolic requirements of a city can be defined as the materials and commodities needed to sustain the city's inhabitants at home, at work and at play…The metabolic cycle is not completed until wastes and residues of daily life have been removed and disposed of with a minimum of nuisance and hazard.

- Abel Wolman "The metabolism of cities" *Science* (1965)

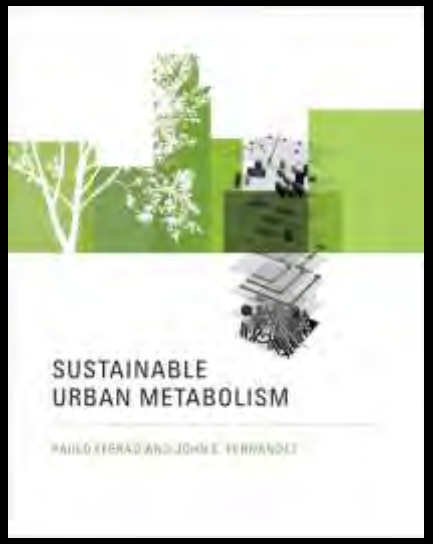


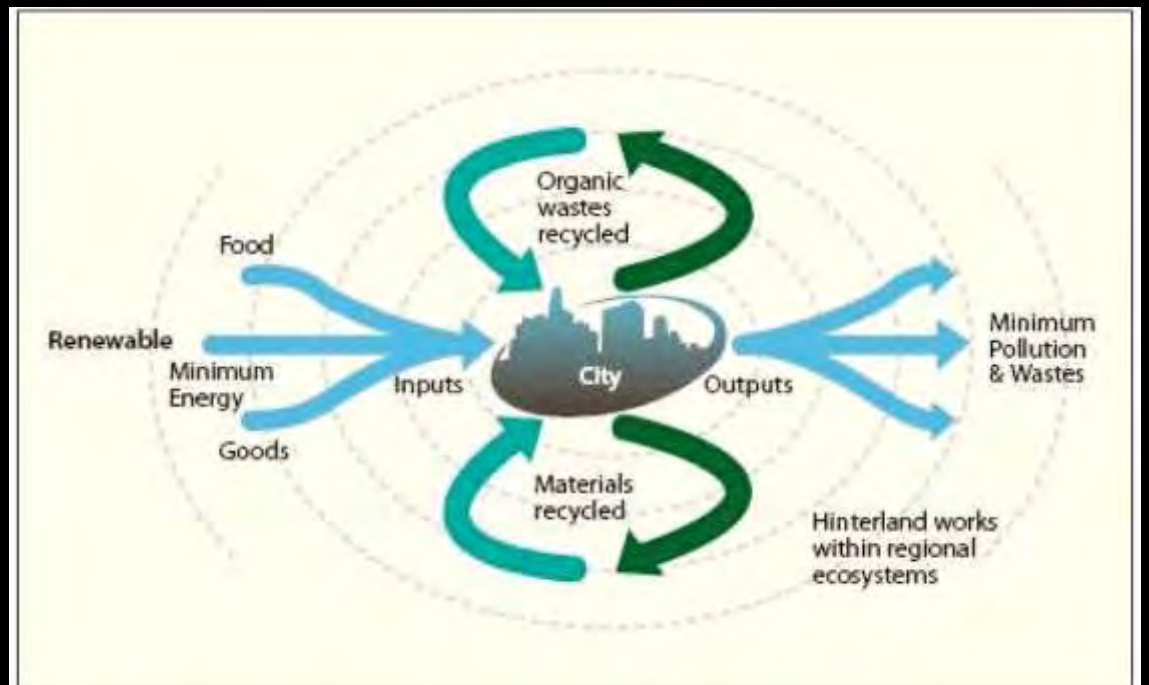
Urban Metabolism – The Earth as an "urban system"

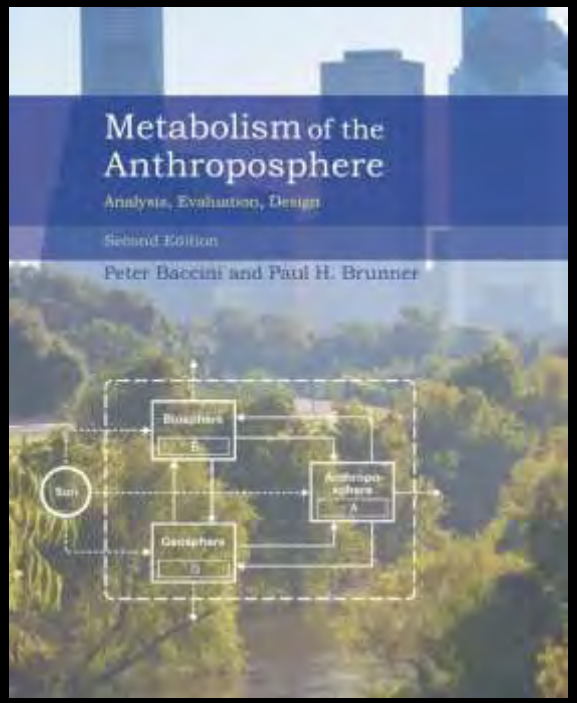
Over the last several thousand years of human life on Earth, agricultural settlements became urban cores, and these regional settlements became tightly connected through infrastructures transporting people, materials, and information.

This global network of urban systems, including ecosystems, is the anthroposphere; the physical flows and stocks of matter and energy within it form its metabolism.

The characterization of these flows and the relationships between anthropogenic urban activities and natural processes and cycles defines the urban metabolism.







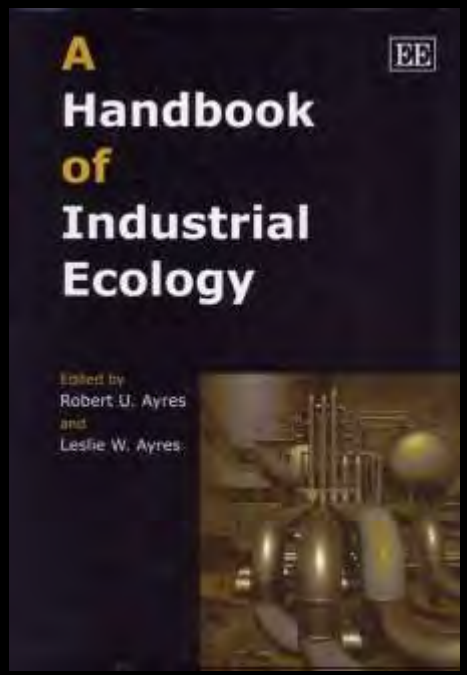
Narrative of Functional Nature

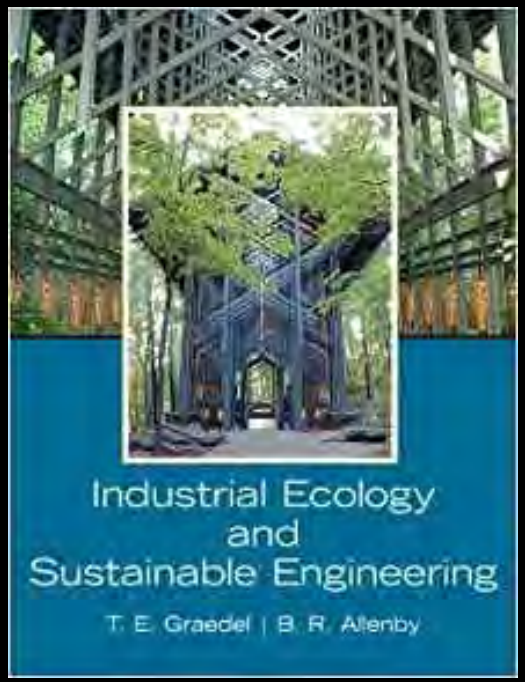
Industrial Ecology and the Earth as an "industrial ecosystem"

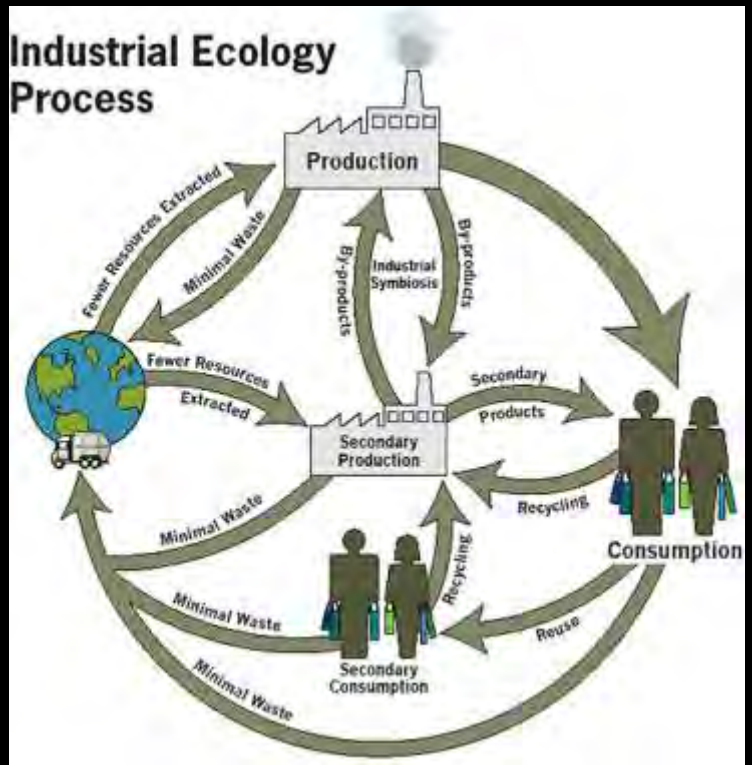
Industrial ecology (IE) is the study of material and energy flows through industrial systems.

The global industrial economy can be modelled as a network of industrial processes that extract resources from the Earth and transform those resources into commodities which can be bought and sold to meet the needs of humanity.

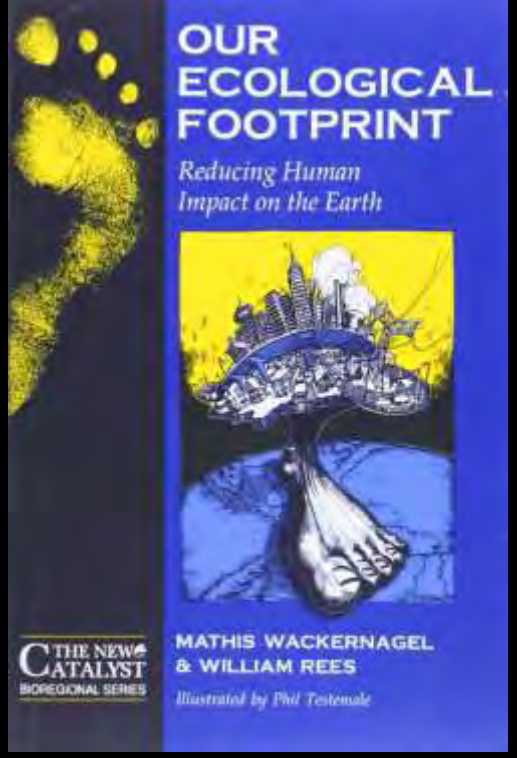
Industrial ecology seeks to quantify the material flows and document the industrial processes that make modern society function. Industrial ecologists are often concerned with the impacts that industrial activities have on the environment, with use of the planet's supply of natural resources, and with problems of waste disposal.

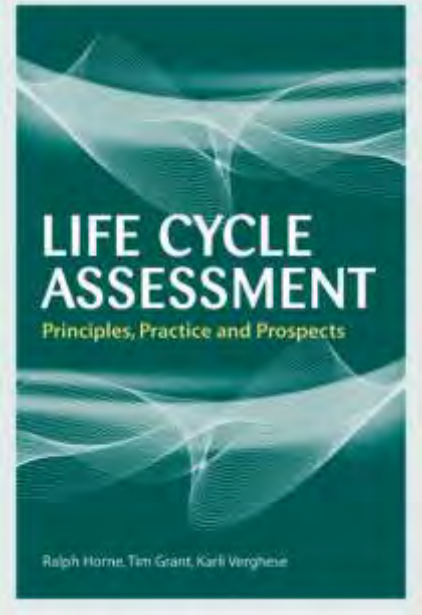


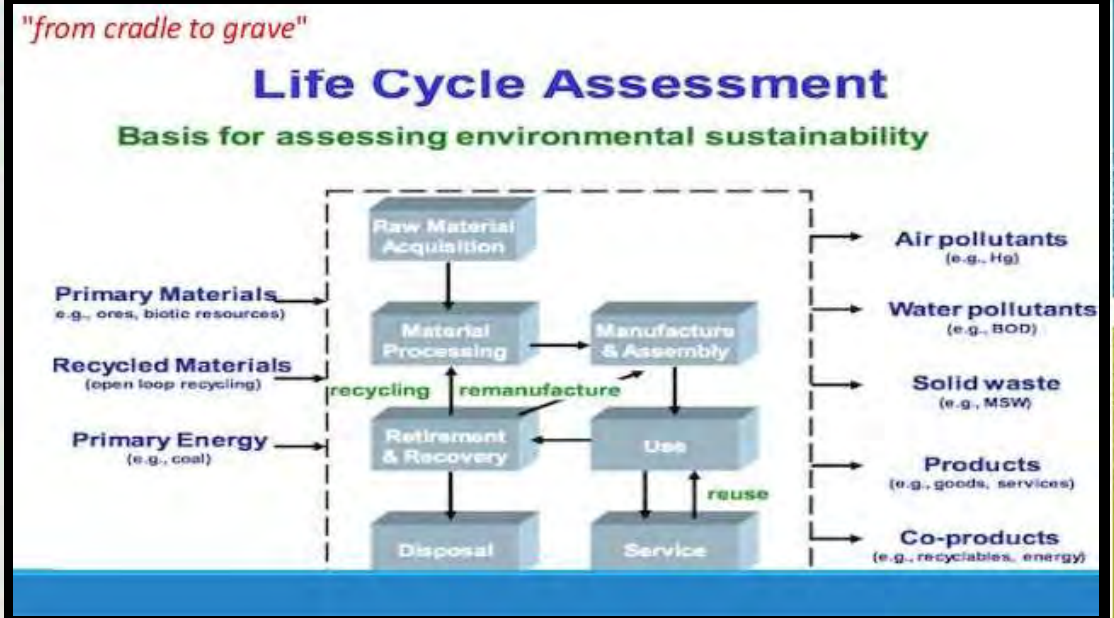


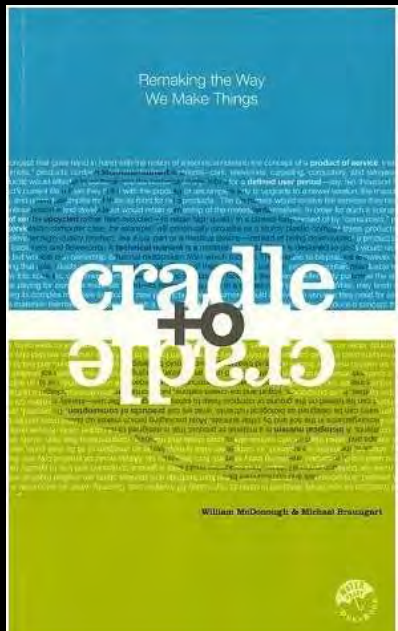



FOREST land
GRAZING land
URBAN land
ENERGY land
CROP land
FISHING land


OUR ECOLOGICAL FOOTPRINT
Reducing Human Impact on the Earth
THE NEW CATALYST BIOREGIONAL SERIES
MATHIS WACKERNAGEL & WILLIAM REES
Illustrated by Phil Testemale


LIFE CYCLE ASSESSMENT
Principles, Practice and Prospects
Ralph Horne, Tim Grant, Karli Verghese


"from cradle to grave"
Life Cycle Assessment
Basis for assessing environmental sustainability
Raw Material Acquisition
Primary Materials
e.g., ores, biotic resources
Material Processing
Manufacture & Assembly
Recycled Materials
(open loop recycling)
recycling
remanufacture
Primary Energy
(e.g., coal)
Retirement & Recovery
Use
reuse
Disposal
Service
Air pollutants
(e.g., Hg)
Water pollutants
(e.g., BOD)
Solid waste
(e.g., MSW)
Products
(e.g., goods, services)
Co-products
(e.g., recyclables, energy)


Remaking the Way We Make Things
cradle to cradle
William McDonough & Michael Braungart

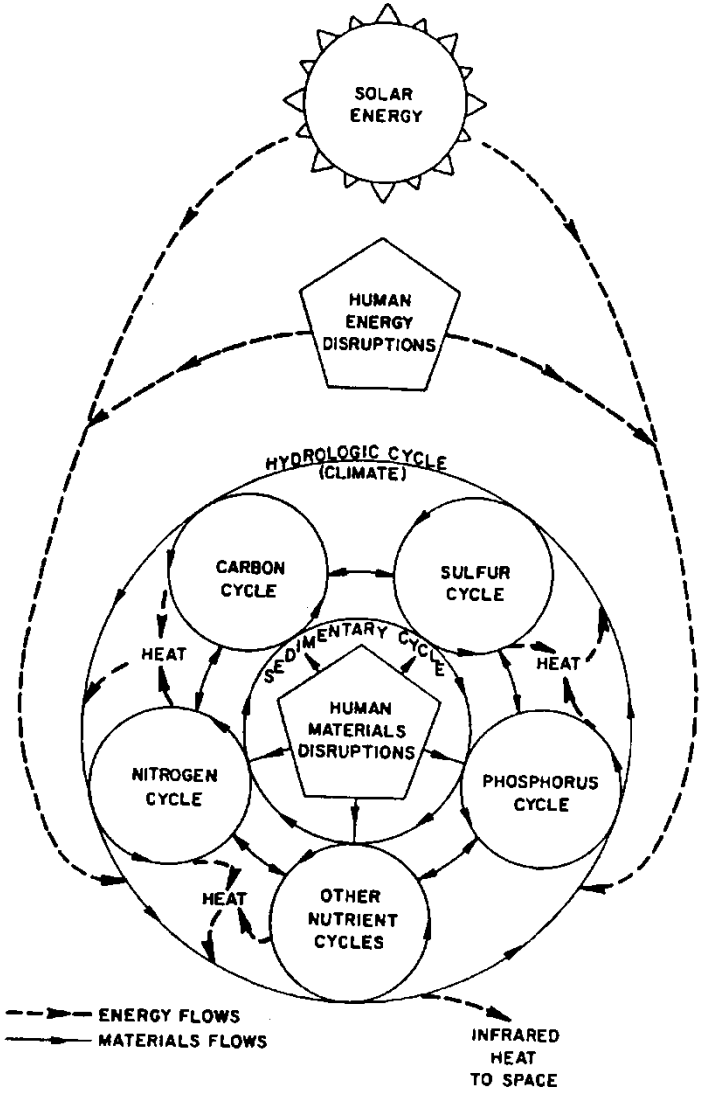


Figure 5.1. Climate and life are linked by a complex web of interconnected cycles. Life on earth depends on the cycling of nutrients through air, water, soil, and living things. The climate mediates the flow of materials through these global cycles. Solar energy degrades to heat at each stage of the cycling process and is eventually returned to space as infrared radiation. The composition of the earth's atmosphere regulates the radiative balance on earth between absorbed solar energy and emitted infrared energy, which, in turn, controls the climate.

Source: Schneider and Morton 1981.

Industrial Ecology

Urban Metabolism

Ecosystem Cycles

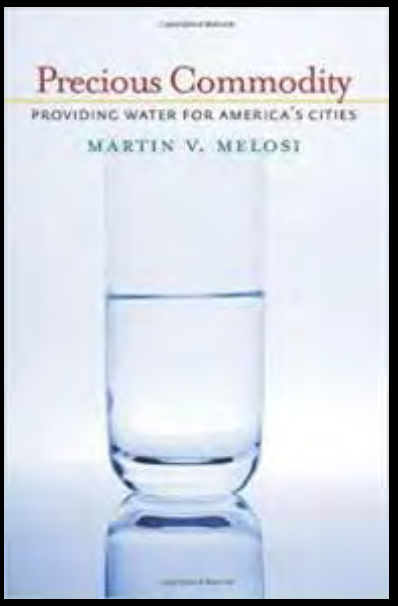
[Biogeochemical Cycles]

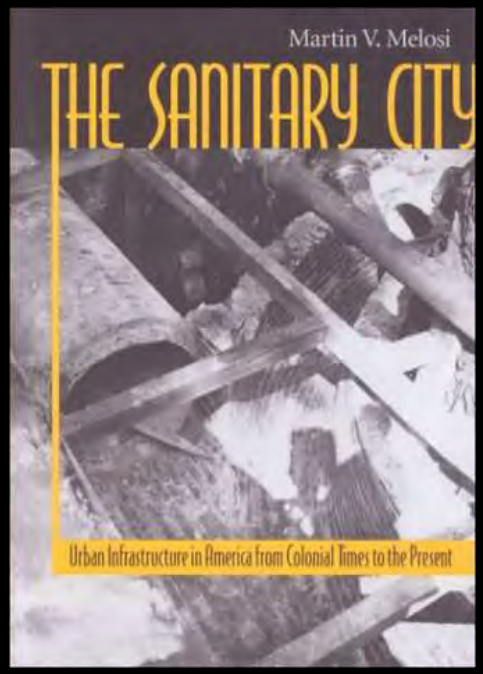
- Water cycle
- Carbon cycle
- Nitrogen cycle
- Phosphorus cycle
- Other trace minerals and metals
- Short-circuiting Cycles
- Recycling and Sustainability?

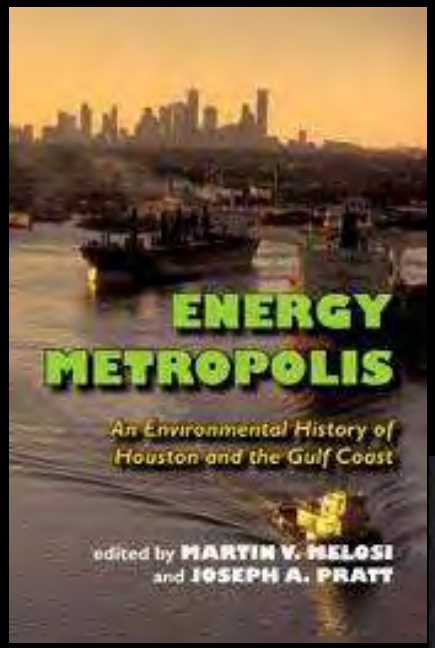
Narrative of Functional Nature

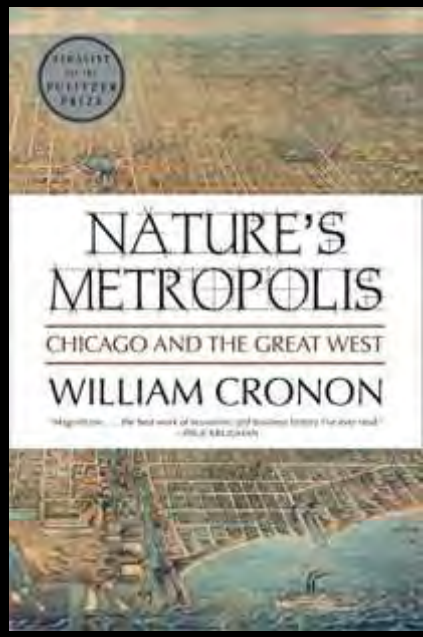
Version 2 – Urban Environmental History

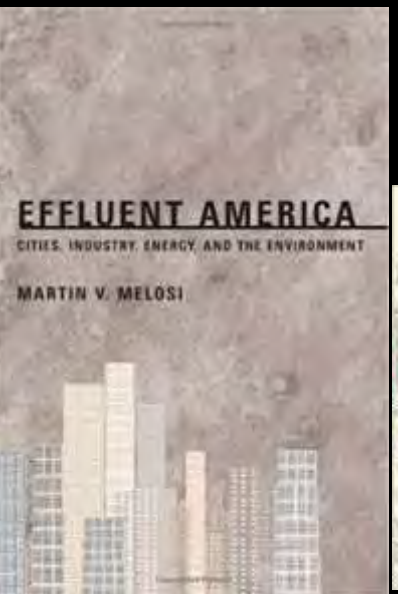
Urban Infrastructure - Planning, History, Politics

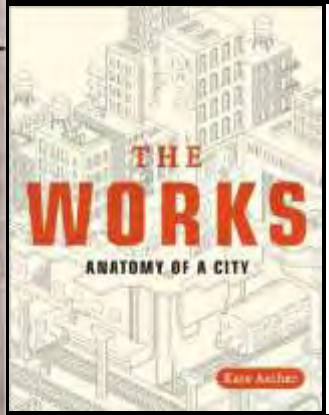


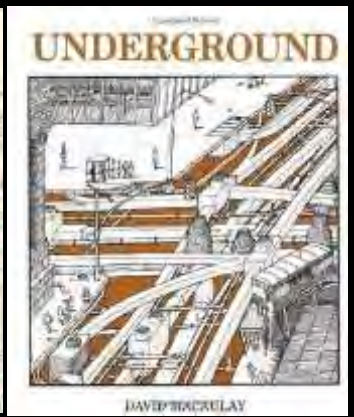


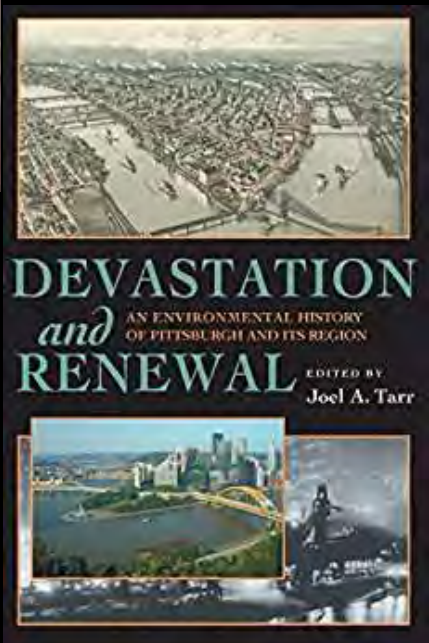












Version 3- Urban Political Ecology

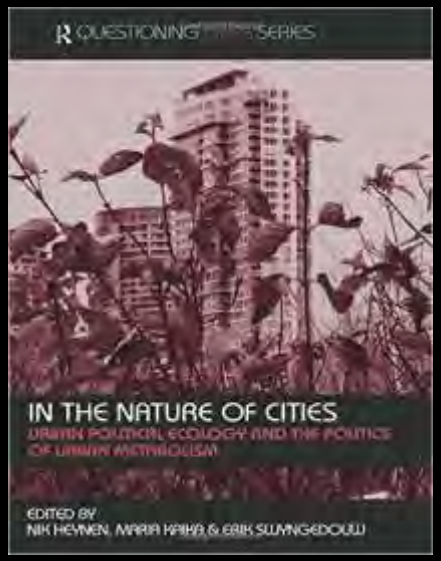
Urban Metabolism + Socioecological + Politics/Capital

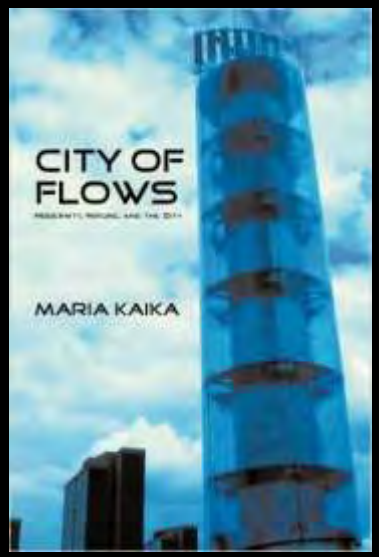
To the extent that cities are produced through socio-ecological processes, attention has been paid to the political processes through which particular socio-environmental urban conditions are made and remade. - Nik Heynen, et. al. (2006) *In the Nature of Cities*

Cities are dense networks of interwoven socio-spatial processes that are simultaneously human, material, natural, discursive, cultural, and organic…the analysis of the circulation of socially and physically metabolized "nature" - Maria Kaika (2005) *City of Flows: Modernity, Nature, and the City*

Nature is a biophysical fabric or network
- Matthew Gandy (2002) *Concrete and Clay: Reworking Nature in New York City*

NATURE?





Narrative of Functional Nature

Urban Ecology

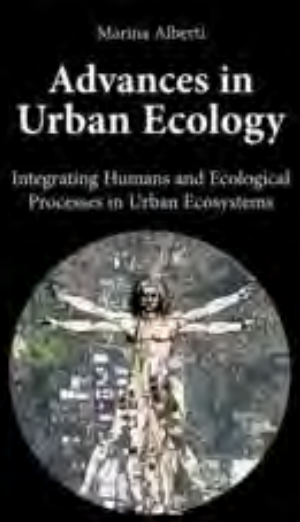
Version 4 – Science and Environmental Management

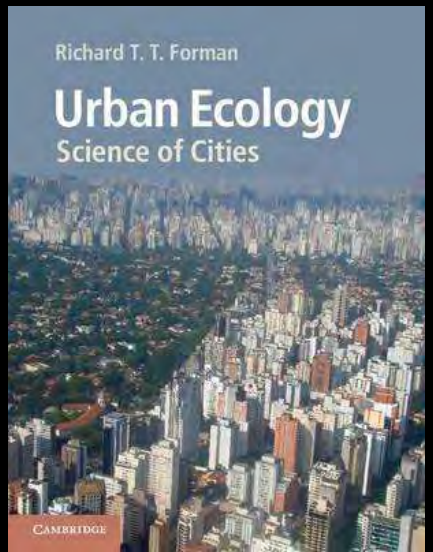
Ernst Haeckel and Ecology – the study of Life Systems [ecosystems] – biotic and abiotic 1866

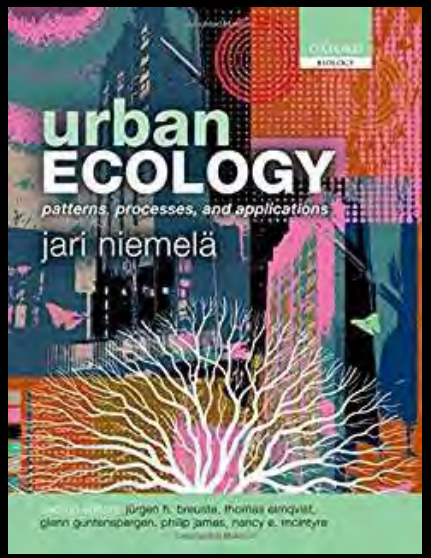
Urban ecology is the scientific study of the relation of living organisms with each other and their surroundings in the context of an urban environment.

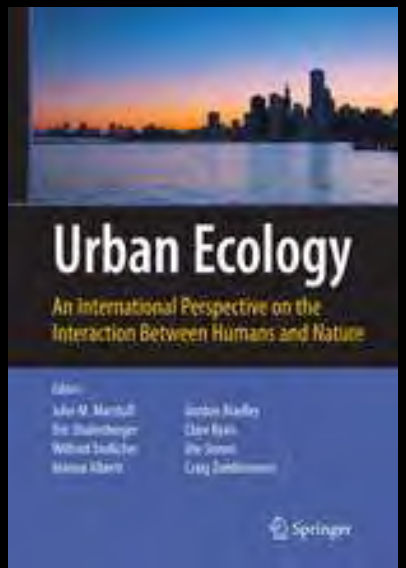
The urban environment refers to environments dominated by high-density residential and commercial buildings, paved surfaces, and other urban-related factors that create a unique landscape dissimilar to most previously studied “natural” eecosystems in the field of ecology.

Leading ecologists to ask about the city…

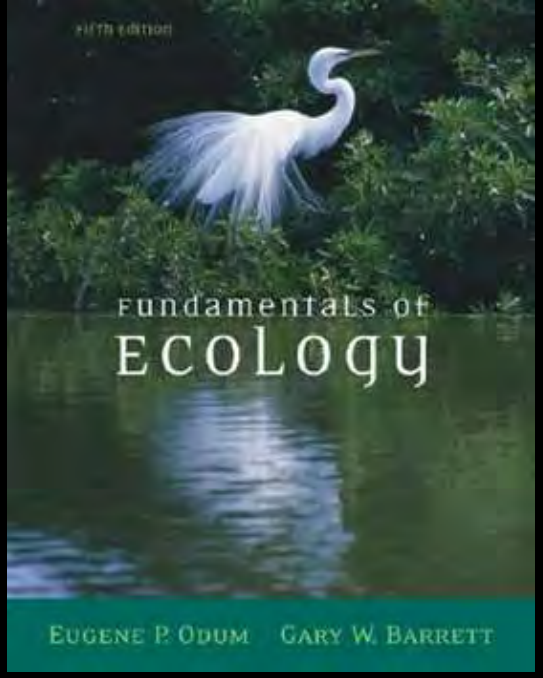






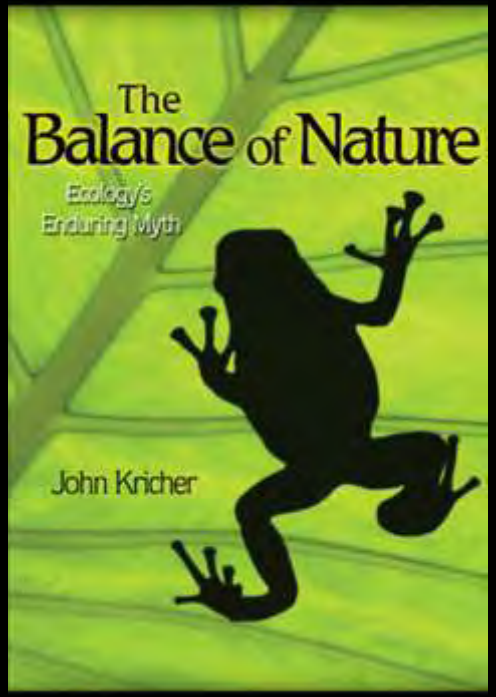


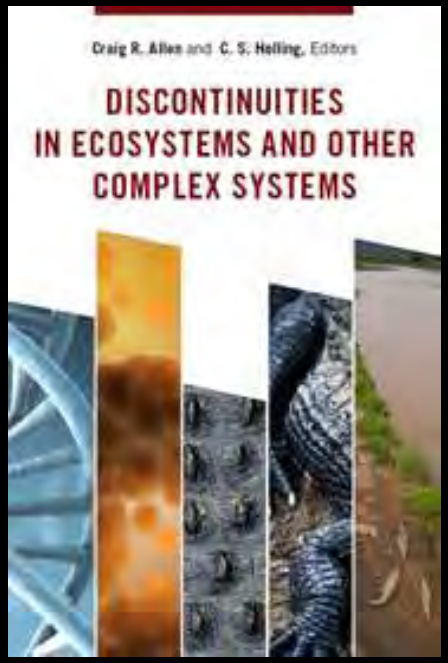

Natural What?

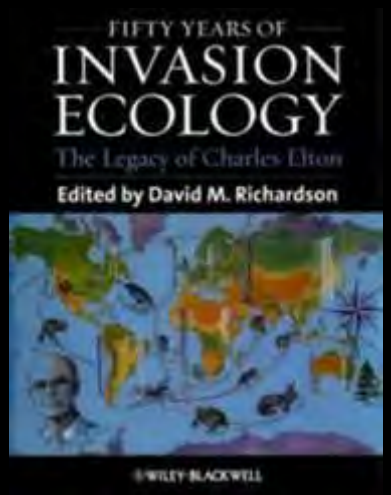


"Old" Ecology 1864-1960s – Humans the Great Disruptors

"New" Ecology 1973 onwards – Disruption is how nature works







Don't judge species on their origins

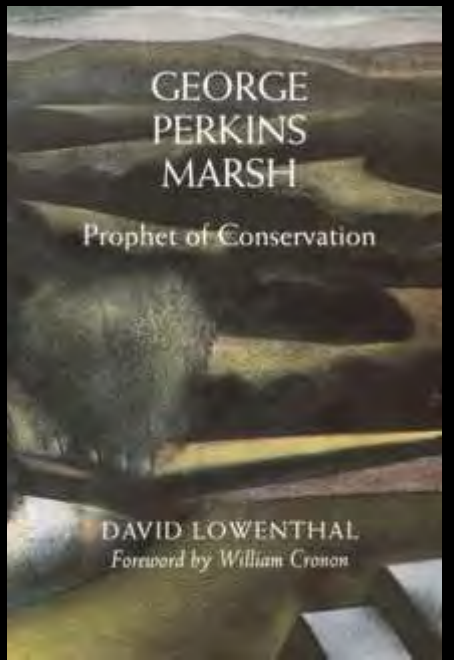
Conservationists should assess organisms on environmental impact rather than on whether they are natives, argue **Mark Davis** and 18 other ecologists.

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

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

- Engendered worldwide awareness of the ill-effects of human agency, along with efforts to repair the damage and conserve the fabric of nature.
- Most noteworthy was Marsh's stress on the unforeseen and unintended consequences, as well as the heedless greed, of technological enterprise.
- Wallace Stegner "the rudest kick in the face that American initiative, optimism and carelessness had yet received."

1801-1882



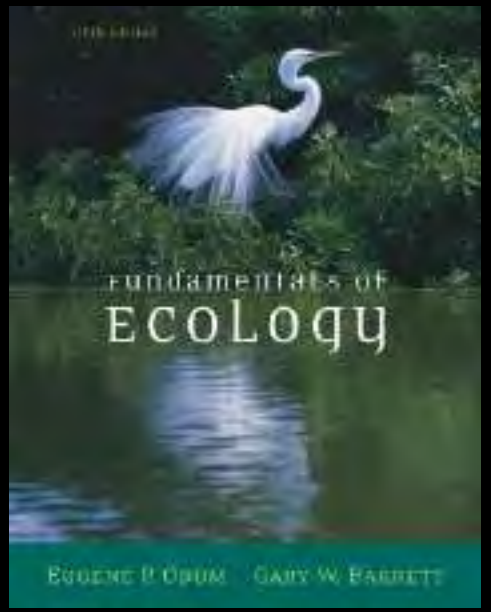
Humans the Great Disrupters – the Old Ecology of Stability

20th Century Development of Ecology – Ecosystem and Stability

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

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?



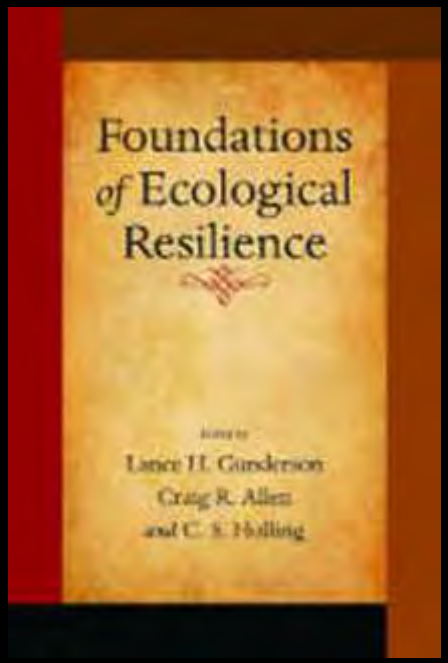
The New Ecology of Disruption - Ecological Resilience

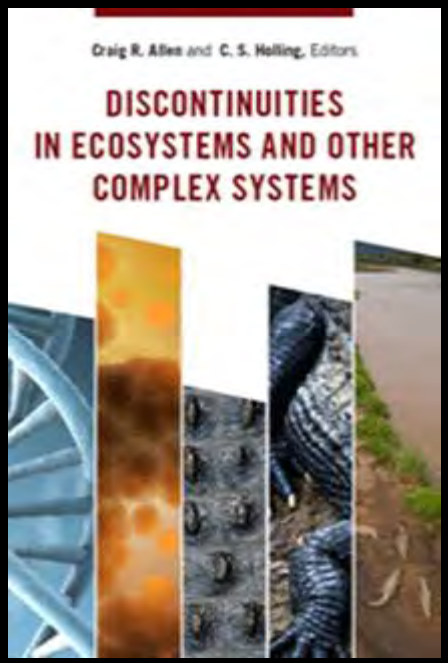
How does identity persist amidst change? Nothing Endures But Change - Heraclitus 540-480BC

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.

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

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





Adaptive Cycle

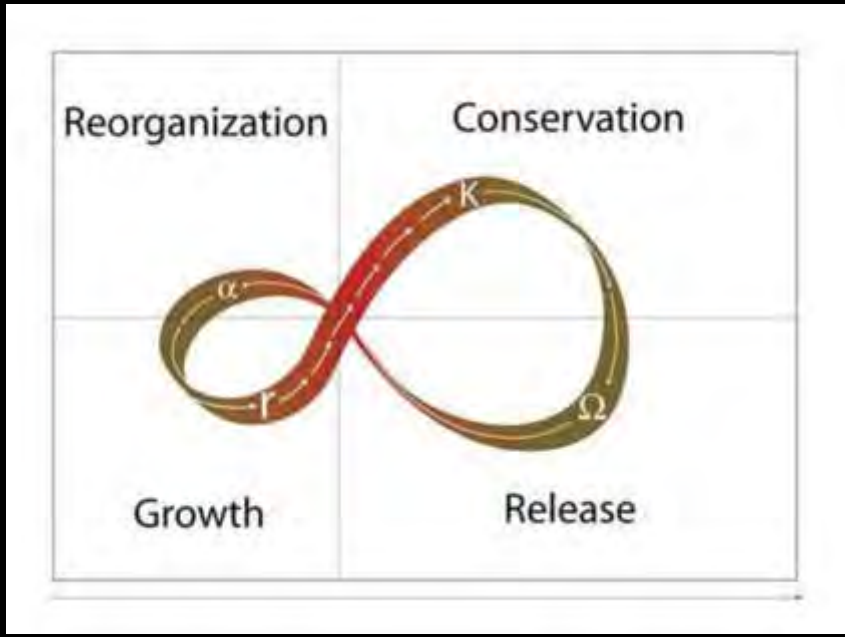
An adaptive cycle that alternates between long periods of aggregation and transformation of resources and shorter periods that create opportunities for innovation, is a fundamental unit for understanding complex systems from cells to ecosystems.

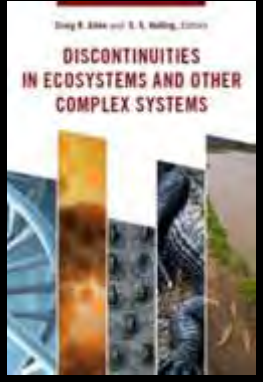
Growth - where species and systems grow and diversify to exploit new opportunities and develop entirely new ecological ways of being.

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

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

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



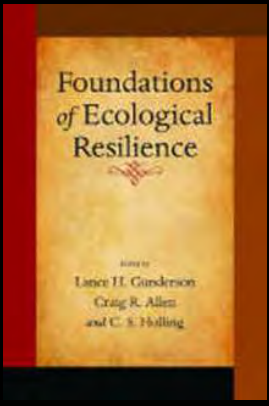


Resilience is...

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

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

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



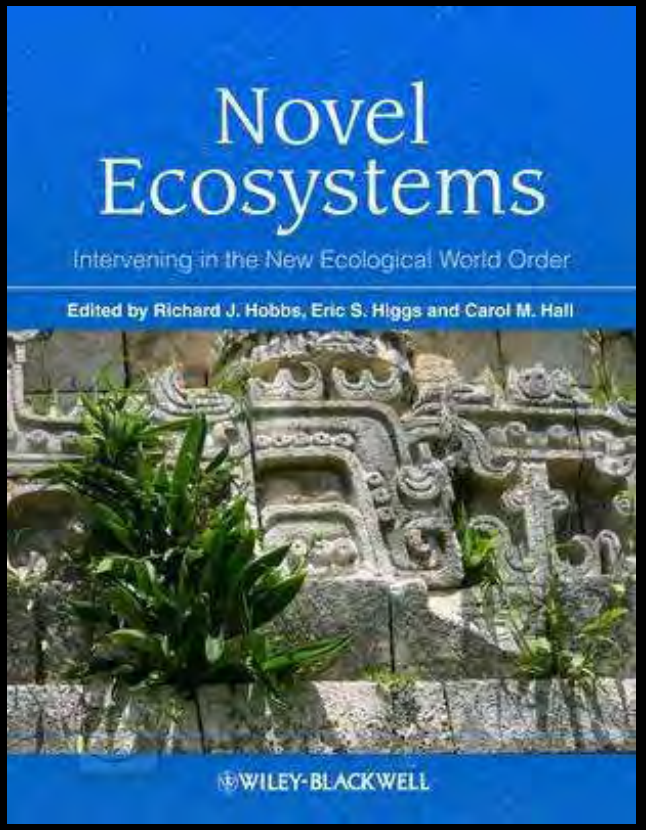
2005

2017

2012

New Nature - Novel Ecosystems

- Assemblages of species in a given area that have not previously occurred.
- Novel ecosystems are not under human management, but they are mostly the result of direct or indirect human activities.
- They lack natural analogs
- 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 that resulted from demarcation disputes among early ecologists and sociologists.



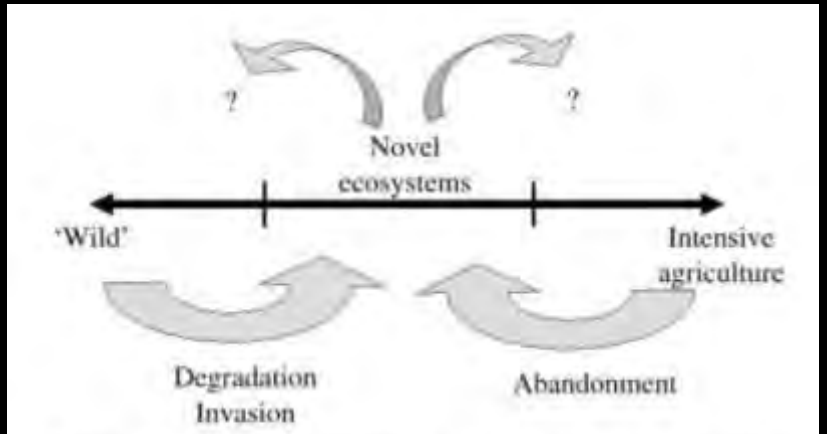


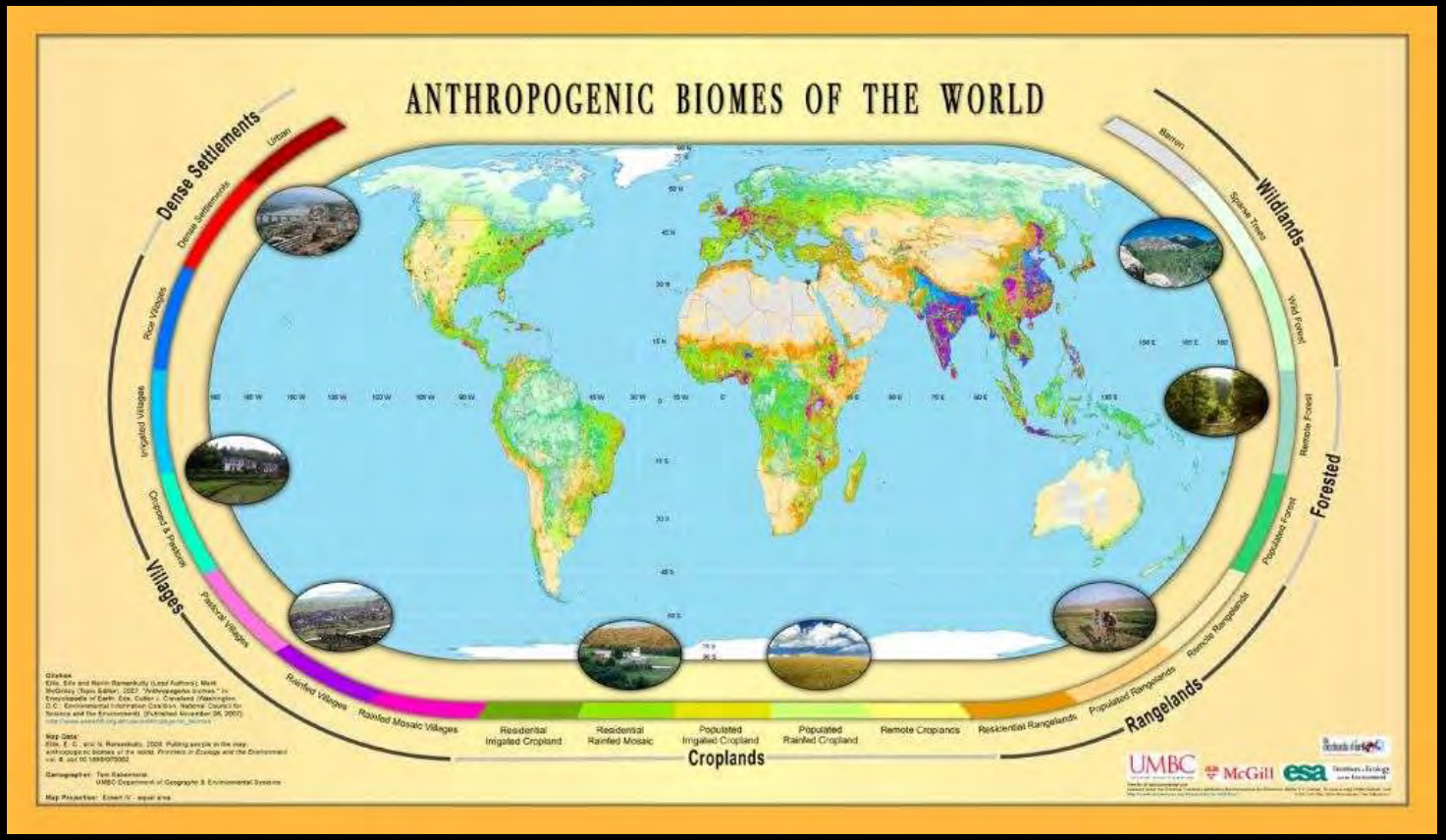
Figure 1 Novel ecosystems arise either from the degradation and invasion of 'wild' or natural/seminatural systems or from the abandonment of intensively managed systems.

Anthropogenic Landscapes, or "Human Landscapes"

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

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

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



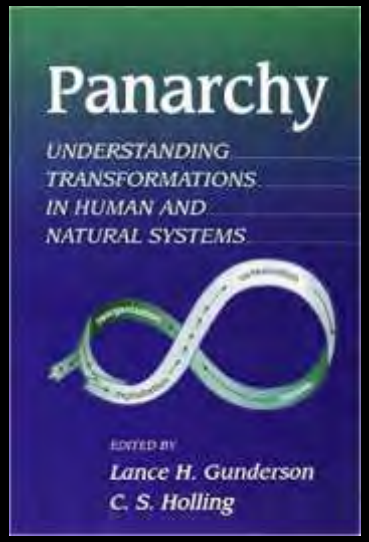
Resilience, Ecology, and Managing Socio-Ecological Systems

The basic concepts are:

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

The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

The Nature Conservancy
Protecting nature. Preserving life.™

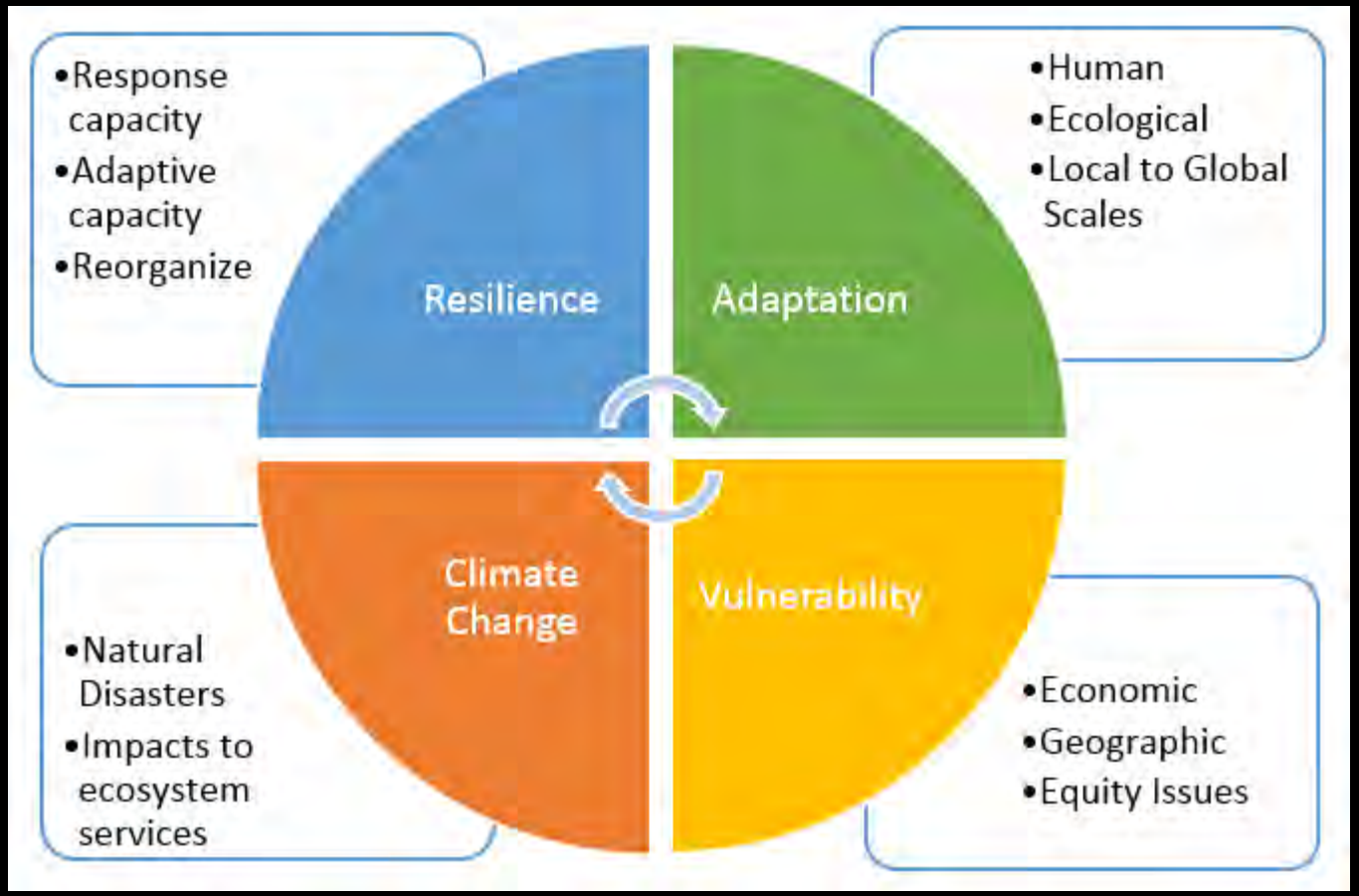


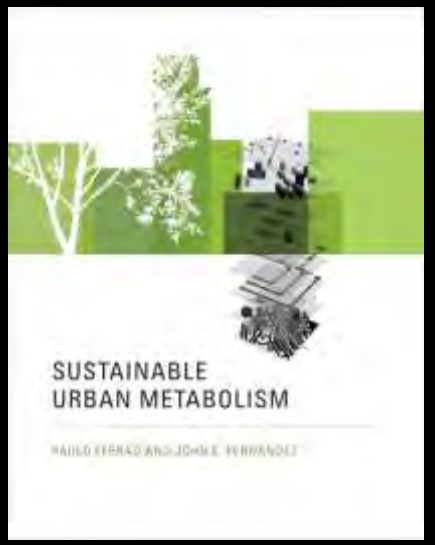
http://www.resalliance.org

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

Resilience and Urban Metabolism

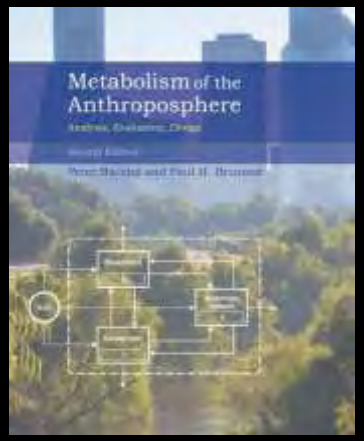
The characterization of flows and the relationships between anthropogenic urban activities and natural processes and cycles defines the behavior of urban production and consumption.

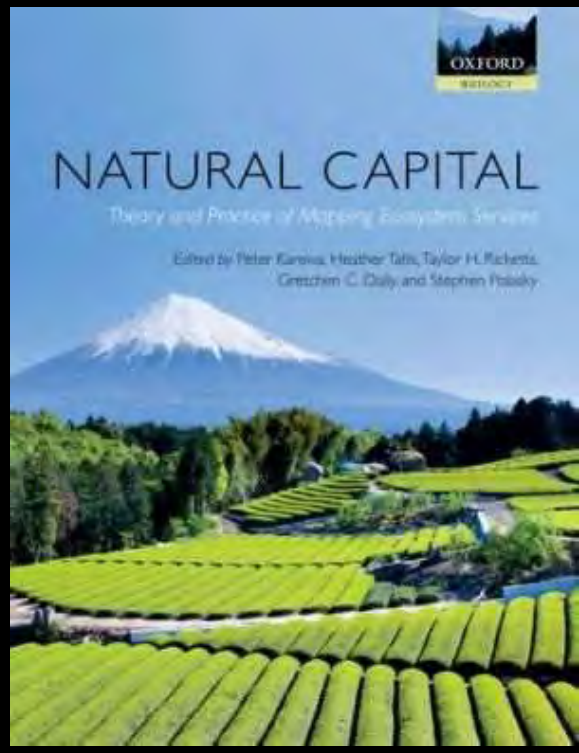


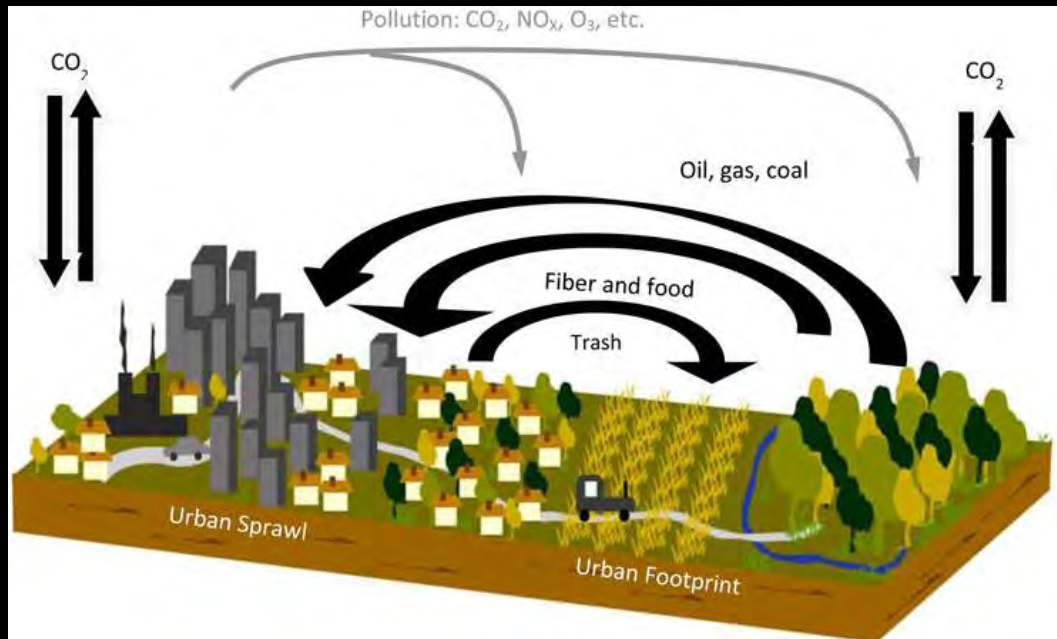


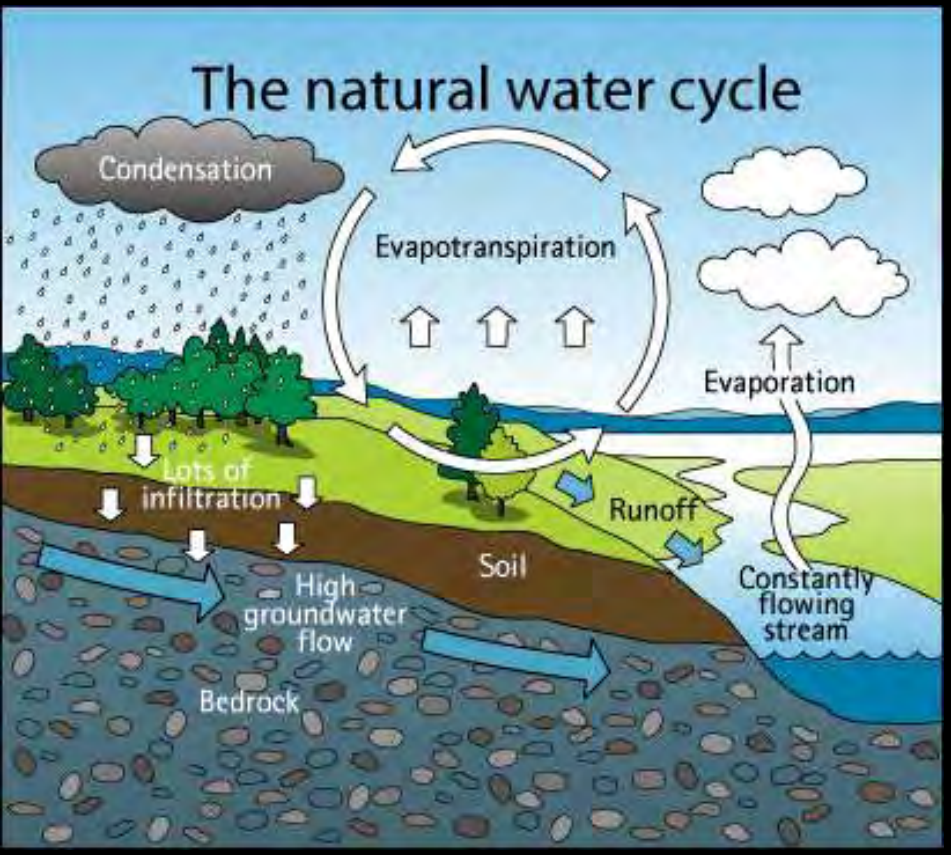
Ecosystem Cycles and Services

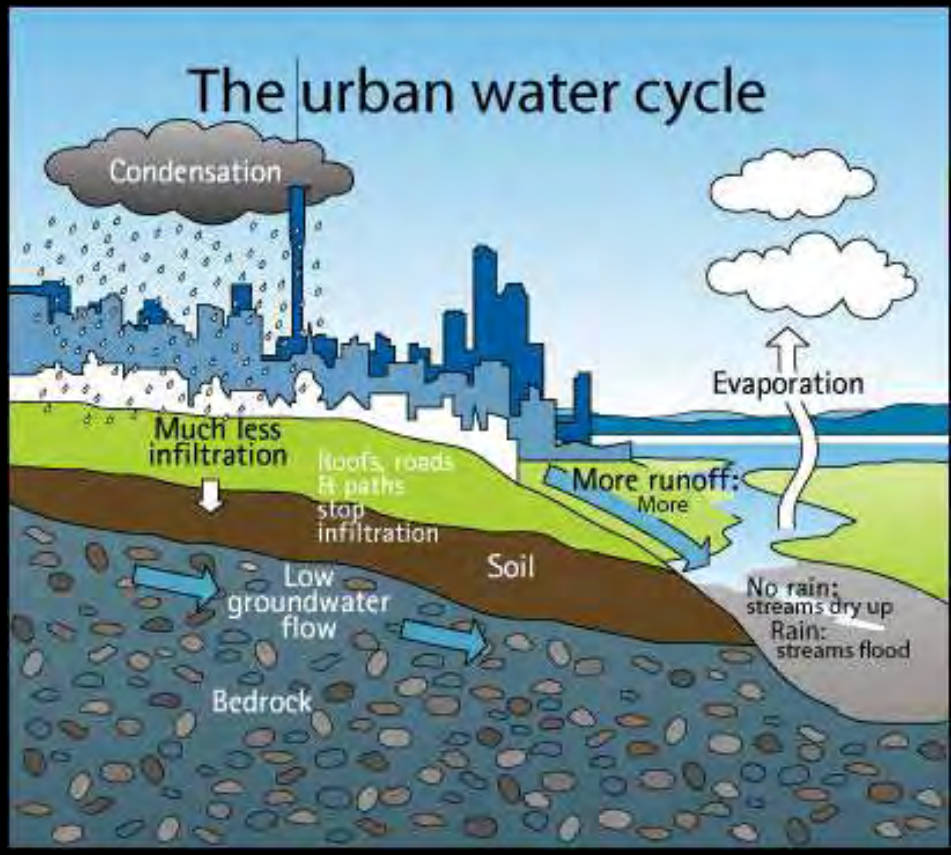
- ✓ Maintenance of atmosphere
- ✓ Protection from ultraviolet rays
- ✓ Regulation of climate
- ✓ Maintenance of genetic diversity
- ✓ Purification of air and water
- ✓ Detoxification and decomposition of wastes
- ✓ Generation of soil and renewal of soil fertility
- ✓ Pollination of vegetation
- ✓ Control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

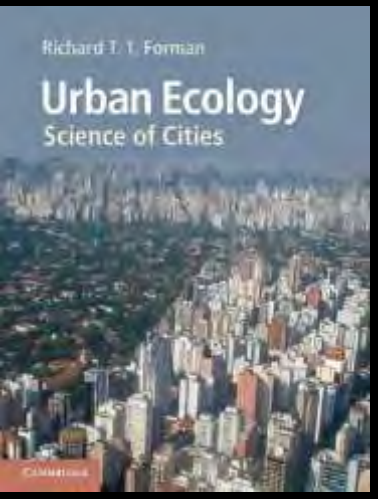


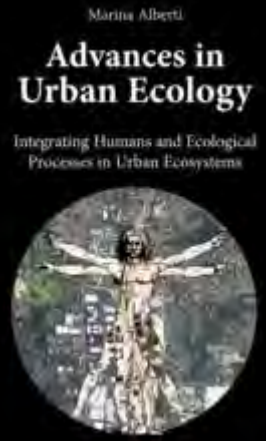


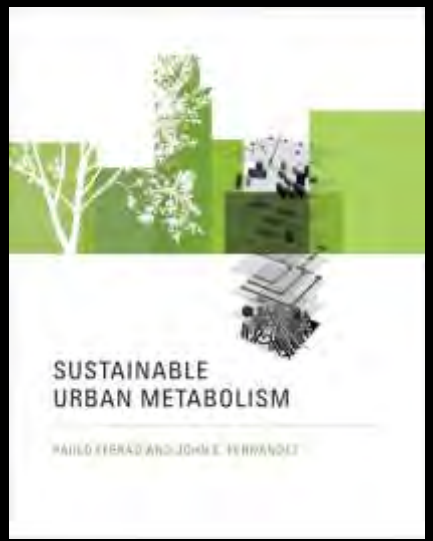


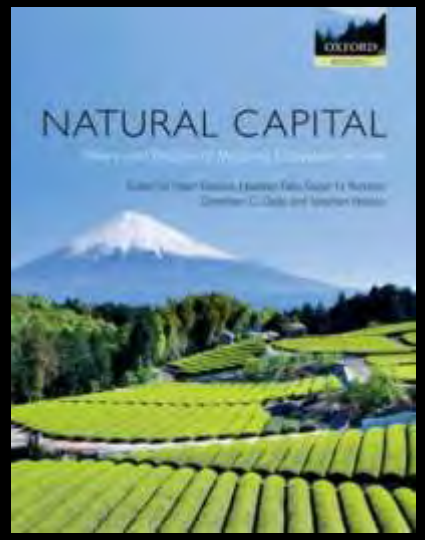

The natural water cycle
Condensation
Evapotranspiration
Evaporation
Lots of infiltration
Runoff
Soil
High groundwater flow
Constantly flowing stream
Bedrock

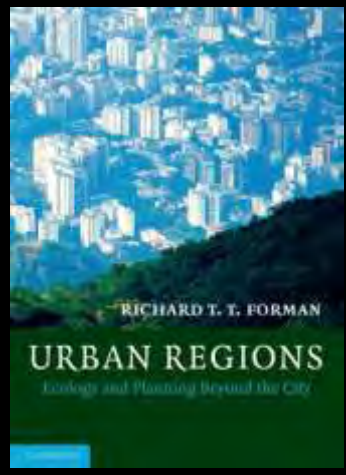

The urban water cycle
Condensation
Evaporation
Much less infiltration
Roofs, roads & paths stop infiltration
More runoff: More
Soil
Low groundwater flow
No rain: streams dry up
Rain: streams flood
Bedrock


Richard T. T. Forman
Urban Ecology
Science of Cities


Marina Alberti
Advances in Urban Ecology
Integrating Humans and Ecological Processes in Urban Ecosystems


SUSTAINABLE URBAN METABOLISM


OXFORD
NATURAL CAPITAL


RICHARD T. T. FORMAN
URBAN REGIONS


Urban Ecology
History and Trends

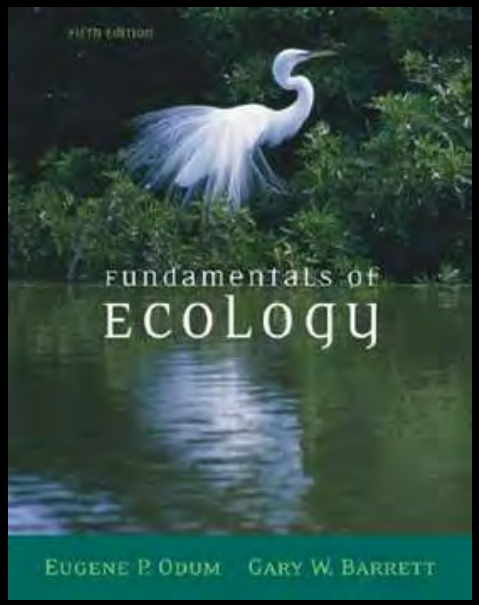
Humans as Disruptors - Narrative of Degraded Nature in American (Urban) Ecology

Perceptions of American Urban Biologists, Ecologists, and Environmentalists

Ecology "in" cities - A weedland community of inappropriate nature

(Urban growth) replaces the native species that are lost with widespread "weedy" nonnative species. This replacement constitutes the process of biotic homogenization that threatens to reduce the biological uniqueness of local ecosystems.

Michael L. McKinney, "Urbanization, biodiversity, and conservation". *Bioscience* 52(10), (2002), 883–890.



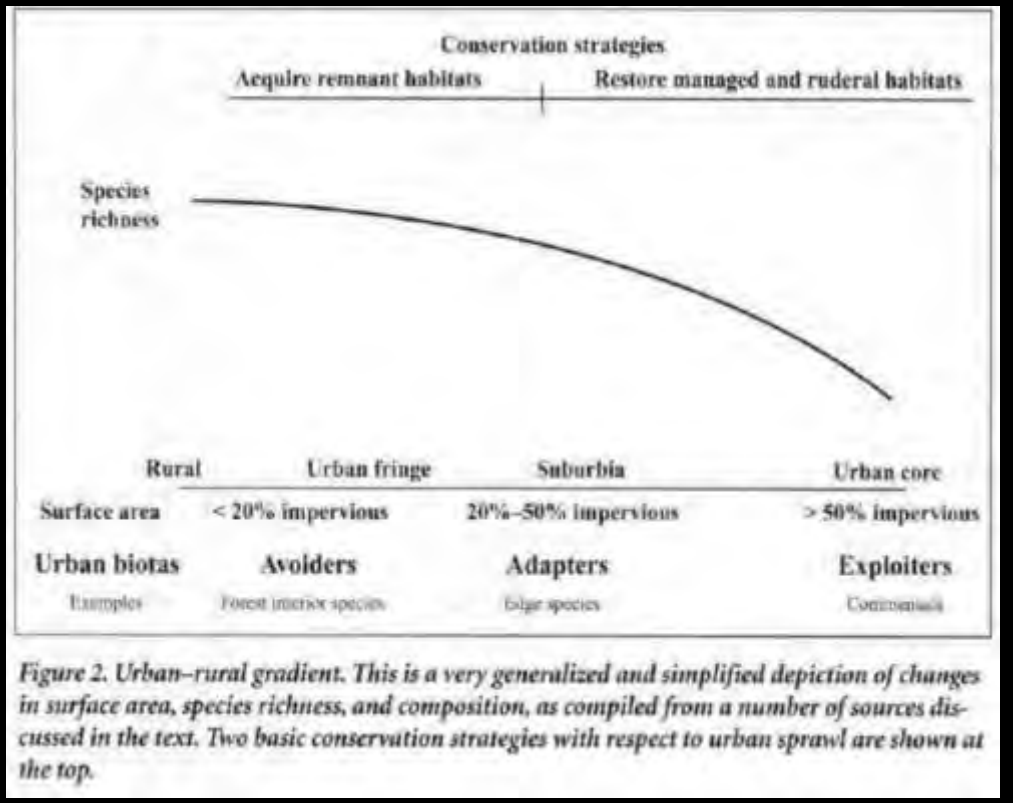


Figure 2. Urban–rural gradient. This is a very generalized and simplified depiction of changes in surface area, species richness, and composition, as compiled from a number of sources discussed in the text. Two basic conservation strategies with respect to urban sprawl are shown at the top.

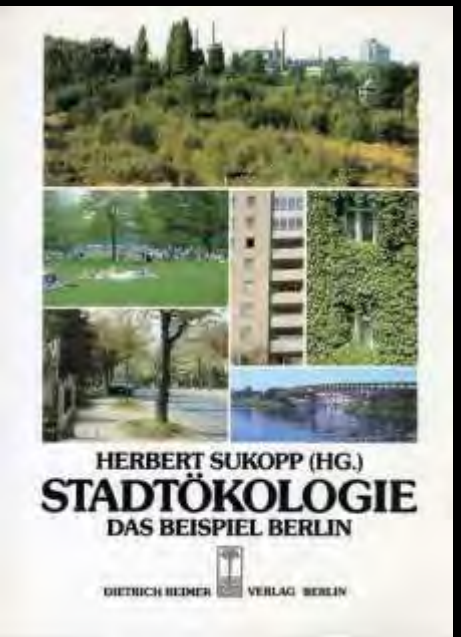
Alternative Ecological Perspectives on Ecology “in” cities

Perceptions of European Urban Ecologists – Cosmopolitan Community

German urban ecologist, Herbert Sukopp

Urban ecosystems are:

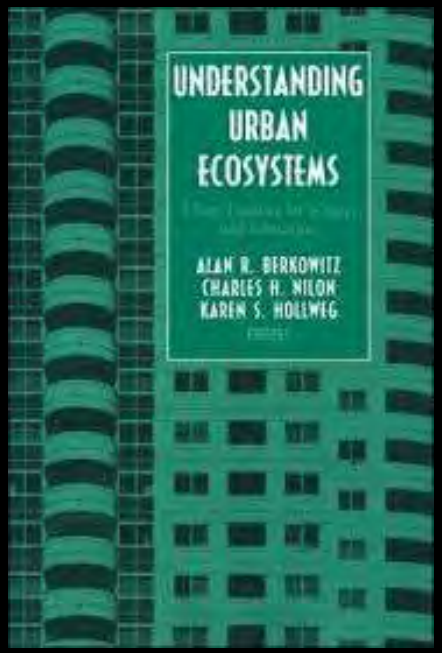
- A cosmopolitan community of uniquely adapted organisms
- the field laboratories where possibly new and well-adapted ecotypes of our native or naturalized wild plants will originate in the changed environmental conditions.
- Ecosystems which have developed in urban conditions may be the prevailing ecosystems of the future.

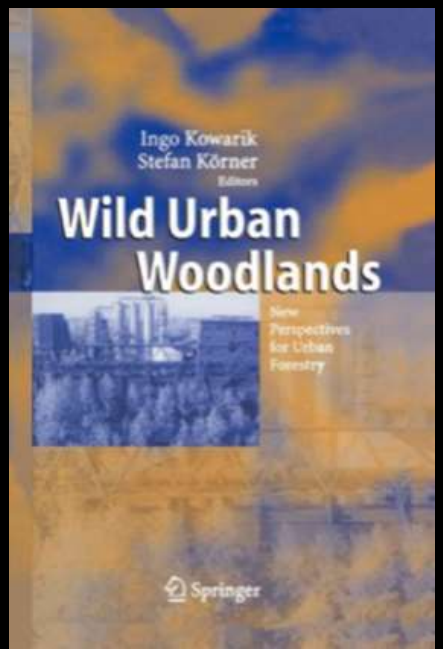


Ecology “in” cities
Resilience and European Urban Ecology

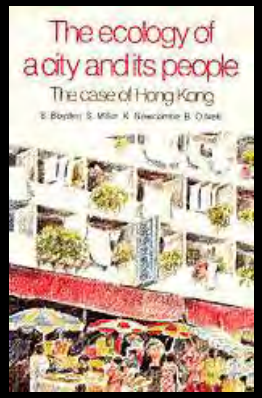
… the reference point is not an original condition of a natural landscape, but rather a condition defined based on the current site potential and the greatest possible degree of self-regulation. From this perspective, therefore, the natural capacity for *process* is the central point, not a particular, retrospectively determined and often idealized, *picture* of nature.
- Ingo Kowarik *Urban Wild Woodlands* (2005)

…although wild and rather specialist species may be missing, cities are great havens for biodiversity, in terms of both ecology and species, even in industrial areas.
- Anthony Bradshaw in Berkowitz, *Understanding Urban Ecosystems: A New Frontier for Science and Education.* (2003)





The ecology ‘of’ cities – Hong Kong and Man and the Biosphere

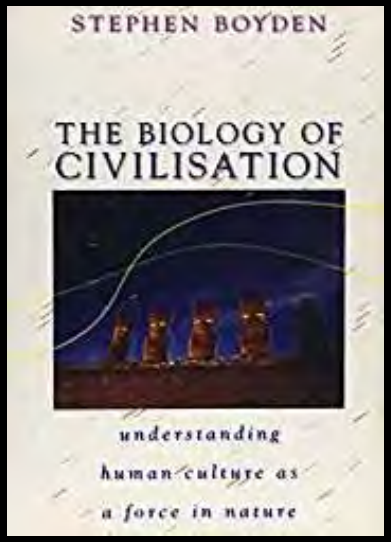


The Ecology of a City and its People: The Case Study of Hong Kong
Stephen Vickers Boyden, et. al. (1981)

The first classic book on the ecology of a city.

In the early 1970s Boyden initiated and directed the Hong Kong Human Ecology Program, which was composed of a multidisciplinary group of researchers from the Australia National University. The program started in 1972 and became the first pilot program of the UNESCO Man and the Biosphere Program (MAB) in 1974.

This book provides a comprehensive account of the Hong Kong Human Ecology Program which was the first comprehensive ecological study of a city.

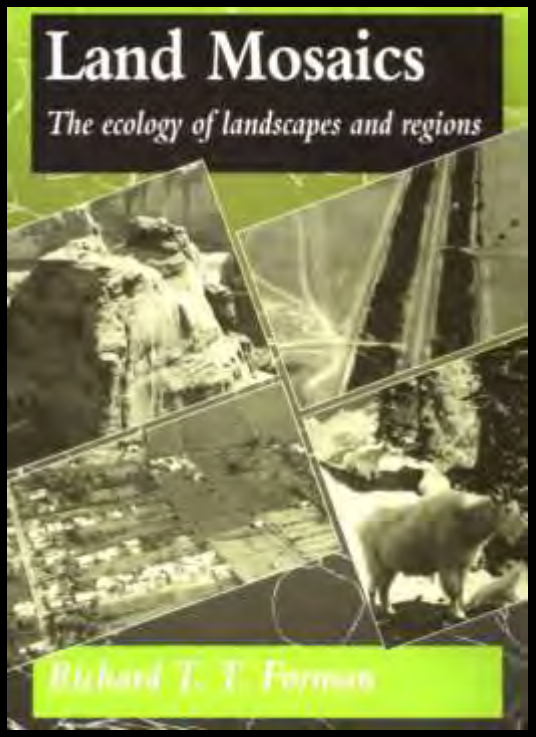


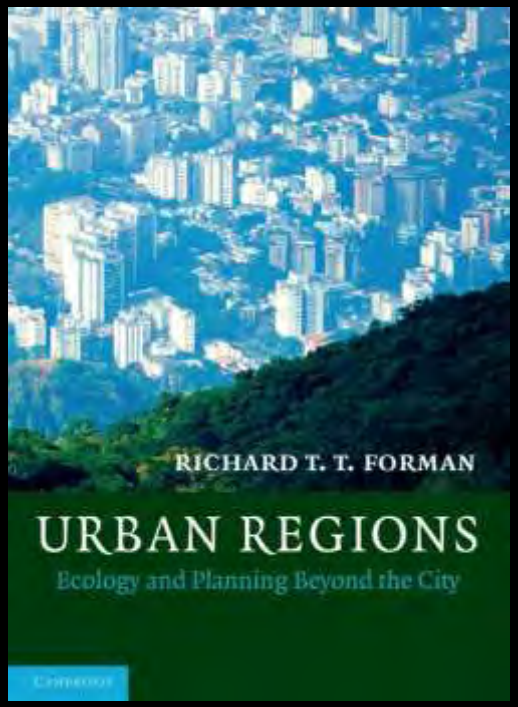
Contemporary American Approaches to Urban Ecology
Ecology “of” Cities

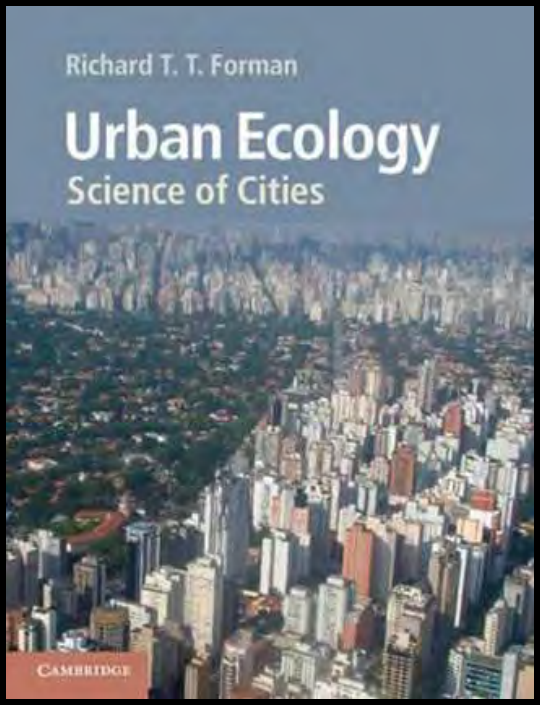
Landscape Ecology to Urban Ecology
Richard Forman – Harvard University

Spatial Patterns – Cities as heterogeneous mosaics

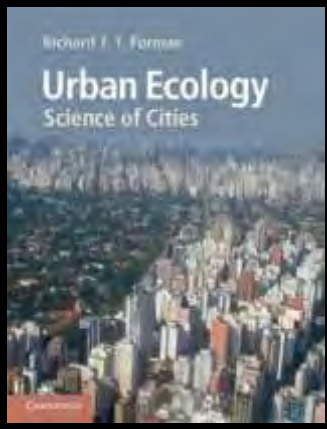
In short, then, it takes the whole region to make the city.
Patrick Geddes, *Cities in Evolution*, 1914







Distinctive attributes, hierarchical scales, and gradients



1. Habitats and species
   - Usually diverse intermixed greenspaces and built patches cover the area.
   - Small sites tend to have few species, whereas large areas are often species rich.
   - Planted ornamentals, as well as spontaneous colonized species, are widespread.
   - Generalist species survive and predominate in urban conditions.

2. Patches and areas
   - Housing developments and house plots emphasize rectilinear repetition.
   - Boundaries are overwhelmingly straight, abrupt, and in high density.
   - Mowed grassy areas range from abundant to essentially absent.
   - Widespread impervious surfaces absorb solar radiation, generate heat, and greatly increase stormwater runoff.
   - Air and water are often heavily polluted.

3. Corridors and flows
   - Rectilinear road networks channel hordes of moving vehicles and people.
   - Underground branching conduits permeate and connect the place.
   - Animal movement is often along stepping stones rather than continuous strips.
   - Watercourses are channelized and flood-prone areas common.

4. Change
   - Many ecological changes are human-caused, rapid, and drastic.
   - Abundant species from afar endlessly arrive, while both native and non-native species disappear.
   - The city expands directionally over suburbs, and suburbs over rural land.

For a natural or agricultural landscape, these patterns would be bizarre. In urban areas they predominate.

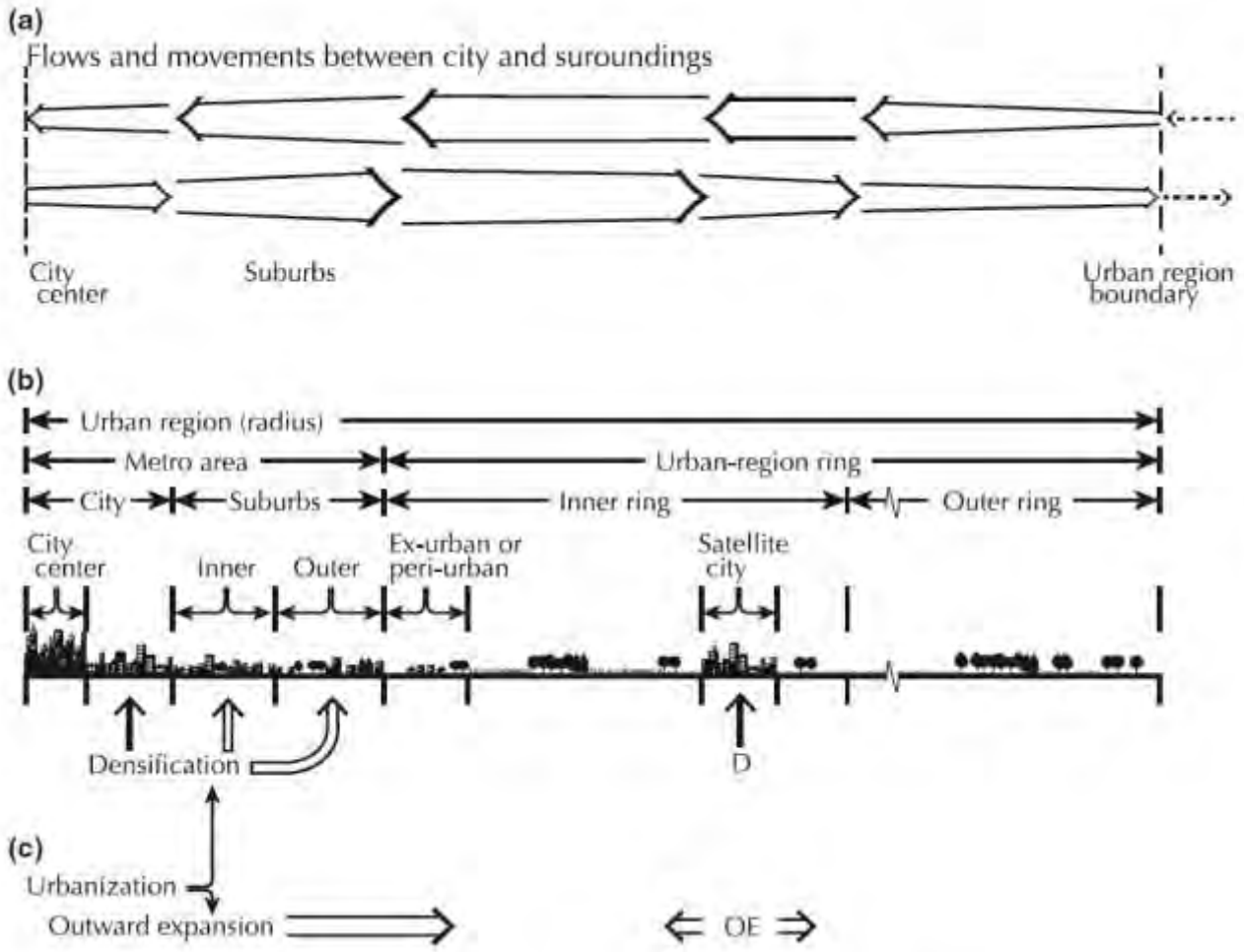
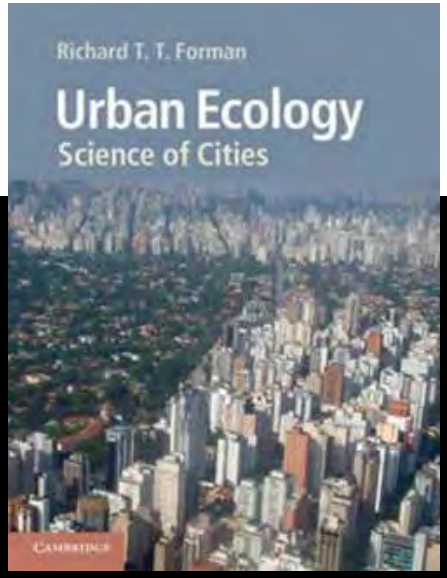
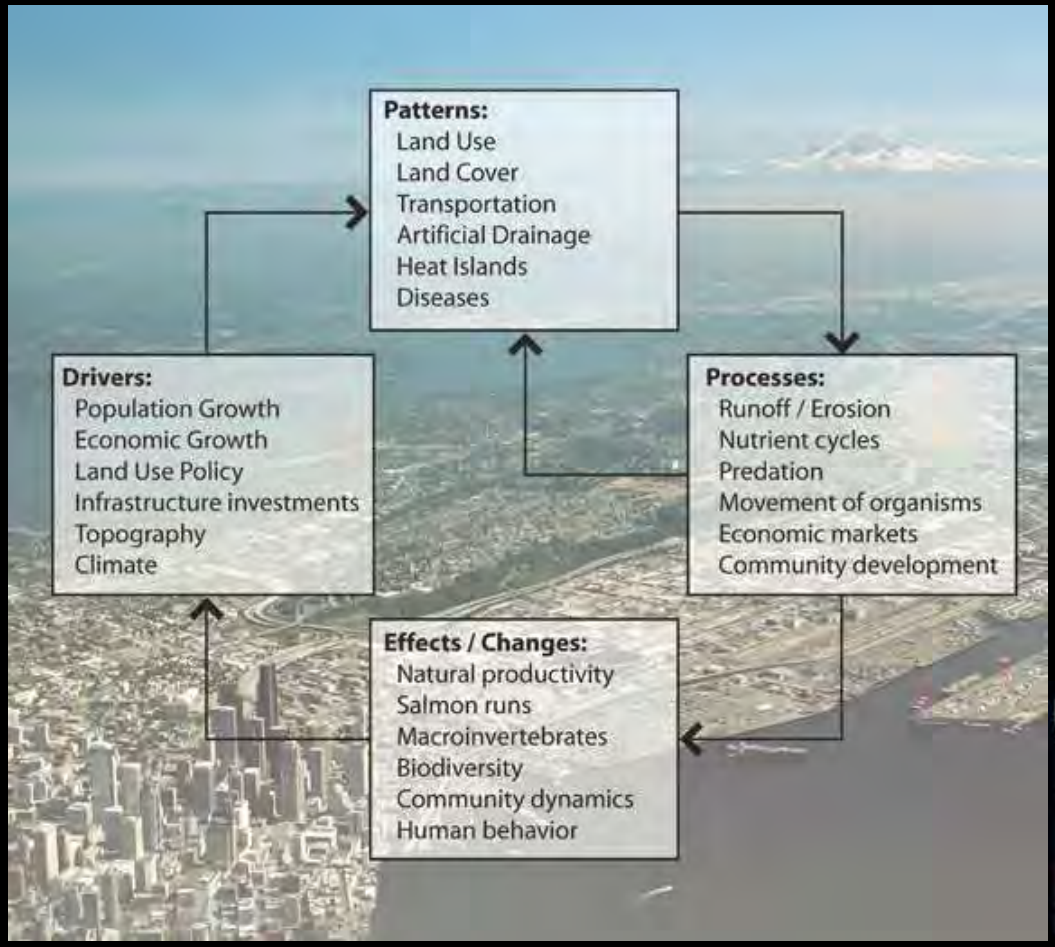


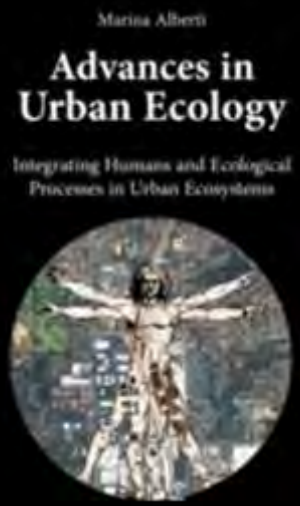
Figure 1.4. Concepts and terms for urban ecology. Metro area extends outward to the edge of the essentially continuous all-built area. Some suburbs extend beyond the metro area, and include some or all of the exurban or peri-urban zone. The urban-region ring also contains separate towns and villages. (a) Width of arrows roughly proportional to amount of flows and movements. (b) Concepts and terminology used in this book. (c) The two components of urbanization in different areas [see (b)] of the urban region. (d) Examples for bits of green cover (in built space) = window box, street trees, back yard space, green roof; examples of created greenspaces = city plaza/square, cemetery, vacant lot, dump, waterworks, golf course. Based on Forman (2008) and other sources.

Two approaches to the study of urban ecosystems that can be expressed as

1) the ecology ‘in’ and ‘of’ cities
2) the ecology of urbanization gradients







Spatial Patterns, Material Flows, Complex Systems Theory
Marina Alberti, University of Washington

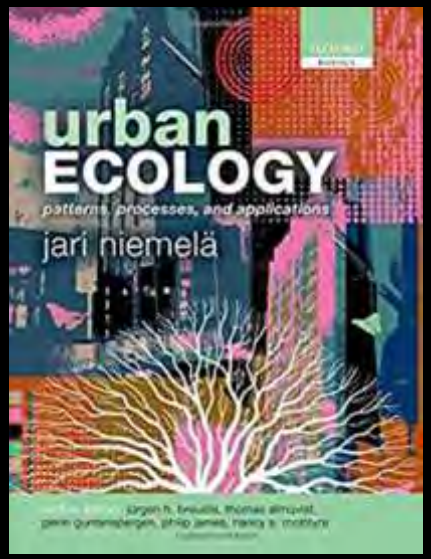
Complex systems theory provides the conceptual basis and methodology for studying urban ecosystems to decode “emergent” phenomenon, such as urban sprawl, and devise effective policies to minimize their effects on ecosystem function.

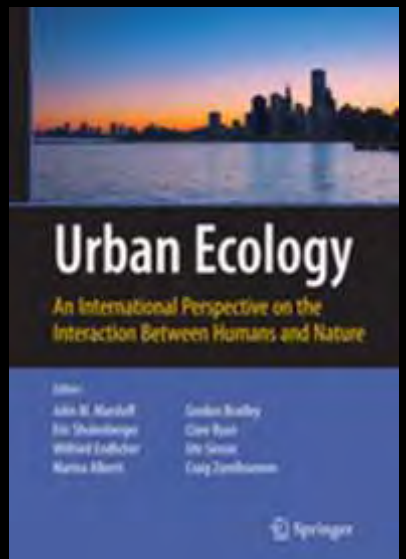
Current Trends in Urban Ecology

Two approaches to the study of urban ecosystems that can be expressed as
1) the ecology 'in' and 'of' cities
2) the ecology of urbanization gradients

Today's major urban-ecology approaches and centers of research include:

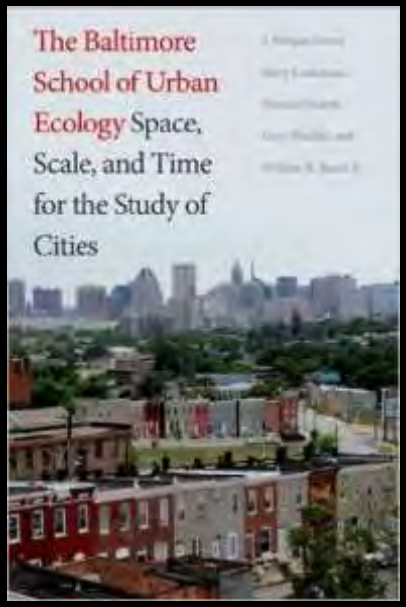
(1) habitat/biotope mapping and related analyses (especially in Berlin and Central Europe)
(2) species types and richness (Berlin, Melbourne)
(3) city-to-rural gradient (Melbourne, Baltimore)
(4) modeling and biogeochemical/ material flows (Phoenix, Seattle)
(5) coupled biophysical-human systems (Phoenix, Baltimore, Seattle)
(6) urban-region spatial patterns, processes, and changes (worldwide analyses)





Central Arizona-Phoenix
Long-Term Ecological Research
CAP LTER

BALTIMORE
ecosystem
STUDY



The Elemental City: Narrative of Functional Nature
Ecology "and" the City

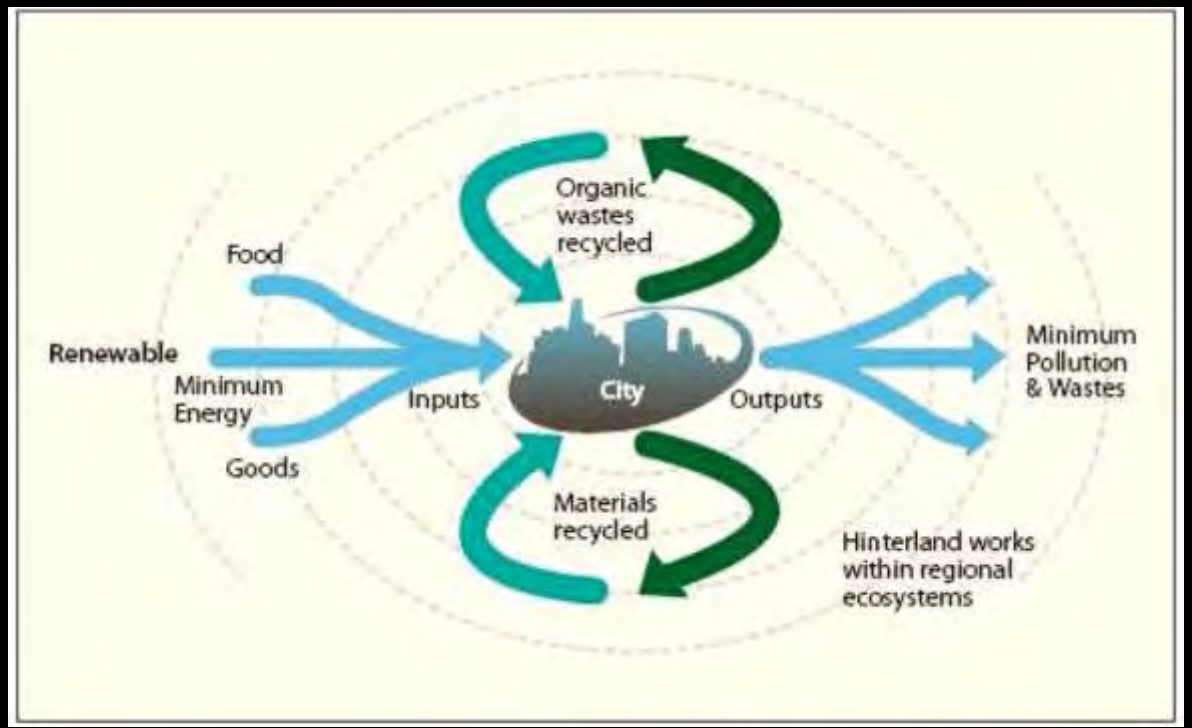
Ecological Narrative and "City as Organism" Metaphor

Version 1 – Engineering and Resource Management
Version 2 - Urban Environmental History
Version 3 - Urban Political Ecology

Ecology "in" and "of" a City

Version 4 – Science and Environmental Management - Urban Ecology

NATURE?




Applause