Cities as ecosystems

Cities aren't just centers of commerce, industry, education, and culture. They are also living entities — urban ecosystems with green spaces and waterways that bring together nature and human habitat.

Bill Moyers

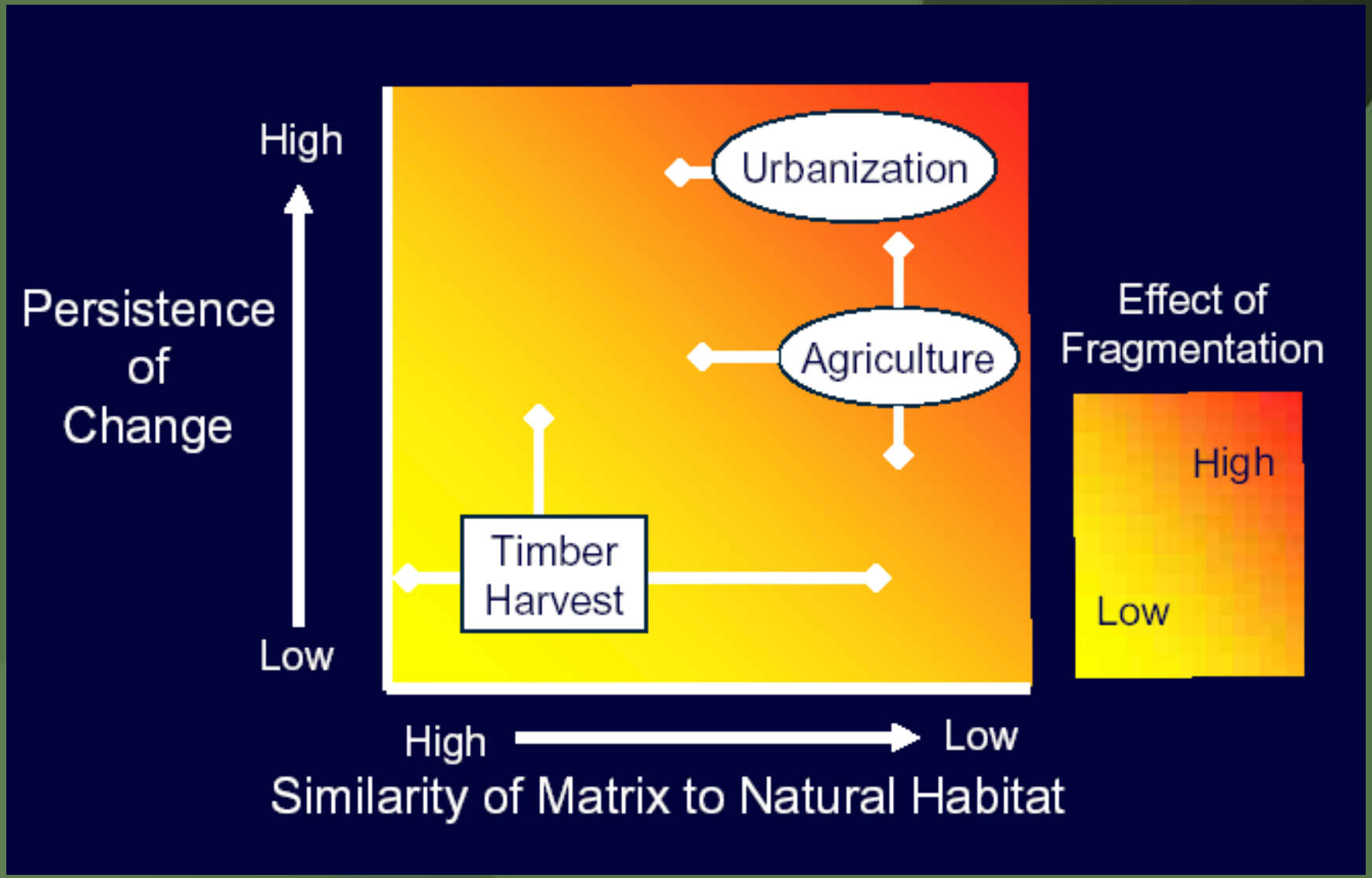
Outline

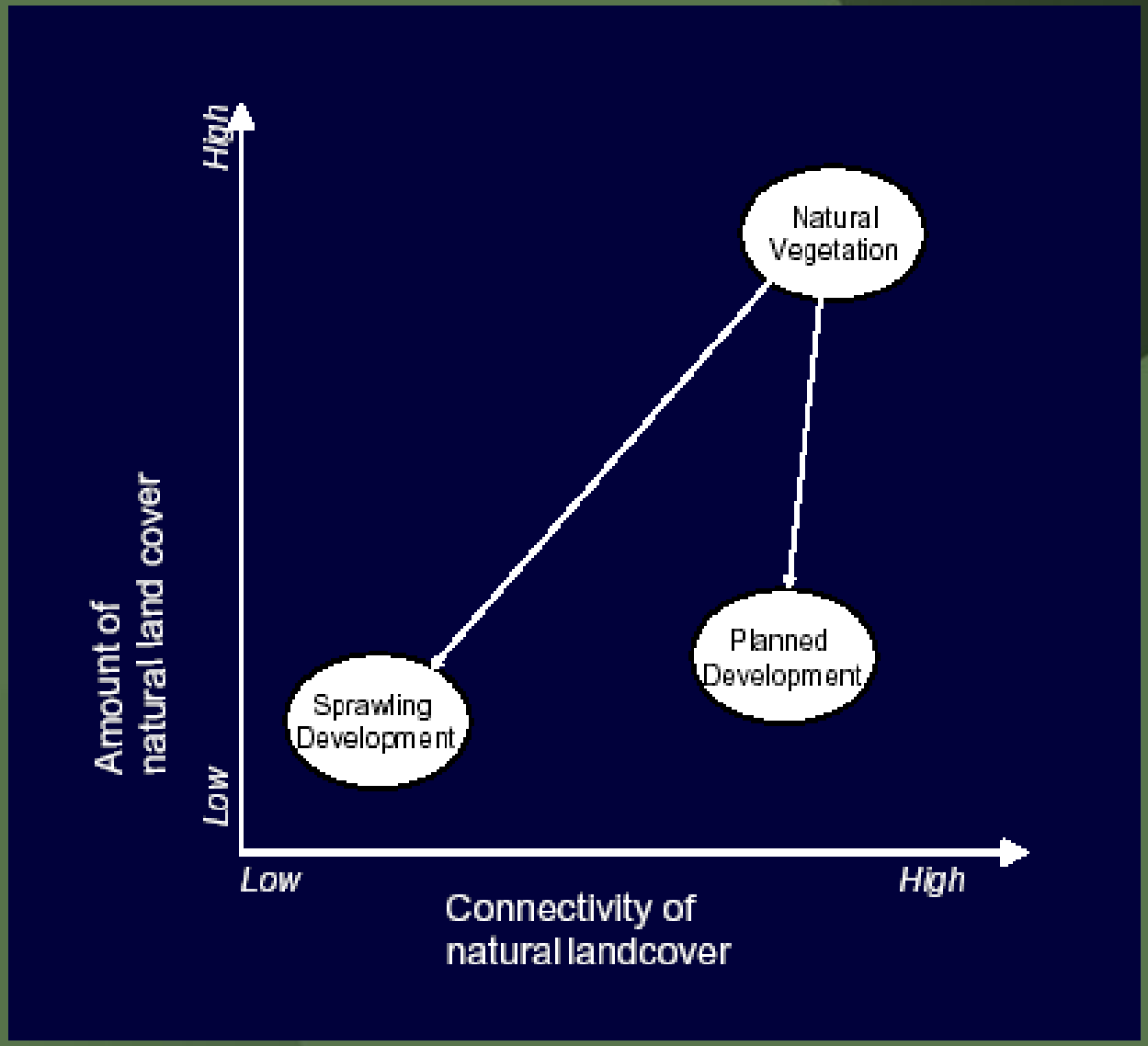
1. Natural vs. urban ecosystems.
2. Why study urban ecosystems?
3. Differing ecologies.
4. Sources & sinks.
5. Urban ecosystem conceptual model.
6. Urban ecosystem - goods & services.

1. Natural vs. Urban ecosystems

Urban ecosystems differ greatly from natural ecosystems even though they share many characteristics.

Cities change landscapes




High
Low
Amount of natural land cover
Natural Vegetation
Planned Development
Sprawling Development
Low
High
Connectivity of natural landcover

Natural ecosystem

Encompasses the biotic community and the abiotic environment:

- biotic - components that are living (animals, plants, etc.)
- abiotic - non-living components (soil, water, air, nutrients, etc.)

The flow of energy and nutrients through ecological systems.

The interactions among one or more biotic and associated abiotic features.

Urban ecosystem

An urban ecosystem:

- is the community of plants, animals, and humans that inhabit the urban environment.
- is physically dominated by built structures like buildings, roads, sewers, and power lines.
- contains a rich patchwork of green spaces (parks, yards, street plantings, greenways, urban streams, commercial landscaping, and unbuilt lots).

Urban ecosystem

Urban ecosystems comprise suburban areas, exurbs, sparsely settled villages connected by commuting corridors or by utilities, and hinterlands directly managed or affected by the energy and material from the urban core and suburban lands.

Urban ecosystem

Urban ecosystems are generally highly disturbed systems, subject to rapid changes in soil and plant cover, as well as temperature and water availability.

Construction in Nepal

Urban ecosystem boundaries

Boundaries often set by:

- watersheds.
- airsheds.
- commuting radii.
- convenience.

Need to consider that many physical and ecological fluxes and interactions extend far beyond political or biophysical reasoning.

Human ecosystem model

Combines the ecosystem concept derived from the biologically based ecology with insights about social institutions and interactions.

Recognizes the openness of ecosystems, and does not assume equilibrium or self-regulation of urban ecosystems.

Recognizes spatial heterogeneity in both the natural and social components of urban ecosystems, and that this heterogeneity can be dynamic.

S. Pickett et. al., 1997. A conceptual framework for the study of human ecosystems in urban areas, *Urban Ecosystems*

Human Ecosystem Model

Critical resources ⟷ Social System

Biophysical Resources
Air Water
Energy Land
Flora Fauna
Materials Nutrients

Socio-economic Resources
Information
Population
Labor
Capital

Cultural Resources
Ornization
Belefs
Myth

Social Institutions
Health
Justice
Faith
Commerce
Education
Leisure
Government
Sustenance
Family

Social Cycles
Physiological
Individual
Organizational
Institutional
Environmental

Identity
Age Gender
Class Race
Caste Clan

Social Order

Social Norms
Informal
Formal

Hierarchy
Wealth
Power
Status
Knowledge
Territory

2. Why study urban ecosystems?

Increased interest in creating and maintaining cities that are ecologically sustainable.

People need to understand how cities work as ecological systems to take control of the vital links between human actions and environmental quality.

Urban and rural residents require information on urban ecosystems to help them better understand the future changes likely to occur in forest and agricultural systems.

Institute of Ecosystem Studies, NY, 1999

Why study urban ecosystems?

We study urban ecosystems because:

- they include almost 50% of global population.
- they consume approx. 75% of world resources.
- they have environmental impacts far beyond their political or geographic borders.

Understanding urban ecosystems

Requires collaborative research by ecologists, physical and social scientists.

City dwellers' lives are enriched through appreciating and understanding their local environment.

Studying cities as ecosystems cannot be accomplished in isolation from the problems that cities face. Issues such as sustainability and environmental justice provide the context in which urban ecosystems studies increasingly need to occur.

Institute of Ecosystem Studies, NY, 1999

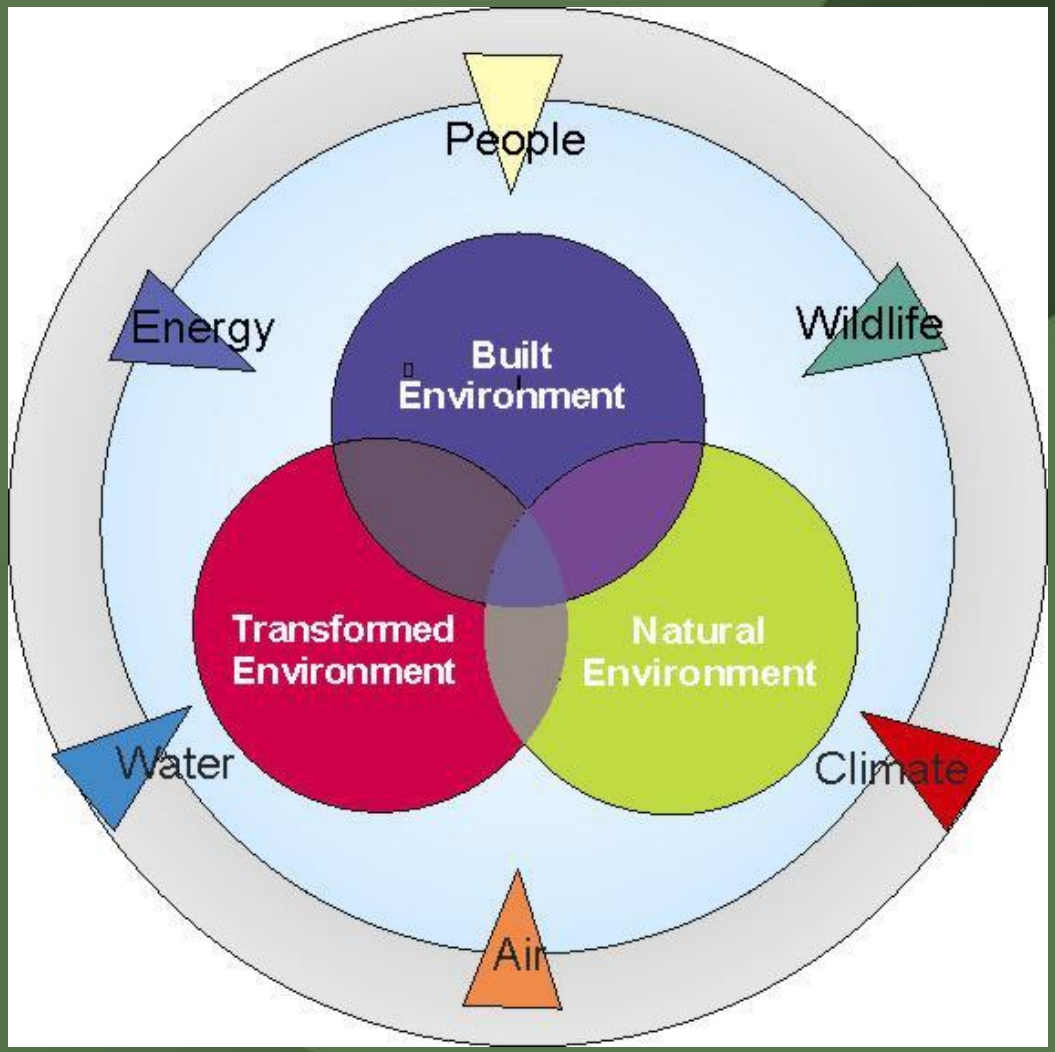
Understanding urban ecosystems.

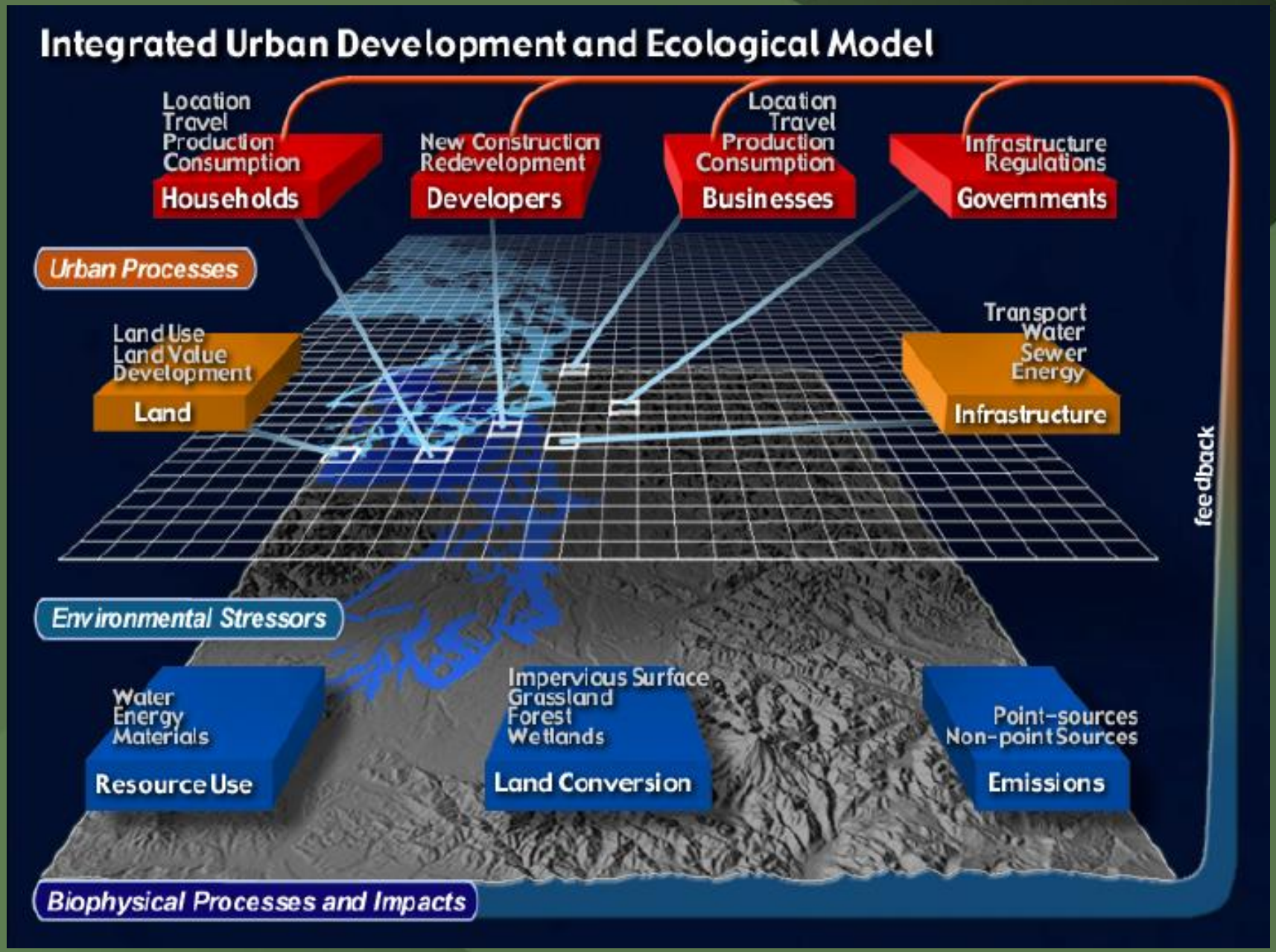
Social science insights must be thoroughly integrated with the traditional ecosystem perspective to build an understanding that embraces:

- the biota
- the physical environment
- ecological interactions, controls, and boundaries
- humans and their institutions, i.e., the built environment, information and behaviors, social structure, money and power hierarchies.

Institute of Ecosystem Studies, NY, 1999

A simplified model




Integrated Urban Development and Ecological Model
Location
Travel
Production
Consumption
Households
New Construction
Redevelopment
Developers
Location
Travel
Production
Consumption
Businesses
Infrastructure
Regulations
Governments
Urban Processes
Land Use
Land Value
Development
Land
Transport
Water
Sewer
Energy
Infrastructure
feedback
Environmental Stressors
Water
Energy
Materials
Resource Use
Impervious Surface
Grassland
Forest
Wetlands
Land Conversion
Point-sources
Non-point Sources
Emissions
Biophysical Processes and Impacts

Emergent Urban Patterns

Traffic Jam

Sprawl

Air Pollution

People preferences

Mobility patterns

Land values

Emissions

Emission standards

Gasoline prices

Infrastructure

Microclimate

Topography

3. Differing ecologies.

There are two basic ways of examining the ecosystem of urban areas:

- ecology in the city.
- ecology of the city.

Ecology in the city

The traditional method through which understanding about the cities evolved:

- physical environment.
- soils.
- vegetation and flora.
- animals and wildlife.

Ecology of the city

Examination of systems-oriented processes:

- biogeophysical budgets.
- ecological footprints.
- ecosystem patterns and processes.

4. Sources & sinks

The industrial city at the simplest level of ecological synthesis is a system of one-way flows of energy and materials:

Sources in the outer landscape

⇩

Production and consumption in the city

⇩

Waste sinks in the air, water, and land.

Sources & sinks

Sources: farms, forests, mines, oil fields, and large areas of the oceans.

Sinks:

- the upper and lower atmosphere, where the by-products of combustion tend to accumulate.
- lakes and bays, where we usually put our sewage wastes.
- on the land, where we bury garbage and chemical wastes.

Sources & sinks

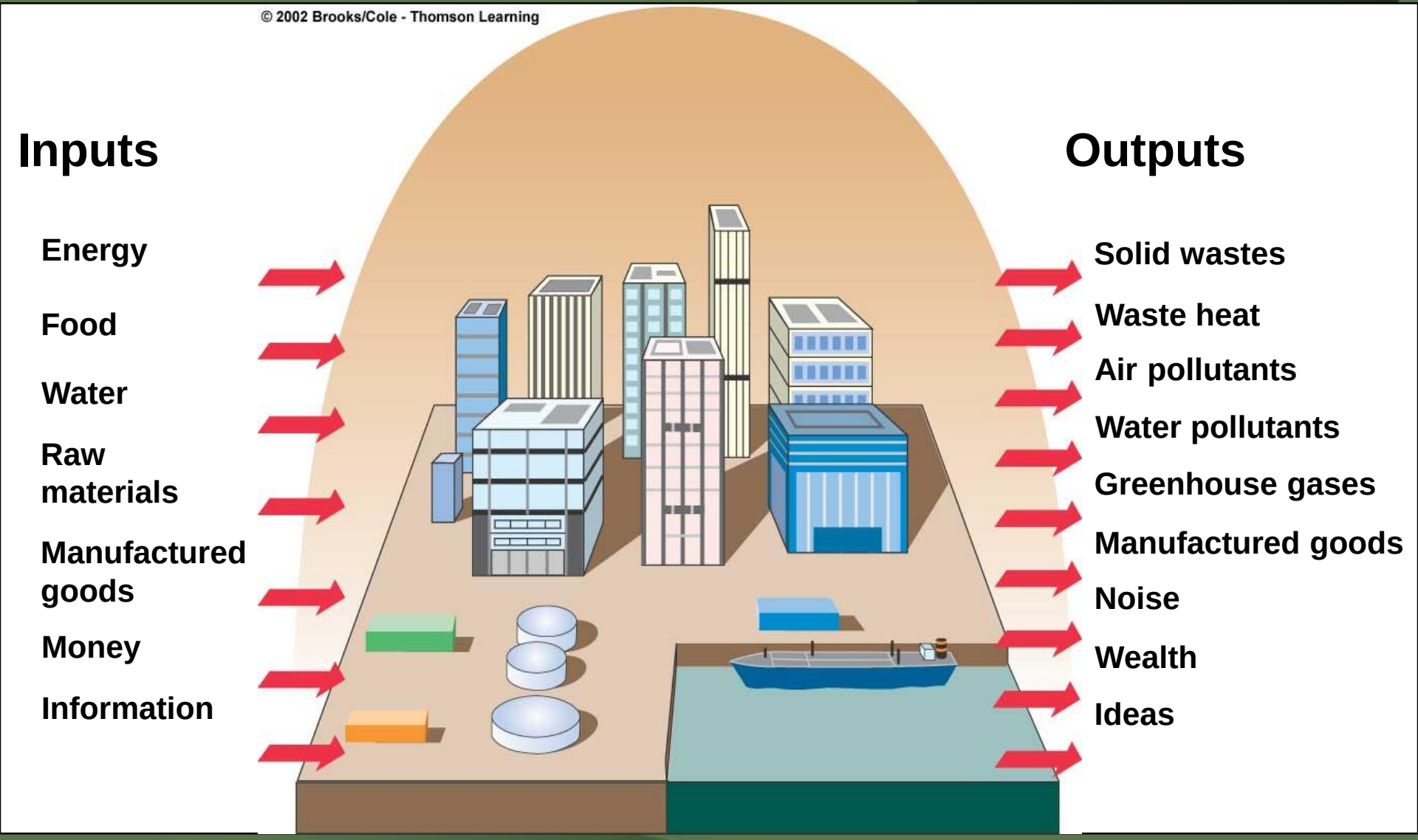
Sources + sinks = virtually the entire Earth

Sources & sinks

Sources are continuously depleted and have few means of regeneration because the materials that might otherwise replenish them are going into distant sinks.

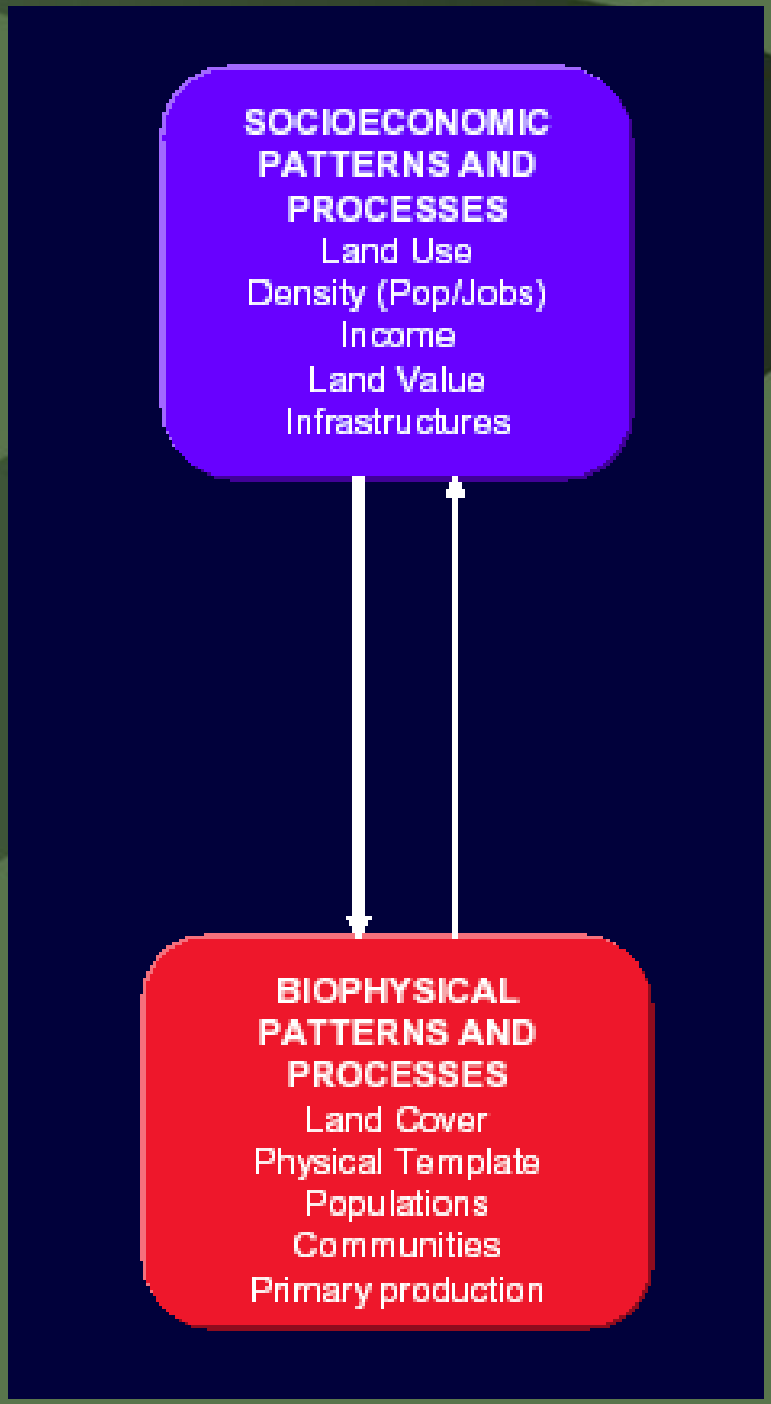
Sinks are continually overfilled because their natural capacity to assimilate energy and materials is far exceeded by the concentrated quantities being put out from the cities.

Urban Areas: Inputs and Outputs (no self-sustaining systems)

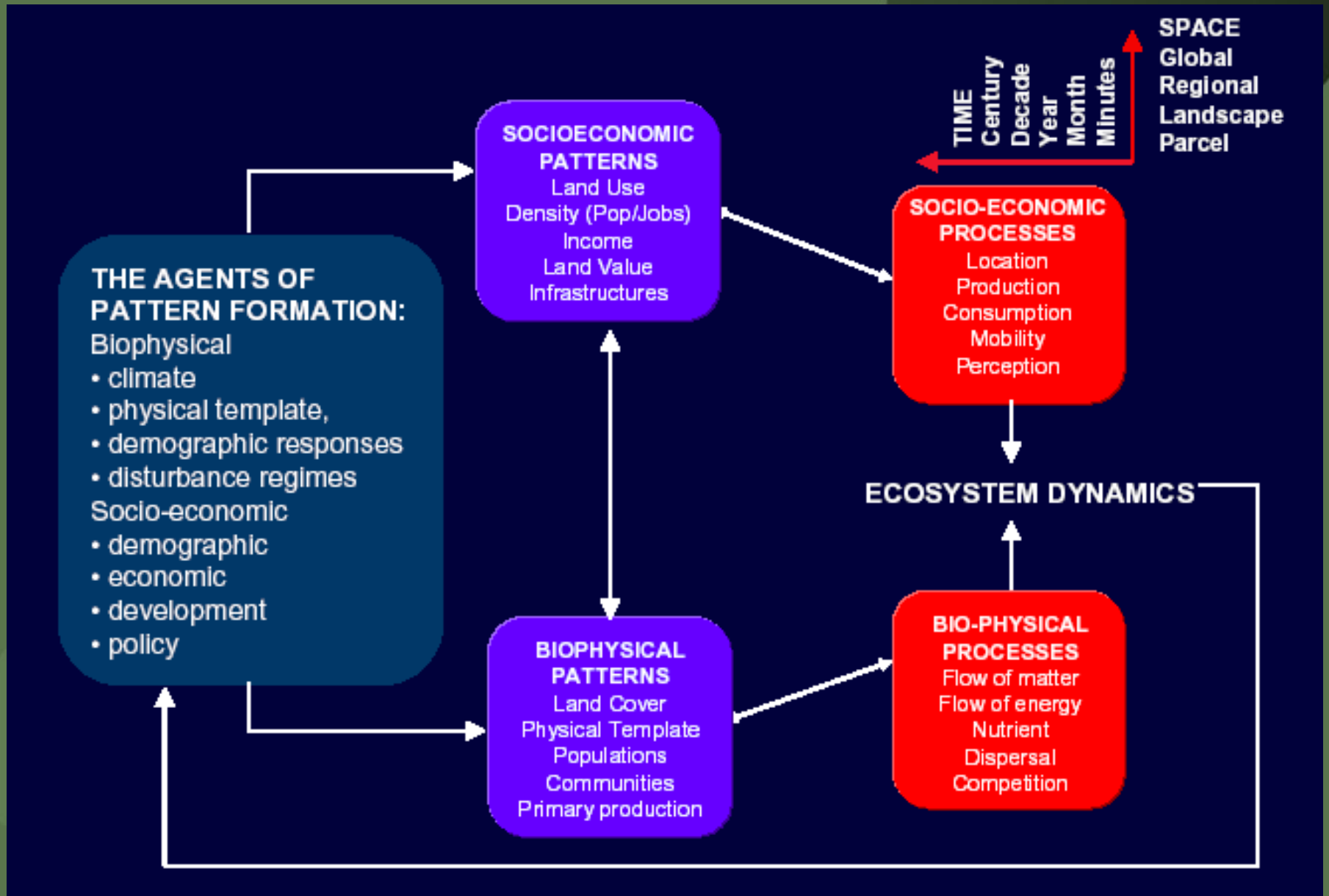


5. Urban ecosystem model

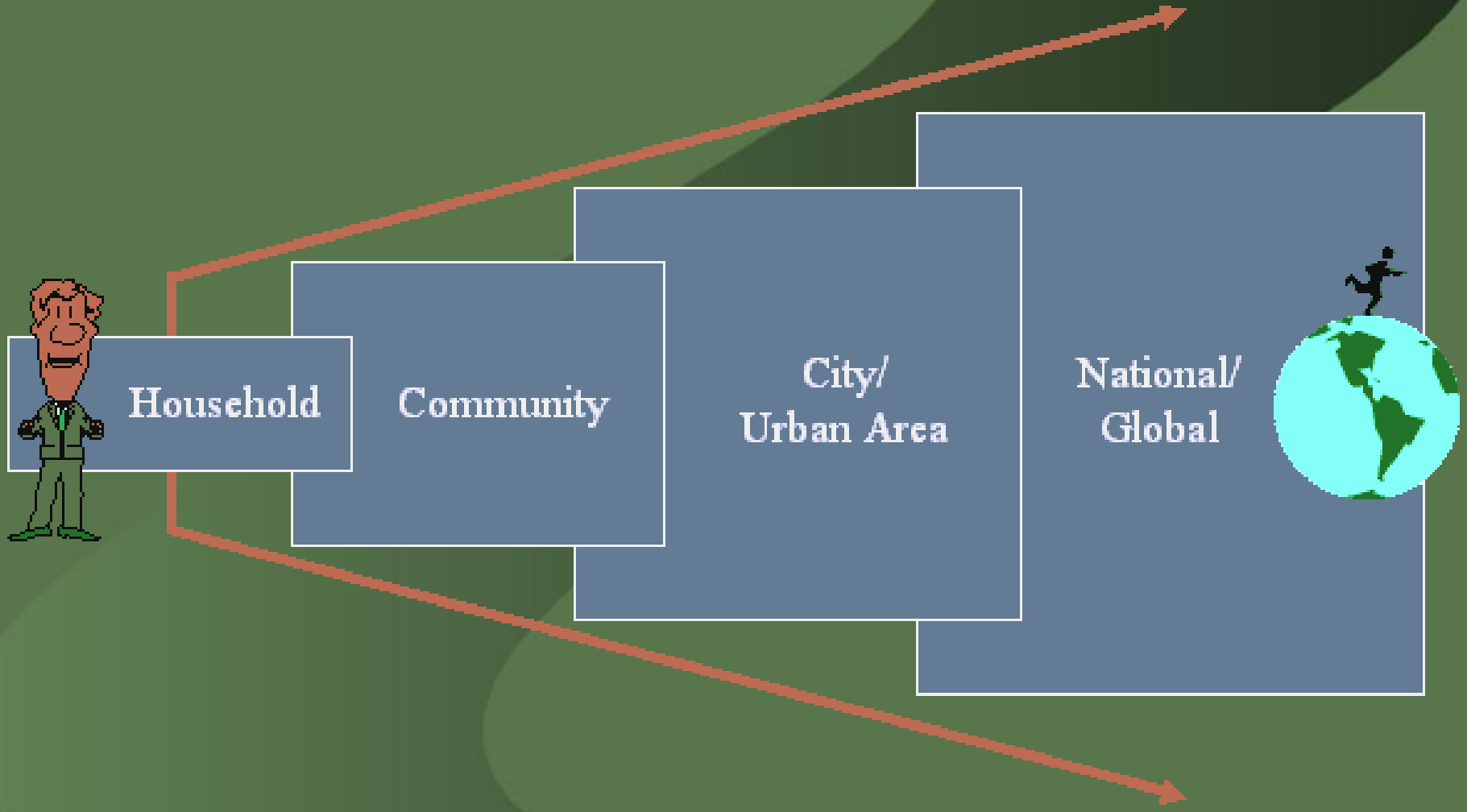
This represents only a partial (and simplified) view of the urban situation.



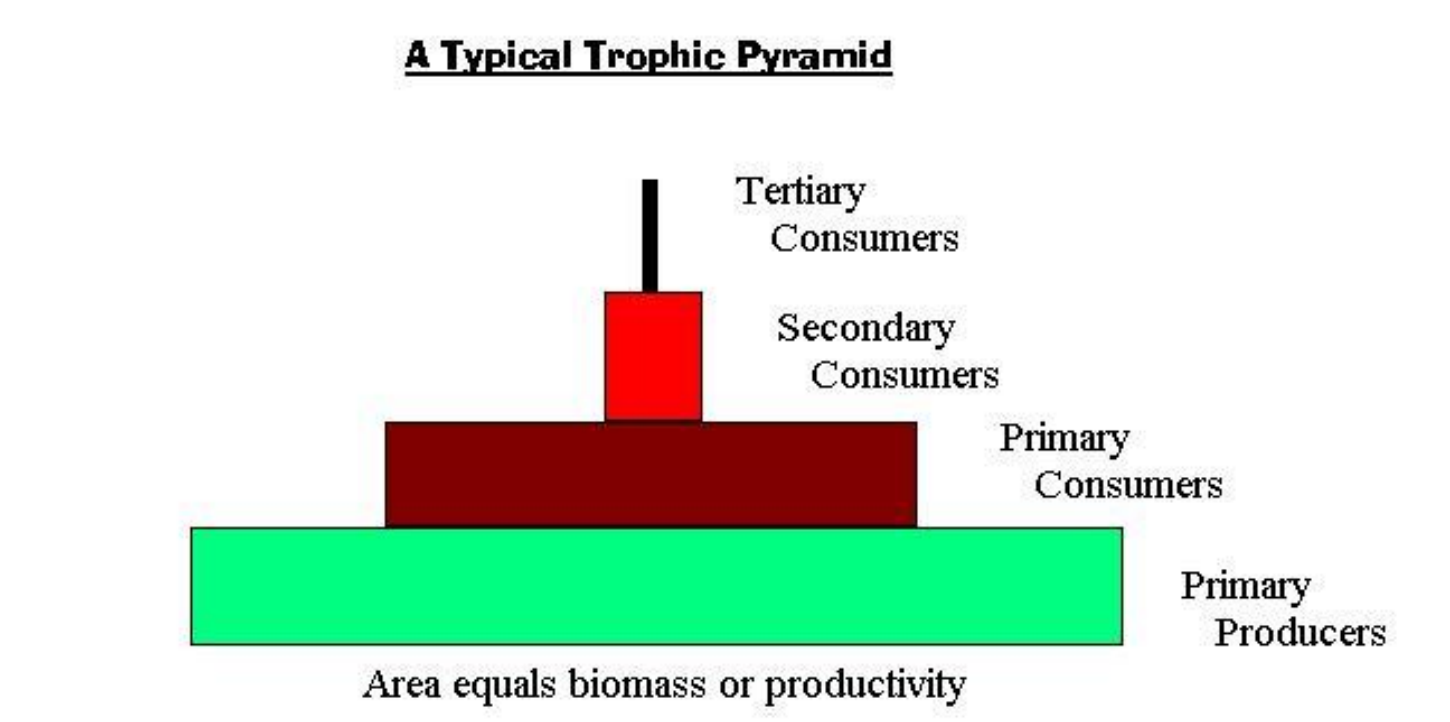
Linking human & ecosystem functions: a conceptual model



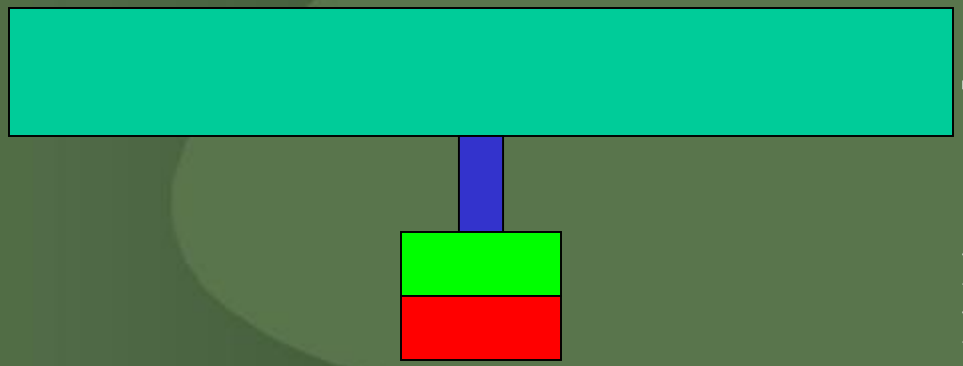
Magnification of urban effects



Urban trophic pyramid

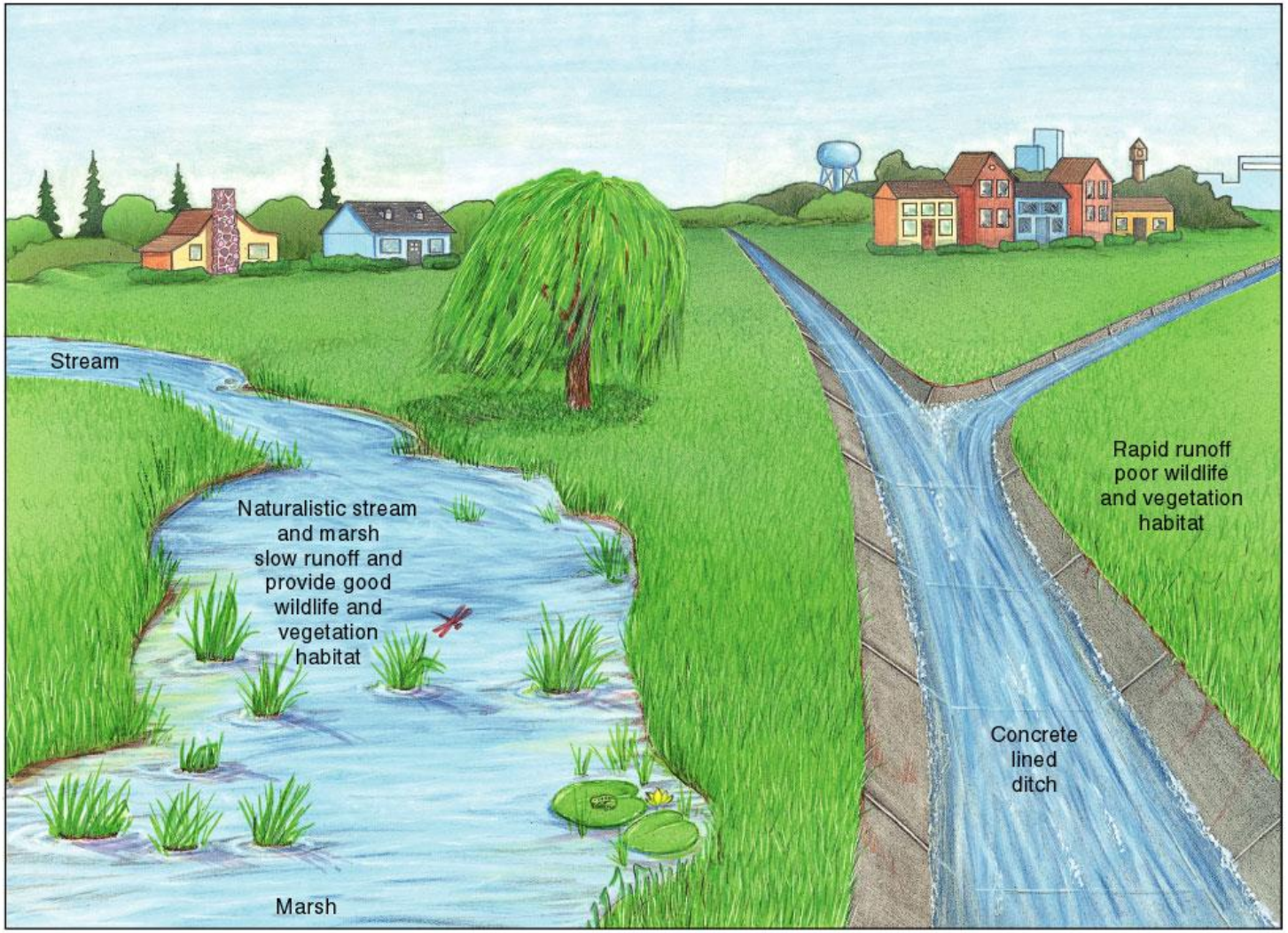


Urban Trophic Pyramid



Tertiary Consumers
Humans
Secondary Consumers
Primary Consumers
Primary Producers

Simplification of an urban ecosystem



6. Urban ecosystem – Goods & Services

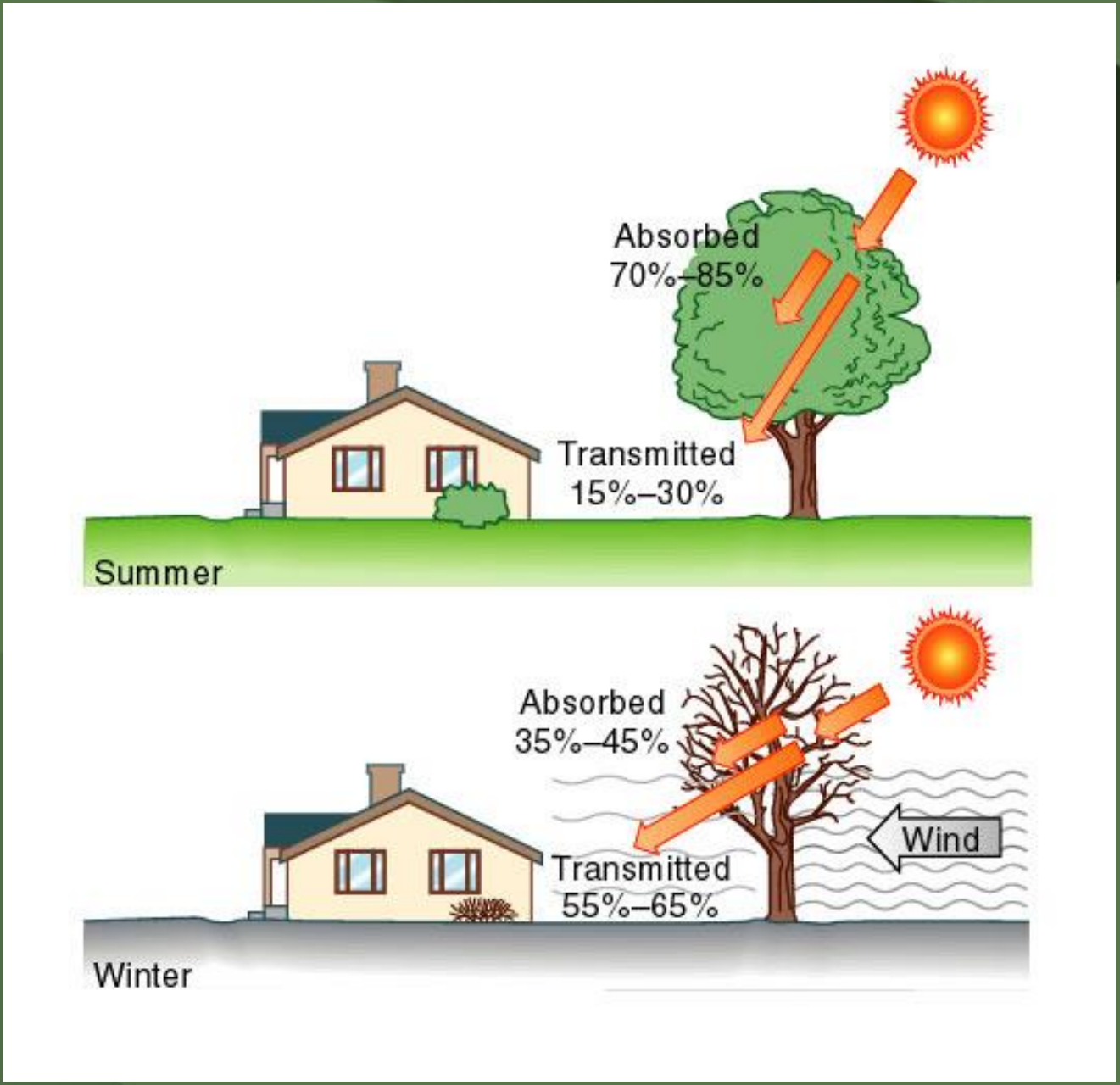
Includes all those “things” that the natural components of urban environments do within the overall ecosystem.

Urban ecosystem - 1

Shade and Temperature Control

- trees provide shade, lowering ground temperatures
- trees also transpire large amounts of water that, when evaporated, provide a cooling effect.
- the shading effect of trees translates to energy savings and reduced regional pollution.
- Chicago: estimated that planting about three more trees per building lot could save $50-$90 in air conditioning costs per house.

Trees can improve the microclimate near a house.



Goods & Services - 2

Air Filtering

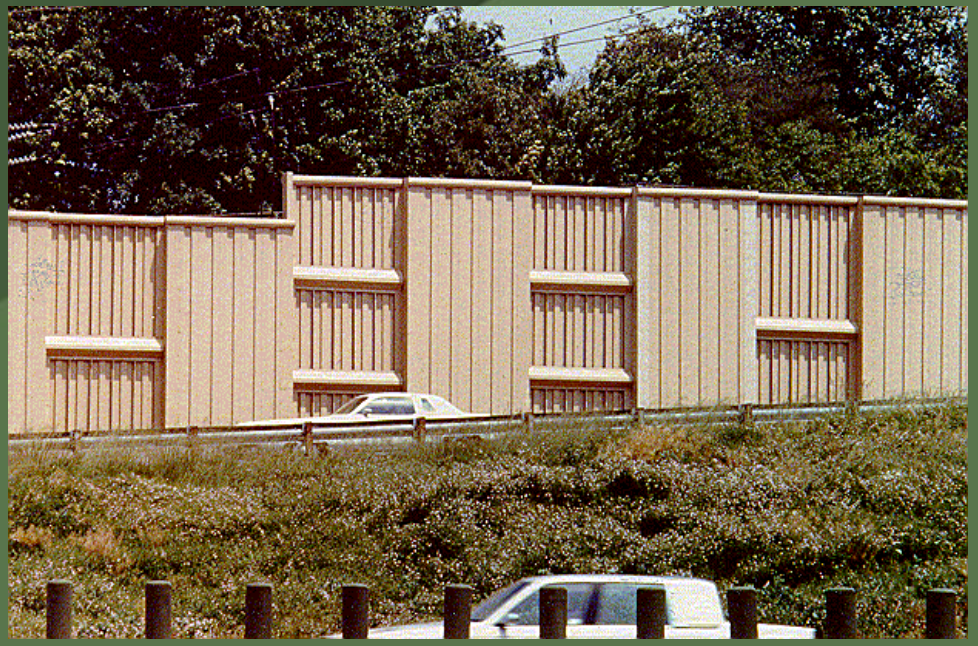
- the leaf surfaces of trees can filter out as much as 85% of the ambient air pollution (mostly particulates).
- trees can also be effective air purifiers, removing up to 70% of particulates on a tree-lined street.
- urban forests in the Baltimore-Washington region remove some 17,000 tons of air pollutants per year, worth at least $88 million annually.

Goods & Services - 3

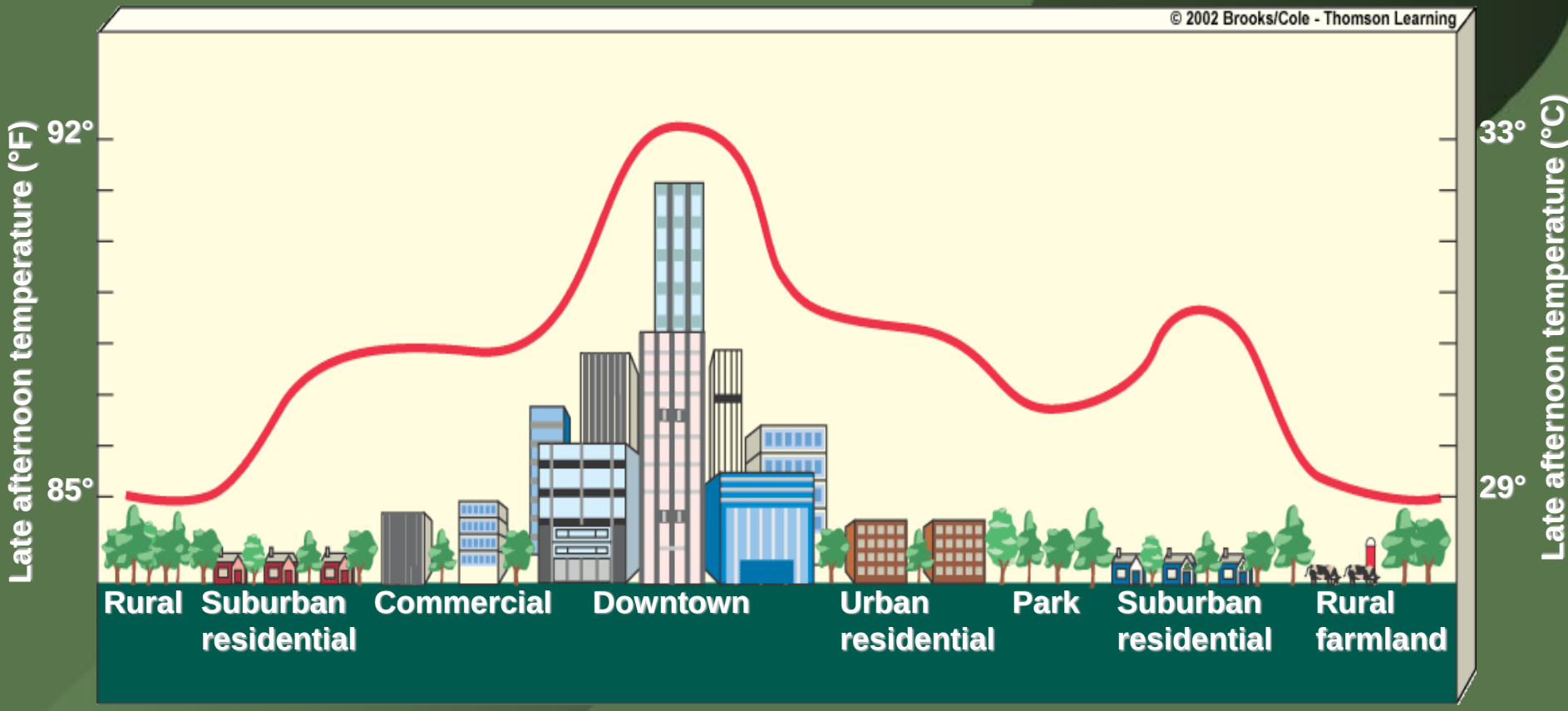
Noise reduction

• trees and shrubs can help filter out noise pollution.

• a 30-meter belt of tall dense trees combined with soft surfaces can reduce local noise levels by 50%.



Urban Heat Island



Vegetation “service”: absorb air pollutions, give off oxygen, cool the air as water transpires, provide shade hence less AC required, reduce soil erosion, muffles noise, provides wildlife habitat and gives us an island of peace.

Goods & Services - 4

Stormwater Control

Urban forests, wetlands, and streamside vegetation help to restore some of the natural balance by:

- buffering storm water runoff.
- absorbing pollutants.
- recharging groundwater reservoirs.

Goods & Services – 5

Biodiversity and Wildlife Habitat

- cities support a wide variety of plants and animals.
- provide critical habitat to many migratory species. Eg., neotropical migrants
- approx. 1/3 of urban residents in the USA participate in wildlife watching activities within 1 mile of their homes (US Park Service).

Goods & Services - 6

Recreation, Aesthetic, and Spiritual Values

• we tend to surround ourselves with little patches of nature - our lawns and yards.

• parks and green spaces provide city dwellers with invaluable recreational opportunities.

Goods & Services - 7

Food Production

- urban agriculture is very important on a global basis.
- worldwide: est. 800 million city residents grow food in backyards, vacant lots, roadsides, and small suburban farms.
- Kenya and Tanzania: 2 out of 3 urban families are engaged in farming
- Cuba: urban agriculture produced 800,000 tons of fresh organic produce and employed 165,000 people (1999).

Global ecosystem G&S

Estimated value of global natural capital stocks and ecosystem services (US $ per year):

$33,000,000,000,000

Global gross national product (total):

US $18 Trillion