Water Resources Sustainability: An Ecological Economics Perspective

Christopher Lant, Professor
Dept. of Geography and Environmental Resources
Southern Illinois University Carbondale
Executive Director
Universities Council on Water Resources

Intellectual Leadership in Sustainability

The International Society of Ecological Economics

Journal: *Ecological Economics*

Sante Fe Institute

Focus on the study of complex systems

National Science Foundation

Biocomplexity in the Environment Program

Env. Education and Research 10-Year Plan

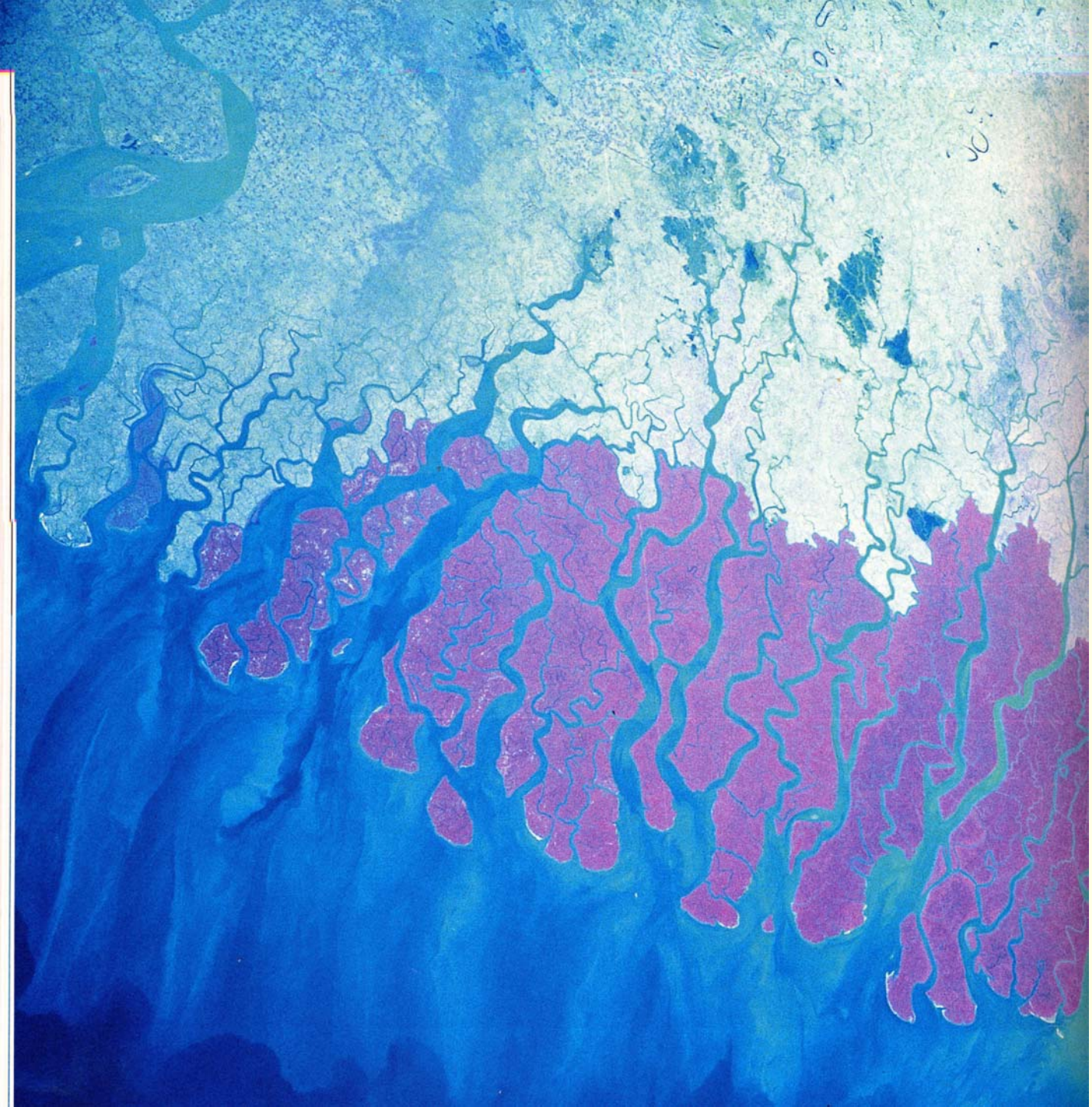
Three Challenges

- The continuing effort to *conceptualize* sustainability
- Developing analytical approaches to measure sustainability and evaluate management options
- Developing new modes and principles of sustainable water resources *management*


Conceptualizing Sustainability

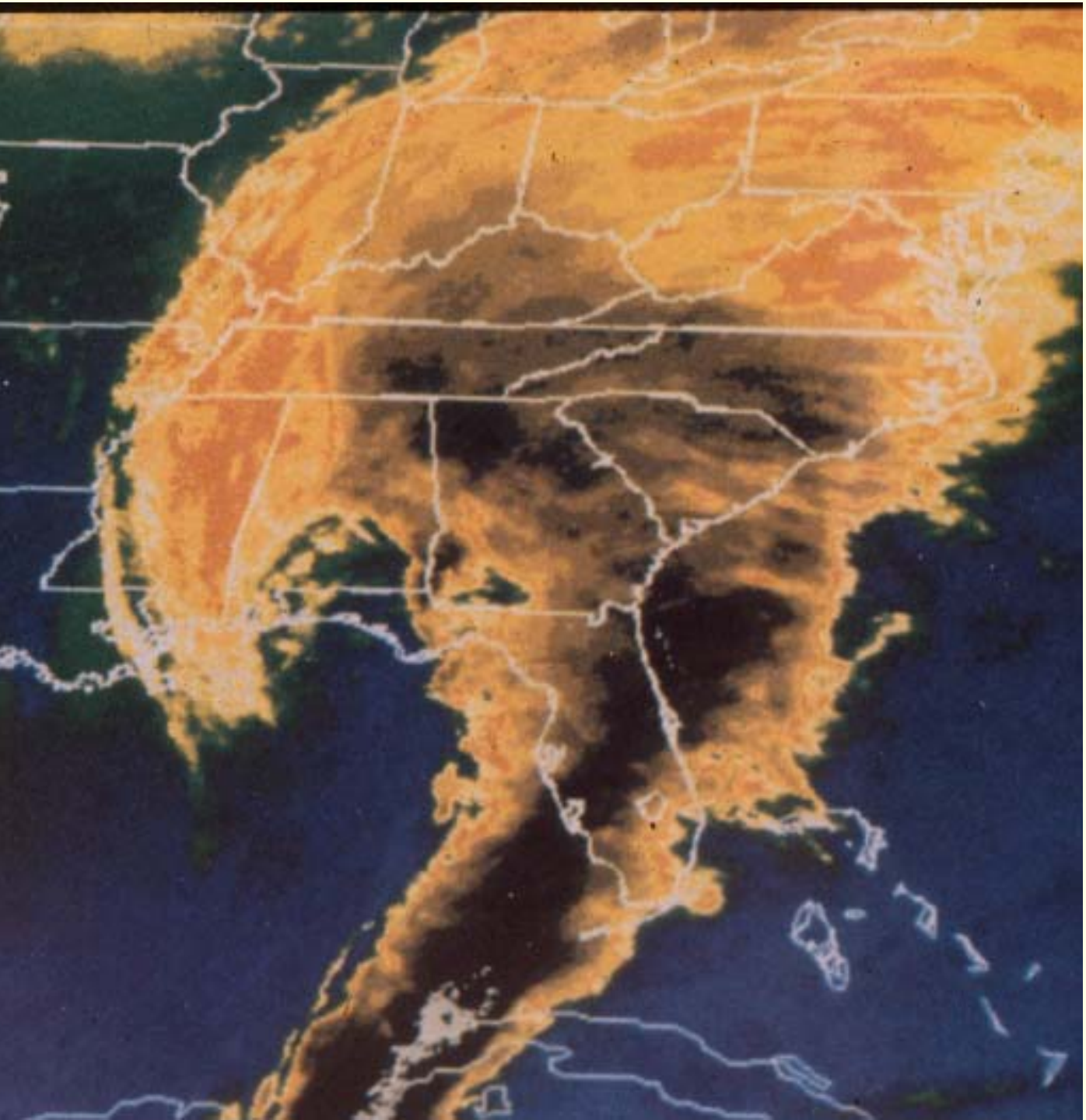
What are the char-acteristics of the Earth that make it habitable?

1) It has a lot of water



It has a temper-ature range in which most of that water is liquid.
32-212 F
0-100 C

It has an atmos-phere that provides oxygen,



filters out harmful radiation, and transports water

It has

E
C
O
S
Y
S
T
E
M
S

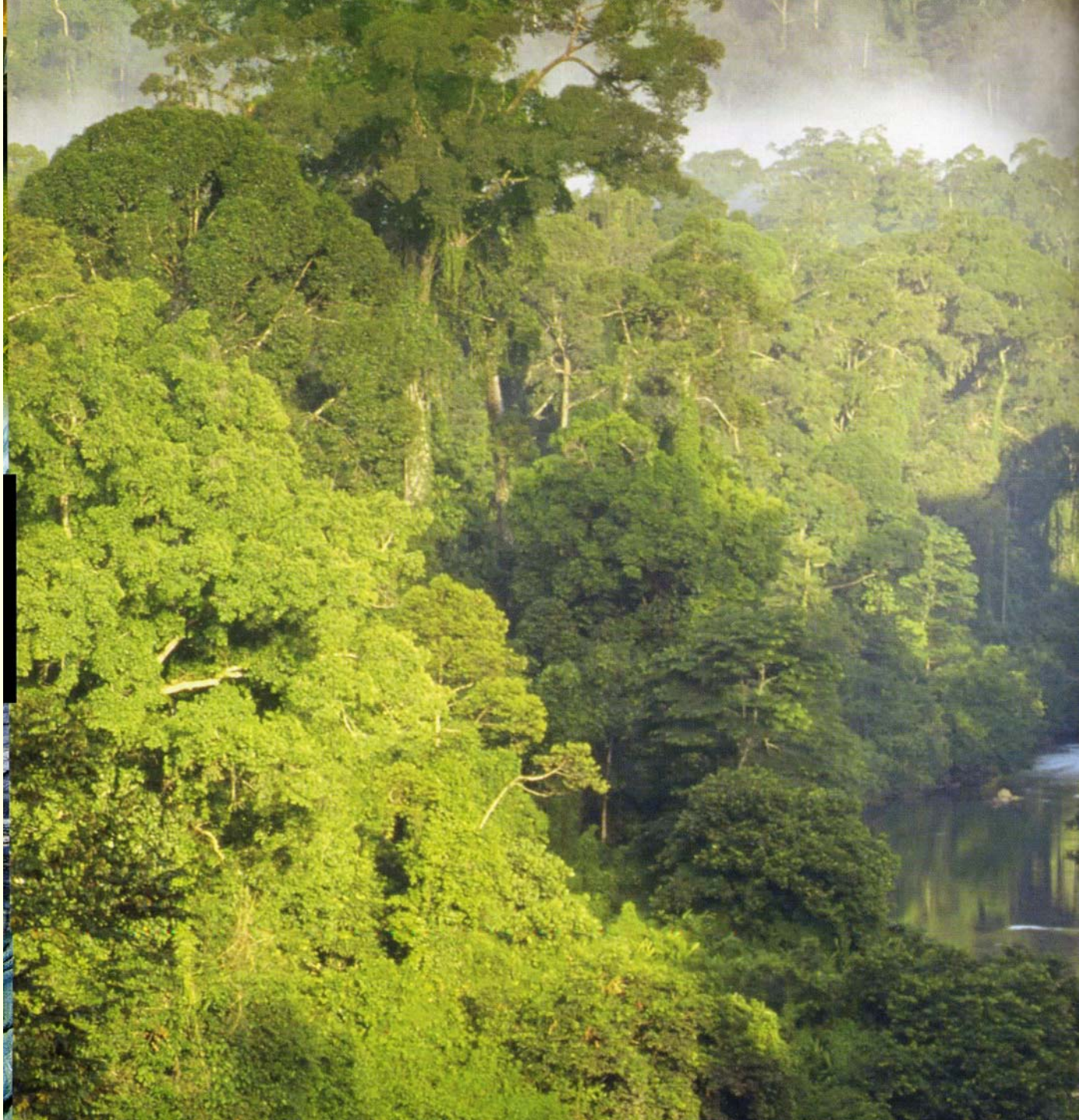
What do ecosystems do for people (who are usually more interested in other things)?

How do they support our cities, our farms, our lifestyles?

They supply natural resources

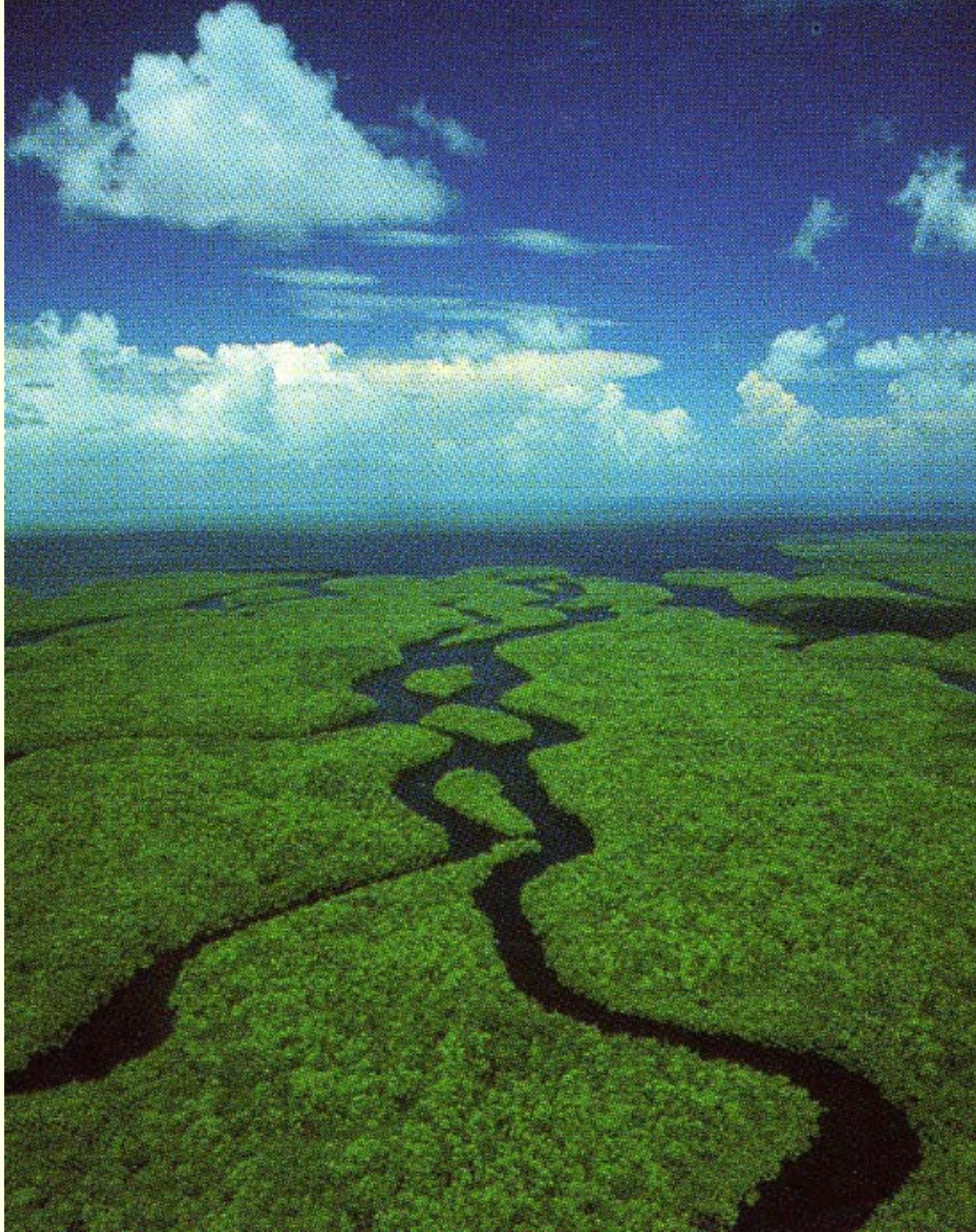
LIQUID RESERVES
The Glen Canyon Dam on the Colorado River generates hydroelectric

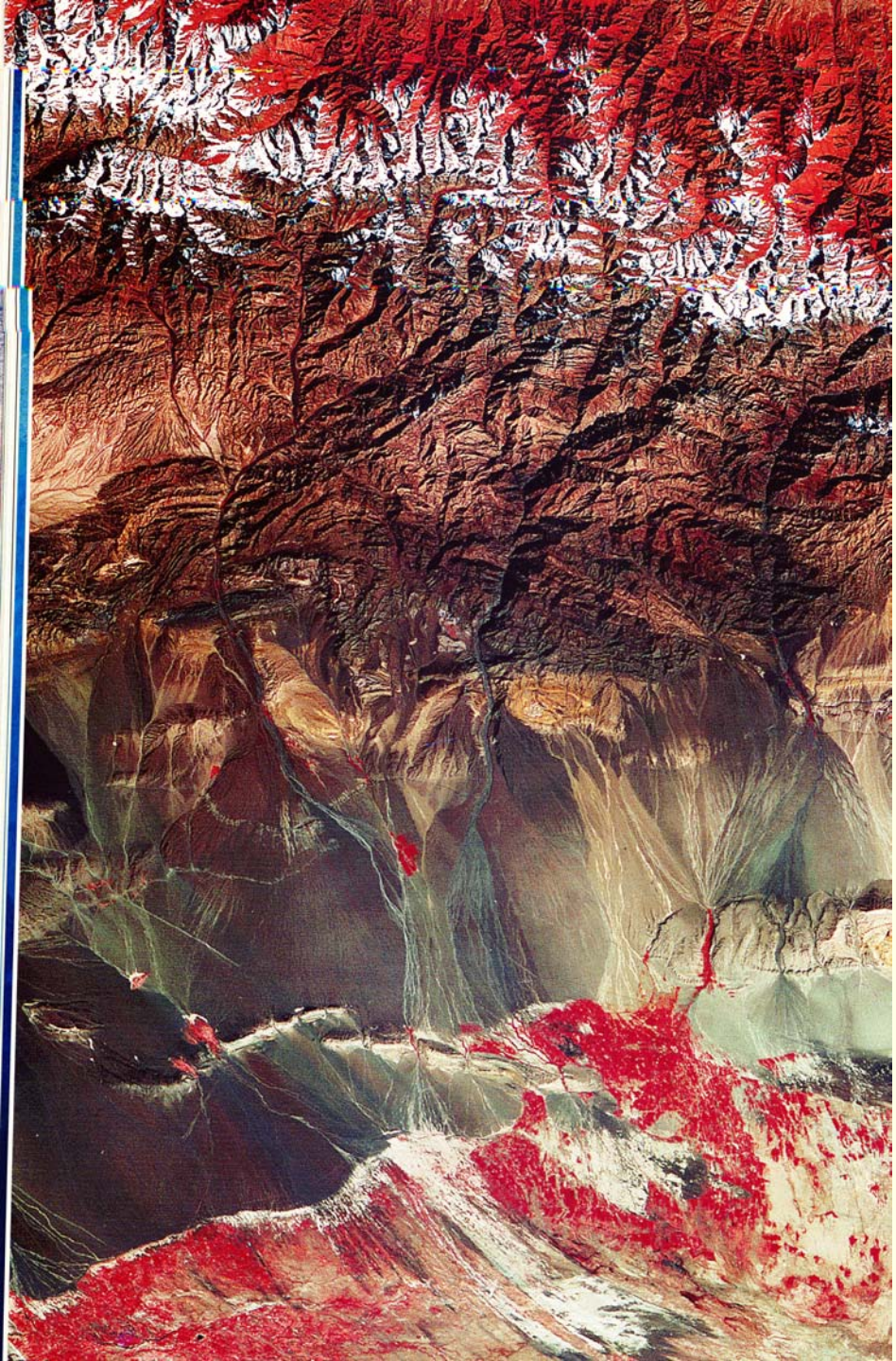
But eco-systems also supply some-thing else.



They are an
“asset,”
like money in
the bank

This asset is known as “natural capital”





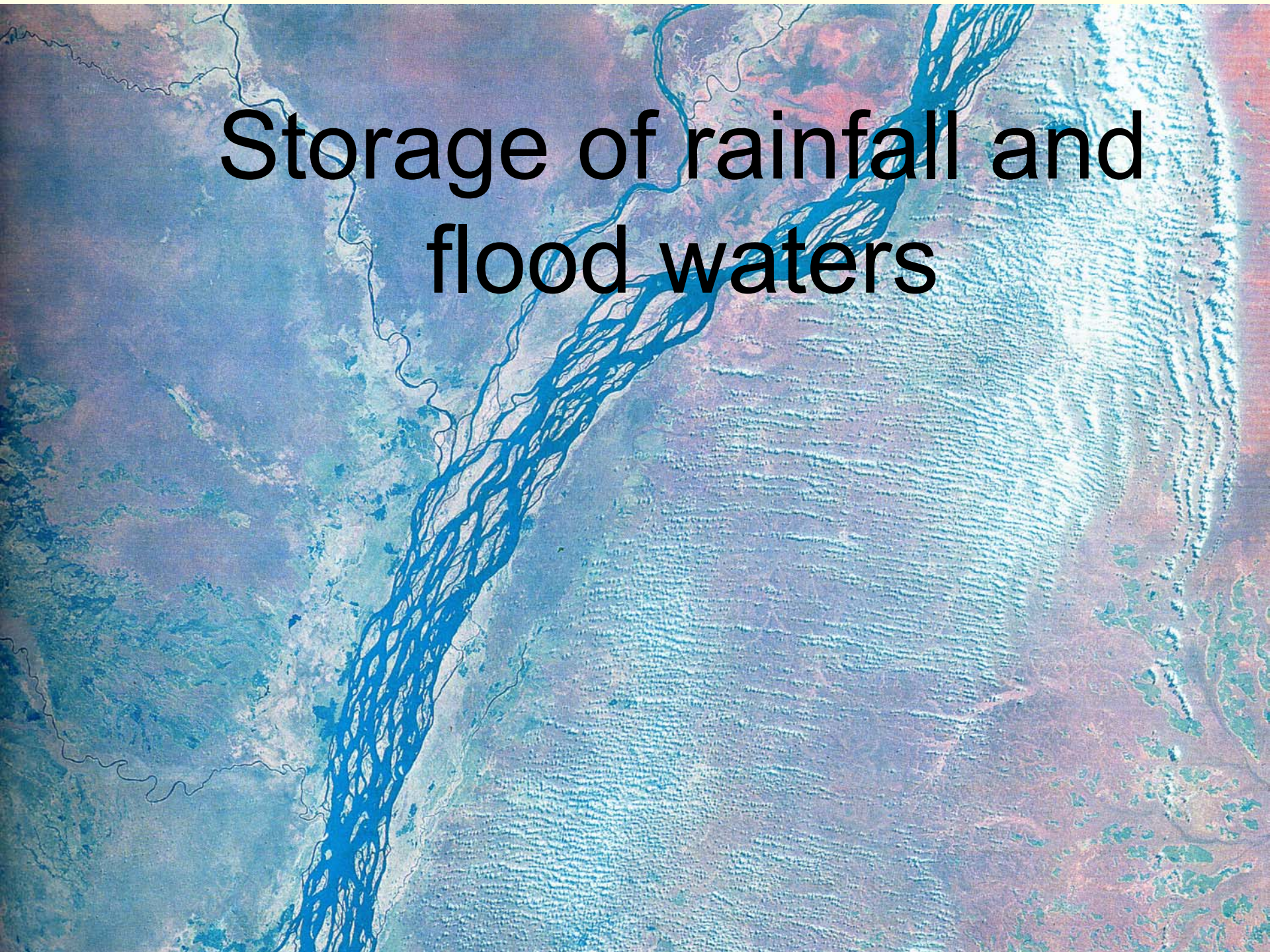
Natural Capital

Characteristics of ecosystems that provide a capacity to:

1. produce natural resources for future economic use
2. absorb waste products from the economy
3. generate ecosystem services

Ecosystem Services:

Effects of ecosystem functioning that are valuable to people

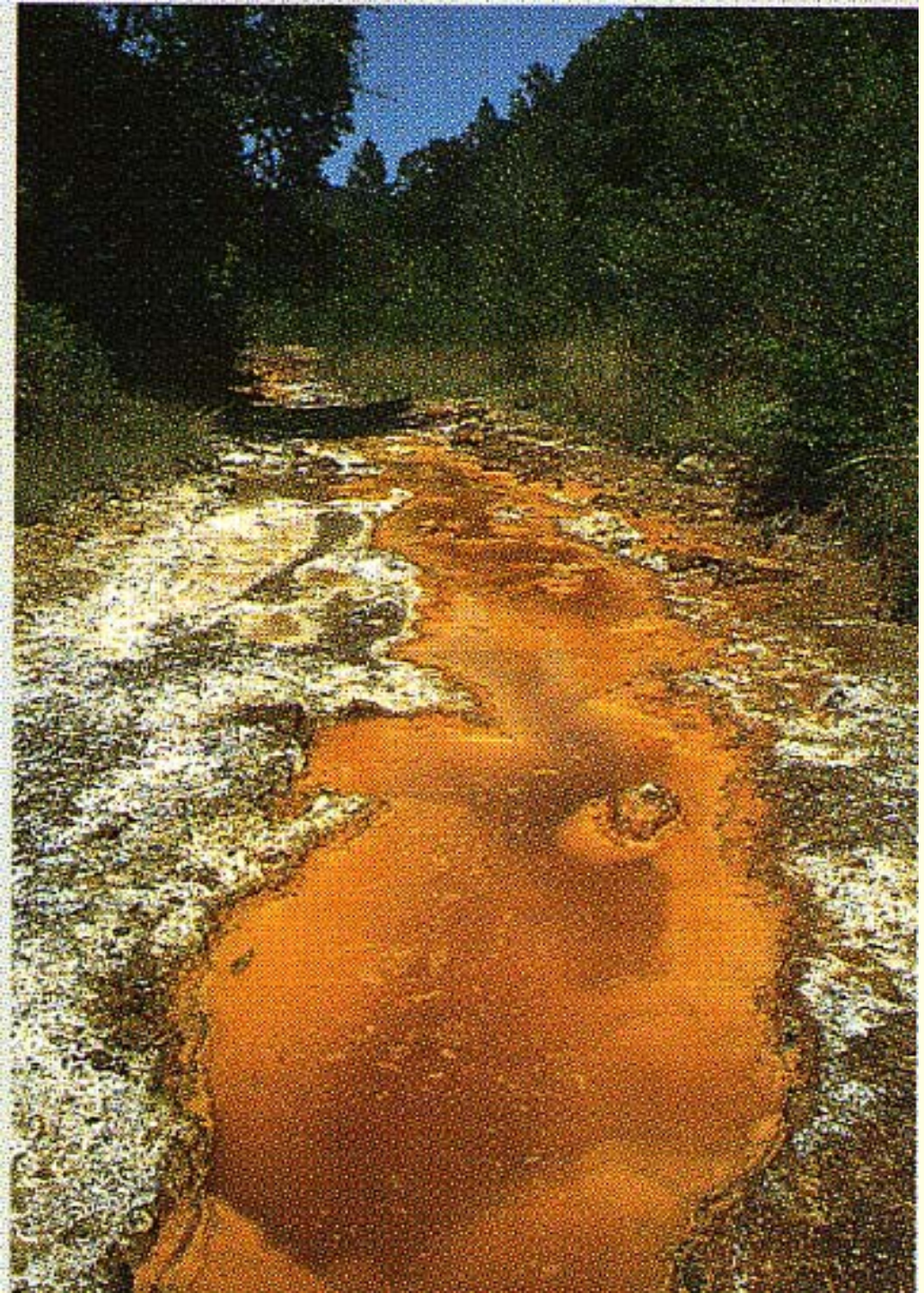

Storage of rainfall and flood waters


Carbon storage
Maintenance of biodiversity
Cycling of nutrients

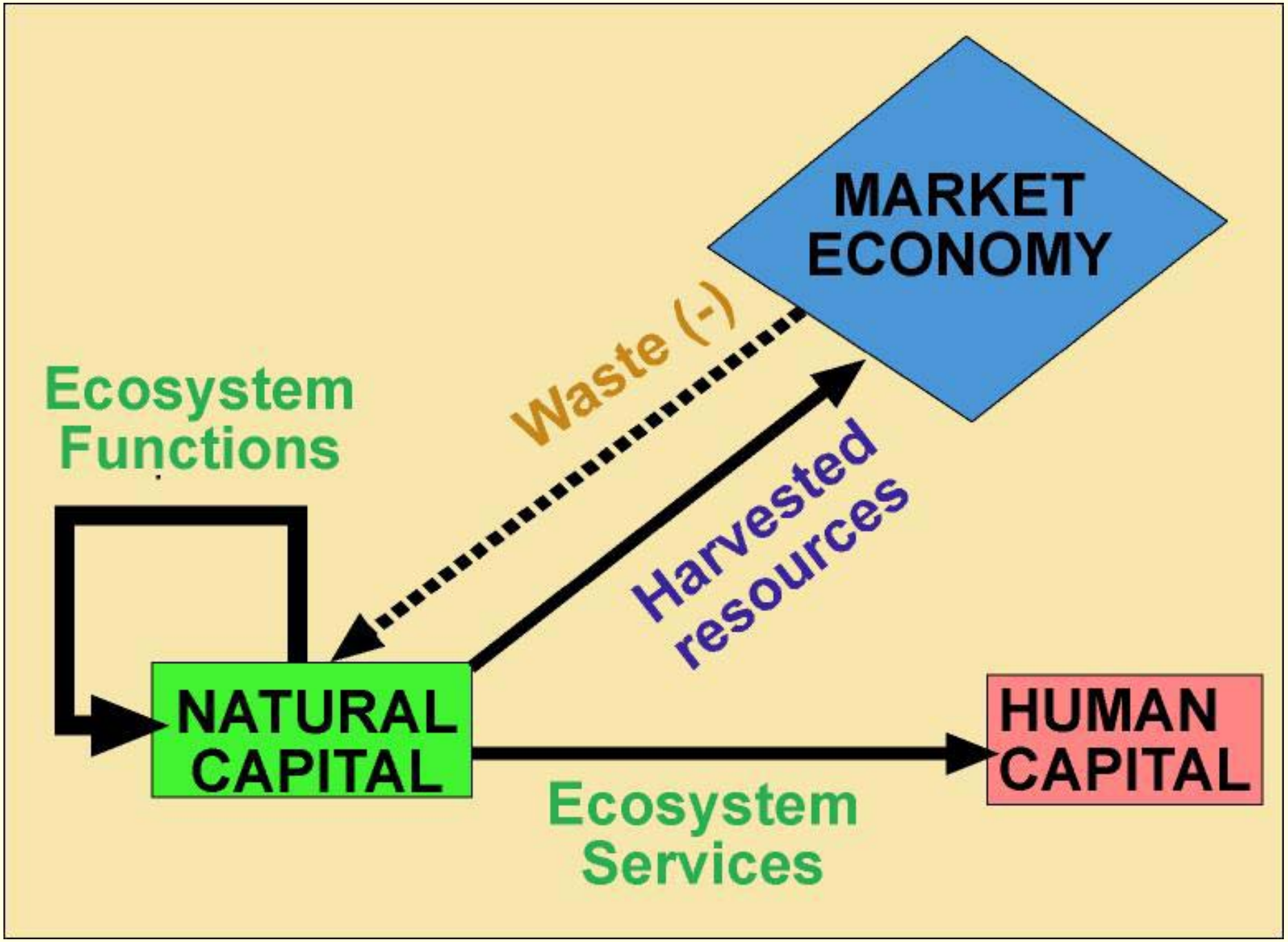

Maintenance of soil fertility

What happens when ecosystem services fail?

When increasing populations or economic growth overuse water supplies



Use streams as chemical dumps


MARKET ECONOMY
Waste (-)
Ecosystem Functions
Harvested resources
NATURAL CAPITAL
HUMAN CAPITAL
Ecosystem Services

Manufactured Capital

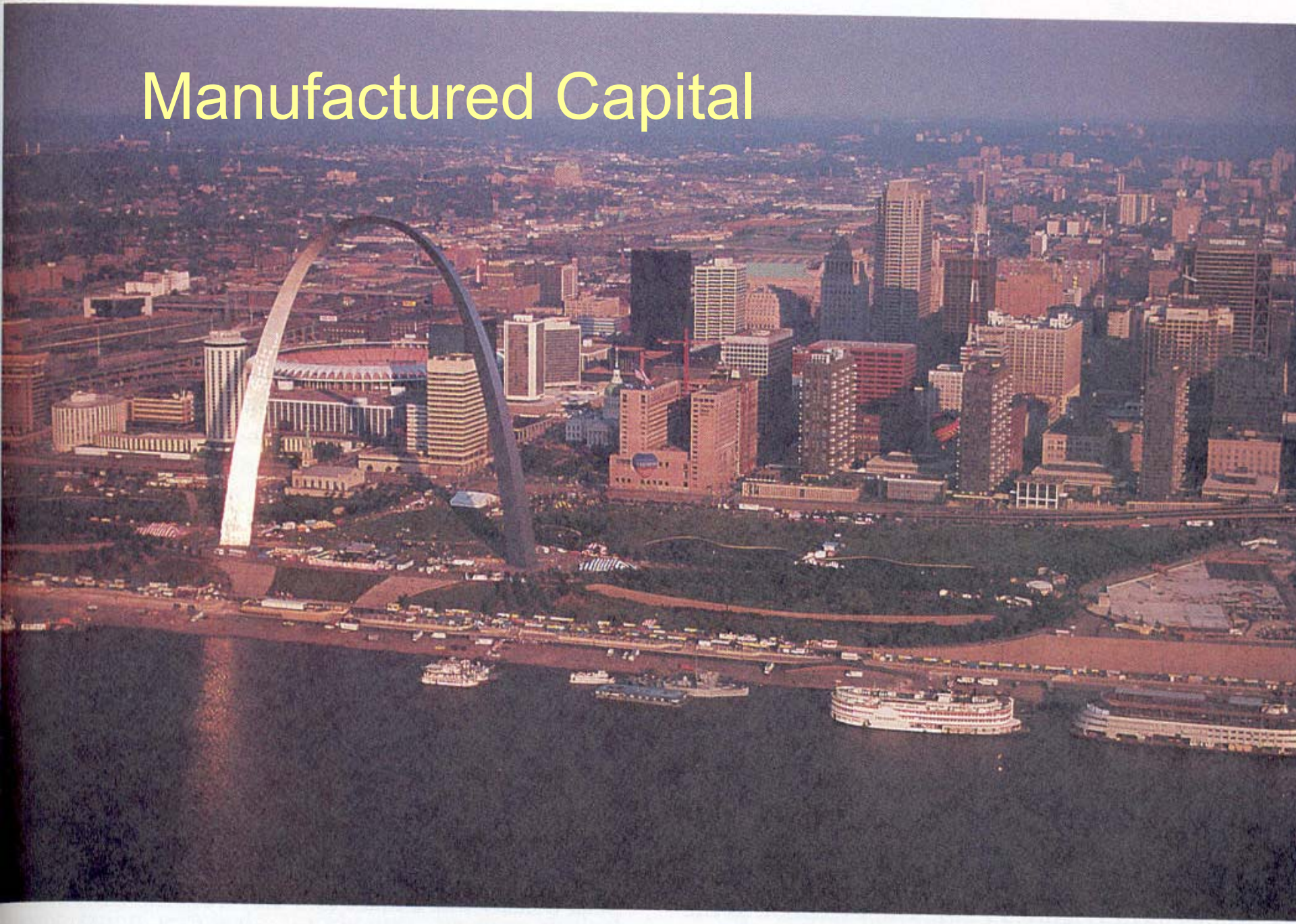
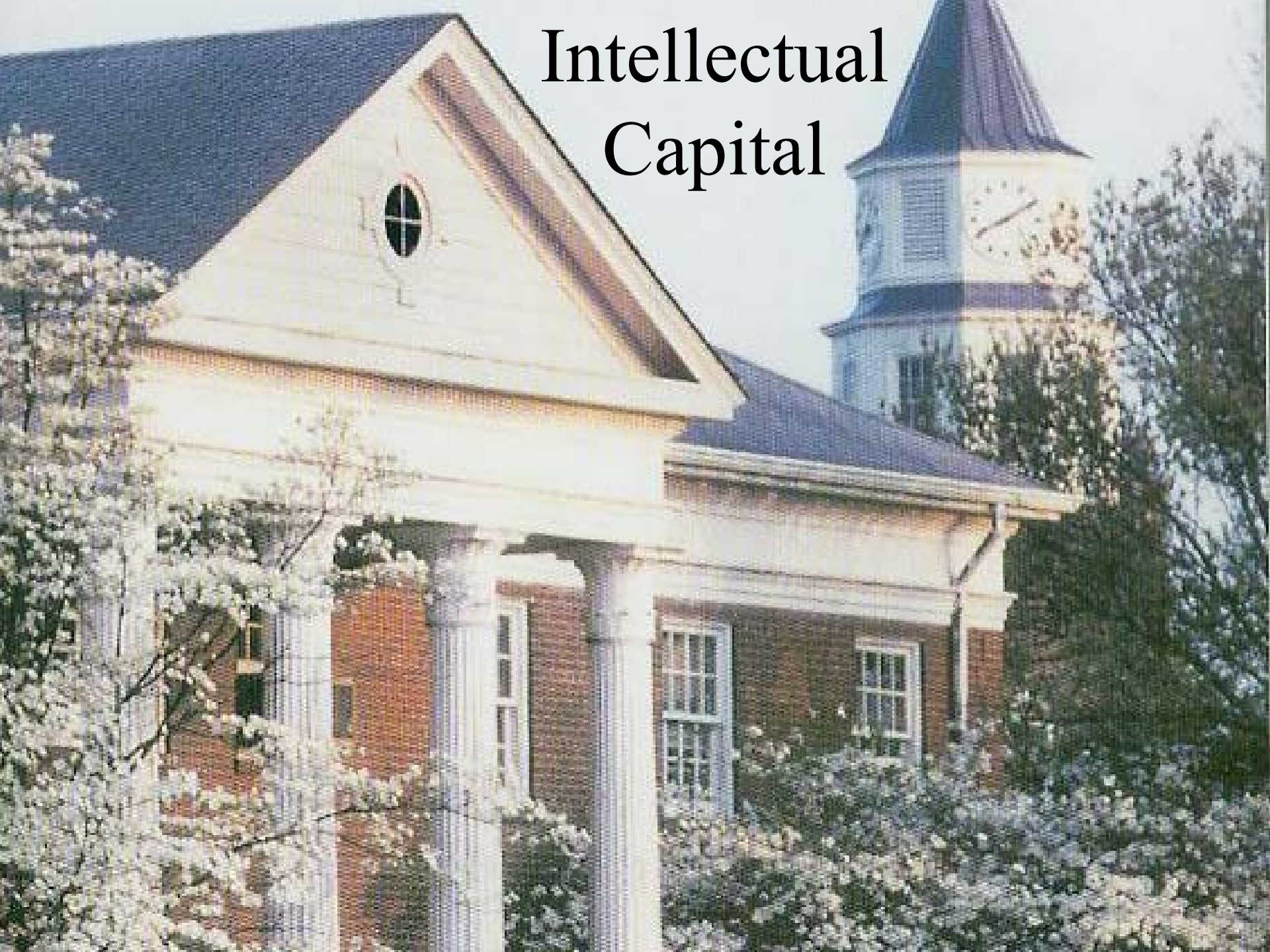


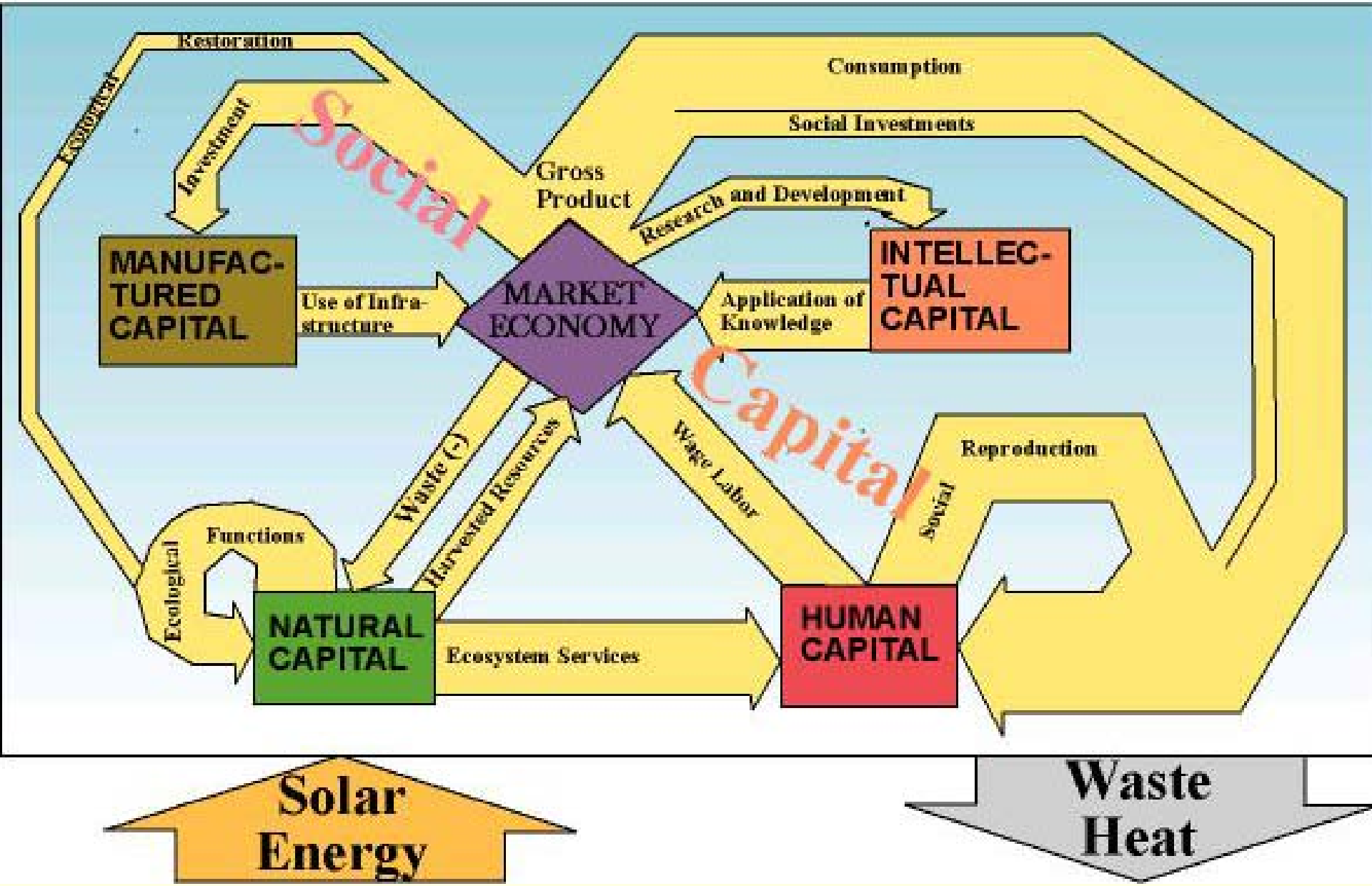
Figure 11.21 In older cities, the central business district

Human Capital

Intellectual Capital




Social Capital

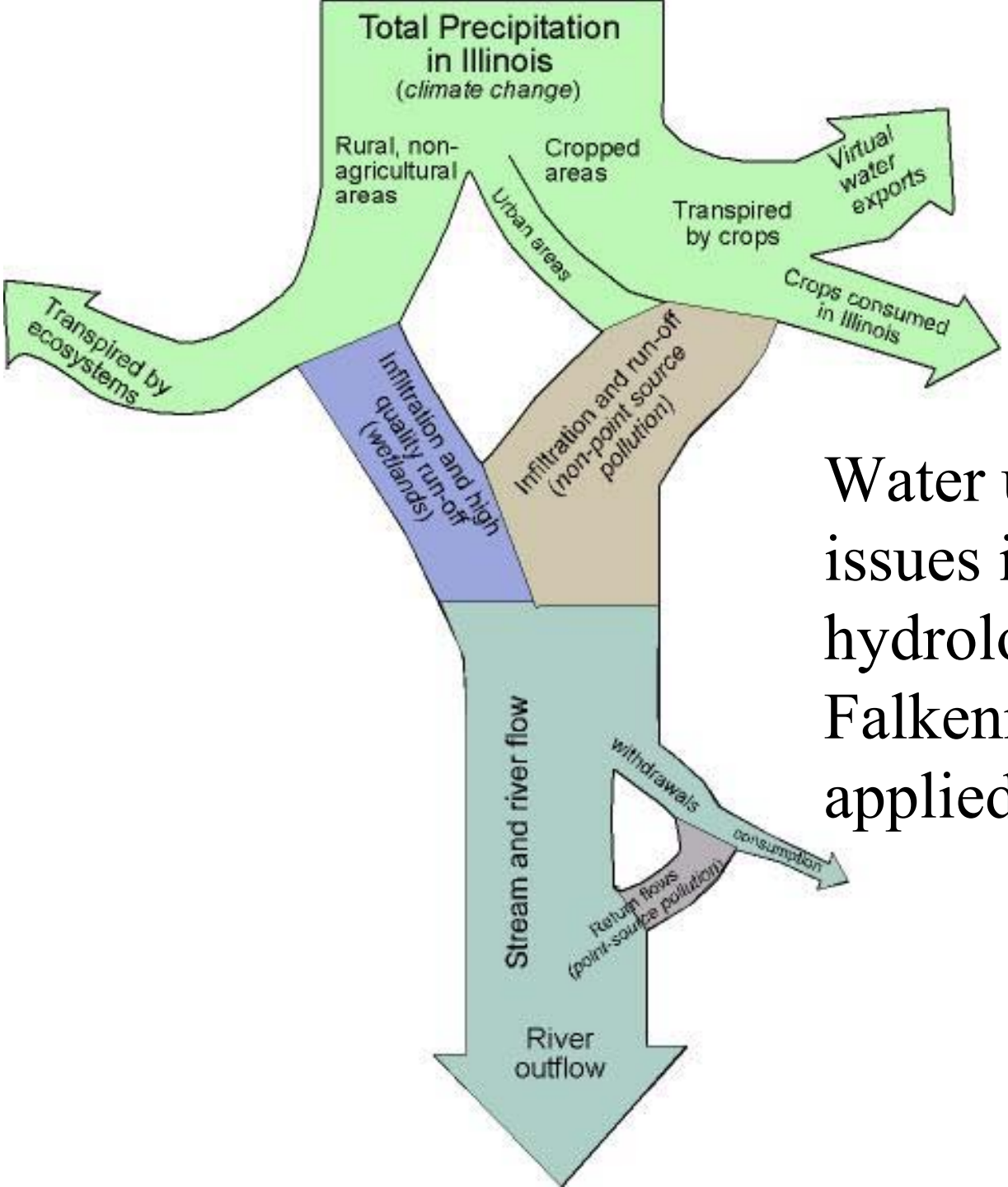


Adapted from: **Costanza, R., 2001. Visions, values, valuation, and the need for an ecological economics, *Ecological Economics* 51(6): 459-468.**

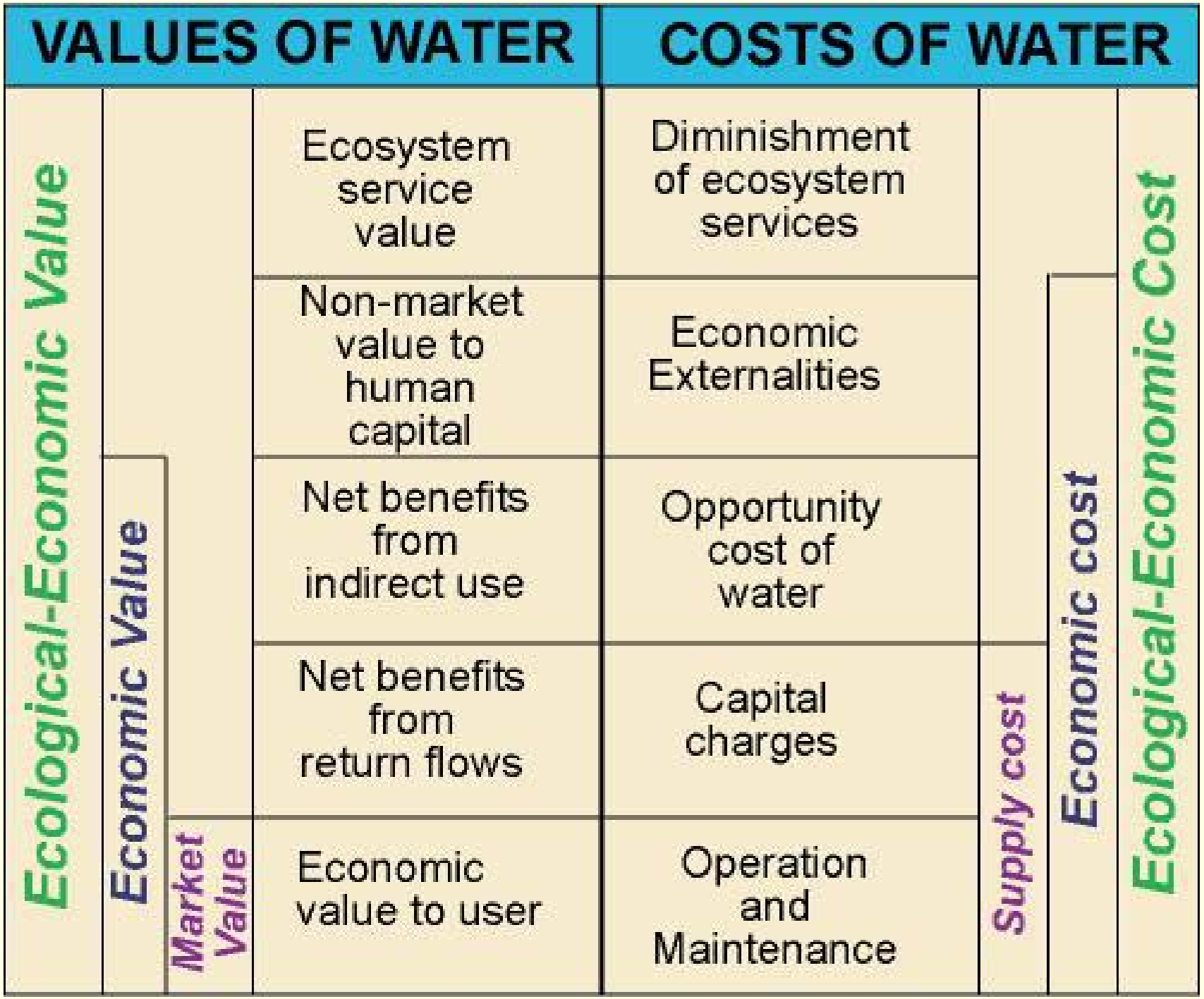
Water is the Most Critical Factor of Production of *Ecosystem Services*

Ecosystem Type	**$/ha/yr**
1) Estuaries	$22,832
2) Seagrass beds	$19,004
3) Swamps/floodplains	$19,580
4) Tidal marsh/mangroves	$ 9,990
5) Lakes/rivers	$ 8,498
6) Coral reefs	$ 6,095
7) Tropical rainforests	$ 2,007

Source: Costanza et al., 1997. The value of the world's ecosystem services and natural capital, *Nature* 387: 253-260.

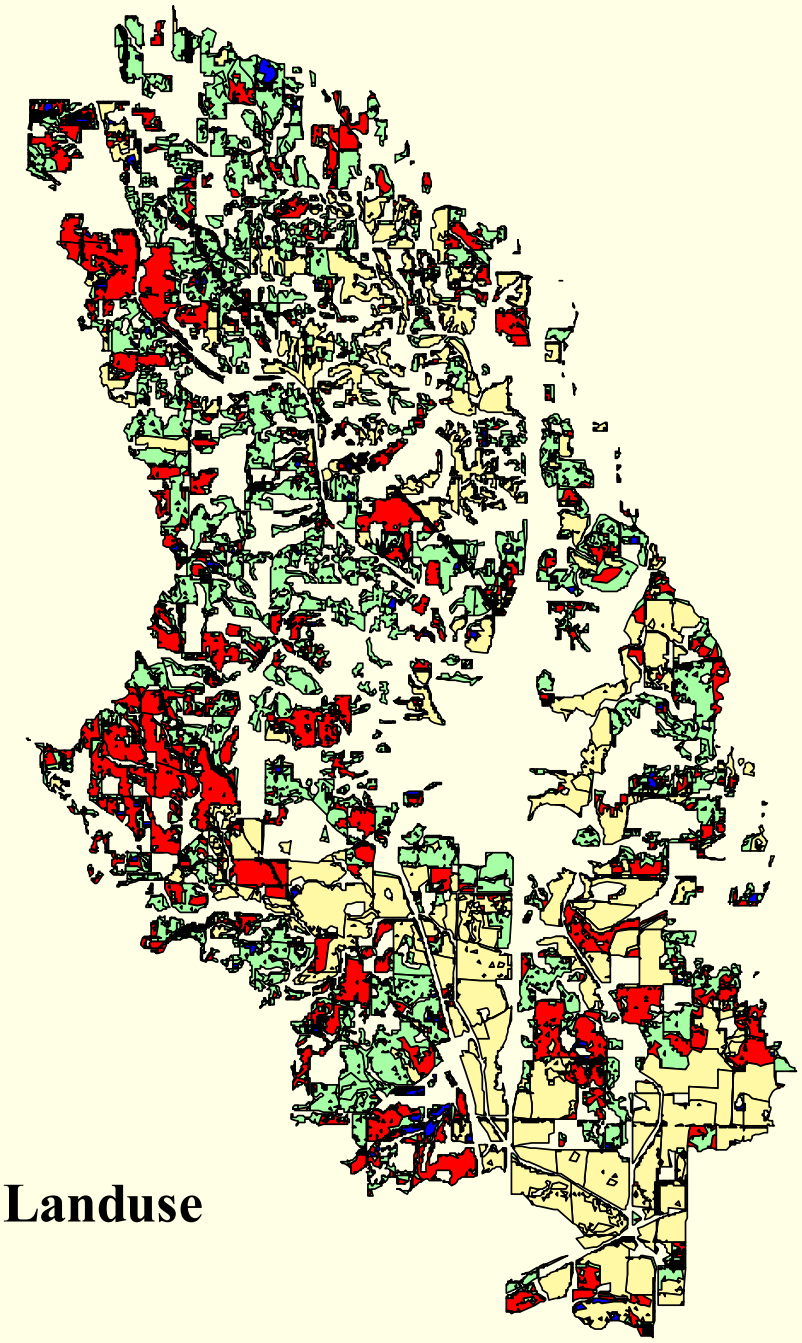


Water uses and policy issues in relation to the hydrologic cycle: The Falkenmark approach applied to Illinois


VALUES OF WATER
COSTS OF WATER
Ecological-Economic Value
Economic Value
Market Value
Ecosystem service value
Non-market value to human capital
Net benefits from indirect use
Net benefits from return flows
Economic value to user
Diminishment of ecosystem services
Economic Externalities
Opportunity cost of water
Capital charges
Operation and Maintenance
Supply cost
Economic cost
Ecological-Economic Cost

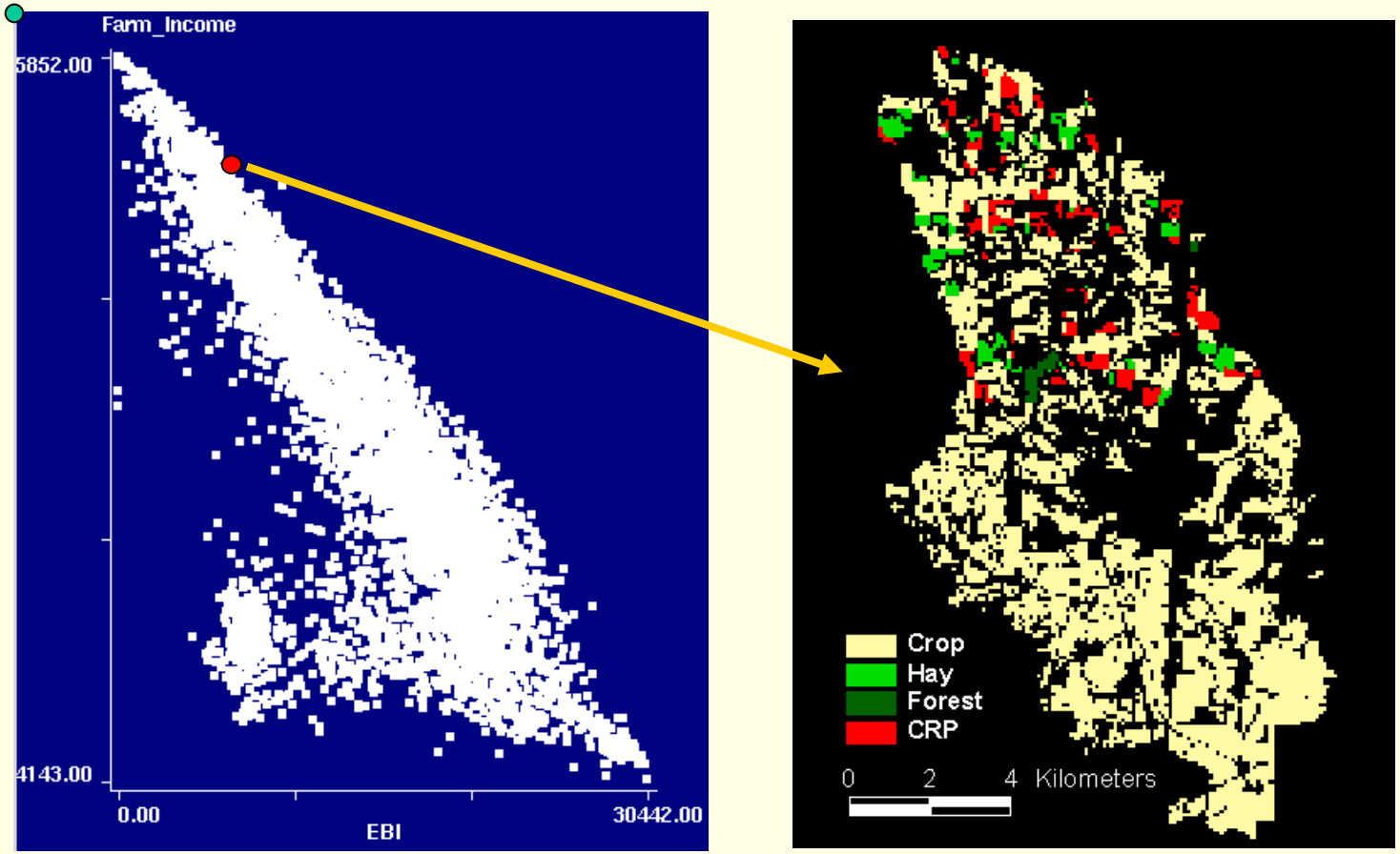
II. Developing analytical approaches to measure sustainability and evaluate management options

An example: Evaluating watersheds for their economic and ecosystem service production



Classified Landuse

Each point along the trade-off curve is a specific land use pattern and can be associated with the relative importance of alternative criteria.



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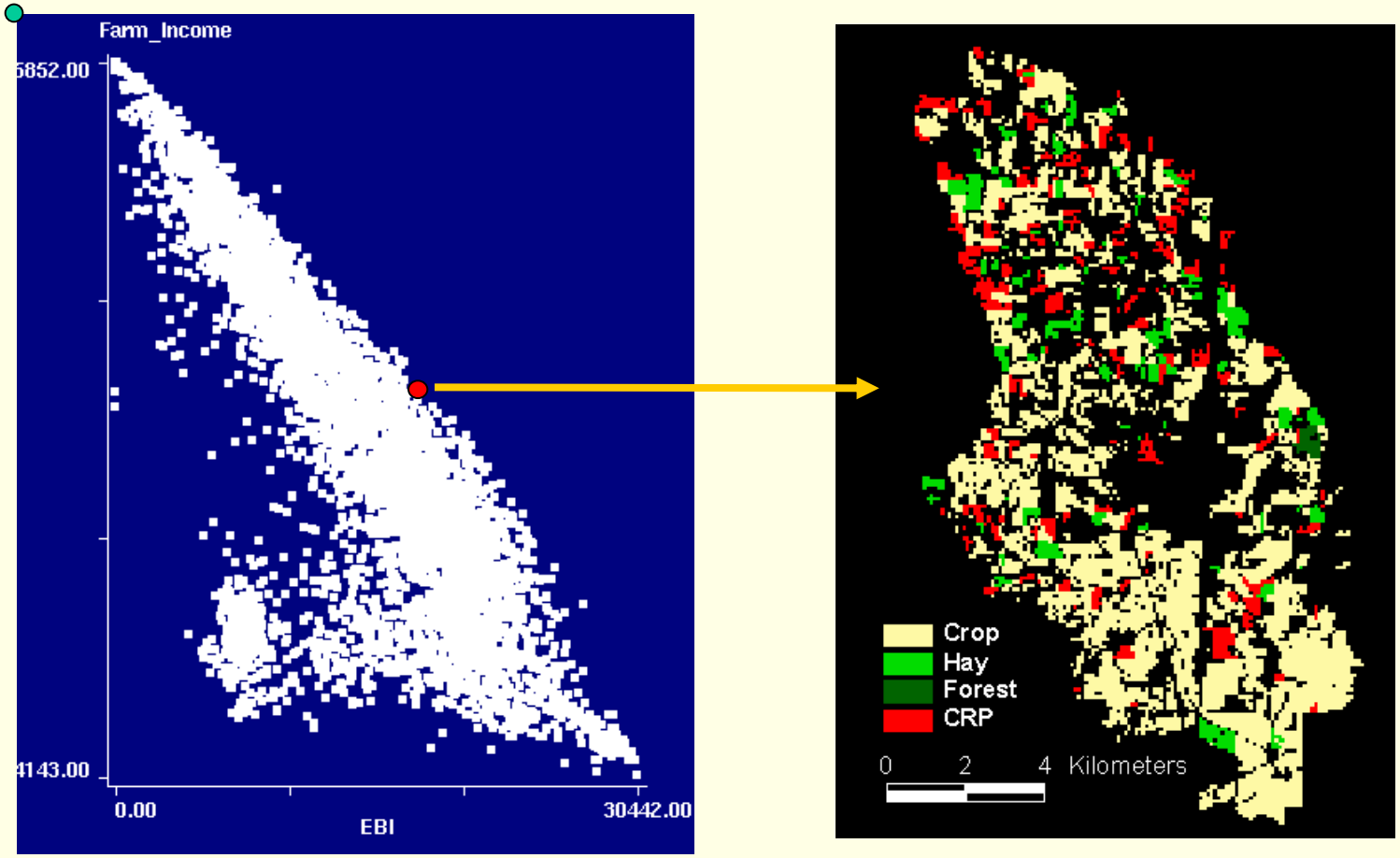

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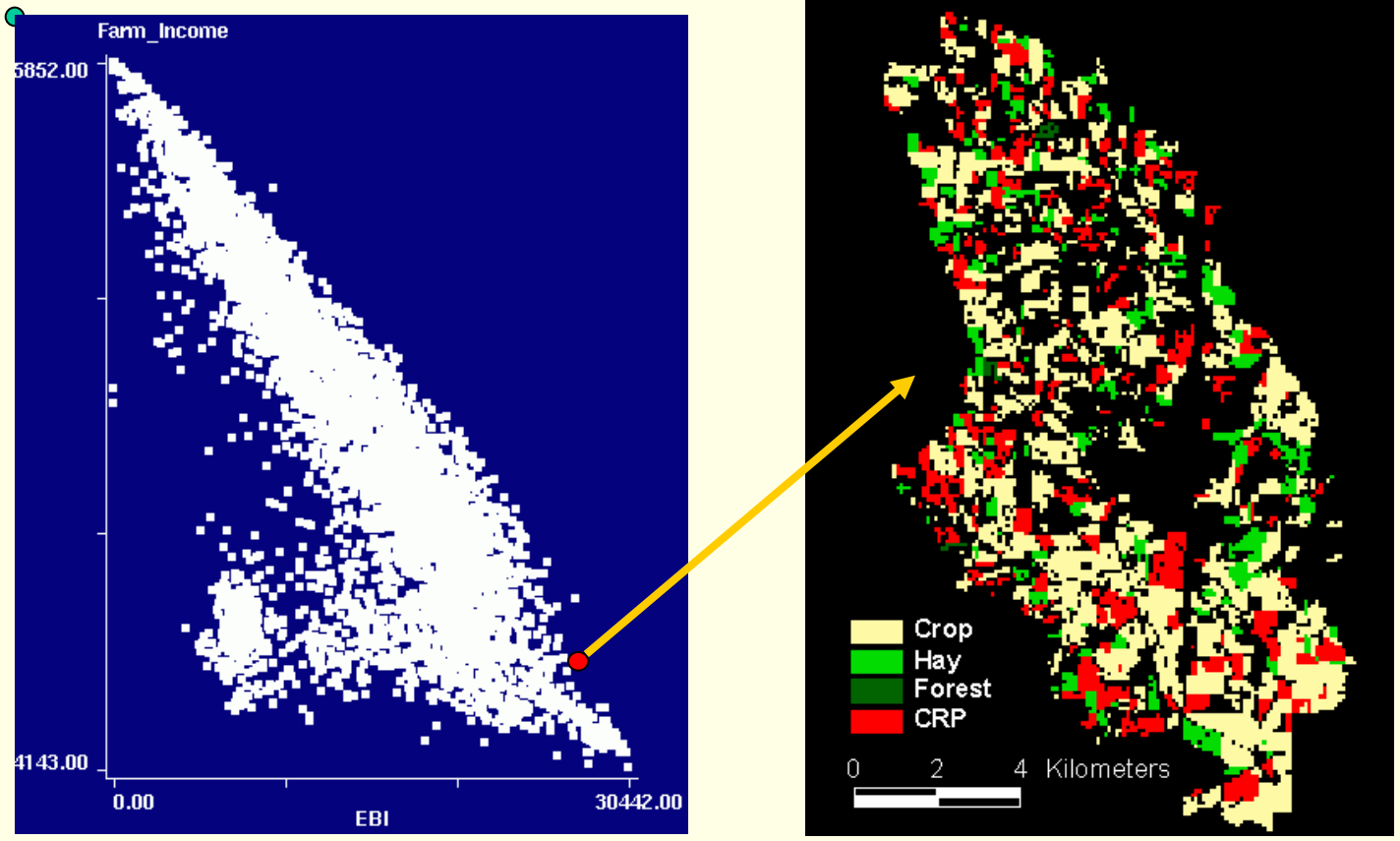
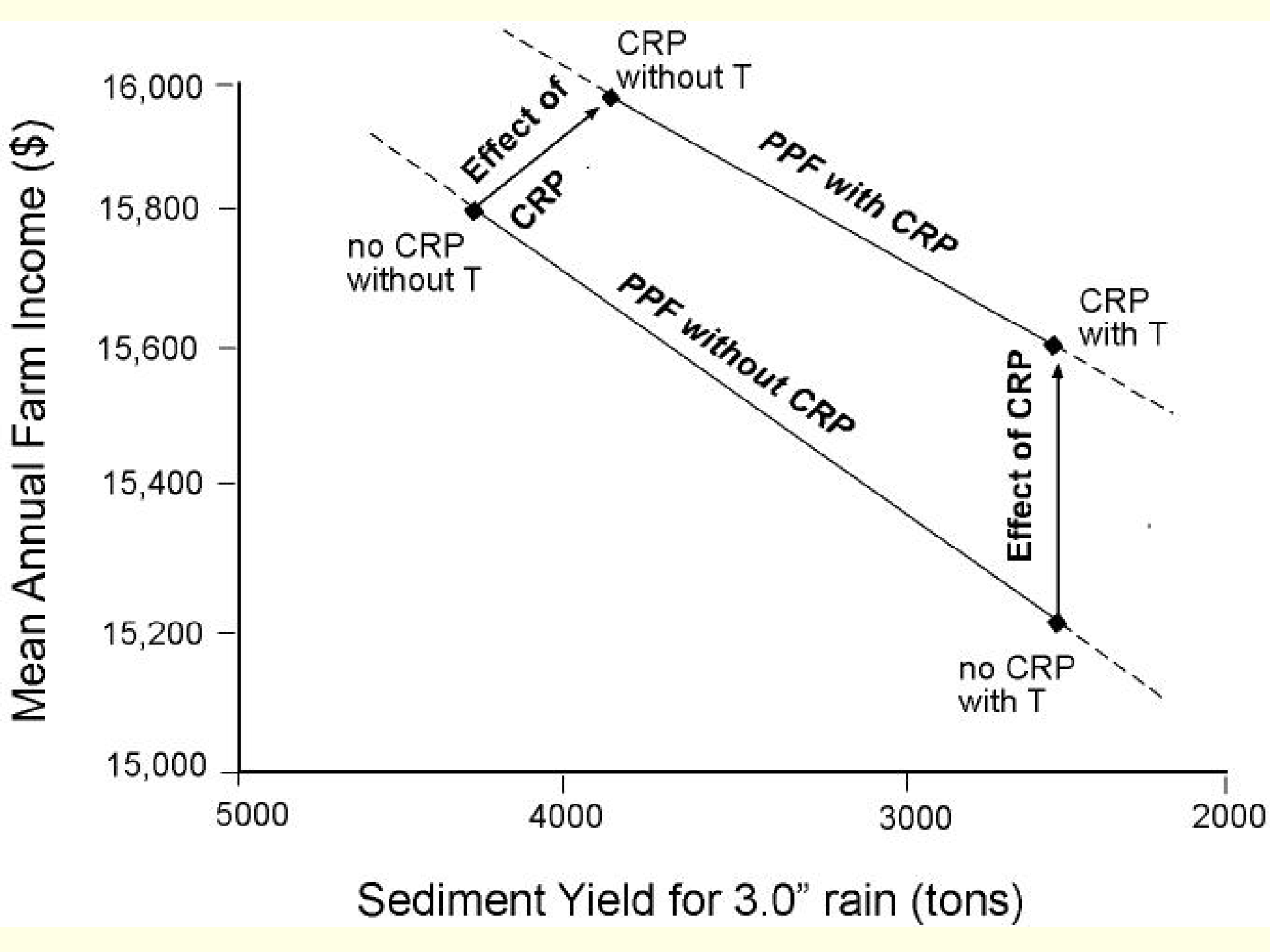



CRP
without T
Effect of
CRP
PPF with CRP
no CRP
without T
PPF without CRP
CRP
with T
Effect of CRP
no CRP
with T
16,000
15,800
15,600
15,400
15,200
15,000
Mean Annual Farm Income ($)
5000
4000
3000
2000
Sediment Yield for 3.0" rain (tons)

Research Questions and Hypotheses

Q: How do current landscapes perform relative to the PPF?

H: Current landscapes perform sub-optimally with respect to the PPF, but, due to reward systems inherent in historic decision environments, approach the PPF more closely for economic performance measures than for ecosystem services.

Research Questions and Hypotheses

Q: Can manipulation of discrete policy variables in an adaptive management framework improve the ecological performance of agricultural landscapes?

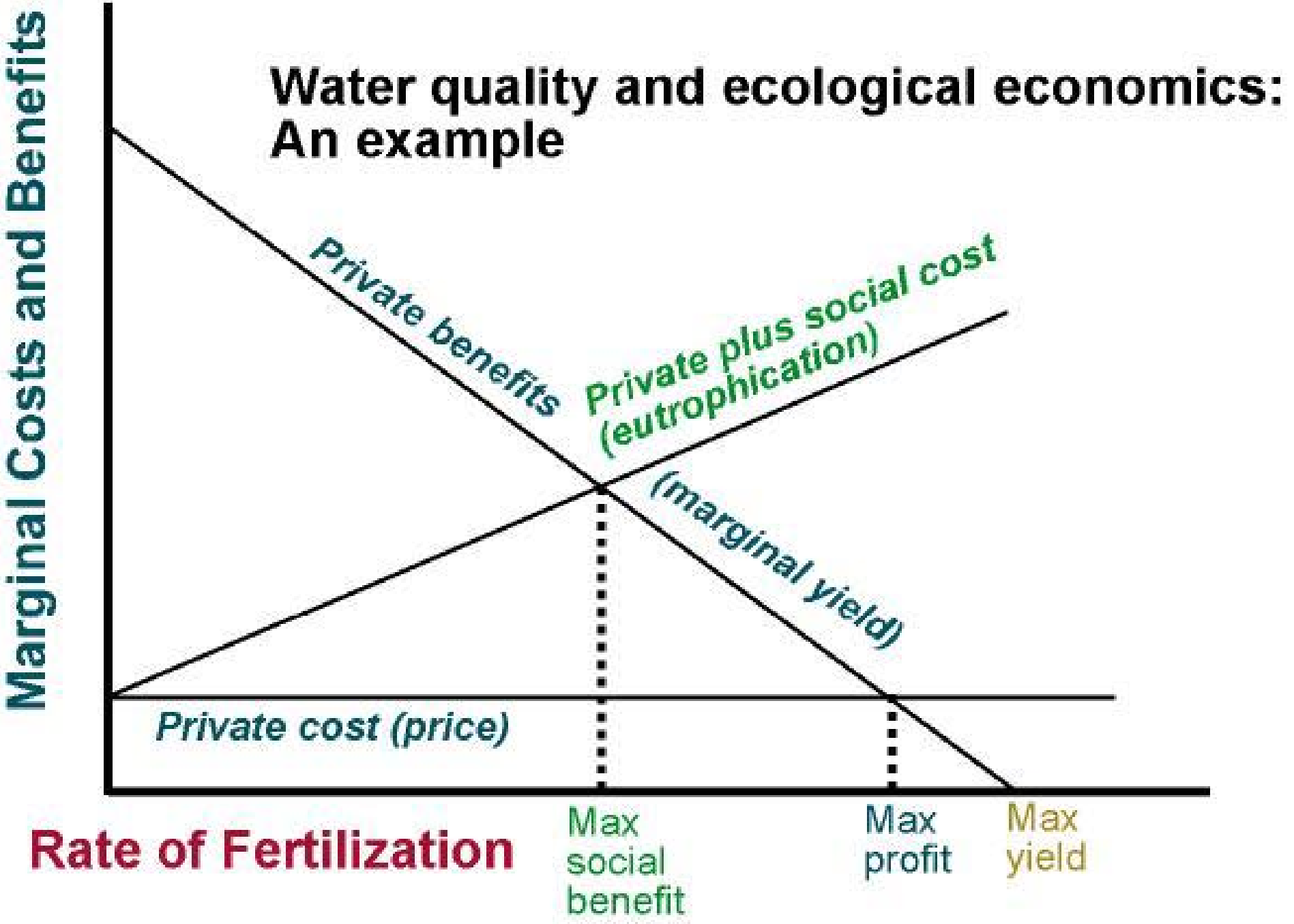
H: Greater economic incentives rewarding ecosystem service provision produce landscapes that perform closer to the PPF than empirical landscapes.

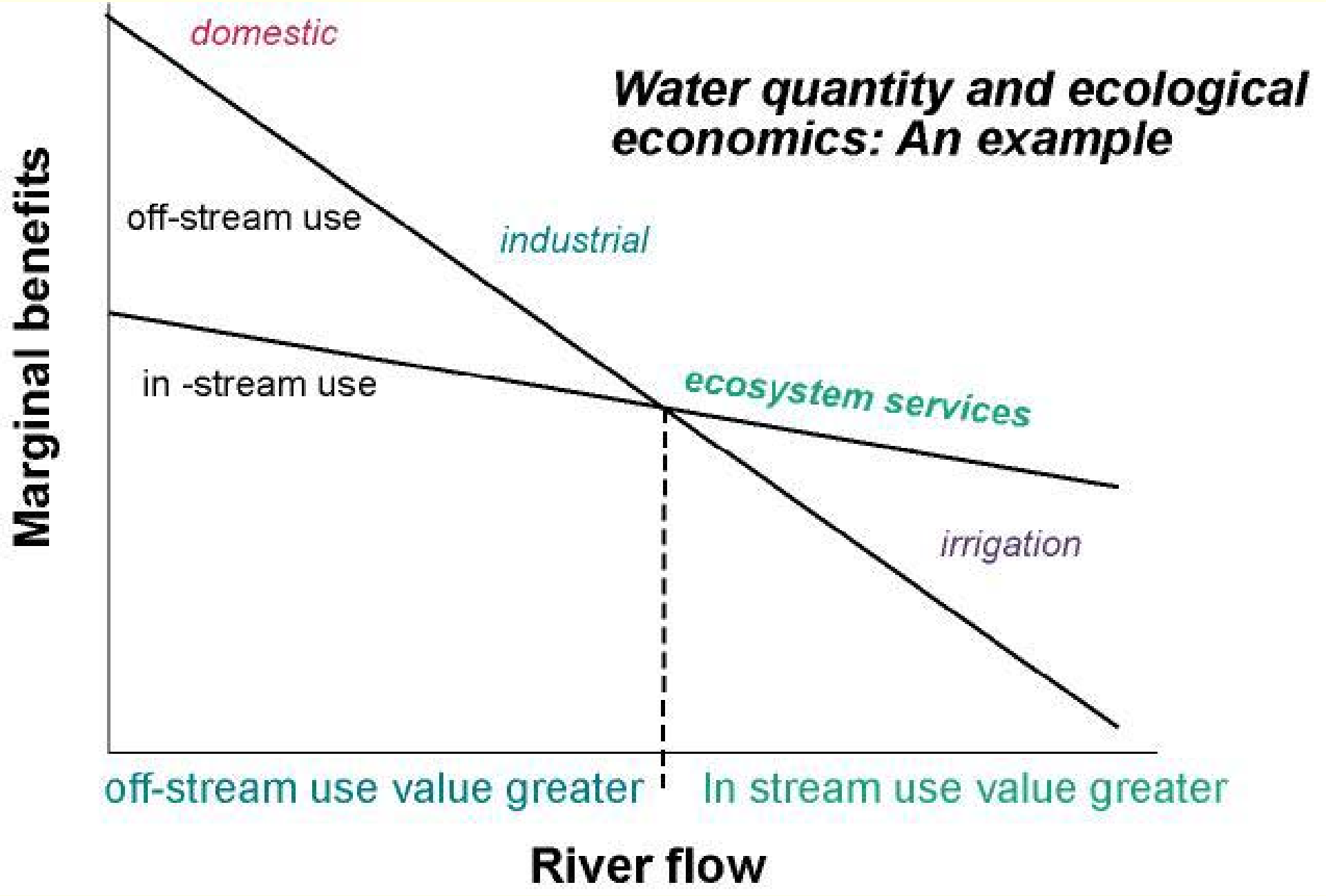
III. Managing Water Sustainably

How can we reform institutions and policies (social capital) governing water managers so that the aggregate effect of their behavior, under new decision-environments, better sustains natural capital and ecosystem service flows?

III An Ecological Economics Agenda for U.S. Water Management

- Making water prices reflect full ecological-economic cost
- Greatly improving irrigation efficiency
- Protecting in-stream flows
- Using agri-chemicals more prudently
- Producing ecosystem services at a watershed scale including ecological restoration
- Limiting groundwater depletion and protecting groundwater quality


Water quality and ecological economics:
An example
Marginal Costs and Benefits
Private benefits
Private plus social cost
(eutrophication)
(marginal yield)
Private cost (price)
Rate of Fertilization
Max
social
benefit
Max
profit
Max
yield

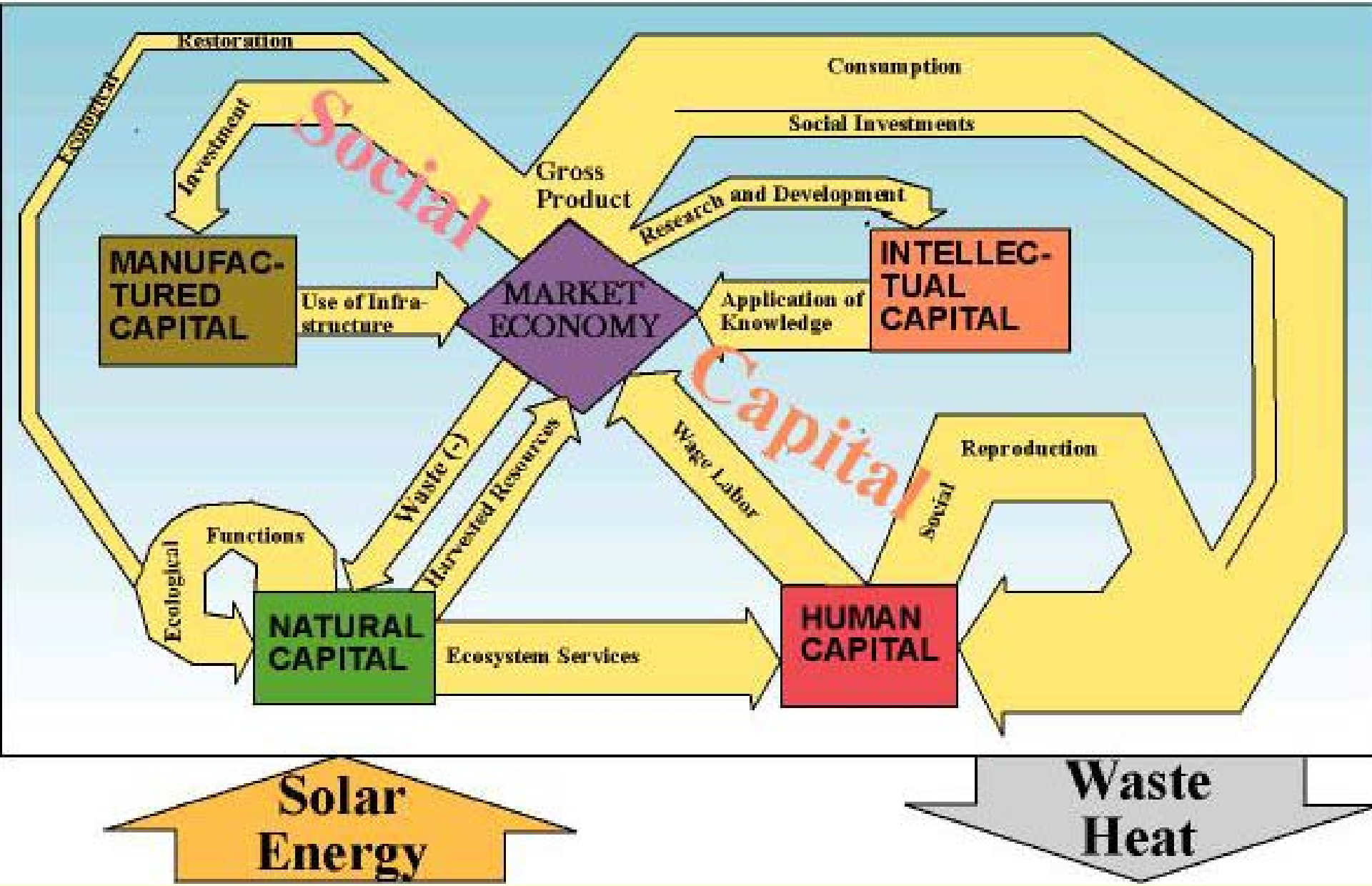

Water quantity and ecological economics: An example
Marginal benefits
domestic
off-stream use
industrial
in -stream use
ecosystem services
irrigation
off-stream use value greater
In stream use value greater
River flow

Ecological Economics' Contribution to Sustainability

1. A systems approach
2. The concepts of natural capital and ecosystem services.
3. The high value of ecosystem services

Ecological Economics: Needed Improvements

- Better understanding of how ecosystems deliver services to society
- Better measurement of full ecological-economic value of water:
marginal ecological opportunity cost
- Development of ecosystem service trade-off models that guide policy designs to achieve sustainability goals


Restoration
Consumption
Investment
Social
Social Investments
Gross Product
Research and Development
MANUFAC-TURED CAPITAL
Use of Infra-structure
MARKET ECONOMY
Application of Knowledge
INTELLEC-TUAL CAPITAL
Capital
Waste (-)
Harvested Resources
Wage Labor
Reproduction
Social
Ecological Functions
NATURAL CAPITAL
Ecosystem Services
HUMAN CAPITAL
Solar Energy
Waste Heat

Questions?