



Ecosystem Services: An Overview

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Outline

- ✧ Findings from the Millennium Ecosystem Assessment
- ✧ Indicators from State of the Nations Ecosystems
- ✧ Change is the thing
- ✧ Research Conundrum



Ecosystems

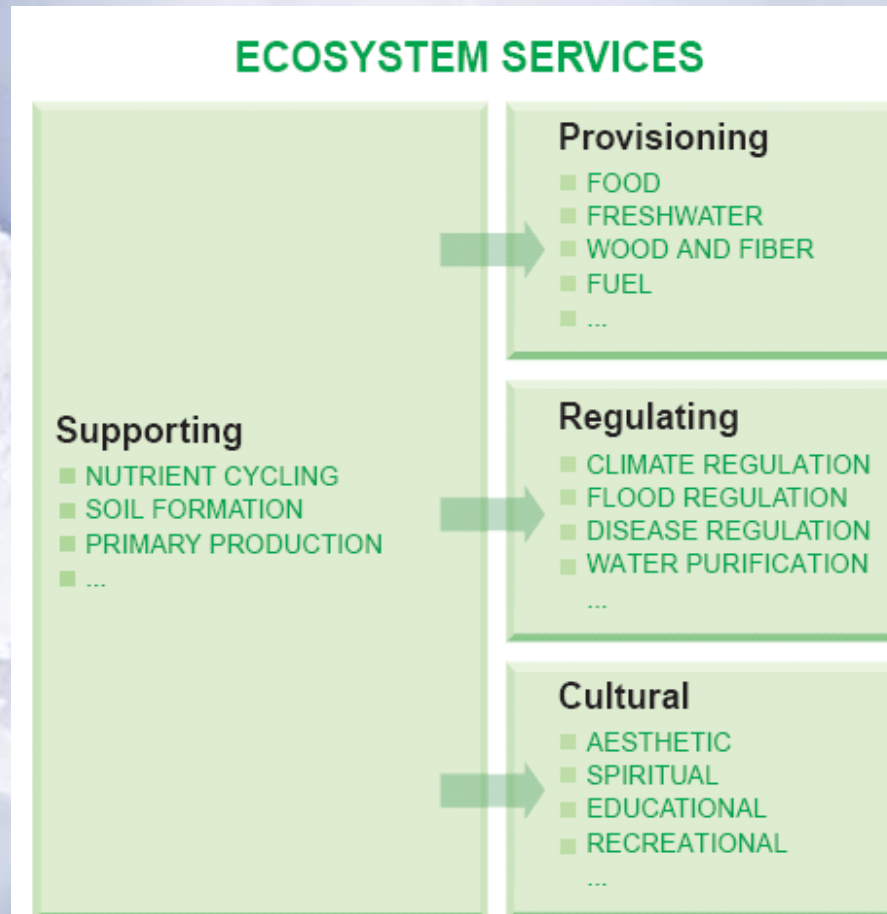
- ✧ Biological communities and their physical environment
- ✧ Scale is a function of the intent of the analysis
- ✧ People and infrastructure should be thought of as part of ecosystems, not apart from them



Ecosystem Services

- ✧ Work, or functioning, that ecosystems do from which we benefit
- ✧ Benefit can be direct or indirect
- ✧ An unabashedly anthropocentric concept at its core
- ✧ Originally articulated to point out that there are things that ecosystems provide that we depend on, but do not pay for (until we have to replace them)
- ✧ This concept has grown to recognize that services can be either outside or inside of existing markets

Millennium Assessment Focus: Ecosystem Services- Benefits obtained from ecosystems





MA Finding #1

- ✧ Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history
- ✧ This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth



Unprecedented change: Ecosystems

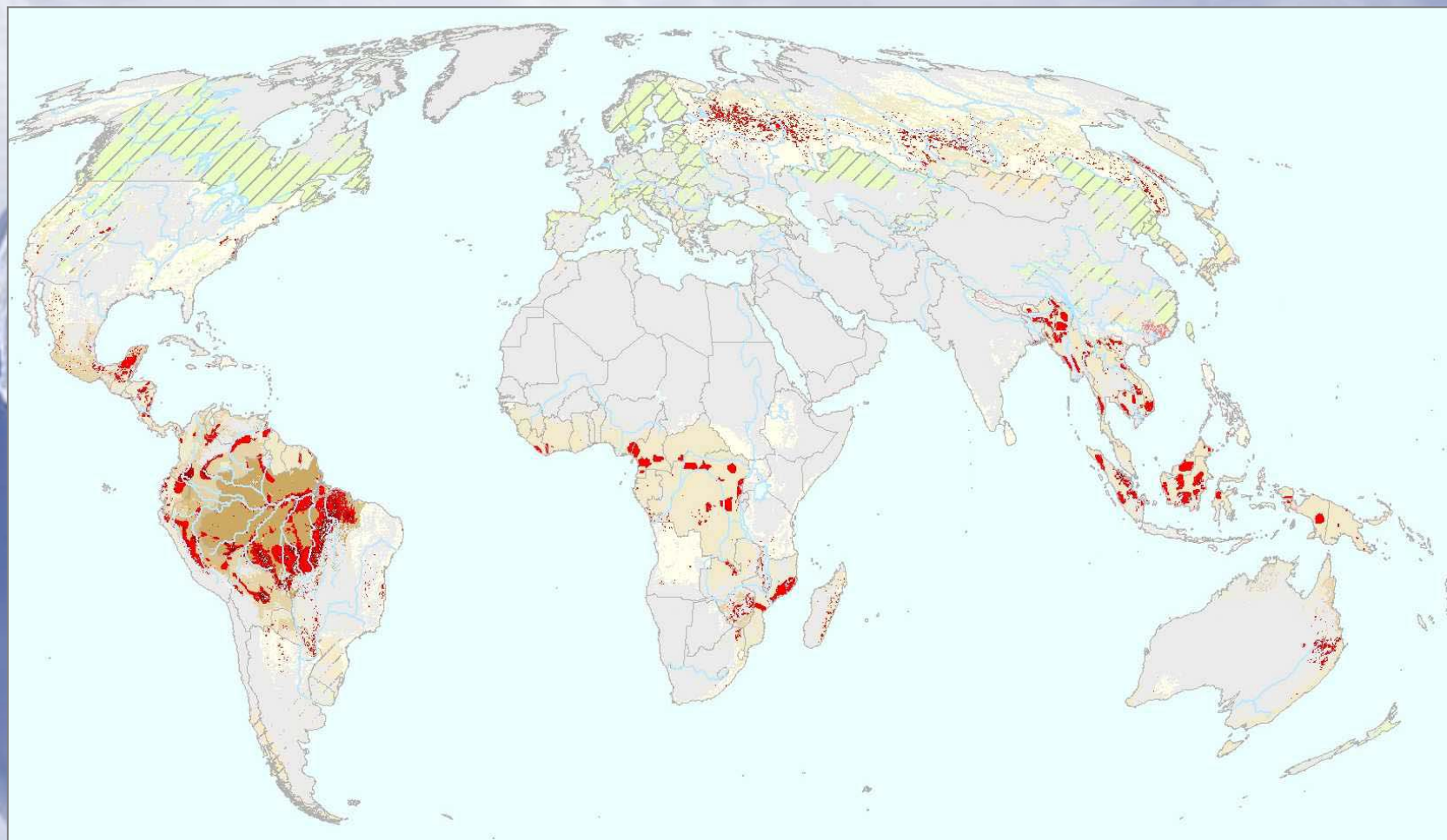
- ✧ More land was converted to cropland since 1945 than in the 18th and 19th centuries combined
- ✧ 20% of the world's coral reefs were lost and 20% degraded in the last several decades
- ✧ 35% of mangrove area has been lost in the last several decades
- ✧ Amount of water in reservoirs quadrupled since 1960
- ✧ Withdrawals from rivers and lakes doubled since 1960



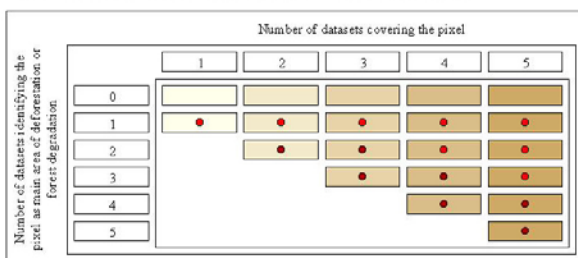
Land-Cover and Land-Use Change

- ✧ Perhaps the most consequential human-driven change of Earth's important characteristics
 - ✧ About half of original forest area converted to agricultural production
 - ✧ Roughly doubled the amount of biologically available nitrogen
 - ✧ Increases in atmospheric concentrations of CO₂
 - ✧ Biggest contribution to loss of biological diversity

Figure 1: Main areas of deforestation and forest degradation over the last twenty years (1980-2000)

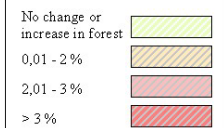


Forest covered by one or more studies based on remote sensing data or expert opinion



Forest covered only by national statistics

Average annual deforestation rate



Unforested areas





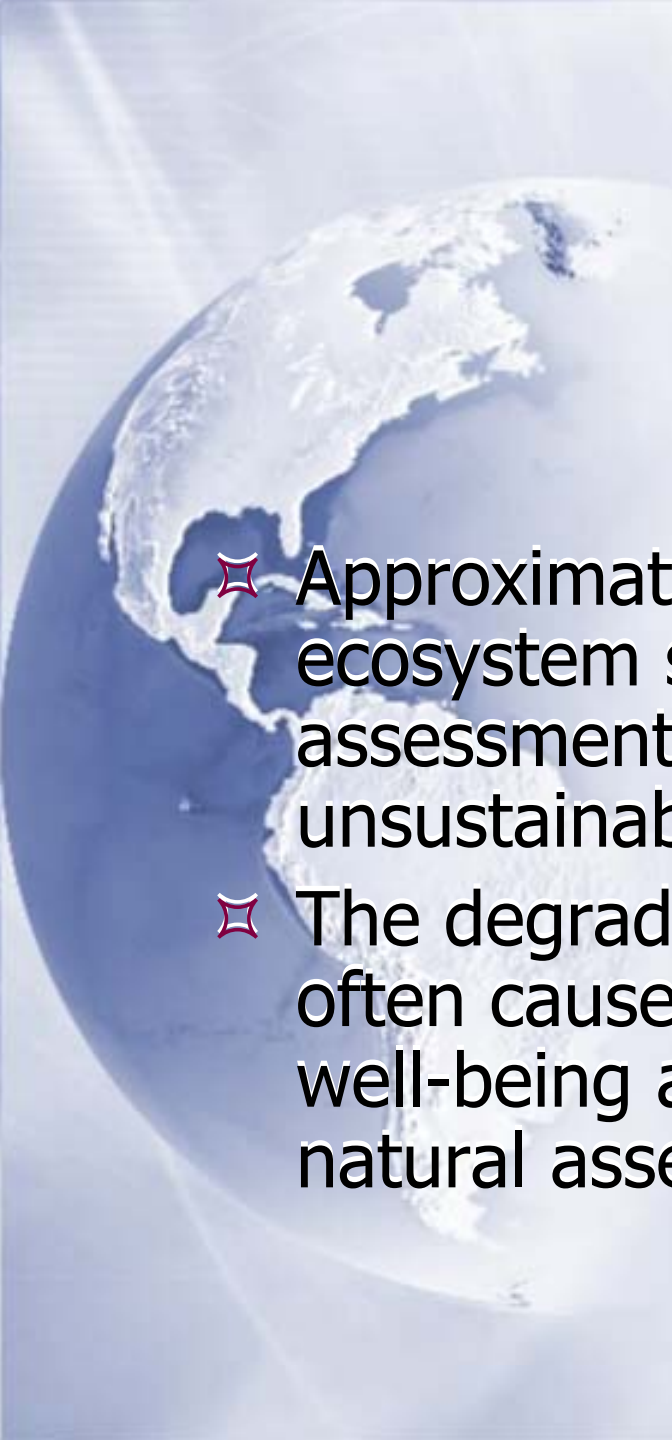
Implications

- ❖ Rationale emphasized documentation of services for purpose of understanding tradeoffs
- ❖ This is possible for some tradeoffs:
 - ❖ Increase in timber production against carbon sequestration potential
 - ❖ Increase in agricultural output against a variety of other ecosystem services
- ❖ Not possible for others because of lack of information on state, even though we understand processes



MA Finding #2

- ✧ The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development
 - ✧ Since 1960, while population doubled and economic activity increased 6-fold, food production increased 2 1/2 times, food price has declined, water use doubled, wood harvest for pulp tripled, hydropower doubled.
- ✧ But these gains have been achieved at growing costs that, unless addressed, will substantially diminish the benefits that future generations obtain from ecosystems



Degradation and unsustainable use of ecosystem services

- ✧ Approximately 60% (15 out of 24) of the ecosystem services evaluated in this assessment are being degraded or used unsustainably
- ✧ The degradation of ecosystem services often causes significant harm to human well-being and represents a loss of a natural asset or wealth of a country

Direct drivers growing in intensity

		Habitat change	Climate change	Invasive species	Over-exploitation	Pollution (nitrogen, phosphorus)
Forest	Boreal	↗	↑	↗	→	↑
	Temperate	↘	↑	↑	→	↑
	Tropical	↑	↑	↑	↗	↑
Dryland	Temperate grassland	↗	↑	→	→	↑
	Mediterranean	↗	↑	↑	→	↑
	Tropical grassland and savanna	↗	↑	↑	→	↑
	Desert	→	↑	→	→	↑
Inland water	↑	↑	↑	→	↑	
Coastal	↗	↑	↗	↗	↑	
Marine	↑	↑	→	↗	↑	
Island	→	↑	→	→	↑	
Mountain	→	↑	→	→	↑	
Polar	↗	↑	→	↗	↑	

✧ Most direct drivers of degradation in ecosystem services remain constant or are growing in intensity in most ecosystems

RESULT OF PAST EVOLUTION

Driver's impact on biodiversity over the last century

Low	□
Moderate	□
High	□
Very high	□

WHAT HAPPENS TODAY

Driver's actual trends

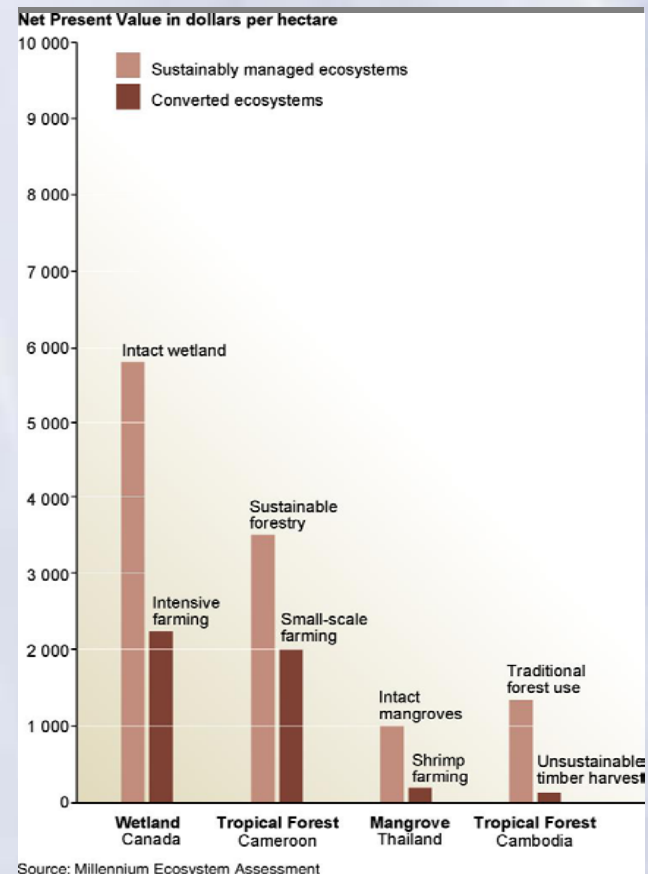
Decreasing impact	↘
Continuing impact	→
Increasing impact	↗
Very rapid increase of the impact	↑

Source: Millennium Ecosystem Assessment

Degradation of ecosystem services often causes significant harm to human well-being

✧ The total economic value associated with managing ecosystems more sustainably is often higher than the value associated with conversion

✧ Conversion may still occur because private economic benefits are often greater for the converted system





The degradation of ecosystem services represents loss of a capital asset

- ✧ Loss of wealth due to ecosystem degradation is not reflected in economic accounts
 - ✧ Ecosystem services, as well as resources such as mineral deposits, soil nutrients, and fossil fuels are capital assets
 - ✧ Traditional national accounts do not include measures of resource depletion or of the degradation of these resources
 - ✧ A country could cut its forests and deplete its fisheries, and this would show only as a positive gain in GDP without registering the corresponding decline in assets (wealth)
 - ✧ A number of countries that appeared to have positive growth in net savings (wealth) in 2001 actually experienced a loss in wealth when degradation of natural resources were factored into the accounts

The State of The Nation's Ecosystems

Measuring the
Lands, Waters, and
Living Resources of
the United States

THE H. JOHN HEINZ III CENTER FOR
SCIENCE, ECONOMICS AND THE ENVIRONMENT

THE
HEINZ
CENTER

Coasts and
Oceans



Farmlands



Forests



Fresh Waters



Grasslands and
Shrublands



Urban and
Suburban Areas



SYSTEM DIMENSIONS

●	Total Cropland	How much land is used directly for production of crops and livestock?	Trends
●	The Farmland Landscape	How much of the farmland landscape is forest, grasslands and shrublands, wetlands, or urban and suburban?	Current data only, regional comparison
⊖	Fragmentation of Farmlands Landscapes by Development	How intermingled are croplands and urban and suburban development?	No data reported
⊖	Shape of "Natural" Patches in the Farmland Landscape	How much of the "natural" area in farmlands is in patches of different shapes?	No data reported

CHEMICAL AND PHYSICAL CONDITIONS

●	Nitrate in Farmland Streams and Groundwater	How much nitrate is there in farmland streams and groundwater?	Current data only, federal standard, cross-ecosystem comparison
●	Phosphorus in Farmland Streams	How much phosphorus is there in farmland streams?	Current data only, federal guideline, cross-ecosystem comparison
●	Pesticides in Farmland Streams and Groundwater	How many pesticides are found in farmland streams and groundwater, and how often do they exceed federal standards and guidelines?	Current data only, federal standards and guidelines
⊖	Soil Organic Matter	How much organic matter is there in cropland soils?	No data reported
●	Soil Erosion	How much cropland is subject to erosion by wind or water?	Trends, national map
⊖	Soil Salinity	How much cropland soil has high salt levels?	No data reported

What Indicators Are Used To Describe Farmlands?

Can we report trends? Are there other useful reference points?

BIOLOGICAL COMPONENTS

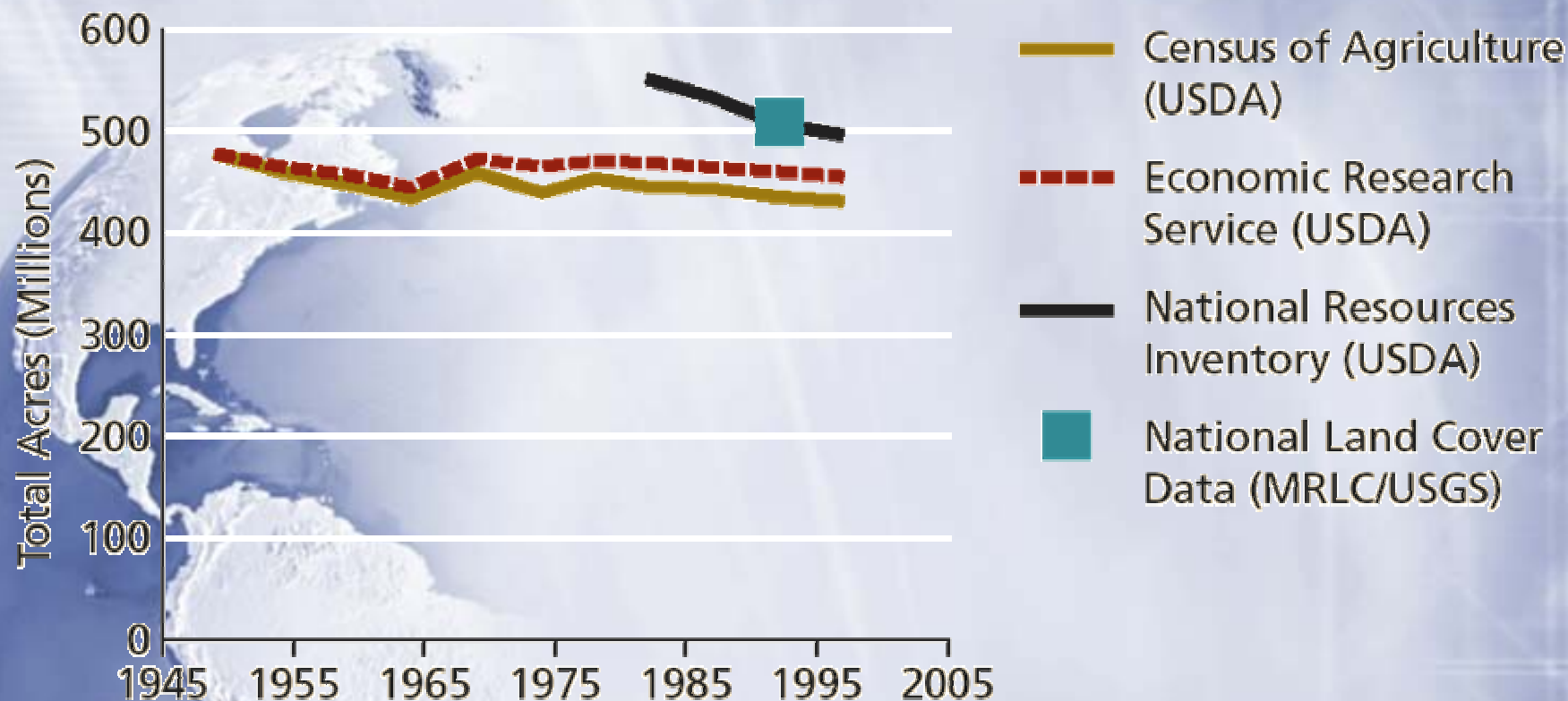
⊖	Soil Biological Condition	What is the condition of the microscopic animal communities in cropland soils?	No data reported
?	Status of Animal Species in Farmlands Areas	What is the condition of wildlife in areas that are heavily dominated by farmlands?	No data reported
?	Native Vegetation in Areas Dominated by Croplands	In areas that are heavily dominated by croplands, is most of the remaining non-cropland vegetation native or non-native?	No data reported
?	Stream Habitat Quality	What is the quality of the habitat in farmland streams?	No data reported

HUMAN USES

●	Major Crop Yields	How has the per-acre yield of major crops changed over time?	Trends
●	Agricultural Inputs and Outputs	How have farm output and the inputs (pesticides, fertilizers, labor, land, etc.) needed to produce that output, changed over time?	Trends
●	Monetary Value of Agricultural Production	What is the value of the nation's production of crops and livestock?	Trends, national map
⊖	Recreation on Farmlands	How much recreation takes place on farmlands?	No data reported

● All Necessary Data Available
 ◐ Partial Data Available
 ⊖ Data Not Adequate for National Reporting
 ? Indicator Development Needed

Cropland Estimates



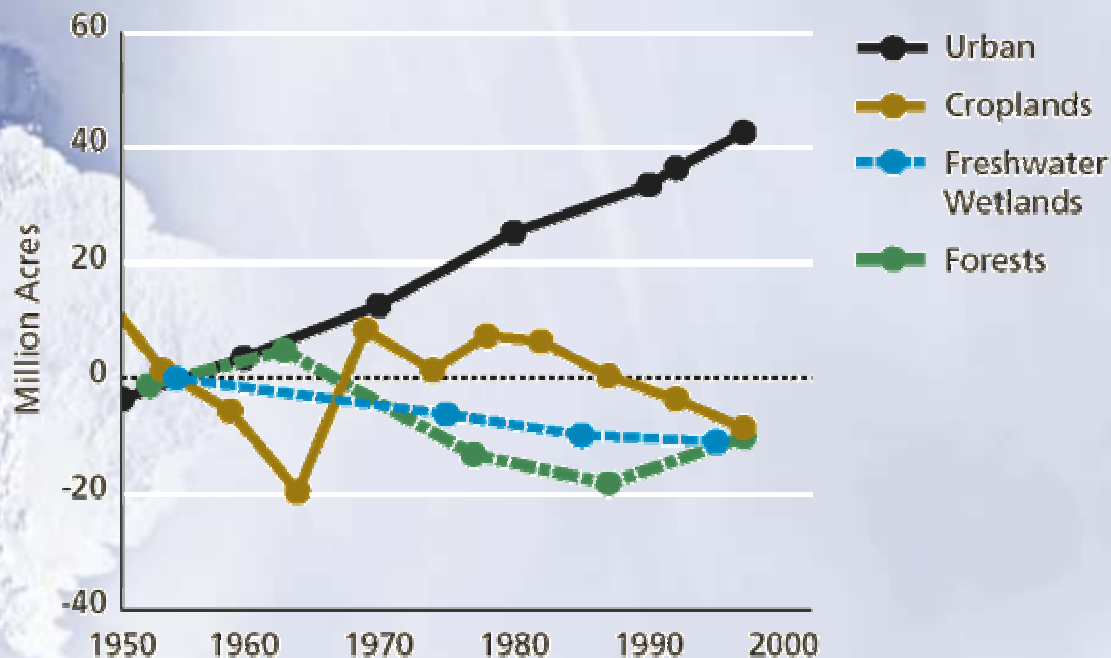
Data Source: USDA National Resources Conservation Service, National Resources Inventory (NRI) program; USDA National Agricultural Statistical Service, Census of Agriculture; USDA Economic Research Service (ERS); Multi-Resolution Land Characterization Consortium (MRLC) and the U.S. Geological Survey. Coverage: lower 48 states. Conservation Reserve Program acreage has been removed from all but the ERS data set; also, some CRP lands may be included in the National Land Cover Data.

Change in Ecosystem Area (Compared to 1955)

Data Not Adequate for National Reporting on

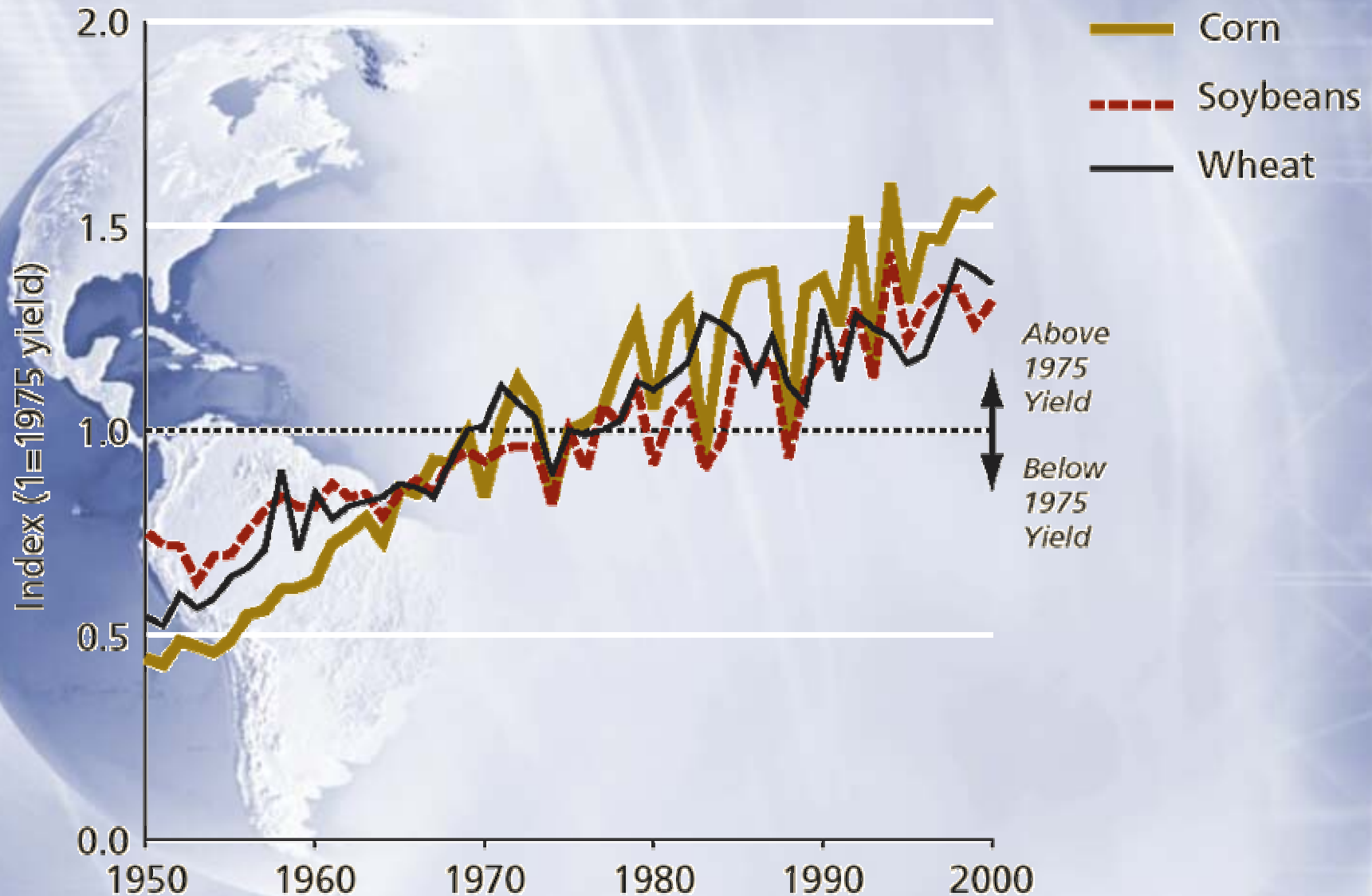
■ Extent of brackish coastal waters

Partial Indicator Data: Forests, Croplands, Grasslands/ Shrublands, Urban/Suburban, Freshwater Wetlands



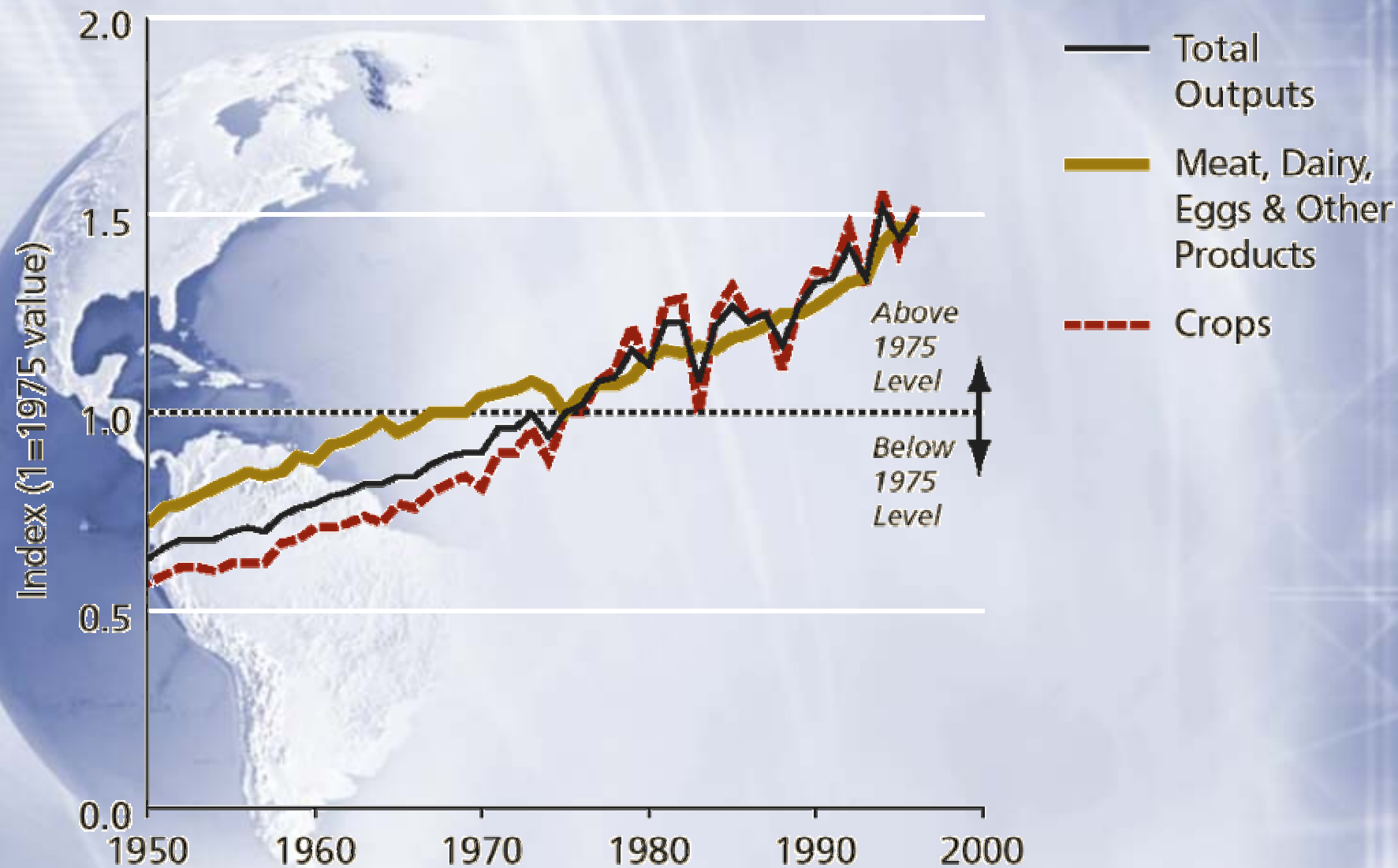
Data Source: USDA Forest Service (forest trends), USDA Economic Research Service (cropland and urban area trends), U.S. Fish and Wildlife Service (FWS, freshwater wetlands trends). Coverage: lower 48 states.

Crop Yields: Corn, Soybeans, and Wheat



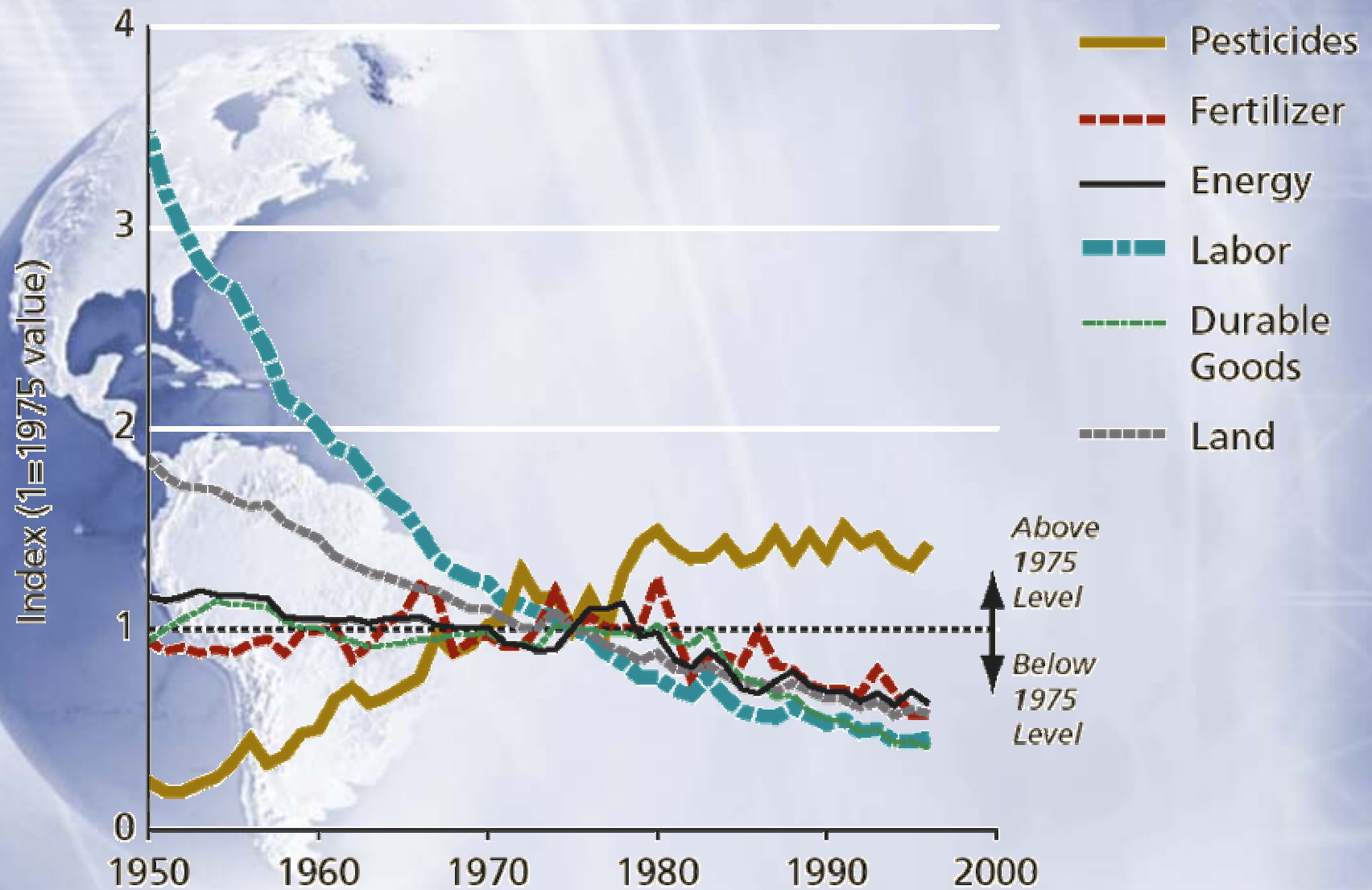
Data Source: USDA National Agricultural Statistics Service. Coverage: all 50 states.

Agricultural Outputs



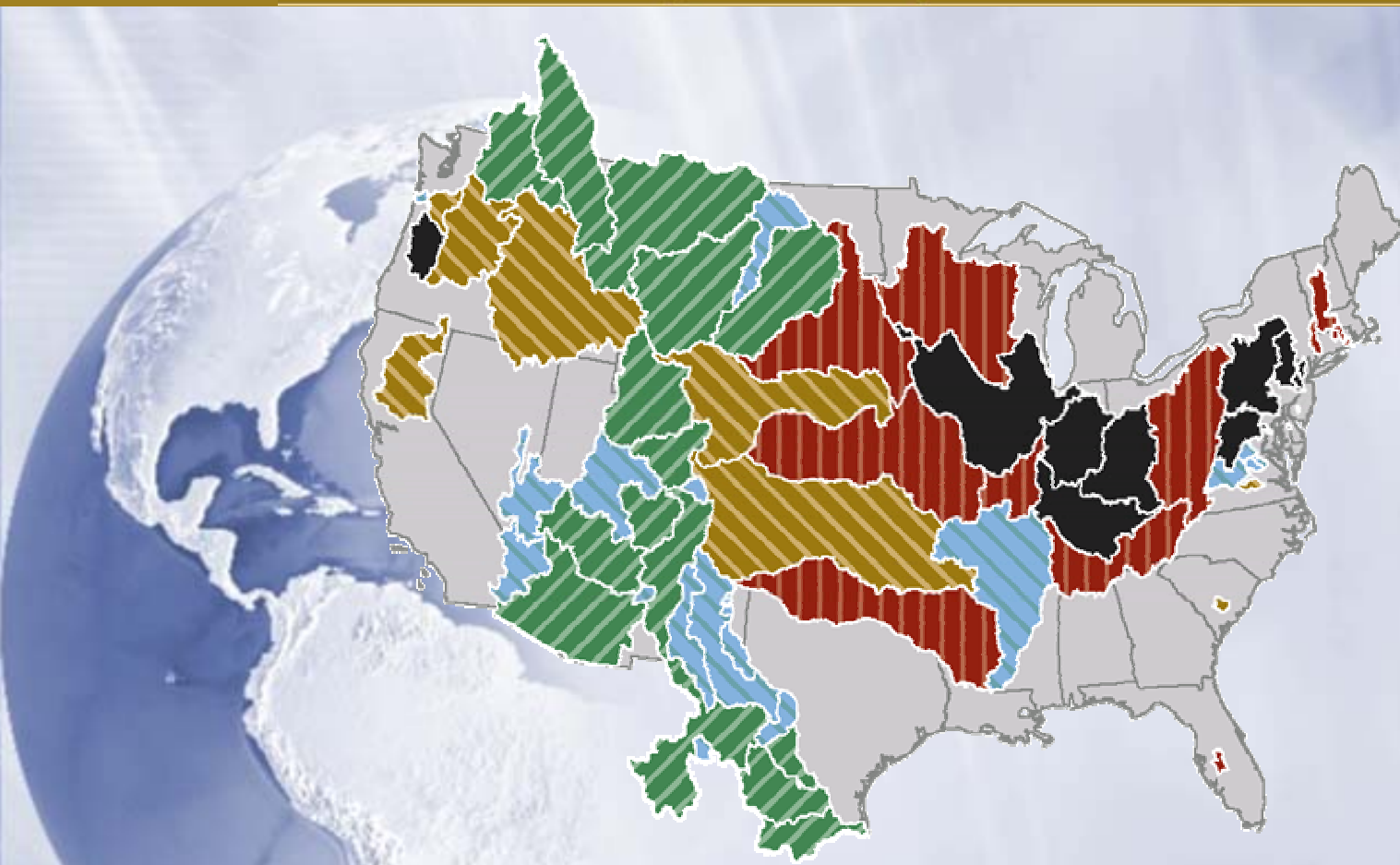
Data Source: USDA Economic Research Service. Coverage: all 50 states.

Agricultural Inputs per Unit of Output



Data Source: USDA Economic Research Service. Coverage: all 50 states.

Yield of Total Nitrogen from Major Watersheds (1996–1999)



Total Nitrogen (pounds of nitrogen per sq. mile per year)



Data Source: U.S. Geological Survey National Stream Quality Network (NASQAN), National Water Quality Assessment (NAWQA), and Federal–State Cooperative Program. Coverage: selected areas of lower 48 states.



Are We Showing Ecosystem Services?

- ✧ Process not set up that way
- ✧ But identification and consensus on indicators is explicitly a value-laden process
- ✧ Saying what it is that broad spectrum of stakeholders value about ecosystems
- ✧ So in fact, much of what we report is consistent with notion of services



Change is the Thing

- ✧ Can certainly document the big tradeoffs: agricultural productivity vs. carbon storage (globally)
- ✧ Agricultural productivity vs. availability of fresh water for other uses
- ✧ But documentation on smaller, more detailed scales is difficult, even when we are confident about underlying processes



*Implications for Research
and a Conundrum*



Implications for Research

- ✧ Need to be able to document change - periodic snapshots of state of ecosystems (and their processes) not good enough
- ✧ Need process-level understanding of tradeoffs and balance sheet
- ✧ Consistently derived time series are absolutely crucial



Research Conundrum

- ✧ Capacity to make the measurements is growing - technological advancements in observations, data management and sharing, modeling
- ✧ Commitment to make the measurements and share the information is shrinking - GAO findings
- ✧ Suggests we have a major research problem - need to shore up the infrastructure at same time as pursue the new science