Natural Capital and Ecosystem Services for Economic and Financial Analysis

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Disclaimer: The views presented are those of the authors and do not represent the views of the Federal Reserve Board, the National Oceanic & Atmospheric Administration, or any other groups.

Outline

- What are natural capital and ecosystem services?
- Applications in economic and financial analysis – why does natural capital matter?
- Natural capital and climate change
- Statistical measurement and models

What is natural capital?

- Natural capital: Environmental asset that provides a flow of services used in production or consumption
- Examples
  - Lakes, rivers, oceans
  - Forests, prairies, wetlands
  - Intact soils
  - Mineral deposits
  - Breathable air

Source: https://greatecology.com/portfolio-item/brooklyn-bridge-park/

What are ecosystem services?

- Flow of environmental services from natural capital
- Categories:
  - Provisioning – Pollination, seed dispersal, soil fertility renewal
  - Regulating – Waste decomposition, air/water purification, mitigation of heat, floods, and droughts, biodiversity support
  - Cultural – Benefits to cultures derived from human adaptation to local environment, aesthetic beauty, enjoyment
- See Daily et al. 1997

Types of ecosystem services

Theme	Class	Group
Provisioning	Nutrition	Terrestrial plant and animal foodstuffs
		Freshwater plant and animal foodstuffs
		Marine plant and animal foodstuffs
		Potable water
	Materials	Biotic materials
		Abiotic materials
	Energy	Renewable biofuels
		Renewable abiotic energy sources
Regulation and Maintenance	Regulation of wastes	Bioremediation
		Dilution and sequestration
	Flow regulation	Air flow regulation
		Water flow regulation
		Mass flow regulation
	Regulation of physical environment	Atmospheric regulation
		Water quality regulation
		Pedogenesis and soil quality regulation
	Regulation of biotic environment	Lifecycle maintenance & habitat protection
		Pest and disease control
		Gene pool protection
Cultural	Symbolic	Aesthetic, Heritage
		Religious and spiritual
	Intellectual and Experiential	Recreation and community activities
		Information & knowledge

From: Daily, Gretchen. “Nature's Services: Societal Dependence On Natural Ecosystems,” 1997.
Classification of ecosystem services (EEA) (UNCEEA/5/7) -- https://cices.eu

What are externalities?

- **Negative externalities** are deleterious effects produced by an activity, where the producer does not pay the full cost of the negative effect on others
  - Water pollution, excess noise, carbon emissions
- **Positive externalities** are beneficial effects produced by an activity, where the producer/provider does not receive full compensation for the benefits of the activity to others
  - Public art, beautiful viewscapes, many ecosystem services

Pricing of ecosystem services

Some are extractable, priced

E.g., timber harvest

Others are positive externalities, not priced – e.g., storm surge protection

Underpricing ecosystem services has implications across economic and financial analysis

1) **Macroeconomic modelling**
   - Contributions to economic activity and growth are undervalued, model error is misattributed
2) **Investment and productivity**
   - Land use decisions allocatively inefficient; underinvestment in preservation of natural capital assets
3) **Financial risks and financial stability**
   - Assets that depend on vulnerable ecosystem services may be mispriced
4) **Investor decisions**
   - Taxonomies to assess climate risks may omit effects on natural capital

Ecosystem services in macroeconomic modelling

- Ecosystem services are unmeasured inputs to production or consumption
- Negative externalities can degrade natural capital (depreciation)
- Investment in natural capital increases future services

New international financial frameworks

- Financial risks
  - Network for Greening the Financial System (NGFS): Nature-related Financial Risks: a Conceptual Framework to guide Action by Central Banks and Supervisors
  - OECD: Assessing biodiversity-related financial risks: Navigating the landscape of existing approaches
- Firms' activities and investment focus
  - Task Force on Nature-Related Financial Disclosures (TFND) Framework: Private-sector initiative to help investors and organizations report and act on evolving nature-related risks

Key concepts in frameworks

- **Dependencies** of economic activity on ecosystem services
  - Beach houses depend on dunes
- **Impacts** of economic activity on ecosystem services
  - Development causes deforestation
- **Physical risks** – Risk exposure due to lost ecosystem services
- **Transition risks** – Risk exposure to policy change to protect ecosystems, changing investor sentiment

Source: https://greatecology.com/portfolio-item/brooklyn-bridge-park/

Interactions with climate change

1) Climate change can damage natural capital
   - Heat and drought – forest decline, hotter wildfires
2) Damage to natural capital contributes to climate change
   - Damage to forests and peatlands releases stored carbon
3) Tools to mitigate and adapt to climate change can damage natural capital
   - Deforestation for biofuels; replacing natural areas with gray infrastructure to capture stormwater or generate electricity
4) Investment in natural capital can mitigate climate change, lessen impacts
   - Conservation of forests, peatlands increases carbon sequestration
   - Protection of forests, wetlands, dunes improves resilience to storms, floods

More direct pricing of ecosystem services could enhance efficiency in adapting to climate change

- Solar field on natural lands with deforestation
- Land inefficiently cheap - lack of pricing of ecosystem services
  - Carbon and stormwater sequestration
  - Temperature regulation

- Solar field on parking lot
- No loss of natural capital, benefit of shade in built environment
- Reduces “false choice” of climate vs environment, if alternatives available

Improved ecosystem valuation could support buffering climate change impacts

- Vegetation reduces likelihood of floods, landslides, erosion
- Moderates temperatures, preserves biodiversity
- Valuation of services is rising in importance

Haiti-Dominican Republic border
Source: NASA

Policy tools that internalize positive externalities from ecosystem services

- Regulation, direct legal protection or purchase
  - Establishment of protected areas by governments, requirements to consider ecosystem services in policy decisions
  - Purchase and protection by mission-focused organizations (e.g., Nature Conservancy)
- Market-based methods
  - Conservation easements – tax reductions from contractual commitment not to develop land
  - Direct payments to landowners to hold lands intact
  - Carbon offsets
  - Taxonomies that reflect ecosystem services for investor decisionmaking (indirect)

Statistical accounting – Limitations of traditional national accounts

- National accounts do not explicitly include “inputs from the environment to the economy or costs of environmental degradation”
- Examples:
  - Depletion of fishing stock
  - Effects of pollution
  - Damage to natural capital from extreme wildfire

Source: https://greenliving.lovetoknow.com/Solutions_for_Ocean_Pollution

Natural capital accounting - new U.S. initiative

- National Capital Accounts Initiative
  - Spans multiple Executive Branch measurement agencies (BEA, NOAA, NASA, USGS, etc)
  - Longer-term, comprehensive program
  - **National Strategy** document released in January 2023
  - Expected to take 10-15 years before publication of standard statistical product
- Builds on earlier interagency work
  - Experimental/pilot System of Environmental Economic Accounting (SEEA)

New academic and policy initiatives

- Many additional academic and policy initiatives underway to reflect ecosystem services

- Example of an initiative with broadly applicable potential: Stanford Natural Capital Project / InVEST
  - Interdisciplinary - develops tools to assess natural capital to support decision-makers
  - Substantial investments in research, data and modeling
  - High geographic granularity

Prototype Natural Capital World Viewer

natural capital PROJECT

1) Select Area of Focus

- Global
- National
  - United States
- In-country Region
  - Search or click a region
- Draw custom area of focus

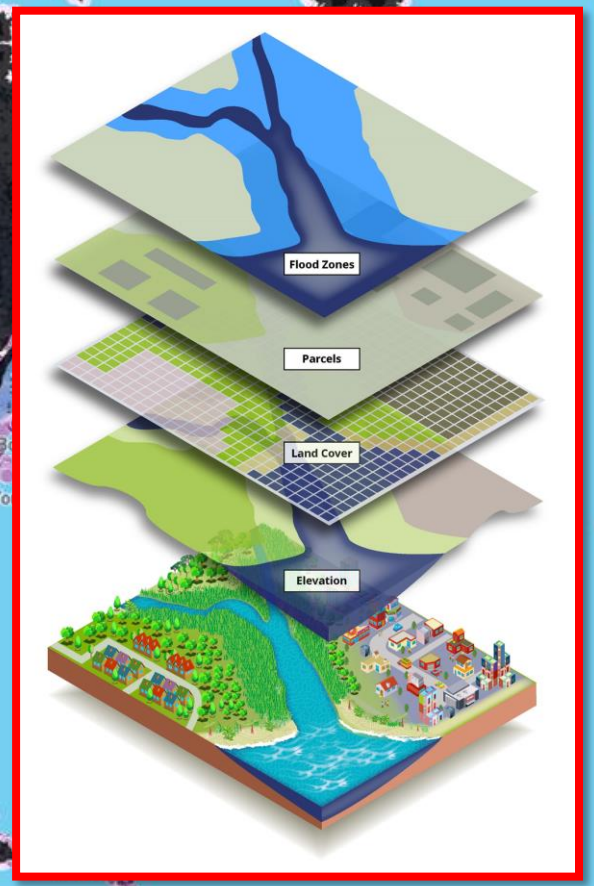
2) Explore Ecosystem Services

- Clean water: nitrogen retention
- Clean water: sediment retention
- Coastal storm risk reduction
- Local nature access
- Crop pollination
- Livestock grazing

3) Explore Other Layers

Discover and Case Studies

[Coming Soon]



Legend

Risk reduction for coastal communities

Low Med High

Nitrogen retention for downstream users

Low Med High

zoom: 2.74 | long, lat: -95.23 , 55.51

Basemap Control

InVEST Model (Integrated Valuation of Ecosystem Services and Tradeoffs) - uses 60+ datasets

Dataset name	Datasource name	Variable category
Map of Life	Mapping Life	Biodiversity
IPCC Tier-1 Global Biomass Carbon Map for the Year 2000	CDIAC - Carbon Dioxide Information Analysis Center	Carbon
IPCC Default Soil Classes	ISRIC World Inventory of Soil Emission Particles	Carbon
Daily Gridded Precipitation Analysis	NOAA - Climate Prediction Center	Climate
Daily Gridded Temperature Analysis	NOAA - Climate Prediction Center	Climate
Major River Basins of the World	GRDC - Global Runoff Data Centre	Hydrology
Watershed Boundaries of GRDC Stations	GRDC - Global Runoff Data Centre	Hydrology
National Biomass and Carbon Dataset	WHRC - Woods Hole Research Center	LULC
Geo-Referenced Field Photos	Earth Observation - Geo-referenced field photo library	LULC
Soil Survey Geographic Database	Natural Resources Conservation Service	Soil
Harmonized World Soil Database	IIASA - International Institute for Applied Systems Analysis	Soil
National Elevation Dataset	USGS	Topography
Global Land Survey Digital Elevation Model	GLCF - Global Land Cover Facility	Topography

Questions and discussion

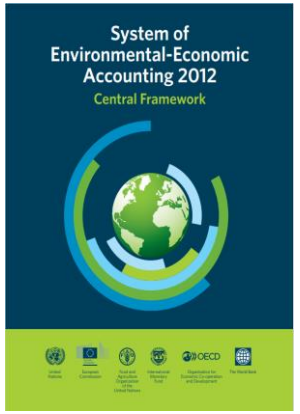
Appendix

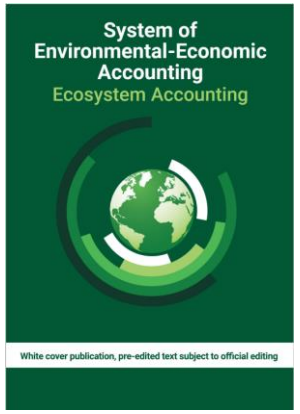
Appendix: System of National Accounts (SNA)

Account	Balancing item	Main aggregates
Current accounts		
Production account		
Production account	Value added	Domestic product
Distribution and use of income accounts		
Primary distribution of income accounts		
Generation of income account	Operating surplus/ mixed income	
Allocation of primary income account	Balance of primary income	National income (GNI,NNI)
Entrepreneurial income account	Entrepreneurial income	
Allocation of other primary income account	Balance of primary income	
Secondary distribution of income account	Disposable income	National disposable income
Redistribution of income in kind account	Adjusted disposable income	
Use of income accounts		
Use of disposable income account	Saving	
Use of adjusted disposable income account	Saving	National saving
Accumulation accounts		
Capital account	Net borrowing(+)/ net lending (-)	
Financial account	Net borrowing(+)/ net lending (-)	
Other changes in assets accounts		
Other changes in the volume of assets account		
Revaluation account		
Balance sheets		
Opening balance sheet	Net worth	National wealth
Changes in assets and liabilities	Changes in net worth	
Closing balance sheet	Net worth	National wealth
Contributions to change in net worth		
Capital account	*Change in net worth due to saving and capital transfers*	
Other changes in the volume of assets account	*Change in net worth due to other changes in the volume of assets*	
Revaluation account	*Changes in the value of net worth due to nominal holding gains and*	

Source: Figure 2.2: Summary of the main accounts, balancing items and main aggregates, *System of National Accounts, 2008*

Appendix: Global environmental-economic accounting frameworks





- SEEA Central Framework
  - Measures flows of materials and energy, stocks of environmental assets, and economic transactions related to the environment
  - Accounts for discrete assets such as water, minerals, energy, land, timber, and pollution
  - Flexible and modular framework allows development of select accounts
- SEEA Ecosystem Accounting
  - Focus on spatially explicit data, ecosystem assets, and services they produce
  - Supports organizing data around policy-relevant themes, such as biodiversity or climate change
  - Allows ecosystem contributions to be expressed in monetary terms (but valuation is difficult)

Appendix:
U.S. Natural Capital Account Initiative

- April 2022: Launch of U.S. **Natural Capital Account** initiative, Executive Order 14072
  - Directs the 13-agency U.S. Global Change Research Program to develop an assessment of the condition of nature in the U.S.
  - Directs OMB to issue valuation guidance to help agencies better account for ecosystem and environmental services
  - Directs interagency group to continue to improve and update baseline information on economic value of existing natural assets and new nature-based solutions
- Interagency Policy Working Group includes representatives from 18 departments/agencies, co-chaired by White House Office of Science and Technology Policy, White House Office of Management and Budget, and the Department of Commerce
- August 2022: **Draft Workplan:** *National Strategy to Develop Statistics for Environmental-Economic Decisions: A U.S. System of Natural Capital Accounting and Associated Environmental-Economic Statistics*
- Recommendations:
  - Use expertise at Federal agencies by coordinating to develop the system of natural capital accounts and environmental-economic statistics
  - Use a 15-year phased approach to transition from research grade environmental-economic statistics and natural capital accounts to Core Statistical Products
  - Embed the system of natural capital accounts and associated environmental-economic statistics in the broader U.S. economic statistical system
- January 2023: **National Strategy** document released

Appendix: Academic and policy initiatives underway to reflect ecosystem services

Modeling and Implementation

- Stanford Natural Capital Project / InVEST

Accounting and Frameworks

- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)
- Taskforce on Nature-Related Financial Disclosures
- Network for Greening the Financial System Task Force on Biodiversity Loss and Nature-Related Risks
- U.S. Natural Capital Accounting Strategy