Natural Capital Accounts: Aligning valuation methods for ecosystem goods, services and natural capital with accounting principles

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Introduction

- Main question: how to value ecosystem services and natural capital and bring these values into the national income and wealth accounts
- Economics & ecology but NOT accounting
- Advice to ecological economists: “it is necessary to consider their conceptual models concerning the links between ecosystems and the economy in a strict accounting sense, and to consider the complexities of integrating new measures of assets and services with traditional economic measures.”

Ecosystem services and natural capital

	Biophysical	Monetary value
Flows	Quantitative measure of ecosystem services (e.g., tons of carbon sequestered)	Value of ecosystem services
Stocks	Quantitative measure of natural capital (e.g., tons of carbon stored)	Value of natural capital

My experience

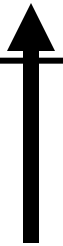
- Estimates of value for use in evaluation of alternative decisions
- Consistent with benefit-cost analysis

The Impact of Land Use Change on Ecosystem Services, Biodiversity and Returns to Landowners: A Case Study in the State of Minnesota

Polasky, Nelson, Pennington, Johnson. 2011. *Environmental and Resource Economics* 48(2): 219-242

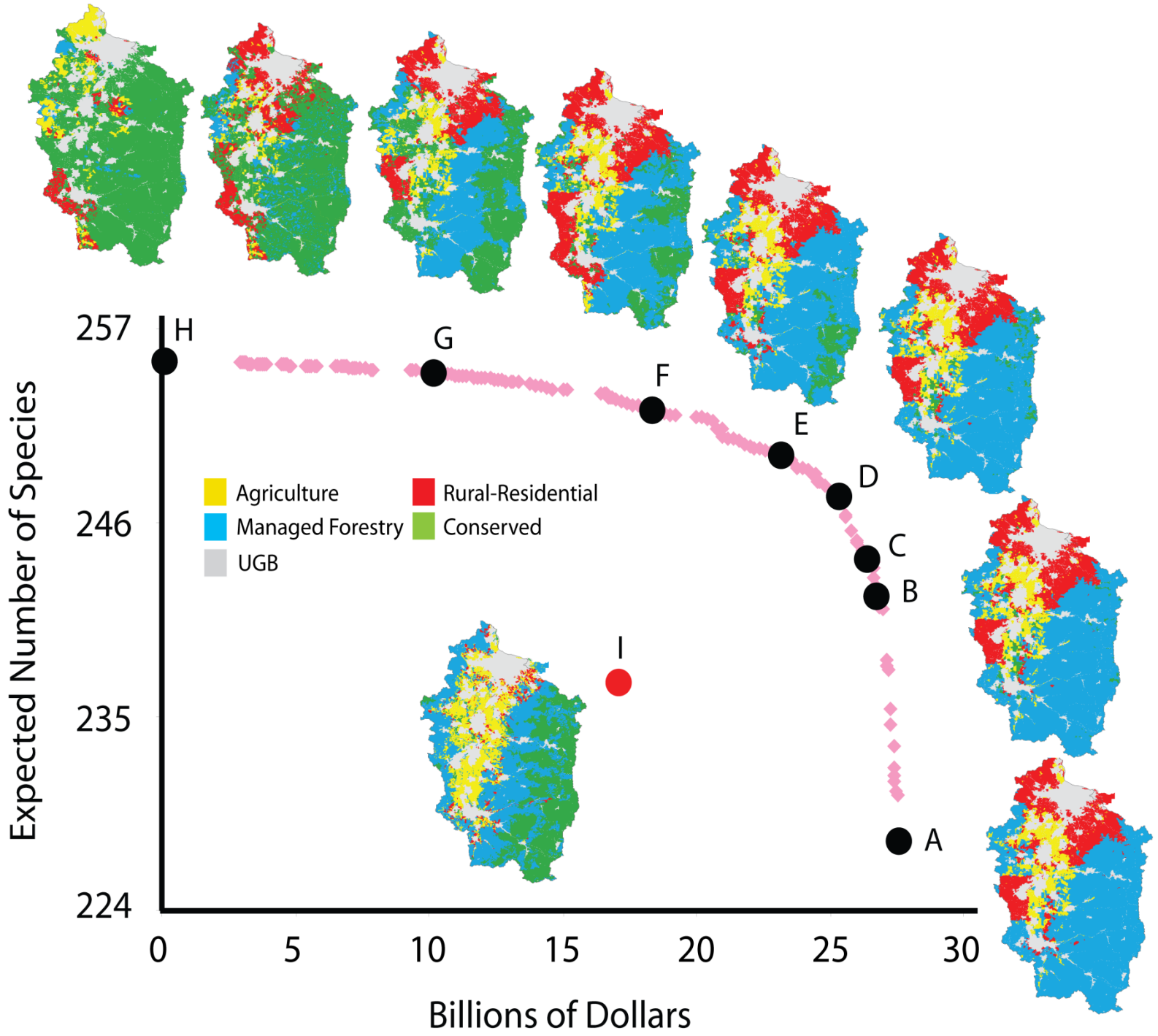
Annual value from land use change scenarios 1992-2001

	Actual land use	No ag expansion	No urban expansion	Ag expansion	Forest expansion	Conser-vation
Change in total value: carbon, water quality, ag & forest production, urban using actual prices (M1992 $)	$3,328	$3,407	$3,040	$2,742	$3,300	$3,380
Change in returns to landowners: ag & forest production, urban using actual prices (M1992 $)	$3,320	$3,343	$3,027	$3,418	$3,292	$3,221



Where to put things? Spatial land management with biological and economic objectives

Polasky et al. 2008. *Biological Conservation* 141(6): 1505-1524.


257
246
235
224
Expected Number of Species
0
5
10
15
20
25
30
Billions of Dollars
H
G
F
E
D
C
B
A
I
Agriculture
Managed Forestry
UGB
Rural-Residential
Conserved

Three general points

- Expanding the boundaries of accounts to include non-market values
  - Valuation approaches
- Intermediate versus final goods
- Focus on ecosystem services and natural capital not on ecosystem types or area

Ecosystem services and natural capital in income and wealth accounts

- Focus: System of Environmental-Economic Accounts (SEEA) Central Framework
- SEEA Central Framework provides guidance on the valuation of market goods and services but not on non-market goods and services
- “Full valuation of assets and flows related to natural resources and land beyond the valuation included in the SNA remains an outstanding issue.”

Non-market valuation

- Expanding the boundary of accounts to include non-market values
- Identified research need for SEEA: "Development of consistent valuation techniques beyond the SNA in the absence of market prices."
- Principle: "When market prices are not observable, valuation according to market price equivalents should be used to provide an approximation to market prices."

Non-market valuation

- Variety of methods from environmental economics: willingness-to-pay (analog to market price)
- Revealed preference methods
  - Hedonic models
  - Random utility (travel cost) models
  - Averting behavior
- Stated preference methods
  - Conjoint analysis
  - Contingent valuation

Non-market valuation

- Replacement cost: valid to use if
  - Alternative method provides an equivalent quality and quantity of the service
  - It is the lowest cost alternative method
  - People would be willing-to-pay the cost of this alternative method to provide the service

  (Shabman and Batie 1978)
- Example: NYC-Catskills water supply

Non-market valuation

- SNA Satellite Accounts: valuation of household labor
  - Alternative to household labor is to hire paid labor
  - Compute the wage cost be for hired labor
- Wage cost is replacement cost for household labor

Intermediate v final goods

- Many ecosystem services are intermediate goods or services
  - Example: pollination services to agricultural crops
- GDP (or green GDP) – only count value of final goods and services (avoid double counting)
- Attribution of value to factors of production – value of intermediate goods and services is of interest

Double counting

- Some obvious double counting: include both value of intermediate and final good (pollination value and value of crops)
- Some less obvious examples: social cost of carbon

Valuation of ecosystem services and natural capital

- Corollary to income (flow value): ecosystem services (goods and services)
- Corollary to wealth (stock value): natural capital
- An ecosystem is not a good or service: it can be thought of as an asset that provides multiple goods and services (joint products)

Valuation of ecosystem services and natural capital

- Use of value per unit area of ecosystem type (wetlands, forests, grasslands…) can only be used if it closely maps to provision and value of ecosystem services
- The value ecosystem services depends on location
- Example: flood protection
  - How does action contribute to flood mitigation
  - How does flood mitigation lead to reduction in damage from flooding
- Non-ecosystem example: value of housing (location, location, location….)
- Some cases where area based valuation can work: carbon storage value

Three examples

- Renewable resource (fish, timber) - provisioning service
- Coastal protection – regulating service
- Aesthetics – cultural service

Valuing ecosystem services: Renewable resource

- Value of commercial harvests already included in income accounts
- Subsistence (non-market) harvest:
  - Estimates of subsistence harvest (quantity)
  - Use market price of harvest (price)
  - Analogous to household labor case
- Recreational harvest:
  - Not really the harvest value but the experience
  - Payments for fishing guides/boats already in accounts
  - Use market price for guides/boats
  - Some recreational harvest there is no close market substitute: may need to use random utility model to estimate value

Valuing ecosystem services: Coastal protection

- Coastal ecosystems (marshes, dunes, seagrass beds…) can provide protection from storm surge, waves and wind from coastal storms for buildings and infrastructure located near the coast
- The value of protection afforded by coastal ecosystems does not show in income accounts (with some exceptions)

Valuing ecosystem services: Coastal protection

- If the coastal ecosystem were removed and coastal properties had increased risk, what value would be lost?
- Valuation methods:
  - Replacement cost: what would it cost to restore ecosystem or provide substitute means of protection (e.g., hardened shoreline)
  - Change in expected damages (per annum):
  - Value of insurance coverage
  - Hedonic property price model
  - Stated preference survey of willingness-to-pay to avoid risks

Valuing ecosystem services: Coastal protection

- Production value vs. use value
  - For market goods production value and use values are equal (or nearly equal)
  - For non-marketed goods, production and use values need not be close
  - Example: replacement cost estimate on production side, avoided damage or insurance contract on the use side
- When production and use values differ, what is the general principle for reporting value?
  - Minimum value (consistent with Shabman and Batie advice on replacement cost)
  - Use value

Valuing ecosystem services: Aesthetics

- Nature providing aesthetic value (e.g., beautiful views)
- Aesthetic values do not show up in income accounts (with some exceptions)

Valuing ecosystem services: Aesthetics

- If the natural amenities were removed and aesthetics were affected, what value would be lost?
- Valuation methods:
  - Replacement cost: what would it cost to restore ecosystem or provide substitute (Is it possible?)
  - Random utility model – travel to scenic places (note: travel expenses already are in the income accounts)
  - Hedonic property price model: good for value of amenities capitalized into property values but not necessarily for
  - Stated preference survey of willingness-to-pay

Valuing natural capital

- SEEA preferred approach to value assets – net present value formulation
- Range of approaches to calculate present value
  - Simplest: assume current conditions continue to hold in future (both quantities and prices), known discount rate
  - Harder (more realistic): model likely future conditions to predict both future quantities and prices, endogenous discount rates

Valuing natural capital

- Non-market valuation issues remain with natural capital – not really new issue
- Focus on renewable resource example as this is best understood (provides clearest discussion of principles)

Valuing natural capital

- Simple version: NPV = $\sum_{t=0}^{T} \delta^t pq$
- Hard version: NPV = $\sum_{t=0}^{T} \delta(t)p(t)q(t)$
- Renewable resource example
  - δ = discount factor
  - q = harvest
  - p = price of harvest

Valuing natural capital

- Simplest version: steady-state harvest with constant (current) price and constant discount factor
- Harder version: need to predict path of future harvests, prices, discount factors

Valuing natural capital: Predicting future harvest

- Predicting future harvests: take account of how stocks evolve given growth and harvest
- Stock equation:
  $S(t+1) = F(S(t), E(t), q(t), t)$

Valuing natural capital: Predicting future harvest

- Harvest depends on both stock and behavioral rules
- Optimal harvest:

  V(S(0)) = Max $\sum_{t=0}^{T} \delta(t)p(t)q(t)$

  s.t. $S(t+1) = F(S(t), E(t), q(t), t)$

  Solution: q*(t)

- Open access: $q_{OA}(t)$

  $V_{OA}(S) = \sum_{t=0}^{T} \delta(t)p(t)q_{OA}(t)$

Valuing natural capital

- Stock equation: $S(t+1) = F(S(t), E(t), q(t), t)$
- Two important stocks:
  - Renewable resource stock (fish, trees…) S(t)
  - Environment stock – determines productivity of renewable resource E(t)
  - E(t) as an input into production of future stock, that determines future harvests
- Change in either stock (S, E) will affect net present value V

Valuing natural capital

- Simplest version is, well, simple (easy)
- Full/complete version is impossible to get fully correct (degrees of being accurate…)

Conclusions

- Add the non-market values to accounts
  - Attributional
  - Final total accounting
- Accounting for ecosystem services and natural capital in a rigorous but practical way