System of Environmental Economic Accounting

Valuation

United Nations

Outline

- Context
- Concepts
- Valuation methods for ecosystem services
  > Group exercise
- Valuation of ecosystem assets
- Degradation
- Recording options
- Country Examples
- Discussion

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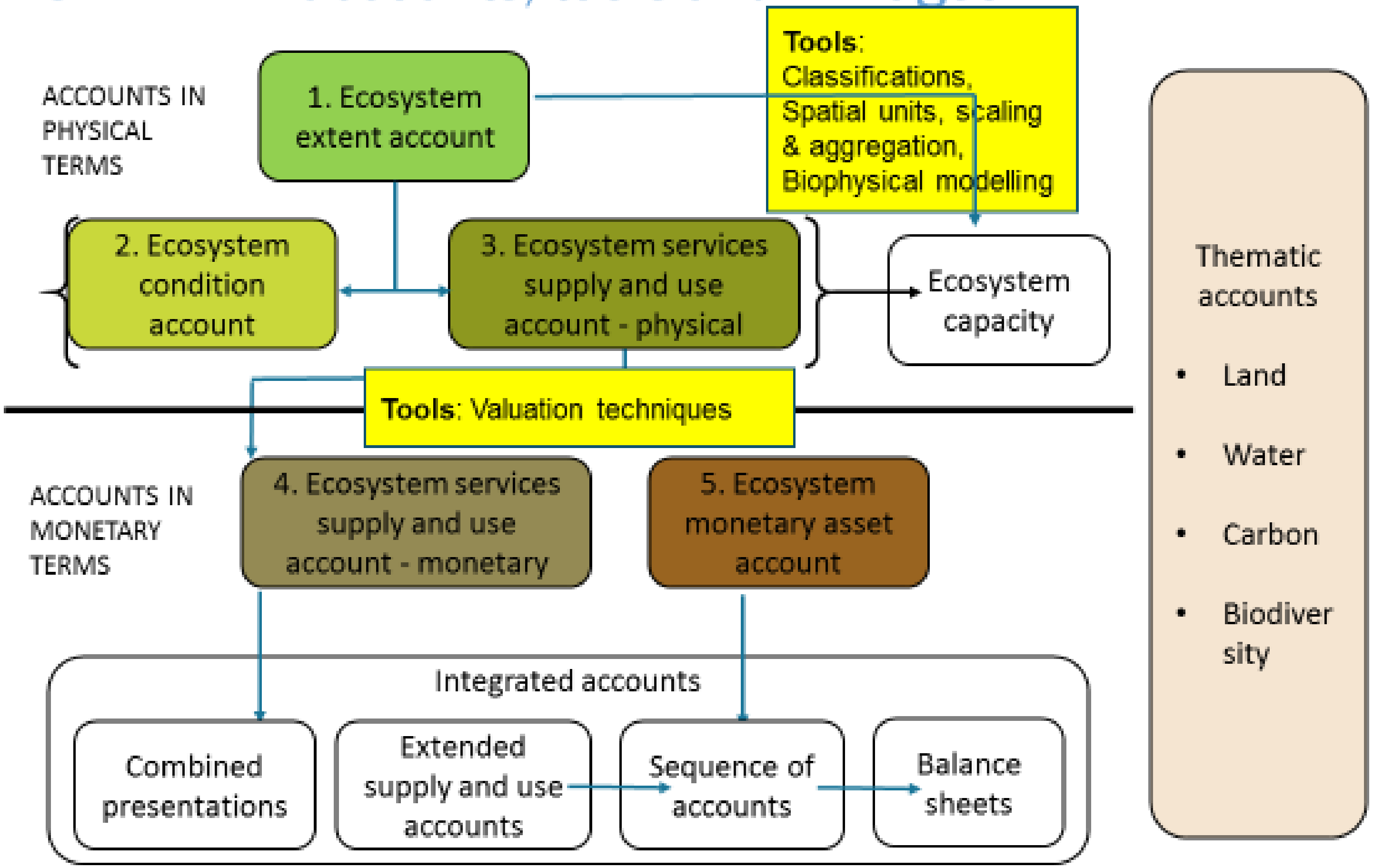
SEEA-EEA accounts, tools and linkages



SEEA

Context

- What is conventional economics?
  - > Discipline concerned with “the efficient allocation of scarce resources in society”
  - > ‘scarcity’ implies finite supply and opportunity cost
  - > use of the ‘price mechanism’
  - > 3 questions:
    - what, how and for whom to produce?

Context

- Why do we need to value the natural environment?
  - ‘Market failures’ exist
  - The natural environment as a ‘public good’:
    - non-excludable – individuals cannot be effectively excluded
    - non-rivalrous - use by one individual does not reduce availability to others
  - Need for intervention in the market

Context

- What is the purpose of valuing the natural environment?
  - To integrate environmental issues in economic decision making and development planning – to do so the valuation must be purposeful
    - To raise awareness about the intangible, non-marketed benefits that nature provides
    - Inputs to Evaluation frameworks such as Cost-Benefit analysis, Multi-Criteria Decision-Making
    - Evidence base for full cost pricing

Context

- Criticisms of valuing nature (i)?
  - ‘Commoditization’ of nature
    - John Stuart Mill (1862) *Principles of Political Economy and Chapters on Socialism*

      ‘I sincerely hope, for the sake of posterity, that they [humanity] will be content to be stationary, long before necessity compels them to it’
    - Hermann Daly (1992) *Steady State Economics*

      ‘Is the nature of the Ultimate End such that, beyond some point, further accumulation of physical artefacts is useless or even harmful?..Could it be that one of our wants is to be free from the tyranny of infinite wants?’

‘

Context

- What are the criticisms of valuing nature (ii)?
  - Feeds into dominant economic discourse which focuses on efficiency but not distributional equity
    - ‘Just processes’ versus ‘just outcomes’
  - *Lexicographical preferences*
  - Valuation methods invariably capture a subset of the benefits of nature
  - Valuation as input to Natural Capital Accounting assumes substitutability between capital stocks

Context

- What are we trying to value when we 'value nature'?
  - Ecosystem services
    - Flows: during the year
  - Ecosystem capital
    - Assets: value at beginning/end of year and changes therein
  - Degradation of ecosystems
    - The decline in the condition of ecosystem assets as a result of economic and other human activity

Context

- Measurement challenges
  - Non-linear responses
    - Thresholds/resilience, climate change, refuge areas
  - Aggregating values of different services
    - Services can be competing, complementary or independent (but typologies attempt to address this)
  - Transferring measured values from one site to another
    - Benefits Transfer
    - http://lukebrander.com/wp-content/uploads/2013/07/UNEP-2013-Guidance-manual-on-value-transfer-methods-for-ecosystem-services.pdf

Context

- Measurement challenges
  - More challenging for Regulating and Cultural Services
  - How to measure monetary value of regulating services?
    - *Spatial dependencies* (downstream, species/habitat)
    - *Multiple beneficiaries* (local, national, global)
    - *Risks* (e.g. probabilistic estimate of flood control)

Key concepts

articles

The value of the world's ecosystem services and natural capital

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The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US\$16–54 trillion (10^{12}) per year, with an average of US\$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US\$18 trillion per year.

Because ecosystem services are not fully 'captured' in commercial markets or adequately quantified in terms comparable with economic services and manufactured capital, they are often given too little weight in policy decisions. This neglect may ultimately compromise the sustainability of humans in the biosphere. The economies of the Earth would grind to a halt without the services of ecological life-support systems, so in one sense their total value to the economy is infinite. However, it can be instructive to estimate the 'incremental' or 'marginal' value of ecosystem services (the estimated rate of change of value compared with changes in ecosystem services from their current levels). There have been many studies in the past few decades aimed at estimating the value of a wide variety of ecosystem services. We have gathered together this large (but scattered) amount of information and present it here in a form useful for ecologists, economists, policy makers and the general public. From this synthesis, we have estimated values for ecosystem services per unit area by biome, and then multiplied by the total area of each biome and summed over all services and biomes.

Although we acknowledge that there are many conceptual and empirical problems inherent in producing such an estimate, we think this exercise is essential in order to: (1) make the range of potential values of the services of ecosystems more apparent; (2) establish at least a first approximation of the relative magnitude of global ecosystem services; (3) set up a framework for their further analysis; (4) point out those areas most in need of additional research; and (5) stimulate additional research and debate. Most of the problems and uncertainties we encountered indicate that our estimate represents a minimum value, which would probably increase: (1) with additional effort in studying and valuing a broader range of ecosystem services; (2) with the incorporation of more realistic representations of ecosystem dynamics and interdependence; and (3) as ecosystem services become more stressed and 'scarce' in the future.

Ecosystem functions and ecosystem services

Ecosystem functions refer variously to the habitat, biological or system properties or processes of ecosystems. Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions. For simplicity, we will refer to ecosystem goods and services together as ecosystem services. A large number of functions and services can be identified[1–4]. Reference 5 provides a recent, detailed compendium on describing, measuring and valuing ecosystem services. For the purposes of this analysis we grouped ecosystem services into 17 major categories. These groups are listed in Table 1. We included only renewable ecosystem services, excluding non-renewable fuels and minerals and the atmosphere. Note that ecosystem services and functions do not necessarily show a one-to-one correspondence. In some cases a single ecosystem service is the product of two or more ecosystem functions whereas in other cases a single ecosystem function contributes to two or more ecosystem services. It is also important to emphasize the interdependent nature of many ecosystem functions. For example, some of the net primary production in an ecosystem ends up as food, the consumption of which generates respiratory products necessary for primary production. Even though these functions and services are interdependent, in many cases they can be added because they represent 'joint products' of the ecosystem, which support human

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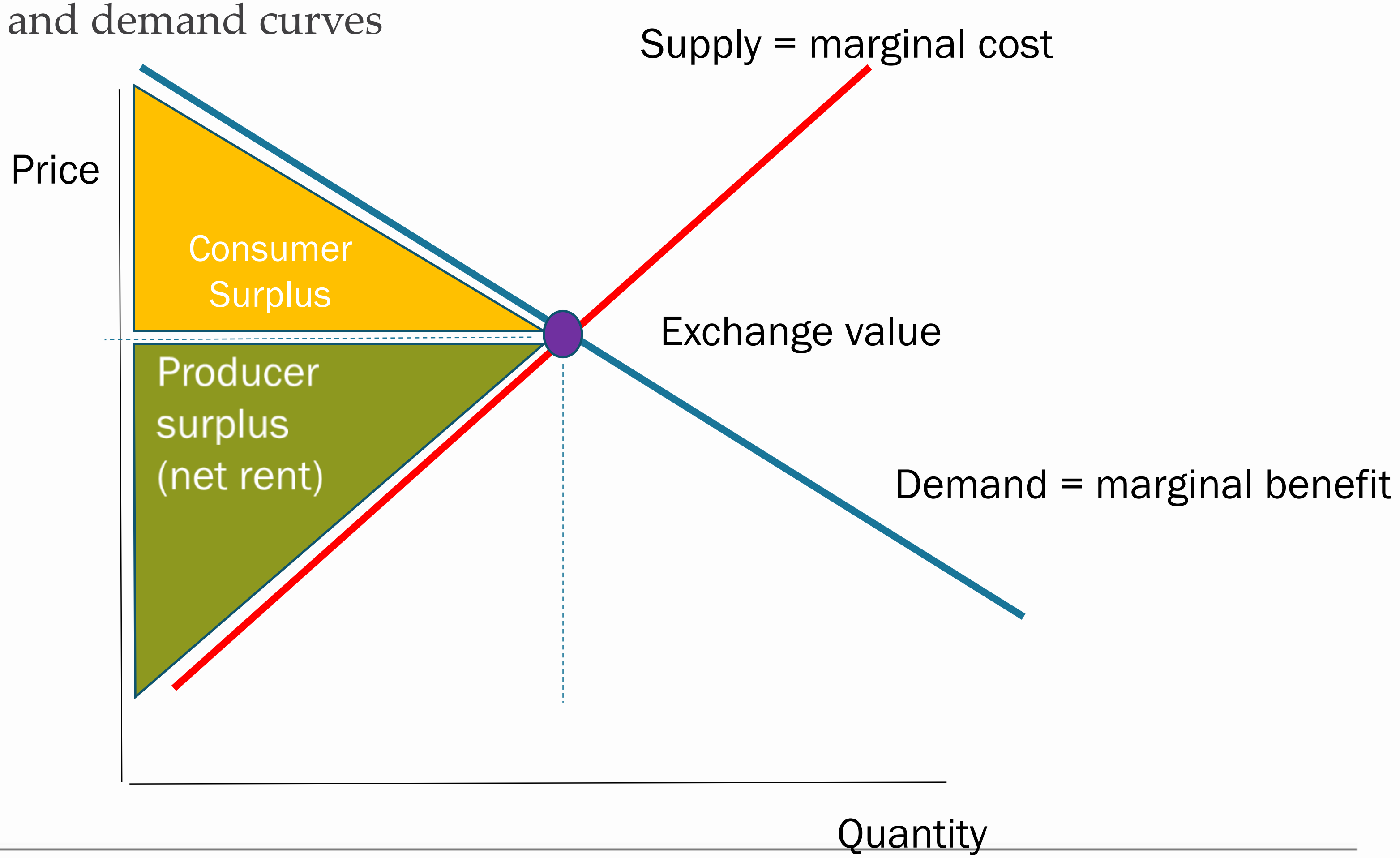
- "For the entire biosphere, the value… is estimated to be in the range of US \$16-54 trillion per year"
- "Global gross national product total is around US \$18 trillion per year."

Key concepts

- Costanza et al. (1997) - estimated a per Hectare unit value of the flows of all services
  - "(in order of preference) either: (1) the sum of consumer and producer surplus; or (2) the net rent (or producer surplus); or (3) price times quantity as a proxy for the economic value of the service"

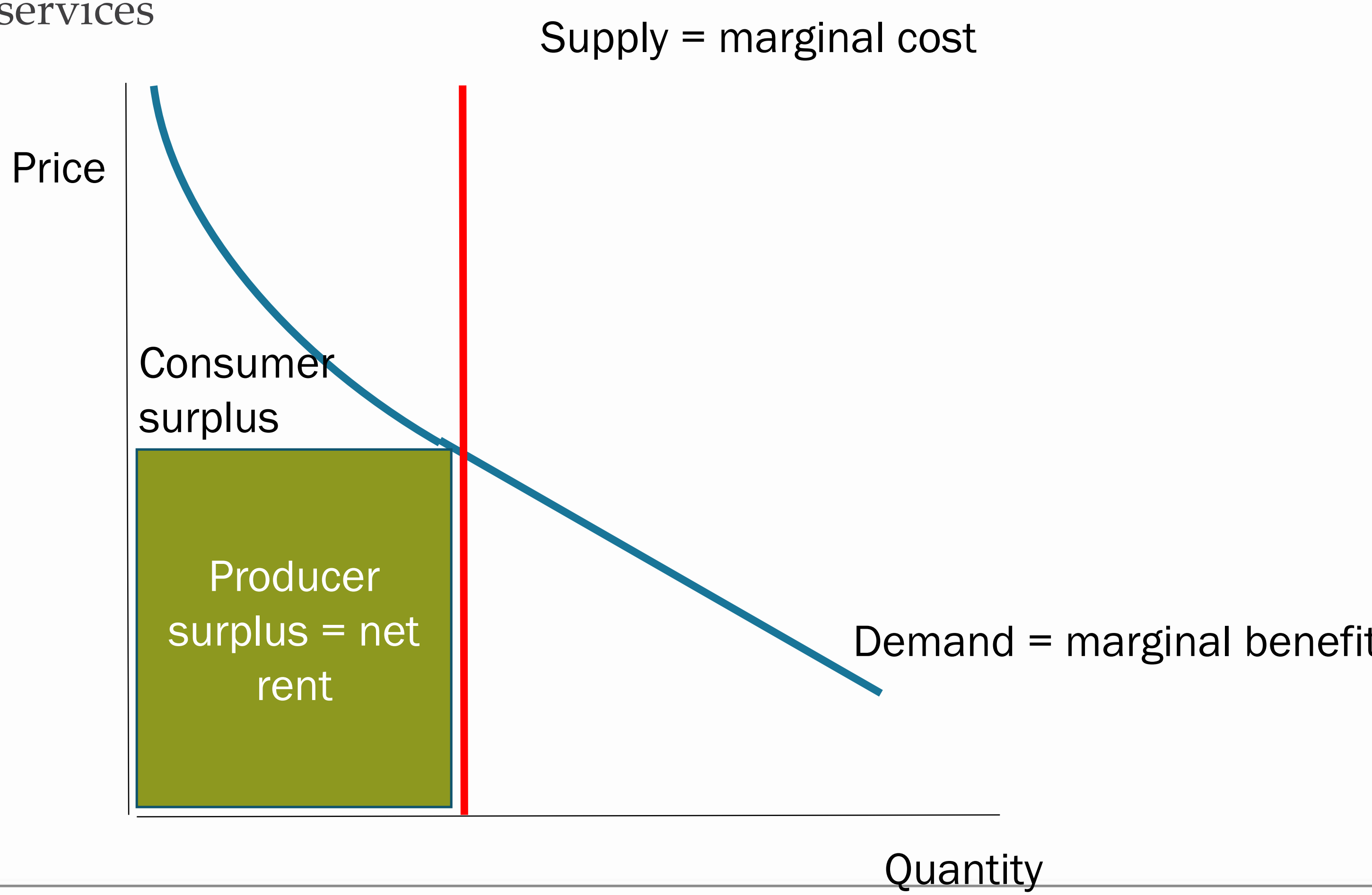
Key concepts

- Supply and demand curves

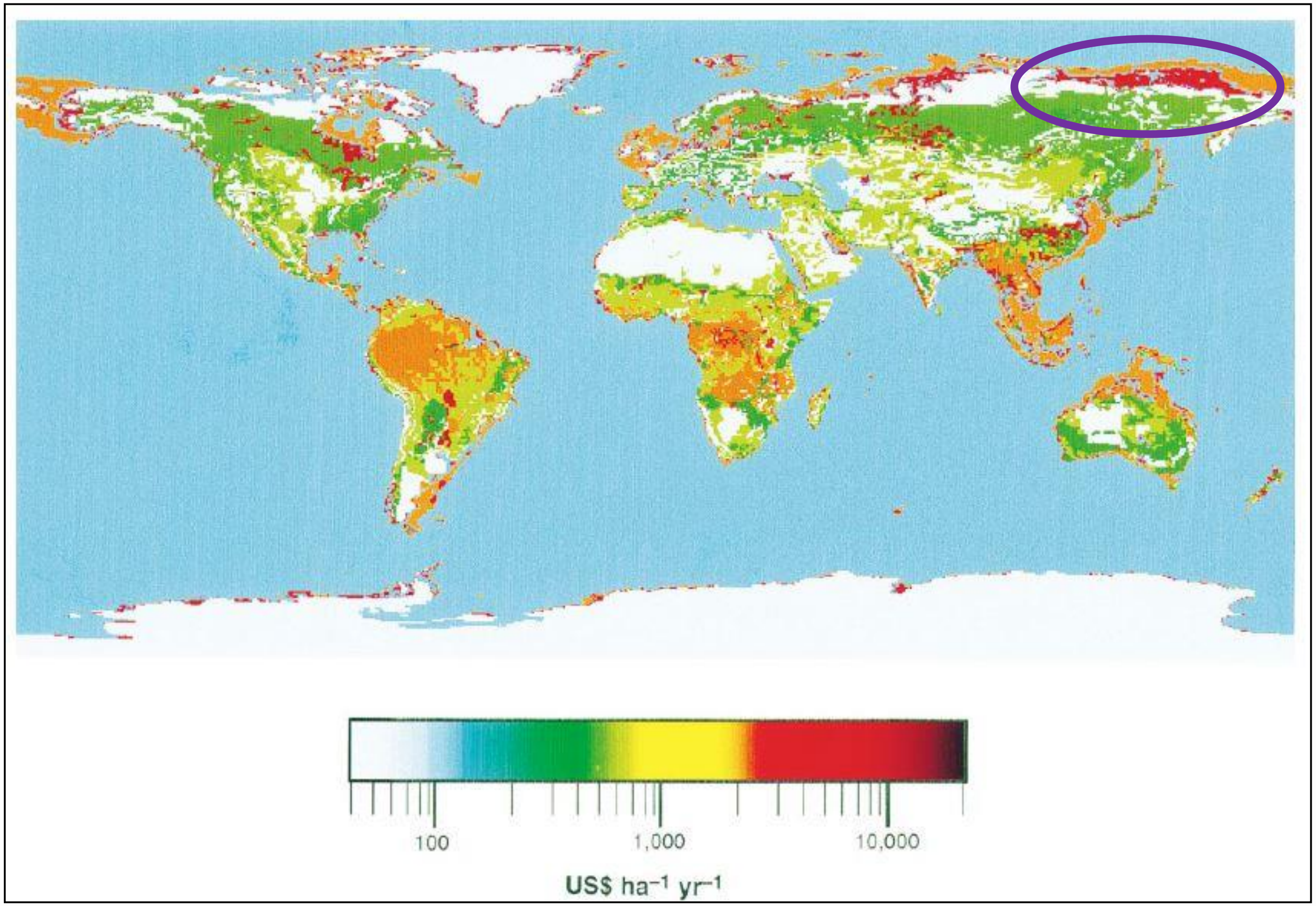


Key concepts

Essential services



Key concepts



- High values where no beneficiaries are located (Siberia)
- Inconsistent with the SEEA EEA approach

Source: Costanza et al 1997

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Changes in the global value of ecosystem services

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ABSTRACT

In 1997, the global value of ecosystem services was estimated to average $33 trillion/yr in 1995 $US ($46 trillion/yr in 2007 $US). In this paper, we provide an updated estimate based on updated unit ecosystem service values and land use change estimates between 1997 and 2011. We also address some of the critiques of the 1997 paper. Using the same methods as in the 1997 paper but with updated data, the estimate for the total global ecosystem services in 2011 is $125 trillion/yr (assuming updated unit values and changes to biome areas) and $145 trillion/yr (assuming only unit values changed), both in 2007 $US. From this we estimated the loss of eco-services from 1997 to 2011 due to land use change at $4.3–20.2 trillion/yr, depending on which unit values are used. Global estimates expressed in monetary accounting units, such as this, are useful to highlight the magnitude of eco-services, but have no specific decision-making context. However, the underlying data and models can be applied at multiple scales to assess changes resulting from various scenarios and policies. We emphasize that valuation of eco-services (in whatever units) is not the same as commodification or privatization. Many eco-services are best considered public goods or common pool resources, so conventional markets are often not the best institutional frameworks to manage them. However, these services must be (and are being) valued, and we need new, common asset institutions to better take these values into account.

Key concepts

- Costanza et al. (2017)
  - "The estimate for the total global ecosystem services in 2011 is $125 trillion/yr (assuming updated unit values and changes to biome areas) and $145 trillion/yr (assuming only unit values changed), both in 2007 $US."
  - "we estimated the loss of eco-services from 1997 to 2011 due to land use change at $4.3–20.2 trillion/yr, depending on which unit values are used"
  - "We emphasize that valuation of ecoservices (in whatever units) is not the same as commodification or privatization. Many eco-services are best considered public goods or common pool resources, so conventional markets are often not the best institutional frameworks to manage them."

Key concepts

- Issues with Benefits Transfer:
  - Majority of studies in developed world countries – simply adjusting for Purchasing Power Parity likely not sufficient
  - Selection bias: studies are sometimes commissioned where a funder wants to make a case for conservation, and the study area may have productive systems that are atypically high
  - Unit value transfer particularly subject to flaws as relies on the site from which values are transferred to have the same characteristics as the policy site (economic, social, ecological)
  - Issue re: statistics - welfare based, hence includes consumer surplus

Key concepts

- Dealing with non-marketed goods using valuation in SEEA:
  - System of National Accounts principle: Nordhaus (2005): "purpose should be to include activities that are economic in nature and those that substitute for market activities"
  - SEEA-EEA trying to achieve price that would have been revealed in most likely institutional arrangement (i.e. the market that would exist if there was an actual market involving ecosystem assets)
  - This is different to an ideal market that internalizes externalities
  - Fairly straight-forward in some cases, e.g. subsistence farming

Key concepts

- National Accounts is a transaction based system:
  - Both ends of the transaction require the same entry (supply = use)
  - Recorded is the marginal exchange value *(P*Q)*
  - *Consumer surplus* is excluded
  - Also *externalities* are excluded -> focus is on actual exchange regardless of institutional setting

Valuation methods

- Three different principles for generating exchange values:

  1. Price of similar good or service: near-market case
  2. Estimate how much of the value of marketed goods or services are due to ecosystem services: only applies is ES contributes to market goods
  3. Estimated cost of not having the ecosystem service: such as avoided damages, cost-saved or replacement costs techniques

Valuation methods

Method	Appropriate for exchange value	Applicability for which ES?
Resource rent	Yes (already used in SNA)	Provisioning (and cultural)
Production function	Yes	Provisioning (and regulating)
PES schemes	Yes	E.g. carbon sequestration
Hedonic pricing	Yes (already used in SNA)	Amenity values
Replacement cost	When conditions apply	Regulating
Damage cost avoided	When conditions apply	Regulating
Averting behavior	Likely no	
Restoration cost	No (perhaps for estimating degradation)	
Travel cost	Possibly	Recreational services
Stated preference	Not direct values, but demand curve usable	Cultural
Marginal values from revealed demand functions	Yes	Regulating Cultural

Based on: SEEA Technical Recommendations
Table 6.1

Valuation methods

Method	Appropriate for exchange value	Applicability for which ES?
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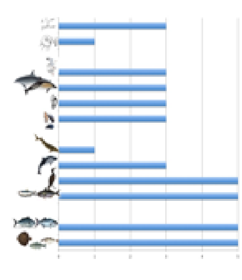
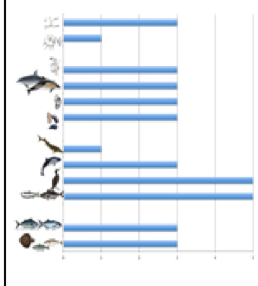
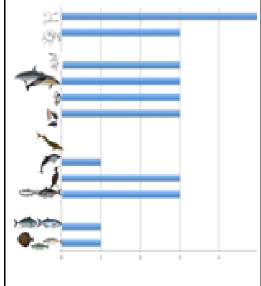
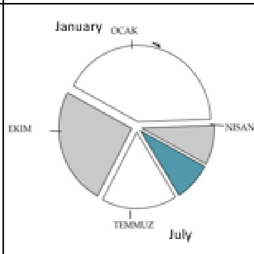
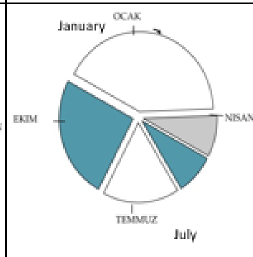
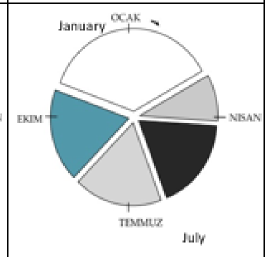
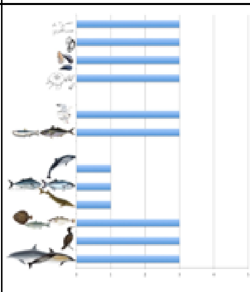
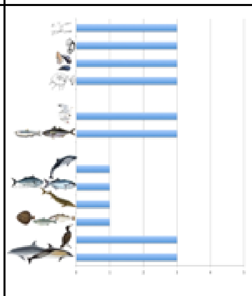
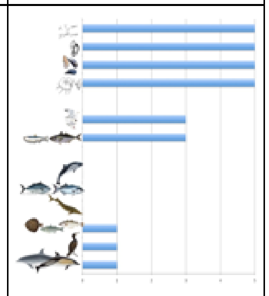
Averting behavior	Likely no	
Restoration cost	No (perhaps for estimating degradation)	
Travel cost	Possibly	Recreational services
Stated preference	Not direct values, but demand curve usable	Cultural, *Provisioning, Regulating, Habitat/supporting*
Marginal values from revealed demand functions	Yes	Regulating Cultural

SEEA

Based on: SEEA Technical Recommendations
Table 6.1

Valuation methods

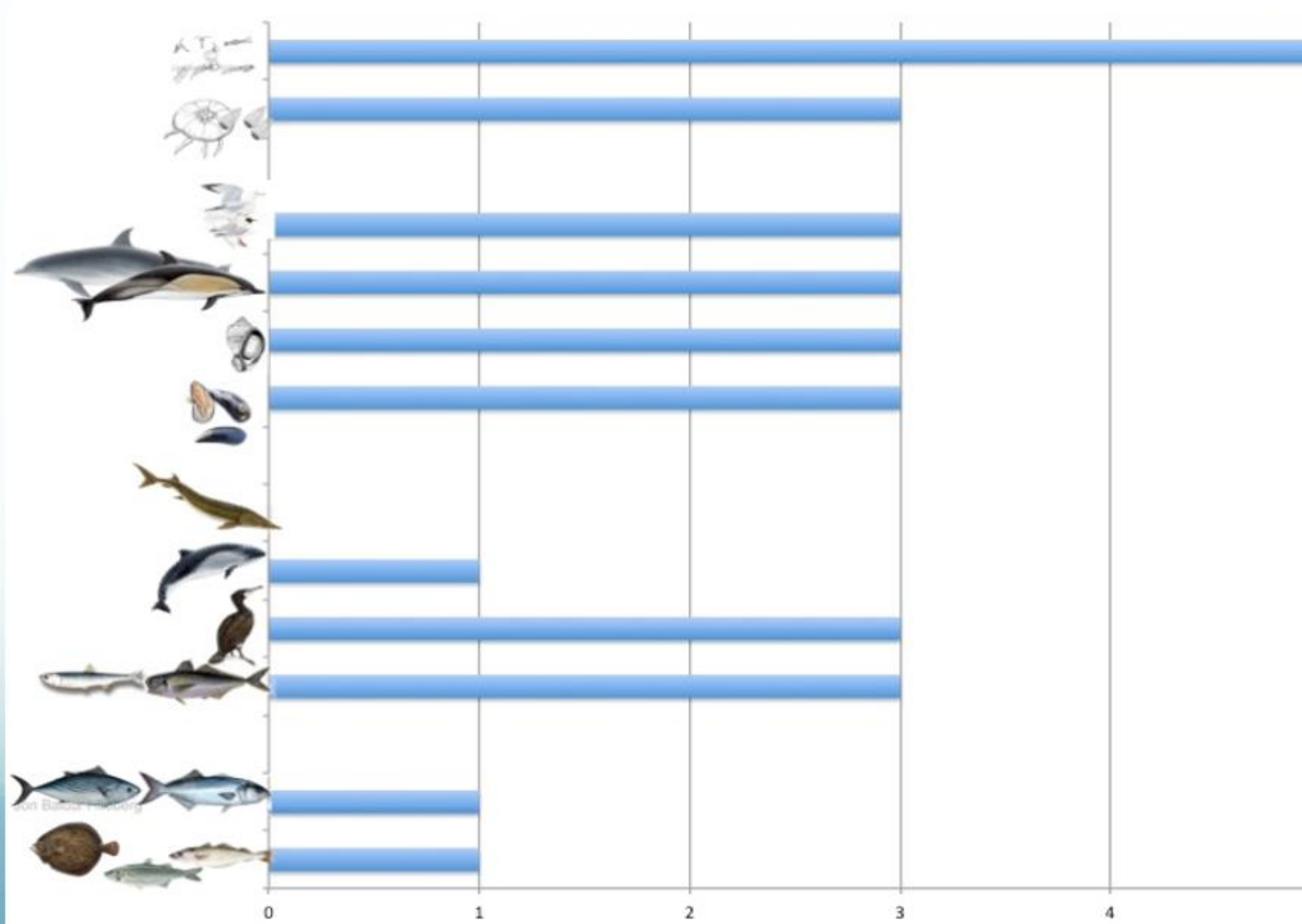
- Stated preference methods
  - Elicit willingness-to-pay for a marginal change
  - Contingent Valuation Method, i.e. respondent's valuation is contingent on the change
  - If there are multiple attributes changing between scenarios then Choice Experiments can be used

Key	Substantial Increase	Moderate Increase	Status Quo
Species Visibility 0: No encounter 1: Rare 3: Common 5: Very common			
Local Anchovy in 2020 1: Local Anchovy quantity 2: Available during... 3: Sources 4: Quality	Substantial increase compared to now Winter and Summer Black Sea Only Firm texture Few spoiled	Slight increase compared to now Winter only Some from Black Sea, Some from other sources Moderate texture Some spoiled	Substantial decrease compared to now Rarely From sources other than the Black Sea Limp texture Large percentage spoiled
The excessive increase of jellyfish calendar [Intensity and Duration] No Blooms Low Intensity Moderate Intensity High Intensity			
Species Population size (in Western Shelf Black Sea) 0: Almost extinct 1:1/2 historic size 3: Historic size 5: 20-30% more than the historic size			
Price	**X TL**	**X TL**	**0 TL**

- Options for Delivering Ecosystem-based Marine Management (ODEMM)
- EC-funded project
- Baulcomb C., Fletcher R., Lewis A., Akoglu E, Robinson L.A., von Almen A., Hussain S., Glenk K. 2015. **A pathway to identifying and valuing cultural ecosystem services: An application to marine foodwebs**. Ecosystem Services 11(2015)128–139
- Böhnke-Henrichs A., Baulcomb C., Koss R., Hussain S.S, de Groot R. 2013. **Typology and indicators of ecosystem services for marine spatial planning and management**. Journal of Environmental Management 130, (2013) 135–145

Visibility of Species

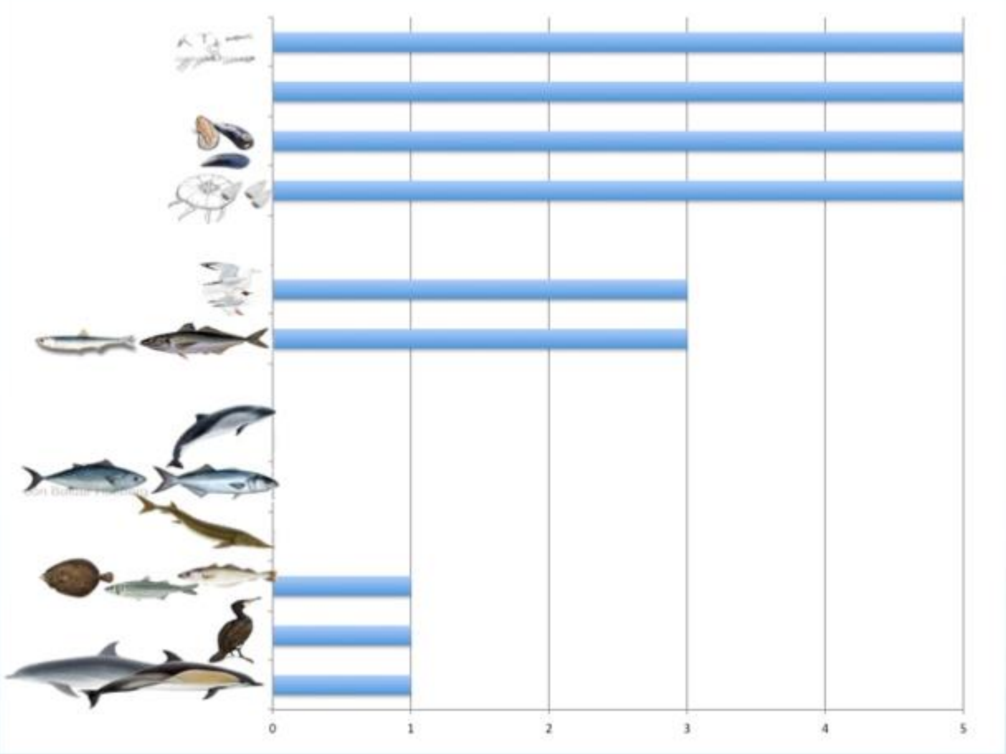
- Visibility of Species is how often we can see these species at market or at wild, and showing like this graph.



SEEA

- **Population Mass**

Population Mass is total number of species.

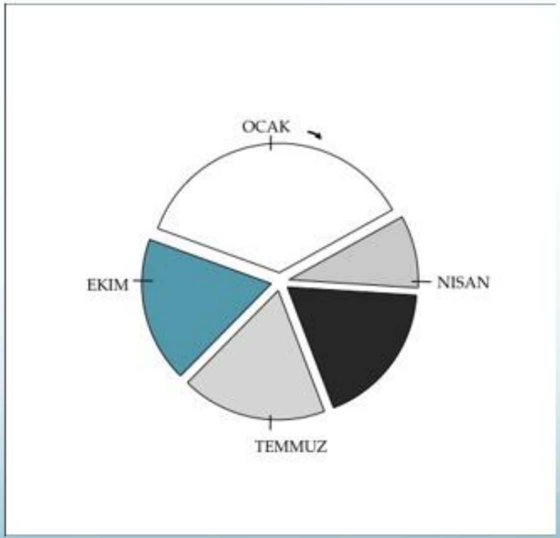


- We can see at this example, Anchovy population is bigger than population of Whiting, Turbot, Grey Mullet.

Jellyfish Blooms

- There is a lot of Jellyfish blooms at Blacksea. Jellyfish affects a lot of thing like swimming, boating, fishing.

- The all circle describes 1 year, and colors describes consistency amount of described months. Every slice at graph describes the intensity of the bloom.



Cost

- There is a cost for each scenario at survey. This amount is for a year. It's important to learn how much people can pay.

Valuation methods

- Stated preference methods
  - <u>Hypothetical by design</u>
    - Many ecosystem services *can only be captured in this way* as we cannot map them to a change in a marketed commodity
    - The vast majority of environmental economics studies have used stated preference methods
    - Demand curve not usually revealed in the study

Valuation methods

- 'Replacement costs'/'avoided damage costs'
  - Assumes a service can *and would be* replaced
  - Engineering-type focus
    - Method feasible for regulating services such as water regulation, water purification and air filtration
  - Least cost alternative
  - Replacement cost are close to National Accounts concepts used in capital measurement (depreciation)
  - Famous example: Catskills watershed (returns on costs savings)

Valuation methods

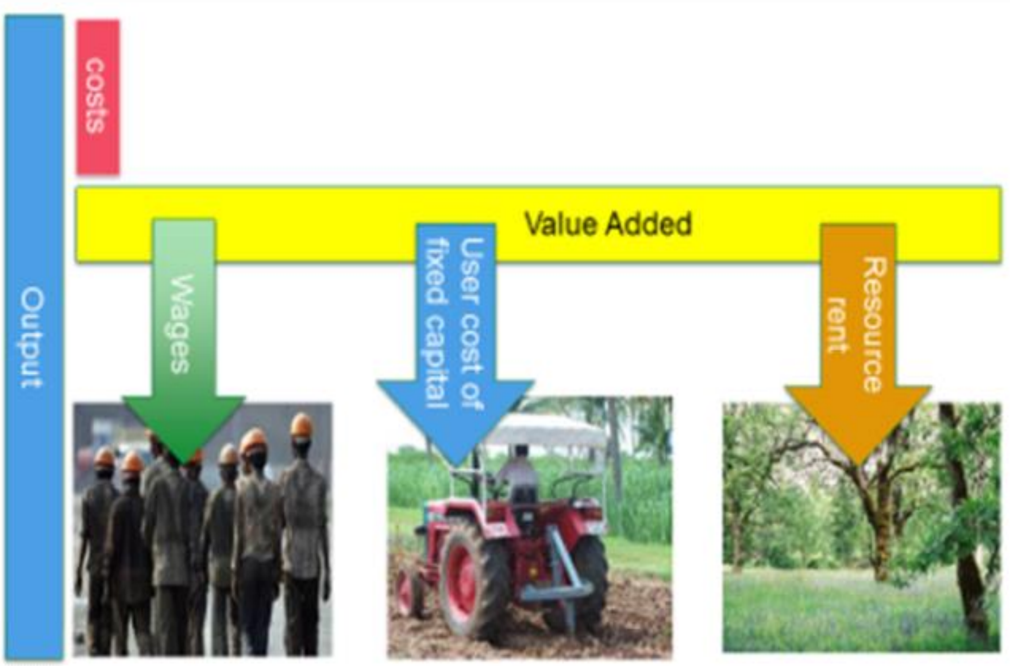
- 'Replacement costs'/'avoided damage costs'
  - Graciela Chichilnisky and Geoffrey Heal (*Nature*, 1998):
    - "In 1996, New York City invested between $1 billion and $1.5 billion in natural capital, in the expectation of producing cost savings of $6 billion–$8 over 10 years."
    - "New York City has floated an 'environmental bond issue' and will use the proceeds to restore the functioning of the watershed ecosystems responsible for water purification ...."
    - "demonstrated how New York City realized billions of dollars in economic benefits by sustaining the Catskills watershed as a water filtration system, rather than . . . building a new filtration plant."

Valuation methods

Example:

Resource rent (RR) approach:

- Value added of economic activities seen as return to all assets used in production
- RR estimated as residual
- Measures contribution by the ecosystem to production (= ES)
- Ecosystem service < benefit



Resource rent

sales at basic prices, includes all subsidies on products, excludes taxes on products)

	Output (sales)
Less	Operating costs
	a) Intermediate consumption
	b) Compensation of employees (input costs for labour)
Equals	**Gross Operating Surplus**
Less	User costs of produced assets
	a) Consumption of fixed capital (depreciation)
	b) Return to produced assets
Equals	**Resource rent**

(input costs of goods and services at purchasers' prices)

SEEA

Group exercise

Estimate the resource rent for crop provisioning services for a hypothetical farm using the following data:

• Sales	25 tons
• Market price	20 Reais
• Costs of seeds, fertilizers	40
• Wages	200
• Value of machinery	400
• Remaining lifetime of machinery	10 years
• Rate of return for investment	8 %
• Investment	50

Level 1: Tools 3: Valuation

Exercise 1: answer

Resource rent = 188

Step 1: estimate the gross operating surplus (in basic prices)

500-40-200 = 260

Step 2: deduct the return to produced capital

depreciation: 10% of 400 = 40

rate of return = 8% 400 = 32

260 - 72 = 188

<u>*Ecosystem service = contribution by ecosystem to benefit*</u>

Valuation of assets

- Assets: in absence of market prices
  - Written down replacement cost
  - Net Present Value of future services
- NPV: the value of an asset equals the discounted value of the flow of services from the asset:

$$NPV = \sum_{t=0}^{T} \frac{C_t}{(1+r)_t} = C_0 + \frac{C_1}{(1+r)_1} + \frac{C_2}{(1+r)_2} + \ldots + \frac{C_T}{(1+r)_T}$$

NPV = Net Present Value

C = Net benefits in year t

T = Discount period (e.g. 20 year)

r = Discount rate

Valuation of assets

- The value of the asset equals the discounted flow of services from the asset

Current values	t0	t1	t2	Sum
ES1	40	30	35	
ES2	60	40	20	
Total, undiscounted	100	70	55	225
Total, discounted	100	64	45	209

$$\mathrm{NPV} = 100 + \frac{70}{(1+0.1)} + \frac{55}{(1+0.1)^2} = 209$$

Valuation of assets

NPV is challenging:

- NPV of expected flows -> requires information of all the ES extended into the future
  - Therefore, interest emerged in the notion of “capacity” or “sustainable flow”
  - Sustainable flows of ES by definition extend into the future circumventing the issue of assessing specific paths
  - Capacity may be monetised on the basis of the NPV of the sustainable flow of ecosystem services
- Choosing an appropriate discount rate

Degradation

Several approaches to measuring degradation:

- Physical terms through changes in ecosystem condition indicators
- Monetary terms through changes in the NPV of expected use
- Monetary terms through changes in NPV of capacity.
- Through changes in the NPV of potential supply or capability of ES

When degradation is assessed through changes in NPV:

- Degradation is not simply the change in value of the asset in time
- In an asset account, change in value is decomposed in various elements
  - Important to identify the part that is due to using up of the asset -> exclude changes in value due to price changes
  - Distinguish between human and non-human induced degradation
  - Link to deterioriation of capacity and condition of the ecosystem

Degradation

Alternative approach to measuring degradation through NPV is **restoration (and maintenance) costs.**

- Such approaches were initially suggested in the original 1993 SEEA
- Under this approach, an estimate is made of required expenditure to restore an ecosystem to a previous condition
- Similar to "valuation at cost" which is undertaken in SNA in the absence of market prices (e.g. education or health services by govern.)
- This line of thinking is sometimes extended to consider that the accumulated, unpaid restoration costs represent a liability – an ecological debt (Weber, 2011; Vanoli 2005).
- Caveats:
  - restoration to previous condition, not to return the asset to an "as new" condition
  - The change in total restoration cost between two points in time may be an alternative valuation of degradation

Integration

- Integrating services into Supply and Use tables
- Assume we have a hypothetical simple economy
- GDP = 200

	Ecosystem	Economy	Household	Total
Supply				
Ecosystem service A				
Ecosystem service A				
Product X		200		200
Use				
Ecosystem service A				
Ecosystem service A				
Product X			200	200
Value added (supply less use)		200		**200**
			200	

Integration

- Integrating services into Supply and Use tables
- Suppose the economy depends on a ecosystem service B

	Ecosystem	Economy	Household	Total
Supply				
Ecosystem service A				
Ecosystem service A	50			50
Product X		200		200
Use				
Ecosystem service A				
Ecosystem service A		50		50
Product X			200	200
Value added (supply less use)	50	150		**200**
			200	

- This increases output, but GDP remains the same
- We have made the contribution by nature visible !

Integration

- Now suppose there is an additional ecosystem service A finally consumed by households (say an amenity service)

	Ecosystem	Economy	Household	Total
Supply				
Ecosystem service A	100			100
Ecosystem service A	50			50
Product X		200		200
Use				
Ecosystem service A			100	100
Ecosystem service A		50		50
Product X			200	200
Value added (supply less use)	150	150		**300**
			300	

- Now we see that both output and GDP of the economy changes

Integration

- The impact of including ecosystem services in the national accounts will depend on the type of services and their usage: output will increase but GDP may not
- Likewise, various possibilities exist for recording degradation in the accounts. By definition GDP will remain the same (but NDP may change) [one of the reasons to dislike green GDP]
- No standardization yet for precise recording of either ecosystem services (Model A and B in the TR and degradation)-> more research needed

Level 2: Tools 3: Valuation

References

- UN et al. 2017, Technical Recommendations on Ecosystem Accounting
- Costanza et al. 1997
- Obst, Hein and Edens, 2015
- Nordhaus, 2005, Principles of National Accounting for Non-Market accounts

Further information

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