Valuation of ecosystem services in an accounting context

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What is value ?

Why should we consider the monetary value of ecosystems and ecosystem services ?

- To allow comparison with /integration in national accounts
- To support decision making on ecosystem management
- To allow comparison of physical changes within the ecosystem account

But.. Valuation is often not straightforward and not all methodological issues have been clarified

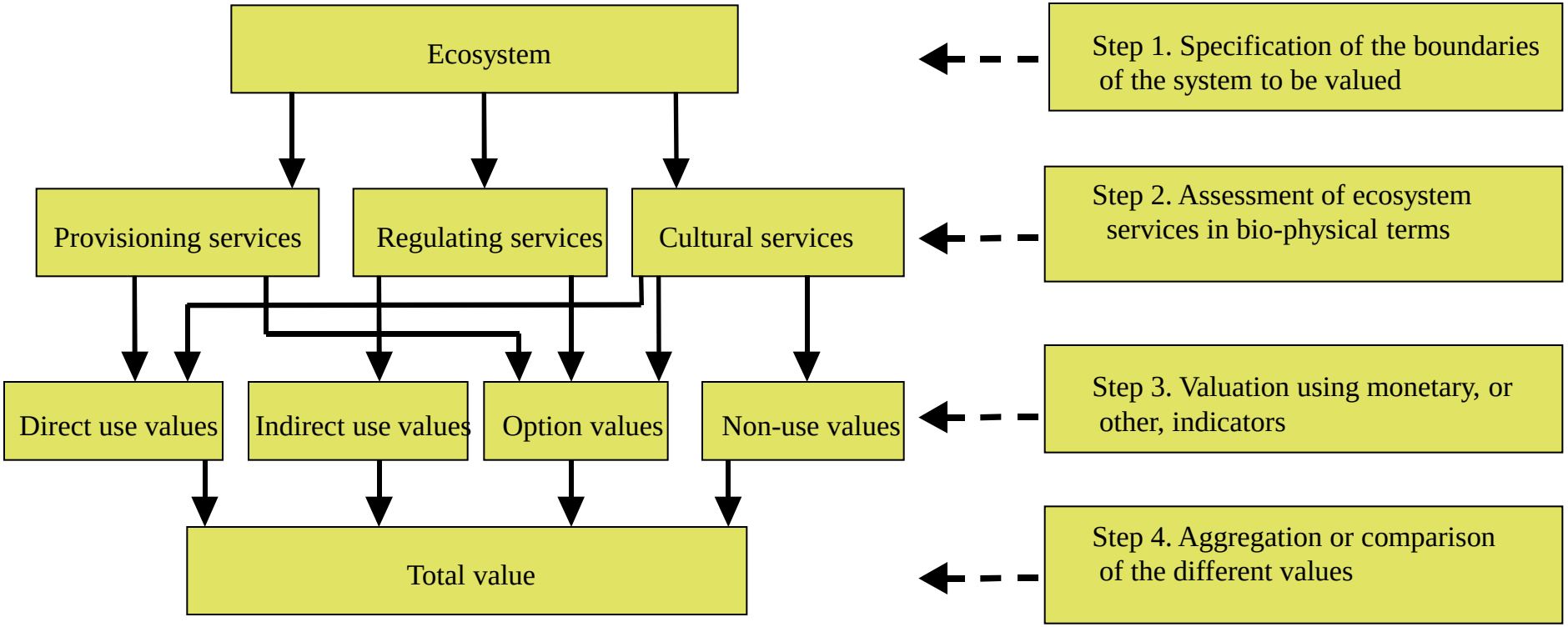
Value Types (1): Use Values

- Use value – benefit derived from physical use or access to an ecosystem service
  - Direct use value – benefit derived from directly consuming services provided by an environmental good (e.g. provisioning services)
  - Indirect use value – benefit resulting from the contribution to other activities and/or services (e.g. flood control facilitating agriculture)

Value types (2): Non-use and option value

- Non-use value (existence value) – benefit received from the continuance of an environmental good - independent of any use, present or future, that people might make of the good
  - Bequest value - knowing that others including offspring derive benefits from an environmental good
  - Pure non-use value: Stewardship – the sense of obligation to preserve the environment for future generations
- Option value - relates to risk. Because people are unsure about their future demand for a service, risk averse people are willing to pay to keep the option of using a resource in the future
- Total Economic Value TEV = UV + NUV + OV
- Non-use and option values are **not** in national (and therefore ecosystem) accounts

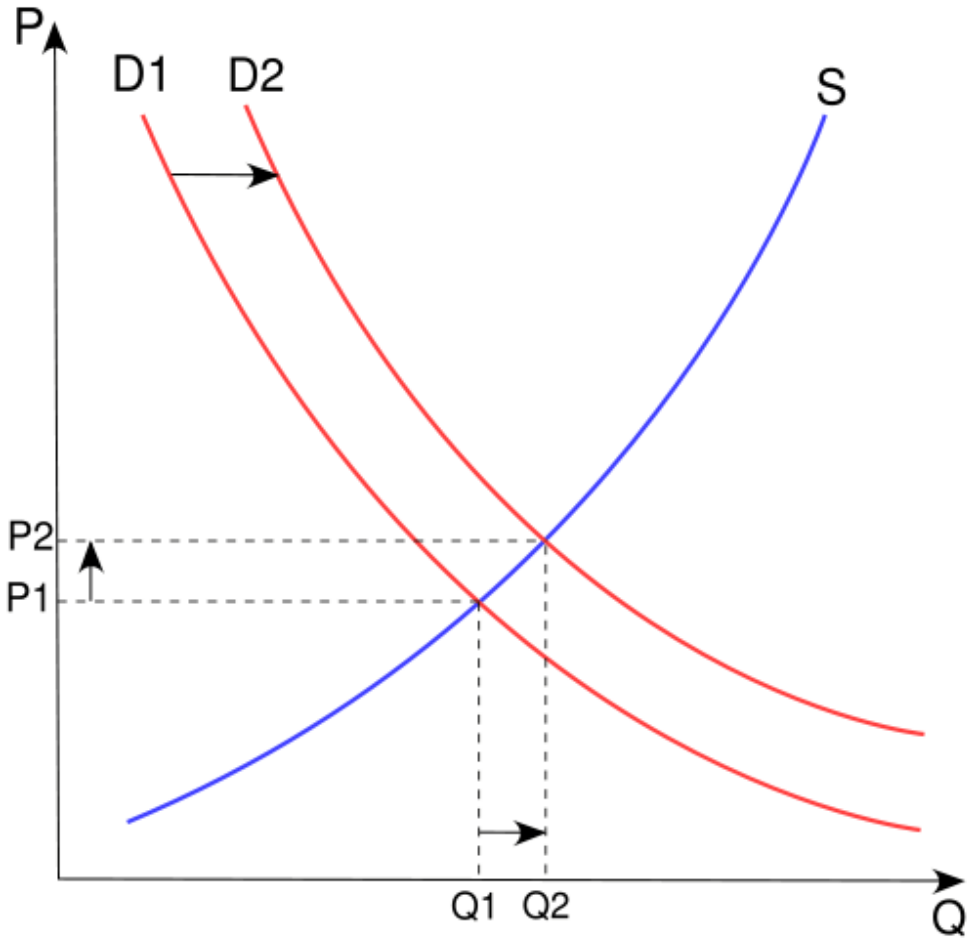
Linking services to values



Private versus public goods

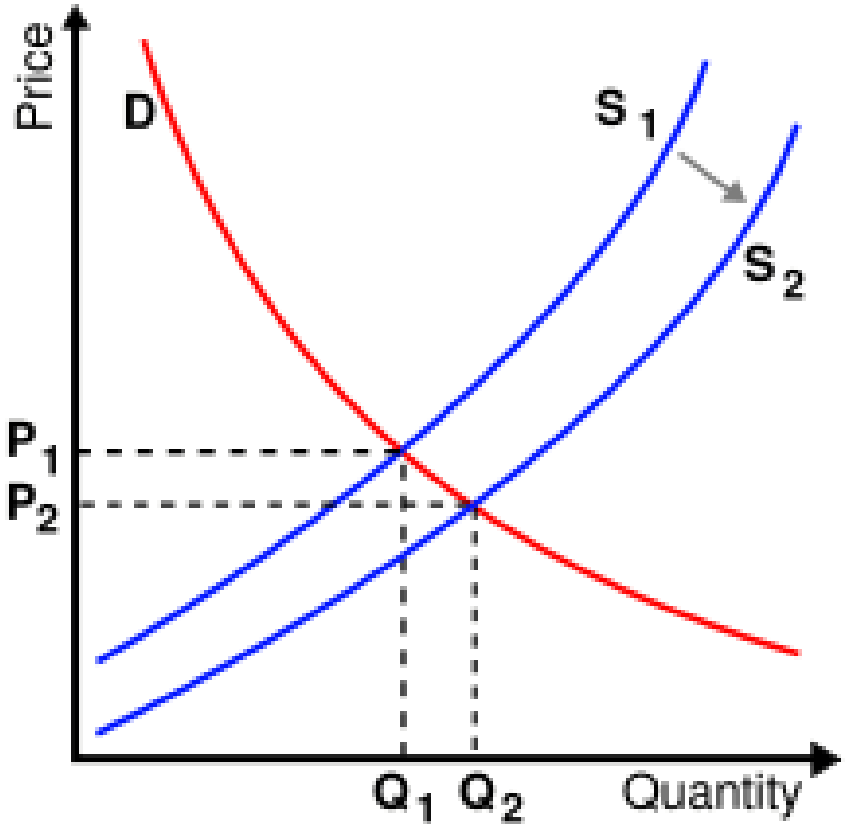
- Public goods (e.g. dykes):
  - Non rivalrous: consumption of the good by one individual does not reduce the amount of the good available for consumption by others; and
  - Non excludable: no one can be effectively excluded from using the good
  - Quasi public goods (e.g. cable TV, recreation in national park)
- Many regulating and cultural ecosystem services are public goods and therefore not traded in a market
- Note that Payment for Ecosystem Schemes intend to establish markets for such services (carbon, hydrological service)

Market goods: demand and supply curves



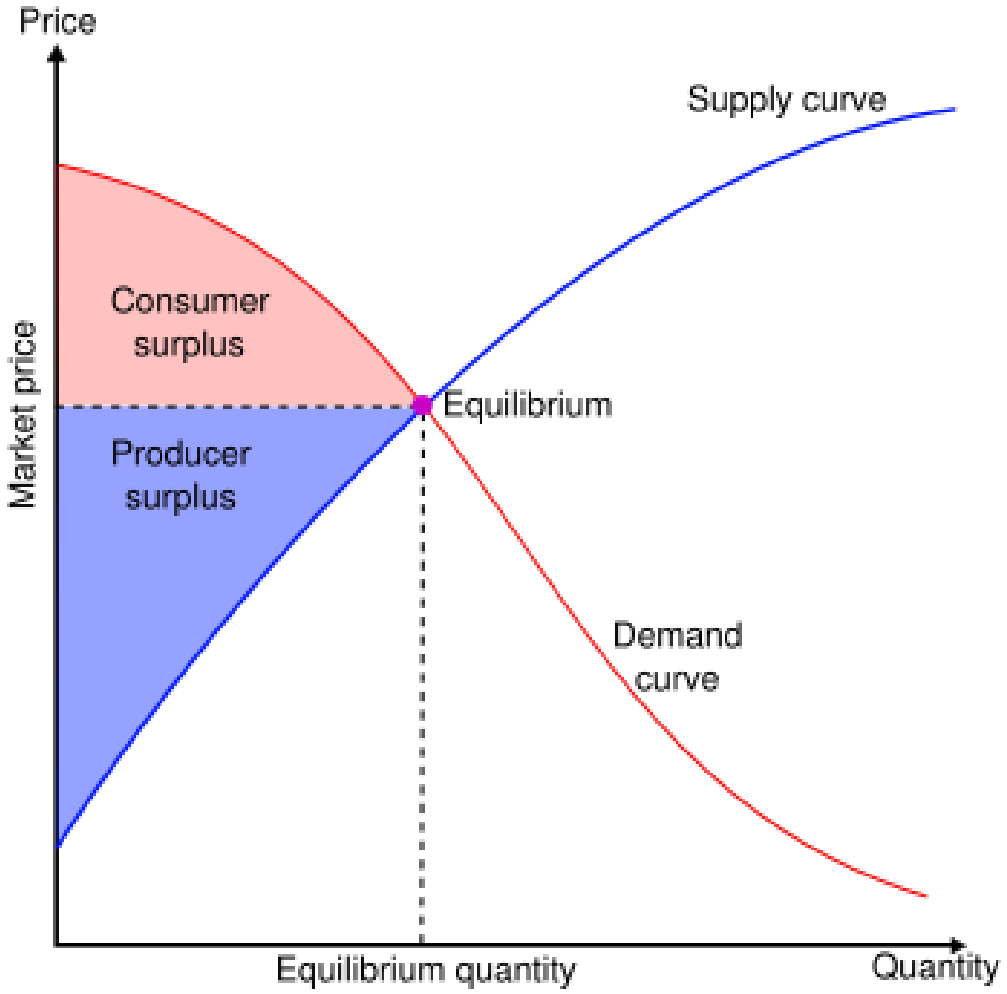
Increase in demand reflected in a change in the demand curve

Market goods: demand and supply curves



Increase in supply reflected in a change in the supply curve

Consumer and Producer surplus



Welfare based valuation: (MA, TEEB) considers producers and consumers surplus

Production based valuation (SNA and Ecosystem Accounting) focusses on production (excludes consumer surplus)

Private goods...

...are often traded in a market. Their price (marginal value) is reflected in market transactions.

The SNA measures three kind of prices to measure output:

- Basic price: selling price minus any tax plus any subsidy
- Producer's price: the price invoiced by producer to purchaser (minus VAT).
- Purchaser price: including transport required for delivery

- Note that it is assumed that the revealed prices reflect the 'truthful response' of the market participants, i.e. that transactions occur in well-functioning markets.

Measuring value

- National accounts record the value of production (in the production account).
- Value added is the value created by production
  - Gross value added: the value of output less the value of intermediate consumption (GDP)
  - Net value added : the value of output less the value of intermediate consumption and consumption of fixed capital ('depreciation'). (NDP)
- Outputs are valued at basic prices (if not available: producer's prices), intermediate inputs are valued at purchaser's prices.
- Note that production for home consumption is within the SNA production boundary *(to be valued at equivalent farm-gate price)*

Valuing public goods

Principle in SNA (2008): Public goods (e.g. education) are valued at cost. I.e. as the sum of:

- Intermediate consumption
- Compensation of employees
- Consumption of fixed capital
- Other taxes (less subsidies) on production

There are challenges in applying these valuation principles to ecosystem services..

Valuation of non-market goods in Ecosystem Accounting (in order of preference..)

- Production factor approaches: Production function approaches estimate the contribution of ecosystem services to production processes in terms of their contribution to the value of the final product being traded on the market (e.g. pollination).
- Replacement costs (not restoration costs !): In case an ES provides input into a whole range of different benefits (e.g. a coastal protection service). It is required that it can be reasonably be expected that society would indeed replace the service if it was lost.
    - Example: the value of coastal protection equals the costs of dykes ***if*** it can be expected that these dykes would indeed be constructed
- Avoided damage cost: This valuation approach may be applicable where replacement investments are not likely to be made.

Valuation methods for non-market goods and services

- Revealed Preferences (indirect)
  - Hedonic pricing
  - Travel Cost Method
  - Physical linkages
  - Behavioral linkages
- Stated Preferences (direct)
  - Price data
  - CVM and Choice modelling

Case 1: Valuation of the pollination service

- Local value of coffee pollination in Costa Rican coffee plantations (Ricketts et al., 2004).
- Enhanced pollination of coffee plants near forest edges led to a 20.8% higher yield in comparison with coffee plants in the centre of the fields.
- Local producer surplus = S. Δq. (p-c)
- Annual surplus generated by the forest patches on the plantation was US$ 62,000 (7% of total annual income of the plantation).

Case 2: Valuation of the *welfare* effects of the pollination service

- Gordon and Davis (2003) estimate the costs of the loss of honey bee pollination related to Australian agriculture
- Partial equilibrium model requiring supply and demand elasticities of all crops

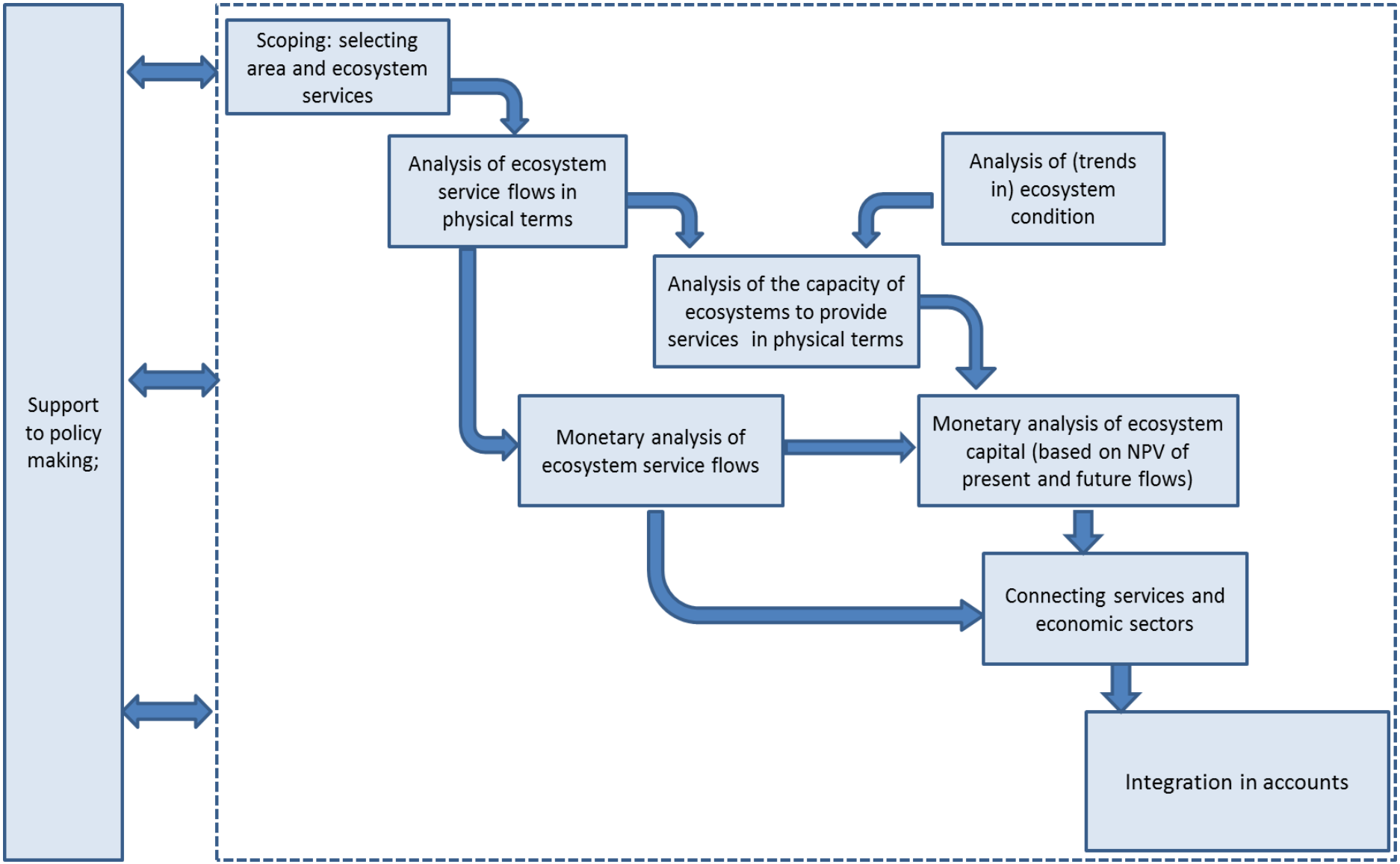
Crop	Dependency on honey bee	Producer Surplus	Consumer Surplus	Total surplus	Change in industry output
Apple	90%	-174	-125	-298	-261
Orange	30%	-29	-23	-52	-65

Case 3: Valuation of the pollination service

- Marginal benefits of Pollination in Indonesia (Olschewski et al. 2006)

Land use conversion (ha)	Coffee net revenu (1000 $)	Net revenue from other crops (1000 $)
0	16.3	0
58	14.5	9.3
100	11.7	16.0

Key elements of Ecosystem Accounts



Biophysical and Monetary indicators

	Biophysical	Monetary
Ecosystem condition	X	
Ecosystem service flows	X	X
Ecosystem service capacity	X	X

Valuing provisioning services in ecosystem accounting: basic approach

$$RR = TR - (IC + LC + CC)$$

where

RR = resource rent

TR = total revenue

IC = intermediate consumption

CE = labour costs

CC = consumption of fix capital

Net value added equals gross wages, pre-tax profits net of depreciation, and indirect taxes less subsidies.

Valuing regulating services

- Carbon sequestration:
  - Carbon market (but: prices strongly dependent on set-up of the market)
  - Marginal damage costs (but: strongly dependent on discount rate, and the way complex dynamics (large-impact, low probability events) are taken into account).
  - Marginal damage costs range from US$ 20 to over US$ 1000/ton C (Ceronsky et al., 2009)
- Hydrological services:
  - Production factor approach (if flood risk can be linked to one or few economic activities)
  - Replacement costs (costs of levees, dykes)
  - Avoided damage costs (avoided costs of flooding)

Valuing recreation

- Benefits for recreation industry: resource rent approach
- Benefits for visitors: consumers surplus to be excluded (alternative valuation options are being explored, e.g. by Campos, Camparrós, Edens)

Valuing capacity

Capacity is valued on the basis of the discounted flows of services provided by the ecosystem

This is a forward looking valuation approach and requires assumptions on future output of ecosystems (present management or sustainable management)

It also requires the selection of a discount rate. SNA: market discount rate. But: many ecosystem services are public benefits, two options:

- Market discount rate for all services
- Market discount rate for private services, public discount rate for public services

The discount rate and the Net Present Value (NPV)

$$NPV = \sum_{t=0}^{T} \frac{Ct}{(1+r)^t} = C_0 + \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + \ldots$$

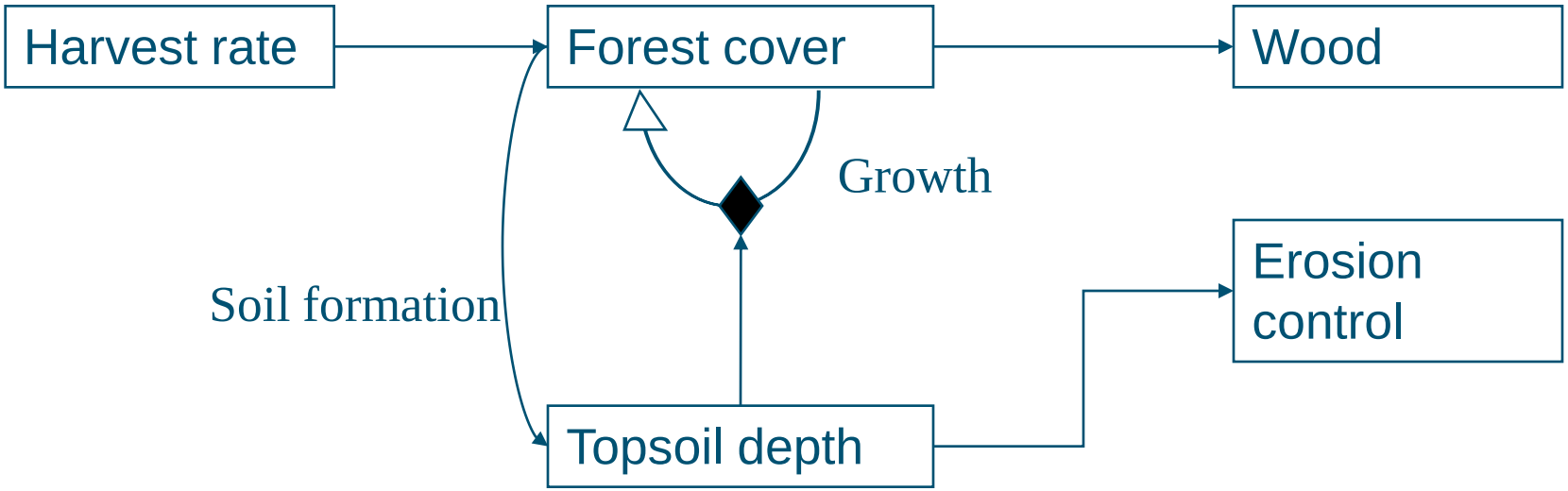
- NPV = Net Present Value
- C = Net benefits in year t
- T = Discount period (e.g. 20 year)
- r = Discount rate

The NPV reflects the monetary value of an investment on the basis of it's cash flow during a discounting period and a discount rate

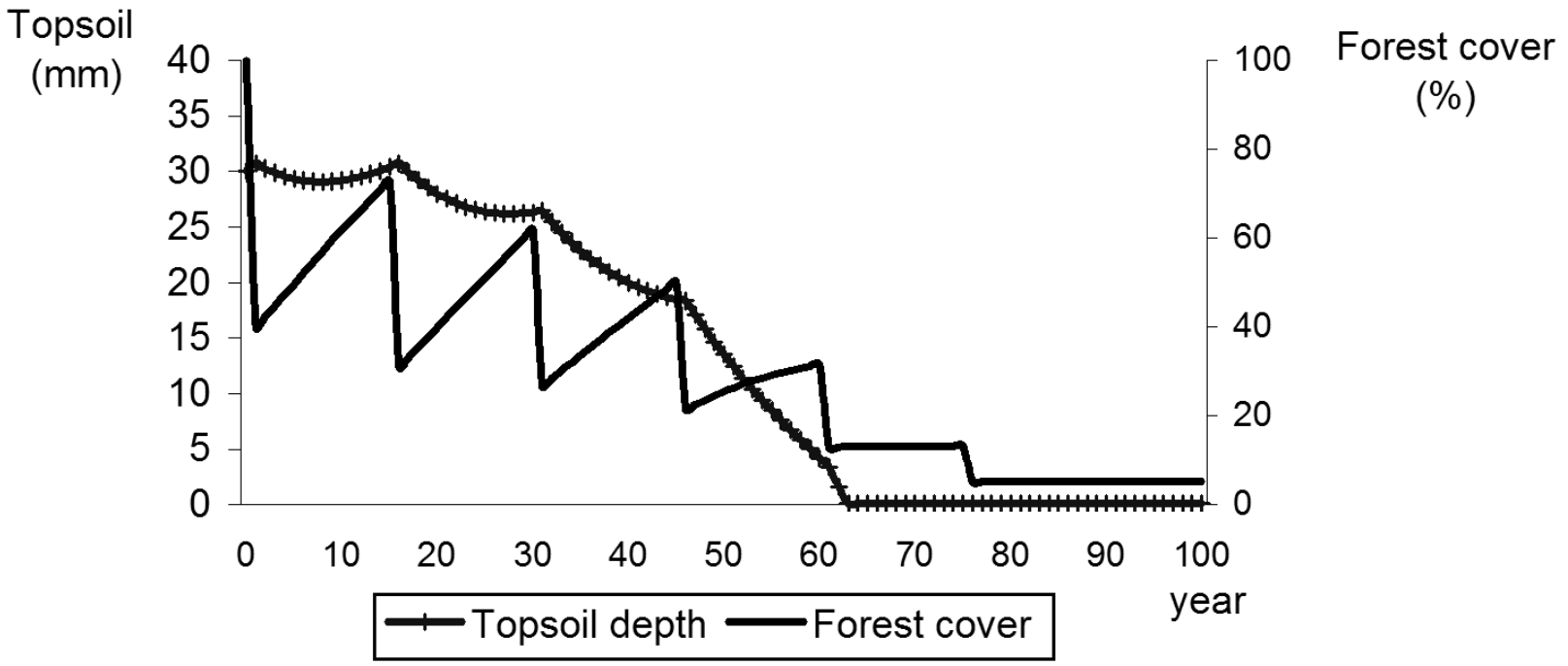
Illustration NPV under different management options (forest ecosystem)

- Modelling of irreversible responses to overharvesting
- Analysis of two ecosystem services: wood and erosion control
- Modelled for a hillside plot (30 by 30 meter) with a uniform slope (20^{o})

Case study: the model structure

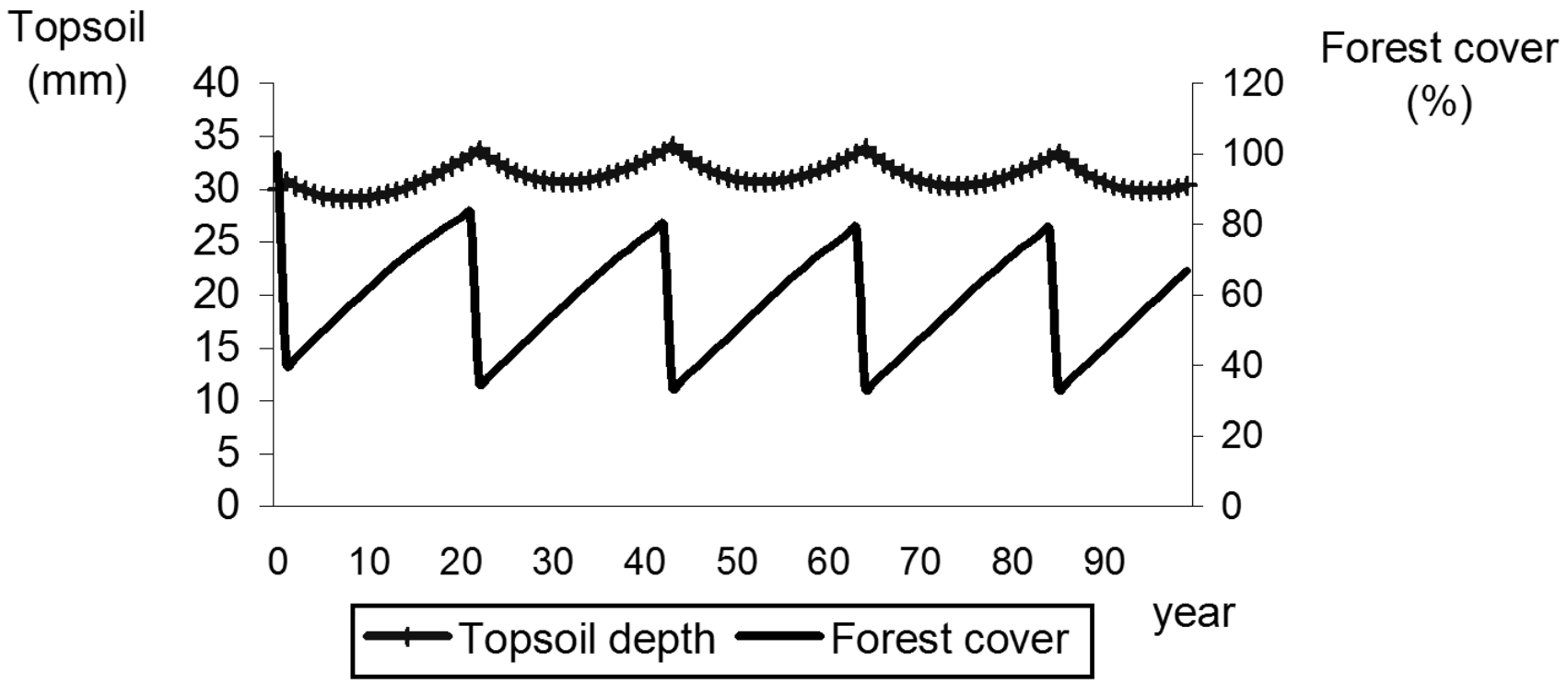


Profit maximisation (felling cycle=15 years)



Source: Hein and Van Ierland, 2006

Sustainable management (felling cycle=21 years)



Source: Hein and Van Ierland, 2006

Comparison of management options

Management strategy	Felling cycle (years)	NPV (US$)
	Discount rate =5%	
Profit maximization	15	585
Sustainable management	21	475
Maintaining the minimum sustainable stock	variable	572
Actual management	?	?

Source: Hein and Van Ierland, 2006

Valuing degradation

Long standing debate, two options

- Impacts on flows of benefits (e.g. ecosystem services)
- Restoration costs (to restore ecosystem to prior state), two disadvantages:
    - What is the prior state ? (a pristine ecosystem ??)
    - Would society indeed restore the ecosystem ?

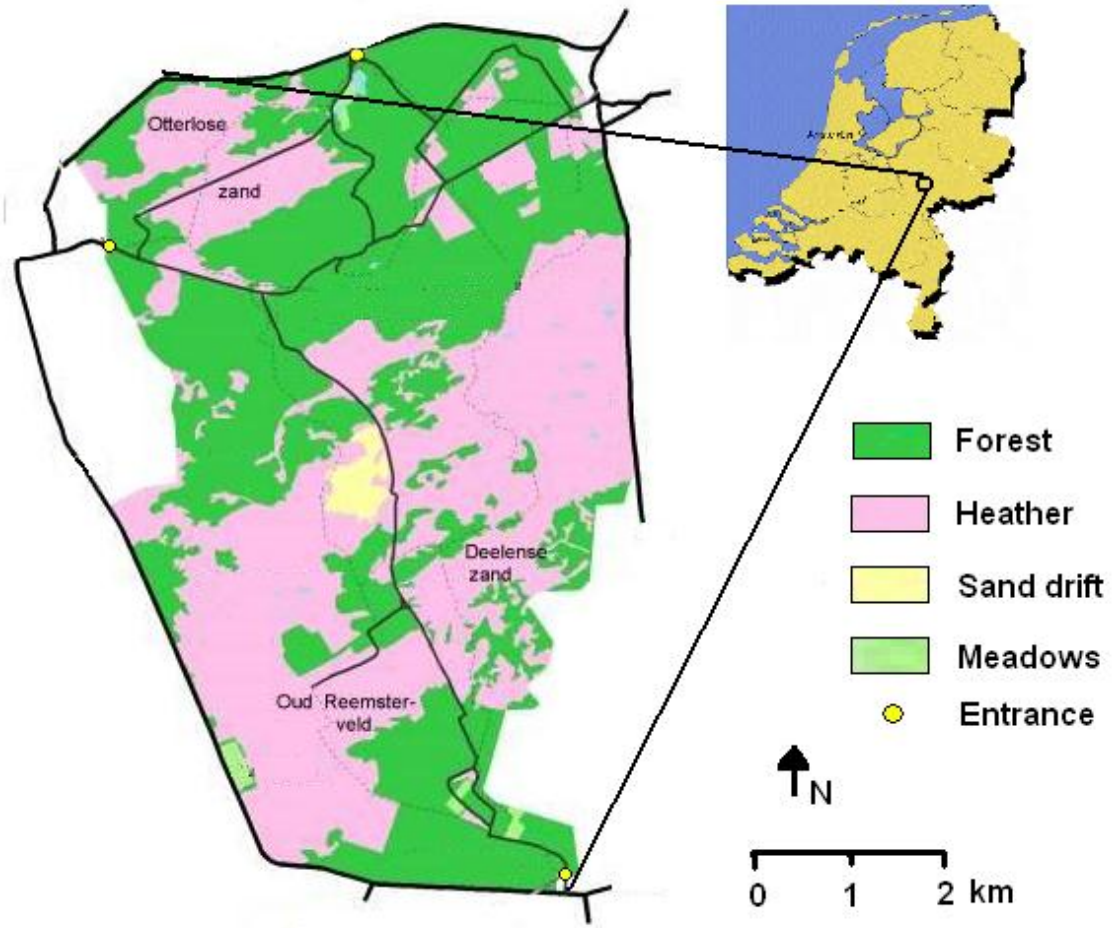
Ecosystem accounting: degradation is valued through a change in the capacity of ecosystems to generate ecosystem services.

Note: there is not necessarily a reference ecosystem state in this approach, any given year can be chosen as baseline.

Valuing biodiversity ?

- Lack of methods to reliably value biodiversity
- In addition: mostly a non-use value not aligned with SNA
- Therefore, current thinking: not to value biodiversity in monetary terms (physical account only).
- Measuring degradation of biodiversity requires comparison with a baseline, for which a base year, or baseline condition can be selected (e.g. pre-European in the case of Australia or New Zealand).

Example: National Park Hoge Veluwe



- 5500 ha of forest and heather
- Important for biodiversity and recreation
- Foundation: operated without government subsidy
- Range of services including regulation services

Ecosystem services and valuation methods

Service	Value indicator
Wood production	Resource rent (park)
Game (deer and wild boar meat)	Resource rent (park)
Groundwater infiltration	Avoided costs
CO2 capture	Marginal damage costs CO2
Air filtration	Not valued
Recreational hunting	Resource rent (park)
Recreation: hiking and cycling - Visitors - Service providers	 Not valued Resource rent (park)
Nature conservation	Not valued

Valuation of the groundwater infiltration service

- Total groundwater replenishment in the Hoge Veluwe park is 16.8 million m^3/year. About 1/3rd of this is used for drinking water production.
- River water (Rhine) would alternatively have been used. Production costs are higher because more treatment is required. Average additional costs for purification are 0.40 euro/m^3
- The value generated by this service is: 0.40 euro/m^3 x 16.8 million m^3/year = 6.7 million euro/year.

Monetary value of the Hoge Veluwe park (2010)

Service	Value (1000 euro/year)
Wood production	354
Game (deer and wild boar meat)	50
Groundwater infiltration	6700
CO2 capture	150
Air pollution removal	-
Recreational hunting	125
Recreation	1853
Nature conservation	-
Total	9232

This equals 1670 euro/ha/year

Synthesis

- Monetary valuation in Ecosystem accounting is conform SNA (2008), and measures production values not welfare.
- For private goods, exchange values (prices) can generally be observed in or derived from market transactions.
- For public goods, including most regulating services, alternative approaches need to be followed, based on the production factor approach, the replacement cost method or avoided damage costs.

Further reading

- Welfare based valuation: MA framework (2003), NRC (2005), TEEB (2010), Bateman et al. (2013); www.ecosystemvaluation.org
- Production based valuation: SNA (2008), SEEA Vol 2 (2012), Edens and Hein (2013)

Questions ?