An Introduction to Nature Valuation

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My background

- Agriculture & Forestry

2008 – MSc Agriculture Engineering & Forestry (Univ. of Liege, Belgium)

- Natural Resource Mgmt

2008 – MSc Natural Resource Management (Cranfield University, UK)

- GIS industry (ESRI)

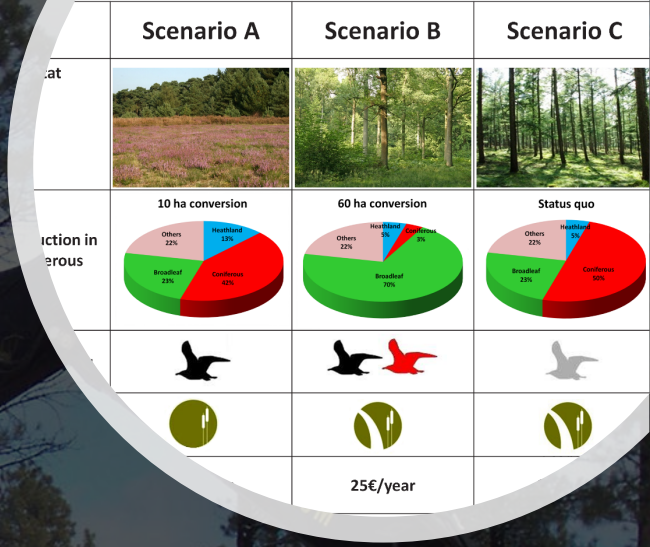
2 years – Project Manager

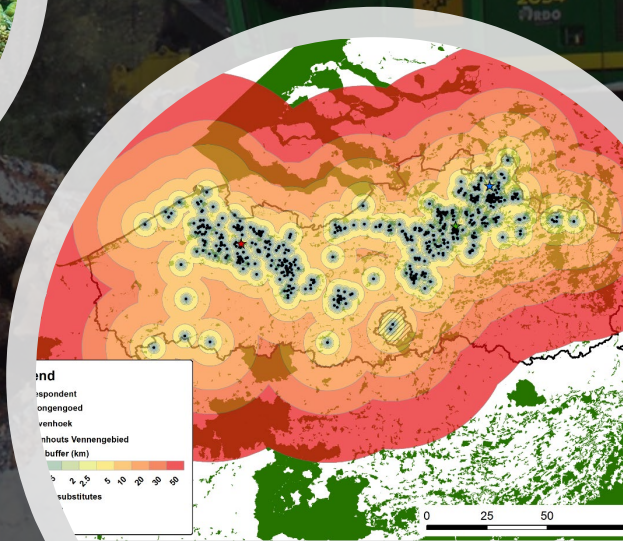
- Environmental Economics

2015 – "Valuation and mapping of cultural ecosystem services" (KU Leuven, Belgium)

- Postdoc, Water Quality Economics in the GBR

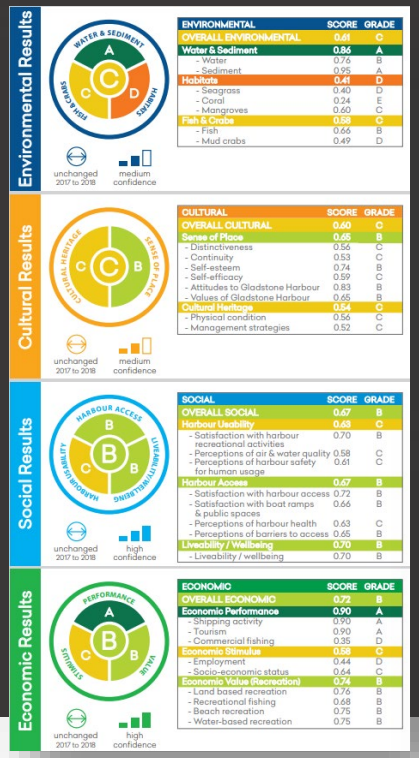
2016-now: Applied Economics Research Group (CQU, Brisbane, Australia)





What I do at CQU

- Applied Economics Research Group – Prof. John Rolfe
  - Environment/Resource Economics
  - Agricultural Economics
  - Regional Development
- Active on several research projects, mostly in Gladstone: e.g.
  - Gladstone Healthy Harbour Report Cards
  - Mud Crabs ecotoxicology
  - Gladstone Ports Corporation
- Research related to water quality improvements in the GBR
- Non-market valuation (especially choice modelling)
- Both theoretical/conceptual work and case studies



Overview

- Cost Benefit Analysis (in a nutshell)
- Nature valuation: What is “value”?
- Nature valuation: What is “nature”
- Concept of Ecosystem Services
- Valuation techniques:
  - Direct valuation methods
  - Revealed preference methods
  - Stated preference methods
  - Benefit transfer
- Take-home messages

Cost-Benefit Analysis in a nutshell

- Need to make a decision about different development projects
- Costs vs. Benefits ➔ Decision-making
- Financial CBA (individual) vs. Economic CBA (whole society)

Nature valuation: what for?

Power plant project

Shopping centre project

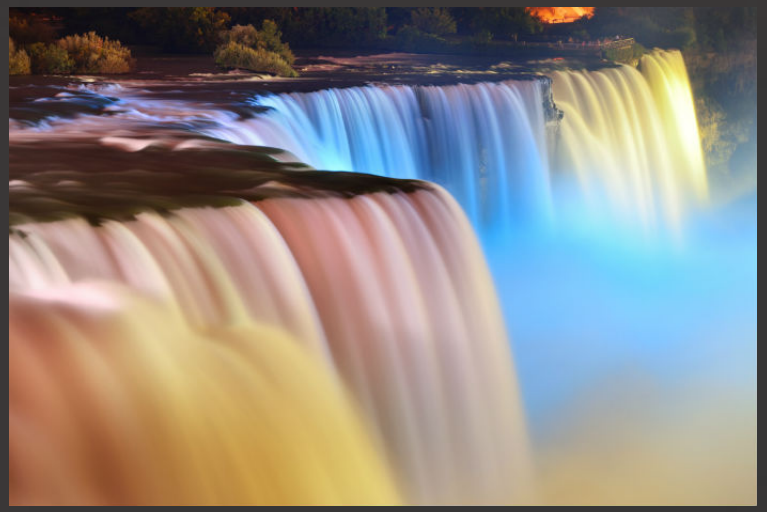
Nature conservation project

➔ How to make decisions if we do not know that "nature" we are trying to protect?

NATURE VALUATION:
WHAT IS “VALUE”?

What is value? (1)

- Price vs. Value ➔ Consumer surplus
- Example: Diamond-water paradox



- **Subjective theory of value:** Properties of the good vs. Importance someone places on a good for the achievement of his desired ends (happiness?).

  ➔ Not only about money!

What is Total Economic Value?

- Total Economic Value (TEV)
  - Use Values
    - Direct use Values
    - Indirect use values
    - Option Values
  - Non-Use Values
    - Existence Values
    - Bequest Values
    - Altruistic Values

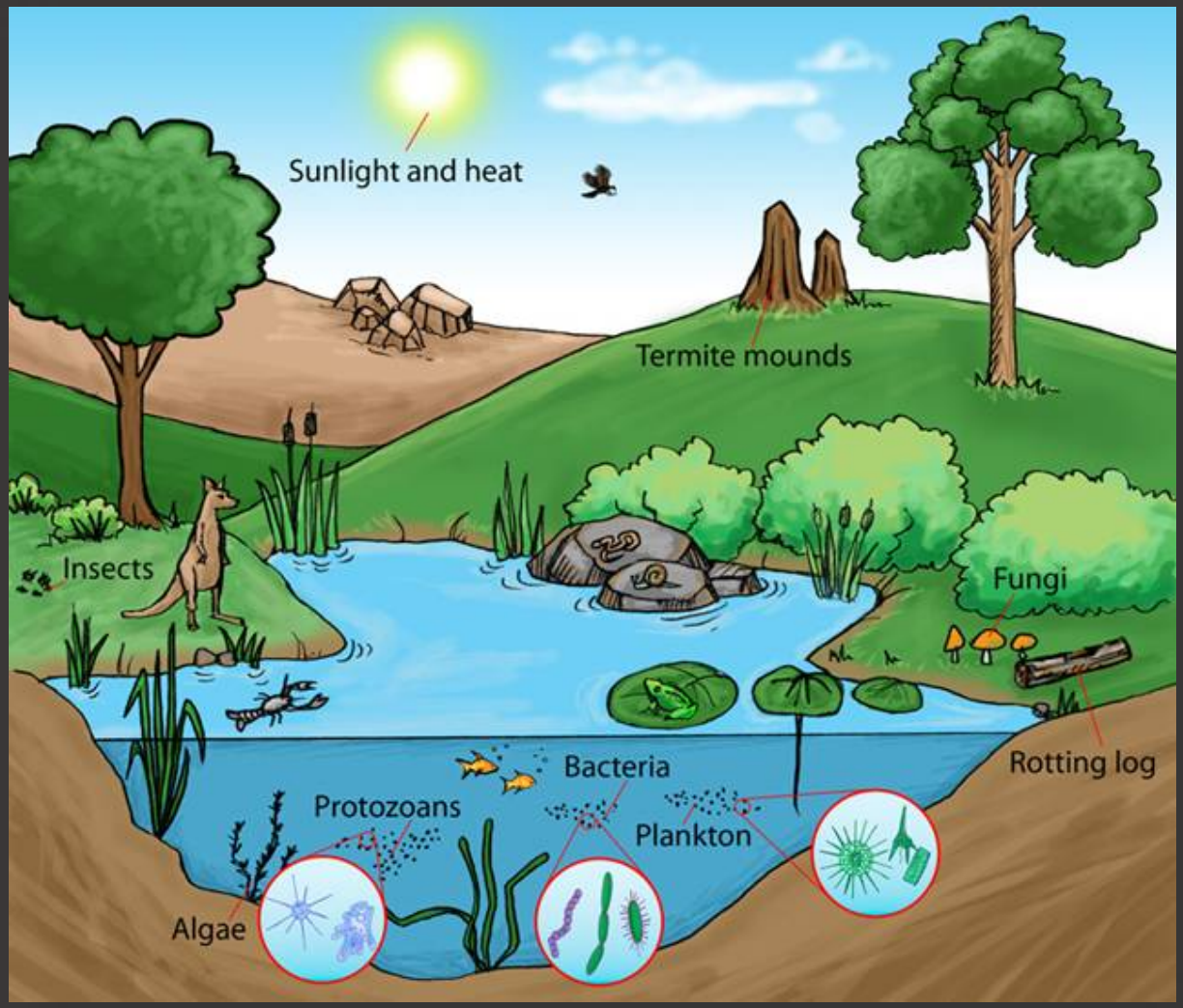





NATURE VALUATION:
WHAT IS “NATURE”?

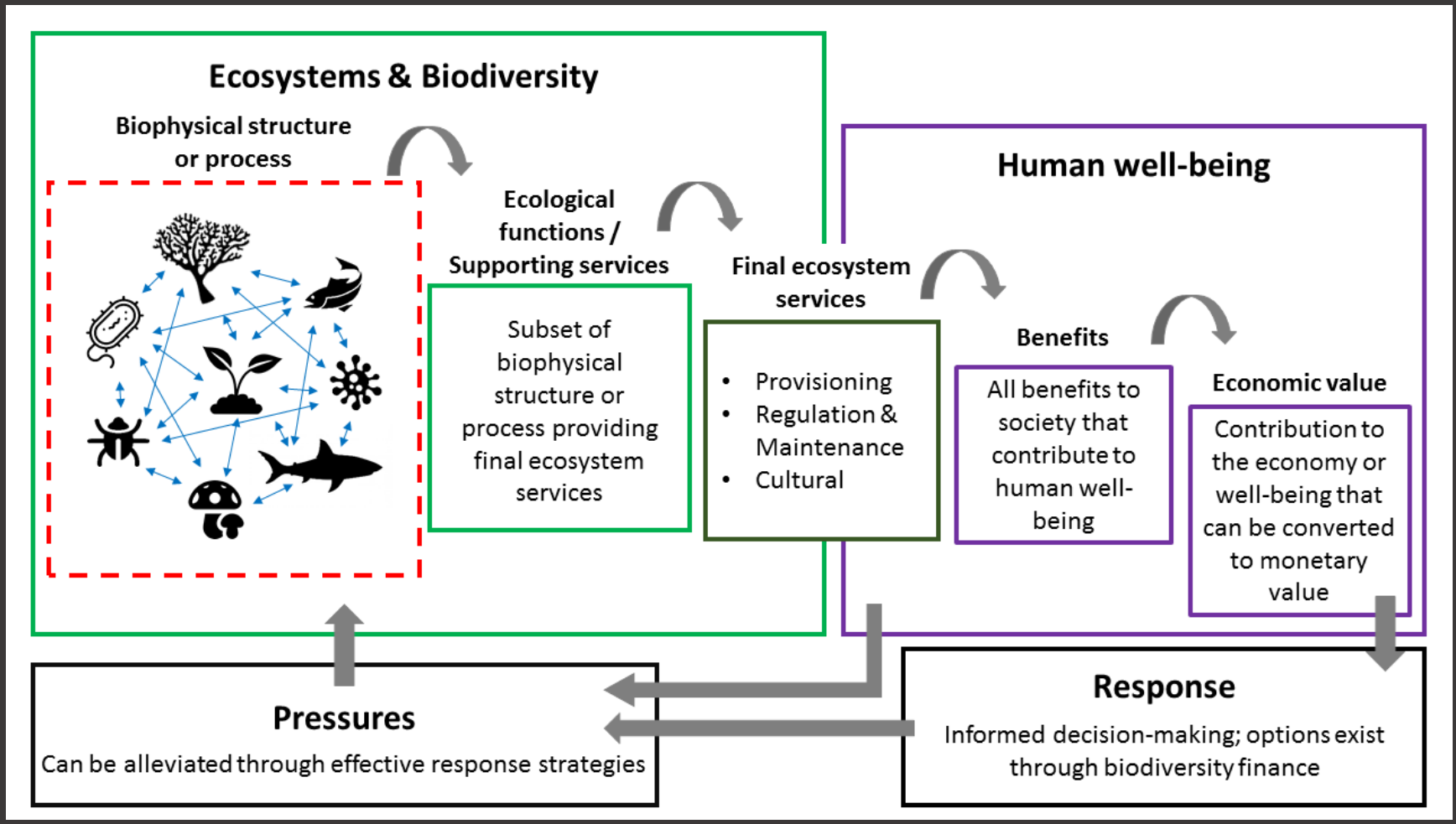
What is “Nature”?

- Nature ➔ Ecosystems
- Ecosystems: Complex dynamic ecological systems
- Biotic (living) + Abiotic (non-living) interactions



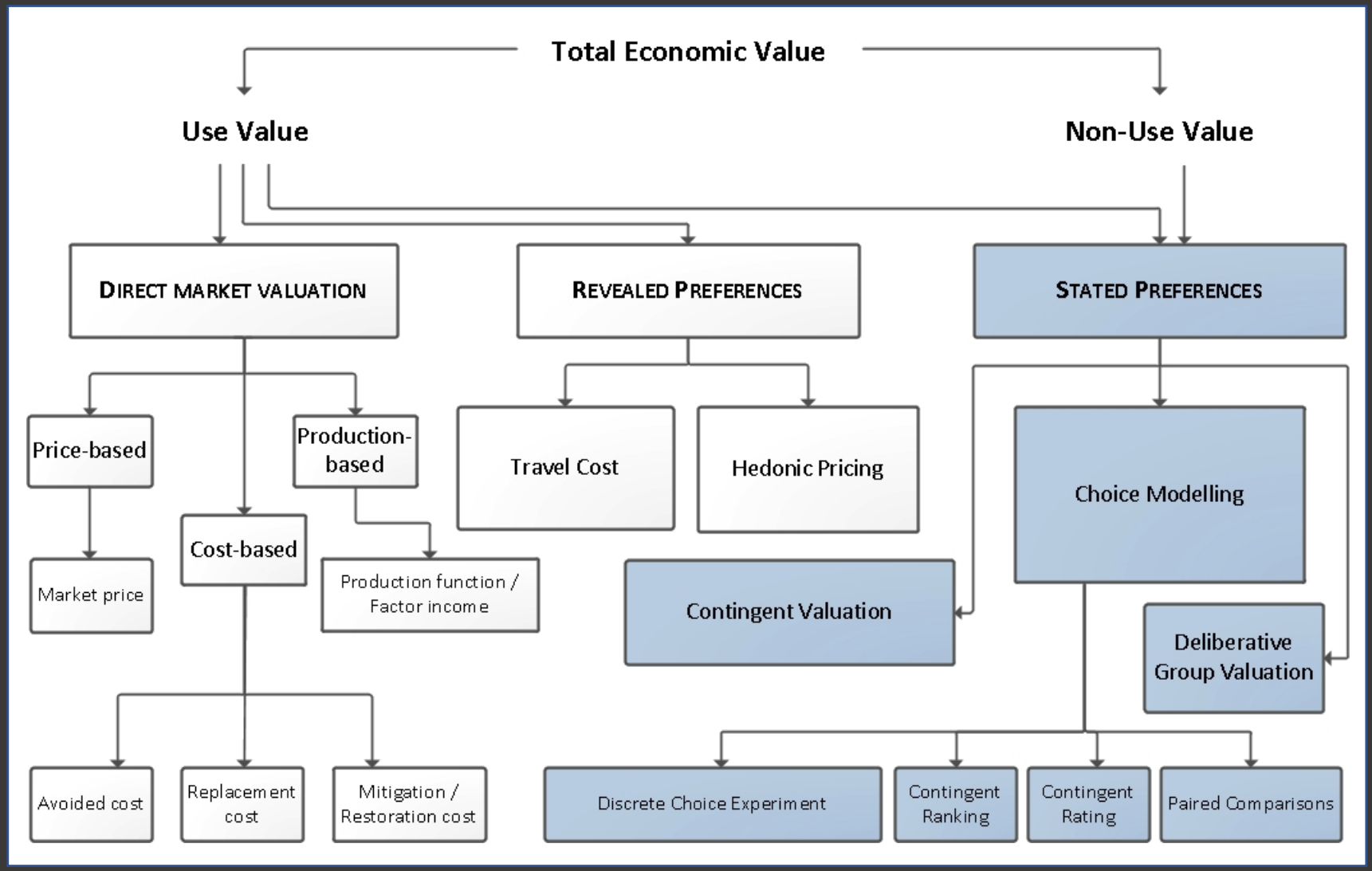
THE CONCEPT OF ECOSYSTEM SERVICES

Biodiversity, ecosystem services and human well-being



Source: De Valck & Rolfe (2019) (adapted from de Groot et al., 2010; Haines-Young and Potschin, 2009, 2018)

Different valuation techniques



Market valuation, non-market valuation techniques and the concept of Total Economic Value (adapted from TEEB (2010) and Pearce & Özdemiroglu (2002))

DIRECT MARKET VALUATION

Direct market valuation

- Price-based
  - Market price
- Cost-based
  - Avoided cost
  - Replacement cost
  - Mitigation/Restoration cost
- Production function-based
  - Productivity methods

Price-based valuation

- ∃ market price? ➔ Let's use it then!

Pros

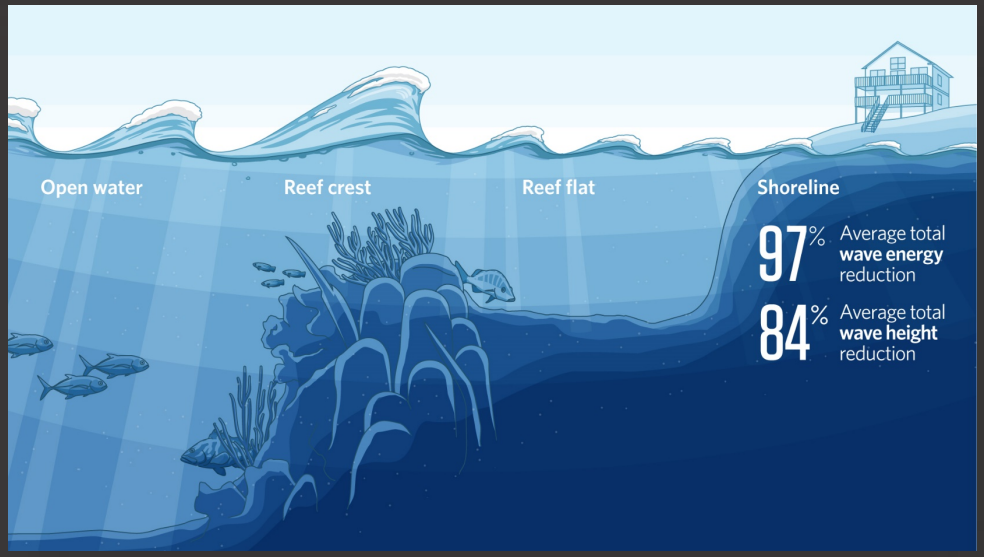
- Easiest
- Based on actual, consumer preferences
- Relies on standard economic techniques

Cons

- Only several, provisioning ES
- Direct use value only, not TEV
- Market failures
- Other resources used to bring the good on market usually not accounted for ➔ overstated benefits

Cost-based valuation

- Avoided cost:
  - Models all factors affecting property damage from storms and assume that all that would be lost ➔ approximates protection value of ecosystem (e.g reef, mangrove…)



Cost-based valuation (2)

- Replacement cost:
  - Money needed to replace an ES with a human-made equivalent

  E.g. wetland vs. water treatment plant, mangroves vs. dykes…

Cost-based valuation (3)

- Mitigation/Restoration cost:
  - Money needed to bring back ecosystem to ex ante baseline state after implementation of a project

  E.g. BP oil spill restoration work & legal fees ≈ US$65B

Production-based valuation (1)

- Ecosystem services introduced as arguments in production functions (instead of utility functions)

- Q=f(L,K,E) and see how Q changes with changes in E (ecological productivity)

- Example: Johnston et al. (2002): Food web and habitat values of wetland ecosystems
  - Food web estimates:
    - How much food produced by a habitat?
    - Fraction converted to marketed products, i.e. finfish and shell fish
    - Converts in $ using species-specific fishery values
  - Habitat estimates:
    - For several species with human use values
    - Average abundance per unit area of habitat
    - Expected yield of finfish and shellfish per habitat type ➔ market prices
    - Abundance of birds using the habitat ➔ non-market recreational trips for hunting and viewing

Production-based valuation (2)

Marginal values of PES wetlands (1995 dollars)

	Existing habitats		Created habitats		
	Annual value per acre[a]	Asset value per acre[b]	Years to become fully functional[a]	Asset value per acre[b]	Estimated number of acres in PES (millions)
Wetland type					
Eelgrass	$1,065	$12,412	10	$9,996	6.04
Saltmarsh	$ 338	$ 4,291	15	$3,454	13.51
Inter-tidal mud flat	$ 67	$ 786	3	$ 626	14.05

Source: Johnston et al. (2002)

REVEALED PREFERENCE VALUATION

Revealed preference valuation

- ES value revealed through a complementary market
  - Use proxies for non-marketed goods in actual markets for related goods or services
  - Approach use value only

- Techniques:
  - **Hedonic pricing**
  - **Travel Cost method**

Hedonic Pricing

- Mostly property market
- Direct & indirect use values of surrounding nature and that affect property price
- Also applied to noise nuisance, air/water quality, etc. ➔ desirability studies
- $p_h = p(S_i, N_j, Q_k) + \varepsilon$

Hedonic Pricing

Pros

- Intuitive
- Straightforward
- Based on market prices

Cons

- Requires heaps of data
- Omitted Variable Bias
- Multi-collinearity
- Market Segmentation
- Spatial Auto-correlation

Travel Cost Method (TCM)

- Recreation-specific
- Direct use value
- # Visits ≈ Demand for the environmental good (~Entrance fee)
- Local visitors

  ➔ ↓costs, ↑visits
- Distant visitors

  ➔ ↑costs, ↓visits

Zonal TCM recipe

1. Define (concentric) zones around site
2. Survey on # visits/zone/year (V_z)
3. Visitation rate: $v_z = V_z/P_z$
4. Using standard value/unit of distance travelled ($/km) & standard value/unit of time ($/h) ➔ calculate c_z
5. Regress $v_z = \alpha + \beta c_z$
6. Use that linear regression to predict visitation rate with entrance fee: $\widehat{v_z} = \alpha + \beta(c_z + F)$
7. Compute total visitor numbers across z zones: $\sum_1^z (\widehat{v_z} * P_z)$ ➔ gives a point on demand curve
8. Repeat process for different entrance fees to create demand curve
9. Obtain total economic benefit of the site by calculating area under demand curve

Travel Cost Method

Pros

- Inexpensive
- Straightforward
- Based on actual behaviour
- Easy to interpret results

Cons

- Correct travel costs estimation
- Multi-purpose trips
- Resident vs. Non-resident visitors
- Scarcity vs. Commodity value of time
- Spatial sorting

STATED PREFERENCE VALUATION

Stated preference valuation

- Based on survey data
- Use and non-use values
- Techniques:
  - **Contingent Valuation (CV)**
  - Choice Modelling:
    - **Discrete Choice Experiments**
    - Contingent Ranking
    - Contingent Rating
    - Paired Comparisons
  - Deliberative Group Valuation

Contingent Valuation (CV)

- Valuation is *contingent* on the hypothetical scenario presented to respondents

- What would you be *willing to pay* (or willing to accept) for such scenario (involving ES changes)?

- CVM Recipe:
  1. Design survey
     - Hypothetical scenario
     - WTP or WTA?
     - Imagine means of payment/compensation
     - Select elicitation vehicle (open-ended, single/double bounded dichotomous choice, etc.)
  2. Choose survey technique
  3. Select target population and sampling strategy
  4. Collect and analyse survey responses
  5. Aggregate WTP/WTA over the population

Contingent Valuation (CV)

Example: Water quality improvement of Lake Mendota, Wisconsin (Stumborg et al., 2001)

- 50% P↓ entering Lake Mendota over 10 years
- WTP for clean-up tax (each year for the next 3 years)
- Mean present WTP per HH: $354±$36
- 155,200 HH in county
- Total WTP: $54.9±$11M
- Expected costs: $17.8M

- We ask you to vote across a range of amounts because the project costs are uncertain at this time.
- Remember that if you vote "YES" for an amount you would no longer have that money to spend elsewhere, so consider what you would be willing to give up for a cleaner Lake Mendota.
- Also keep in mind that instead of paying to clean-up Lake Mendota, you could use this money to visit and enjoy other lakes in the area.

HOW WOULD YOU VOTE?

Would you vote for the proposed program if it would cost your household these **amounts each year for the next 3 years?** (CIRCLE ONE ANSWER ON EACH LINE TO SHOW HOW YOU WOULD VOTE AT THAT COST LEVEL)

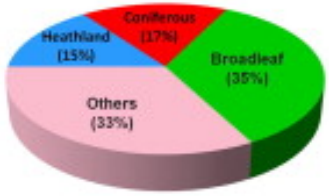
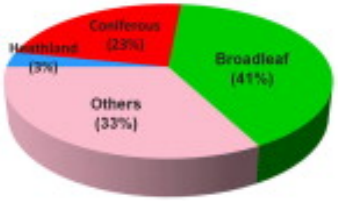
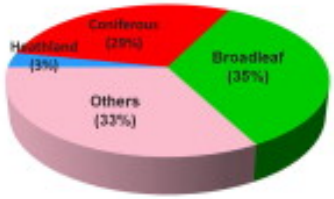
$0	YES	NO
$5	YES	NO
$10	YES	NO
$15	YES	NO
$20	YES	NO
$25	YES	NO
$30	YES	NO
$35	YES	NO
$40	YES	NO
$50	YES	NO
$60	YES	NO
$70	YES	NO
$80	YES	NO
$100	YES	NO
$120	YES	NO
$150	YES	NO
$200	YES	NO
$250	YES	NO
$300	YES	NO
More than $300	YES	NO

If you voted "YES" for "More than $300," what is the maximum amount your household would be willing to pay for the program **each year for the next 3 years?** (PLEASE FILL IN THE BLANK) $_____.

Discrete Choice Experiment

Example 1 : Nature restoration (De Valck et al., 2014)

- Can control for multi-dimensionality and uncertainty of biodiversity via attributes and levels
- €88 for a 50ha conversion from conifers to heathland, with more common natural species and sufficient accessibility
- €56 for same conversion but to broadleaves
- 3 groups, with varied preferences

	Scenario A	Scenario B	Scenario C
Habitat			
Reduction in coniferous forest	100 ha conversion 	50 ha conversion 	Status quo 
Biodiversity			
Accessibility			
Price (€)	10€/year	25€/year	0€/year

Example 2: Using discrete choice experiments to assess environmental and amenity values of the Great Barrier Reef
(De Valck & Rolfe, In prep.)

- Assess the extent to which values for protecting the GBR are interrelated with values for using the GBR
- Built on a number of earlier studies that used DCE to identify protection values for GBR

Whole GBR	Cost	Environmental value		Amenity value		Your choice
		Coral	Seagrass	Recreation	Tourism	
Option A	$100	0% change	↑5%	↑5%	↑10%	☐
Option B	$20	0% change	↑2%	↑5%	↓5%	☐
No action (assuming that situation stays the same):	$0	Current coral: 24,099 km^2	Current seagrass: 34,864 km^2	Current recreation: 1,139,283 inhabitants	Current tourism: 2,792,755 visitors	☐

Other choice modelling techniques (1)

- Contingent ranking
- Contingent rating
- Pairwise comparisons

Contingent ranking proceeds in the same way as a choice experiment but asks respondents to **rank options** in terms of desirability. In the case below, three options are shown but more than three may be provided.

	Option A	Option B	Option C
Attribute	A1 A2 A3 A4 (price)	B1 B2 B3 B4 (price)	C1 C2 C3 C4 (price)
Ranking of options: 1.....2.....3.....			

Contingent rating proceeds by drawing up an option as a scenario and asking the respondent to give it a 'rating' on a scale (say, 1...10). The same respondent is then presented with a different scenario and asked to rate that.

Attribute	Option A A1 A2 A3 A4
Tick one level showing your preference for Option A 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 *Very low preference* ... *Very high preference*	

Pairwise comparisons proceed as with choice experiments but respondents indicate their strength of preference for their choice.

	Option A	Option B	Change in attribute level from A to B (+ better, – worse): illustrative only
Attribute	A1 A2 A3 A4 (price)	B1 B2 B3 B4 (price)	+ – + +
Tick one level 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 *Strongly prefer A* ... *Strongly prefer B*			

Source: Pearce & Ozdemiroglu (2002)

Other choice modelling techniques (2)

- Best-Worst Scaling

Agree least	Statement	Agree most
◯	Lean meat (low fat content) is very important to me.	◯
◯	I am concerned about the carbon footprint (CO2 emissions) of the meat I buy.	◯
◯	Price is very important in my decision to buy meat.	◯
◯	Organic certification is very important when I buy meat.	◯

Deliberative group valuation

- Small groups of citizens >< Individually
- Relies on collective knowledge
- Constructs a hypothetical representation of what public opinion on a particular issue might look like if citizens were given a chance to become more informed
- Combines deliberative polling (political science) and SP valuation
- Useful to understand fairness dilemmas over ES allocation

Stated preference valuation

Pros

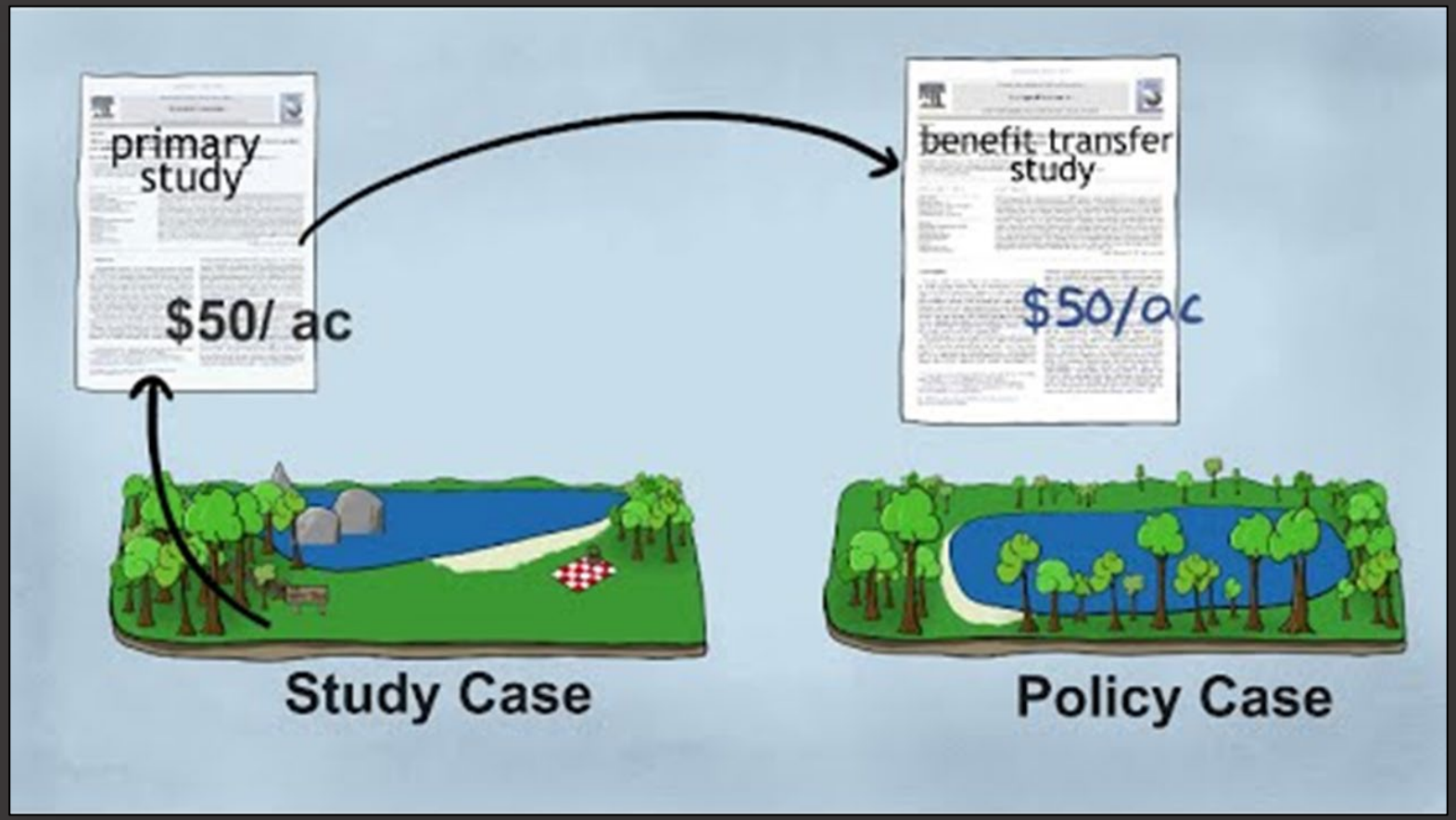
- Only way to estimate non-use values
- Participative
- Flexible
- Provide detailed information (DCE)

Cons

- Stated, hypothetical
- Rely on people's judgment ➔ Subject to many biases (information, interviewer, warm glow, fatigue, etc.)
- Design, implementation & analysis can be challenging
- Data collection can be expensive

BENEFIT TRANSFER

Benefit Transfer



Benefit Transfer

- Meta-regression model for benefit transfer:
- Losses of European wetlands induced by climate change (Brander et al., 2012)

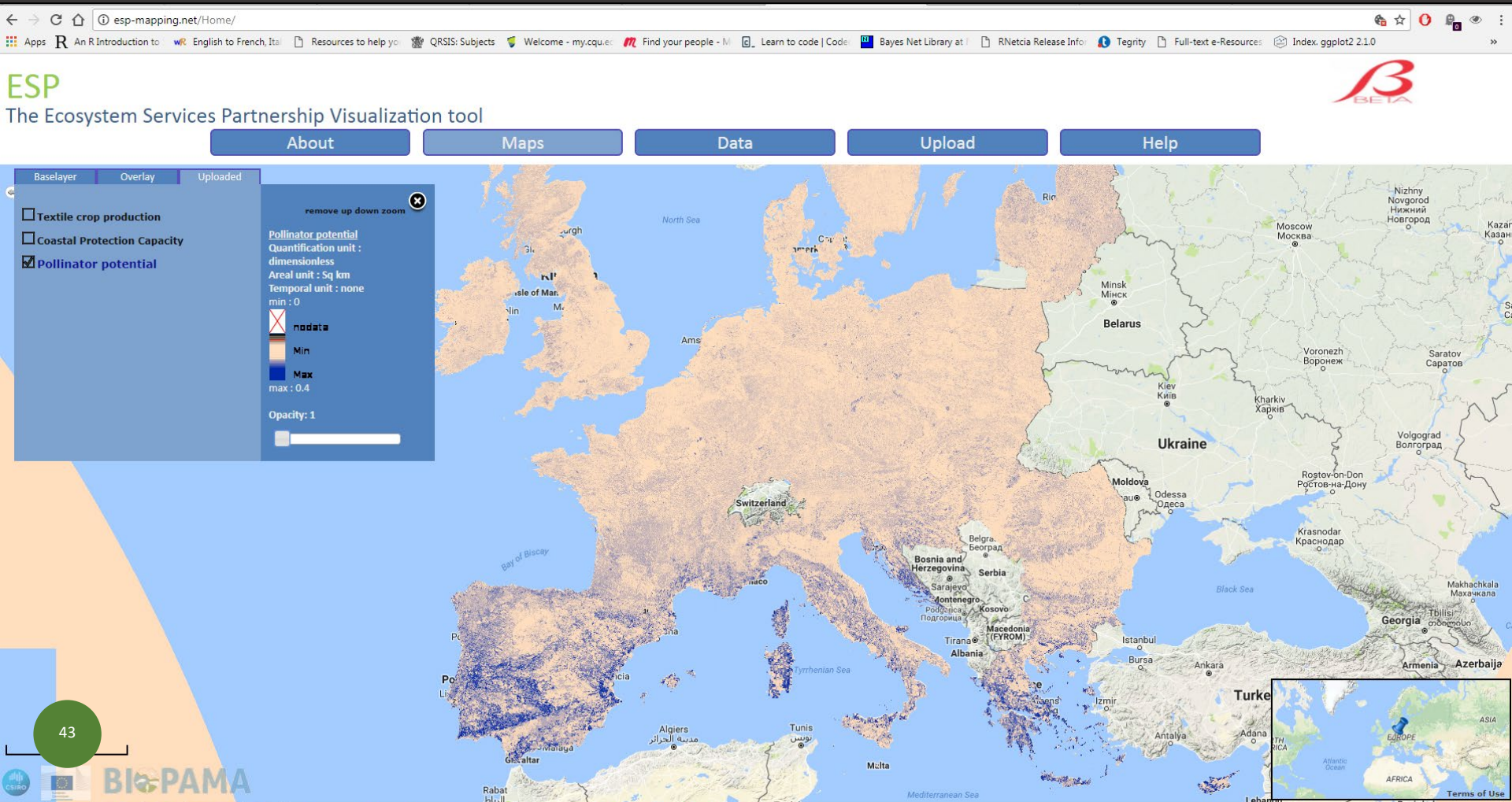
Table 1 Dependent and explanatory variables included in the meta-regression model

	Variable	Mean	Standard deviation
Dependent variable	Wetland value, US$/ha/year (ln)	5.893	2.385
Study variables			
Valuation method	Contingent valuation	0.269	0.444
	Choice experiment	0.031	0.175
	Hedonic pricing	0.022	0.148
	Travel cost method	0.170	0.377
	Replacement cost	0.206	0.406
	Net factor income	0.143	0.351
	Production function	0.058	0.235
	Market prices	0.161	0.369
	Opportunity cost	0.040	0.197
Marginal value	Marginal valuation	0.166	0.373
Wetland variables			
Wetland type	Inland marshes	0.762	0.427
	Peatbogs	0.054	0.226
	Salt marshes	0.166	0.373
	Intertidal mudflats	0.121	0.327
	Saline wetlands	0.076	0.266
Wetland size	Wetland size before change, ha (ln)	8.913	2.864
Ecosystem service	Flood control and storm buffering	0.148	0.356
	Surface and groundwater supply	0.126	0.332
	Water quality improvement	0.175	0.381
	Commercial fishing and hunting	0.193	0.395
	Recreational hunting	0.215	0.412
	Recreational fishing	0.197	0.399
	Harvesting of natural materials	0.121	0.327
	Fuel wood	0.036	0.186
	Non-consumptive recreation	0.287	0.453
	Amenity and aesthetics	0.166	0.373
	Natural habitat and biodiversity	0.139	0.347
Context variables			
	Real GDP per capita, US$ (ln)	9.509	1.346
	Population in 50 km radius (ln)	12.815	1.385
	Wetland area in 50 km radius, ha (ln)	11.083	2.014

NB Variables without an explicit dimension are dummy variables that take on the value 1 if applicable and 0 if not

Benefit Transfer

- ES maps and data catalogue ➔ Ecosystem Services Partnership Visualization Tool (Drakou et al., 2015)



Benefit Transfer

Pros

- Fast
- Easy
- Inexpensive

Cons

- Data availability and validity
- Requires good match between study and policy sites (Site & population characteristics)
- ES comparability across sites
- Spatial heterogeneity
- Scope & scale sensitivity

TAKE-HOME MESSAGES

Take-home messages (1)

- Environmental economics → Useful decision-support tools for our leaders (e.g. CBA)
- Empower local communities by making them aware of what the environment provides them
- Helps bring social justice → internalising externalities
- Ecosystem services → simplify complex reality of environmental problems in the 21st century

Take-home messages (2)

- Many types of "values" ➔ direct, indirect use, non-use, option, etc.
- Some techniques more adapted to certain ES

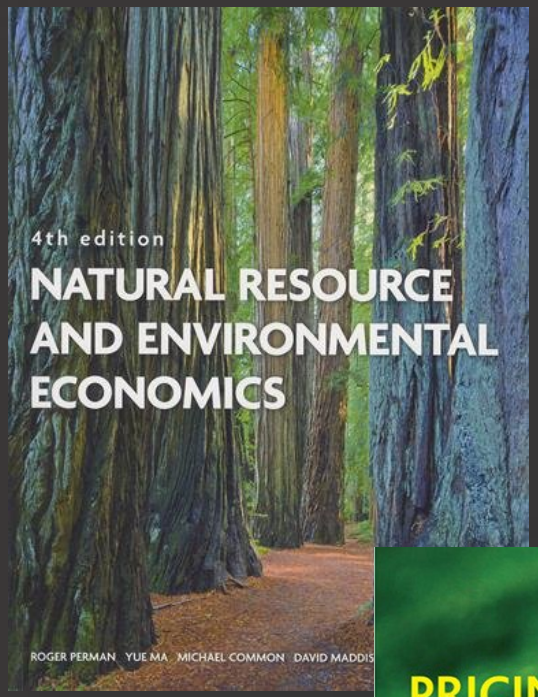
➔ need to choose beforehand; case-specific

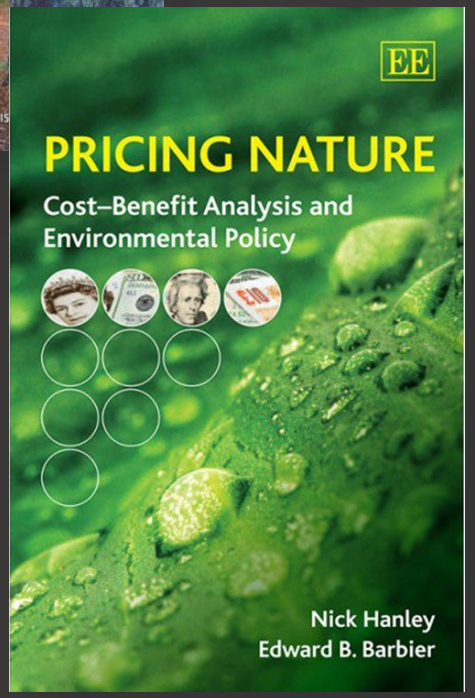
- All techniques come with pros and cons
- Flexible tools that can be used locally or globally ➔ Europe, Australia, Worldwide
- Recent and vibrant area of research ➔ still much to be done!

Further reading

- '**Natural Resource and Environmental Economics – 4th Edition**',
  - by Perman, Ma et al. (2011) – Pearson Education Ltd.

- '**Pricing Nature**',
  - by Hanley and Barbier (2009) – Edward Elgar Publishing Ltd.





Thanks for your attention!

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