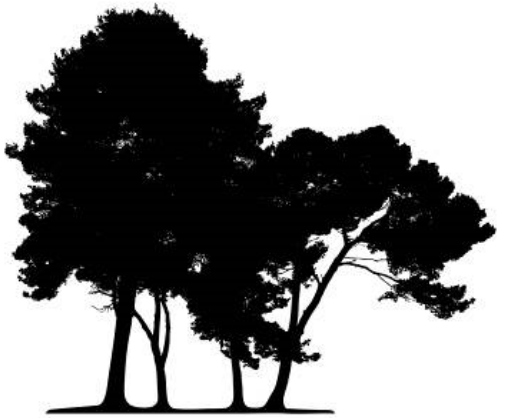
# Introduction to Ecosystem Services

1. Introduction and concepts
2. Ecosystem services and valuation
3. Steps of an assessment
4. Examples

# Ecosystem services introduction

# Ecosystem services framework

**People impact nature**



**Nature provides people benefits**

# Some definitions

**Ecosystem**

- A dynamic complex of plant, animal, and micro-organism communities and the non-living environment interacting as a functional unit

**Biodiversity**

- The variability among living organisms within species and populations, between species, and between ecosystems
- Serves as the foundation for all ecosystem services

**Ecosystem services**

- The benefits people obtain from ecosystems

Source: WRI, Ecosystem Services: A Guide for Decision Makers

# Ecosystem function impacts of IAS: Georgia (US)

- Asian Needle Ant
  - (invasive)

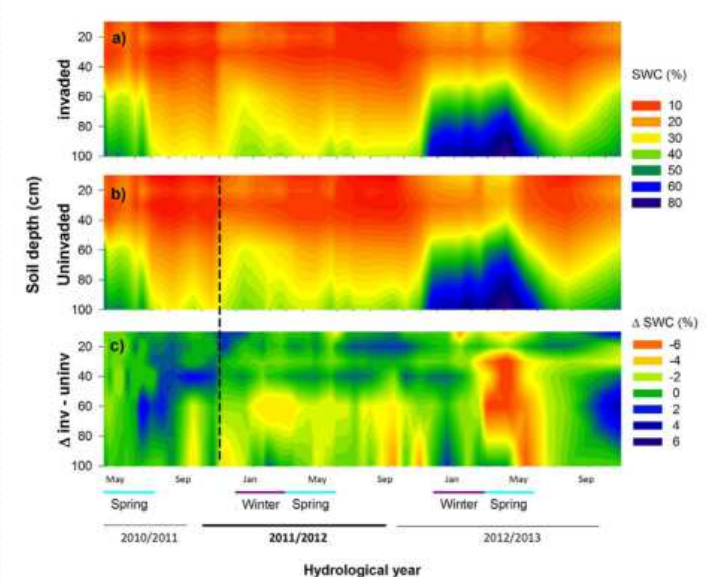
- Aphaenogaster rudis
  - (native)

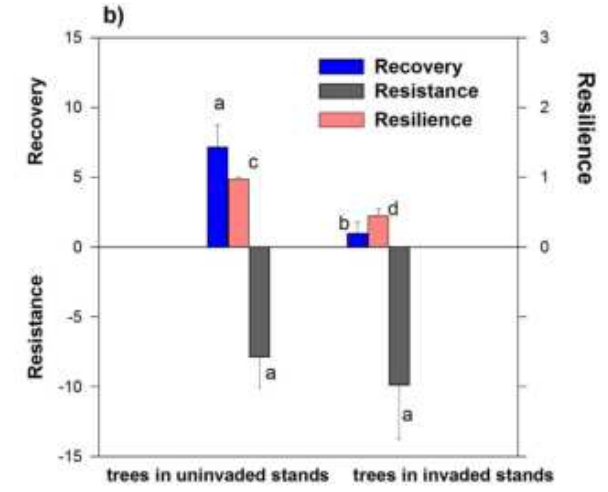
Source: Warren et al., 2015, Biological Invasion

# Ecosystem function impacts of IAS: Spain

- Cistus ladanifer (invasive)

- Quercus suber (native)




Source: Caldeira et al., 2015, Scientific Reports

# Ecosystem services impacts of IAS

- Yellow star thistle (California)
  - US$ 7.7 million in lost grazing

- Prickly pear (Kenya)
  - Cattle disease and deaths
  - == wealth loss

Source: Pechjar & Mooney, 2009, Trends in Ecology and Evolution

# Ecosystem services impacts of IAS

- Water hyacinth (Lake Victoria, Kenya)
  - Fishing
  - Boat movement
  - Water supply
  - Diseases
  - Evapotransmission

Source: Pechjar & Mooney, 2009, Trends in Ecology and Evolution

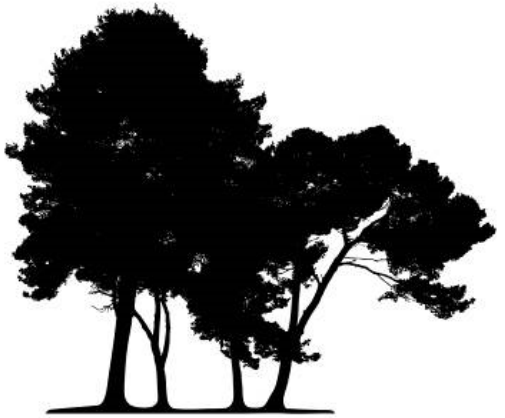
# Ecosystem service assessments

- ‘Mainstreaming’ of ecosystem service values:
  - **communicate range of environmental values**
  - **prioritise environmental problems**
  - understand incentives
  - compare environmental policies
  - assess outcomes for development goals

# Ecosystem services framework

**People impact nature**

**ESS assessments**
***clarify***
**these relations**
**so we know what to**
***quantify***



**Nature provides people benefits**

# Ecosystem service classifications and Total Economic Value

# Ecosystem Services Classification: MA

| PROVISIONING<br>*Products obtained from ecosystems* | REGULATING<br>*Benefits from regulation of ecosystem processes* | CULTURAL<br>*Non-material benefits obtained from ecosystems* |
|---|---|---|
| Biochemical, natural medicines & pharmaceuticals | Air Quality Maintenance | Aesthetic Values |
| Food & Fibre | Biological Control | Cultural Heritage Values |
| Freshwater | Climate Regulation | Cultural Diversity |
| Fuel | Erosion Control | Educational Values |
| Genetic Resources | Human Disease Regulation | Inspiration |
| Ornamental Resources | Pollination | Knowledge Systems |
| | Storm Protection | Recreation & Ecotourism |
| | Water Purification | Sense of Place |
| | Water Regulation | Spiritual & Religious Values |
| | | Social Relations |

**SUPPORTING**

*Services necessary for the production of all other ecosystem services*

| | |
|---|---|
| Nutrient & water cycling | Provisioning of habitat |
| Primary production | Soil formation & retention |
| Production of atmospheric oxygen | |

Adapted from the Millennium Ecosystem Assessment (2005)

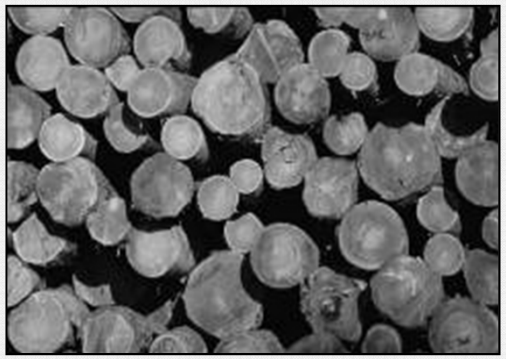
# Other ecosystem service classifications

- The Economics of Ecosystems and Biodiversity (TEEB)
  - For policy development
  - Focus on final services

- Common International Classification of Ecosystem Services (CICES)
  - For accounting purposes
  - Focus on quantification

# Key categories of ecosystem services

## Provisioning

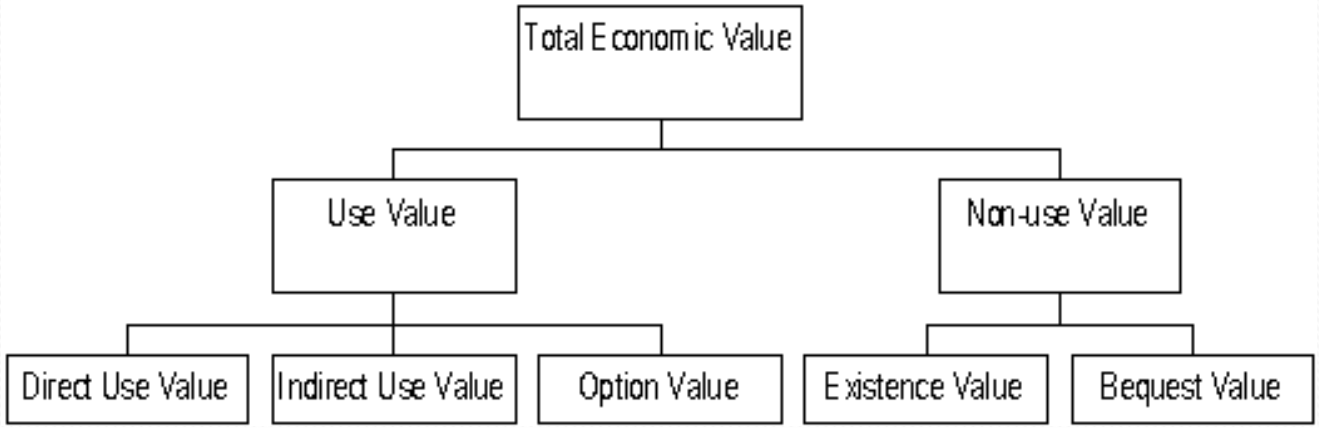


## Regulating

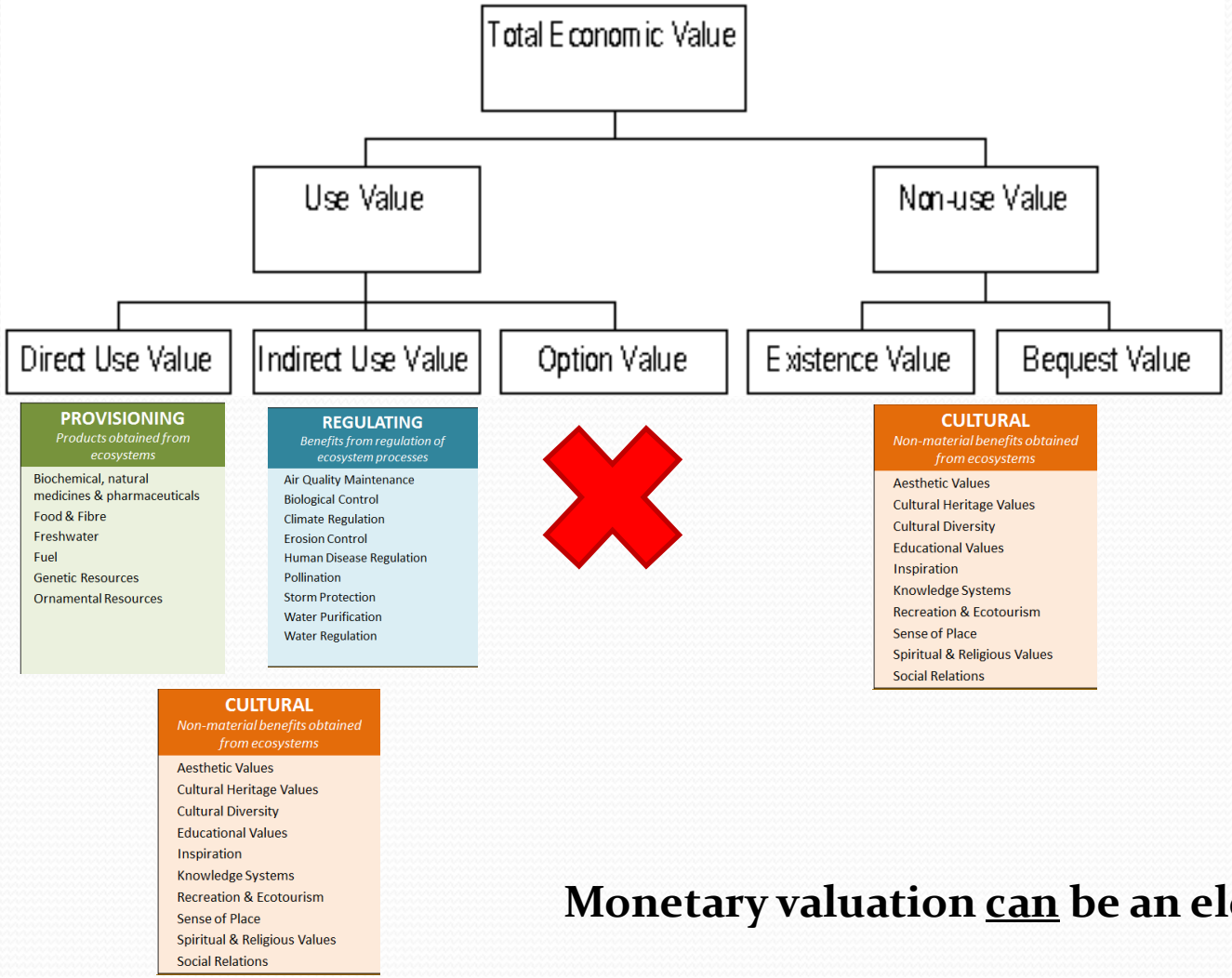
## Cultural

Ecosystem Services: A Guide for Decision Makers

# ESS and TEV: similar, but different



# ESS and TEV: similar, but different




**Monetary valuation <u>can</u> be an element**

# Steps of an (TEEB) ecosystem service assessment

# Ecosystem services assessment

- Step 1: Agree on problem to be solved by assessment
- Step 2: Identify key ESS affected
- Step 3: Define information needs and methods
- Step 4: Assess and value ESS
- Step 5: Compare policy options, including distributional impacts
- Step 6: Review, refine and report

Source: TEEB Guidance manual for country studies; TEEB Quick guide for local and regional policy makers

# Example:
# Forest watershed policy in Chile

Source: Moorman et al., 2013, Society and Natural Resources

Moorman et al., 2013, Journal of Sustainable Forestry

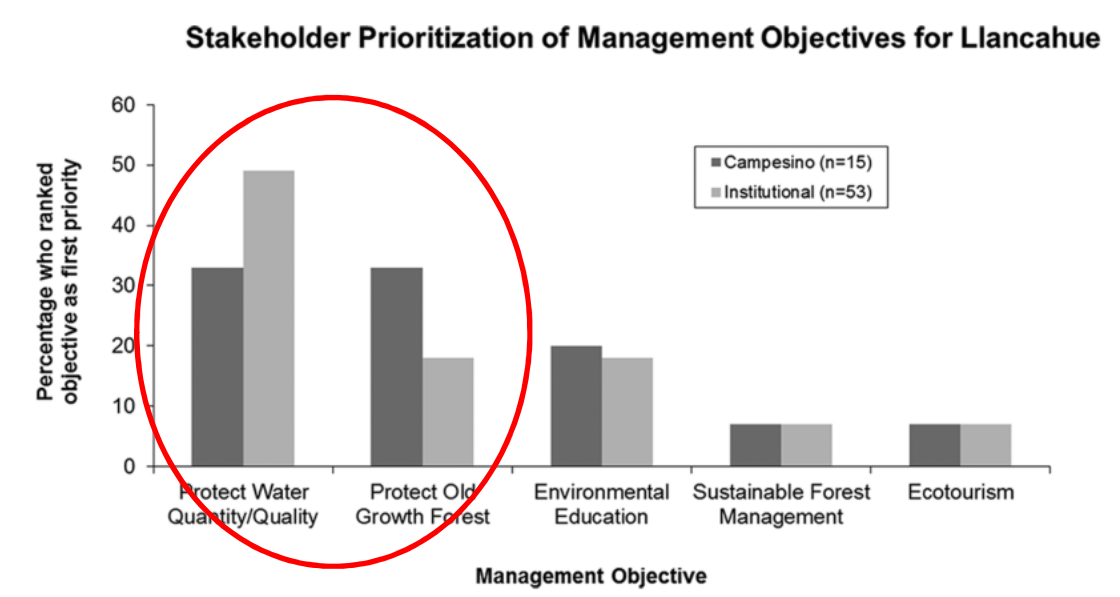
# Ecosystem services assessment (of IAS)

- Context
  - Peri-urban watershed
  - ~ 50% old-growth forest
  - Lomas del Sol, a rural subsistence community
    - Illegal logging and grazing
- University Austral de Chile applied for concession
  - Protect quality and quantity of water provisioning
  - Protect biodiversity
  - Find financing for sustainable management
  - (but no funds)

# Ecosystem services assessment (of IAS)

Step 1: Agree on problem to be solved by assessment

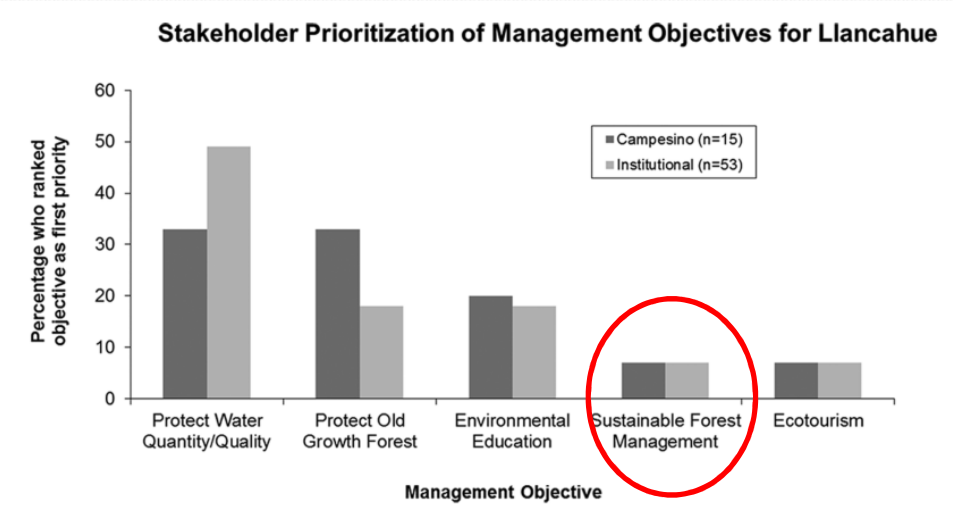
- Sampling: 45 partners
  - Institutional and *campesino*
- Agreement on need for conservation



# Ecosystem services assessment (of IAS)

Step 2: Identify key ESS affected

- Water supply
- **Grazing**
- **Non-timber forest products**
- Biodiversity
- Recreation



# Ecosystem services assessment (of IAS)

Step 3: Define information needs and methods

- Need for water provision beyond doubt – not assessed
- How to stop illegal activities
  - Illegal logging essential
  - Timber yields for old-growth & secondary forest
    - population/cohorts model
  - Viable alternative livelihoods
    - preferred activities, income needed

# Ecosystem services assessment (of IAS)

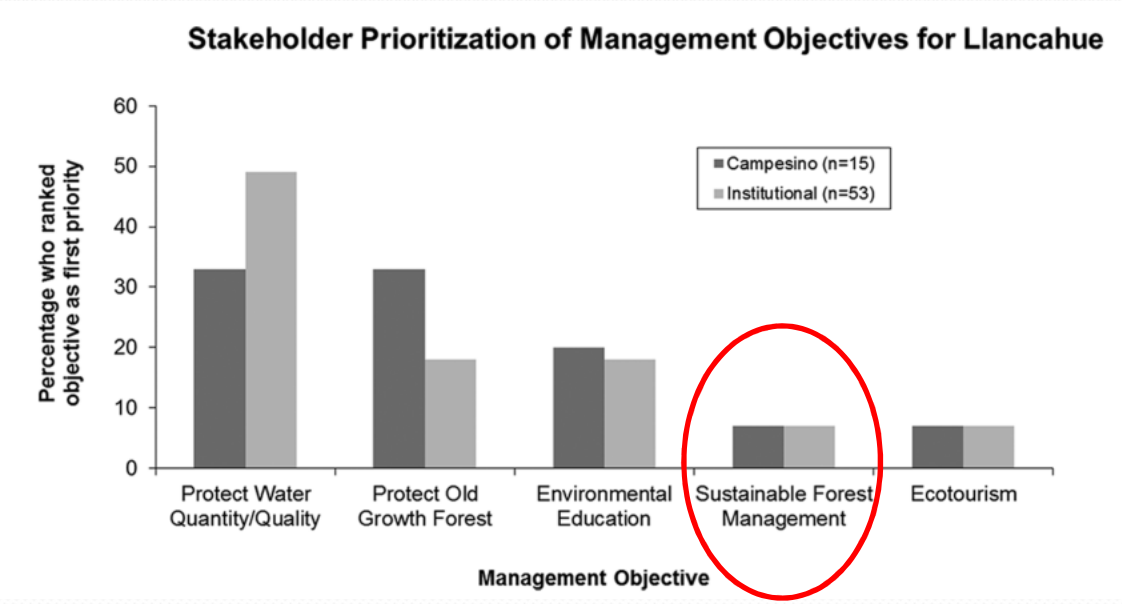
Step 4: Assess and value ESS

- Forest maintenance
  - 2,000 – 3,000 $m^3$ firewood and logs
  - 600 $m^3$ for winter charcoal
- $20,000 - $30,000 annually
  - 9 members of Lomas de Sol paid 'sufficiently' + waste wood
  - Forest ranger, trail maintenance, environmental education

# Ecosystem services assessment (of IAS)

Step 5: Compare policy options, including distributional impacts

- Forest thinning  vs do-nothing



# Example:
# CBA of shrimp farming in Thailand

Source: Sathirathat & Barbier, 2001, Contemporary Economic Policy
Barbier, 2007, Economic Policy

# Mangrove ecosystem services vs shrimp farms

Mangrove

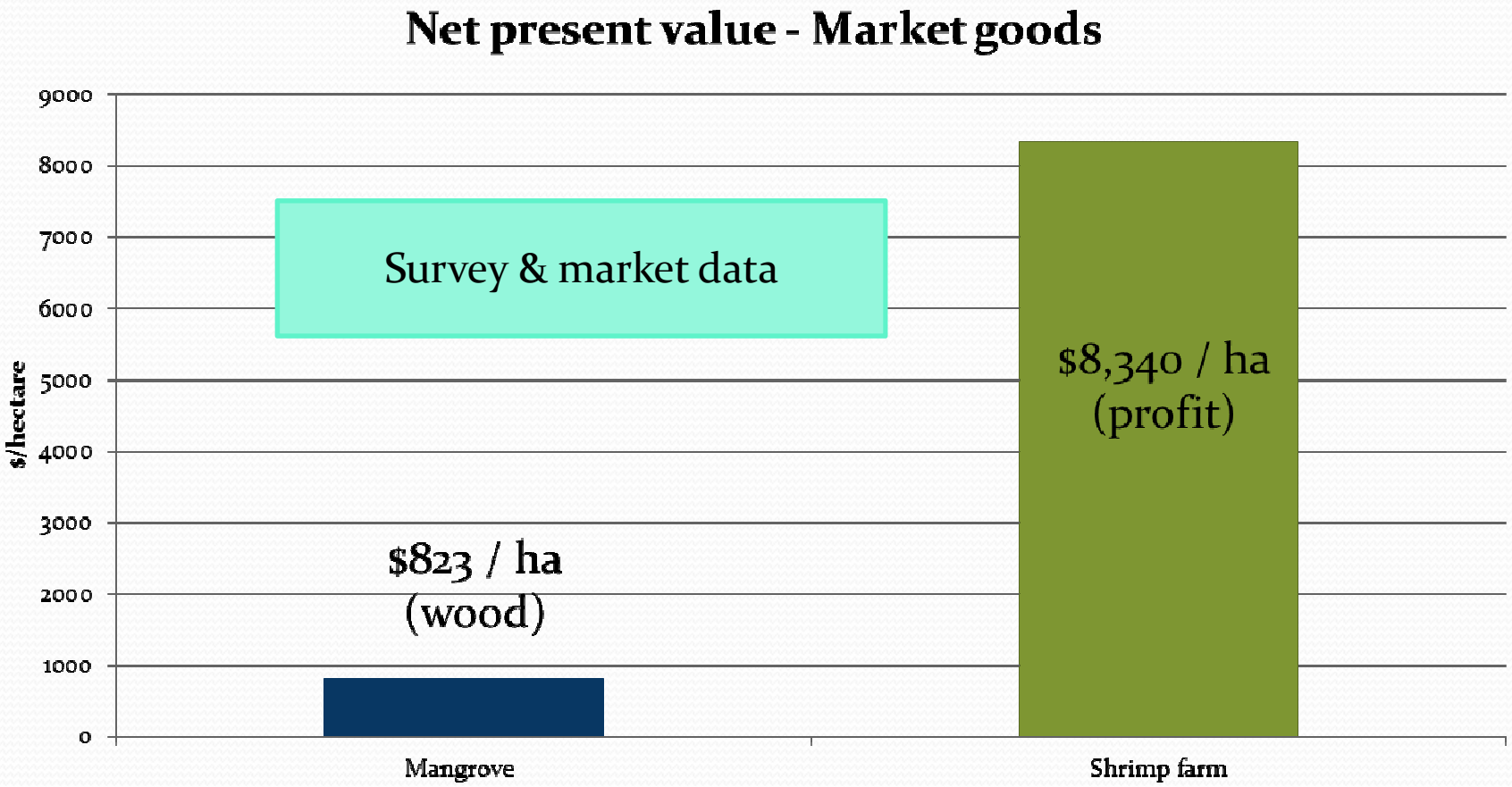
- Wood for fishing gear
- Honey, birds, crabs
- Nursery for fish stocks
- Protection against coastal erosion & storms

Shrimp farms

- Profits
- Pollution
- Displacement of local communities

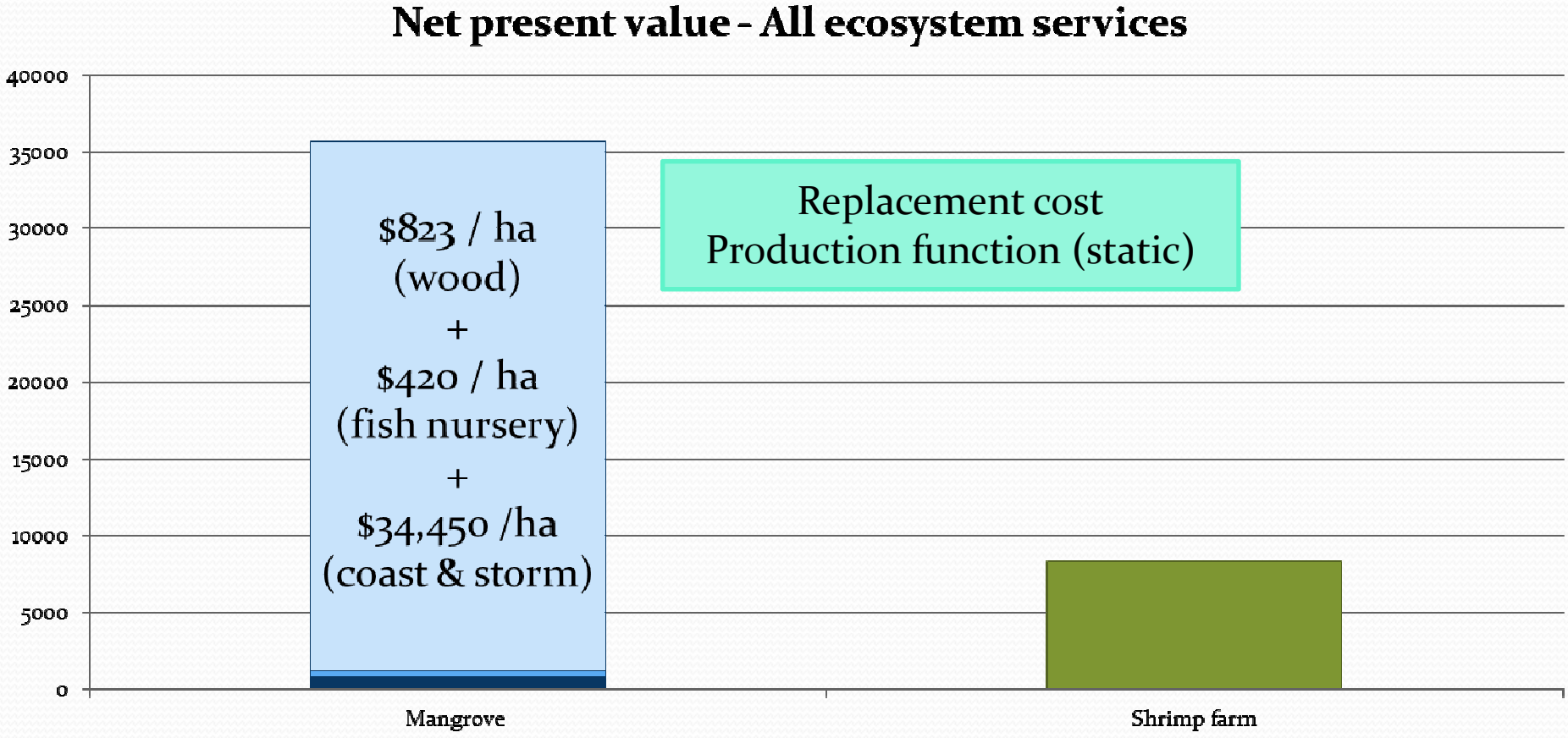
Source: Sathirathat & Barbier, 2001, Contemporary Economic Policy

# Mangrove ecosystem services vs shrimp farms



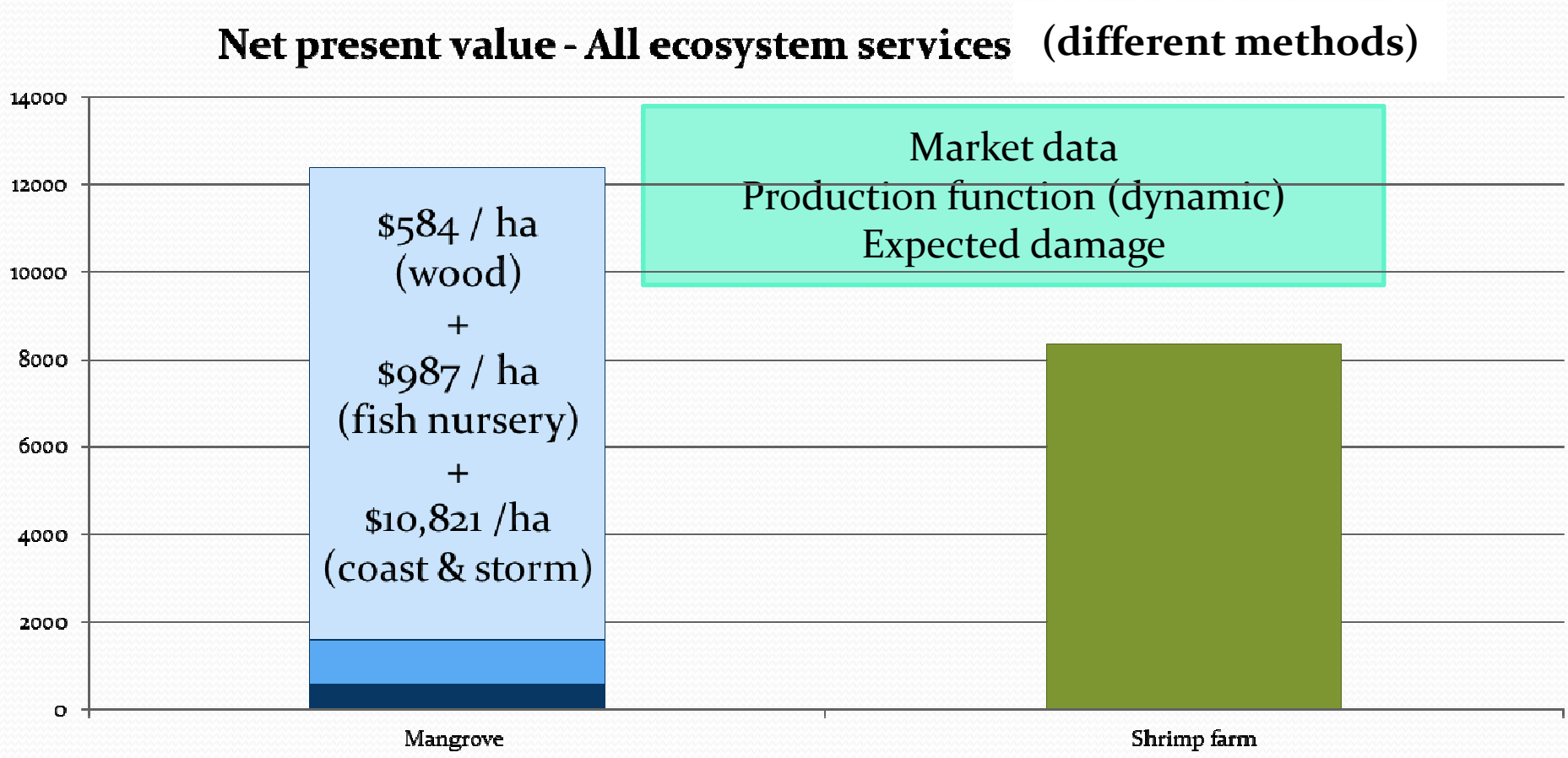

Source: Sathirathat & Barbier, 2001, Contemporary Economic Policy

# Mangrove ecosystem services vs shrimp farms



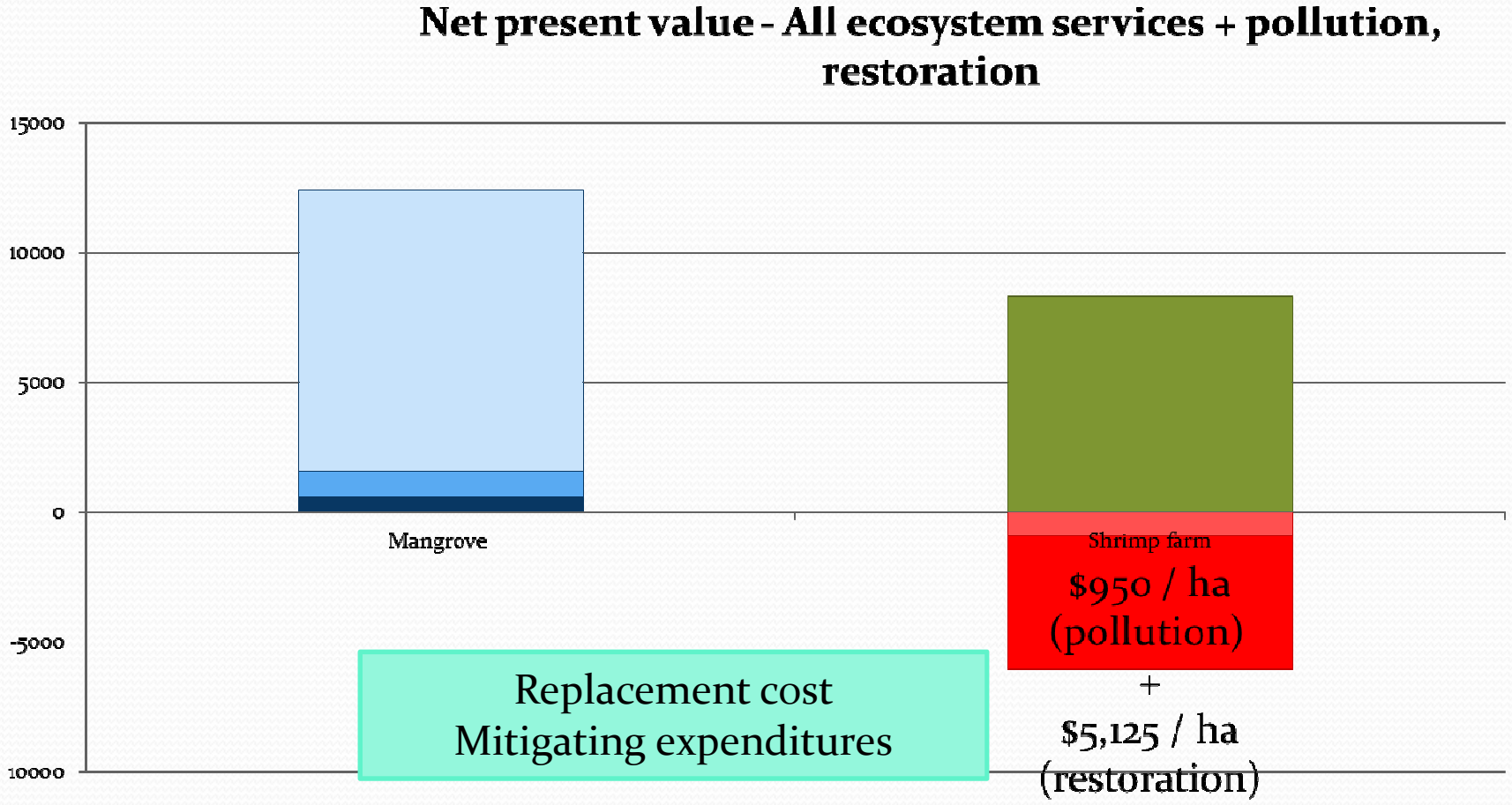

Source: Sathirathai & Barbier, 2001, Contemporary Economic Policy

# Mangrove ecosystem services vs shrimp farms

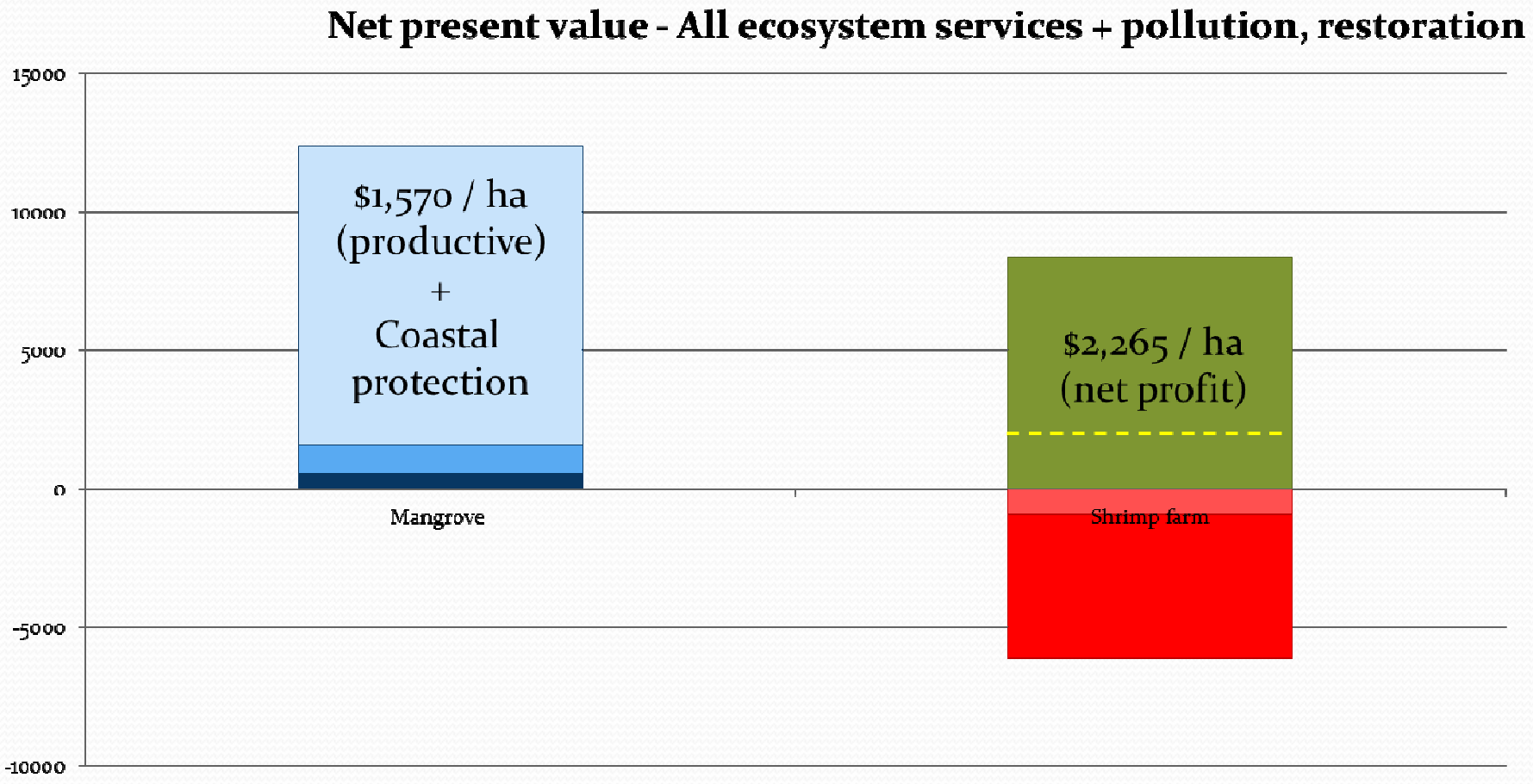



Source: Barbier, 2007, Economic Policy

# Mangrove ecosystem services vs shrimp farms



# Mangrove ecosystem services vs shrimp farms



# ESS:
# Coral reef tourism in south-east Asia

Source: Brander et al. 2015 in Johnston et al., Benefit transfer of environmental and resource values: a guide for researchers and practioners

# Coral reef tourism in south-east Asia

- Coral reefs in south-east Asia
  - 70,000 km², or 28%
  - 76% of all known coral species and hosts
  - 37% of all known coral reef fish species
  - … and an important tourist attractions
- Reefs are declining due to
  - pollution , sedimentation, dredging
  - water temperature rises & acidity increases

Source: Brander et al. 2015 in Johnston et al., Benefit transfer of environmental and resource values: a guide for researchers and practioners

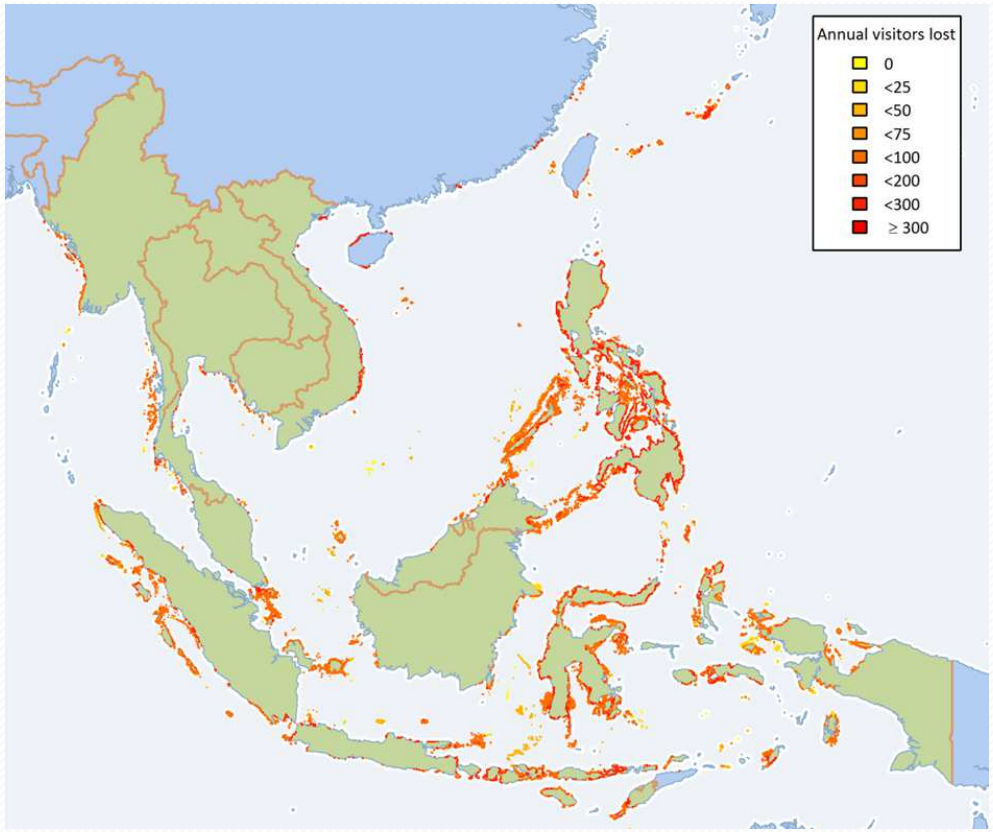
# Coral reef tourism in south-east Asia

- Assessment based on secondary information and value transfer
  - Tourism numbers
  - Coral reef value per visitor
  - Scenarios of predicted loss 2000-2050

- Tourism numbers linked to
  - Siltation, fishing damage, storm damage, area, water and air temperature, …
  - Sources: Reefs at Risk, ReefCheck, …

Source: Brander et al. 2015 in Johnston et al., Benefit transfer of environmental and resource values: a guide for researchers and practioners

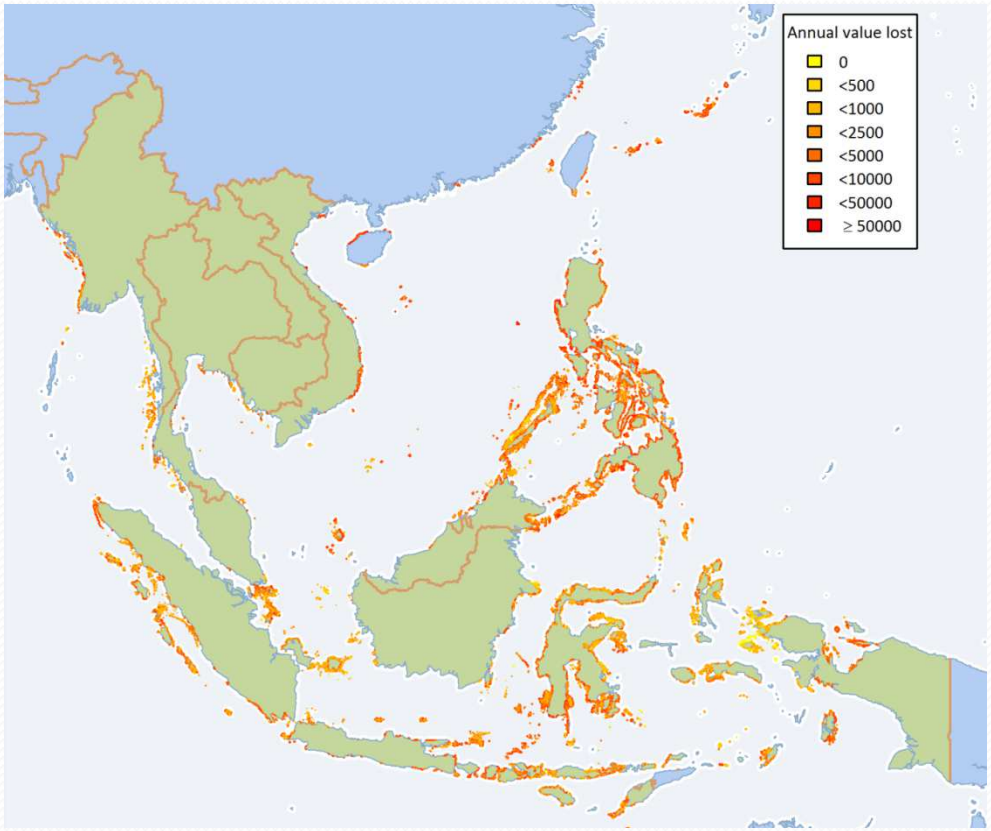
# Coral reef tourism in south-east Asia




| Variable | Variable definition | Coefficient | | Standard error |
|---|---|---|---|---|
| Constant | - | -37.301 | ** | 16.073 |
| Siltation | Dummy: 1 = siltation; 0 = none | -5.866 | *** | 0.932 |
| Dynamite fishing damage | Dummy: 1 = fishing damage; 0 = none | -7.036 | *** | 1.212 |
| Air temperature | Air temperature ($^{o}$C) | -0.569 | *** | 0.162 |
| Area of coral cover | Natural log of area of coral cover (km$^2$) | 1.027 | | 0.638 |
| Area of mangroves | Natural log of area of mangroves within 50 km (km$^2$) | 0.685 | * | 0.373 |
| Population | Natural log of population within 50 km | -0.886 | * | 0.467 |
| GCP | Natural log of Gross Cell Product within 50 km (US$) | 9.672 | *** | 1.373 |
| Level 1 (observation) variance | | 145.509 | *** | 12.697 |
| Level 2 (reef) variance | | 12.569 | *** | 0.927 |
| -2*loglikelihood | | 4447.873 | | |
| N | | 658 | | |

Source: Brander et al. 2015 in Johnston et al., Benefit transfer of environmental and resource values: a guide for researchers and practioners

# Coral reef tourism in south-east Asia




| Variable | Variable definition | Coefficient | | Standard error |
|---|---|---|---|---|
| Constant | | 3.871 | *** | 1.087 |
| Visits per day | Natural log of visits per day | -0.434 | ** | 0.174 |
| Area of coral cover | Natural log of area of coral cover ($km^2$) | 0.451 | * | 0.278 |
| Caribbean | Dummy: 1 = Caribbean; 0 = other | 1.482 | ** | 0.736 |
| Indian Ocean | Dummy: 1 = Indian Ocean; 0 = other | 2.932 | *** | 0.943 |
| Southeast Asia | Dummy: 1 = Southeast Asia; 0 = other | 1.456 | * | 0.822 |
| Australia | Dummy: 1 = Australia; 0 = other | 0.065 | | 1.087 |
| Diving | Dummy: 1 = Diving; 0 = other | -0.276 | | 0.476 |
| Snorkelling | Dummy: 1 = Snorkelling; 0 = other | -0.980 | ** | 0.446 |
| Fishing | Dummy: 1 = Recreational fishing; 0 = other | 0.131 | | 0.491 |
| CVM | Dummy: 1 = Contingent valuation; 0 = other | -1.949 | *** | 0.449 |
| Adjusted $R^2$ | 0.41 | | | |
| N | 74 | | | |

Source: Brander et al. 2015 in Johnston et al., Benefit transfer of environmental and resource values: a guide for researchers and practioners

# Coral reef tourism in south-east Asia

| Country | Value per visitor day | Total change in consumer surplus (000's) | Lower bound 95% prediction interval (000's) | Upper bound 95% prediction interval (000's) |
|---|---|---|---|---|
| Cambodia | 11.20 | -124 | 0 | -1,392 |
| Indonesia | 8.90 | -59,468 | -1,099 | -665,880 |
| Malaysia | 10.80 | -3,140 | -280 | -35,161 |
| Myanmar | 4.60 | -2,836 | -253 | -31,754 |
| Philippines | 6.50 | -56,749 | -5,068 | -635,440 |
| Singapore | 2.60 | -176 | -16 | -1,972 |
| Thailand | 5.80 | -1,936 | -30 | -21,680 |
| Vietnam | 4.00 | -3,577 | -319 | -40,058 |
| Southeast Asia | 6.80 | -128,007 | -2,848 | -1,433,337 |

Source: Brander et al. 2015 in Johnston et al., Benefit transfer of environmental and resource values: a guide for researchers and practioners

# Summary of ESS examples

- Watershed policy came about without monetising most important ecosystem service
- Ecosystem service-based CBA of shrimp farming shows to preserve mangroves
- Ecosystem services like tourism can make policy makers pay attention to large economic losses

# Conclusion - Taking a step back

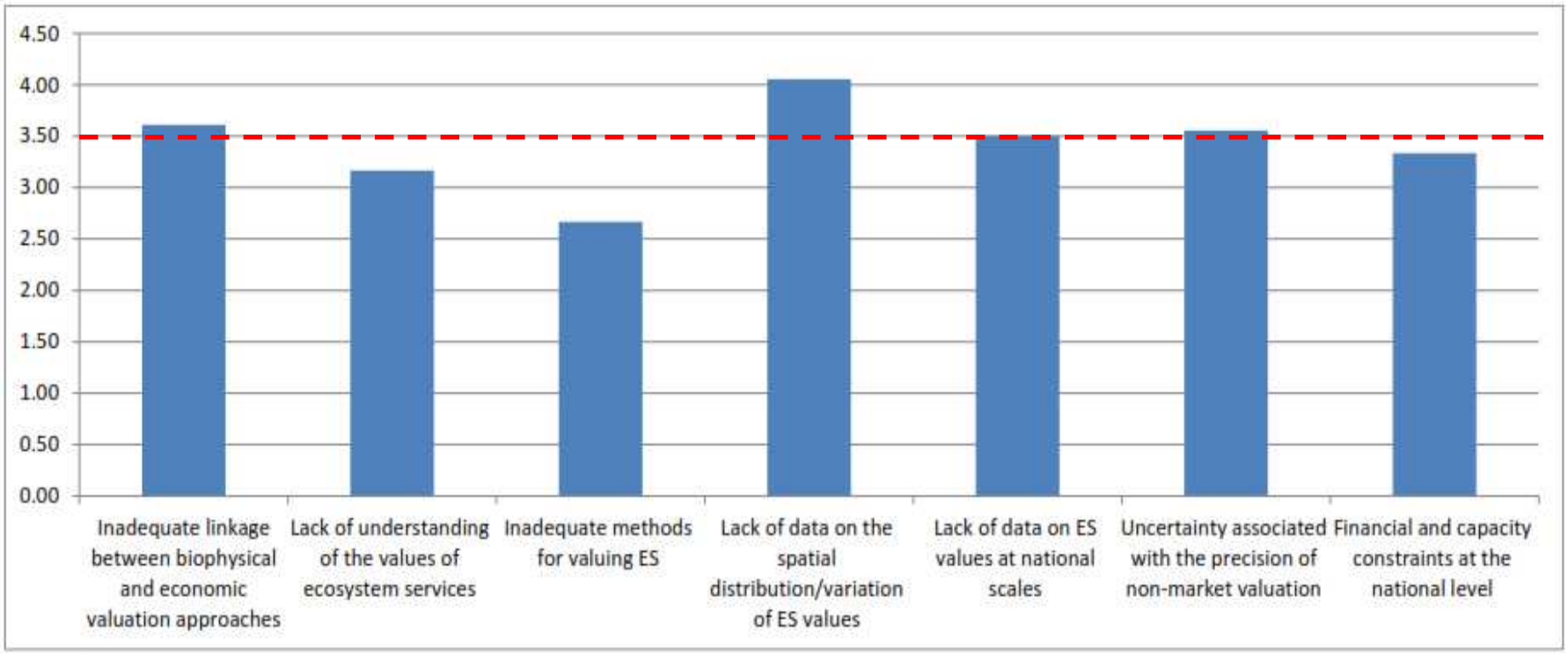
# Global Trends in Ecosystem Services

| PROVISIONING SERVICES | | | REGULATING SERVICES | |
|---|---|---|---|---|
| Food | Crops | ▲ | Air Quality Regulation | ▼ |
| | Livestock | ▲ | Climate Regulation | ▼ |
| | Capture Fisheries | ▼ | Global | ▲ |
| | Aquaculture | ▲ | Regional and Local | ▼ |
| | Wild Foods | ▼ | Water Regulation | + / – |
| Fiber | Timber | + / – | Erosion Regulation | ▼ |
| | Cotton, Hemp, Silk | + / – | Water Purification and Waste Treatment | ▼ |
| | Wood Fuel | ▼ | Disease regulation | + / – |
| Genetic Resources | | ▼ | Pest Regulation | ▼ |
| Biochemicals, Pharmaceuticals, Natural Medicines | | ▼ | Pollination | ▼ |
| Freshwater | | ▼ | | |
| **CULTURAL SERVICES** | | | | |
| Spiritual and Religious Values | | ▼ | Recreation and Ecotourism | + / – |
| Aesthetic Values | | ▼ | | |

Source: Millennium Ecosystem Assessment (2005)

# Scientific challenges for ESS

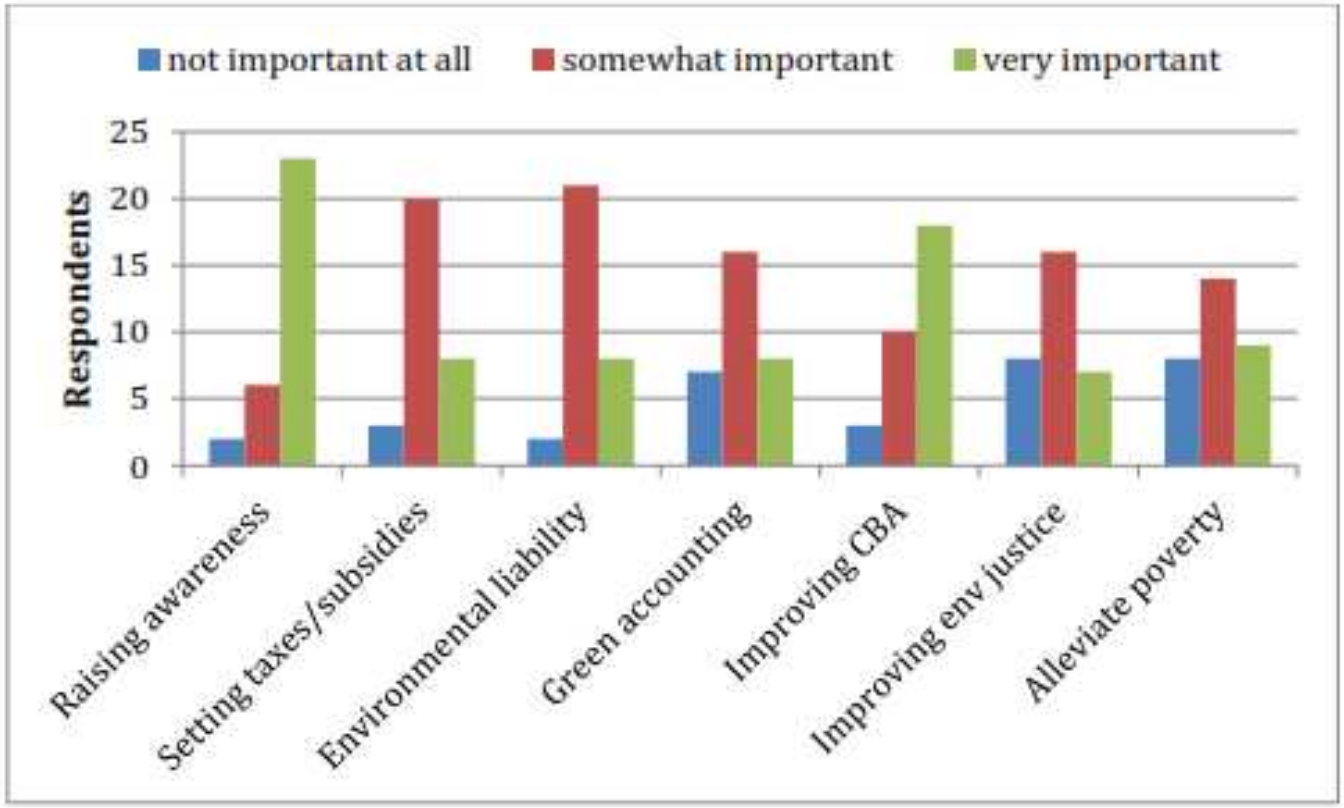
- Survey at TEEB conference (2012)
  - 0 (not important) – 5 (very important)




Source: Brouwer et al. 2013 (EU report)

# Monetary valuation in policy

- Responses of 2012 TEEB conference attendees




Source: Brouwer et al. 2013 (EU report)

# Considerations for ecosystem service valuation

- ES that cannot be monetised are at risk
  - What happens to ES that are not 'valuable' enough?
- ESS framework helps identify *all* benefits and options for CBA
- ESS assessment is more than monetary valuation
  - Identify benefit
  - Demonstrate value
  - Capture value

# Extra Slides

# Monetary valuation in policy

- By valuing nature, we emphasise that it is just another tradeable commodity
- With technological progress, man-made replacements can become cheaper than controlling the invasive
- Invasive species provide services, native species provide disservices

*What if monetary analysis suggests*
*to not control the invasive species?*

# Ecosystem Services Classification: TEEB

- Provisioning
  - Food
  - Raw materials
  - Freshwater
  - Medicinal

- Regulating
  - Local climate and air quality
  - Carbon sequestration and storage
  - Moderation of extreme events
  - Waste-water treatment
  - Erosion prevention and soil fertility
  - Pollination
  - Biological control

- Cultural
  - Recreation and health
  - Tourism
  - Aesthetic and inspiration
  - Spiritual and sense of place

- Habitat or supporting
  - Habitat for species
  - Maintenance of genetic diversity

From TEEB (http://www.teebweb.org 2015)

# Ecosystem Services Classification: CICES

- European Environment Agency + United Nations Statistical Division
- ESS support in System of Environmental-Economic Accounting (SEEA)
  - http://unstats.un.org/unsd/envaccounting/seearev/
  - Related initiatives: WAVES, MAES
- More elaborate than MA or TEEB classifications

# Monetary valuation and policy

- Evidence suggests that monetary information causes people to pay *less* attention to other information
- Multi-criteria analysis does not really help in this respect
  - weighting is fundamentally like monetary valuation
  - Results are easily manipulated
- No easy solution to these issues

# Summary

- ES: The benefits people obtain from ecosystems and/or the "services of nature"
- Quantifying and valuing ES provides:
  - a consistent way to assess the changes in provisioning, regulating and cultural services
  - a larger scope of costs and benefits of a project/intervention
- **Coming up:** techniques to estimate ecosystem services and non-market values

# Class Exercise: Which of these ecosystem services can you quantify?

| **PROVISIONING**<br>*Products obtained from ecosystems* | **REGULATING**<br>*Benefits from regulation of ecosystem processes* | **CULTURAL**<br>*Non-material benefits obtained from ecosystems* |
|---|---|---|
| Biochemical, natural medicines & pharmaceuticals | Air Quality Maintenance | Aesthetic Values |
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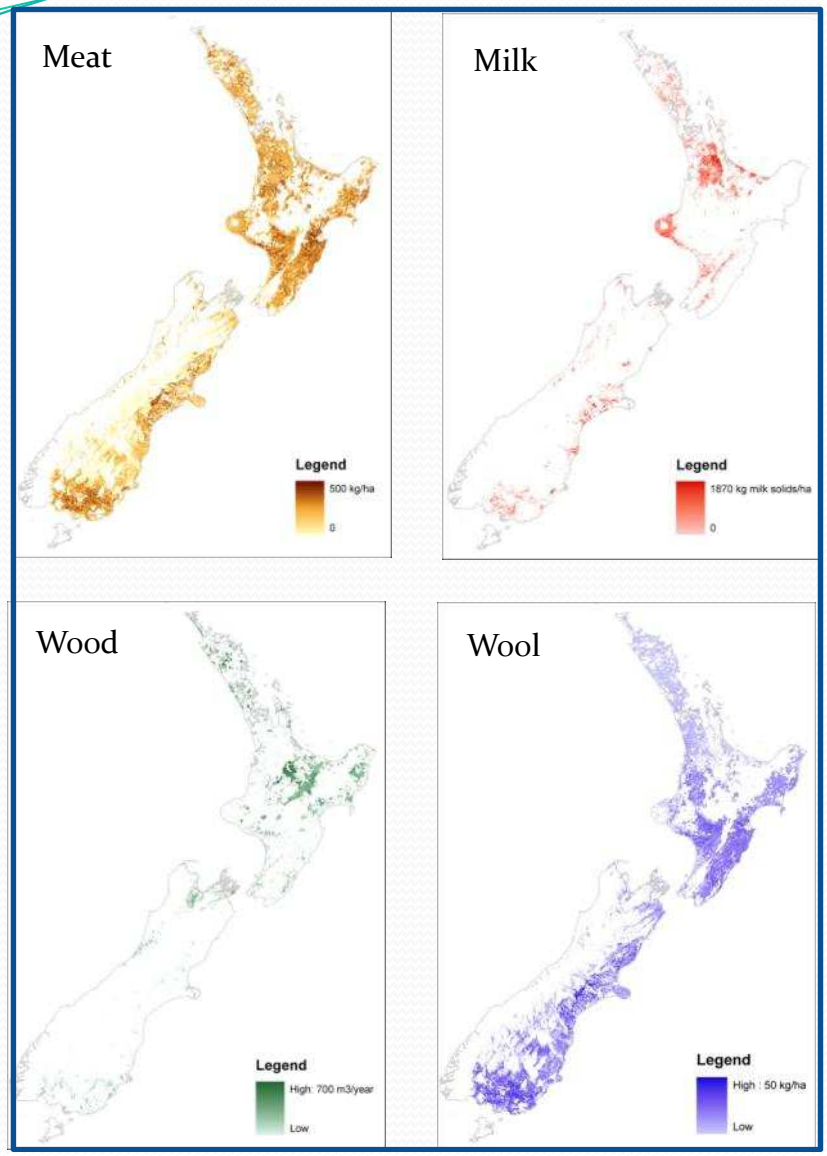
| Freshwater | Climate Regulation | Cultural Diversity |
| Fuel | Erosion Control | Educational Values |
| Genetic Resources | Human Disease Regulation | Inspiration |
| Ornamental Resources | Pollination | Knowledge Systems |
| | Storm Protection | Recreation & Ecotourism |
| | Water Purification | Sense of Place |
| | Water Regulation | Spiritual & Religious Values |
| | | Social Relations |

**SUPPORTING**

*Services necessary for the production of all other ecosystem services*

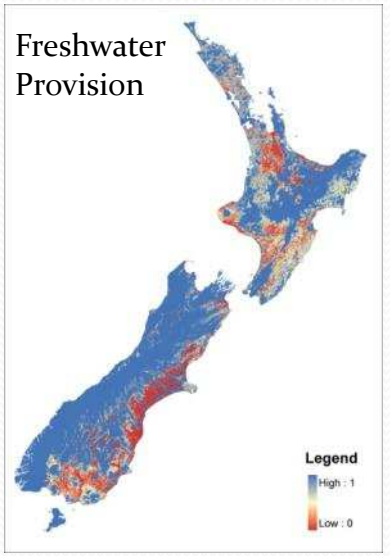
| | |
|---|---|
| Nutrient & water cycling | Provisioning of habitat |
| Primary production | Soil formation & retention |
| Production of atmospheric oxygen | |

# Quantifying Ecosystem Services for New Zealand




**Food and Fiber Provisioning Services**



# The Ecosystem Services Approach

- A **framework** for integrating ecosystem services into decision making
- Incorporates a variety of methods, including ecosystem service **dependency** and **impact assessment**, **valuations**, **scenarios**, and **policies**
- Often applied at a **watershed** or **landscape level**

# What types of decision processes can the Ecosystem Services Approach inform?

| | |
|---|---|
| **National and sub-national policies and plans** | • National budgets<br>• National development policies<br>• Climate adaptation |
| **Economic and fiscal incentives** | • Subsidies<br>• Tax policies to promote sustainable technology<br>• Payments for ecosystem services |
| **Sector policies and plans** | • State of the environment reports<br>• Land use zoning<br>• Technology transfer |
| **Governance** | • Freedom of information<br>• Participatory decision making |

# Key elements in the Ecosystem Services Approach to making a decision

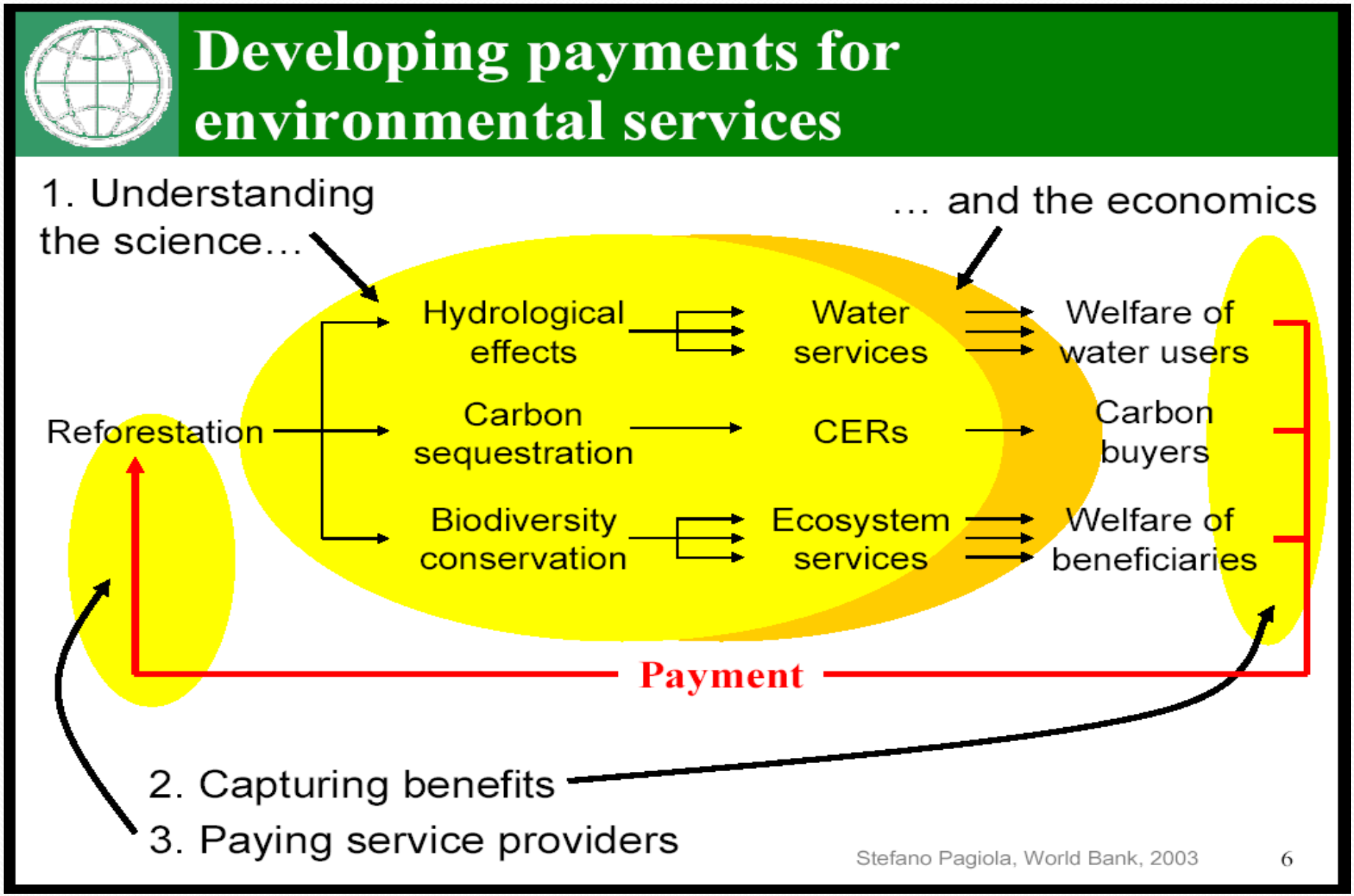

What is the relationship between ecosystems and human well-being? How can an ecosystem services framework help organize decision-making?

What are the ecosystem service dependencies and impacts? When and how can ecosystem services be valued?

How can future changes be taken into account?

How can ecosystem service risks and opportunities be incorporated into the decision? What policies can help sustain ecosystem services?

# In reality, not so simple…



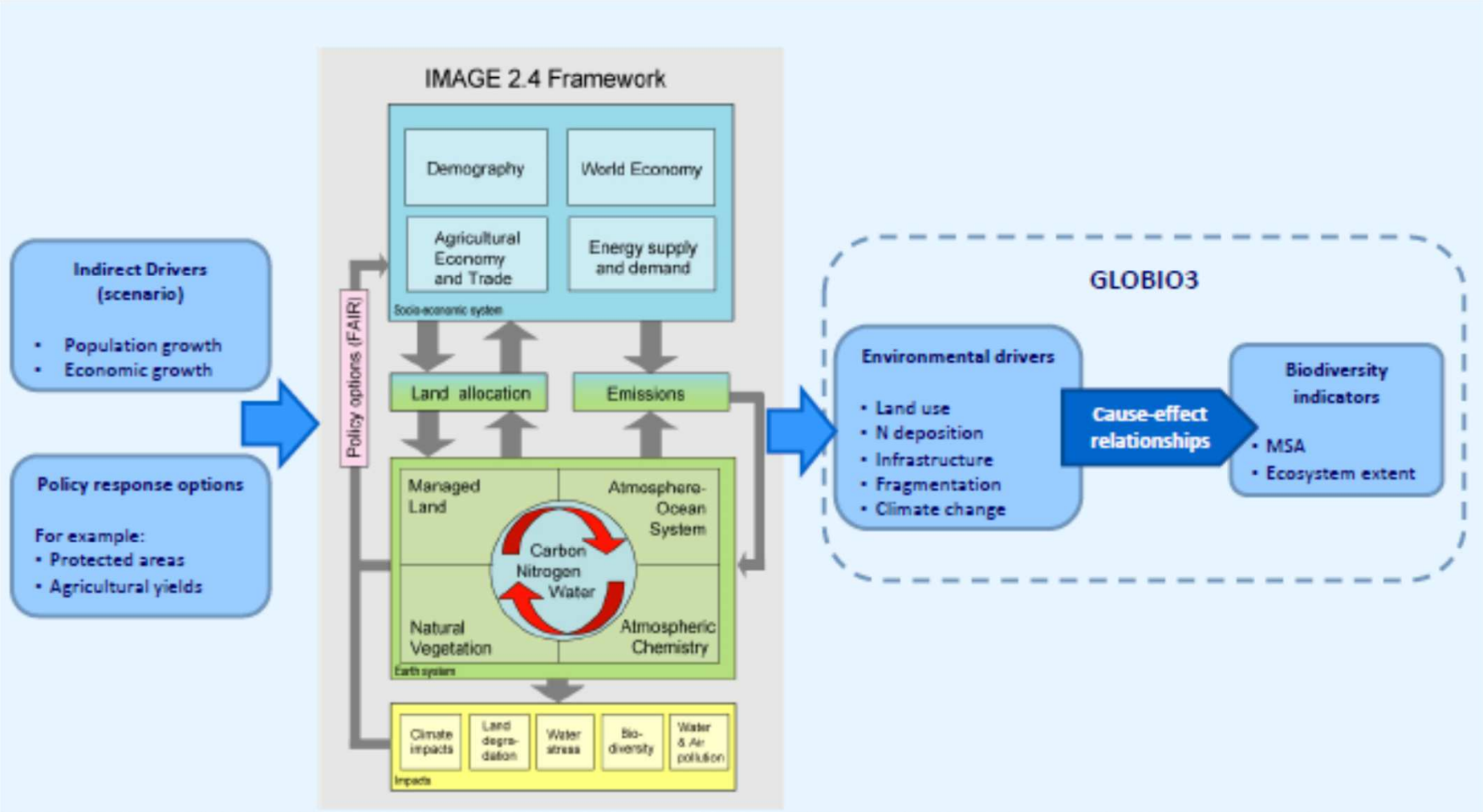
# Classifications compared

| | Strengths | Weaknesses |
|---|---|---|
| MA | Defined ecosystem services for first time<br>High policy impact | Inconsistent with SNA approach *<br>No distinction between intermediate and final delivery of services |
| TEEB | Avoids risk of double counting by focusing on final services<br>Habitat services included as separate category | No intermediate services<br>Inconsistent with SNA approach |
| CICES | Consistency with SNA<br>Complementary tables for abiotic outputs can be developed<br>Avoids risk of double counting by distinguishing clearly between intermediate and final services as in SNA | Aims to be comprehensive, hence there is most probably a need for more detailed prioritization of relevant ecosystem services across EU Member States |

*System of National Accounts

Source: Brouwer et al. 2013 (EU report)

# Global Trends in Ecosystem Services




Source: TEEB / www.ecosystemassessments.net; Visconti et al., 2015, Phil. Trans. Royal Soc. B

# Global Trends in Ecosystem Services

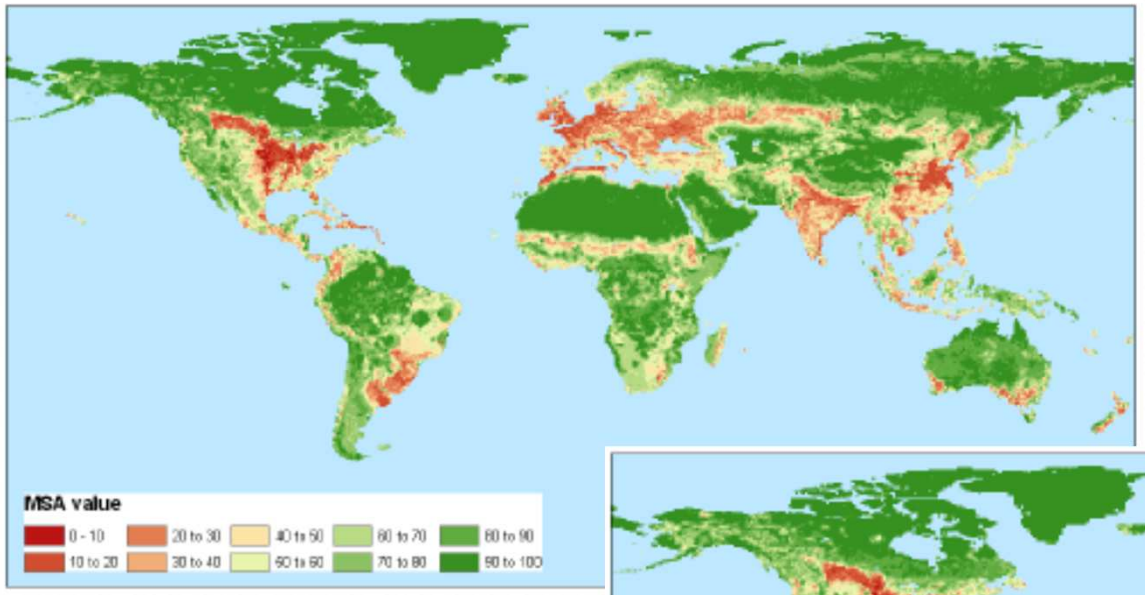
Baseline developed from OECD projections:

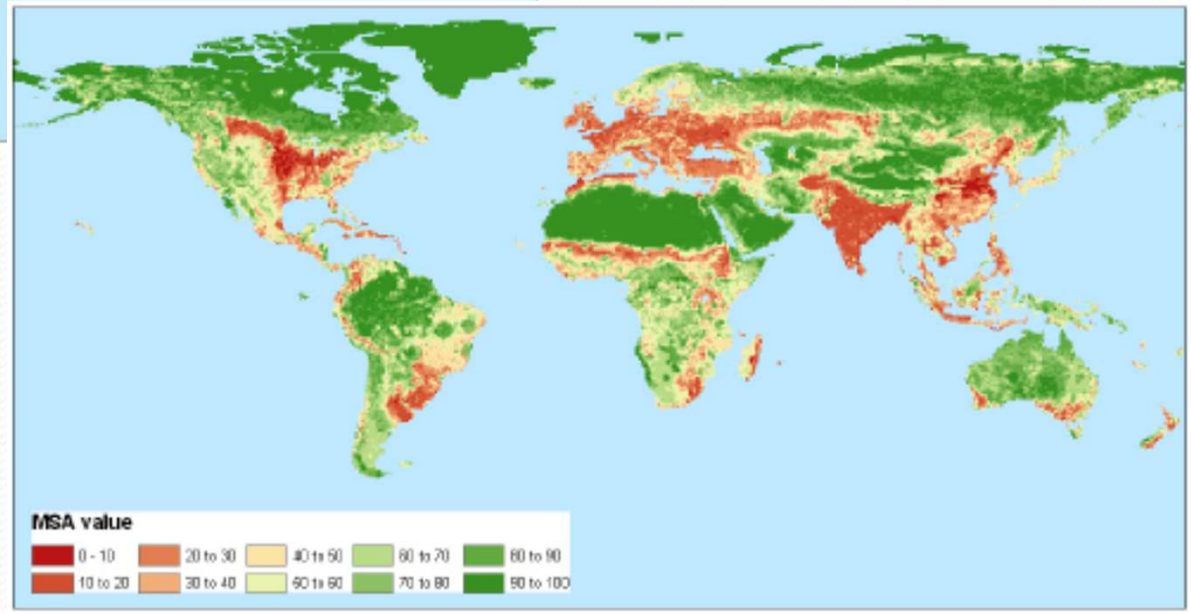
- World population grows from 6 to 9 billion
- Fourfold increase in economic output (~ 2.8% per annum)
- Per capita incomes grow particularly in BRIC countries
- Agricultural productivity increases at 1.8% per annum – does not keep pace with population or consumption patterns
- No change in environmental or trade legislation
- Timber demand increases with population and incomes
- Global mean temperature increases to 1.6ºC above pre-industrial level
- No change in protected areas (14%)

Source: TEEB / www.ecosystemassessments.net

# Global Trends in Ecosystem Services

2000




2050

Source: TEEB / www.ecosystemassessments.net

# Global Trends in Ecosystem Services

- Indirect drivers are critical

Source: TEEB / www.ecosystemassessments.net

# Ecosystem service assessments

- Ecosystem services rarely factored into planning
- Reinforcing feedback between behaviour and environment