Integrated Valuation of Ecosystem Services and Tradeoffs: Use an ecosystem service modeling approach to inform decisions for sustainable development

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Contents

1. Introduction to
   - Ecosystem Service (ES)
   - ES Modeling: InVEST

2. ES Model Applications for Decision Making
   - Jeju Island, Korea: sustainable development
   - Sumatra, Indonesia: land use planning
   - Hainan Island, China:

3. Summary & Discussion

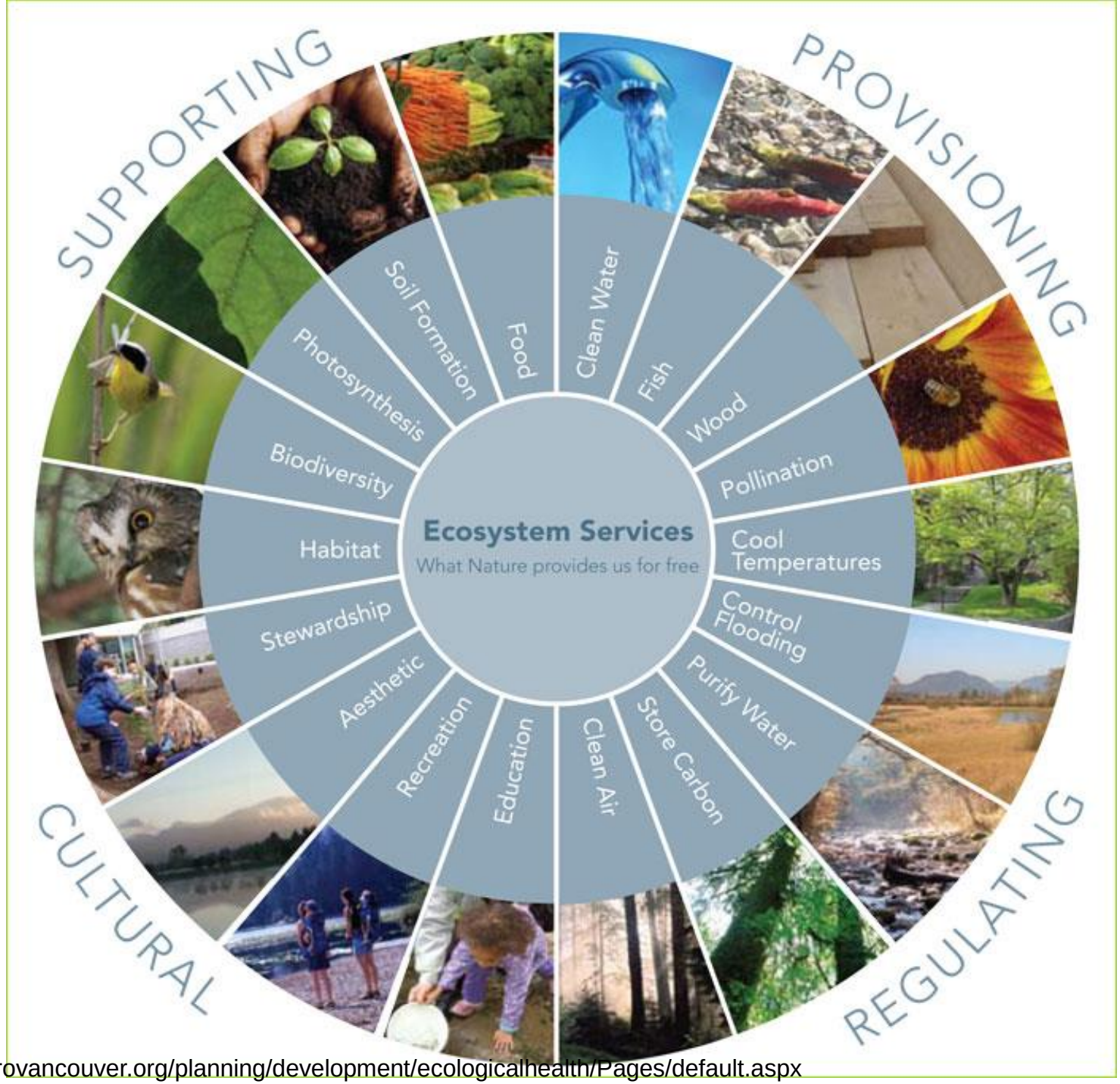
Food, fuel, fiber

Pollination

Coastal protection

Clean water

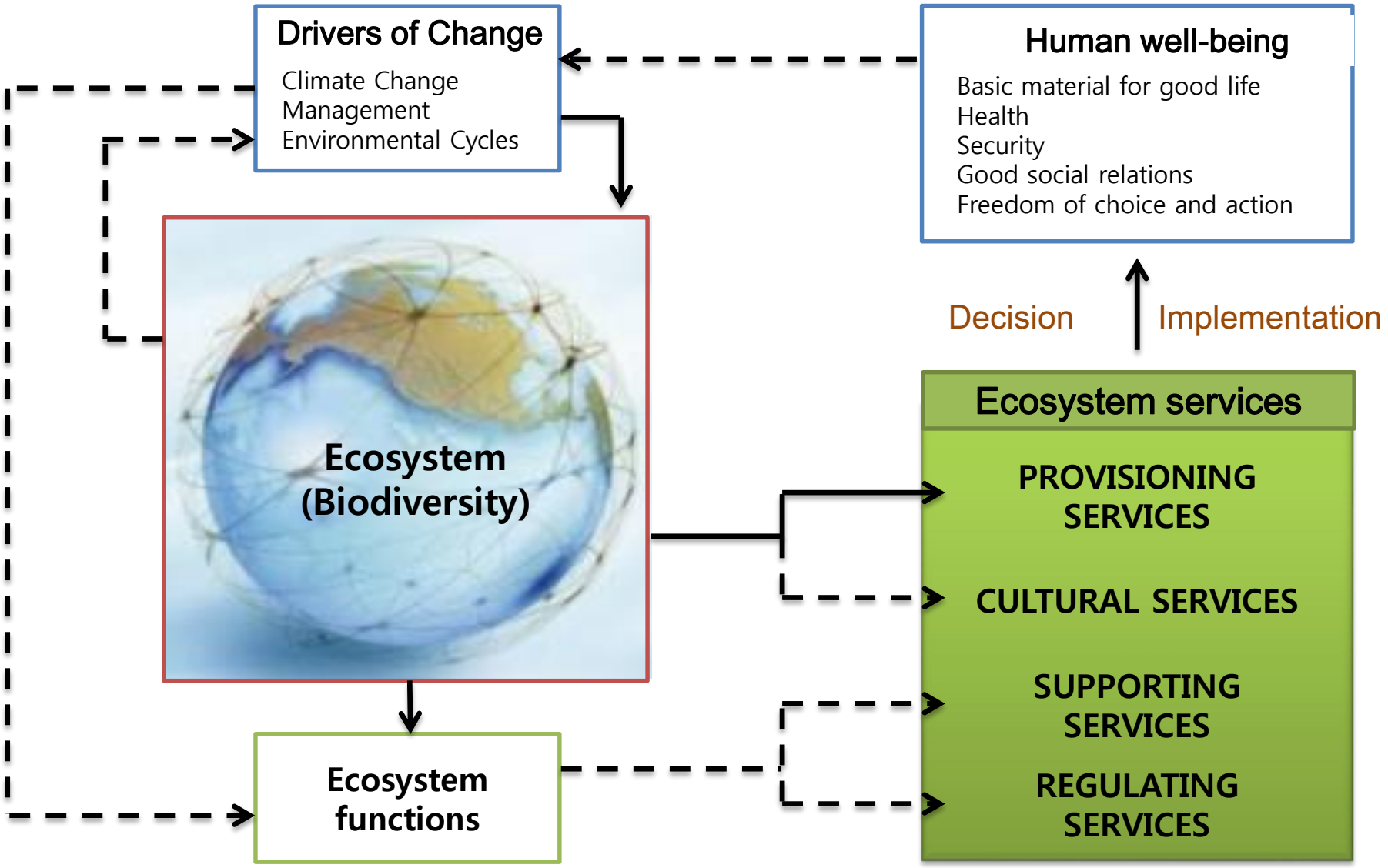
Recreation



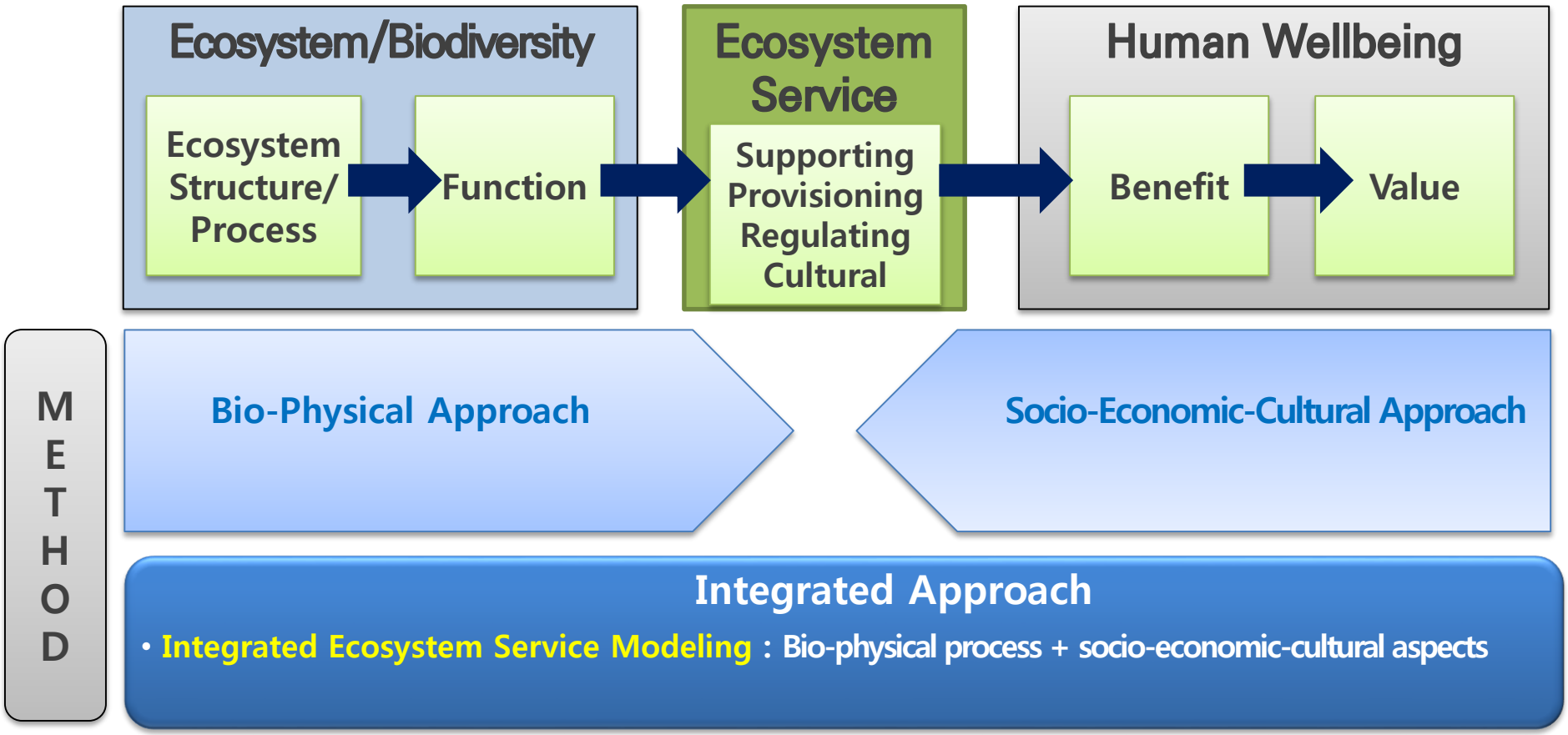
http://www.metrovancouver.org/planning/development/ecologicalhealth/Pages/default.aspx

Linkages among Ecosystem, Ecosystem Services, and Human Well-being

Modified from MA (2005)



Decision Support Tools: Integrated ES Modeling

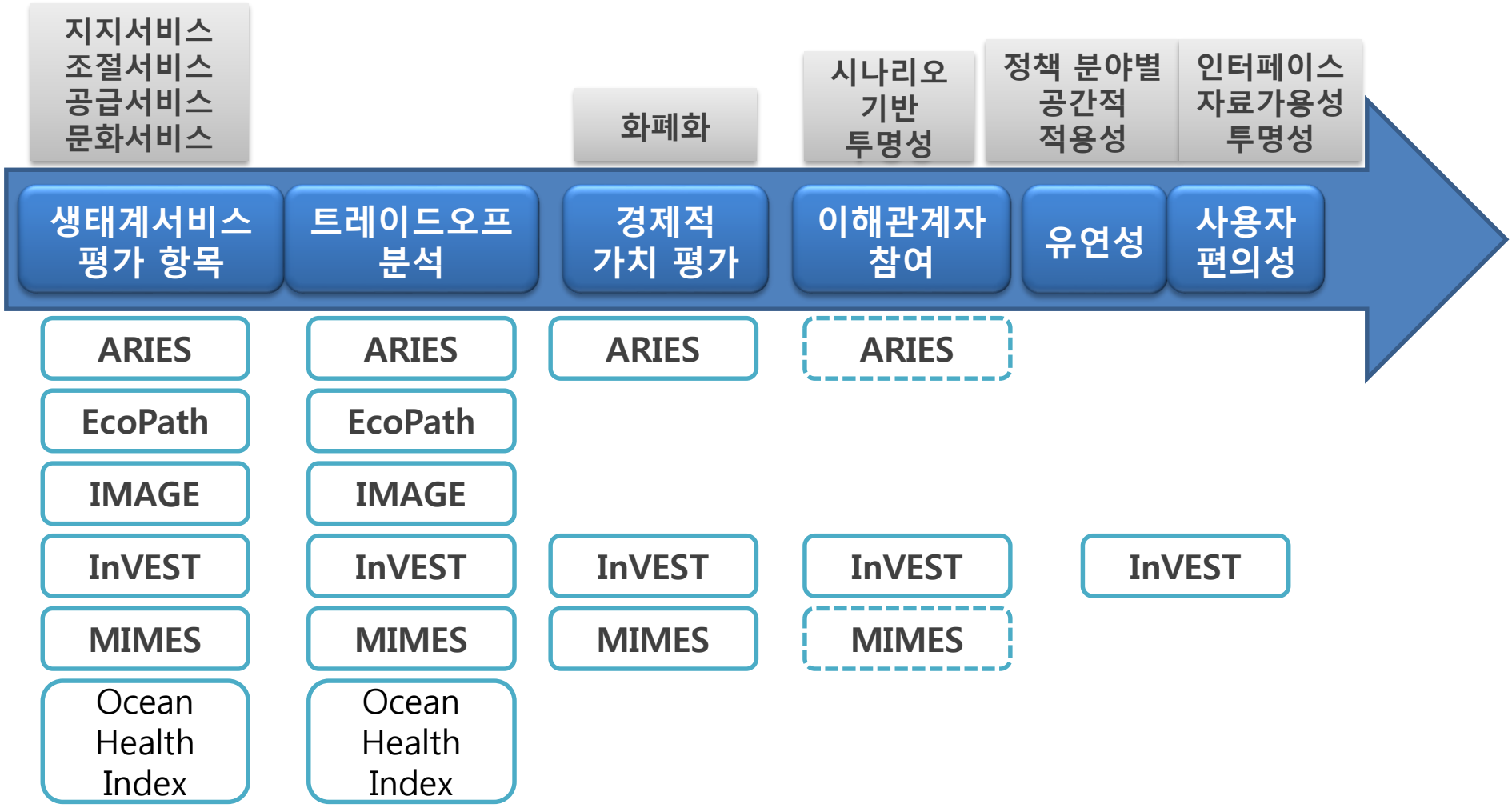


※ MA (2005), TEEB(2010), Ahn (2010)

Decision Support Tool : Integrated ES Modeling

Model	ES Types	Economic Valuation	Stakeholder Engagement	Tradeoff Analysis	Spatial Scale	Temporal Scale	Ecosystem	User Friendly
InVEST	14	Δ	○	○	Watershed /National/ Regional/ Global	Static	Terrestrial Marine	High
ARIES	10	Δ	○	○	Watershed /National/ Regional/ Global	Static	Terrestrial Marine	Low
MIMES	17	Δ	○	○	Watershed /National/ Regional/ Global	Dynamic	Terrestrial Marine	Low
EcoPath/ EcoSim	3	×	○	○	Local/Nati oanl	Dynamic	Marine	Medium
Ocean Health Index	10	×	○	○	National/R egional/Gl obal	Static	Marine	High
IMAGE	8	×	×	○	Global	Dynamic	Terrestrial Marine	Low

생태계서비스 기반 의사결정지원 도구 선정 절차



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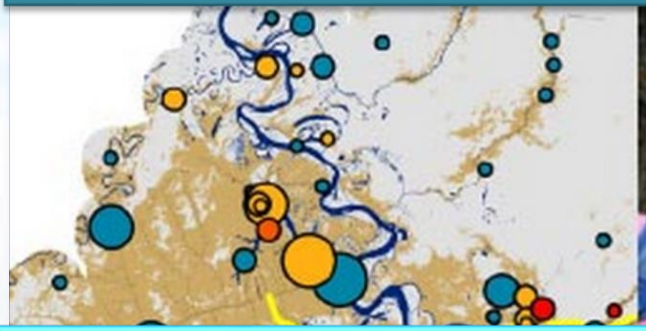
Natural Capital Project help people understand what we get from nature



Use that understanding to inform decision to improve human welfare

Download InVEST

InVEST

integrated valuation of environmental services and tradeoffs

InVEST is the leading tool for incorporating natural capital into decisions

waters and their biodiversity

of vital benefits flowing from natural capital to people

Stanford Woods Institute for the Environment

WWF

The Nature Conservancy

Institute on the Environment

University of Minnesota

Driven to Discover℠

The NatCap Team

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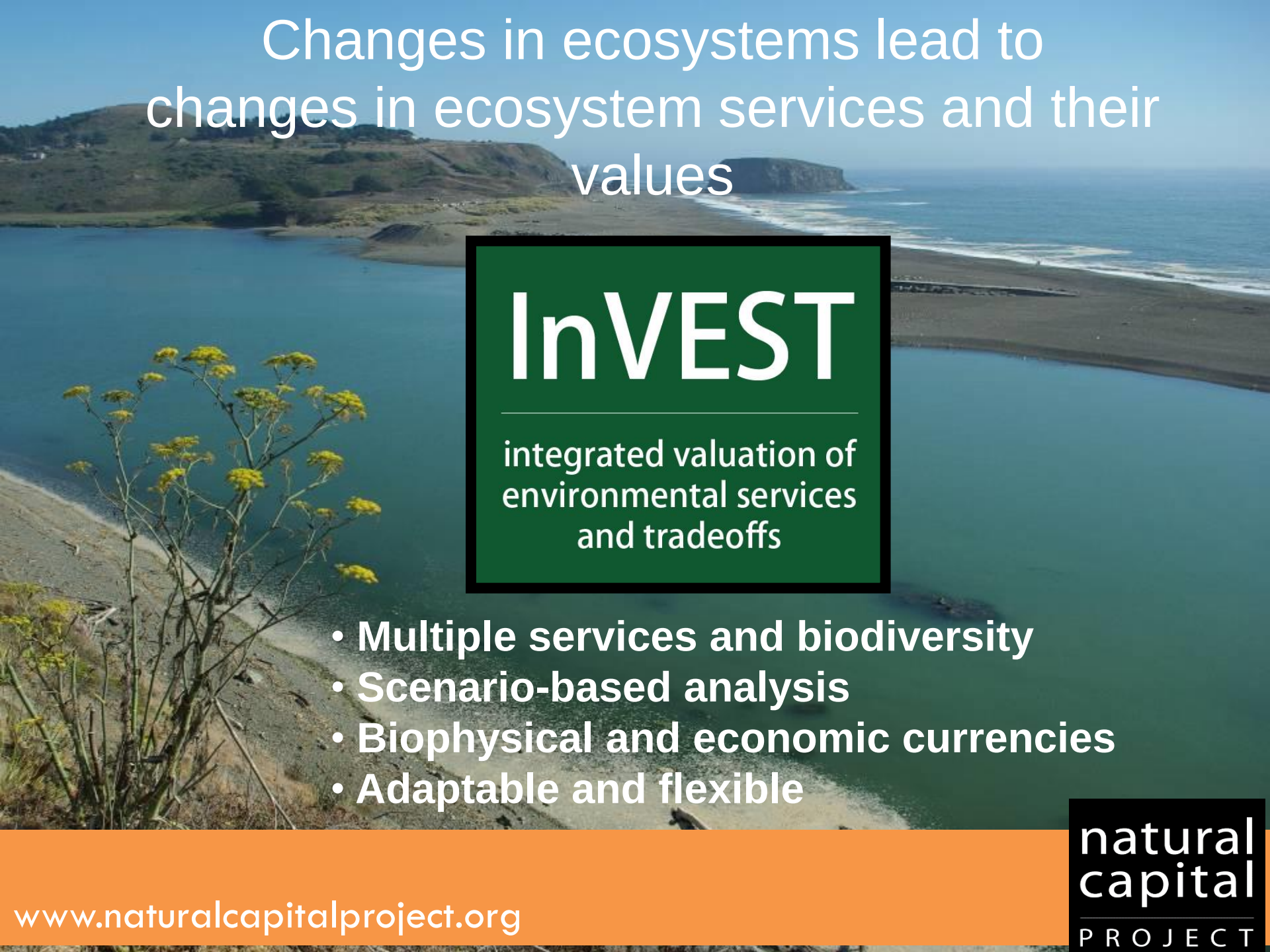
- ecologists
- oceanographer
- coastal engineers
- hydrologists
- software engineers
- biologists
- policy, GIS and communication specialists
- economists
- geographers

Changes in ecosystems lead to changes in ecosystem services and their values



- **Multiple services and biodiversity**
- **Scenario-based analysis**
- **Biophysical and economic currencies**
- **Adaptable and flexible**

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Current Terrestrial Models

InVEST
integrated valuation of environmental services and tradeoffs

Biodiversity: Habitat Quality

Water yield for hydropower production

Erosion control: reservoirs and WQ

Water purification: nutrient retention

Carbon sequestration & storage

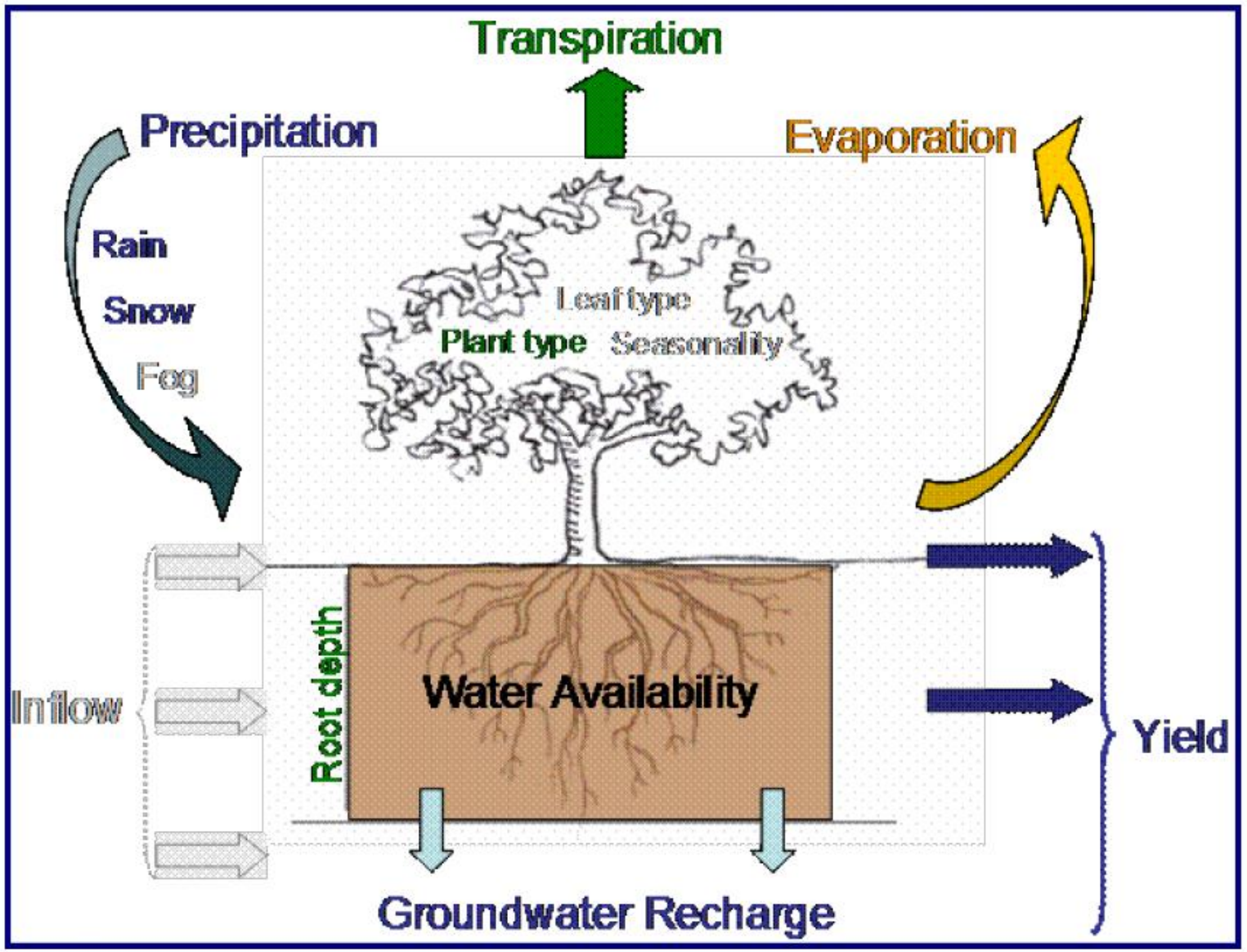
Managed timber production

Crop pollination



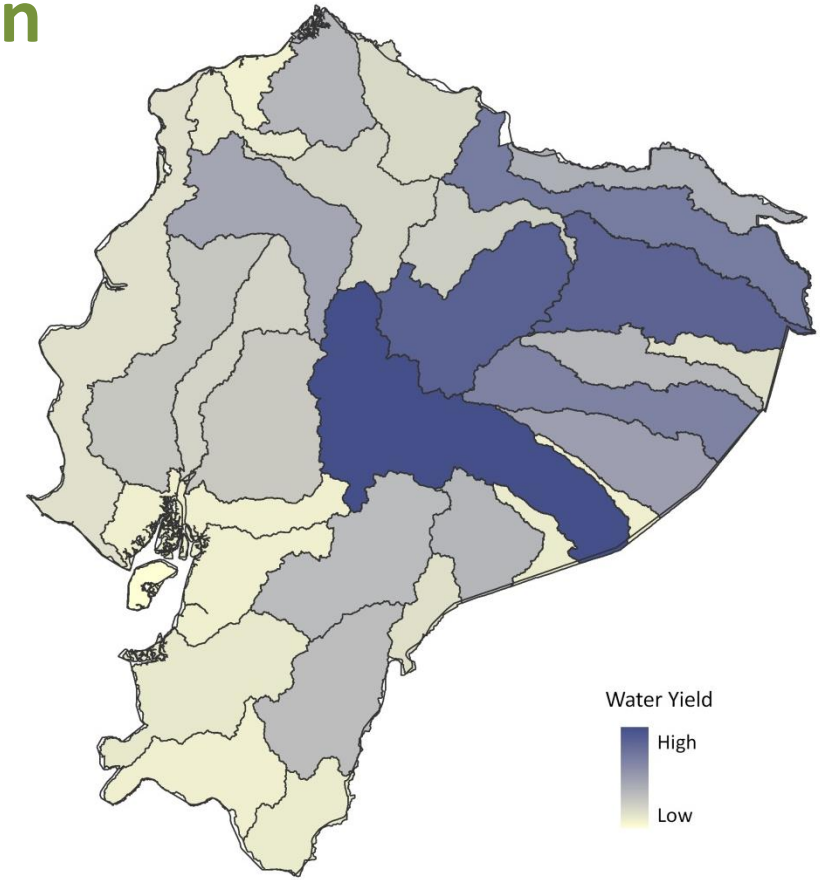



Water Yield: Reservoir Hydropower Production

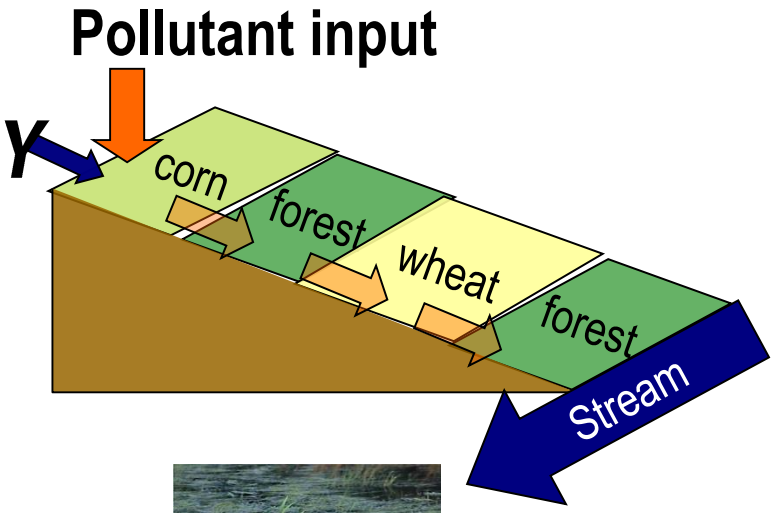


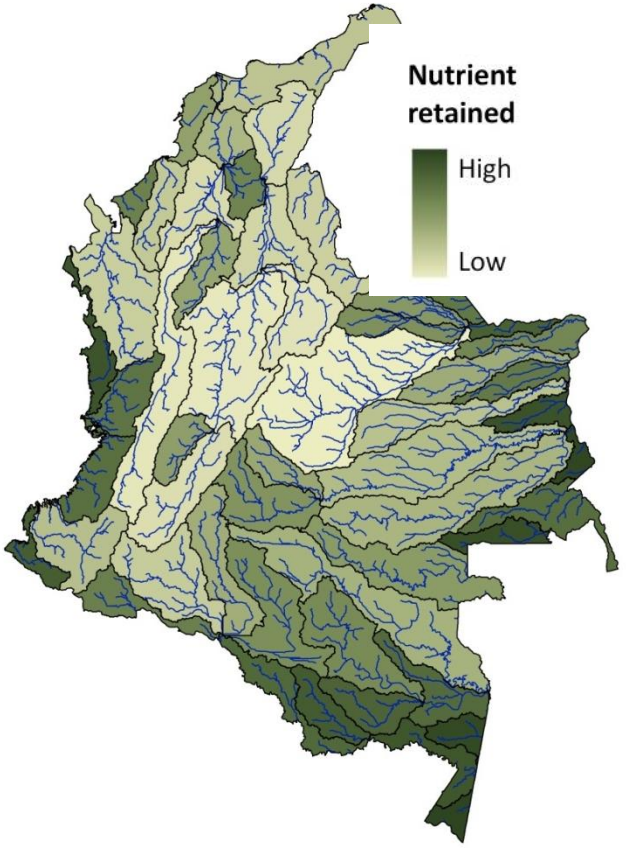
Water Yield: Reservoir Hydropower Production

- **Actual Evapotranspiration**
  mm/year
- **Water yield**
  mm/year
- **Water supply**
  m^3/year
  Used in valuation
- **Energy/value for hydropower**
  Kw/currency over timespan



Nutrient Retention Model





Overland flow

Nutrient Exported

Nutrient Retained

Valuation

Sediment Retention: Water Quality or Reservoir Dredging

Potential Soil loss

Calculated from USLE

Tons/year

Sediment Retained

Tons/year

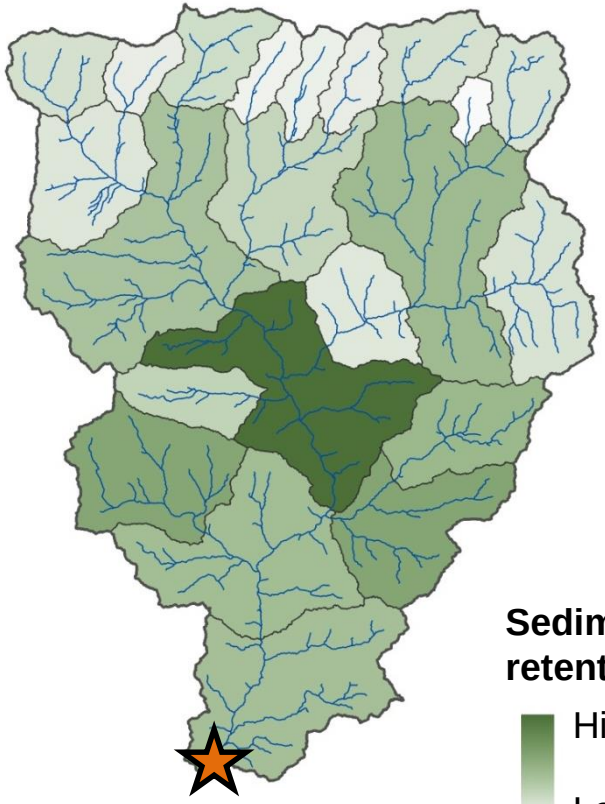
Used in valuation

Sediment Exported

Tons/year

Value of Sediment Removal for Water Quality/Dredging

Currency over time period



+ Total export to reservoir

Current Marine Models

InVEST
integrated valuation of environmental services and tradeoffs

Recreation

Aquaculture

Fisheries

Coastal Protection

Renewable Energy (wave and wind)

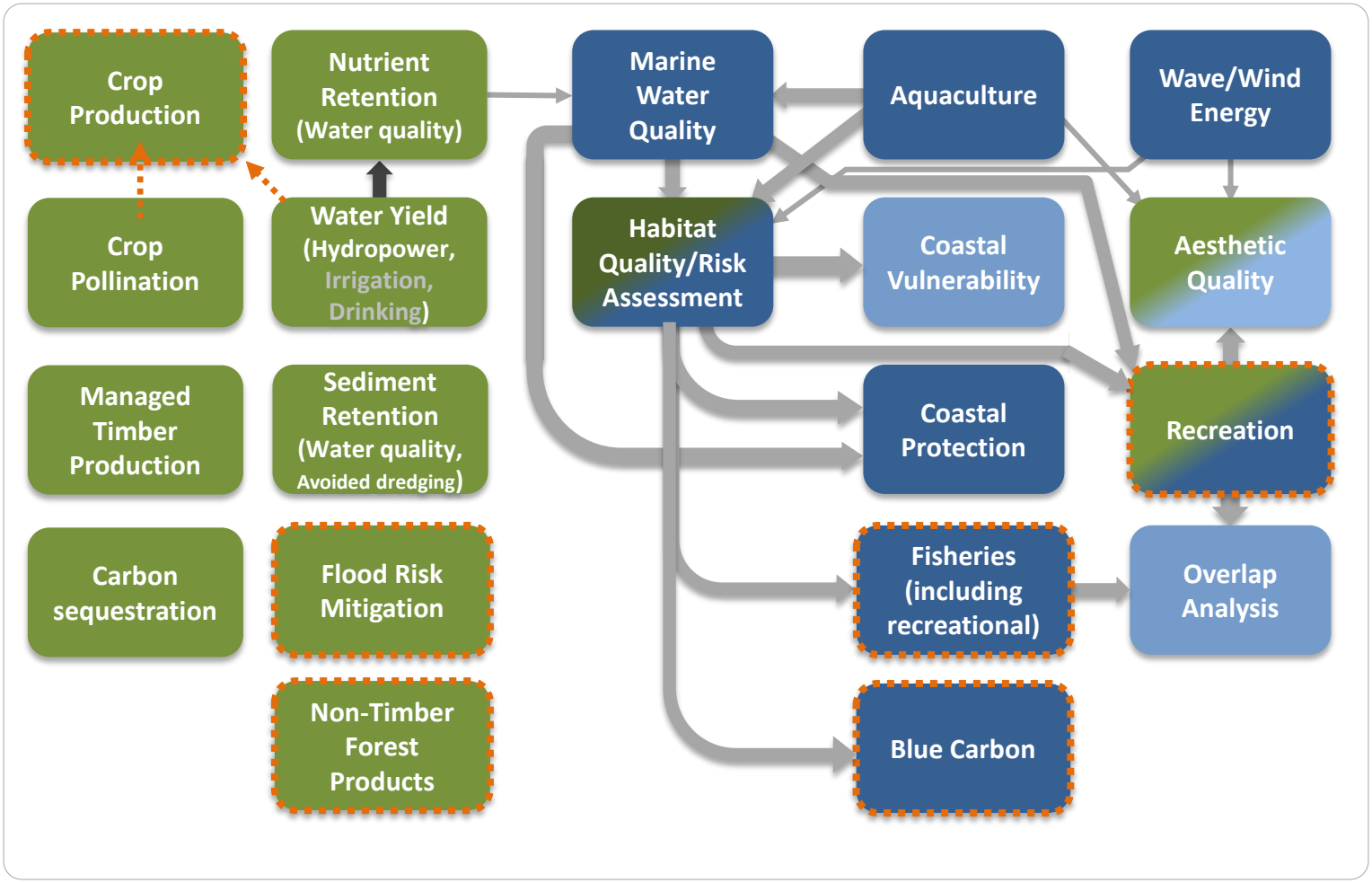
Aesthetic Quality

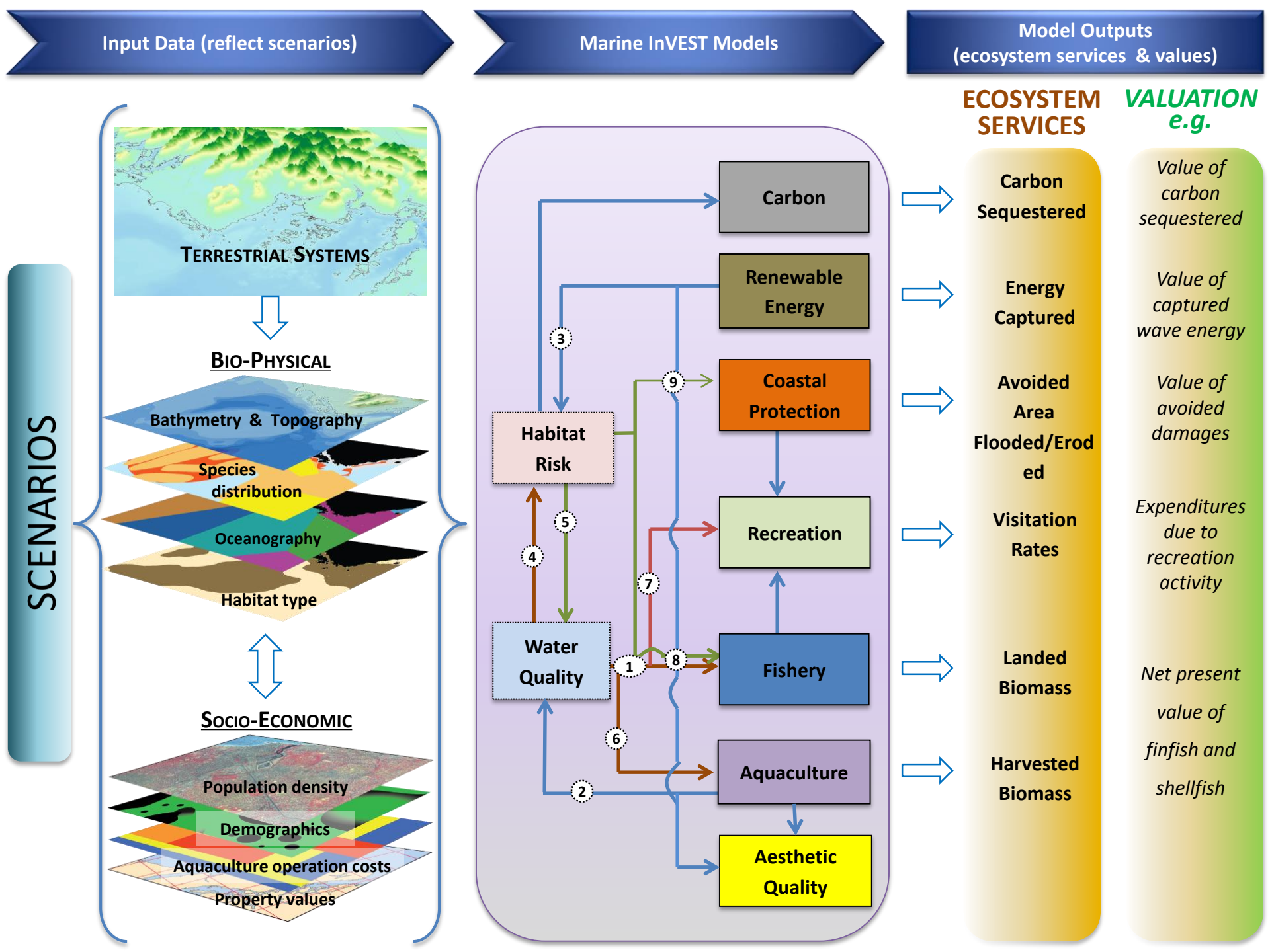
Water Quality

Habitat Risk Assessment

Carbon Sequestration

InVEST Models & Linkages

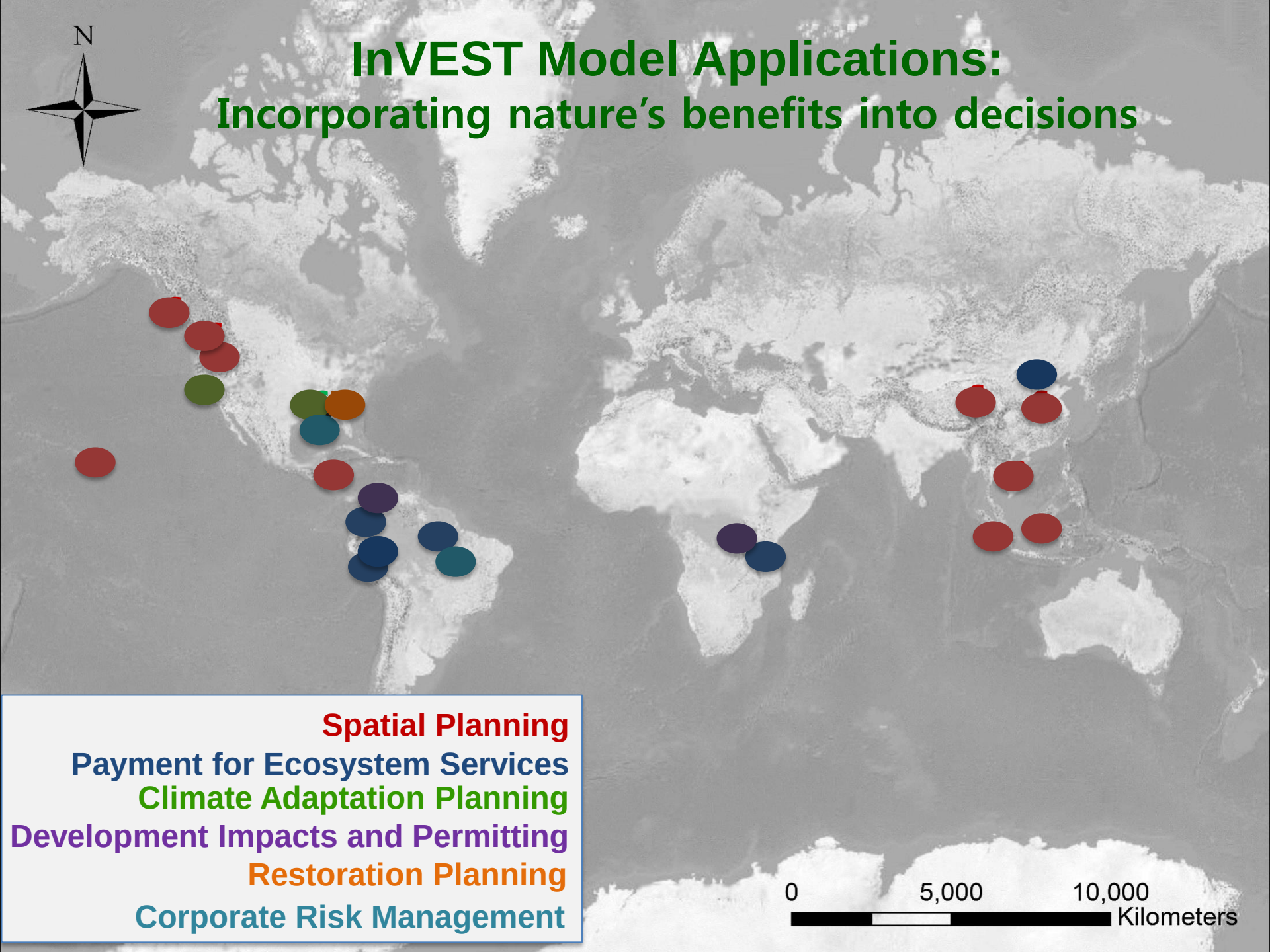



Input Data (reflect scenarios)
Marine InVEST Models
Model Outputs (ecosystem services & values)
ECOSYSTEM SERVICES
VALUATION e.g.
SCENARIOS
TERRESTRIAL SYSTEMS
BIO-PHYSICAL
Bathymetry & Topography
Species distribution
Oceanography
Habitat type
SOCIO-ECONOMIC
Population density
Demographics
Aquaculture operation costs
Property values
Carbon
Renewable Energy
Coastal Protection
Habitat Risk
Recreation
Water Quality
Fishery
Aquaculture
Aesthetic Quality
1
2
3
4
5
6
7
8
9
Carbon Sequestered
Energy Captured
Avoided Area Flooded/Eroded
Visitation Rates
Landed Biomass
Harvested Biomass
Value of carbon sequestered
Value of captured wave energy
Value of avoided damages
Expenditures due to recreation activity
Net present value of finfish and shellfish

Economic valuation methods

InVEST
integrated valuation of environmental services and tradeoffs

- Market valuation
  - Carbon
  - Timber
  - Non-timber forest products
- Avoided damage costs
  - Water purification
  - Flood mitigation
  - Avoided erosion and flooding
- Production Economics
  - Fish for food
  - Pollination of agricultural crops

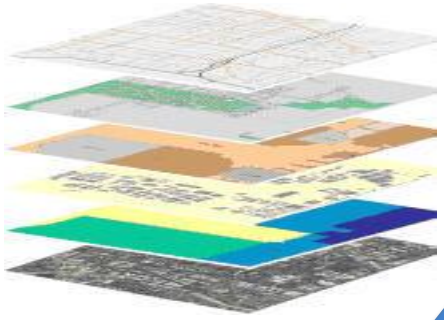

N
InVEST Model Applications:
Incorporating nature's benefits into decisions
Spatial Planning
Payment for Ecosystem Services
Climate Adaptation Planning
Development Impacts and Permitting
Restoration Planning
Corporate Risk Management
0
5,000
10,000
Kilometers

1

Define Partnerships, Roles & Objectives

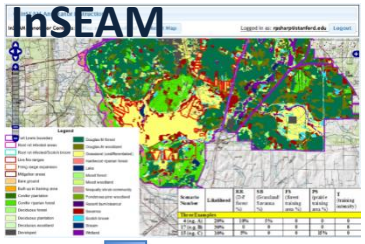
2

Compile Data



3

Generate Baseline & Scenarios



4

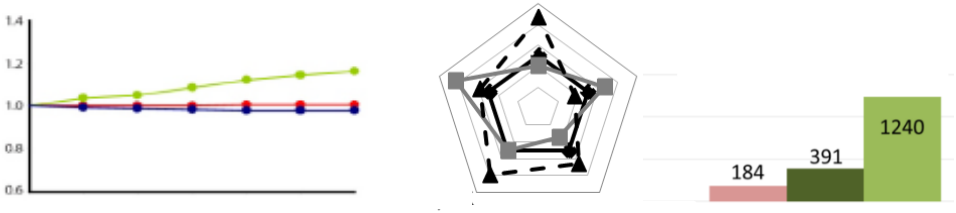
Assess Outcomes

InVEST

integrated valuation of environmental services and tradeoffs

5

Synthesize Results



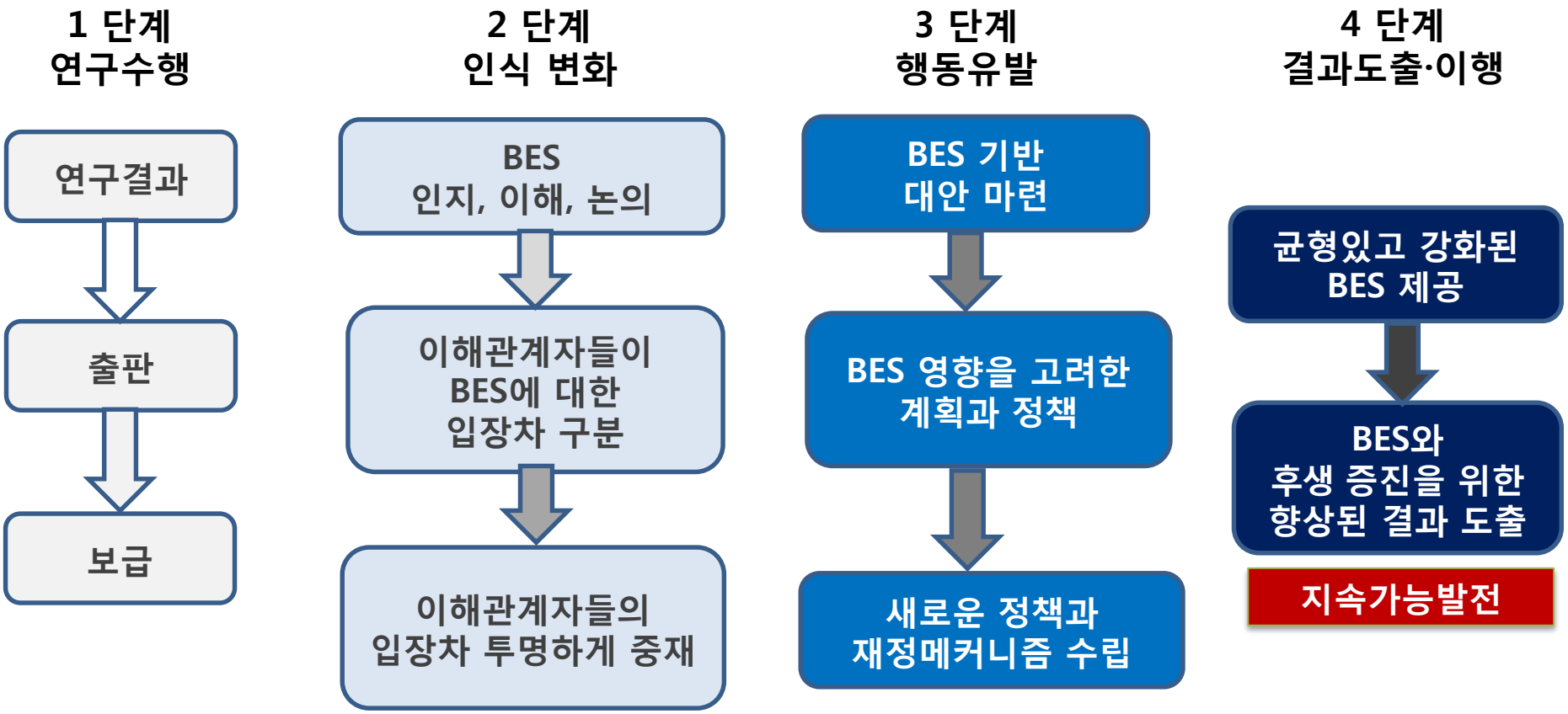
6

Iterate & Build Capacity

7

Inform Decisions

의사결정지원 단계



※ 출처 : Rucelshaus et al.. 2015. Notes from the field: Lessons learned from using ecosystem service approaches to inform real-world decisions.

※ 본 연구는 3단계로 구분하여 논술할 예정

생태계서비스 기반 의사결정 지원 사례

Ecosystem Service Model Applications for Decision Making

1. Jeju Island, Korea: Sustainable development
2. Sumatra, Indonesia: Land use planning
3. Hainan Island, China:

   How to integrate ES tradeoffs into sustainable land-use man agement?

Sumatra, Indonesia: sustainable land use planning



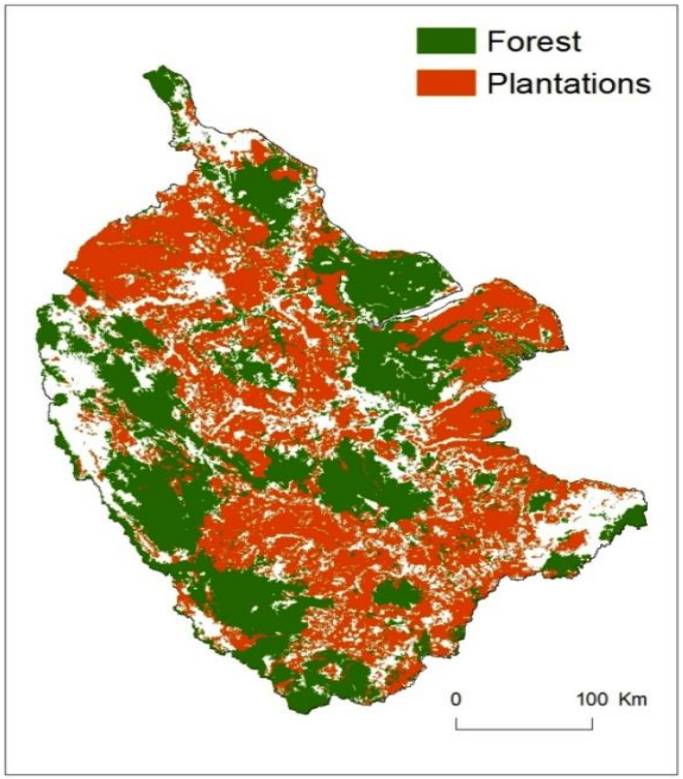
Background Information

Deforestation is the largest threat

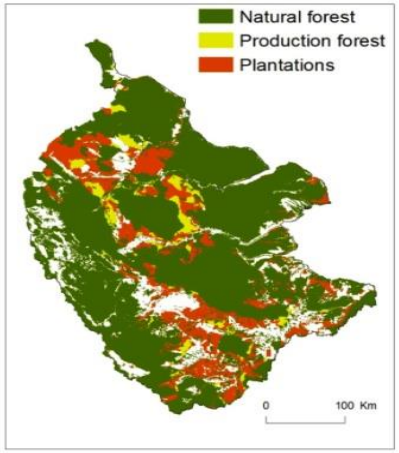
- Decrease water quality and forest products

- Identify ecosystem-based land use plans that would support **biodiversity conservation** and **ecosystem service production** while fostering economic development

(1) 'ecosystem vision' scenario of sustainable land use
(2) the government's spatial land plan: a business as usual scenario.

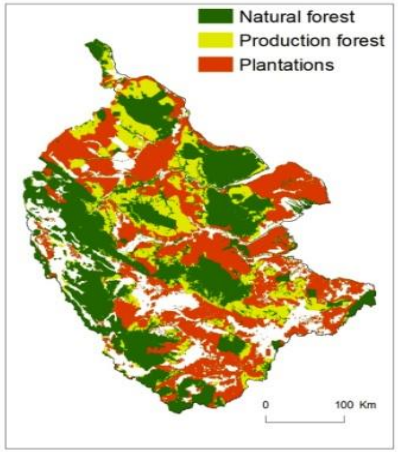


Central Sumatra in 2008



Scenario #1
Sumatra
Ecosystem
Vision

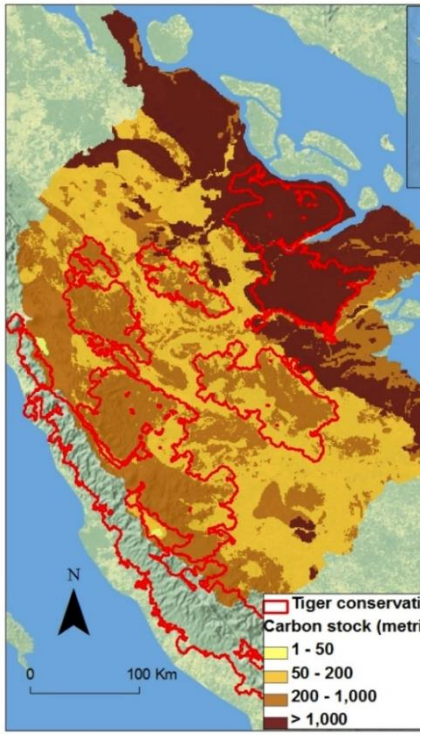
(60% more forest than 2008)



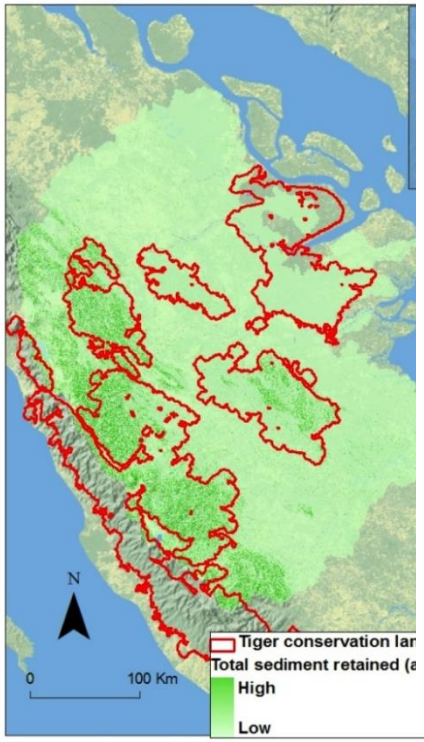
Scenario #2
Government
spatial plan

Same natural forest as 2008 (but likely worse)

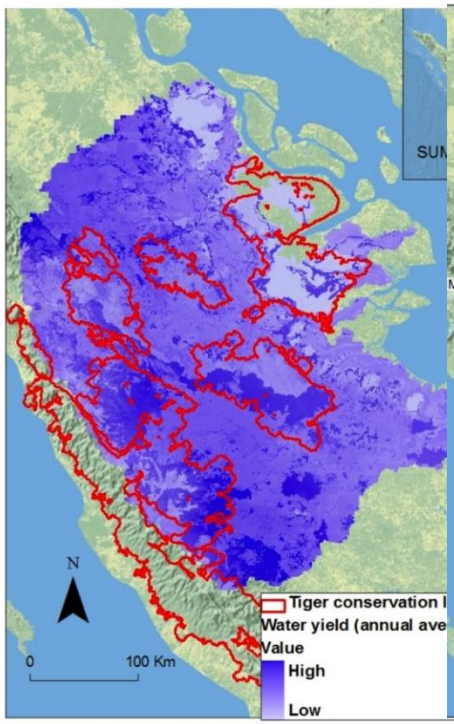
InVEST model results:



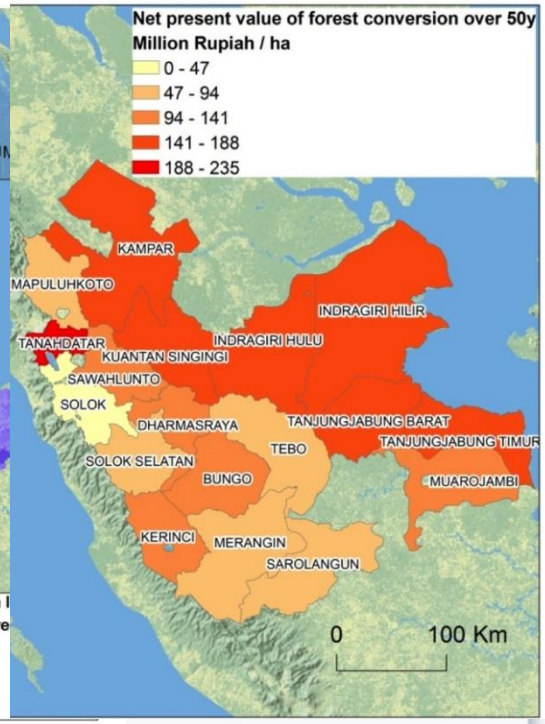
Carbon stock



Sediment retained

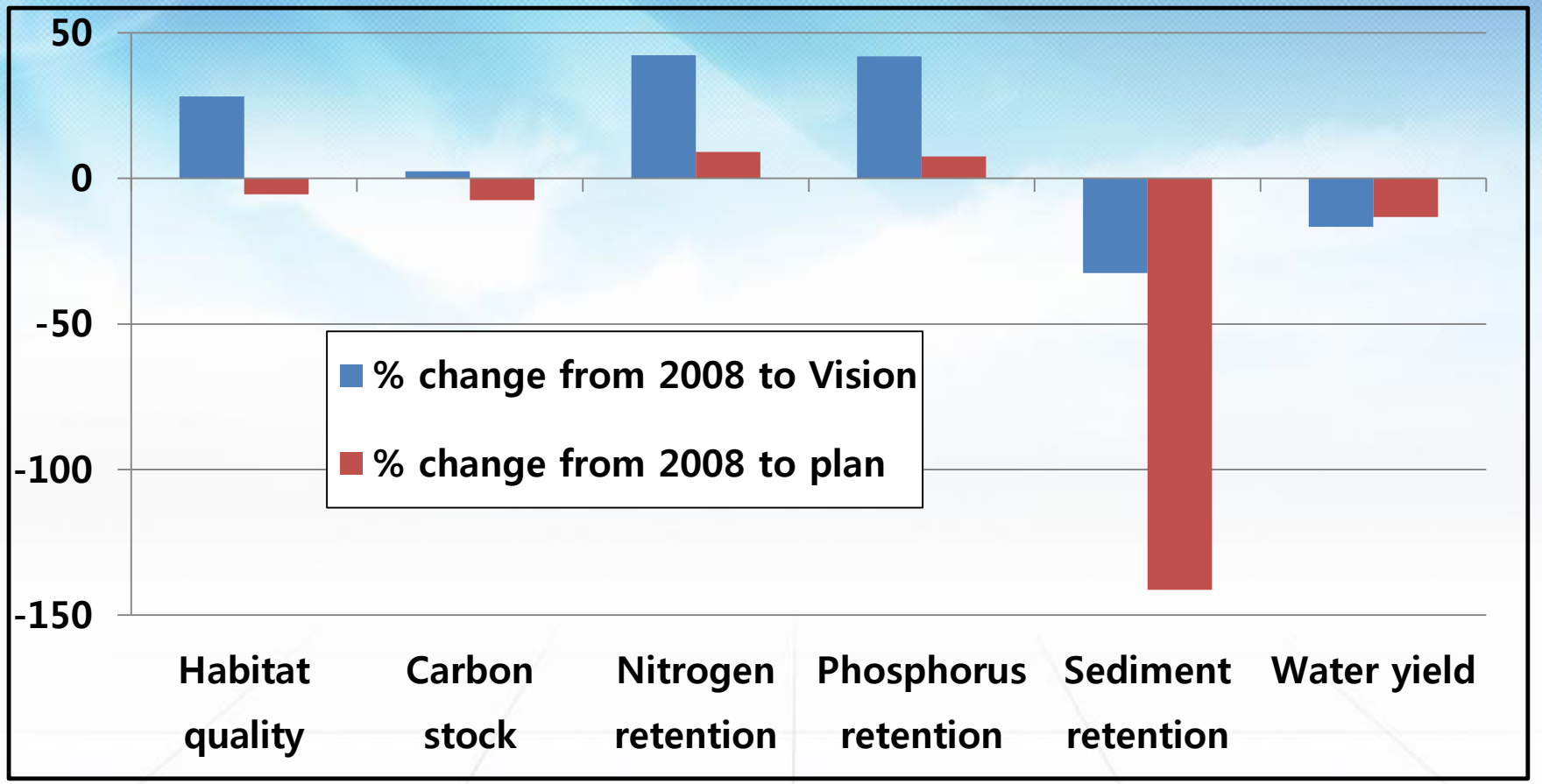


Water yield

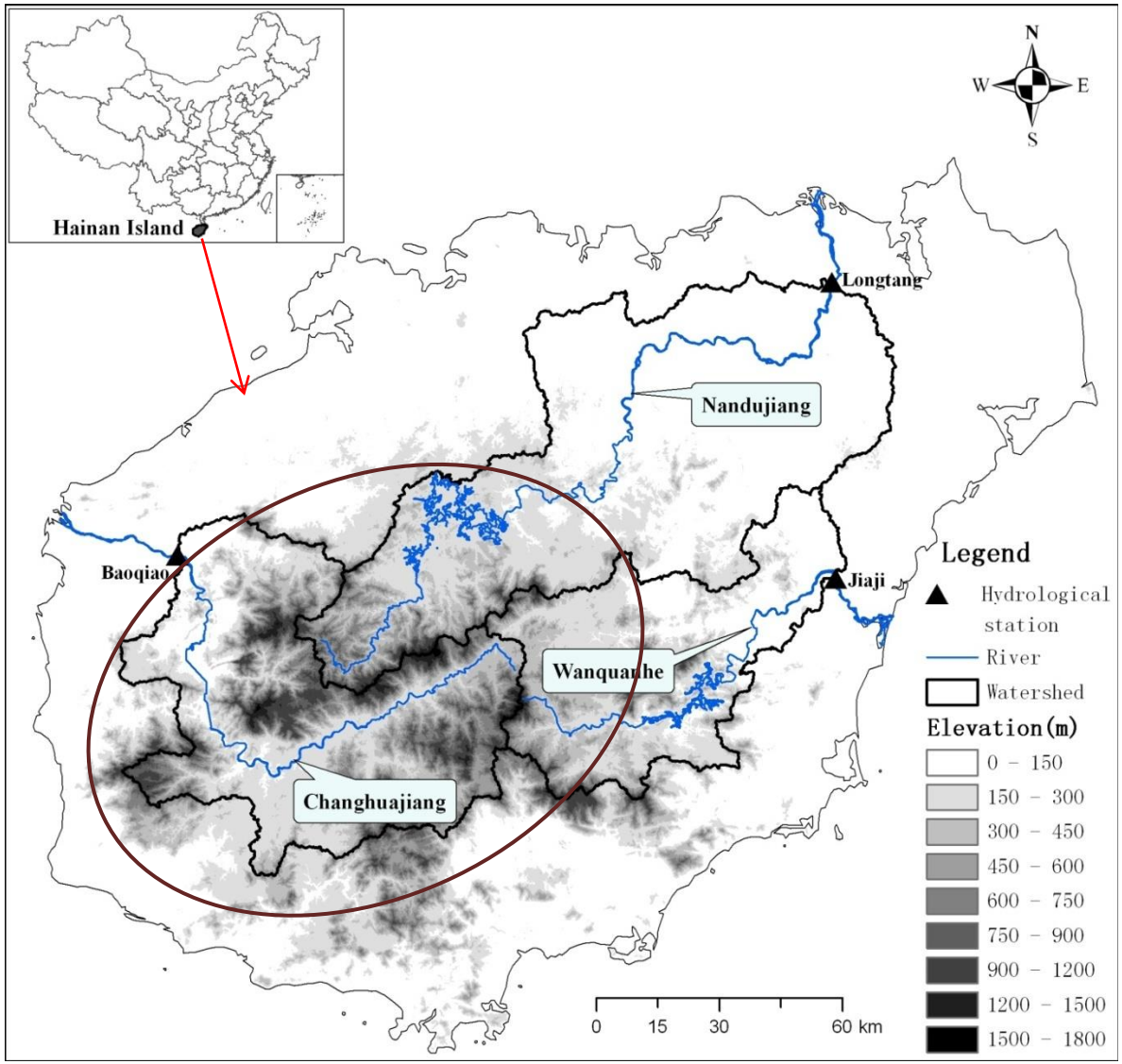


Average expected agricultural returns to forest conversion over 50 years (million Rp/ha)

Landscape-wide changes in ecosystem services and habitat quality under two scenarios:



Hainan demonstration



Setting

3.4×10^4 km^2

8.7 million people (2010)

The first ecological demonstration province

Goals

Biodiversity conservation

Water resource conservation

Storm peak mitigation (2010 flooding lost USD $2 billion)

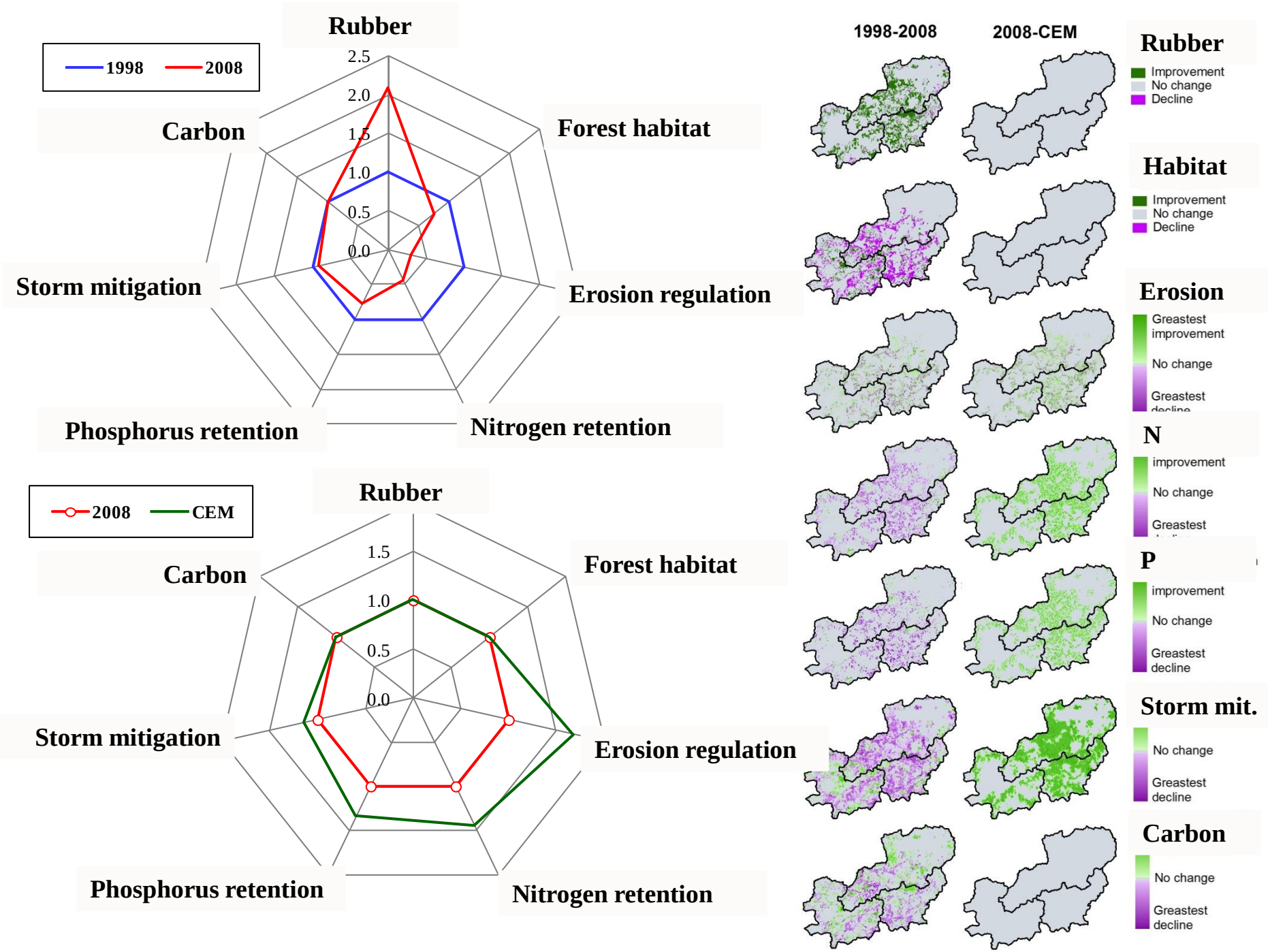
Hainan demonstration

LULC change impacts on ES between 1998-2008

- Natural forest: 37.4% → 28.0% (lost 25.3%)
- Rubber plantation: 17.3% → 36.1%

Solution

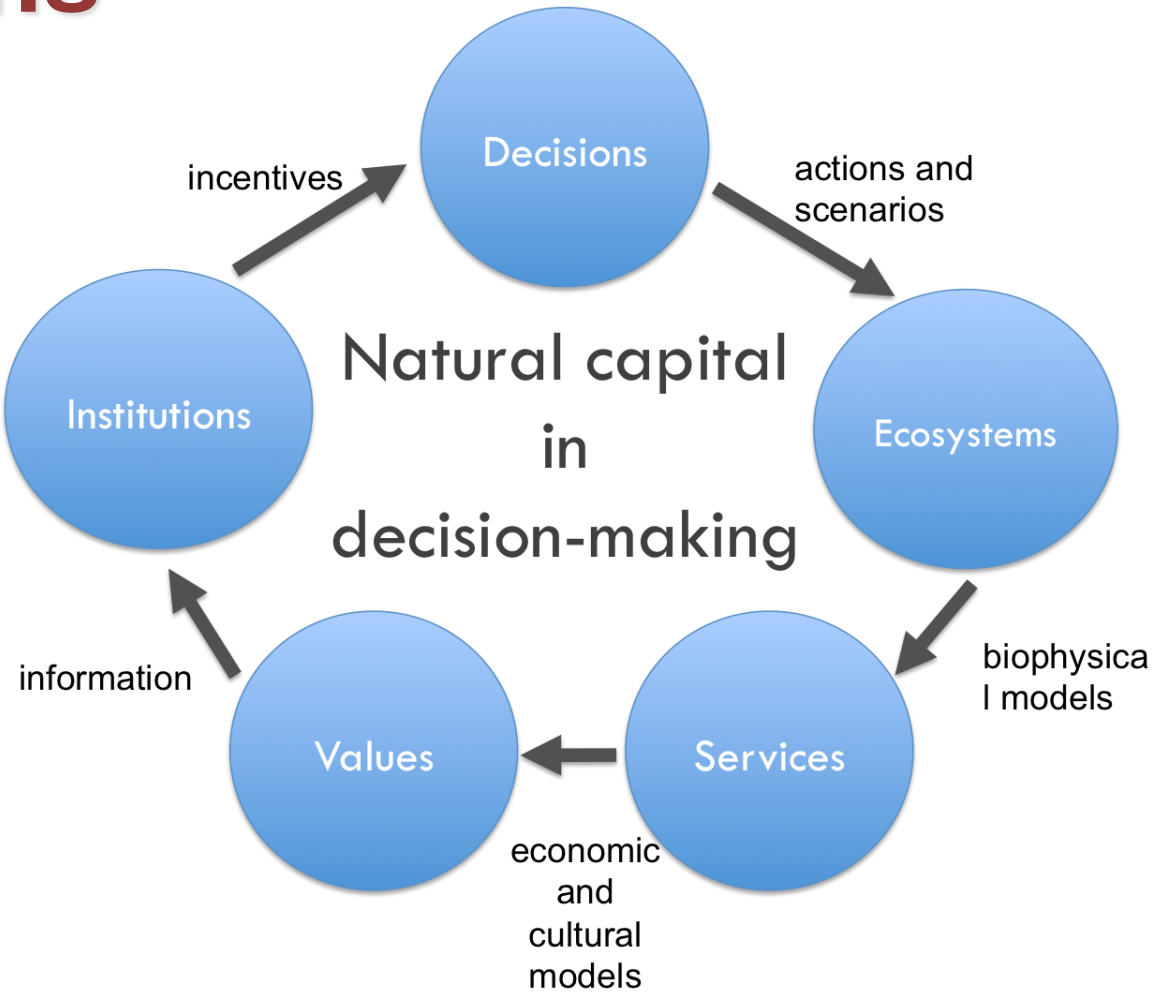
- CEM: Complex Ecosystem Management


1998
2008
Rubber
Forest habitat
Erosion regulation
Nitrogen retention
Phosphorus retention
Storm mitigation
Carbon
2.5
2.0
1.5
1.0
0.5
0.0
2008
CEM
Rubber
Forest habitat
Erosion regulation
Nitrogen retention
Phosphorus retention
Storm mitigation
Carbon
1.5
1.0
0.5
0.0
1998-2008
2008-CEM
Rubber
Improvement
No change
Decline
Habitat
Improvement
No change
Decline
Erosion
Greastest improvement
No change
Greastest decline
N
improvement
No change
Greastest
P
improvement
No change
Greastest decline
Storm mit.
No change
Greastest decline
Carbon
No change
Greastest decline

Hainan lessons

Rubber comes at the expense of many other ecosystem services

Complex ecosystem management can help mitigate environmental costs

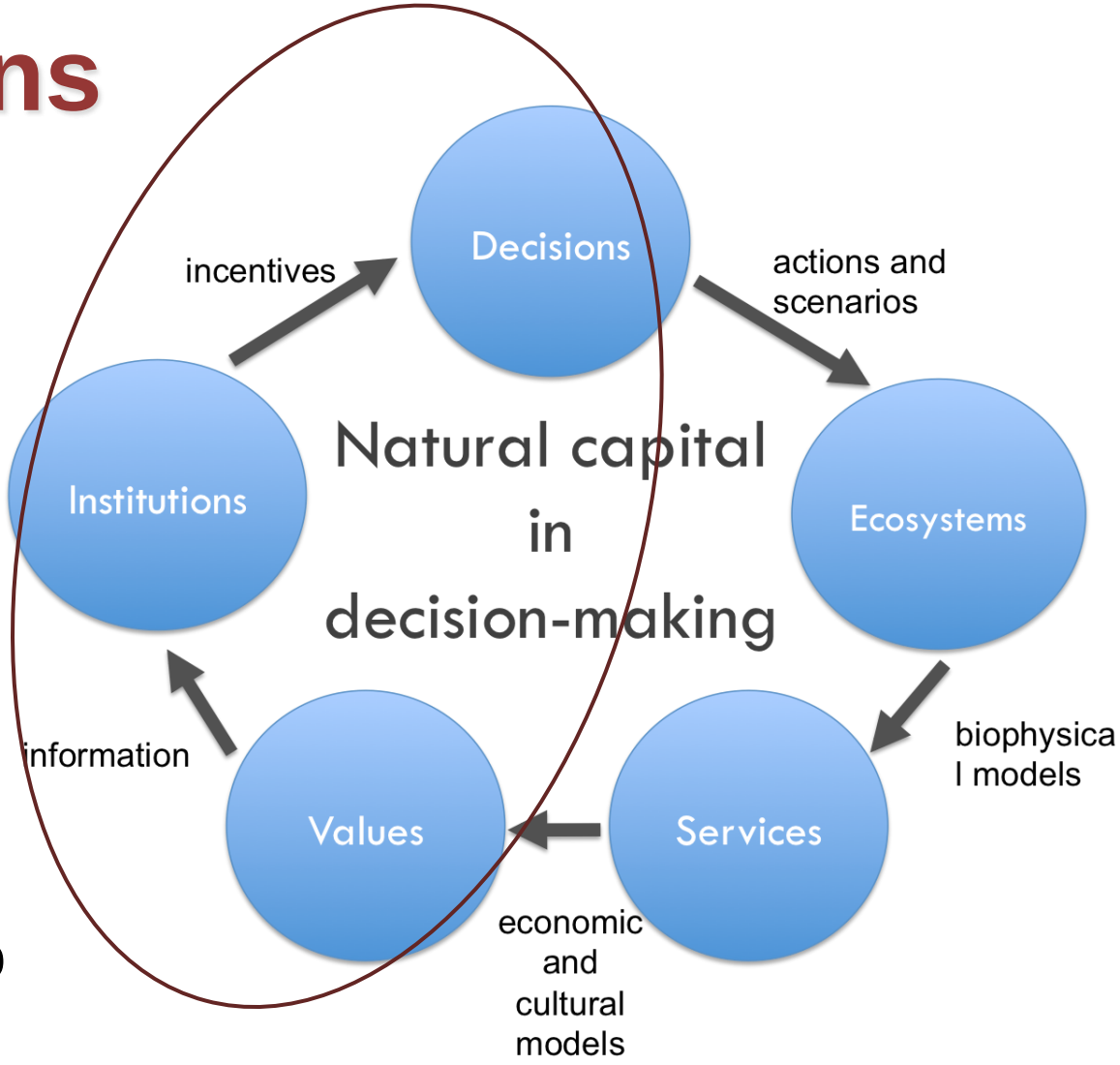


Hainan lessons

Rubber comes at the expense of many other ecosystem services

Complex ecosystem management can help mitigate environmental costs

Lots of effort needed to "close the loop"

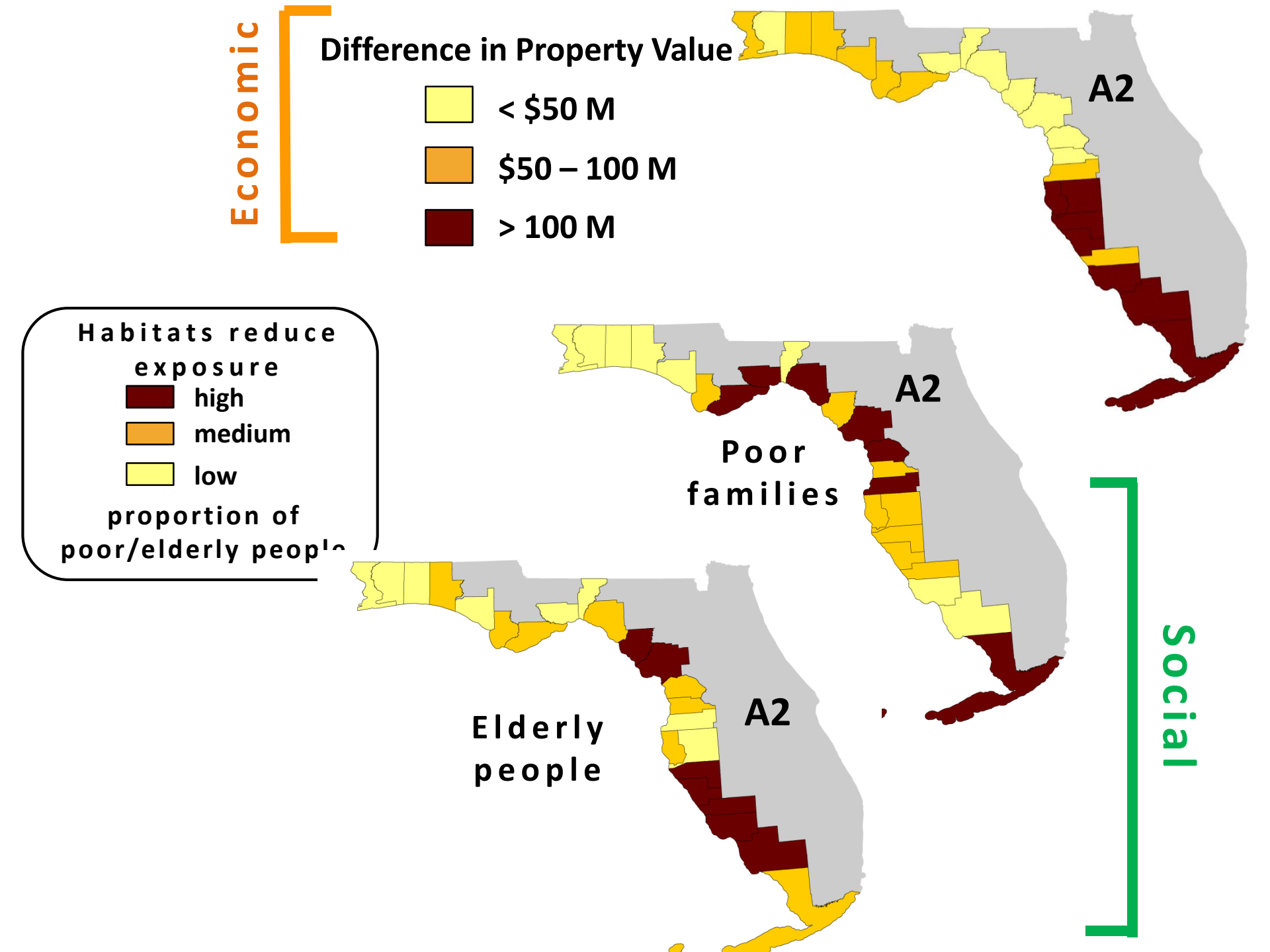


Benefits, costs, and livelihood implications of a regional payment for ecosystem service program (China)

Summary

Ecological Economics (Ruckelshaus et al. 2013)

- ✓Applying a **BES approach** is most effective in leading to policy changes
- ✓**Simple ecological production function models** have been useful in a diverse set of decision contexts
- ✓**Training local experts** in the approaches and tools is important for building local capacity, ownership, trust, and long-term success
- ✓Decision makers and stakeholders prefer to **use a variety of BES value metrics**


Economic
Difference in Property Value
< $50 M
$50 – 100 M
> 100 M
A2
Habitats reduce exposure
high
medium
low
proportion of poor/elderly people
A2
Poor families
A2
Elderly people
Social

Summary: challenges

✓An important **science gap exists** in linking changes in BES to changes in livelihoods, health, cultural values, and other metrics of human wellbeing

✓**Communicating uncertainty** in useful and transparent ways remain challenging

✓**Limited Data Availability** in different scale in time and space

Thank You