Advancing the SEEA Experimental Ecosystem Accounting

Ecosystem Service Measurement and Modelling

Advancing the SEEA-EEA Project

UNEP

Convention on Biological Diversity

NORWEGIAN MINISTRY OF FOREIGN AFFAIRS

Overview: Measurement and Modelling ES

- Data needs for measuring ecosystem condition
- Selection reference state
- Biophysical modelling

Issues for testing:

1. *Selection of models*
2. *Generic versus detailed*
3. *Reference state and indicators*
4. *Link ecosystem condition to capacity*
5. *Driver account*
6. *Scenario analysis*

Issues for further research:

Models, future services, linking ecosystem condition to capacity

10 minute presentations

Working session: Break out groups

Measuring Ecosystem Condition

Lack of detailed data:

- Use multiple sources, combining the best, reduce errors
- Less detailed data can also be valuable
- Not all data need to be measured (or measured frequently)
- Can estimate condition or services from other condition data using **Biophysical Modelling**

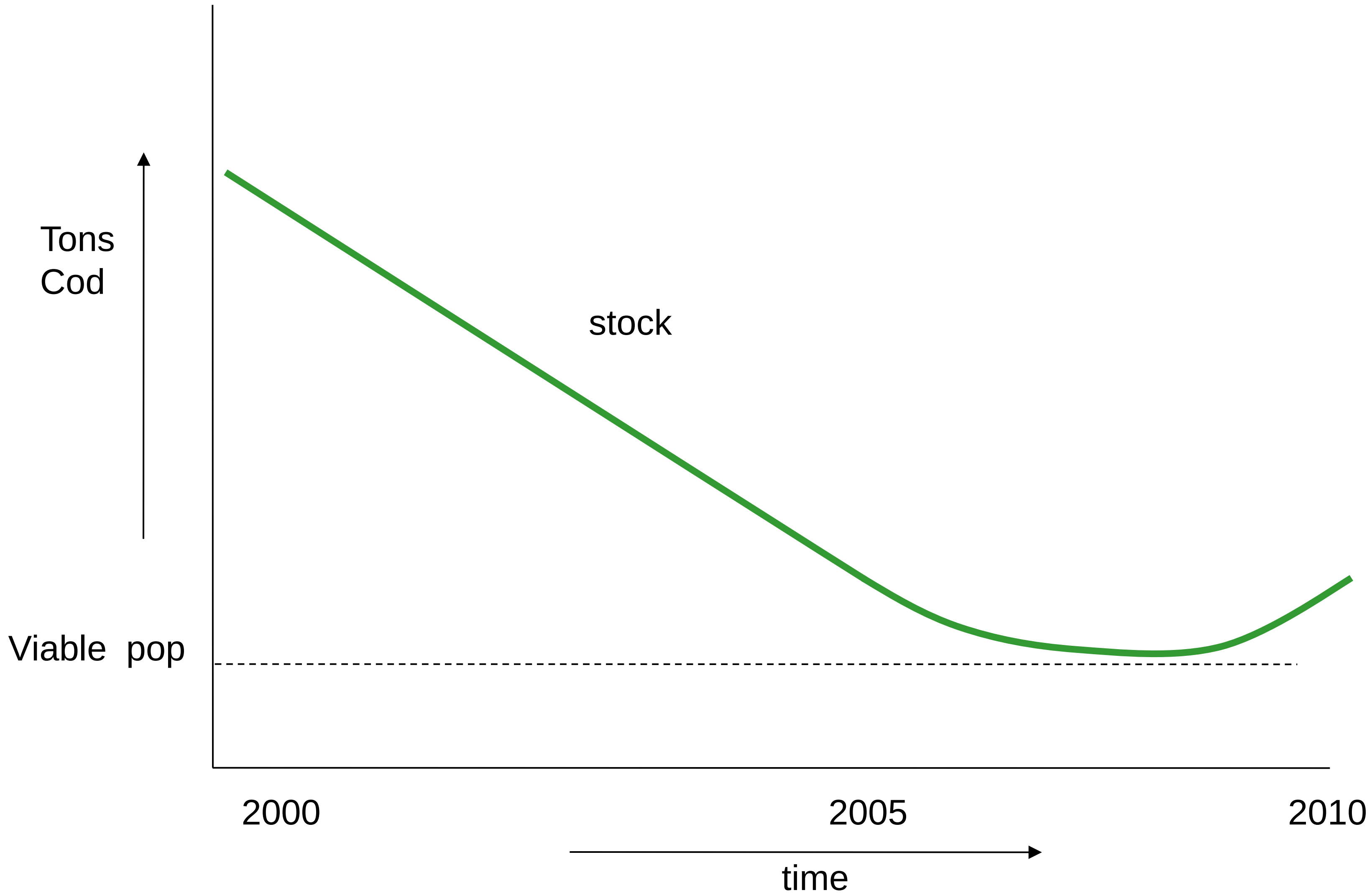
Examples data and linkage to service:

- Land cover class → carbon storage
- Sampled data on forest production → estimate for other areas
- Forest cover, distance from roads, etc. → orangutan habitat
- Land use, infrastructure and fragmentation, etc. → biodiversity
- Primary production (from remote sensing), soil respiration → carbon sequestration

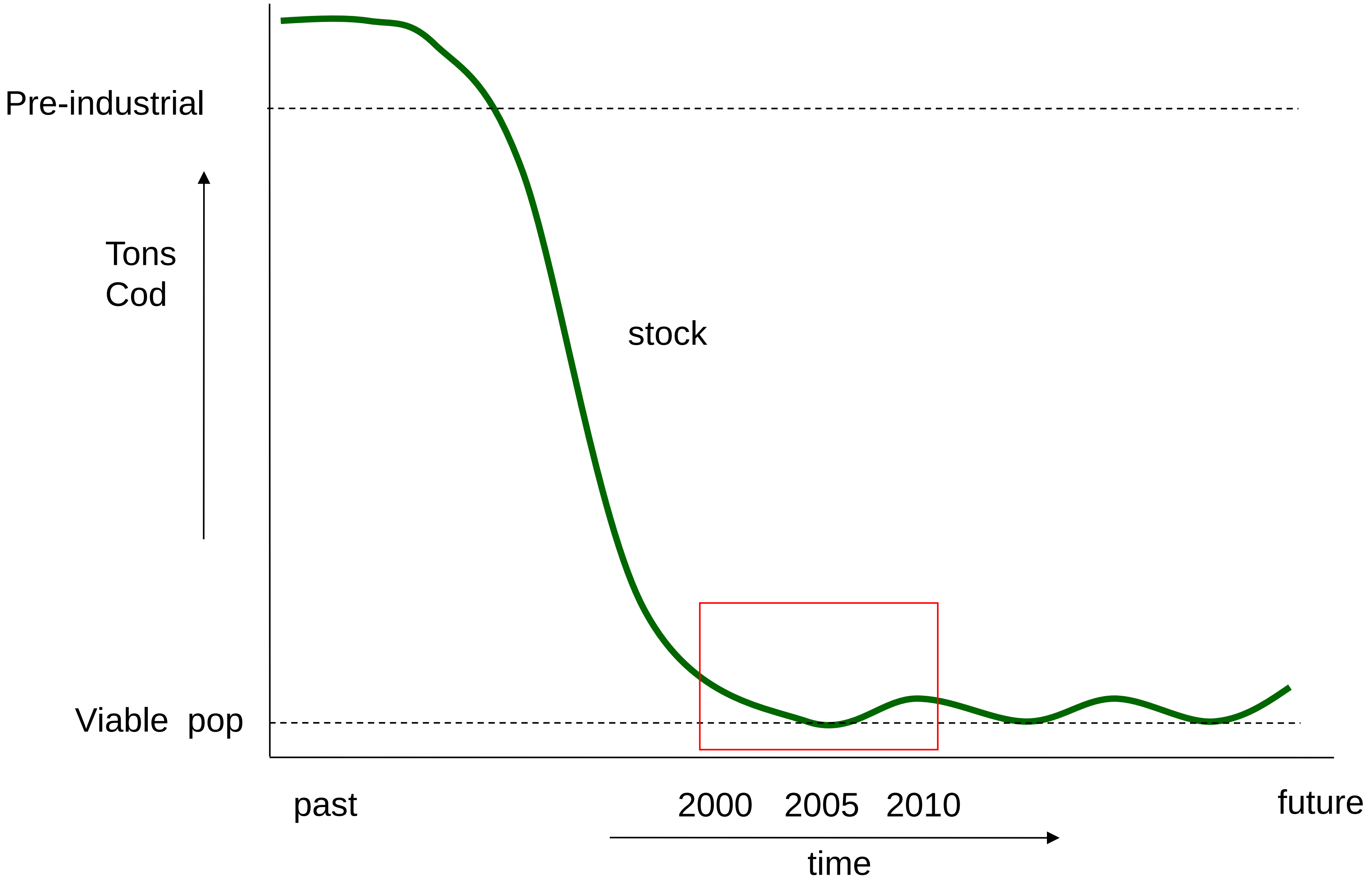
Measuring Ecosystem Condition

- **Selection of reference state**
  - Aggregates could be “arbitrary”
    - For example, average of water quality measures
  - Or, indexed to a “reference state”
    - For example, compare with “quality standard” for use (drinking, recreation, livestock, wildlife, irrigation…)
    - Can compare with known past or “ideal” reference condition:
      - Pristine or `pre-development state,
      - Sustainable state (e.g. max sustainable value)
      - Earliest available information
    - Choice of reference state can affect interpretation
      - e.g., Are we experiencing short-term fluctuations or a long-term trend?

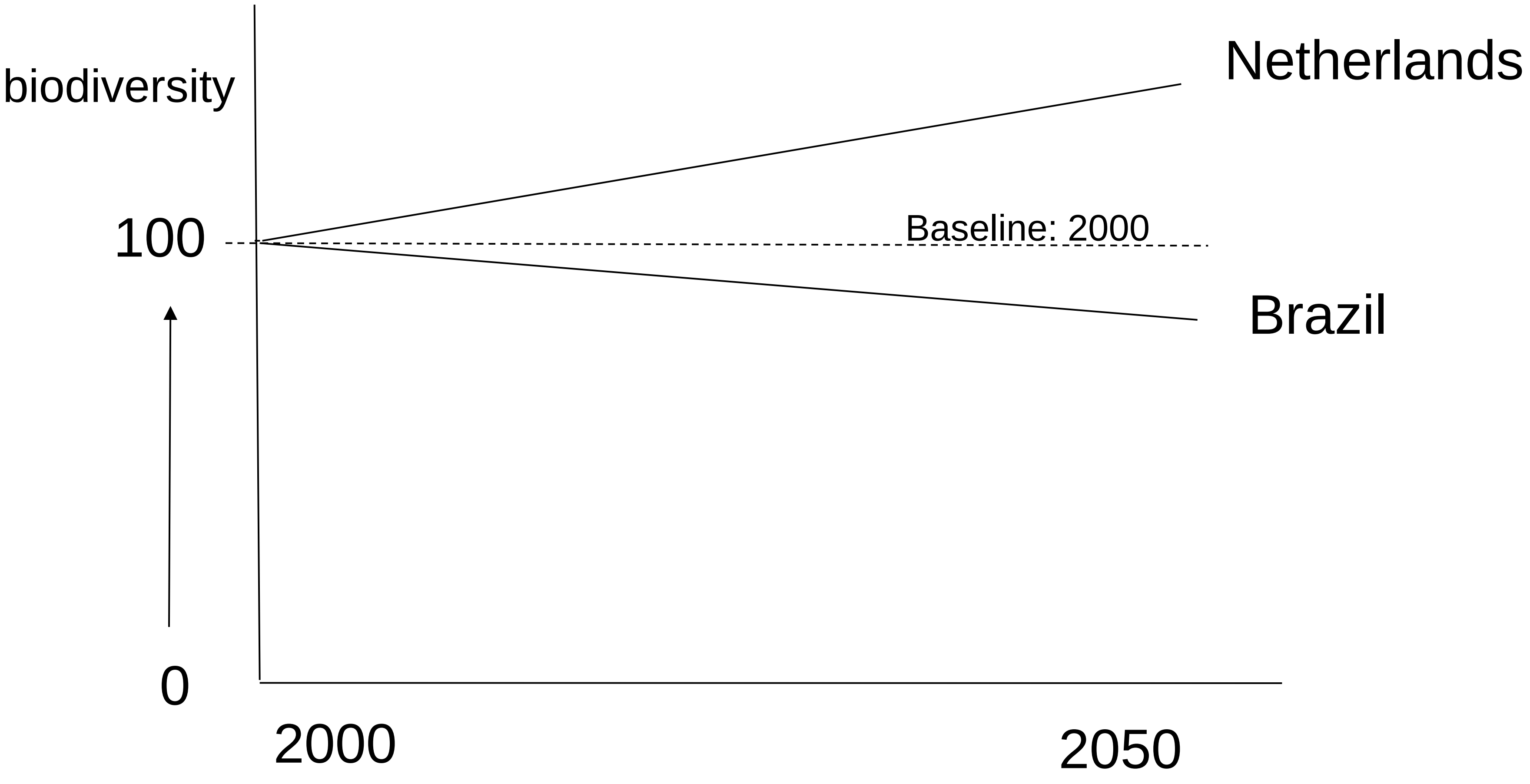
Time frame: short



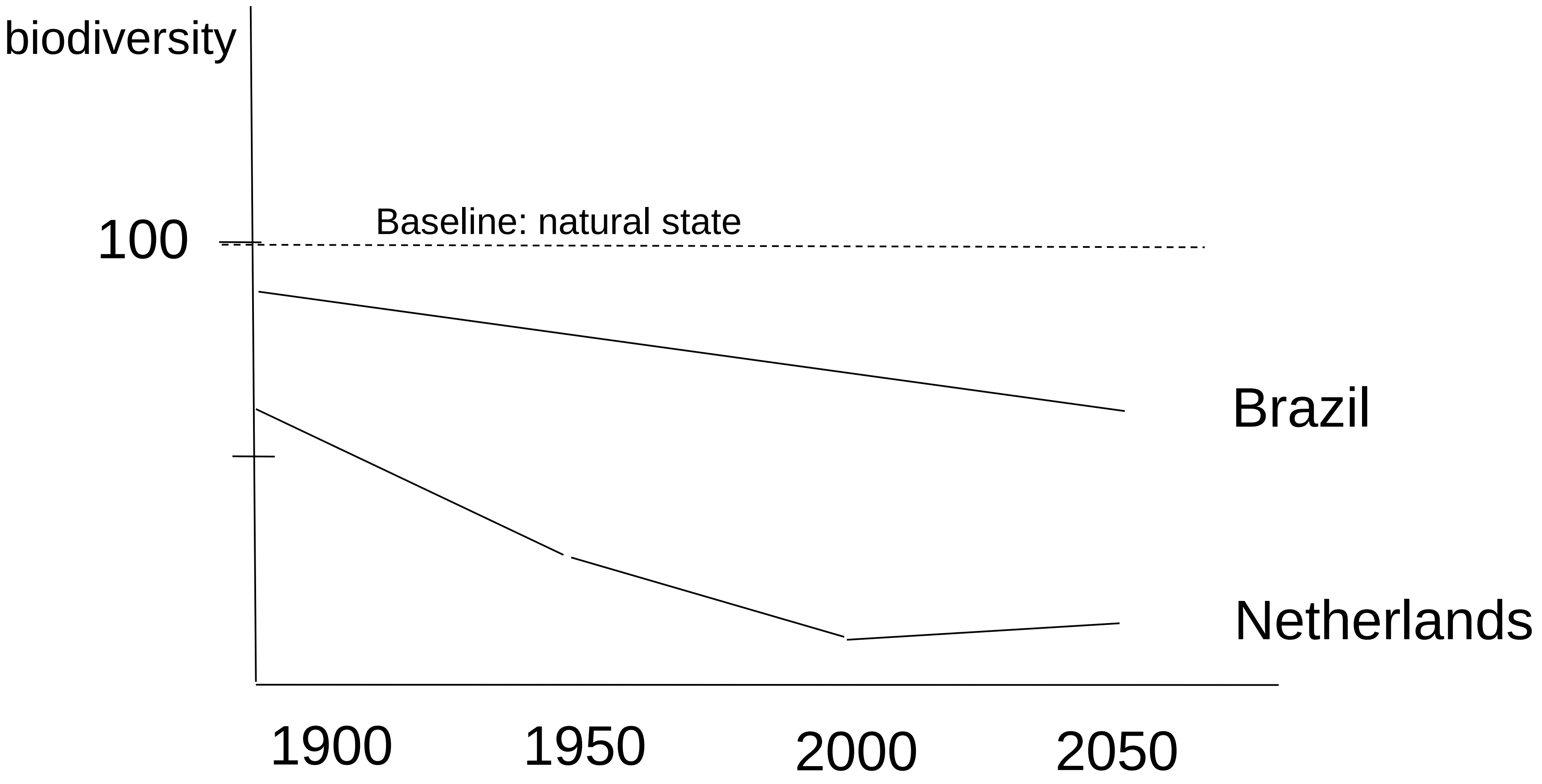
Time frame: longer



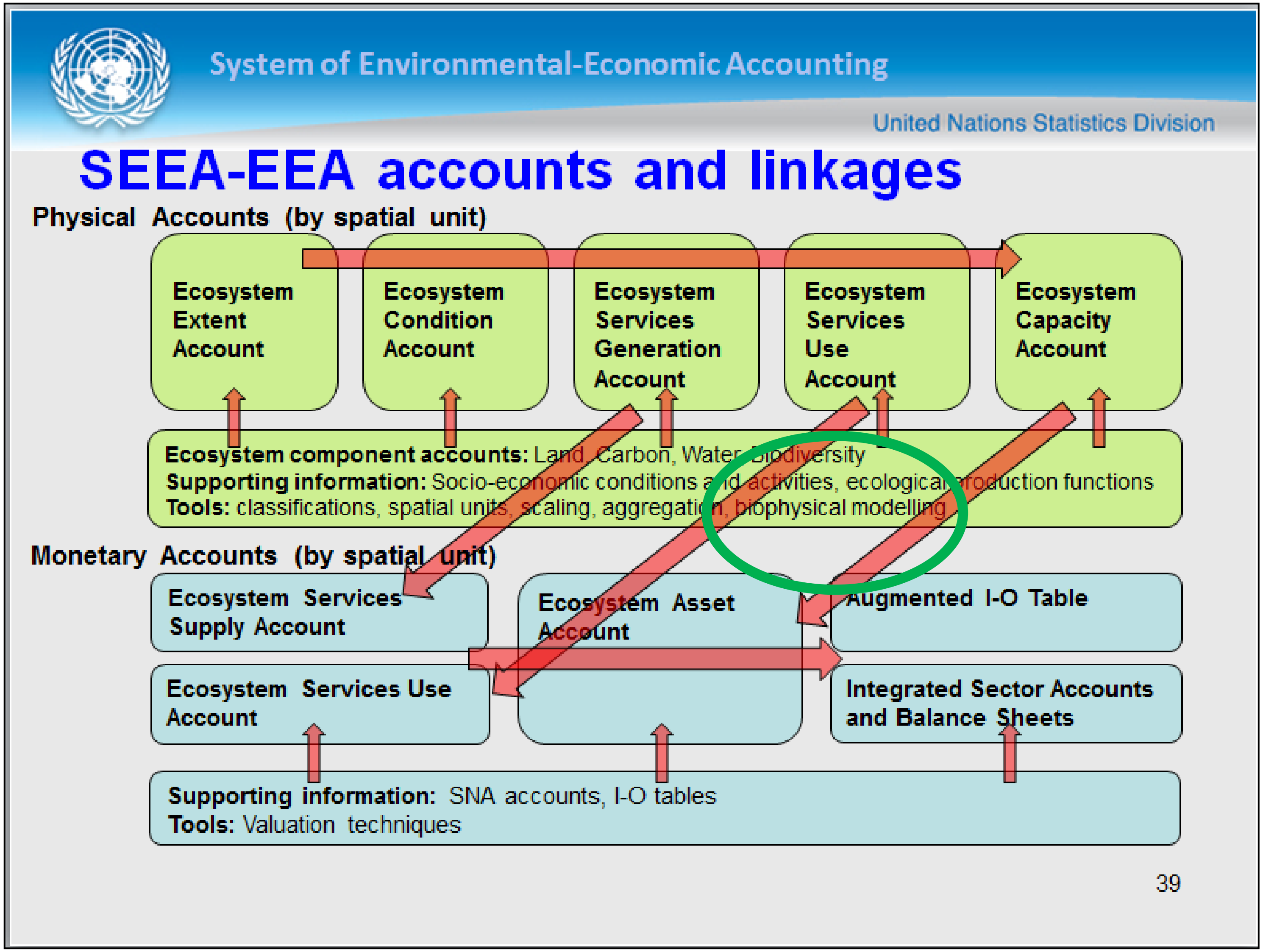
Recent baseline: Fair comparison?



Historic baseline: Fair comparison?



Biophysical modelling



Biophysical modelling: Which type to choose

- **Types**
  - Four main approaches:

1. Look-up tables
2. Statistical approaches
3. Geostatistical interpolation
4. Process-based modelling

- **In order to**
  - Estimate Ecosystem Services across spatial units and time
  - Estimate Ecosystem Capacity from Ecosystem Condition
  - Combine data from various sources and scales (e.g., point field data and satellite data)
  - Estimate unknown data values
  - GIS-based spatial modelling approaches have methods built-in

Biophysical modelling

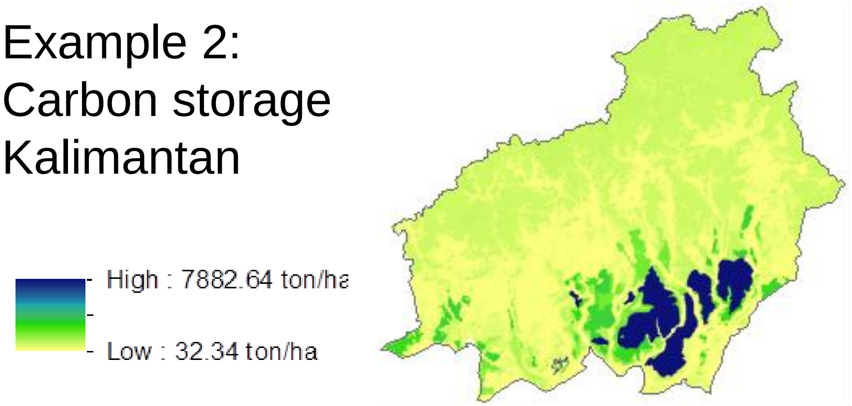
- **Approaches**:

  1. **Look-up tables**
  2. Statistical approaches
  3. Geostatistical interpolation
  4. Process-based modeling

Attribute values for an ecosystem service (or other measure) to every Spatial Unit in the same class (e.g., a land cover class).

- Example: **Benefits Transfer**
- *one ha of forest = $5000 → attribute to each ha of forest*
- error rate: medium

Example 2:
Carbon storage
Kalimantan



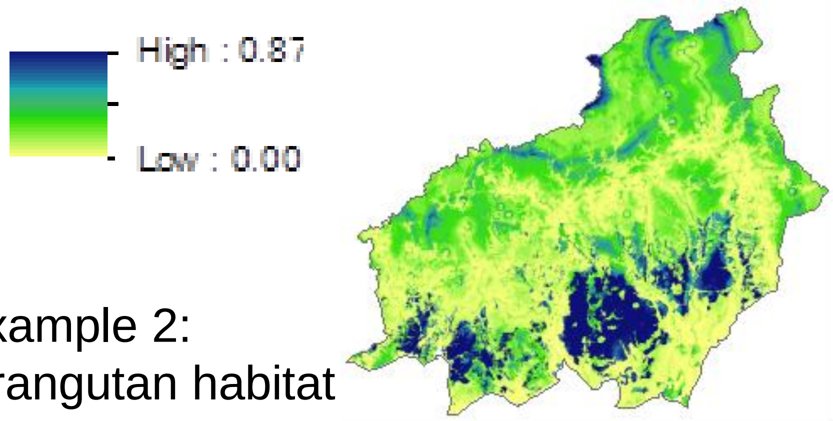
Biophysical modelling

- **Approaches**:

1. Look-up tables
2. **Statistical approaches**
3. Geostatistical interpolation
4. Process-based modeling

Estimate ecosystem services, asset or condition based on known explanatory variables such as soils, land cover, climate, distance from a road, etc., using a statistical relation.

- Example: **Function Transfer**
- *Value = f(land cover, population, roads, climate)*
- Error rate = medium



Example 2:
Orangutan habitat

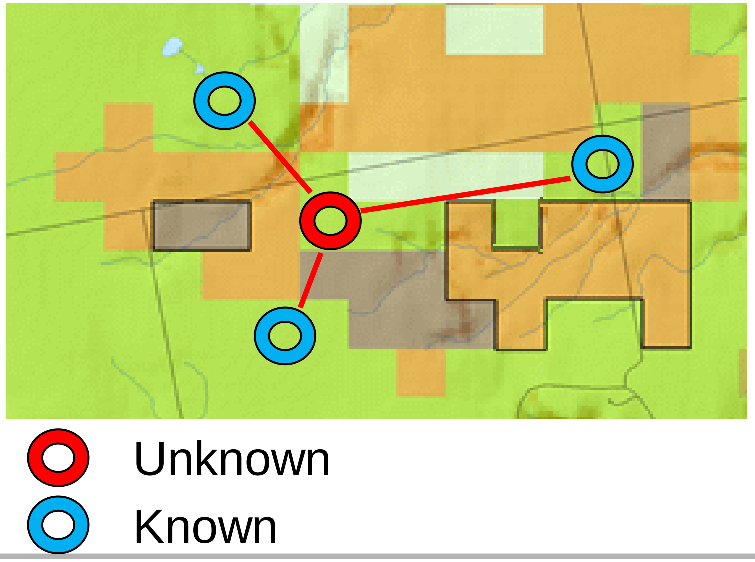
Biophysical modelling

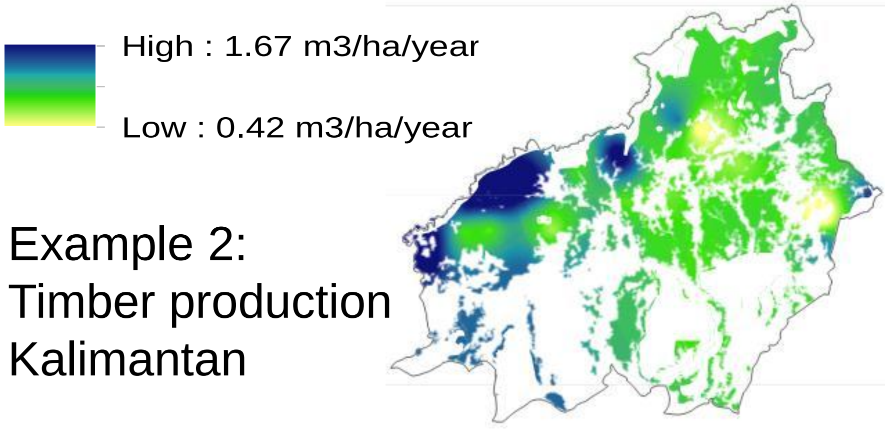
- **Approaches**:

1. Look-up tables
2. Statistical approaches
3. **Geostatistical interpolation**
4. Process-based modeling

Use algorithms to predict the measure of unknown locations on the basis of measures of nearby known measures:

- Example: **Kriging**
- Error rate = ?





Example 2:
Timber production
Kalimantan

Biophysical modelling

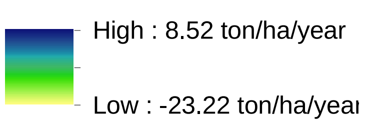
- **Approaches**:

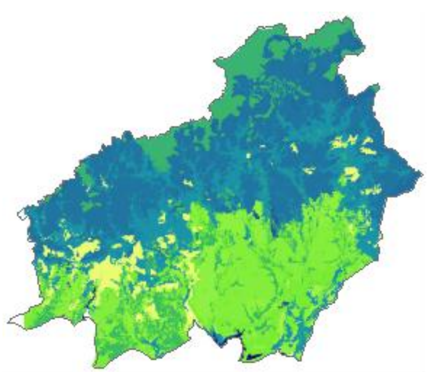
  1. Look-up tables
  2. Statistical approaches
  3. Geostatistical interpolation
  4. **Process-based modeling** →

Predict ecosystem services based on a set of future condition or management scenarios:

- Example: Scenario for future services based on expected changes in land cover, demand and management
- Error rate = large

Example 2: Carbon sequestration





Issues for testing: 1. Selection of models

Which models to choose for ecosystem accounting?

- Is there an ideal set of models that can be used by all Statistical Offices?
  - With an optimal resolution, scale, data needs ….

→ There are many variables that might be different in each country:

- Purpose, policy relevancy
- Implementation scale: Global versus national versus local
- Data availability
- Desired level of detail
- Available capacity and budget
- etc.

Issues for testing: 1. Selection of models

First define requirements for your country and organization:

- Who will be using the results and what for?
  - Policy makers (for local, national, international issues), sectors, organizations, type of use, end users, desired accuracy, integration with existing assessments
- What output is required?
  - Type ES, scale / level of detail, quantitative or qualitative, time requirement, frequency, monetary or non-monetary valuation, accuracy, uncertainty
- What input data do you have?
  - Indicators, sources, scale, data quality, data frequency
- Who will implement, use and develop the models?
  - Type of organizations, institutional framework, independency, required skill level, allocated capacity
- What is the budget?
  - For data collection, purchase & implementation & development of models

Issues for testing: 1. Selection of models

Selection criteria: Characteristics of model

- Model theme
  - What type of ES are supported, what drivers and indicators are used
  - Quantitative or qualitative, includes valuation or not, policy context
- Model dimensions:
  - Model resolution, temporal coverage, scalability
  - What input is required, can it use standard statistical data and make use of SEEA classification system?
  - What are the minimum data requirements and how does it handle data gaps?
  - Can it calculate projections over time?
- Model use:
  - Complexity, required skills, ownership, international acceptance, ownership, preparation (data) and run time, stand alone or dependent on input of other models, integration with environmental themes
- Model development
  - Developed by who + purpose, open source or not, script language, can it be adjusted to local conditions, how to calibrate data and carry out uncertainty analysis

Issues for testing: Model matrix

Model matrix (Plansup 2014)	Model theme and policy							Model dimension												Model use									Model development							
Model	Type ES supported	Drivers included	Input indicators	Output indicator	Qualitative/quantitative	Policy context	Includes valuation	Part of model group	Type of input data	Type of output data	Min data requirements	Solution data gaps	Implementation scale	Model resolution	Temporl coverage	Projection over time	Classification used	Aggregation	Key references	Ease of use	Target group	International acceptance	Type ofownership	Time and cost involved forcollection of input data	Run time model	Stand alone or dependent on other models	Type of assessment	Integration with environmental themes	Open source	Script language	Developer	Can be adjusted to local conditions	Extended functionality	Calibration data	Validated	Uncertainty analysis
ARIES																																				
EcoAIM																																				
EcoSer																																				
Envision																																				
EPM																																				
ESValue																																				
InFOREST																																				
InVest																																				
LUCI																																				
MIMES																																				
SolVES																																				
Ensym																																				
GLOBIO3																																				
CLUE																																				
Tessa																																				
CEV																																				
ESR (aspatial)																																				
Co$ting Nature (spatial)																																				
BBOB																																				
IBAT																																				
IBAP																																				
EBS																																				
Ecometrix																																				
LUCI																																				
HCV																																				
NAIS																																				
Ecosystem Valuation Toolkit																																				
Benefit Transfer & Use Estimation Model Toolkit																																				
EcoAIM																																				
NVI																																				
GLUCOSE																																				
INVEST models:																																				

Issues for testing: 2. Generic versus detailed

Use of generic versus specific models: Both useful but different purposes:

Generic models:

- Global / (Sub-)National scale
- Strategic decisions, national/regional government, int. organizations
- Advantages: Relative simple models, low data requirement, quick run time, comparison between countries
- Disadvantages: Scale, resolution, accuracy, disaggregation limited

Specific/detailed models:

- Sub-national / local scale
- Local decisions, regional/local government, local NGO's, science
- Advantages: Level of detail, accuracy
- Disadvantages: Often more complex, high data demand, skill requirements, longer run time, data often need to be aggregated if to be used for comparison between countries

Issues for testing: 3. Reference state & indicators

Defining the most appropriate reference state in order to link changes in condition with the generation of ES:

Suggestions Certain and Skarpaas (2010):

- Carrying capacity
- Precautionary level
- Pristine state
- Knowledge of past situation
- Traditionally-managed habitat,
- Maximum sustainable level
- Best theoretical value of indices,,
- Amplitude of fluctuations experienced in the past

Or

- Beginning of accounting period
- Arbitrary period in the past

Issues for testing: 3. Reference state & indicators

Determining reference state and indicator testing for:

- **Water**
  - Freshwater, coastel and marine ecosystems
    - *Number of vegetation classes, invasive species*
  - Inland waters and open wetlands
    - *Variability of streamflows past&current, hydrological retention for wetlands*
  - Coastal water bodies and Sea
    - *Wave intensity (past + current)*
- **Biodiversity**
    - *Diversity Indices*
- **Soil**
    - *Soil class, moisture content, topsoil texture, erosion degree, toxidity*
- ***Carbon***
    - *Respiration loss, metabolic efficiency (respiration as fraction of total biomass)*
- **Air**? *Air quality, temperature, wind direction, solar energy, etc.*

Issues for testing: 4. Link condition and capacity

Linkage between asset condition and capacity

- As some services increase (e.g., crops, timber) the quality of other services (biodiversity, heterogeneity) may decrease
  - Intensive cropping creates ecosystems that are less resilient to change.
- Some services (e.g., iconic species habitat) may be very sensitive to disturbance.
- Research on resilience of all ecosystem functions trying to understand how to better link conditions with all services.

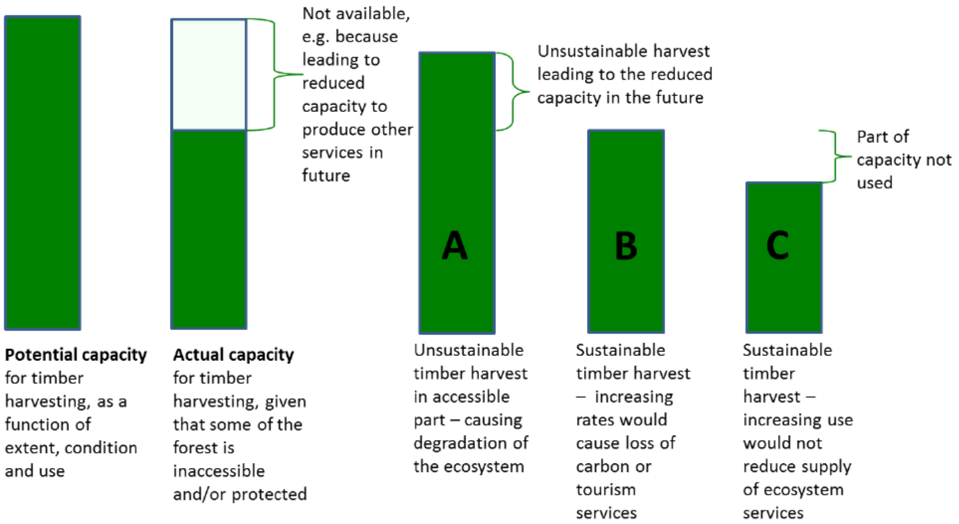
Issues for testing: 4. Link condition and capacity

Example for provisioning services:

(Actual) ***Capacity:***
The ability of the ecosystem to generate an ecosystem service under current ecosystem conditions and uses at the maximum level that does not lead to a decline in condition of the ecosystem

Potential Capacity:
Capacity to **sustainably** generate an ecosystem service under the current ecosystem conditions and uses, but with ecosystem use that would prioritize the **sustainable supply of this specific ecosystem service** (and that accepts a potential decline in the capacity to generate other ecosystem services

Timber harvesting: potential capacity, capacity and three types (A, B and C) of use.



Source: 'A perspective on capacity in the context of ecosystem accounting'. Concept EEA paper Lars Hein, Bram Edens, Ken Bagstad, Carl Obst. April 2015

Issues for testing: 5. Driver account

Would a separate driver account, that records available socio-economic information, provide information that can be used to explain changes in condition?

Socio economic data, e.g. on:

- *Changes in population density,*
- *Land use, incl. agricultural and forest use intensity and lu change*

Global, national and regional drivers, such as:

- *Commodity prices,*
- *Economic growth rates*
- *Export and import of crops and timber*
- *Urban growth*
- *Policies on land use change and nature conservation*

Issues for testing: 6. Scenario Analysis

Could scenario analysis provide information to derive information on future services?

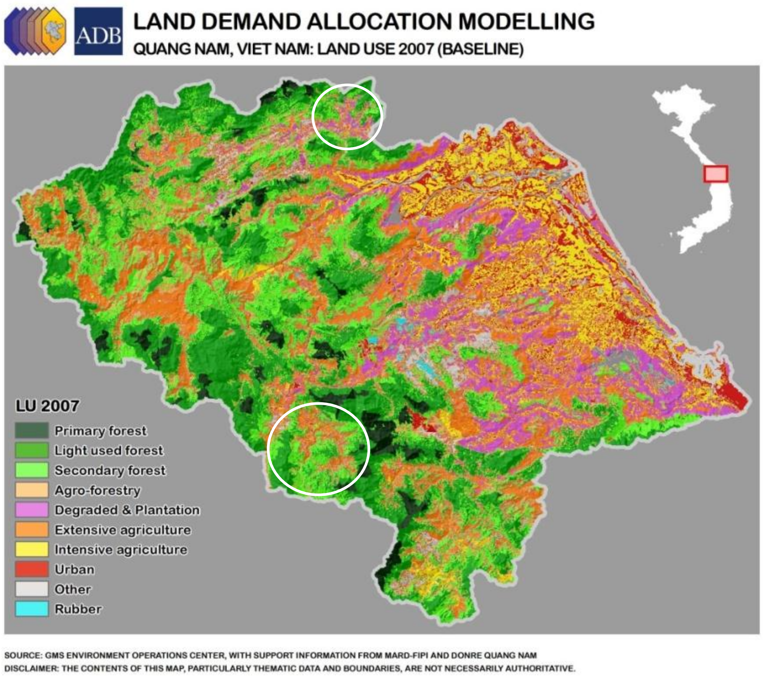
Example: **Clue land use model**
Using land use scenarios to quantify future land use
Land use → relation with Ecosystem Condition → Ecosystem Function

e.g. In GLOBIO biodiversity model:
Relation between land use and biodiversity
+ infrastructure + fragmentation + nitrogen deposition + climate change

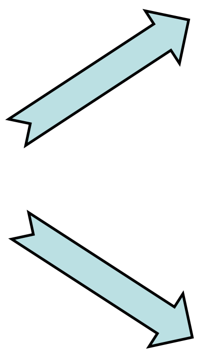
Future land use: Relation with future Biodiversity

CLUE model

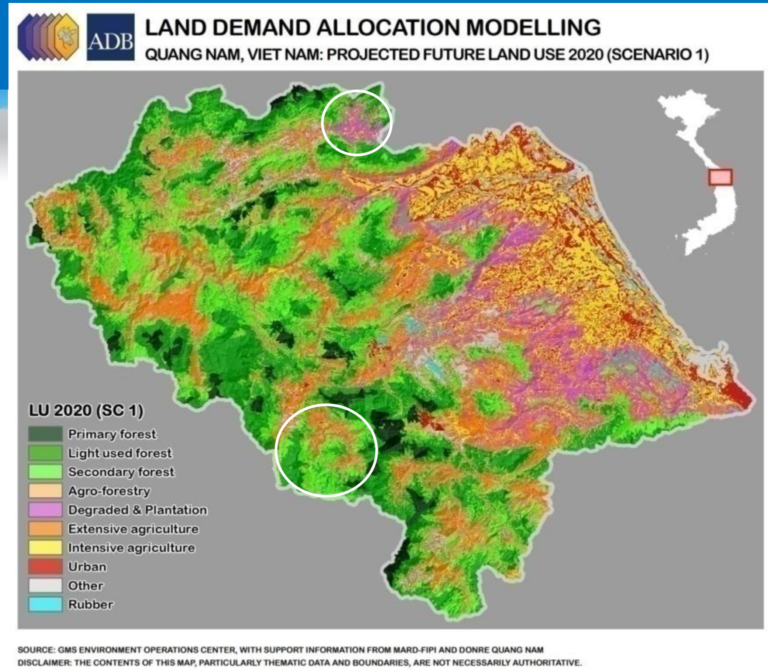
Development	Total projected land demand (ha)	of which within: Protected Area	%	HP catchment	%	Poor commune	%
Scenario 1	92,989	7,376	8%	23,022	25%	46,283	50%
Scenario 2	188,927	20,430	11%	54,974	29%	118,657	63%

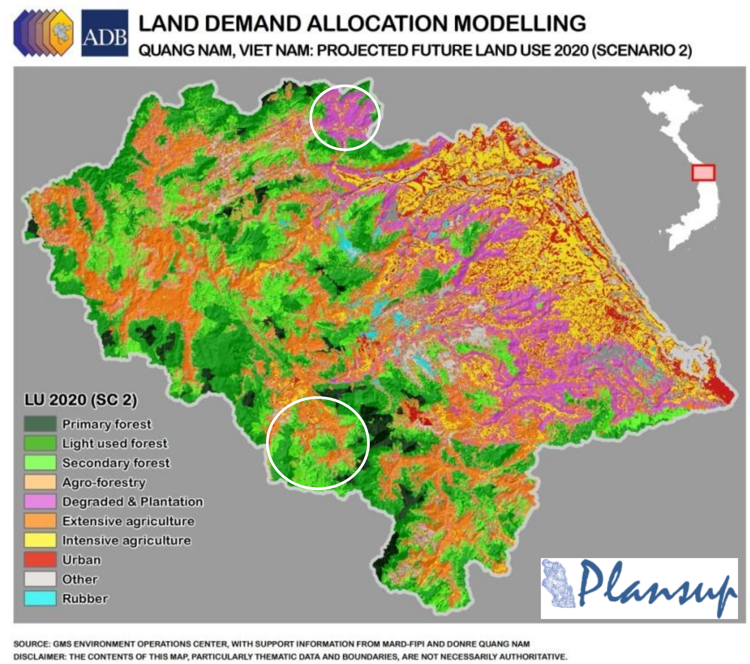


Scenario 1



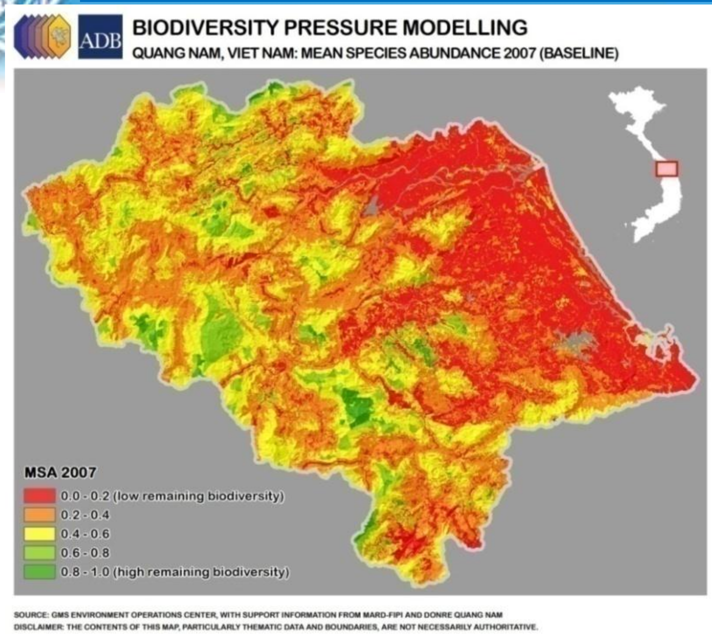
Scenario 2



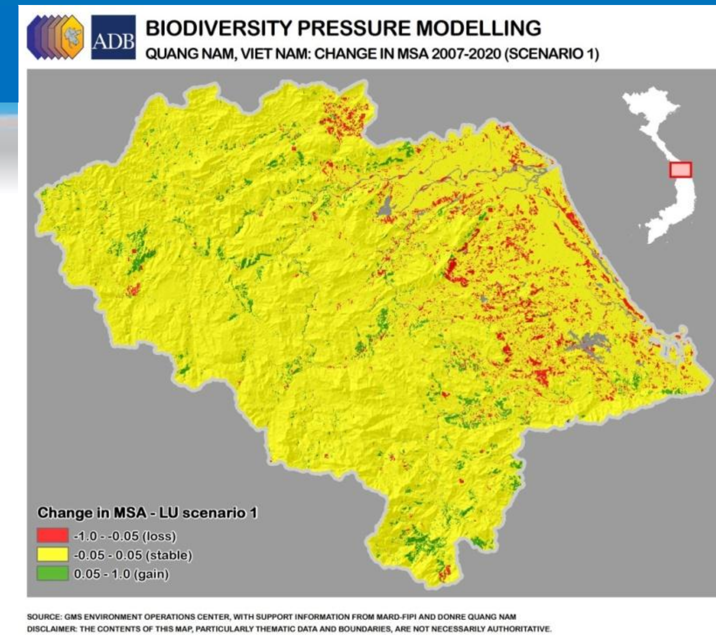


Protected Area	Area (ha)	Scenario 1	%	Scenario 2	%
Ngoc Linh	19,173	611	3%	1,108	6%
Phu Ninh	31,000	3,884	13%	7,601	25%
Que Son	18,605	309	2%	5,390	29%
Sao La 1	8,034	7	0%	784	10%
Sao La 2	9,993	55	1%	894	9%
Song Thanh	85,594	2,510	3%	4,653	5%
Total	*172,398*	*7,376*	4%	*20,430*	12%

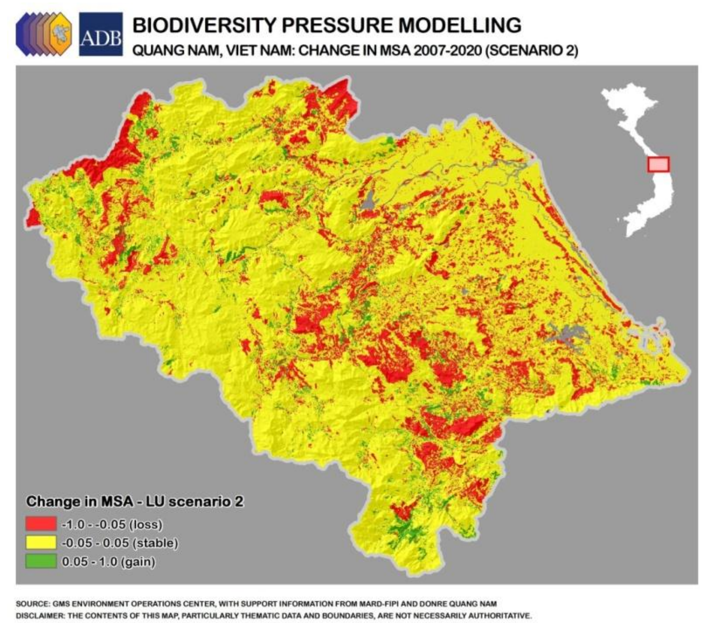
GLOBIO3 model

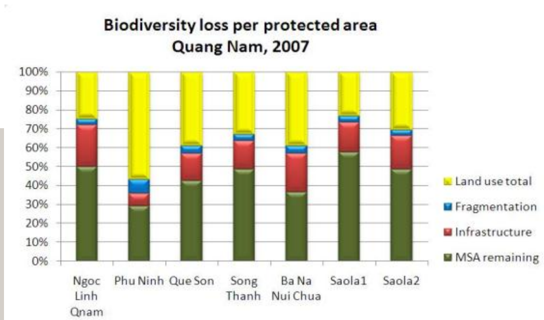


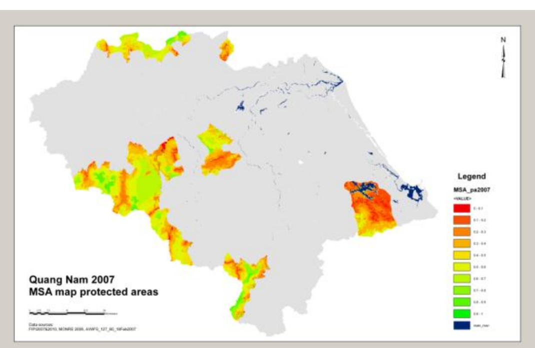
Scenario 1



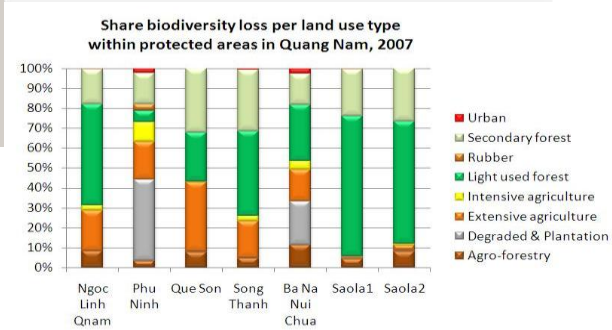
Scenario 2







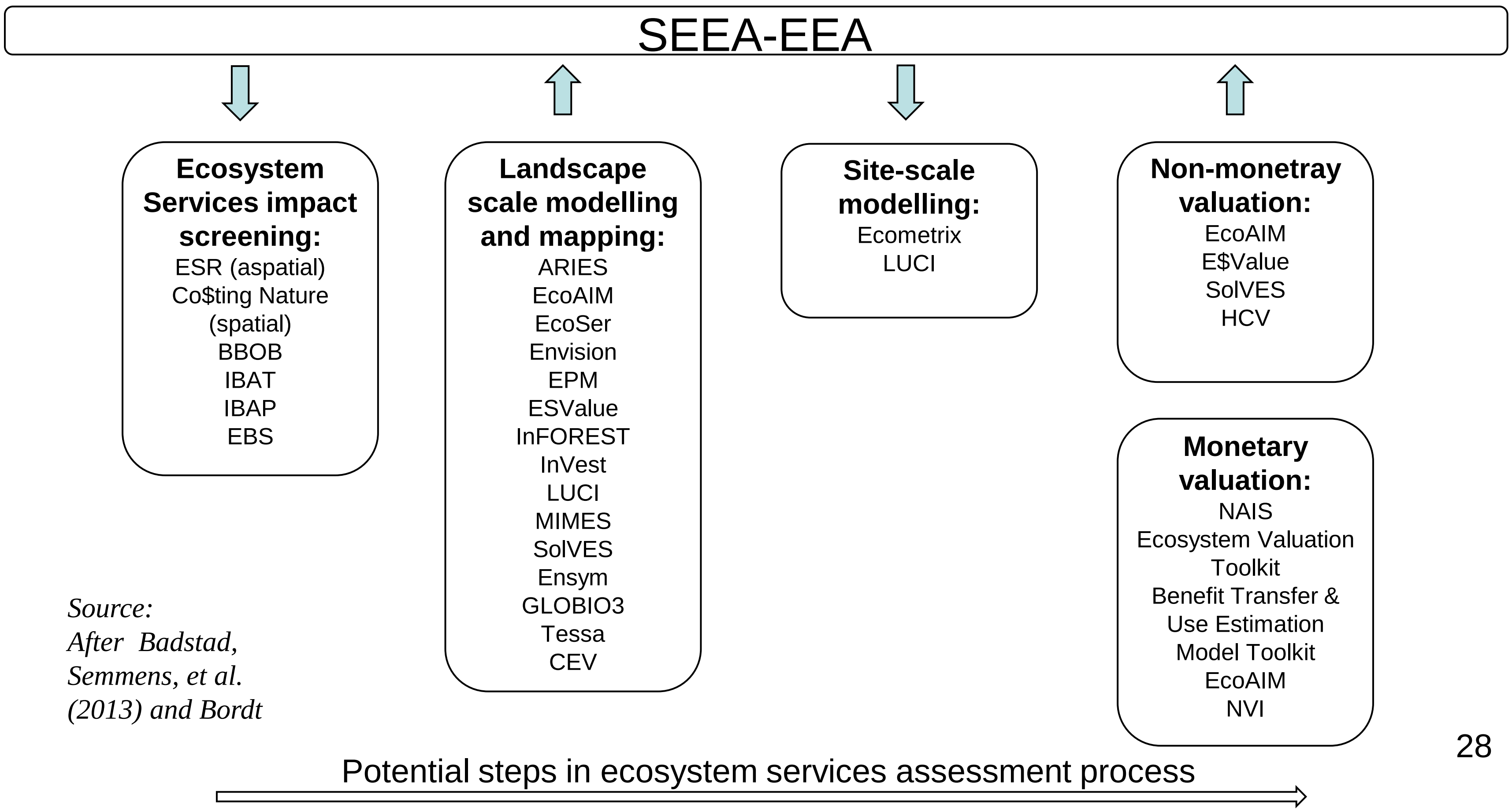
Protected areas



Plansup

Recommendations for Research: Models

- Can multiple models provide enough info for ecosystem accounting?



Source: After Badstad, Semmens, et al. (2013) and Bordt

Recommendations for Research: Models and future services

- Could multiple models and ecosystem accounting develop a coordinated approach to delineating ecosystems, measuring their condition, capacity and flows of services to the economy and other human activities?
- Are there opportunities for the developers of the ecosystem services decision support tools and models to incorporate the principles of the SEEA-EEA and to supply reliable estimates of condition, services generation and capacity for ecosystem accounting?
- Could existing ecological models be further explored to derive functional relationships to estimate future services based on scenarios of future conditions?
- Could researchers concentrate on measuring specific aspects of the "ecosystem services cascade" and more coherently inform the understanding of ecosystems and their capacity to generate services?

Recommendations for Research: Linking Ecosystem condition to capacity

Ecosystem accounting could support linking ecosystems condition to capacity by providing:

- A framework for codifying the functional class of species that would support research into functional diversity and resilience;
- A framework for codifying species and ecosystem responses to changes in condition that would support research into response diversity;
- A conceptual linkage between CICES (or other services classifications) with ecosystem type, function and “intermediate” services that would support the selection of condition measures to include in ecosystem accounting;
- Support further research in macro-ecological theory, modelling and scale-independent measures (such as variance and heterogeneity) that would help develop appropriate measures of ecosystem condition, capacity, degradation and enhancement.

Suggestions for breakout groups

1. **Selection of models:** **a: What are the most important criteria (-groups) and b: the minimum requirements, per Ecosystem Component Account (ECA: land, water, biodiversity, carbon)?**
   Criteria; data, scale, users, gaps, link with economic data, etc.
2. **Generic versus detailed** (data and models): **Give examples for both types**
   Local versus global, policy relevance, type of users and use, are details important, multiple scales
3. **Reference state and indicators:** **Discuss reference state(s) for common indicators per ECA**
4. **Link between asset condition and capacity:** **Give examples per ECA**
   Capacity and Potential Capacity
5. **Driver account:** **Discuss additional value and give examples**
   Would a separate driver account, that records available socio-economic information, provide information that can be used to explain changes in condition?
6. **Scenario analysis:** **How useful are scenarios for the SEEA?**

Acknowledgements

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