Ecosystem Services and Assets
Lecture 1: Ecosystem service accounting and biophysical modelling in support of accounting

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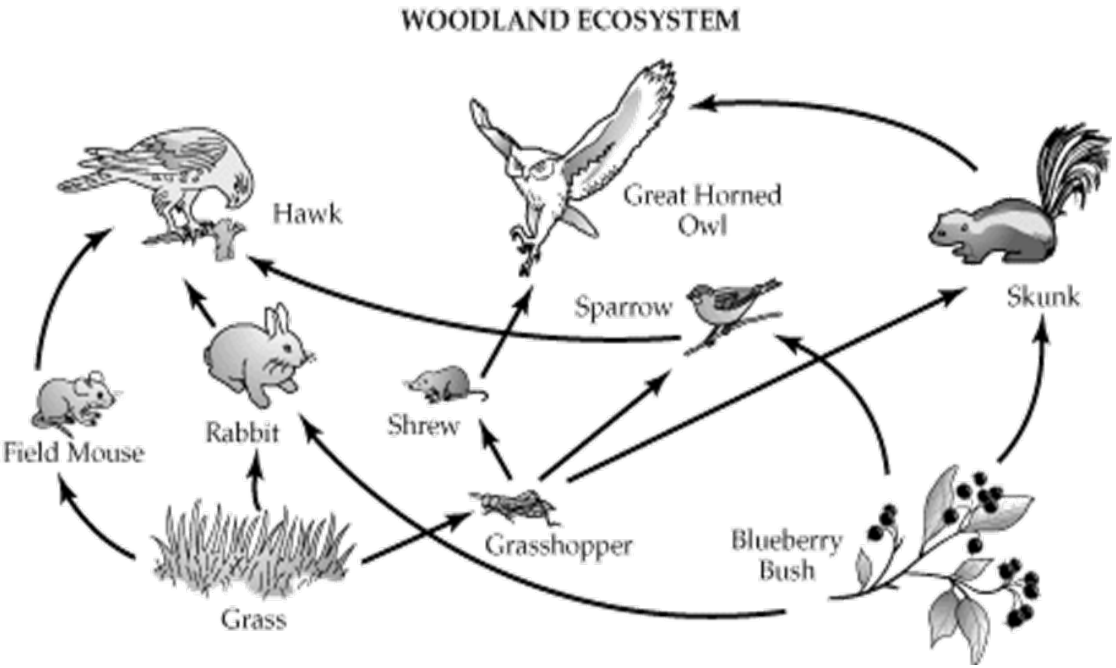
Contents (Lecture 1)

- Ecosystems services concepts
- Biophysical modelling of ecosystem services
- Illkustrations and case studies

Ecosystems

Ecosystem: 'A dynamic complex of **plant, animal** and micro-organism communities and **non-living** environment'



Pastures

Forests

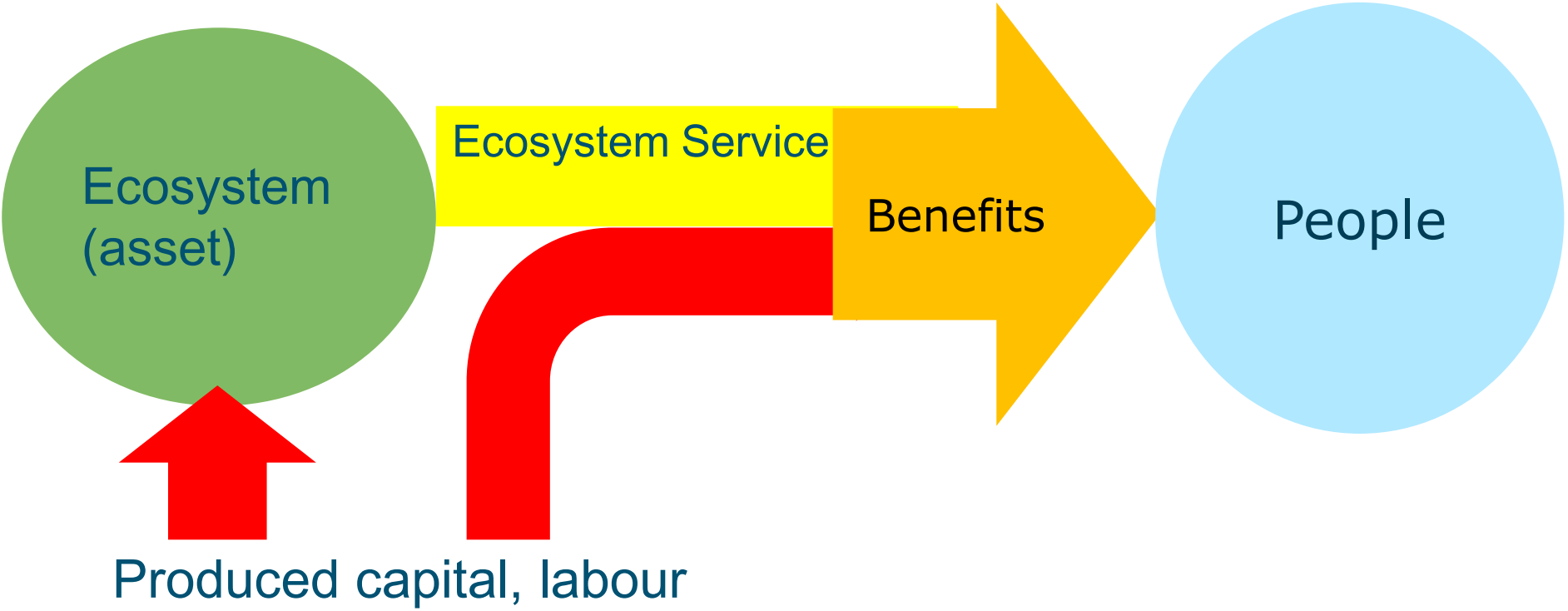
Cropland

Oceans

Ecosystems as assets

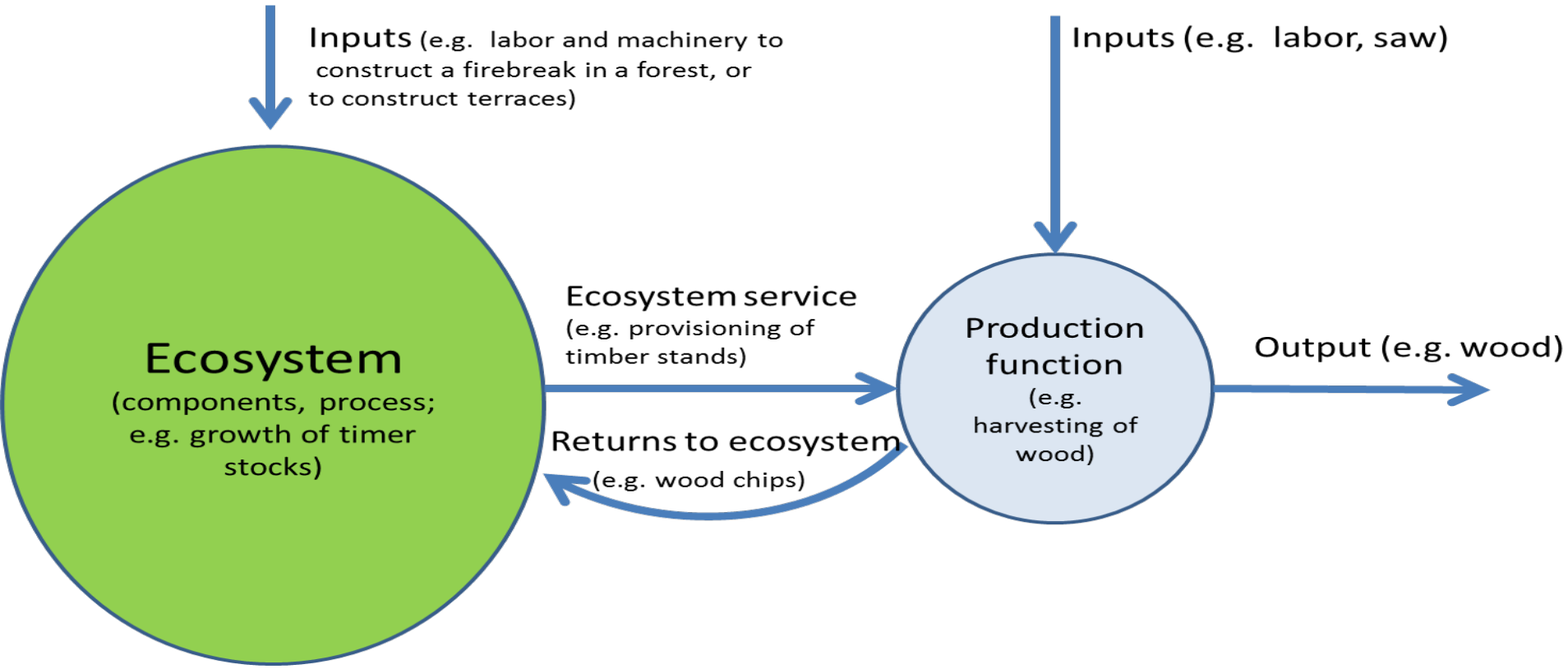
- We can see ecosystems as presenting a form of 'capital', i.e. an asset, that sustains human well-being by providing ecosystem services, including:
  - Providing (renewable) inputs to a broad range of economic activities
  - Regulating environmental processes such as breaking down waste and emissions
  - Enjoying and interacting with nature, e.g. through tourism and recreation.
- The Experimental Ecosystem Accounting Guidelines (EEA) uses the term 'ecosystem assets', defined as "spatial areas containing a combination of biotic and abiotic components and other characteristics that function together"
- Ecosystem capital ≠ natural capital

Ecosystem services (1)



Benefit versus service

Ecosystem services (2)



There are several classifications for ecosystem services

- Millennium Ecosystem Assessment (MA, 2003)
- The Economics of Ecosystems and Biodiversity Project (TEEB, 2010)
- UK National Ecosystem Assessment (2011)
- CICES (Common International Classification for Ecosystem Services) – 2012-present
- IPBES (Intergovernmental Panel on Biodiversity and Ecosystem Services (2017)
- Typology of the SEEA

Types of ecosystem services (SEEA)

Ecosystem services = the benefits provided by ecosystems to people

- **Provisioning services**: the products that can be extracted from or harvested in ecosystems
- **Regulating Services**: the regulation of ecological, hydrological and climate processes
- **Cultural services**: the non-material benefits from ecosystems (e.g. recreation)

Provisioning services

Provisioning services are the products that can be extracted from or harvested in ecosystems

Regulating services

Flood control

Air filtration

Climate regulation

Regulation of ecological, hydrological and climate processes – essential for maintaining a habitable planet

- Other examples: pollination, control of erosion and sedimentation, nursery service

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Cultural services

Recreation

Religious / cultural heritage

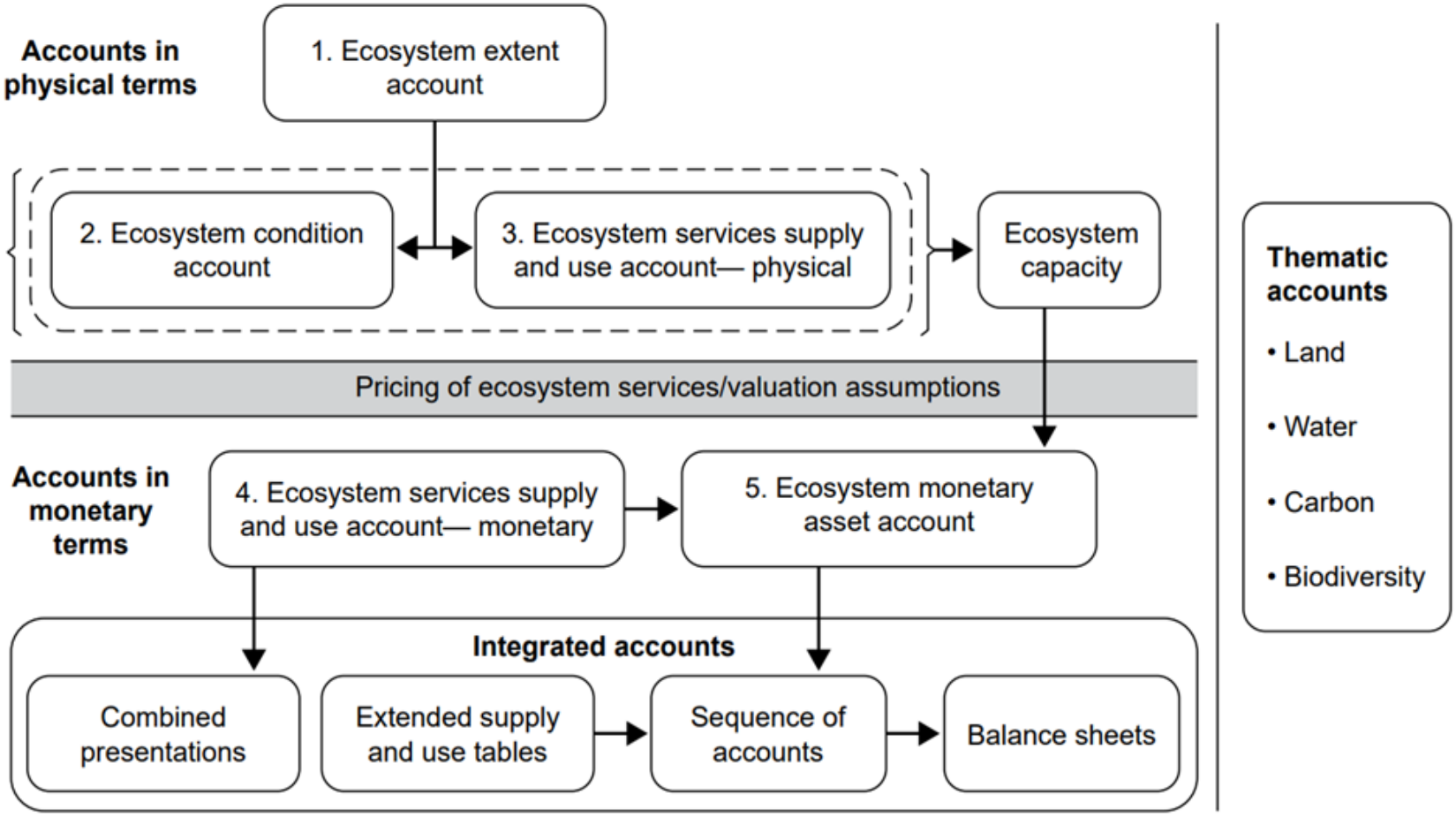
Education

The non-material benefits people obtain from ecosystems

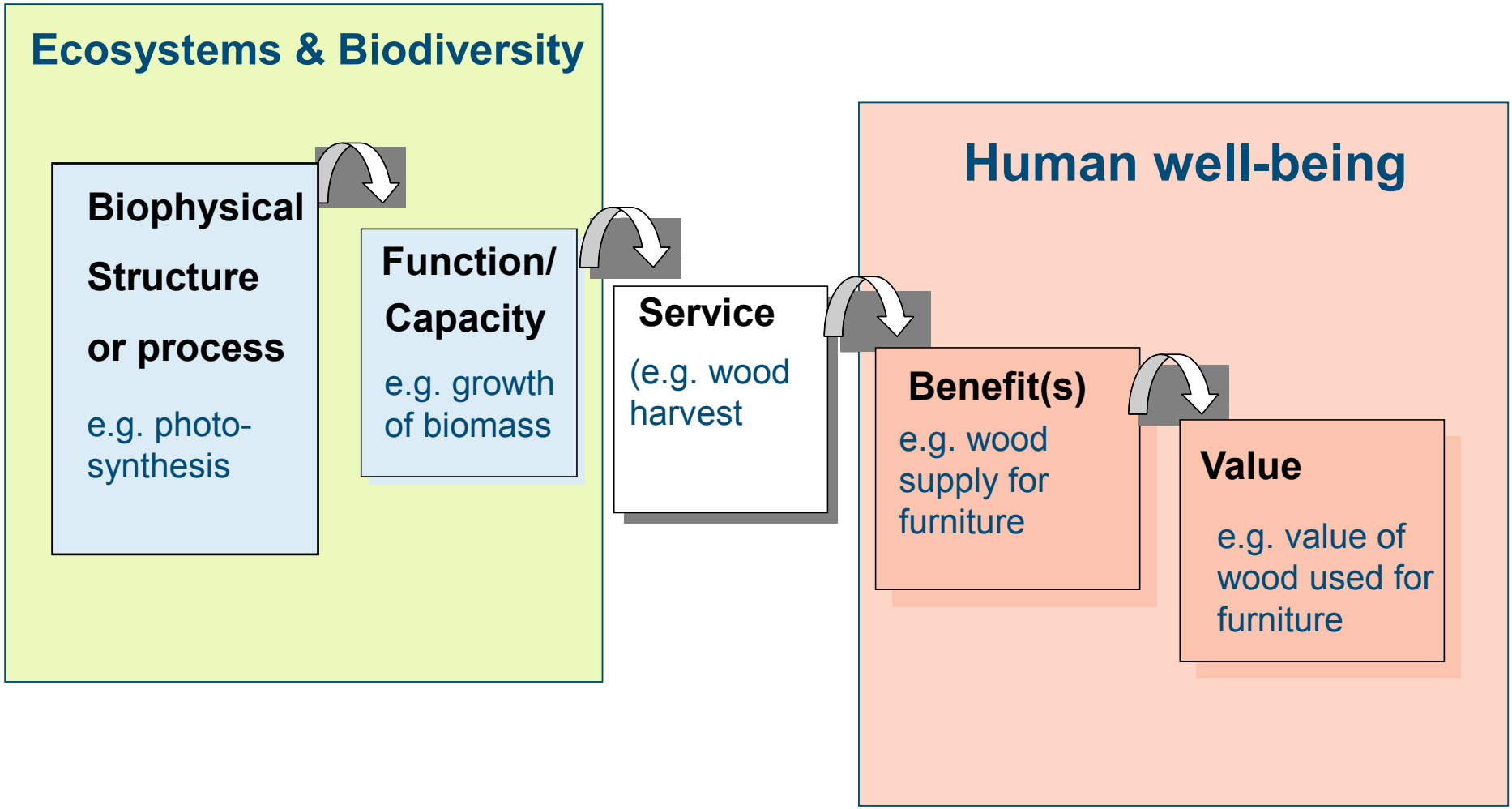
Ecosystem services in the SEEA Experimental Ecosystem Accounting framework (1)

- Ecosystem accounting measures **stocks** and **flows** of 'ecosystem' capital (as part of natural capital)
- Stocks are represented by ecosystem assets
  - Extent (type) of ecosystems
  - Condition (quality/health) of ecosystems
  - Their capacity to supply ecosystem services
- Flows are represented by
  - Ecosystem services
  - Also the regeneration of ecosystem needs to be considered

Ecosystem services in the SEEA Experimental Ecosystem Accounting framework (2)

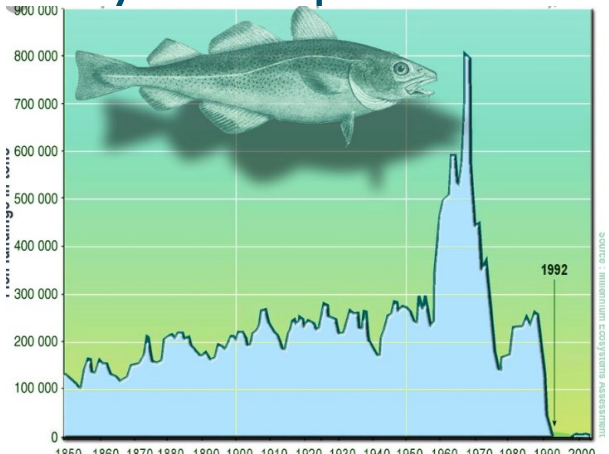


The Cascade diagram



Capacity to provide ecosystem services

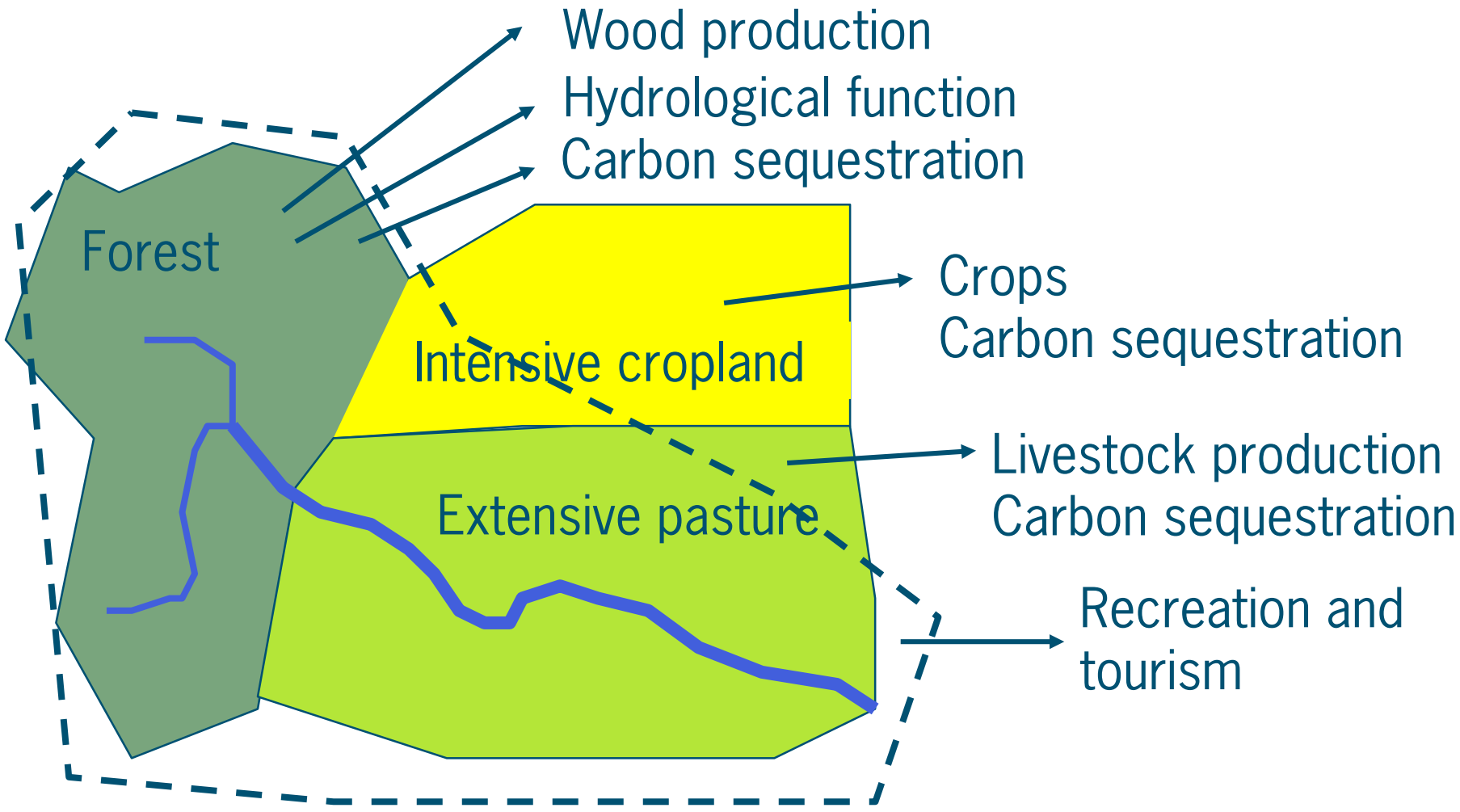
- Capacity is an ecological concept that can be modelled based on the extent and condition of the ecosystem
- It indicates the amount of product (e.g. timber, fish) that can be sustainably harvested (i.e. without depleting the ecosystem)
- Maintaining ecosystem's capacity to supply services is important in reaching ecological sustainability
- Constant flows of ecosystem services are possible when there is an increase in harvesting effort – unless harvests are reduced an ecosystem may 'collapse'
- Capacity as a concept is in scope of SEEA



Key elements of Ecosystem Accounts

- Extent = area covered by a certain type of ecosystem
- Condition = reflects the state or health of the ecosystem
- Capacity = reflects the capacity of the ecosystem to generate ecosystem services, now and in the future (for provisioning services: as a function of the stock and of the regenerative capacity)
- Ecosystem service = the contribution of the ecosystem to a benefit, e.g. the production of a good or to consumption (a flow, to be recorded for a specific time unit – usually a year)
- Ecosystem asset = spatial, heterogeneous area that (i) has a certain size (ha); (ii) has a certain condition and capacity; and (iii) provides services.

Ecosystem types and ecosystem services



Modelling approaches

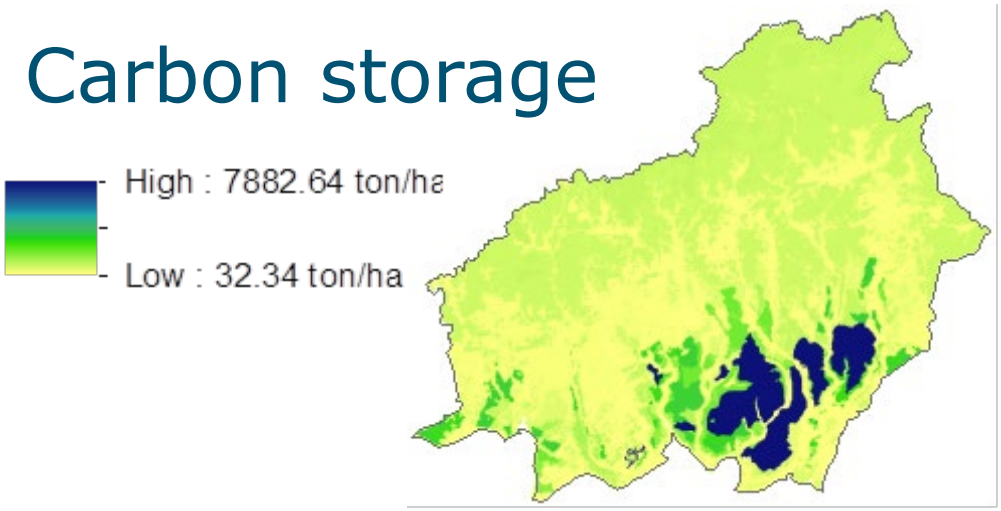
Mapping Approach	Basic characteristic	Mapping techniques applied
Dedicated ecosystem services mapping tool such as InVEST;	Predefined modules for mapping ecosystem services	Mostly based on Look-up Tables, predefined techniques for specific services.
Modeling framework such as ARIES	Enables designing specific algorithms for individual ecosystem services in a dedicated GIS environment, using predefined modules where appropriate	Flexible, different mapping techniques are supported in ARIES.
Using ArcGIS or a freeware GIS programs.	All services need to be modelled individually	Flexible, all mapping techniques can be used.

Mapping and modelling techniques

- **Look-up tables**. A specific value for an ecosystem service or other variable is attributed to every pixel in a certain class,
- **Geostatistical interpolation**. Use of statistical algorithms to predict the value of un-sampled pixels on the basis of nearby pixels in combination with other characteristics of the pixel. (e.g. kriging).
- **Statistical approaches**. For instance Maxent analyses the likelihood of occurrence of a species (or other services) as a function of predictor variables, based on an analysis of the occurrence of that species in those data points where the species occurrence has been recorded.
- **Process based modeling**. This method involves predicting ecosystem services flows or other variables based on a set of environmental properties, management variables and/or other spatial data sources.

Ecosystem services Central Kalimantan Indonesia

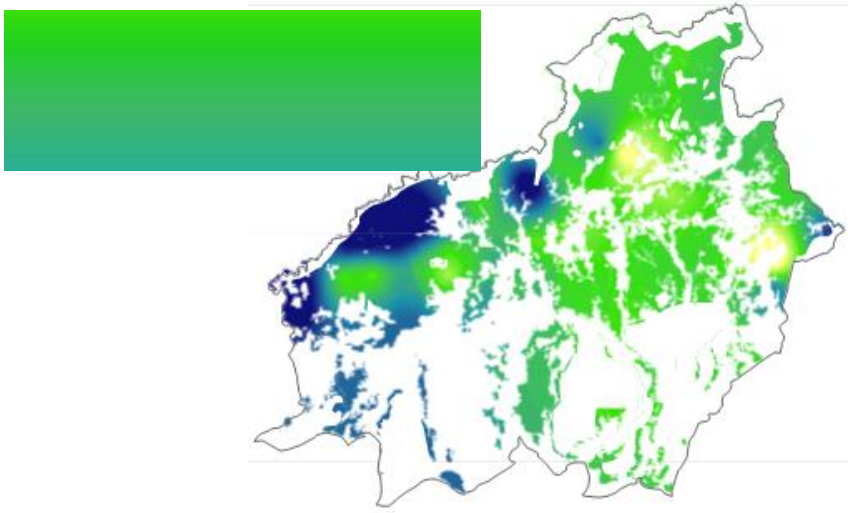
Carbon storage



Modelled using

Look Up Tables

Timber production

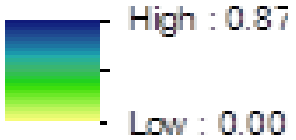


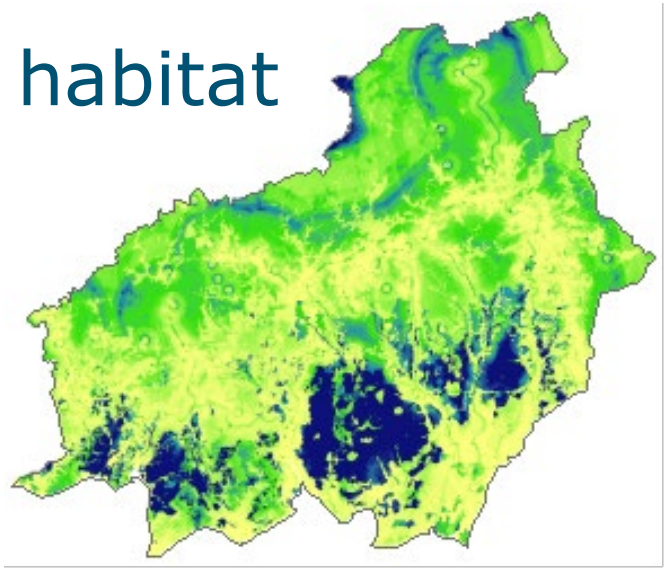
Kriging

Source: Sumarga and Hein, 2015

Ecosystem services in Central Kalimantan

Orangutan habitat

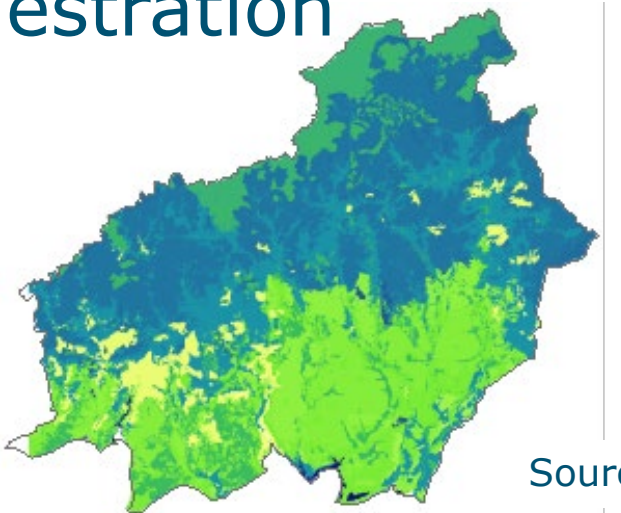




Modelled using

Statistical models (Maxent)

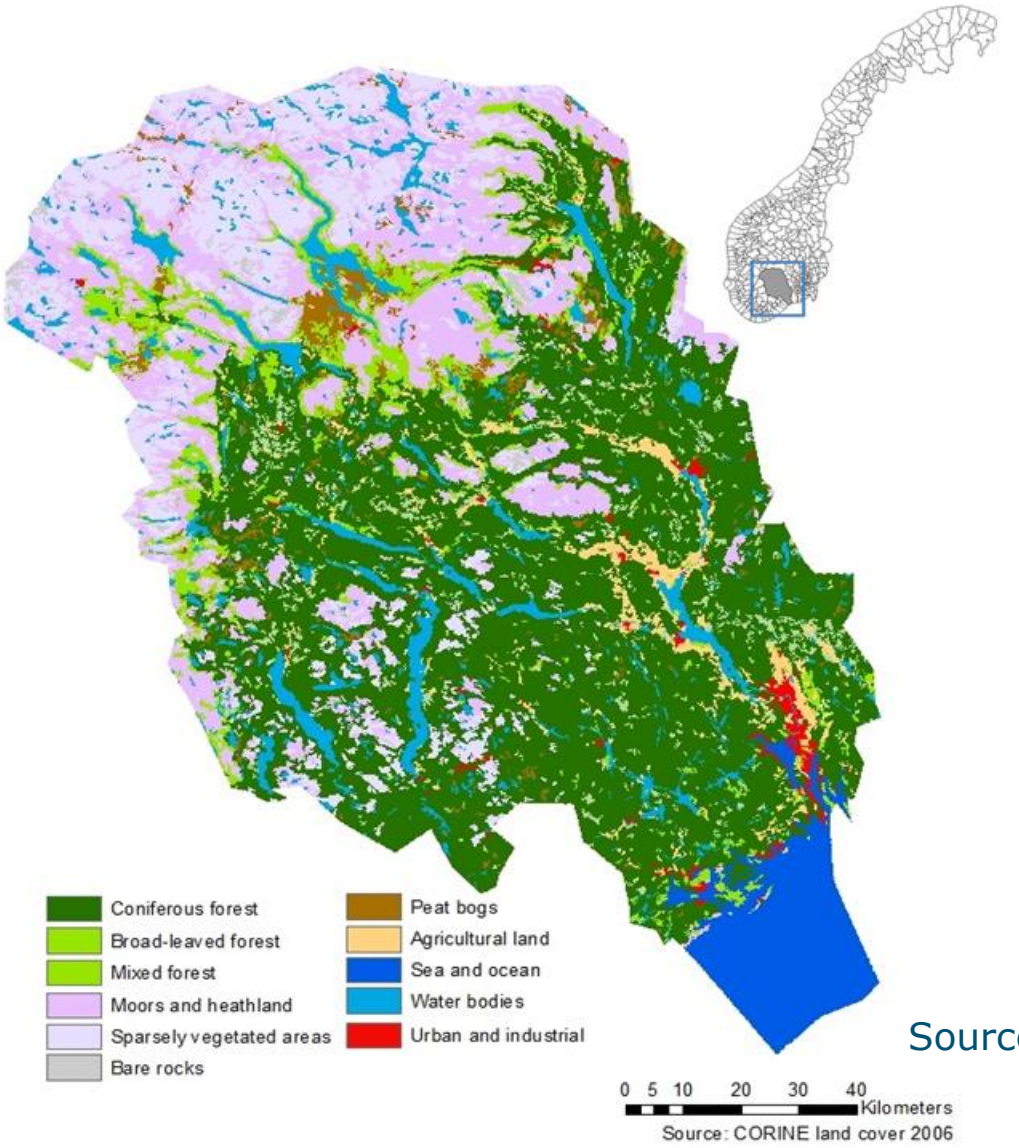
Carbon sequestration



Look up tables (or: NPP minus soil respiration)

Source: Sumarga and Hein, 2015

Case 1. Telemark, Norway



Mountainous, semi-boreal, low population density

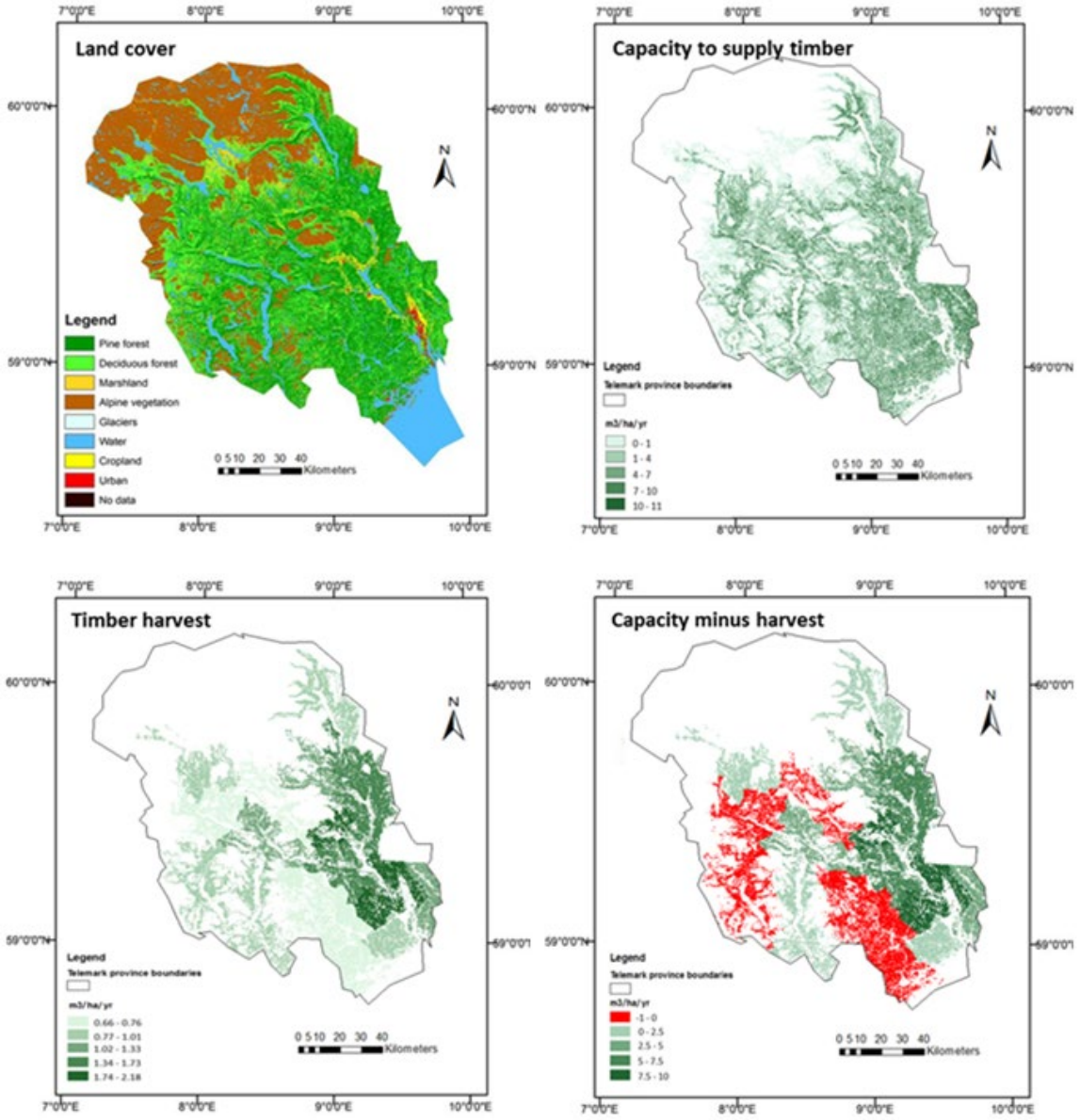
Modelled services (8) include:

- Forestry
- Hunting
- Reindeer herding
- Carbon storage and sequestration
- Tourism

Specific aim: to test different methods to model services

Source: Schröter et al., 2014)

Timber capacity and flow in Telemark



Timber harvest capacity, flow (i.e. timber harvest) and difference between capacity and flow in Telemark, Norway

Telemark, Norway

Measuring carbon sequestration in ecosystems

Only long term (>100 years) storage in ecosystems counts as carbon sequestration

There are two methods:

- Carbon sequestration = Net Primary Production (NPP) – Autotrophic soil respiration – Carbon loss due to fire – Carbon loss due to wood harvest
- Carbon sequestration = Carbon stock in year$_{(t)}$ – Carbon stock in year$_{(t-1)}$

Both methods have advantages and disadvantages

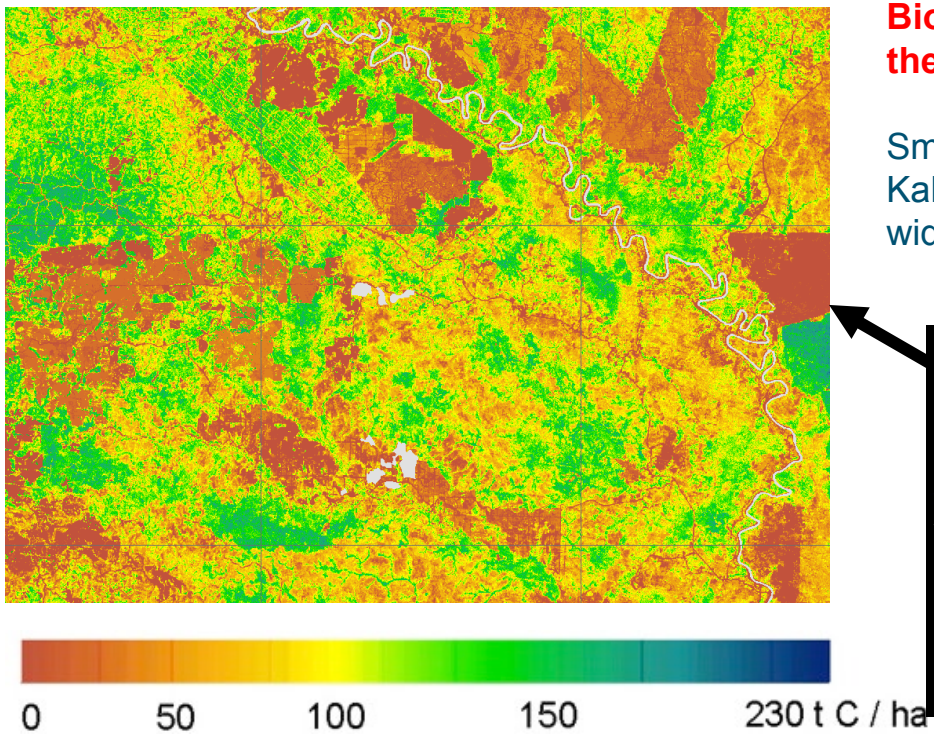
Carbon sequestration in Telemark

Method	total stock in t C (forest)	sequestration tC/ha
1Forest inventory data and maps	546 578	0.63
2. MODIS NPP minus soil respiration model after Raich et al. (2002)	1 070 123	1.28
3. NEP: MODIS GPP minus TER after Luyssaert et al. (2007)	911 651	1.04

Source: Schröter et al., 2014)

The future: using satellite data: Biomass (and carbon) monitoring

SarVision
Applications in remote sensing



Biomass time series over the years 2000-2012

Small section of the East Kalimantan map (50 km wide).