System of
Environmental
Economic
Accounting

Supply of ecosystem services

(Level 1 and Level 2)

October 2017

United Nations

Overview: Services Supply

1. Learning objectives
   1. Review of Level 0 (5m)

2. Level 1 (Compilers)
   1. Concepts (15m)
   2. Group exercise & Discussion (30m)

3. Level 2 (Data providers)
   1. Data options, examples & issues (15m)
   2. Group exercise & Discussion (15m)

4. Closing Discussion (10m)


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SEEA-EEA Training Levels 1 and 2

- Learning objectives
  - > Level 1: To understand:
    - Why accounting for Ecosystem Services is important
    - The basics of the "ecosystem services cascade" and the difference between its components
    - How Services Supply is treated in the SEEA, including basic concepts and the structure of the accounts that include services
    - How to start to compile a Services Supply account
  - > Level 2:
    - Understand the data options and sources
    - Be aware of how other countries have approached Ecosystem Services Supply

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Review of Level 0:
Services Supply Account

Services Supply

SEEA-EEA accounts, tools and linkages
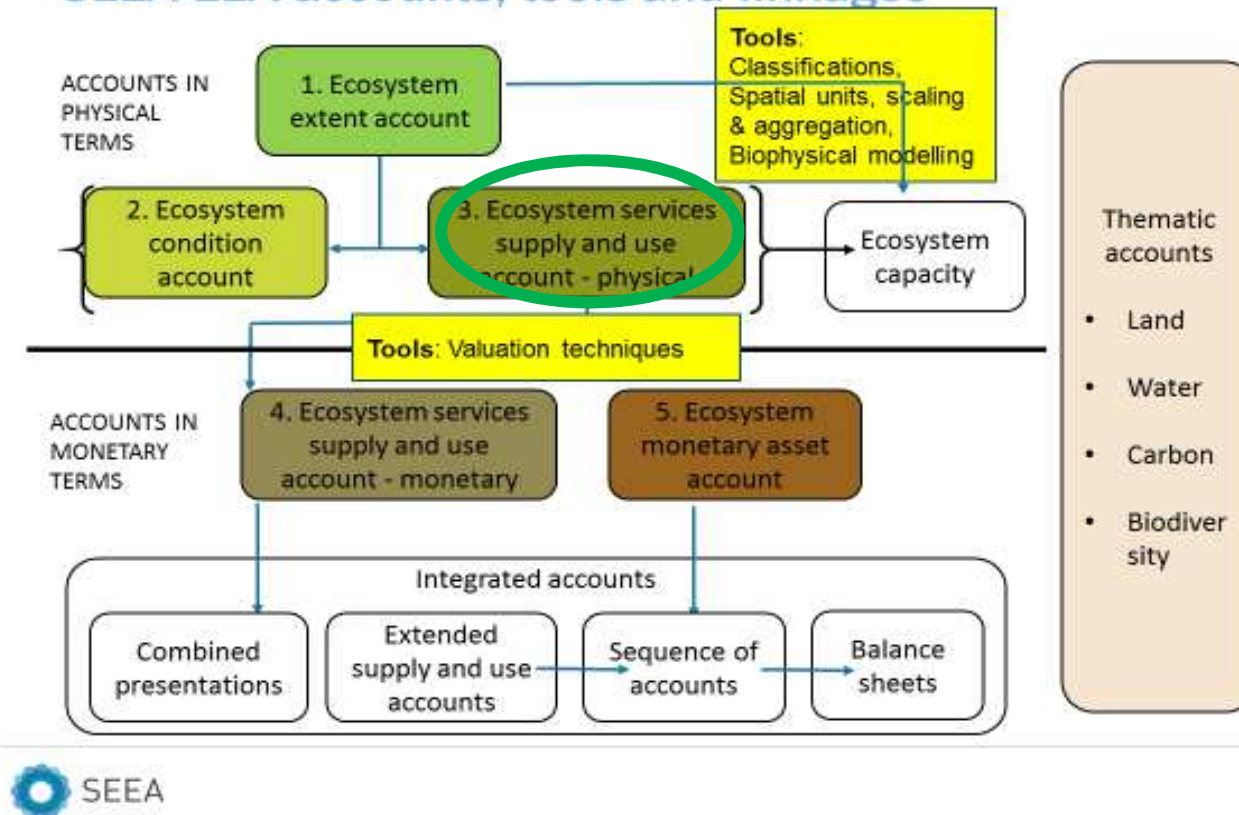
Level 0: Account 3: Services Supply

- **What?**
  - Physical flows of "final" ecosystem **services** from ecosystems to beneficiaries
  - Directly used by (or affect) people
- **Why?**
  - Inform policies of contribution of ecosystems to human well-being
  - Assess trade-offs between development and conservation
  - Link to standard economic production measures in SNA
  - Link to other SEEA-EEA accounts (**Condition, Services Use, Monetary Ecosystem Services; Ecosystem Monetary Asset** valuation)
  - Indicators:
    - Flows of individual services (physical and monetary) ➔ change
    - Indices of aggregated services by ecosystem type ➔ change
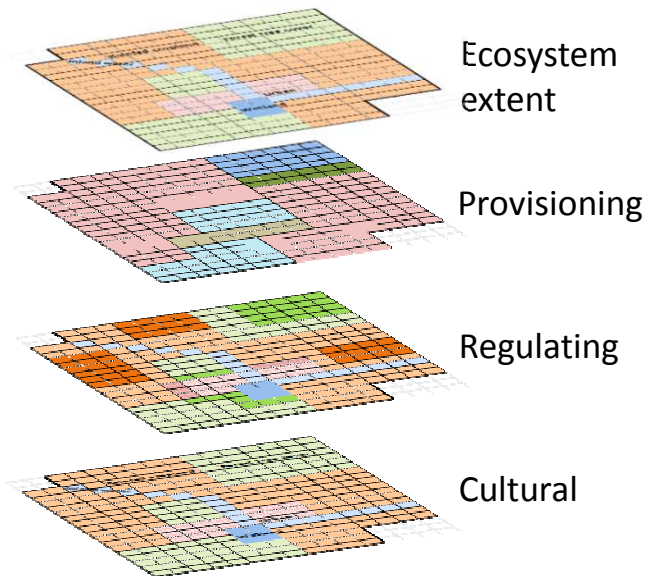
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Level 0: Account 3: Services Supply

Service Group	Final Ecosystem Service	Mountains, Moorlands & Heaths	Semi-natural Grasslands	Enclosed Farmland	Woodlands	Freshwaters – Openwaters, Wetlands & Floodplains
Provisioning	Crops		↔	↑		↓
	Livestock/Aquaculture	↓	↗	↔	↔	↘
	Fish					↘
	Trees, standing vegetation, peat	↘	↔	↗	↗	↘
	Water supply	↔	↘	↘	↔	↘
	Wild species diversity	↔	↓	↓	↗	↘
Cultural	Environmental settings: *Local places*	↔	↔	~	↑	↗
	Environmental settings: *Landscapes/seascapes*	↔	↔	↔	↗	↔

Source: UK National Ecosystem Assessment (2011)

Level 0: Account 1: Services supply

What does an Ecosystem Service Supply Account look like?

Maps

Tables

Ecosystem
extent

Provisioning

Regulating

Cultural

Type of service	Ecosystem type			
	Urban and associated	Forest tree cover	Agricultural land	Open wetlands
Provisioning		e.g., tonnes of timber	e.g., tonnes of wheat	
Regulating	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of P absorbed
Cultural	e.g., hectares of parkland	e.g., number of visitors / hikers		e.g., hectares of duck habitat

Look up tables
Biophysical modelling

Valuation

Monetary Services Supply

Level 0: Account 3: Services Supply

- **Example (Services Supply in physical units)**

Ecosystem service		Units	Urban	Pasture	Cropland	Forest	Heath	Peat	Surface Water	Other nature	Provincial total
											Land cover type
Provisioning	Hunting	kg meat	-	9,100	14,732	8,100	678	70		1,513	34,193
	Drinking water extraction	10^3 m³ water	4,071	7,026	11,227	3,117	214	-	478	862	26,995
	Crop production	10^6 kg produce	-	-	1,868	-	-	-	-	-	1,868
	Fodder production	10^6 kg dry matter		533	251						784
Regulation	Air quality regulation	10^3 kg PM$_{10}$	272	404	717	700	45	7	40	69	2,254
	Carbon sequestration	10^6 kg carbon	875	8,019	273	50,664	393	149	-	1,056	61,429
Cultural	Recreational cycling	10^3 trips	2,690	1,863	2,611	1,565	30	3	139	220	9,121

Source: Remme et al., 2014 (Limburg, the Netherlands)

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Level 0: Account 3: Services Supply

- **What does a Services Supply Account look like?**
  - Spatially-detailed physical measures of "final" services according to a common **Classification**:
    - Provisioning
    - Regulating
    - Cultural
  - Physical measures (crops, flood control, clean drinking water, carbon sequestration, recreation, …)
  - Services supply account in physical terms forms the basis for **Valuation** where appropriate and available
    - → **Monetary Services Supply**

Level 0: Account 3: Services Supply

- **What do you need to create a Services Supply Account?**
    - **Ecosystem Extent**
    - Common spatial infrastructure (**Spatial Units**)
    - Common **Classification** of services
    - **Data**:
        - Field studies
        - Economic production (agriculture, forestry, fisheries, water)
        - **Biophysical modelling** of individual ecosystem services
    - **Expertise**: ecologists, geographers (GIS), economists, policy analysts, statisticians
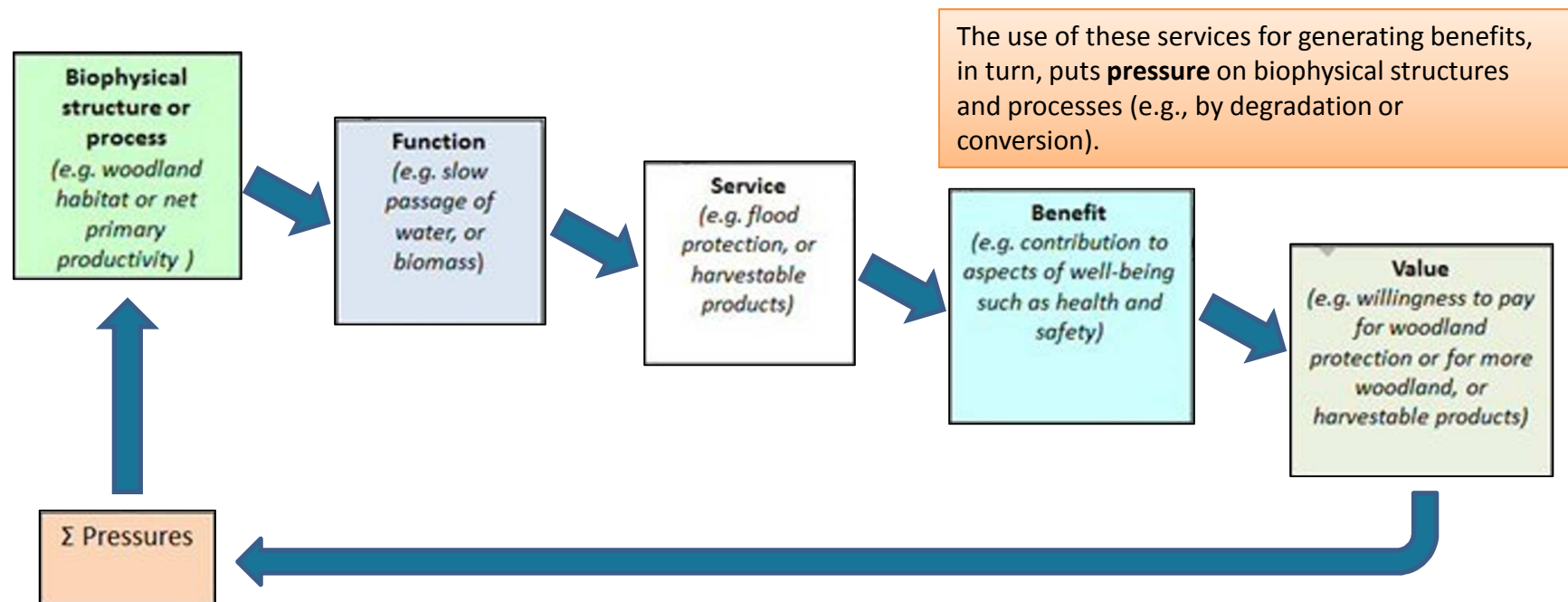
Level 1:
Services Supply Account

Level 1: Account 3: Services Supply
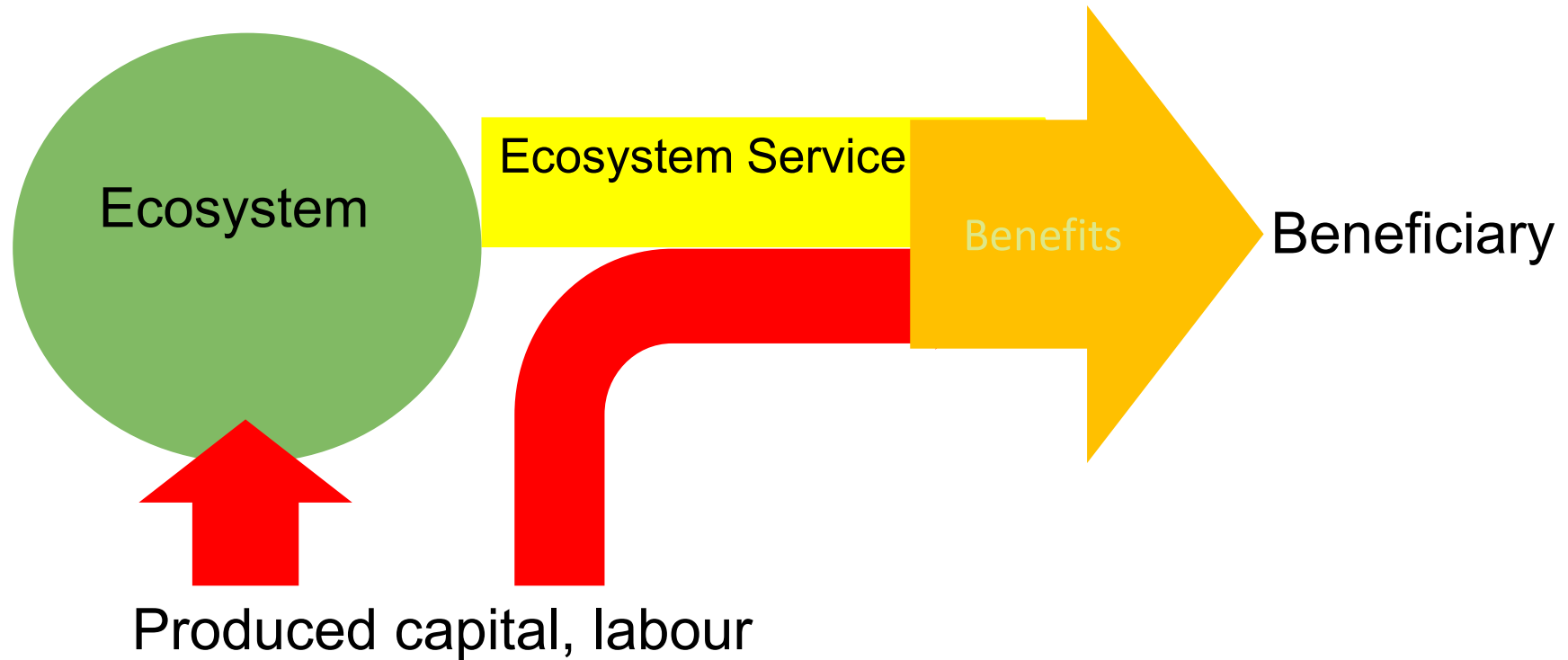
- Why Services Supply Accounts?
  - > Ecosystems provide services that are essential to the economy and human activities:
    - Food supply
    - Clean water
    - Flood protection
    - Carbon sequestration
    - Recreation, cultural and religious importance
  - > Ecosystems are being converted and degraded
    - Which ones are most important to conserve?
    - How can they best be managed to maintain services?
    - Link with national planning and accounting to ensure ecosystems are mainstreamed in decisions

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The Ecosystem Services Cascade

Ecosystem services are the contribution of ecosystems to benefits for people…

The use of these services for generating benefits, in turn, puts **pressure** on biophysical structures and processes (e.g., by degradation or conversion).

Biophysical structure or process
(e.g. woodland habitat or net primary productivity)

Function
(e.g. slow passage of water, or biomass)

Service
(e.g. flood protection, or harvestable products)

Benefit
(e.g. contribution to aspects of well-being such as health and safety)

Value
(e.g. willingness to pay for woodland protection or for more woodland, or harvestable products)

Σ Pressures

Ecosystem services (are not benefits)

Ecosystem

Ecosystem Service

Benefits

Beneficiary

Produced capital, labour

Ecosystem services are the contribution of ecosystems to benefits for people.

Level 1: Account 3: Services Supply

- **Ecosystem services are the contribution of ecosystem to benefits for people...**

  > They are **not** the benefits; benefits require capital and labour to use

  > We need to calculate the contribution of ecosystems, for example:

  Crops = f(nature, equipment, inputs, labour, energy...)

  > To grow crops, nature provides biomass growth, nutrients, water, flood control, pollination...

  > Without these, there would be no crops.

  > In the Services Supply Account, we measure the physical services (e.g., the addition to biomass of the crop).

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Types of Ecosystem Services

Provisioning Services → = goods that can be harvested from, or extracted from ecosystems → Example: providing fish for fisheries, or providing wood for timber harvest

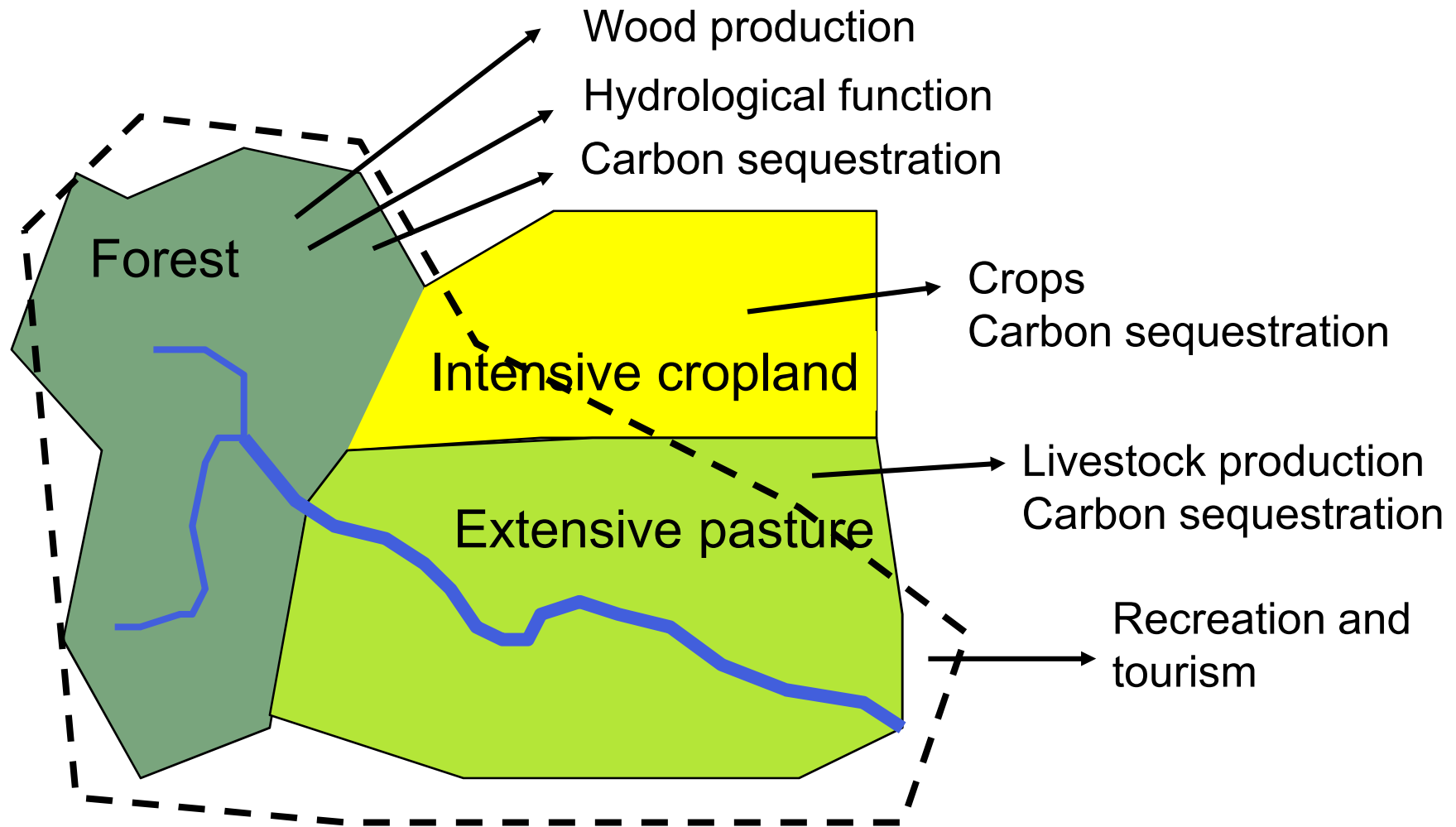**Regulating Services** → = the regulation of climate, hydrological, ecological and soil processes → Example: pollination, carbon sequestration, flood control

Cultural Services → = the non-material benefits provided by ecosystems → Example: recreation, tourism, providing a setting for cultural or religious practices

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Ecosystem services and maps

Wood production

Hydrological function

Carbon sequestration

Forest

Intensive cropland

Crops
Carbon sequestration

Extensive pasture

Livestock production
Carbon sequestration

Recreation and tourism

Level 1: Account 3: Services Supply

- **The SEEA-EEA focuses on "final" services**
  - > The point **before** human involvement transforms the services to benefits
    - biomass → harvesting
    - fish → capture
  - > Ecosystem processes and functions are **not** final services
    - e.g., reproduction, predation, food web, nutrient cycle…
  - > **Biodiversity** itself is not a "final" service
    - It is an aspect of **Ecosystem Condition** and is recorded in the **Biodiversity Account**.

Level 1: Account 3: Services Supply

Services
- Based on **Common International Classification of Ecosystem Services** (CICES)
- Not mutually exclusive
- A list of "final" services
- Detailed (4-digit)
- Does **not** include "supporting" or "intermediate" services (= ecosystem functions)

Section	Division	Group
01. Provisioning	01.01 Nutrition	01.01.01 Biomass
		01.01.02 Water
	01.02 Materials	01.02.01 Biomass
		01.02.02 Water
	01.03 Energy	01.03.01 Biomass-based energy sources
		01.03.02 Mechanical energy
02. Regulation & Maintenance	02.01 Mediation of waste, toxics and other nuisances	02.01.01 Mediation by biota
		02.01.02 Mediation by ecosystems
	02.02 Mediation of flows	02.02.01 Mass flows
		02.02.02 Liquid flows
		02.02.03 Gaseous / air flows
	02.03 Maintenance of physical, chemical, biological conditions	02.03.01 Lifecycle maintenance, habitat and gene pool protection
		02.03.02 Pest and disease control
		02.03.03 Soil formation and composition
		02.03.04 Water conditions
		02.03.05 Atmospheric composition and climate regulation
03. Cultural	03.01 Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	03.01.01 Physical and experiential interactions
		03.01.02 Intellectual and representative interactions
	03.02 Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	03.02.01 Spiritual and/or emblematic
		03.02.02 Other cultural outputs

Level 1: Account 3: Services Supply

- How?

  > Direct measure (e.g., socio-economic survey on recreational use, field survey of available fish…)

  > **Remember** Level 0 – Biophysical modelling?

  - **Lookup tables:** Take values from another location

  - **Statistical approaches:** Estimate based on known explanatory variables

  - **Geostatistical interpolation:** Estimate from nearby known locations

  - **Process-based modelling:** Use models of processes (e.g., land cover change, demand for services…)

  > The group exercise will use only **Lookup Tables…**

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Level 1: Account 3: Services Supply

- Compilation Group Exercise (30m)
  - Situation:
    - **Know** total services supply for some EAs
    - **Need to** calculate:
    - Missing services supply for missing EAs based on known data and lookup table

  - Objective (Groups of 3-5):
    1. Calculate missing services
    2. Calculate totals
    3. Report and discuss results

Level 1: Account 3: Services Supply

Group Exercise: Step 1 – Calculate unknown services

e.g., Crop for EU04 = (18,700 / 500) * 281.3

e.g., Carbon for EU04 = (500 * 20)

Services Supply Database

EU	Extent (ha)	(C) Crop tonnes/year	(R) Recreation trips/year	(W) Water m^3/year	(S) Carbon Sequestration tonnes /ha/year	tonnes /year
EA01 = Herbaceous crops	500.0	18,700.0	500.0	600.0	20	
EA02 = Tree covered areas	262.5	0.0	1,500.0	500.0	30	
EA03 = Inland water bodies	68.8	0.0	1,600.0	15,000.0	5	
EA04 = Herbaceous crops	281.3				20	
EA05 = Tree covered areas	75.0				30	
EA06 = Artificial surfaces (urban)	56.3	0.0	500.0	500.0	0	
EA07 = Artificial surfaces (urban)	68.8	0.0	700.0	400.0	0	
EA08 = Shrubs..regularly flooded (wetland)	37.5	700.0	5,000.0	10,000.0	40	
EA09 = Inland water bodies	50.0				5	
EA10 = Tree covered areas	225.0				30	
EA11 = Herbaceous crops	175.0				20	
Total	**1,800.0**					**0**

Level 1: Account 3: Services Supply

- Is everyone clear on the objectives?

- 30 minutes group work

- Please ask questions!

- Results:

- Each group report:
    - > Totals for each service
    - > Which EU generates
    - > the most of each service?

- Were there any surprises?

Services Supply Database

EU	Extent (ha)	(C) Crop tonnes/year	(R) Recreation trips/year	(W) Water m³/year	(S) Carbon Sequestration tonnes /ha/year	tonnes /year
EA01 = Herbaceous crops	500.0	18,700.0	500.0	600.0	20	
EA02 = Tree covered areas	262.5	0.0	1,500.0	500.0	30	
EA03 = Inland water bodies	68.8	0.0	1,600.0	15,000.0	5	
EA04 = Herbaceous crops	281.3				20	
EA05 = Tree covered areas	75.0				30	
EA06 = Artificial surfaces (urban)	56.3	0.0	500.0	500.0	0	
EA07 = Artificial surfaces (urban)	68.8	0.0	700.0	400.0	0	
EA08 = Shrubs..regularly flooded (wetland)	37.5	700.0	5,000.0	10,000.0	40	
EA09 = Inland water bodies	50.0				5	
EA10 = Tree covered areas	225.0				30	
EA11 = Herbaceous crops	175.0				20	
Total	**1,800.0**					0

Level 1: Account 3: Services Supply

The answers:

EA01 generates the most services for Crop and Carbon Sequestration.

EA03 generates the most services for Water

EA08 generates the most services for Recreation

Services Supply Database

EU	Extent (ha)	(C) Crop tonnes/year	(R) Recreation trips/year	(W) Water m^3/year	(S) Carbon Sequestration tonnes /ha/year	tonnes /year
EA01 = Herbaceous crops	500.0	18,700.0	500.0	600.0	20	10,000
EA02 = Tree covered areas	262.5	0.0	1,500.0	500.0	30	7,875
EA03 = Inland water bodies	68.8	0.0	1,600.0	15,000.0	5	344
EA04 = Herbaceous crops	281.3	10,518.8	281.3	337.5	20	5,625
EA05 = Tree covered areas	75.0	0.0	428.6	142.9	30	2,250
EA06 = Artificial surfaces (urban)	56.3	0.0	500.0	500.0	0	0
EA07 = Artificial surfaces (urban)	68.8	0.0	700.0	400.0	0	0
EA08 = Shrubs..regularly flooded (wetland)	37.5	700.0	5,000.0	10,000.0	40	1,500
EA09 = Inland water bodies	50.0	0.0	1,163.6	10,909.1	5	250
EA10 = Tree covered areas	225.0	0.0	1,285.7	428.6	30	6,750
EA11 = Herbaceous crops	175.0	6,545.0	175.0	210.0	20	3,500
Total	**1,800.0**	**36,463.8**	**13,134.2**	**39,028.0**		**38,094**

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Level 2:
Services Supply Account

Level 2: Account 3: Services Supply

- Learning objectives (Level 2)
  - > Understand the data options and sources
  - > Be aware of how other countries have approached Services Supply Accounting

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Level 2: Account 3: Services Supply

- A full Services Supply Account is more complex than the exercise:

  > More services (48 "final" services in CICES)

  > More types of data (tonnes, risks, visitors, air quality, cultural significance…)

  > Less measured data → need models to estimate

  > High variability among ecosystem types and region (e.g., salt marsh carbon = 650 to 1750 tCO_2/ha/year)

- **Do not** need to include all services:

  > High priority services → measure or estimate

  > Get started with available data

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Example - SA

- Example from South Africa: Durban area

- Map shows annual sustainable fuelwood output (m3/ha) from different habitats

- In the absence of local data, cubic volume of wood for estimated using the following simplified equation

- *Volume (m^3/ha) = basal area (m^2/ha)×canopy height (m)/3*

- A sustainable yield of 3% of standing crop applied for all vegetation classes

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Example - SA

- Example from South Africa, Durban area

- Estimated annual sustainable hunting output (kg/ha) across the EMA

- Based on various studies,

- In total: 26 000 kg of wild meat and birds with a total estimated value of R565 500

- Forest, thicket and woodland habitats are estimated to be able to supply the majority of this output.

- Based on sustainable offtake levels, do not consider illegal hunting

- Highest levels of output associated with habitats in outer-west and southern regions where natural habitat patches are larger, less fragmented and on communal land

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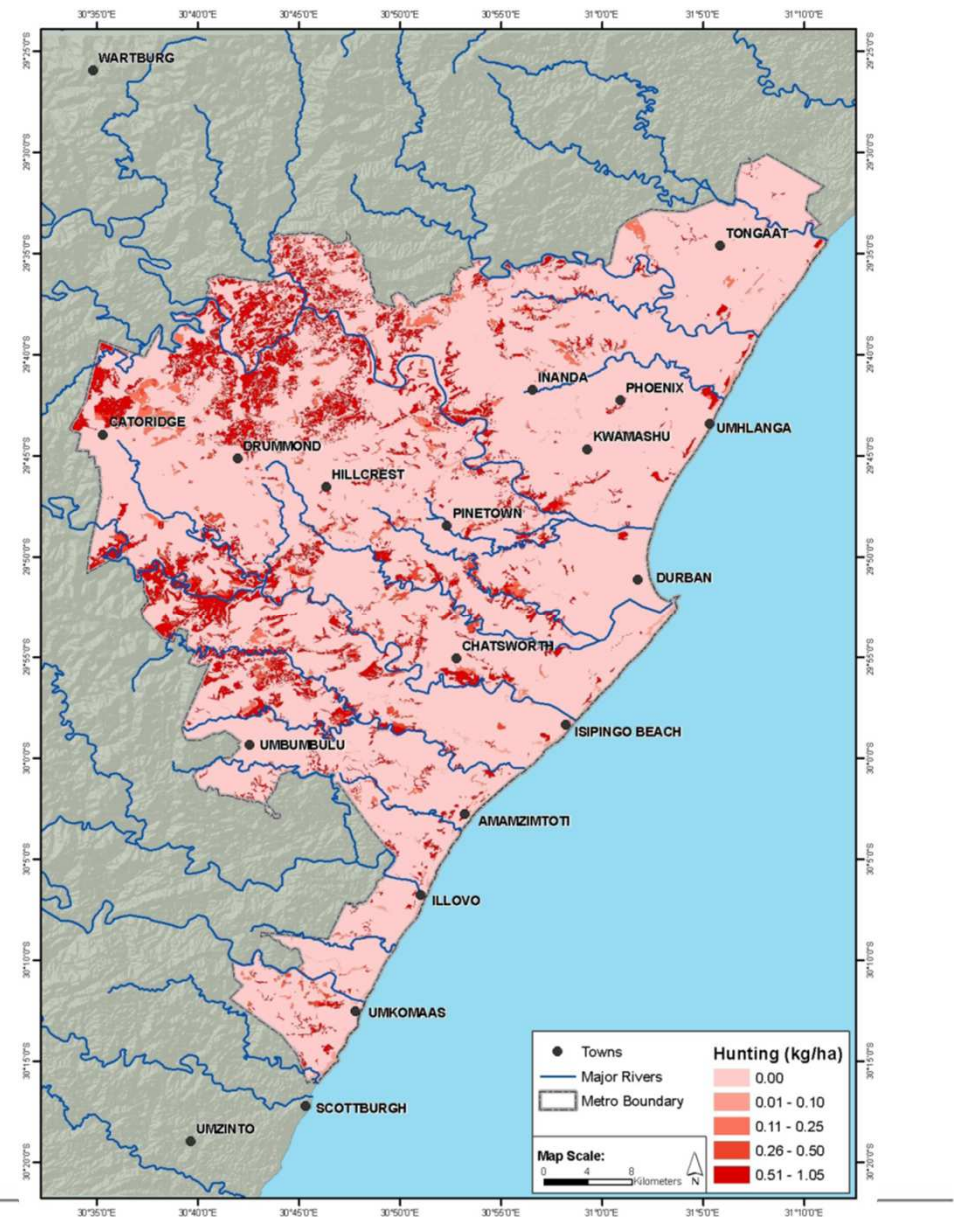
Source: Turpie et al, 2017

Example – Indonesia (Kalimantan)
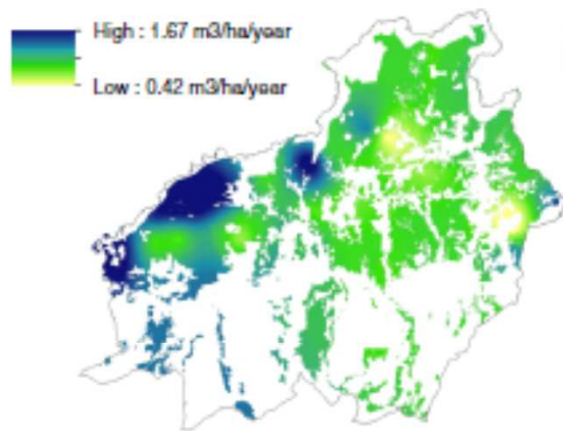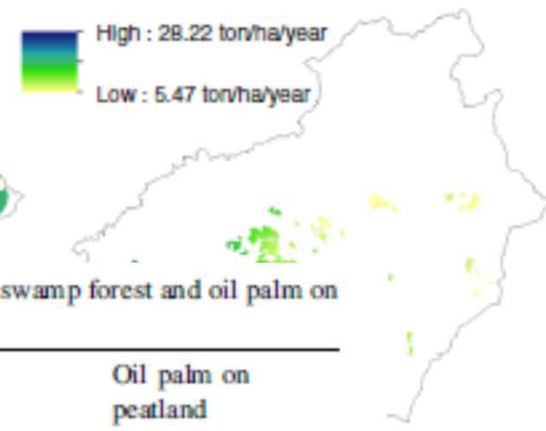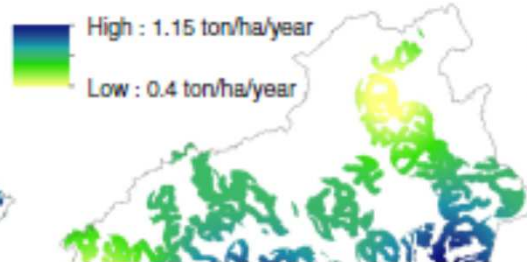
Table 3 Average ES provided by peat swamp forest and oil palm on peatland

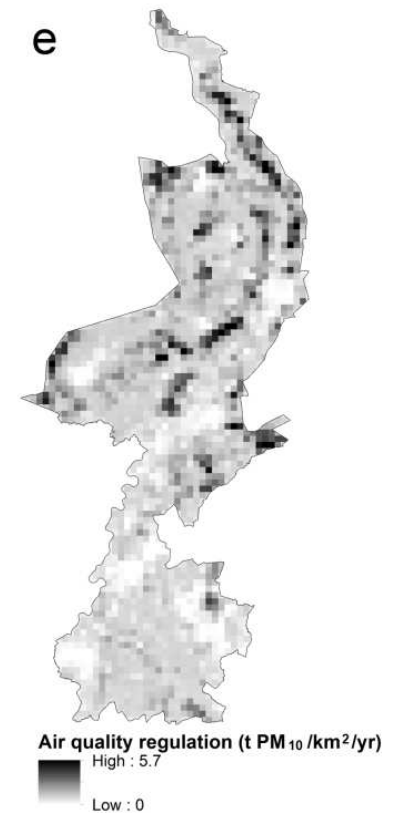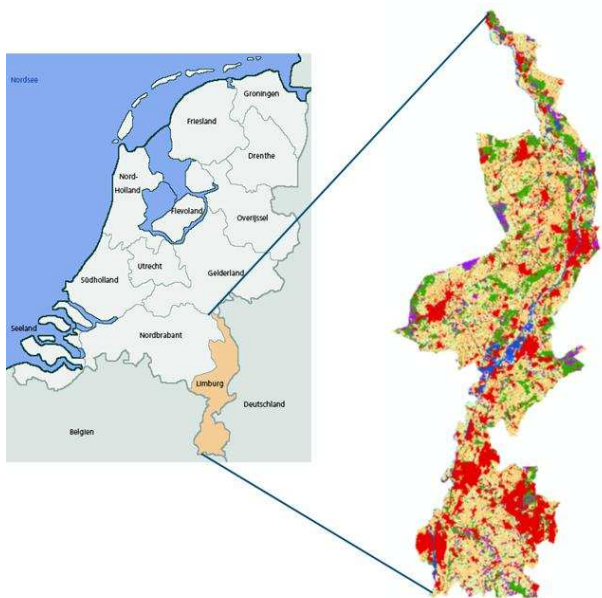|	Peat swamp forest	Oil palm on peatland
Timber production	On average 0.83 m³/ha/year	n.a.
Oil palm production	n.a.	On average 14.8 ton/ha/year
Carbon sequestration	From +5 (non-drained) to −4 (drained) ton C/ha/year	Emissions of up to 23 ton C/ha/year
Habitat for orangutan	Mostly suitable, depending on forest cover	Not suitable

Source: Sumarga and Hein, 2014
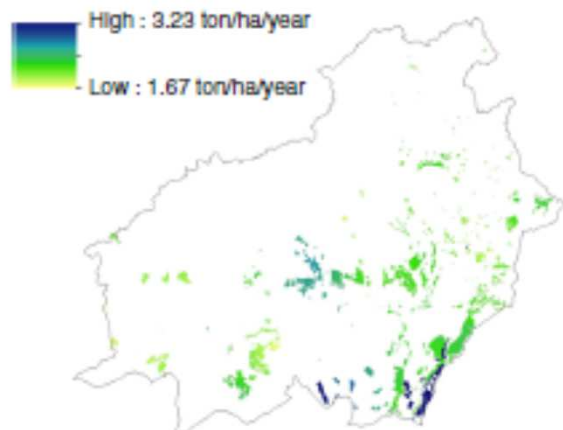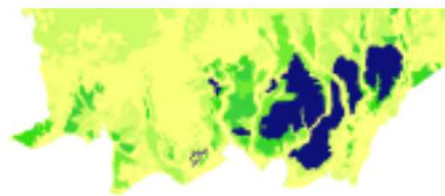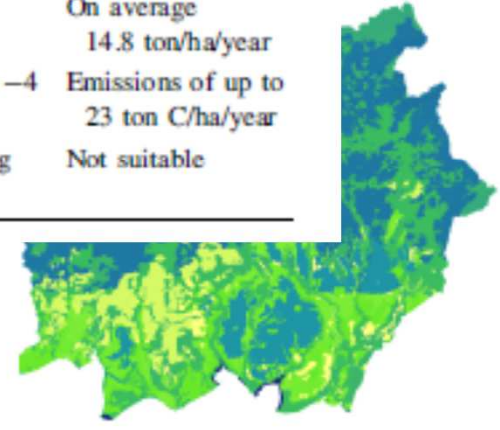
Ecosystem services in an account

- Ecosystem service account developed for Limburg Province, the Netherlands

- 2200 km², 1.1 million inhabitants

- Analysis of 7 ecosystem services

Crop production (t produce/ha/yr)
High : 71
Low : 0

Air quality regulation (t PM$_{10}$ /km²/yr)
High : 5.7
Low : 0

Level 2: Account 3: Services Supply

- **Example (services in physical units)**

Ecosystem service		Units	Land cover type								
			Urban	Pasture	Cropland	Forest	Heath	Peat	Surface Water	Other nature	Provincial total
Provisioning	Hunting	kg meat	-	9,100	14,732	8,100	678	70		1,513	34,193
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Cultural	Recreational cycling	10^3 trips	2,690	1,863	2,611	1,565	30	3	139	220	9,121

Note: Units of measure are **very** different

Level 2: Account 3: Services Supply

- Data options and sources
  - Field studies
    - Literature on similar sites or specific research
  - Economic production (agriculture, forestry, fisheries, water)
    - Socio-economic statistics already available with spatial detail
  - Biophysical modelling
    - Know conditions, can estimate some services using production functions (e.g., hydrology → flood control)
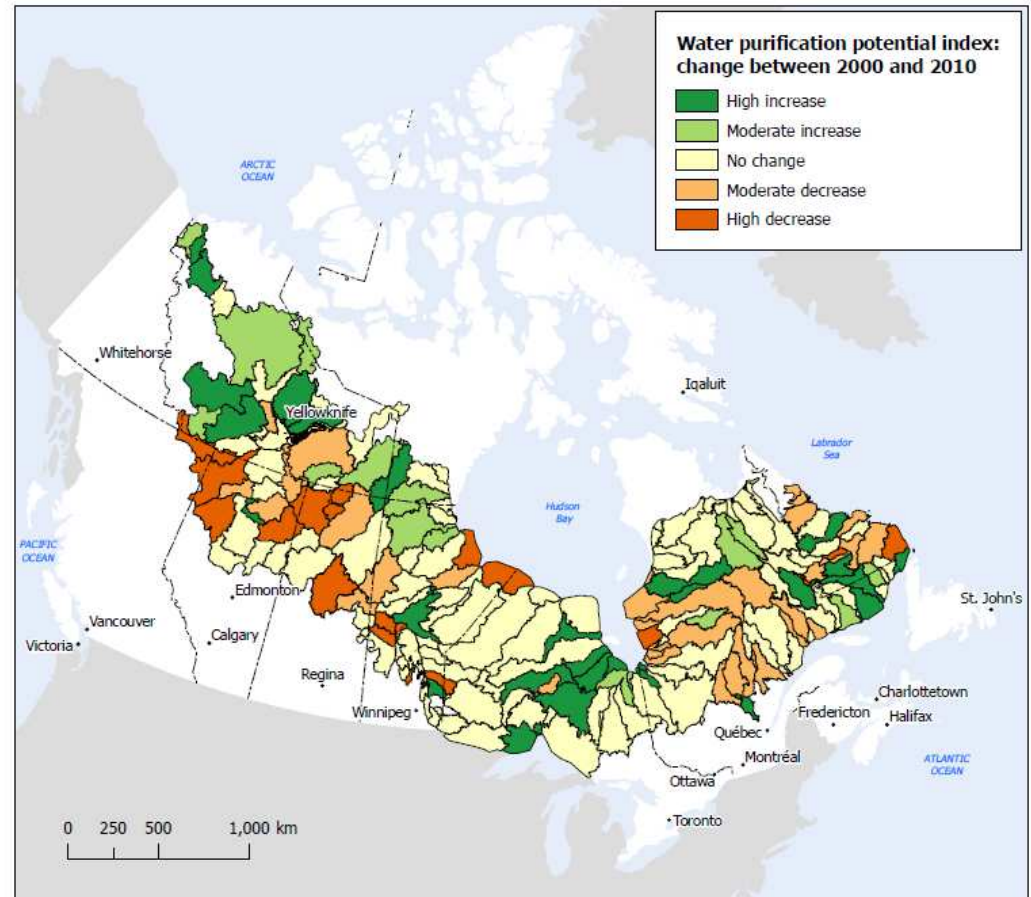
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Level 2: Account 3: Services Supply

Canada Example

Water purification potential change by drainage area for boreal wetlands

Index based on:
- % forest cover
- % agricultural land
- % riparian forest
- % wetlands
- % anthropogenic disturbance
- % burn area
- Edge & linear density (fragmentation)
- Human footprint
- Slope
- Nitrogen & Sulphur exceedance (from atmospheric deposition)

Water purification potential index: change between 2000 and 2010
- High increase
- Moderate increase
- No change
- Moderate decrease
- High decrease

Source: Statistics Canada, 2013

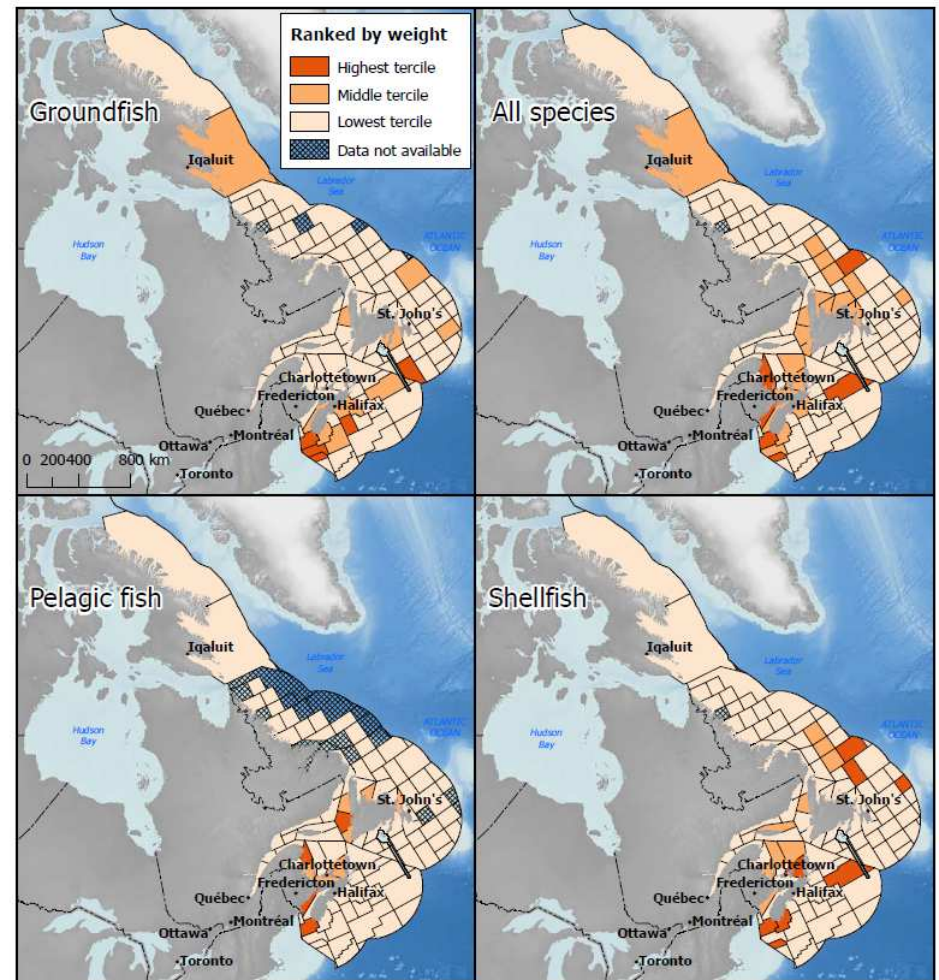# Level 2: Account 3: Services Supply

Canada example

Weight of commercial fish landings by marine statistical area

Includes:
- Groundfish
- Pelagic fish
- Shellfish

Also done for west coast

Statistical area defined by Ministry of Fisheries and Oceans

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Level 2: Account 3: Services Supply

- **Some services flow data are available**

Service	Flow measure
Provisioning services	
Timber services	timber increment
Crops	crop production
Livestock	livestock production
Water provision	annual freshwater supply
Regulating services	
Water quantity regulation	total amount of water stored
	total amounts of pollutants removed annually
Climate regulation	annual carbon fixation
Storm protection	total number of storms mitigated
Air quality regulation	total amount of pollutants removed via dry deposition on leaves
Erosion control	total amount of soil retained
Pollination	increased yield of crops due to pollination
Soil quality regulation	increased yield of crops attributable to soil quality
Cultural services	
Recreation	number of visitors

Source: (Maes, Paracchini et al. 2011)

Level 2: Account 3: Services Supply

- **Data sources:** Socio-economic statistics
  - > Agricultural statistics: crop, livestock production
  - > Energy statistics: biomass for fuel
  - > Fisheries statistics: catch, stock
  - > Forestry statistics: timber stock, harvest
  - > Park surveys: visitors, use
  - > Water statistics: withdrawals, consumption
  - > Natural disasters: incidence of floods, erosion, storms
  - > Soil inventories: erosion potential
  - > Health statistics: regulation of biotic environment
- Best if they are national and good quality

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Level 2: Account 3: Services Supply

- **Data sources:** Environmental statistics
    - > Iconic species ranges & habitats
    - > Land cover → carbon sequestration, air filtration
    - > Hydrology & weather data: Flow rates, variability → flood risk
    - > Topography, land cover, soil & weather data → erosion and landslide risk
    - > Carbon storage and sequestration (see Carbon Accounts)
    - > Remote sensing → primary production
- Best if they are national and good quality

Level 2: Account 3: Services Supply

- **Data sources:** Specific studies & models
    - > These may not be included in valuation databases
    - > Specific studies:
        - National or regional ecosystem assessments (Millennium Ecosystem Assessment, UK National Ecosystem Assessment)
        - Small-area studies (e.g., one park, one region)
        - TEEB studies and country studies (multiple ecosystems and services)
    - > Decision-support models:
        - There are landscape-scale and site-scale models that can help estimate service flows (AIRES, InVEST, LUCI…)
        - See Biophysical Modelling

Level 2: Account 3: Services Supply

- **Data sources:** Special surveys and case studies
  - > High-priority data gaps may also be addressed by collecting **new** data
    - ⁻ Ecological field studies to determine "production functions"
    - ⁻ Socio-economic surveys to determine use of services (e.g., water, food, recreation)
    - ⁻ Case-studies for specific locations or social groups (e.g., dependence on nature of low-income residents)
  - > If possible, add questions to existing surveys, for example,
    - ⁻ Households use of water, source of food, incidence of hazards (flooding, erosion, drought, disease), source of biomass for fuel

Level 2: Account 3: Services Supply

Group exercise (15m)

(Groups of 3-5)

1. In your country (or region), what are **three** important **ecosystem services** that should be included in a Services Supply Account?

2. Which ecosystem types supply them?

3. What **national data** are available in your country on the supply of these services?

4. Report your results

Level 2: Account 3: Services Supply

- Concepts Group exercise (15m)

- Group reports

  > The **ecosystem services** you selected

  > The main land cover types for each

  > Are **national data** available in your country on the supply of these services?

- Discussion

  > What other ecosystem services would be important to measure?

  > On what topic might a special survey be used to fill priority data gaps?

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Level 2: Account 3: Services Supply

- Discussion and questions

- Take home points
    - > Services Supply in biophysical terms is one of the **most important** aspects of ecosystem accounting
    - > Data on Services Supply are available from many sources
    - > There are some simple methods and models available to integrate these data and fill gaps
    - > Start by focussing on available data and priority services

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Level 2: Account 3: Services Supply

- Further Information
    - > SEEA Experimental Ecosystem Accounting (2012)
    - > SEEA-EEA Technical Guidance
        - Detailed supporting documents
        - "Linkages between ecosystem service accounts and ecosystems asset accounts" and
        - "Biophysical Modelling and Analysis of Ecosystem Services in an Ecosystem Accounting Context" by Lars Hein

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