System of
Environmental
Economic
Accounting

Ecosystem Services Accounts

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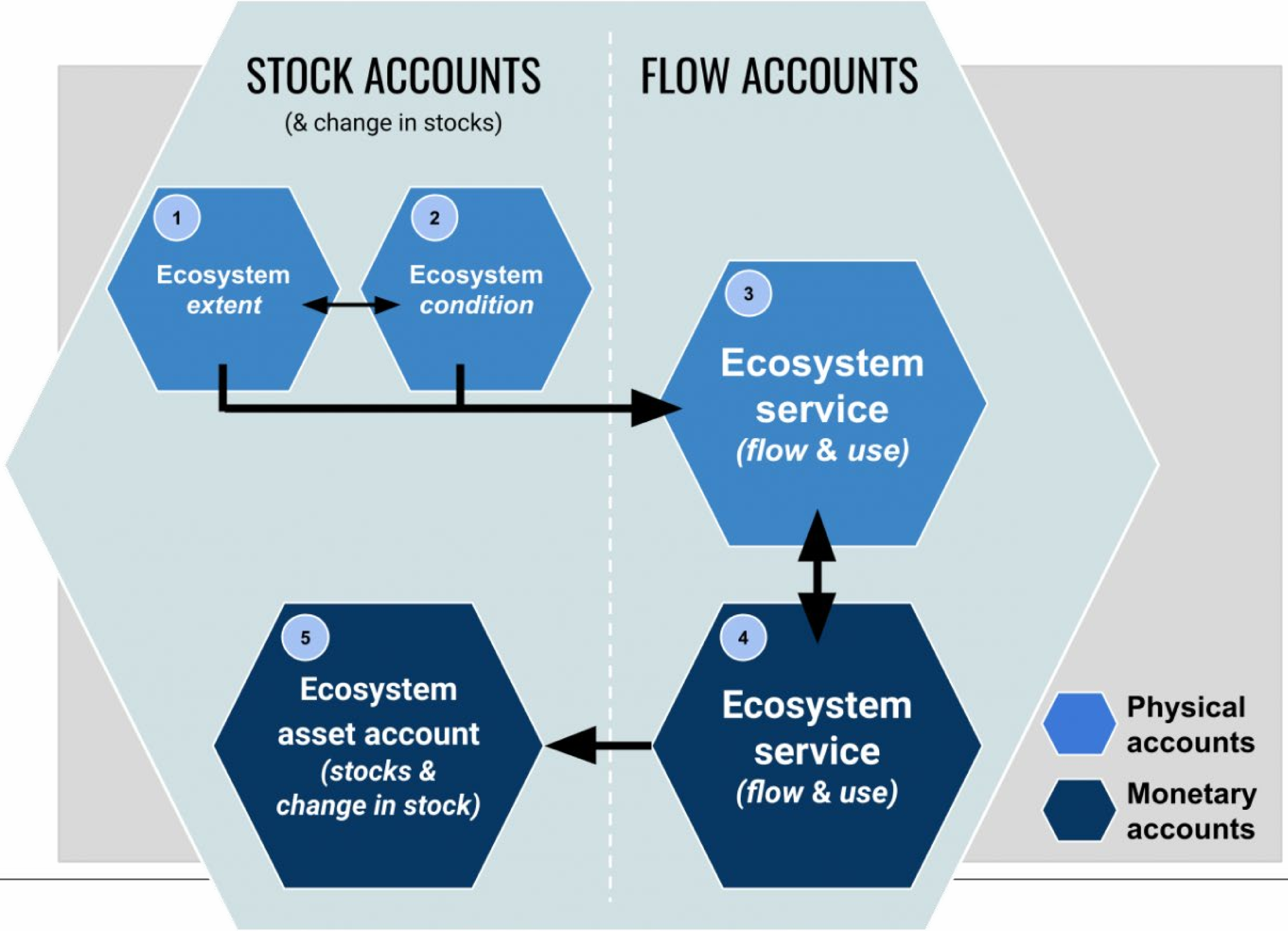
Outline

- Main ecosystem accounts
- Biophysical modelling
  - Guidelines on biophysical modeling for SEEA Ecosystem Accounting
    - Modelling techniques
    - Main modelling platforms
- Monetary valuation of ES
- Examples of measuring individual ES

SEEA EA Framework



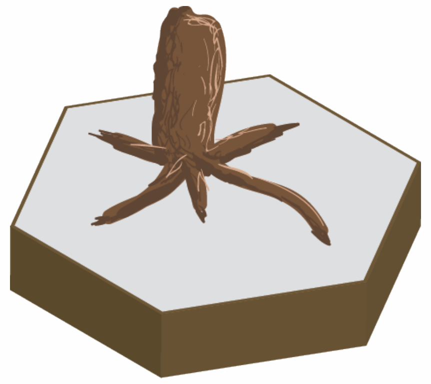
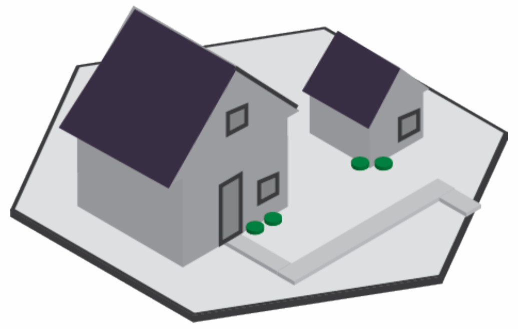
Ecosystem services

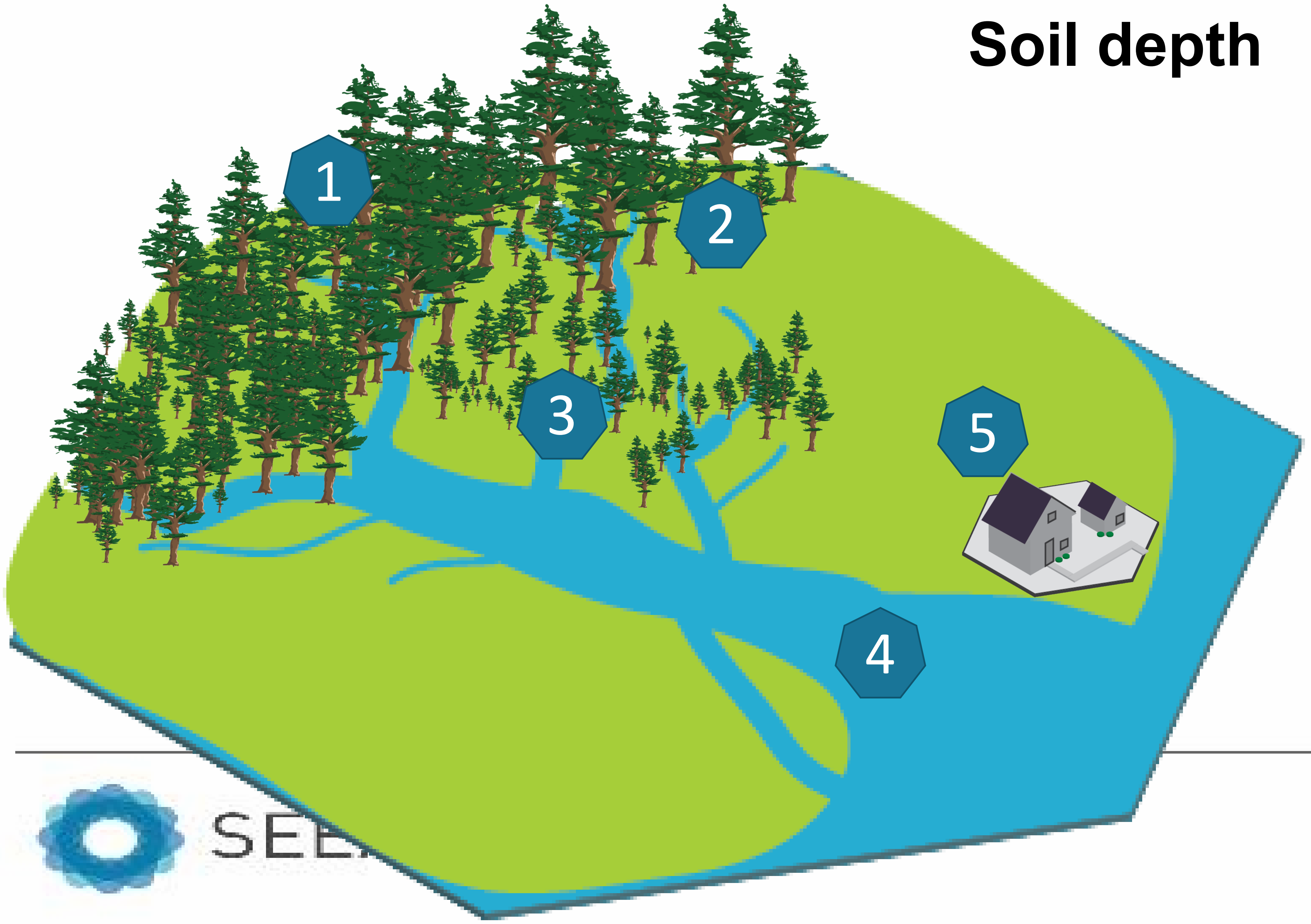
- **Ecosystem services: contributions of ecosystem to benefits used in economic and other human activity**
  - Expansion of the production boundary of SNA
  - They are **not** equal to the benefits;
    - Need to calculate the contribution of ecosystems
    - Avoid double counting
  - Ecosystem services are treated as transactions:
    - National accounts: quadruple-entry based system that registers transactions (i.e. flows of goods and money) occurring between statistical units (e.g. households, companies, etc.).
    - Recording entries in ecosystem accounts follows general principles of national accounting
    - Each transaction can only be characterized by a single value (in physical or monetary units) i.e. **supply** of ES has to **equal use**
    - Valuation basis of the accounts (which are called exchange values), as it rules out consumer surplus.

Ecosystem services

- **The SEEA-EA includes intermediate and final ecosystem services**
  - Final ecosystem service
    - Transactions between ecosystem assets (suppliers) and economic units (users)
    - Represent final output of the ecosystem before interaction with the economy
  - Intermediate ecosystem service
    - Flows of services between and within ecosystem assets
    - Reflect underlying ecosystem characteristics and processes and can have high policy relevance, e.g. pollination

SEEA EA Framework – Illustrative Example

1	2	3	4	5
Asset – forest	Condition	Services	Benefits	Beneficiaries
				
	Soil depth	Water filtration	Clean water	People



- Beneficiaries: wide range of businesses, governments and households that benefit from the ES
- Users: subset of beneficiaries; those closest to the service (e.g. water supply company)

Ecosystem services

- SEEA EA includes a reference list of 25 ecosystem services
- Final and intermediate ES

- Provisioning:
  - > Biomass
    - Grazed biomass
    - Livestock
    - Aquaculture
    - Wood
    - Wild fish + other
    - Wild animals, plants + other
  - > Genetic material
  - > Water supply
- Cultural:
  - > Recreation-related
  - > Visual amenity
  - > Education, scientific and research
  - > Spiritual, artistic and symbolic services
- Other ES
- Non-use

- Regulating and maintenance services
  - > Global climate regulation
  - > Rainfall pattern
  - > Local (micro and meso) climate regulation
  - > Air filtration
  - > Soil quality regulation
  - > Soil and sediment retention
  - > Solid waste remediation
  - > Water purification
  - > Water flow regulation
  - > Flood control
  - > Storm mitigation
  - > Noise attenuation
  - > Pollination
  - > Biological control
  - > Nursery population & habitat maintenance

Ecosystem service supply table

Ecosystem services

				Selected ecosystem types (based on Level 3 - EFG of the IUCN Global Ecosystem Typology)																		Total Supply resident ecosystem assets	Supply from non-resident ecosystem assets - Imports	Total Supply ecosystem services	TOTAL SUPPLY
				Terrestrial												Freshwater			Marine						
				T1 Tropical-subtropical forests				T2 Temperate-boreal forests and woodlands				...		T7		F1	...	FM1	M1	...	MFT1				
				Tropical-subtropical lowland rainforests	Tropical-subtropical dry forests and scrubs	Tropical-subtropical montane rainforests	Tropical heath forests	Boreal and temperate high montane forests and woodlands	Deciduous temperate forests		Temperate pyric sclerophyll forests and woodlands				Derived semi-natural pastures and old fields	Permanent upland streams		Intermittently closed and open lakes and lagoons	Seagrass meadows		Coastal saltmarshes and reedbeds				
SUPPLY			UNITS OF MEASURE	T1.1	T1.2	T1.3	T1.4	T2.1	T2.2	...	T2.6	...	...	...	T7.5	F1.1	...	FM1.3	M1.1	...	MFT1.3				
Selected ecosystem services (reference list)																									
Provisioning services																									
	Biomass provisioning	Crop provisioning																							
		Grazed biomass provisioning																							
		Livestock provisioning services																							
		Aquaculture provisioning services																							
		Wood provisioning services																							
		Wild fish and other natural aquatic biomass provisioning services																							
		Wild animals, plants and other biomass provisioning services																							
	Genetic material services																								
	Water supply																								
	Other provisioning services																								
Regulating and maintenance services																									
	Global climate regulation services																								
	Rainfall pattern regulation services																								
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	Pollination services																								
	Biological control services																								
	Nursery population & habitat maintenance services																								
	Other regulating and maintenance services																								
Cultural services																									
	Recreation-related services																								
	Visual amenity services																								
	Education, scientific and research services																								
	Spiritual, artistic and symbolic services																								
	Other cultural services																								

Ecosystem types

Ecosystem service use table

				Selected economic units															Selected ecosystem types (based on Level 3 - EFG of the IUCN Global Ecosystem Typology)																					
				Selected industries															Terrestrial												Freshwater			Marine						
																			T1 Tropical-subtropical forests				T2 Temperate-boreal forests and woodlands				...		T7		F1	...	FM1	M1	...	MFT1				
USE			UNITS OF MEASURE	Agriculture	Forestry	Fisheries	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water supply; sewerage, waste management and remediation activities	Services	Other industries	Total Industry	Government consumption	Household consumption	Total use by resident economic units	Exports - final ecosystem services	Total Use by economic units	Tropical-subtropical lowland rainforests	Tropical-subtropical dry forests and scrubs	Tropical-subtropical montane rainforests	Tropical heath forests	Boreal and temperate high montane forests and woodlands	Deciduous temperate forests	...	Temperate pyric sclerophyll forests and woodlands	...	...	...	Derived semi-natural pastures and old fields	Permanent upland streams	...	Intermittently closed and open lakes and lagoons	Seagrass meadows	...	Coastal saltmarshes and reedbeds	Total use resident ecosystem assets	Exports - intermediate services	Total Use by ecosystem assets	TOTAL USE
																			T1.1	T1.2	T1.3	T1.4	T2.1	T2.2	...	T2.6	...	...	...	T7.5	F1.1	...	FM1.3	M1.1	...	MFT1.3				
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	Other cultural services																																							

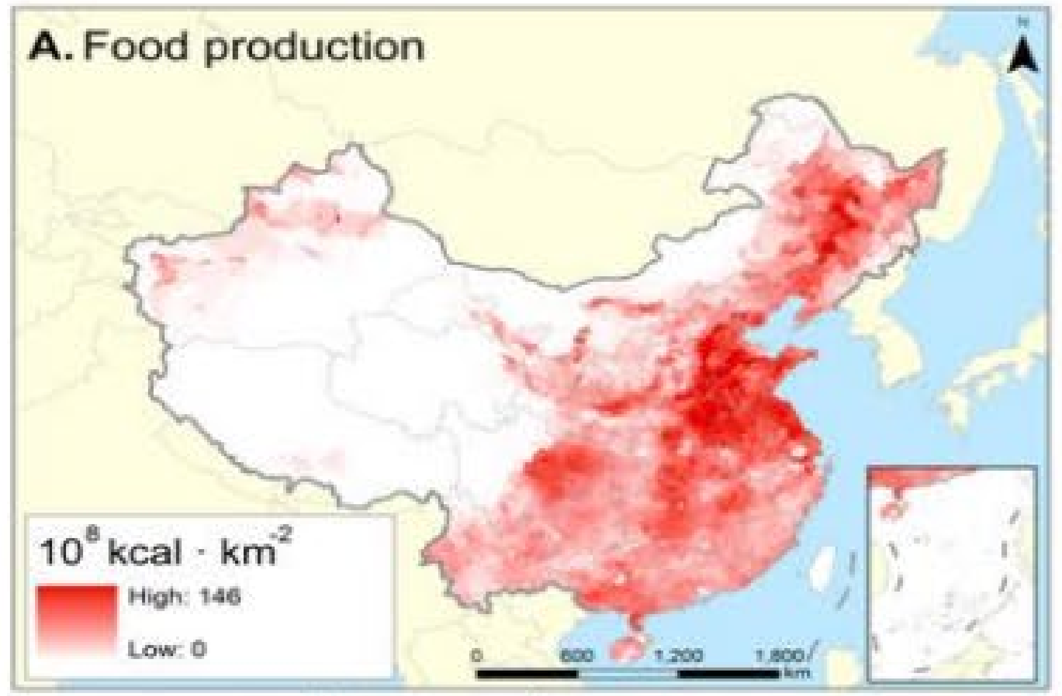
Economic units-final services

Ecosystem types-intermediate services

Ecosystem services

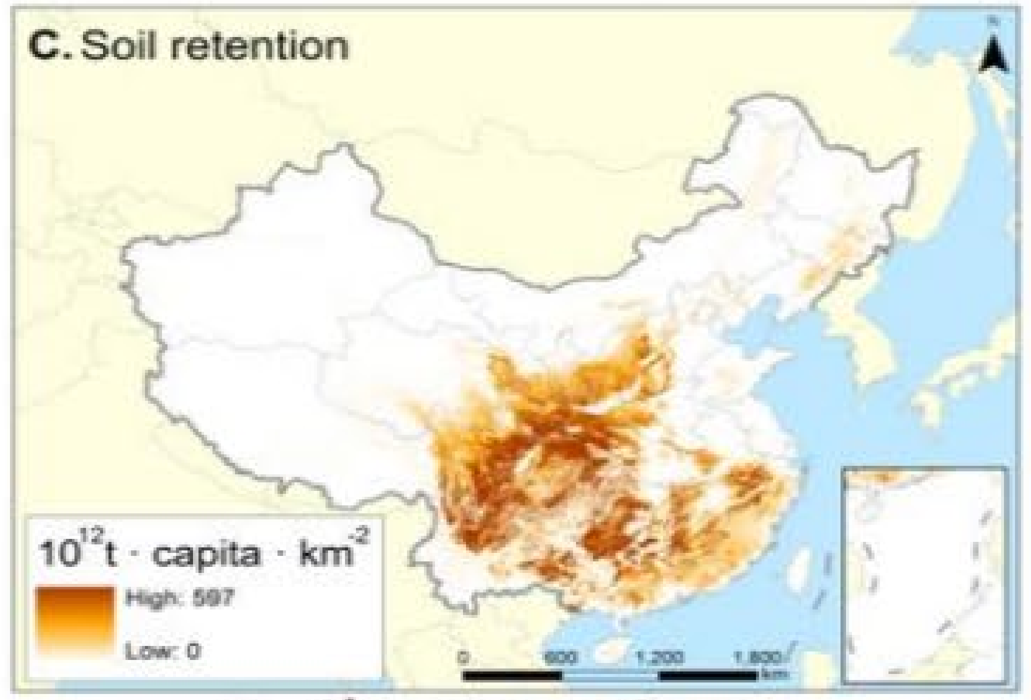
Application: Mapping ecosystem services

Spatial pattern of ecosystem services in China

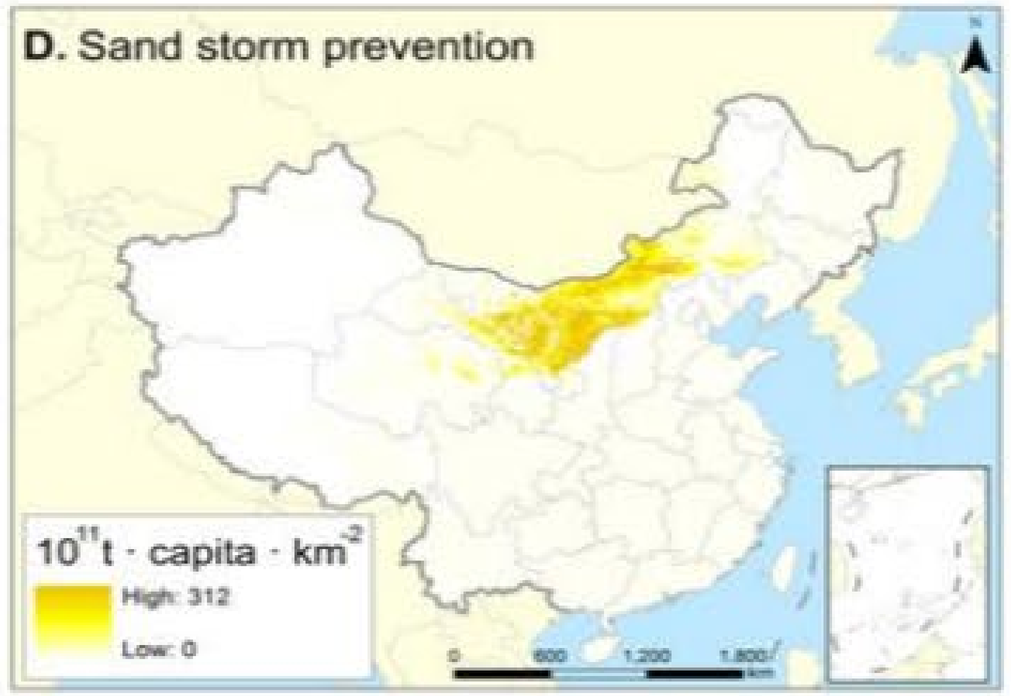


Food production

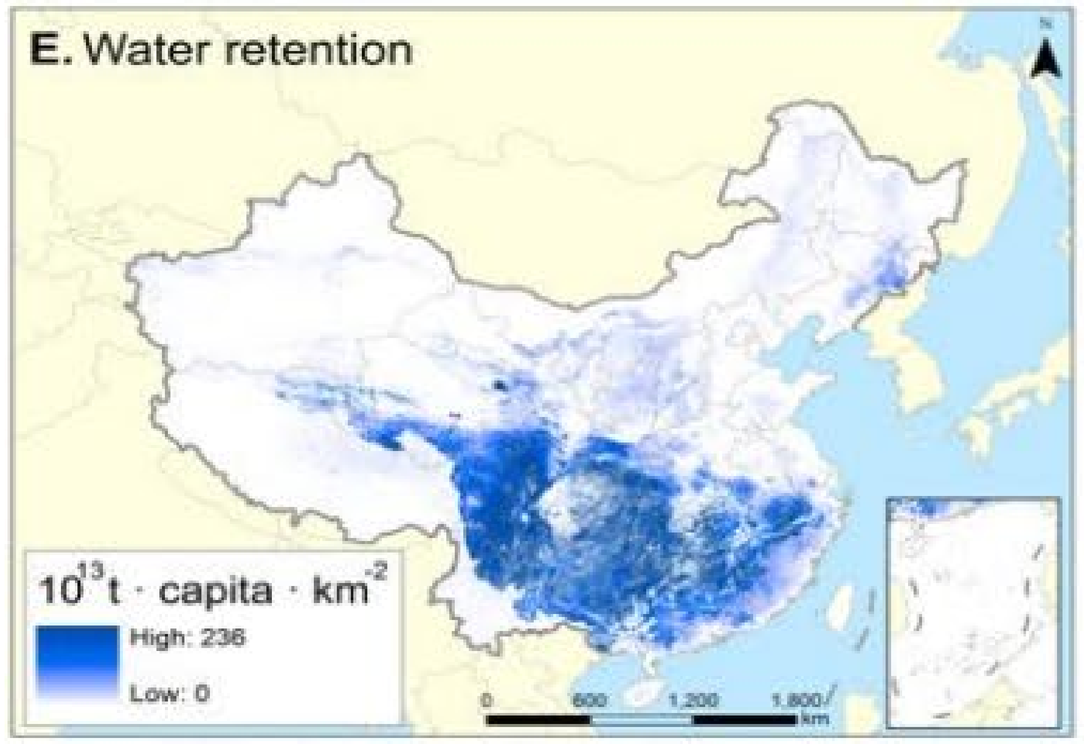
Carbon sequestration



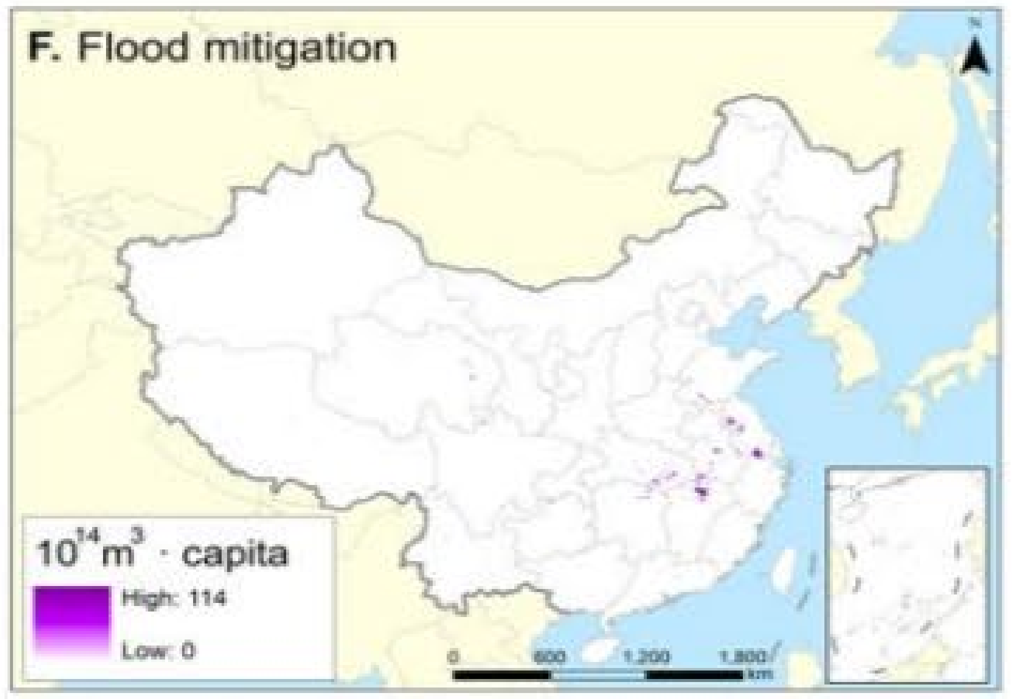
Soil retention



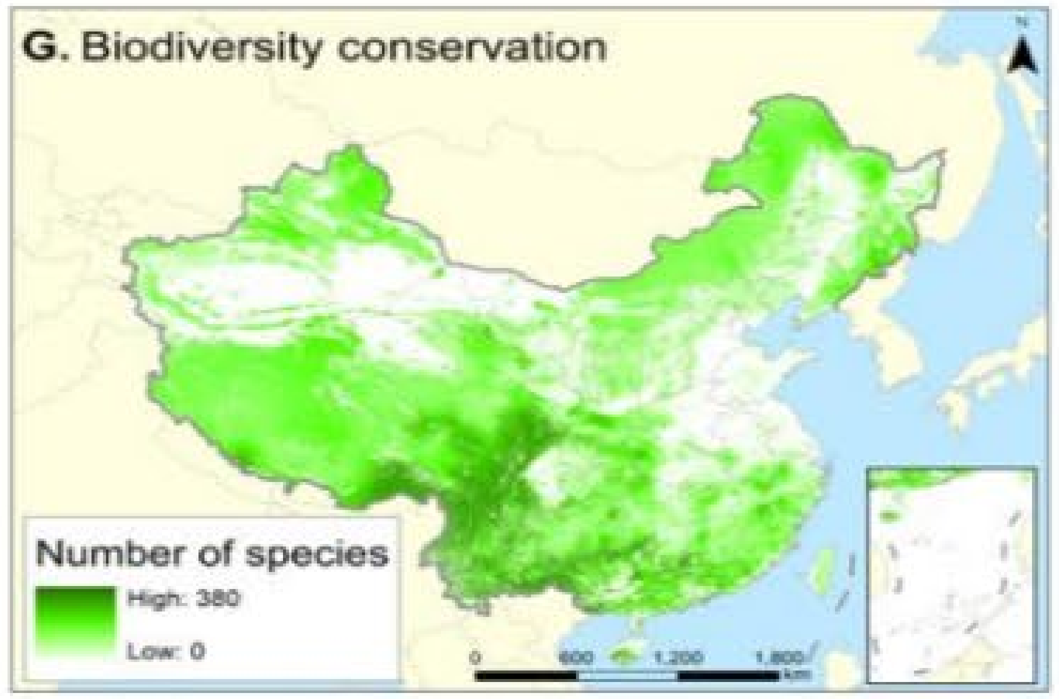
Sand storm prevention



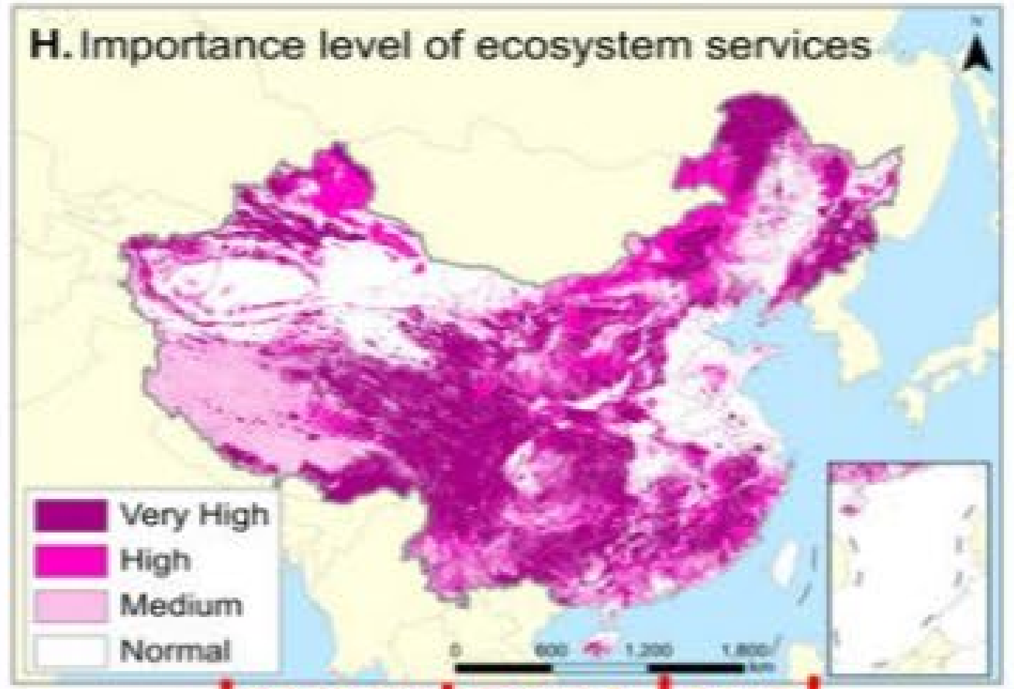
Water retention



Flood mitigation



Biodiversity conservation



Importance level

Source: Presentation by Zhiyun Ouyang, Chinese Academy of Sciences at Third Forum on Natural Capital Accounting for Policy Decisions, November 2018

Biophysical modelling

What is biophysical modelling?

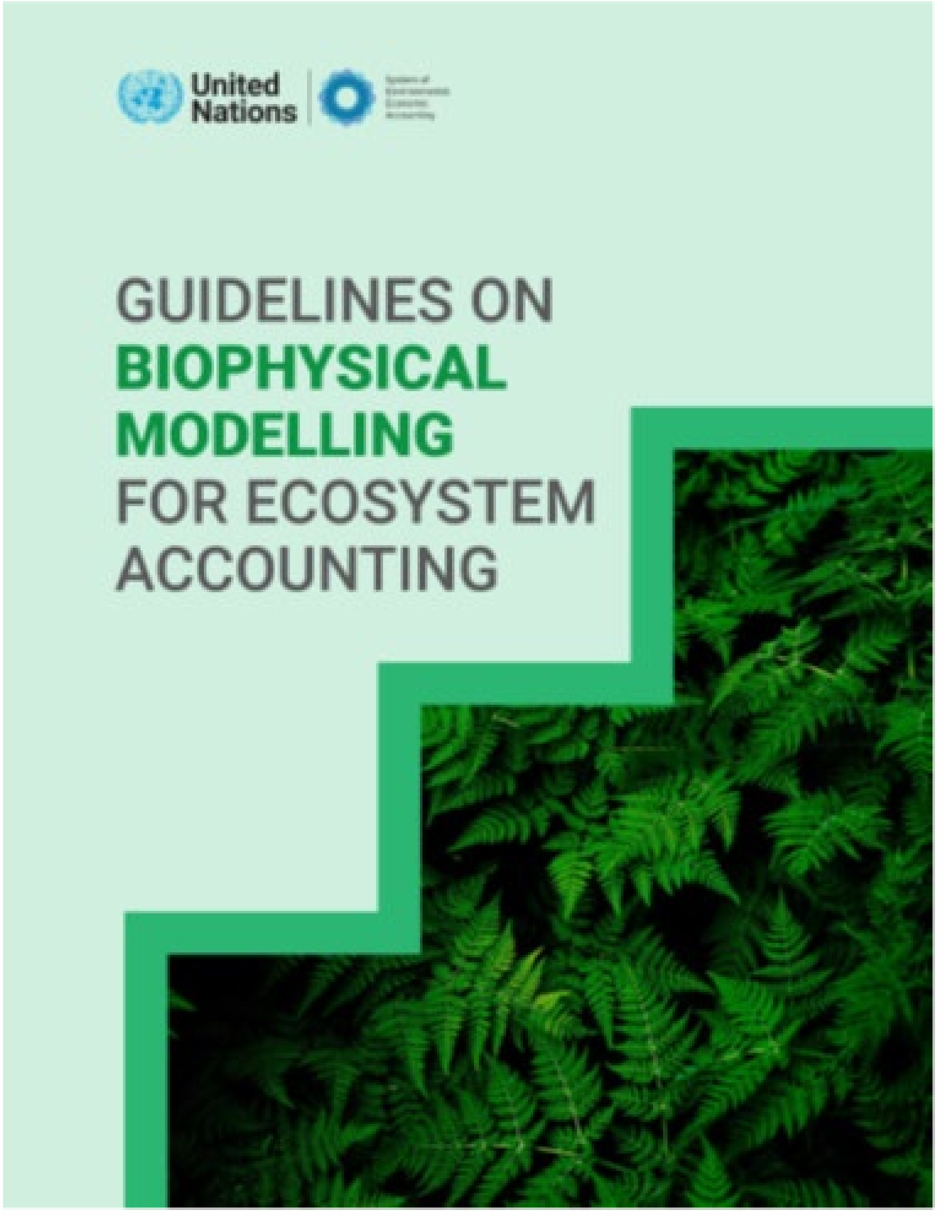
- Biophysical modelling: the quantitative estimation of biophysical phenomena or processes that are difficult to fully observe directly.
- Distinguish between models and modelling platforms.
  - Models are highly diverse in purpose and approach, many are set-up to analyse a specific problem (e.g. a model to estimate carbon sequestration).
  - Modelling platforms: tools consisting of multiple models
- Biophysical models can be useful for compiling many of the extent, condition, as well as supply and use tables and maps produced in SEEA EA.
- Biophysical modelling may be instrumental, it can never replace data collection processes:
  - Earth observation data sets need ground-truthing
  - Models rely on in situ data (adjust model setup to local circumstances / calibration)

Why do we need modelling?

- Ecosystem accounting - as spatially explicit - requires maps with full spatial cover of ecosystem types, condition variables, and ecosystem services flows
- Data needed for ecosystem accounts not usually captured in regular data sources
  - Measuring ecosystem services directly is often difficult or costly to measure *in situ*.
- For some services or condition indicators, data are only available for specific locations
  - Spatialize tabular data (e.g. visitors, or water quality
- Usually, data from various sources and scales need to combined (e.g., point field data and satellite data)

Biophysical guidelines (1/3)

- Why developed?
  - > Diverse models and tools have proliferated over the past decade and are constantly evolving.
  - > Most models not developed specifically for accounting purposes, many models produce results can be used directly in SEEA EA or produce results that can be modified for use in SEEA EA.
- Audience:
  - > Ecosystem accounts compilers + managers
  - > Assumes familiarity with SEEA Ecosystem Accounting but does not assume knowledge of biophysical modelling
- Process:
  - > Under auspices of UNCEEA
  - > Global consultation in 2021
  - > Adopted by UN Statistical Commission



Biophysical guidelines (2/3)

1. Introduction
2. Process guidance for agencies
3. Modeling for ecosystem accounts
4. Modeling for extent accounts
5. Modeling for condition accounts
6. Modeling for ecosystem service accounts
7. Data quality
8. Future of biophysical modeling

Annexes

1. Global data sources + data portals
2. Modelling techniques
3. Cartography essentials
4. Literature list (16 pages)

NB: Living document: see for latest tables:

https://seea.un.org/ecosystem-accounting/biophysical-modelling

Biophysical guidelines (3/3)

- Tiered approach
  - recognizes countries are in different circumstances (data availability + expertise)
  - may differ per ES
  - progress over time
- Decision trees to facilitate choices

TIER 1

Ecosystem services modelled from global datasets with no or little user input data

TIER 2

Ecosystem services modelled from national datasets customized for national contexts, some validation

TIER 3

Ecosystem services modelled with local data and direct surveys, better validation, and best available tools

Figure 2: *Tiered approach*

Modelling techniques

Model technique	Definition	Data needs	Efforts
Look-up Table	Specific values for an ecosystem service or condition variable are attributed to every pixel in a certain class, usually a land cover, land use, or ecosystem type class.	Limited	Easy
Spatial interpolation	Creates surfaces from measured points	Moderate	Moderate
Geostatistical models	Statistical algorithms predict the value of un-sampled pixels based on nearby pixel values in combination with other characteristics of the pixel.	Moderate	Moderate
Statistical models	Values of pixels are assigned based on a set of underlying variables. The relation between the value and the independent variables is developed with a regression analysis.	Moderate	Moderate
Dynamic systems (such as process-based models)	Dynamic systems modelling uses sets of differential equations to describe responses of a dynamical system to all possible inputs and initial conditions. The equations include a set of state (level) and flow (rate) variables in order to capture the state of the ecosystem, including relevant inputs, throughputs and outputs, over time. Most process-based models are examples of dynamic systems models that predict ecosystem services supply or other variables based on a mathematical representation of one or several of the processes describing the functioning of the ecosystem.	High	High
Machine learning	A type of artificial intelligence. Machine learning uses training data to build algorithms to make predictions without explicit programming.	High	Moderate

Example modelling techniques (1/2)

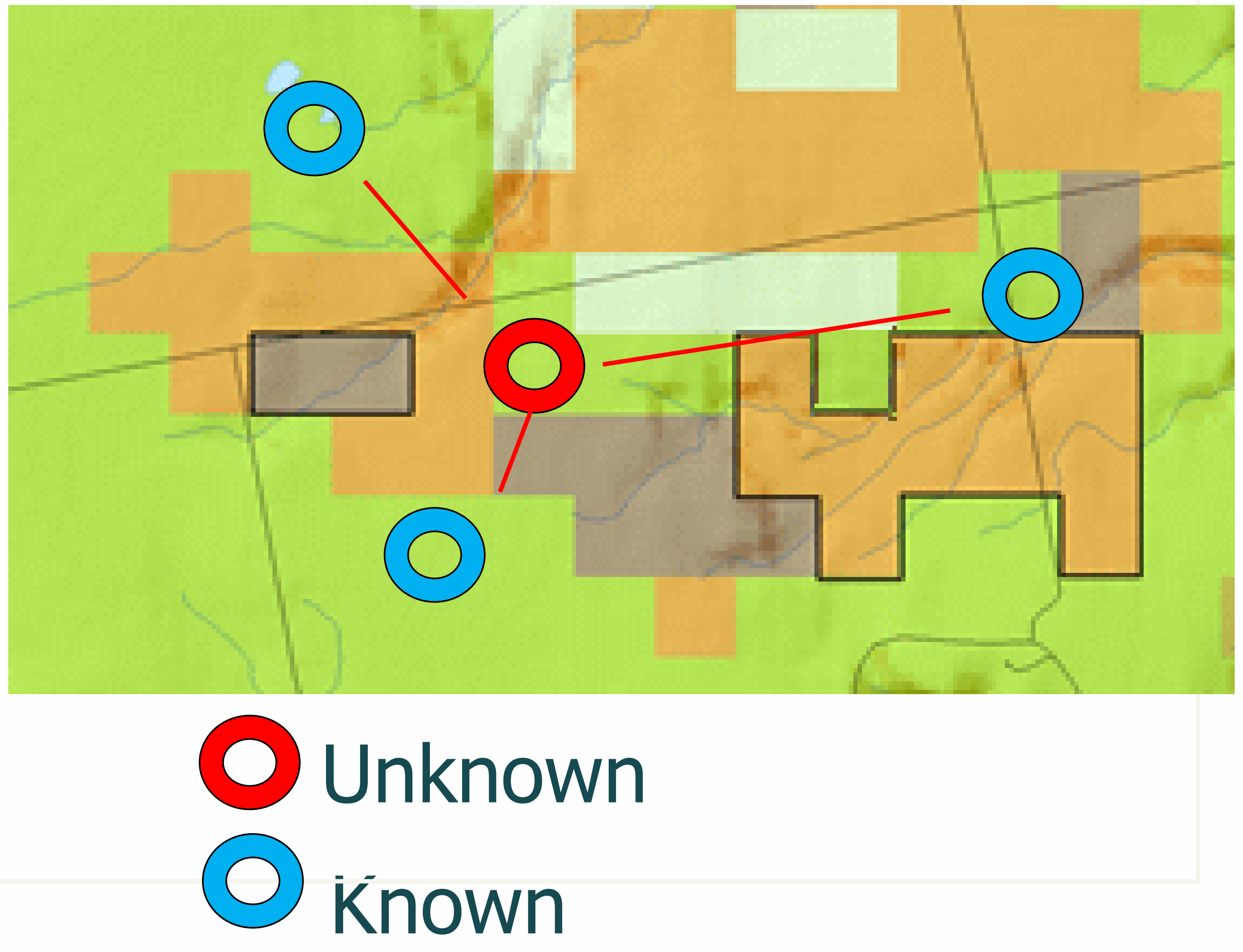
- Look-up table:
  - Attribute values for an ecosystem service (or other measure) to every spatial unit in the same class (e.g., a land cover class).
  - Example: Carbon storage
    - one ha of forest = X tonnes
      → attribute X tonnes each ha of forest
- Statistical model:
  - Estimate ecosystem 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: **Habitat quality**

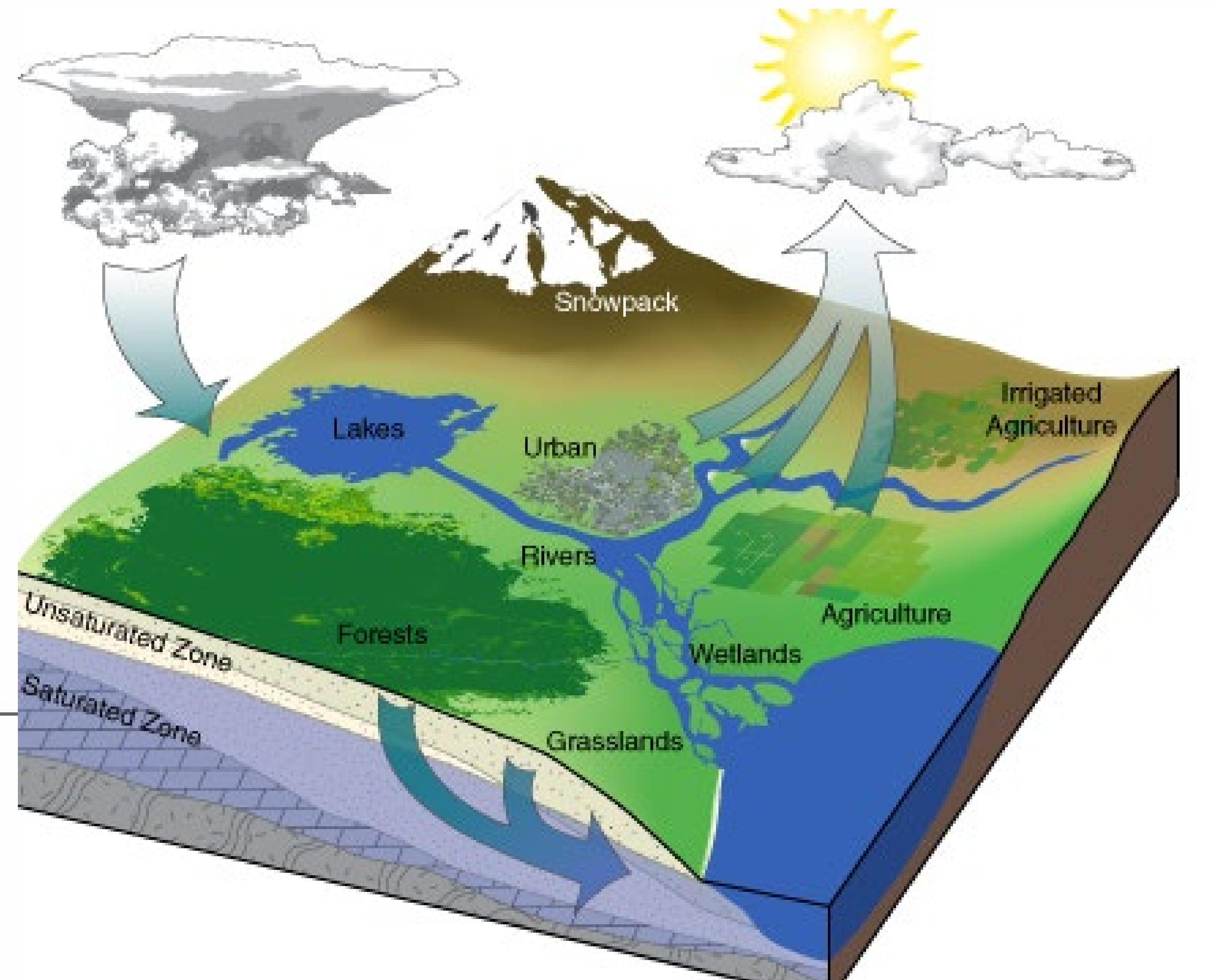
  value = f(land cover, population, distance to roads, climate,..)

Example modelling techniques (2/2)

- Geostatistical model
  - > Use algorithms to predict the measure of unknown locations on the basis of measures of nearby known measures:
  - > Spatial interpolation

- Dynamic systems (such as process-based models)
  - > Predict ecosystem services based on modelling of processes involved in supplying the service:
  - > Example:
    - Hydrological model to model water flow regulation
    - SWAT (soil and water assessment tool)





SEEA

Software and tooling

- Depending on types of accounts prioritized, available data and expertise in the country, different ecosystem extent, condition and service models may require different software.
- GIS software for displaying spatial data will likely be needed regardless
- Two most widely used GIS systems are:
  - ArcGIS: commercial product
  - QuantumGIS (also called QGIS): freeware
- Which one to select - depends upon context:
  - Which systems are already used in the government agencies supplying / processing data?
  - Budget
- Also other web-based platforms to consider such as Google Earth Engine
- Programming languages like R or Python have several packages for spatial analysis that can facilitate efficient workflows in the production of results and reports

Overview of platforms with potential use in SEEA EA

Modelling platform	Primary goal of platform	Coverage
ARIES (Villa et al., 2014)	ARIES (Artificial Intelligence for Ecosystem Services). Provides easy access to data and models through a web-based explorer and using Artificial Intelligence to simplify model selection, promoting transparent reuse of data and models in accordance with the FAIR principles.	Extent, Condition, Ecosystem Services
Data4Nature	Data4Nature (formerly known as EnSym - Environmental Systems Modelling Platform) is a decision support tool that is designed to answer questions about where organizations should invest in their natural resources. Data4Nature is specifically designed with SEEA EA in mind.	Extent, Ecosystem Services
ESTIMAP (Zulian et al., 2018)	ESTIMAP (Ecosystem Services Mapping tool) is a collection of models for mapping ecosystem services in a multi scale perspective (it can be applied at different scales) (Zulian et. al 2018).	Ecosystem Services
InVEST (Sharp et al., 2018)	A compilation of open-source models for mapping and valuing ecosystem services. InVEST is the flagship tool of the Natural Capital Project and has been the most widely used ecosystem service modelling tool globally.	Ecosystem Services, Condition
i-Tree	i-Tree is a tool developed by the USDA Forest Service with capabilities of modelling ecosystem services related to trees, particularly in urban settings (i.e. air filtration, carbon storage urban heat island mitigation, and rainfall interception and infiltration).	Ecosystem Services (forest related)
Nature Braid (Jackson et al., 2013)	The Nature Braid (formerly LUCI/Polyscape) provides a suite of high spatial resolution ecosystem services models designed to improve decision-making around restoration and land management. The Nature Braid is particularly well suited for mapping soil, water and chemical transport processes at high resolution.	Extent, Condition, Ecosystem Services (hydrological, soil)

Coverage by selected modeling platforms

			ARIES	InVEST	LUCI	ESTIMAP	Data4Nature	iTree
Provisioning services								
	Biomass pr	Crop provisioning	x	x	i		x	
		Grazed biomass provisioning					x	
		Timber provisioning	x				x	
		Non-timber forest products and other biomass provisioning	m					
		Fish and other aquatic products provisioning		x				
	Water supply		x		x		x	
	Genetic material							
Regulating and maintenance services								
	Global climate regulation services		x	x	x		x	x
	Rainfall pattern regulation services						x	
	Local (micro and meso) climate regulation services			i			x	x
	Air filtration services					x		x
	Soil erosion control services		x	x	x	x	x	
	Water purification services			x	x	x	x	
	Water flow regulation services			x	i	x	x	
	Flood mitigation services (coastal or riverine)		x	i		x	x	
	Storm mitigation services					x		x
	Noise attentuation services							
	Pollination services		x	x		x		
	Pest control services					x		
	Nursery population & habitat maintenance services					x	x	
	Soil waste remediation services							
	Other regulating and maintenance services						x	
Cultural services								
	Recreation-related services		x	x		x		

Monetary valuation

Context

- SEEA relation to SNA:
  - SEEA CF expands asset boundary
  - SEEA EA expands also the production boundary with ecosystem services
  - ES conceptualized as transactions between ecosystems assets (supply) and beneficiaries (users)
  - ES are contributions to benefits, not benefits per se
    - For example: crops -> already exchanged in markets
  - Distinguishing ES as “outputs” from “costs” as inputs, clear departure from restoration cost approach
- Main approach/intent is to be consistent with valuation principles of SNA
  - Exchange value (not welfare value)
  - Similar to for instance unpaid household work

Monetary valuation accounts in SEEA EA

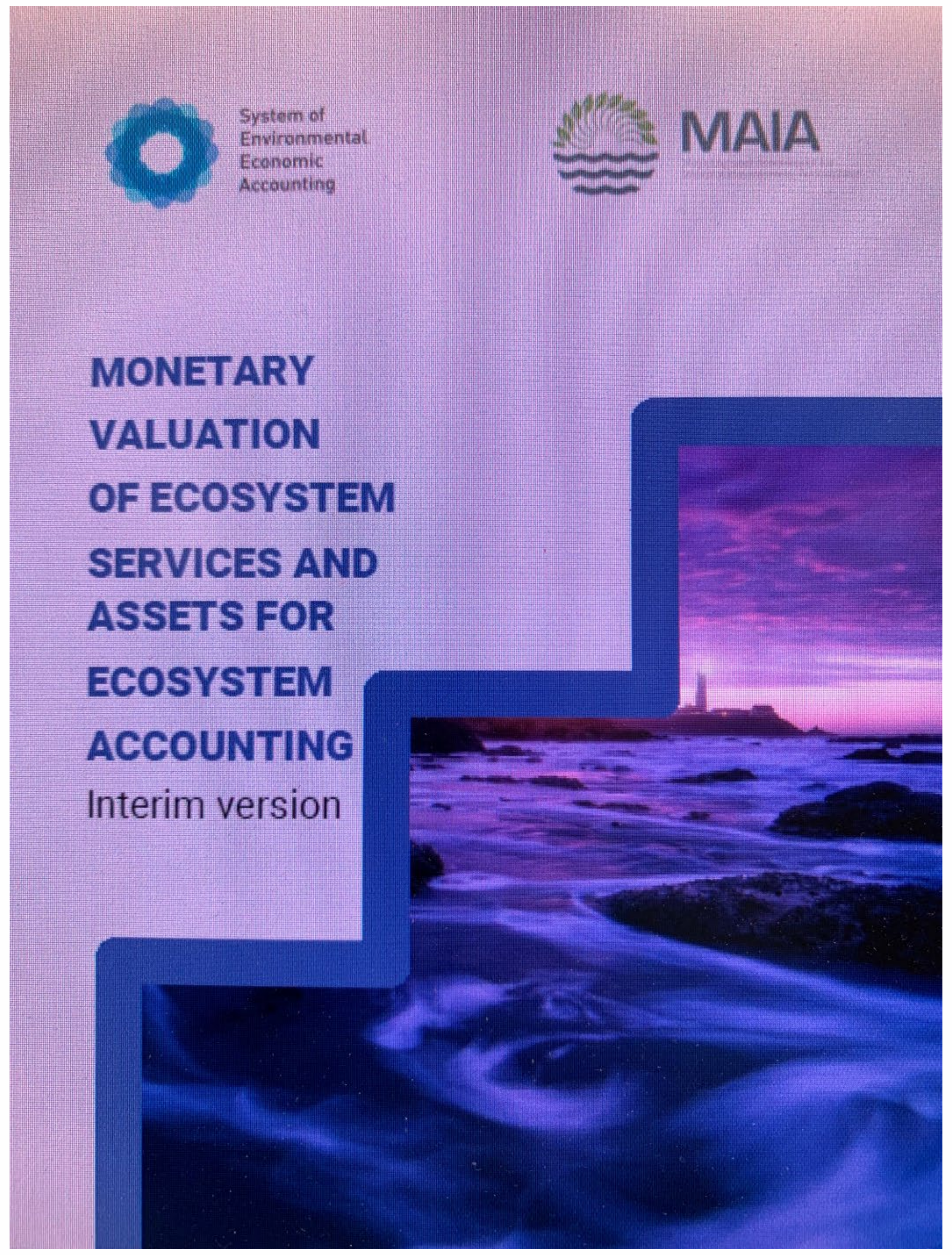
- Foundation in physical measurement
- Place SEEA EA in context of broader welfare measurement (focus on "use")
- Accounts, described in Chapters 8-11:
  - Ecosystem services accounts in monetary units
  - Monetary ecosystem asset accounts (including degradation / enhancement)
  - Integrated presentations
  - Complementary valuation approaches (e.g. welfare based; polluter pays principle etc.)
- SEEA Ecosystem Accounting adopted in March 2021
  - *Chapters 1-7 with conceptual framework and physical accounts as statistical standard*
  - *Chapters 8-11 recognized as describing <u>internationally recognized statistical principles and recommendations</u> for the valuation of ecosystem services and assets <u>in a context that is coherent with the concepts of System of National Accounts</u>*
  - *Requested the Committee to promptly resolve the <u>outstanding methodological aspects</u> in chapters 8–11 as identified in the <u>research agenda</u>.*

Valuation methods that generate exchange values

EA order	SEEA EA Category of method	
1	**Prices are directly observable**	Market prices
2	**Prices from similar markets**	Similar markets
3	**Prices embodied in market transactions**	Residual value; Reso
		Hedonic Pricing
		Productivity Change
4	**Prices from revealed expenditures on related goods and services**	Averting Behaviour
		Travel Cost
5	**Prices from expected expenditures or expected markets**	Replacement Cost
		Avoided Damage Co
		Simulated Exchange

Valuation report – outline

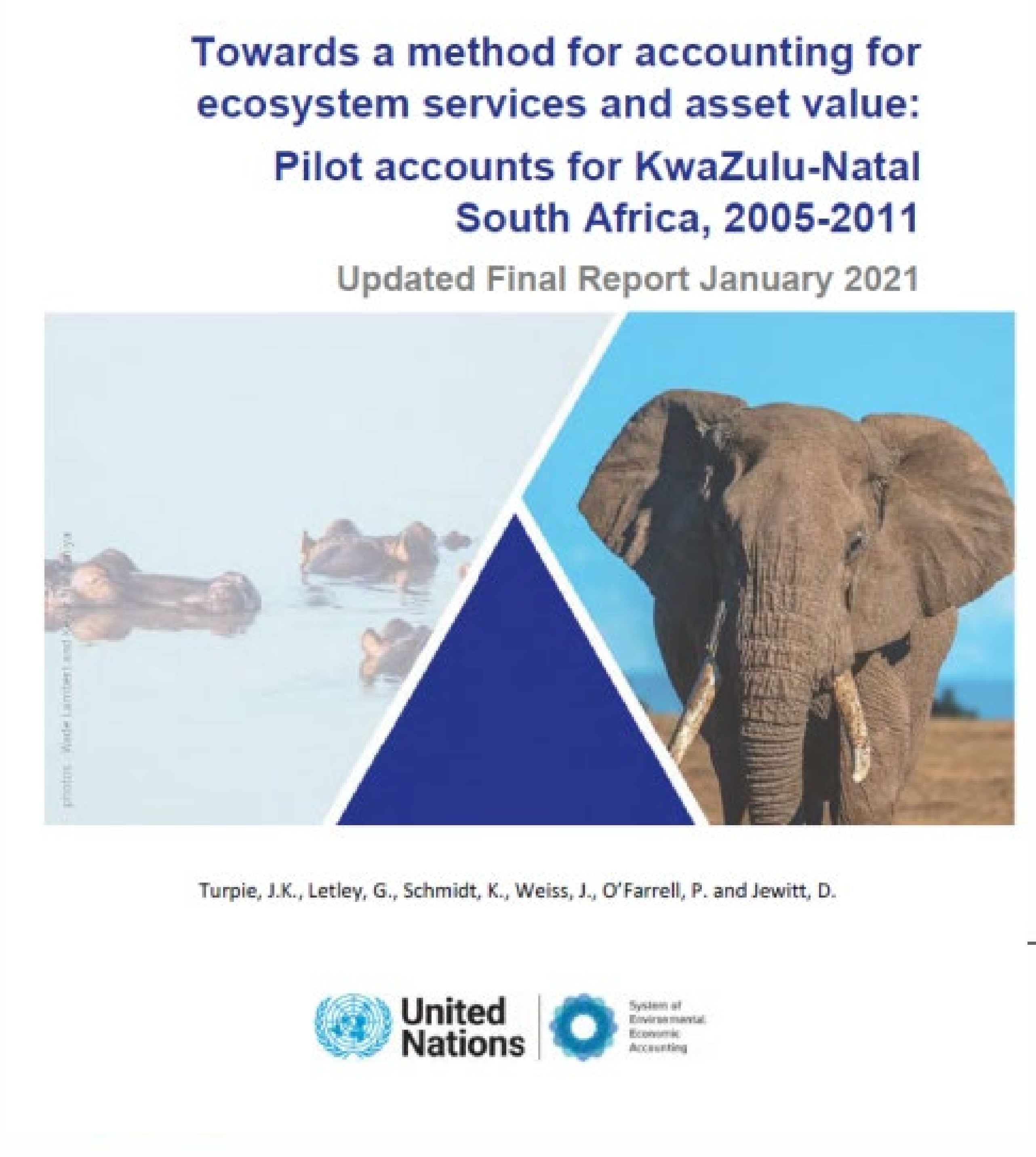
1. Introduction
2. Foundations
3. Valuation methods
4. Valuing ecosystem services
    1. *Tiers per ES*
5. Valuing ecosystem assets
6. Other considerations
    1. *Value transfer*
    2. *Platforms and tools*
    3. *Aggregation*
    4. *Communicating values*



Examples

Example: South Africa (1/10)

- Output of the NCAVES project
- Modelled 11 different ES for 2005 and 2011
- Kwazulu-Natal (KZN) province
- Physical + monetary

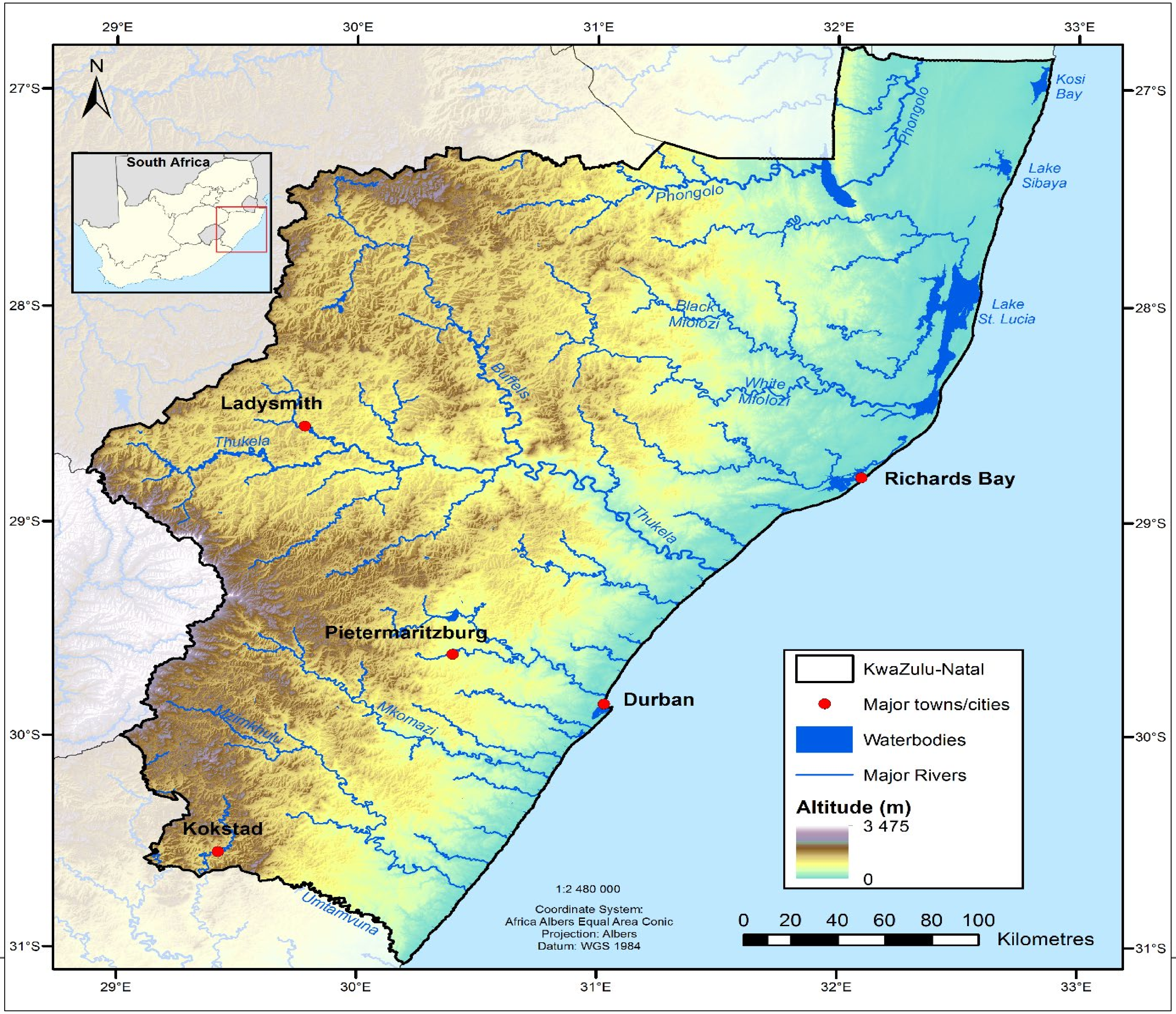

Towards a method for accounting for ecosystem services and asset value:

Pilot accounts for KwaZulu-Natal South Africa, 2005-2011

Updated Final Report January 2021

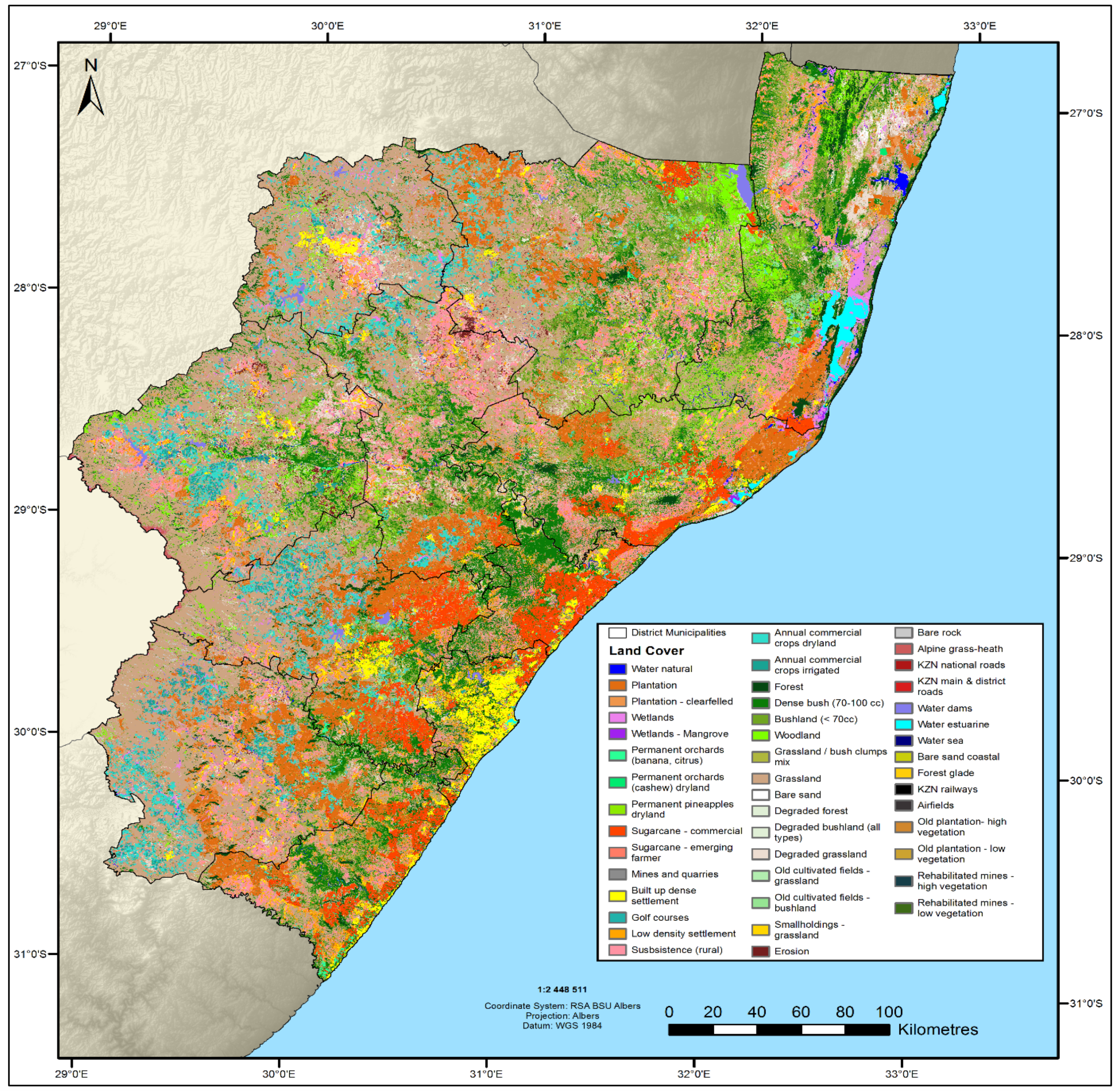
Turpie, J.K., Letley, G., Schmidt, K., Weiss, J., O'Farrell, P. and Jewitt, D.

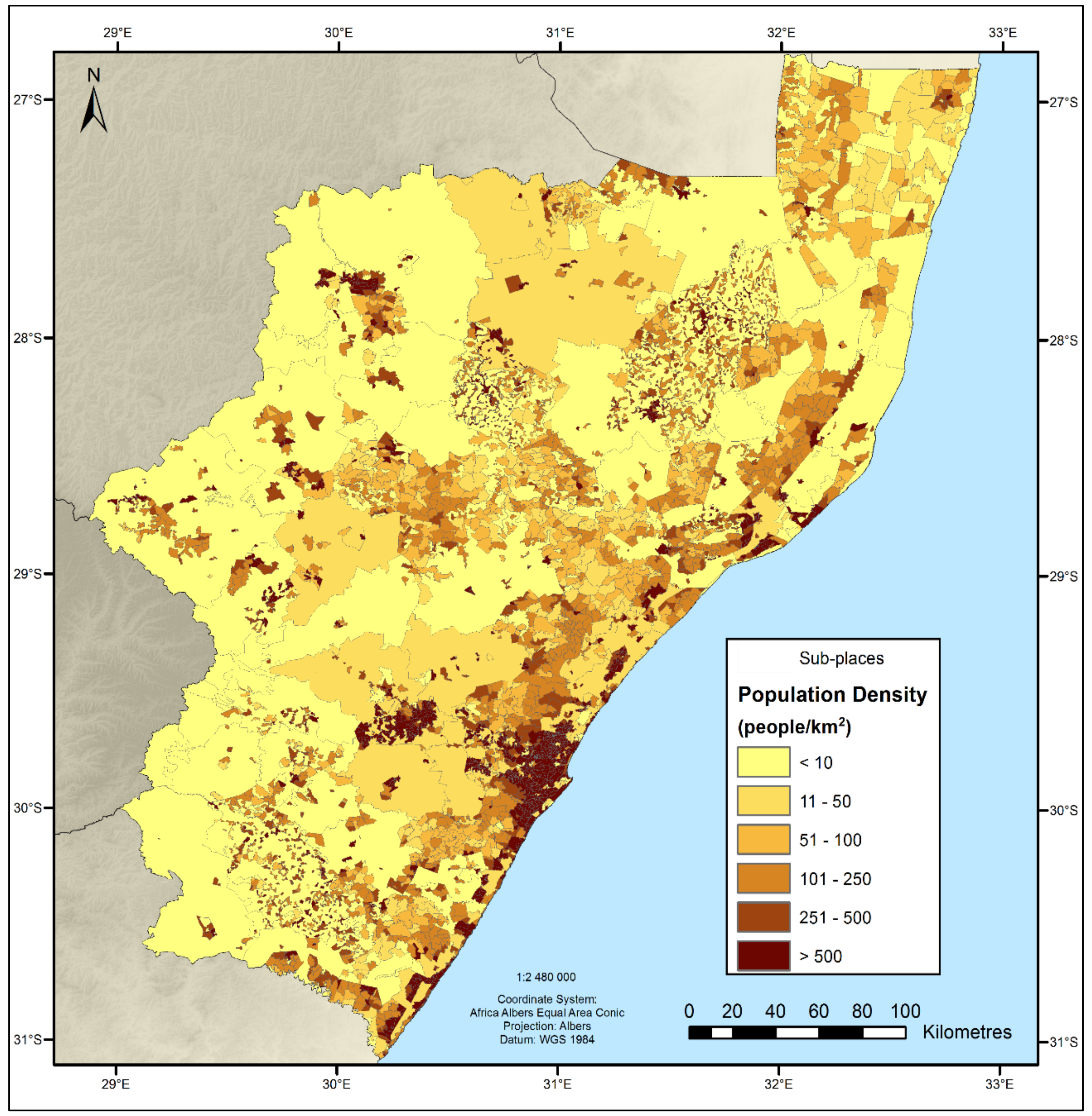
United Nations

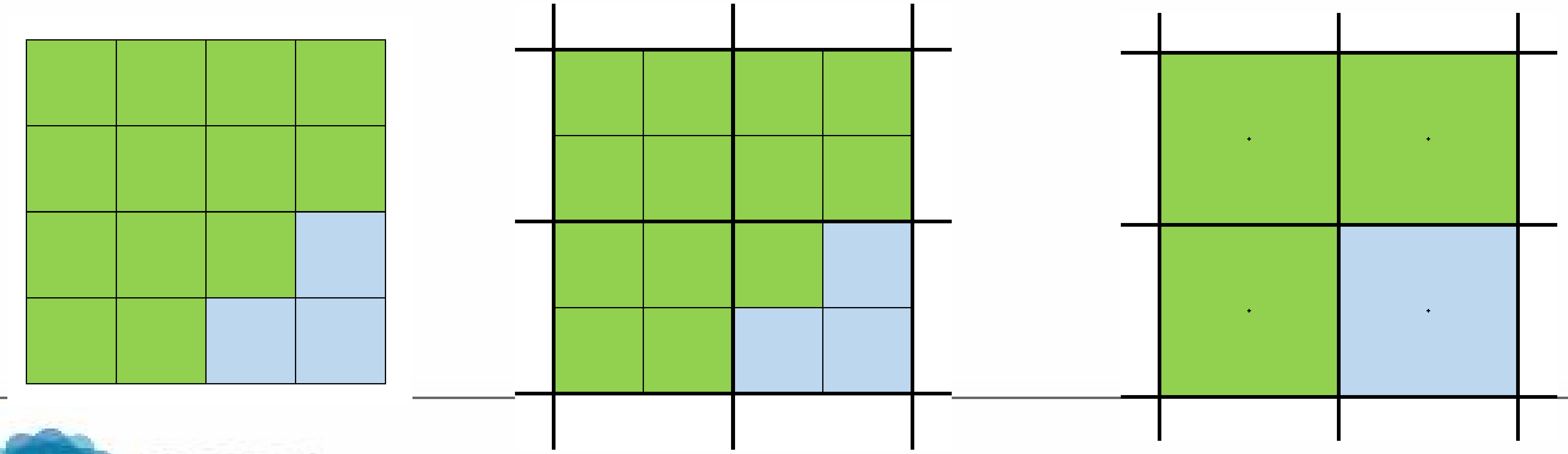


Source: Turpie et al. 2021

Example: South Africa (2/10)







- Spatial framework supported by creating a 100x100 m (1 ha) basic spatial unit grid
- All raster layers (e.g. land cover, use, biomes, census areas) are projected and snapped to the South Africa BSU grid
- →Allows integration of different spatial datasets, which are often at different resolutions
- →Ensures consistency across analysis of all ecosystem services; ensures that you do not have any overlaps for any given area per land cover or ET type

SEEA

Source: Turpie et al. 2021

Example: South Africa (3/10)

ES1: Wild resources

- People in KZN use hundreds of species of plants and animals for food, medicine, energy and raw materials.
- For the purposes of this study and based on the nature of the data, the resources were grouped

	Purpose	Group
Wild plant resources	Nutrition and health	Wild plant foods and medicines
	Energy	Wood fuel
	Raw materials	Grass
		Reeds and sedges
		Palm leaves
		Poles and withies
		Timber
		Wood for carving/curios
Wild animal resources	Nutrition	Terrestrial birds and animals
		Fish and other aquatic organisms

Source: Turpie et al. 2021

- Step 1: Quantities demanded
  - Estimated at the census sub-place (~village) level based on household survey data and census data on numbers of households and types of dwelling.
  - Relevant census data: population, number of households, average household size, number of traditional dwellings, number of informal dwellings, households using wood, number of households collecting water from rivers and streams, and number of households using wood for heating and cooking.

Example South Africa (4/10)

- Step 2: Aggregate potential household demand estimated using additional information but also statistical models
  > To relate average use to household characteristics,
  > in this way, the total demand (e.g. kg/y, m3/y) for each resource was estimated for each sub-place

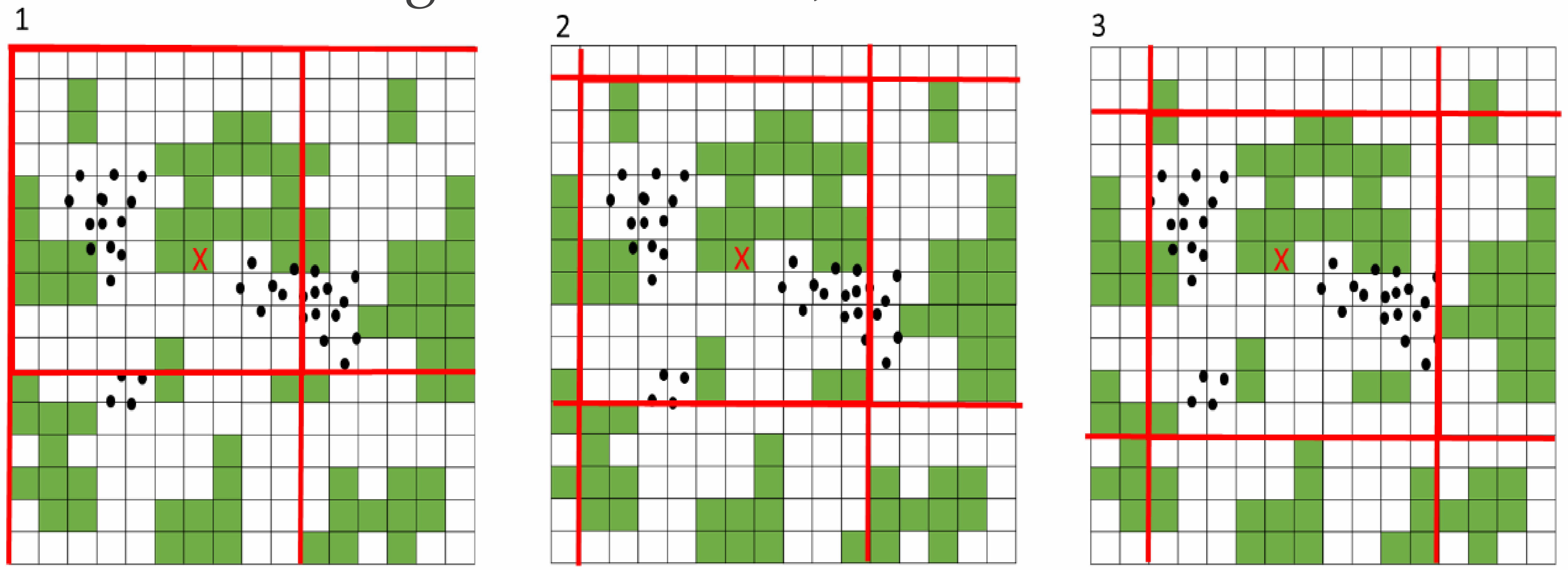
Resource group	Method/assumptions	Number of studies used	Other information
Fuelwood	hh using fuelwood; 3000 kg/hh/year	18	Converted kg/y into m^3/y using avg. wood density of 0.855 g/cm^3 (FAO)
Poles & withies	66% hh, 200 kg/hh/year	12	
Timber & wood	4% hh; 900 kg/hh/year	3	
Grass	33% hh; 76 bundles/hh/year	7	Grass bundle = 4.9 kg
Reeds & sedges	Turpie *et al.* (2010a) model	2	Reed bundle = 7 kg
Palm leaves	1.2% trad. hh; 660 leaves/hh/year	2	Each leaf provides 0.31 kg of weaving material
Wild fruits	Turpie *et al.* (2010a) model	1	
Wild vegetables	75% hh; 20 kg/hh/year	9	
Medicines	26% hh; 32 kg/hh/year	4	
Wild animals	Turpie *et al.* (2010a) model	1	
Wild birds	Turpie *et al.* (2010a) model	1	Avg. bird weight of 0.9kg
Fish	Turpie *et al.* (2010a) model	1	

Source: Turpie et al. 2021

- Step 3: Estimate the supply:
  > Estimated using vegetation maps
  > All harvestable resources were considered fully available and accessible within areas under communal land tenure.
  > Availability reduced to 10% of standing stocks in protected areas and for natural land under private ownership, such as commercial rangelands or wildlife ranches.

Example South Africa (5/10)

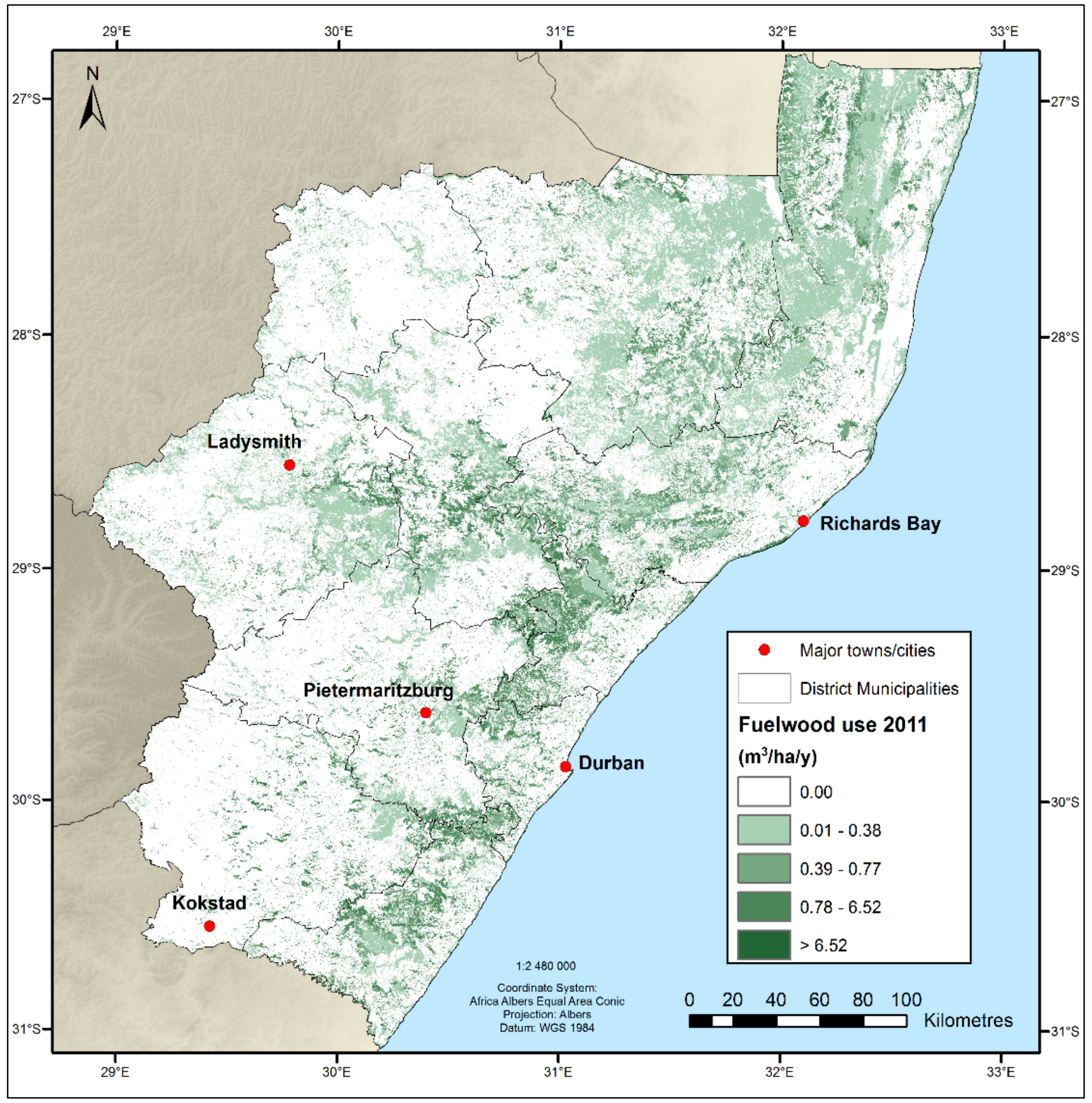
- Supply and demand secured→
- Step 4: Model actual amount of wild resources harvested for subsistence using a geostatistical model:
  - > Goal: estimation of the amount harvested for each grid cell
  - > Estimation based on the minimum of the estimated demand and the estimated available stocks of resources within a specified distance of the demand source
  - > an estimated average travelling distance to harvest natural resources of about 6 km
  - > implemented with a "running mean" model, which allows to estimate at a higher resolution

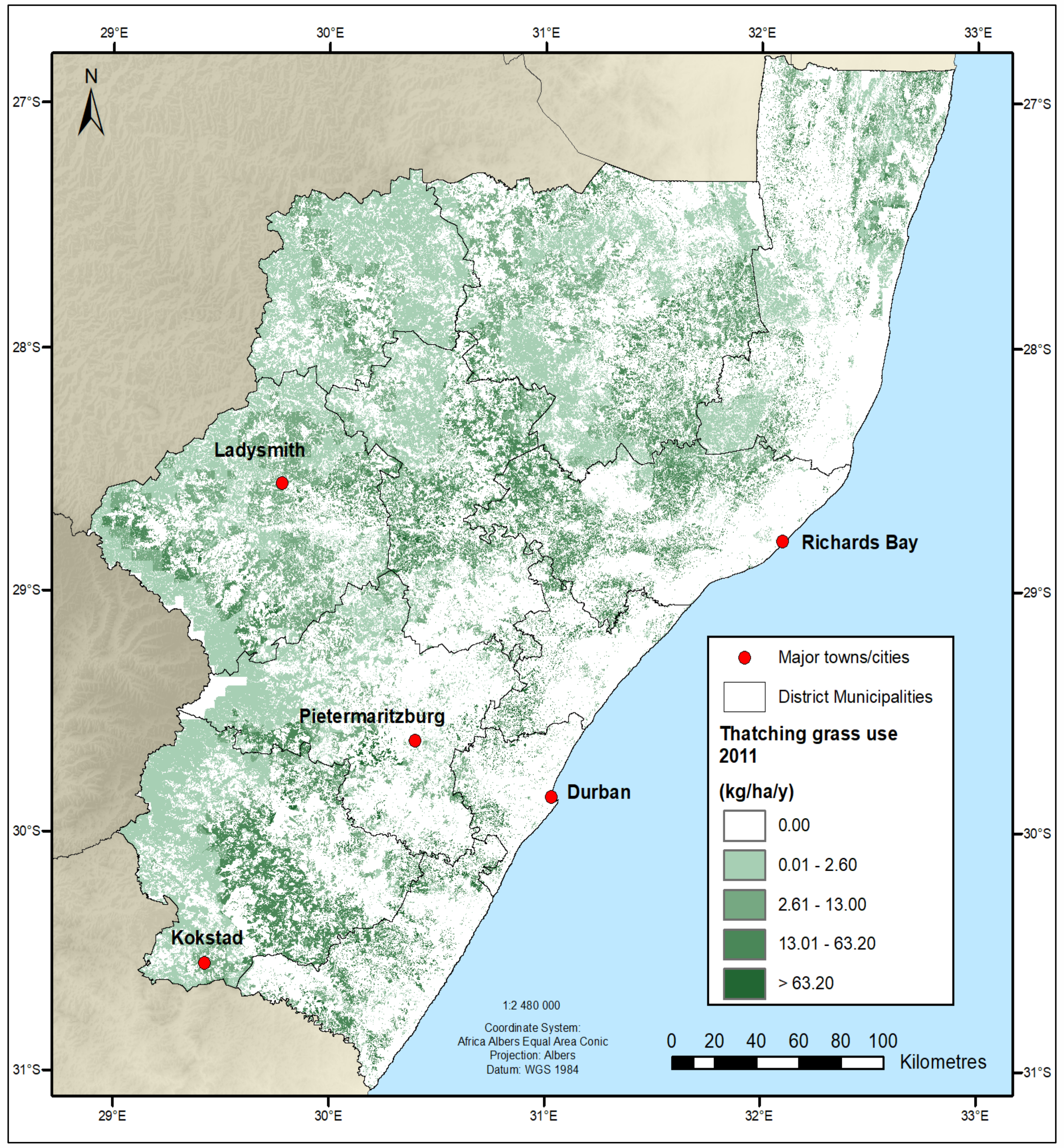


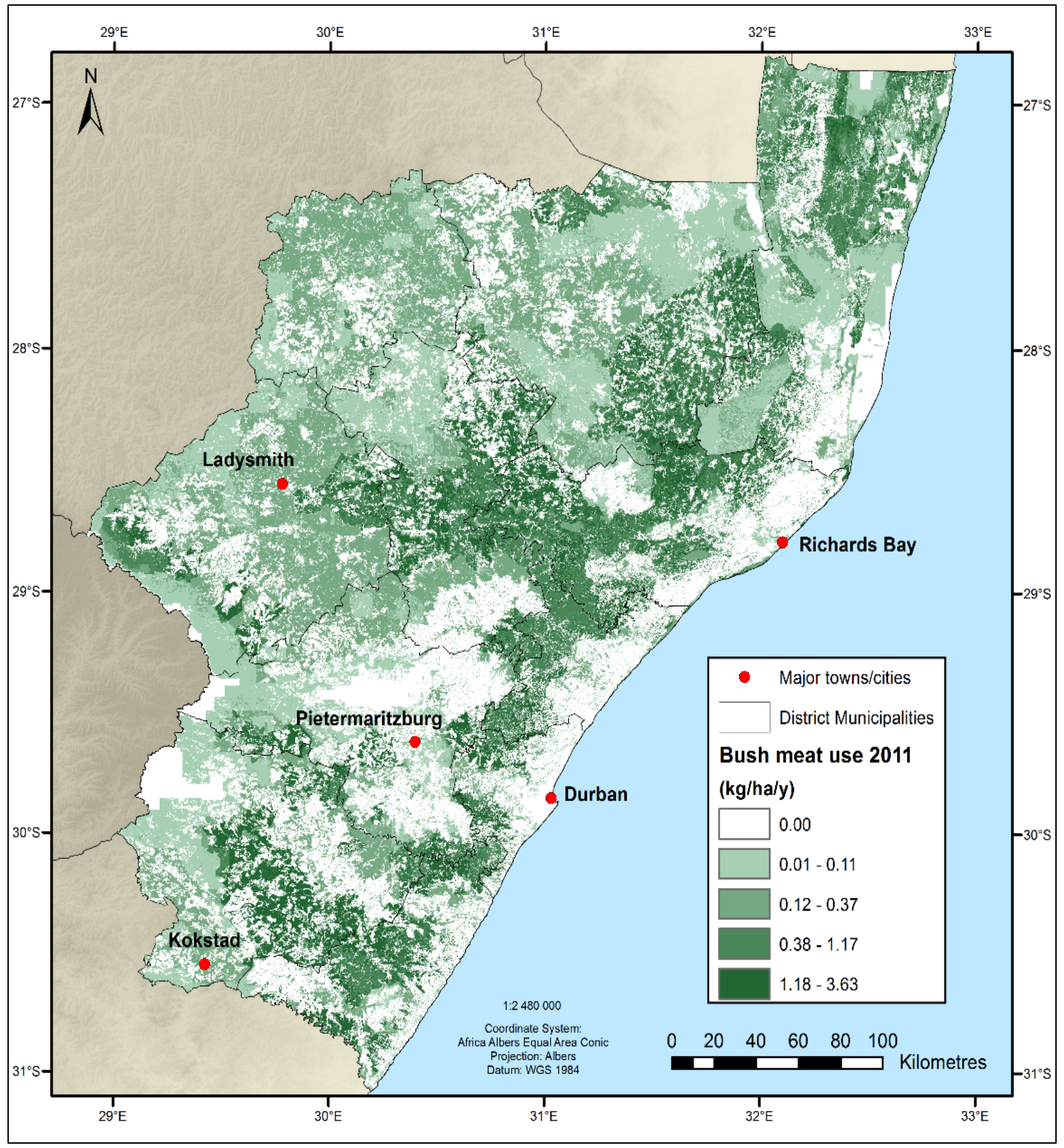
Source: Turpie et al. 2021

Running mean model used: Green areas are areas with stocks of a resource, and the dots are households demanding the resource at a certain rate.

Example South Africa (6/10)







Source: Turpie et al. 2021

- Results in form of maps
- Fuelwood, thatching grass, bush meat 2011

SEEA

Example South Africa (7/10)

- After spatial overlay with ecosystem extent map
- Summarized as physical supply and use tables

Biome / Resource	Freshwater ecosystems	Grassland	Indian Ocean Coastal Belt	Savanna	Forests	Estuaries	TOTAL
Fuelwood (m^3)	3 341	663 349	223 178	755 244	247 315	158	**1 892 584**
Poles (m^3)	163	29 645	10 948	28 560	11 165	8	**80 489**
Timber (m^3)	20	2 643	999	3 491	8 567	3	**15 723**
Thatching grass (tonnes)	33	25 973	4 935	17 383	59	3	**48 384**
Reeds & sedges (tonnes)	752	3 801	1 508	2 371	324	22	**8 779**
Palm leaves (tonnes)	-	-	292	-	-	-	**292**
Wild foods/med (tonnes)	121	14 483	4 951	13 113	2 327	6	**35 001**
Bushmeat (tonnes)	6	1 542	338	1 934	179	0	**3 998**
Fish (tonnes)*	42	315	75	298	22	8	**759**

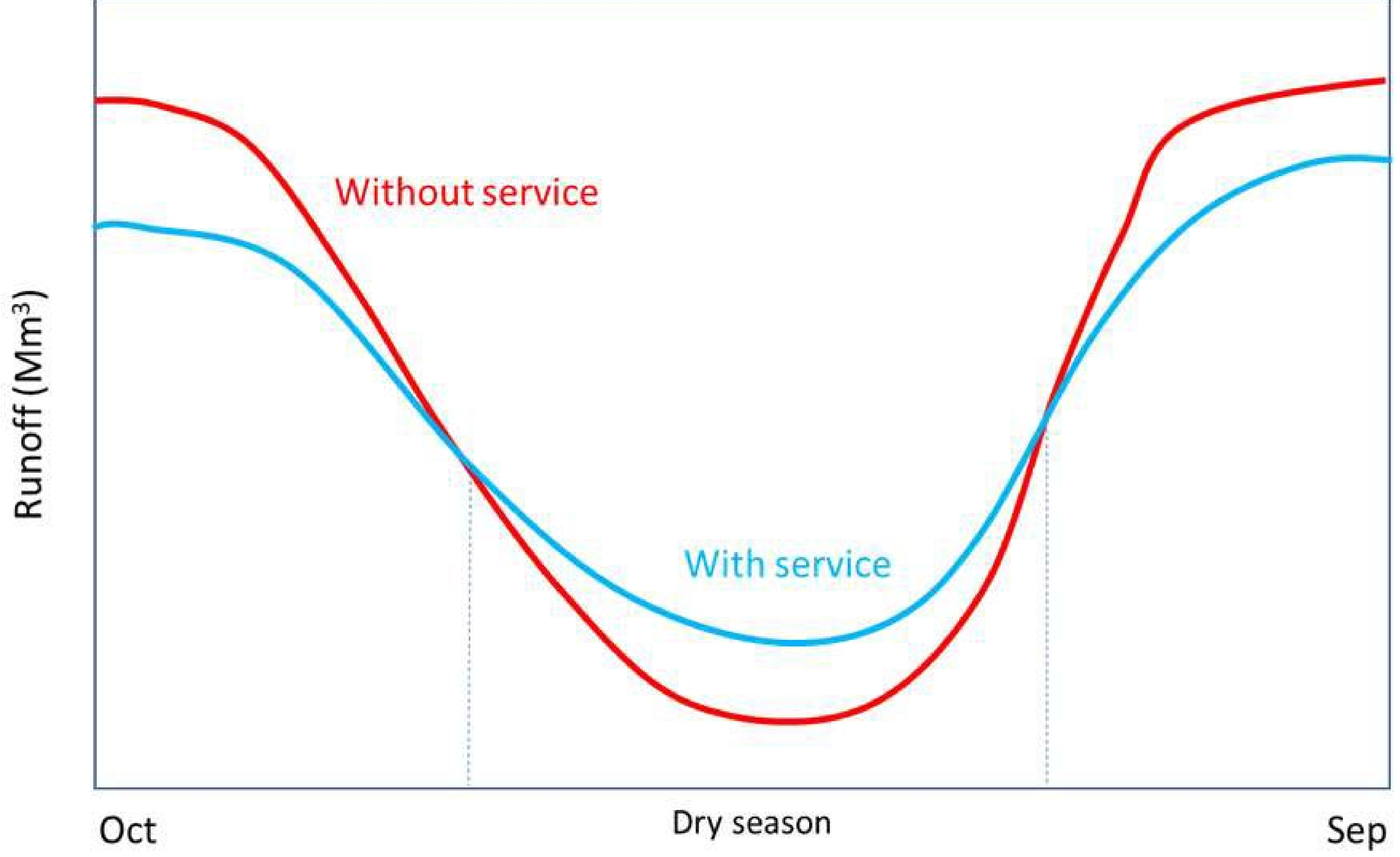
Source: Turpie et al. 2021

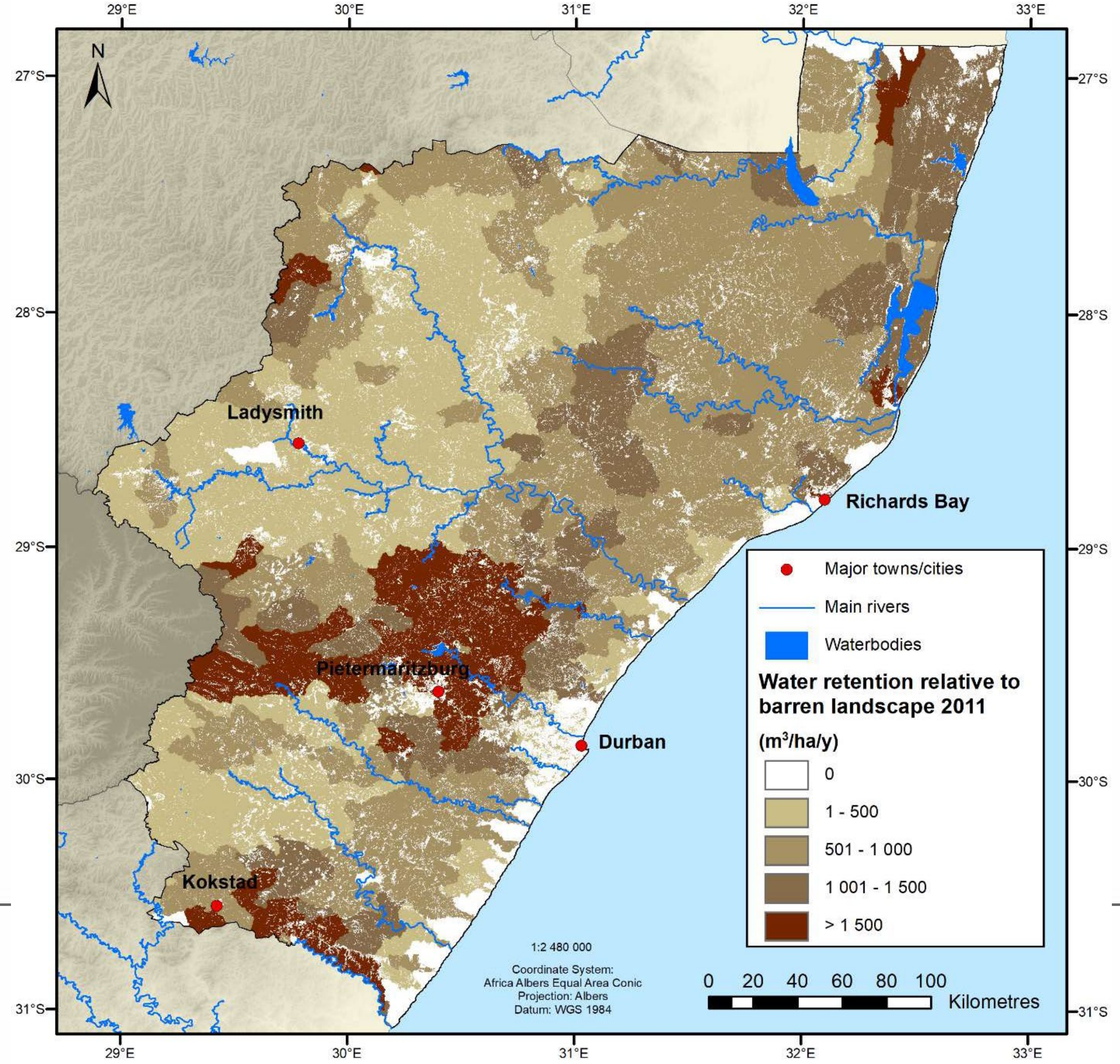
SEEA

Example South Africa (8/10)

ES 2: Water flow regulation

- KZN – water flow regulation modelled with SWAT – soil and water assessment tool—process based model for quality/quantity of surface and ground water
- Used rainfall data from 1979-2015; model calibrated using gauging station data
- ES measured as difference in infiltration relative to a barren scenario, in m3 per ha. This was obtained from the SWAT output “Percolation”, given in mm.
- Main intuition: ecosystems function as ‘sponges’ mitigating peaks and ensuring higher base flows
- Modeled at sub river basin level
- Results in maps and tables





Source: Turpie et al. 2021

SEEA

Example: South Africa (9/10)

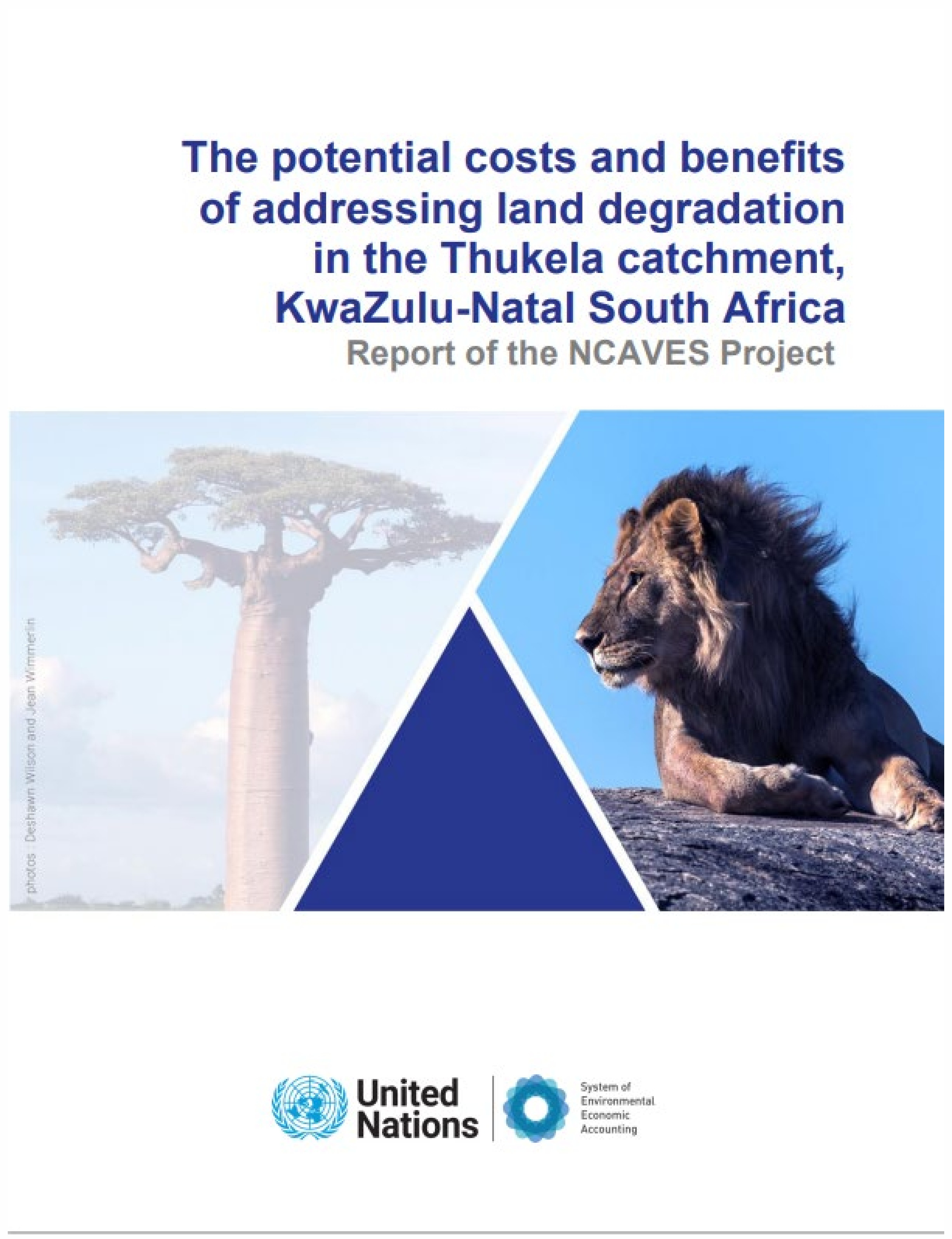
- All 11 ES modeled spatially
- After integration, physical supply and use tables (and monetary SUTs + monetary asset account

Table 5.1. Total biophysical supply per ecosystem type 2005

Resource / Biome	Freshwater ecosystems	Grassland	Indian Ocean Coastal Belt	Savanna	Forests	Estuaries	Cultivated	Urban green space	Total
Wood products (m^3)	3 523	695 638	235 125	787 294	267 047	169			**1 988 796**
Non-wood products (tonnes)	834	46 494	11 489	34 952	2 911	38			**96 718**
Livestock production (LSU)	1 716	684 698	52 162	289 663	2 010	340			**1 030 589**
Crop production (tonnes)							43 305 781		**43 305 781**
Experiential value (R millions)	14	237	179	218	55	24	85	885	**1 698**
Carbon storage (Tg C)	5	512	61	348	33	0	279		**1 237**
Pollination (R millions)	0	12	6	31	2	0			**51**
Flow regulation (million m^3)	78	3 315	421	2 198	634	36			**6 682**
Flood attenuation (R millions)								31	**31**
Sediment retention (million tonnes)	2	45	6	27	18	2			**99**
Water quality amelioration (tonnes P)	-	3 829	525	5 394	97	6			**9 850**

Source: Turpie et al. 2021

Example South Africa (10/10)


The potential costs and benefits of addressing land degradation in the Thukela catchment, KwaZulu-Natal South Africa
Report of the NCAVES Project

- Policy use:
  - > Accounts applied in policy scenario analysis
  - > Cost-benefit analysis of addressing land degradation in the Thukela catchment
- Key outcomes:
  - > Halting and reversing ecosystem degradation has positive net economic benefits
  - > Preventing degradation now is more cost effective than fixing it later.
  - > In summary, the benefits of restoring the Thukela basin would outweigh the costs.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ENVIRONMENT
It pays to save the Thukela River catchment
Sheree Bega 17 Jul 2021
Benefits: The Wagendrift Dam on the Bushmans River, a tributary of the Thukela River. Rehabilitating the Thukela River catchment in KwaZulu-Natal would reduce soil erosion, improve the grasslands and water supply, all of which

Source: Turpie et al. 2021 b

THANK YOU

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