



Carbon Accounting

(Levels 0, 1 and 2)

Project: Advancing the SEEA
Experimental Ecosystem Accounting



Convention on
Biological Diversity





Overview: The Carbon Accounting

1. Learning objectives

2. Review of Level 0 (5m)

- What is it?
- Why do we need it?
- What does it look like?
- Expertise & data required
- Links to related training materials

3. Level 1 (Compilers)

- Concepts (15m)
- Group exercise & Discussion (30m)

4. Level 2 (Data providers)

- Data options, examples & issues (15m)
- Group exercise & Discussion (15m)

5. Closing Discussion (10m)





SEEA-EEA Training Levels 1 and 2

- **Learning objectives**

- Level 1: To understand:

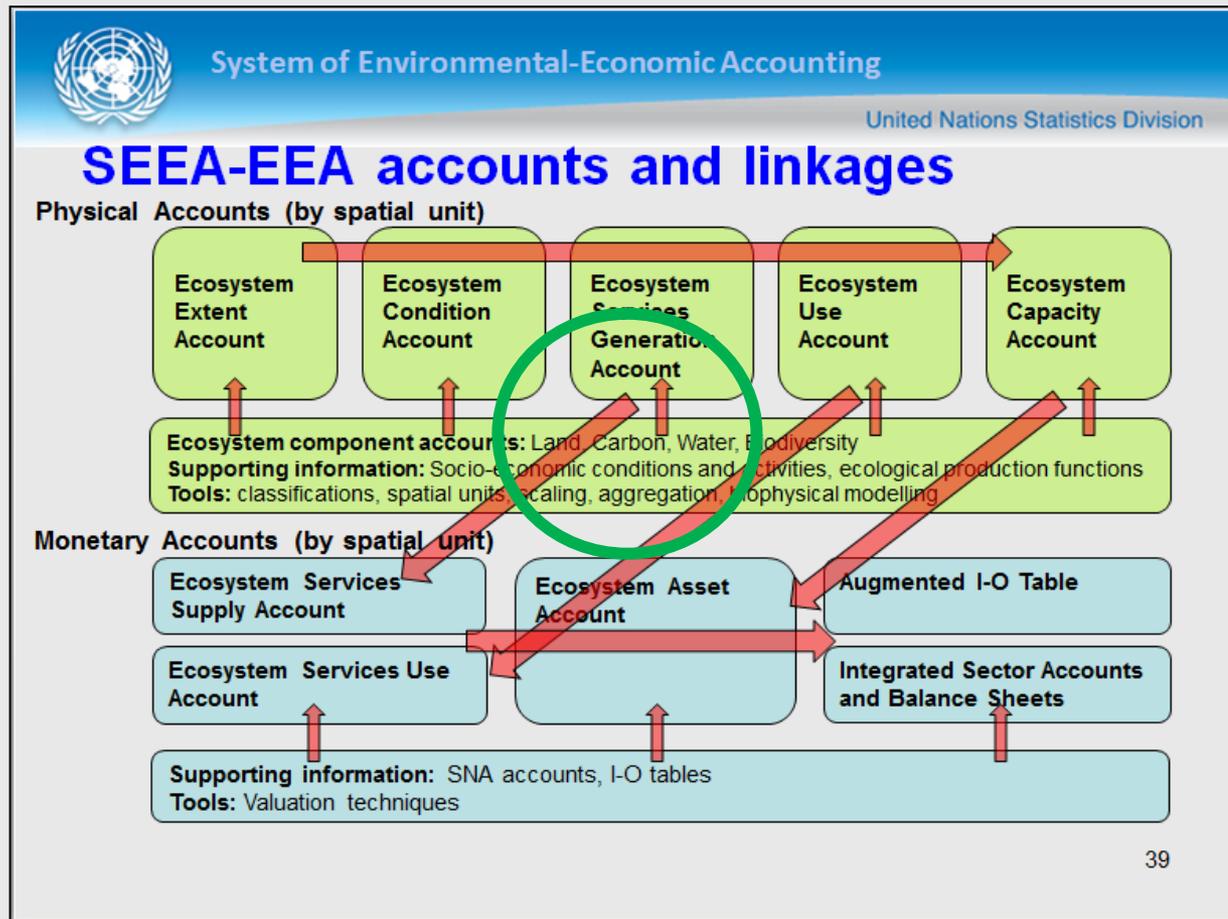
- Why carbon accounts are important
 - The basics of the carbon cycle and the difference between carbon stocks and carbon flows
 - How carbon is treated in the SEEA, including basic concepts and the structure of the accounts that include carbon
 - How to start to build a carbon asset account

- Level 2

- Understand the data options and sources
 - Be aware of how other countries have approached Carbon Accounting



Account 4: Carbon





Level 0: Account 4: Carbon

- **What?**

- Accounting for biocarbon as an asset (depletion)
- Carbon-related services (sequestration and storage)
- Carbon as a characteristic of ecosystem condition (productivity)

- **Why?**

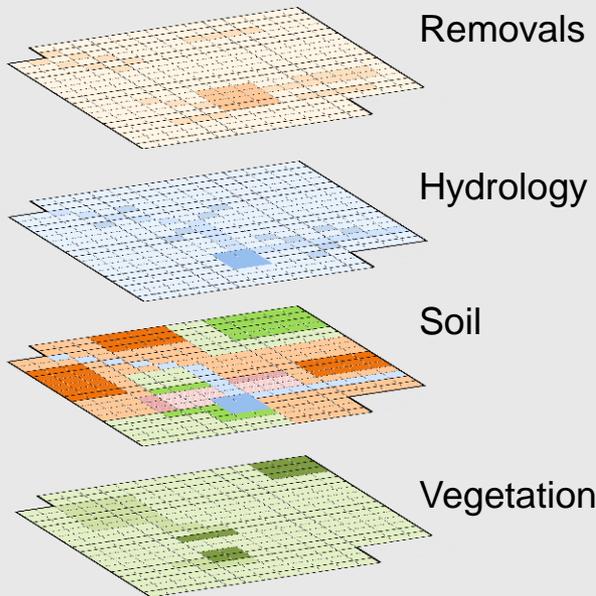
- Policies on climate change, low-carbon economy
- Assess changes in land cover, land use on carbon stocks and sequestration
- Links to other SEEA accounts (**Condition**, materials, **Services**)
- Links to SEEA-CF (timber and soil)
- Links to international guidelines ([IPCC](#) and [REDD+](#))
- Indicators:
 - Natural and human additions to carbon stock → where
 - Natural and human removals from carbon stock → where



Level 0: Account 4: Carbon

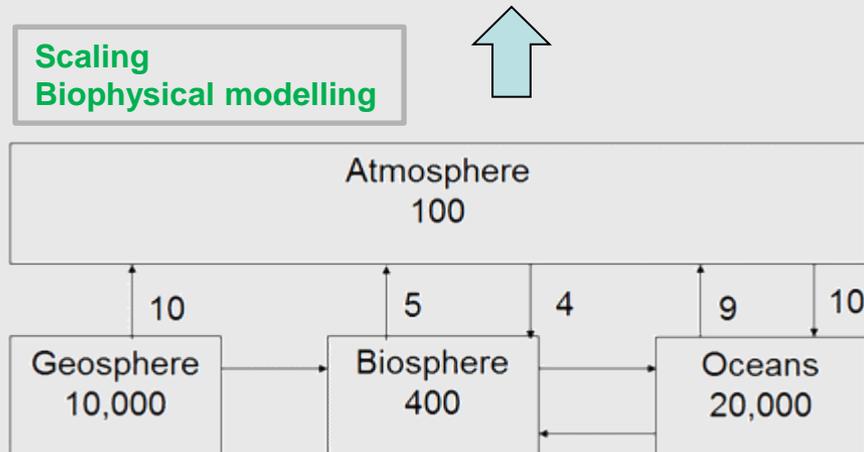
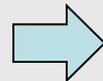
What does a Carbon Account look like?

Maps



Tables

	Geocarbon	Biocarbon	Oceans	Atmosphere
	billion tonnes C			
Opening stock	10,000	400	20,000	100
Additions	-	4	10	24
Reductions	10	5	9	14
Closing stock	9,990	399	20,001	110





Level 0: Account 4: Carbon

- **What does a Carbon Account look like?**
 - Spatially detailed in terms of:
 - Stock,
 - Additions, and
 - Reductions of biocarbon
 - Natural & human additions and removals



Level 0: Account 4: Carbon

- **What do you need to compile a Carbon Account?**
 - **Ecosystem Extent Account**
 - Common spatial infrastructure (**spatial units**)
 - Lookup tables (storage and sequestration by land cover type)
 - **Data:**
 - Biocarbon (above-ground biomass) from satellite data
 - Carbon sequestration and storage from vegetation cover
 - Soil carbon from soil type
 - Removals from agriculture, forestry data, fires
 - **Expertise:**
 - Ecologists (biophysical modelling)
 - Agriculture, forestry experts
 - Geographers (GIS, remote sensing)



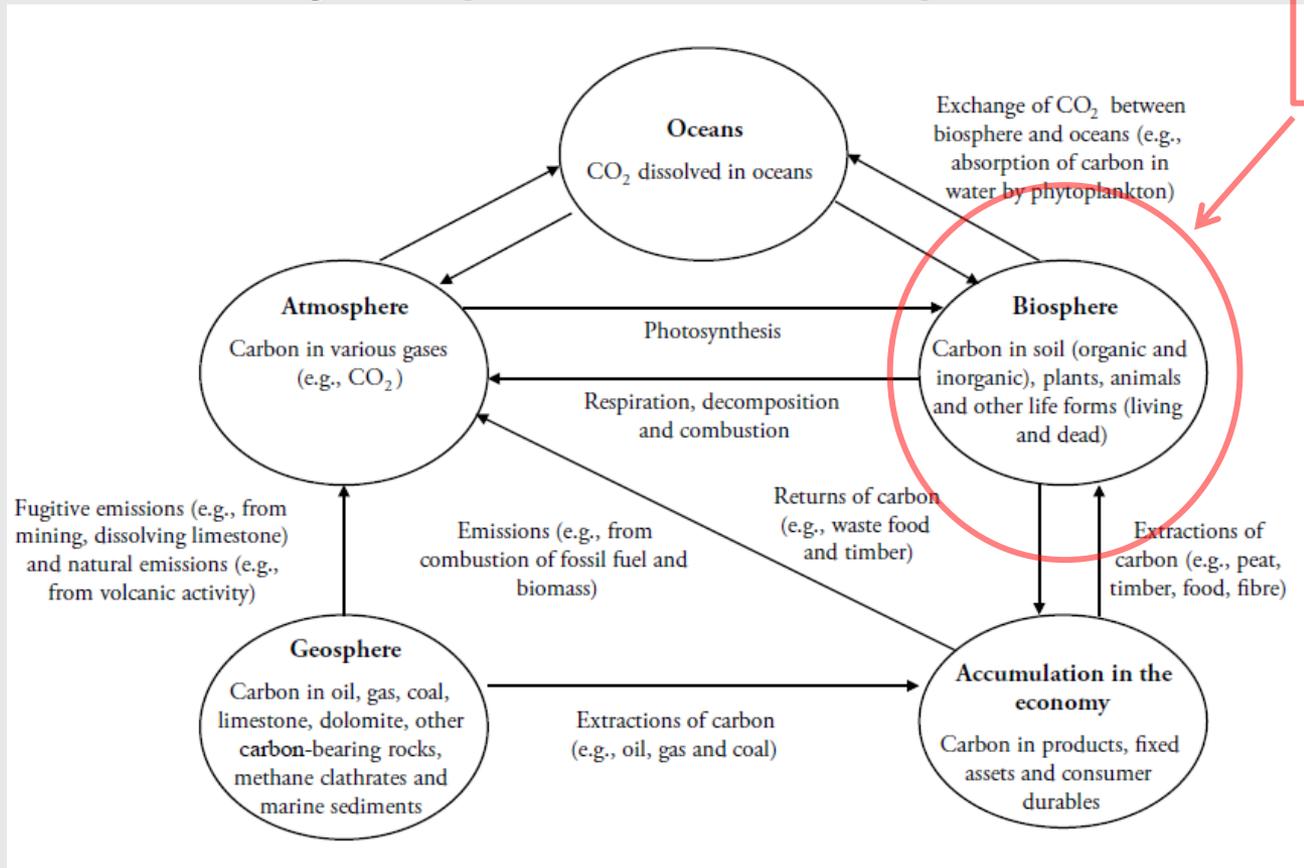
Level 1: Account 4: Carbon

- **Why carbon accounts?**
- Increasing atmospheric carbon is causing climate change:
 - Increasing temperatures, changes in rainfall, sea level rise
- Information on carbon stocks and flows supports:
 - Assessing the impact of changes in land cover and land use on carbon stocks and carbon sequestration
 - Assessing the impact of different policy options on industries and sectors. For example, a mandated reduction in the level of emissions from fossil fuels on the mining, manufacturing and agricultural industries
 - Information compilers to improve coherence between data sources and systematically address gaps and deficiencies in primary information sources



Level 1: Account 4: Carbon

▪ The Carbon Cycle (main elements)



This module



Level 1: Account 4: Carbon

The SEEA-EEA describes:

1. Carbon as an asset
 - Fossil fuels, soil carbon
2. Carbon-related ecosystem services
 - **Stock** = stored in soil, water and biomass
 - **Sequestration** = removal from the atmosphere
3. Carbon as a characteristic of ecosystem asset condition (**Condition Account**)
 - Biomass accumulation is an indicator of productive ecosystems



Level 1: Account 4: Carbon

- **Compilation Group Exercise (30m)**
 - **Situation:**
 - Land cover units defined for two periods (Opening and Closing)
 - Need to calculate: Land Cover Change, Carbon Stock and Carbon Sequestration
 - **Objective (Groups of 3-5):**
 1. Transfer Land Cover from map to table
 2. Calculate Land Cover Change Matrix
 3. Calculate Physical Account for Land Cover
 4. Calculate Simplified Carbon Stock Account
 5. Calculate Account for Ecosystem Services from Carbon Sequestration
 6. Report and discuss results



Level 1: Account 4: Carbon

Group Exercise: Step 1 – Calculate Land Cover

Opening Land Cover									
M	M	M	M	M	S	G	G	S	S
G	M	M	S	S	S	G	S	S	S
T	G	S	G	G	G	G	S	S	S
T	G	A	A	G	G	S	T	T	T
T	G	A	A	A	A	T	T	T	T
T	T	T	A	A	A	C	C	C	T
E	T	A	P	P	A	A	C	C	T
S	S	A	P	P	P	C	C	T	T
S	A	A	P	R	R	R	G	T	T
S	S	A	R	R	R	R	T	T	T

Closing Land Cover									
P	M	M	M	M	S	G	G	S	S
G	M	M	S	S	S	G	S	S	S
C	G	S	G	G	G	G	C	C	S
C	C	A	A	G	G	S	C	C	T
C	G	A	A	A	A	C	C	C	T
T	T	T	A	A	A	C	C	C	T
E	T	A	A	A	A	A	C	C	T
S	S	A	A	P	P	C	C	T	T
S	A	A	P	R	R	R	G	T	T
S	S	A	R	R	R	R	T	T	T

Land Cover Table

Opening Land Cover	Code	Count
Artificial surfaces	A	
Crops (a)	C	
Grassland	G	
Tree covered area	T	
Mangroves	M	
Shrub covered area	S	
Regularly flooded areas	R	
Sparse natural vegetated areas	P	
Terrestrial barren land	E	
Permanent snow, glaciers and inland water bodies	X	
Total		100

Closing Land Cover	Code	Count
Artificial surfaces	A	
Crops (a)	C	
Grassland	G	
Tree covered area	T	
Mangroves	M	
Shrub covered area	S	
Regularly flooded areas	R	
Sparse natural vegetated areas	P	
Terrestrial barren land	E	
Permanent snow, glaciers and inland water bodies	X	
Total		100



Level 1: Account 4: Carbon

Group Exercise: Step 2 – Calculate Land Cover Change

Land Cover Table

Opening Land Cover	Code	Count (ha)
Artificial surfaces	A	
Crops	C	
Grassland	G	
Tree covered area	T	
Mangroves	M	
Shrub covered area	S	
Regularly flooded areas	R	
Sparse natural vegetated areas	P	
Terrestrial barren land	E	
Permanent snow, glaciers and inland water bodies	X	
Total		100

Closing Land Cover	Code	Count (ha)
Artificial surfaces	A	
Crops	C	
Grassland	G	
Tree covered area	T	
Mangroves	M	
Shrub covered area	S	
Regularly flooded areas	R	
Sparse natural vegetated areas	P	
Terrestrial barren land	E	
Permanent snow, glaciers and inland water bodies	X	
Total		100

Land Cover Change Matrix

Table 1: Net Land Cover Change Matrix (hectares)

	Code	Closing Land Cover										Opening
		Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	
Opening Land Cover	Code	A	C	G	T	M	S	R	P	E	X	
Artificial surfaces	A											
Crops	C											
Grassland	G											
Tree covered area	T											
Mangroves	M											
Shrub covered area	S											
Regularly flooded areas	R											
Sparse natural vegetated areas	P											
Terrestrial barren land	E											
Permanent snow, glaciers and inland water bodies	X											
Closing												

Note: Rows represent reductions in stock; columns represent deletions in stock

Record "No change" in diagonal
 Rows = No change + Reductions
 Columns = No change + Additions



Level 1: Account 4: Carbon

Group Exercise: Step 3 – Calculate Physical Land Cover

Land Cover Change Matrix

Table 1: Net Land Cover Change Matrix (hectares)

		Closing Land Cover										
		Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Opening
Opening Land Cover	Code	A	C	G	T	M	S	R	P	E	X	
Artificial surfaces	A											
Crops	C											
Grassland	G											
Tree covered area	T											
Mangroves	M											
Shrub covered area	S											
Regularly flooded areas	R											
Sparse natural vegetated areas	P											
Terrestrial barren land	E											
Permanent snow, glaciers and inland water bodies	X											
Closing												

Note: Rows represent reductions in stock; columns represent deletions in stock

Additions to (A) Artificial surfaces

Physical Land Cover Account

Table 2: Physical Account for Land Cover

	Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Total
Opening Stock											
Additions to Stock											
Reductions in Stock											
Closing Stock											

Note: Reductions are sum of row, excluding areas that remained the same

Additions = Column total – no change
 Reductions = Row total – no change



Level 1: Account 4: Carbon

Group Exercise: Step 4 – Calculate Carbon Stock Account

Physical Land Cover Account

Table 2: Physical Account for Land Cover

	Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Total
Opening Stock											
Additions to Stock											
Reductions in Stock											
Closing Stock											

Note: Reductions are sum of row, excluding areas that remained the same

Carbon Stock Account

Table 4: Simplified Carbon Stock Account

	Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Total
Carbon Stored (tonnes/ha)	5	40	10	200	800	80	300	8	0	0	
Carbon Stock											
Opening											
Increases											
Decreases											
Net change											
Closing											

Note: Opening is Opening Land area * Carbon Stored
Net change is Increases - Decreases

Multiply Land Cover Area by Carbon Stored (Lookup Table)
e.g., Opening 16ha Artificial Surface * 5 tonnes/ha = 80 tonnes
Net Change = Increases + Decreases



Level 1: Account 4: Carbon

Group Exercise: Step 4 – Calculate Carbon Sequestration

Physical Land Cover Account

Table 2: Physical Account for Land Cover

	Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies
Opening Stock										
Additions to Stock										
Reductions in Stock										
Closing Stock										

Note: Reductions are sum of row, excluding areas that remained the same

Carbon Sequestration Services

Table 5: Account of Ecosystem Services from Carbon Sequestration (tonnes/ha/year)

	Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Total
Carbon Sequestration (tonnes/ha/year)	0	20	2	30	100	5	40	1	0	0	
Carbon Sequestration (tonnes/year)											
Opening: Carbon Sequestration											
Closing: Carbon Sequestration											
Net change											

Note: Opening is Opening land area * Carbon Sequestration

Multiply Land Cover Area by Carbon Sequestration (Lookup Table)
 e.g., Opening 7ha Crops * 20 tonnes/ha/year = 140 tonnes/year
 Net Change = Closing - Opening



Level 1: Account 4: Carbon

- Is everyone clear on the objectives?
- 30 minutes group work
- Please ask questions!
- Results:
 - Each group report:
 - Net change in Storage
 - Net change in Sequestration
 - What was the main source of change?
 - Bonus question:
 - Why does deforestation and degradation of forests often result in higher releases to the atmosphere?

Table 4: Simplified Carbon Stock Account

	Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Total
Carbon Stored (tonnes/ha)	5	40	10	200	800	80	300	8	0	0	
Carbon Stock											
Opening											
Increases											
Decreases											
Net change											
Closing											

Note: Opening is Opening Land area * Carbon Stored
Net change is Increases - Decreases

Table 5: Account of Ecosystem Services from Carbon Sequestration (tonnes/ha/year)

	Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Total
Carbon Sequestration (tonnes/ha/year)	0	20	2	30	100	5	40	1	0	0	
Carbon Sequestration (tonnes/year)											
Opening: Carbon Sequestration											
Closing: Carbon Sequestration											
Net change											

Note: Opening is Opening land area * Carbon Sequestration



Level 2: Account 4: Carbon

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

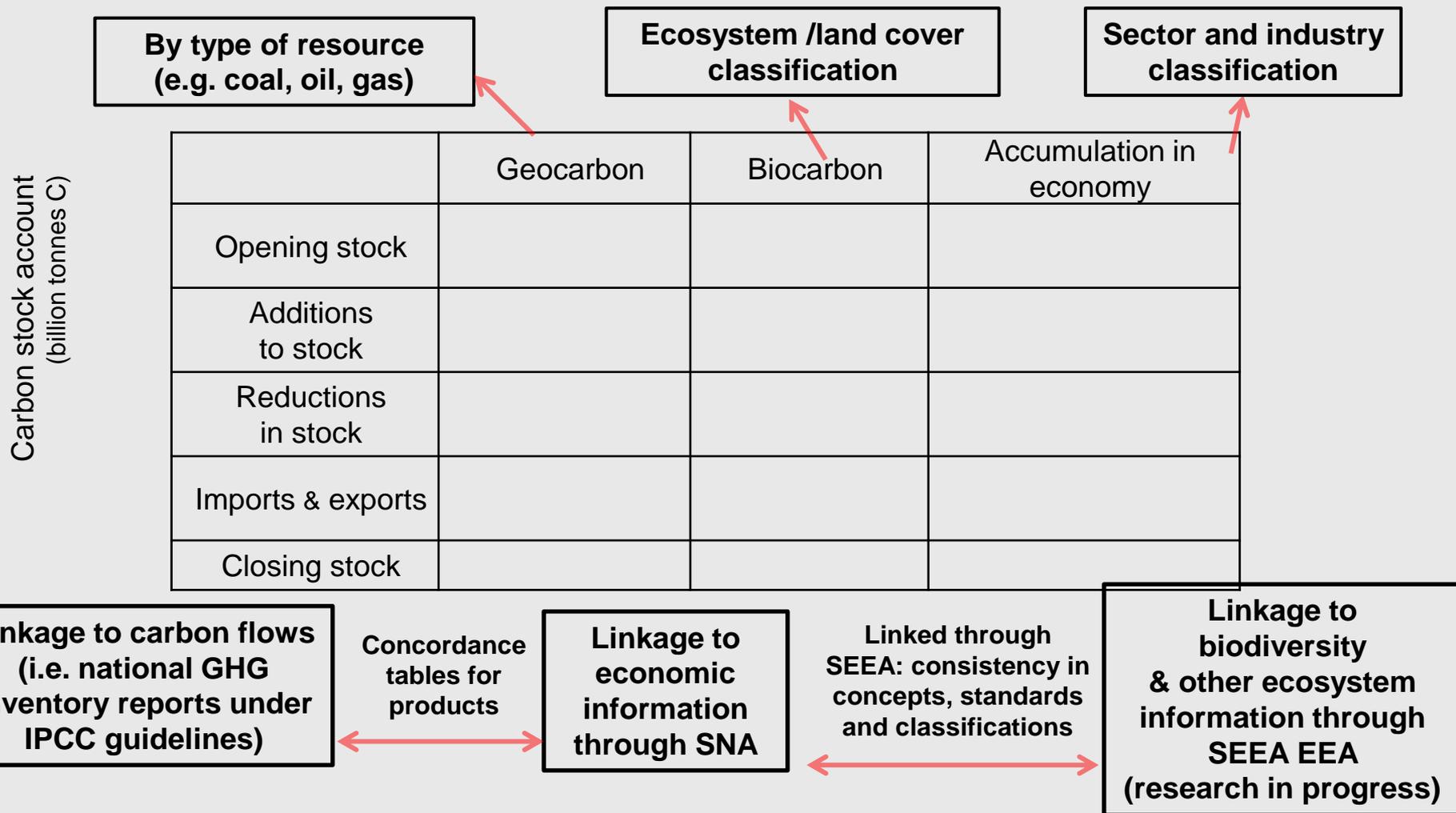


Level 2: Account 4: Carbon

- **A full Carbon Account is more complex**



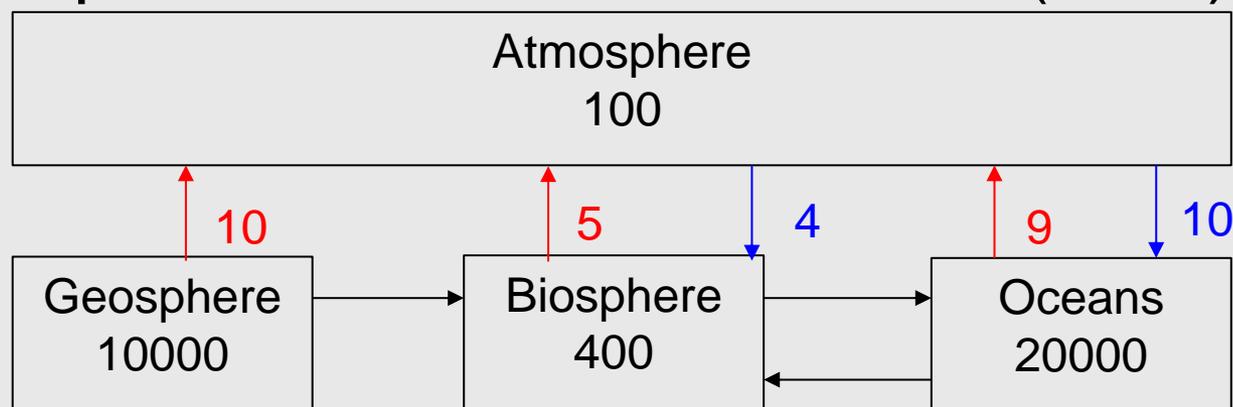
A full Carbon Account, Linking carbon stocks and flows to ecological and economic information





Level 2: Account 4: Carbon

- A simplified carbon stock account (Mt C)



Additions to Atmosphere

Reductions from Atmosphere

	Geocarbon	Biocarbon	Oceans	Atmosphere
Opening stock	10000	400	20000	100
Additions	-	4	10	24
Reductions	10	5	9	14
Closing stock	9990	399	20001	110



Level 2: Account 4: Carbon

■ Additions to Stock:

- Natural expansion (e.g. natural growth of unmanaged ecosystems)
- Managed expansion (e.g. human managed growth of plantations)
- Discoveries (geocarbon)
- Upwards reappraisals (new information resulting in increased estimates of stock)
- Reclassifications (e.g. between seminatural and natural ecosystems)
- Imports (show separately with exports)



Level 2: Account 4: Carbon

▪ Reductions in Stock

- Natural contraction (natural losses from unmanaged ecosystems, e.g. due to fire or floods)
- Managed contraction (e.g. human removal of timber from plantations)
- Downwards reappraisals (new information resulting in decreased estimates of stock)
- Reclassifications (e.g. between semi-natural and natural ecosystems)
- Exports (show separately with imports)



Level 2: Account 4: Carbon

- **Building carbon accounts – data sources and methods**
- Geocarbon is **not** a focus as it is addressed in other places. For example:
 - SEEA Energy <http://unstats.un.org/unsd/envaccounting/seeae/>
 - International Recommendations for Energy Statistics <http://unstats.un.org/unsd/energy/ires/default.htm>
 - Energy Statistics Compilers Manual. <http://unstats.un.org/unsd/energy/ESCM.htm>
 - Key Energy Statistics 2014 <http://www.iea.org/publications/freepublications/publication/KeyWorld2014.pdf>
 - European Commission (2003). Subsoil asset accounts for oil and gas - Guidelines for the set of standard tables. http://unstats.un.org/unsd/envaccounting/ceea/archive/Energy/Eurostat_Guidelines_Jan2003.PDF



Level 2: Account 4: Carbon

- **Building carbon accounts – data sources and methods**
 - Biocarbon **is** the focus:
 - Land cover or vegetation maps are the starting point for estimates of stocks and flows
 - Global land cover or vegetation maps are available
 - Standard “look-up” tables convert land cover information into stocks of carbon



Level 2: Account 4: Carbon

International data sources for carbon stocks

Carbon stocks		
Terrestrial Carbon Management Data Sets and Analyses	Carbon Dioxide Information Analysis Centre (CDIAC)	http://cdiac.ornl.gov/carbonmanagement/
Land use and ecosystems	Carbon Dioxide Information Analysis Centre (CDIAC)	http://cdiac.ornl.gov/land_use.html
Global carbon biomass look-up table	Carbon Dioxide Information Analysis Centre (CDIAC)	http://cdiac.ornl.gov/epubs/ndp/global_carbon/carbon_tables.pdf
National Biomass and Carbon Dataset	Woods Hole Research Centre	http://www.whrc.org/mapping/nbcd/
Project Carbon Sequestration	Forestry Commission (UK)	http://www.forestry.gov.uk/forestry/INFD-8JUE9T



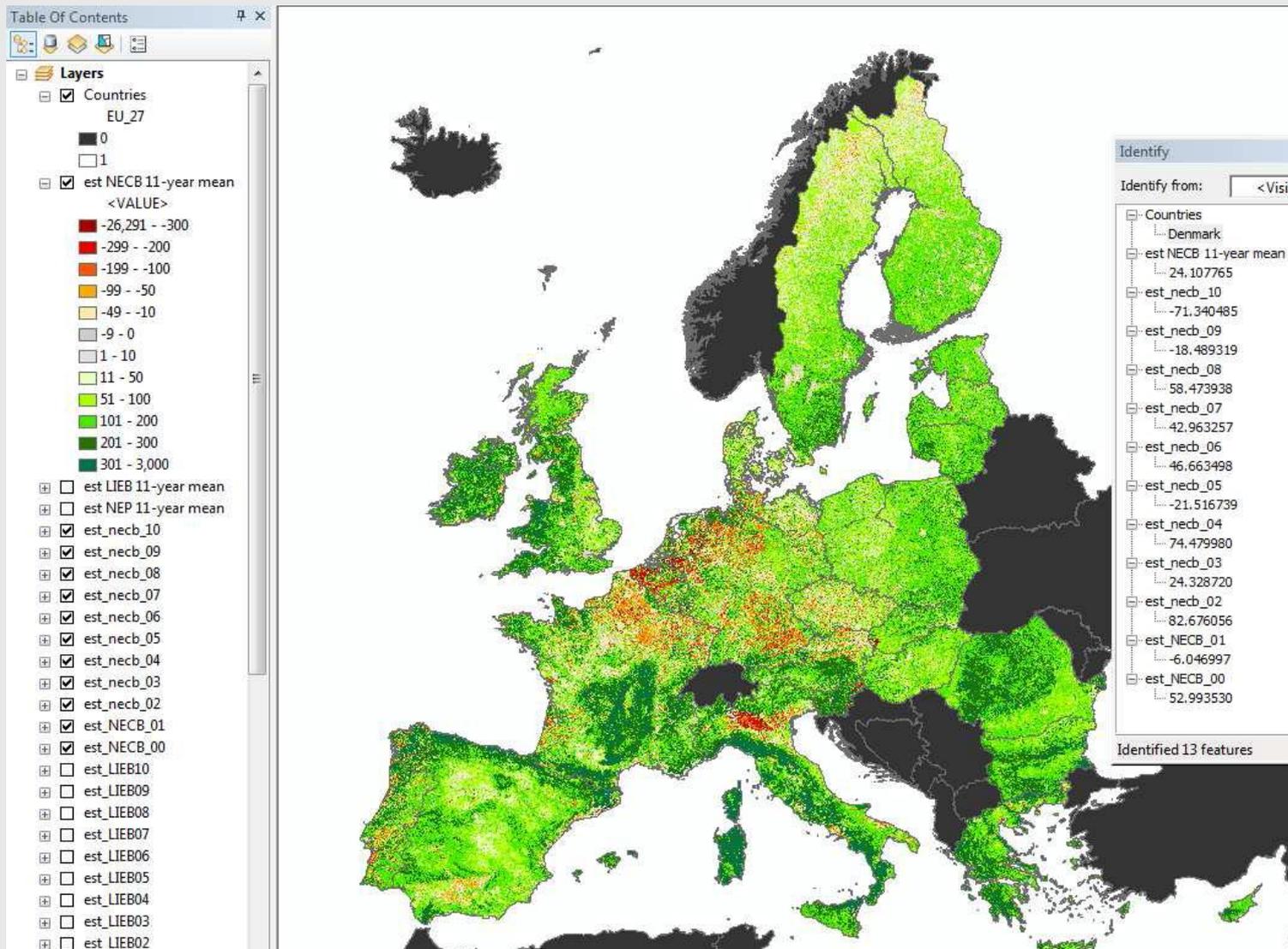
Level 2: Account 4: Carbon

International data sources for carbon sequestration and storage

Carbon sequestration and storage		
Carbon and biodiversity calculator	CBD Secretariate, LifeWeb and UNEP-WCMC	http://carbonbiodiversitycalculator.unep-wcmc.org/
UNEP-WCMC Ecosystem Services Toolkit	Climate regulation	UNEP-WCMC, 2011
Envision	Oregon State University	http://envision.bioe.orst.edu/Default.aspx
InFOREST	Virginia Department of Forestry	http://inforest.frec.vt.edu/
REDD+ (Reduce Emissions from Deforestation and forest Degradation).		https://www.forestcarbonpartnership.org/
Guidelines for National Greenhouse Gas Inventories Vol. 4. Agriculture, Forestry and other Land Use (AFOLU)	IPCC (Intergovernmental Panel on Climate Change). 2006.	http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html
Greenhouse gas emissions from Agriculture, Forestry and other Land Use	FAO	http://faostat3.fao.org/faostat-gateway/go/to/download/G2/*E



European Union – Map of carbon sequestration



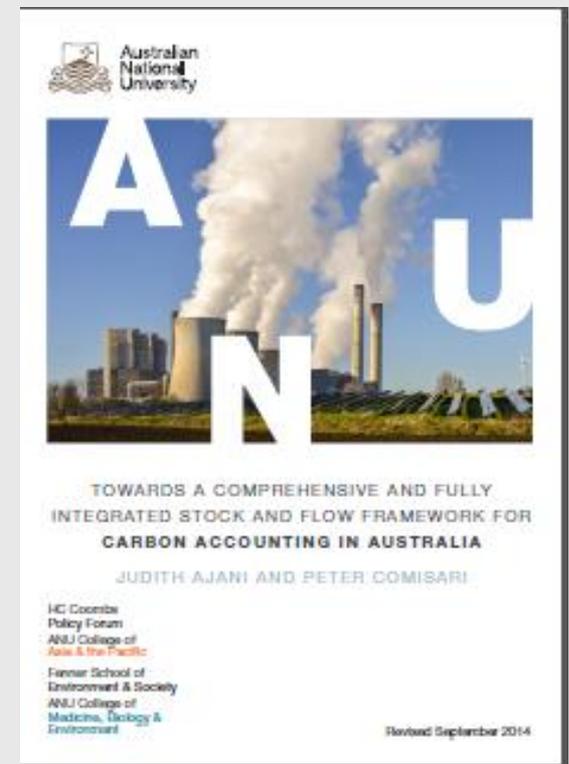


Carbon Accounting in Australia

Towards a Comprehensive and Fully Integrated Stock and Flow Framework

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<https://coombs-forum.crawford.anu.edu.au/publication/hc-coombs-policy-forum/4708/carbon-accounting-australia>



Background

- November 2012, the Australian Bureau of Statistics, Department of Environment and Australian National University began a project to:
 - Identify the need for carbon stock information and potential data
 - Populate the SEEA carbon stock account for Australia.
 - Assess what is needed for regularly producing a carbon stock account for Australia.



Results for Australia

- Biocarbon 31,081 Mt C
- Geocarbon 239,581 Mt C (fossil fuel only)
- Total 270,662 Mt C

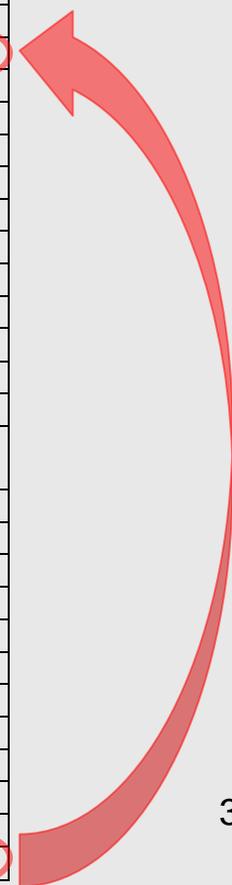
Geocarbon (fossil fuel only) is overwhelming majority of carbon

(Biocarbon 11.5% and geocarbon 88.5% of total estimate)



Australian Biocarbon by type of ecosystem

Primary reservoir	Geocarbon (Mt C)	Hectares (million)	Biomass carbon (Mt C)	Soil organic carbon (Mt C)	Total biocarbon (Mt C)
Biocarbon					
Natural ecosystems					
<i>Rangelands</i>		596.3	6,374	6,603	12,977
<i>Non rangelands:</i>					
<i>Eucalypt native forests</i>		16.7	4,671	3,753	8,424
<i>Shrub lands & woodlands</i>		14.7	500	636	1,137
<i>Grass, shrub & heath lands</i>		1.6	37	51	87
<i>Rainforests</i>		2.3	1,225	252	1,477
<i>Other</i>		0.7	15	16	32
<i>Marine ecosystems</i>		1.8	114	1,084	1,198
<i>Fresh water ecosystems</i>		9.9	4	7	11
Total Natural ecosystems		644.0	12,941	12,402	25,343
Semi-natural ecosystems					
<i>Highly modified rangelands</i>		50.0	750	1,500	2,250
<i>Grazing in modified pastures outside rangelands</i>		32.9	132	1,315	1,447
Total Semi-natural ecosystems		82.9	882	2,815	3,697
Agricultural ecosystems					
<i>Cropping</i>		25.5	102	1,022	1,124
<i>Irrigated agriculture</i>		2.6	12	105	117
<i>Plantation wood</i>		2.4	177	120	296
<i>Reservoir/dam</i>		0.6	1	6	7
<i>Other</i>		6.3	120	244	363
Total Agriculture ecosystems		37.4	412	1,497	1,907
Settlements		2.6	30	79	108
Other		0.5	7	19	26
Total Settlements and Other		3.1	37	98	134
Total biocarbon^d		767.4	14,270	16,811	31,081





Key points from Australian carbon accounts

1. It is **possible** to construct carbon stock accounts for Australia with current information.
2. Having comparable information on carbon stocks in fossil fuels and ecosystems (terrestrial and marine) linked to economic information enables **past policies and future policy options** to be assessed (including scenario analysis).
3. Different parts of government and academia can successfully **work together** to assess the usefulness and feasibility of producing environmental or ecosystem accounts



Level 2: Account 4: Carbon

- Concepts group exercise (15m) (Groups of 3-5)
 1. In your country, what are some important **land cover types** for carbon sequestration?
 2. What are some main sources of change in their capacity to sequester carbon? (positive and negative)
 3. Are **national** data available in your country on the extent and change in these ecosystem types?
 4. Report your results



Level 2: Account 4: Carbon

- Concepts Group exercise (15m)

- Group reports
 - The **land cover types** you selected
 - Main sources of **change** (positive and negative)
 - Are **national data** available in your country on the extent and change in these ecosystem types?

- Discussion
 - What other land cover types would be important to measure?
 - What other data sources could you suggest?



Level 2: Account 2: Carbon

- Discussion and questions
- Take home points
 - Data on biocarbon may be limited, but much can still be used in ecosystem accounting
 - There are some simple methods to calculate carbon storage and sequestration from land cover data
 - Testing will provide a better understanding of data opportunities and constraints
 - Focus on available data and priority services



Level 2: Account 4: Carbon

- Further Information
 - SEEA Experimental Ecosystem Accounting (2012)
 - SEEA-EEA Technical Guidance (forthcoming)
 - Detailed supporting document on “Carbon Accounts” by Michael Vardon



References

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Evaluation of the training module

- Please complete the evaluation form for this module
- For this module
 - What did you learn that you could apply in your work?
 - Was the presentation clear and informative?
 - Was it too simple? Too complex?
 - Was there anything you did not understand?
 - What additions or deletions would you suggest (recognizing that the unit is intended for a general audience)?
 - Do you have any suggestions as to how the SEEA-EEA may be improved (concepts, principles) in this area?



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