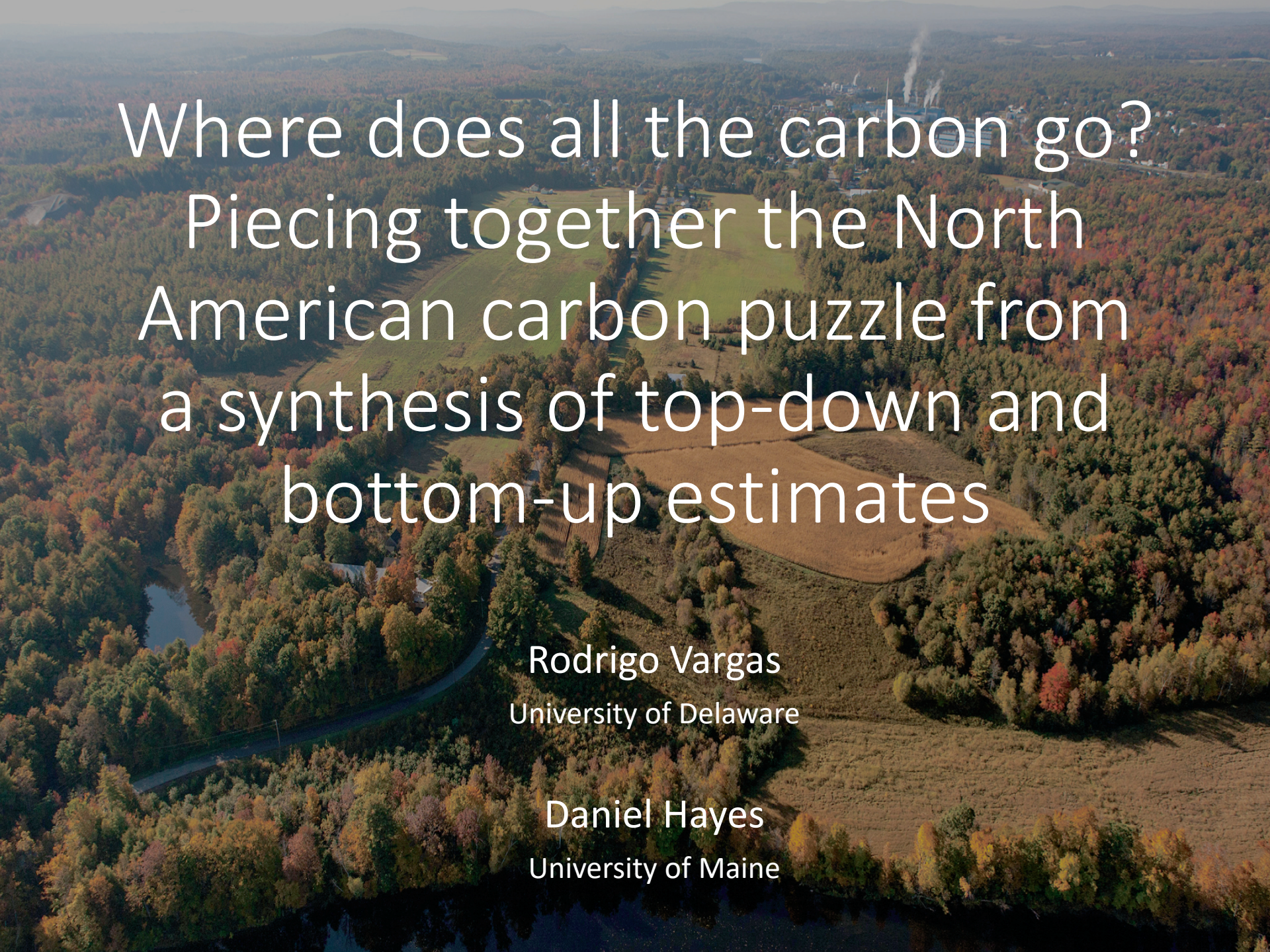

Where does all the carbon go? Piecing together the North American carbon puzzle from a synthesis of top-down and bottom-up estimates

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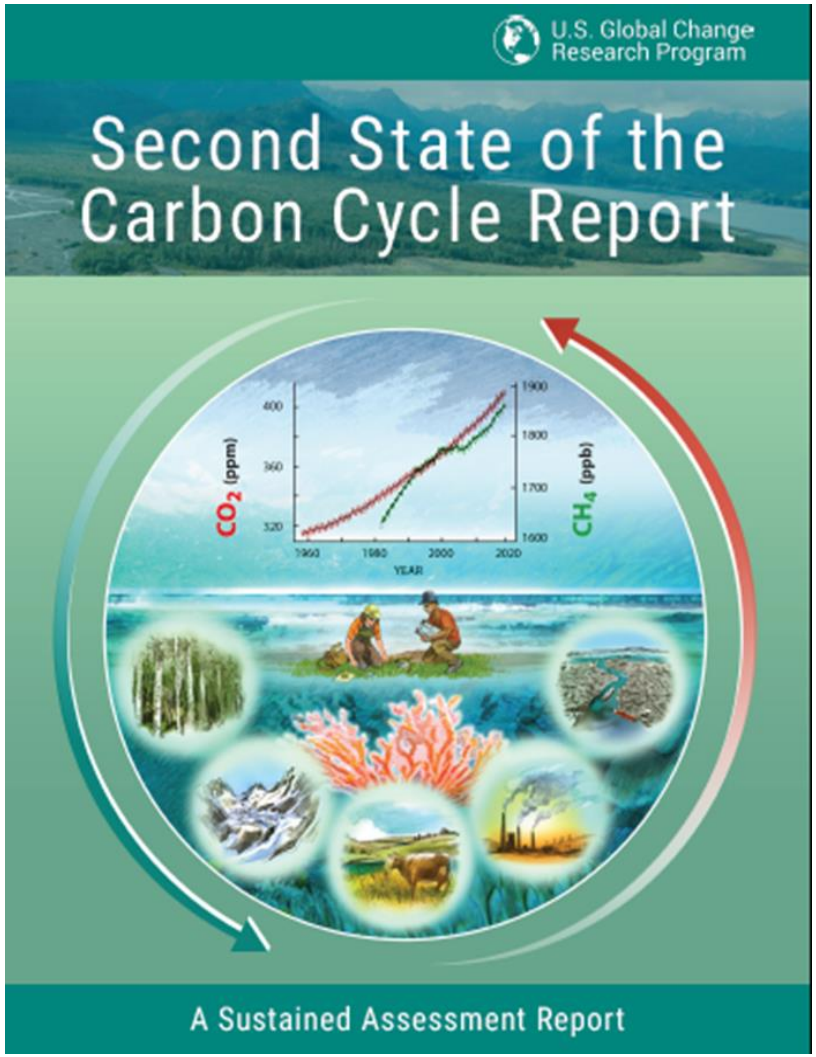
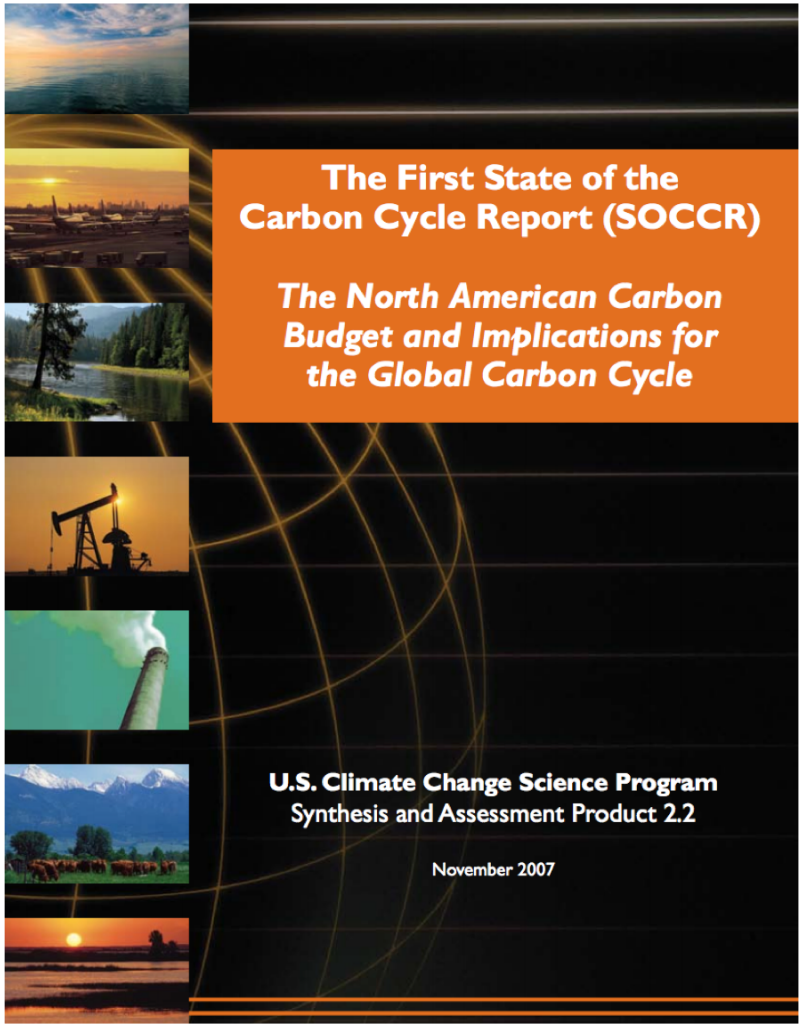
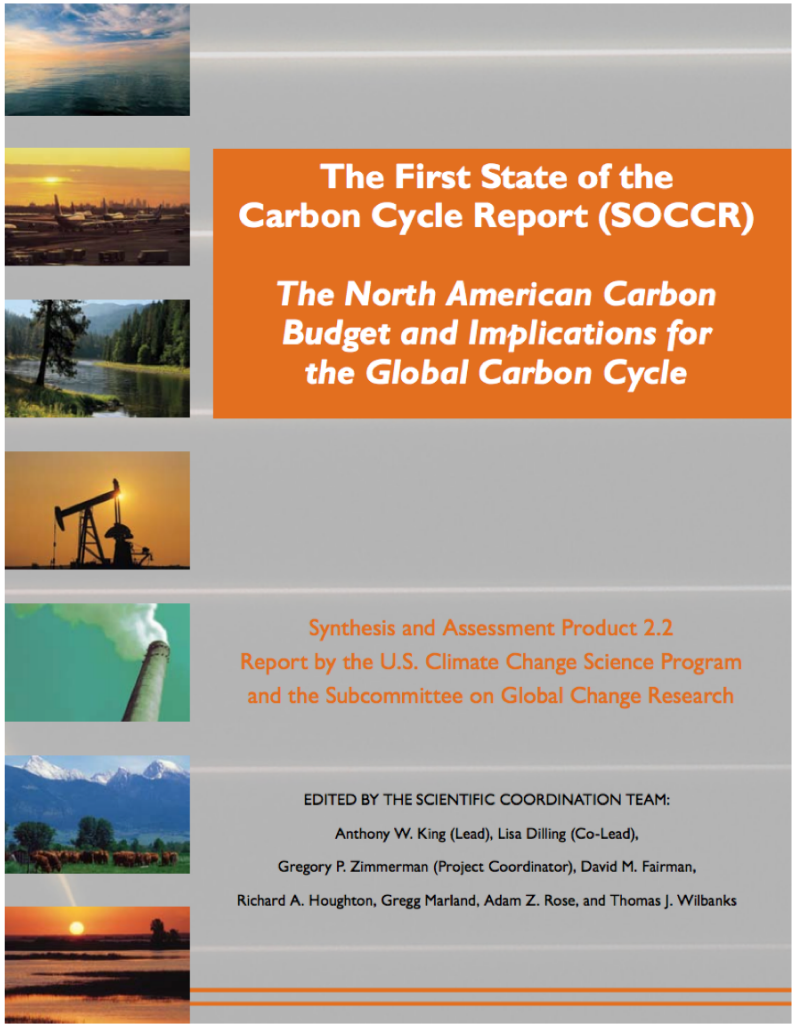


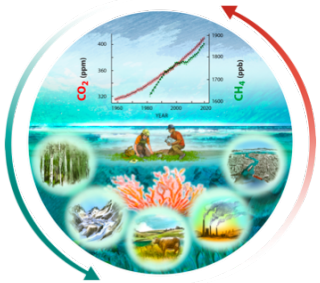
USGCRP, 2018: Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report [Cavallaro, N., G. Shrestha, R . Birdsey, M. A. Mayes, R . G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu (eds.)]. U.S. Global Change Research Program, Washington, D.C., USA, 878 pp., https://doi.org/10.7930/SOCCR2.2018.

Today's talk: Chapter 2

November 2007







The *Second State of the Carbon Cycle Report* (SOCCR2) provides a current state-of-the-science assessment of the carbon cycle in North America (i.e., the United States, Canada, and Mexico) and its connection to climate and society.

These findings are based on multidisciplinary research that includes experimental, observational, and modeling studies from the last decade.

It is intended for a diverse audience that includes scientists, decision makers in the public and private sectors, and communities across the United States, North America, and the world,

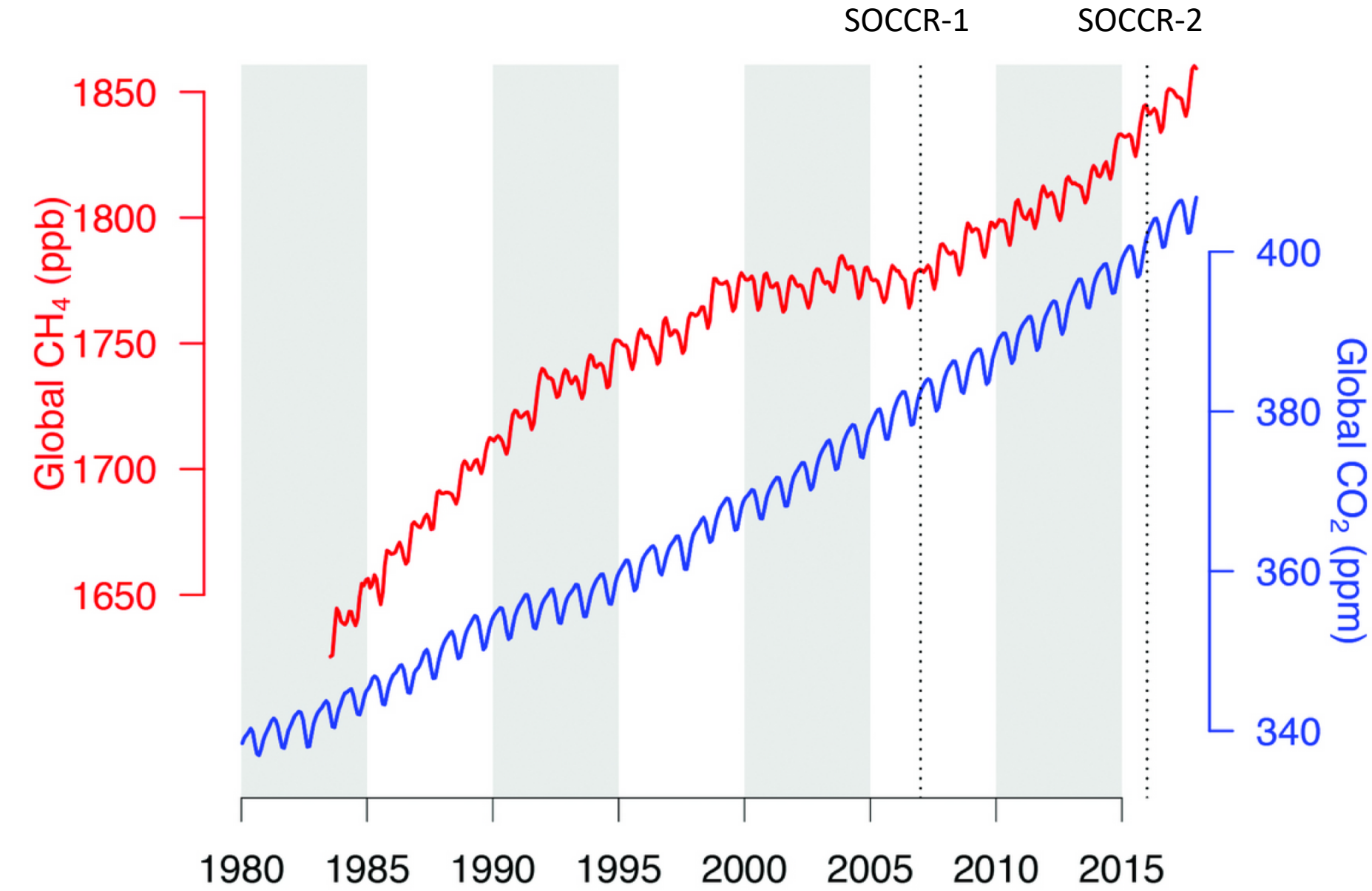
Facts

- Contains 878 pages

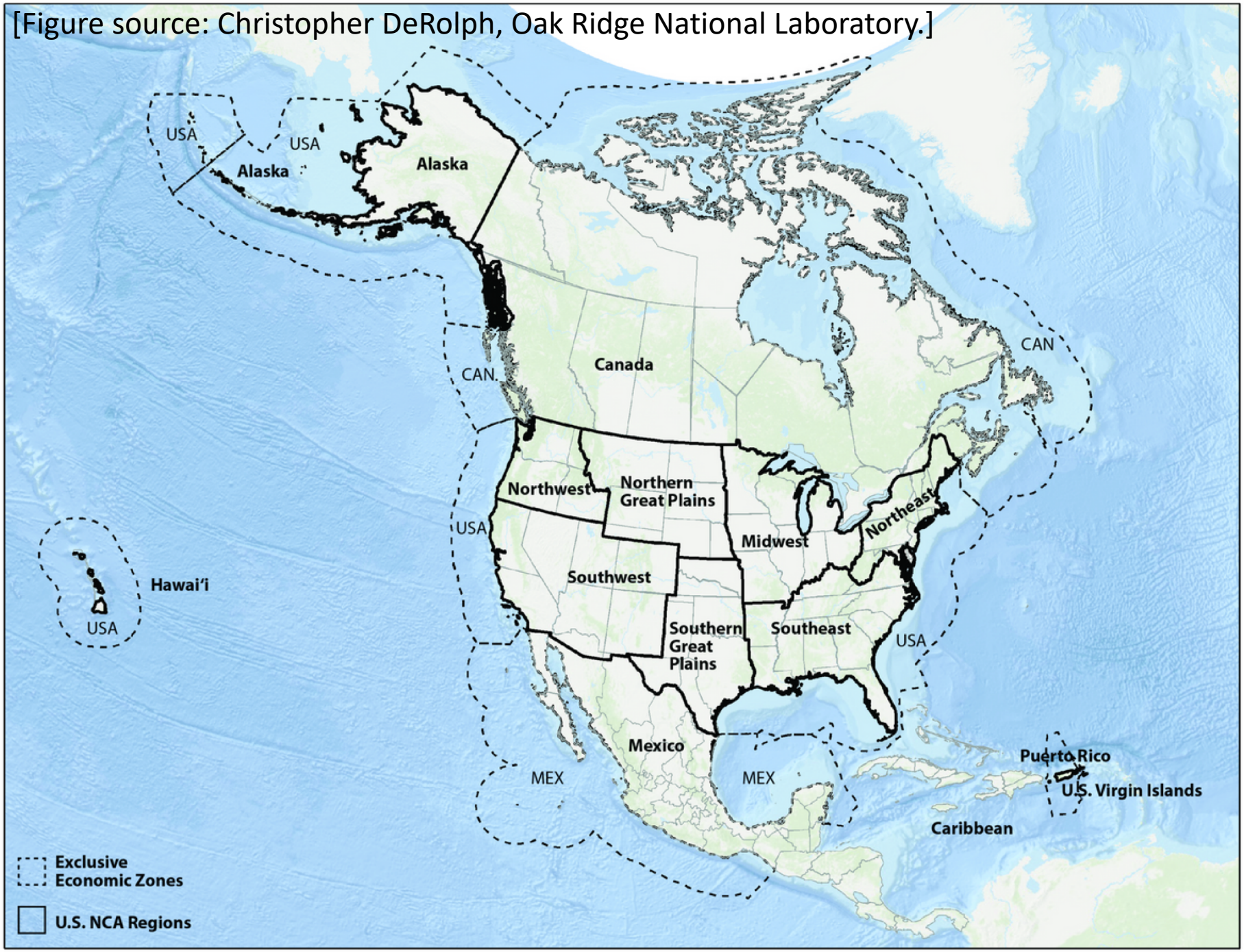
Highlights (plain language) & Executive Summary (technical) 4 sections 19 chapters, 7 appendices

- Developed by 200+ diverse cross-sectoral experts
- 3764 publications cited
- 33 Chapter Leads
- 200 Contributing Authors
- 5 Science (cross-chapter section) Leads
- 11 Review Editors
- 3 years formulation & production (2015-18)
- Over 6 Drafts reviewed over 6 times incl. by Public, U.S. National Academy of Sciences (NAS) publicly nominated committee, expert external reviewers, 21 Federal Steering Committee members.

Why is it important?



https://carbon2018.globalchange.gov/chapter/8/


[Figure source: Christopher DeRolph, Oak Ridge National Laboratory.]
USA
USA
Alaska
Alaska
CAN.
Canada
CAN
Northwest
Northern Great Plains
USA
Midwest
Northeast
Southwest
Hawai'i
USA
Southern Great Plains
Southeast
USA
Mexico
MEX
MEX
Puerto Rico
U.S. Virgin Islands
Caribbean
Exclusive Economic Zones
U.S. NCA Regions

SOCCR-2

- Synthesis
  - Global Context (1), **North America (2),** Projections (19)
- Human Dimensions
  - Energy Systems (3), Urban Carbon Fluxes (4), Agriculture (5), Social Science Perspective (6), Tribal Lands (7), Decision-making (18)
- The State of Air & Land
  - Atmosphere (8), Forests (9), Grasslands (10), Arctic & Boreal (11), Soils (12)
- The State of Water
  - Terrestrial Wetlands (13), Inland Waters (14), Tidal Wetlands & Estuaries(15), Coastal Oceans & Continental Shelves (16)
- Consequences (17)

SOCCR-2, Chapter 2

Chapter 2 of the SOCCR-2 synthesizes the latest scientific information on the North American carbon budget, incorporating terrestrial, anthropogenic, aquatic, and coastal margin CO_2 and CH_4 dynamics. Estimates are summarized from different methods at the continental scale and across the three countries (i.e., Canada, the United States, and Mexico),

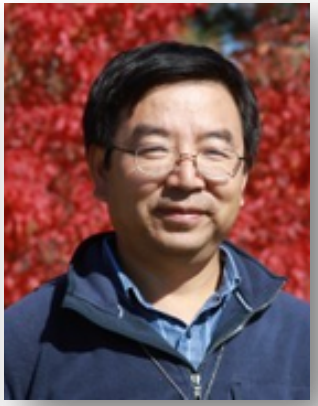
Simone Alin, NOAA

Rich Conant, CSU

Lucy Hutyra, BU

Andy Jacobson, NOAA

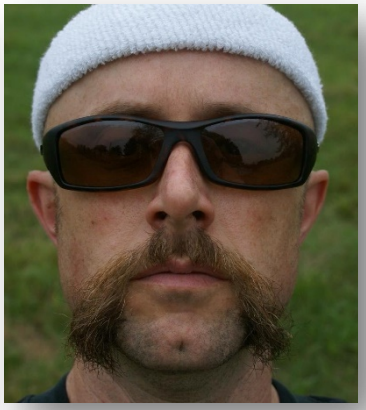
Werner Kurz, CFS



“Leo” Liu, USGS

Ben Poulter, NASA GSFC

Dave McGuire, USGS / UAF



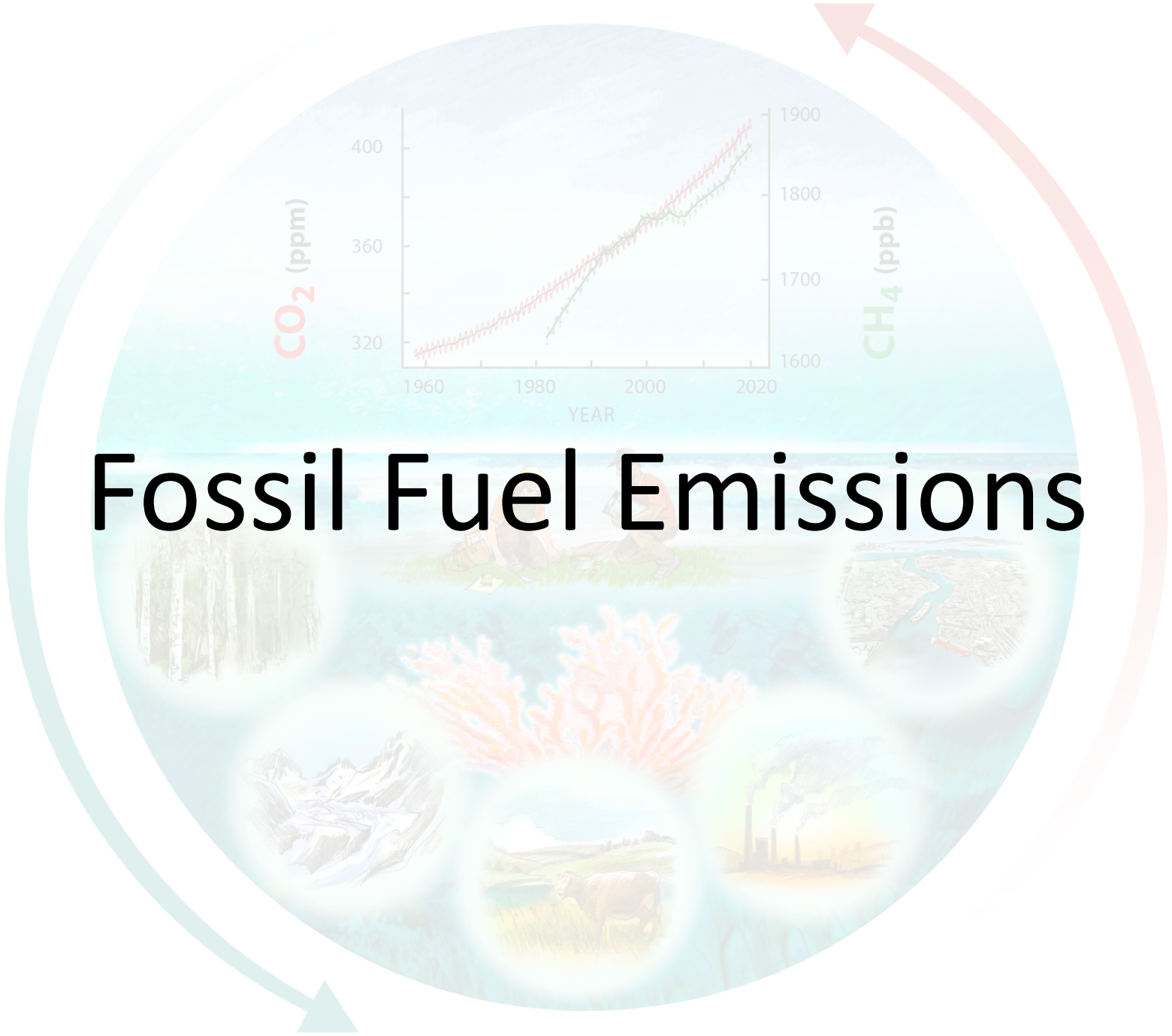
Chris Woodall, USFS

Some Key Finding

- North America—including its energy systems, land base, and coastal ocean—was a net source of carbon dioxide to the atmosphere from 2004 to 2013, contributing on average about 1,008 teragrams of carbon (Tg C) annually (±50%) *(very high confidence).*

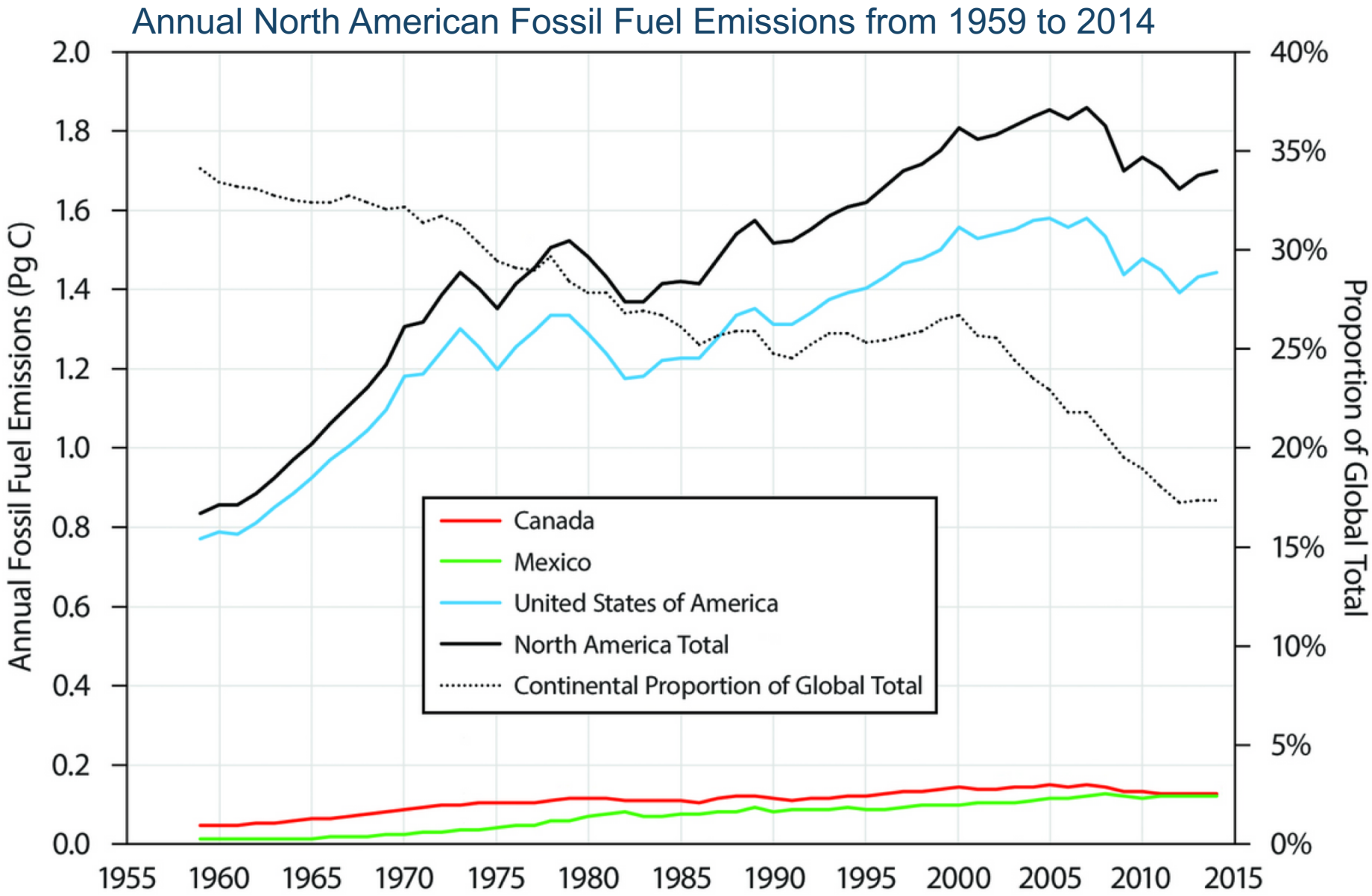
- Fossil fuel emissions were the largest carbon source from North America from 2004 to 2013, averaging 1,774 Tg C per year (±5.5%). Emissions during this time showed a decreasing trend of 23 Tg C per year, a notable shift from the increasing trend over the previous decade. The continental proportion of the global total fossil fuel emissions decreased from 24% in 2004 to 17% in 2013 *(very high confidence).*

- Approximately 43% of the continent's total fossil fuel emissions from 2004 to 2013 were offset by natural carbon sinks on North American land and the adjacent coastal ocean *(medium confidence).*



Fossil Fuel Emissions

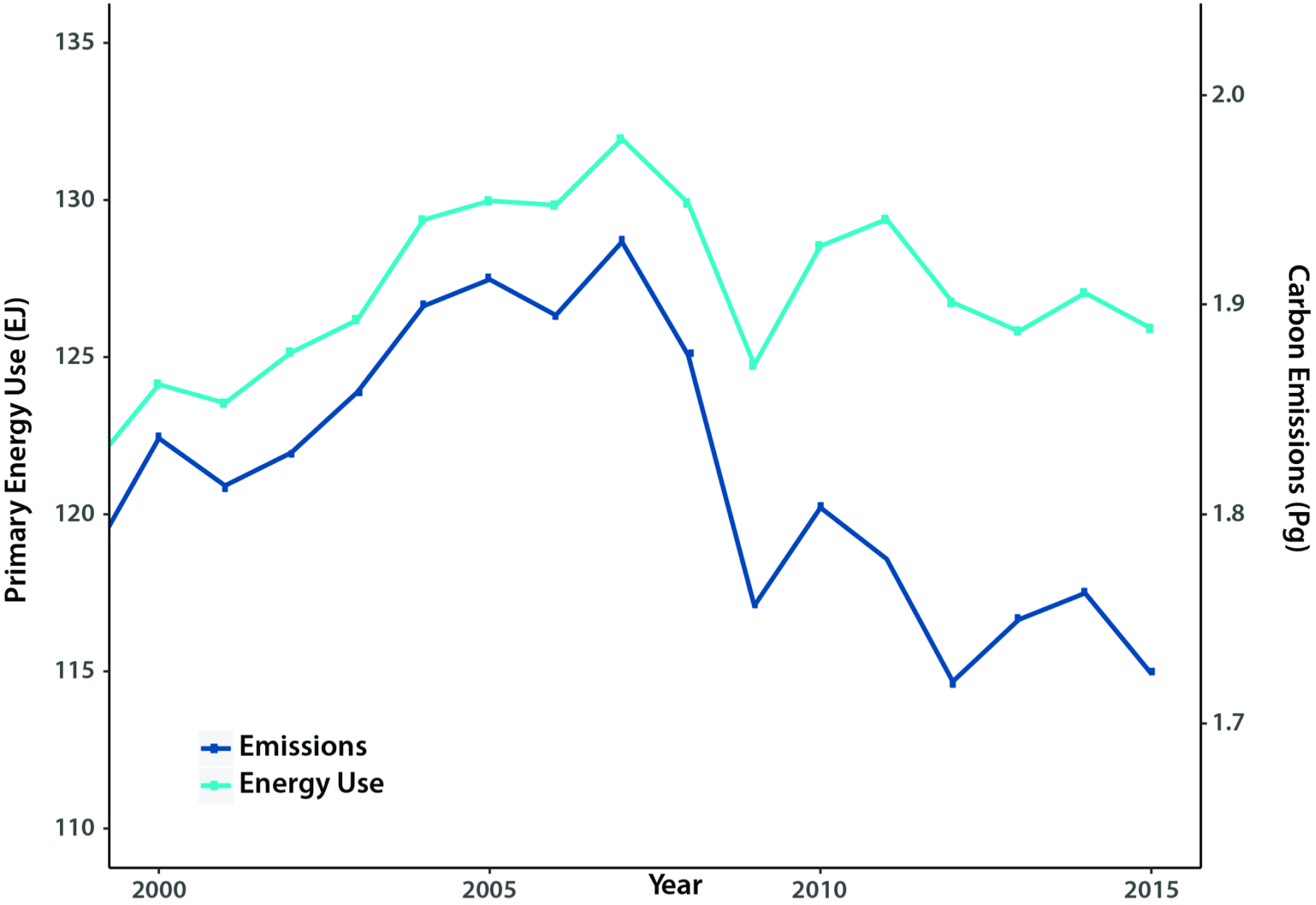
https://carbon2018.globalchange.gov/chapter/2/



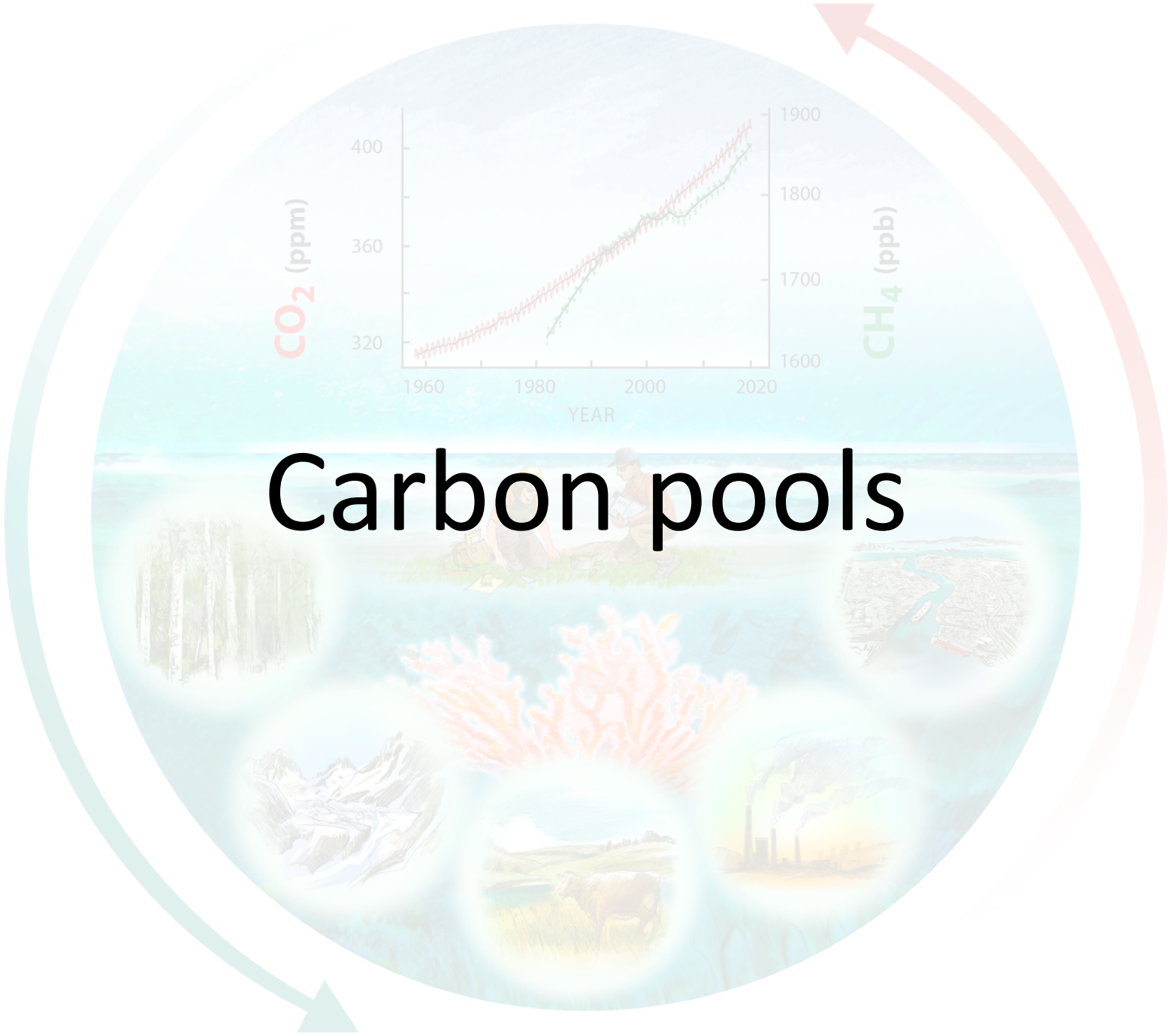
Data source: Carbon Dioxide Information Analysis Center (Boden et al., 2017).]

https://carbon2018.globalchange.gov/chapter/3/

North American Primary Energy Consumption and Carbon Emissions, 2000–2015



Energy use in exajoules (EJ); carbon emissions in petagrams (Pg). [Data source: EIA 2017i]



Carbon pools

Carbon Pools

Forest Biomass
Forest Soils
Agricultural Soils
Grassland Biomass
Grassland Soils
Tundra Biomass
Permafrost Soils

Terrestrial Wetland Biomass

Terrestrial Wetland Soils

Inland Waters Sediment

Tidal Wetland and Estuary Soils

Coastal Ocean Sediment

Carbon Pools

Forest Biomass

Forest Soils

Agricultural Soils

Grassland Biomass

Grassland Soils

Tundra Biomass

Permafrost Soils

Terrestrial Wetland Biomass

Terrestrial Wetland Soils

~~Inland Waters Sediment~~

Tidal Wetland and Estuary Soils

~~Coastal Ocean Sediment~~

Carbon Pools

Carbon Pools	Canada	United States	Mexico	North America
Total Biomass	20,547	21,799	2,011	44,357
Total Soils	83,249	70,691	11,879	626,705

Teragrams of C (Tg C)

https://carbon2018.globalchange.gov/chapter/2/

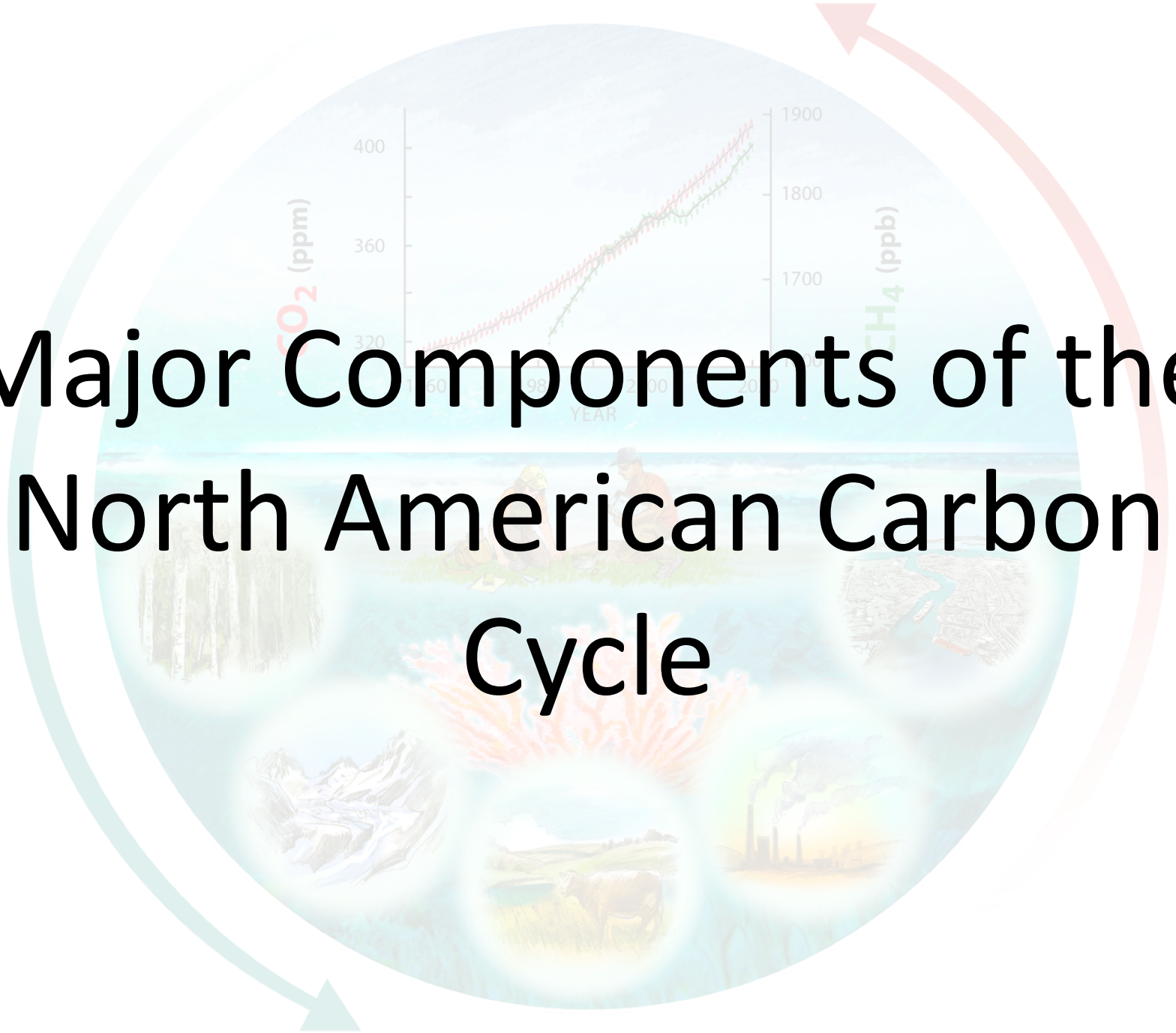
Carbon Pools

Carbon Pools	Canada	United States	Mexico	North America
Total Biomass	20,547	21,799	2,011	44,357
Total Soils	83,249	70,691	11,879	626,705

Teragrams of C (Tg C)

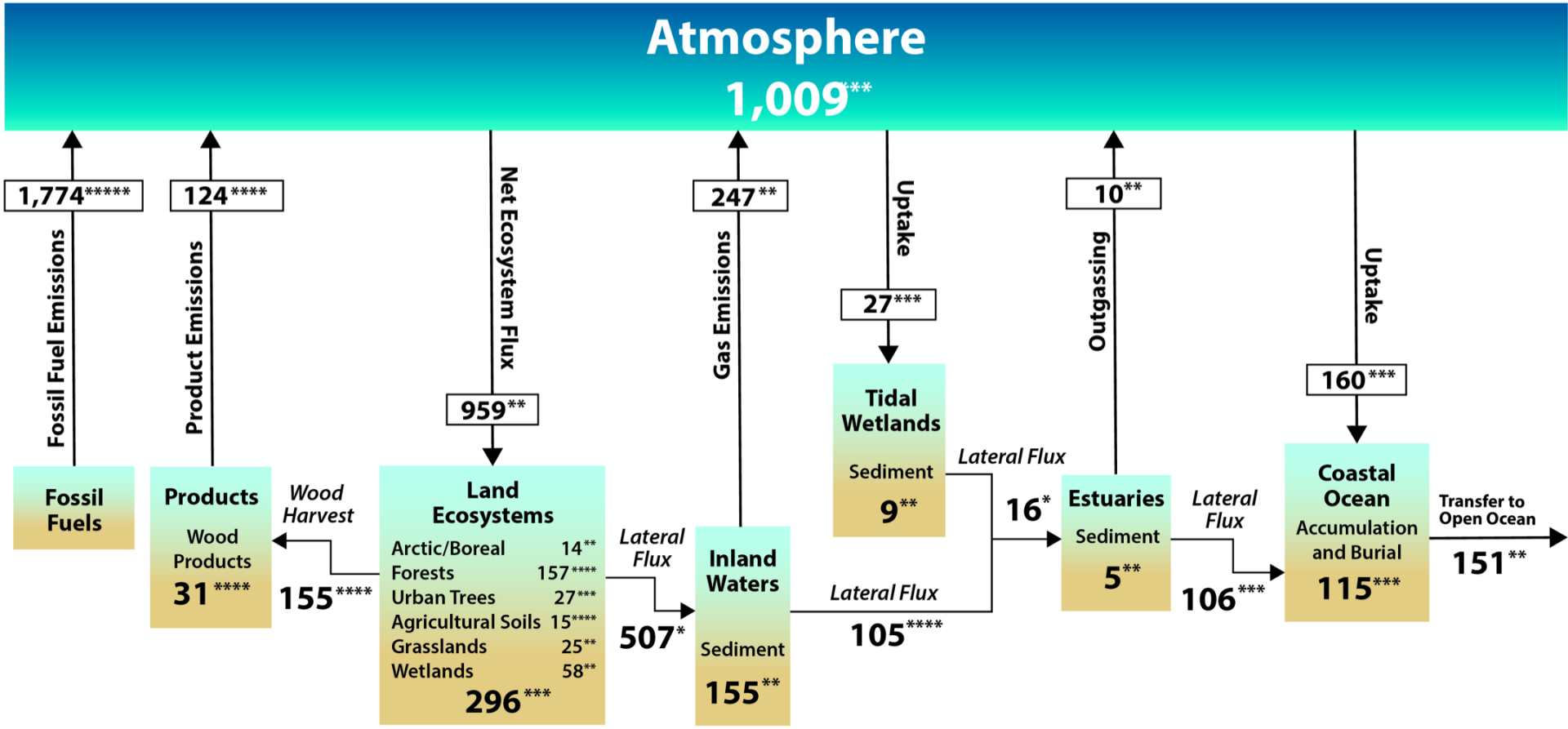
Permafrost soils (459,000 Tg C)

https://carbon2018.globalchange.gov/chapter/2/



Major Components of the North American Carbon Cycle

All values as teragrams of C per year (Tg C / yr)



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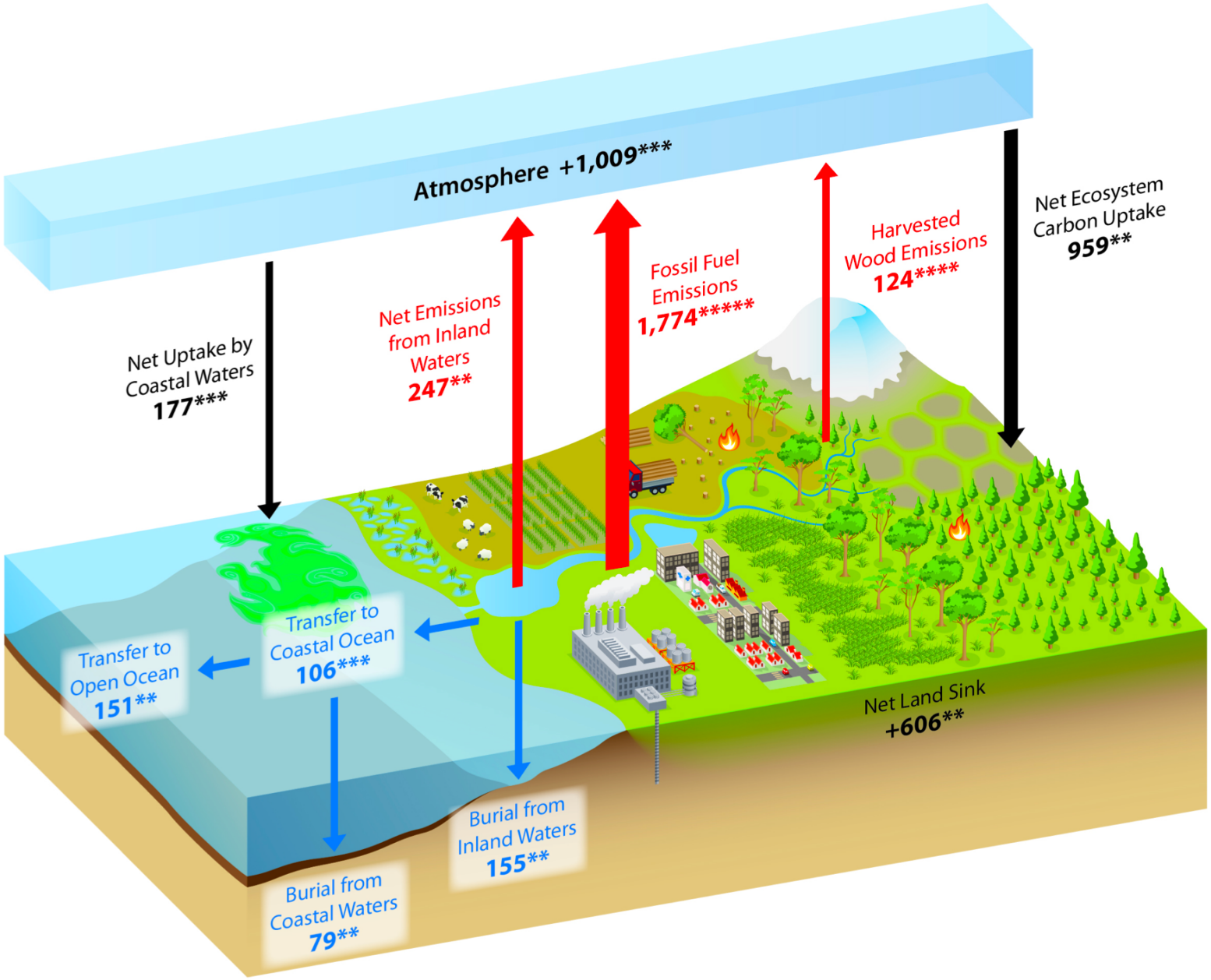
https://carbon2018.globalchange.gov/chapter/executive-summary/



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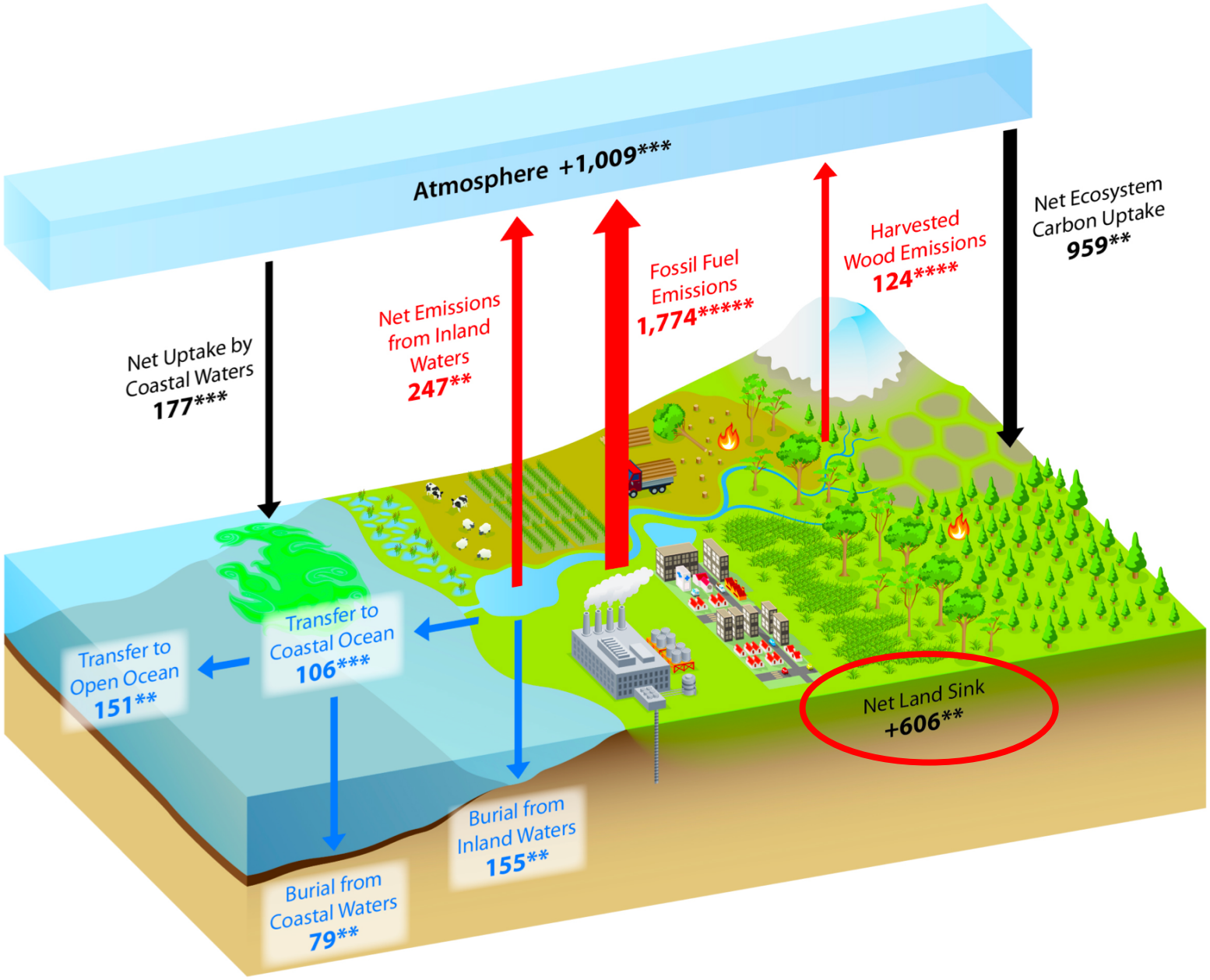
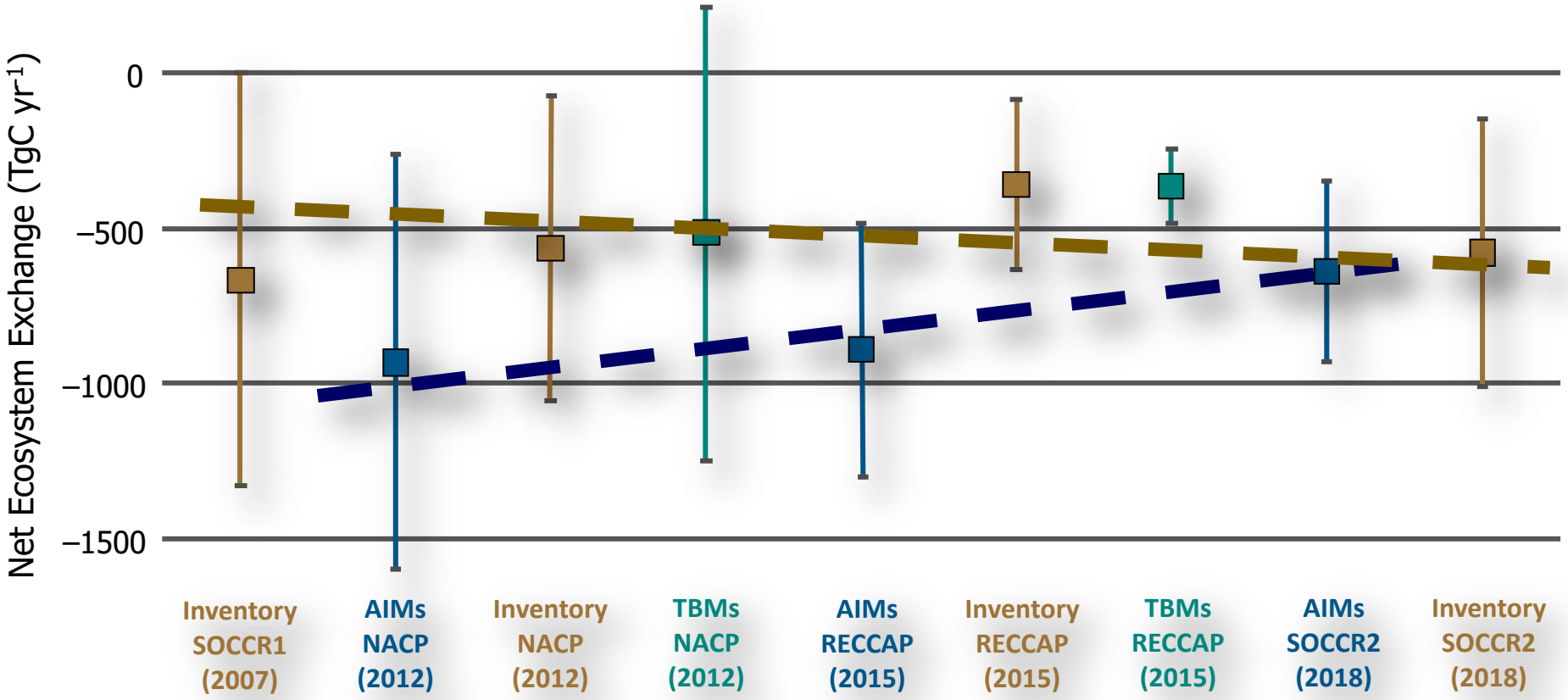


Other Key Finding

- Using bottom-up, inventory-based calculations, the Second State of the Carbon Cycle Report (SOCCR2) estimates that the average annual strength of the land-based carbon sink in North America was 606 Tg C per year (±75%) during the 2004 to 2013 time period, compared with the estimated 505 Tg C per year (±50%) in ca. 2003, as reported in the First State of the Carbon Cycle Report (CCSP 2007). There is apparent consistency in the two estimates, given their ranges of uncertainty, with SOCCR2 calculations including additional information on the continental carbon budget. However, large uncertainties remain in some components *(very high confidence).*

- The magnitude of the continental carbon sink over the last decade is estimated at 699 Tg C per year (±12%) using a top-down approach and 606 Tg C per year (±75%) using a bottom-up approach, indicating an apparent agreement between the two estimates considering their uncertainty ranges.*

Estimates of North American Land-Atmosphere CO_2 Exchange.



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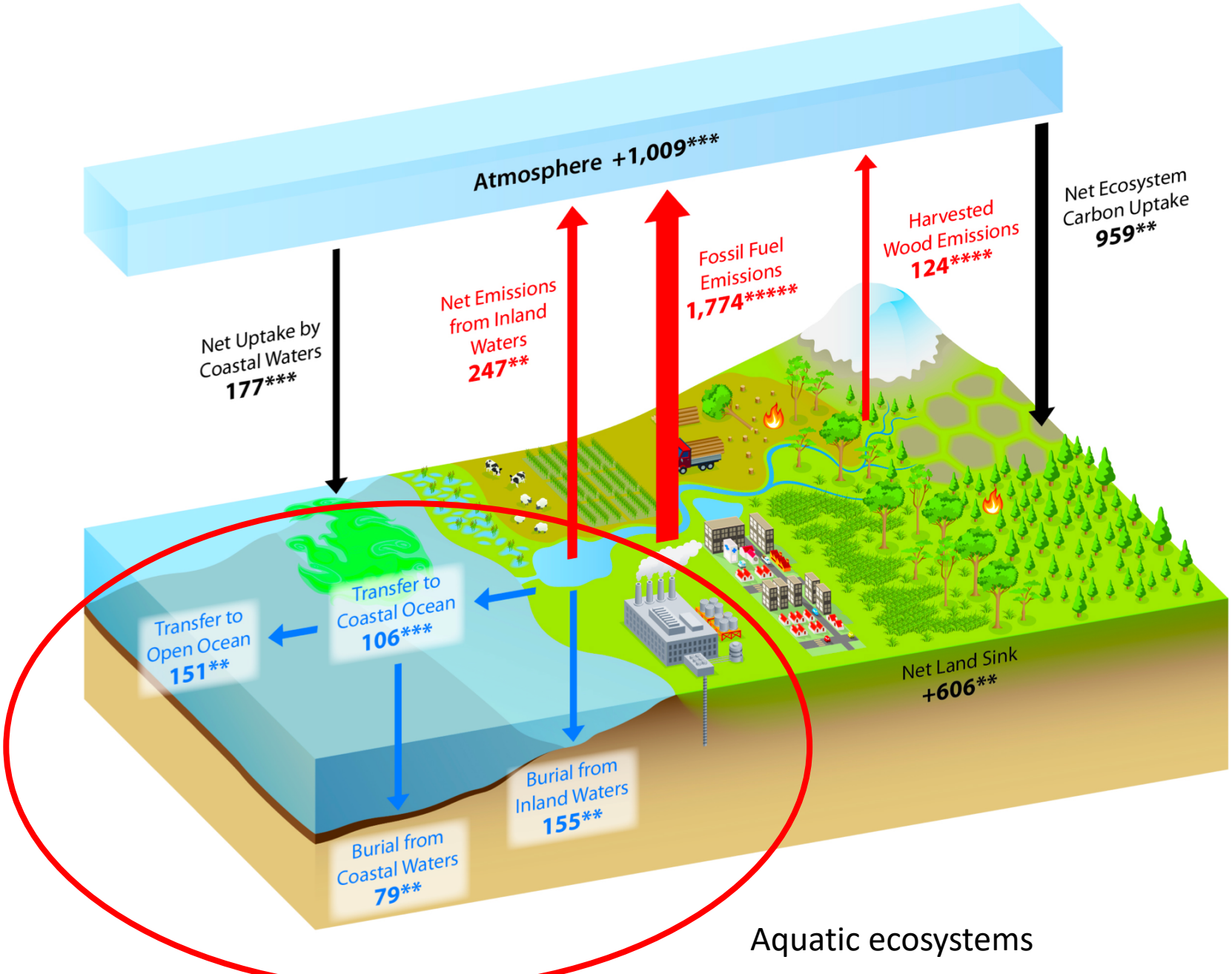

Aquatic ecosystems

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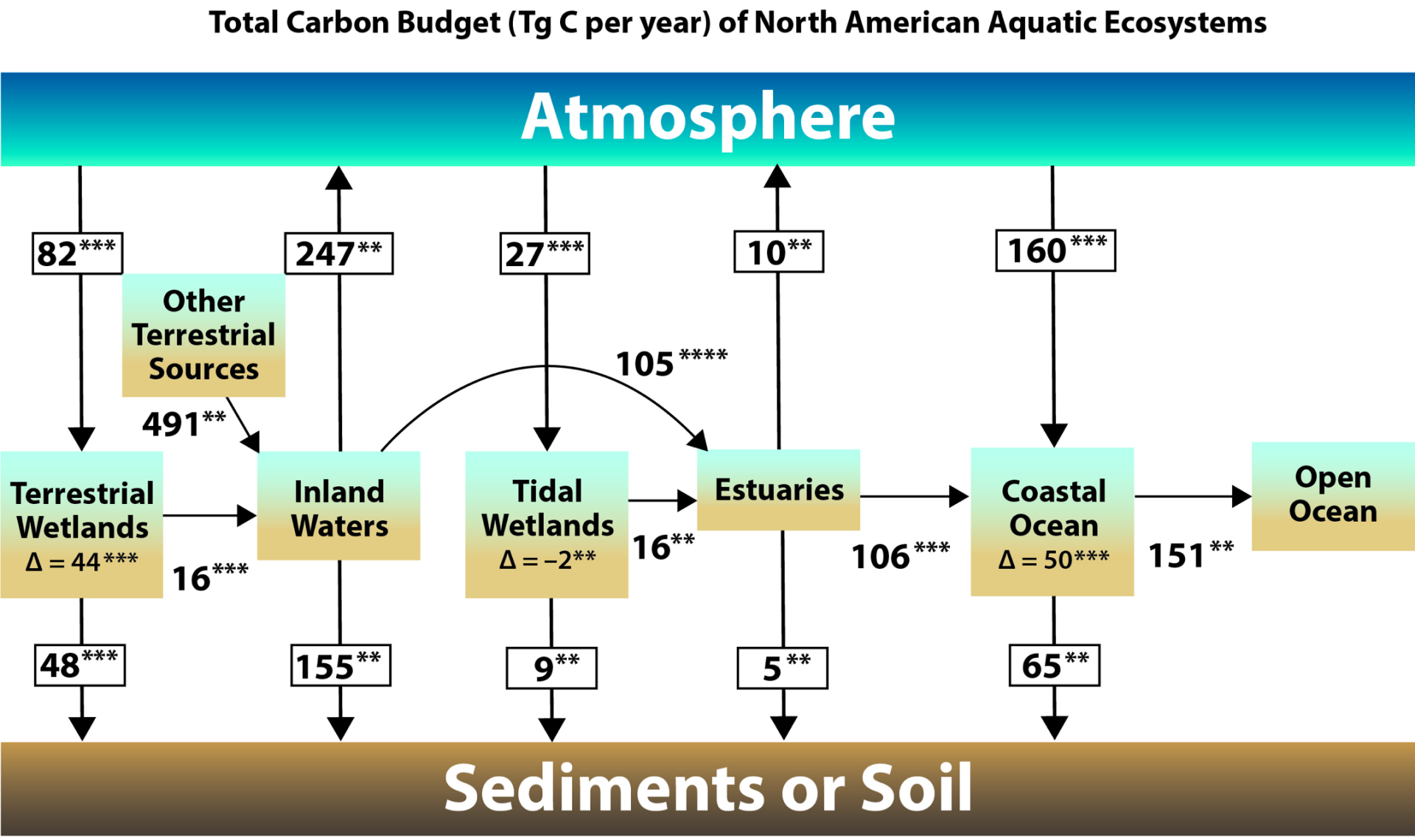

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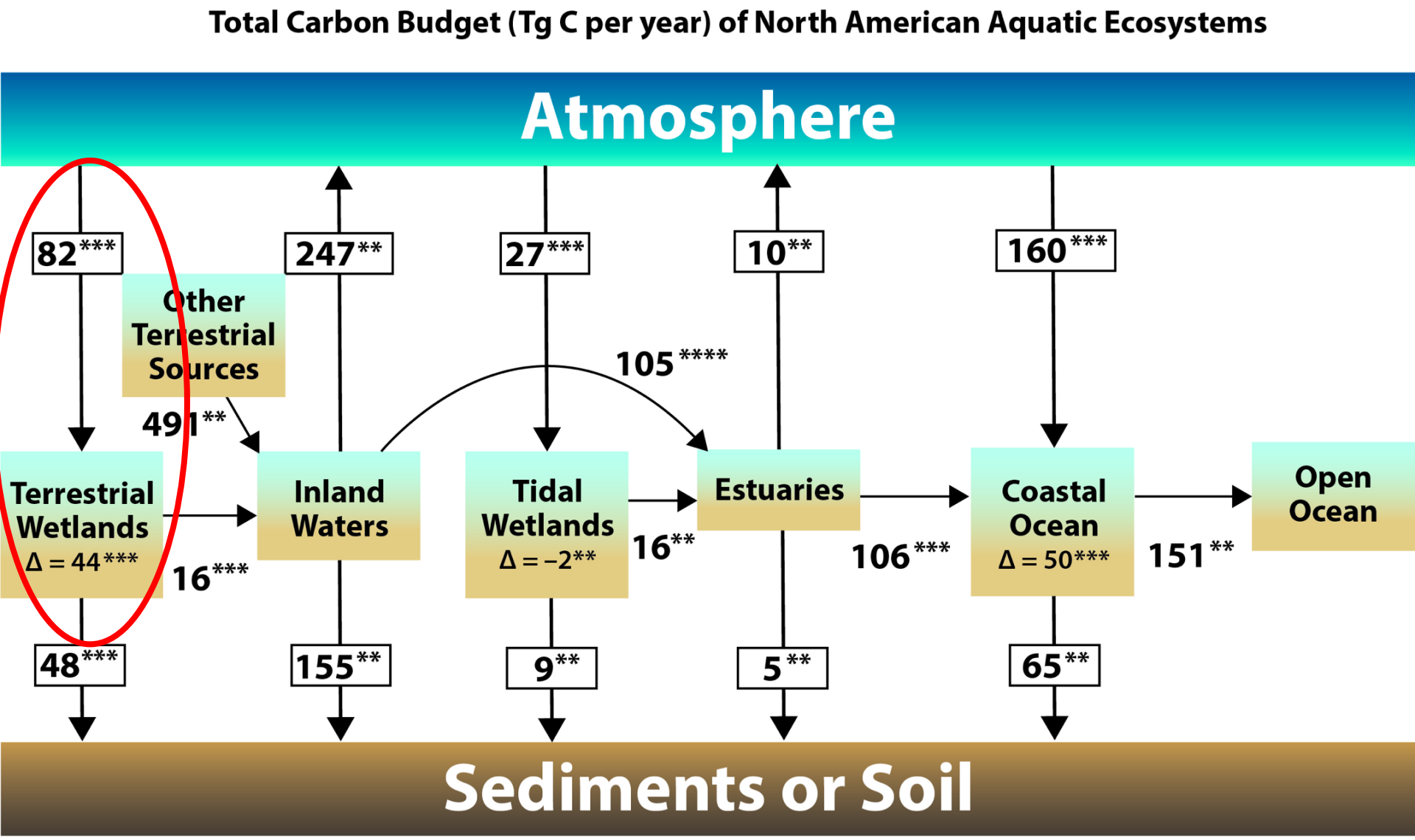
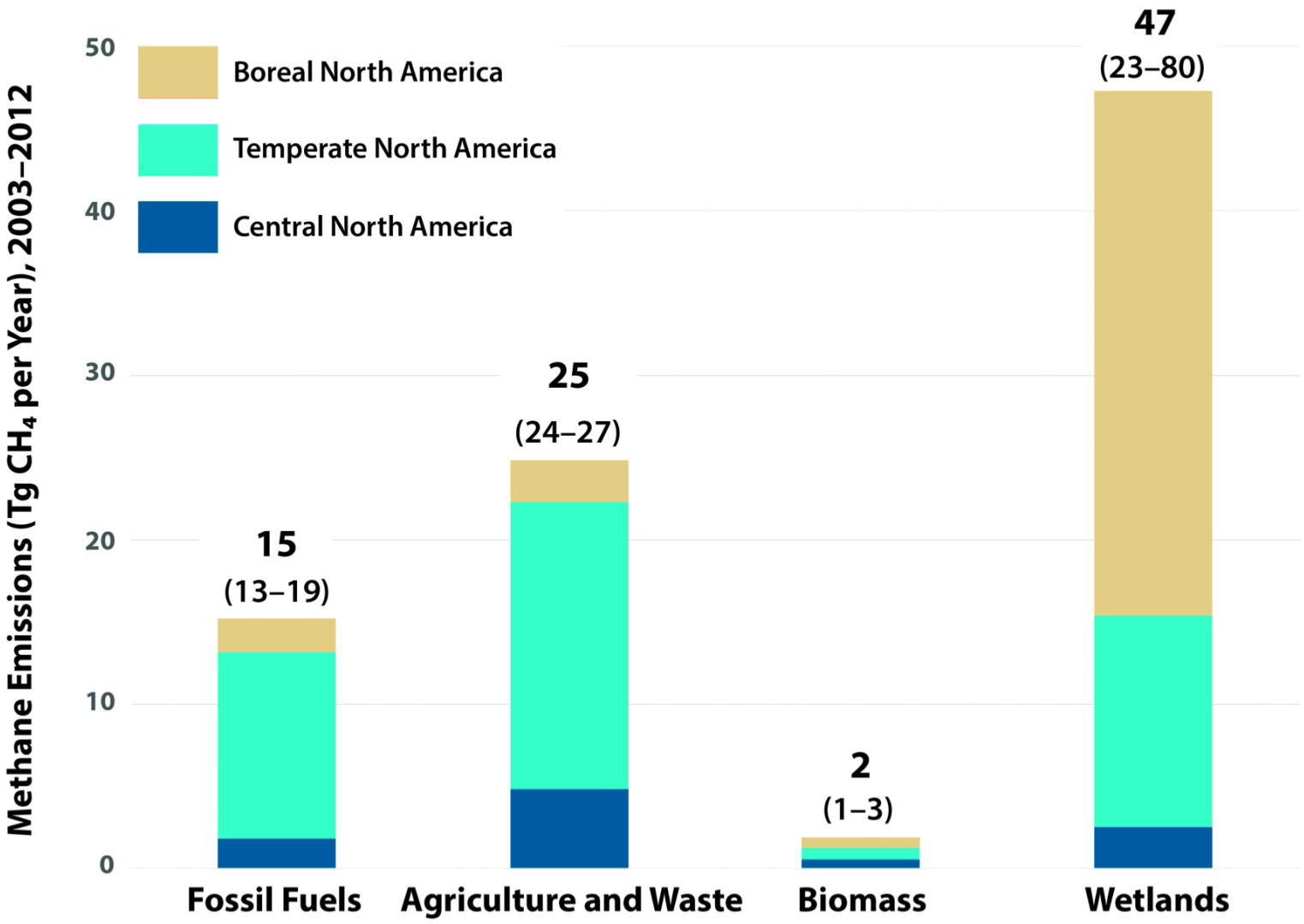


Sources of Methane (CH_4) Emissions Estimated from Bottom-Up Methods for Three Regions of North America from 2003 to 2012

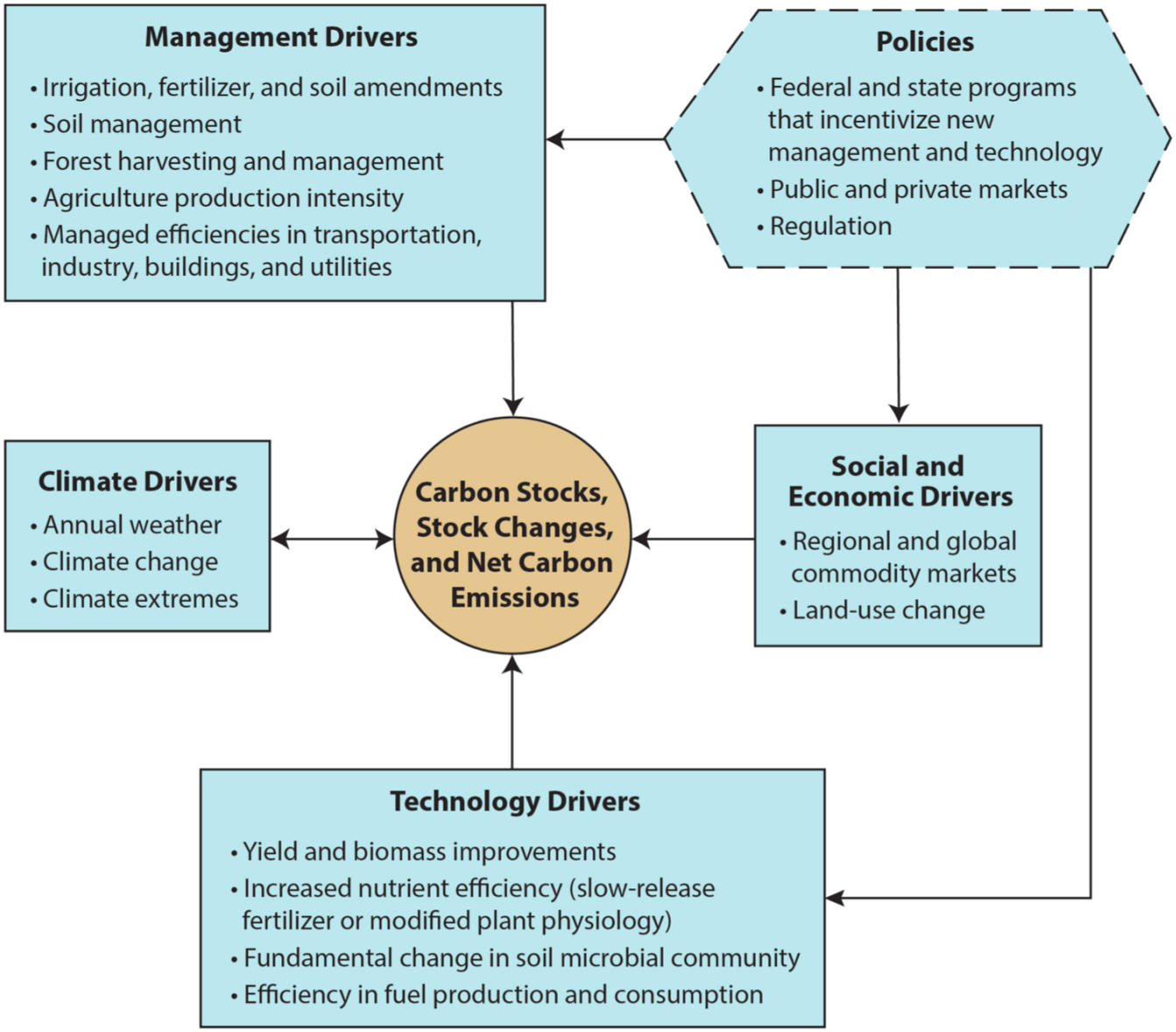


compiled by Saunois et al., 2016

https://carbon2018.globalchange.gov/chapter/2/

SOCCR-2 and social aspects

Primary Drivers of Carbon Stocks and Emissions



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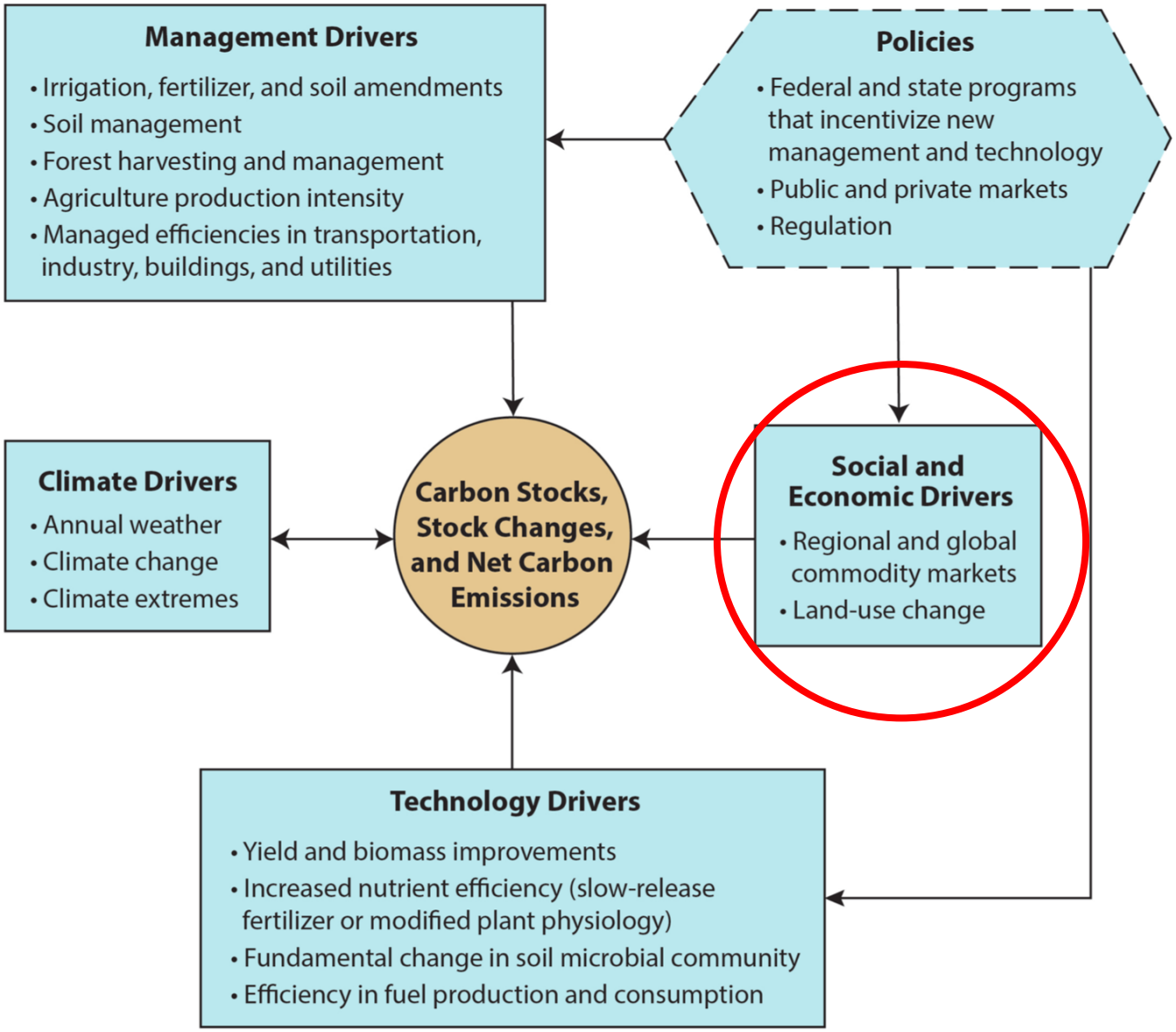
Primary Drivers of Carbon Stocks and Emissions



https://carbon2018.globalchange.gov/chapter/18/

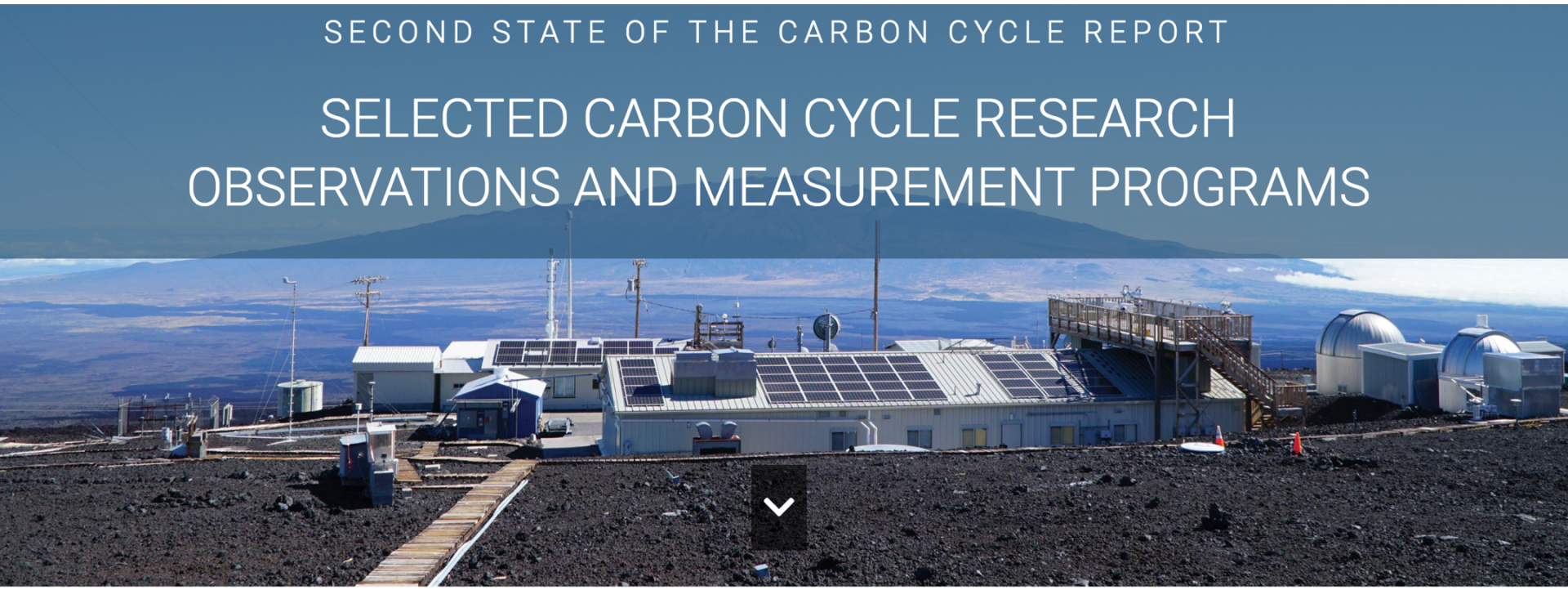
https://carbon2018.globalchange.gov/chapter/6/

Box 6.2 Embedded Carbon

Social science perspectives describe social arrangements and practices and then identify how carbon is embedded in them. “Embeddedness” means that carbon is an integral but often invisible part of how people lead their lives, so they do not think of themselves as using carbon but instead see the services and products without seeing their embedded carbon. Moreover, people do not often make choices about carbon as such—they choose from what is available in the market.

https://carbon2018.globalchange.gov/chapter/6/

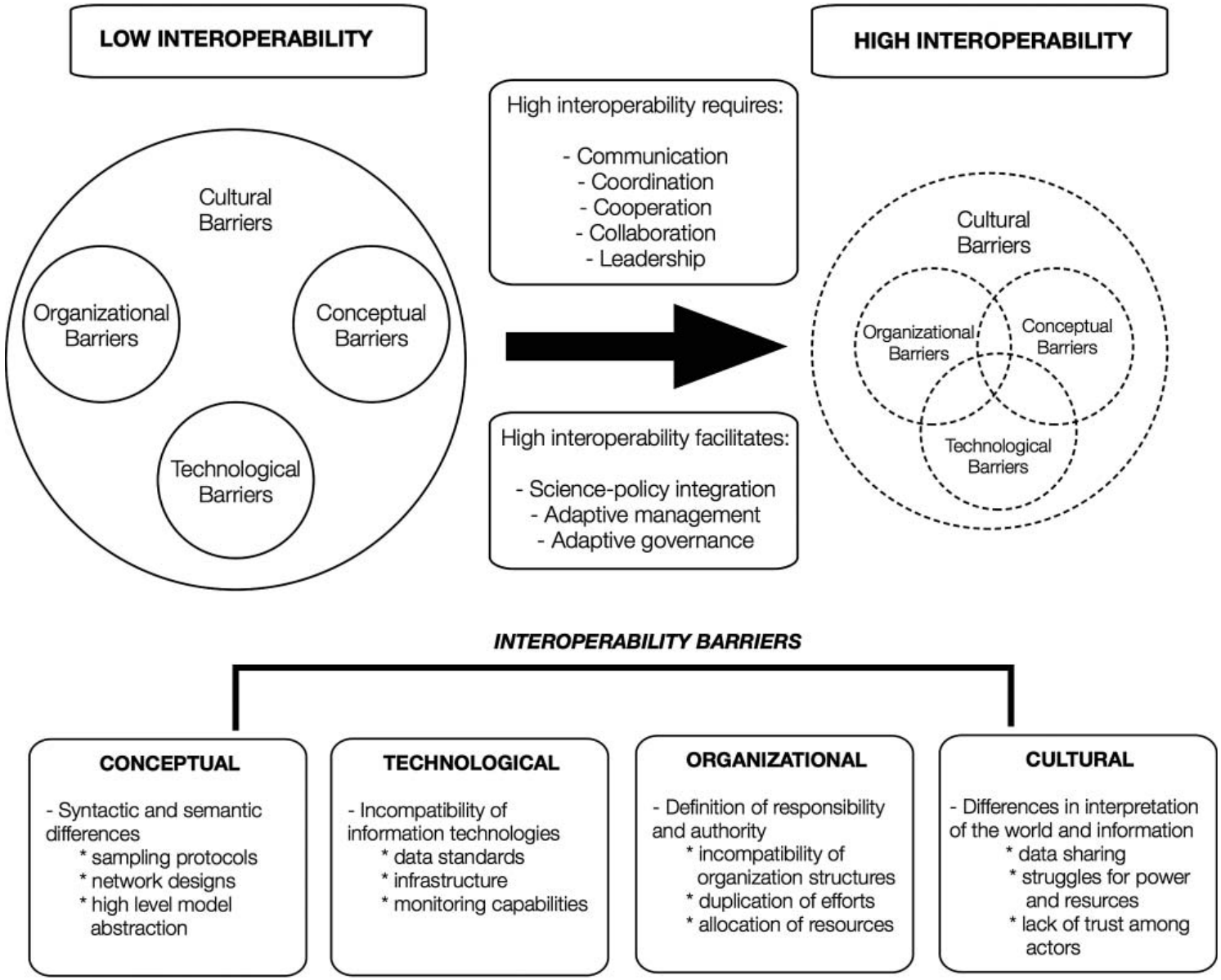
https://carbon2018.globalchange.gov/chapter/appendix-c/



APPENDIX C

Selected Carbon Cycle Research Observations and Measurement Programs

Interoperability for carbon cycle science



Vargas et al 2017

SOCCR2, Chapter 2: Key Findings

- NA a net source of C to the atmosphere over the last decade, driven by fossil fuel emissions
- The ecosystem sinks offset ~40% of fossil fuel emissions
- Consistency of bottom-up estimates in SOCCR2 vs. SOCCR1
- Agreement between bottom-up vs. top-down estimates in SOCCR2

Photo credit (D. Hayes)

Thank You!

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