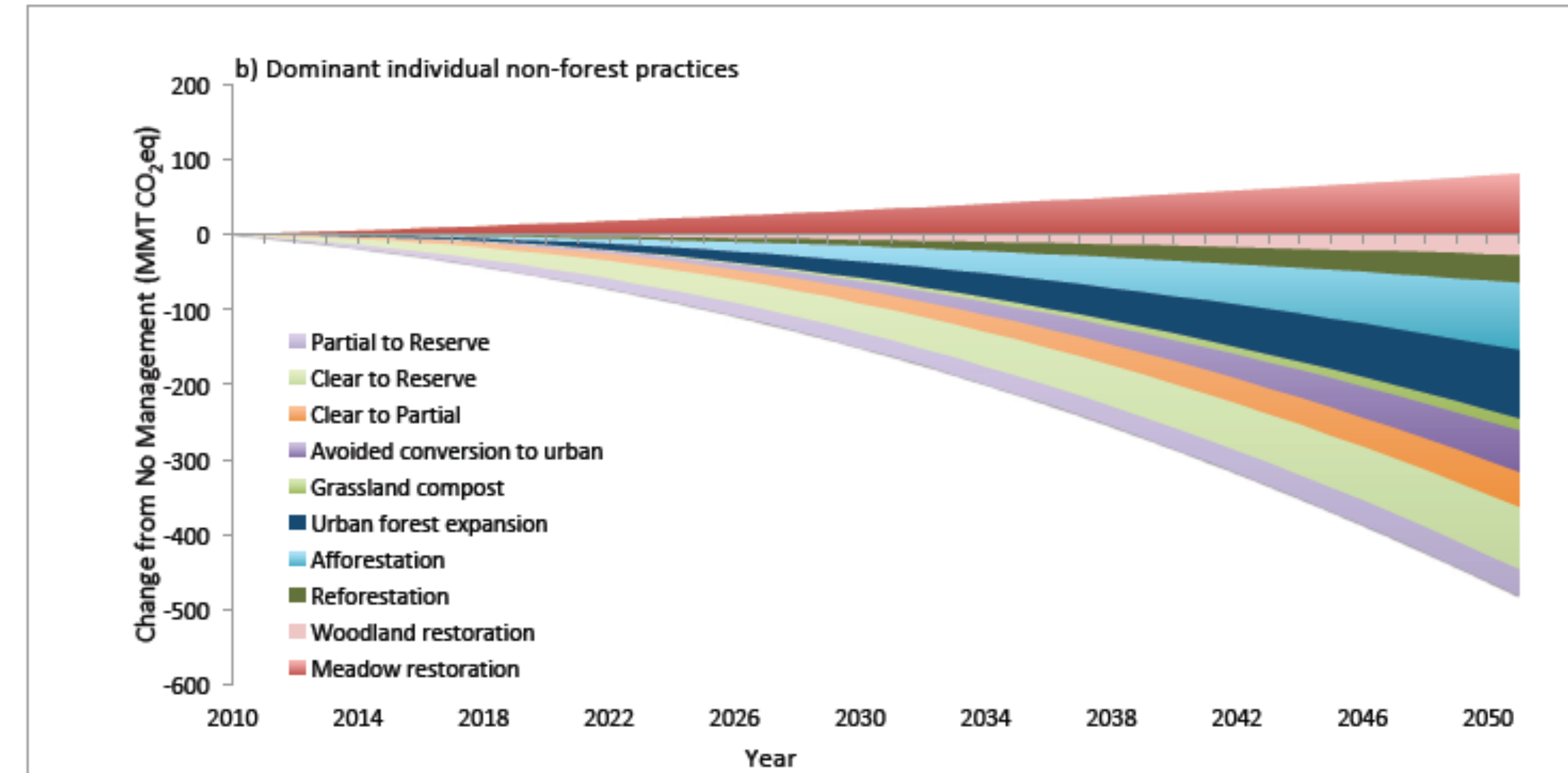
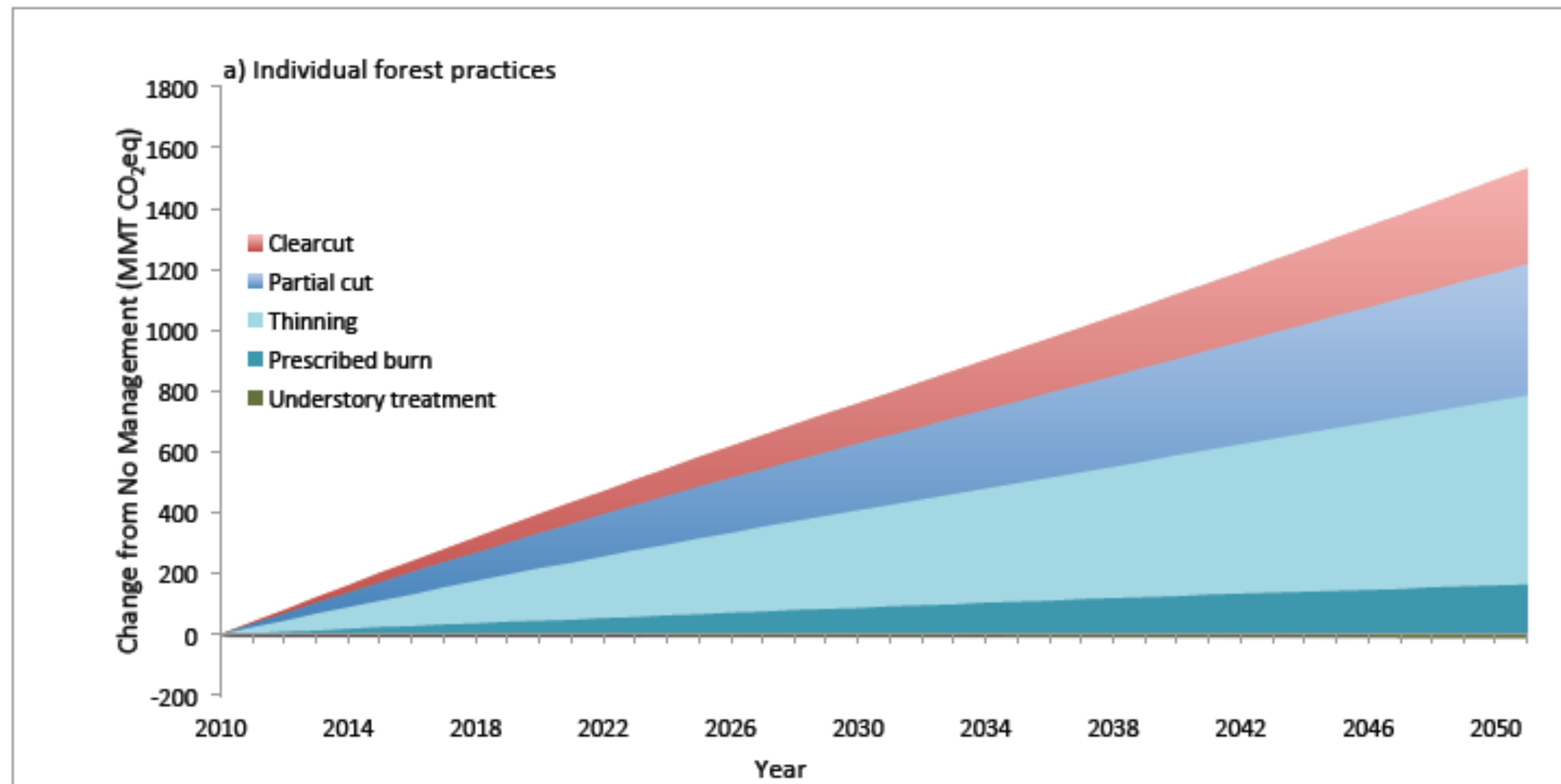
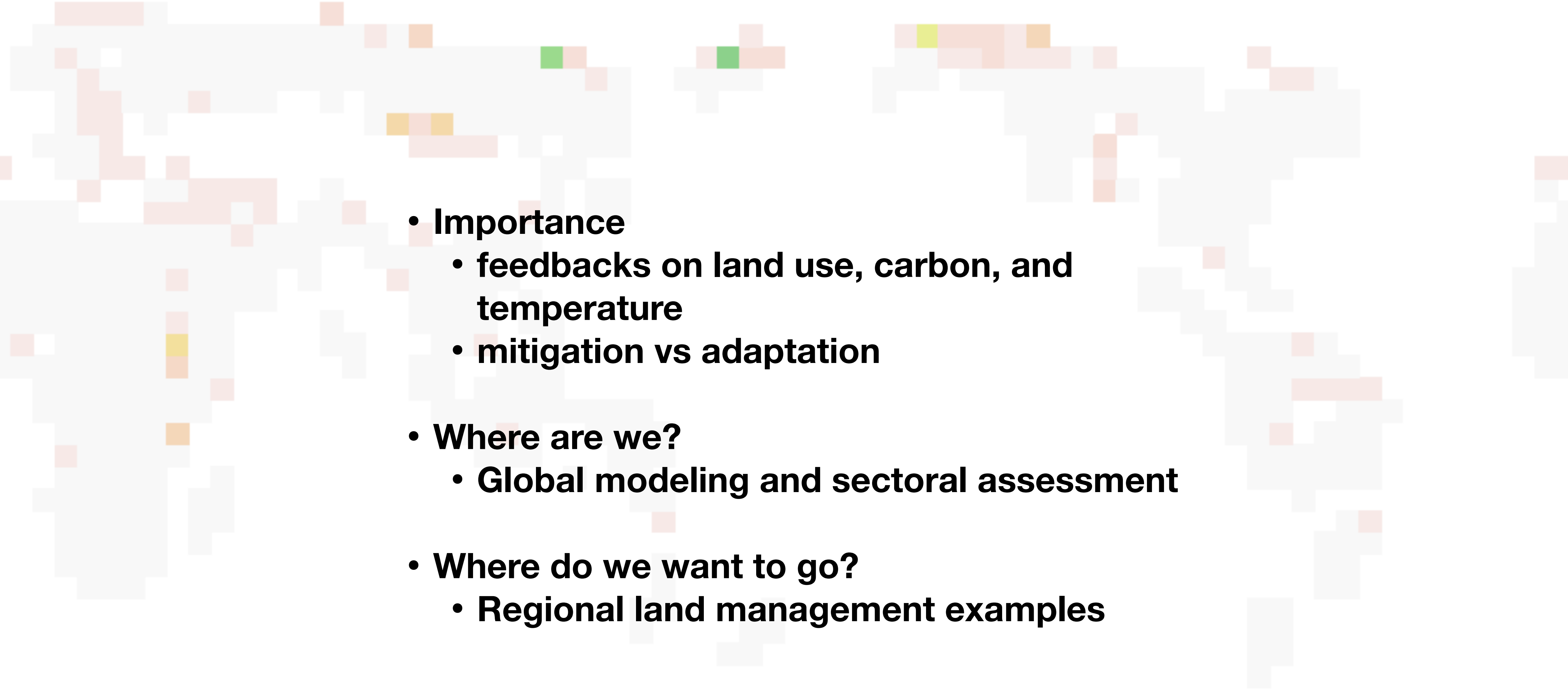


Representation of land use/cover change and land management in scenario-based modeling



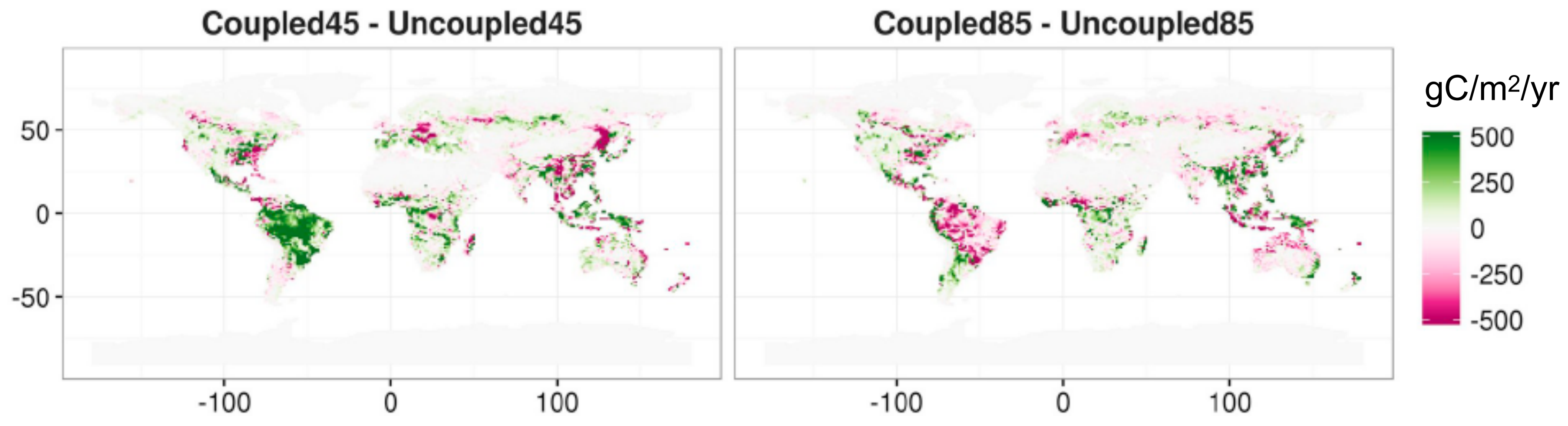
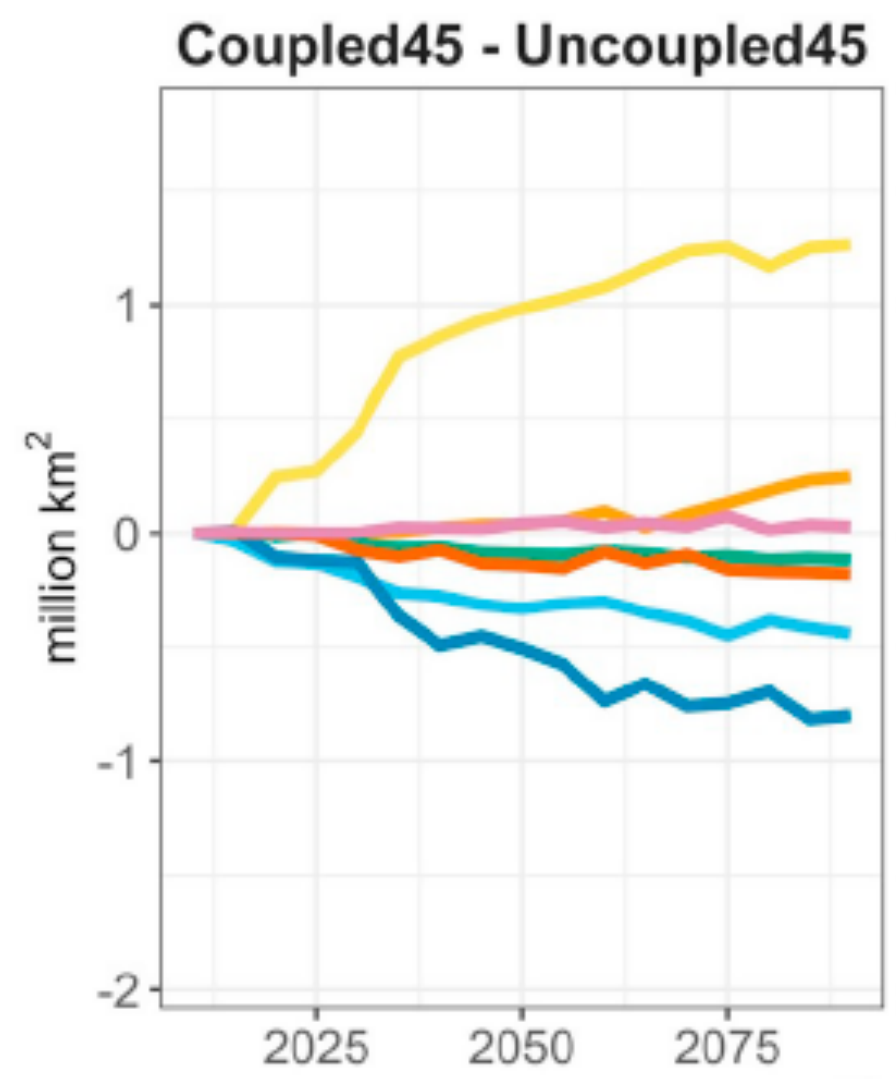
Alan Di Vittorio, Berkeley Lab
AGCI Human-Earth Workshop, 21 July 2021

Overview

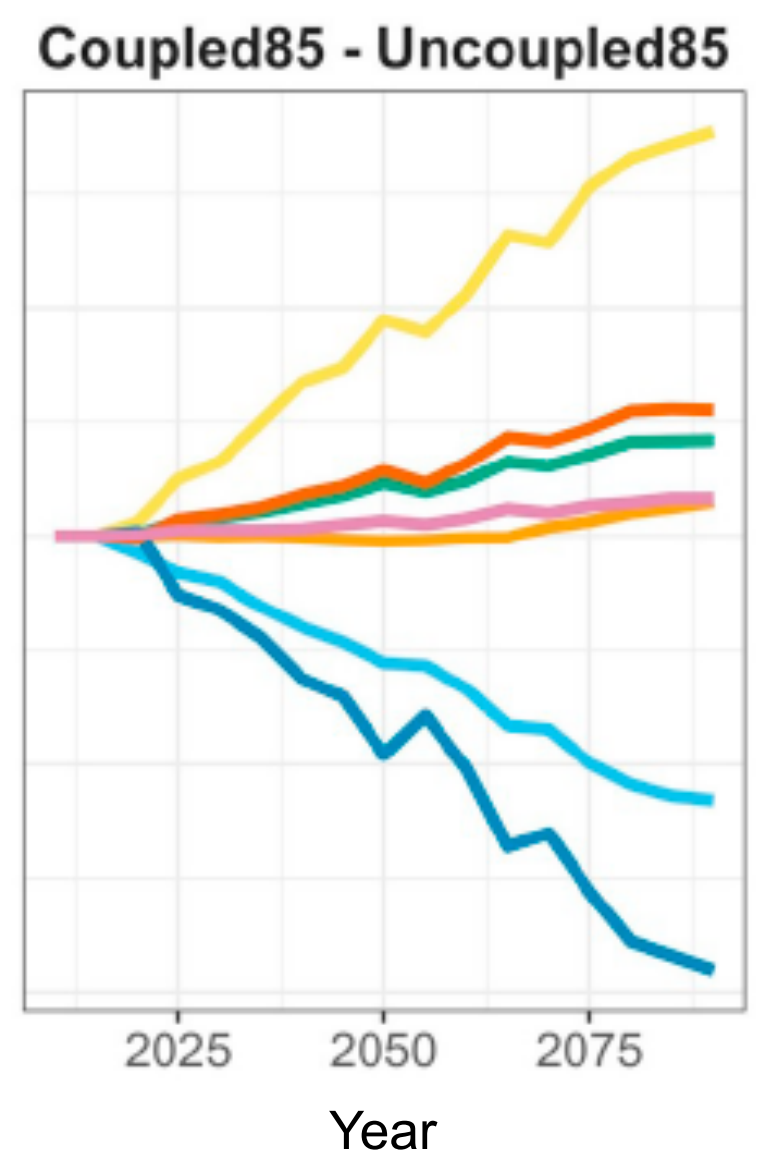
- 
- **Importance**
 - feedbacks on land use, carbon, and temperature
 - mitigation vs adaptation
 - **Where are we?**
 - Global modeling and sectoral assessment
 - **Where do we want to go?**
 - Regional land management examples

Human-Earth feedbacks affect land use, carbon, and temperature

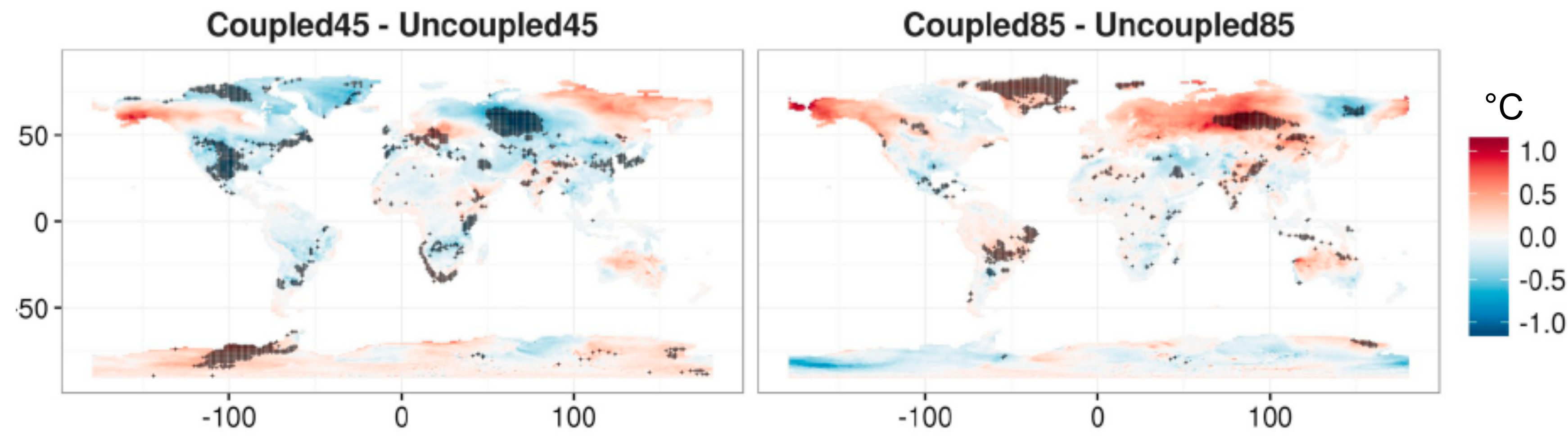
Changes in land carbon uptake (2071-2090)



Significant changes in local temperature



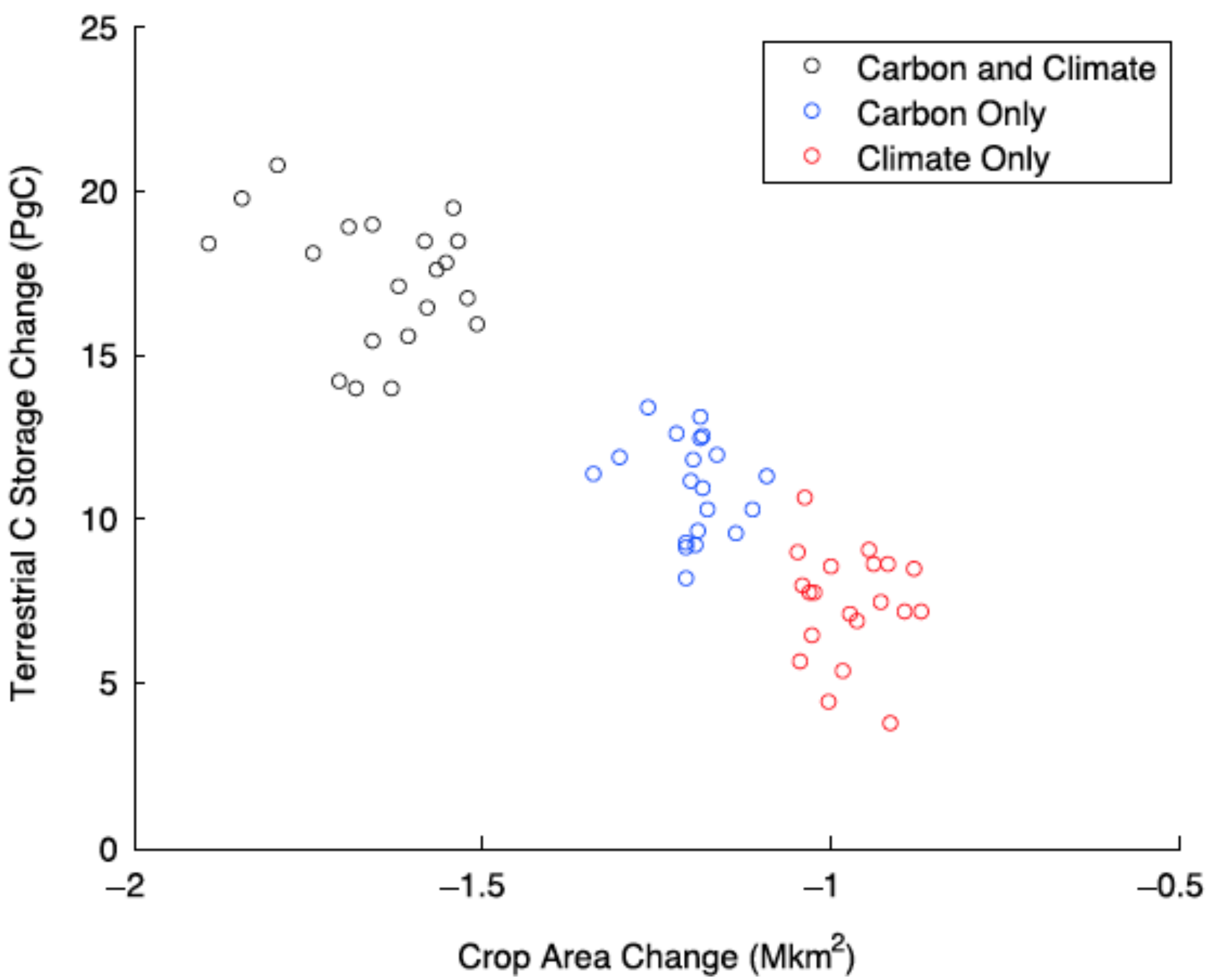
- Bioenergy
- Commercial Forest
- Grassland
- Non-commercial Forest
- Non-Energy Crops
- Pasture
- Shrubland



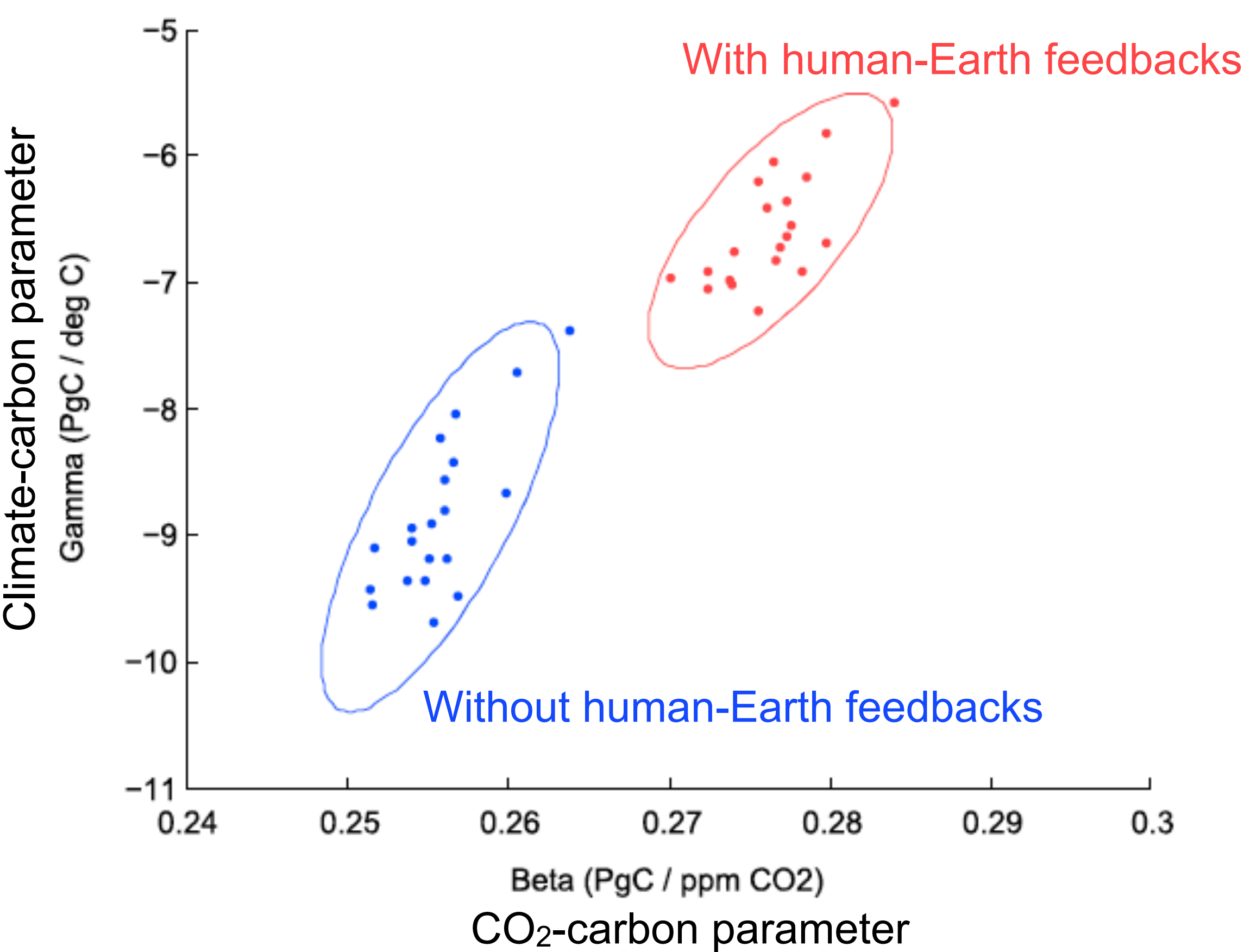
Human-Earth feedbacks affect land carbon feedbacks

RCP 8.5

Changes in land C and crop area (2070-2089)

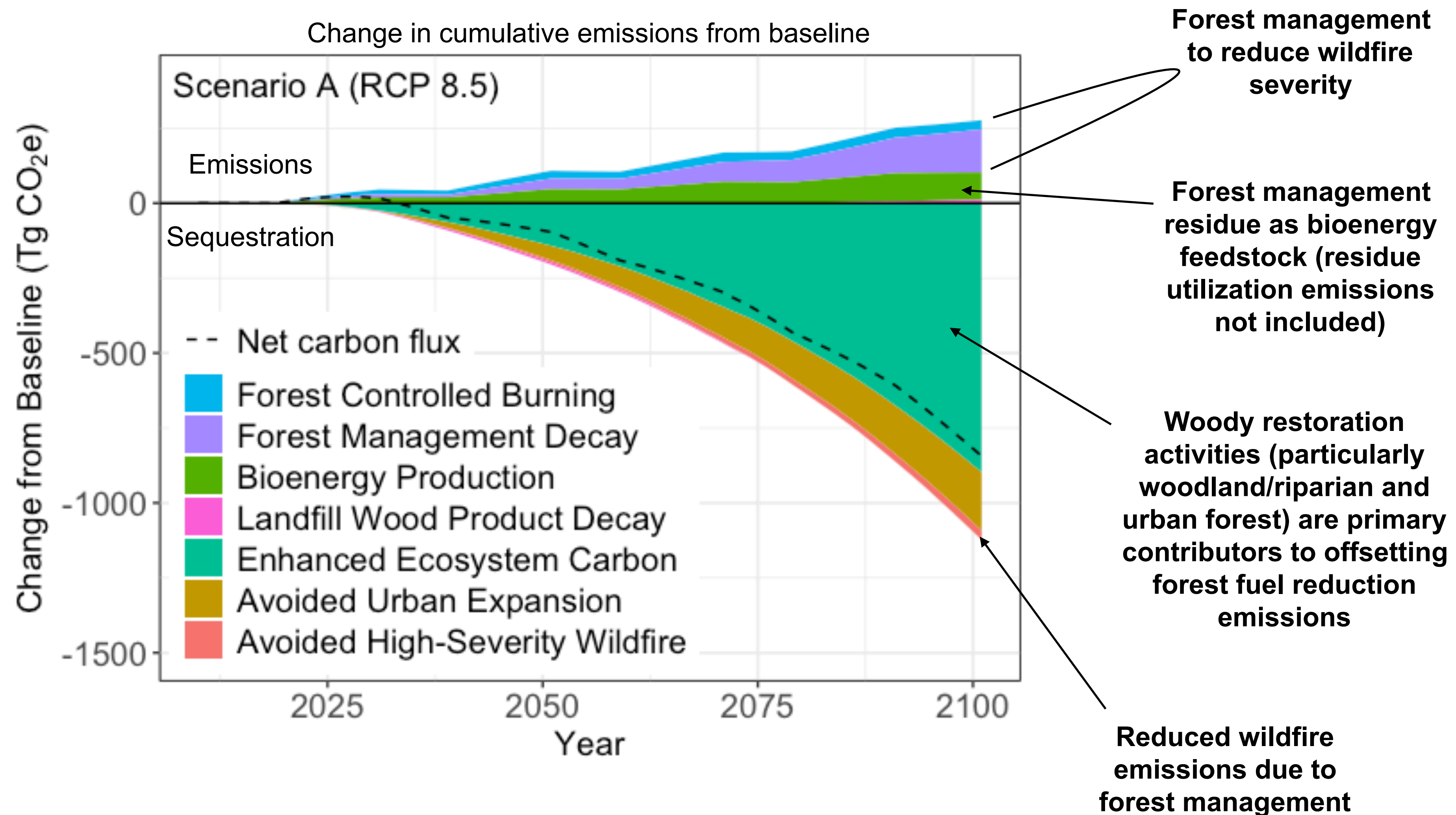


Changes in land C feedbacks (2070-2089)



There are tradeoffs between mitigation and adaptation

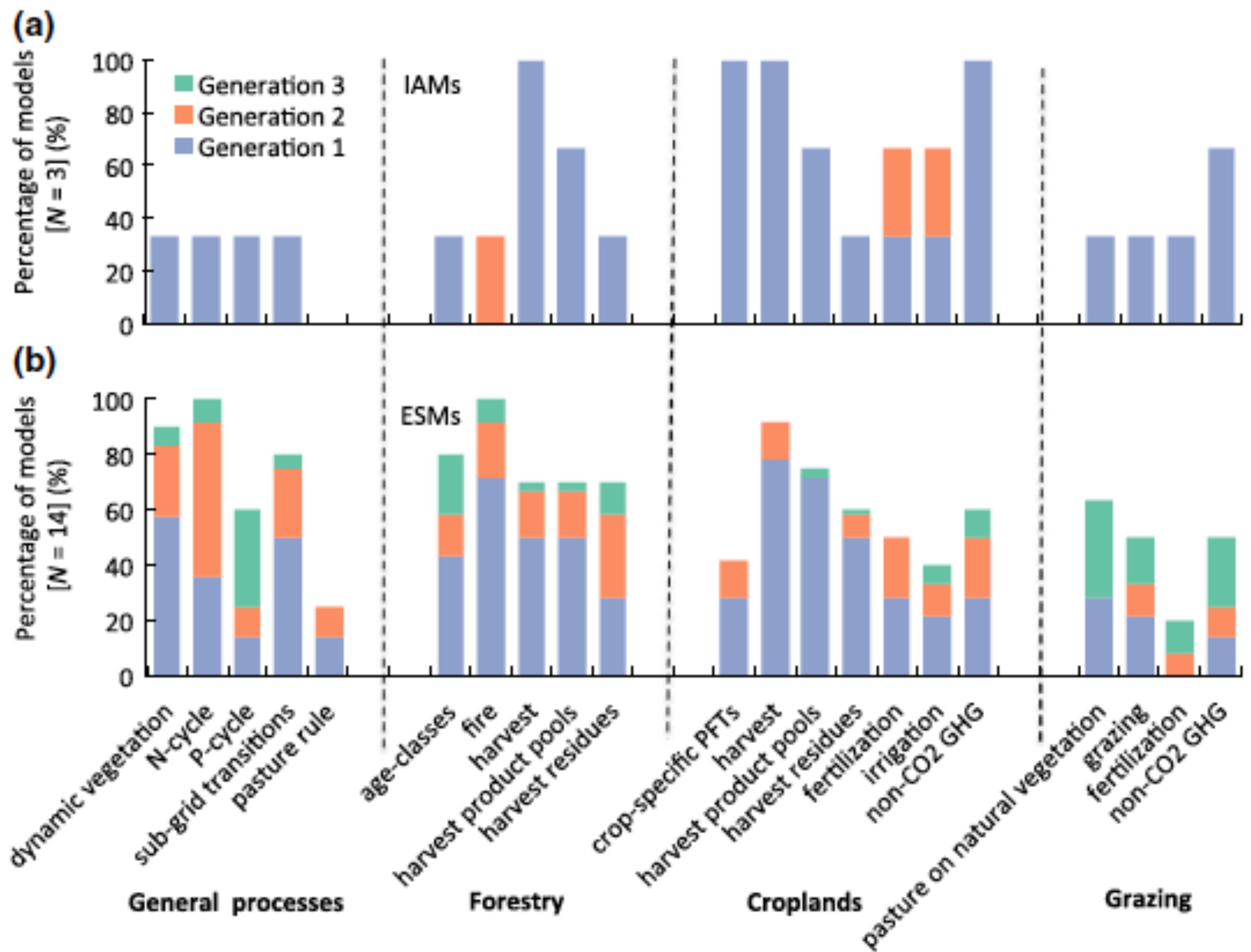
California
Expected
natural and
working lands
scenario



Limited land management differs among IAMs and ESMs

Carbon management is limited (and is only in IAMs)

Basic land management is increasing in implementation



Pongratz et al., 2018

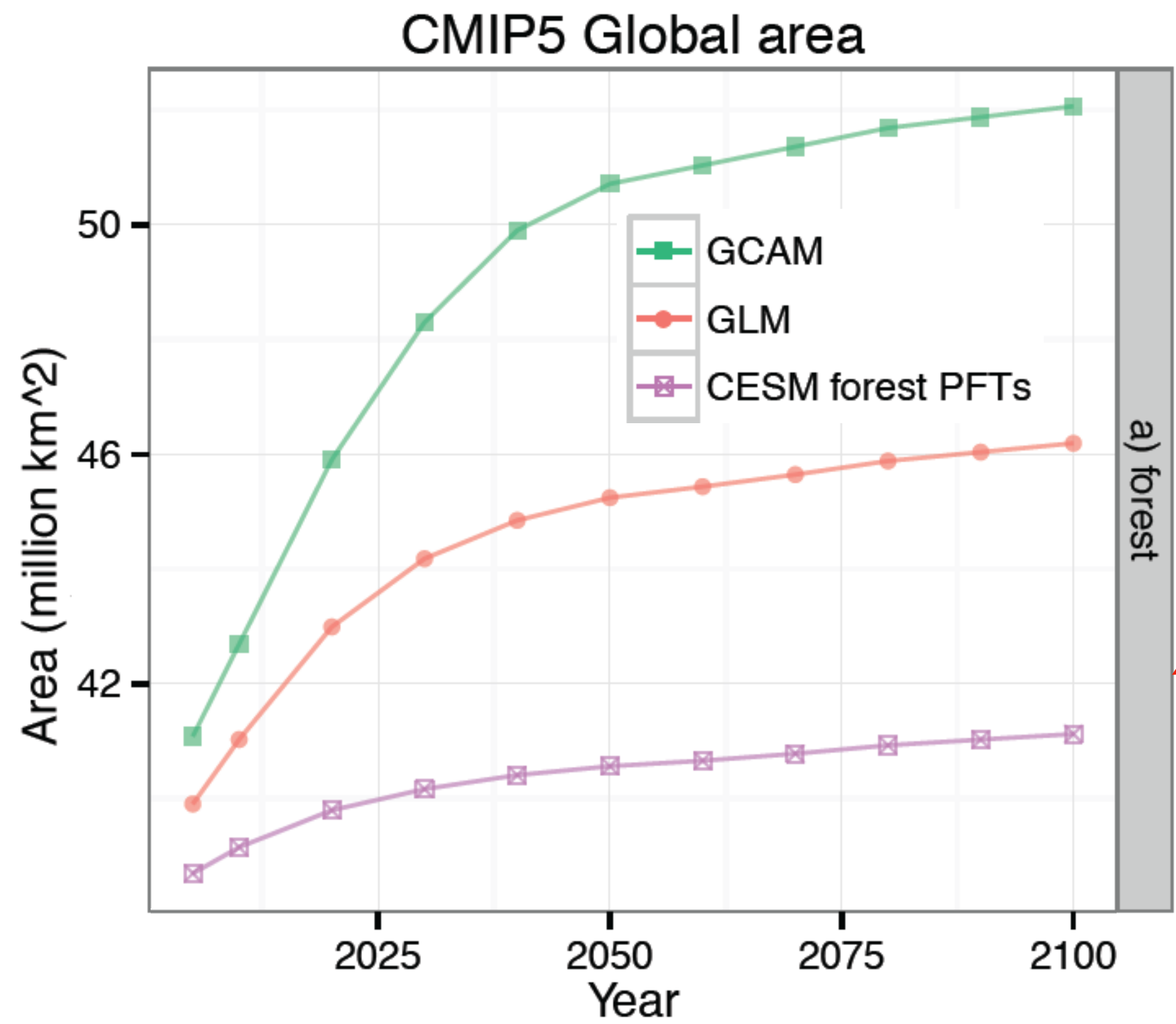
Levels of Inclusion			Model Names																	
	Explicit	Implicit																		
Endogenous	A	C																		
Exogenous	B	D																		
E	Not represented by model																			
Carbon Dioxide (Greenhouse Gas) Removal																				
BECCS			A	A	A	D	A	A	E	E	A	A	A	A	A	A	A	E	A	A
Direct air capture and sequestration (DACs) of CO ₂ using chemical solvents and solid absorbents, with subsequent storage			E	E	E	D	E	E	E	E	E	E	E	E	E	A	E	E	E	E
Forest expansion			A	E	A	C	A	A	E	E	A	E	E	E	B	B	E	A	A	B
Restoration of wetlands (e.g., coastal and peat-land restoration, blue carbon)			E	E	E	D	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Biochar			E	E	E	D	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Soil carbon enhancement, enhancing carbon sequestration in biota and soils, e.g. with plants with high carbon sequestration potential (also AFOLU measure)			E	E	E	D	E	E	E	E	E	E	E	D	E	E	A	A	B	C
AFOLU Measures																				
Reduced deforestation			A	E	A	D	B	A	E	E	B	D	D	E	B	B	E	A	A	B
Forest management			C	E	E	D	E	C	E	E	C	D	D	E	B	B	E	A	A	B
Reduced land degradation, and forest restoration			C	E	D	D	E	E	E	E	C	D	D	E	E	B	E	E	E	B
Agroforestry and silviculture			E	E	D	D	E	E	E	E	E	D	D	E	E	E	E	E	E	E
Urban and peri-urban agriculture and forestry			E	E	E	D	E	E	E	E	E	D	D	E	E	E	E	E	E	E
Fire management and (ecological) pest control			C	E	D	D	E	C	E	E	E	D	D	E	E	E	E	E	E	E
Changing agricultural practices that enhance soil carbon			C	E	E	D	E	E	E	E	E	D	D	E	E	E	E	E	E	B
Conservation agriculture			E	E	E	D	E	E	E	E	E	D	D	E	E	E	E	A	A	E
Increased ag productivity			A	E	A	D	A	B	E	E	B	D	D	E	A	B	E	A	A	E
Methane reductions in rice paddies			C	E	C	D	C	C	C	E	C	D	D	E	C	C	E	A	A	B
Nitrogen pollution reductions (e.g., by fertilizer reduction, increasing nitrogen fertilizer efficiency, sustainable fertilizers)			C	E	C	D	C	C	C	E	E	D	D	E	A	C	E	A	A	B
Livestock and grazing management, for example, methane and ammonia reductions in ruminants through feeding management or feed additives, or manure management for local biogas production to replace traditional biomass use			C	E	C	D	C	C	C	E	C	D	D	E	A	C	E	A	A	B
Manure management			C	E	C	D	C	C	C	E	C	D	D	E	C	C	E	A	A	E
Biophysical effects			E	E	E	D	E	E	E	E	E	D	D	E	E	E	E	E	E	D

Forster et al., 2018

Limited land management differs among IAMs and ESMs

Carbon management is limited (and is only in IAMs)

But existing processes are not yet consistent across human-Earth modeling



Di Vittorio et al., 2014

Levels of Inclusion			Model Names																				
	Explicit	Implicit	AIM	BET	COPPE-COFFEE	C-ROADS	DNE21+	GCAM 4.2	GEM-E3 3.0	GENESYsmod 1.0	GRAPE 1.0	IEA ETP	IEA WEM	IMACLIM 1.1	IMACLIM NL	IMAGE 3.0	MERGE-ETL 6.0	MESSAGE-GLOBIOM	MESSAGE-GLOBIO	POLES	REMIND-MAGPIE	ShellWEM v1	WITCH
Endogenous	A	C																					
Exogenous	B	D																					
E	Not represented by model																						
Carbon Dioxide (Greenhouse Gas) Removal																							
BECCS			A	A	A	D	A	A	E	E	A	A	A	A	A	A	A	A	E	A	A	B	A
Direct air capture and sequestration (DACs) of CO ₂ using chemical solvents and solid absorbents, with subsequent storage			E	E	E	D	E	E	E	E	E	E	E	E	E	E	A	E	E	E	A	E	E
Mineralization of atmospheric CO ₂ through enhanced weathering of silicate rocks			E	E	E	D	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Forest expansion			A	E	A	C	A	A	E	E	A	E	E	E	B	B	E	A	A	B	A	D	A
Restoration of wetlands (e.g., coastal and peat-land restoration, blue carbon)			E	E	E	D	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Biochar			E	E	E	D	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Soil carbon enhancement, enhancing carbon sequestration in biota and soils, e.g. with plants with high carbon sequestration potential (also AFOLU measure)			E	E	E	D	E	E	E	E	E	E	E	D	E	E	A	A	B	C	E	E	E
AFOLU Measures																							
Reduced deforestation			A	E	A	D	B	A	E	E	B	D	D	E	B	B	E	A	A	B	A	D	C
Forest management			C	E	E	D	E	C	E	E	C	D	D	E	B	B	E	A	A	B	E	D	C
Reduced land degradation, and forest restoration			C	E	D	D	E	E	E	E	C	D	D	E	E	B	E	E	E	B	E	D	E
Agroforestry and silviculture			E	E	D	D	E	E	E	E	E	D	D	E	E	E	E	E	E	E	E	E	E
Urban and peri-urban agriculture and forestry			E	E	E	D	E	E	E	E	E	D	D	E	E	E	E	E	E	E	E	E	E
Fire management and (ecological) pest control			C	E	D	D	E	C	E	E	E	D	D	E	E	E	E	E	E	E	E	E	E
Changing agricultural practices that enhance soil carbon			C	E	E	D	E	E	E	E	E	D	D	E	E	E	E	E	E	B	E	D	E
Conservation agriculture			E	E	E	D	E	E	E	E	E	D	D	E	E	E	E	A	A	E	E	E	C
Increased ag productivity			A	E	A	D	A	B	E	E	B	D	D	E	A	B	E	A	A	E	A	D	C
Methane reductions in rice paddies			C	E	C	D	C	C	C	E	C	D	D	E	C	C	E	A	A	B	C	D	C
Nitrogen pollution reductions (e.g., by fertilizer reduction, increasing nitrogen fertilizer efficiency, sustainable fertilizers)			C	E	C	D	C	C	C	E	E	D	D	E	A	C	E	A	A	B	C	D	C
Livestock and grazing management, for example, methane and ammonia reductions in ruminants through feeding management or feed additives, or manure management for local biogas production to replace traditional biomass use			C	E	C	D	C	C	C	E	C	D	D	E	A	C	E	A	A	B	C	D	C
Manure management			C	E	C	D	C	C	C	E	C	D	D	E	C	C	E	A	A	E	C	E	C
Biophysical effects			E	E	E	D	E	E	E	E	E	D	D	E	E	E	E	E	E	E	D	D	E

Forster et al., 2018

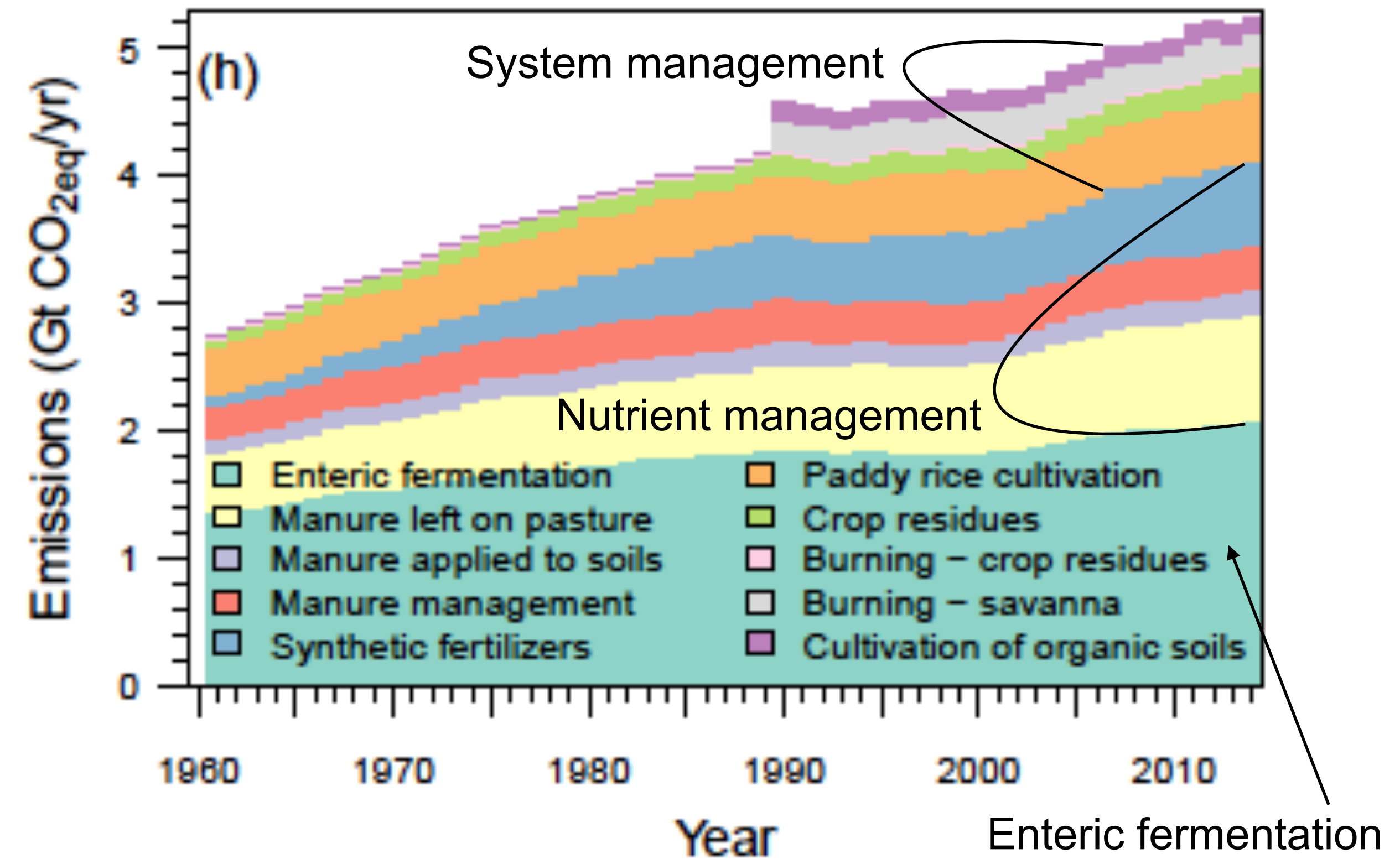
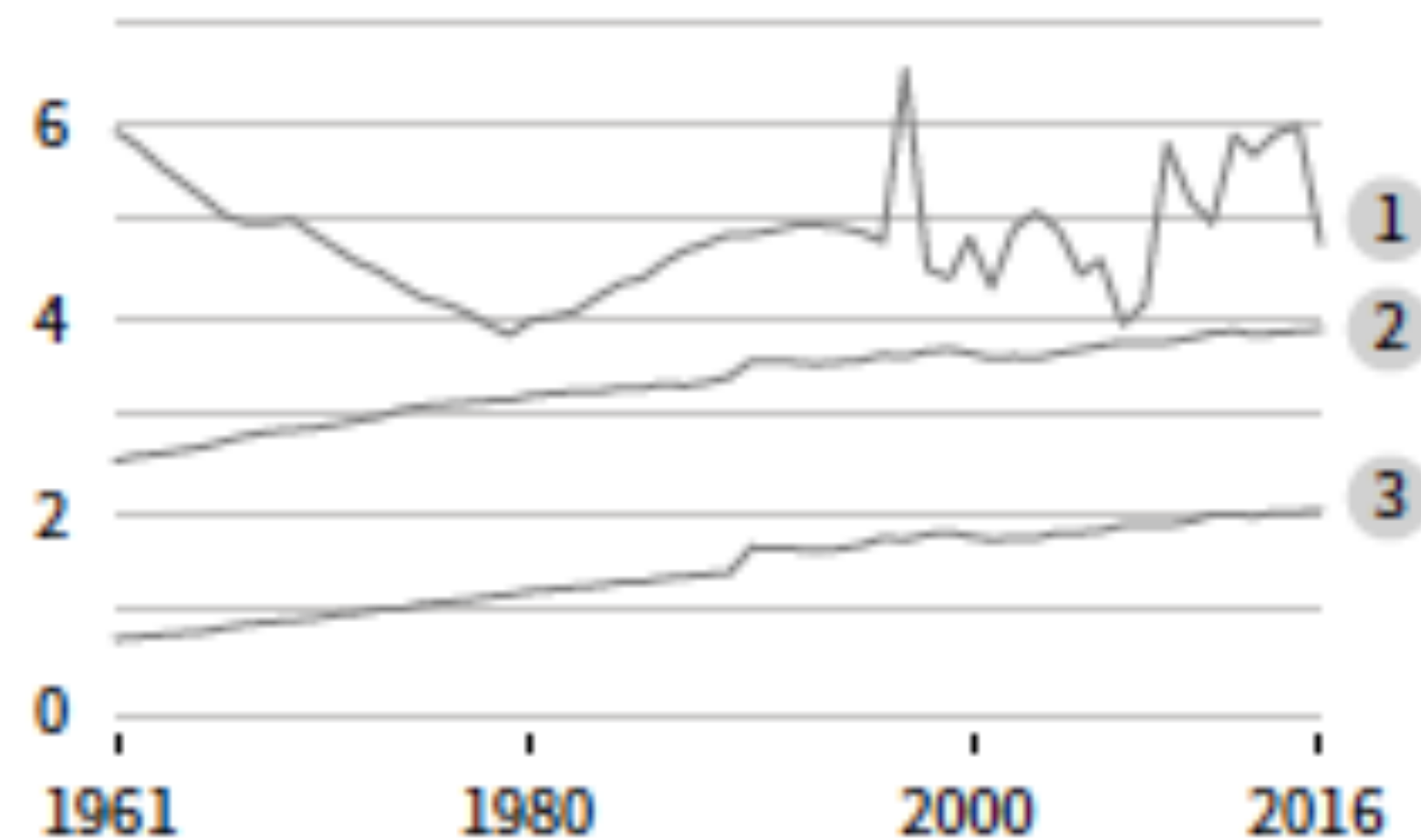
Non-CO₂ sources contribute roughly half of total land emissions

Most of these are area-based activities that can be included in global models

CHANGE in EMISSIONS since 1961

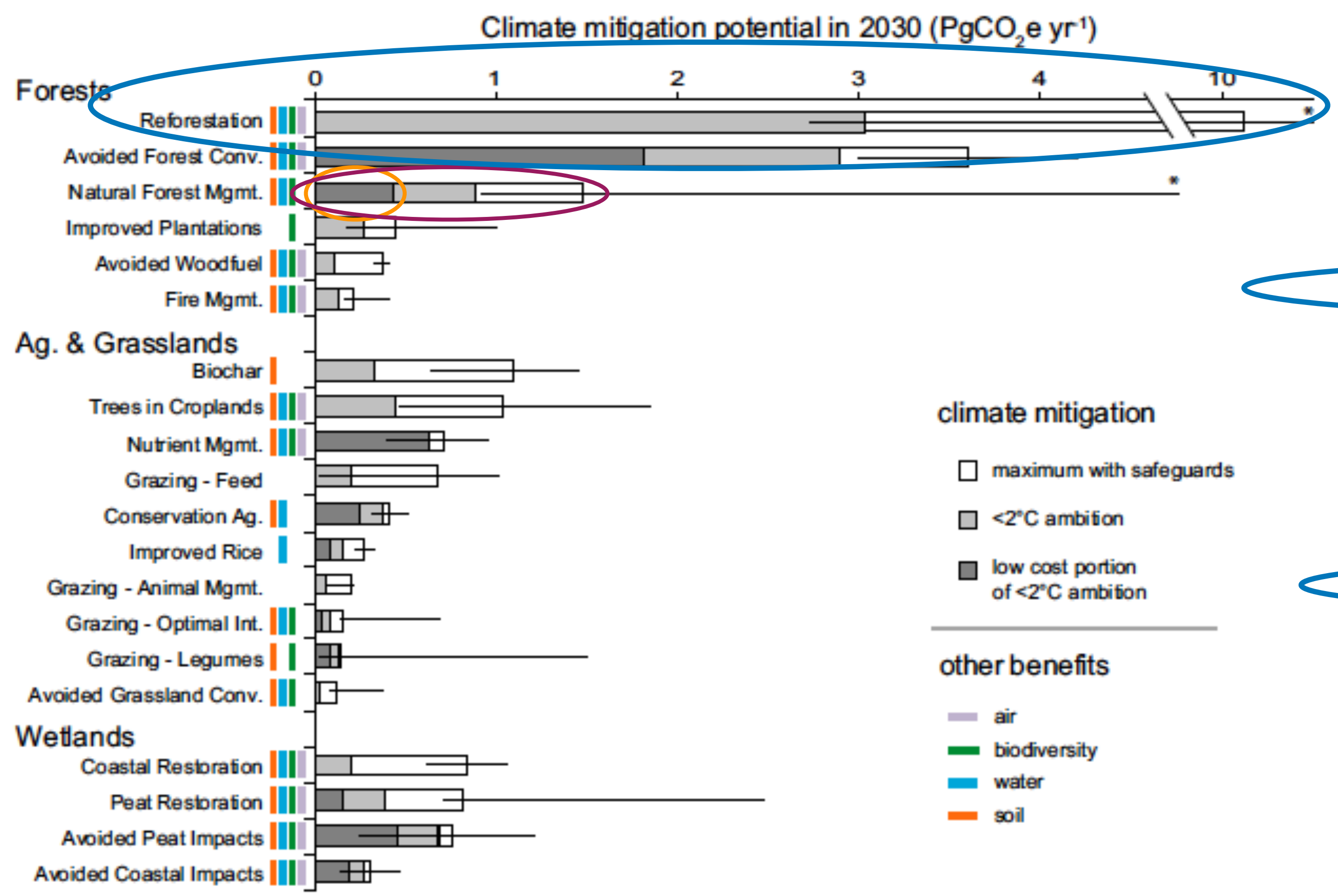
- 1 Net CO₂ emissions from FOLU (GtCO₂ yr⁻¹)
- 2 CH₄ emissions from Agriculture (GtCO₂eq yr⁻¹)
- 3 N₂O emissions from Agriculture (GtCO₂eq yr⁻¹)

GtCO₂eq yr⁻¹

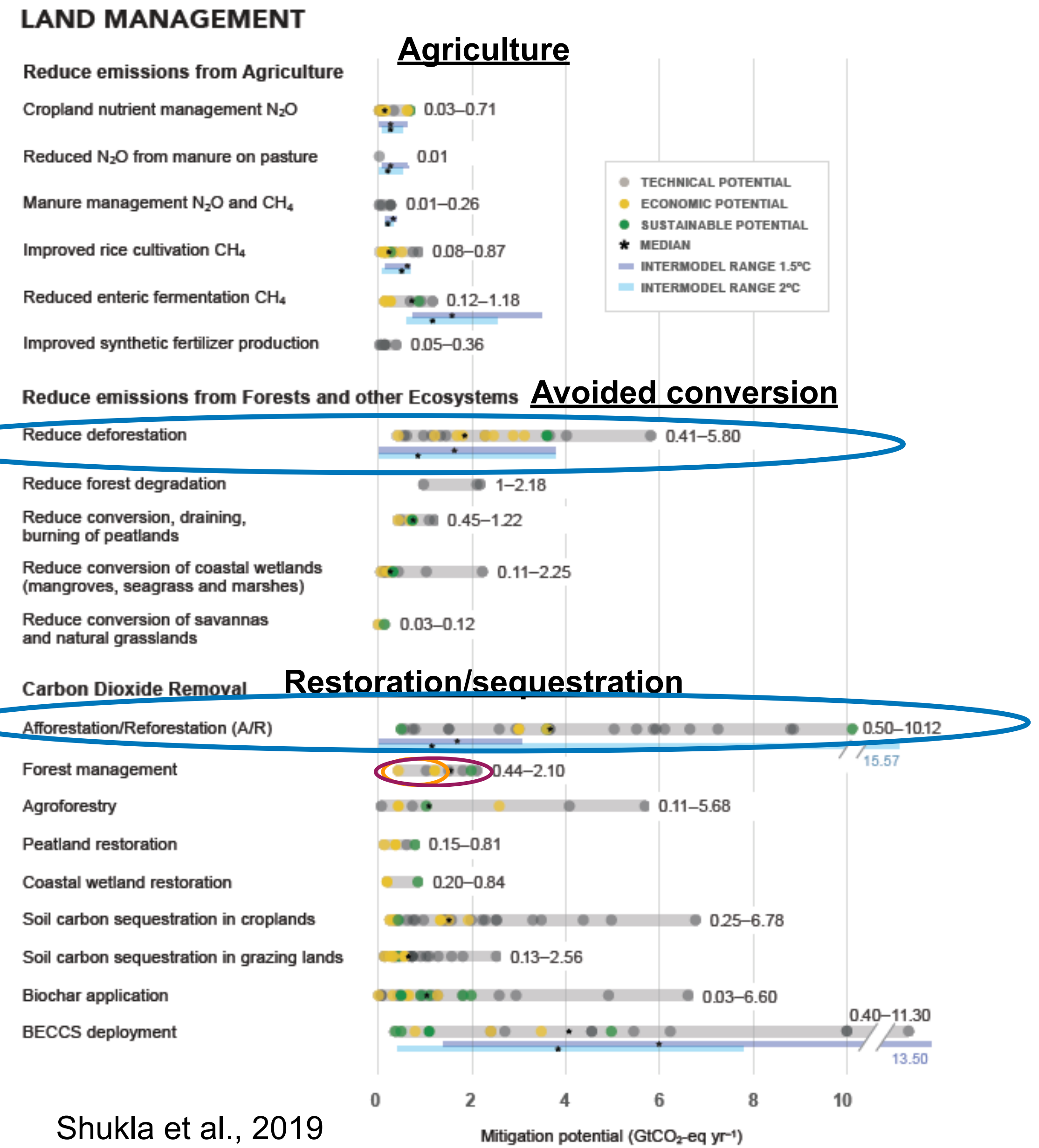


Sectoral studies are used for land-based mitigation estimates

Note that economic potential is often ***much less*** than technical potential

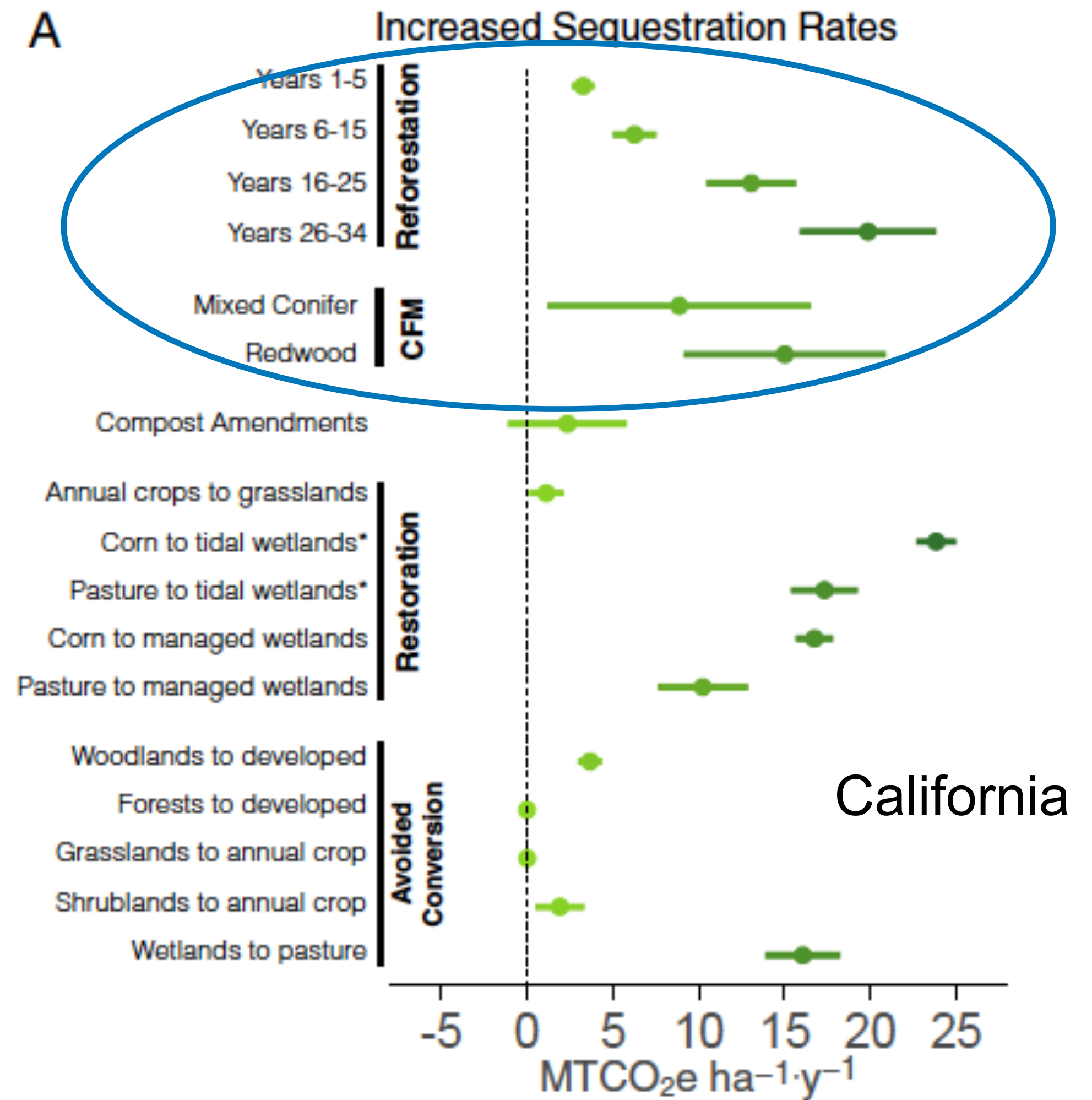
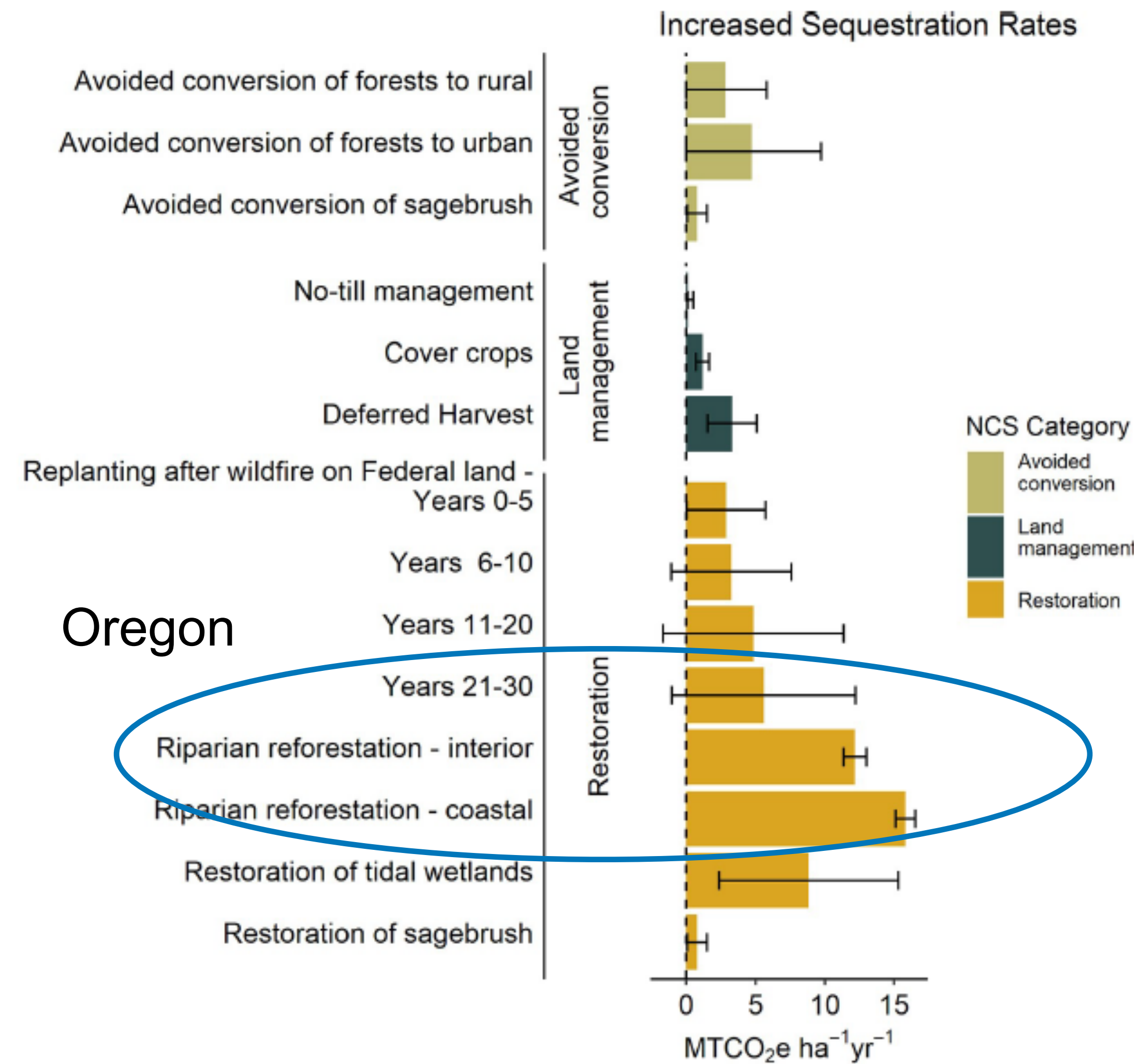


Griscom et al., 2017

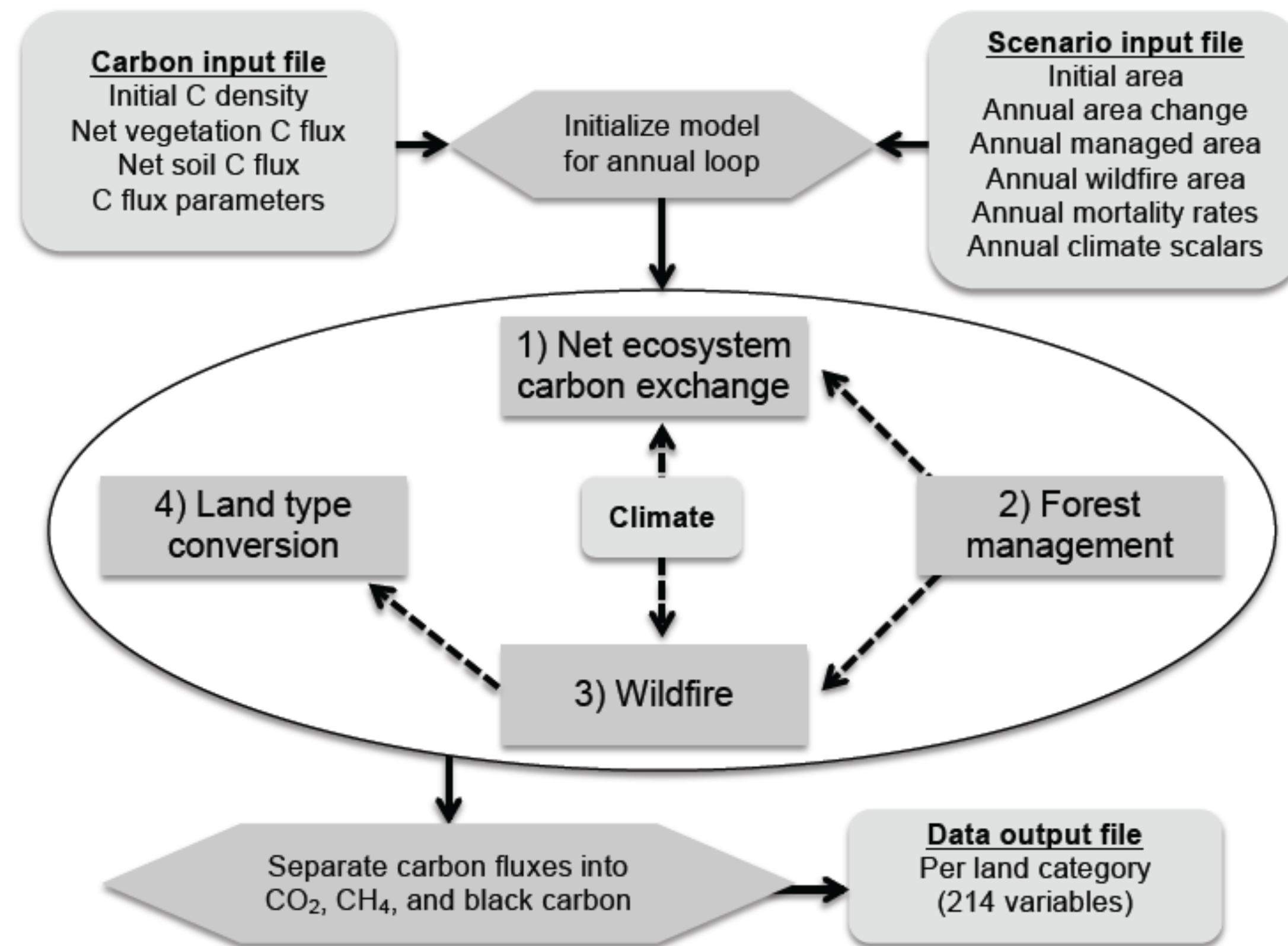


Shukla et al., 2019

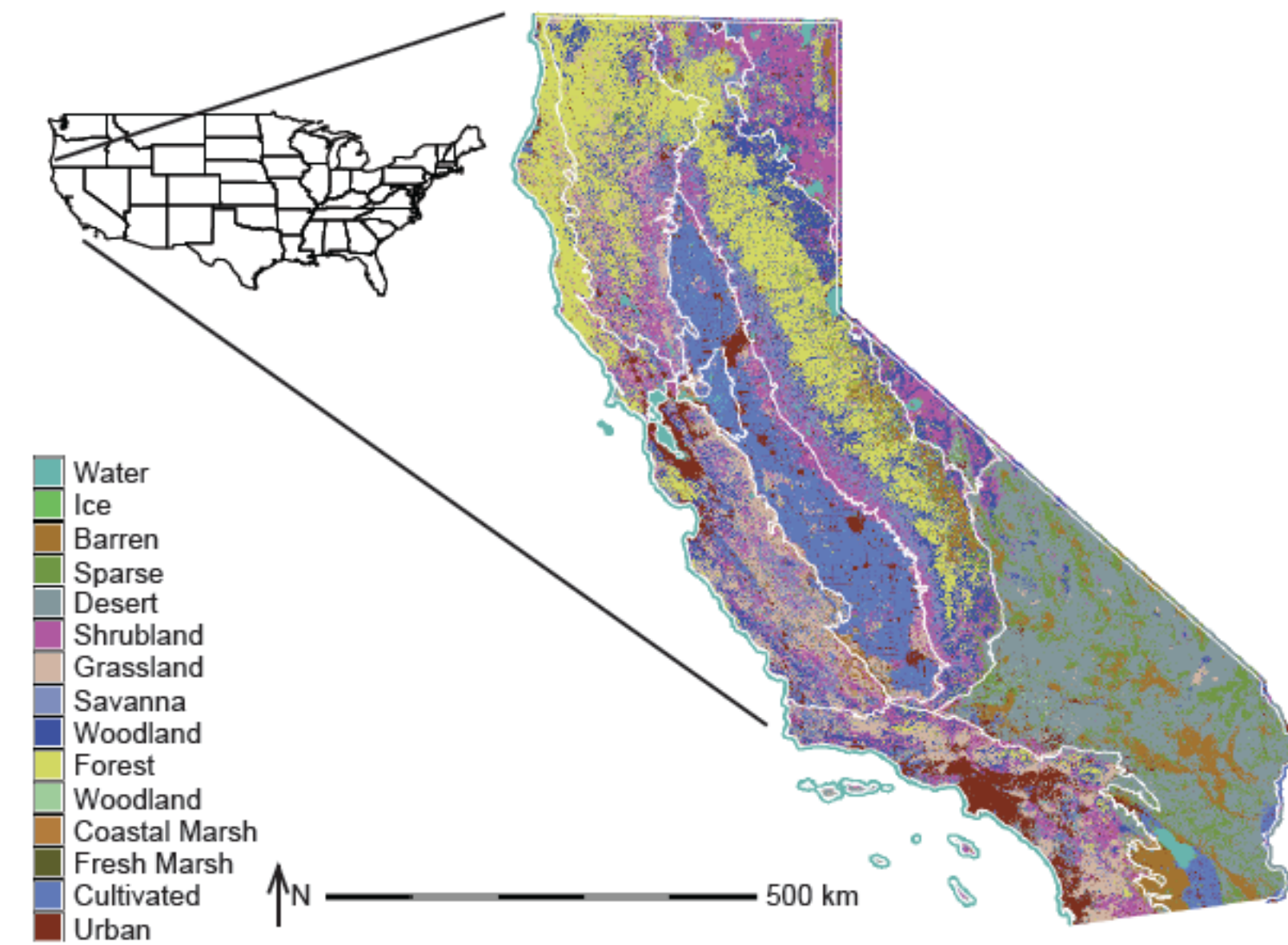
Benefit patterns are similar across scales



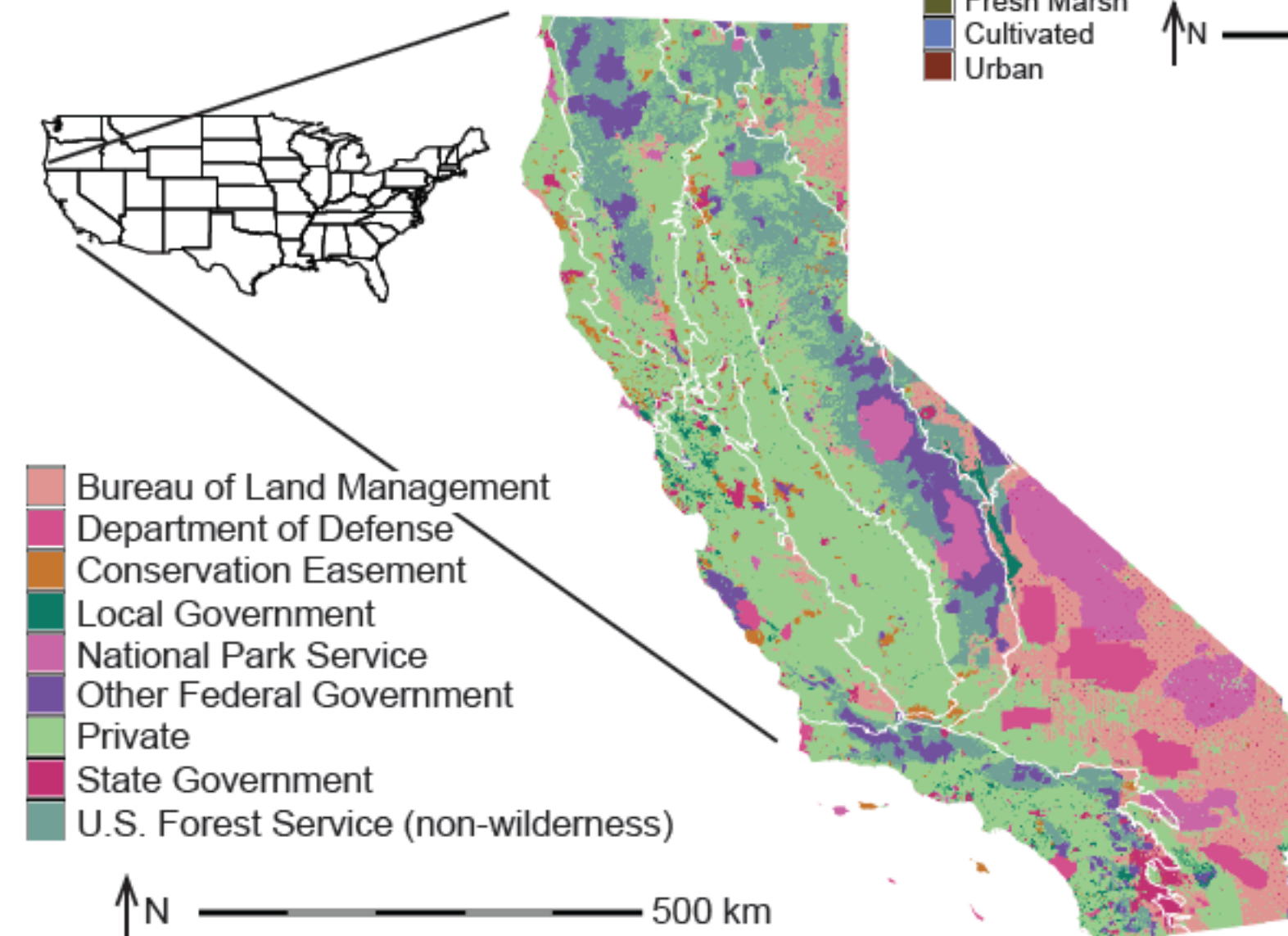
CALAND generates integrated estimates of the carbon consequences of land management in California



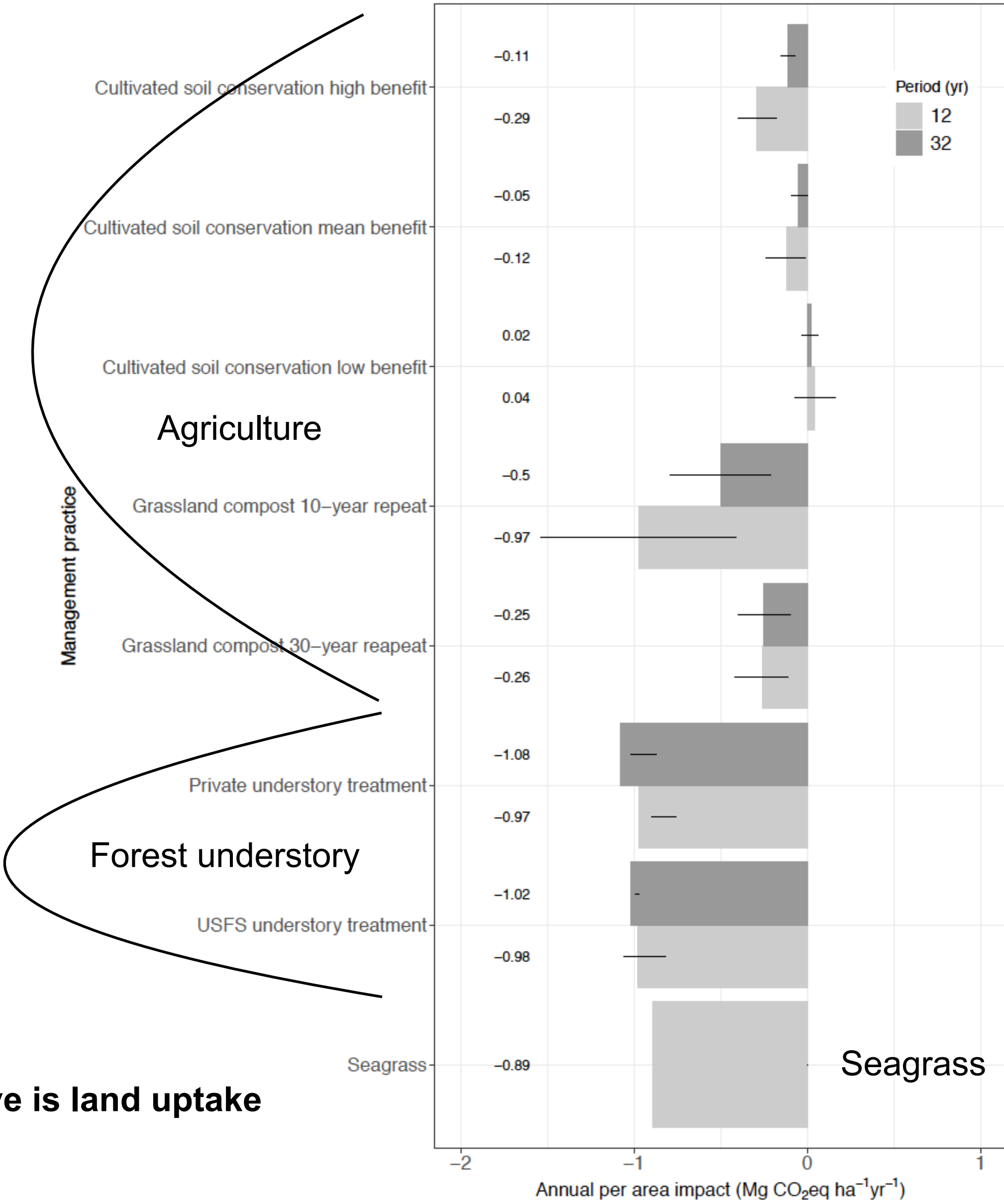
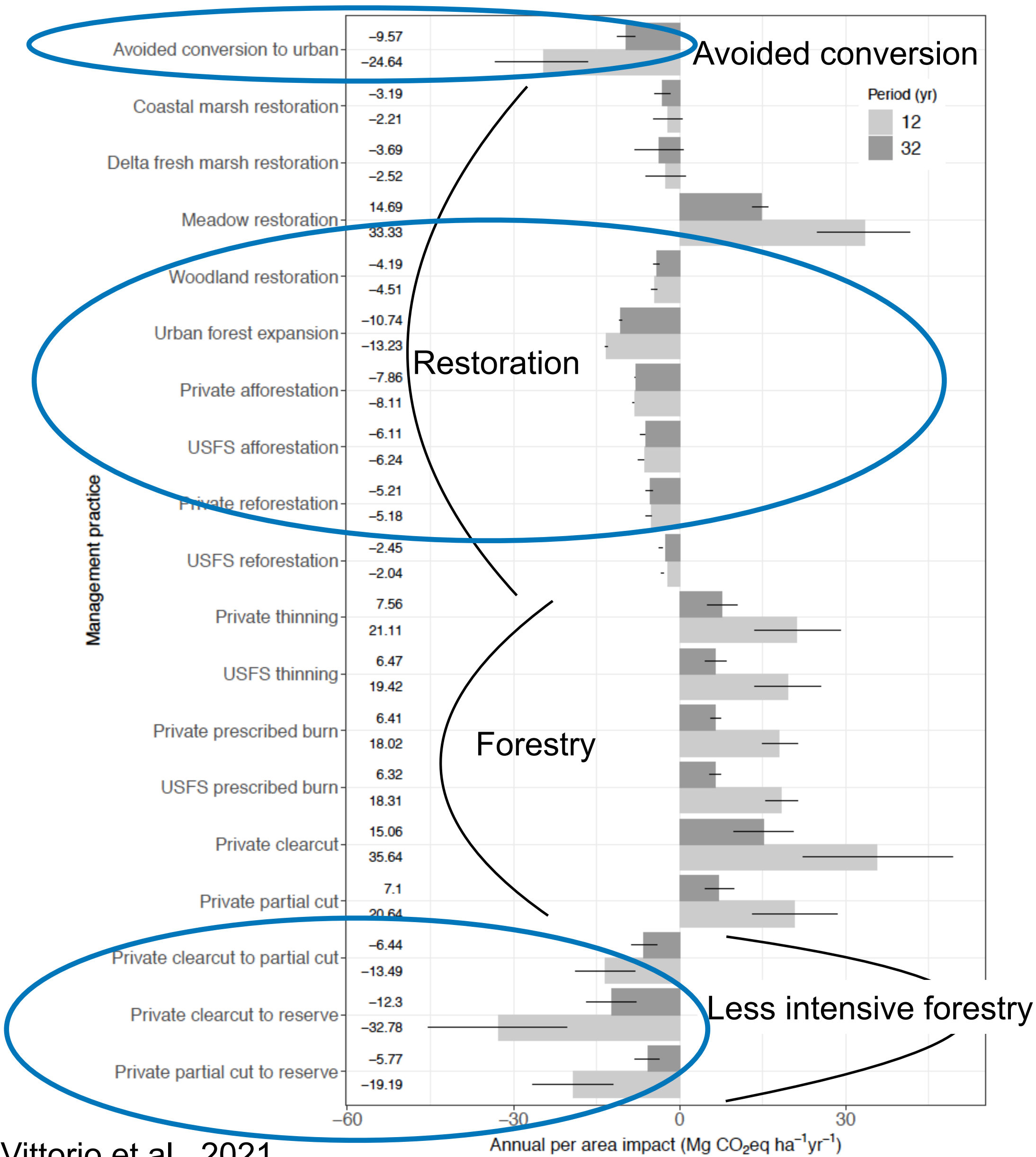
2010 land types



Region-ownership

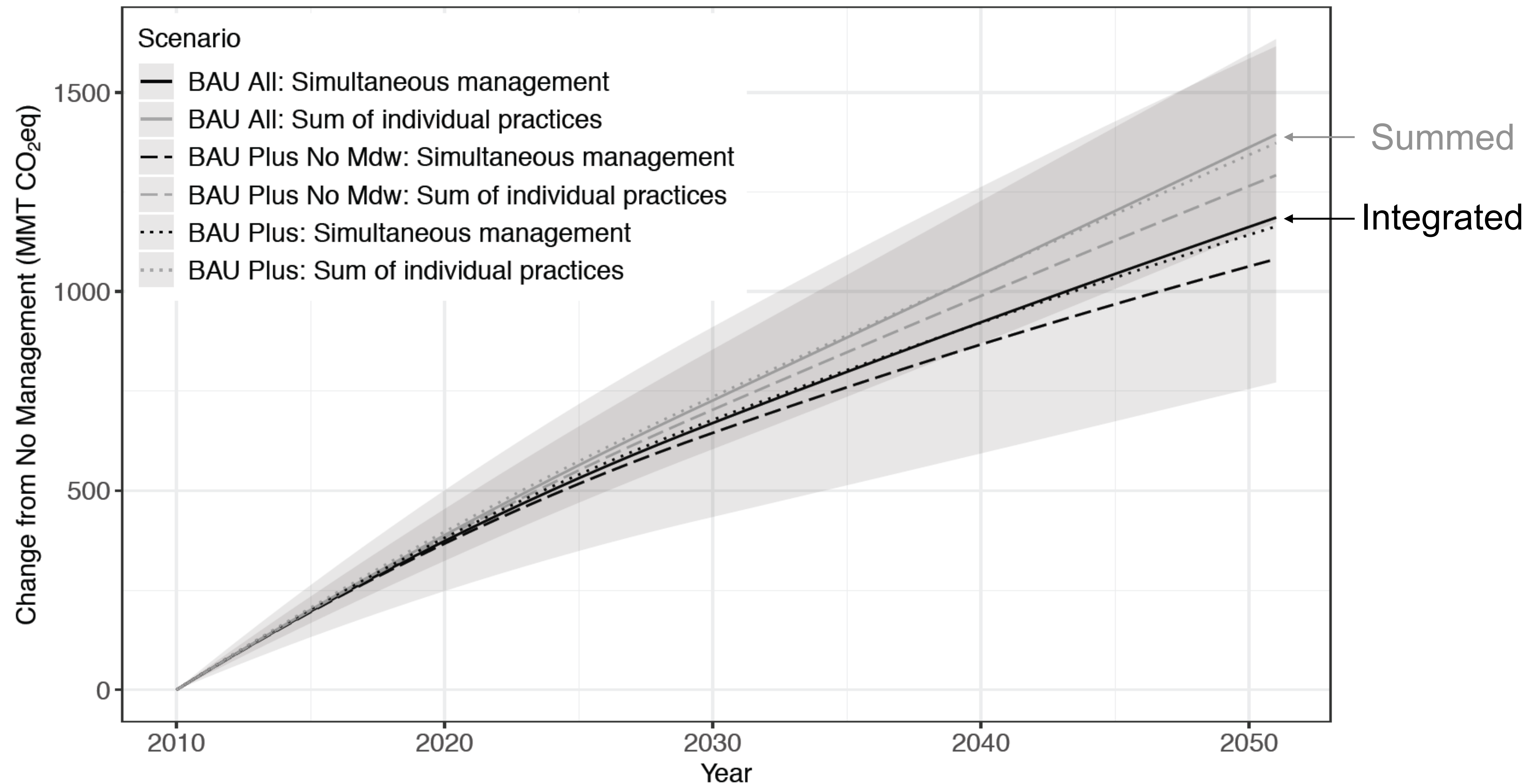


Carbon GHG effects of CALAND individual practices



Negative is land uptake

Integrated estimates give significantly different emissions results to summed estimates



Needs and Opportunities

- **How do we prioritize implementation?**
 - Mitigation, adaption, and feedbacks
 - High-benefit-small-area vs Low-benefit-large-area
- **Consistent representation of land across models is critical, particularly for feedbacks**
- **Explicit characterization of bioenergy feedstock**
- **More detailed forest management**
 - harvest, thinning, fire, residue disposition
- **Improve rice and wetland characterization**
- **Alternative agricultural practices**
 - compost, residue disposition, biochar, rice, grazing
- **Need a paradigm shift away from separate land use and land cover to an integrated land surface!**
 - Policy- vs economic- vs socio-cultural- drivers