Effects of Land Use on Greenhouse Gas Emissions in the PNW

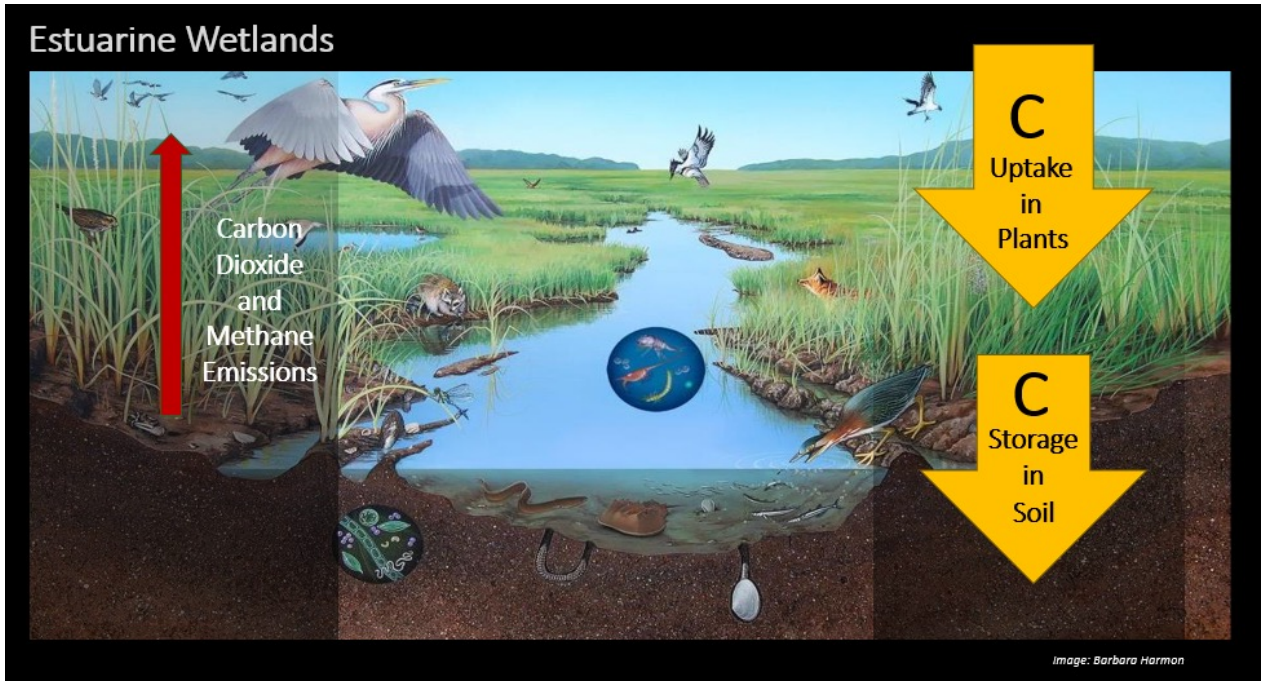
Scott D. Bridgham and the PNW Blue Carbon Working Group

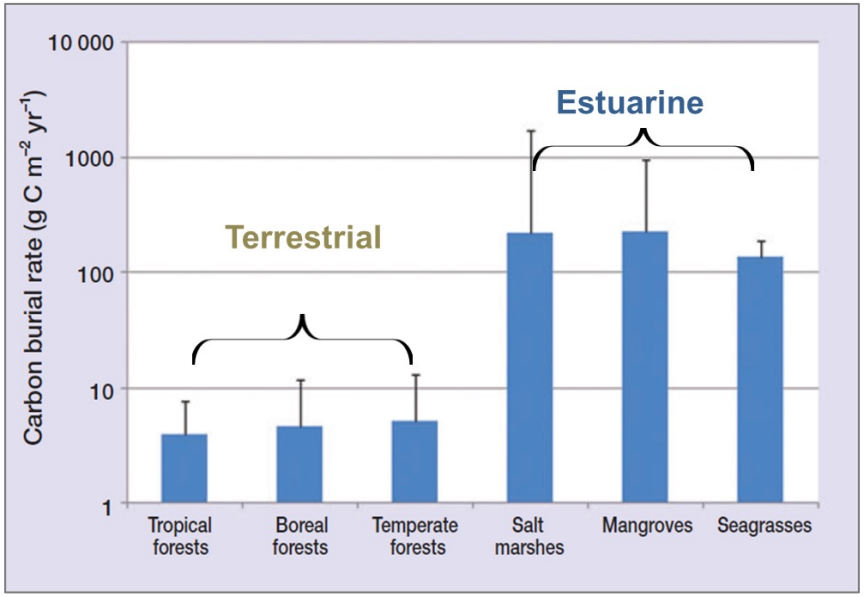
University of Oregon

Lower Columbia Estuary Partnership, May 25th

Blue carbon (BC) is the organic carbon stored in plant biomass and soils in marine and estuarine wetlands.

- Very high soil C densities and sequestration rates
- Widely recognized for many other ecosystem services
- However, high methane (CH_4) emissions can offset positive C gains in climate change forcing





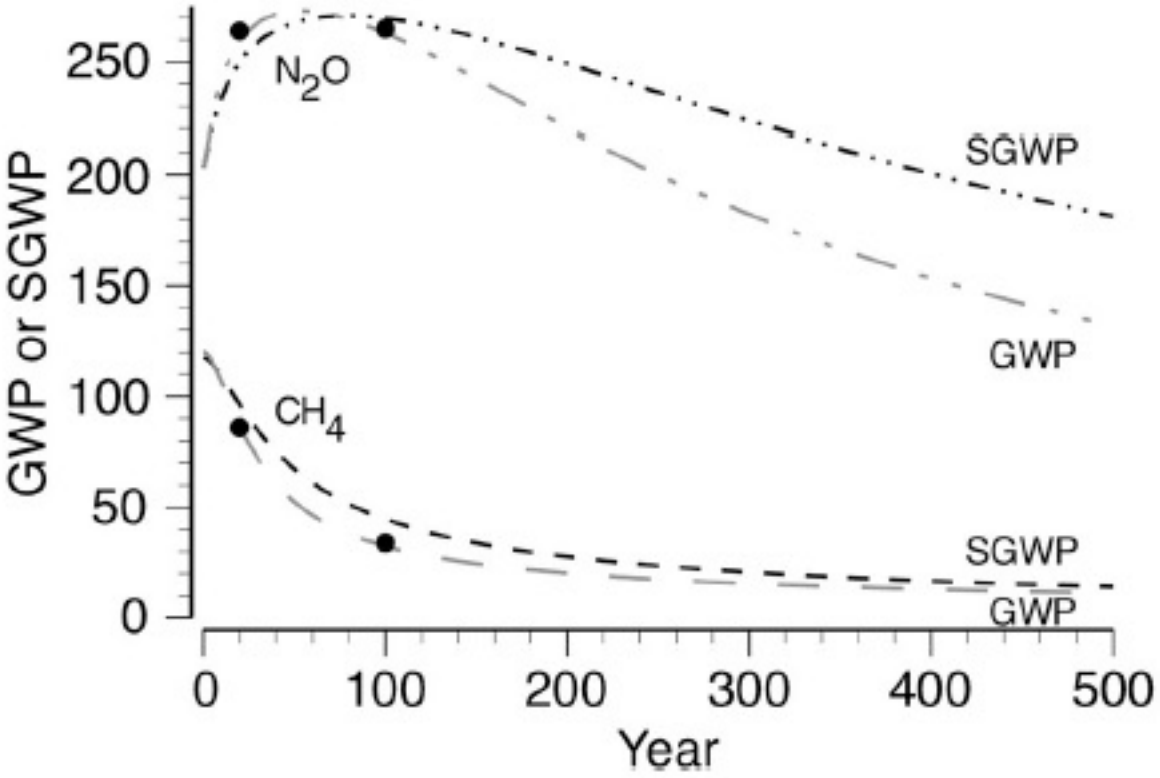
McLeod et al. 2011

BACKGROUND – GLOBAL WARMING POTENTIALS

- The GWP is the time-integrated radiative forcing due to a **SINGLE PULSE EMISSION** of a gas relative to a pulse emission of an equal mass of CO_2.
- Values vary based upon the time-frame because of the different turnover times of the gases in the atmosphere.

Gas	Atmospheric Lifetime (years)	GWP 20 yr	GWP 100 yr
Carbon Dioxide (CO_2)	~ 3 yr to 10^8	1	1
Methane (CH_4)	12.4	87	32
Nitrous Oxide (N_2O)	121	260	263

- However, ecosystems emit GHGs continuously so the GWP is misleading.
- The Sustained GWP (SGWP) accounts for emissions over the entire time frame.



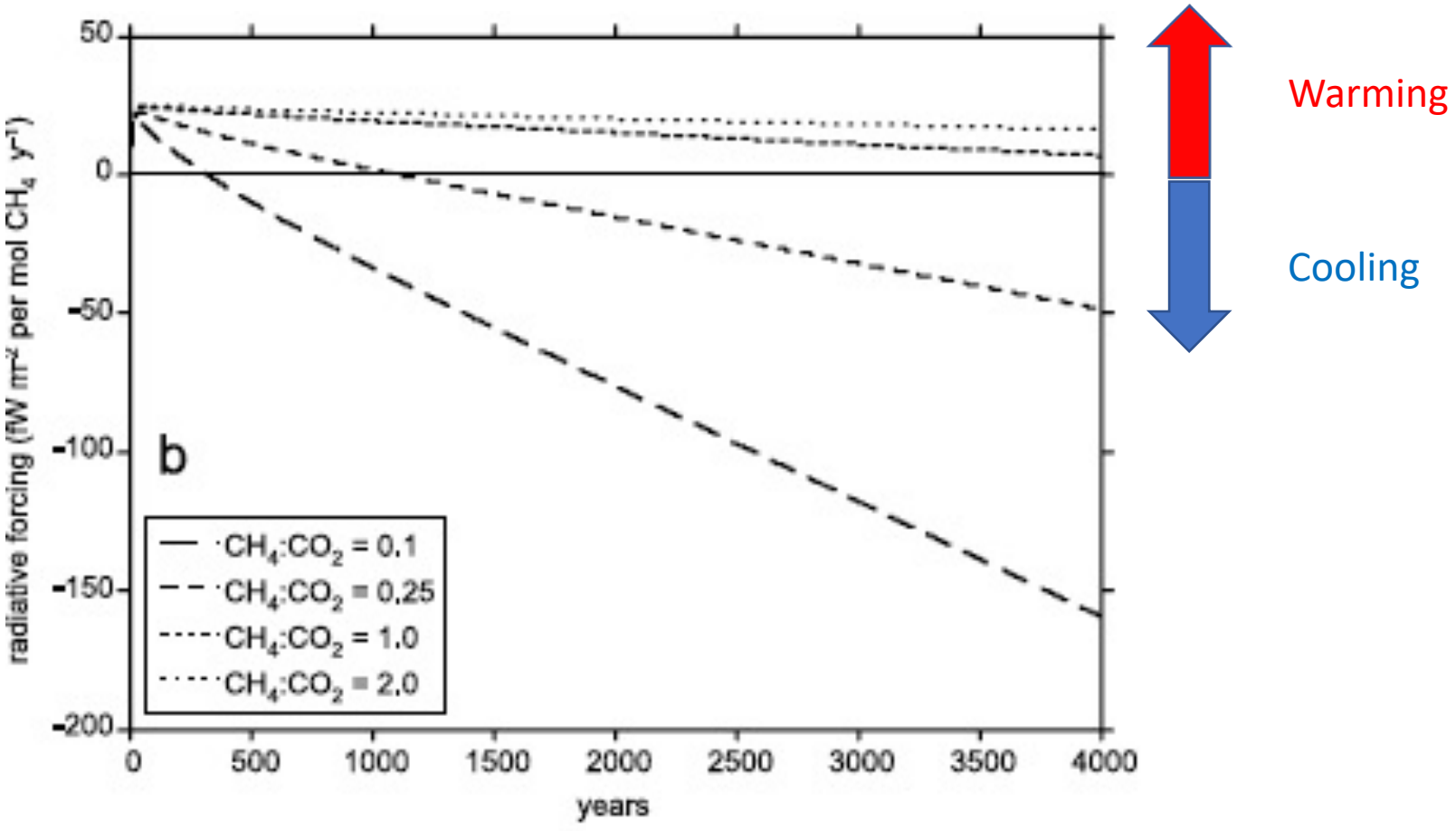
Neubauer and Megonigal 2015

BACKGROUND – GLOBAL WARMING POTENTIALS

- The GWP is the time-integrated radiative forcing due to a pulse emission of a gas relative to a pulse emission of an equal mass of CO_2.
- Values vary based upon the time-frame because of the different turnover times of the gases in the atmosphere.

Gas	SGWP	GWP	SGWP	GWP
	20 years		100 years	
Methane (CH_4)	96	87	45	32
Nitrous Oxide (N_2O)	250	260	263	263

Most wetlands will eventually a cooling effect even if takes millennia to occur.



Frolking et al. 2006

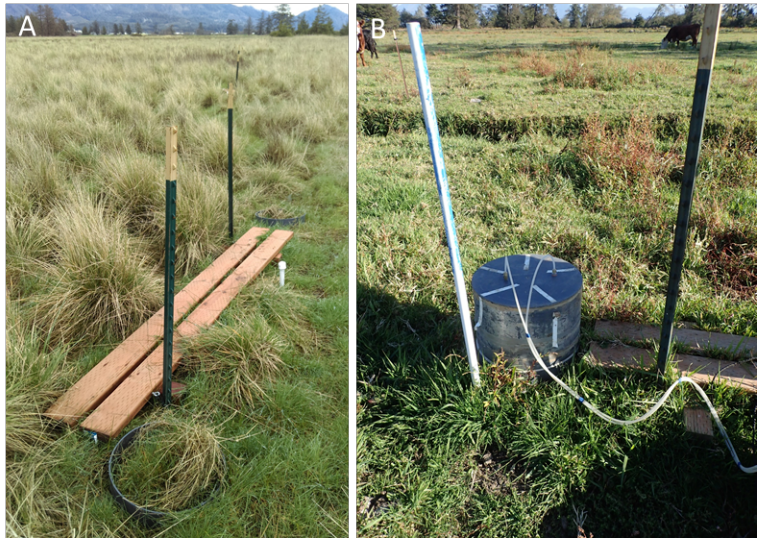
There was a considerable amount of soil C storage and sequestration data available from PNW estuarine wetlands but almost no GHG emission data.

The PNW Blue Carbon Group set out to rectify this data gap at a regional scale embracing the complexity of land uses and environmental drivers that would affect GHGs.

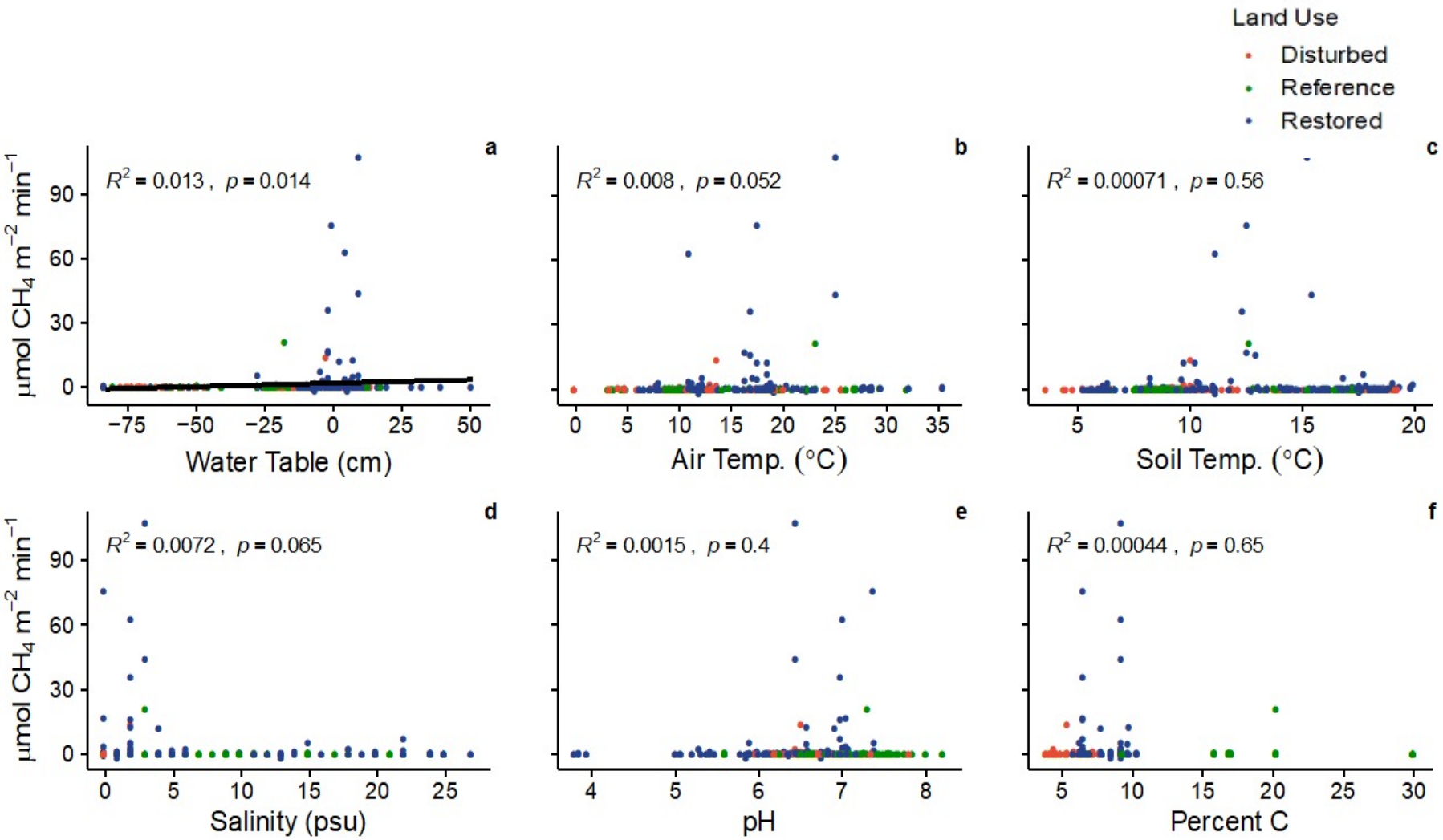
Prior Research – Southern Flow Corridor Project, Tillamook Bay, Oregon (Schultz 2019)

440+ Acre Restoration

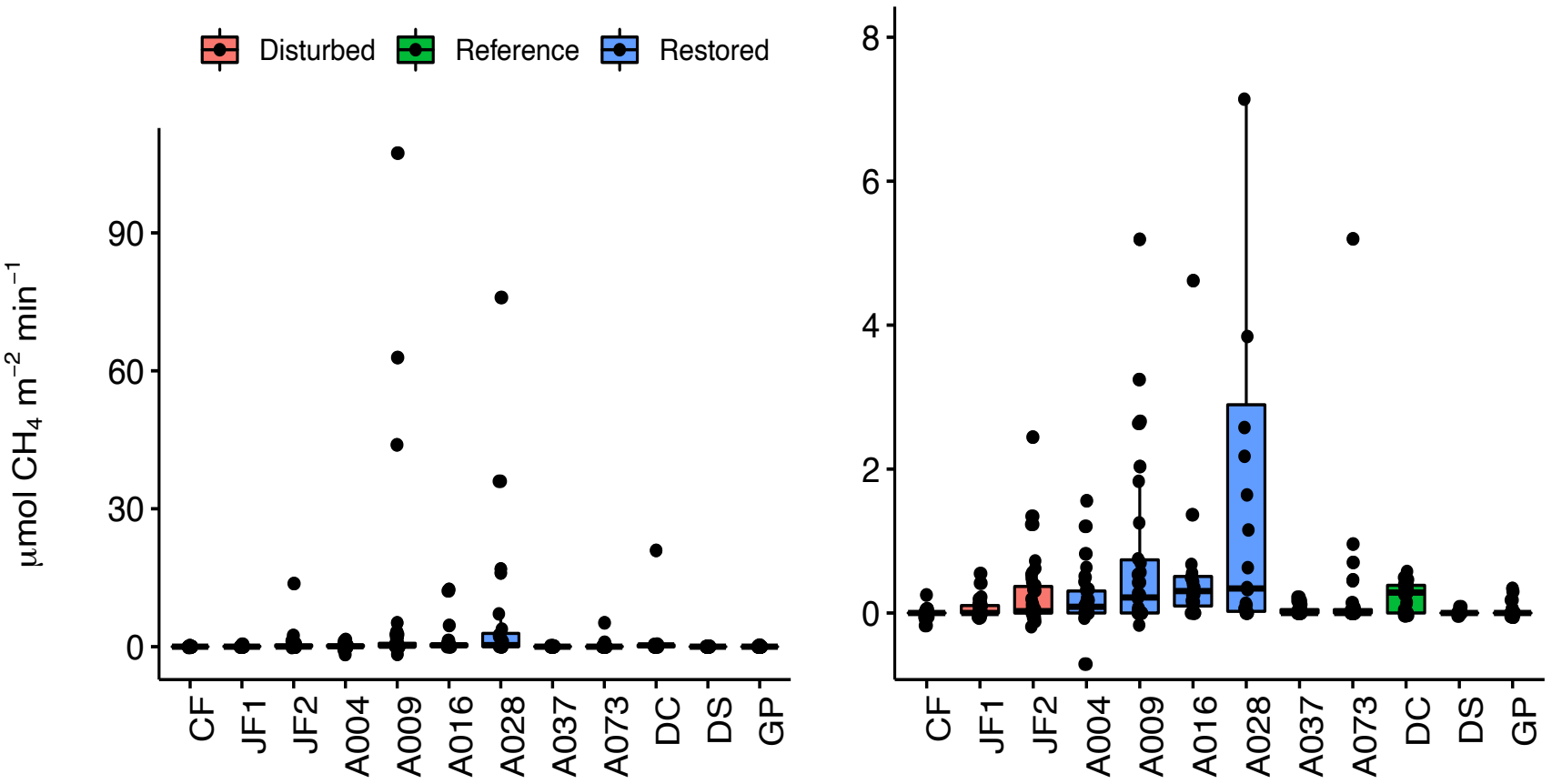
- 12 GHG sites in restored area, ~ 1 yr post-restoration
- 3 least-disturbed reference sites (high marshes)
- 3 ag fields, former tidal sites



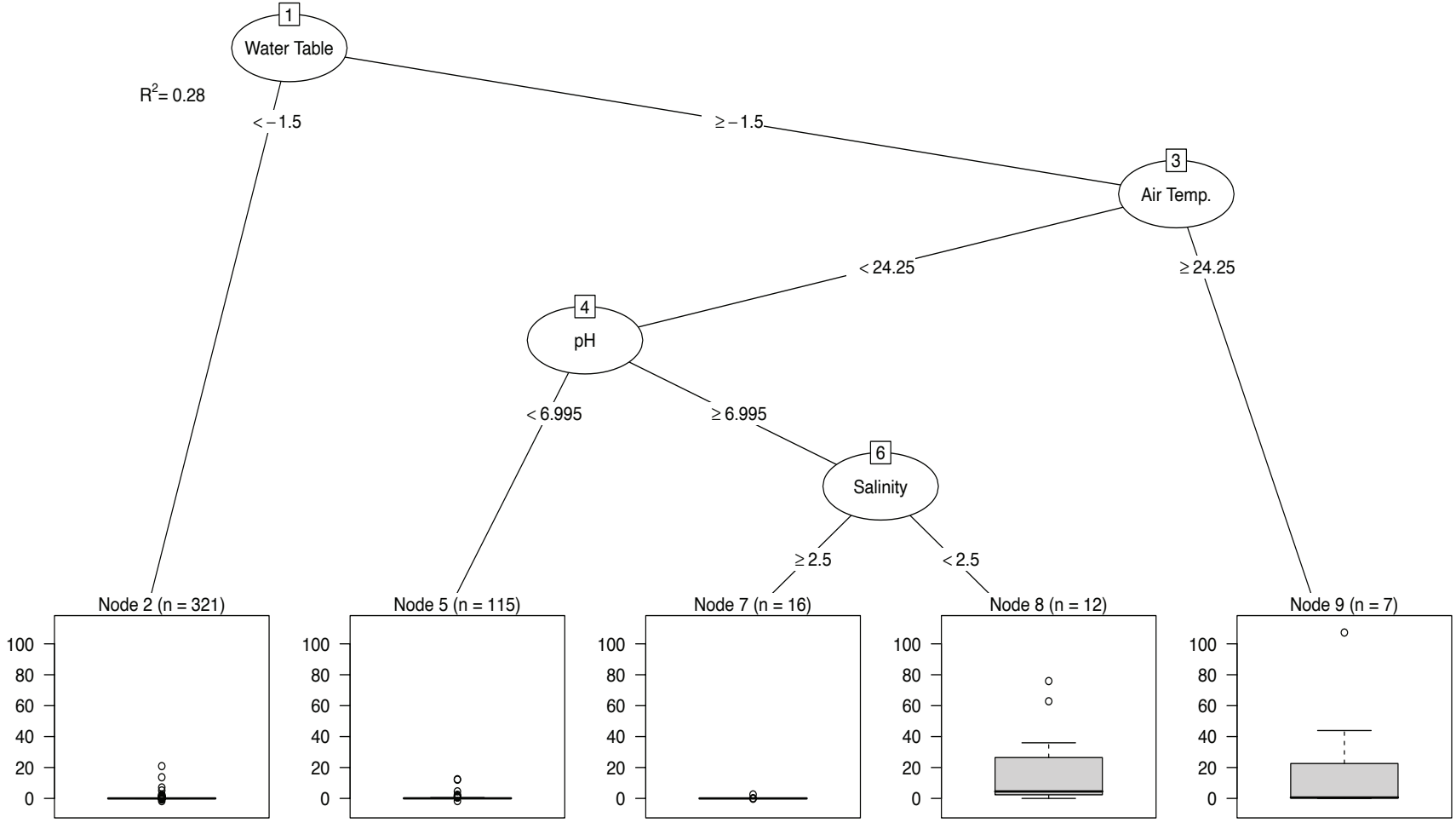
Complex, Non-Linear Environmental Controls Over CH_4



Huge Variability in CH_4 Emissions within the Large Restoration



Complex Dynamics Captured With Classification and Regression Tree Technique



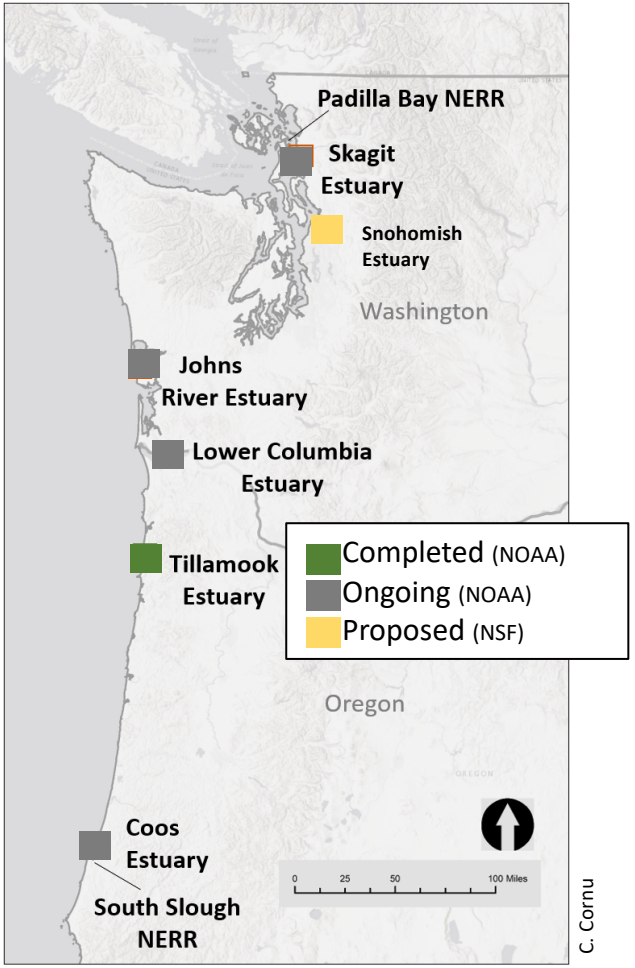
Higher CH_4 Emissions in Restored Sites Because Wetter.

Low Nitrous Oxide Emissions in All Land Uses

	CH_4	$N_2O \times 10^3$
	Instantaneous (μmol m^{-2} min^{-1})	
Disturbed	0.201 (0.06) b	3.43 (2.2) a
Restored	2.095 (0.87) a	7.72 (4.7) a
Reference	0.243 (0.06) b	-1.85 (-7.8) b
	Annual (mol m^{-2} yr^{-1})	
Disturbed	0.111 (0.03) b	1.70 (1.2) b
Restored	1.509 (0.06) a	3.62 (2.3) a
Reference	0.134 (0.01) b	-1.01 (-4.2) c

A regional evaluation of the GHG benefits of estuarine wetland restoration

- Evaluate greenhouse gas (GHG) emissions and C sequestration in natural, restored, and former tidal wetlands.
  - What are the carbon benefits of tidal wetland restoration?
  - Sample across multiple tidal wetland types across natural salinity gradients

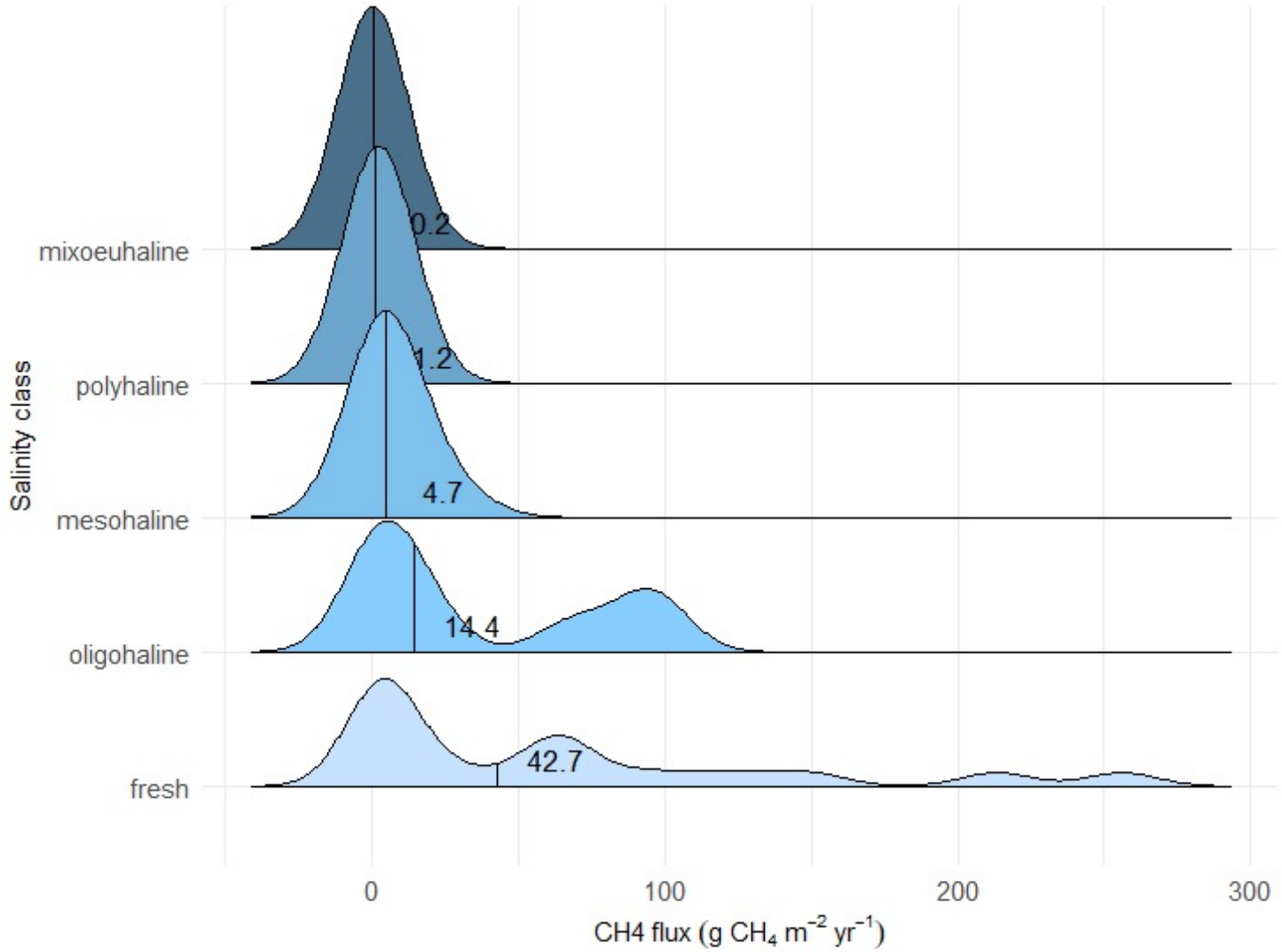


An evaluation of methane emissions in estuarine wetlands the U.S.

Coastal Carbon Research Coordination Network (NSF funded)

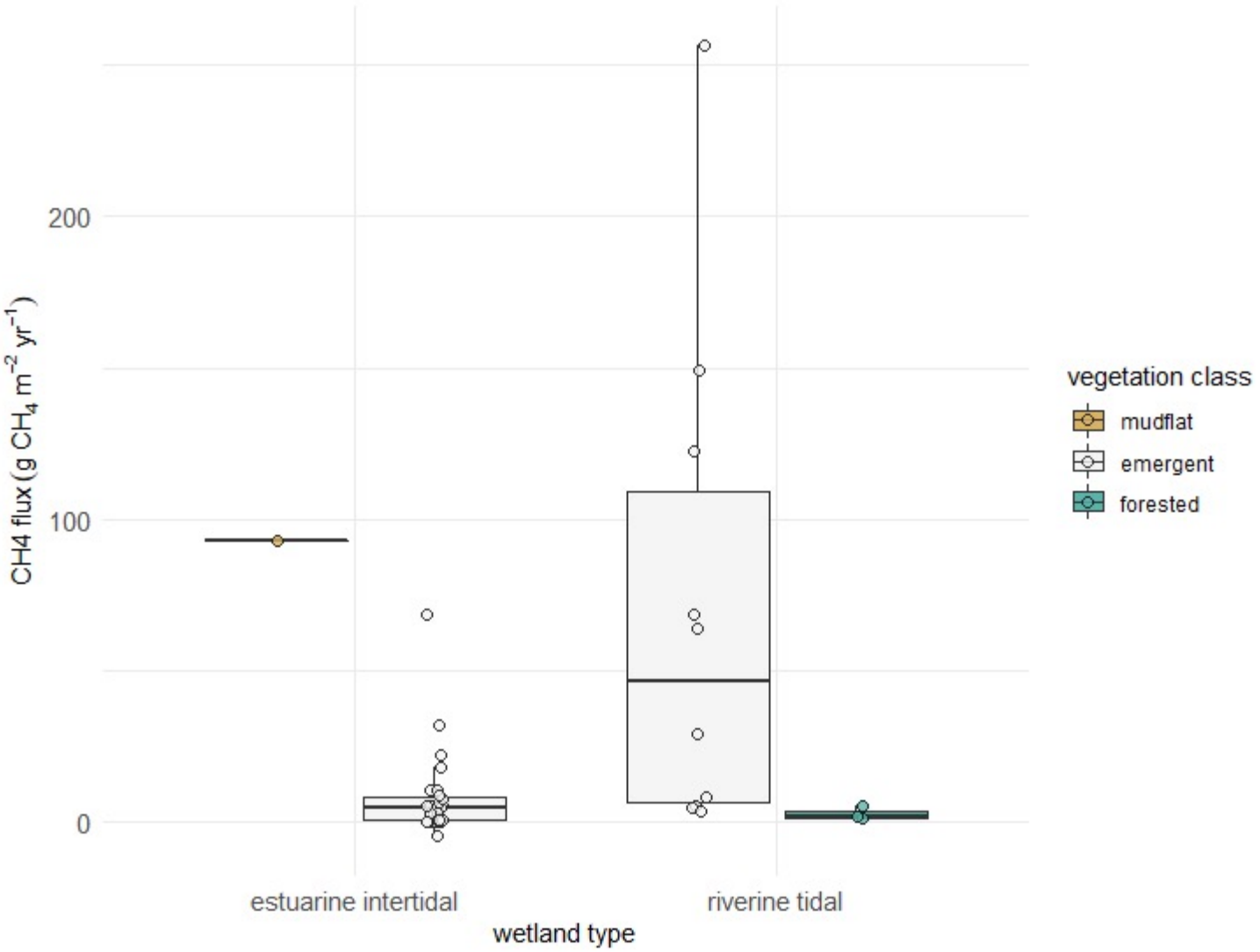
- Evaluation of both chamber and eddy flux tower data in the U.S.
- Development of regional model of GHG fluxes

Vertical line and labels show median CH_4 annual emissions for U.S. estuarine wetlands



Arias-Ortiz et al. unpublished

Methane emissions for U.S. estuarine wetlands by class



Arias-Ortiz et al. unpublished

Applied Thoughts

- Emissions of CH_4 will be difficult to predict in a varied landscape because of complex spatial and temporal controls over its production, consumption, and transport.
- The prior state of the site will matter a lot in the change in CH_4 emissions post-restoration. Pre-restoration GHG gas emission data are invaluable.

Applied Thoughts

- Good candidates for restoration may be (i) sites that pre-restoration are emitting a lot of CH_4, (ii) sites being restored to a saline condition, and (iii) sites high in the tidal frame.
- Restoration of sites with substantial subsidence may be problematic in terms of CH_4 emissions.
- Adequate drainage networks of restored sites may reduce CH_4 emissions.

Applied Thoughts

- Nitrous oxide appears be an unimportant GHG in these systems in most cases.

- There are lots of reasons to restore wetlands that are societally more important than their GHG dynamics!