Mangrove ecosystem responses following a historic snow event on a coastal Louisiana barrier island

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Session 22: Mangrove Encroachment (part II)

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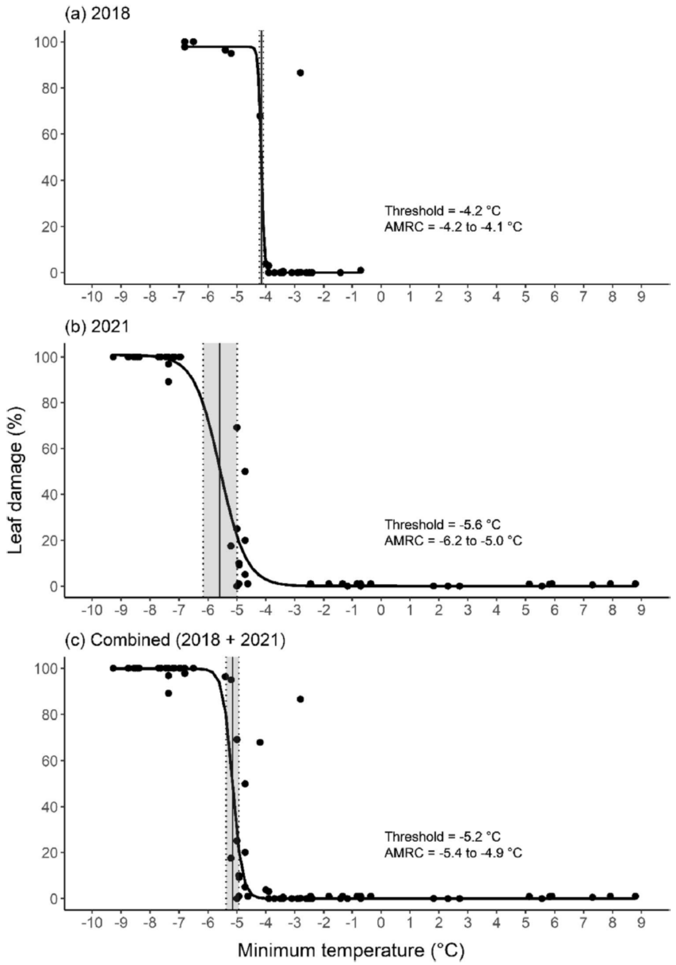
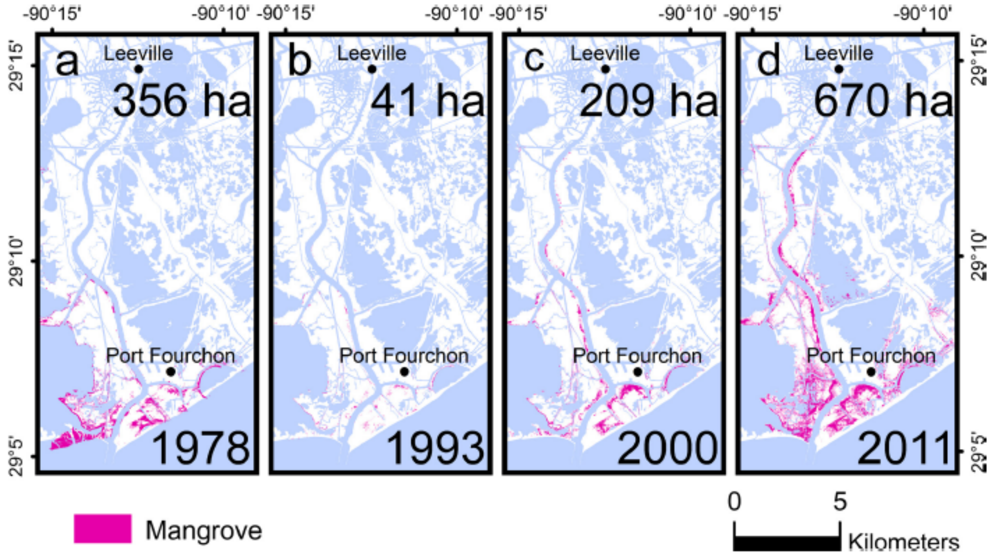
Mangrove expansion in coastal Louisiana



Avicennia temperature thresholds for Gulf of Mexico (Kaalstad et al. 2023)

132 MICHAEL J. OSLAND ET AL. Ecology, Vol. 98, No. 1



Port Fourchon mangrove expansion (Osland et al. 2017)

TABLE 2 State-level means and standard errors (SE; in parentheses) of projected mangrove presence, mangrove relative abundance, coastal wetland vegetation height, and coastal wetland vegetation aboveground biomass under recent climatic conditions (1981–2010; Recent) and two alternative future climate scenarios, SSP2-4.5 (2071–2100; Future-Int) and SSP5-8.5 (2071–2100; Future-High), which correspond to intermediate and high greenhouse gas emissions scenarios, respectively.

	Presence (% probability)			Abundance (%)			Height (m)			Aboveground biomass ($t ha^{-1}$)		
State	Recent	Future-Int	Future-High	Recent	Future-Int	Future-High	Recent	Future-Int	Future-High	Recent	Future-Int	Future-High
TX	68.2 (7.6)	94.4 (2.4)	98.9 (0.5)	14.9 (4.1)	42.2 (5.7)	56.1 (4.4)	0.9 (0.1)	1.4 (0.3)	1.7 (0.4)	15.7 (2.6)	26.5 (4.6)	33.3 (6.2)
LA	20.0 (2.7)	79.8 (3.1)	95.3 (0.9)	0.0 (0.0)	9.0 (2.3)	51.6 (5.2)	1.0 (0.0)	2.0 (0.1)	2.9 (0.1)	18.4 (0.9)	37.2 (1.5)	52.8 (1.8)
MS	9.0 (1.6)	72.0 (3.5)	93.3 (1.2)	0.0 (0.0)	1.6 (0.6)	36.0 (8.1)	0.8 (0.0)	1.7 (0.1)	2.6 (0.1)	14.8 (0.7)	32.7 (1.3)	47.2 (1.9)
AL	2.3 (0.2)	38.7 (2.1)	77.4 (2.3)	0.0 (0.0)	0.1 (0.0)	2.6 (0.7)	0.5 (0.0)	1.2 (0.0)	1.9 (0.1)	10.3 (0.2)	23.5 (0.5)	34.7 (1.0)

Future mangrove expansion (Bardou et al. 2024)

Net ecosystem carbon balance across coastal Louisiana

Baustian et al 2023

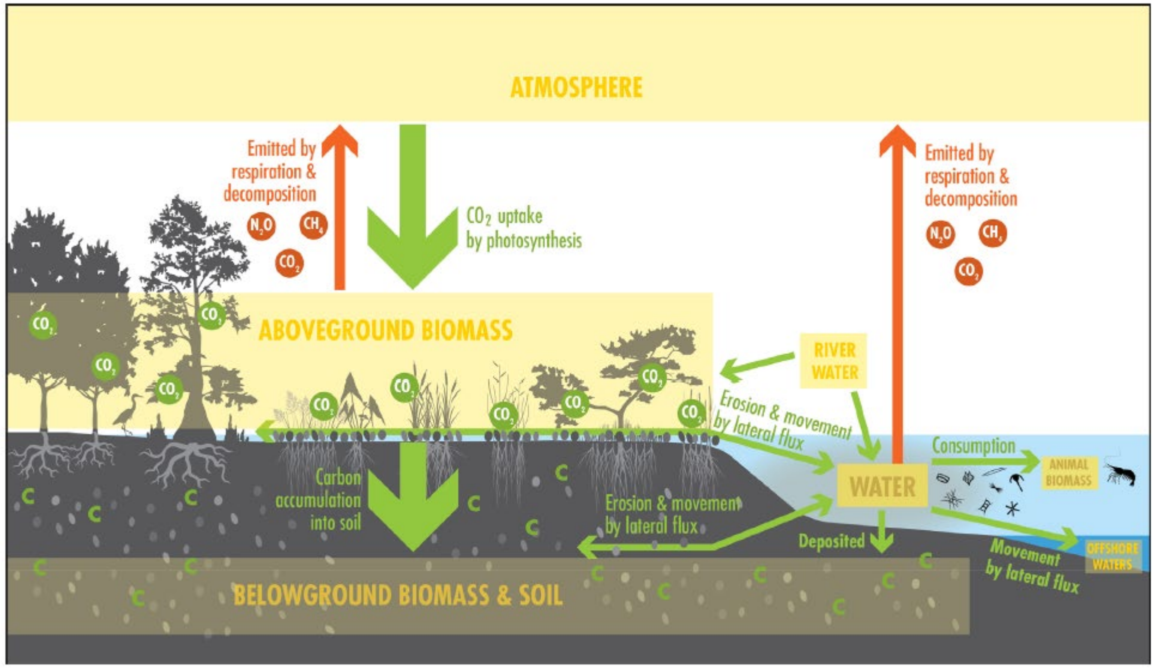


FIGURE 2 Conceptual ecological model that summarizes the major carbon and other greenhouse gas fluxes (green and orange arrows) among the pools (yellow boxes) in coastal habitats of Louisiana that may help with climate mitigation.

Modeling potential net greenhouse gas coastal sinks

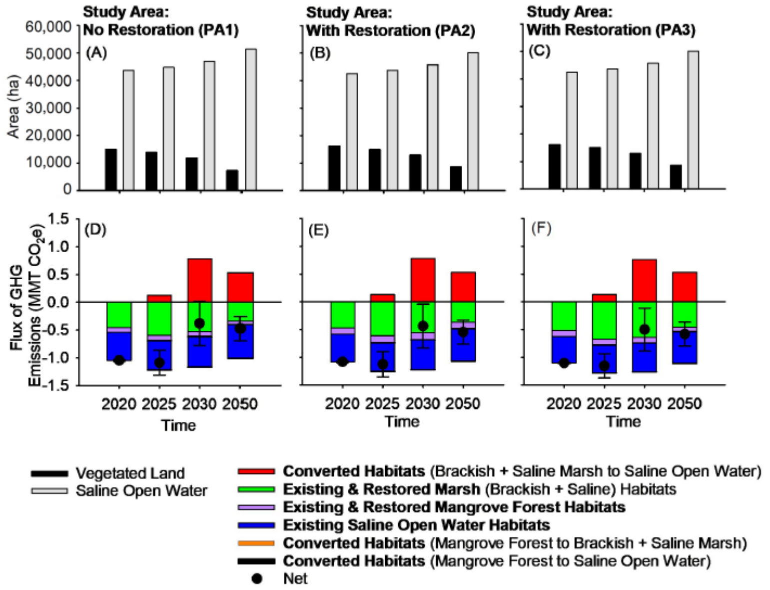


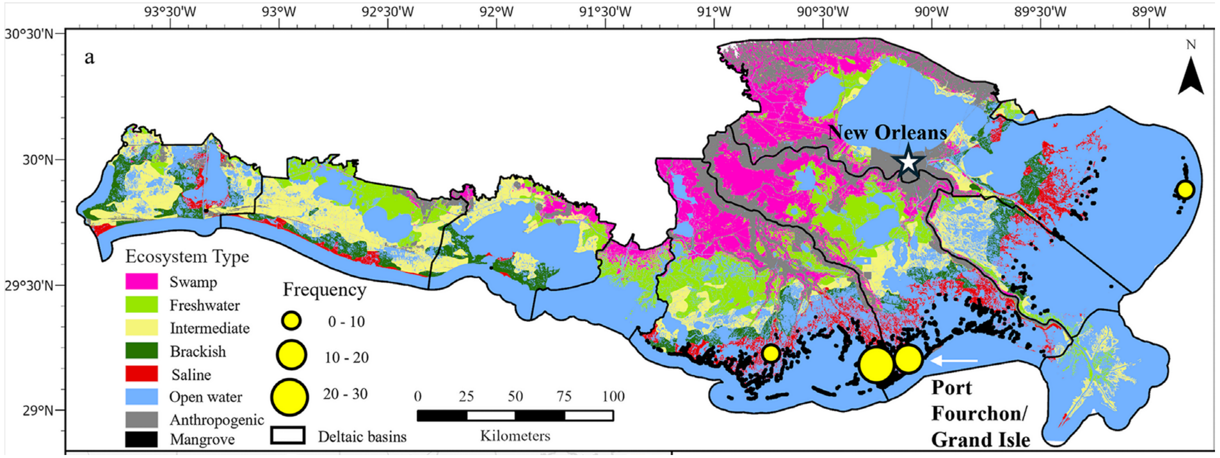
Figure 3. Study area of model-projected vegetated habitats (brackish marsh, saline marsh, and mangrove forest) that were existing, restored, or converted as well as saline open water habitat that was existing or converted from vegetated habitats (top panels of A–C) and flux of GHG emissions (MMT CO_2e) at years 2020, 2025, 2030, and 2050 with and without restoration by placement of dredged material (PA2, PA3; bottom panels of D–F). Stacked bars are in the order listed in the legend. The orange and black bars in panels D–F are present but small. Positive flux values indicate a source and negative values indicate a sink. Error bars of net flux indicate the upper and lower bound.

Baustian et al 2024

NECB: Mangrove > Brackish > Saline > Saline open water

NECB (tonne CO_2e ha^{-1} yr^{-1}): -54.0 ± 26.1 > -48.1 ± 21.0 > -37.5 ± 17.6 > -11.6 ± 1.0

Mangrove research in coastal Louisiana

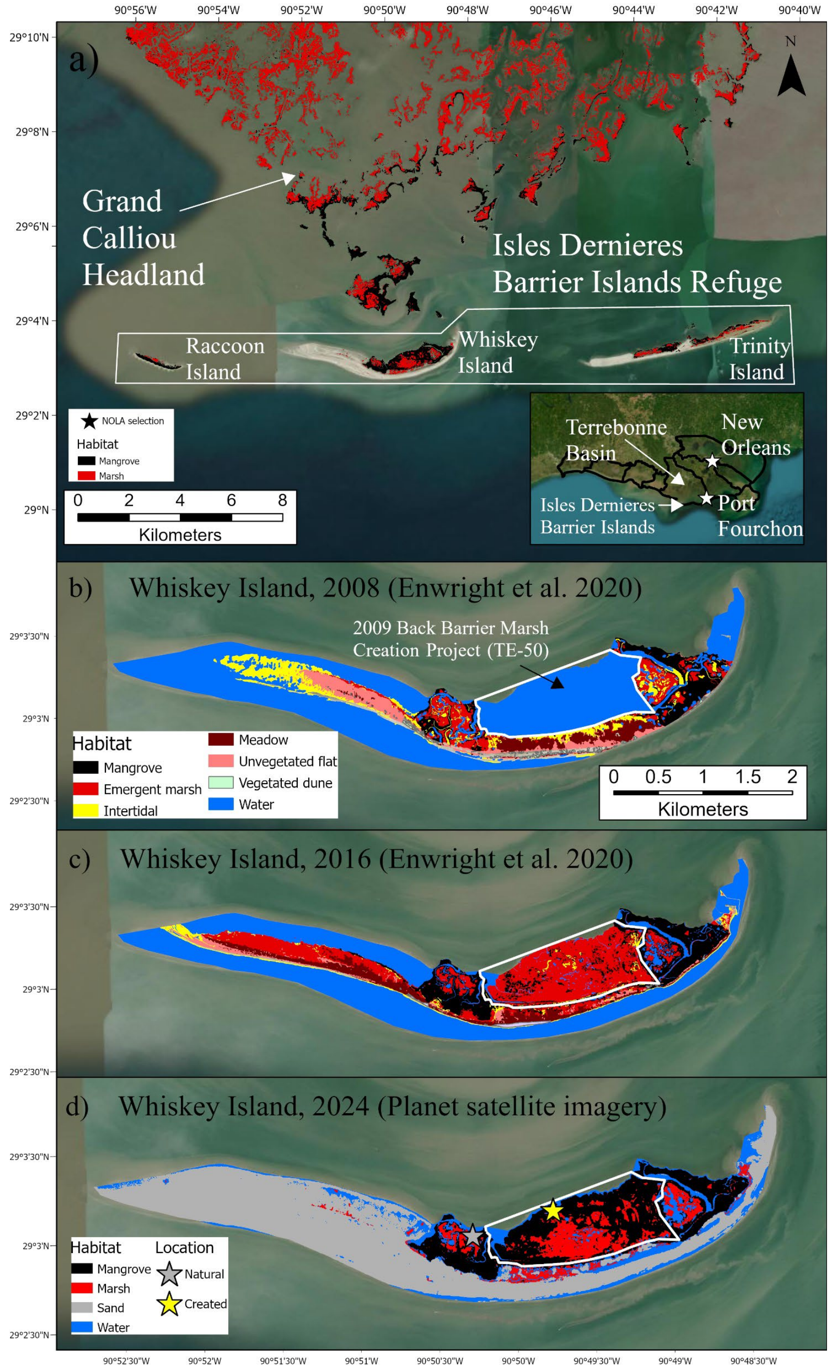


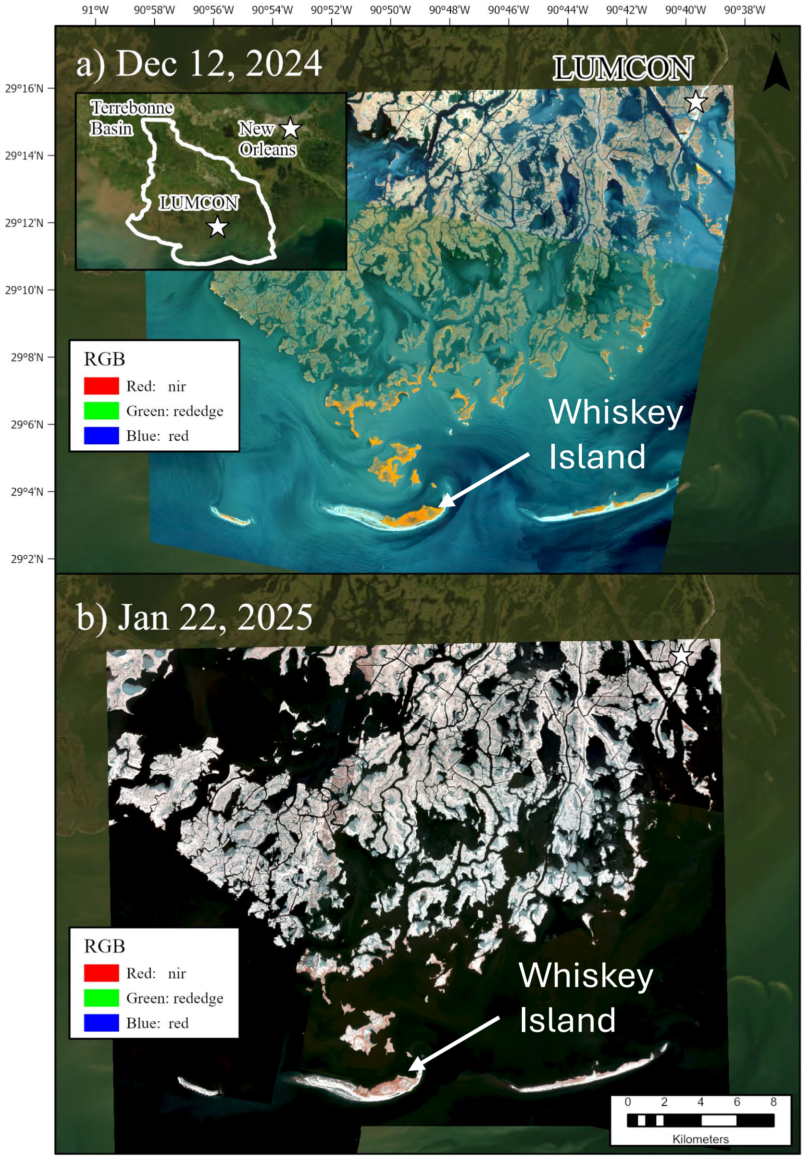
Published mangrove research primarily comes from Port Fourchon, yet mangroves are found across eastern deltaic basins. (Lamb-Wotton et al in review)

Topic	Definition	*n* articles (% of total)
Mangrove expansion	Changes in ecosystem properties with lateral encroachment into salt marsh	17 (32.7%)
Freeze tolerance	Effects of freeze events on mangrove distribution	12 (23.1%)
Coastal restoration	Effects of restoration activities on ecosystem properties, survivorship	11 (21.1%)
Disturbance	Events that impact mangroves: hurricanes, climate change, nutrient enrichment, oiling	10 (19.2%)
Other	Does not fit into one of the above categories	2 (3.8%)

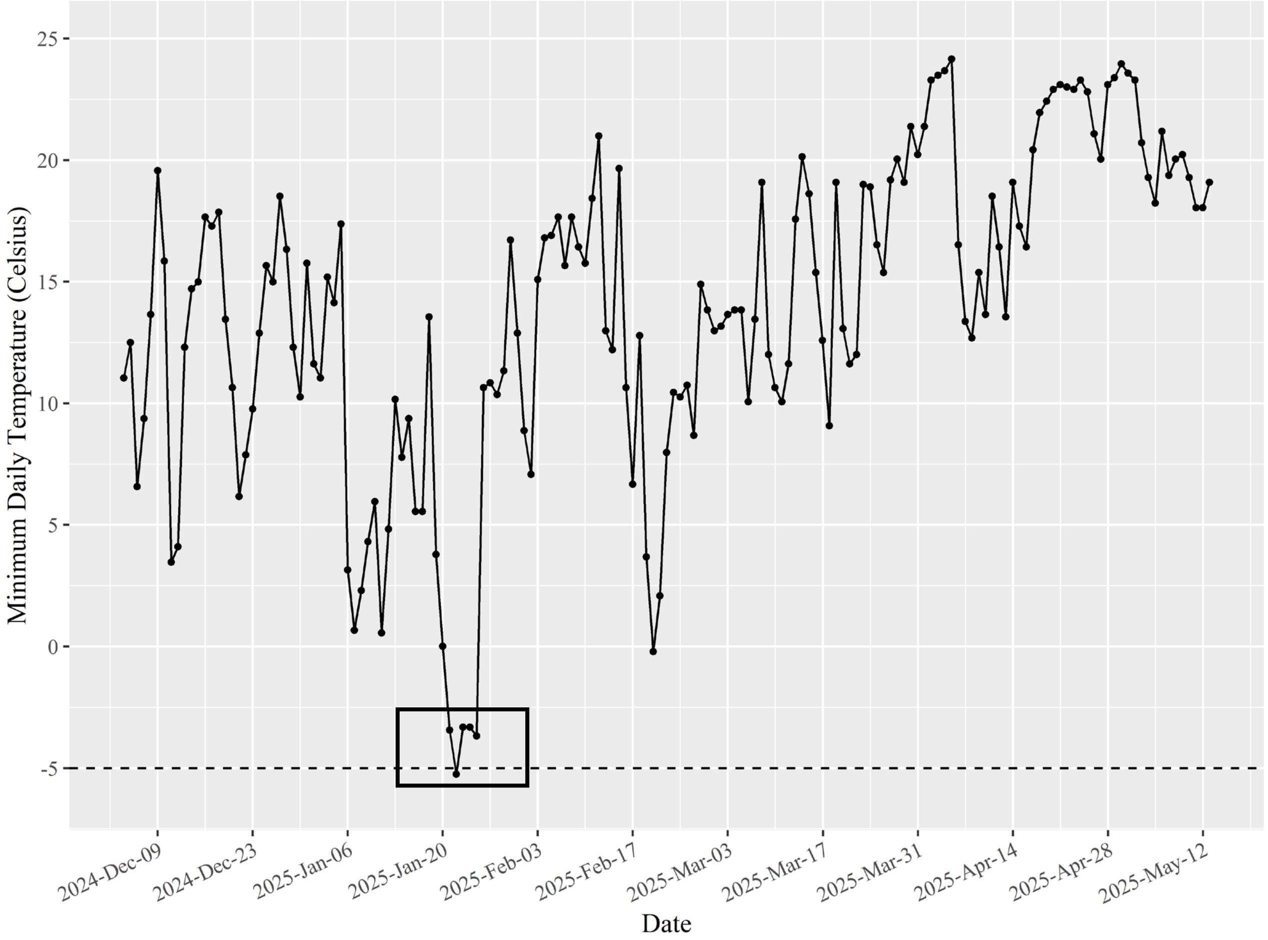
Count and definition of coastal Louisiana mangrove papers within 4 overarching research topics. (Lamb-Wotton et al. in review).

Jan 2025 snow-storm and hard freeze

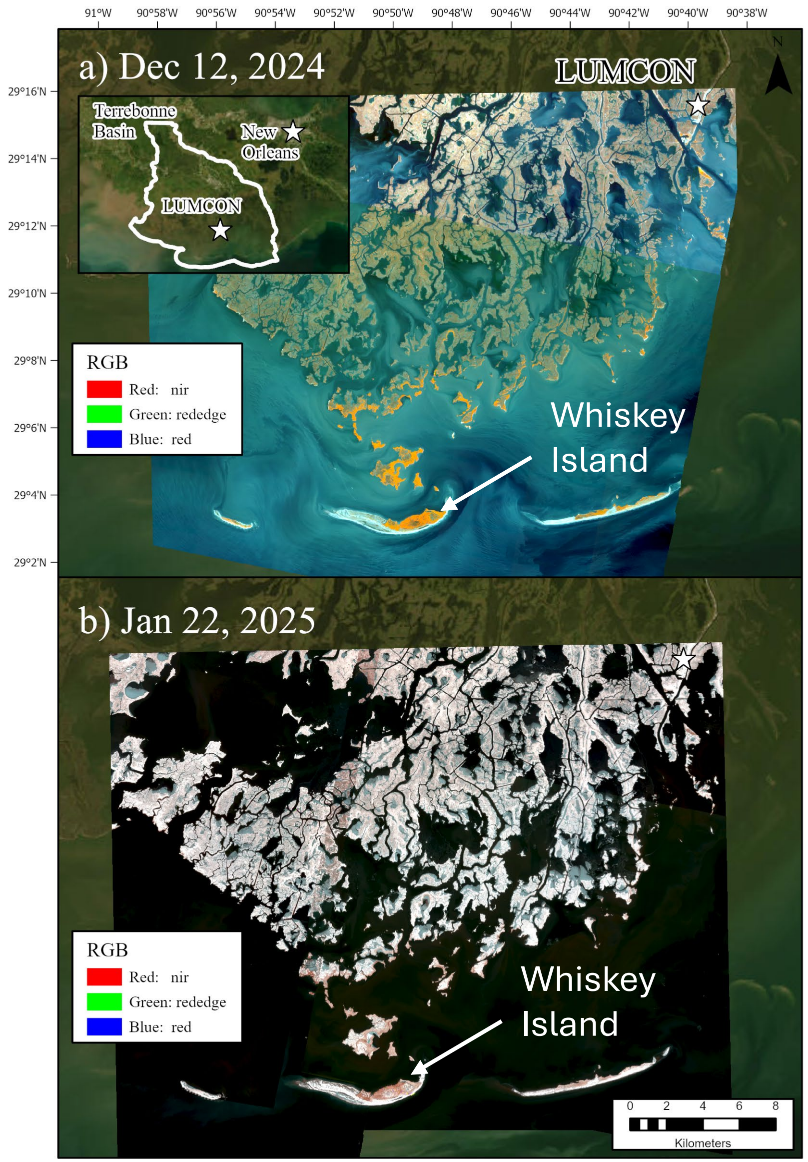




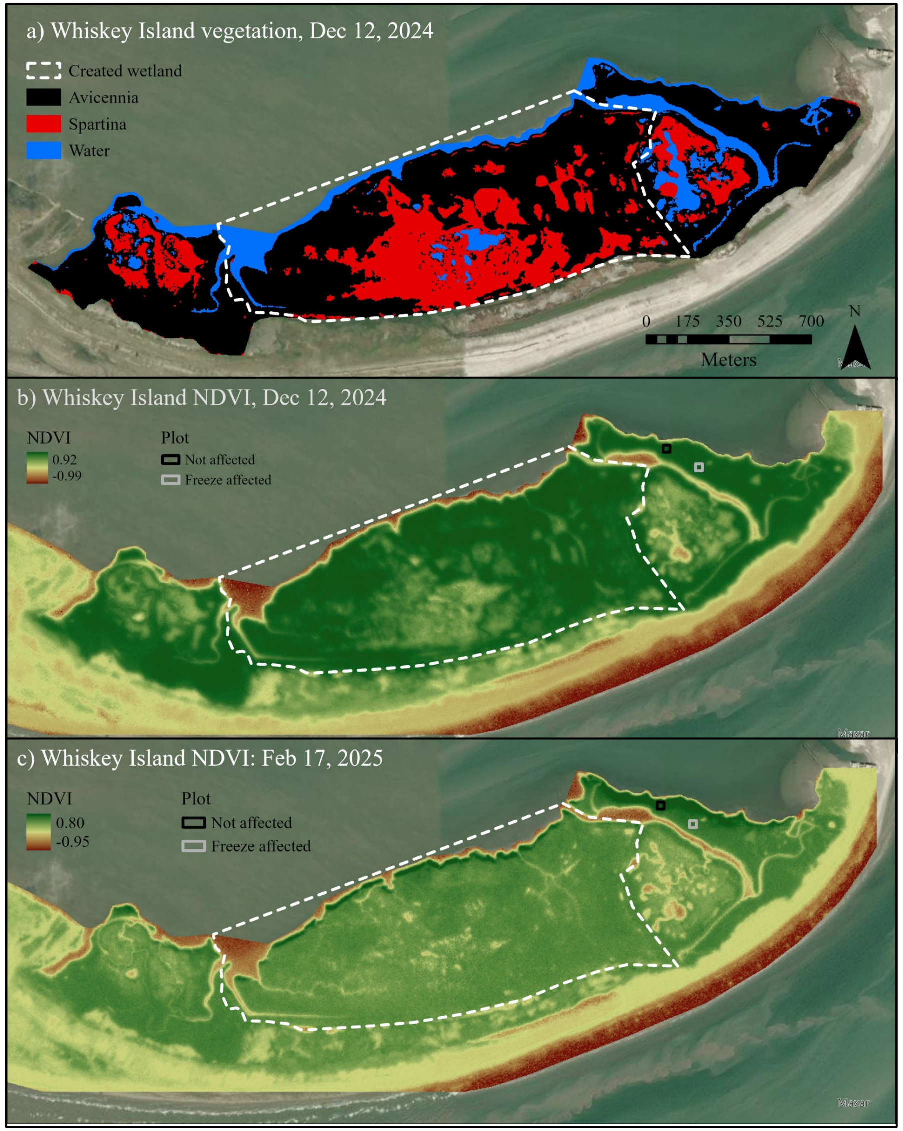
Jan 2025 snow-storm and hard freeze

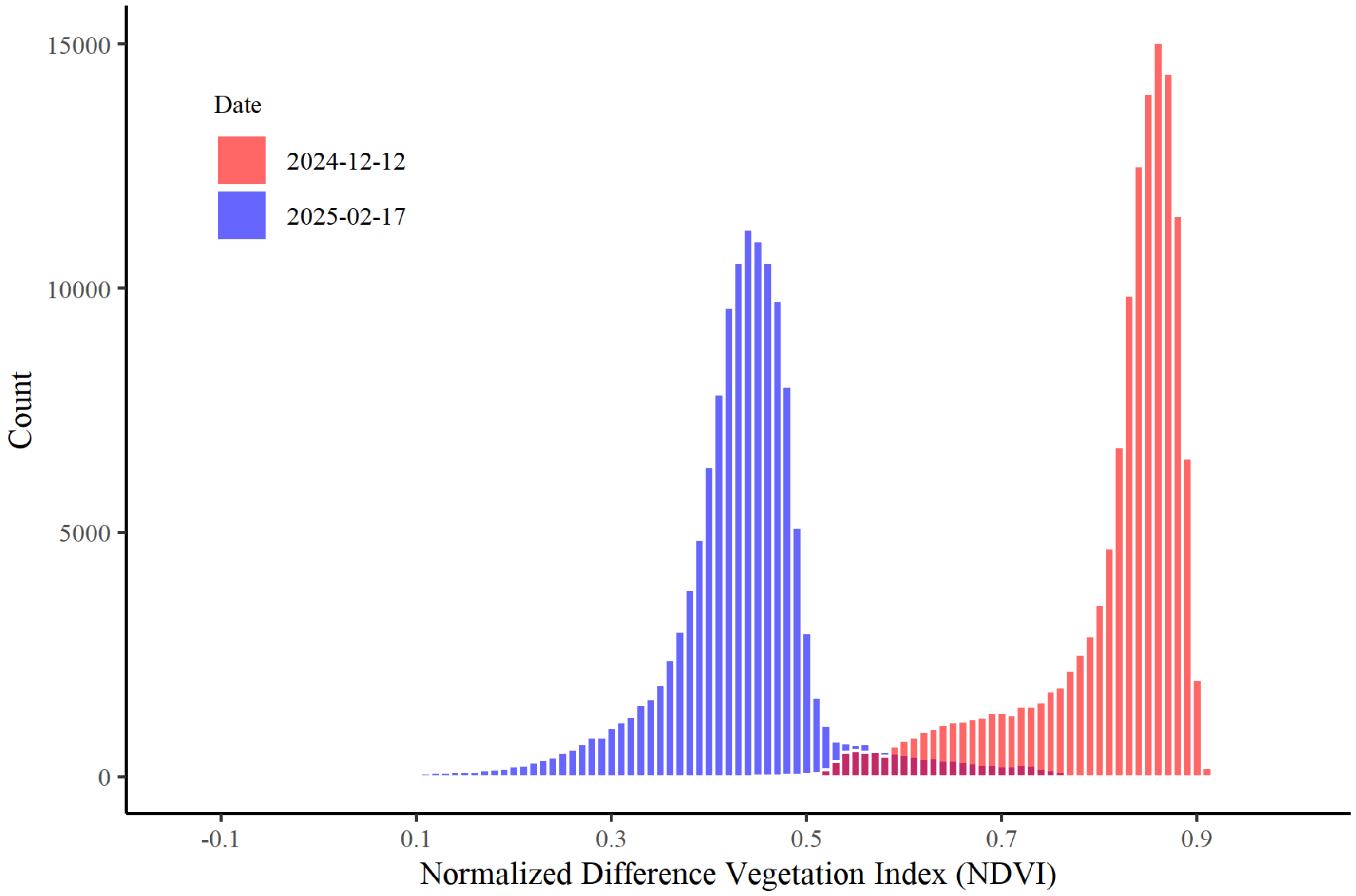


Minimum daily temperatures on Whiskey Island from in situ measurements. Threshold for significant Avicennia leaf mortality is -5 °C

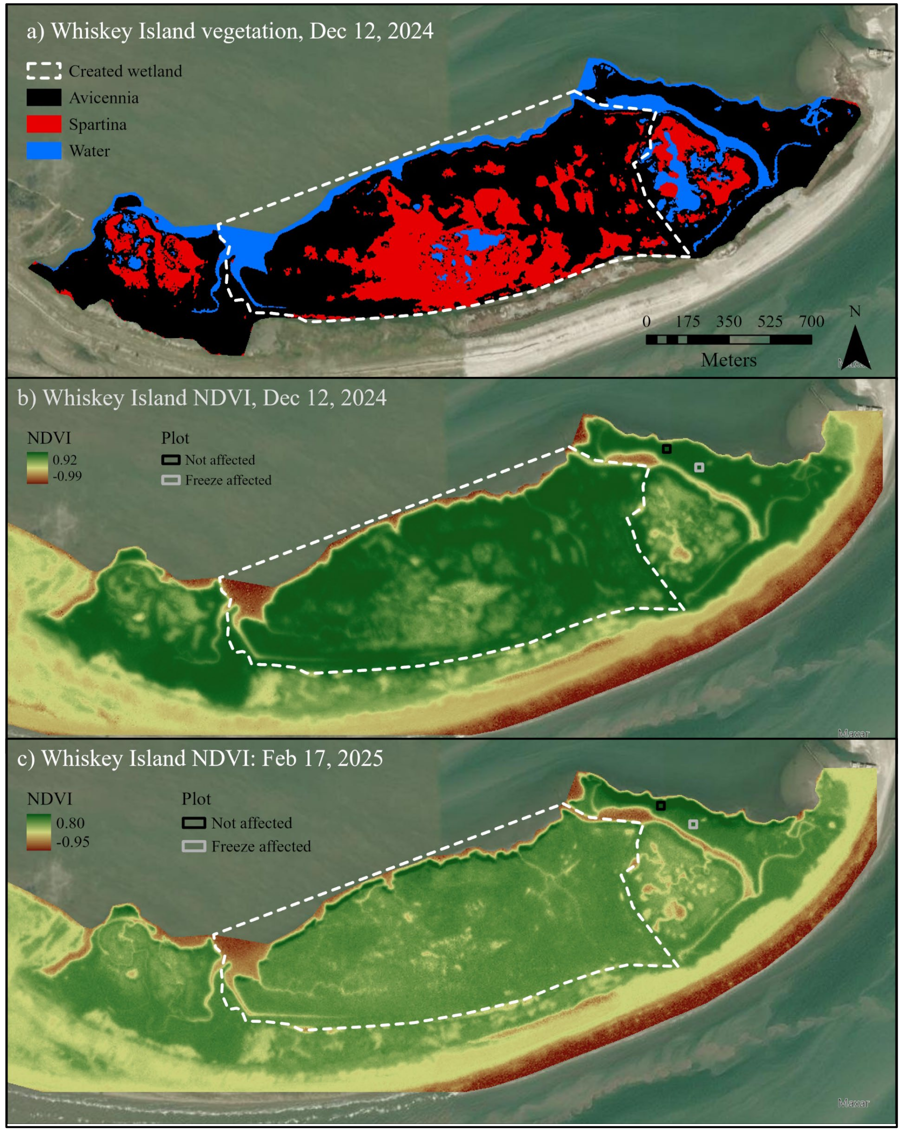


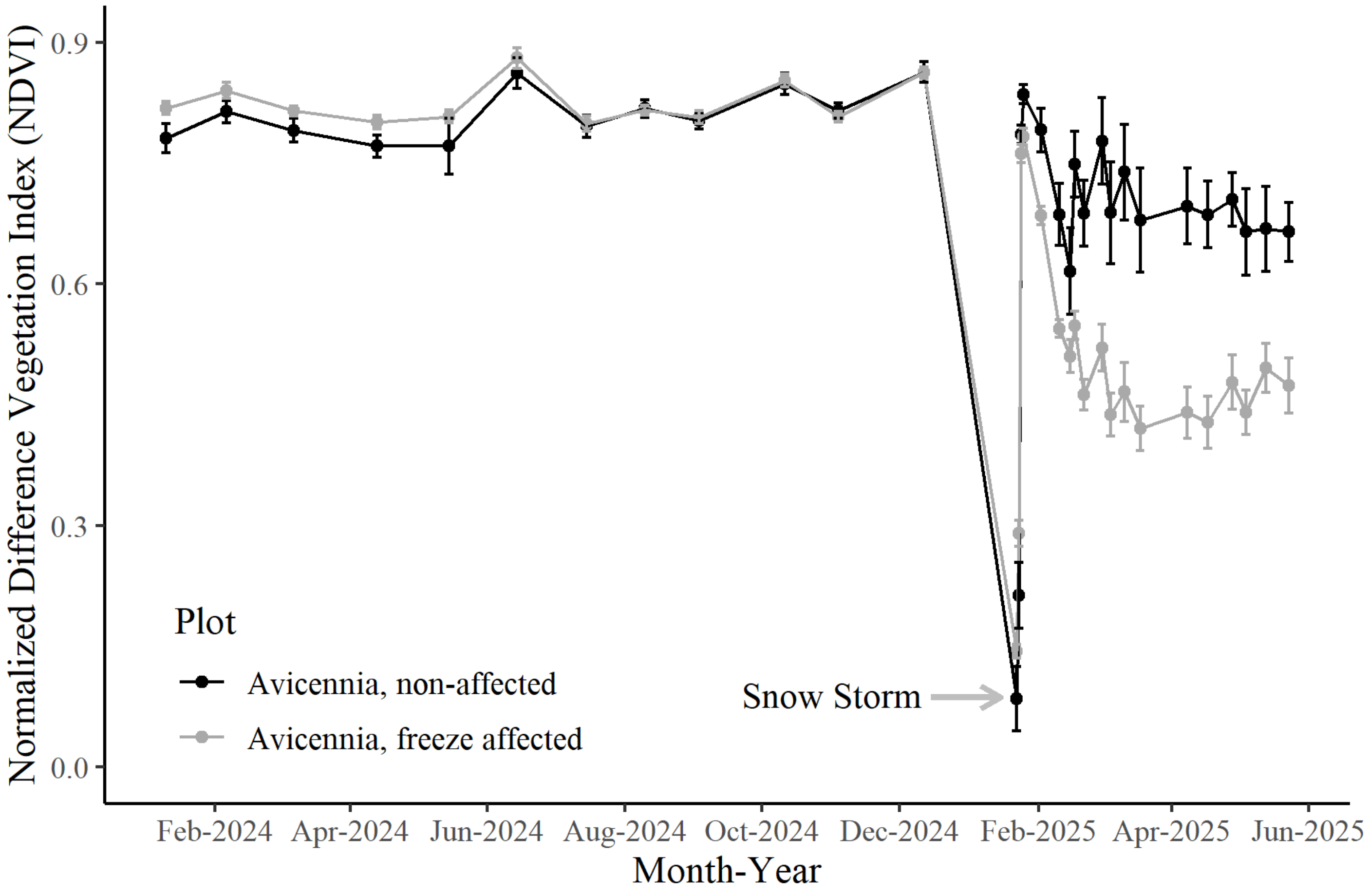
Widespread mangrove freeze affects on Whiskey Island





Widespread mangrove freeze affects on Whiskey Island



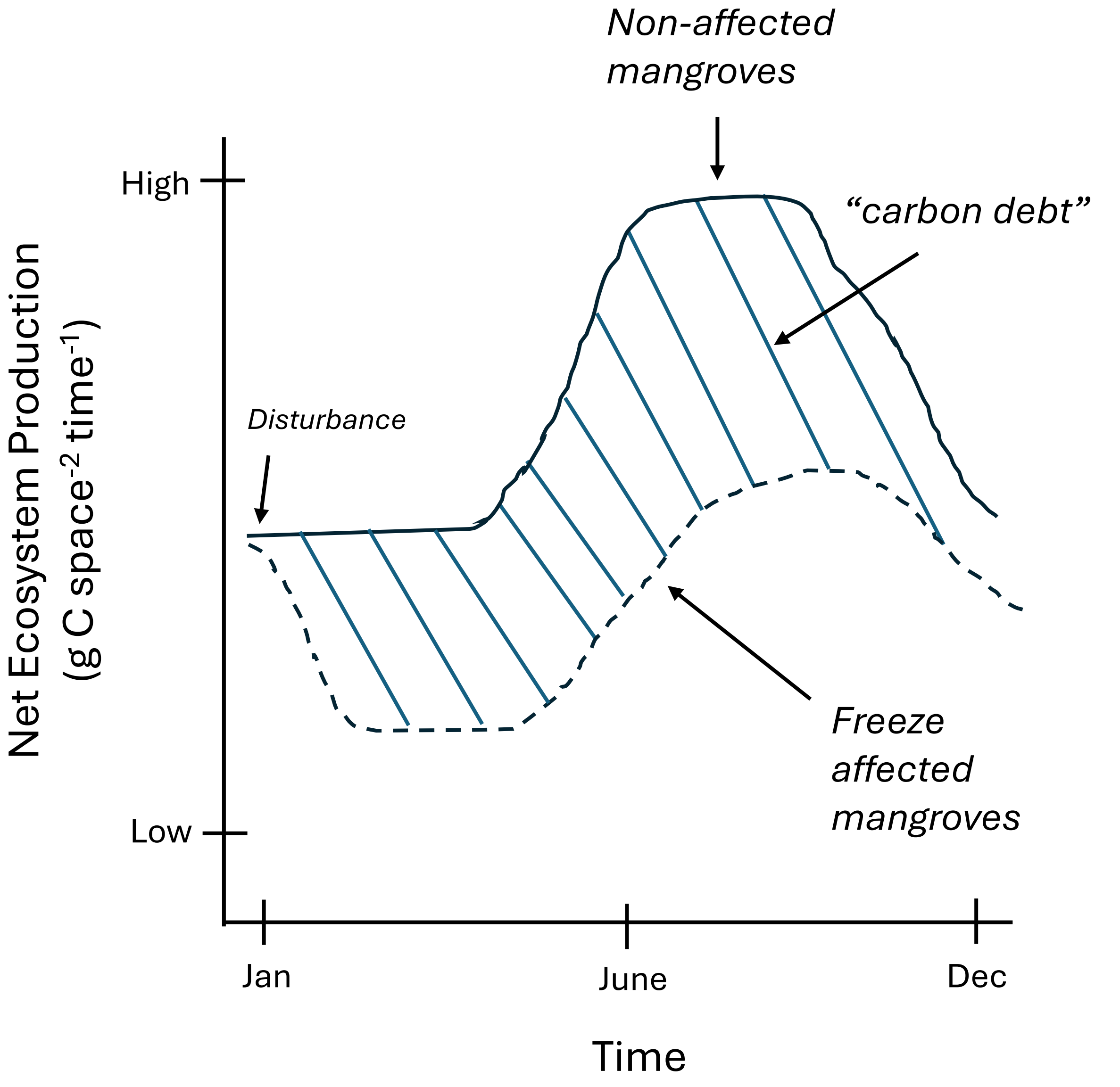


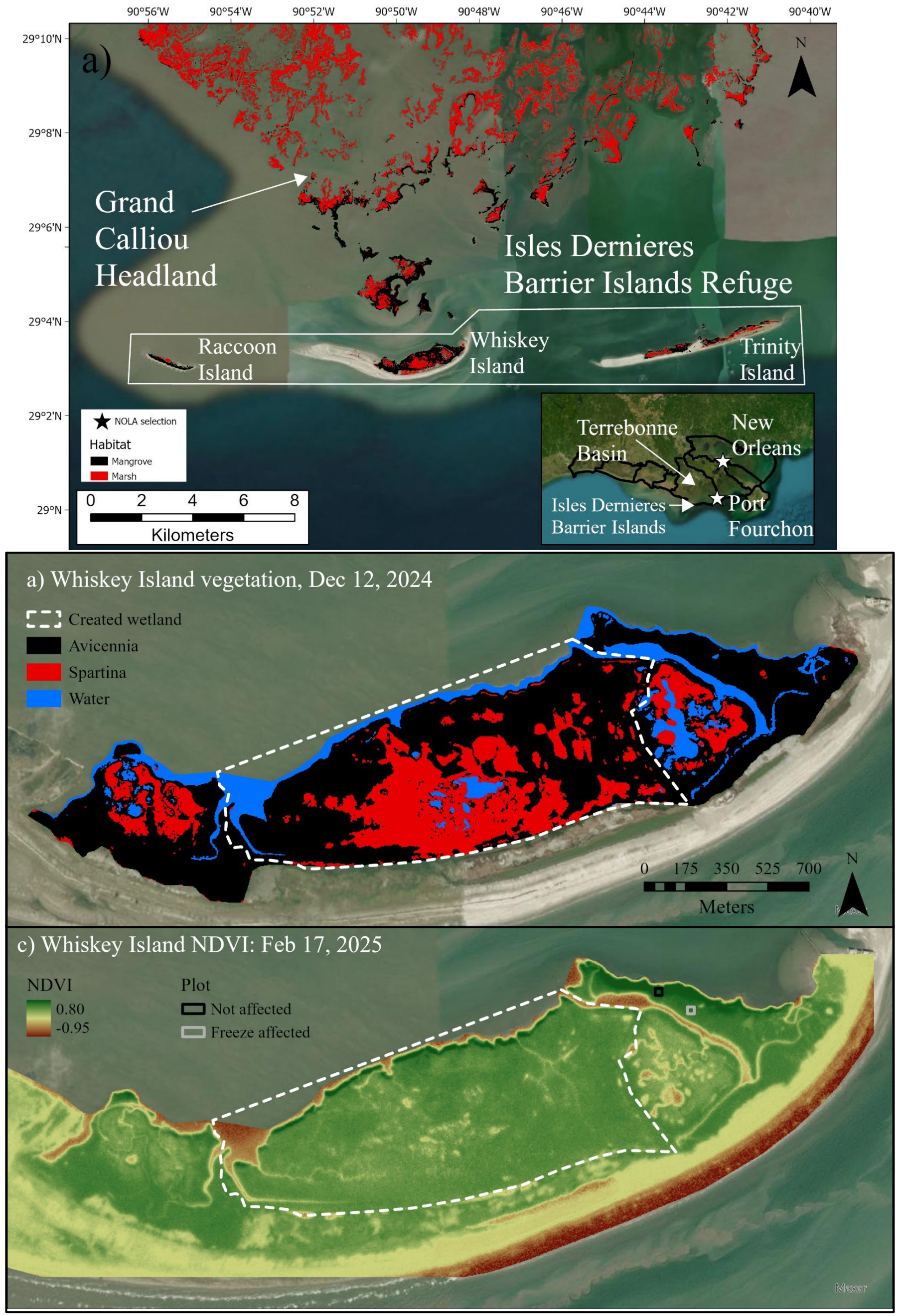
Research question

How does mangrove carbon cycling respond and recover to the Jan 2025 historic snow-storm and subsequent freezing temperatures?

Hypothesis

We will see an abrupt but temporary ecosystem response due to leaf mortality, resulting in an accumulated "carbon debt" that takes 1 – 3 years to recover.





Plot-level measurements

Non-affected mangroves

Freeze affected mangroves

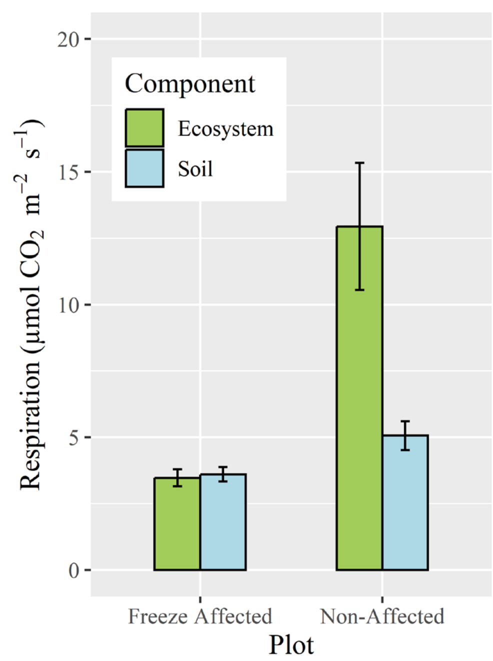
Ecosystem-scale fluxes of mangrove C using plant and soil chambers

CO_2/CH_4 vertical fluxes in freeze affected and non-affected trees

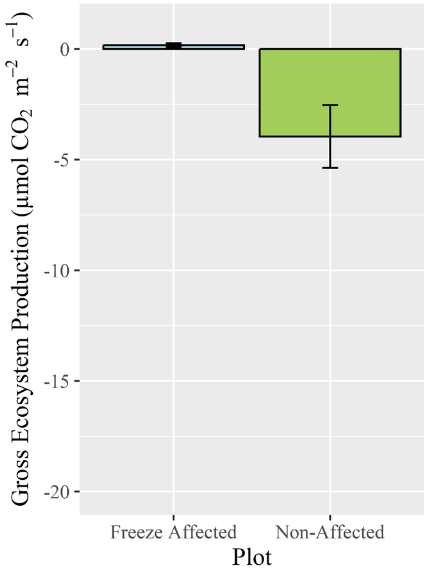
Net Ecosystem Production (NEP)

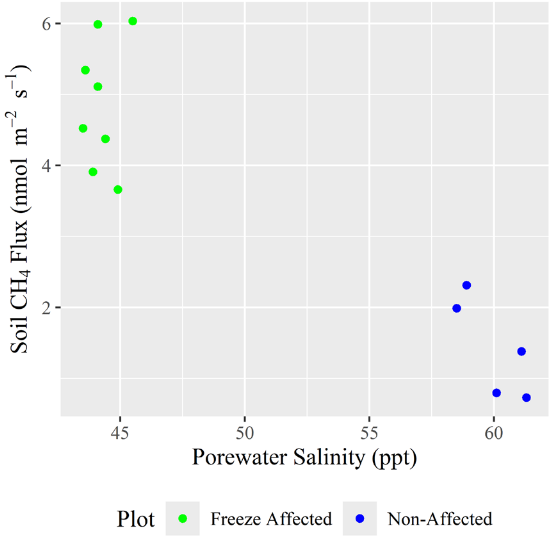
Ecosystem Respiration (ER; mangrove + soil)

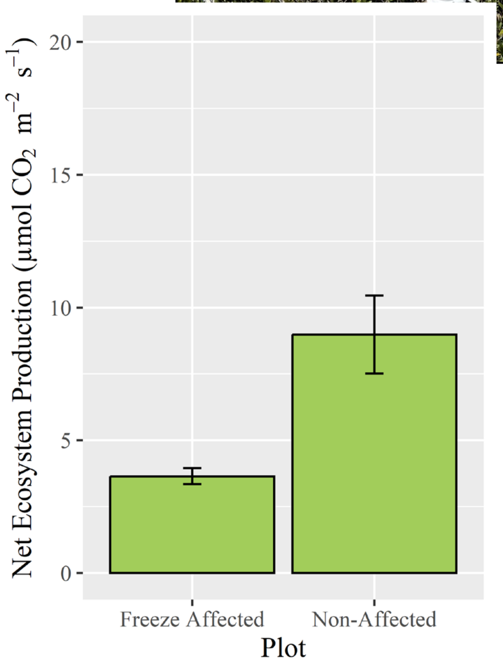
GPP = NEP (light) - ER (dark)



Bars are mean ± SE of March and April measurements ("pre growing season").







Comparison of chamber-based salt marsh C flux measurements

Study	Location	Dominant plant species	Timescale	GEP (µmol CO_2 m^{-2} s^{-1})	ER (µmol CO_2 m^{-2} s^{-1})	NEP (µmol CO_2 m^{-2} s^{-1})	CH_4 (nmol m^{-2} s^{-1})
Wilson et al. (2015)	Dauphin Island, AL	*S. alterniflora, J. romerianus*	Monthly mean, 2012	- 6.1 ± 0.6	3.3 ± 0.4	- 2.8 ± 1.0	12.1 ± 1.7
Hill and Vargas (2022)	Delaware Bay, DE	*S. alterniflora*	Monthly mean, 2020	-10.9 ± 8.6	4.6 ± 3.7	- 6.3 ± 5.0	18.8 ± 20.4
Muench et al. (2024)	Chenier Plains, LA	*S. alterniflora*	May 2017	- 16.7 ± 3.5	9.7 ± 1.6	- 7.0 ± 2.5	NA
This study	Whiskey Island, LA	*A. germinans*	Mean March - April 2025	-3.9 ± 1.4	12.9 ± 2.4	9.0 ± 1.5	1.1 ± 0.1

Next Steps

1. Continue vertical C flux measurements and recovery tracking through summer & fall; process/analyze porewater data.

2. Develop scaling relationships between vertical carbon fluxes, leaf-area index, and aboveground biomass to develop spatially explicit upscaled, maps of NEP using high-resolution satellite imagery.