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Quantifying Changes in Land Area in Louisiana Coastal Restoration Areas 1985-Present with Remote Sensing

CPRA Board Meeting

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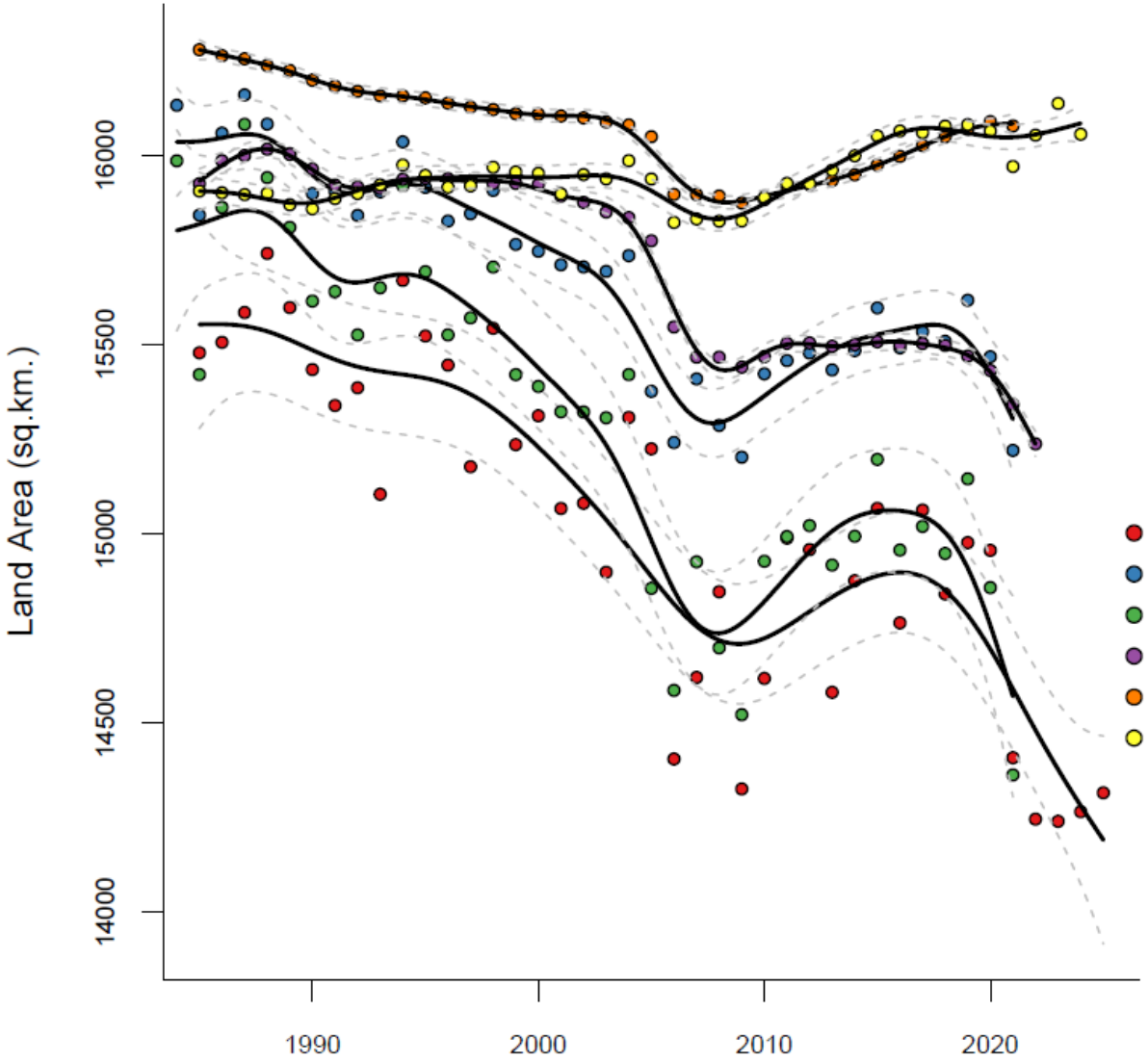
U.S. Department of the Interior
U.S. Geological Survey

Background - Coastwide Land Area Change Trends



Dataset	Average Change Rate (sq.km./yr)
WARC (1985-2025)	-32.60
~~DSWE (1984-2022)~~	~~-20.40~~
GSWD (1984-2021)	-34.68
~~Di_Vittorio (1985-2022)~~	~~-19.21~~
~~LCMAP (1985-2021)~~	~~5.41~~
~~NLCD (1985-2024)~~	~~3.90~~
*Jensen et al., 2022 (1984-2020)	-34.81
* Not depicted on graph	

- WARC (Wetland and Aquatic Research Center)
- DSWE (Dynamic Surface Water Extent)
- GSWD (Global Surface Water Dataset - ESA)
- Di_Vittorio (Di Vittorio et al. 2025)
- LCMAP (Land Change Monitoring, Assessment, and Projection)
- NLCD (Annual National Land Cover Dataset)

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Background

- Coastal restoration projects have been constructed as part of numerous programs and efforts including the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), the Coastal Impact Assistance Program (CIAP), Natural Resource Damage Assessment (NRDA), as well as state, parish, and private programs, initiatives, and/or as part of mitigation activities.
- While individual projects are often evaluated to assess land area pre- and post-construction, there has not yet been a comprehensive evaluation of the cumulative land area benefit of all coastal restoration efforts across Louisiana.
- While several statistics are often quoted, such as "since its inception, 234 (CWPPRA) coastal restoration or protection projects have been authorized, benefiting approximately 100,000 acres", in these cases, the word “benefit” may include benefits to other factors including water quality, wildlife habitat, and recreation opportunities (CWPPRA, 2025). These statements are not specific to land area benefit.

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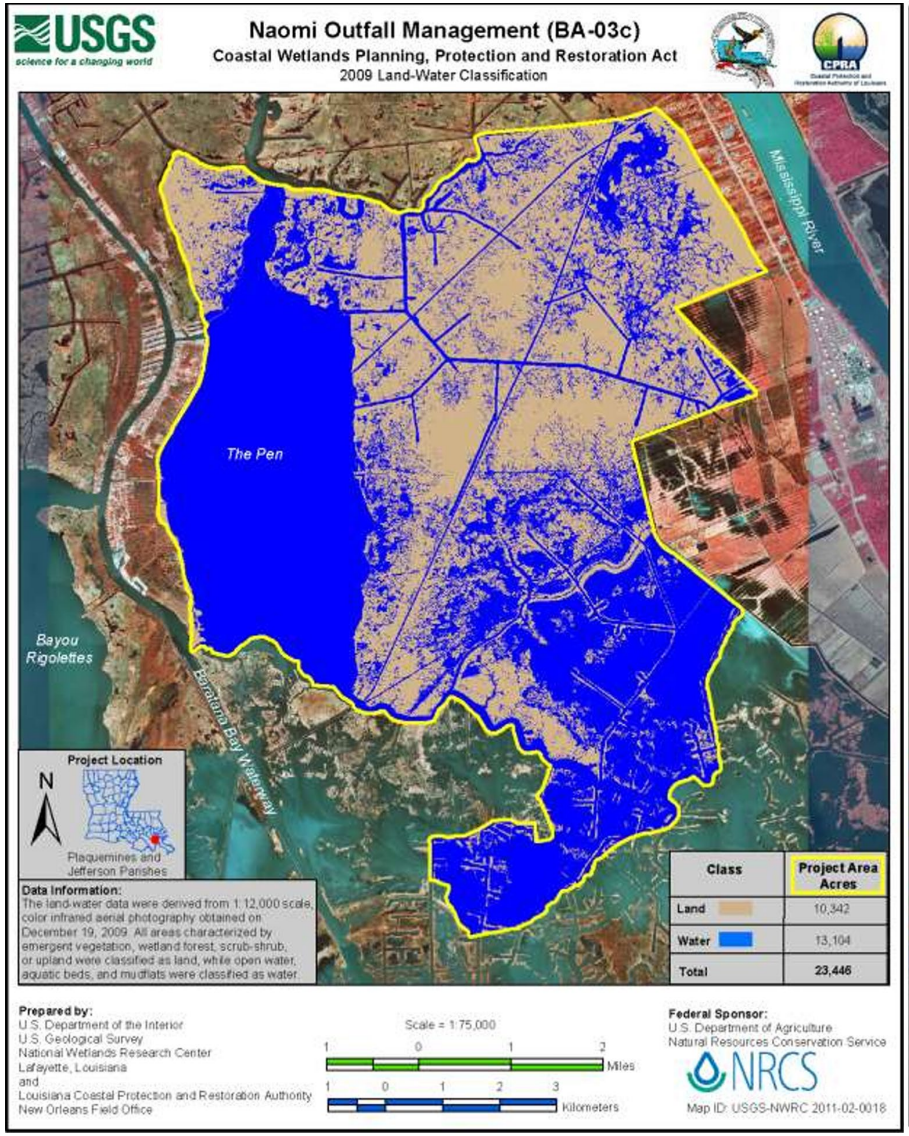
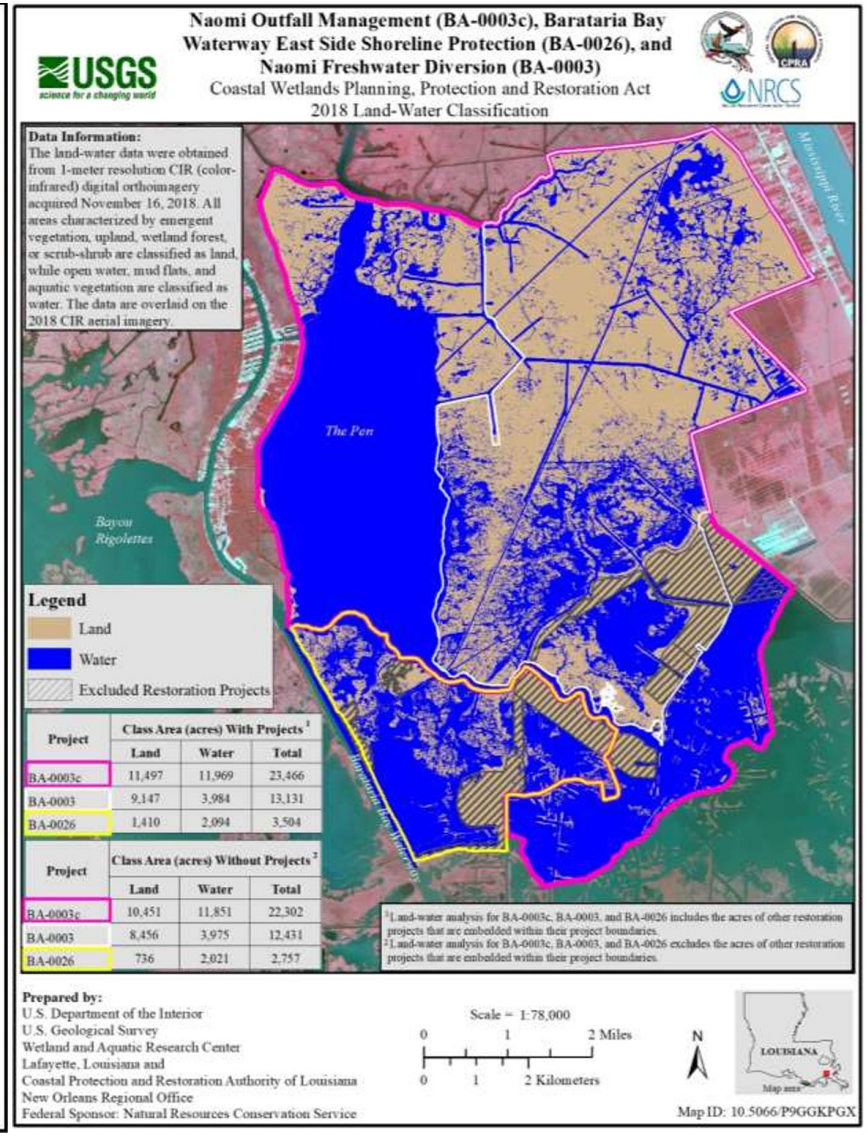
Existing Monitoring





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Objective

Improved Land Area Change, Monitoring and Assessment of Restoration Impacts

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Definition

Land Area Benefit: Land area benefit is defined as land area **built, restored, or sustained** a result of project implementation.

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Approach

- In this study, we used Landsat satellite imagery from 1984–2025 to assess the land-building and resilience and cumulative effects of constructed coastal wetland restoration projects.
- Datasets estimating subpixel land area (i.e., fractional estimates of land area per satellite pixel) were produced to address the limitations of using moderate-resolution imagery (30 m).
- Assessing the land area sustained by restoration projects hinges on a comparison to the counterfactual state of "what would have been present if the project had not been built"; a WOA condition. In general, there are three options for estimating the WOA:
  1. ~~Process-based models~~
  2. ~~Comparison to reference areas~~
  3. Projection of statistically modeled pre-construction dynamics.
- Post-construction observations were then compared to the without-action condition to assess land area benefit.

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Limitations

- Our approach to WOA projection, while effective at capturing temporal uncertainty, does require the assumption that the full regime of temporal dynamics is captured in the pre-construction record. In other words, it assumes that the periodicity and magnitude of future disturbances are captured in the recorded dynamics.
- The validity of this assumption may be strained if drivers unrelated to project implementation—such as sea-level rise rates or hurricane intensity or frequency—differed between pre- and post-construction periods, rendering it impossible to disentangle environmental and project influences on the land area change rates between the two periods.

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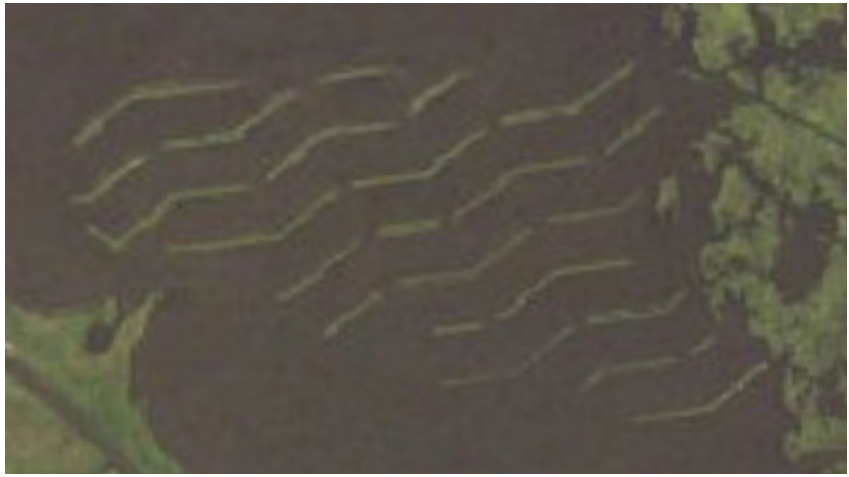
Project Boundary Compilation and Alterations

- An important, but time-intensive aspect of this effort was identifying what restoration has taken place where. The primary data sources for project boundaries were the CPRA Projects database and the CPRA Infrastructure Database.
- Project areas also included information determined from coastal use permits and U.S. Army Corps of Engineers (USACE) project boundaries.
- Additionally, land area change data created in this effort were used to identify areas of wetland gain where all existing spatial databases indicated no projects have been conducted. Some of these areas contained obvious restoration efforts, but no record of restoration was contained within the previously mentioned databases.



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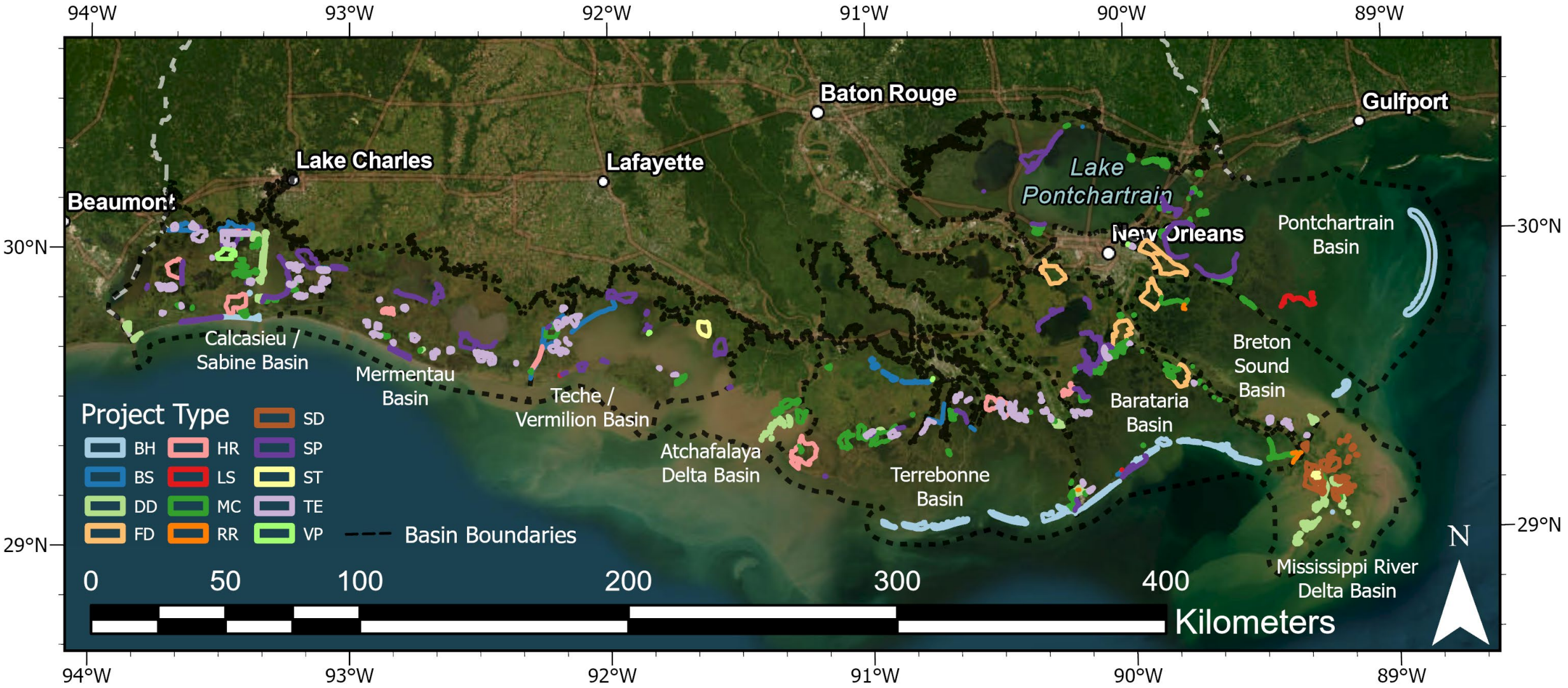
Task 1. Projects/Project Boundaries

507 projects or project segments



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Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Imagery and Land Area Quantification

- Landsat 5,7,8, and 9 imagery were used, resulting in a period of record (POR) for this effort of March 1984 - December 2025, which varies slightly depending on project location and image availability at each location.
- Linear spectral unmixing (LSU) was used to estimate the relative abundance of land and water depicted in each pixel.
- This method assumes each pixel's reflectance is a linear combination of the reflectance of each target within that pixel and, as opposed to categorical classification, provides a fractional estimate of the composition of each pixel, reducing concerns over the use of moderate resolution imagery in small project areas.

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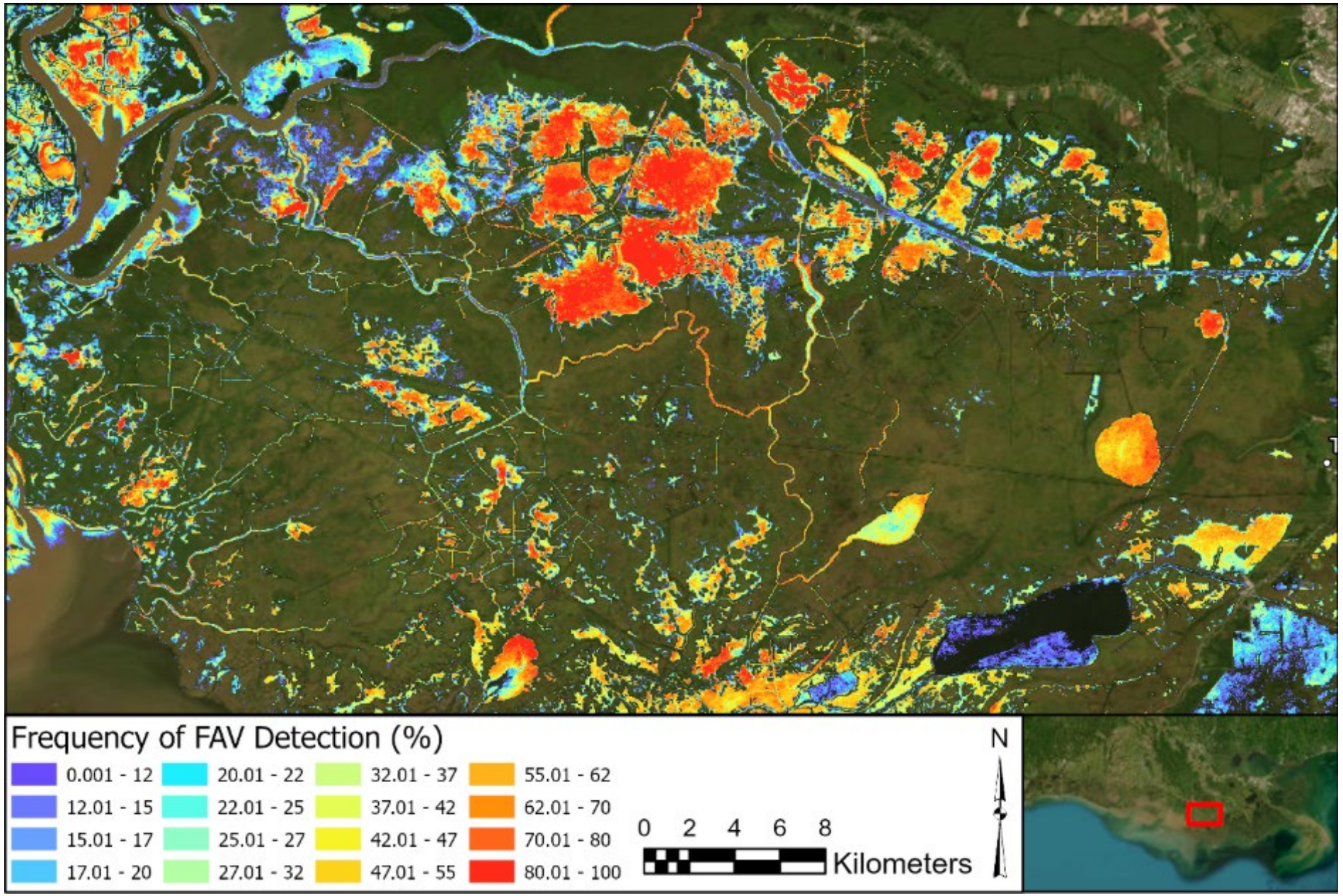
Floating Aquatic Vegetation (FAV)



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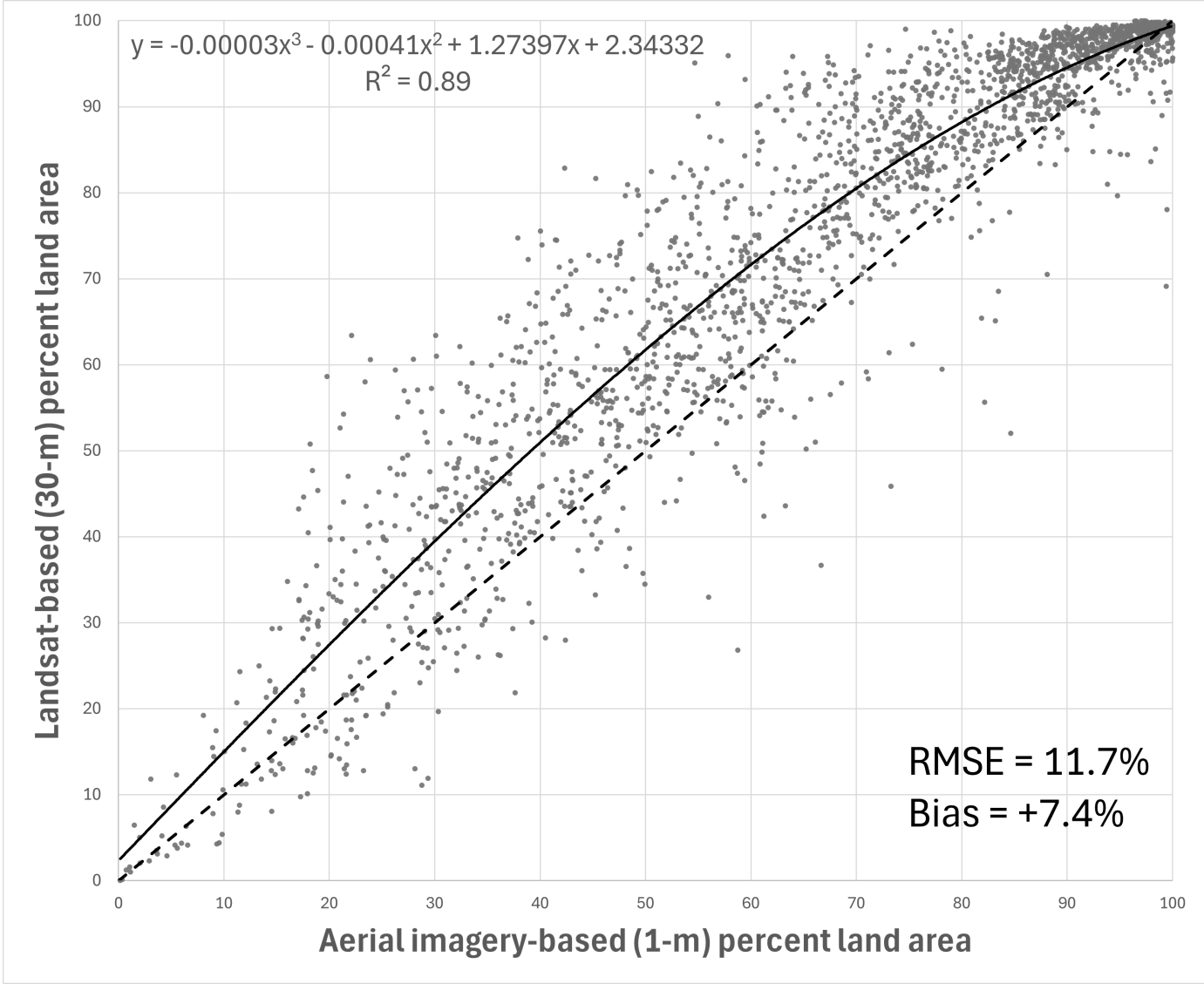
Validation



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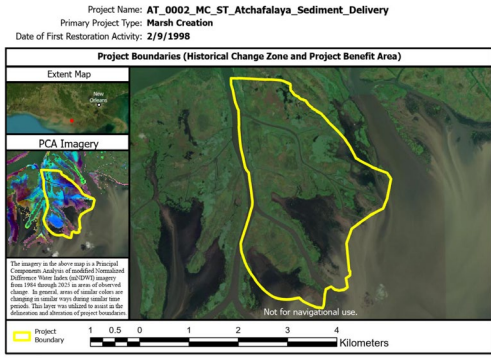
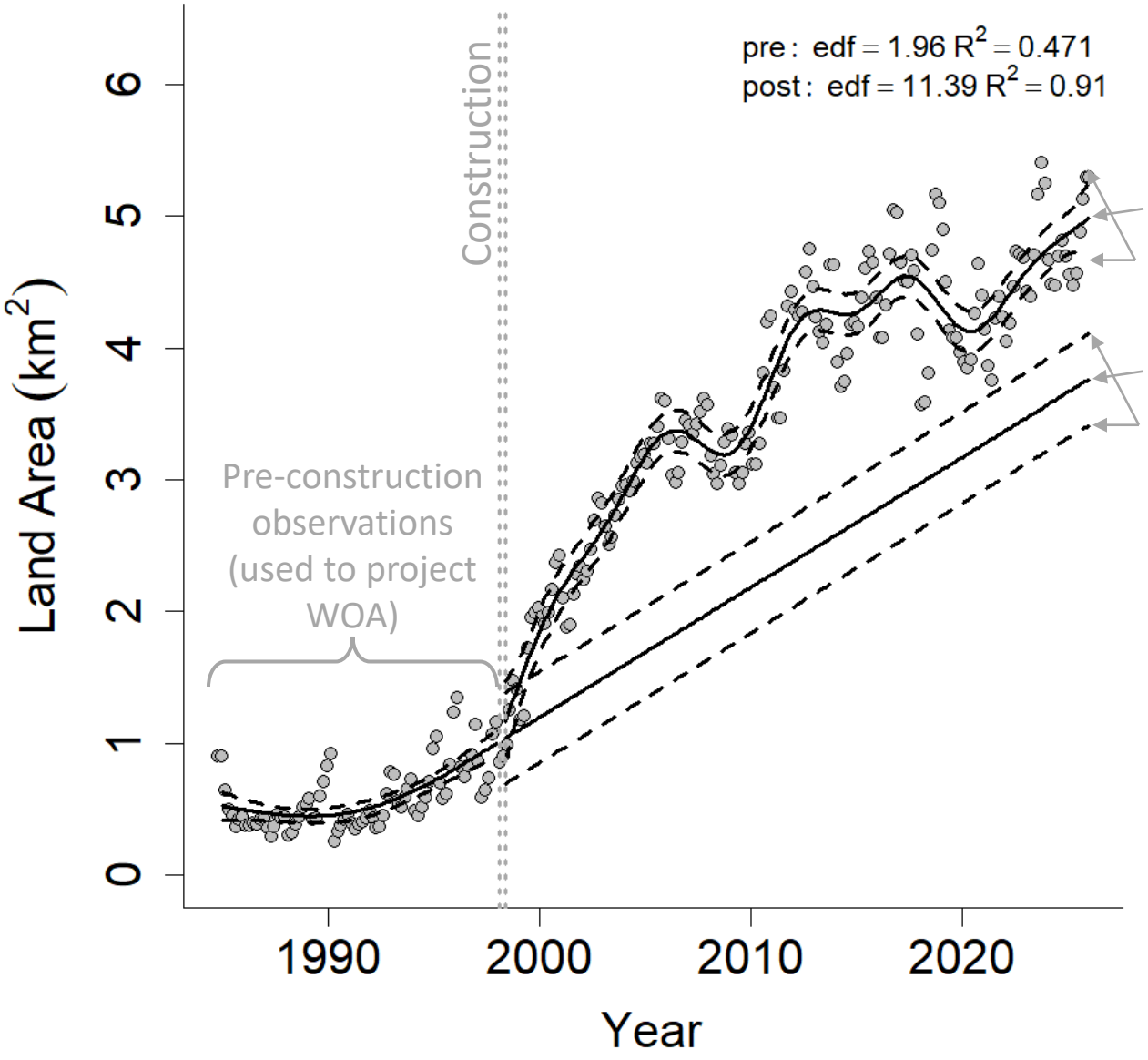
Results

Example Project Level Assessment - Primer





Fitted function of post-construction observations

Standard error of post-construction observations

Median without action (WOA)

WOA 95% confidence interval

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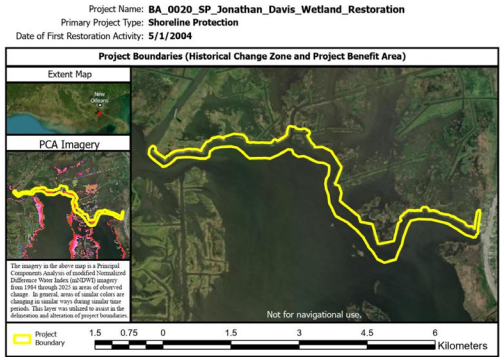
Example Project Level Assessment - Primer



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Marsh Creation

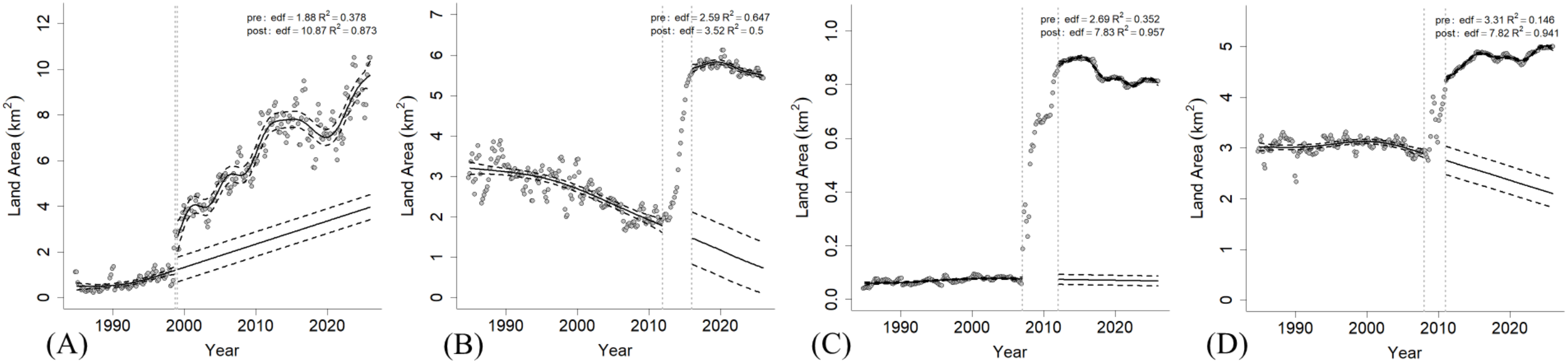

Figure: Example land area change analyses (1984–2025) for selected marsh creation projects in coastal Louisiana (USA): A) AT-03; B) BA-42; C) CS-28-3; D) PO-33. The vertical dotted lines indicate a window of construction. The three lines, one solid and two dashed, extending from the pre-construction period represent the median without action projection with a 95% confidence interval. See Couvillion et al., 2026 for additional project level information including boundaries of these selected projects.

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Barrier Island Restoration

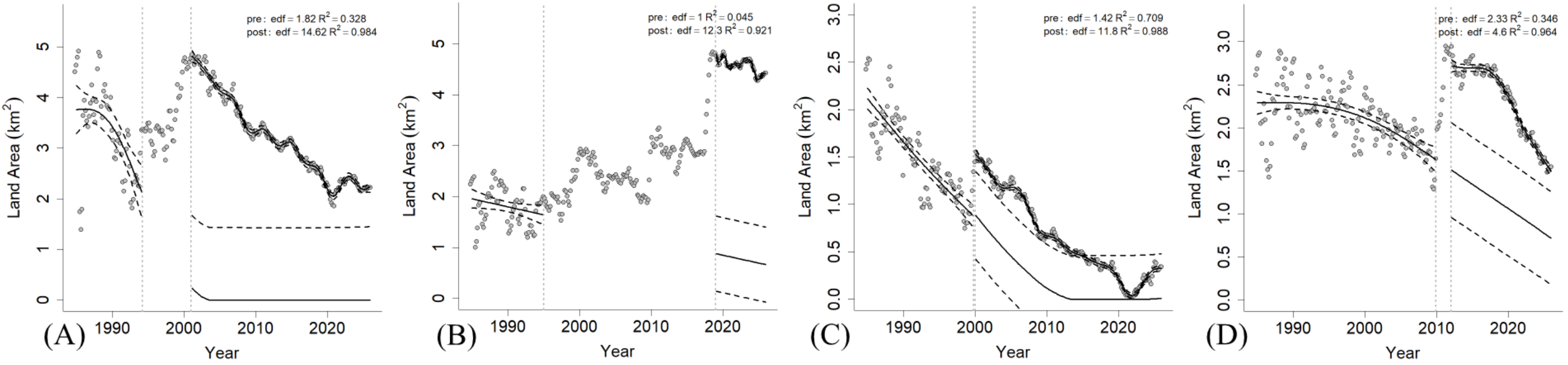

Figure: Example land area change analyses (1984–2025) for selected barrier island restoration projects in coastal Louisiana (USA): (A) TE-20/24/37/133; (B) TE-27/50/100/133; (C) TE-30/25; (D) BA-30. The vertical dotted lines indicate a window of construction. The three dotted lines extending from the pre-construction period represent the median without action projection with a 95% confidence interval. See Couvillion et al., 2026) for additional project level information including boundaries of these selected projects.

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Shoreline Protection/Bankline Stabilization

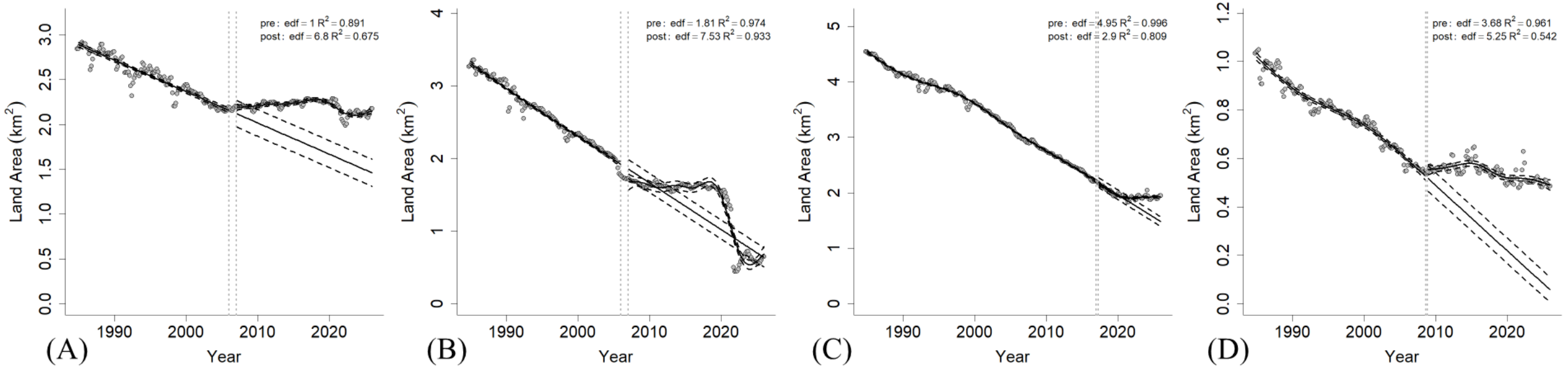

Figure: Example land area change analyses for selected shoreline protection projects in coastal Louisiana (USA): (A) BA-27d; (B) BA-27 West Phases 1&2; (C) ME-18; (D) PO-30 The vertical dotted lines indicate a window of construction. The three dotted lines extending from the pre-construction period represent the median without action projection with a 95% confidence interval.

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Cumulative Benefits

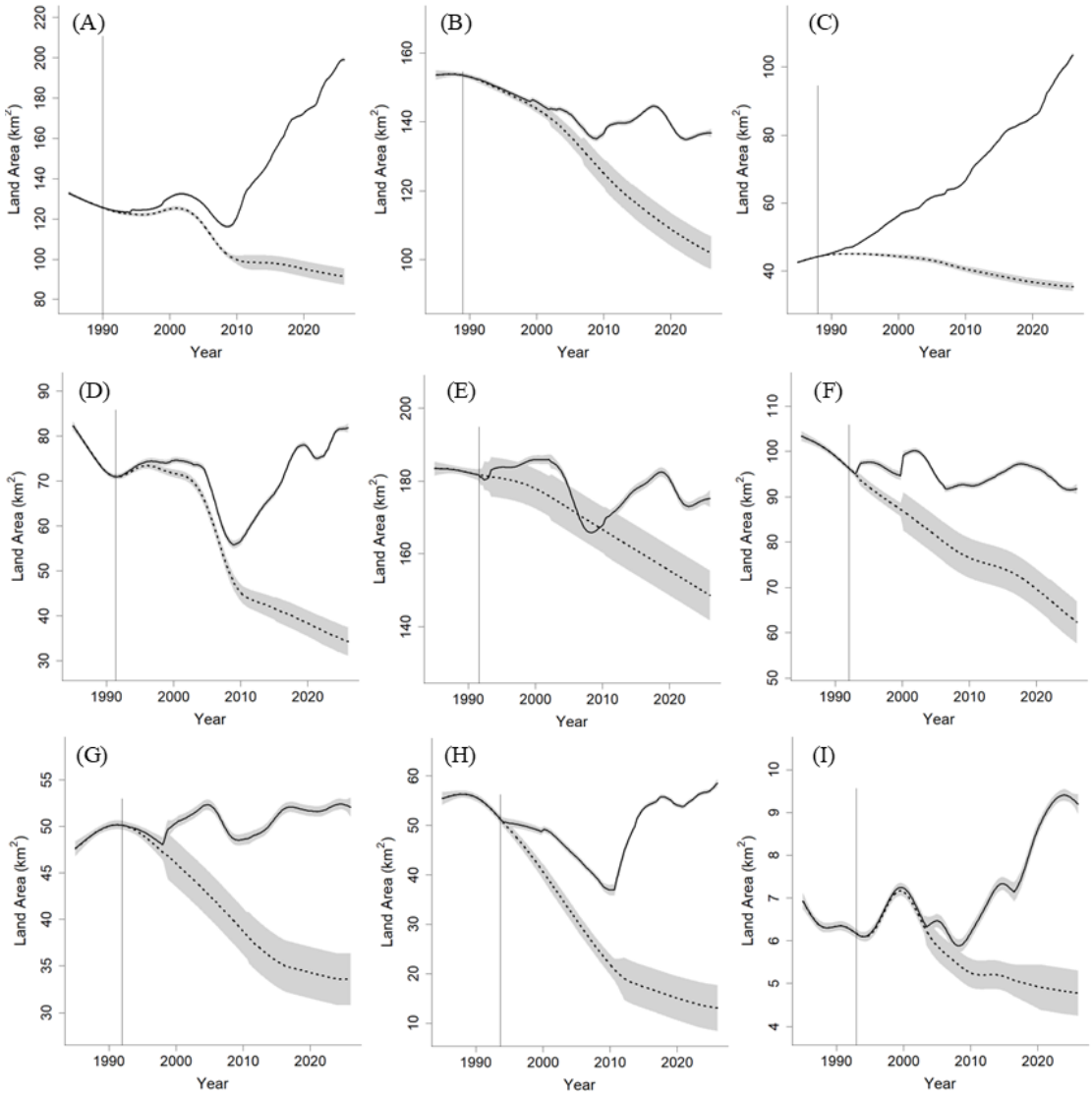

Figure: Cumulative land area change analyses for selected restoration types in coastal Louisiana (USA) from 1984–2025. (A) Marsh Creation; (B) Shoreline Protection; (C) BUDMAT; (D) Terracing; (E) Freshwater Diversions; (F) Hydrologic Restorations; (G) Bankline Stabilization; (H) Barrier Headland; (I) Vegetative Planting. The solid line represents with action (WA) condition or observed land area change and the dashed line represents the without action (WOA; counterfactual) condition. The vertical line delineates the date of first restoration activity and shading represents the 95% confidence interval.

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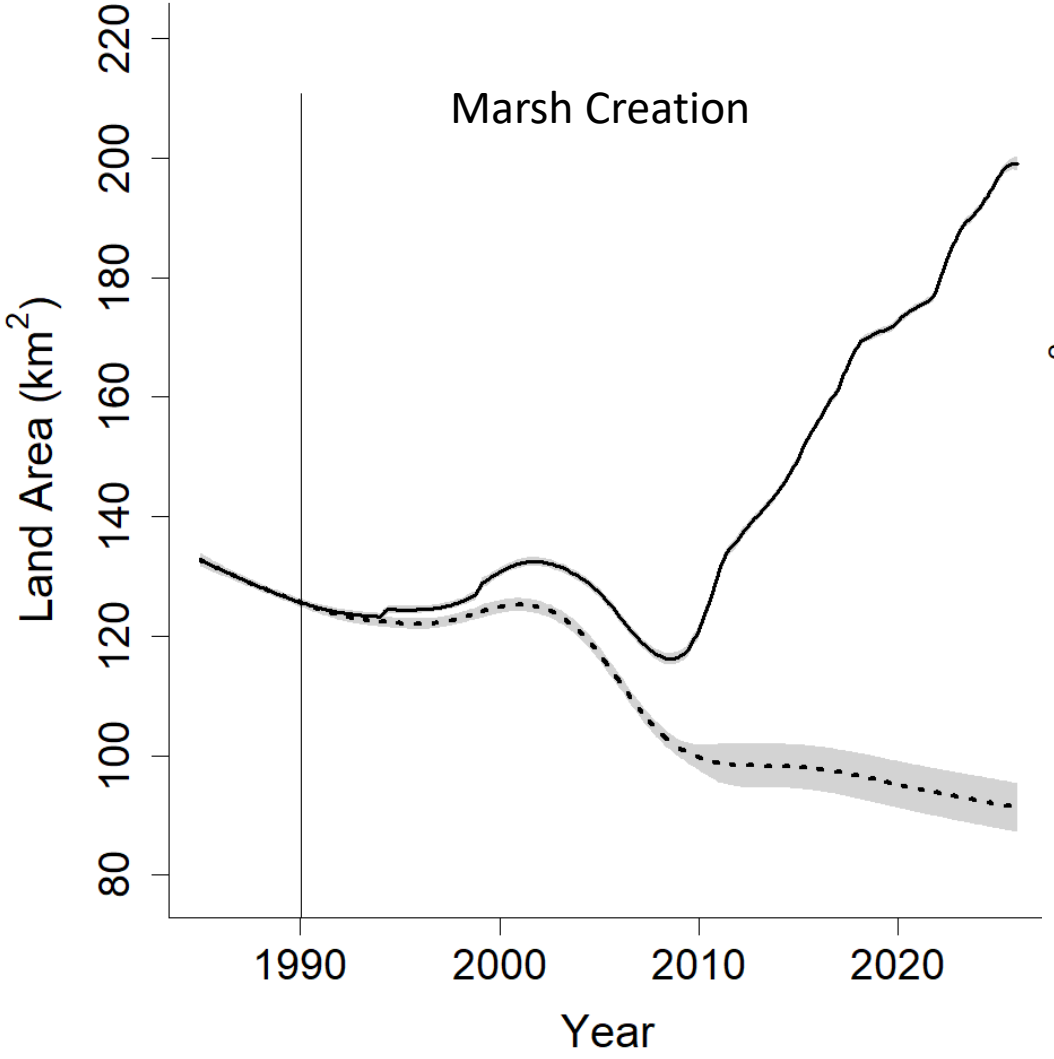
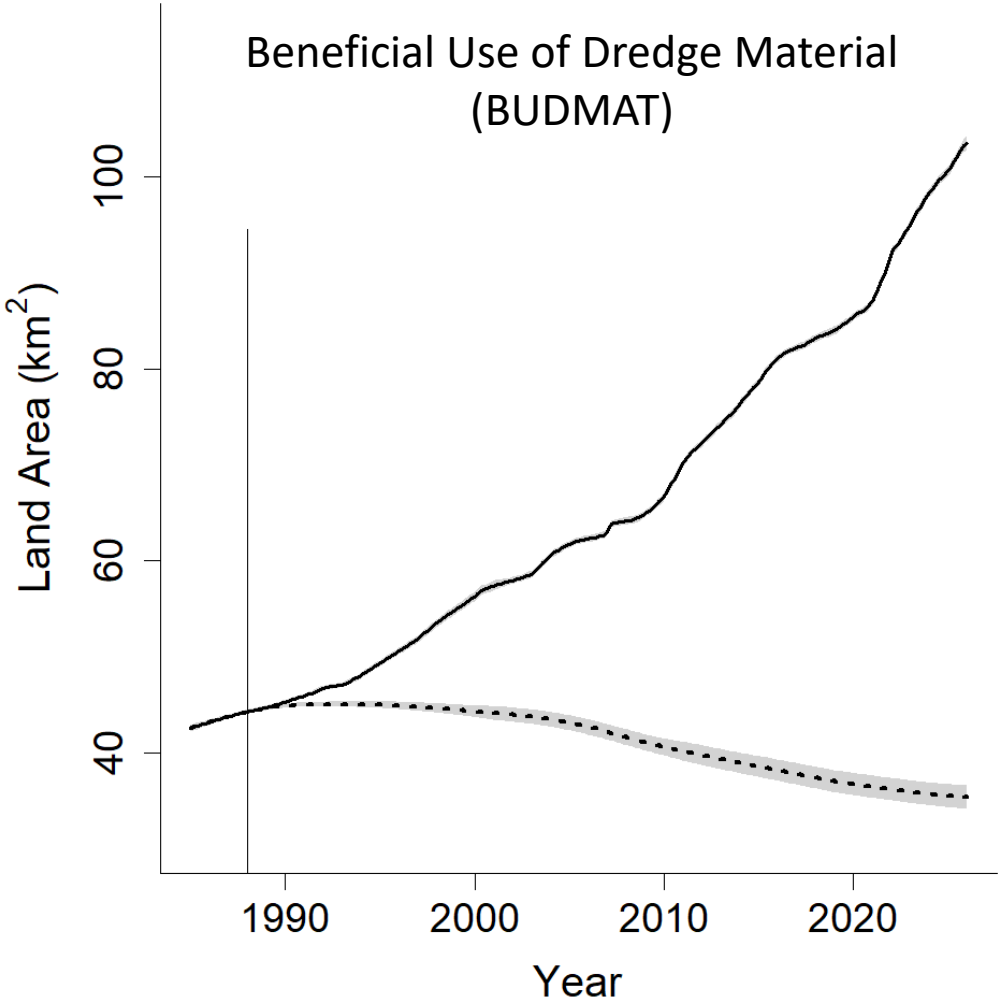
Marsh Creation / Dredging





Marsh creation projects and BUDMAT projects have contributed approximately **107.85 km^2 (+/- 2.63 km^2)** and **68.18 km^2 +/- 1.0 km^2**, respectively, of land to the coastal Louisiana landscape from 1990-2025.

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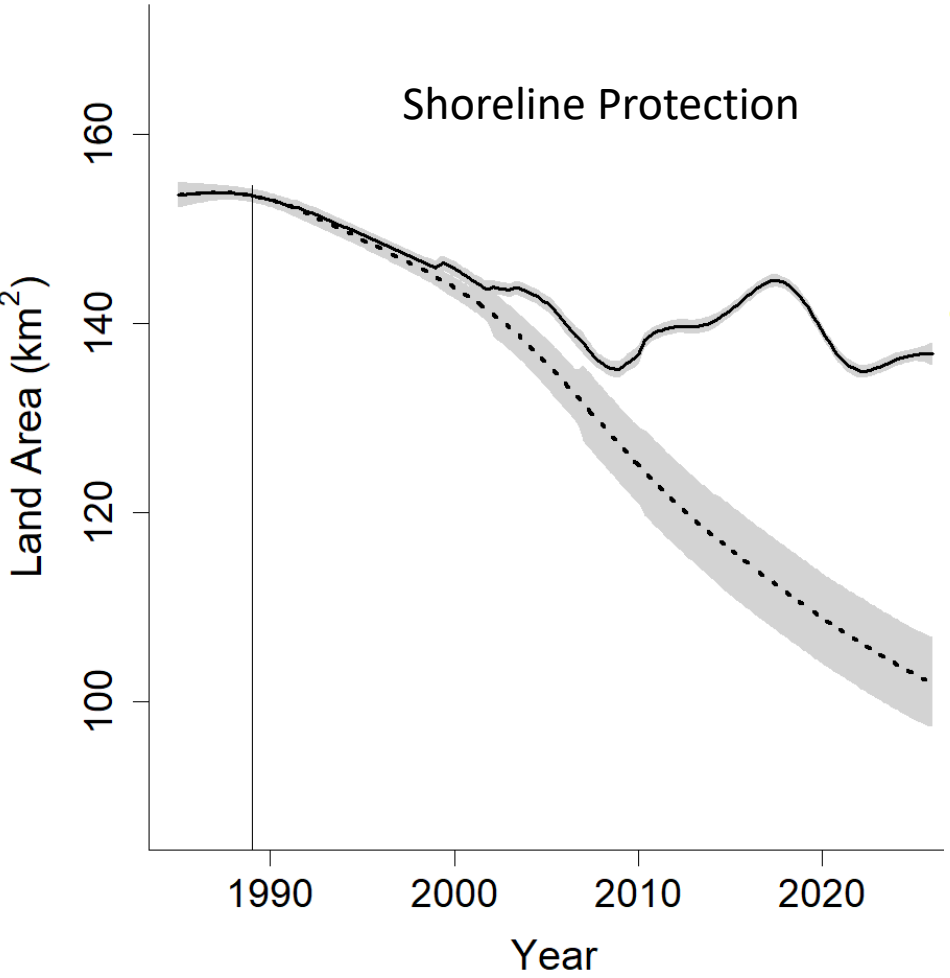
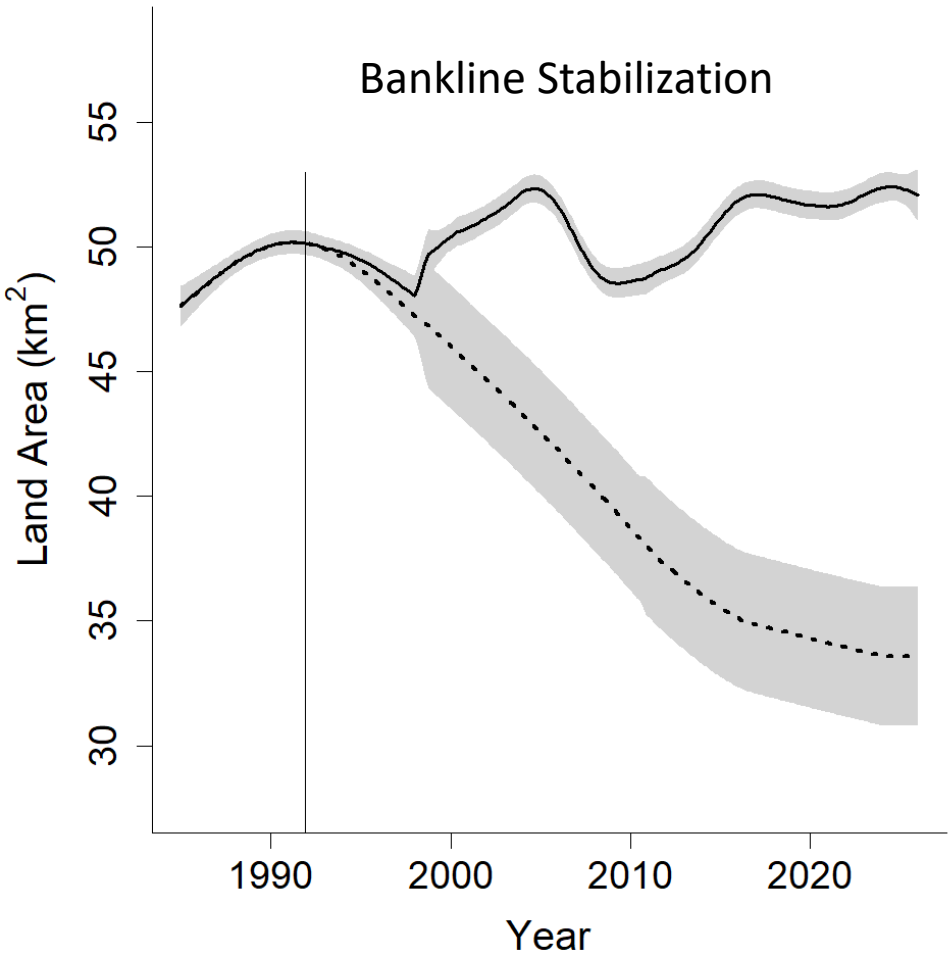
Shoreline Protection/Bankline Stabilization





Shoreline protection and bankline stabilization projects have contributed approximately **34.7 (+/- 3.0) km^2** and **18.5 (+/- 1.9) km^2** of land area benefit to the coastal Louisiana landscape, respectively.

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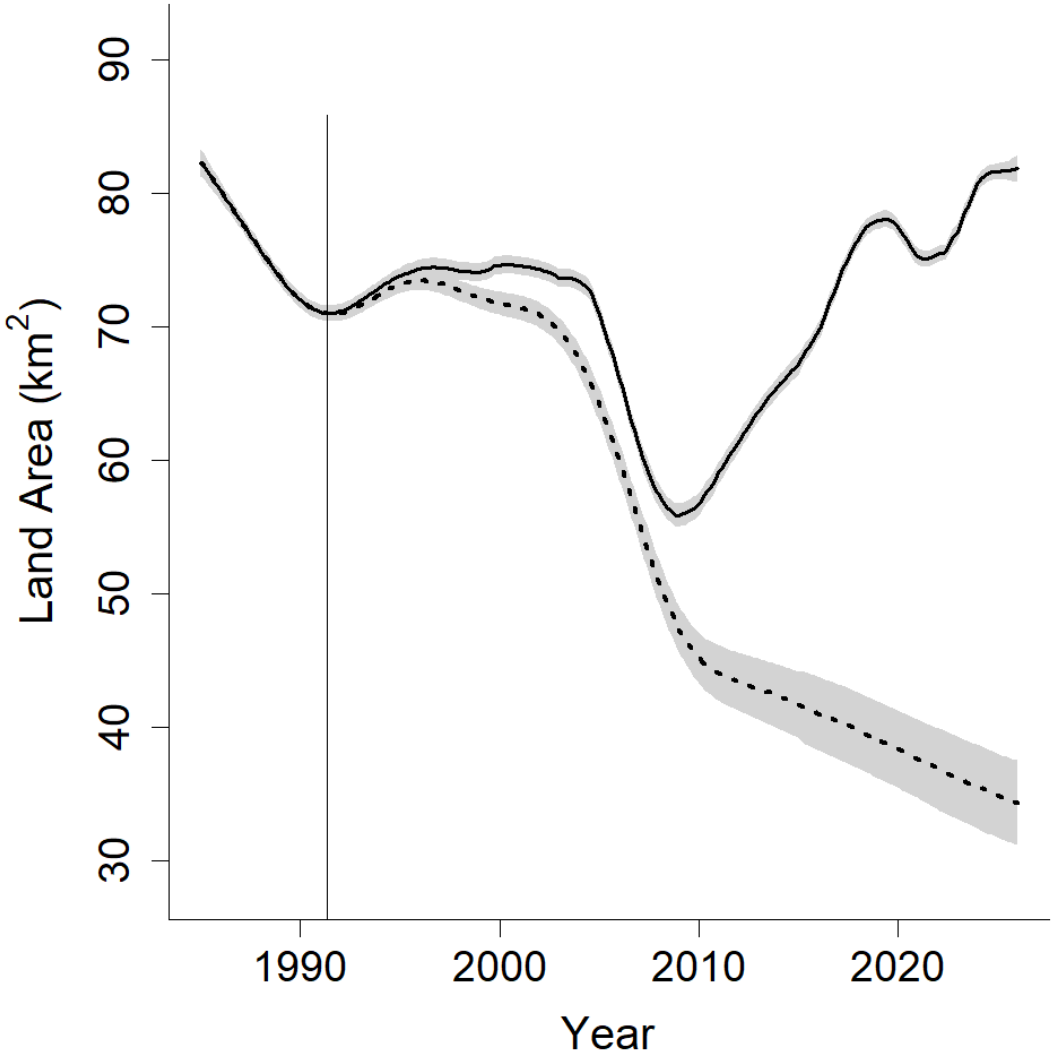
Terracing



Terracing projects have collectively contributed approximately **47.49 km^2 (+/- 2.1 km^2)** of land to coastal Louisiana.

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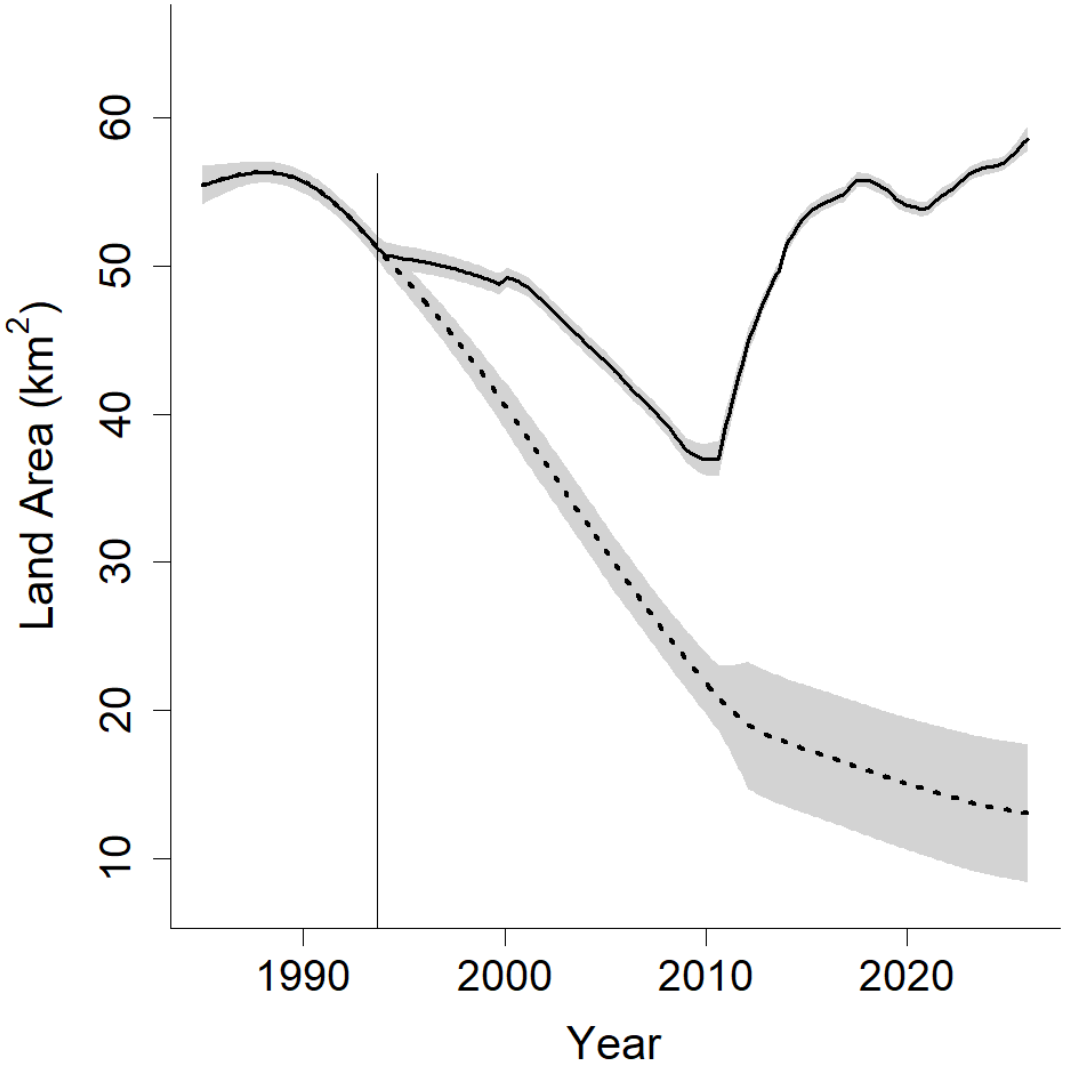
Barrier Island Restoration



We estimated a net positive cumulative land area benefit from all barrier island projects as **45.5 km^2 (+/- 2.7 km^2)**.

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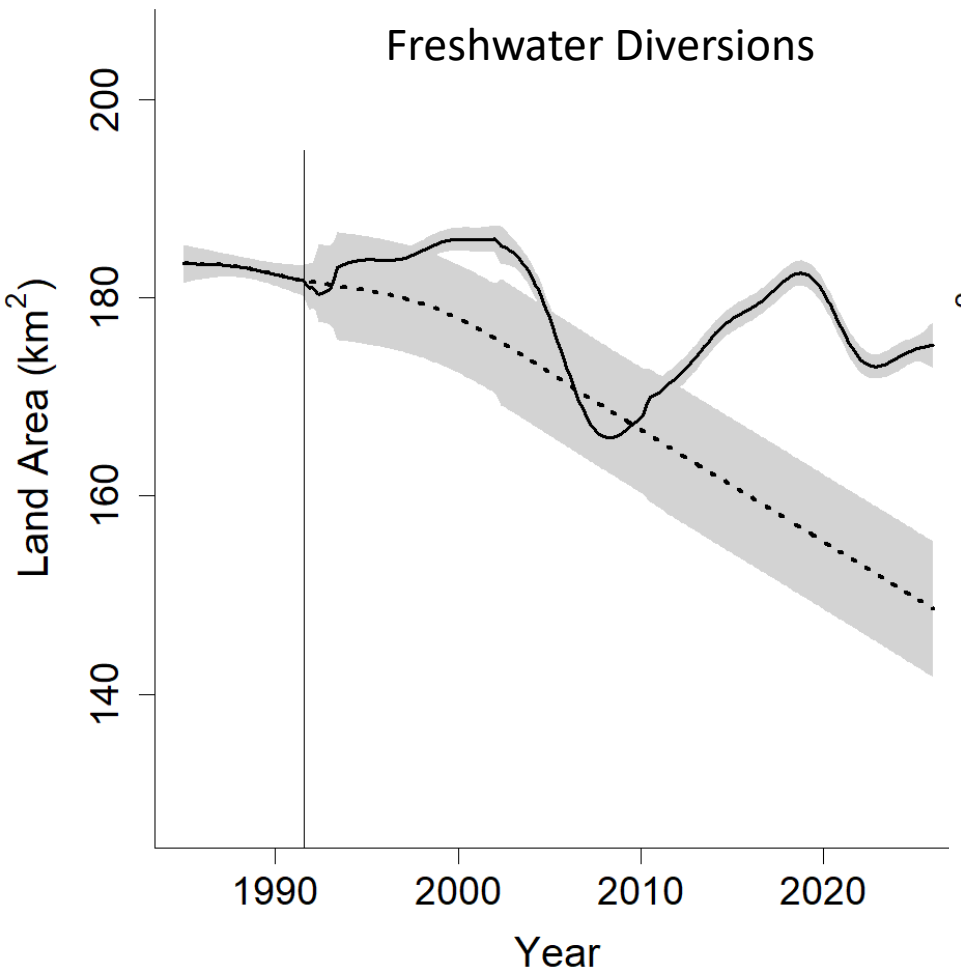
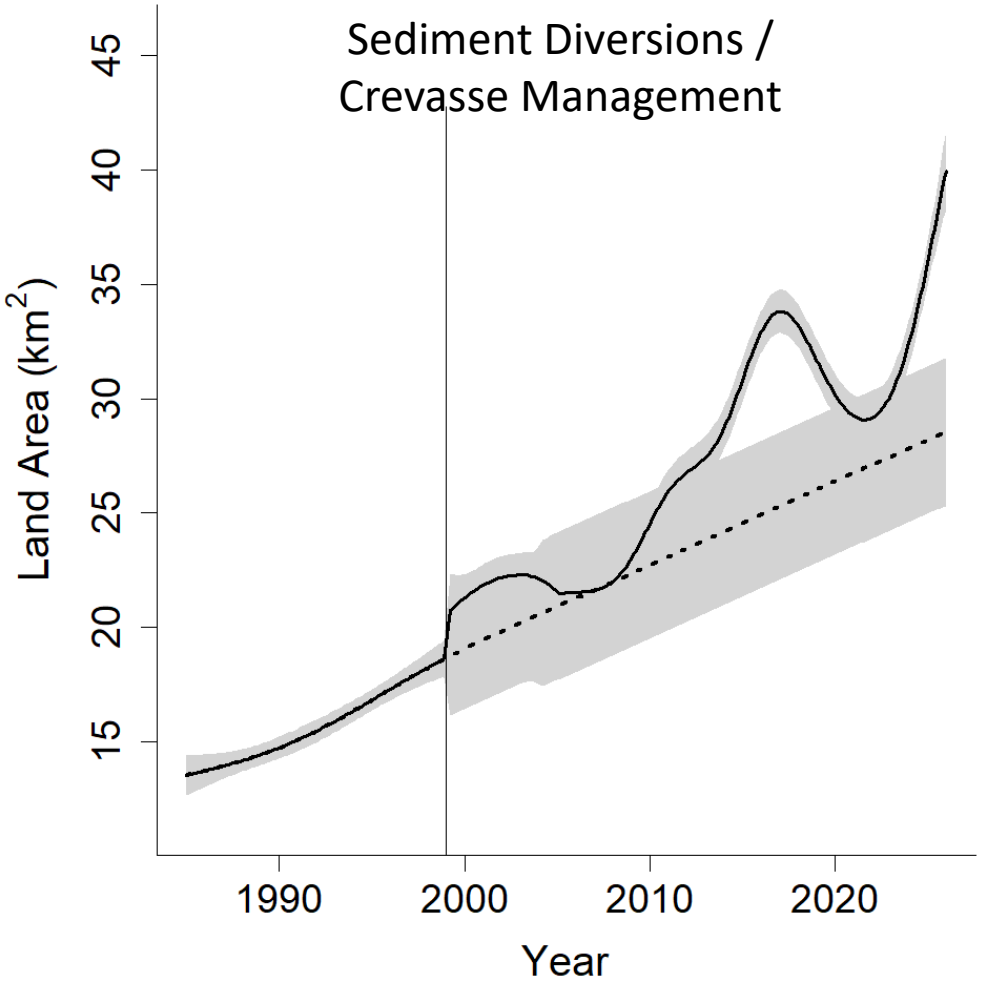
Diversions and/or Crevasse Management





FD and SD projects have collectively contributed approximately **38.0 km^2 (+/- 7.1 km^2)** of land area benefit.

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Grand Total

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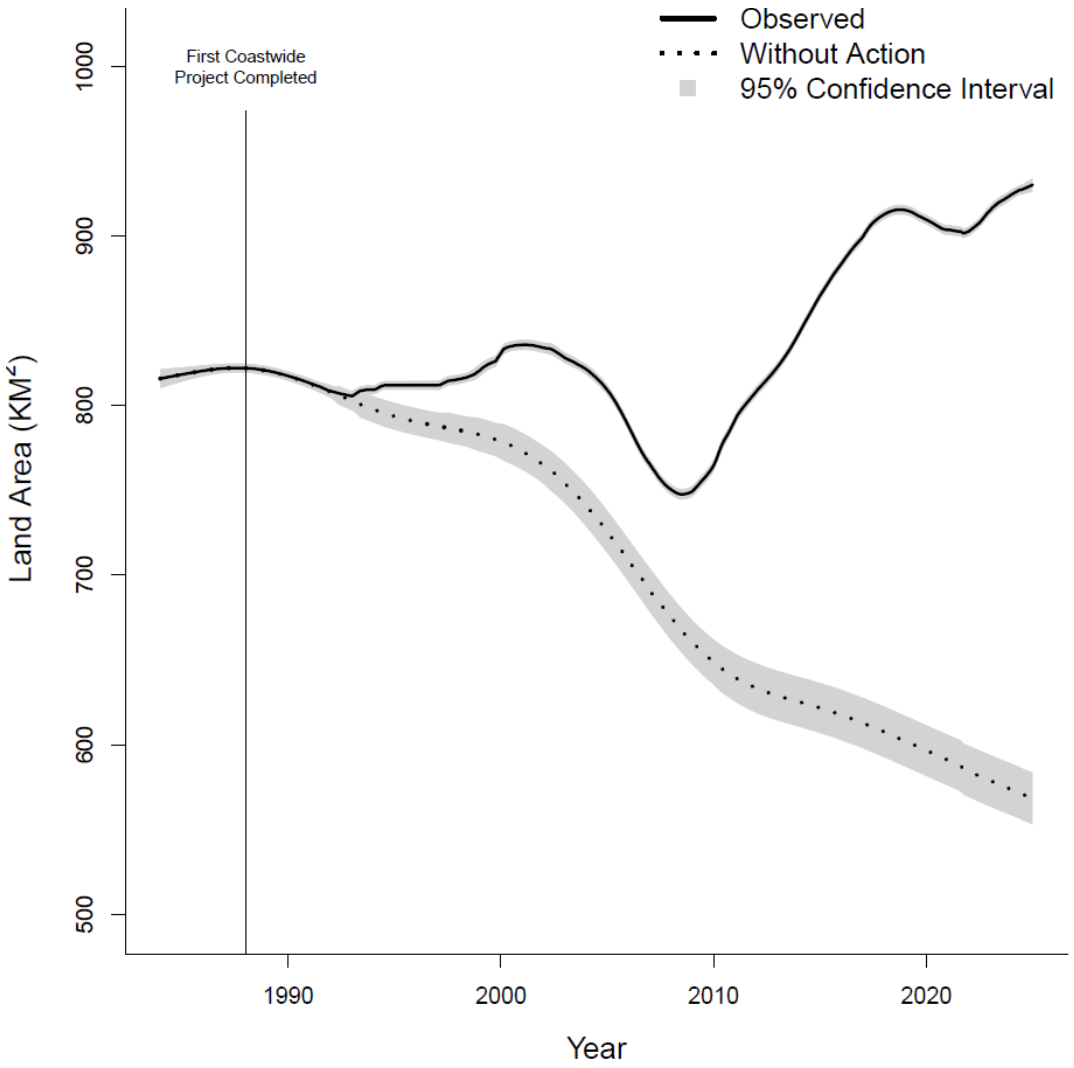
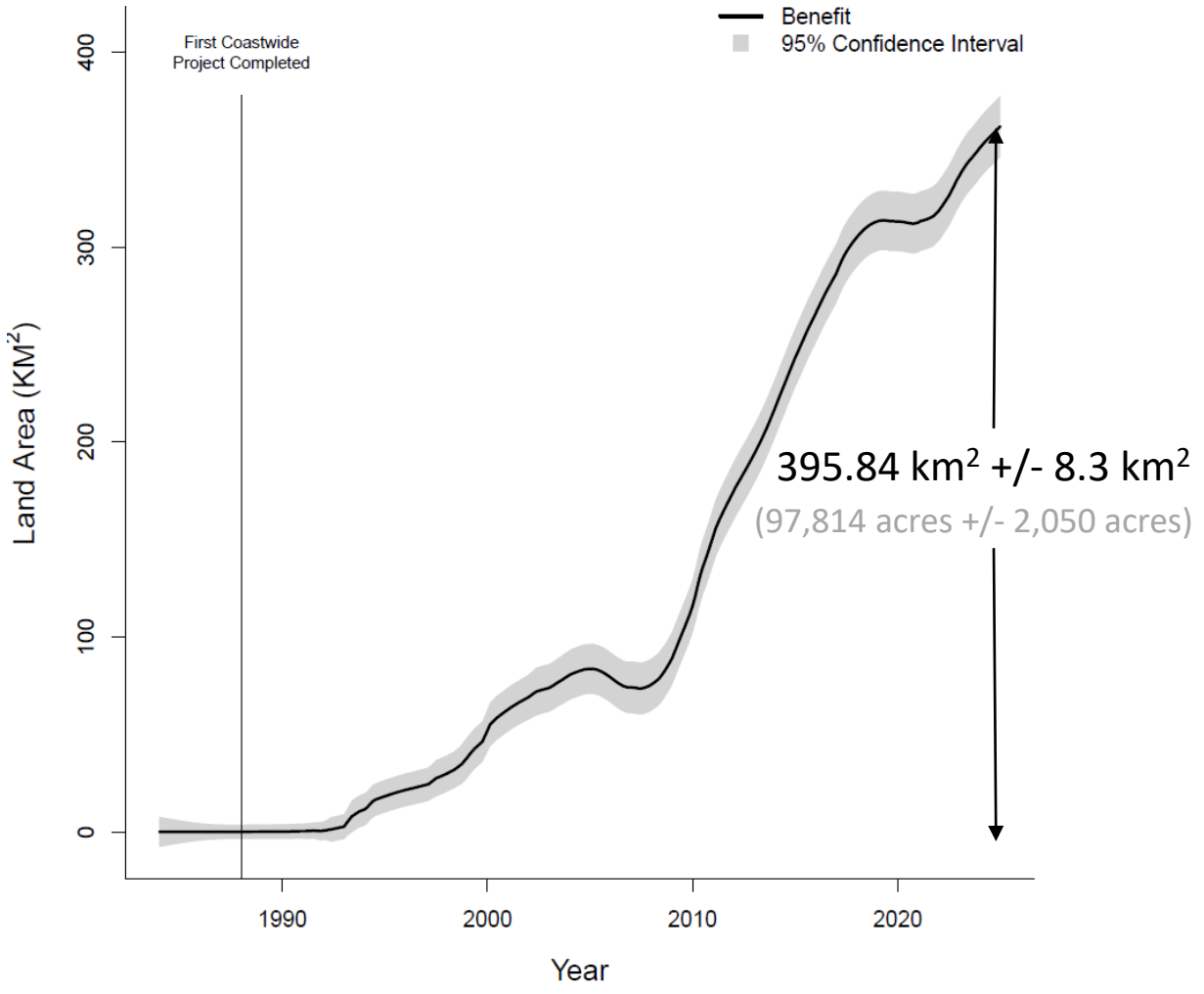
Coastwide Cumulative Benefit

All Restoration Project Areas Combined



All Restoration Project Areas Combined (Land Area Benefit)



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Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Summary of Results

- Constructed coastal restoration projects have contributed an estimated 395.84 km^2 +/- 8.3 km^2 (97,814 acres +/- 2,050 acres) of land area benefit, either through new land built, land restored, or land sustained from project inception through December 2025.
- Restoration types contributing the most land area benefit, included:
  1. Marsh creation projects (107.85 km^2 +/- 2.63 km^2)
  2. BUDMAT/Dredging (68.18 km^2 +/- 1.0 km^2)
  3. Terracing (47.49 km^2 +/- 2.1 km^2)
  4. Barrier island restoration (45.5 km^2 +/- 2.7 km^2)
  5. Freshwater or sediment diversions/crevasse management (38.0 km^2 +/- 7.1 km^2)
  6. Shoreline protection (34.7 km^2 +/- 3.0 km^2)

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Discussion

- This effort has, for the first time, provided a complete assessment of land area benefit from all constructed coastal restoration projects.
- The constructed coastal restoration projects examined here have, thus far, created, restored or sustained an area of land approximately equivalent to the land area of the city of Denver, Colorado (USA), or approximately equivalent to 74,017 American football fields.
- This information will aid in the development of future coastal restoration and protection project design, selection, and management.
- While it is unlikely that restoration efforts alone will completely stop the ongoing coastal land loss crisis in Louisiana, our findings indicate that the coastal restoration efforts assessed here have contributed to substantially reducing losses which would have occurred if no action had been taken.

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