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Future Climate Impacts on CBW BMP Efficiencies

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Agenda

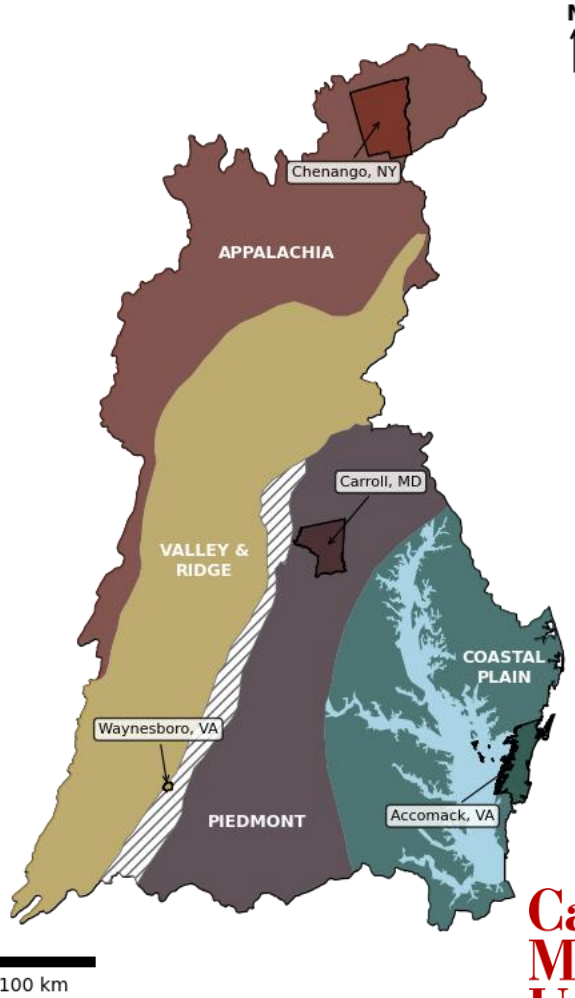
I. Project Overview
II. Sobol Analysis
III. Quantifying BMP Performance
IV. Synthetic Experiment
V. Summary
VI. Deliverables Overview

I. Project Overview

Goal: Quantify the performance of agricultural BMPs in the Chesapeake Bay watershed under current and future climate scenarios

Tools: APEX for agricultural, SWMM for urban

Output: N, P, and TSS removal efficiencies for BMPs under varying hydrologic scenarios



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Watershed Settings

4 regions × **4** crop types × **4-5** BMPs* × **2** RCPs × **7** decades

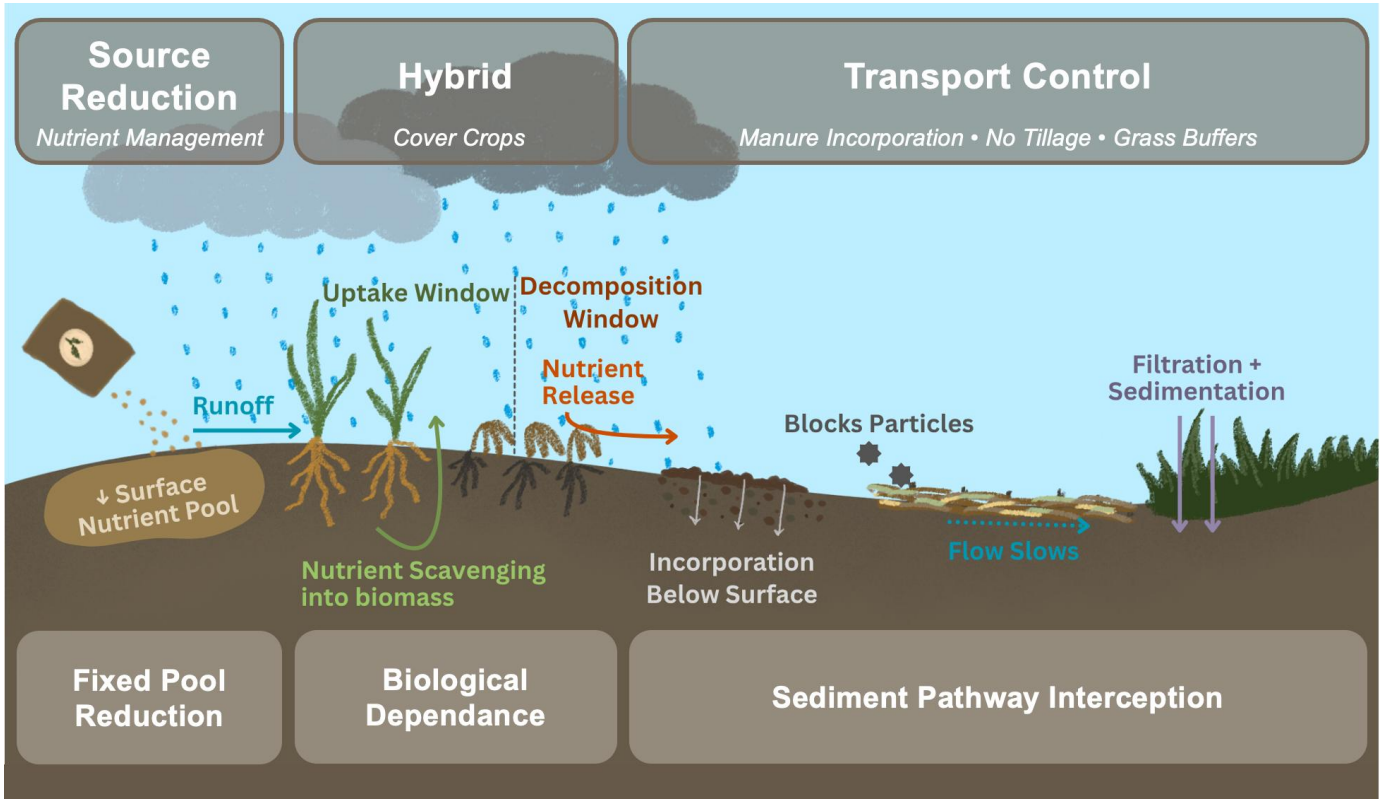
Hydrologic Regimes
- Reference: 1990-2000
- 2021-2090
  - RCP 4.5
  - RCP 8.5

Physiographic Region (PR)	Soybeans (Row Crops)	Corn (Row Crops)	Wheat (Row Crops)	Alfalfa (Hay Land)
	Land Use (LU)			
Ridge & Valley	LU1 PR1	LU2 PR1	LU3 PR1	LU4 PR1
Appalachia	LU1 PR2	LU2 PR2	LU3 PR2	LU4 PR2
Coastal Plain	LU1 PR3	LU2 PR3	LU3 PR3	LU4 PR3
Piedmont	LU1 PR4	LU2 PR4	LU3 PR4	LU4 PR4

BMPs
- No till
- Manure Incorporation
- Nutrient Management
- Grass Buffers
- Cover crops*

**corn and soy only*

BMP Mechanisms Overview

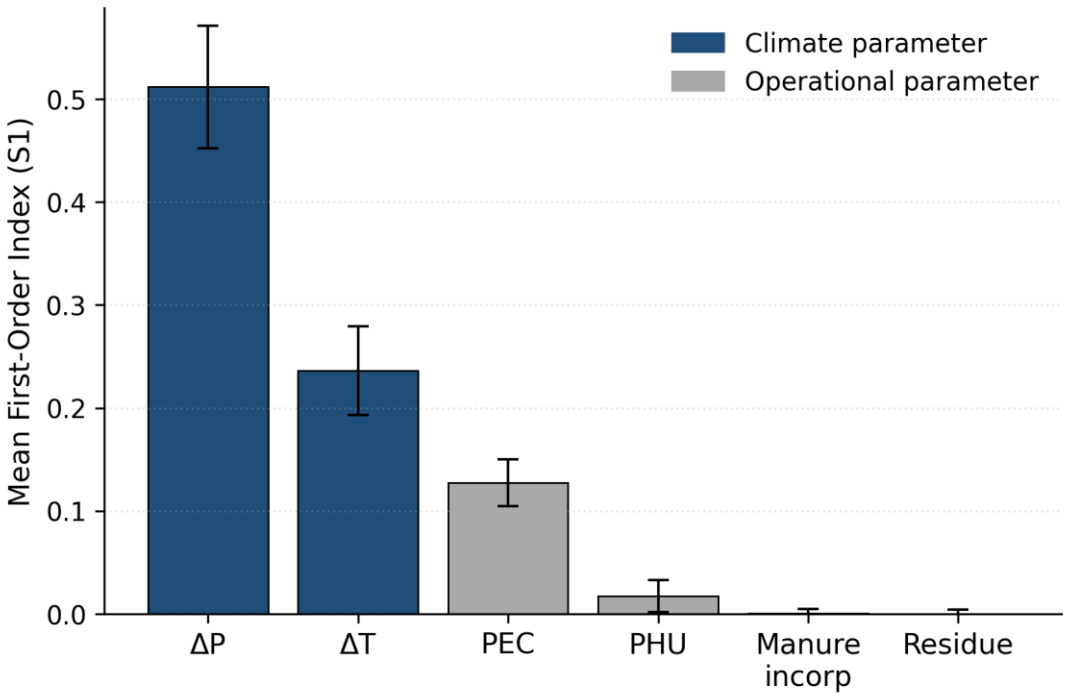


Quantifying Performance

- Load Removal (kg/ha or t/ha)
- Removal Efficiency (%)
- Δ Efficiency (pp)

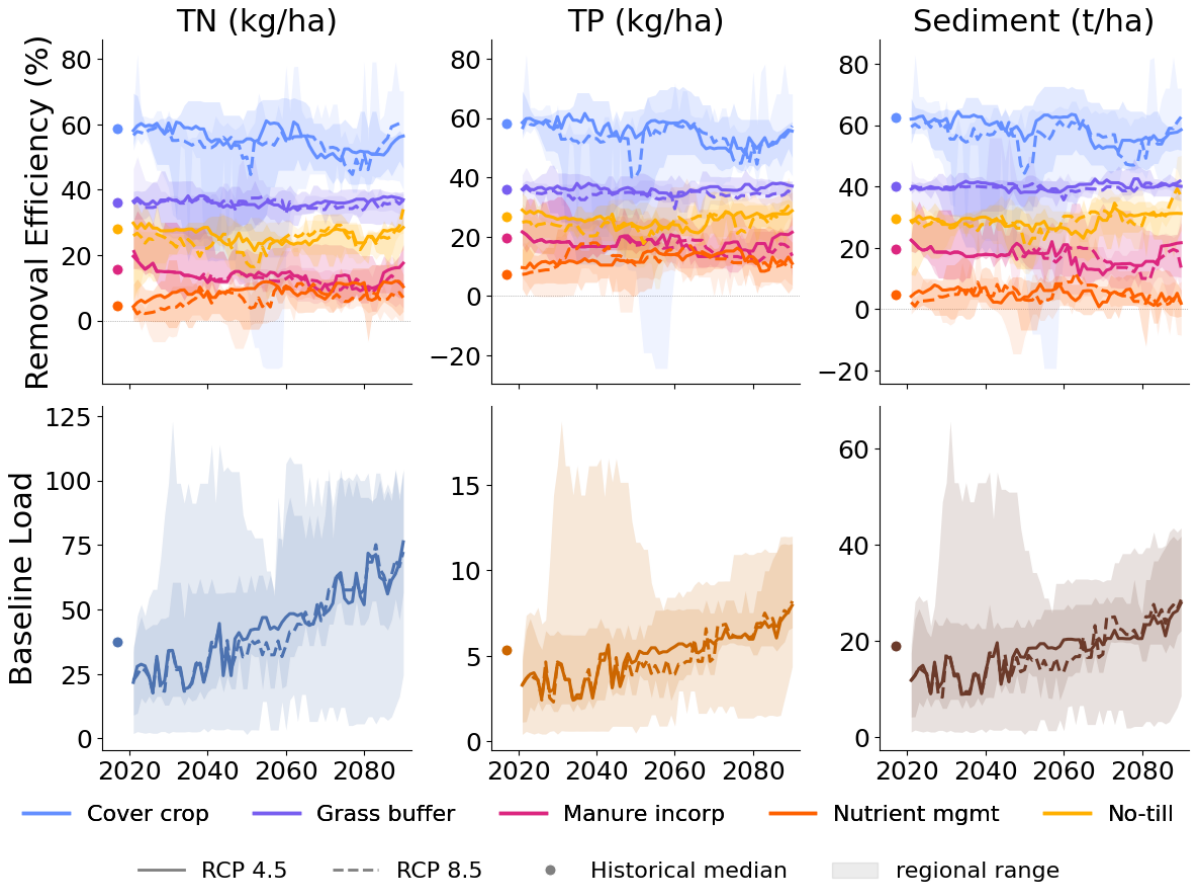
II. Sobol Analysis: What drives variance?

- Climate dominates variance over BMP parameters
- ΔP dominates ΔT in ¾ regions
- ΔT x ΔP is strongest pairwise interaction



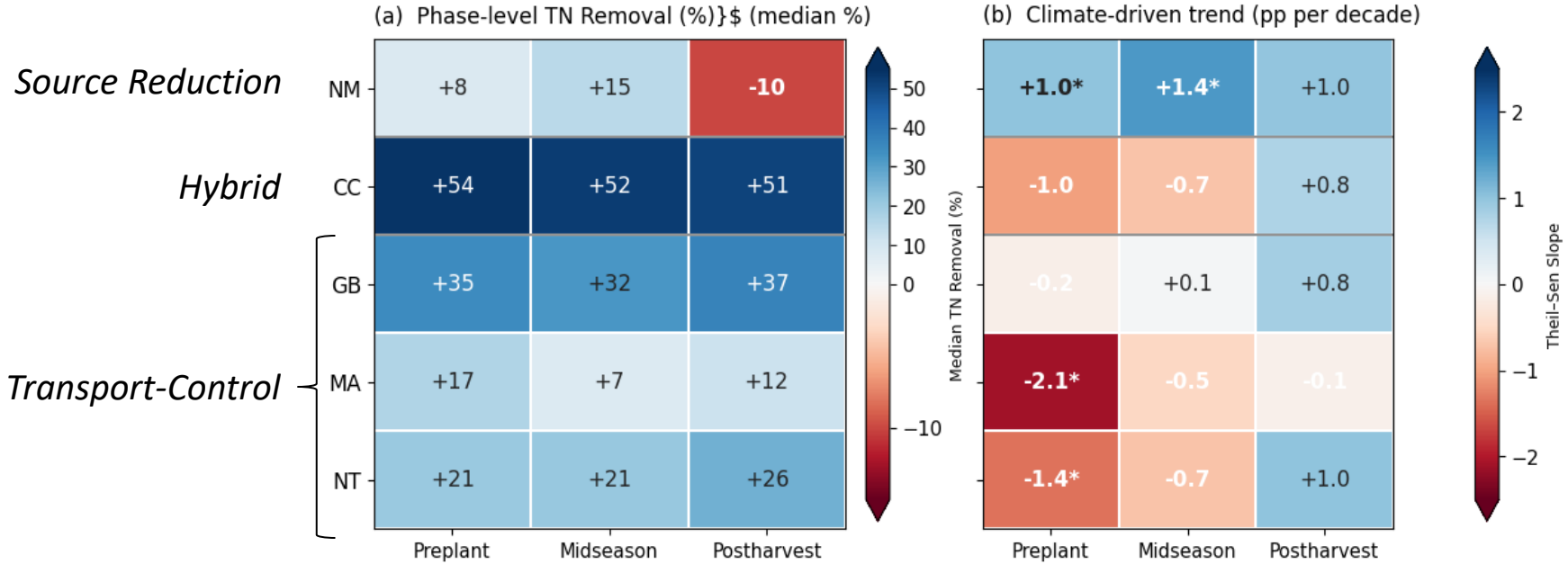
III. Annual Analysis

- Loads are projected to increase
- BMPs are robust long-term
- Cover crops are the only BMPs with any sensitivity (Coastal Plain under RCP 8.5)



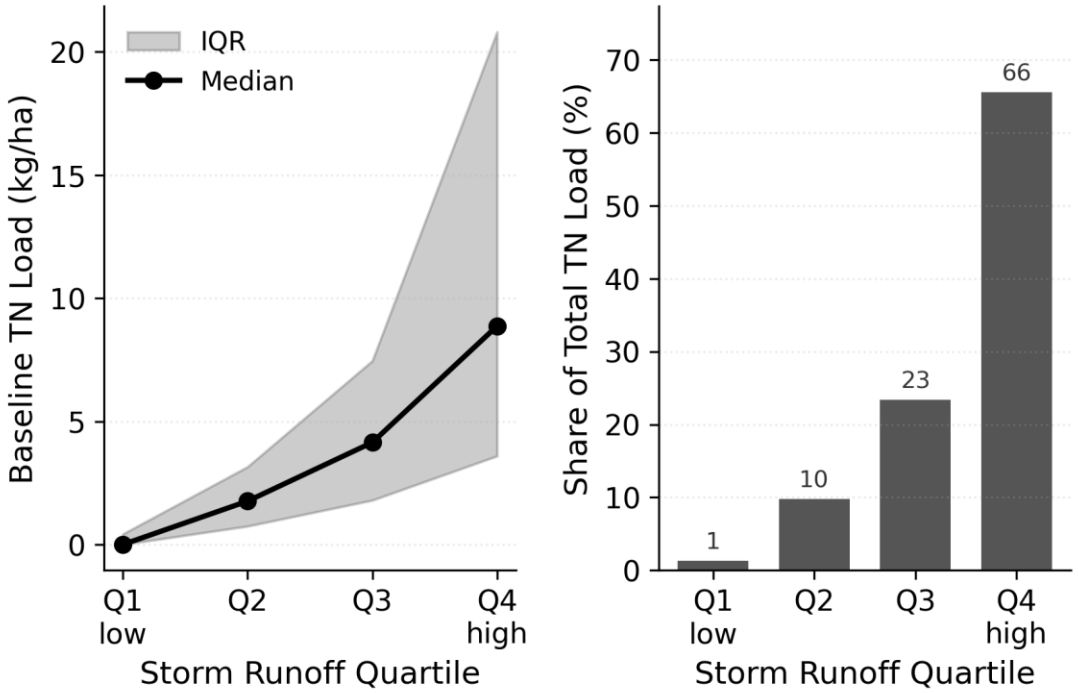
III. Operational-Phase Analysis

- 3 Phases per year
- Phase behavior depends on BMP mechanism class



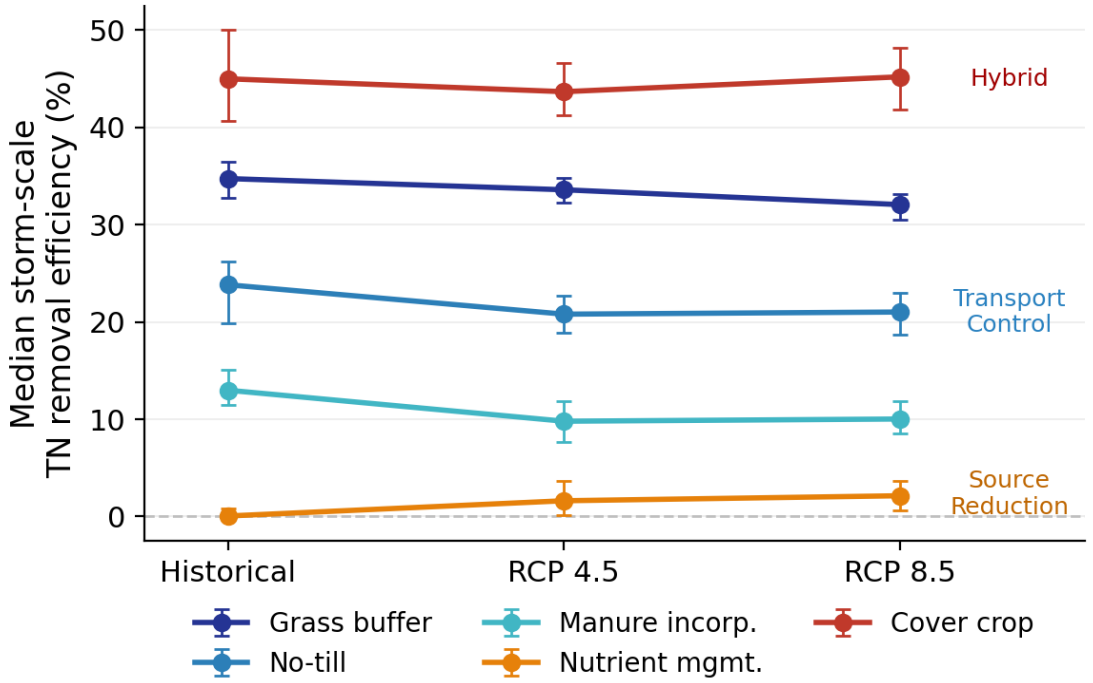
III. Storm-Based Analysis

- ”Storm”: series of consecutive wet days
  - >25mm depth
  - <24 hrs of dryness
- Bigger storms = bigger loads
- Biggest storms contain the majority of load



III. Storm-Based Analysis

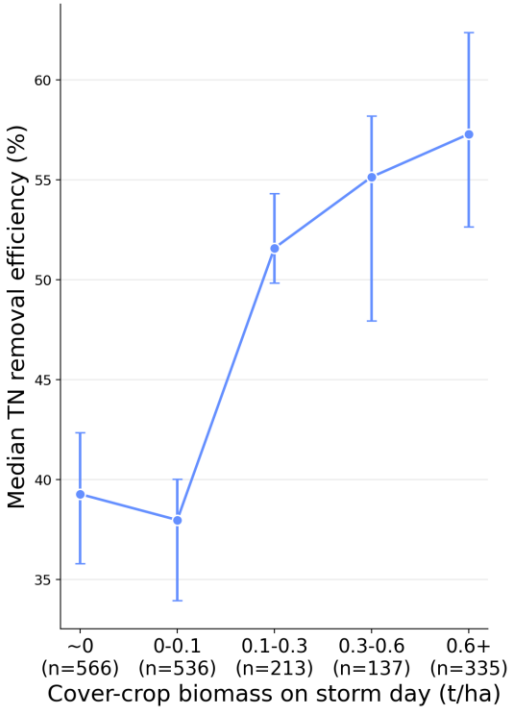
- BMPs continue to be robust
- Maintain their classification ordering under climate change

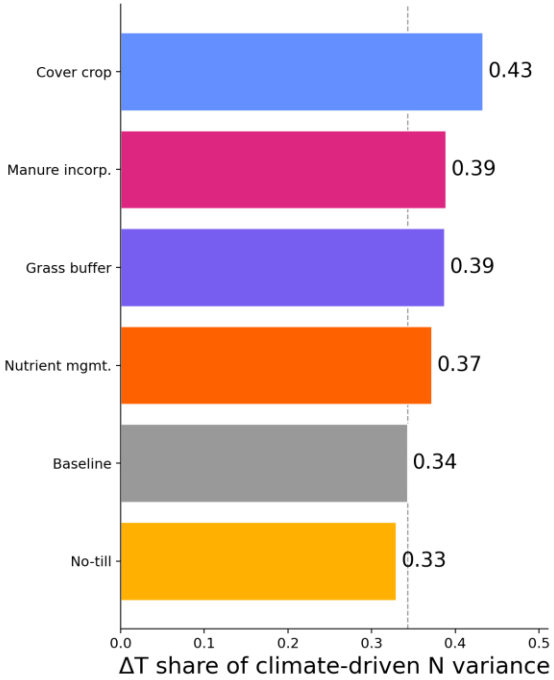


III. Storm-Based Analysis

Cover crop variability driven by:

- Biomass dependence
- Heightened sensitivity to ΔT





IV. Synthetic Experiment

Find "calm" year

- Based on historic runs (1990-2000)
- Median crop yield
- No storms >2yr return period

Define storm characteristics

- SCS Type II
- ATLAS 14 2, 5, 10, 25, 50, 100 yr regional storm depths

Inject storms into calm year

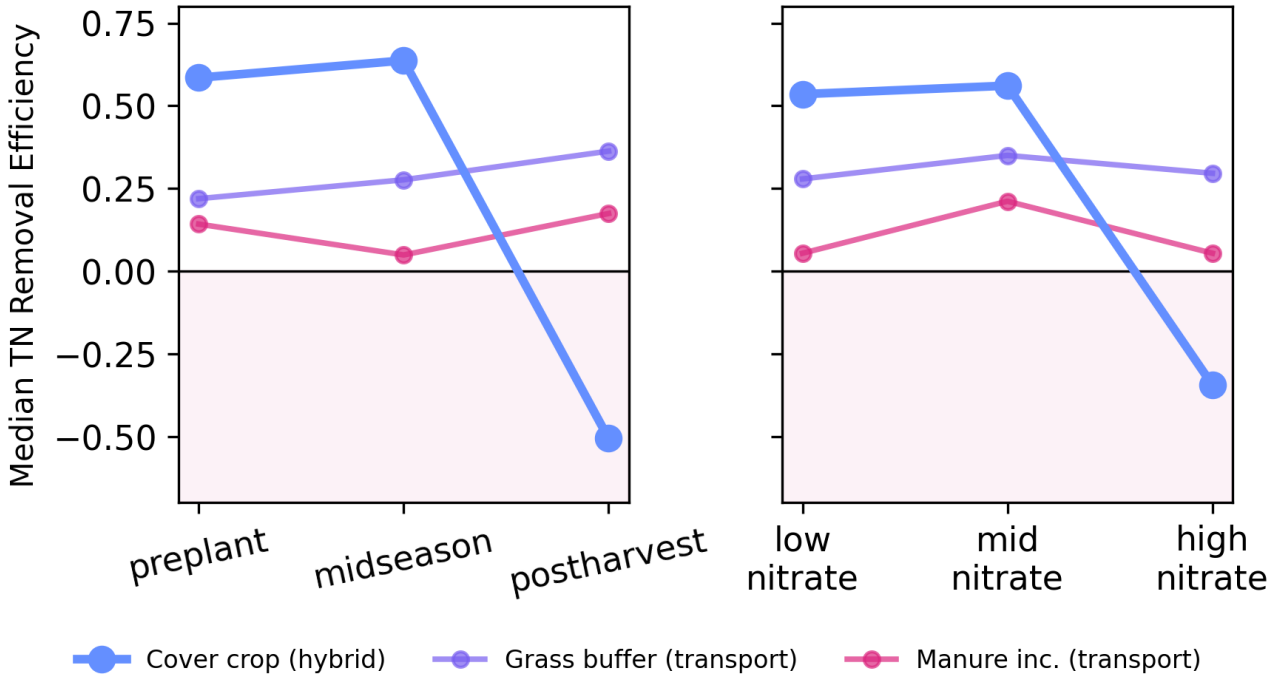
- **Pre-plant**: -3 days from planting
- **Midseason**: half of growth
- **Postharvest**: +3 days from harvest

Run & Extract data

- Compare BMPs, regions, etc.

IV. Synthetic Experiment

- Confirmed insensitivity to return period
- Phase-based export linked to soil nutrient state

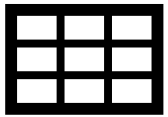


V. Summary

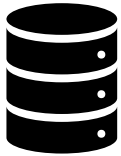
- BMP performance does not change significantly over long-term climate change nor under more intense storm events
- BMPs show declining performance on an operational-phase scale
- Cover crops show the most variability in performance
- BMP mechanism class can be used as a framework to predict robustness under climate change

VI. Deliverables

Technical Report



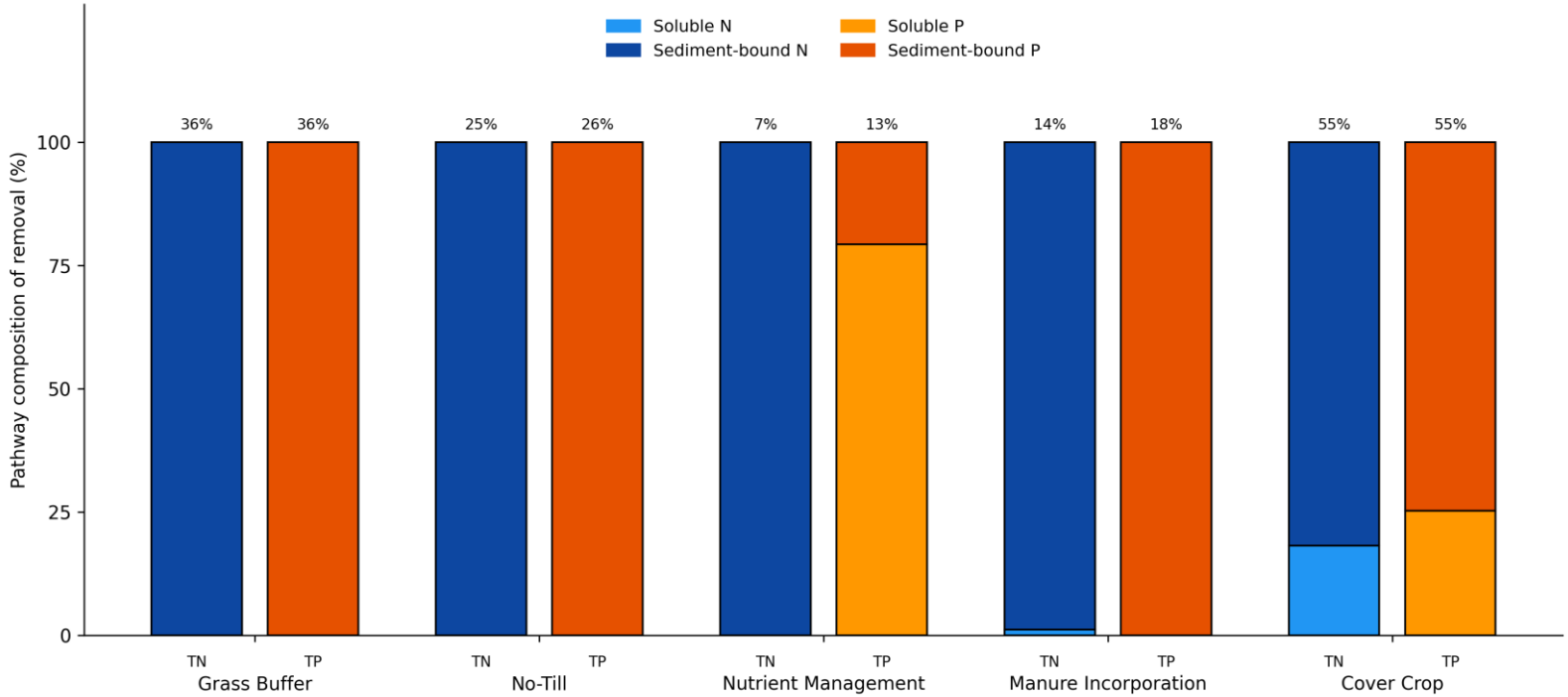
Look-up Tables



APEX models

Peer-Reviewed Journal Article

Mechanism classification



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Load Removal

$$Load\ Removed = Load_{base} - Load_{future}$$

where:

$Load_{base}$ = Load removed (kg/ha or t/ha)

$Load_{BMP}$ = BMP efficiency in reference scenario

***Example**: Appalachia Alfalfa Grass Buffer 1990-2000*

Baseline (no BMP) TN load = 0.0129 t/ha

Grass Buffer TN load = 0.0079 t/ha

$$Load\ Removed = 0.0129 - 0.0079 = \mathbf{0.005\ t/ha}$$

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Removal Efficiency

$$Efficiency = \frac{Load_{base} - Load_{BMP}}{Load_{base}} \times 100\%$$

where:

Load = TN (kg/ha), TP (kg/ha), Sediment (t/ha) yield

Base = non-BMP scenario

***Example**: Appalachia Alfalfa Grass Buffer 1990-2000*

Baseline (no BMP) TN load = 0.0129 t/ha

Grass Buffer TN load = 0.0079 t/ha

$$Efficiency = \frac{0.0129\ t/ha - 0.0079 t/ha}{0.0129\ t/ha} \times 100\% = \mathbf{38.7\%\ removal}$$

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Δ Efficiency

$$\Delta Efficiency = Efficiency_{future} - Efficiency_{reference}$$

where:

$Efficiency_{future}$ = BMP efficiency in future scenario

$Efficiency_{reference}$ = BMP efficiency in reference scenario

***Example**: Appalachia Alfalfa Grass Buffer 1990-2000 vs 2061-2070 (RCP 8.5)*

$Efficiency_{1990\text{-}2000}$ = 38.7%

$Efficiency_{2061\text{-}2070}$ = 0.5%

$$\Delta Efficiency_{ref-2061-2070} = 0.5\% - 38.7\% = \mathbf{-38.2\ pp}$$

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