# CalCAST Updates

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Modeling Workgroup Quarterly Review

01/07/2025

# Phosphorus

# Total Phosphorus

Non-point source load generated by «Non-reg Tree Canopy Over Turfgrass (nch)» load source in catchment c and year t:

Watershed-wide average nch loading rate (lbs/ac)

Difference between local TP fertilizer input in catchment c and year t and watershed-wide long-term average TP fertilizer input (lbs/ac)

Change in fertilizer load exported from nch per change in unit of fertilizer input on nch

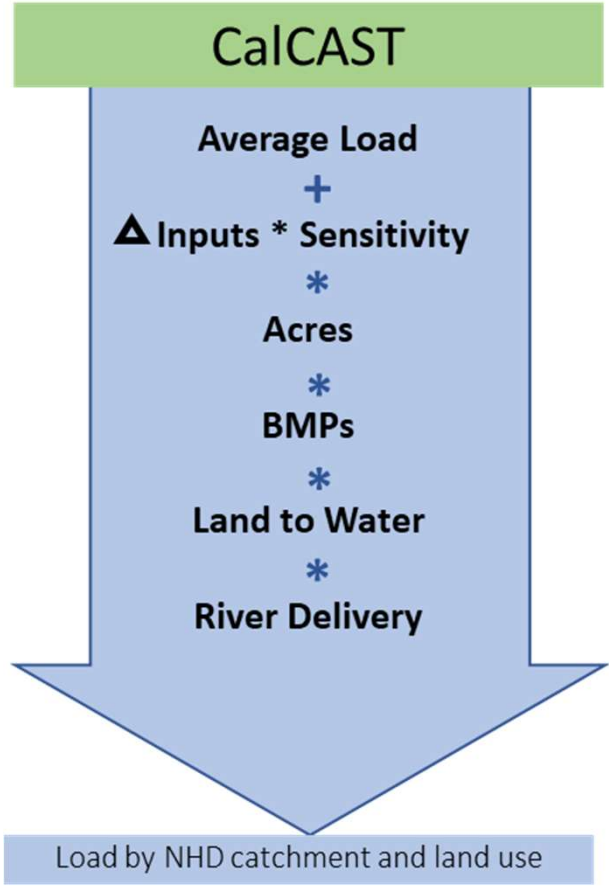
$$NPS_{nch,c,t} = AVE_{nch} + \left(TP_{FERT,c,t} - \widehat{TP_{FERT}}\right) * SENS_{nch,FERT} * ACRES_{nch,c,t} * BMP_{nch,c,t} * L2W_c * DEL_c$$

Acres of nch in catchment c and year t

BMP pass-through factor for nch in catchment c and year t

Land-to-water delivery factor for catchment c

Stream delivery factor for catchment c

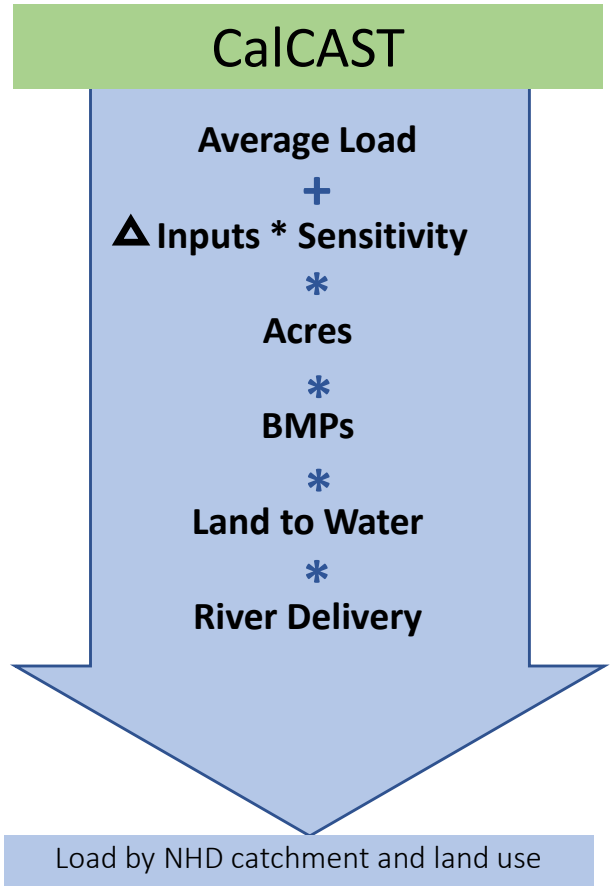


# Total Phosphorus - Inputs

The following P6 inputs were downscaled from CAST to NHDPlus catchment scale (thank you **Jess Rigelman** and **Olivia Devereux**!):

Soil P
Water Extractable P
Fertilizer
Sediment loss (RUSLE)
Stormflow (from Stormflow-CalCAST)

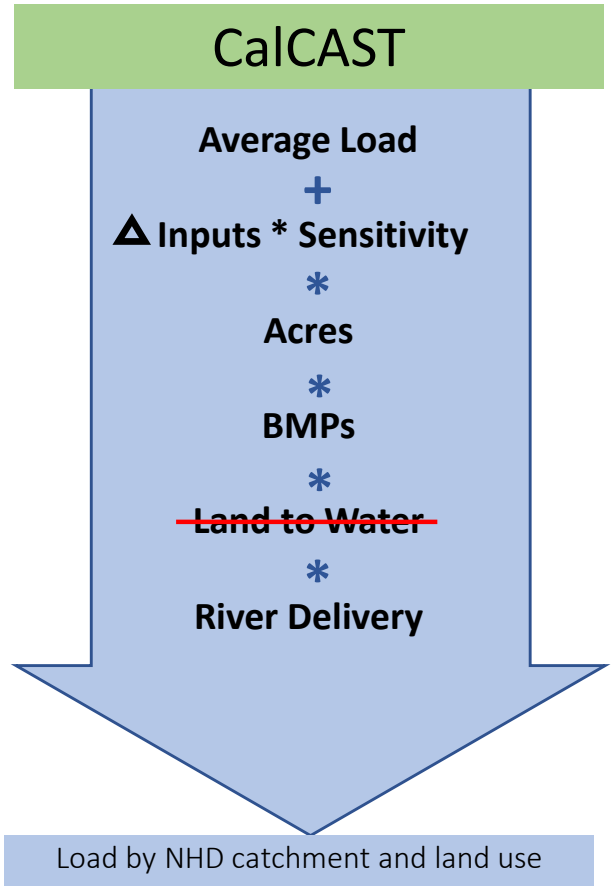
Riparian Pasture Deposition
Rapid Infiltration Basins
Feeding Space
Wastewater
CSOs
Atmospheric Deposition (on water bodies)

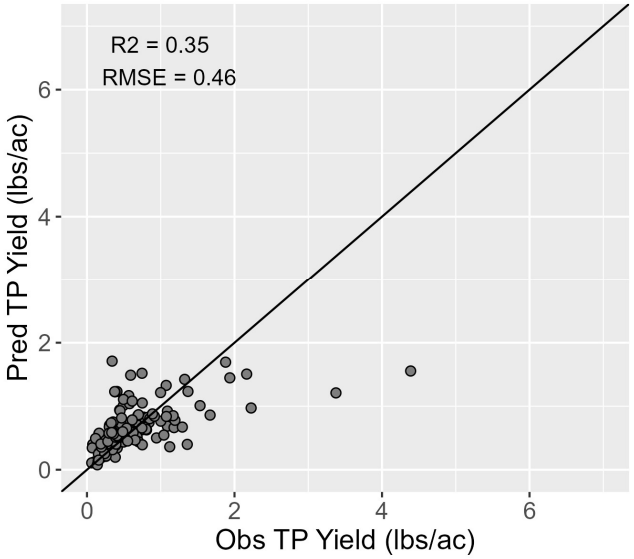


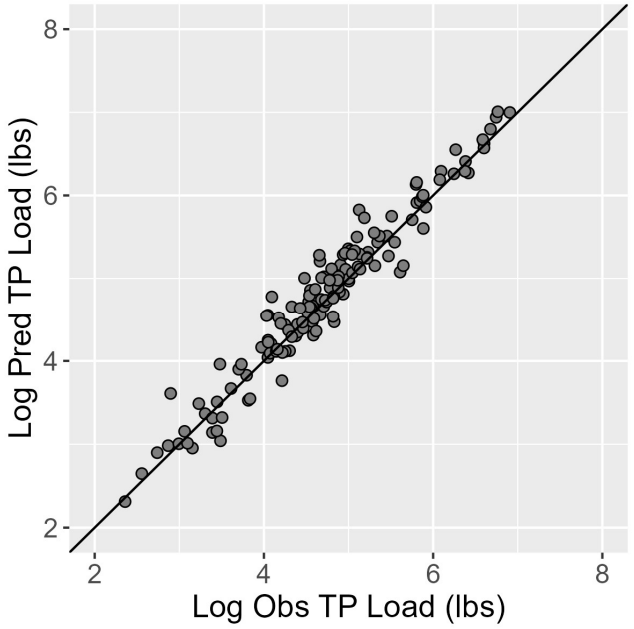

Downscaling methods based on Devereux et al. 2022
https://www.sciencebase.gov/catalog/item/60be31b3d34e86b938910b2f

# Total Phosphorus – Average Annual

No Land to Water Factors



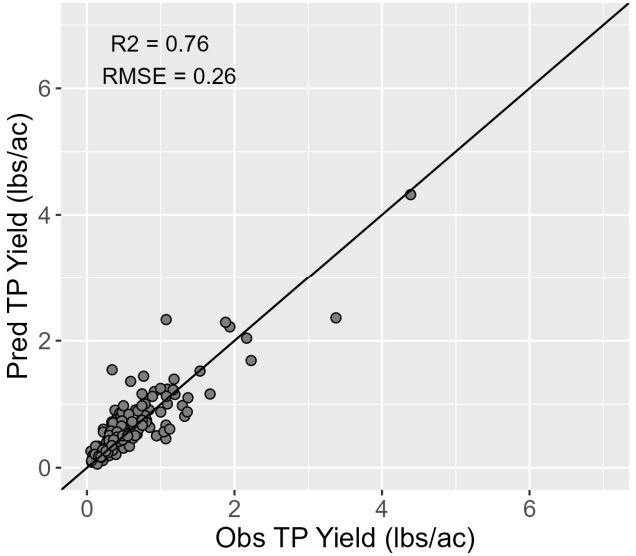



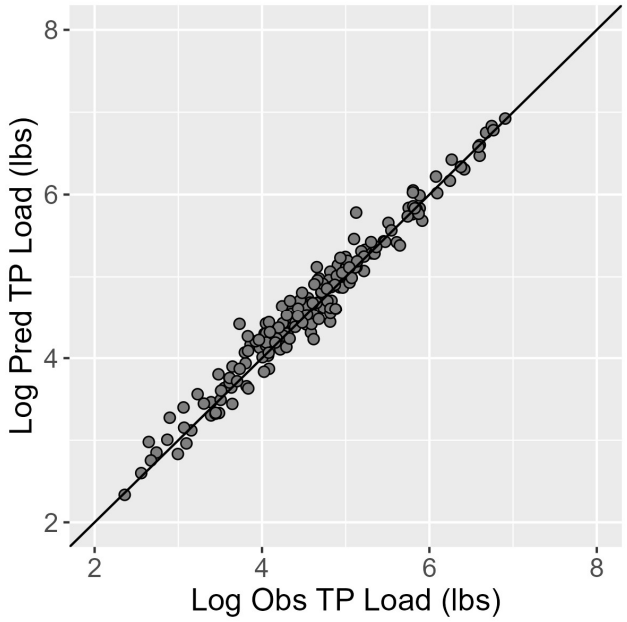



# Total Phosphorus – Average Annual

Best Land to Water Factors so far

| Variable | Coef |
|---|---|
| Soil erosivity (K factor) (dimensionless) | +0.33 |
| Max 1-day precipitation (mm) | +3.89 |
| Hydrogeomorphic region: Mesozoic Lowland (%) | +0.04 |
| Hydrogeomorphic region: Valley and Ridge (%) | -0.48 |
| *Hydrogeomorphic region: Coastal Plain Disected Upland (%)* | *+0.02* |
| Hydrogeomorphic region: Piedmont Carbonate (%) | +0.46 |
| Soil bulk density ($g/cm^3$) | -6.13 |
| *High-res stream density (%)* | *+1.06* |
| Baseflow Index:hgmr1, hgmr2, hgmr3 (%) | -1.87, -0.68, -1.57 |
| *High-res pond density:hgmr1, hgmr2, hgmr3 (%)* | *-0.53, -0.20, -1.80* |




Hgmr1: Appalachian Plateau, Valley and Ridge
Hgmr2: Piedmont, Blue Ridge, Mesozoic Lowland
Hgmr3: Coastal Plain

# Total Phosphorus – Average Annual

Best Land to Water Factors so far

| Variable | Coef | TP Model Reference |
|---|---|---|
| Soil erosivity (K factor) (dimensionless) | +0.33 | **Ator et al., 2011;** Robertson & Saad, 2013; Robertson & Saad 2021; **Schmadel et al., 2019;** Wise et al., 2019; Robertson & Saad, 2019; **Ator, 2019;** Hoos & Roland, 2019 |
| Max 1-day precipitation (mm) | +3.89 | ***Ator et al., 2011; Ator et al., 2019;*** *Domagalski & Saleh, 2005; Elliott et al., 2005; Robertson & Saad, 2013; Robertson & Saad, 2021* |
| Hydrogeomorphic region: Mesozoic Lowland (%) | +0.04 | |
| Hydrogeomorphic region: Valley and Ridge (%) | -0.48 | |
| *Hydrogeomorphic region: Coastal Plain Disected Upland (%)* | *+0.02* | **Ator et al., 2011;** |
| Hydrogeomorphic region: Piedmont Carbonate (%) | +0.46 | |
| Soil bulk density (g/cm$^3$) | -6.13 | **Schmadel et al., 2019** |
| *High-res stream density (%)* | *+1.06* | **Schmadel et al., 2019, 2021** |
| Baseflow Index:hgmr1, hgmr2, hgmr3 (%) | -1.87, -0.68, -1.57 | **Moore et al., 2011** |
| *High-res pond density:hgmr1, hgmr2, hgmr3 (%)* | *-0.53, -0.20, -1.80* | **Schmadel et al., 2019** |

Hgmr1: Appalachian Plateau, Valley and Ridge
Hgmr2: Piedmont, Blue Ridge, Mesozoic Lowland
Hgmr3: Coastal Plain

# Total Phosphorus – Average Annual

% Bias at RIM sites

| Station | % Bias |
|---|---|
| Choptank | -6.2 % |
| Patuxent | +0.5% |
| Rappahannock | -11.1% |
| Mattaponi | +20.2% |
| Pamunkey | +6.7% |
| Appomattox | +13.0% |
| Potomac | -0.4% |
| James | -22.5% |
| Marietta | +3.9% |
| Conowingo | +49% |

# Total Phosphorus – Average Annual

Reservoir loss

Reservoirs:

$$Del_c = \frac{1}{1 + bres * IHL_c}$$

$Del_c$ = Reservoir delivery factor for catchment c
$IHL_c$ = Inverse Areal Hydraulic Load for reservoir in catchment c

*bres* ~ 70 m/yr

| TP Model | bres (m/yr) |
|---|---|
| Ator, 2019 (SPARROW Northeast) | 9.84 |
| Ator, 2011 (CBTP_v4) | 54.3 |
| Schmadel et al., 2019 (SPARROW Northeast) | 18.35-44.92 |
| Schmadel et al., 2019 (SPARROW Northeast) | 5.73 |

# Total Phosphorus – Average Annual

% Bias at RIM sites

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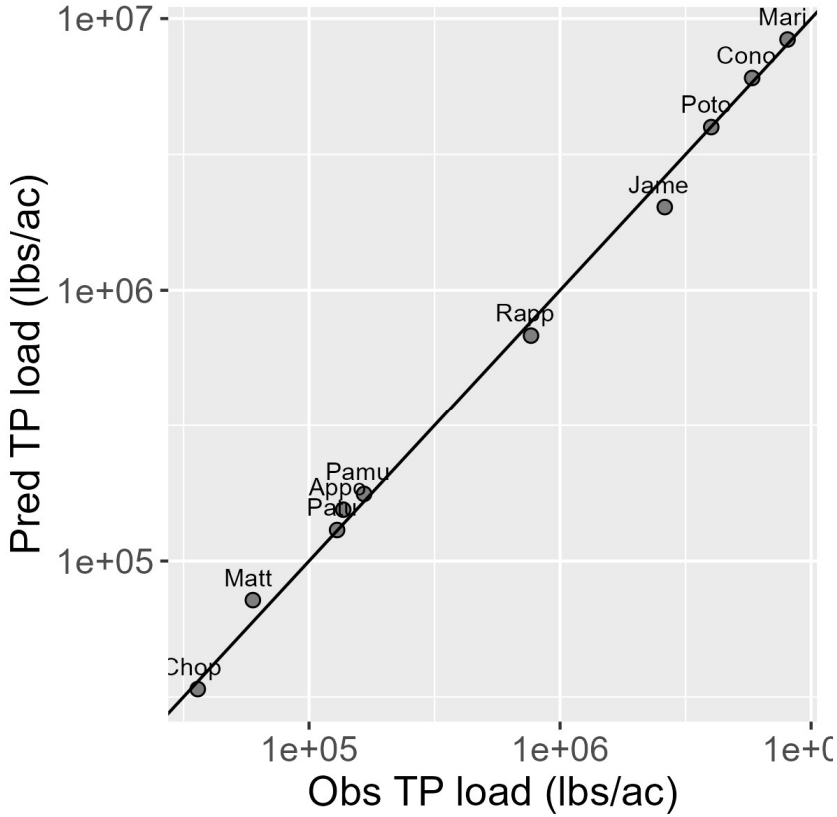
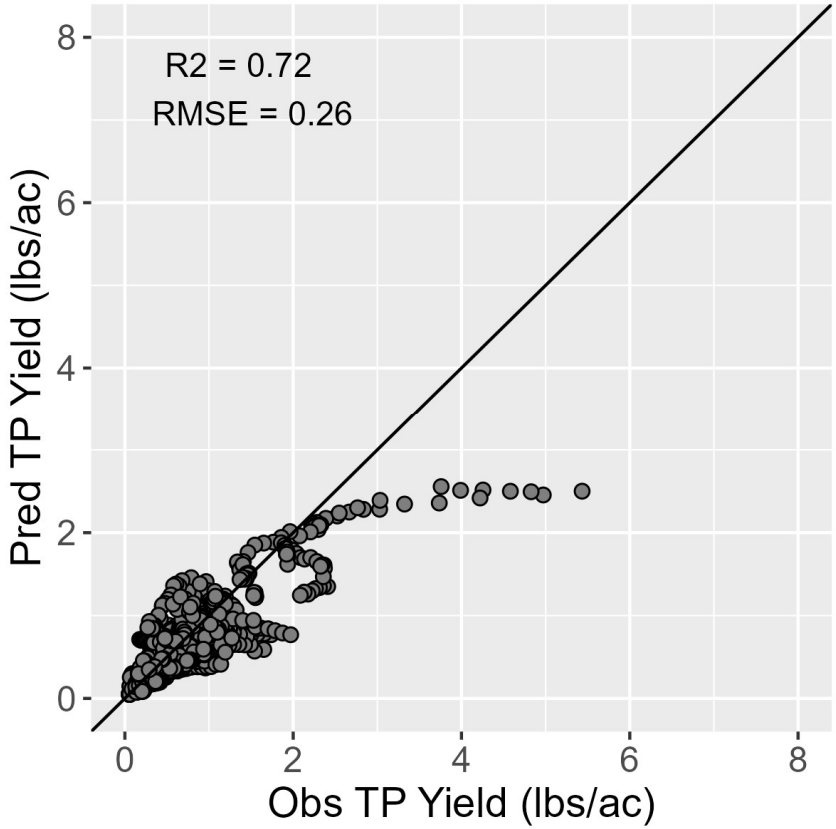
|---|---|
| Choptank | -6.2 % |
| Patuxent | +0.5% |
| Rappahannock | -11.1% |
| Mattaponi | +20.2% |
| Pamunkey | +6.7% |
| Appomattox | +13.0% |
| Potomac | -0.4% |
| James | -22.5% |
| Marietta | +3.9% |
| Conowingo | +3.8% |
| **Overall RIM** | **-3.1%** |

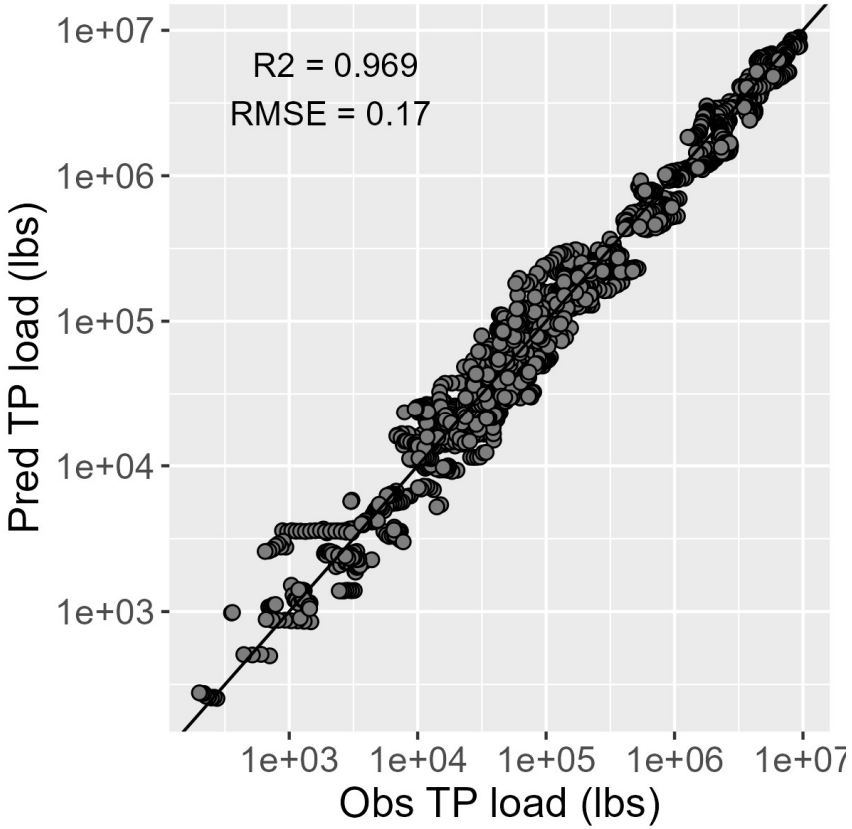
bres ~ 70 m/yr

bres_Conowingo ~ 270 m/yr



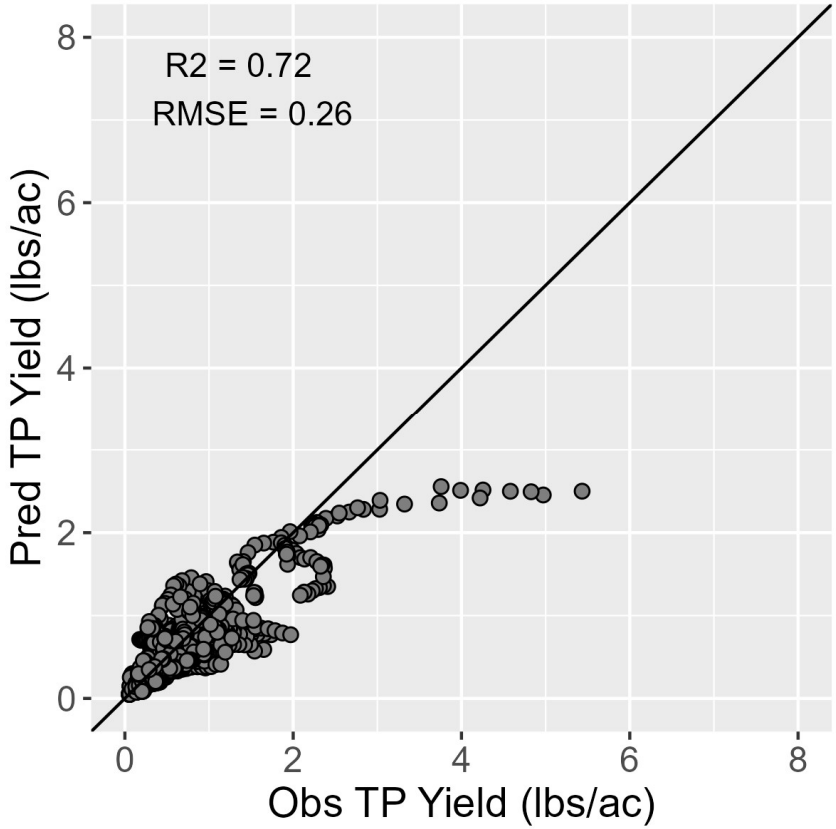
# Total Phosphorus – Annual Flow Normalized



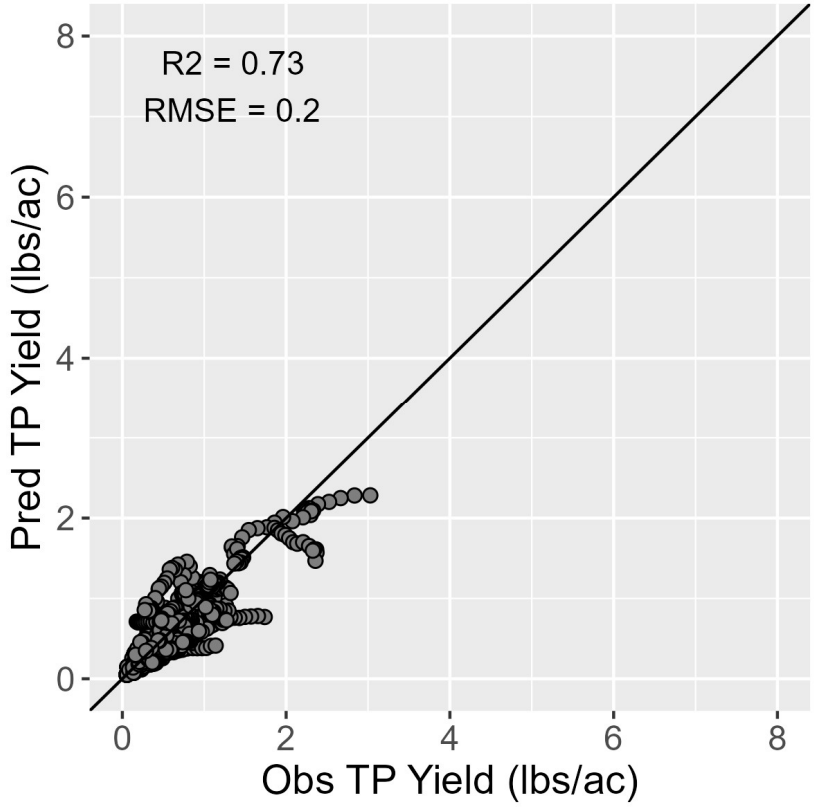



# Total Phosphorus – Annual Flow Normalized

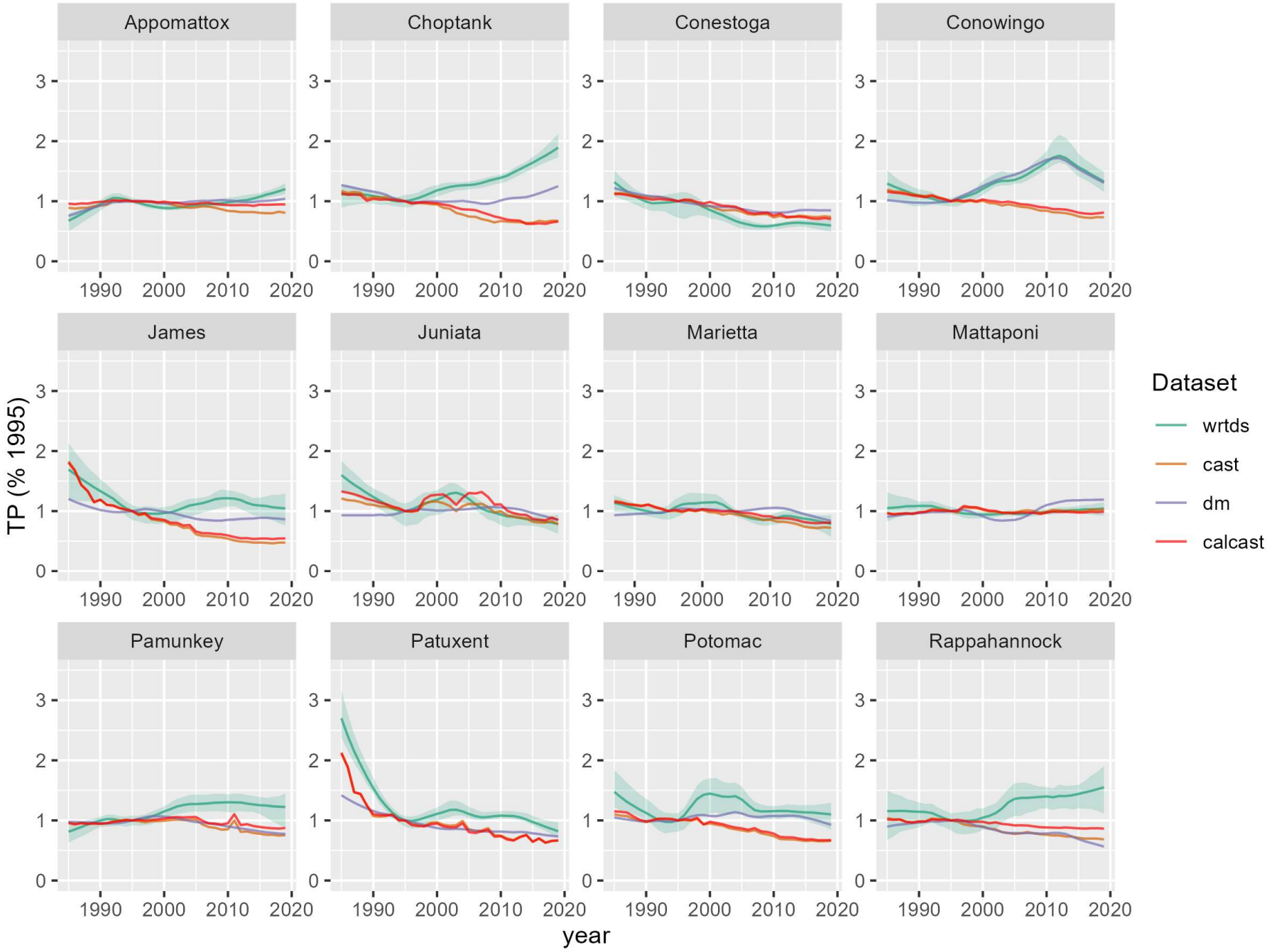
All stations




Stations with at least 10 years



# Total Phosphorus – Annual Flow Normalized



# Sediment

# Sediment

Non-point source load generated by «Grain With Manure (gwm)» load source in catchment c and year t:

Watershed-wide average gwm loading rate (lbs/ac)

RUSLE edge-of-field load for crp in catchment c (lbs/ac)

$$\boldsymbol{NPS_{gwm,c,t}} = RUSLE\_EOF_{crp,c}$$

$$*$$

$$ACRES_{gwm,c,t}$$

Acres of gwm in catchment c and year t

$$*$$

$$BMP_{gwm,c,t}$$

BMP pass-through factor for gwm in catchment c and year t

$$*$$

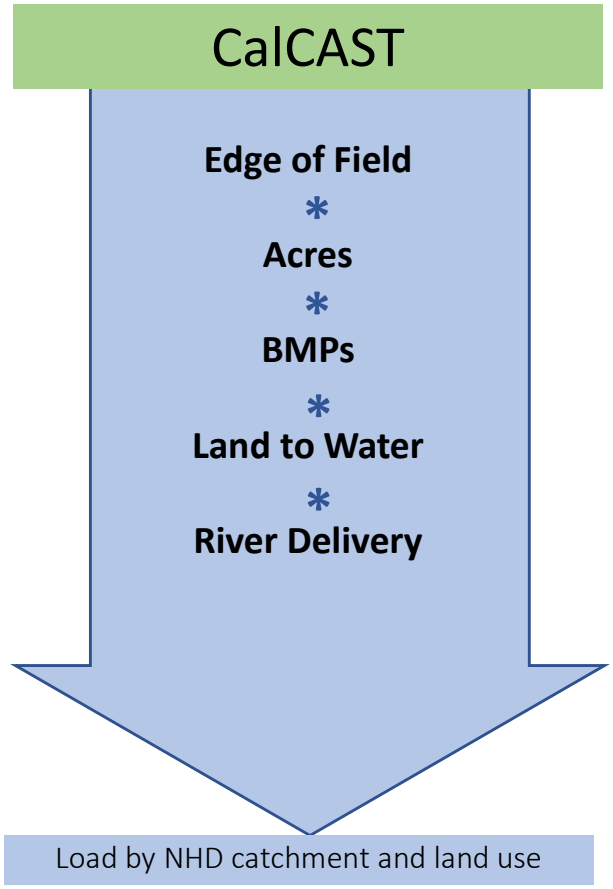
$$\alpha * IC_{crp,c} + \gamma$$

Sediment delivery ratio for crp in catchment c (IC = Index of Connectivity)

$$*$$

$$DEL_c$$

Stream delivery factor for catchment c



# Sediment – Average Annual

CalCAST

**Edge of Field**

*

**Acres**

*

**BMPs**

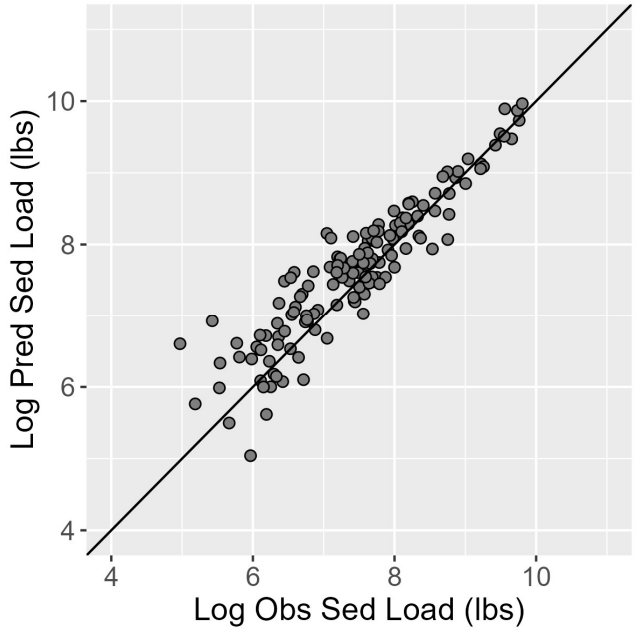
*

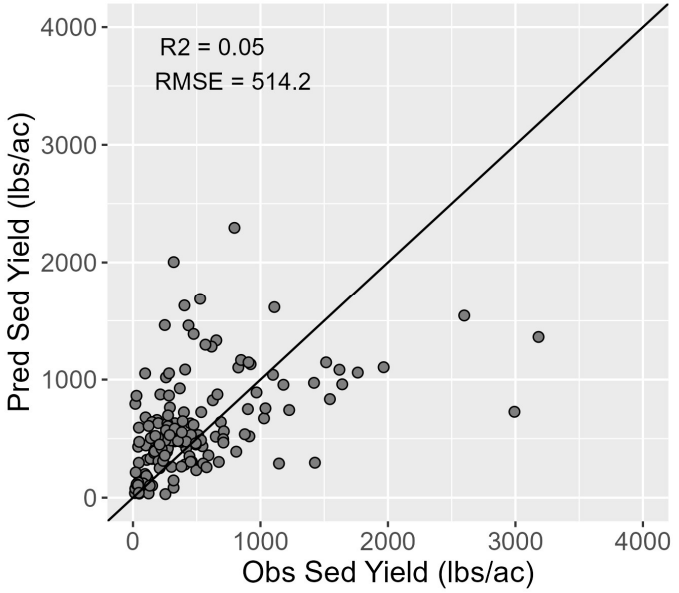
**Land to Water**

*

**River Delivery**

Load by NHD catchment and land use

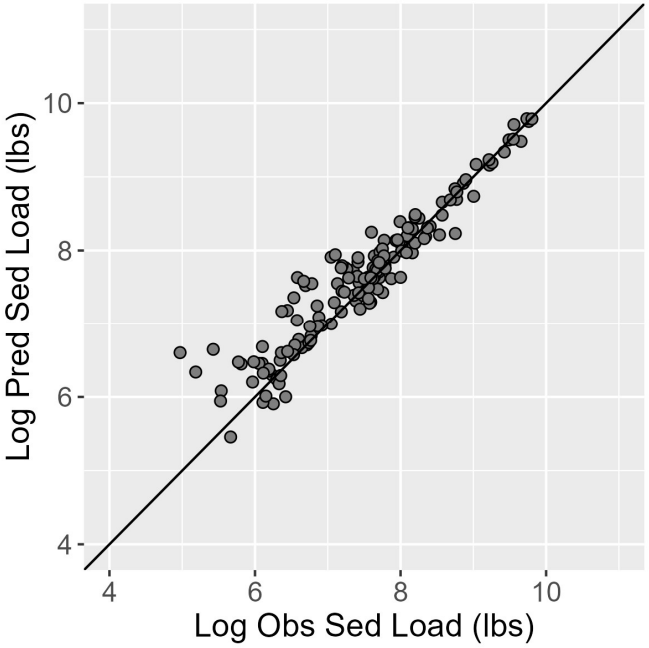


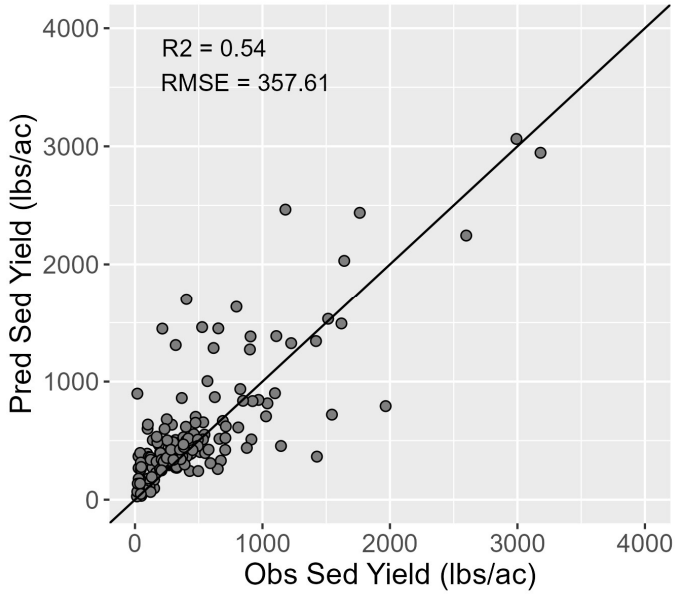



# Sediment – Average Annual

Additional Land to Water and Stream Factors

| Variable | Coef sign |
|---|---|
| Stream Length Above Fall Line (km) | +37.27 |
| Stream Length Below Fall Line (km) | +14.75 |
| Soil erosivity (K factor) (dimensionless) | +1.86 |
| Max 5-day precipitation (mm) | +1.16 |
| Hydrogeomorphic region: Valley and Ridge (%) | -0.15 |
| Percent Impervious Non Roads (%) | -0.04 |
| Baseflow Index:hgmr1, hgmr2, hgmr3 (%) | -1.98, -1.34, -1.09 |
| *High-res stream density:hgmr1, hgmr2, hgmr3 (%)* | *+0.13, +1.21, +0.26* |




Hgmr1: Appalachian Plateau, Valley and Ridge
Hgmr2: Piedmont, Blue Ridge, Mesozoic Lowland
Hgmr3: Coastal Plain

# Sediment – Average Annual

% Bias at RIM sites

| Station | % Bias |
|---|---|
| Choptank | +0.8% |
| Patuxent | +86.5% |
| Rappahannock | -16.1% |
| Mattaponi | +281.1% |
| Pamunkey | +53.7% |
| Appomattox | +9.4% |
| Potomac | 2.6% |
| James | -14.2% |
| Marietta | -4.3% |
| Conowingo | +41.5% |
| **Overall RIM** | **+14.7%** |

# Next Steps

- Final versions of CalCAST by July 2025

- Focus on sediment and annual models
    - Sensitivities
    - Land to water / Stream delivery
    - Lag formulation

- Explore DM-based delivery factor adjustment approaches to generate loads for estuarine model