CalCAST Updates

Isabella Bertani, Gopal Bhatt, Joseph Delesantro, Lewis Linker, and the Modeling Team

Modeling Workgroup Quarterly Review

04/01/2025

Nitrogen

Total Nitrogen

Non-point source load generated by «True Forest (for)» load source in catchment c and year t:

Watershed-wide average "for" loading rate (lbs/ac)

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

Change in atm dep load exported from "for" per change in unit of atm dep input on "for"

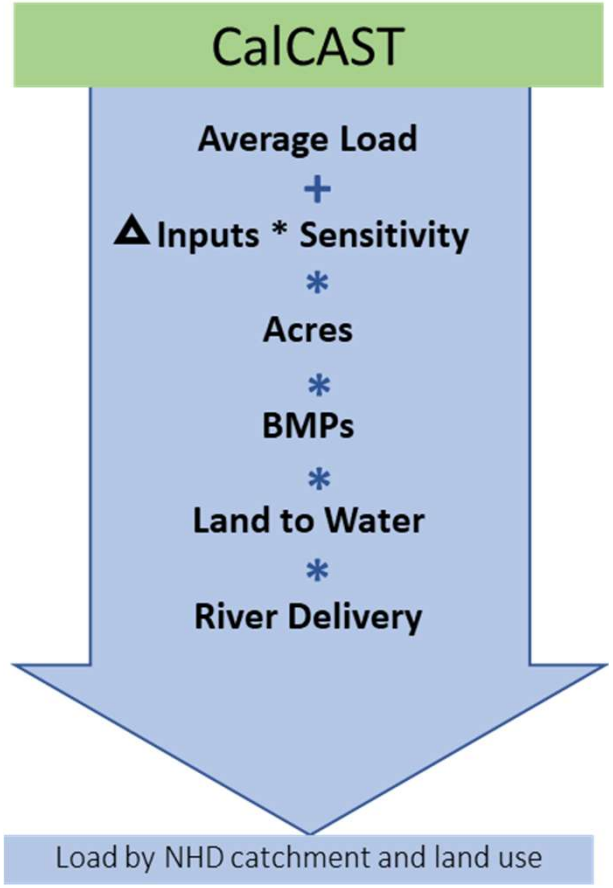
$$NPS_{for,c,t} = AVE_{for} + \left(TN_{ATM,c,t} - \widehat{TN_{ATM}}\right) * SENS_{for,ATM}$$
$$*$$
$$ACRES_{for,c,t}$$
$$*$$
$$BMP_{for,c,t}$$
$$*$$
$$L2W_c$$
$$*$$
$$DEL_c$$

Acres of "for" in catchment c and year t

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

Land-to-water delivery factor for catchment c

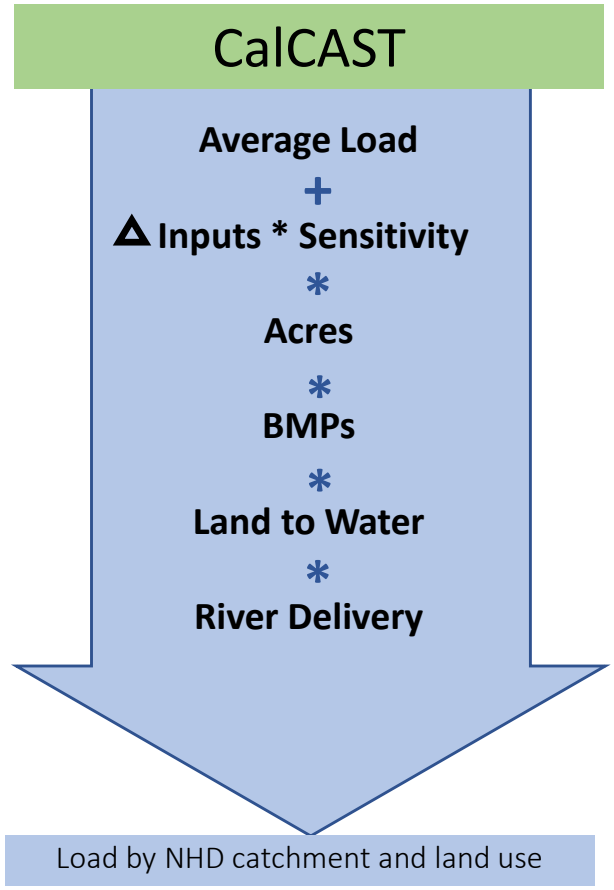
Stream delivery factor for catchment c



Total Nitrogen - Inputs

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

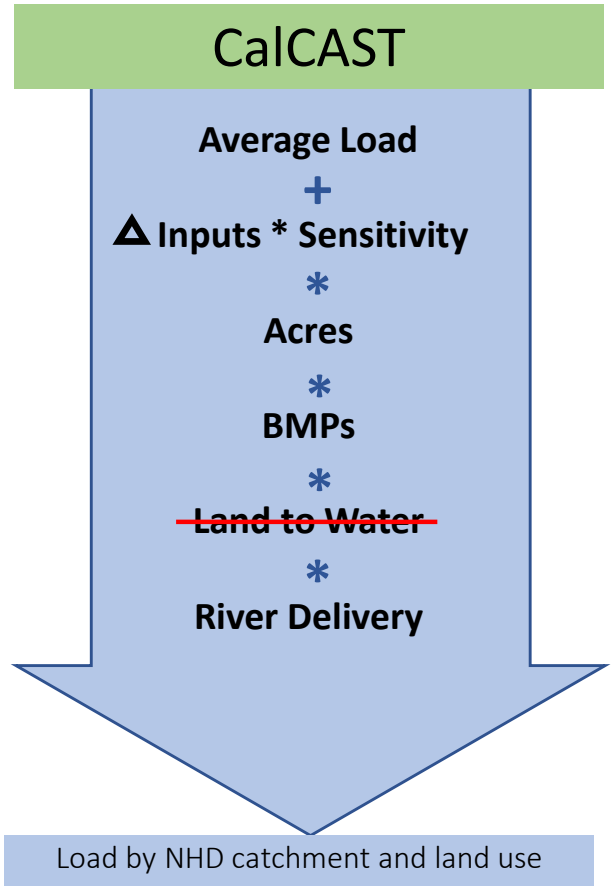
- Atmospheric Deposition
- Crop Cover
- Fertilizer
- Manure
- Nitrogen fixation
- Plant Uptake
- Direct Deposit on pasture
- Riparian Pasture Deposition
- Rapid Infiltration Basins
- Feeding Space
- Biosolids
- Wastewater
- CSO
- Septic

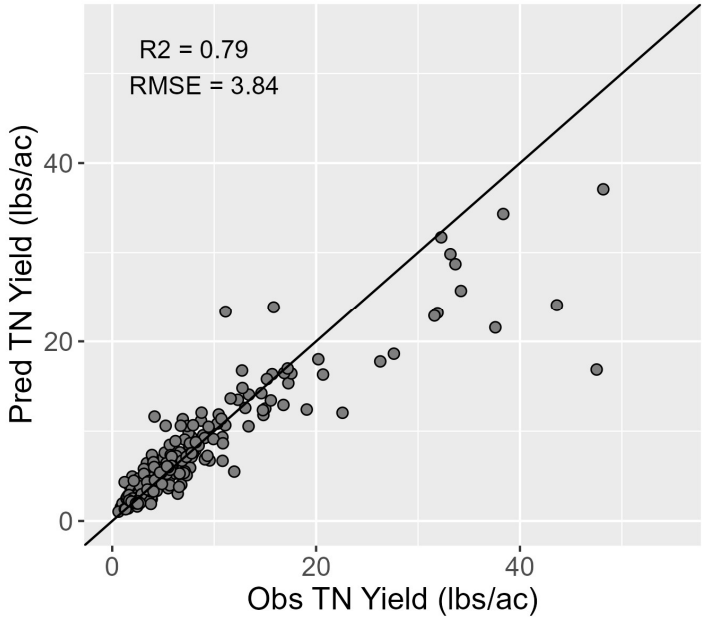


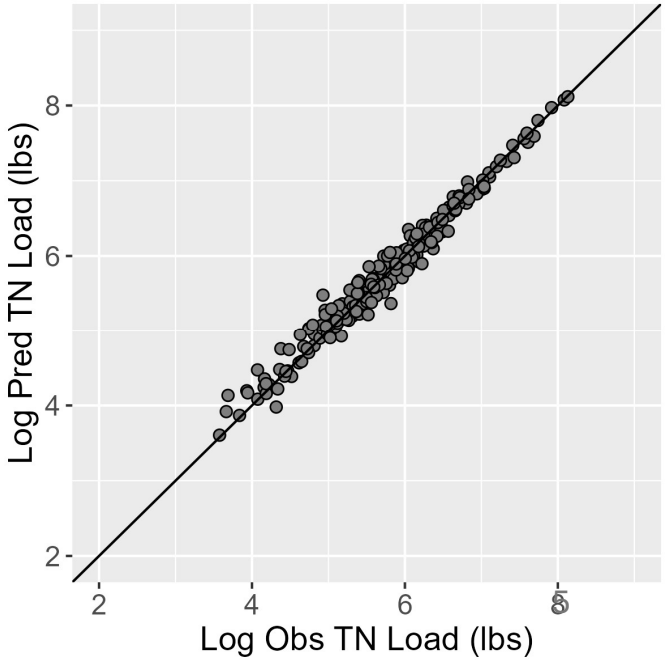
Downscaling methods based on Devereux et al. 2022 (with modifications)
https://www.sciencebase.gov/catalog/item/60be31b3d34e86b938910b2f

Total Nitrogen – Average Annual

No Land to Water Factors



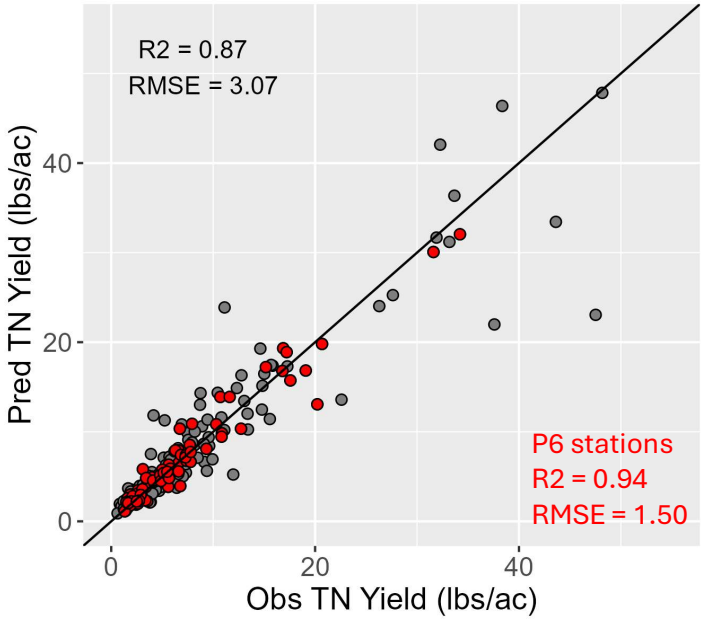


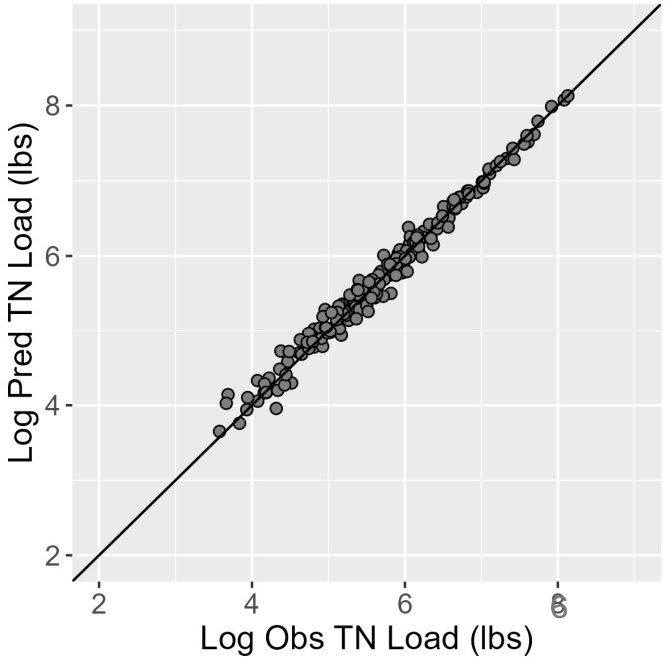


Total Nitrogen – Average Annual

With Land to Water Factors

Variable	Coef sign
Groundwater Recharge (mm)	+
Carbonate lithology (%)	+
Hydrogeomorphic region: Coastal Plain Upland (%)	-
Soil erosivity (K factor) (dimensionless)	+





Total Nitrogen – Loading Rates

CLR = Average CROP loading rate (lbs/ac)

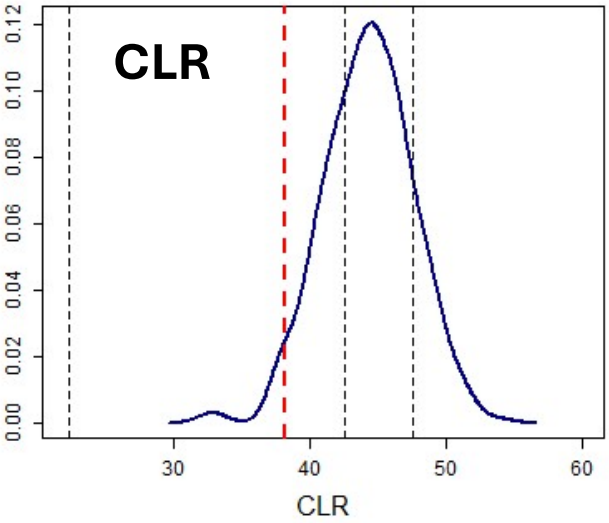
RCpas = Ratio of PASTURE loading rate to CROP loading Rate

RCdev = Ratio of DEVELOPED loading rate to CROP loading Rate

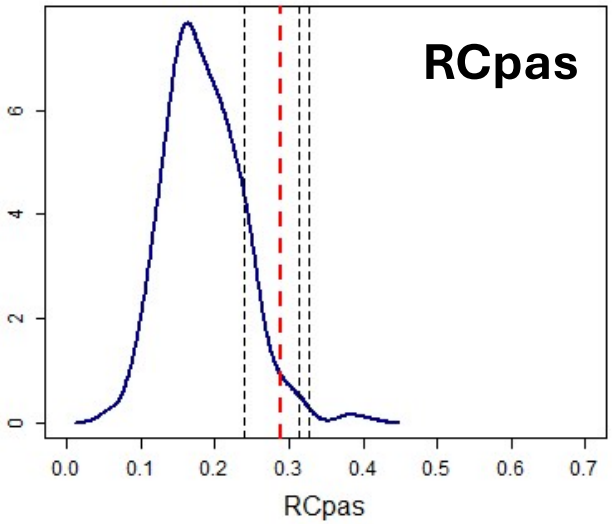
RCnat = Ratio of NATURAL loading rate to CROP loading Rate

Red dashed line = P6
Black dashed lines = P532, SPARROW, CEAP

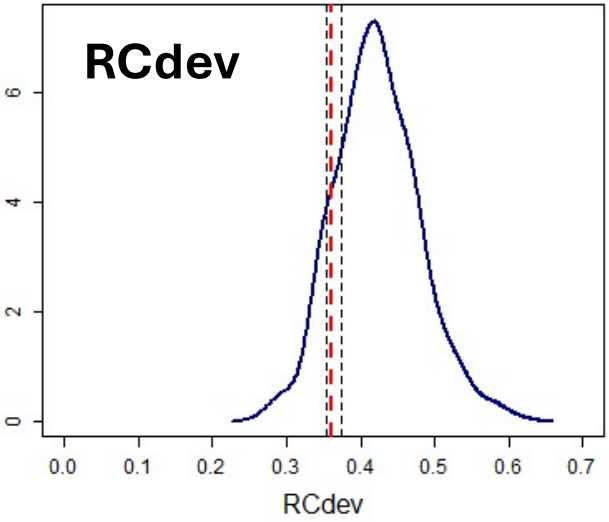
P6 = 38 lbs/ac (22-48)
CalCAST = 44 lbs/ac



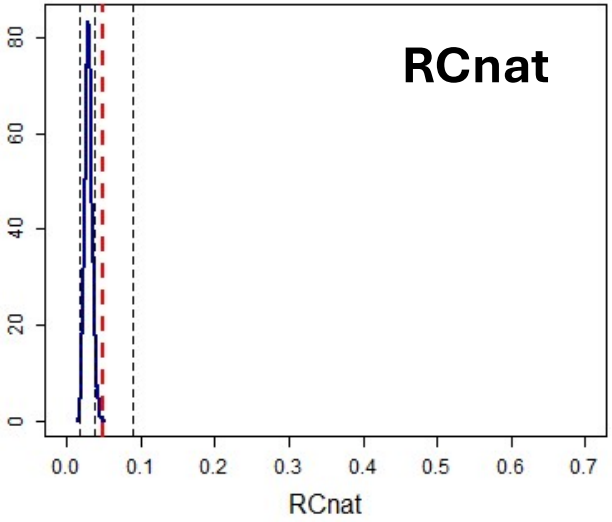
P6 = 0.29 (0.24-0.33)
CalCAST = 0.20



P6 = 0.36 (0.35-0.37)
CalCAST = 0.42

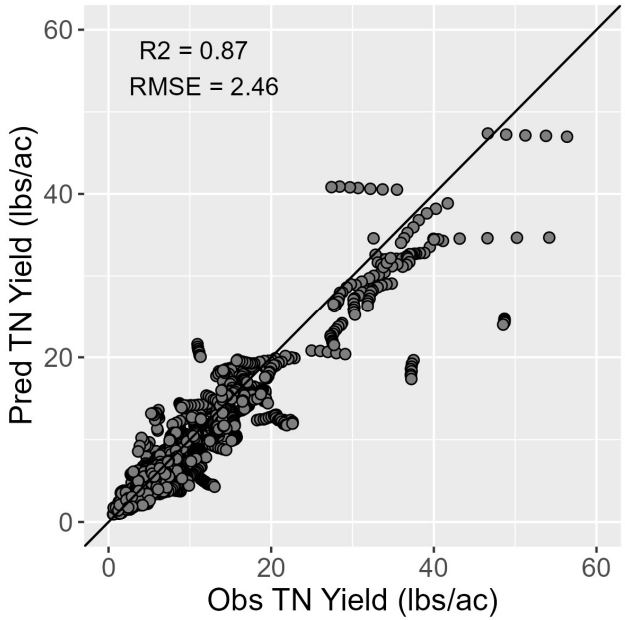


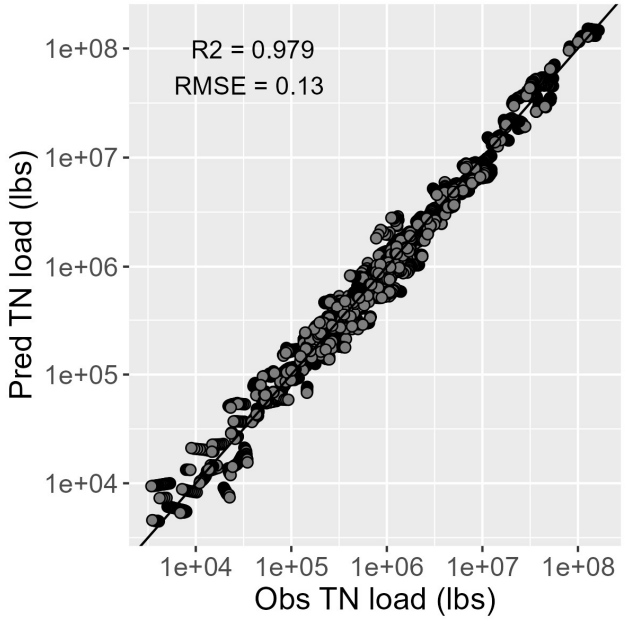
P6 = 0.05
CalCAST = 0.03 (0.02-0.09)



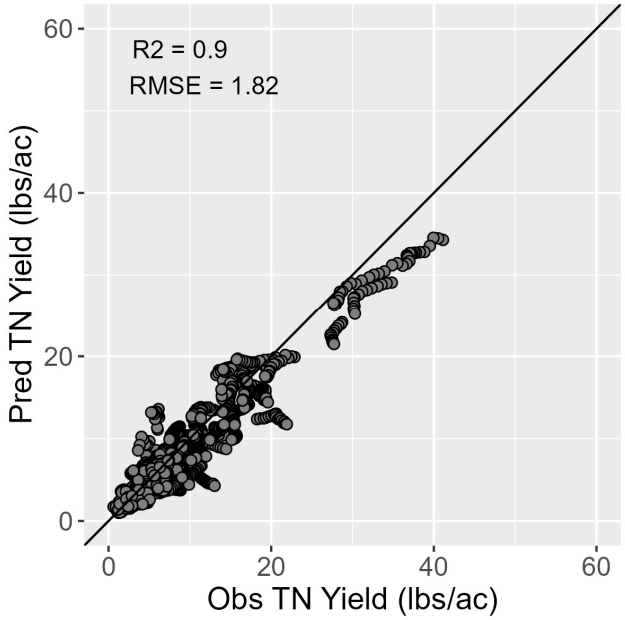
Total Nitrogen – Annual Flow Normalized

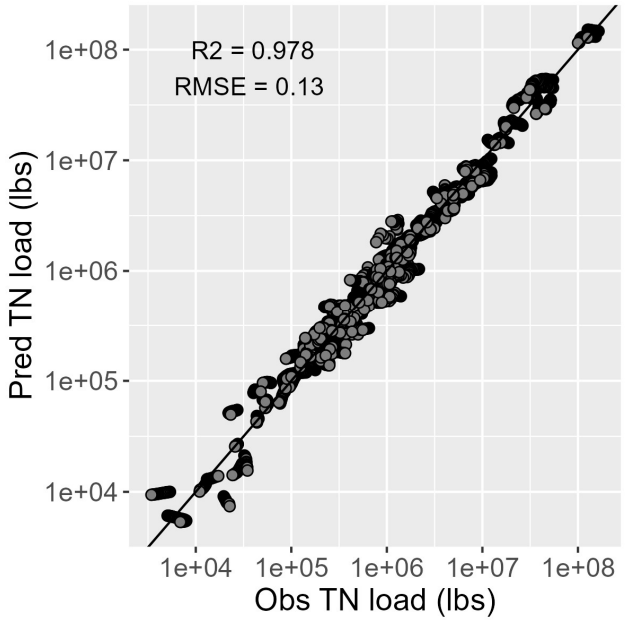
All stations



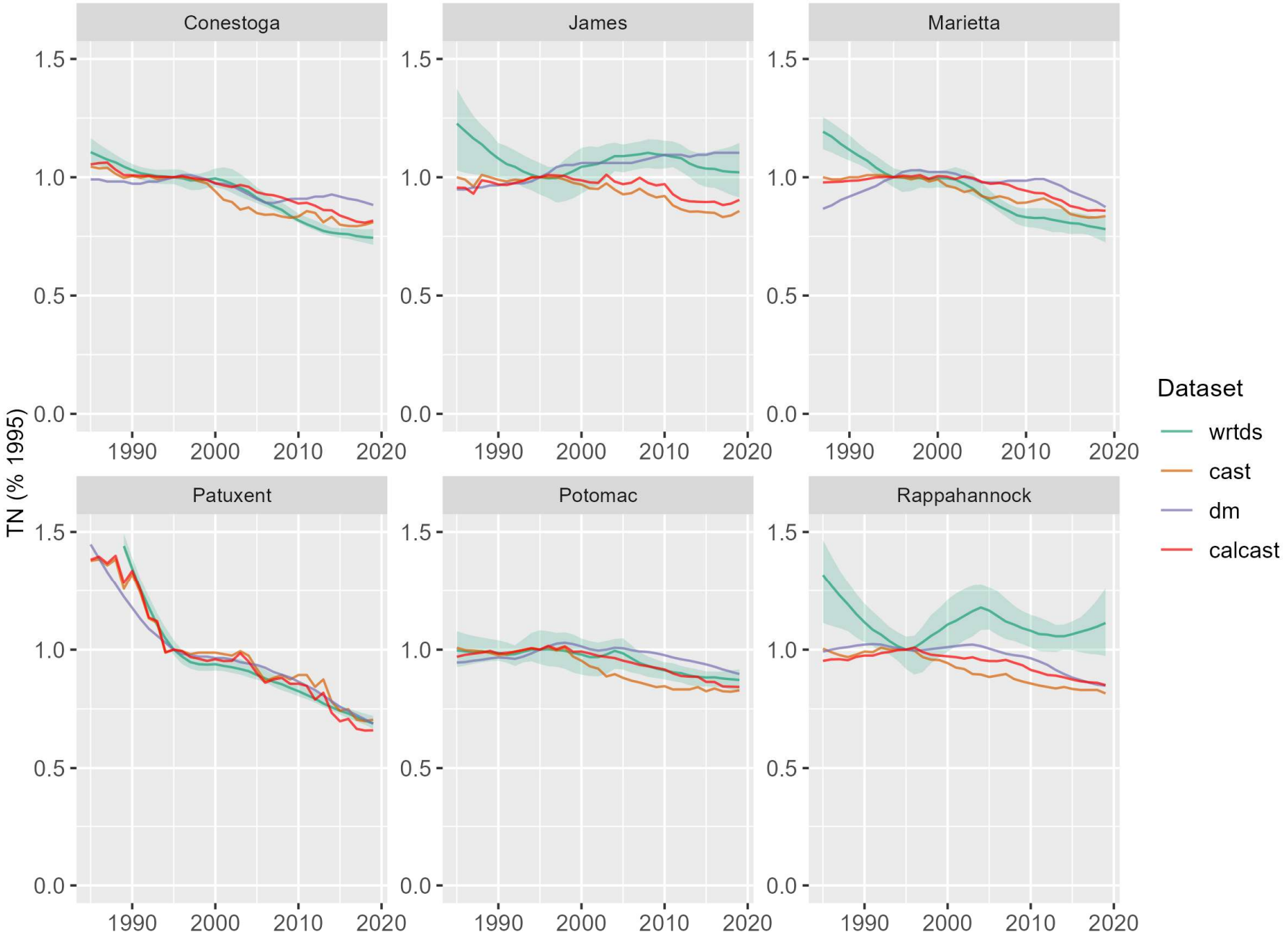


Stations with at least 10 years



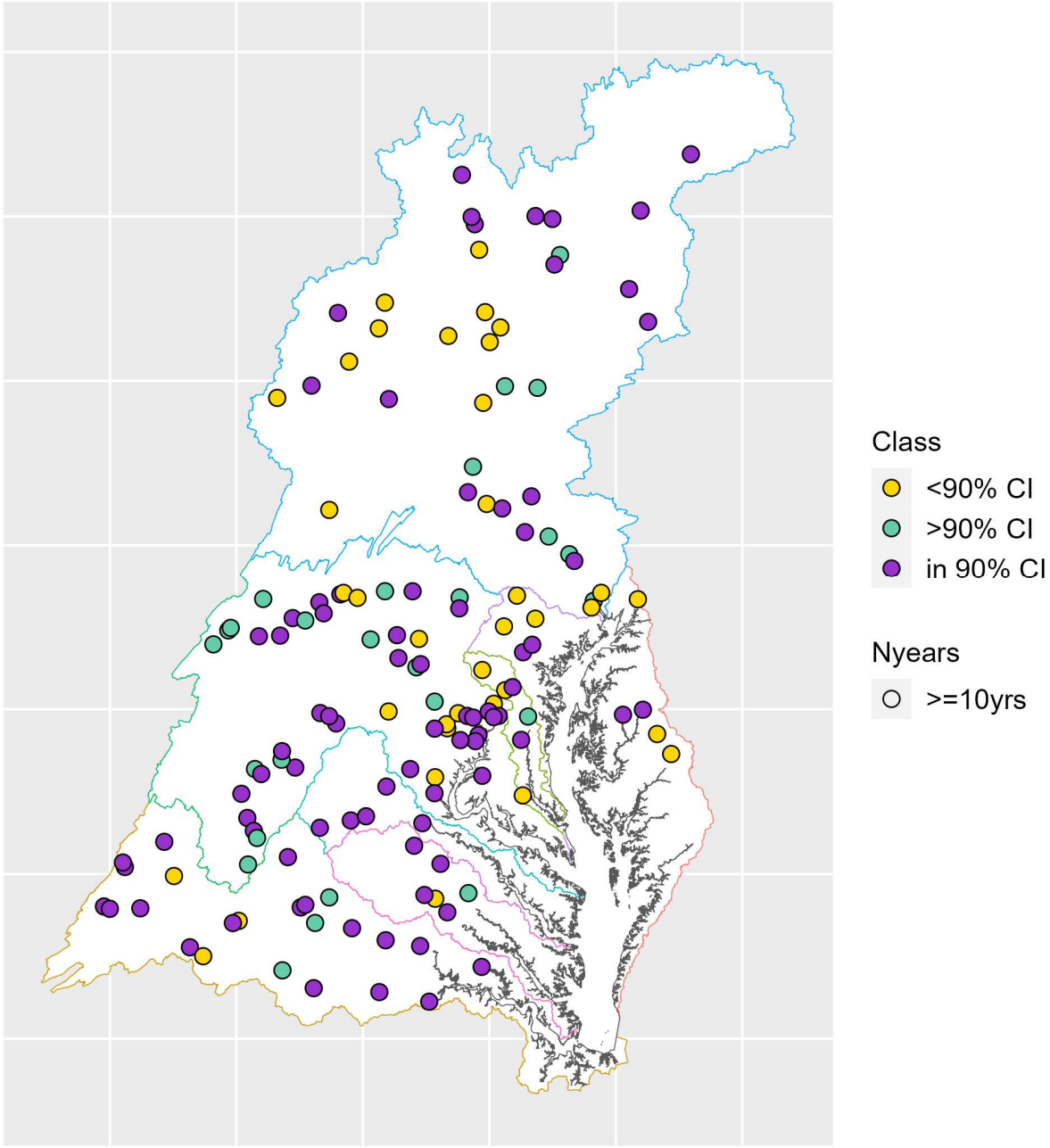


Total Nitrogen – Annual Flow Normalized



Total Nitrogen

Trend agreement (stations >= 10 years)

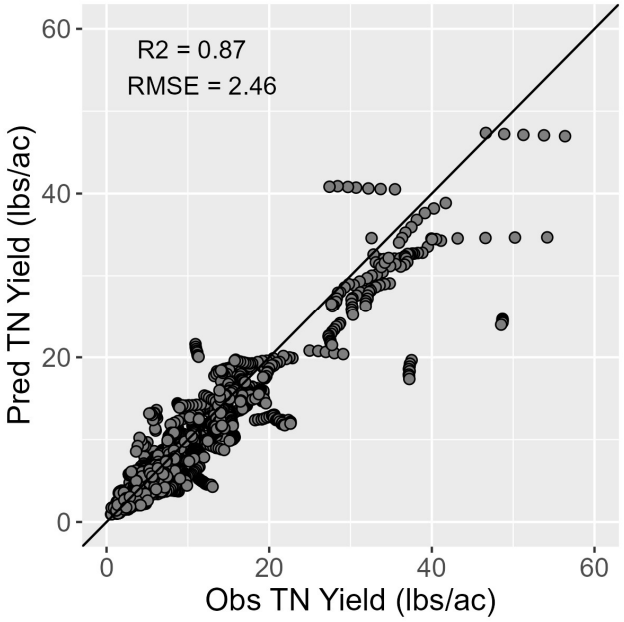


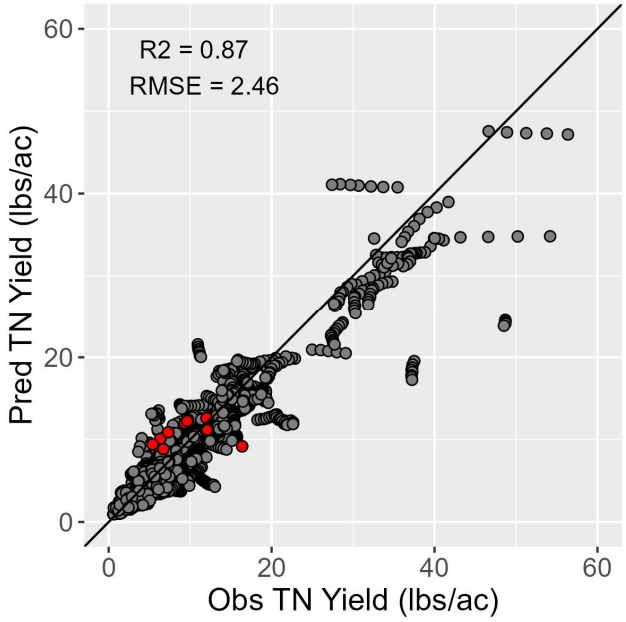
Testing inclusion of 10 Hampton Roads stations

Without Hampton Roads stations

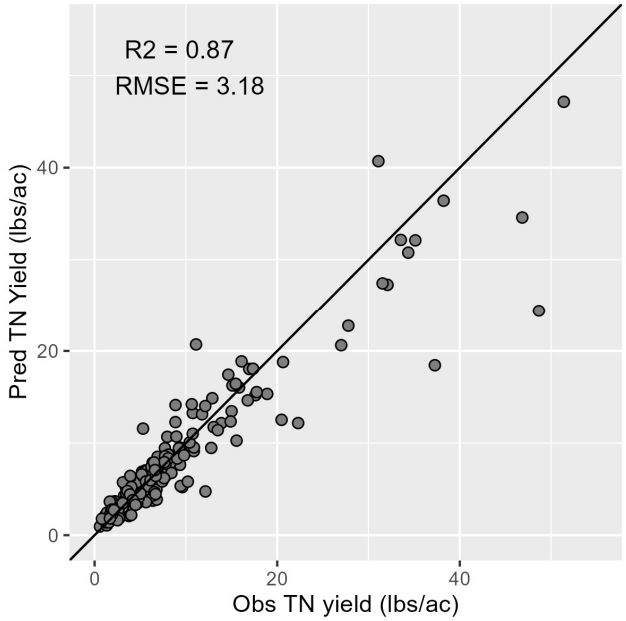
With Hampton Roads stations (**in red**)

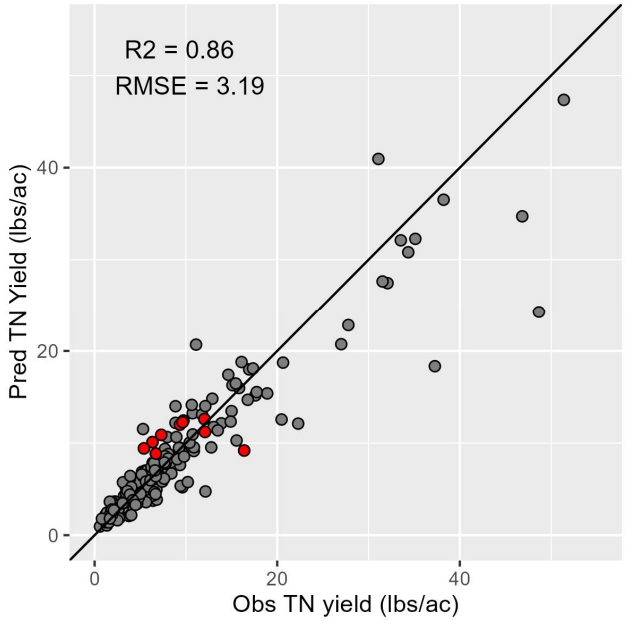
Annual





Average annual





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

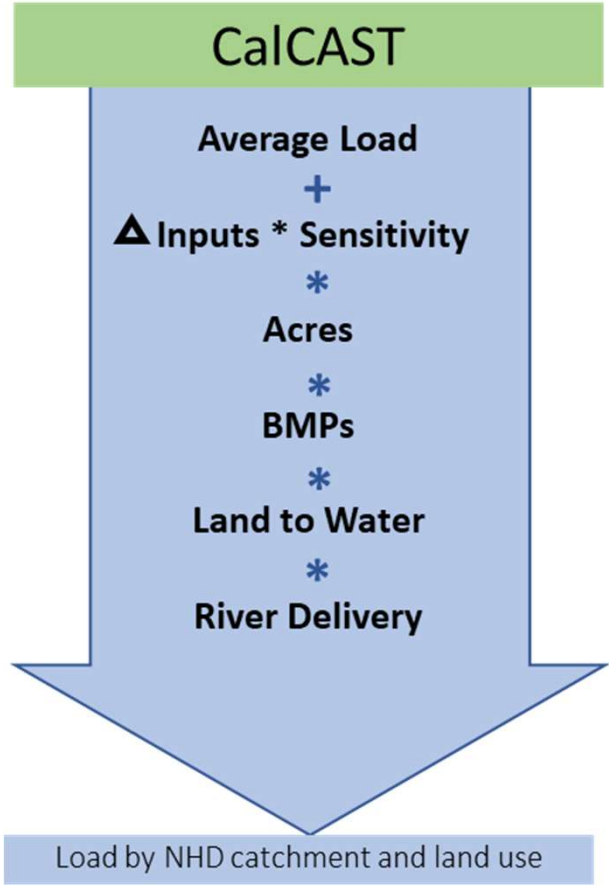
$$NPS_{nch,c,t} = AVE_{nch} + \left(TP_{FERT,c,t} - \widehat{TP_{FERT}}\right) * SENS_{nch,FERT}$$
$$*$$
$$ACRES_{nch,c,t}$$
$$*$$
$$BMP_{nch,c,t}$$
$$*$$
$$L2W_c$$
$$*$$
$$DEL_c$$

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

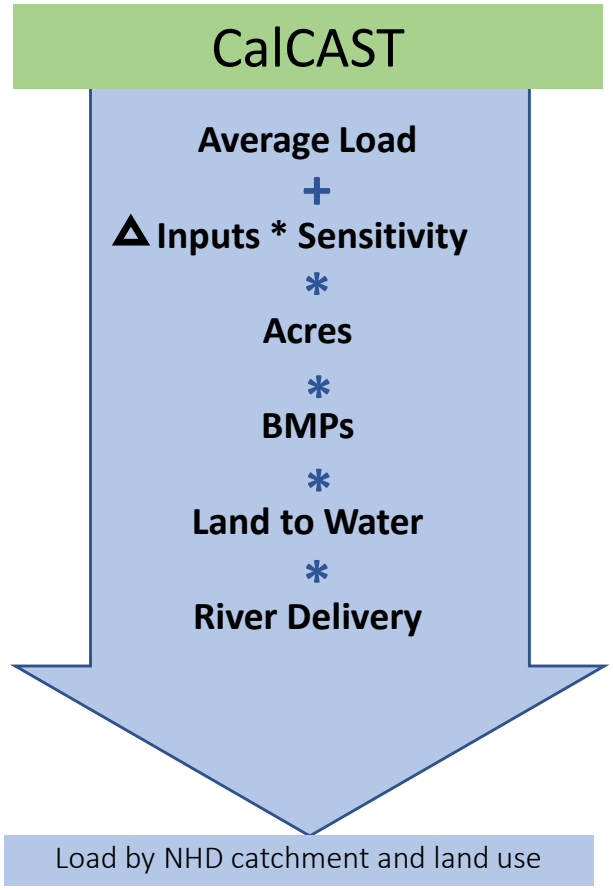
Stream delivery factor for catchment c



Total Phosphorus - Inputs

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

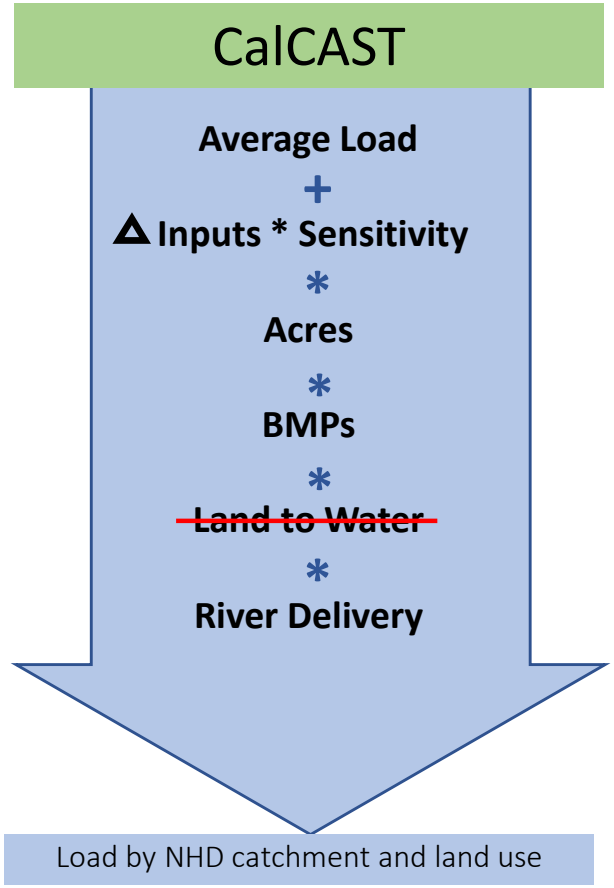
Soil P
Water Extractable P
Fertilizer
Sediment loss (RUSLE)
Stormflow (from Stormflow-CalCAST)
Riparian Pasture Deposition
Rapid Infiltration Basins
Feeding Space
Wastewater
CSOs
Atmospheric Deposition (on water bodies)

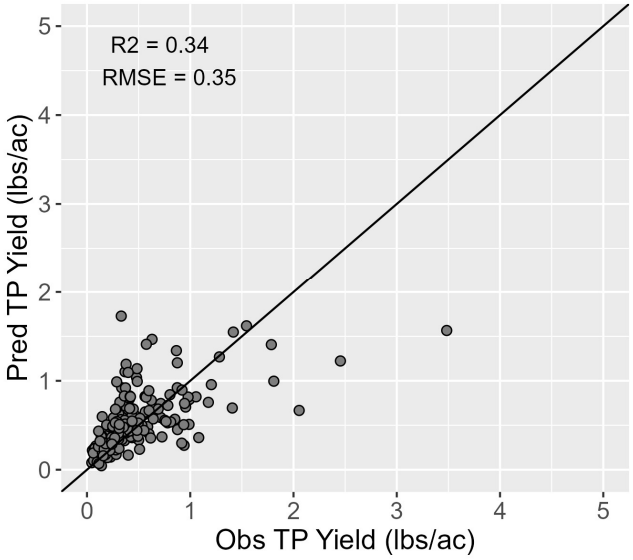


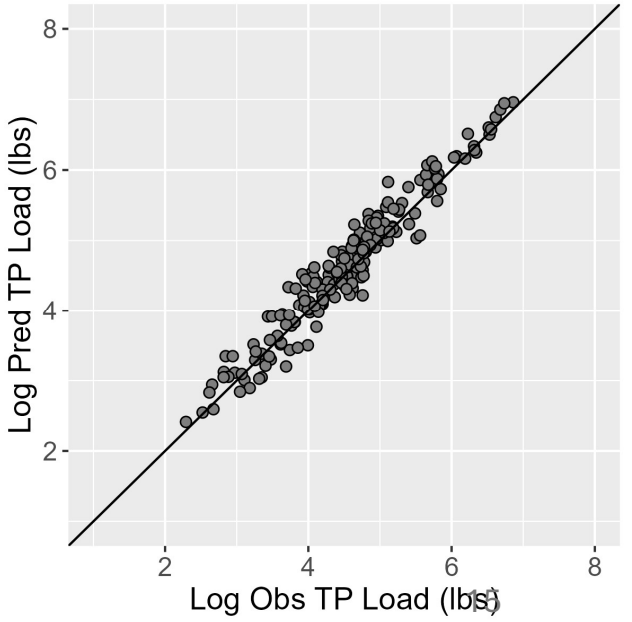
Downscaling methods based on Devereux et al. 2022 (with modifications)
https://www.sciencebase.gov/catalog/item/60be31b3d34e86b938910b2f

Total Phosphorus – Average Annual

No Land to Water Factors



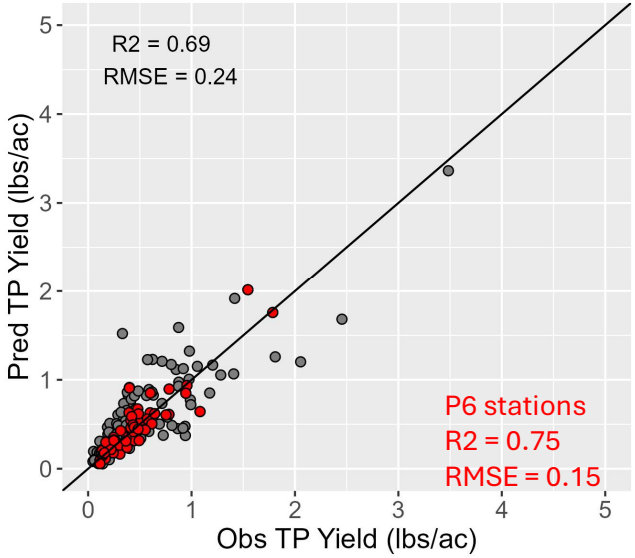


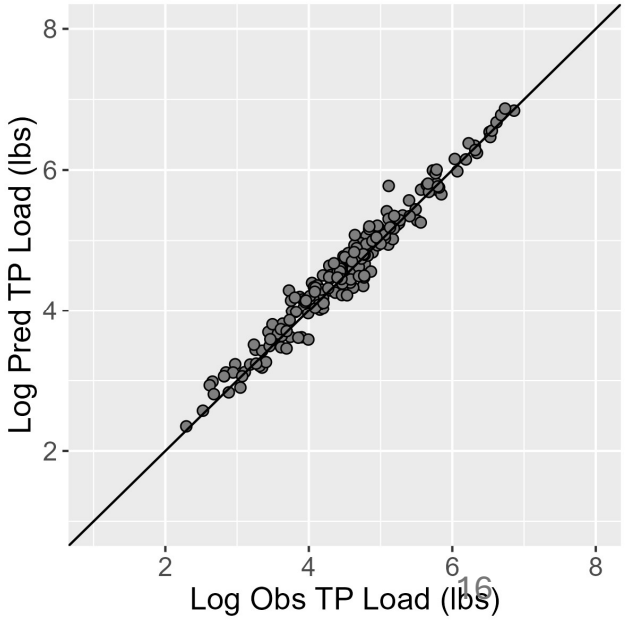


Total Phosphorus – Average Annual

With Land to Water Factors

Variable	Coef sign
Soil erosivity (K factor) (dimensionless)	+
Max 1-day precipitation (mm)	+
Hydrogeomorphic region: Mesozoic Lowland (%)	+
Hydrogeomorphic region: Valley and Ridge (%)	-
Hydrogeomorphic region: Coastal Plain Disected Upland (%)	+
Hydrogeomorphic region: Piedmont Carbonate (%)	+
Soil bulk density (g/cm^3)	-
Baseflow Index:hgmr1, hgmr2, hgmr3 (%)	-





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

Total Phosphorus – Loading Rates

CLR = Average CROP loading rate (lbs/ac)

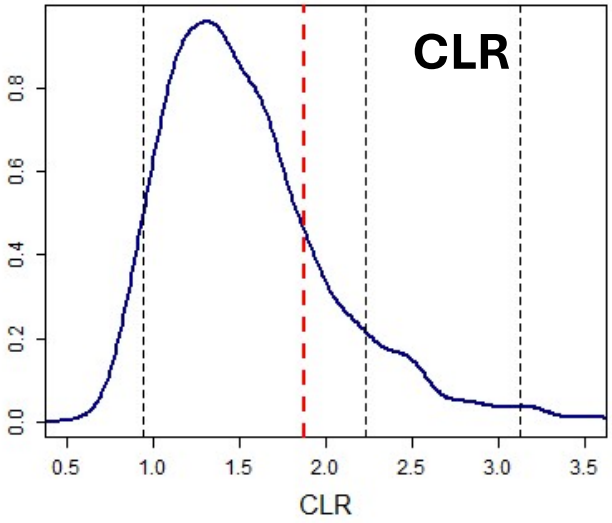
RCpas = Ratio of PASTURE loading rate to CROP loading Rate

RCdev = Ratio of DEVELOPED loading rate to CROP loading Rate

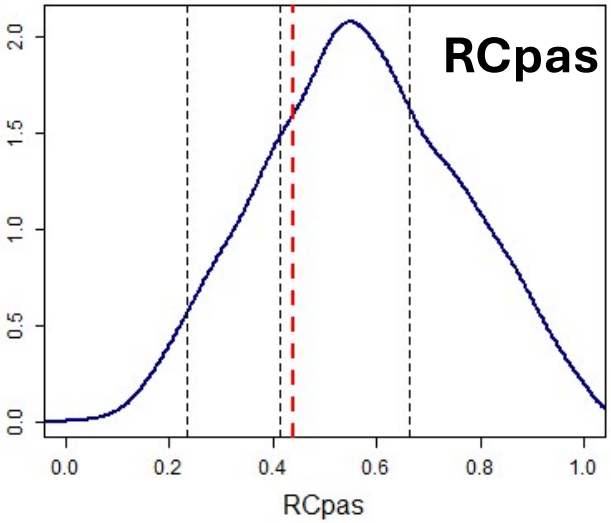
RCnat = Ratio of NATURAL loading rate to CROP loading Rate

Red dashed line = P6
Black dashed lines = P532, SPARROW, CEAP

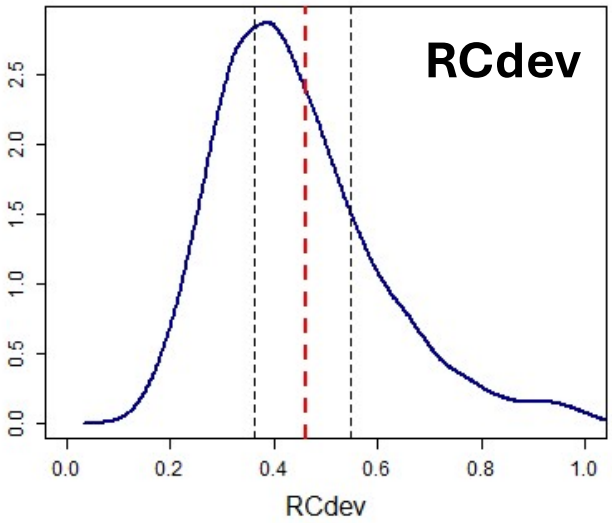
P6 = 1.87 lbs/ac (0.94-3.12)
CalCAST = 1.60 lbs/ac



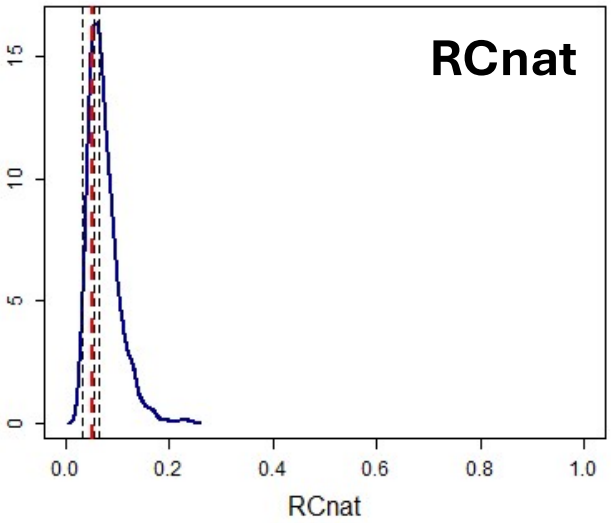
P6 = 0.44 (0.23-0.66)
CalCAST = 0.57



P6 = 0.46 (0.36-0.55)
CalCAST = 0.44

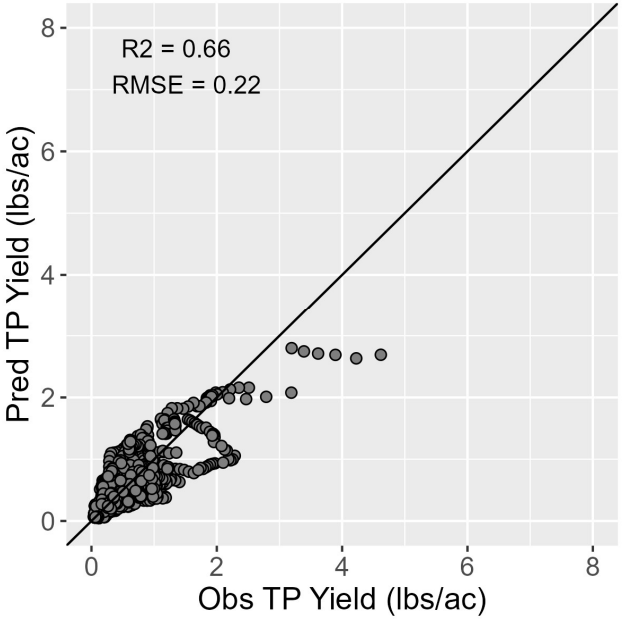


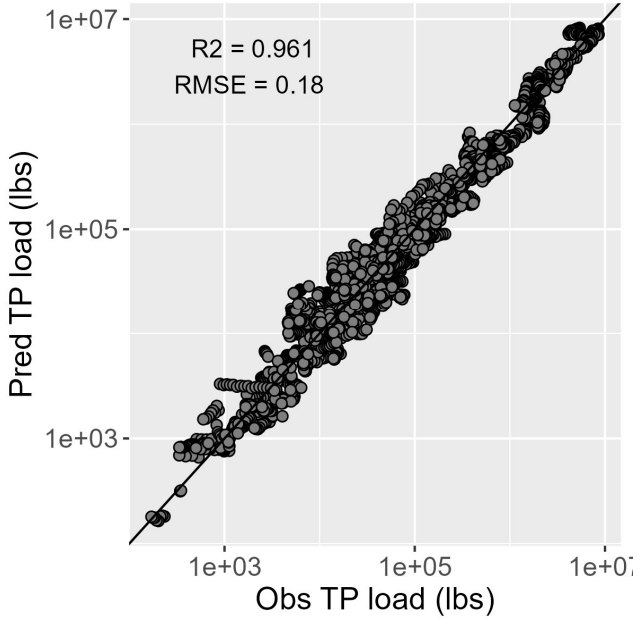
P6 = 0.05 (0.03-0.06)
CalCAST = 0.07



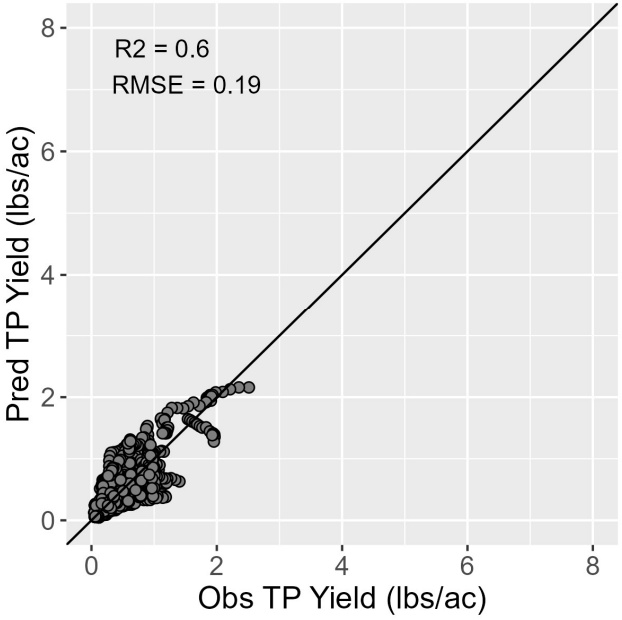
Total Phosphorus – Annual Flow Normalized

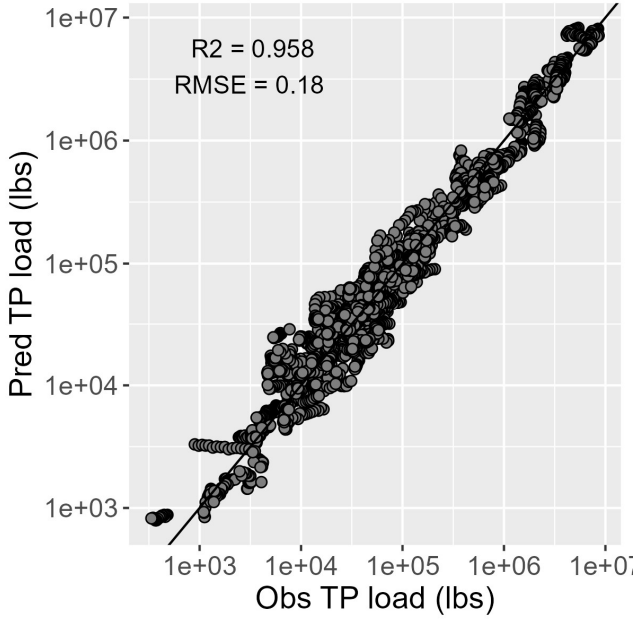
All stations



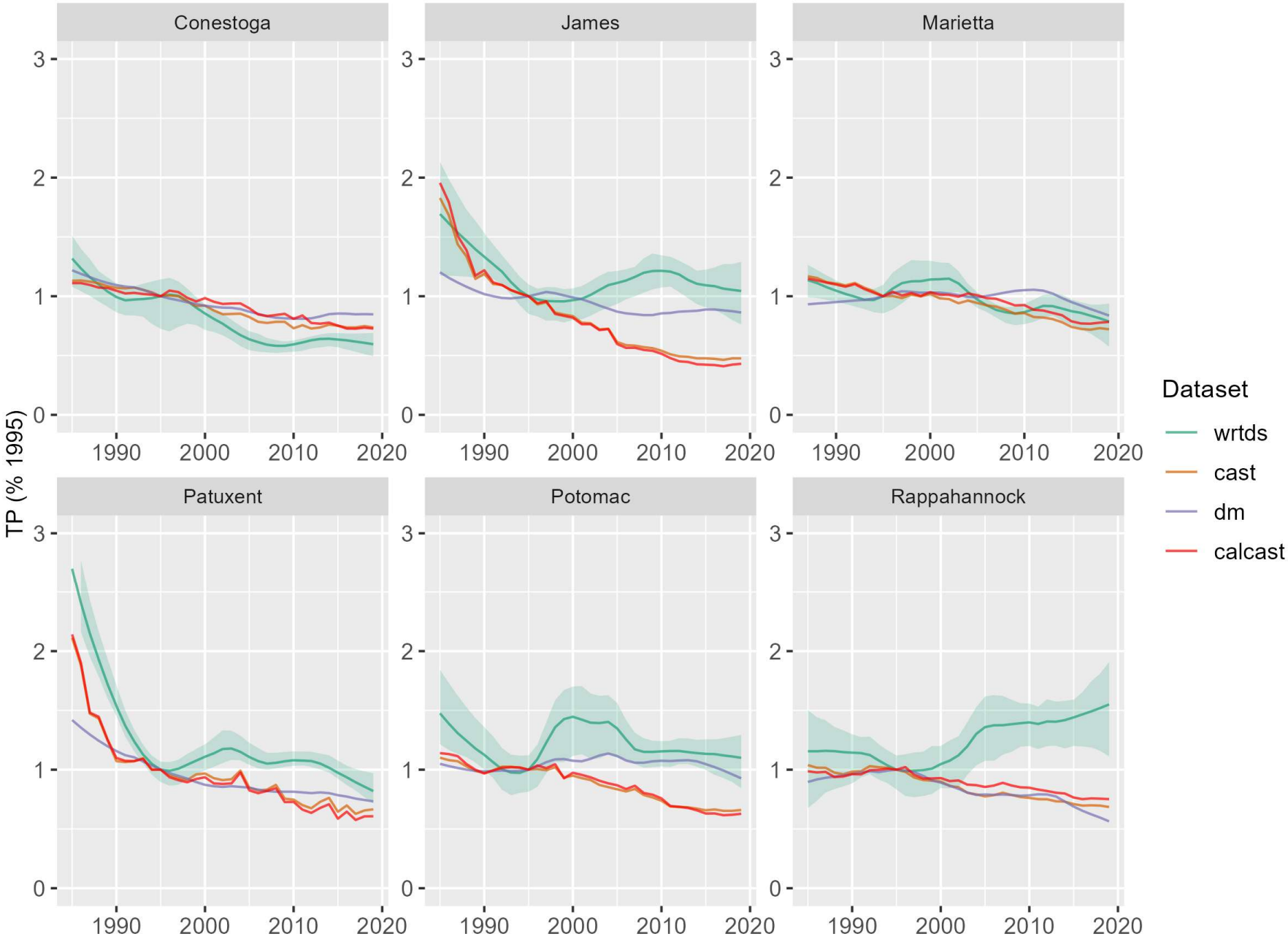


Stations with at least 10 years





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:

gwm loading rate (lbs/ac)

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

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

$$*$$

Acres of gwm in catchment c and year t

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

$$*$$

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

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

$$*$$

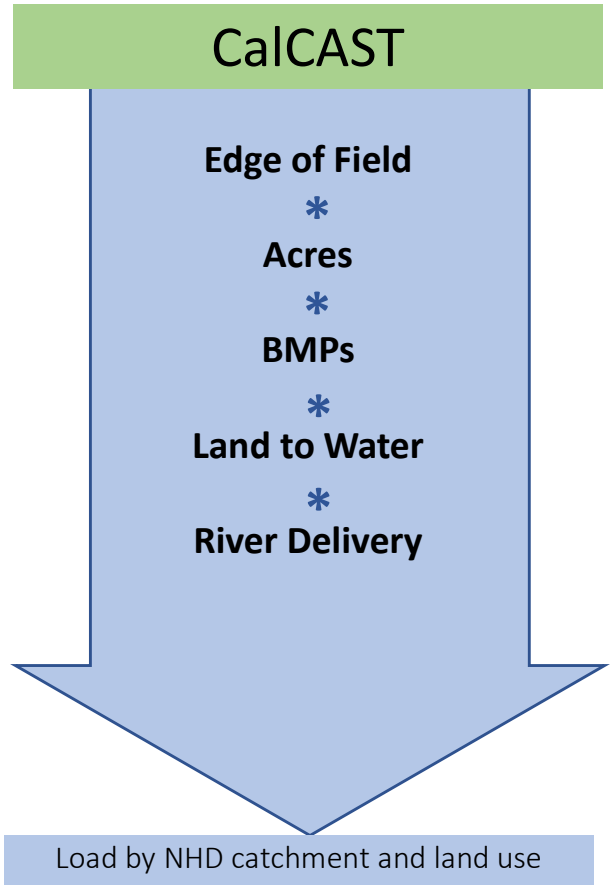
Sediment delivery ratio for crp in catchment c (IC = Index of Connectivity)

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

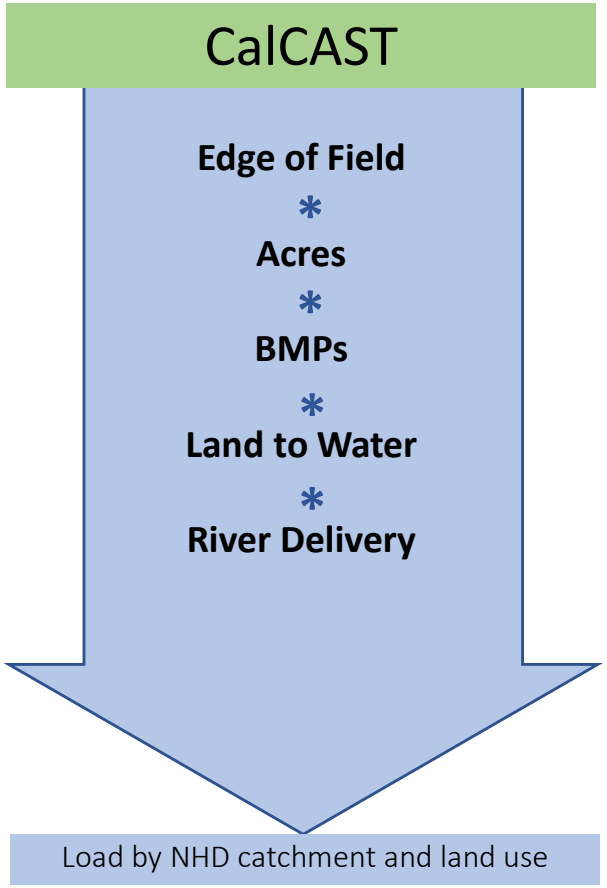
$$*$$

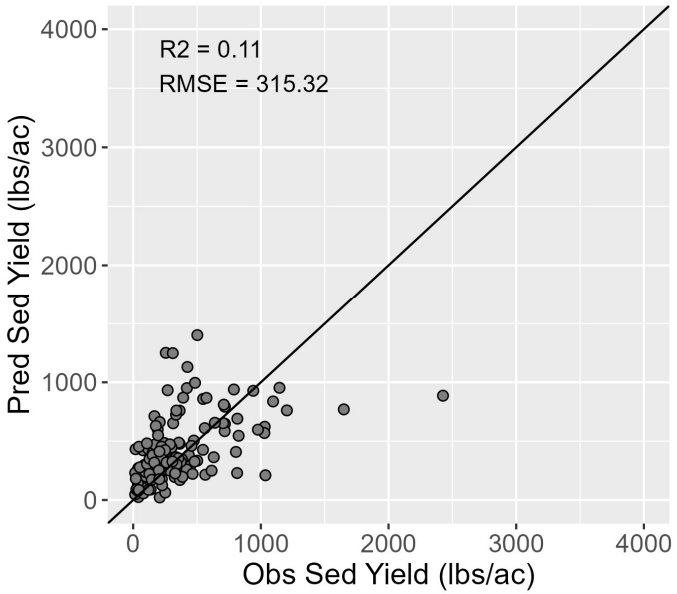
Stream delivery factor for catchment c

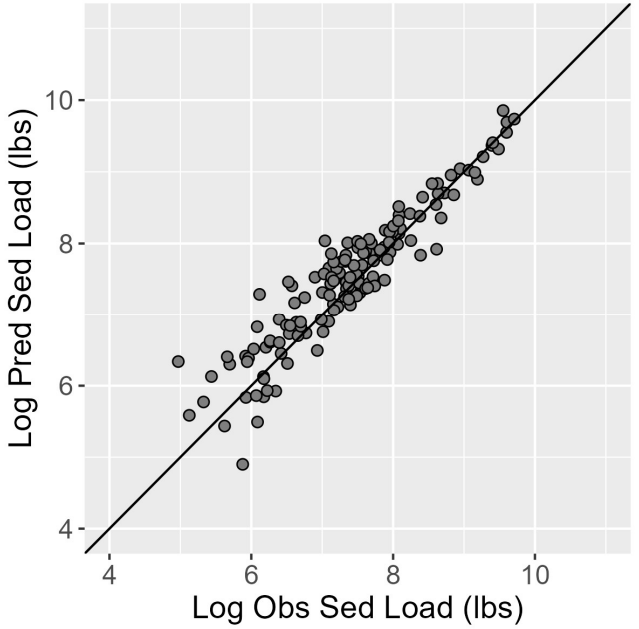
$$DEL_c$$



Sediment – Average Annual



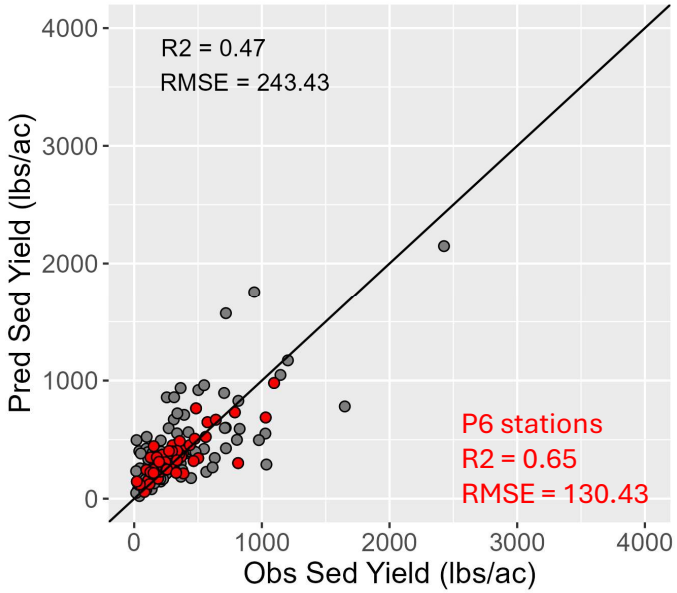


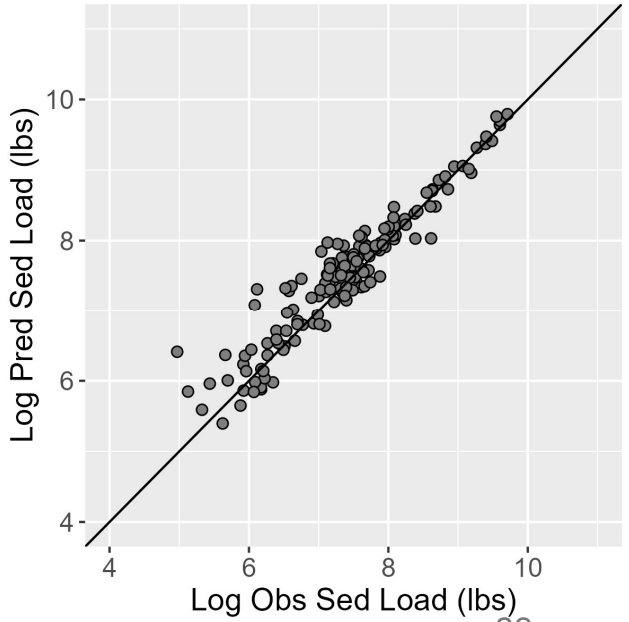


Sediment – Average Annual

Additional Land to Water and Stream Factors

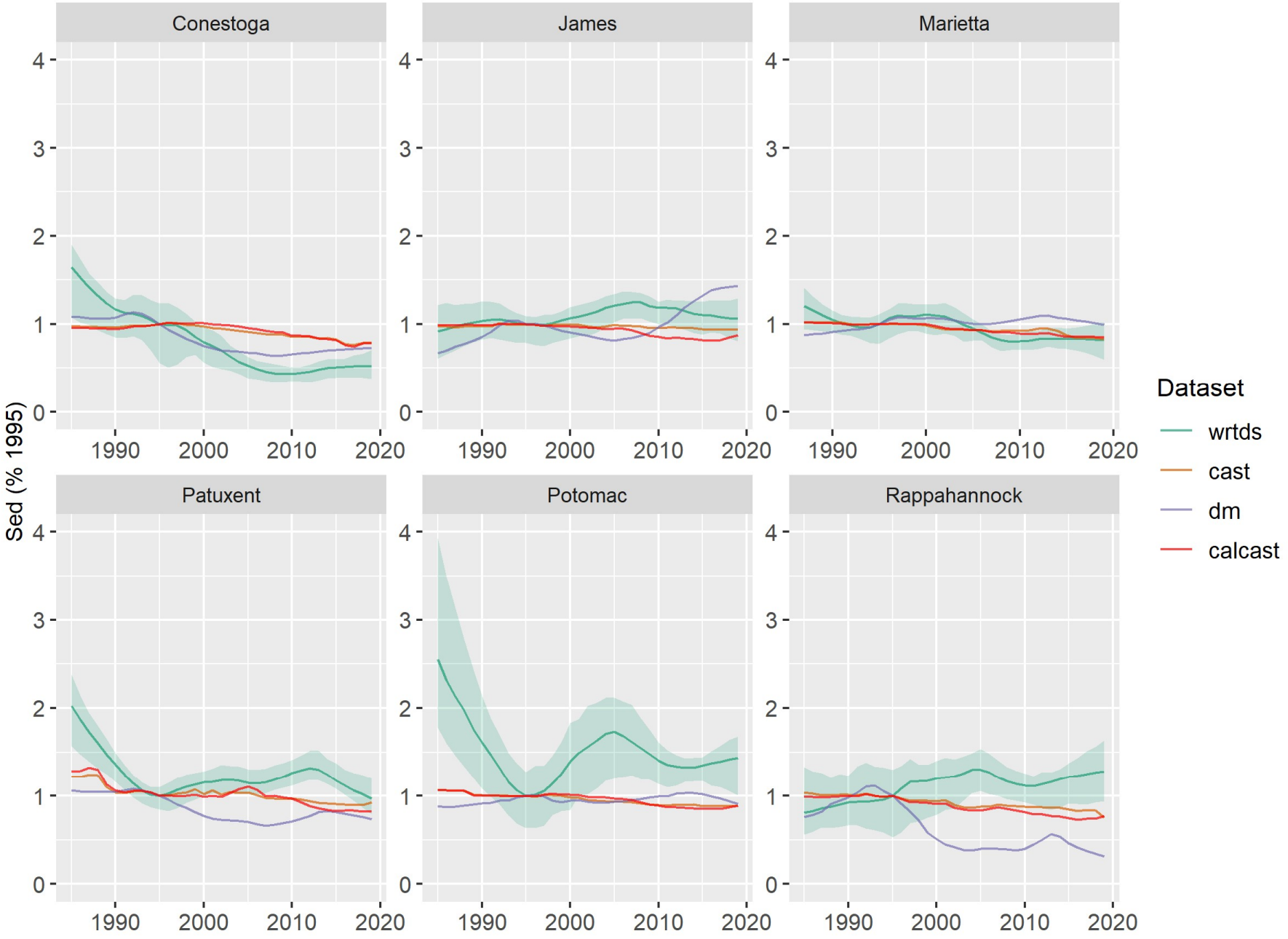
Variable	Coef sign
Stream Length Above Fall Line (km)	+
Stream Length Below Fall Line (km)	+
Soil erosivity (K factor) (dimensionless)	+
Max 5-day precipitation (mm)	+
Hydrogeomorphic region: Valley and Ridge (%)	-
Percent Impervious Non Roads (%)	-
Baseflow Index (%)	-
High-res stream density:hgmr1, hgmr2, hgmr3 (%)	+





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

Sediment – Annual Flow Normalized



Next Steps

- Test N and P sensitivities generated by Joseph's literature review
- Test land-to-water connectivity metrics generated by land use team (presentation by Michelle Katoski later today)
- Explore DM-based delivery factor adjustment approaches
- Final versions of CalCAST by July 2025