Nutrient Processing Within Coastal Prairie Wetlands: A Nexus to Galveston Bay, TX

Margaret Forbes & Robert Doyle

Center for Reservoir and
Aquatic Systems Research

Coastal Prairie Ecosystem

Southern extent of the tallgrass prairie

99.9% converted to agriculture, residential grazing.

http://www.nwrc.usgs.gov/prairie/tcpr2.htm

Losses now due to urbanization

Facilitated by SWANCC & Rapanos

Few data on functions and values

Research Goals

1. Describe water quality functions of CPFWs

2. Develop In & Out nutrient budgets for 6 CPFWs

3. Evaluate impact on receiving waters

Coastal Prairie Freshwater Wetlands

Small & shallow with small watersheds

Flats and depressions


Many occur in remnant channels


Some converted to woody vegetation


Hydrology driven by PPT and EVPT

Seasonally dry - large inter-annual variability

Limited groundwater exchange due to episaturation

“clay plain”

High biodiversity due to micro-topography

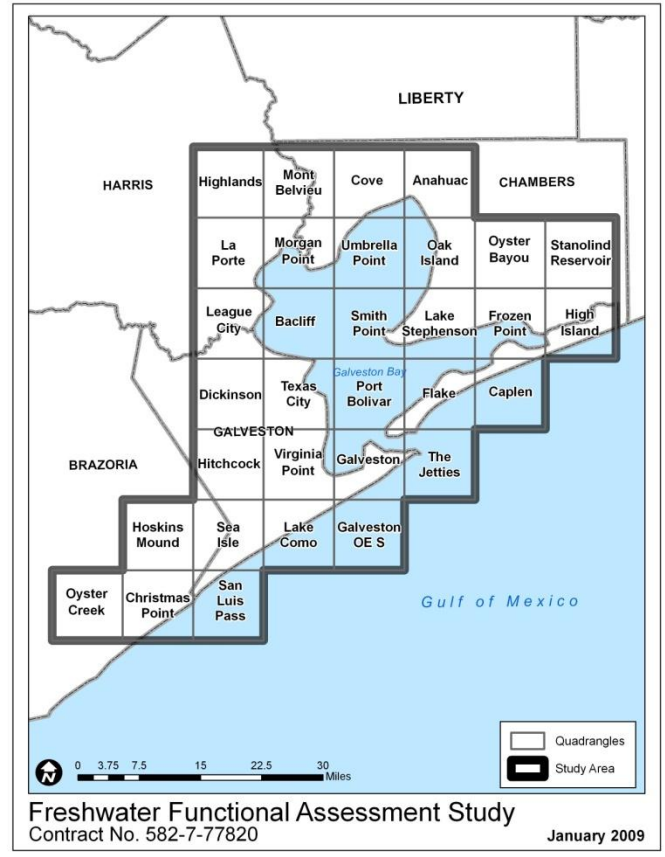
mima mounds

Study Area

HA
TH
KS
UH
LG
KIL
SE
SW
LC
CR
WD
DW
34 km

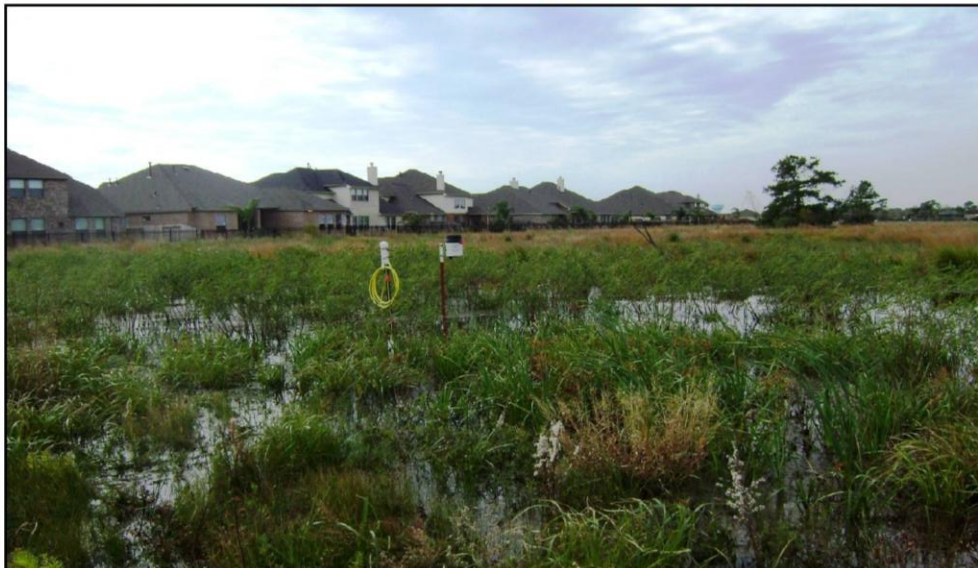
Red = 18 months
Green = 6-10 months
Random: LG, DW, SE, UH

Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Texas General Land Office




0.5
Km
LG


1
Km

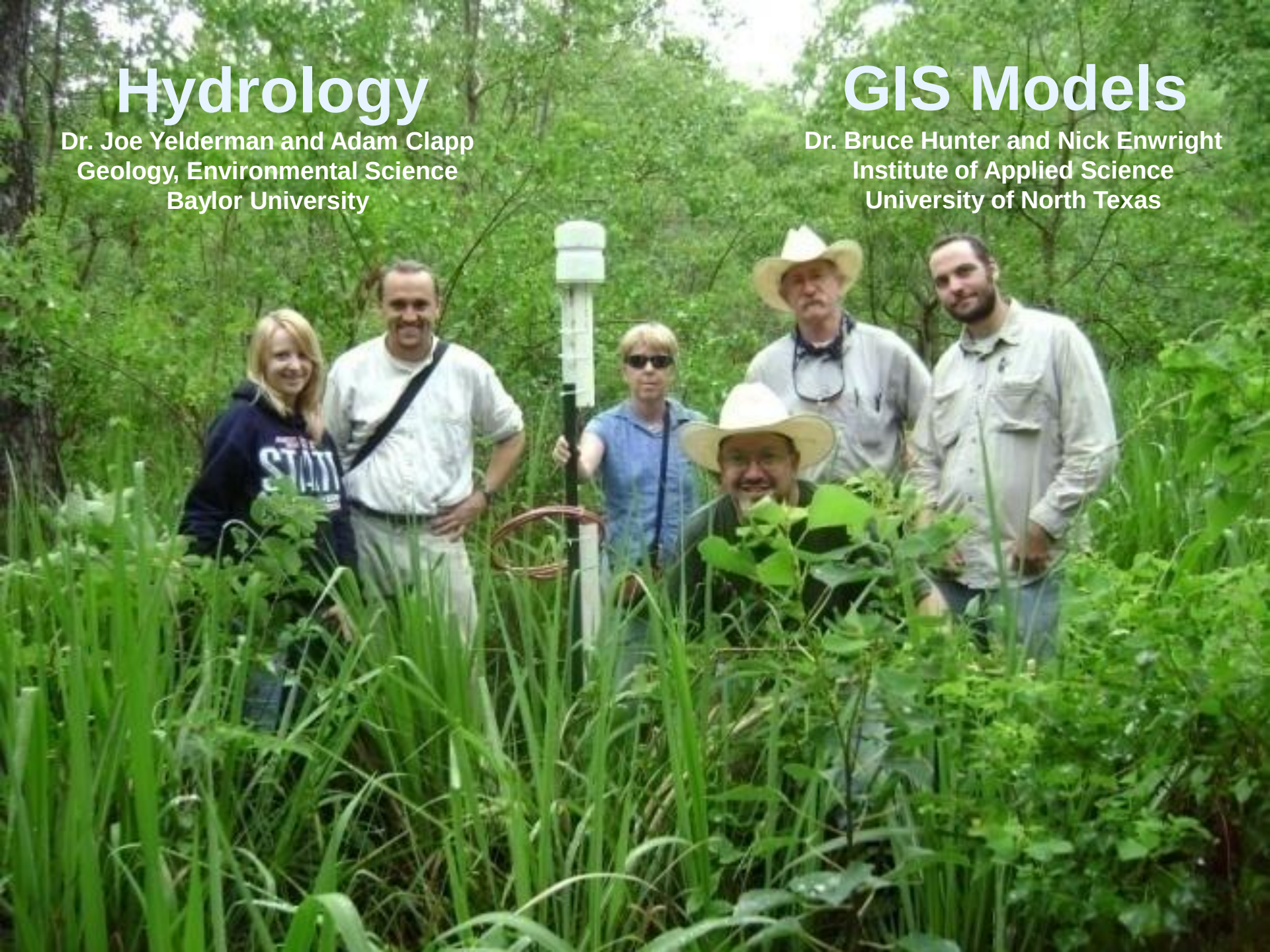


Hydrology

Dr. Joe Yelderman and Adam Clapp
Geology, Environmental Science
Baylor University

GIS Models

Dr. Bruce Hunter and Nick Enwright
Institute of Applied Science
University of North Texas



Abundance and Density

- CPFW + their catchments occupy 40.8% of the land area (36.6% excluding PF/AF wetlands)*

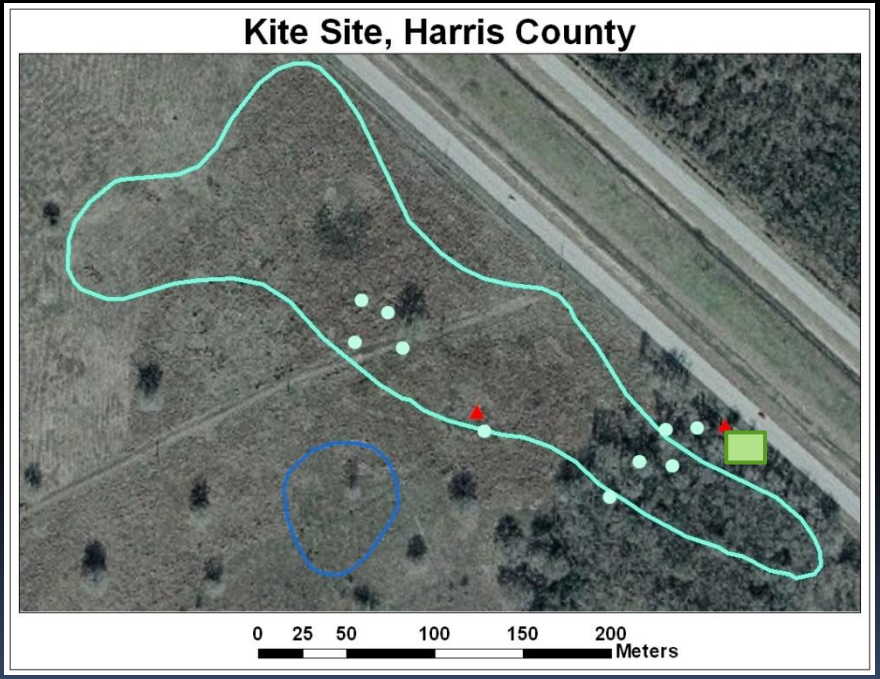
- Thus, over one-third of the precipitation that falls on land within the study area is captured within CPFW basins.*

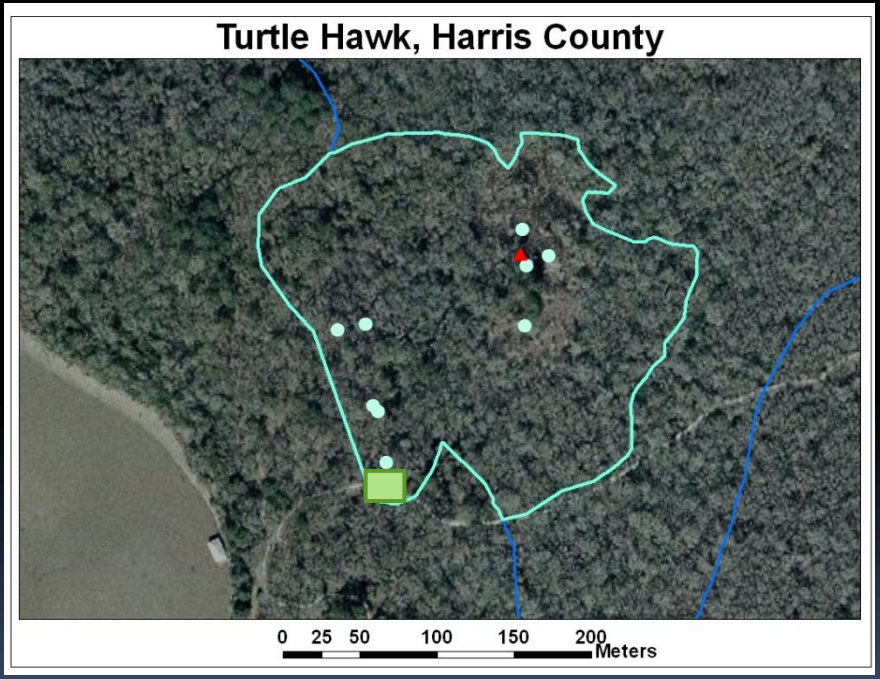
* Enwright NE, Forbes MG, Doyle RD, Hunter B, Forbes W. 2011. Using Geographic Information Systems to Inventory Coastal Prairie Wetlands along the Upper Gulf Coast, Texas. *Wetlands* 31:687-697.

Sampling Design

10-15 randomly selected points (from 50-pt grid) for soils and vegetation

Surface water grab samples collected at plots according to water coverage





Aqua circles = soil and veg sampling location, red = WLR, green = weirs

Water Quality Sampling

- Collect precipitation
  - Teflon bags in rain barrels
- Grab samples from multiple locations within wetlands following rain event (or ~ monthly)
- Water quality analyses
  - Nitrogen (NH_4^+, NO_3^-, TN)
  - Phosphorus (PO_4^{3-}, TP)
  - DOC (non-purgeable organic carbon)
- Nutrient Retention
  - IN = PPT x catchment area x [conc in PPT]
  - OUT = discharge x [conc in wetlands]

Results

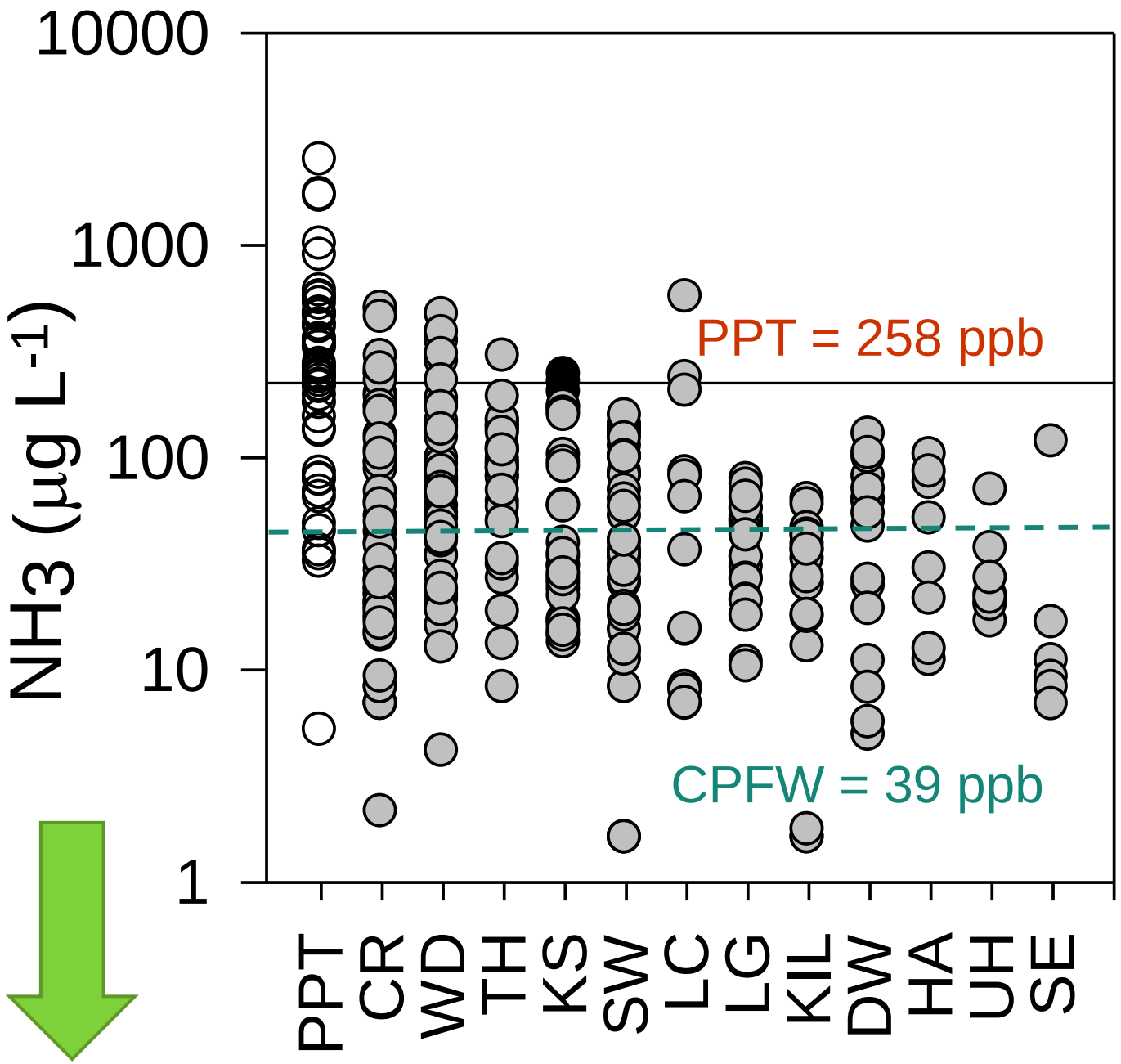
PPT = open symbols,

Grey=sites lower than PPT

Black = sites higher than PPT

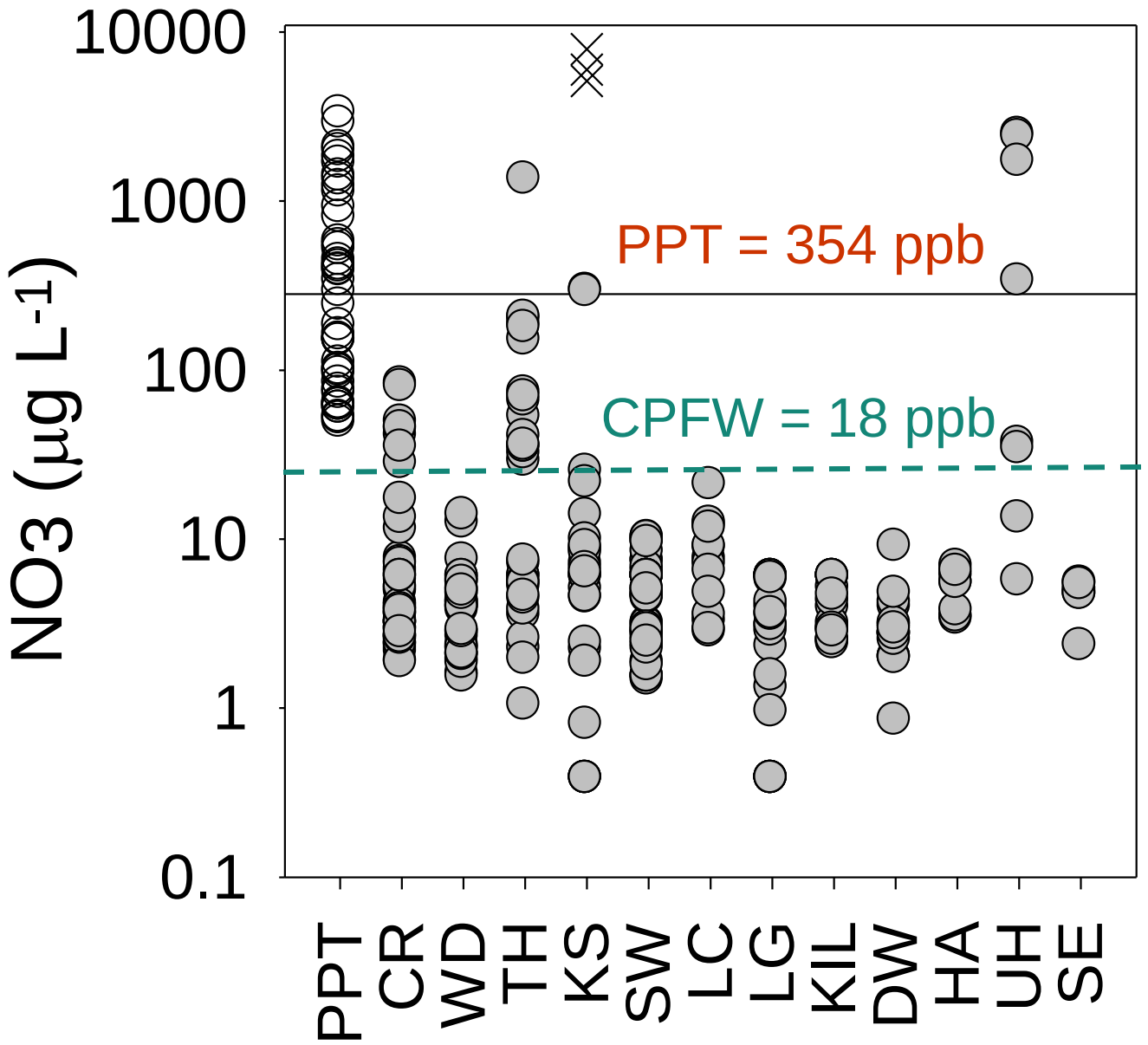
Ammonia -N

85% reduction



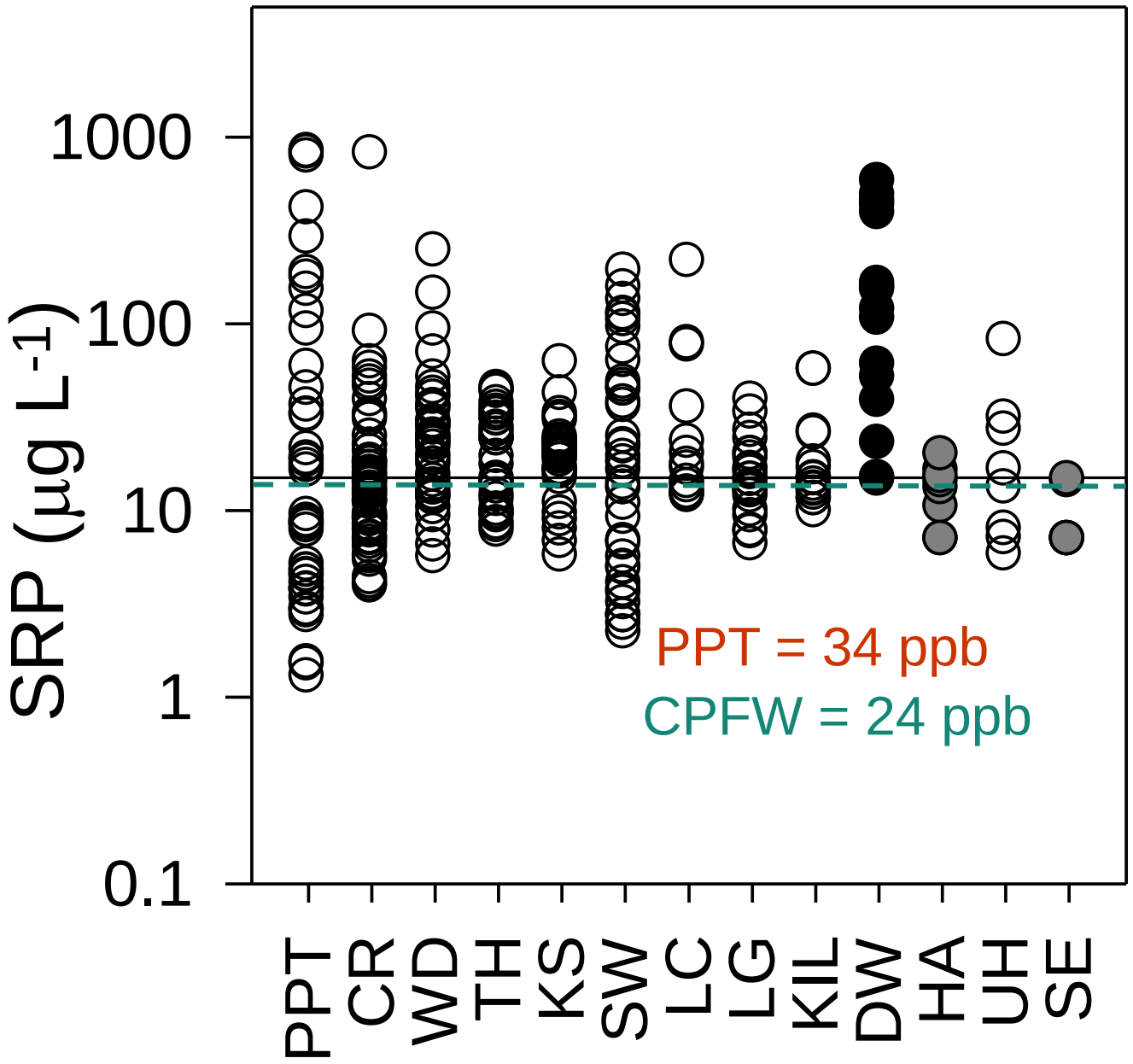
Nitrate-N

95% reduction



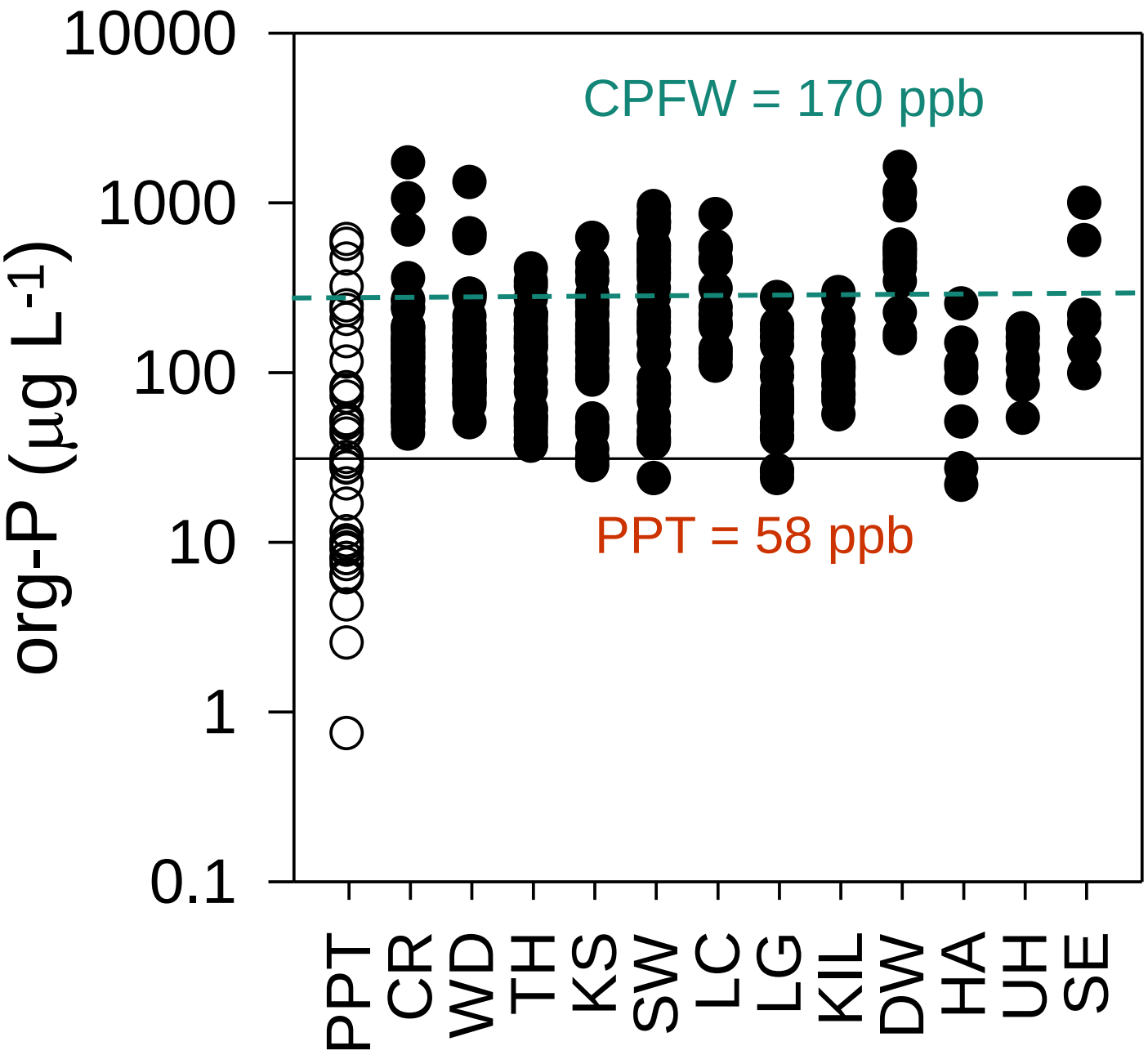
SRP

30% decrease



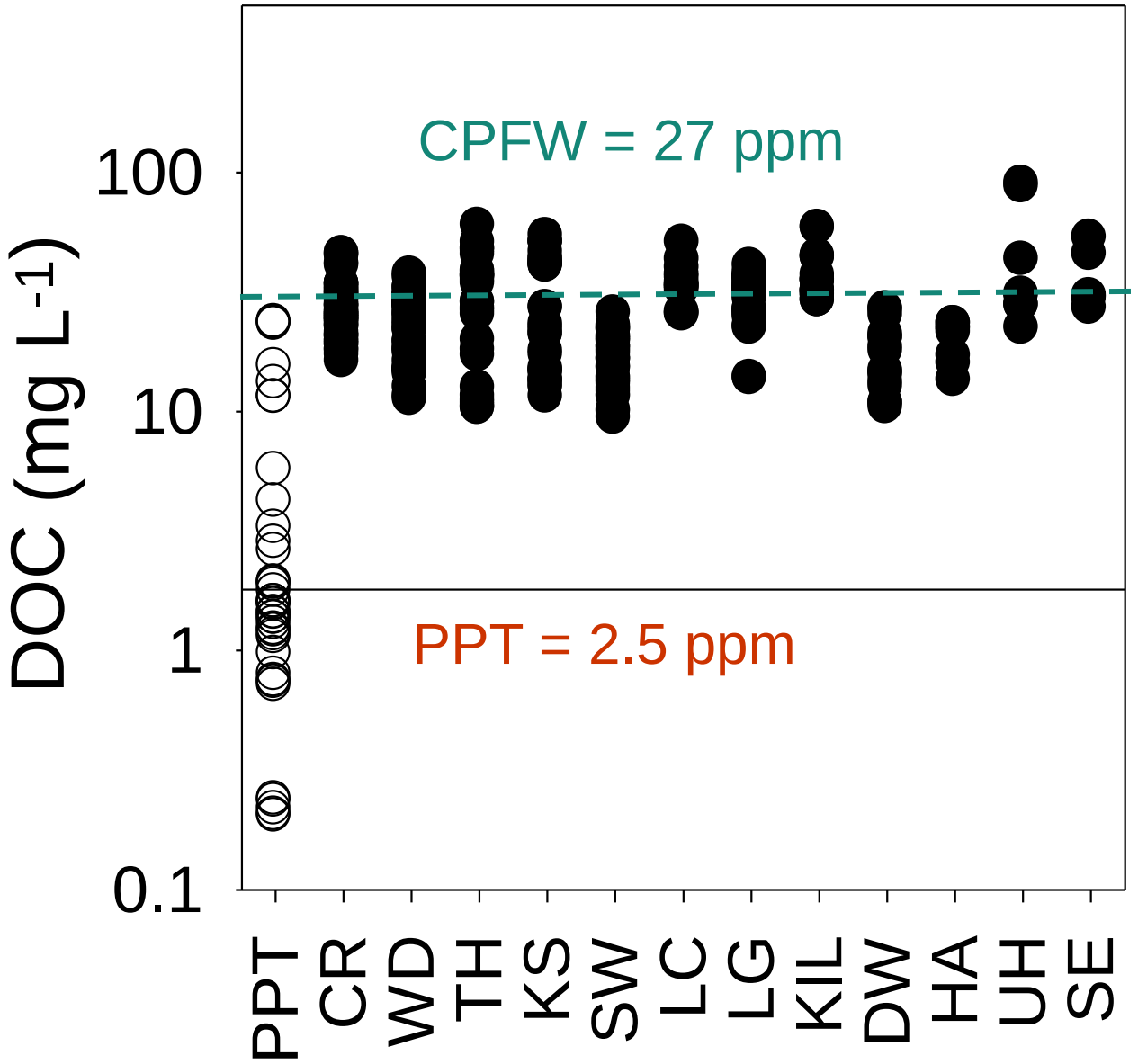
Org-P

290% increase



DOC

1350% increase



Nutrient Loading/Retention Estimates

Summary of hydrology for six CPFWs

Site	PPT	Runoff	PET	Q	Percent OUT as Q	Percent of IN Stored
	(1000 m^3)					
TH	103.5	6.5	92.6	26.9	22%	85%
KS	73.4	628.6	65.6	50.7	44%	95%
CR	142.6	75.8	209.0	49.5	19%	83%
WD	21.3	2.4	31.3	2.1	6%	95%
LC	19.7	66.3	18.6	24.3	83%	15%
SW	43.1	101.6	43.1	24.4	36%	86%
					35±11	76±13

Nitrogen % Retained

Site	NH_3-N	NO_3-N	org-N
CR	97.6	99.7	43.4
WD	97.1	99.8	63.1
TH	94.6	97.3	-65.0
KS	99.7	99.9	80.0
LC	93.0	99.5	2.0
SW	98.7	100	90.3
Geomean	97.8	99.7	56.7
SE	1.0	0.4	23.8

P and DOC % Retained

Site	SRP	Org-P	DOC
CR	91.4	60.9	-140
WD	89.5	64.6	-55
TH	42.2	29.6	-435
KS	94.6	91.3	49
LC	90.3	0.8	-125
SW	99.1	89.7	82
Geomean	92.1	69.1	-26.7
SE	21	35	185

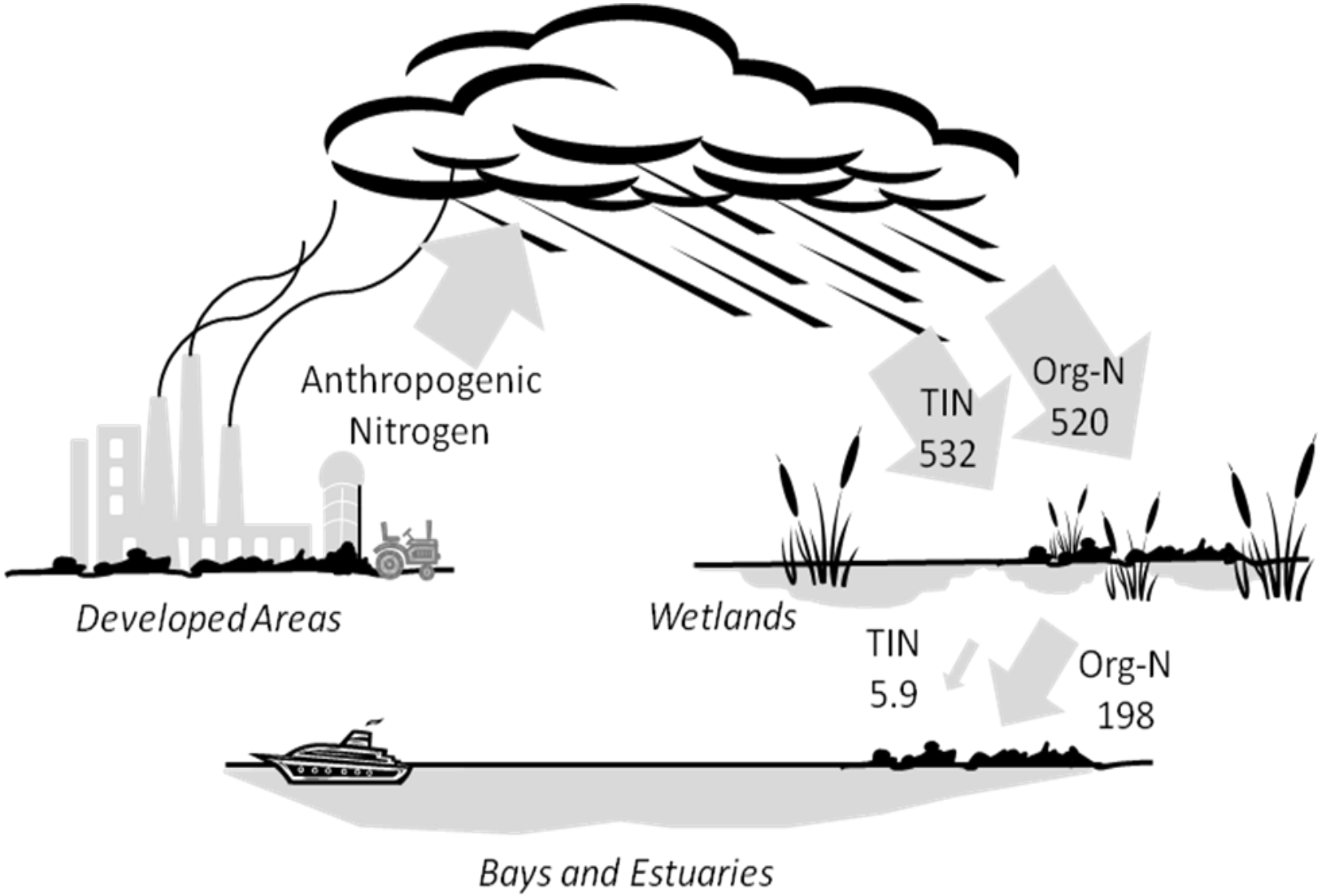
Mean Annual Export Rates (kg $km^{-2}y^{-1}$)

	NH_3-N	NO_3-N	org-N	SRP	org-P	DOC
Geomean	5.1	0.8	198	1.9	16.4	2600
SE	3.1	4.7	3.5	3.4	3.9	3.6

Nexus to Receiving Waters

1. Major source of DOC/DOM to Galveston Bay and its tributaries.

2. Captures, stores and transforms atmospheric nitrogen and phosphorus, reducing inorganic forms dramatically.



Values in kg N $km^{-2}y^{-1}$. TIN = Total inorganic nitrogen

Nexus to Receiving Waters cont

3. Nitrogen regulation of receiving waters.

Using N loading and land use estimates for the lower Galveston Bay watershed (Newell et al. 1992), if CPFWs and their catchments were converted to equal parts urban and residential land uses, N export would increase by a factor of 1.9.

Significant nexus can derive from “functions that may significantly affect the physical, chemical, or biological integrity of downstream traditional navigable waters including nutrient cycling and removal and transferring nutrients and organic carbon vital to support downstream food webs.”

(U.S. Army Corp of Engineers 2011)

Conclusions

1. CPW's collect and store approximately 76% of PPT falling within their catchments.

2. They retain 98% of inorganic-N and 92% of inorganic-P.

3. They provide a significant portion of DOC/DOM to Galveston Bay and its tributaries.

4. Removal of CPFWs from a tributary's catchment nearly doubled its nitrogen export.

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