Forest Modeling in the Phase 5 and Phase 6 CBP Partnership's Watershed Models

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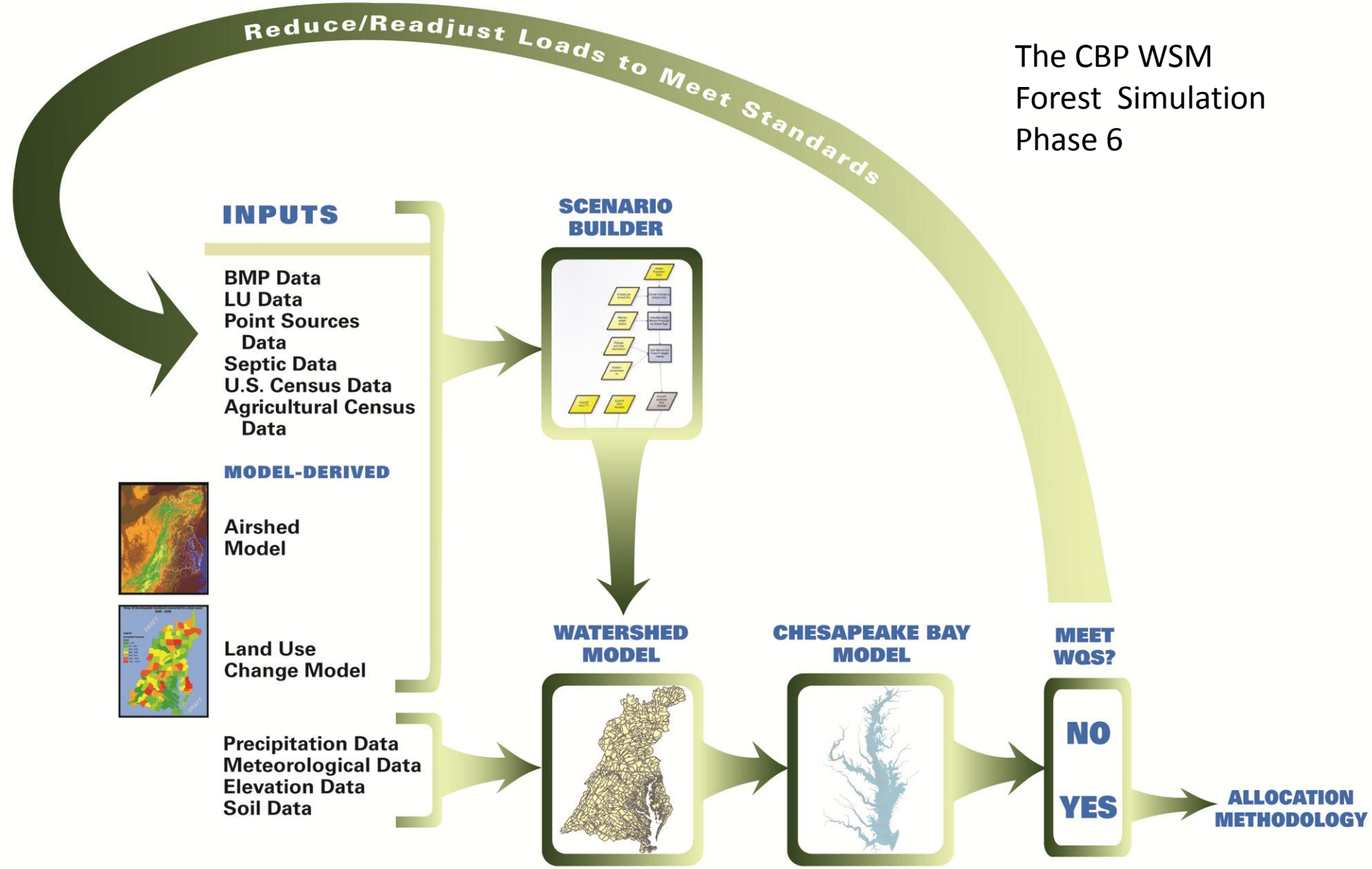
5/1/13

Forestry and Land Use Workgroups

Chesapeake Bay Partnership Models

The CBP WSM
Forest Simulation
Phase 6

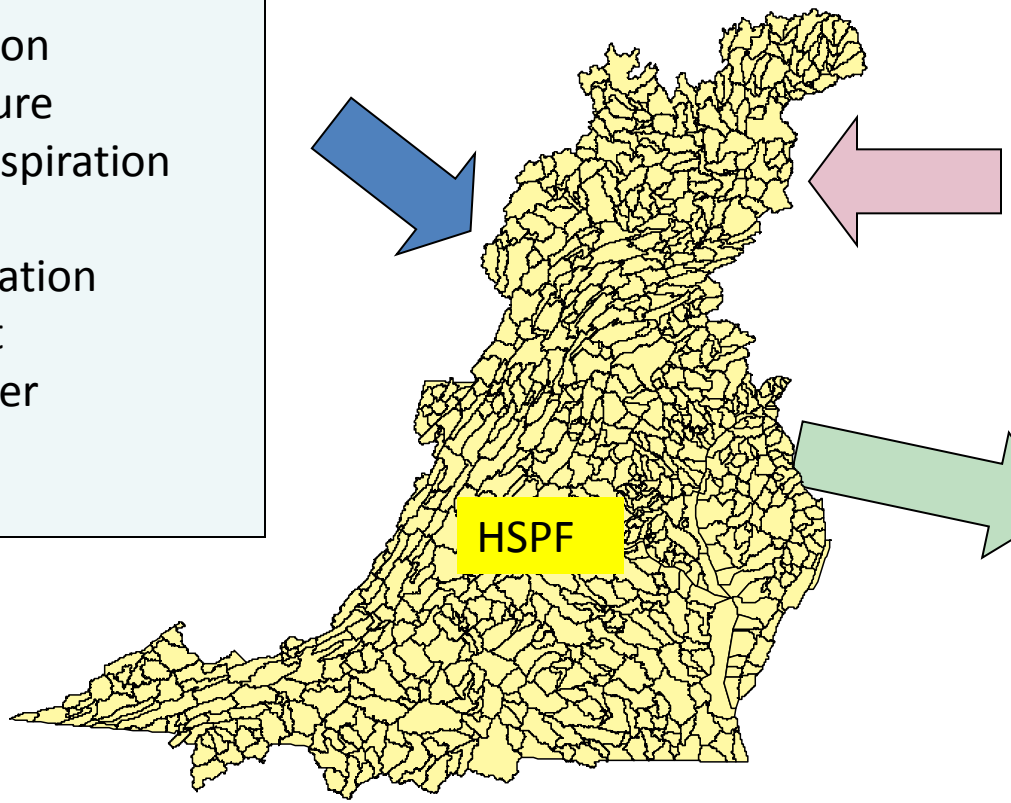


How the Watershed Model Works

Calibration Mode

Hourly or daily values of Meteorological factors:

Precipitation
Temperature
Evapotranspiration
Wind
Solar Radiation
Dew point
Cloud Cover



Annual, monthly, or daily values of anthropogenic factors:

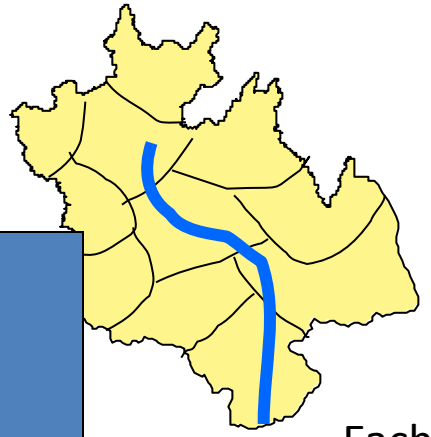
Land Use Acreage
BMPs
Fertilizer
Manure
Tillage
Crop types
Atmospheric deposition
Waste water treatment
Septic loads

Daily flow, nitrogen, phosphorus, and sediment compared to observations over 21 years

How the Watershed Model Works

Each segment consists of 30 separately-modeled land uses:

- Regulated Pervious Urban
- Regulated Impervious Urban
- Unregulated Pervious Urban
- Unregulated Impervious Urban
- Construction
- Extractive
- Combined Sewer System
- Wooded / Open
- Disturbed Forest



Plus: Point Source and Septic Loads, and Atmospheric Deposition Loads

- Corn/Soy/Wheat rotation (high till)
- Corn/Soy/Wheat rotation (low till)
- Other Row Crops
- Alfalfa
- Nursery
- Pasture
- Degraded Riparian Pasture
- Afo / Cafo
- Fertilized Hay
- Unfertilized Hay
  - Nutrient management versions of the above

Each calibrated to nutrient and Sediment targets

How the Watershed Model Works

Precipitation

Fertilizer
Manure
Atmospheric deposition

Management filter

Runoff

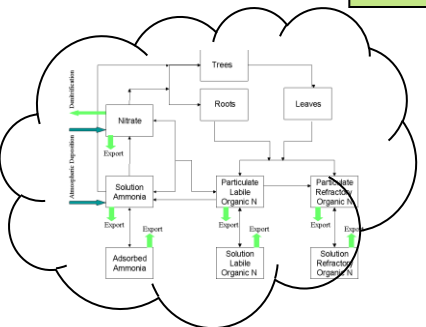
River

Hydrology submodel

Sediment submodel

Phosphorus submodel

Nitrogen submodel

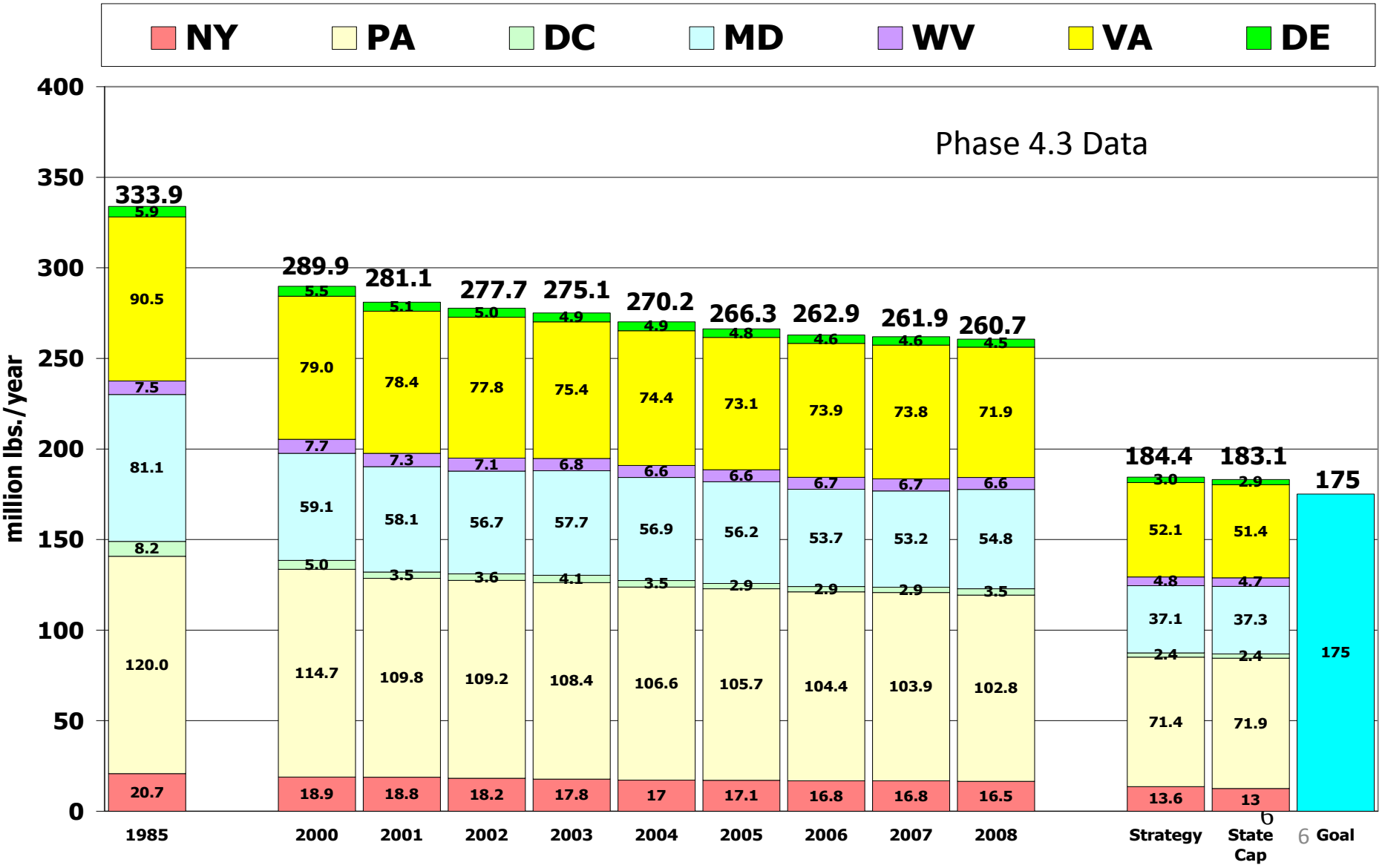


hourly

Buffers
wetlands

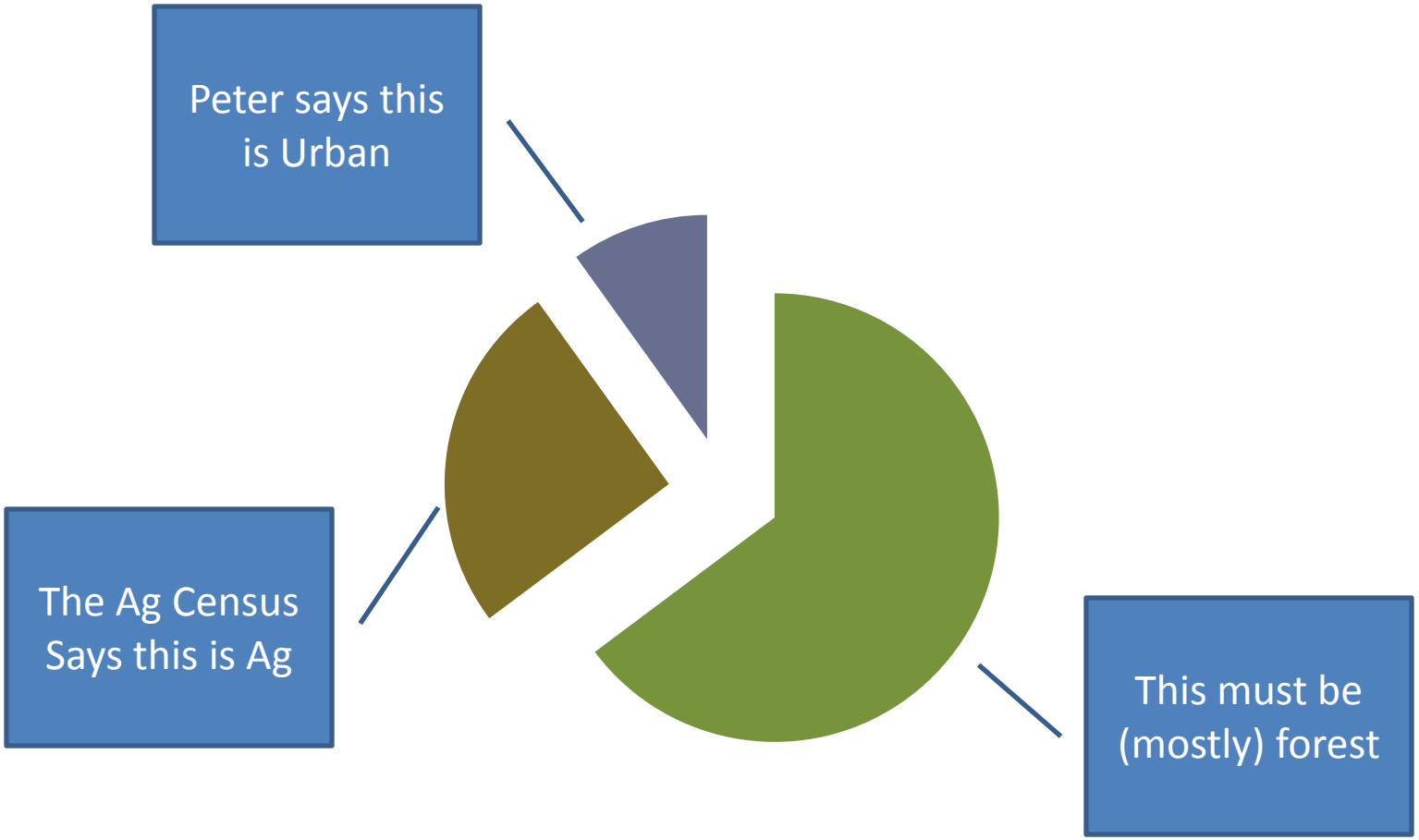
Nitrogen Loads Delivered to the Chesapeake Bay By Jurisdiction

Point source loads reflect measured discharges while
nonpoint source loads are based on an average-hydrology year



6

‘Wooded and other’ land use - an over-simplification

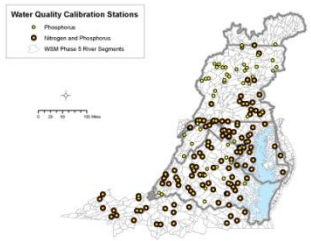


Land use Loads (another simplification)

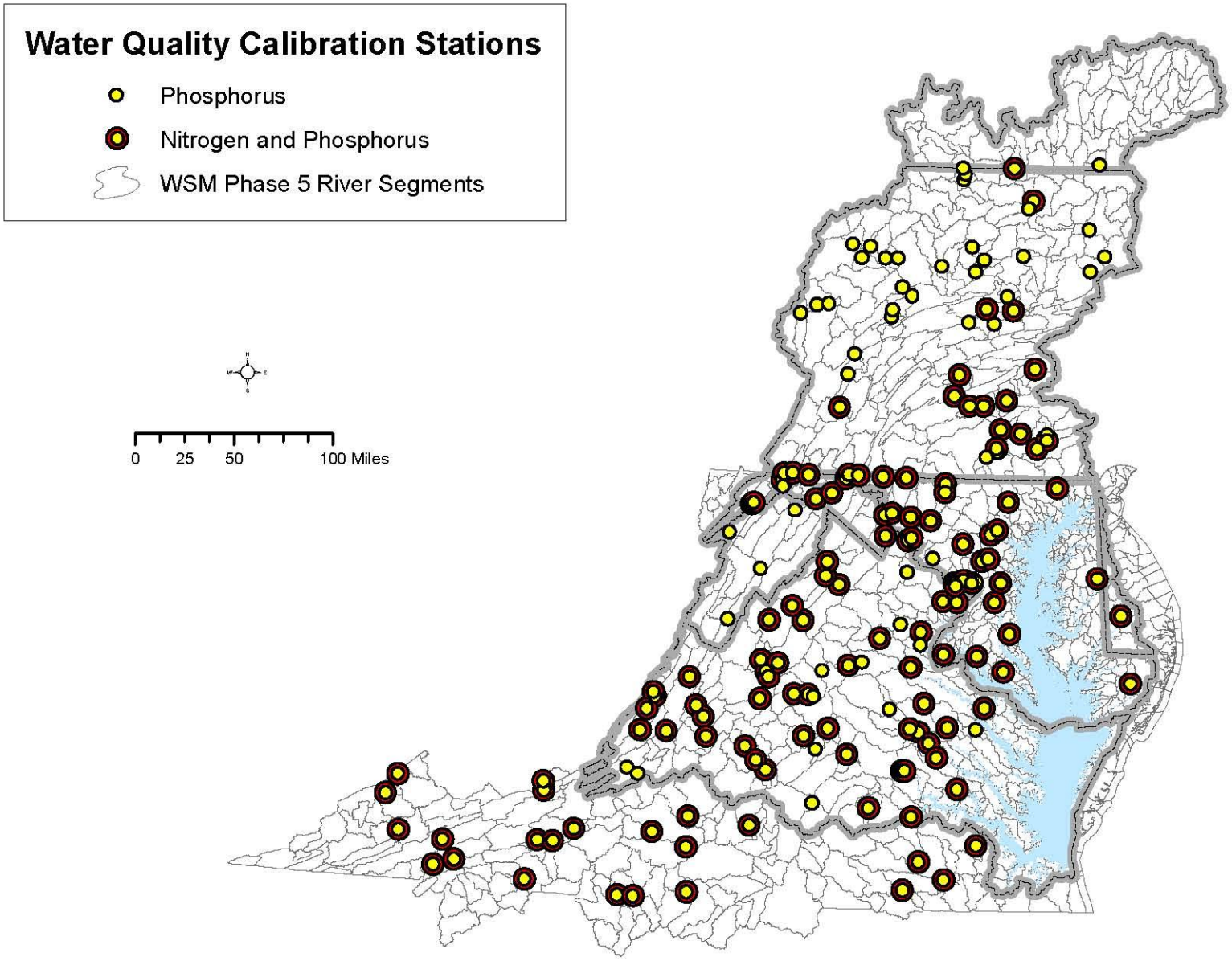
- Literature Surveys
- Additional Literature
- Other calibrated models
  - USGS Statistical Model
  - Earlier CBP WSMs

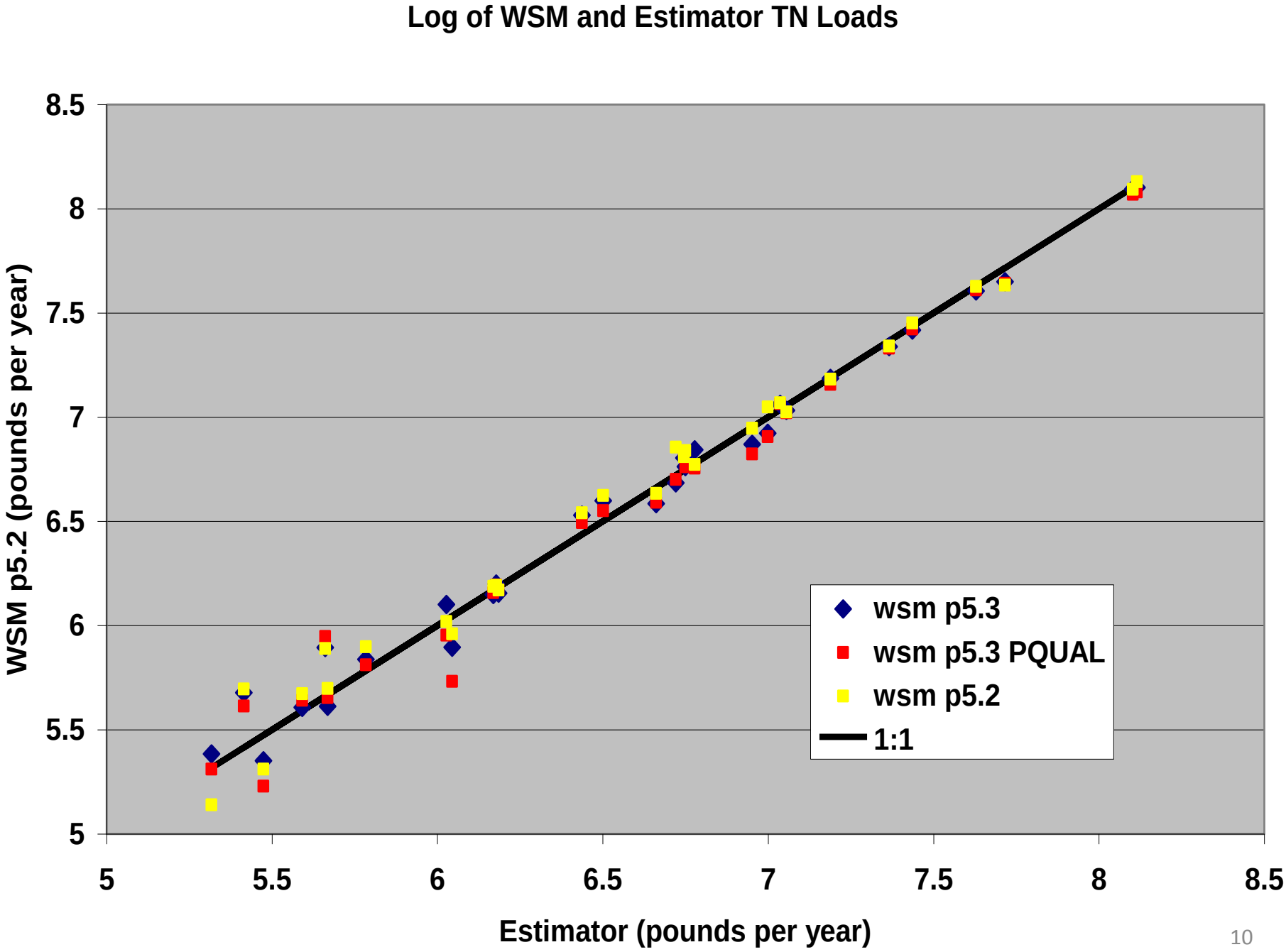
	N	P
• Forest	2	0.1
• Urban	10	1
• Ag	20	2

- Dependence on inputs
- More land use types

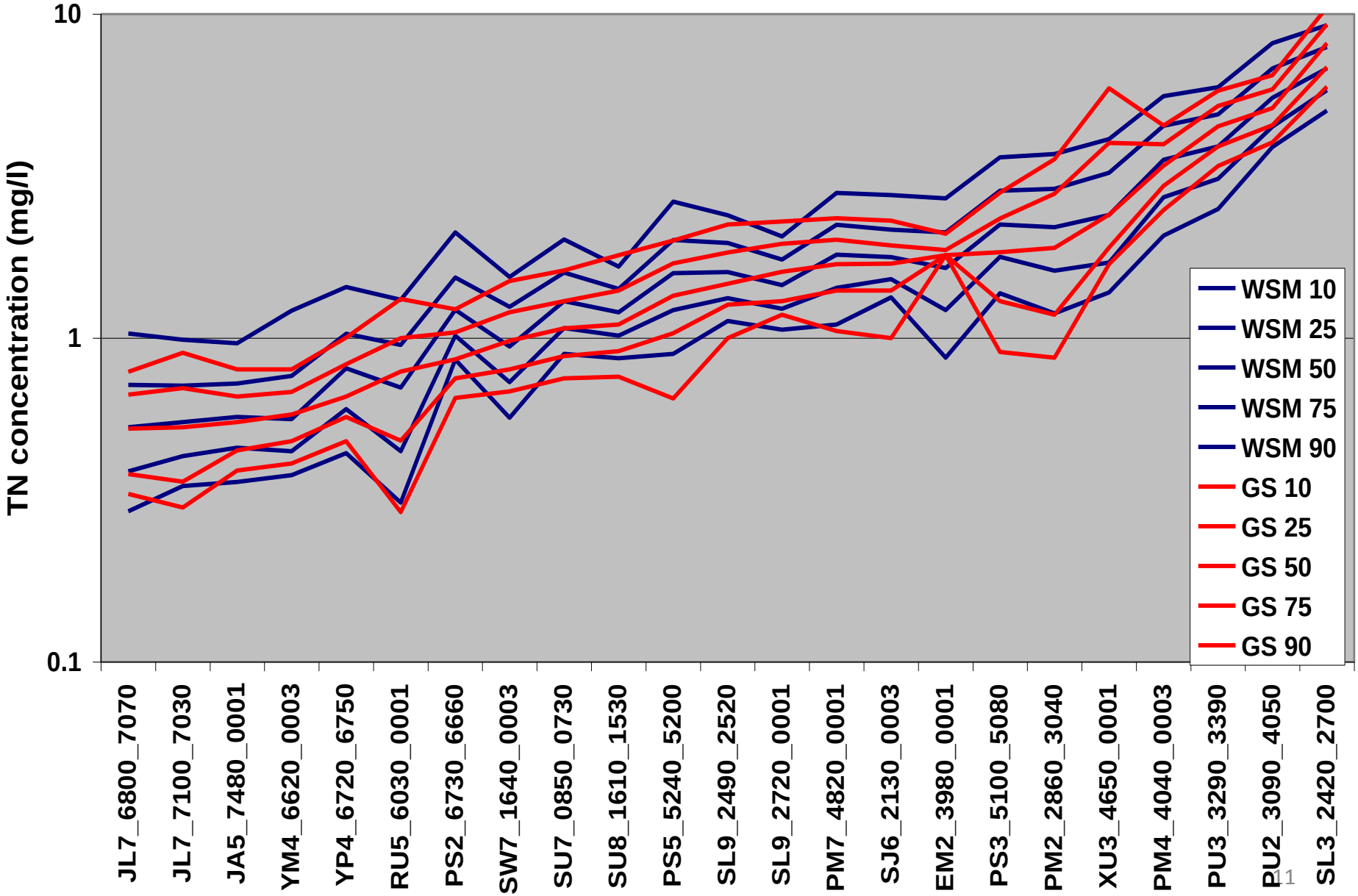


Edge-of-Stream Total Nitrogen (lb/a)	Mean	Median
forest, woodlots, and wooded	3.6	3.1
hay-unfertilized	6.8	6.2
nutrient management pasture	7.3	5.8
pasture	9.5	8.2
nutrient management hay	9.7	9.0
hay-fertilized	10.2	9.5
alfalfa	10.6	9.5
nutrient management alfalfa	10.9	11.6
high intensity impervious urban	11.8	9.9
low intensity impervious urban	11.9	10.4
high intensity pervious urban	12.8	10.9
low intensity pervious urban	13.2	11.2
extractive	14.0	13.1
harvested forest	24.3	21.4
bare-construction	29.5	26.4
nutrient management conservation till	37.1	39.6
conservation till receiving manures	38.1	39.6
nutrient management conventional till with manure	40.5	43.5
conventional till with manure	41.9	44.8
conventional till without manure	42.5	40.2
nutrient management conventional till without manure	42.9	42.4
degraded riparian pasture	52.4	45.9
nursery	286.7	253.8
animal feeding operations	1087.1	1045.7


Water Quality Calibration Stations
Phosphorus
Nitrogen and Phosphorus
WSM Phase 5 River Segments
0
25
50
100 Miles


Log of WSM and Estimator TN Loads
WSM p5.2 (pounds per year)
Estimator (pounds per year)
8.5
8
7.5
7
6.5
6
5.5
5
5
5.5
6
6.5
7
7.5
8
8.5
wsm p5.3
wsm p5.3 PQUAL
wsm p5.2
1:1

'Unbiased' USGS samples vs WSM Population TN p5.3



https://archive.chesapeakebay.net/Modeling/P5Documentation/SECTION_10.pdf

Nitrogen Loading Rates

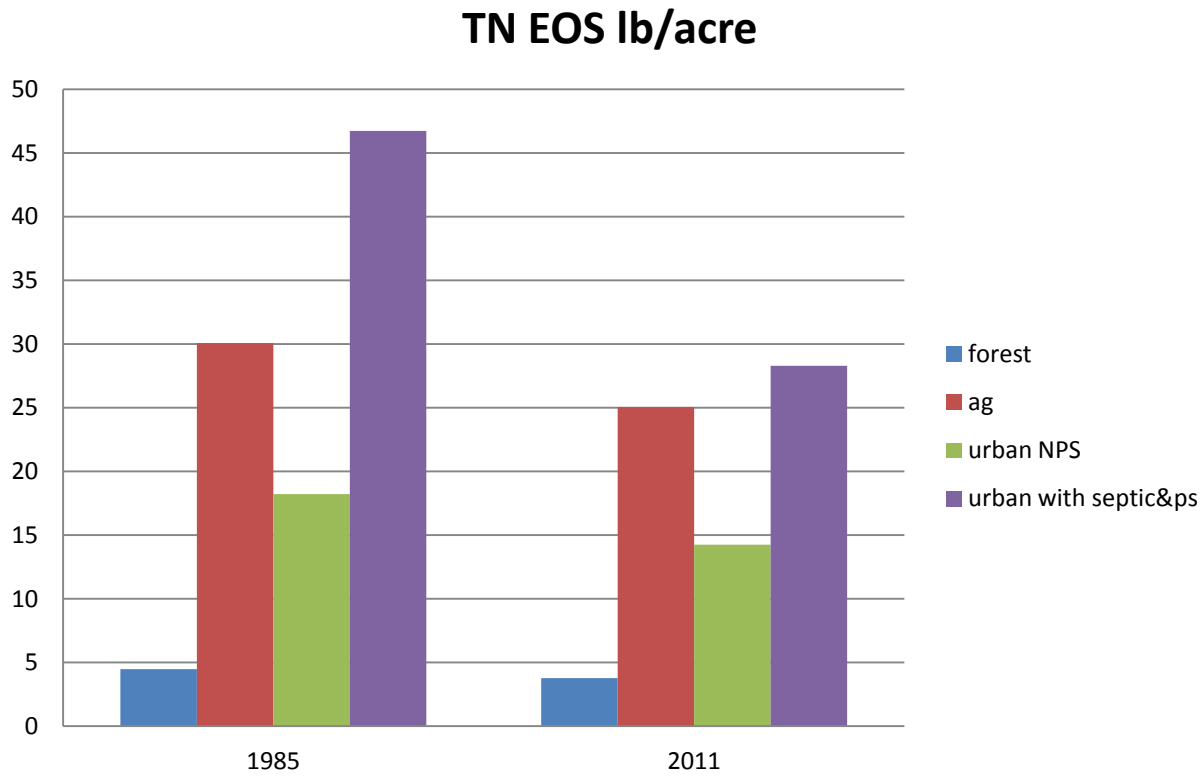
Edge-of-Stream Total Nitrogen (lb/a)	Mean	Median
forest, woodlots, and wooded	3.6	3.1
hay-unfertilized	6.8	6.2
nutrient management pasture	7.3	5.8
pasture	9.5	8.2
nutrient management hay	9.7	9.0
hay-fertilized	10.2	9.5
alfalfa	10.6	9.5
nutrient management alfalfa	10.9	11.6
high intensity impervious urban	11.8	9.9
low intensity impervious urban	11.9	10.4
high intensity pervious urban	12.8	10.9
low intensity pervious urban	13.2	11.2
extractive	14.0	13.1
harvested forest	24.3	21.4
bare-construction	29.5	26.4
nutrient management conservation till	37.1	39.6
conservation till receiving manures	38.1	39.6
nutrient management conventional till with manure	40.5	43.5
conventional till with manure	41.9	44.8
conventional till without manure	42.5	40.2
nutrient management conventional till without manure	42.9	42.4
degraded riparian pasture	52.4	45.9
nursery	286.7	253.8
animal feeding operations	1087.1	1045.7

https://archive.chesapeakebay.net/Modeling/P5Documentation/SECTION_10.pdf

Phosphorus Loading Rates

Edge-of-Stream Total Phosphorus (lb/a)	Mean	Median
hay-unfertilized	0.03	0.03
hay-fertilized	0.06	0.05
forest, woodlots, and wooded	0.14	0.13
nutrient management hay	0.16	0.15
nutrient management alfalfa	0.82	0.83
high intensity pervious urban	0.88	0.89
low intensity pervious urban	0.90	0.90
alfalfa	0.92	0.87
nutrient management pasture	0.94	0.83
pasture	0.99	0.92
harvested forest	1.14	1.02
nutrient management conservation till	1.88	1.56
conservation till with manures	2.00	1.73
nutrient management conventional till with manures	2.39	1.98
conventional till with manures	2.51	2.05
high intensity impervious urban	2.62	2.49
low intensity impervious urban	2.63	2.50
nutrient management high till without manures	3.07	2.92
conventional till without manures	3.09	3.08
extractive	4.83	4.42
bare-construction	9.67	8.81
degraded riparian pasture	11.77	10.97
animal feeding operations	59.97	56.45
nursery	118.51	111.98

Land use Loads - Nitrogen

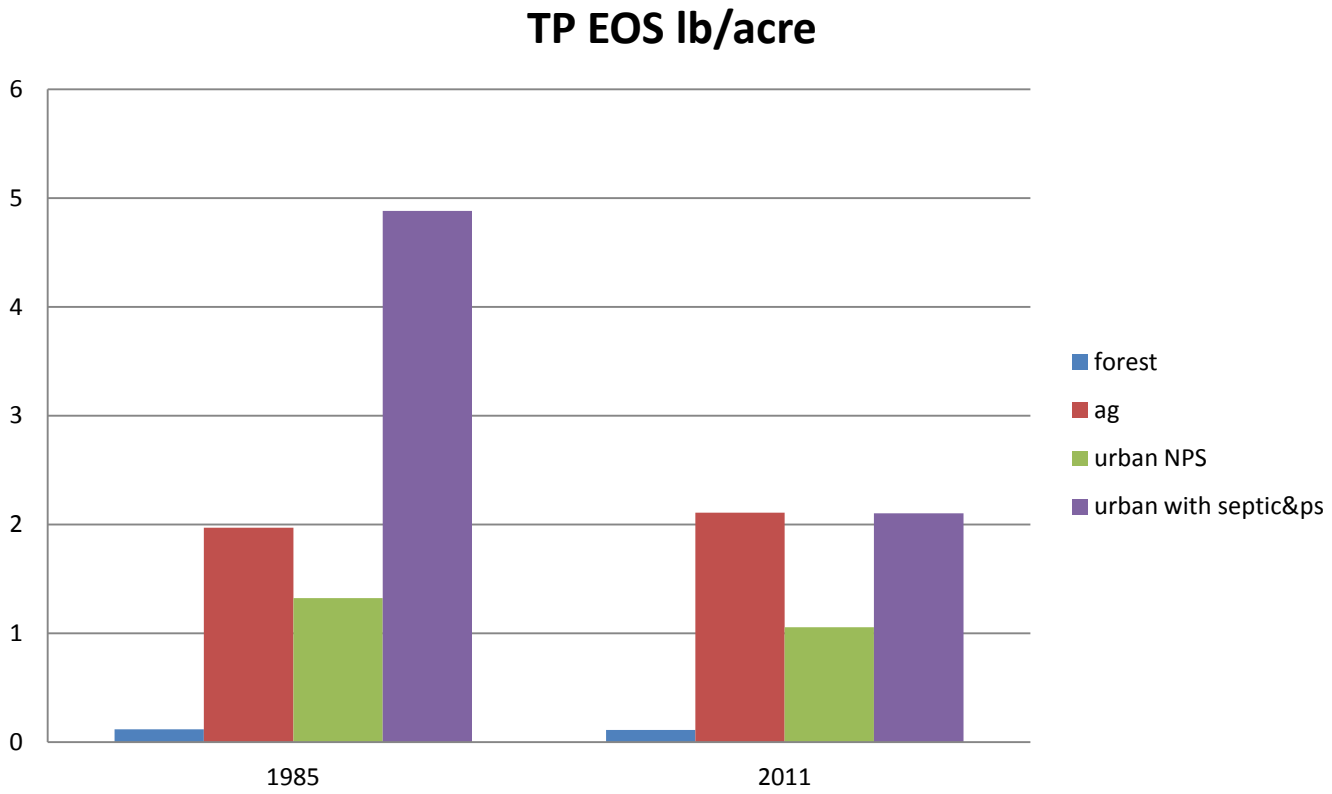


Source: Phase 5.3.2 Watershed model

Originally based on:

- Literature Surveys
- Additional Primary Literature
- USGS Statistical Model (Sparrow)

Land use Loads - Phosphorus



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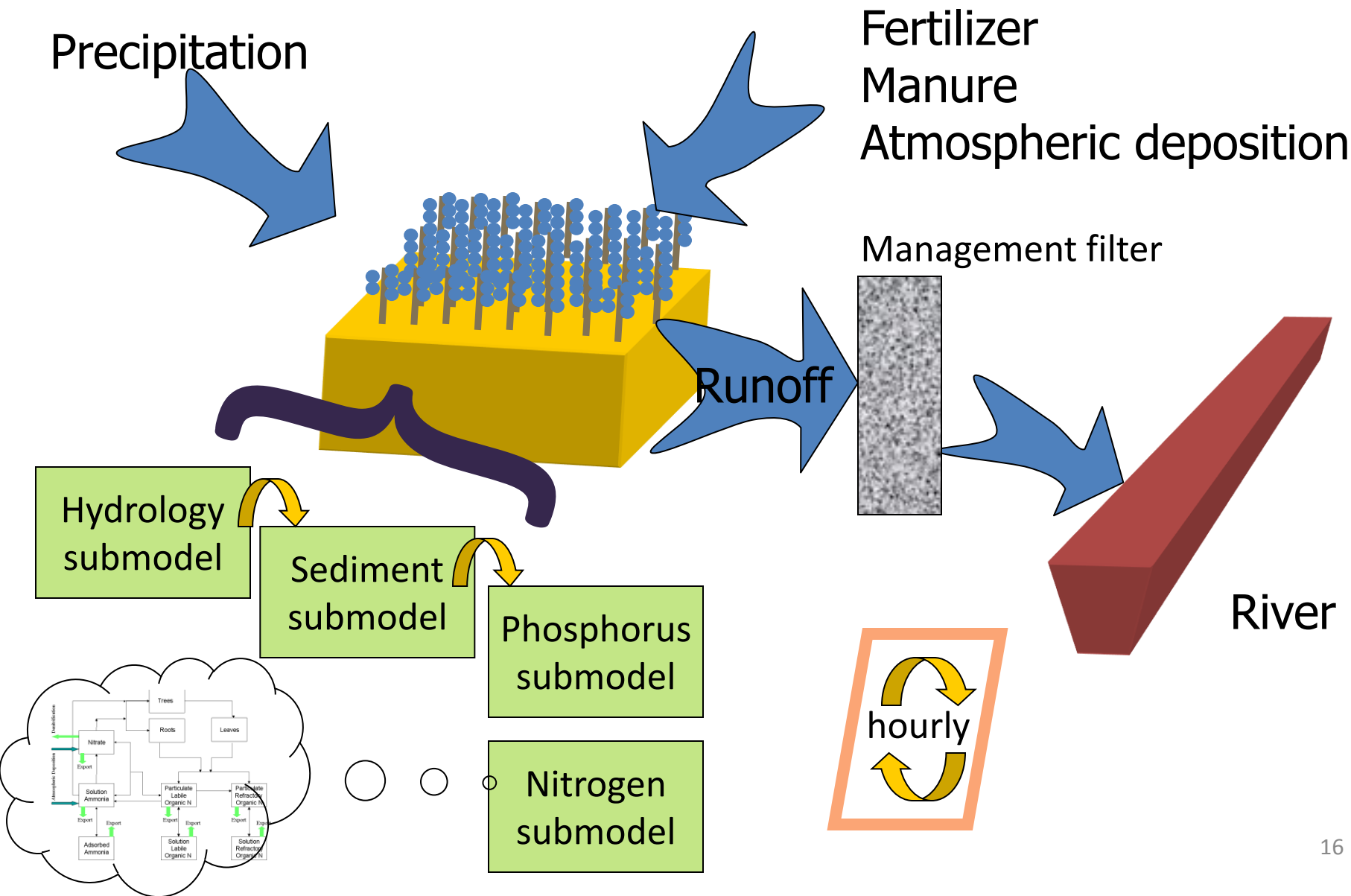
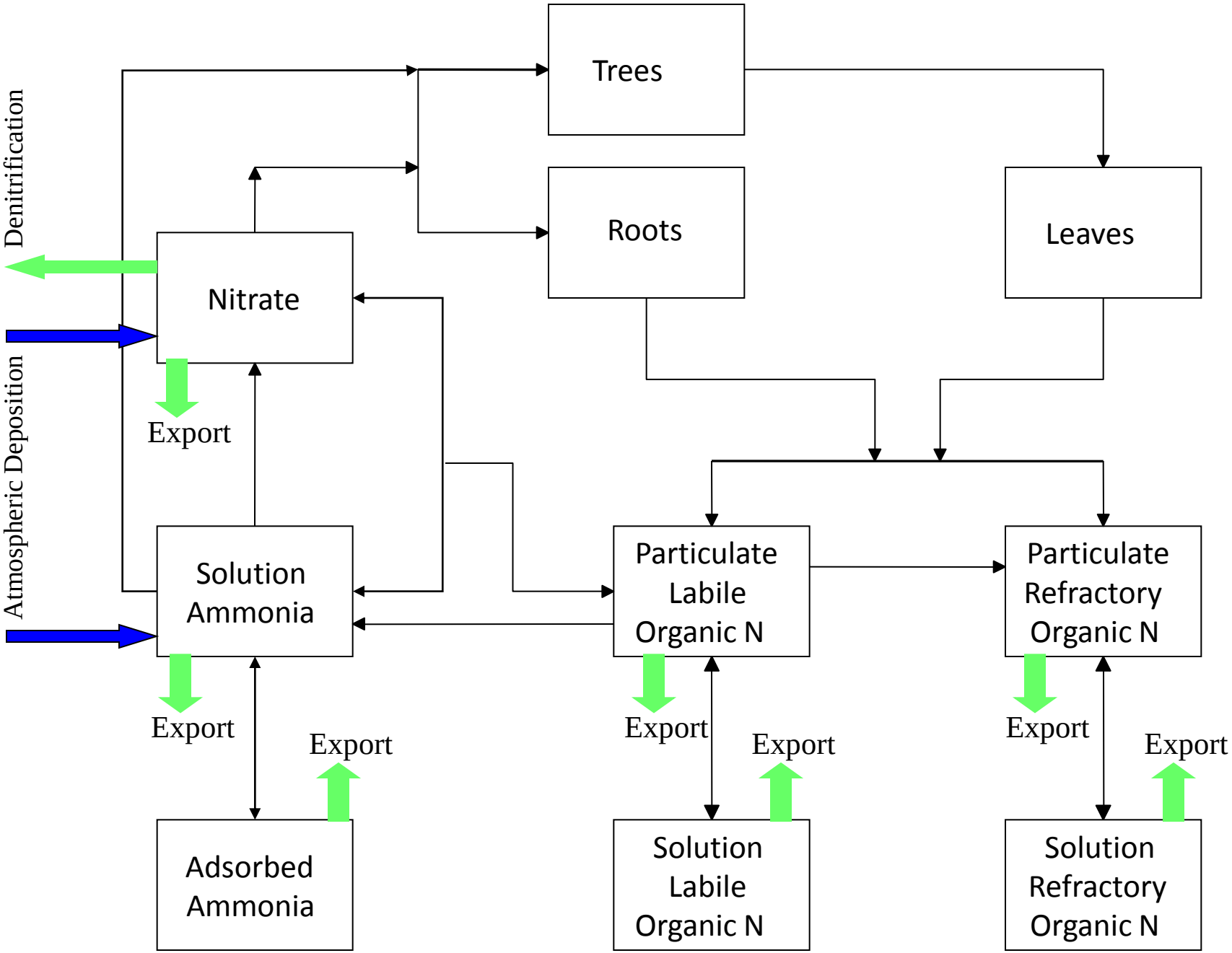
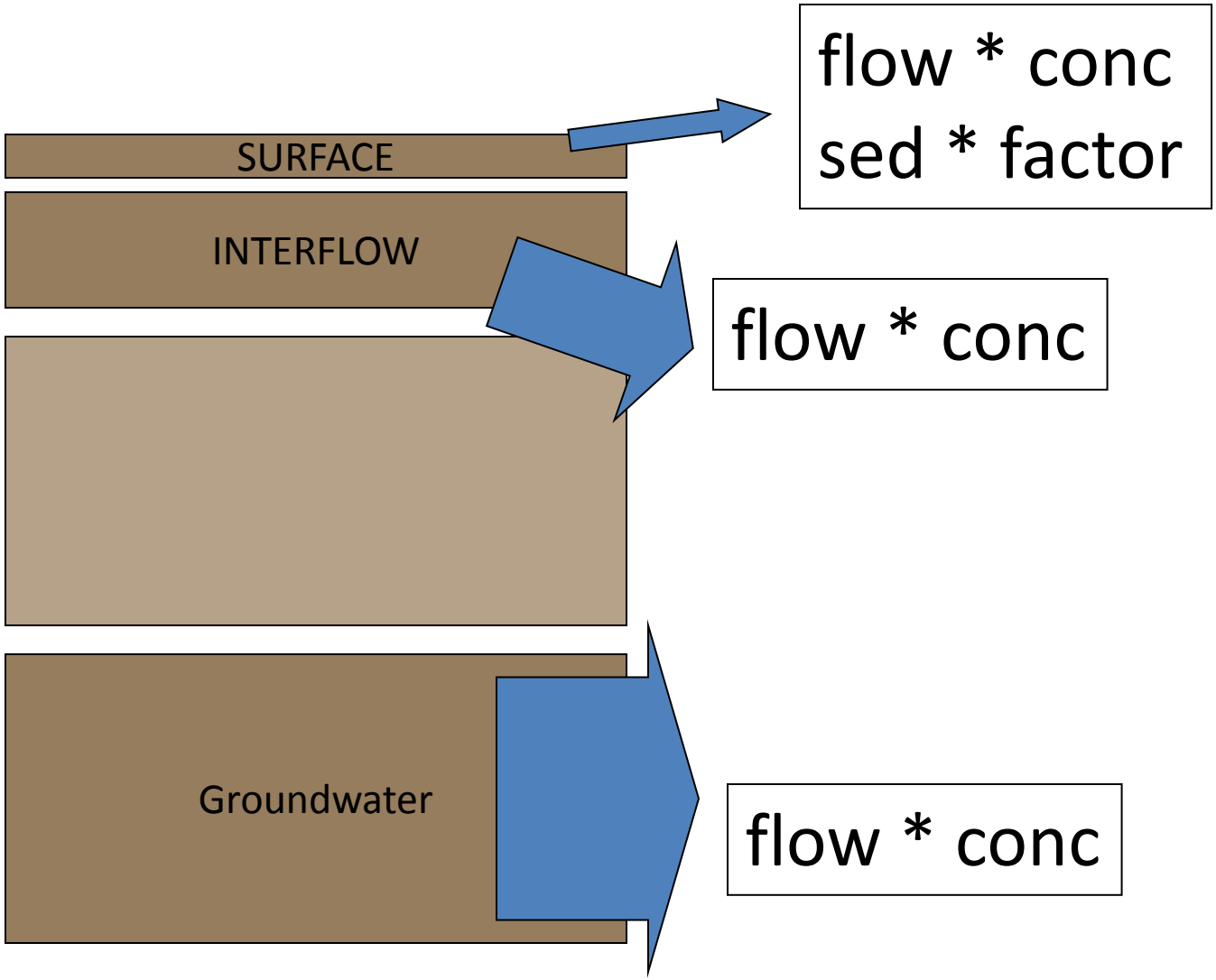
Changes in Phase 6



AGCHEM Loading Model - simulated separately in each soil layer



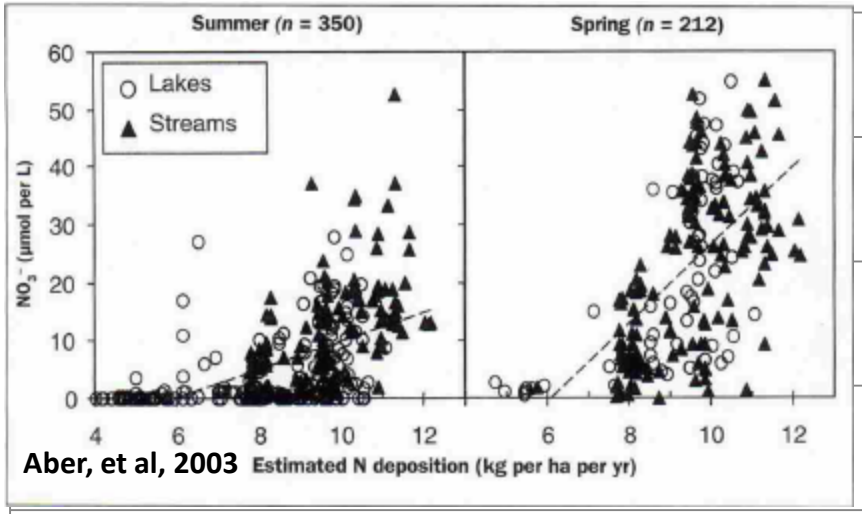
PQUAL loading model



Complex *vs* Simple

Complex	Simple
• Calibration is complex and time consuming	• Calibration is relatively simple and fast
• Calibration is imprecise	• Calibration is precise
• Longer run time	• Shorter run time
• Simulated sensitivity to inputs	• Sensitivity to inputs must be specified

Reduction in forest loads from 1985 to CAIR

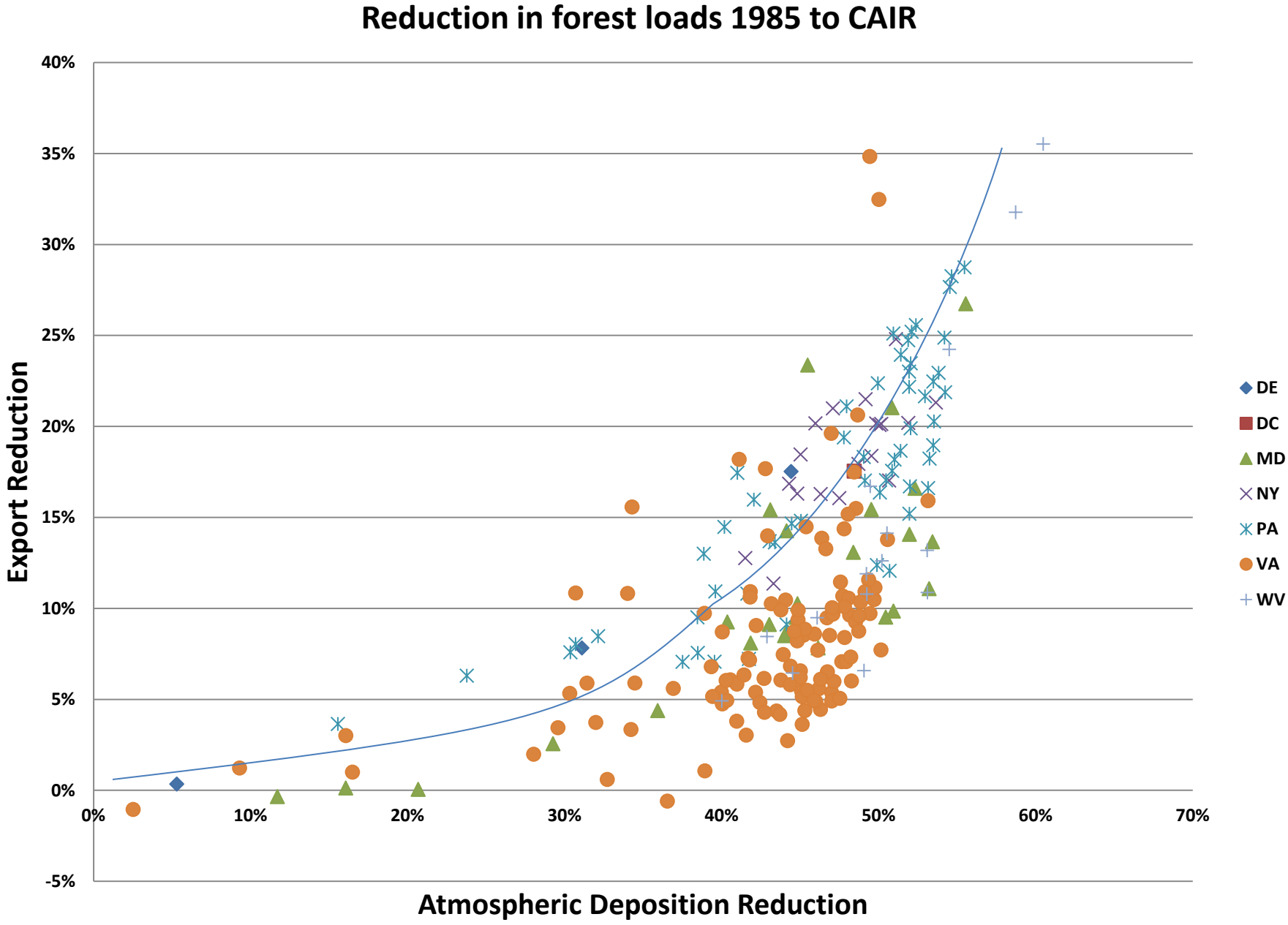


Export Reduction

40%
35%
30%
25%
20%
15%
10%
5%
0%
-5%

0%
10%
20%
30%
40%
50%
60%
70%

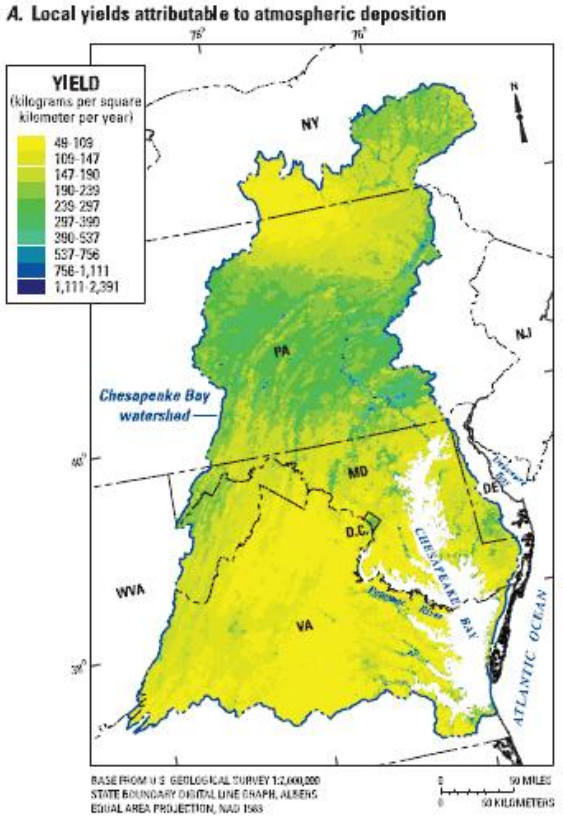
Atmospheric Deposition Reduction


Reduction in forest loads 1985 to CAIR
Export Reduction
Atmospheric Deposition Reduction
40%
35%
30%
25%
20%
15%
10%
5%
0%
-5%
0%
10%
20%
30%
40%
50%
60%
70%
DE
DC
MD
NY
PA
VA
WV

USGS
science for a changing world

SPARROW Surface Water-Quality Modeling

NAWQA Home | Model Description | Fact Sheet | Decision Support System | FAQs

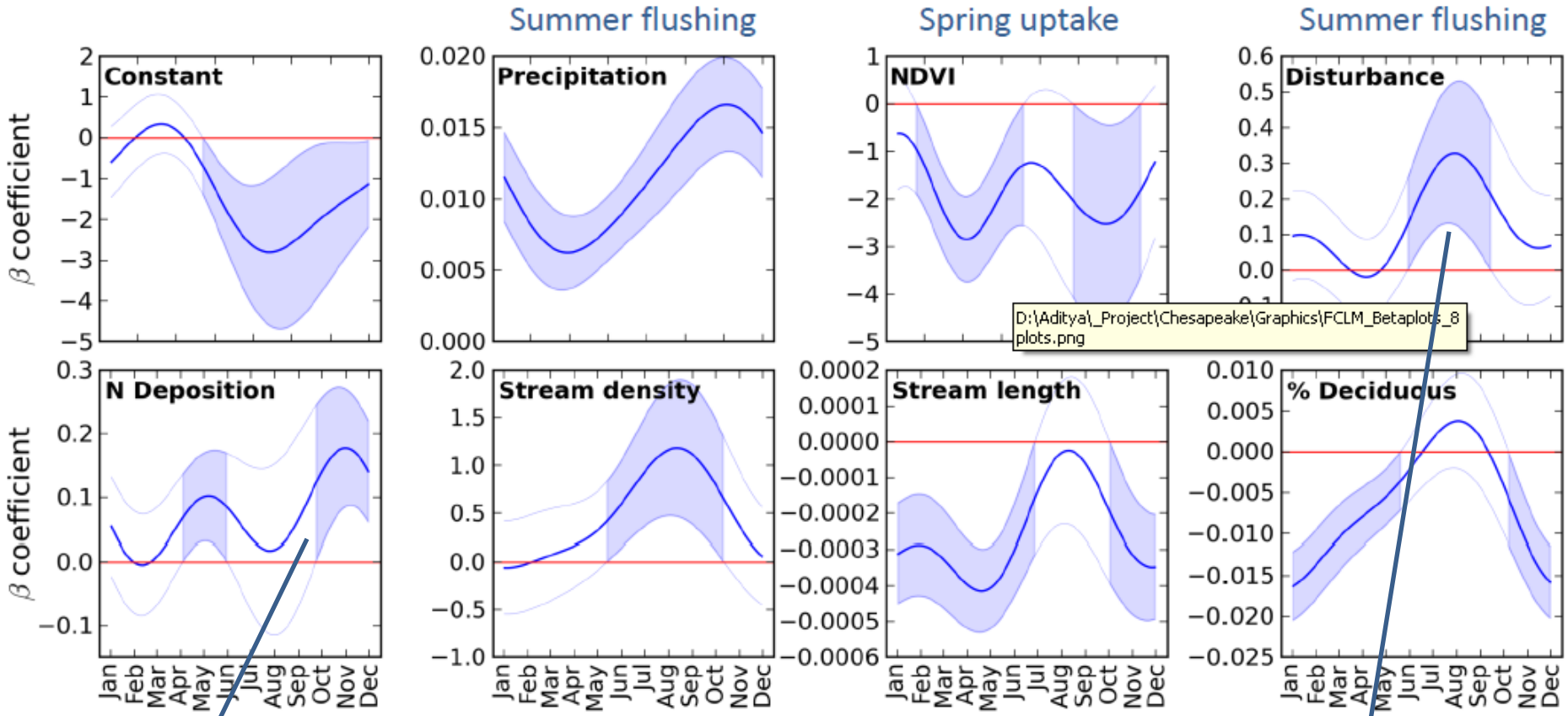


Total Nitrogen, 2002
(n = 181, MSE = 0.0836, RMSE = 0.289, flux R^2 = 0.978, yield R^2 = 0.858

Explanatory variables	Estimate	Units	90-percent confidence interval	Standard error	p[1]
Sources					
Point sources (kg yr^{-1})	0.774		0.375 – 1.17	0.242	0.0008
Crop fertilizer and fixation (kg yr^{-1})	0.237		0.177 – 0.297	0.0363	< 0.0001
Manure (kg yr^{-1})	0.0582		0.0138 – 0.103	0.0269	0.0157
Atmospheric deposition (kg yr^{-1})	0.267		0.179 – 0.355	0.0533	< 0.0001
Urban[2] (km^2)	1,090	kg km^{-2} yr^{-1}	707 – 1,480	234	< 0.0001
Land-to-water delivery					
ln[Mean EVI for WY02 (dimensionless)]	-1.70		-2.65 – -0.737	0.580	0.0039
ln[Mean soil AWC (fraction)]	-0.829		-1.26 – -0.401	0.260	0.0016
ln[Groundwater recharge (mm)]	0.707	mm^{-1}	0.499 – 0.916	0.126	< 0.0001
ln[Piedmont carbonate (percent of area)]	0.158		0.0755 – 0.241	0.0500	0.0018

Results:

Regression of monthly nitrate yield – Preliminary Results



Estimating nitrate export from Chesapeake Bay watersheds using MODIS and climate data

Aditya Singh and Phil Townsend

Angélica Gutiérrez-Magness

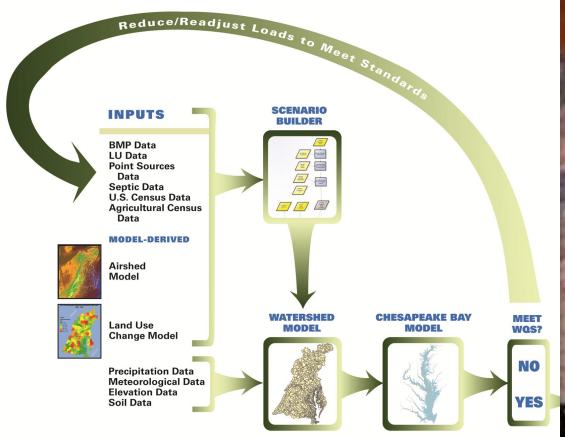
Keith Eshleman

Brenden McNeil

Deposition is Important in the spring and fall

Disturbance is Important in the summer

What's on the table for Phase 6?



What do we need to know about a land use?

- Where it is and how much is there
  - History to 1985
  - Method to estimate current
  - Projection to 2050?
- Loading rates
  - Vary by physical setting
  - Vary by anthropogenic effect
    - Input Loads
    - BMPs

Who Decides?

- WQGIT – Ultimate responsibility
- Forestry Workgroup – Can make recommendations on land use types, loading rates, BMPs, or any other aspect of modeling.
- Land Use Workgroup – primary responsibility to determine land uses and methods to map them. Can make recommendations on loading rates.
- Modeling Workgroup – primary responsibility to determine loading rates. Can make recommendations on land uses.