Development of Phase 6 Model Land Use Targets

Modeling Quarterly Review Meeting

Watershed Modeling

January 29, 2015

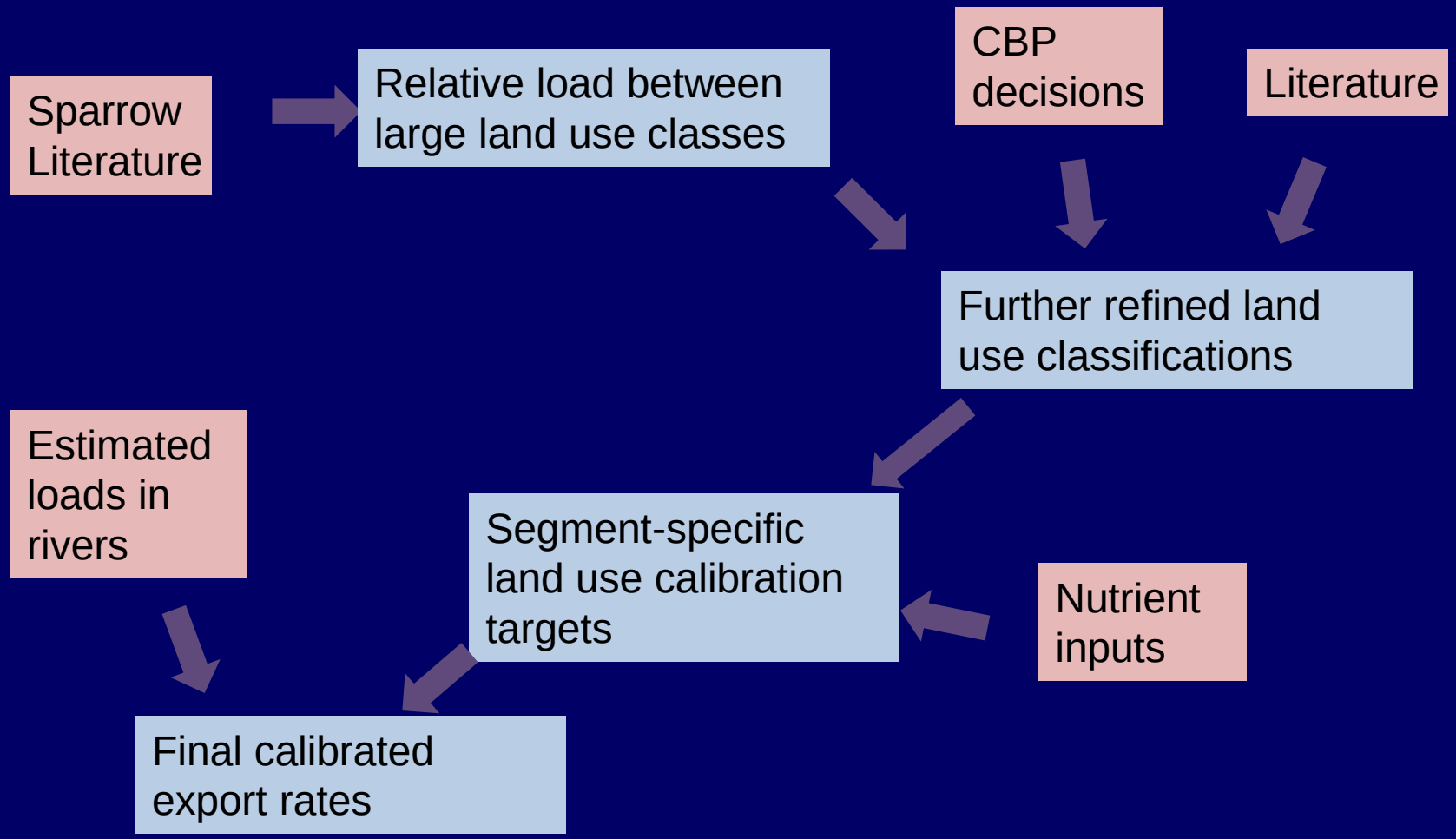
Olivia Devereux

Export Rates and Targets

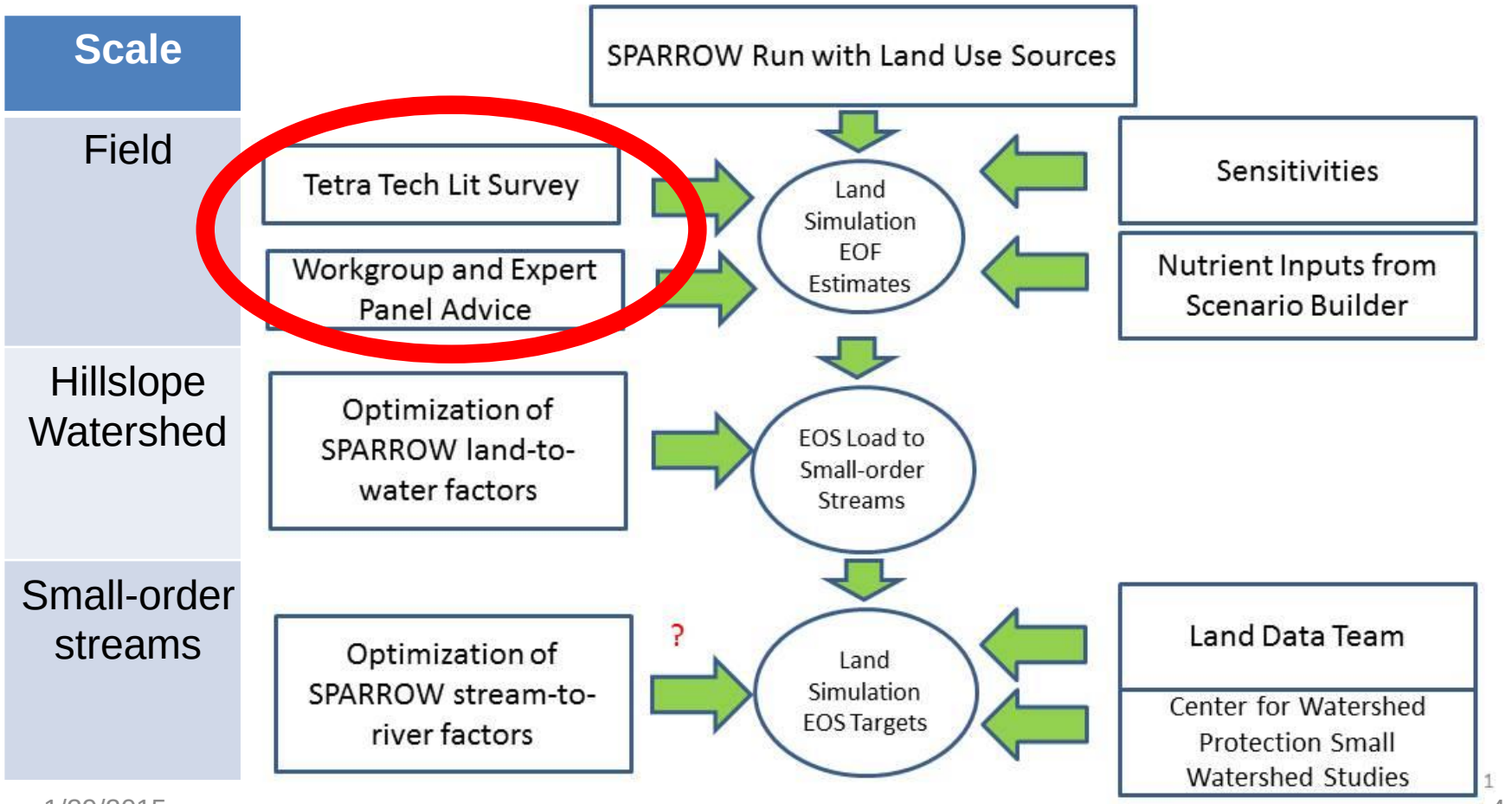
- Export rates from multiple models and literature are used to inform the targets

- Targets are a type of export rate used to calibrate the Phase 6 Watershed Model
  - Do not include BMPs
  - Orders the influence of different land uses
  - Vary geographically based on nutrient and hydrology inputs
  - Subject to modification through calibration: actual rate adjusted while relative differences maintained

Land Use Load Decisions – Phase 6



Land Simulation Development



Data Sources for Establishing Targets

- Panel and workgroup documents and recommendations (e.g.: Erosion and Sediment Control Expert Panel Report)
- Collaborative work with USGS-Sparrow
- Chesapeake Bay Program nutrient input sensitivities using the multiple model framework
  - APLE
  - APEX
  - AgCHEM
  - SPARROW
- Center for Watershed Protection small-scale sediment work
- Land data team riparian analyses
- Land data team impervious connectedness analysis
- STAC recommendations
- Chesapeake Bay Program Partnership Watershed Model Phase 5 background documentation, where relevant and reflects the latest science
- Mandel river calibration work.

Reviews of Scientific Literature and local TMDLs: Developed, Natural and Agricultural Land Uses

TETRA TECH

MEMO

To:	Gary Shenk, EPA; Peter Claggett, USGS
Cc:	Tom Schueler, CSN
From:	Mark Sievers, Tetra Tech Inc.
Date:	March 31, 2014
Subject:	Land Use Loading Literature Review Task Summary and Results

The memo is separated into the following sections (click for hyperlink):

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PRELIMINARY DRAFT

Agricultural and Forest Land Use Loading Rate Literature Review—Summary and Results

January 13, 2015

PREPARED BY:

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Additional Information Gathering

- Wetland Literature Review (conducted in conjunction with the Wetland Expert Panel)
    - Review for wetland efficiency
    - Potential wetland land uses
    - Review for loading rates
- Agriculture “Grey” Literature (collected by Virginia Tech/CBW-ROC)
    - Unpublished, not peer reviewed
    - May include negative results
    - Negative results are generally considered to be systematically censored in peer-reviewed publications; meta-analysis from peer-reviewed sources may be systematically biased
- Forestry (Urban Tree Canopy Expert Panel and Forestry Workgroup)

Role of Sparrow

- Sparrow's strengths are indicating the differences among land use categories
  - edge of field (EOF) export rates by land use

- Sparrow generates uncertainty estimates

Using Sparrow's Large Land Use Groups

When SPARROW is run with land uses as the regression parameters, then the regression coefficients are equivalent to export rates at an edge of small stream scale

Land Use	TN (lb/A)	TP (lb/A)
cropland	24.03	0.90
forest	1.20	0.07
pasture	17.20	0.49
point source	0.83	0.87
urban	9.35	0.49
wetland	0.00	NA

Challenges to Comparing Sources

- Different land use categories in different sources
- Mix of scales: EOF and EOS
- Where Land to Water (LTW) and Regional Factors are accounted for
- Sources of data: Literature review or local TMDL, monitored or modeled

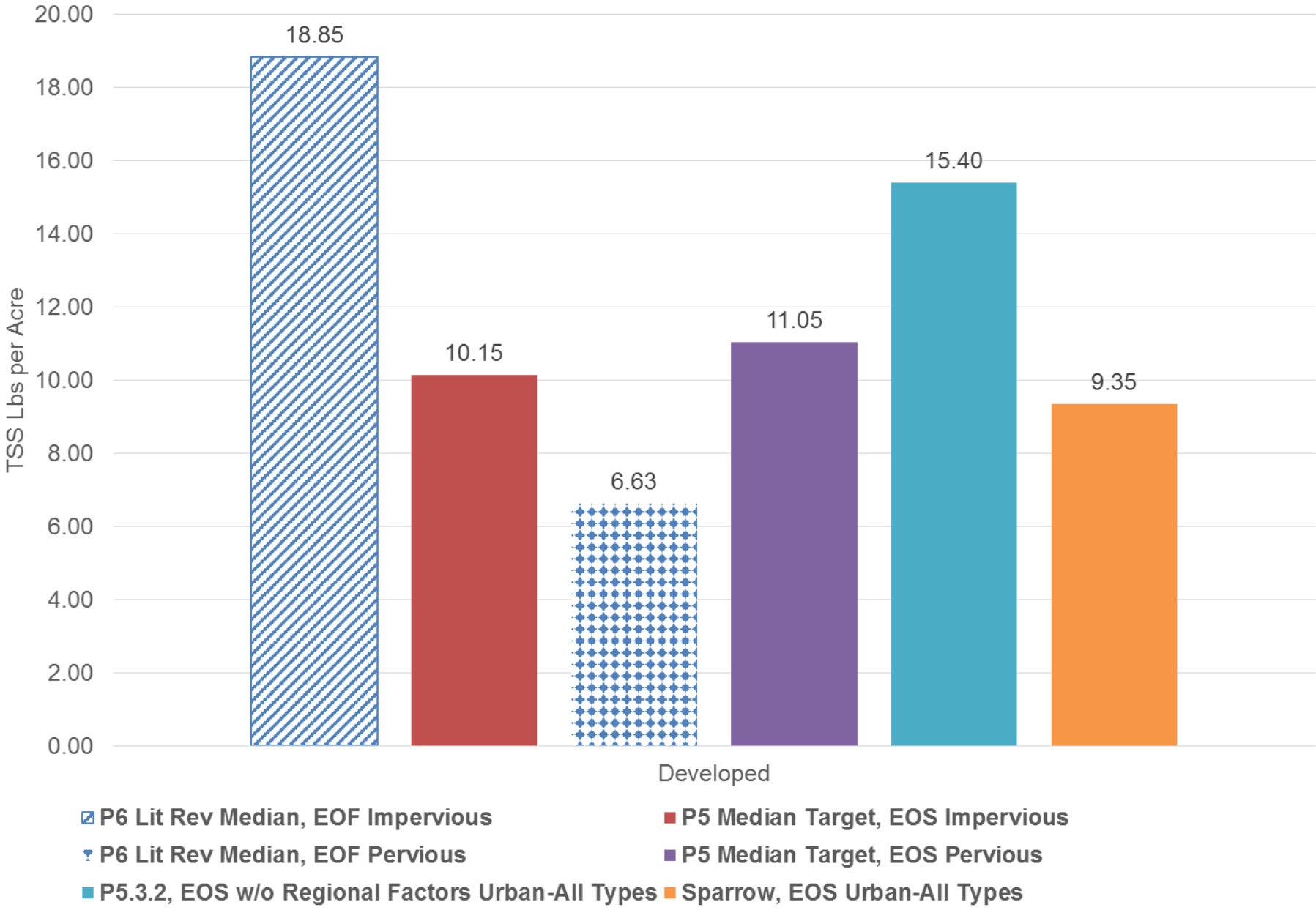
Land Uses: Developed

- Pervious and impervious
  - Converted concentrations to loads using surface runoff rates for impervious land uses and surface + interflow for pervious land uses
- Construction
  - Used the Erosion and Sediment Control Expert Panel recommendations. Adjusts TSS, keeps the loads the same as Phase 5 for TN and TP
- Extractive
  - Mining varies among types (e.g.: coal, gravel, bluestone (dolerite))
  - Literature review generated data from 4 local TMDLs once WSM data was excluded.
  - Need to consider the effect of the Abandoned Mineland BMP

Developed—TN

Data Source	Land use	Scale	TN Lb/A	TN Count
P6 Lit Rev Median	Construction	EOS	26.40	NA
P5 Median Target	bare-construction	EOS	26.40	NA
P6 Lit Rev Median	Developed Impervious Buildings Parking Lots Etc	EOF	17.39	2795
P6 Lit Rev Median	Developed Impervious Roads	EOF	20.31	287
P6 Lit Rev Median	Developed Pervious Open Space	EOF	3.01	294
P6 Lit Rev Median	Developed Pervious Turf	EOF	10.25	1538
P6 Lit Rev Median	Extractive	EOS	0.99	1
P5 Median Target	Extractive	EOS	13.10	NA
P5 Median Target	high intensity impervious urban	EOS	9.90	NA
P5 Median Target	high intensity pervious urban	EOS	10.90	NA
P5 Median Target	low intensity impervious urban	EOS	10.40	NA
P5 Median Target	low intensity pervious urban	EOS	11.20	NA
P5.3.2	Urban-All Types	EOS w/o Regional Factors	15.40	NA
Sparrow	Urban-All Types	EOS	9.35	NA

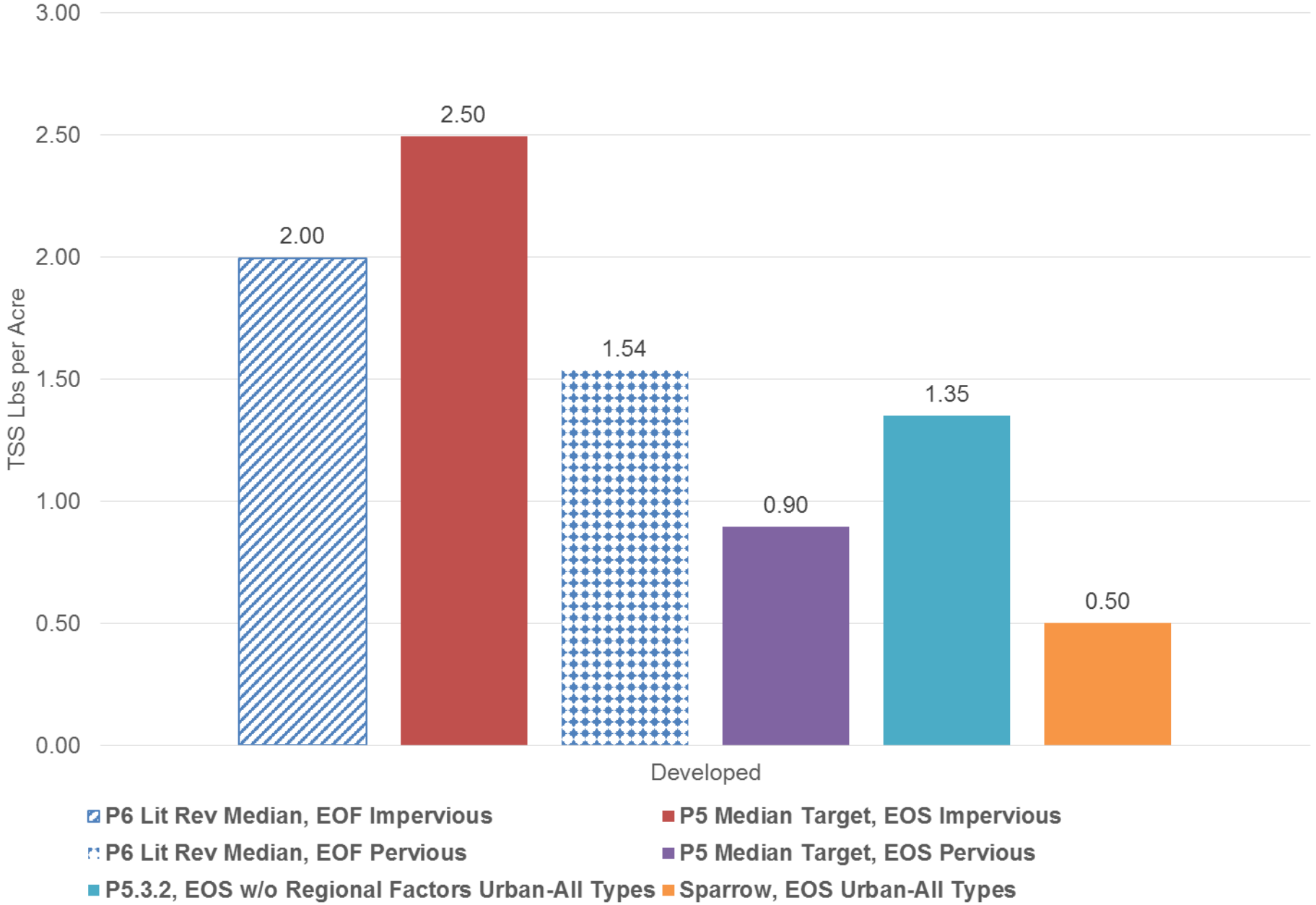
Developed TN



Developed—TP

Data Source	Land use	Scale	TP Lb/A	TP Count
P6 Lit Rev Median	Construction	EOS	8.81	NA
P5 Median Target	bare-construction	EOS	8.81	NA
P6 Lit Rev Median	Developed Impervious Buildings Parking Lots Etc	EOF	1.80	3943
P6 Lit Rev Median	Developed Impervious Roads	EOF	2.19	686
P6 Lit Rev Median	Developed Pervious Open Space	EOF	0.88	355
P6 Lit Rev Median	Developed Pervious Turf	EOF	2.19	2338
P6 Lit Rev Median	Extractive	EOS	5.90	4
P5 Median Target	Extractive	EOS	4.42	NA
P5 Median Target	high intensity impervious urban	EOS	2.49	NA
P5 Median Target	high intensity pervious urban	EOS	0.89	NA
P5 Median Target	low intensity impervious urban	EOS	2.50	NA
P5 Median Target	low intensity pervious urban	EOS	0.90	NA
P5.3.2	Urban-All Types	EOS w/o Regional Factors	1.35	NA
Sparrow	Urban-All Types	EOS	0.50	NA

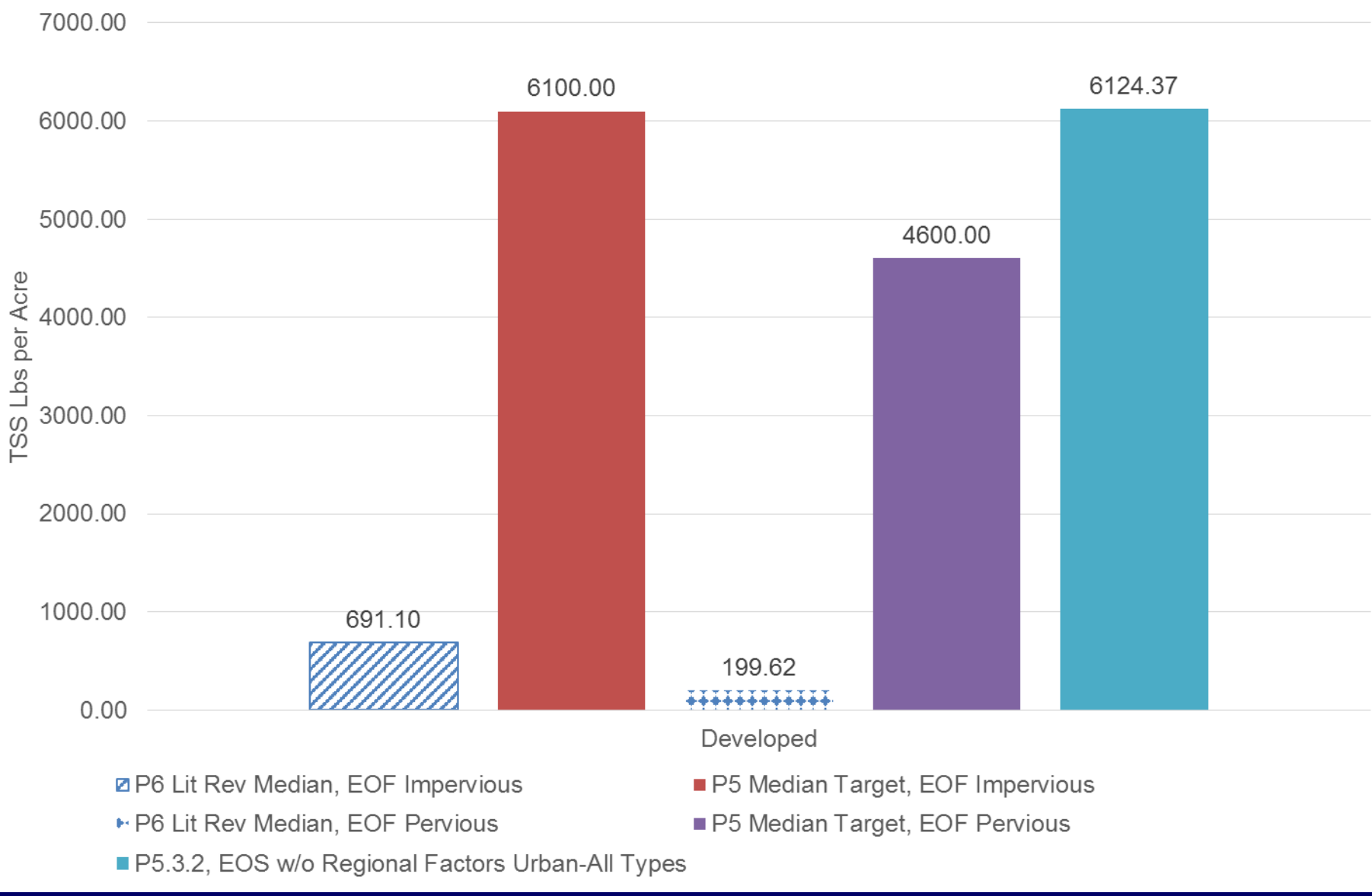
Developed TP



Developed—TSS

Data Source	Land use	Scale	TSS Lb/A	TSS Count
P6 Lit Rev Median	Construction	EOS	24000.00	NA
P5 Median Target	bare-construction	EOF	48000.00	NA
P6 Lit Rev Median	Developed Impervious Buildings Parking Lots Etc	EOF	502.09	3581
P6 Lit Rev Median	Developed Impervious Roads	EOF	880.11	546
P6 Lit Rev Median	Developed Pervious Open Space	EOF	158.36	341
P6 Lit Rev Median	Developed Pervious Turf	EOF	240.87	2211
P6 Lit Rev Median	Extractive	EOS	524.88	4
P5 Median Target	Extractive	EOF	20000.00	NA
P5 Median Target	high intensity impervious urban	EOF	9000.00	NA
P5 Median Target	high intensity pervious urban	EOF	4600.00	NA
P5 Median Target	low intensity impervious urban	EOF	3200.00	NA
P5 Median Target	low intensity pervious urban	EOF	4600.00	NA
P5.3.2	Urban-All Types	EOS w/o Regional Factors	6124.37	NA

Developed TSS



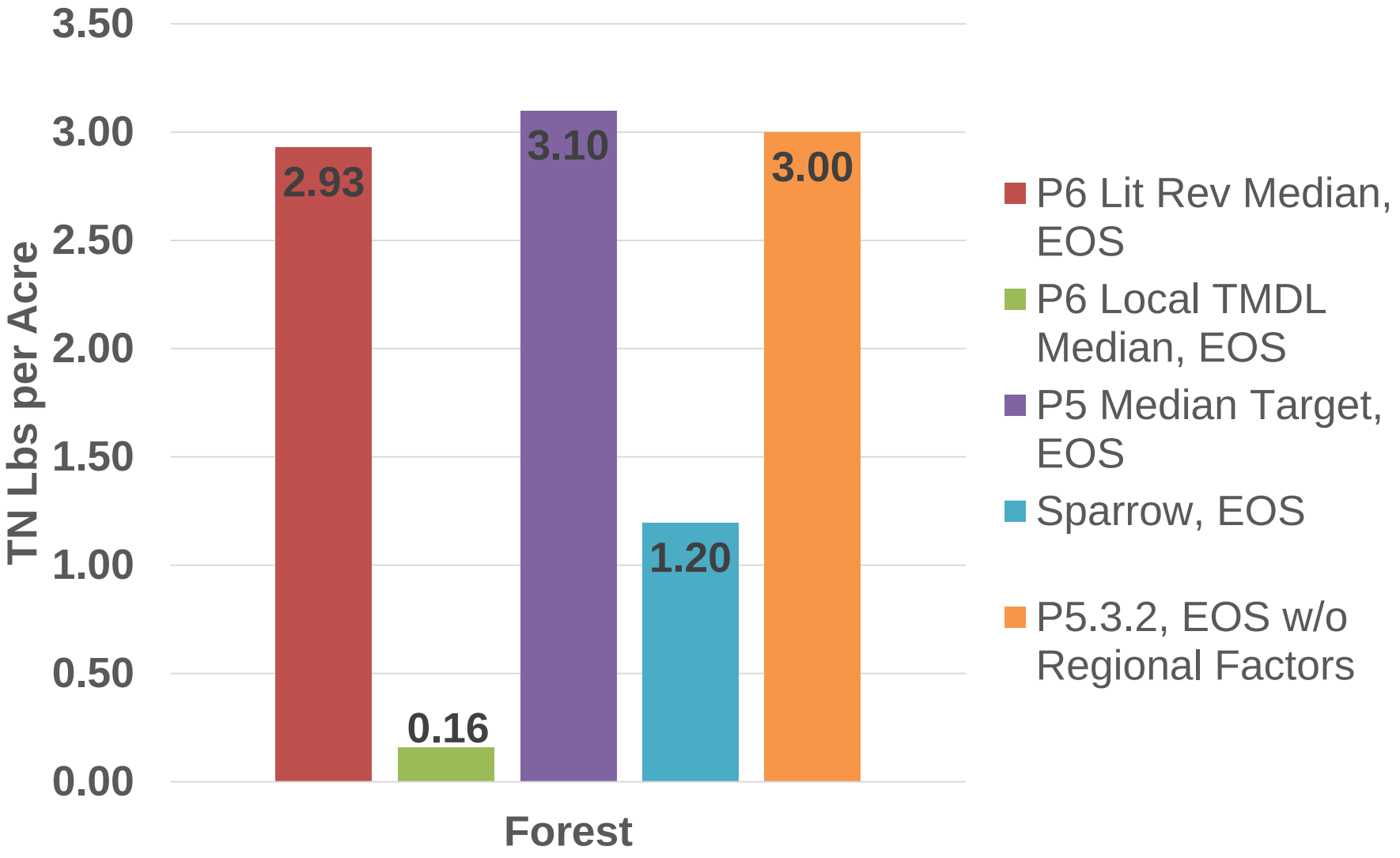
Land Uses: Natural

- Only considered studies from 1995 or later
  - TP pre-1990 loads slightly higher than post-1990
  - TN showed no strong variation before and after 1990
- Data weighted based on location within (66%) or outside (33%) of Chesapeake Bay Watershed
  - TP slightly higher loads in than out of CB watershed
  - TN showed no strong variation in or out of CB watershed
- Spatial differences among land segments incorporated by using an area weighted average of atmospheric deposition
- Recommend using only scientific literature, not TMDL data

Natural—TN

Data Source	Land use	Scale	TN Lb/A	TN Count
P6 Lit Rev Median	Forest	EOF	1.26	4
P6 Lit Rev Median	Forest	EOS	2.93	19
P6 Local TMDL Median	Forest	EOS	0.16	54
P5 Median Target	Forest	EOS	3.10	NA
Sparrow	Forest-All Types	EOS	1.20	NA
P5.3.2	Forest-All Types	EOS w/o Regional Factors	3.00	NA
P5 Median Target	Forest-Harvest	EOS	21.40	NA

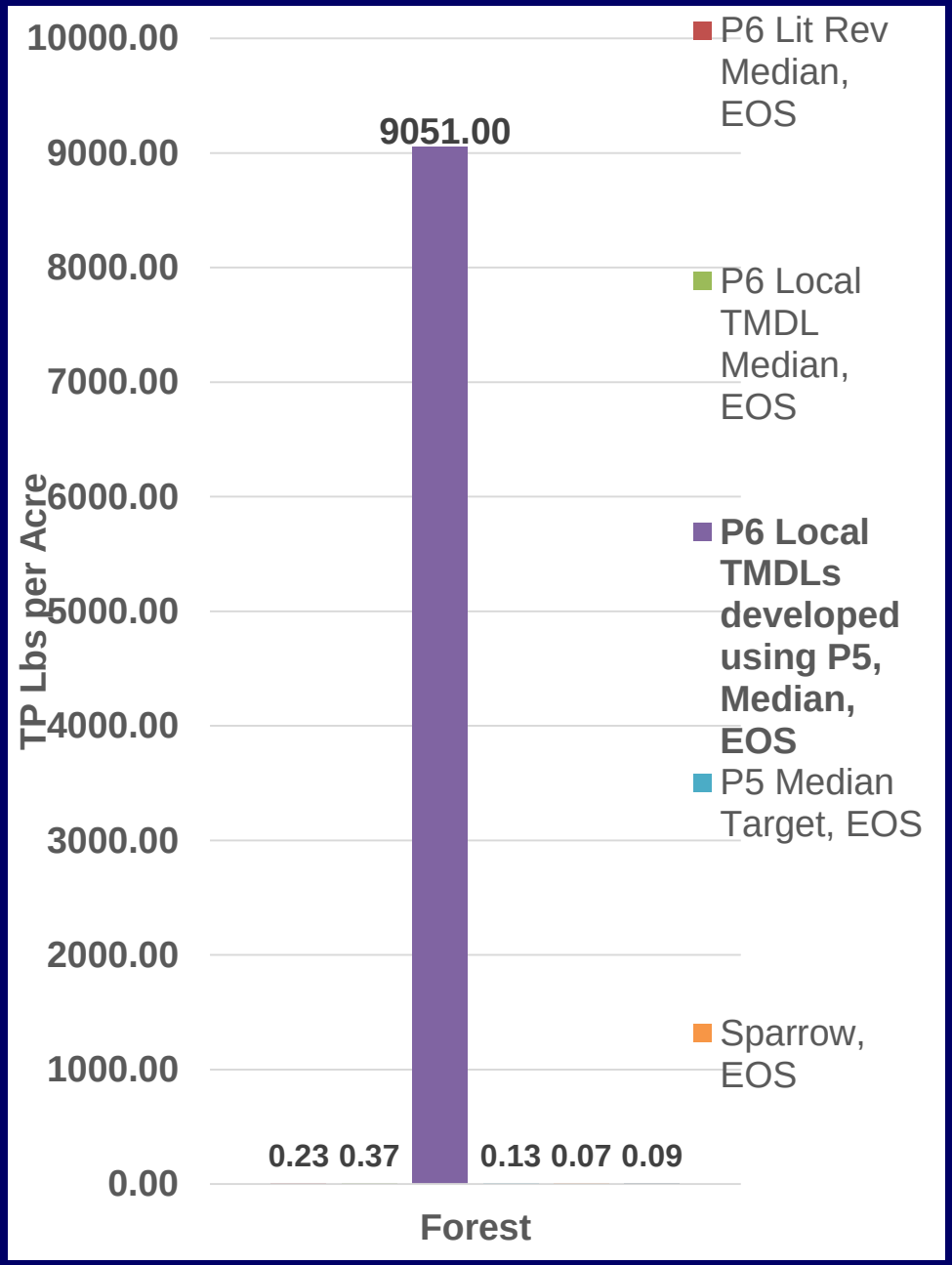
Forest TN—EOS



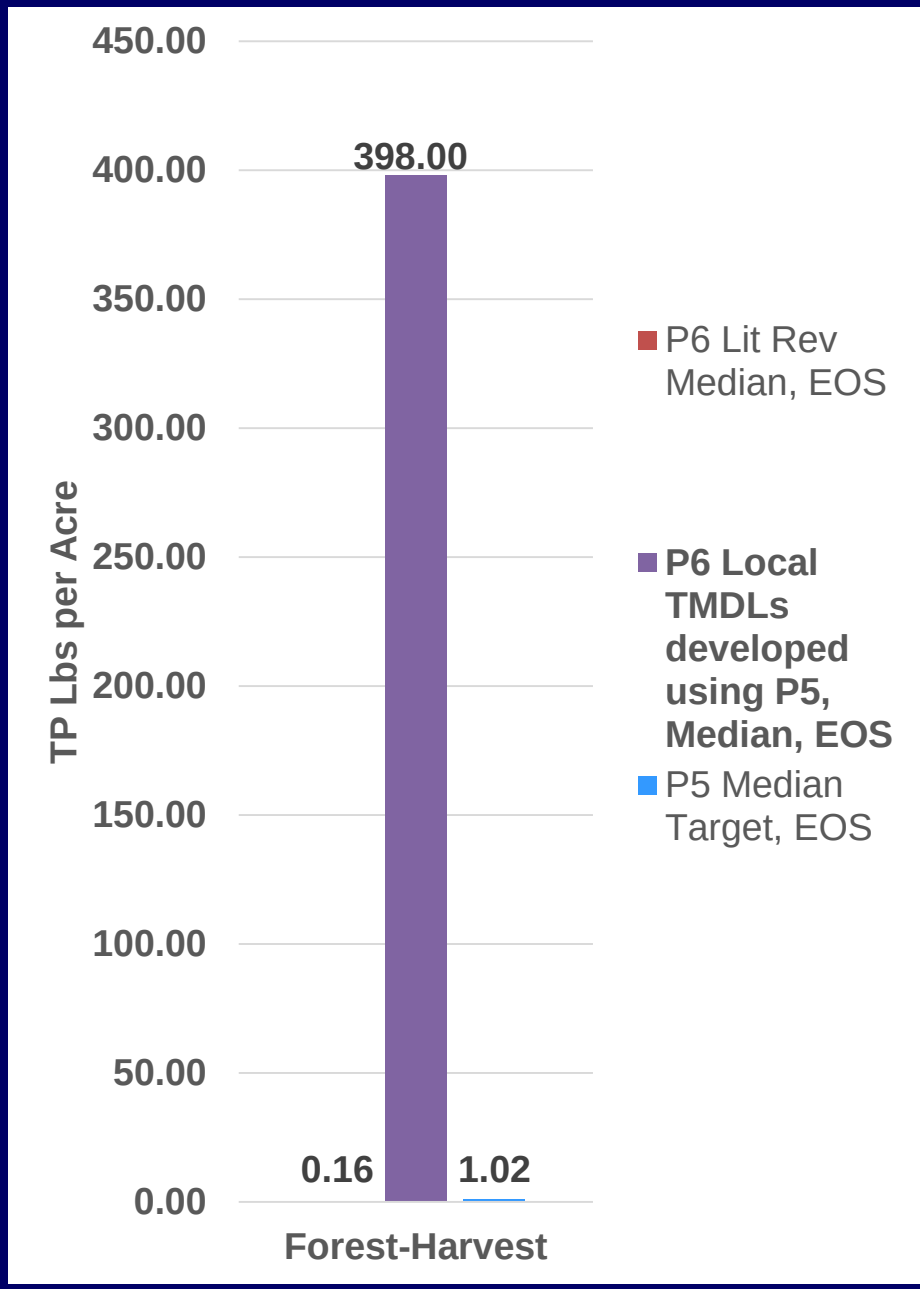
Natural—TP

Data Source	Land use	Scale	TP Lb/A	TP Count
P6 Lit Rev Median	Forest	EOF	0.10	21
P6 Lit Rev Median	Forest	EOS	0.23	16
P6 Local TMDL Median	Forest	EOS	0.37	227
P6 Local TMDLs developed using P5, Median	Forest	EOS	**9051.00**	5
P5 Median Target	Forest	EOS	0.13	NA
Sparrow	Forest-All Types	EOS	0.07	NA
P5.3.2	Forest-All Types	EOS w/o Regional Factors	0.09	NA
P6 Local TMDL Median	Forest-Disturbed	EOS	5.74	3
P6 Lit Rev Median	Forest-Harvest	EOS	0.16	2
P6 Local TMDLs developed using P5, Median	Forest-Harvest	EOS	**398.00**	5
P5 Median Target	Forest-Harvest	EOS	1.02	NA

Forest TP—EOS



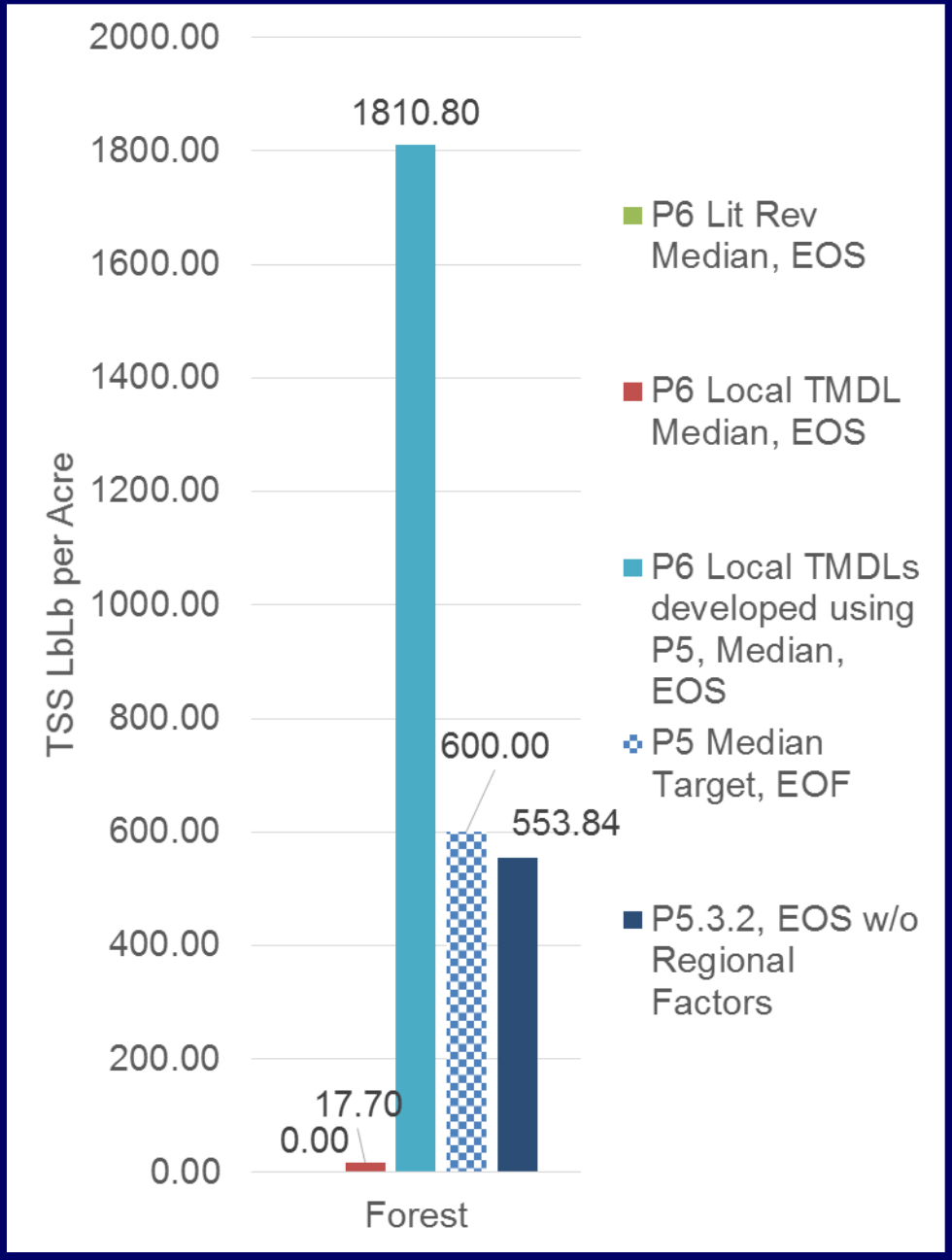
Harvested Forest TP—EOS



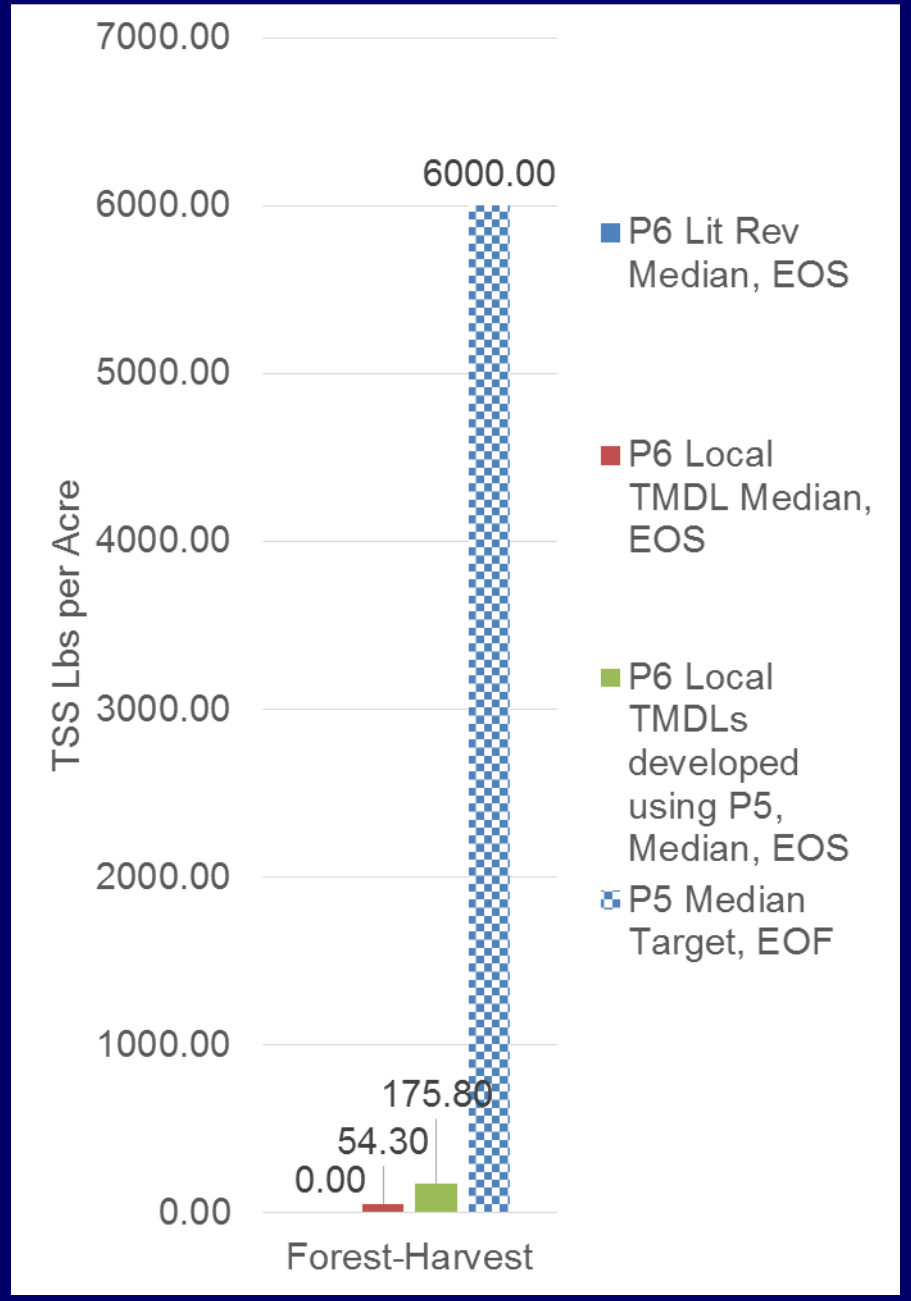
Natural—TSS

Data Source	Land use	Scale	TSS Lb/A	TSS Count
P6 Lit Rev Median	Forest	EOF	25.09	6
P6 Local TMDLs developed using P5, Median	Forest	EOF	0.31	15
P6 Lit Rev Median	Forest	EOS	0.00	1
P6 Local TMDL Median	Forest	EOS	17.70	302
P6 Local TMDLs developed using P5, Median	Forest	EOS	**1810.80**	13
P5 Median Target	Forest	EOF	**600.00**	NA
P5.3.2	Forest-All Types	EOS w/o Regional Factors	553.84	NA
P6 Local TMDL Median	Forest-Disturbed	EOS	15.22	14
P6 Lit Rev Median	Forest-Harvest	EOF	180.49	3
P6 Local TMDLs developed using P5, Median	Forest-Harvest	EOF	3.00	15
P6 Lit Rev Median	Forest-Harvest	EOS	0.00	1
P6 Local TMDL Median	Forest-Harvest	EOS	54.30	3
P6 Local TMDLs developed using P5, Median	Forest-Harvest	EOS	**175.80**	13
P5 Median Target	Forest-Harvest	EOF	**6000.00**	NA

Forest TSS



Harvested Forest TSS



Land Uses: Agricultural

- Only considered studies from 1995 or later
  - Tetra Tech analysis showed higher loads for TN and TP post 1995
- Data weighted based on location within (66%) or outside (33%) of Chesapeake Bay Watershed
- Backed out BMPs
- Excluded local TMDL data that was based on Phase 5 WSM loads
- Cross-walked literature review land uses to proposed Phase 6 land uses
  - Agricultural Phase 6 land uses are still in development and actively being reworked

Agricultural Land Uses

Literature Review = 9

Level 1	Level 2	Level 3
2.1 Commodity crops	TBD	TBD
2.1 Commodity crops	2.1.1 Corn - With manure	2.1.1.1 Grain - fallow
2.1 Commodity crops	2.1.1 Corn - With manure	2.1.1.2 Grain - fall sm grain
2.1 Commodity crops	2.1.2 Soybeans - With Manure	2.1.2.2 Fall sm grain
2.1 Commodity crops	2.1.3 Small grains-with manure	2.1.3.3 Sm grain - fallow
2.1 Commodity crops	2.1.4 Corn - Without manure	2.1.4.2 Grain - fall sm grain
2.2 Hay and Legume and forage	2.2.2 Non-legume Forage	2.2.2.1 Non-Legume Forage with manure
2.2 Hay and Legume and forage	2.2.3 Pasture and pastured cropland	2.2.3 Pasture and pastured cropland
2.3 Specialty & Other crops	2.3.3 High cover	2.3.3.1 High nutrient input

Proposed = 34

Level 1	Level 2	Level 3
2.1 Commodity crops	2.1.1 Corn - With manure	2.1.1.1 Grain - fallow
2.1 Commodity crops	2.1.1 Corn - With manure	2.1.1.2 Grain - fall sm grain
2.1 Commodity crops	2.1.1 Corn - With manure	2.1.1.3 Silage - fallow
2.1 Commodity crops	2.1.1 Corn - With manure	2.1.1.4 Silage - fall sm grain
2.1 Commodity crops	2.1.2 Soybeans - With Manure	2.1.2.1 Fall fallow
2.1 Commodity crops	2.1.2 Soybeans - With Manure	2.1.2.2 Fall sm grain
2.1 Commodity crops	2.1.3 Small grains-with manure	2.1.3.1 Sm grain - Dbl Crop Beans
2.1 Commodity crops	2.1.3 Small grains-with manure	2.1.3.2 Forage
2.1 Commodity crops	2.1.3 Small grains-with manure	2.1.3.3 Sm grain - fallow
2.1 Commodity crops	2.1.4 Corn - Without manure	2.1.4.1 Grain - fallow
2.1 Commodity crops	2.1.4 Corn - Without manure	2.1.4.2 Grain - fall sm grain
2.1 Commodity crops	2.1.4 Corn - Without manure	2.1.4.3 Silage - fallow
2.1 Commodity crops	2.1.4 Corn - Without manure	2.1.4.4 Silage - fall sm grain
2.1 Commodity crops	2.1.5 Soybeans - Without Manure	2.1.2.1 Fall fallow
2.1 Commodity crops	2.1.5 Soybeans - Without Manure	2.1.2.2 Fall sm grain
2.1 Commodity crops	2.1.6 Small grains-Without manure	2.1.5.1 Sm grain - Dbl Crop Beans
2.1 Commodity crops	2.1.6 Small grains-Without manure	2.1.5.2 Forage
2.1 Commodity crops	2.1.6 Small grains-Without manure	2.1.5.3 Sm grain - fallow
2.2 Hay and Legume and forage	2.2.1 Alfalfa and Other Legumes	2.2.1.1 Alfalfa and Other Legumes with manure
2.2 Hay and Legume and forage	2.2.1 Alfalfa and Other Legumes	2.2.1.2 Alfalfa and Other Legumes without manure
2.2 Hay and Legume and forage	2.2.2 Non-legume Forage	2.2.2.1 Non-Legume Forage with manure
2.2 Hay and Legume and forage	2.2.2 Non-legume Forage	2.2.2.2 Non-legume Forage without manure
2.2 Hay and Legume and forage	2.2.3 Pasture and pastured cropland	2.2.3 Pasture and pastured cropland
2.3 Speciality & Other crops	2.3.1 Vines	2.3.1.1 High nutrient input
2.3 Speciality & Other crops	2.3.1 Vines	2.3.1.2 Medium and low nutrient input
2.3 Speciality & Other crops	2.3.2 Low cover	2.3.2.1 High nutrient input
2.3 Speciality & Other crops	2.3.2 Low cover	2.3.2.2 Medium and low nutrient input
2.3 Speciality & Other crops	2.3.3 High cover	2.3.3.1 High nutrient input
2.3 Speciality & Other crops	2.3.3 High cover	2.3.3.2 Medium and low nutrient input
2.4 Animals	2.4.1 Animal Impervious	2.4.1.1 CAFO (regulated)
2.4 Animals	2.4.1 Animal Impervious	2.4.1.2 AFO (unregulated)
2.5 Farmstead	2.5.1 Impervious	2.5.1 Impervious
2.5 Farmstead	2.5.2 Pervious	2.5.2 Pervious

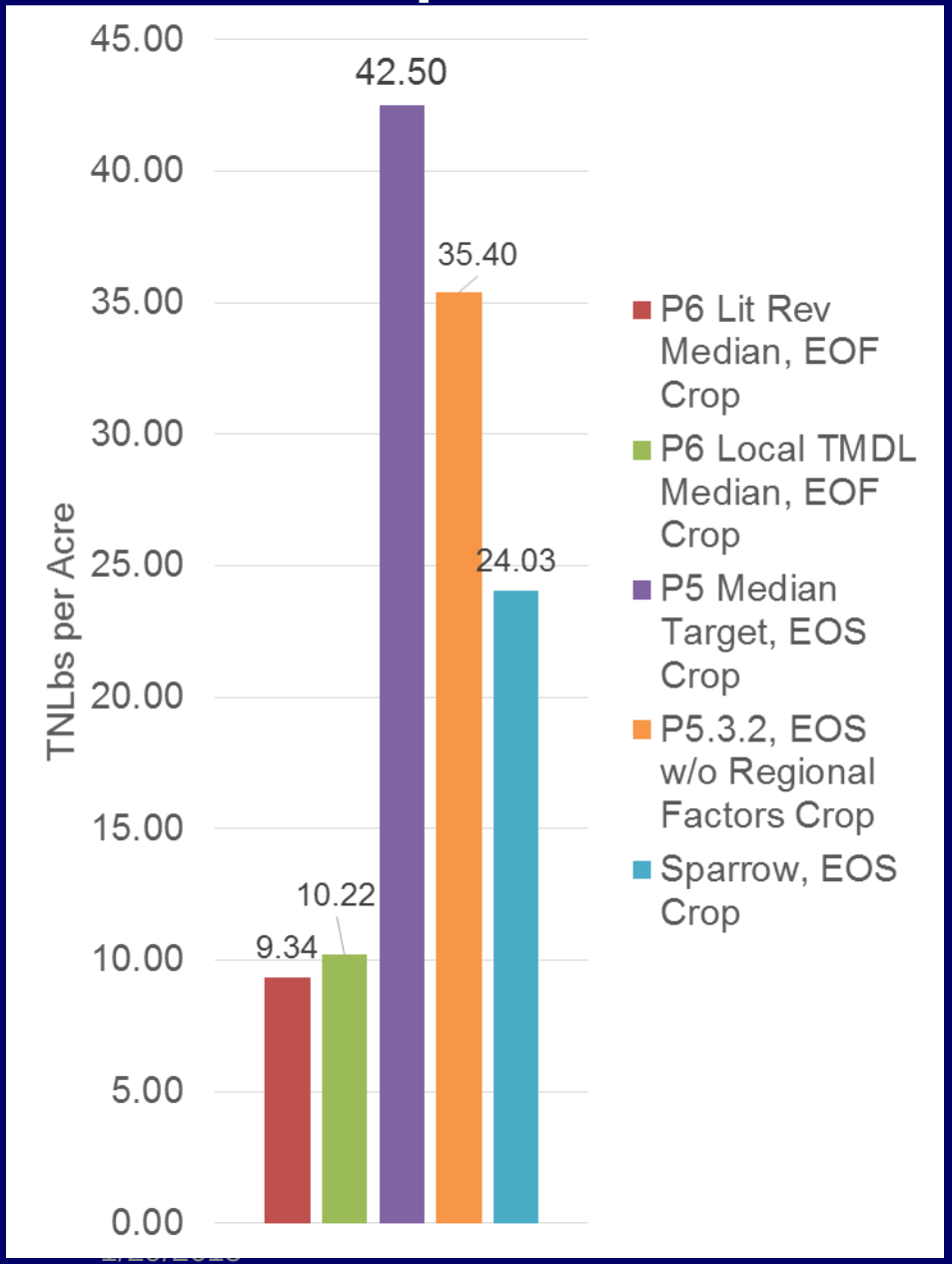
Reasons to Differentiate Land Uses

- Literature, models, other data sources offer distinct land use loading rates
- BMPs are exclusive to one type of land use (e.g.: stream corridor buffers or fencing)
- Helps jurisdictions for planning and reporting purposes (in this case, there would not be a different loading rate).

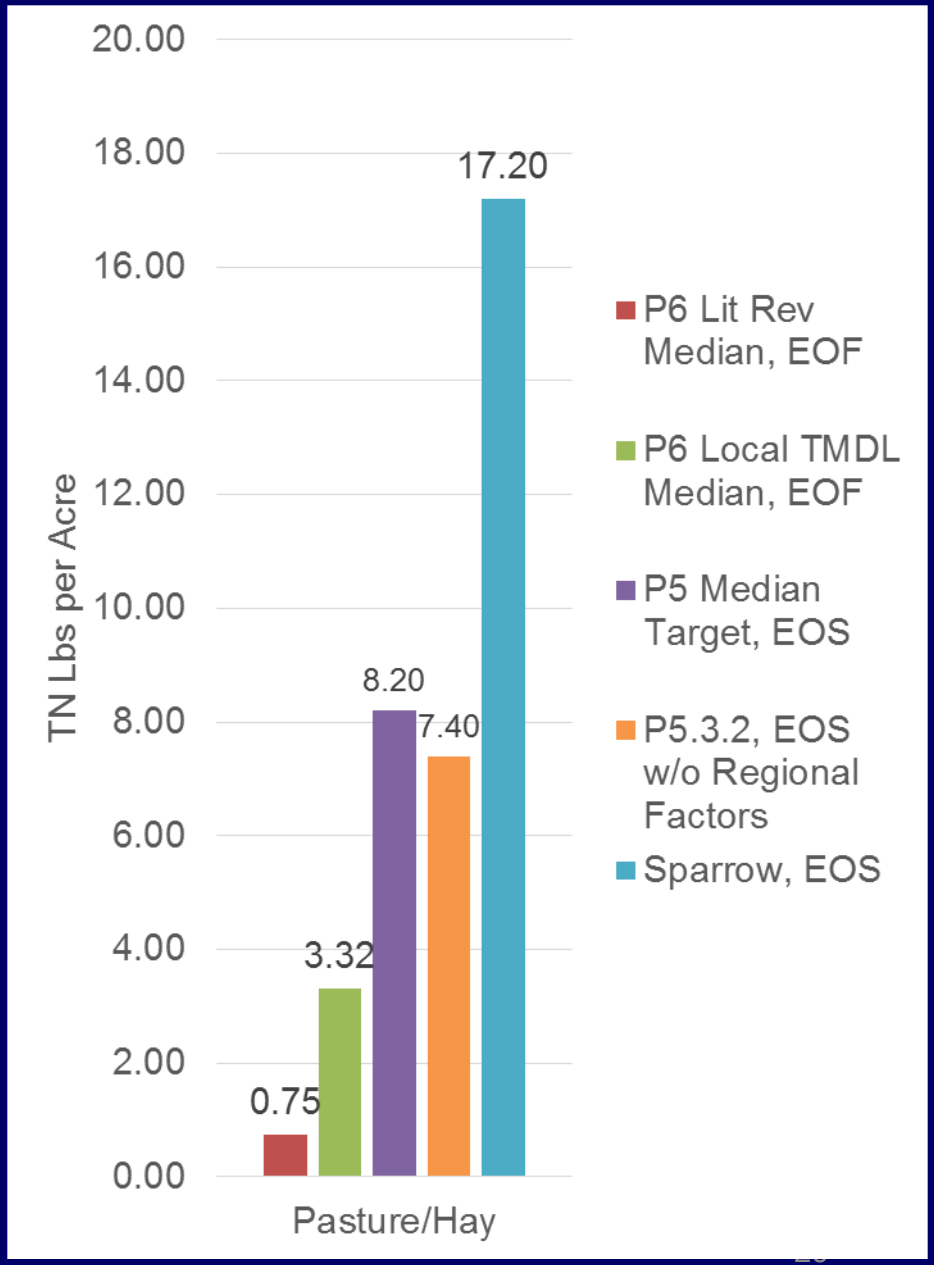
Agriculture — TN

Data Source	Land Use	Scale	TN Lb/A	TN Count
P6 Local TMDL Median	Agriculture	EOF	43.53	21
P6 Lit Rev Median	2.1 Commodity crops	EOF	9.34	77
P6 Local TMDL Median	Cropland	EOF	10.22	15
P5 Median Target	conventional till with manure	EOS	44.80	NA
P5 Median Target	conventional till without manure	EOS	40.20	NA
Sparrow	cropland	EOS	24.03	NA
P5.3.2	cropland	EOS w/o Regional Factor	35.40	NA
P6 Local TMDL Median	Farmstead	EOF	5.80	1
P5 Median Target	animal feeding operations	EOS	1045.70	NA
P6 Lit Rev Median	2.2 Hay and Legume and forage	EOF	0.75	42
P6 Local TMDL Median	Hay and Pasture	EOF	3.32	36
P5 Median Target	pasture	EOS	8.20	NA
Sparrow	pasture	EOS	**17.20**	NA
P5.3.2	pasture	EOS w/o Regional Factor	7.40	NA
P5 Median Target	alfalfa	EOS	9.50	NA
P5 Median Target	hay-fertilized	EOS	9.50	NA
P5 Median Target	hay-unfertilized	EOS	6.20	NA
P6 Local TMDL Median	Nursery	EOF	641.70	1
P5 Median Target	Nursery	EOS	253.80	NA

Crop TN



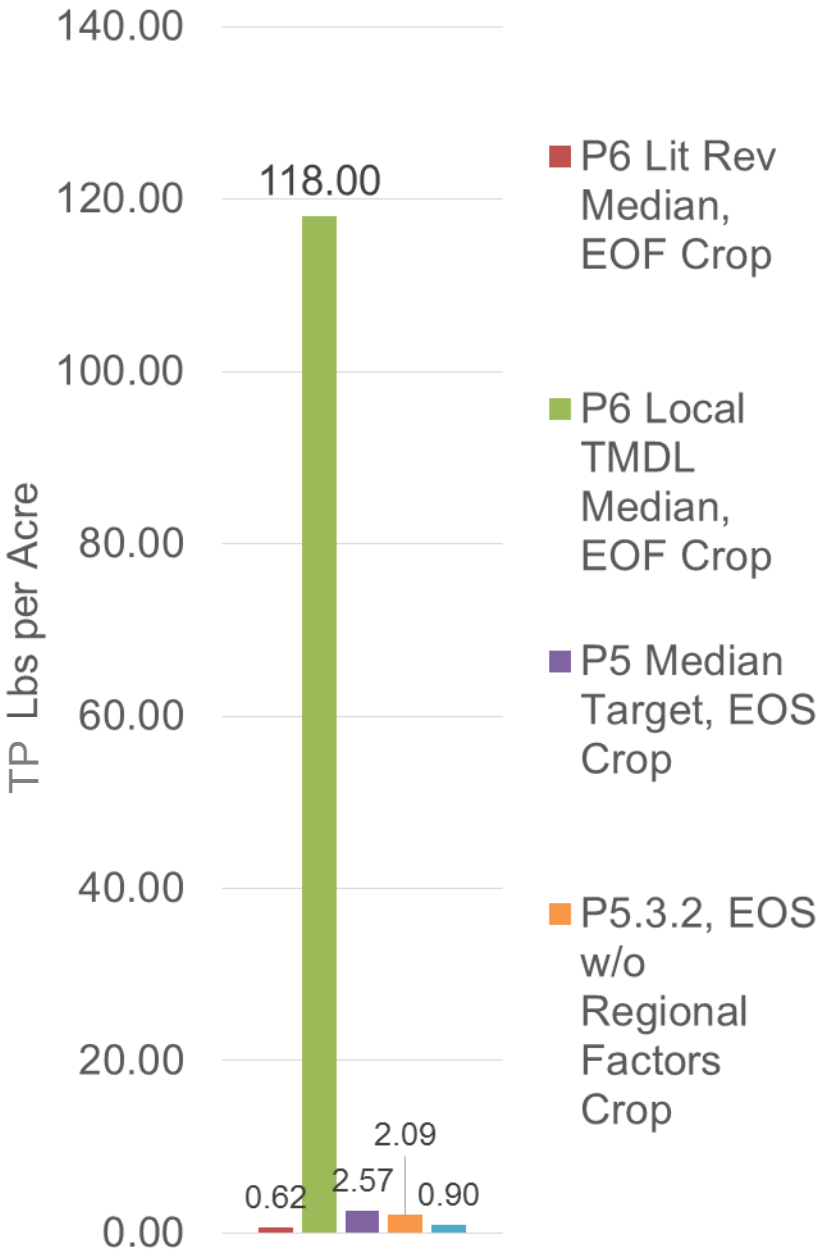
Pasture/Hay TN



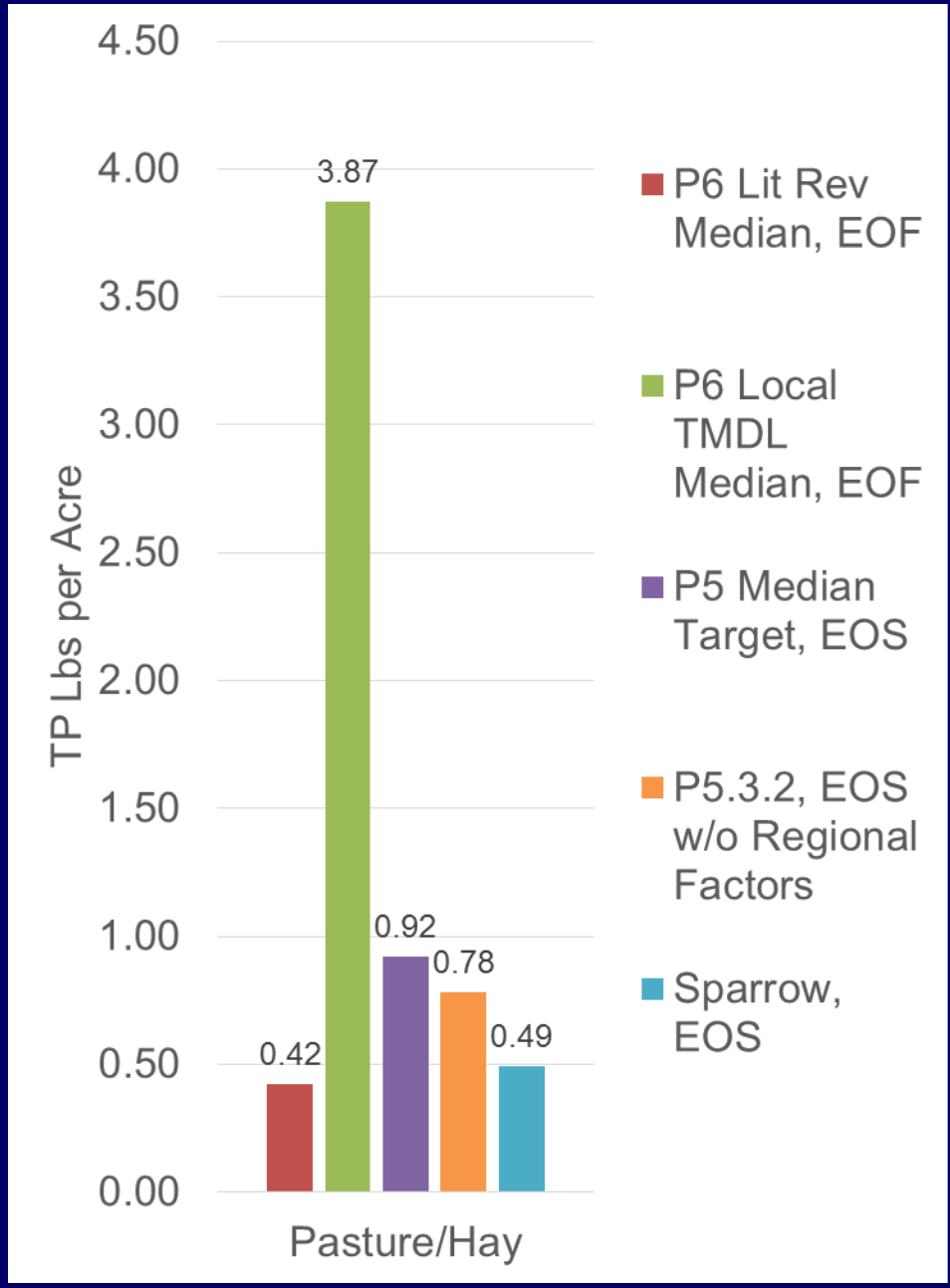
Agriculture—TP

Data Source	Land Use	Scale	TP Lb/A	TP Count
P6 Local TMDL Median	Agriculture	EOF	533.00	69
P6 Lit Rev Median	2.1 Commodity crops	EOF	0.62	182
P6 Local TMDL Median	Cropland	EOF	**118.00**	99
P5 Median Target	conventional till with manure	EOS	2.05	NA
P5 Median Target	conventional till without manure	EOS	3.08	NA
Sparrow	cropland	EOS	0.90	NA
P5.3.2	cropland	EOS w/o Regional Factor	2.09	NA
P5 Median Target	animal feeding operations	EOS	55.45	NA
P6 Lit Rev Median	2.2 Hay and Legume and forage	EOF	0.42	83
P6 Local TMDL Median	Hay and Pasture	EOF	**3.87**	126
P5 Median Target	pasture	EOS	0.92	NA
Sparrow	pasture	EOS	0.49	NA
P5.3.2	pasture	EOS w/o Regional Factor	0.78	NA
P5 Median Target	alfalfa	EOS	0.87	NA
P5 Median Target	hay-fertilized	EOS	0.05	NA
P5 Median Target	hay-unfertilized	EOS	0.03	NA
P6 Lit Rev Median	2.3 Specialty & Other crops	EOF	1.97	7
P6 Local TMDL Median	Nursery	EOF	26.50	1
P5 Median Target	Nursery	EOS	111.98	NA

Crop TP



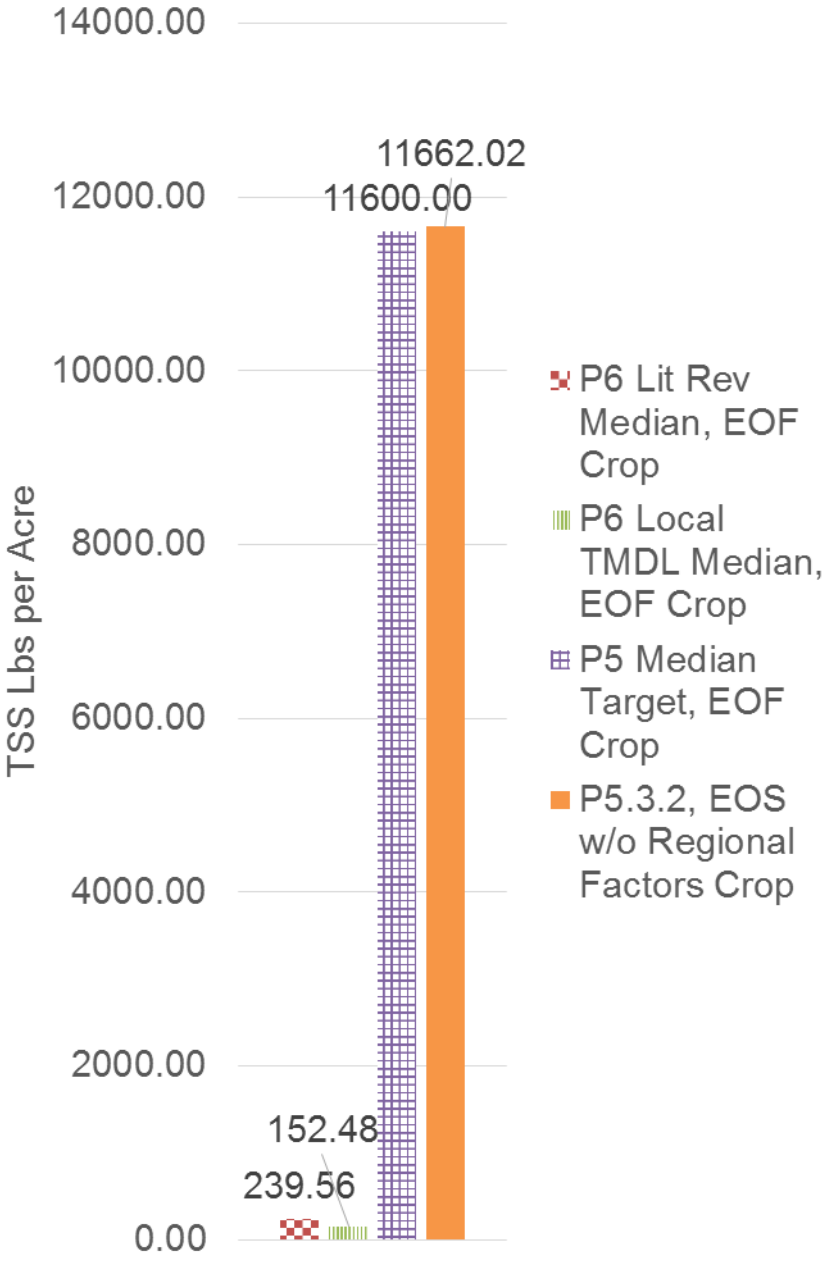
Pasture/Hay TP



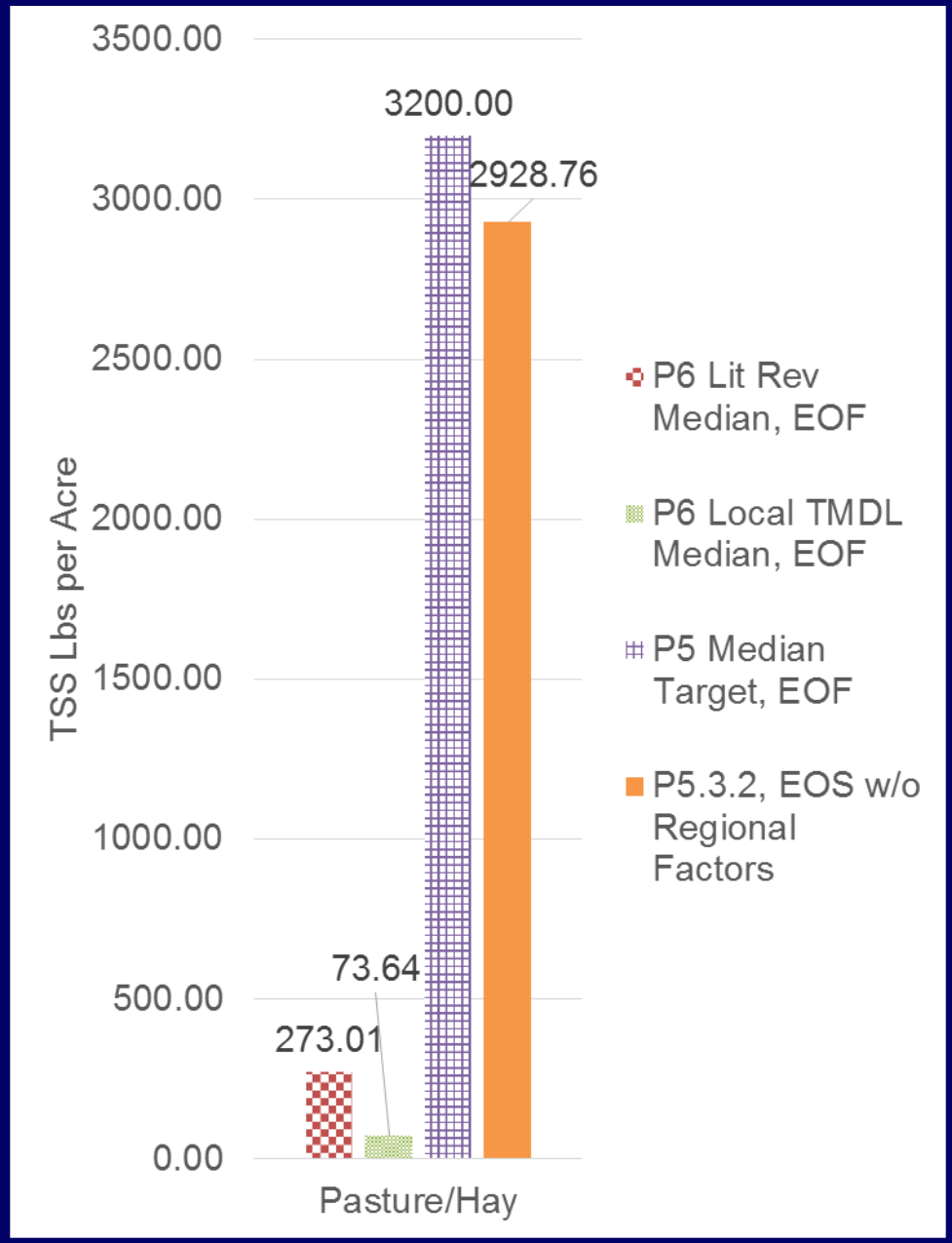
Agriculture—TSS

Data Source	Land Use	Scale	TSS Lb/A	TSS Count
P6 Local TMDL Median	Agriculture	EOF	8595.00	5
P6 Lit Rev Median	2.1 Commodity crops	EOF	239.56	80
P6 Local TMDL Median	Cropland	EOF	152.48	313
P5 Median Target	conventional till with manure	EOF	11600.00	NA
P5 Median Target	conventional till without manure	EOF	11600.00	NA
Sparrow	cropland	EOS	NA	NA
P5.3.2	cropland	EOS w/o Regional Factor	11662.02	NA
P6 Lit Rev Median	2.2 Hay and Legume and forage	EOF	273.01	29
P6 Local TMDL Median	Hay and Pasture	EOF	73.64	314
P5 Median Target	pasture	EOF	3200.00	NA
P5.3.2	pasture	EOS w/o Regional Factor	2928.76	NA
P5 Median Target	alfalfa	EOF	3200.00	NA
P5 Median Target	hay-fertilized	EOF	3000.00	NA
P5 Median Target	hay-unfertilized	EOF	3000.00	NA
P6 Lit Rev Median	2.3 Specialty & Other crops	EOF	3716.82	7
P6 Local TMDL Median	Nursery	EOF	9640.30	1

Crop TSS



Pasture/Hay TSS



Immediate Decisions

- Natural – Use scientific literature only?
- Agricultural and Natural—Using 1995 and later?
- Agricultural and Natural—Weighting by location in or out of watershed as 2/3 for in and 1/3 for out?
- Agriculture – Consider land uses that can be differentiated for targets
- Agricultural– How to determine target where data sources have high variance?

Next Steps

- Refine further to include variation by land segment based on sensitivities to nutrient inputs (lit review median * (nutrient input/export))
  - *Recommendations for PQUAL Sensitivity to Inputs* (Yactayo et al, 2014)
  - *Agricultural balance between nutrient inputs and uptake, and sediment input/losses*
- Generate EOF targets from EOS data using Mandel's work on the small stream factor (?)
- Use Sparrow: set lit review targets as relational within Sparrow land uses loading rates
- Work on land uses where there was little/no information in the lit reviews
- Incorporate additional literature reviews from agricultural grey literature, forestry and wetland panels, iTree Hydro and other sources
- Consider impact of BMPs, especially information considered when BMP reductions were developed originally
- Determine differences in loads by depth (surface, interflow, groundwater)
- Determine differences in loads by nutrient species
- QA/QC checks including verifying data outliers

Role of Workgroups

Chesapeake Bay Program committees, goal implementation teams, workgroups or action teams	Meeting Date
Modeling Team Meeting	9/15/2014, 1/20/2015
Land Use Workgroup	9/25/2014; **2/26/2015**
Modeling Quarterly Review	9/30/2014, 1/29/2015
Forestry Workgroup	10/1/2014, **TBD**
Watershed Technical Workgroup	10/2/2014
Agricultural Workgroup	10/9/2014, 10/22/2014, **2/19/2015**
Wetlands Expert Panel	11/12/2014
Agricultural Modeling Subcommittee	9/16/2014,12/16/2014, **2/?/2015**
Urban Stormwater workgroup	10/21/2014, 12/16/2014, **2/17/2015**

- Panel, workgroup documents and recommendations, and available literature are critical sources of data in addition to the full literature review
- Modeling workgroup approves the final Phase 6 model

Timeline

- December 31, 2014 - Sparrow and literature review results for draft land uses
- January 28, 2015 – Input from Modeling Workgroup on draft targets for draft land uses
- April 30, 2015 - final targets approved by Modeling Workgroup for draft land uses
- Oct 1, 2015 - Once the final land uses are approved, we will finalize targets using a Sparrow update, final sensitivities, and other information.

Keeping Up To Date – Webpages

- Land Use Loading Rates https://www.chesapeakebay.net/about/wmp_for_mpa_effort/land_use_loading_rates

- Additional information on Mid-Point Assessment http://www.chesapeakebay.net/groups/group/water_quality_goal_implementation_team/wmp_for_the_mpa

AN EXAMINATION OF LAND USE – NUTRIENT EXPORT RELATIONSHIPS[1]

Michael N. Beaulac and Kenneth H. Reckhow[2]

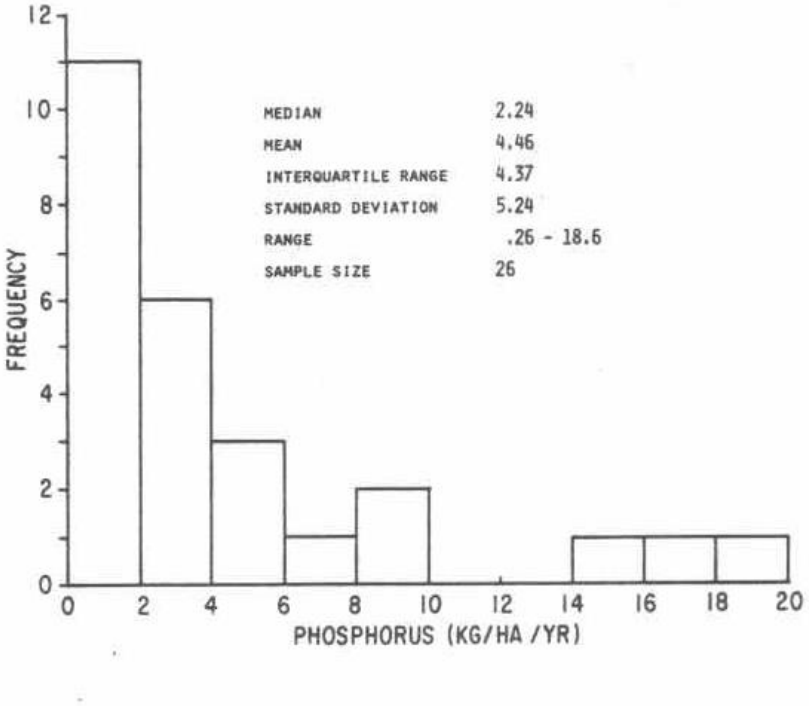


Figure 1. Phosphorus Export From Row Crops.

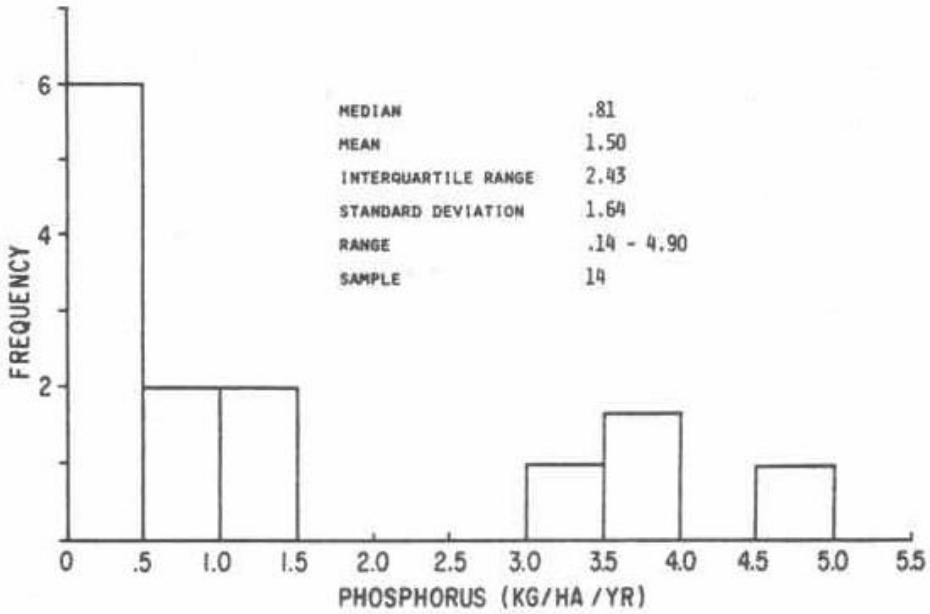


Figure 2. Phosphorus Export From Grazed and Pastured Watersheds.