Development of Calibration Export Rate Targets for the Phase 6 Watershed Model


Modeling Quarterly Review
June 11, 2015
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Purpose of Targets

- Used to calibrate the land use export rates in the Watershed Model

- Data needed
  - Measured load
  - Relative rates for major land use groups
  - Relative rates for land uses within a major land use group
  - Acres for Phase 6 land uses
  - Inputs to the model by land use and land segment
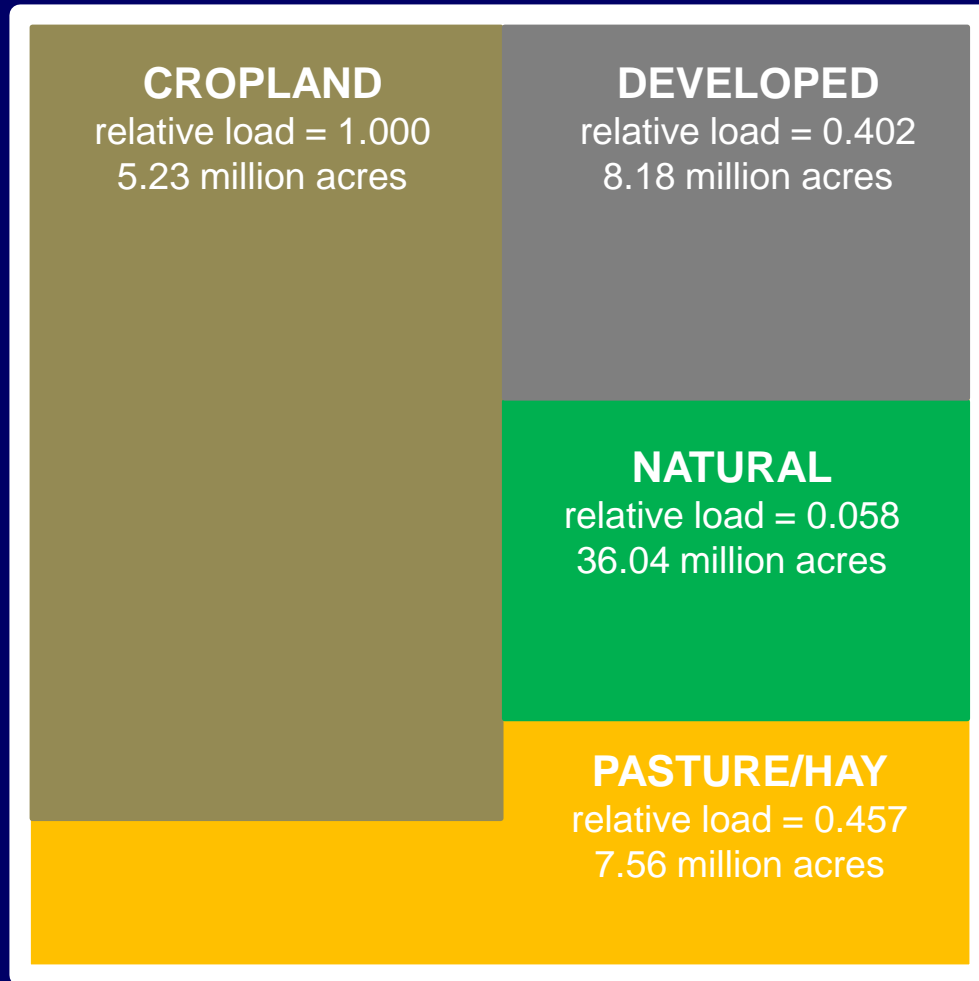 - Sensitivity of nutrient export to inputs

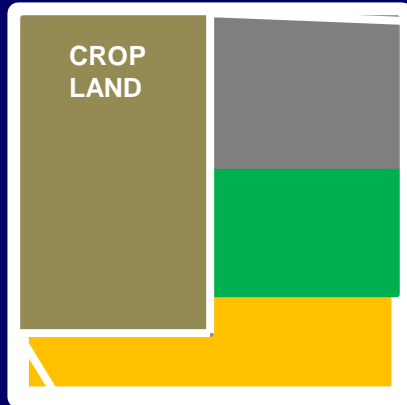# All Land Use Targets Are Relative and Set to Monitored Load
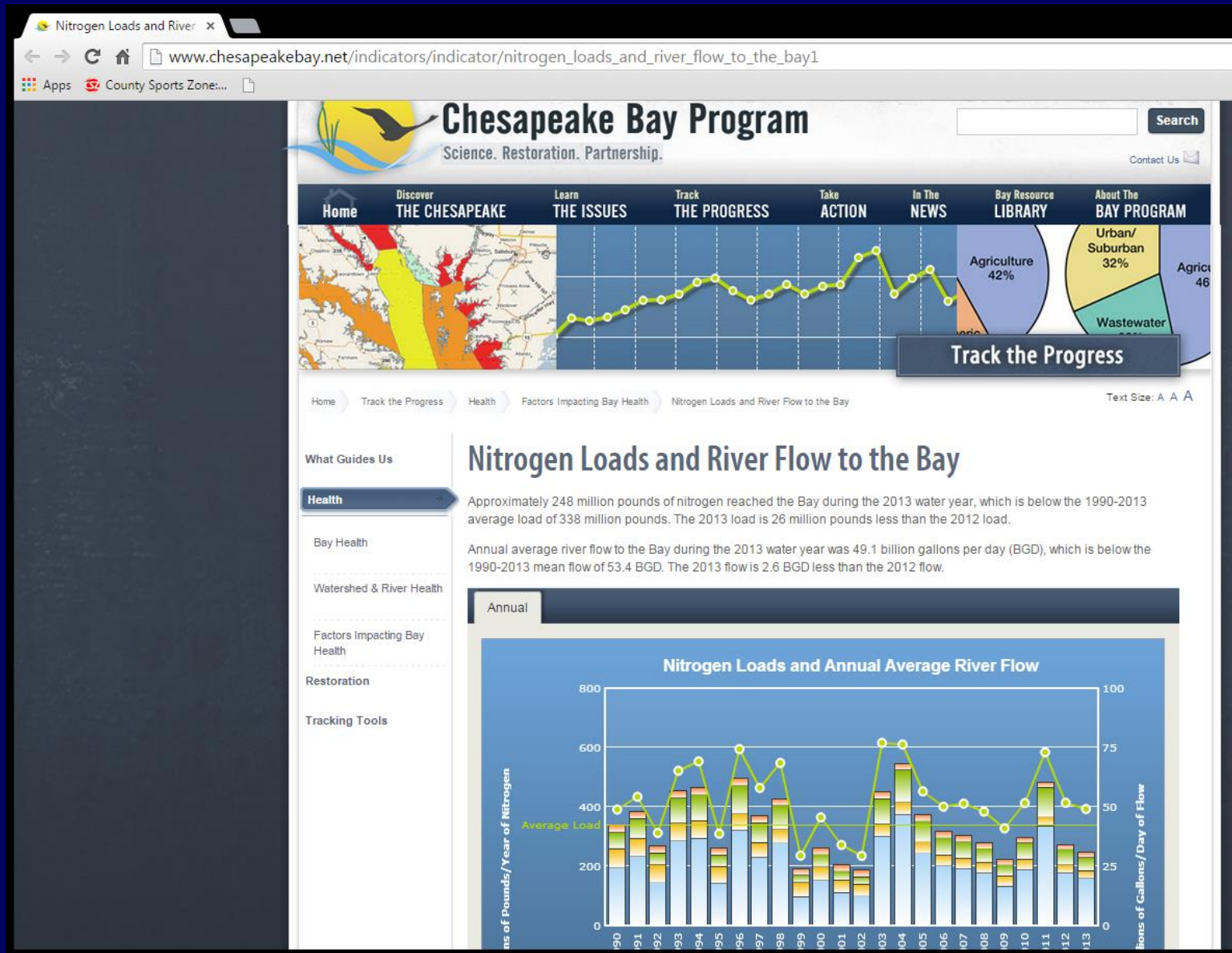
River Input Monitoring (RIM) Stations
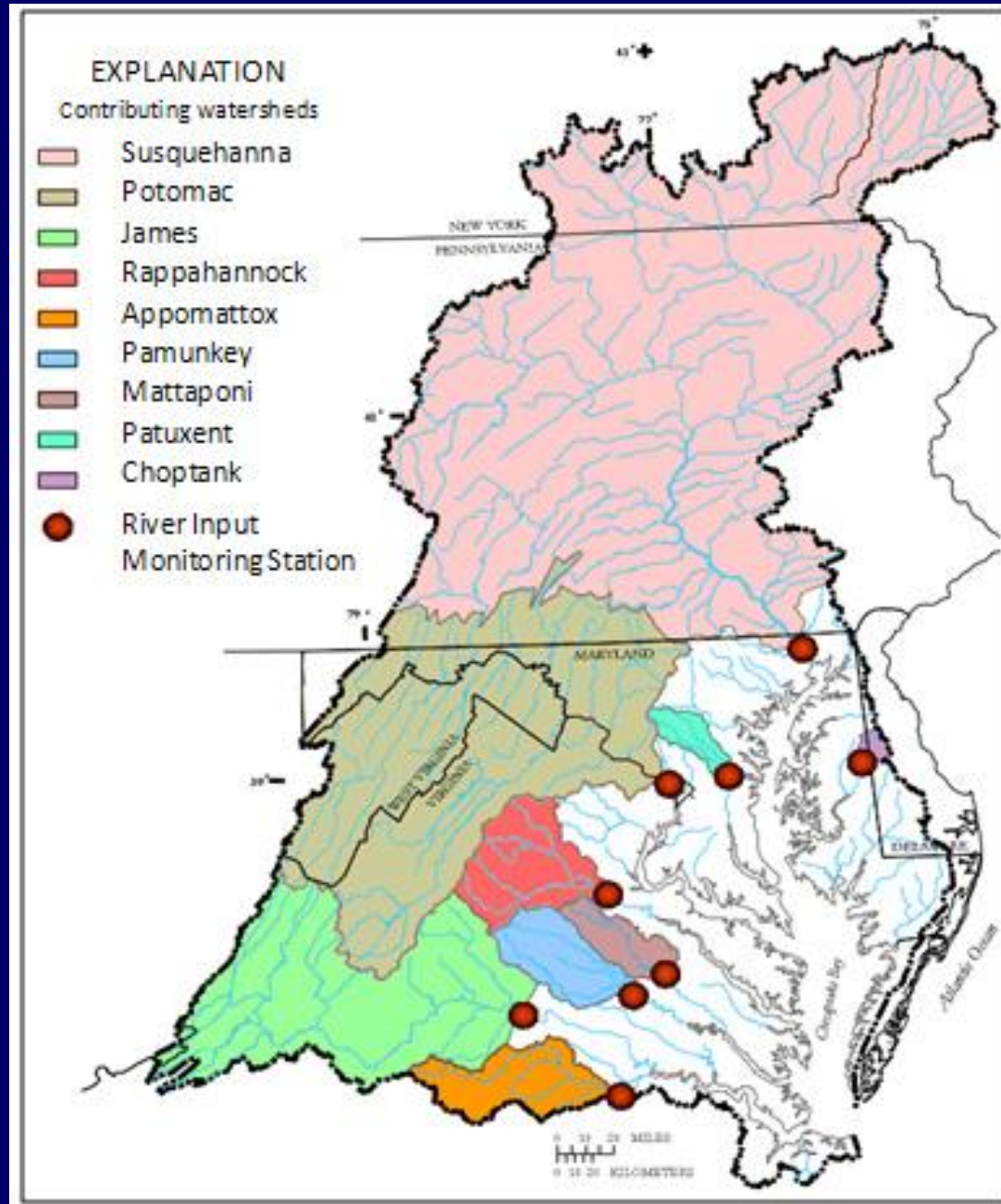
**Total Average Nitrogen Load
Average load from RIM
Stations
1990 - 2013**

CROPLAND
relative load = 1.000
5.23 million acres

DEVELOPED
relative load = 0.402
8.18 million acres

NATURAL
relative load = 0.058
36.04 million acres

PASTURE/HAY
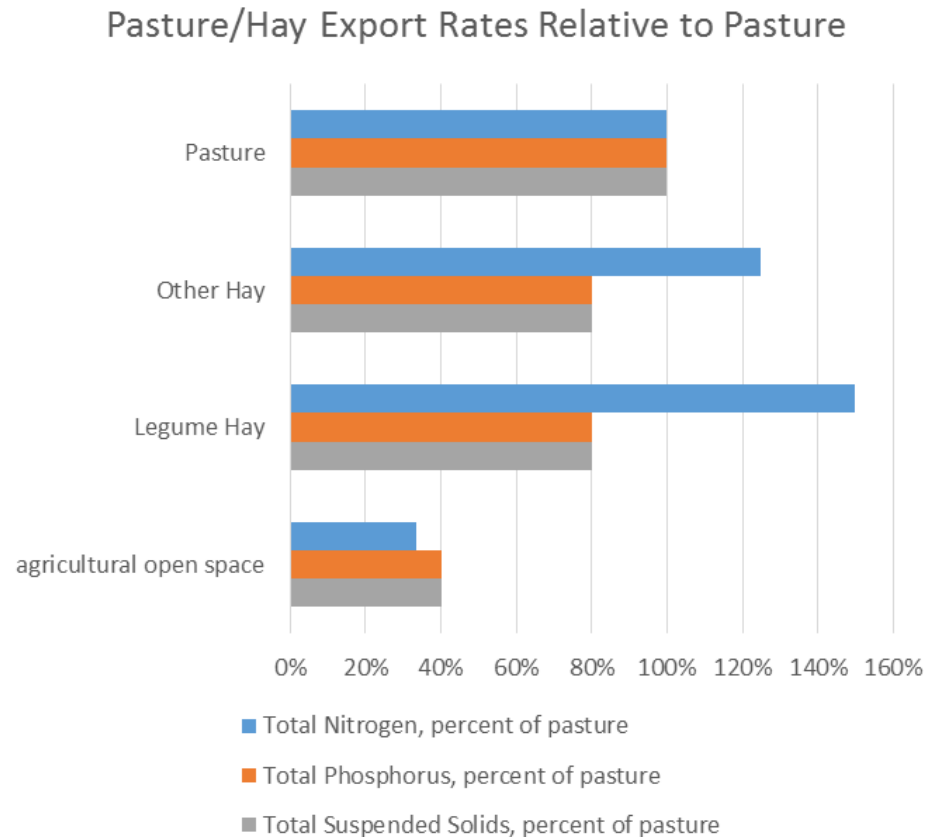relative load = 0.457
7.56 million acres

Cropland Relative Rates

Cropland Export Rates Relative to Corn grain, no manure

Pasture/Hay Relative Rates

PASTURE/HAY

Pasture/Hay Export Rates Relative to Pasture

- Total Nitrogen, percent of pasture
- Total Phosphorus, percent of pasture
- Total Suspended Solids, percent of pasture
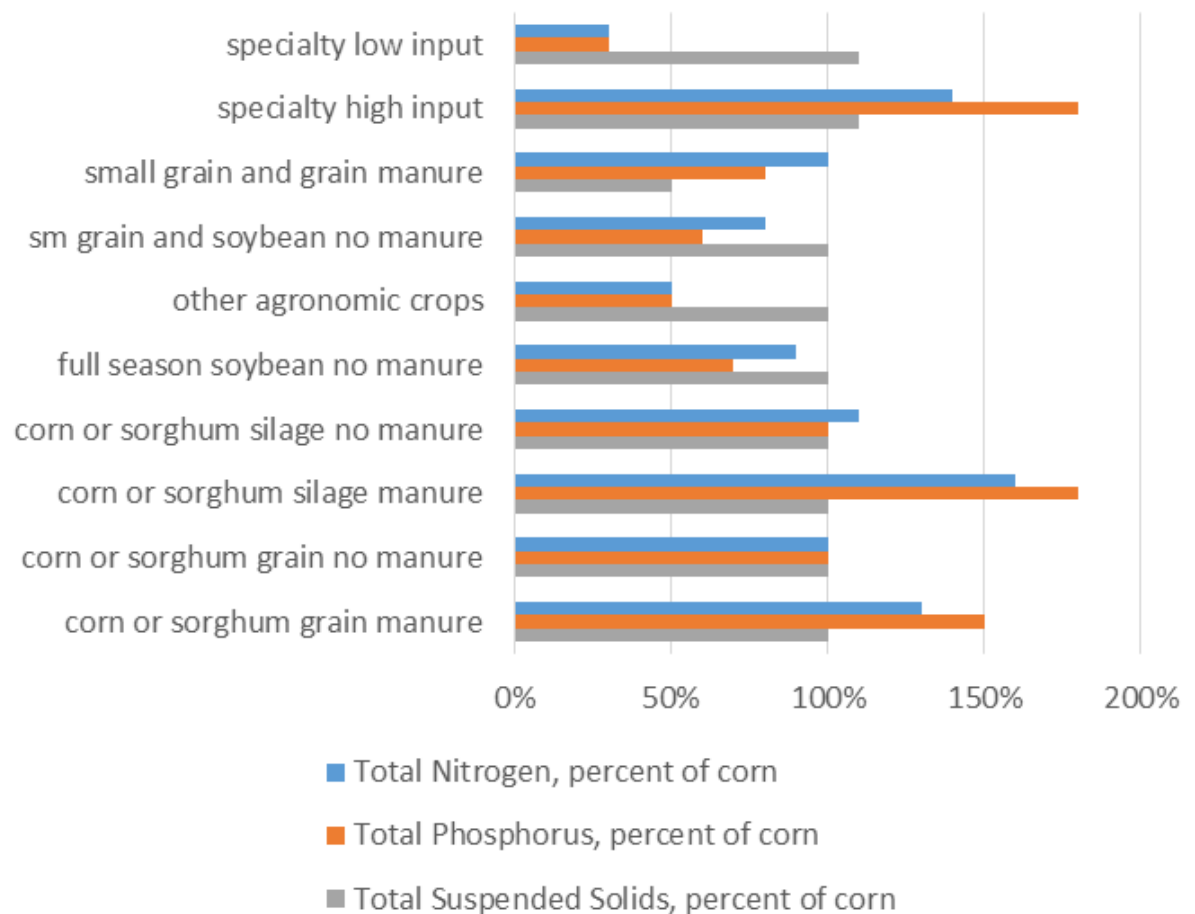
Developed TN Relative Rates

DEVELOPED

Developed Export Rates, relative to roads

Extractive	
Construction	
Developed Pervious Turf	
Developed Pervious Open Space	
Developed Impervious Roads	
Developed Impervious Buildings Parking Lots Etc	

0% 20% 40% 60% 80% 100% 120% 140%

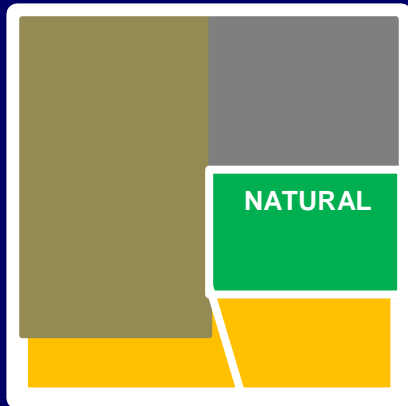■ Total Nitrogen, relative to roads
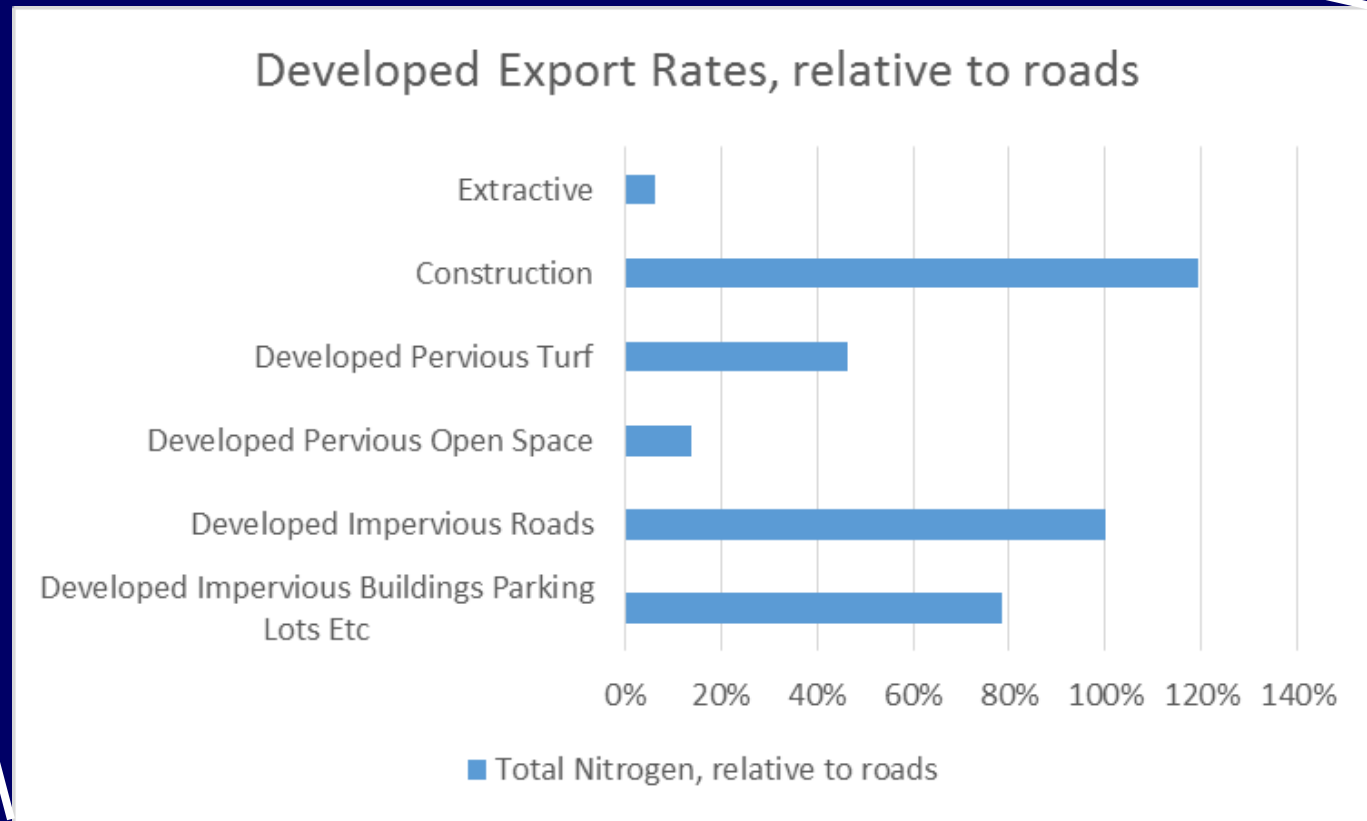
Natural Relative Rates
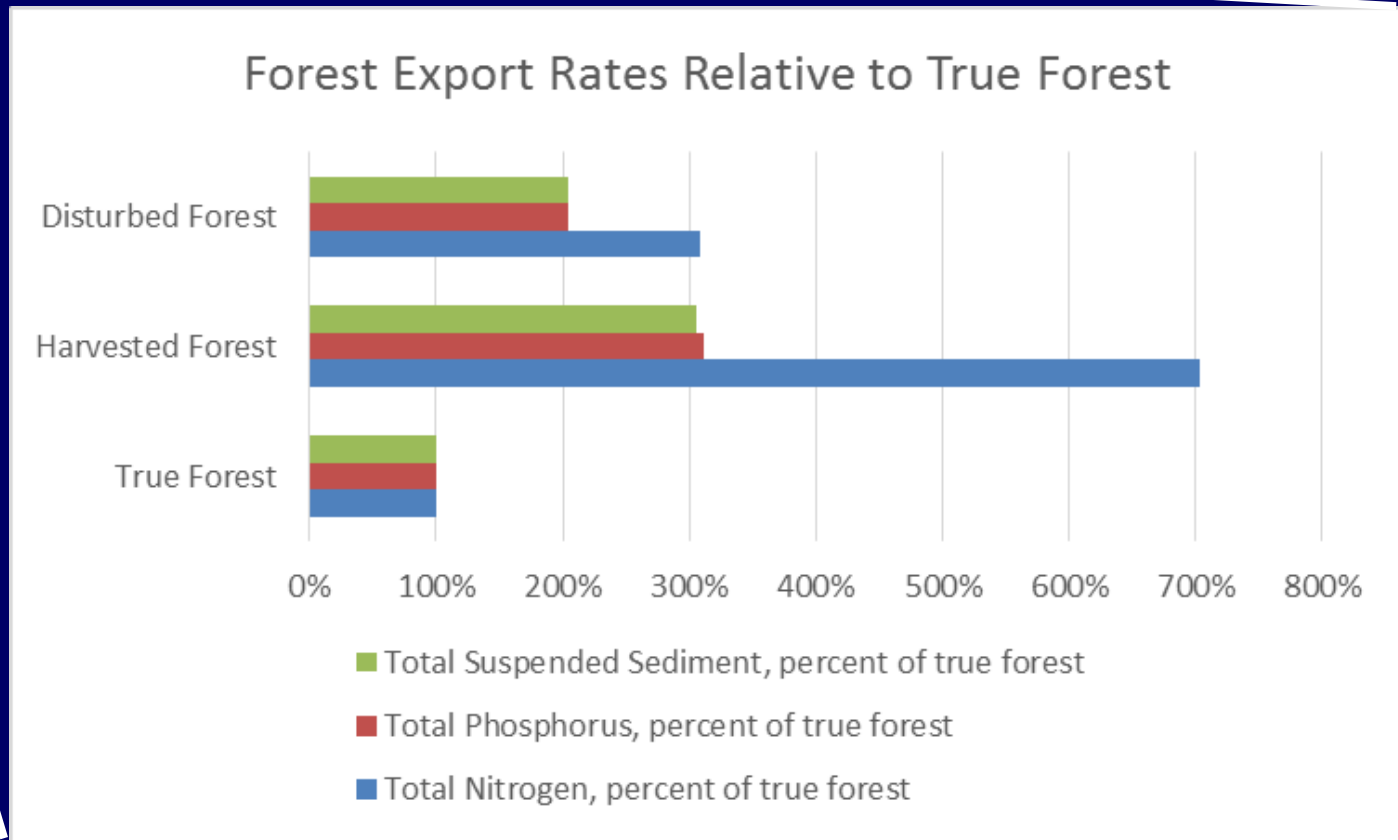
Targets, Land Uses and Sensitivities

- Calibration targets are based on relative loads for specific land uses and sensitivities.

- Relative loads do not vary geographically.

- All geographic variation in the targets comes from the sensitivities. Additional variation is accounted for in the land to water factors (work by Claggett, Mandel, Christianson).

- Sensitivities relate inputs to exports at the scale of a land segment. Inputs:

- Fertilizer	- Manure	- Crop Uptake
- Crop Cover	- Atmospheric Deposition	- Legume Fixation
- Soil P	- Sediment	- Runoff

Calibration Targets

- For each species of nitrogen, phosphorus and sediment.
- Long-term annual, not one for each year. Annual variation comes through hydrology and nutrient inputs.
- Order the influence of different land uses.
- Vary geographically based on nutrient and hydrology inputs.
- Do not include BMPs.
- Subject to modification through calibration: actual rate adjusted while relative differences maintained.

Target Calculation

- Targets are calculated for each nutrient by land use within each land segment.

- The basis for each target is the watershed-wide value and relative differences among land uses.

- Each land segment target is adjusted using sensitivities and a comparison to the median value of each nutrient input across all segments.
  - ➔ This adjustment can be + or – based on the characteristics of each land segment.

Target Calculation

- Targets are for each nutrient species, land use, and land segment.

  $$\text{Target} = \text{literature target} + \sum(\text{Sensitivity(input - average)})$$

- The amount (lbs) are set by the monitored loads and parsed to land uses using the relative rates from the literature review and global targets.
  - Global targets are developed using multiple models (average of CEAP, Phase 5.3.2, SPARROW; except urban which does not use CEAP)
  - Monitored data is pulled from the indicators, available at chesapeakebay.net/indicators/indicator/nitrogen_loads_and_river_flow_to_the_bay1

- Inputs are for nitrogen and phosphorus by land use and land segment as lbs/acre. Inputs are from: crop cover, fertilizer, manure, atmospheric deposition, crop uptake, and legume fixation. The median is the median across all land segments.

Method of Applying Sensitivities

- Show the differences in nutrient export relative to nutrient input.

- Land segment lb/A =
  target + ∑ (sensitivity(lseg input rate–median input for CBWS))

- Sensitivities are determined from the Phase 5.3.2 WSM.

Multiple Models

would be used in decision-making. The outputs of the individual models can be compared, and differences among the models can be related to the different assumptions and approaches. Together the models provide an average prediction, and differences among the predictions can be summarized (perhaps as a range or probability distribution) to provide an estimate of the uncertainty in the model average prediction. For example, a multi-model ensemble approach could be used to define a target nutrient reduction needed to achieve a water quality standard. Multiple solutions (target nutrient reductions) would be obtained from several models and averaged to obtain the mean target nutrient reduction. The main advantage of this approach is the mean model result tends to more correct than any single model result (Reichler and Kim 2008, Bever et al. 2013, Boomer et al. 2013), and the ensemble provides a measure of uncertainty (the variability in the model solutions). The multiple solutions also provide options to select more or less conservative management targets. Weighted averaging and Bayesian methods can improve multi-model ensemble integration (Kadane and Lazar 2004, Tobias and Li 2004, Morales et al. 2006).

STAC Publication 14-004

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Purpose of Global Targets

- Determine relative difference among literature review targets within each major land use group (e.g., crop, pasture and hay, urban stormwater, forest).

- Using relative loading rates among the major land use group
  – Relative rates for global targets controls for differences in magnitude among the three models
  – The absolute amount is set by the monitoring data

- Incorporate multiple models.

Global Target Source Data

- SPARROW's strengths is indicating the differences among land use categories.
  - 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.
  - Remove BMP effects by applying percent change between WSM 2002 Cal Yr. and No Action to SPARROW loads.
    - 2002 Cal Yr will be updated once BMP history is revised.

- CEAP 2013 Average annual loads delivered to watershed outlets (8-digit HUCs) for no-practice scenario—*Not using for urban.*

- Phase 5.3.2 2007 No Action.

Cropland TN
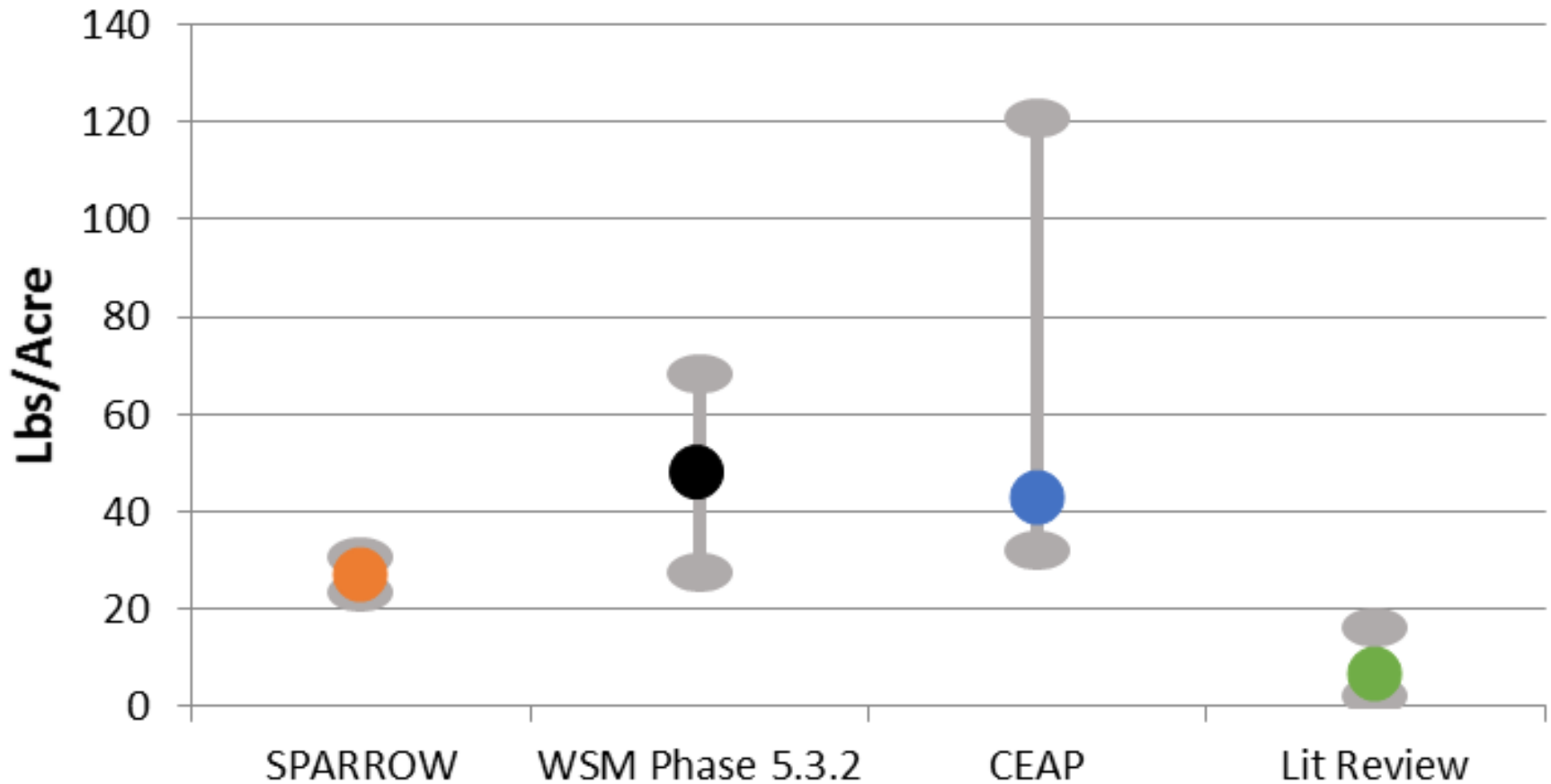
➢ Error bars are not representing the same information.
CEAP: 25th and 75th percentile of the distribution of farmland acres, est. from graphs
SPARROW: Standard Error of the loading rate, not a distribution
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments
Literature Review: 25th and 75th percentile of the studies reviewed

Developed TN
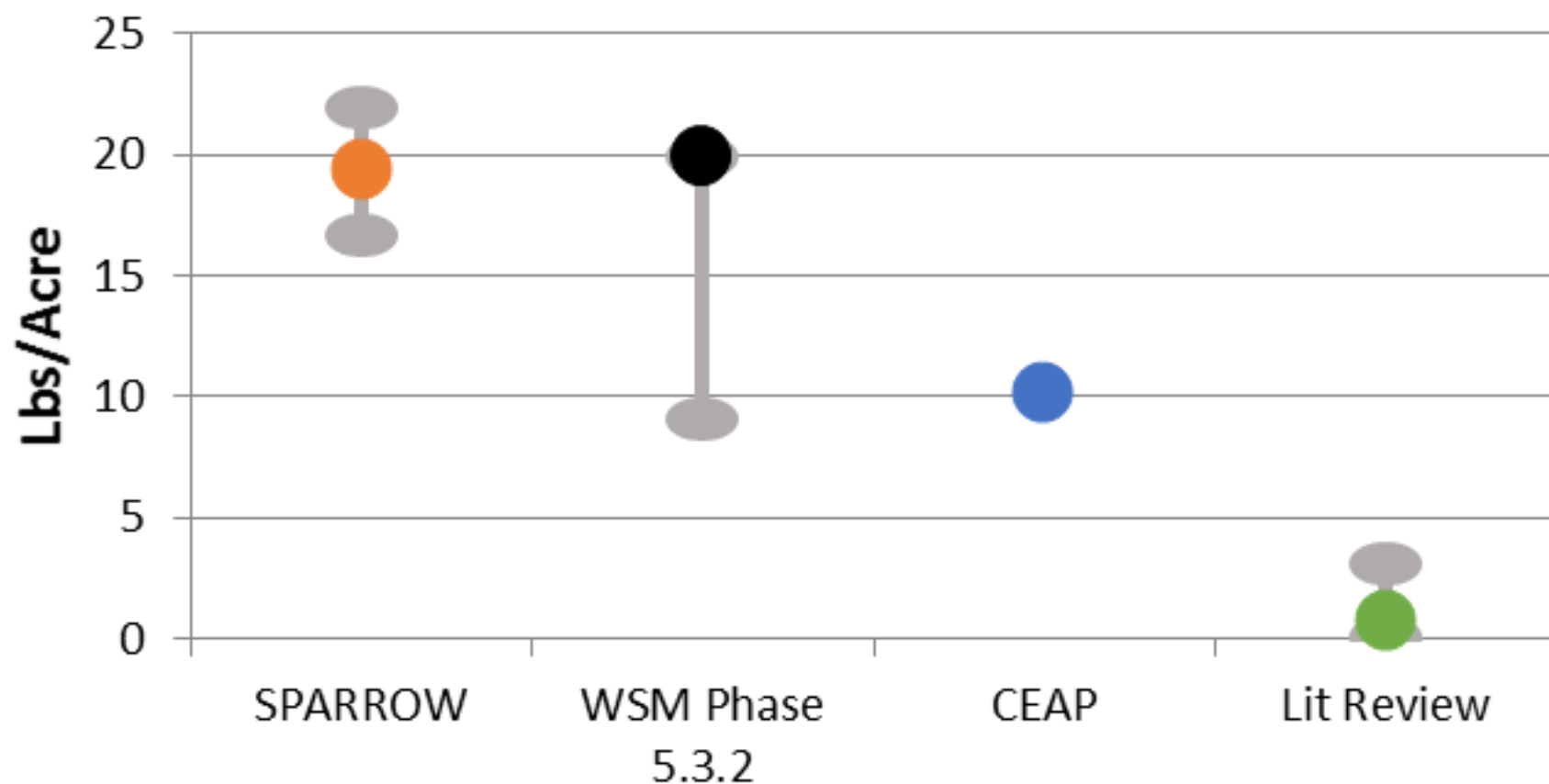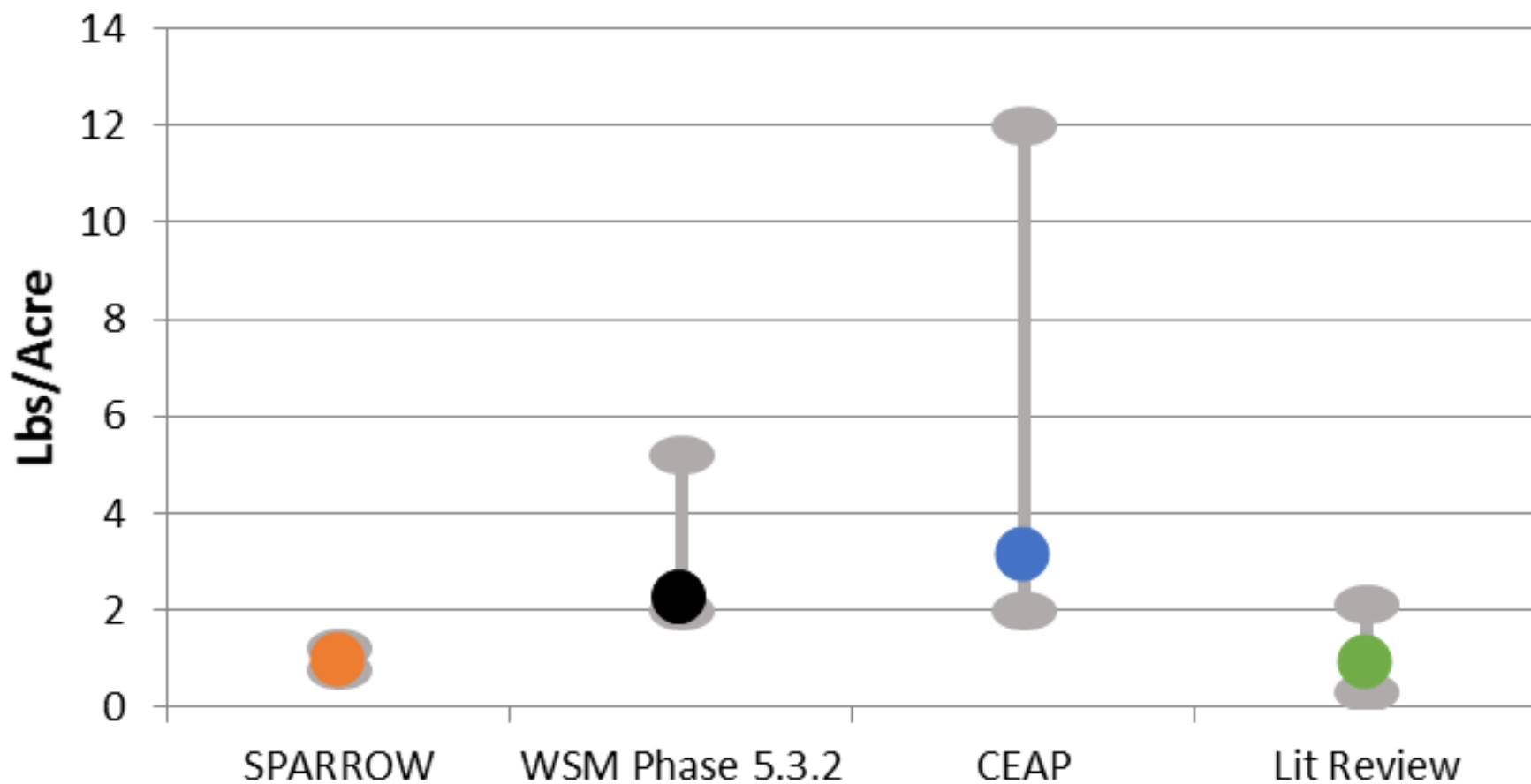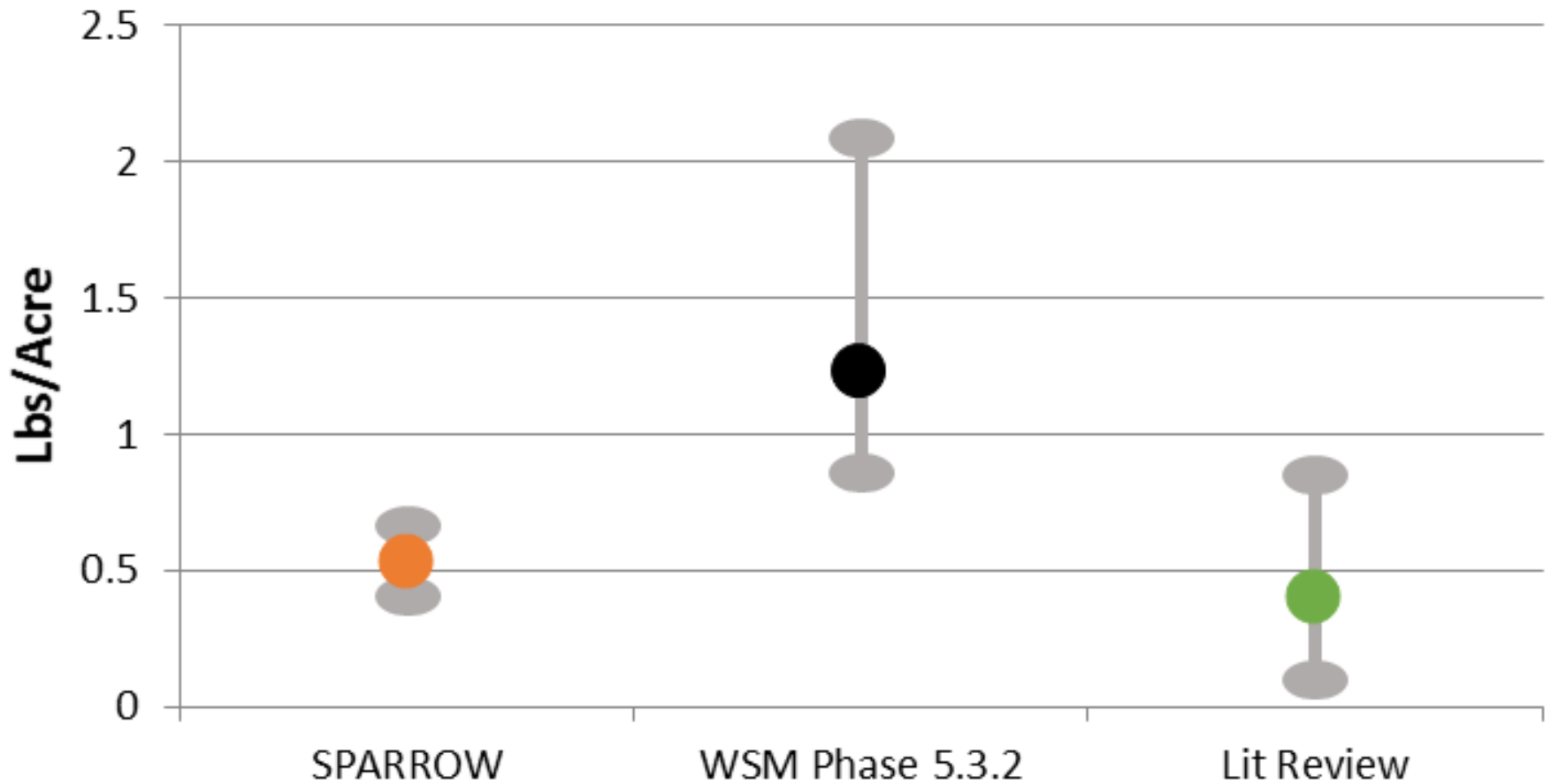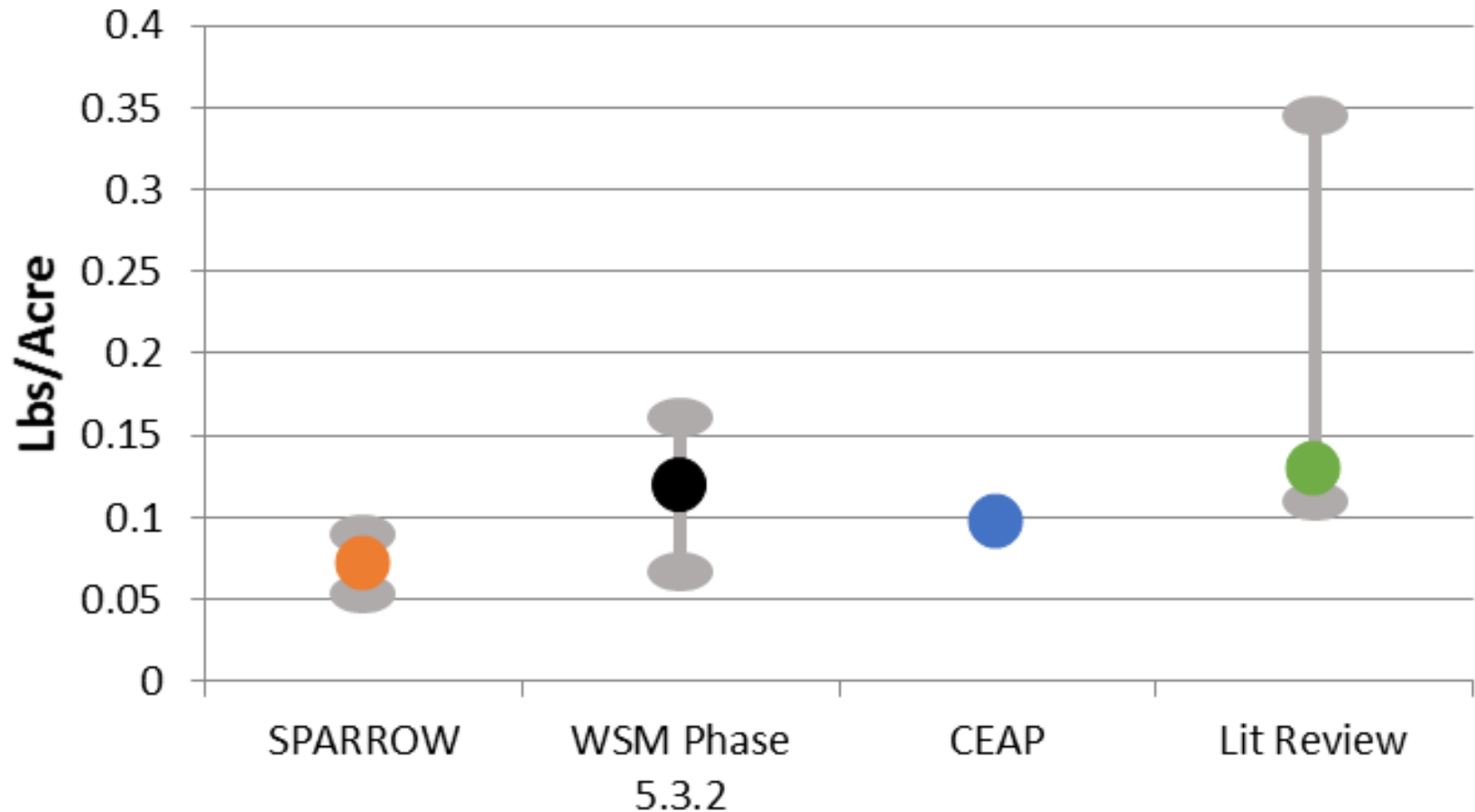
➢ Error bars are not representing the same information.
SPARROW: Standard Error of the loading rate, not a distribution
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments
Literature Review: 25th and 75th percentile of the studies reviewed

➤ Error bars are not representing the same information.
CEAP: Did not provide a graph of the loading rate distribution of the forest acres
SPARROW: Standard Error of the loading rate, not a distribution
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments
Literature Review: 25th and 75th percentile of the studies reviewed

Pasture TN

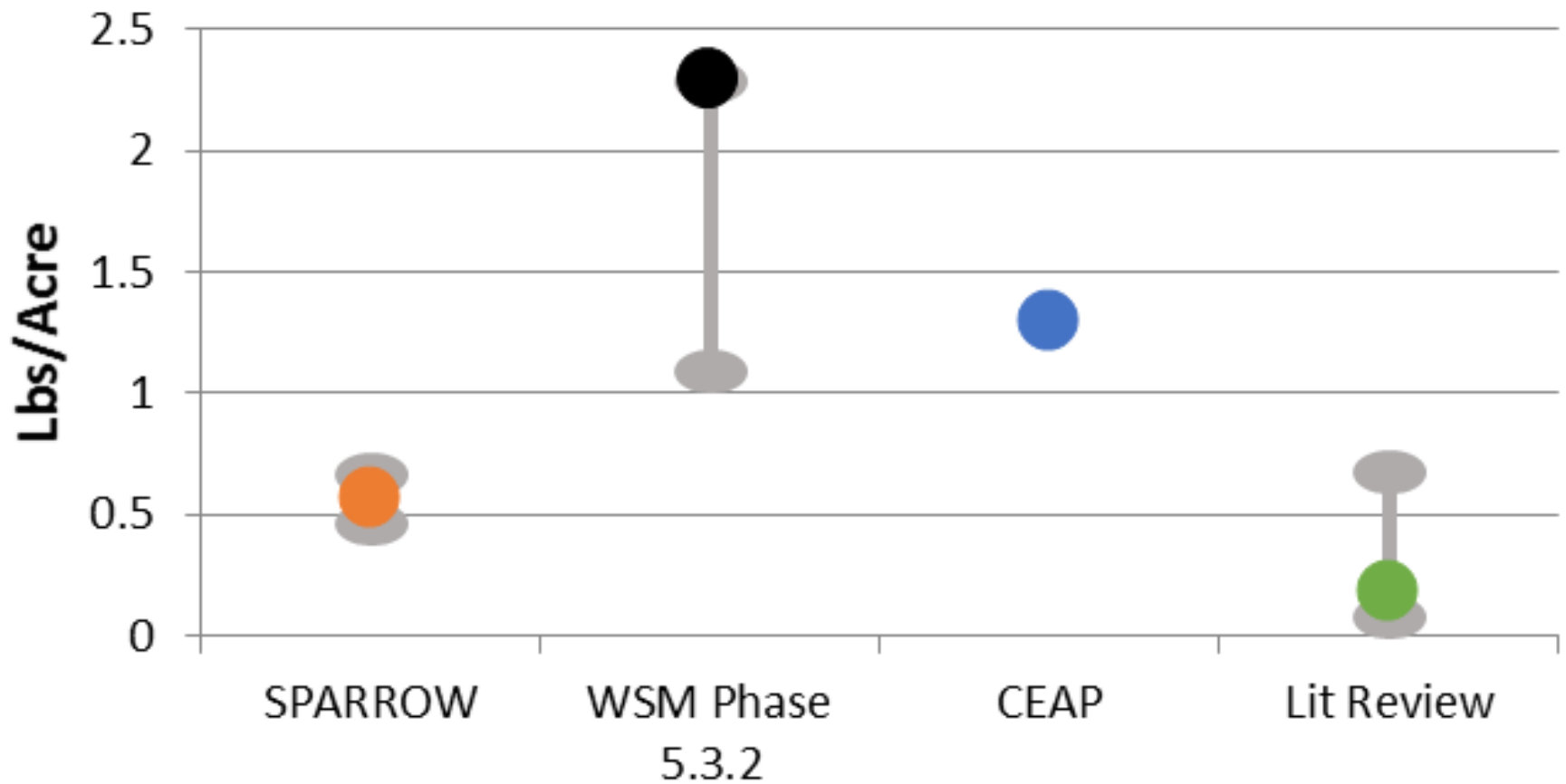- Error bars are not representing the same information among the three models.
CEAP: Did not provide a graph of the loading rate distribution of the pasture acres
SPARROW: Standard Error of the loading rate, not a distribution
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments
Literature Review: 25th and 75th percentile of the studies reviewed

Cropland TP

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SPARROW: Standard Error of the loading rate, not a distribution
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments
Literature Review: 25th and 75th percentile of the studies reviewed

Developed TP

> Error bars are not representing the same information.
SPARROW: Standard Error of the loading rate, not a distribution
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments
Literature Review: 25th and 75th percentile of the studies reviewed

Natural TP

> Error bars are not representing the same information.

CEAP: Did not provide a graph of the loading rate distribution of the forest acres

SPARROW: Standard Error of the loading rate, not a distribution

Phase 5.3.2: 25th and 75th percentile of the distribution of land segments

Literature Review: 25th and 75th percentile of the studies reviewed

Pasture TP

> Error bars are not representing the same information among the three models.
CEAP: Did not provide a graph of the loading rate distribution of the pasture acres
SPARROW: Standard Error of the loading rate, not a distribution
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments
Literature Review: 25th and 75th percentile of the studies reviewed

All Sectors—TN

Targets for Phase 6
All Chesapeake Bay Land Segments

overall statistics					
Min	1.297316	Mean	17.14256	Max	79.36855
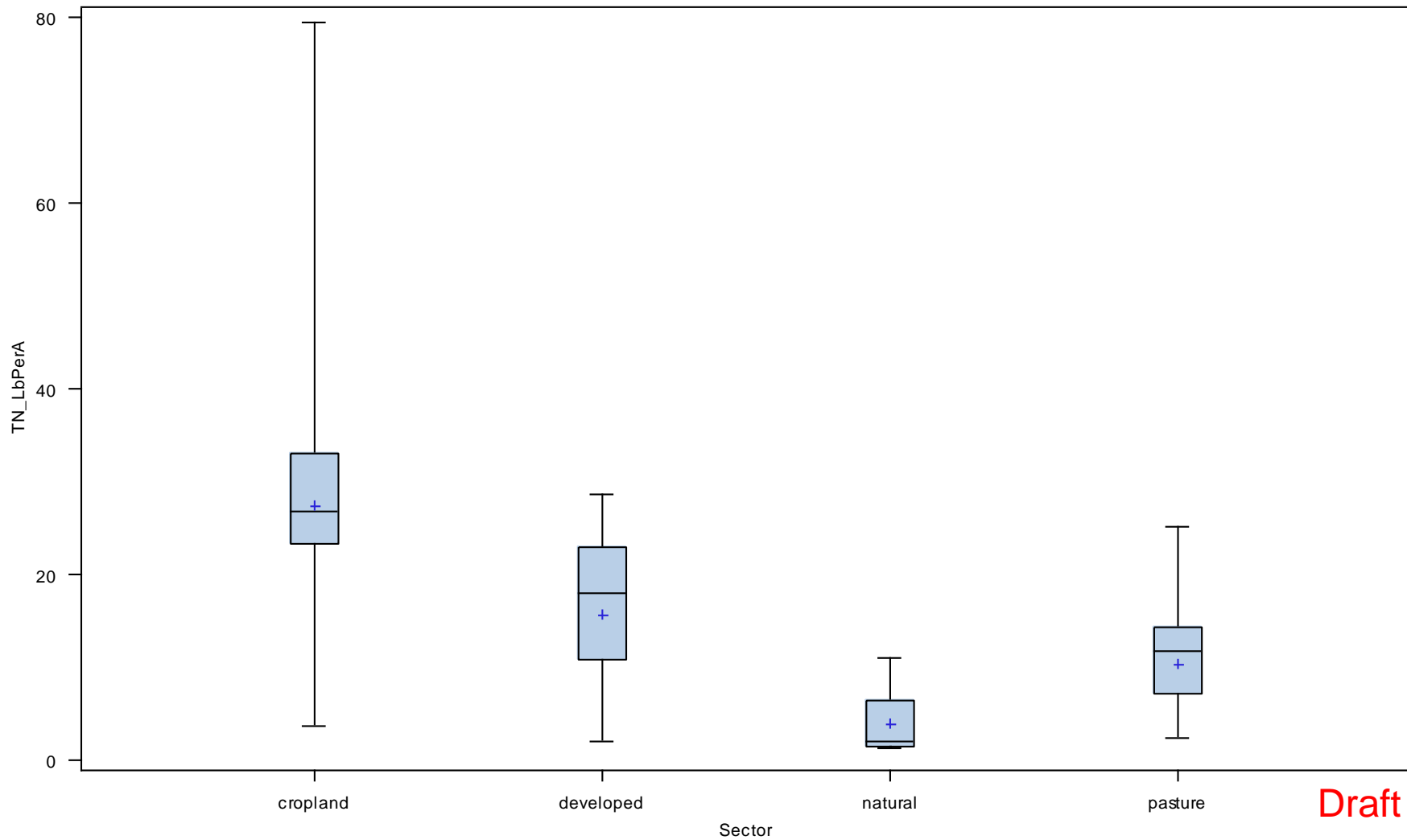
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All Sectors—TP

Targets for Phase 6
All Chesapeake Bay Land Segments

overall statistics					
Min	0	Mean	1.183228	Max	12.59762
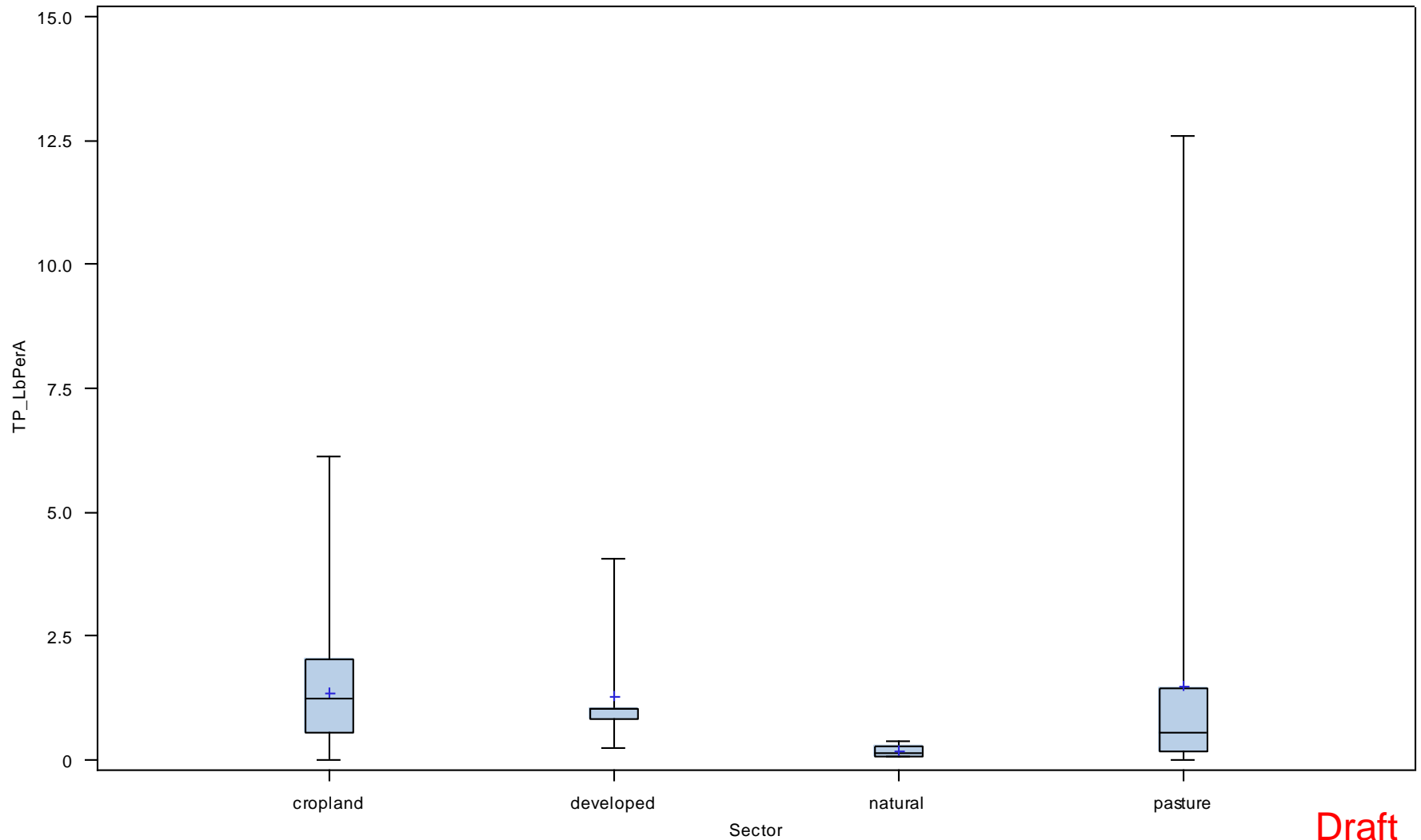
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Targets for Phase 6
All Chesapeake Bay Land Segments

overall statistics					
Min	26.11028	Mean	1537.785	Max	17528.85
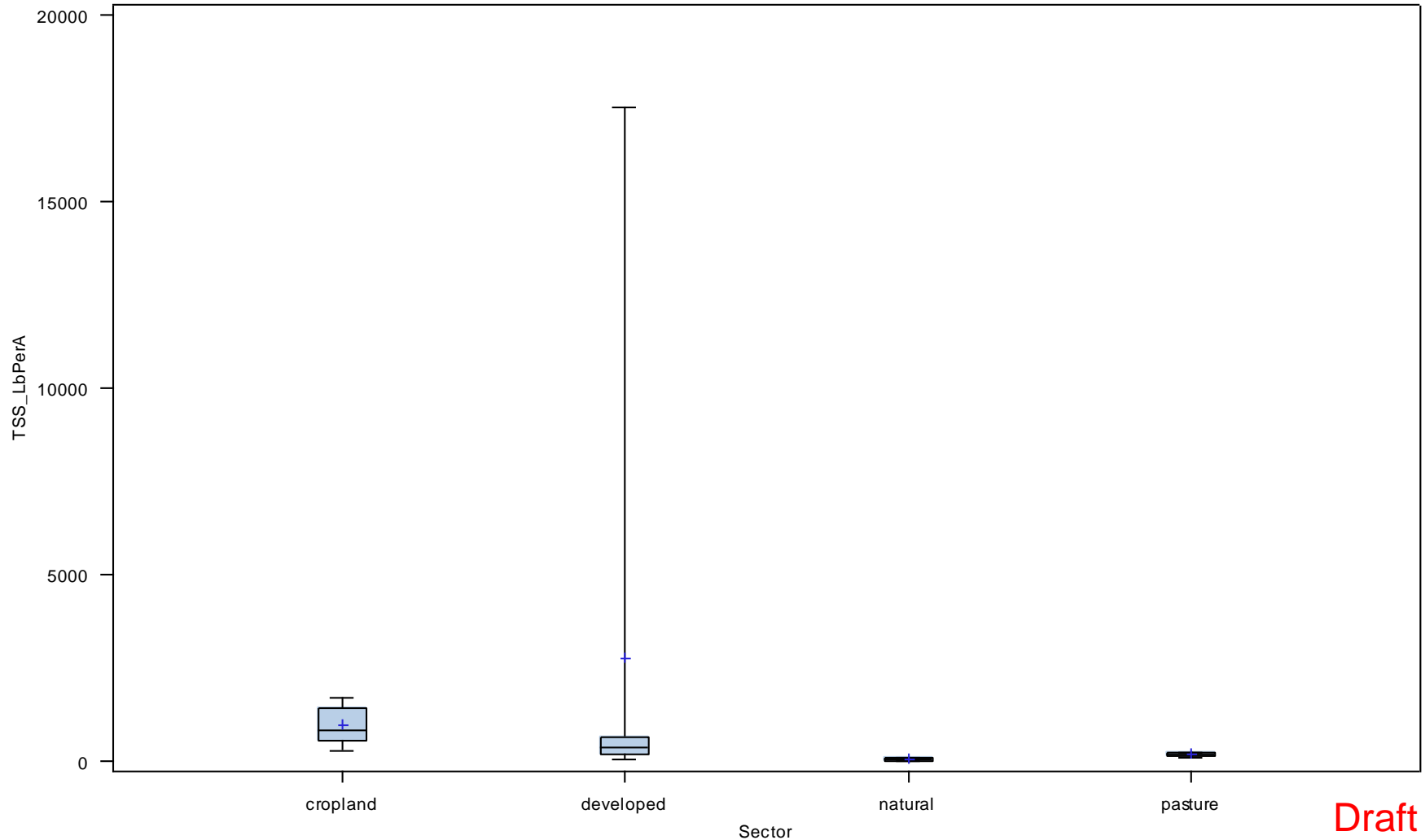
Natural—TN

Targets for Phase 6
Natural-All Chesapeake Bay Land Segments

overall statistics					
Min	1.297316	Mean	3.912566	Max	10.94475
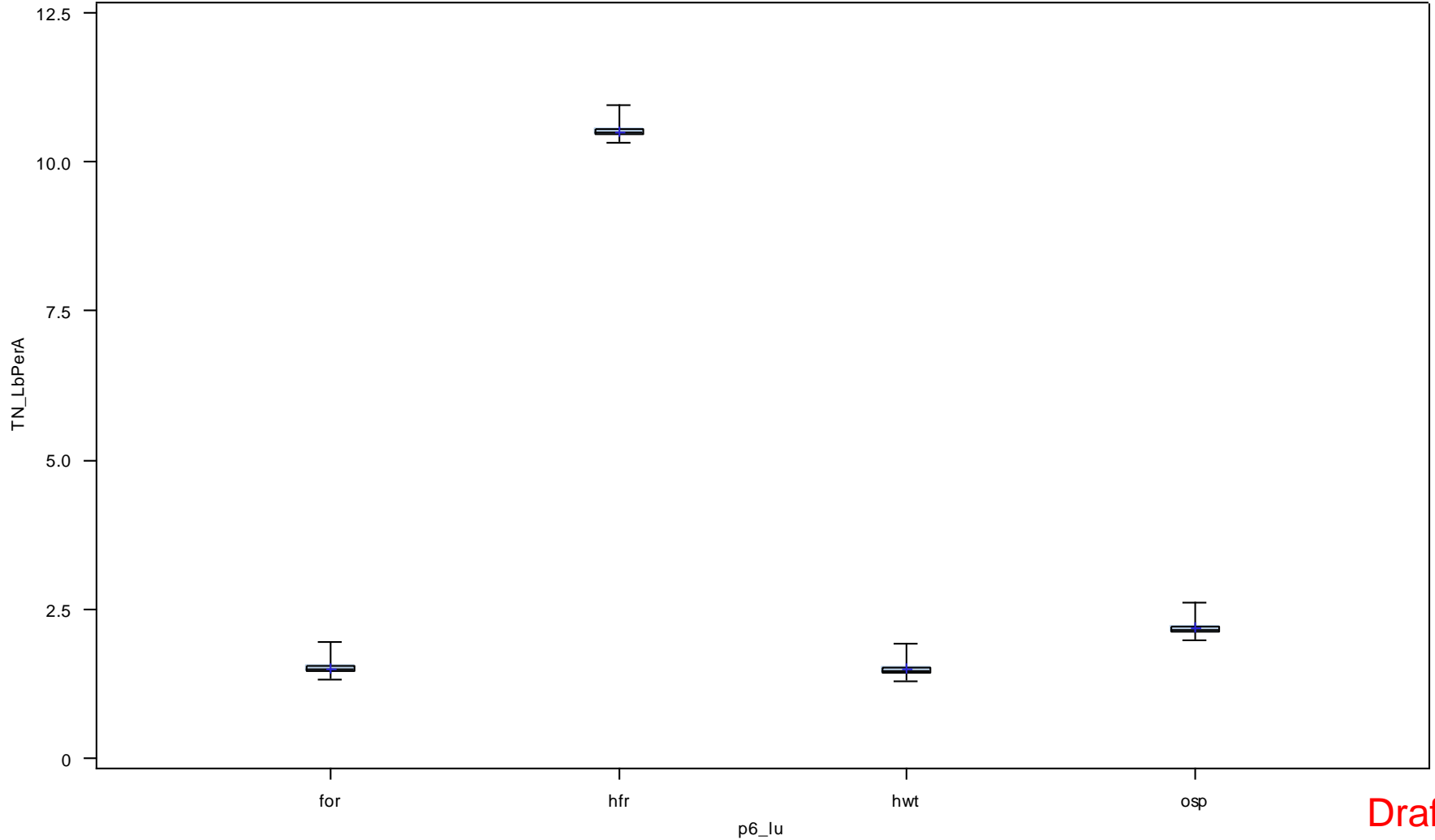
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Natural—TP

overall statistics					
Min	0.066171	Mean	0.178693	Max	0.376262
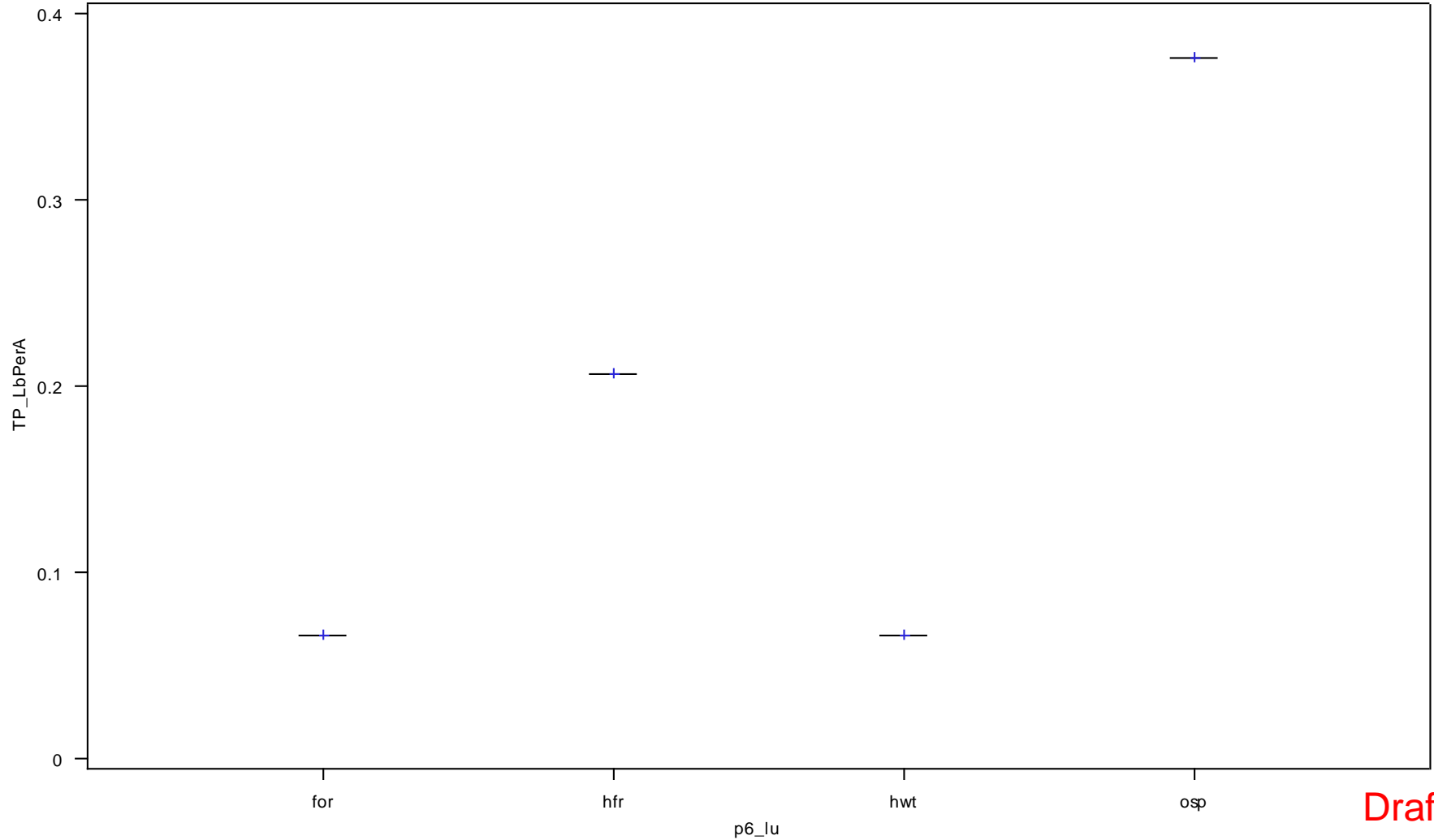
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Natural—TSS

Targets for Phase 6
Natural-All Chesapeake Bay Land Segments

overall statistics					
Min	26.11028	Mean	58.45964	Max	102.0176
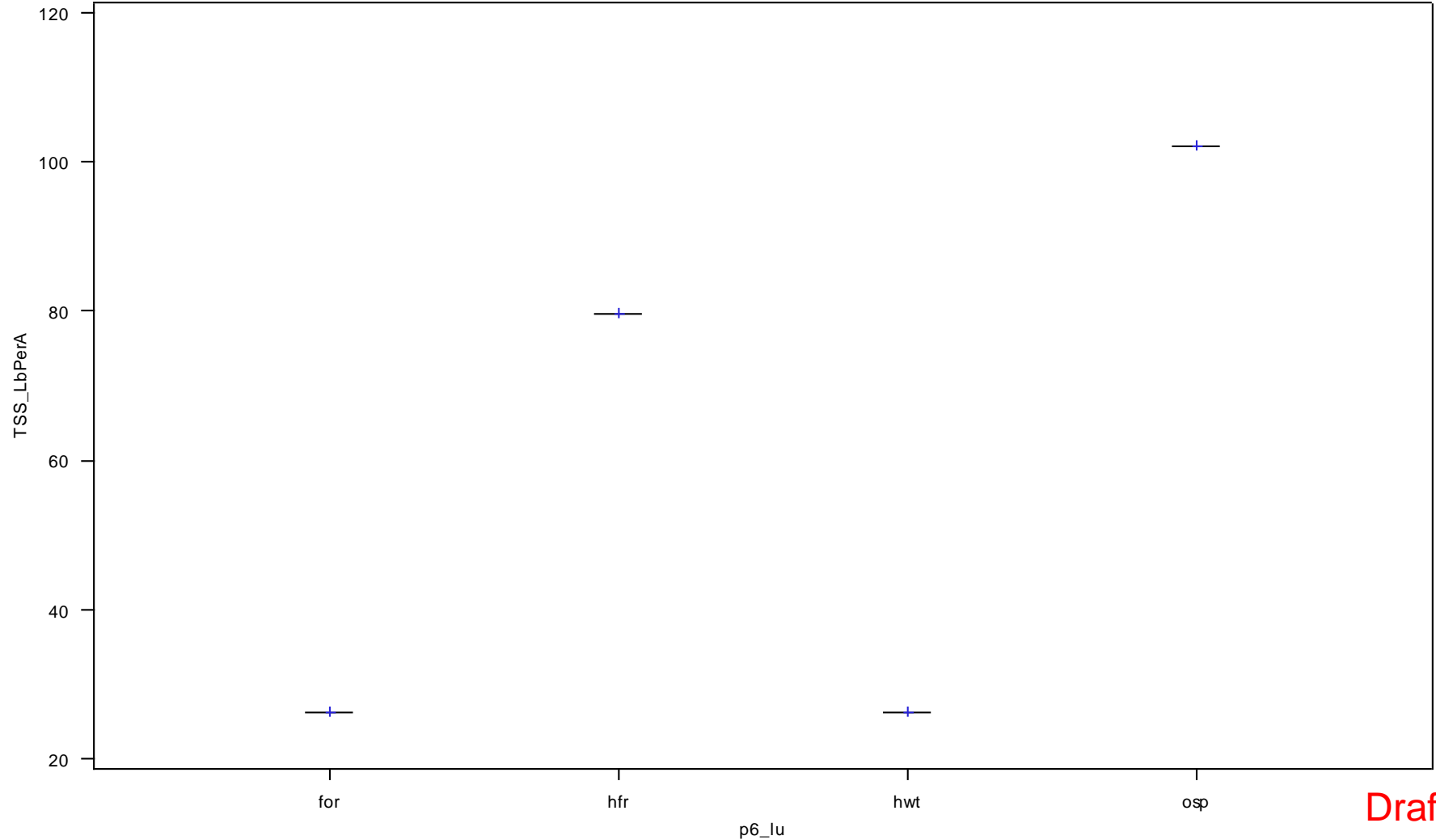
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Developed—TN

Targets for Phase 6
Developed-All Chesapeake Bay Land Segments

overall statistics					
Min	2.068028	Mean	15.59515	Max	28.53441
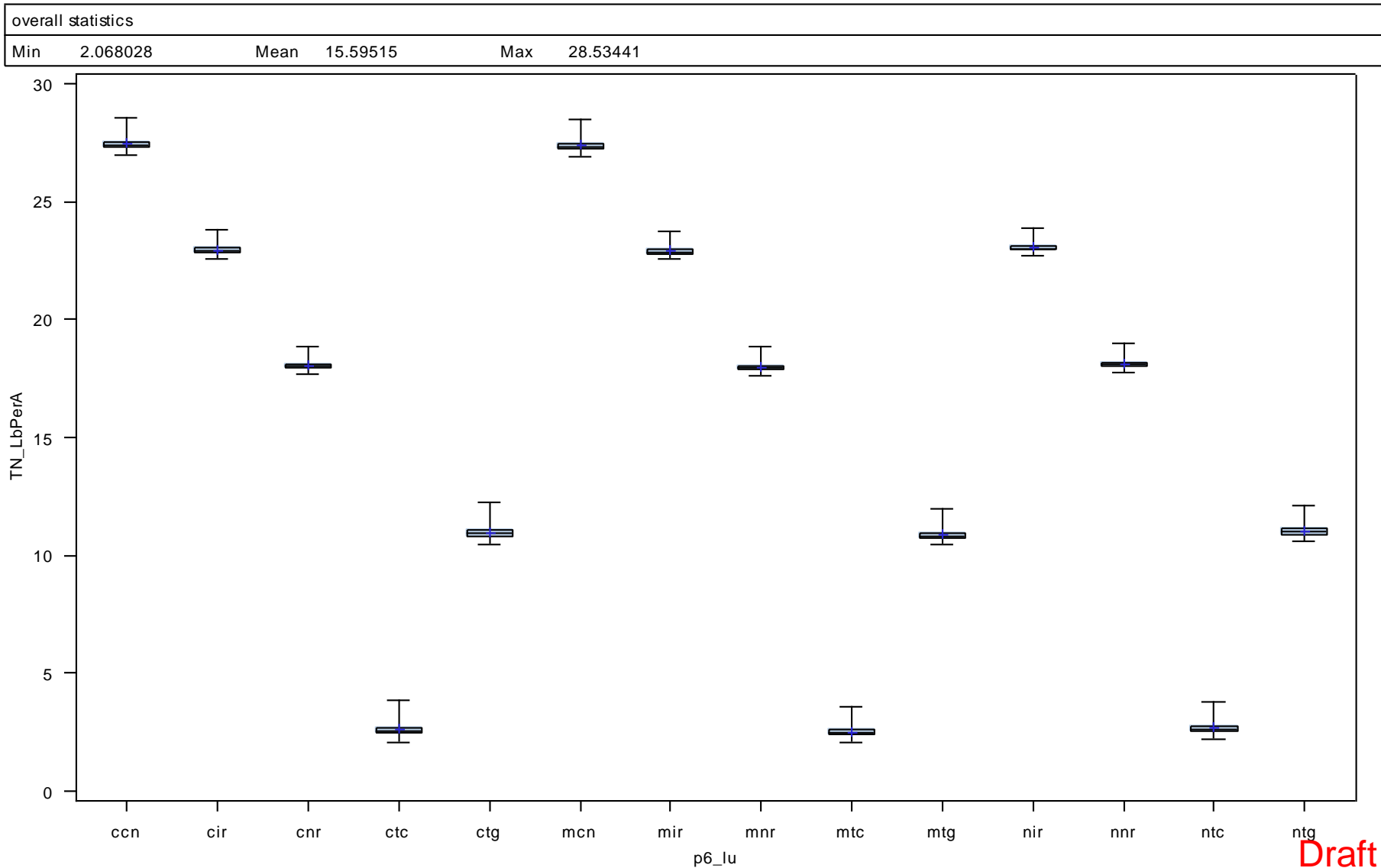
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Developed—TP

Targets for Phase 6
Developed-All Chesapeake Bay Land Segments

overall statistics					
Min	0.253513	Mean	1.264273	Max	4.075543
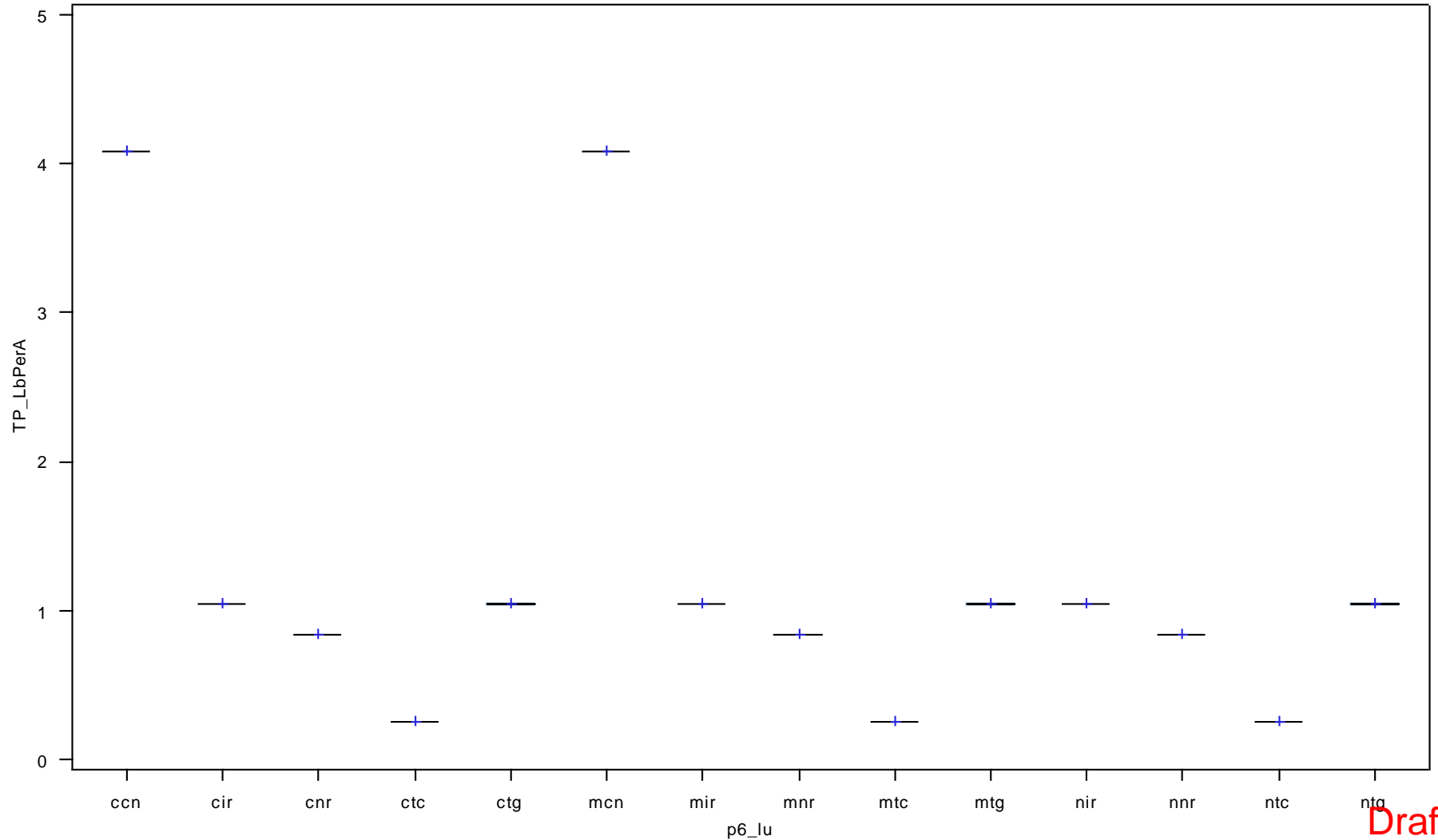
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Developed—TSS

Targets for Phase 6
Developed-All Chesapeake Bay Land Segments

overall statistics					
Min	43.98063	Mean	2767.047	Max	17528.85
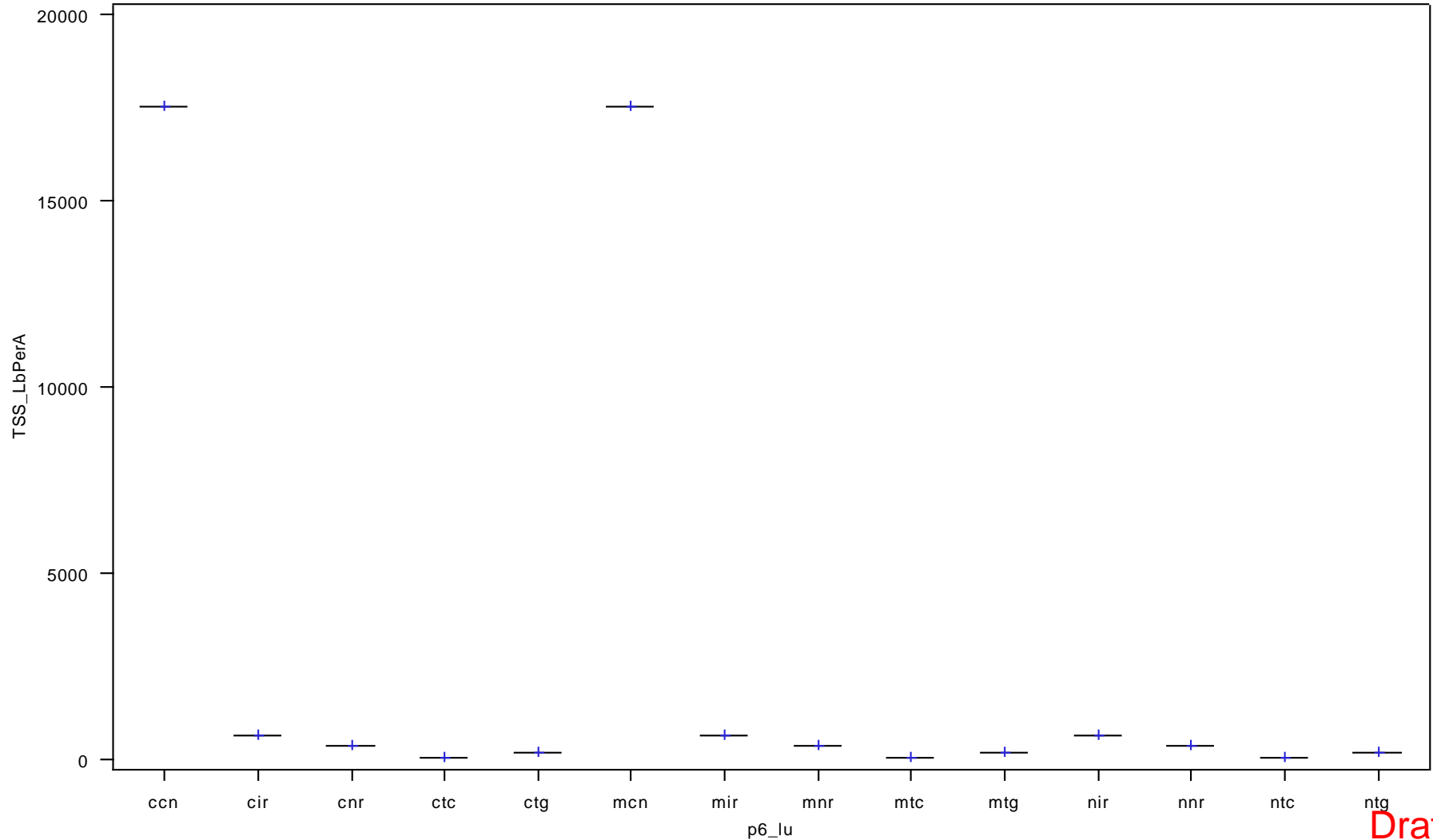
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Cropland—TN

Targets for Phase 6
Cropland-All Chesapeake Bay Land Segments

overall statistics					
Min	3.713424	Mean	27.36094	Max	79.36855
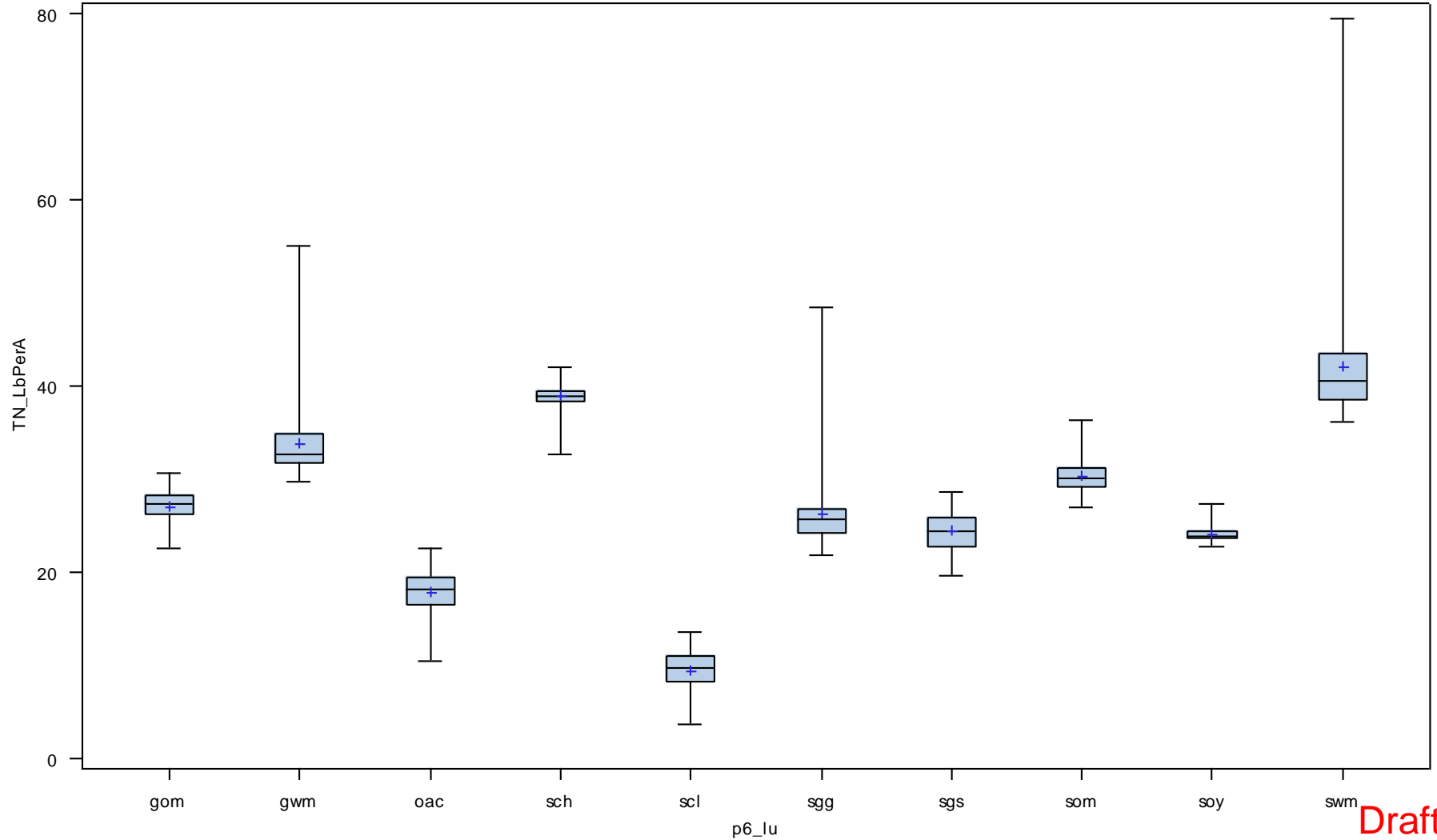
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Cropland—TP

Targets for Phase 6
Cropland-All Chesapeake Bay Land Segments

overall statistics					
Min	0	Mean	1.353027	Max	6.107152
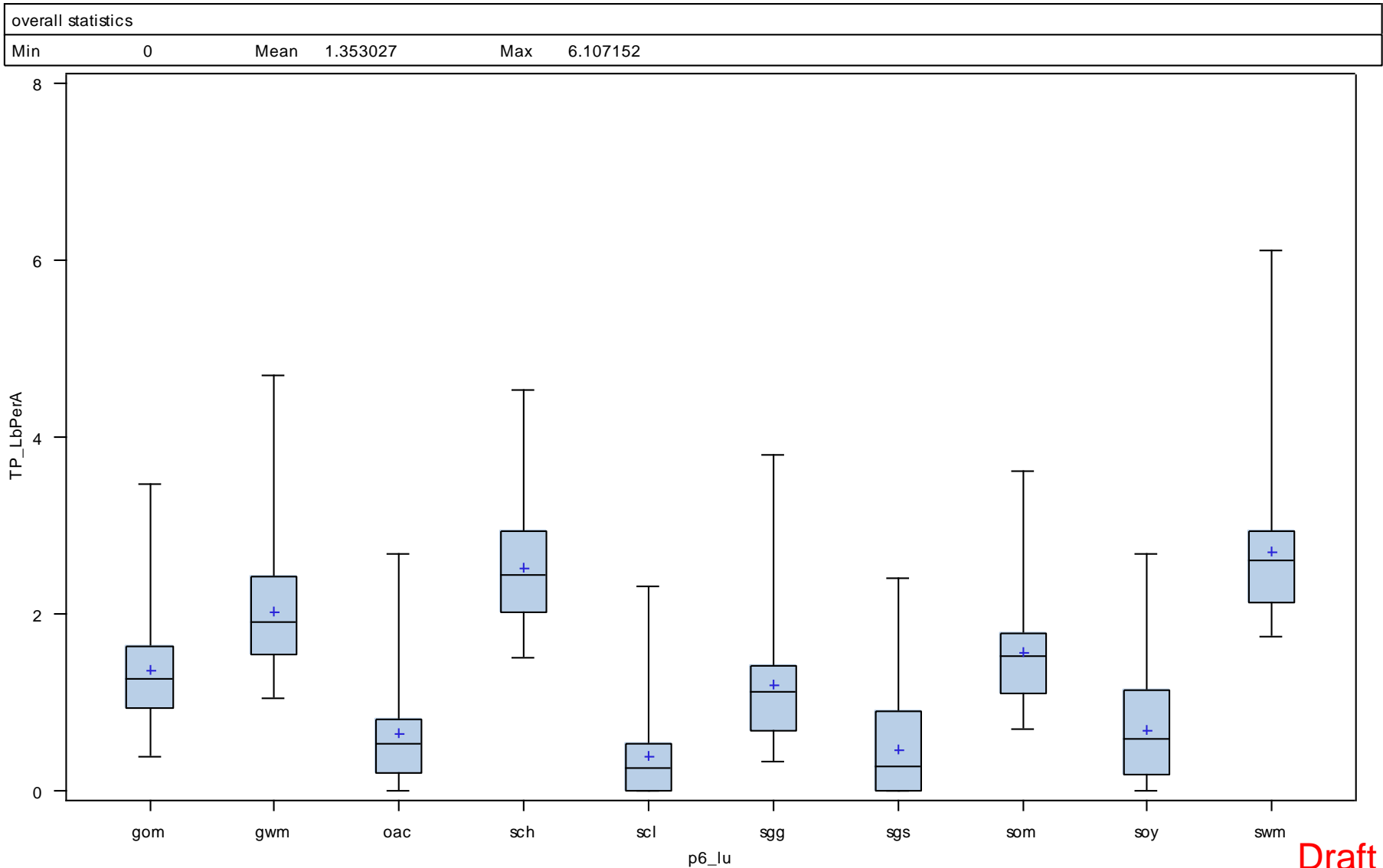
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Cropland—TSS

Targets for Phase 6
Cropland-All Chesapeake Bay Land Segments

overall statistics					
Min	284.0199	Mean	946.7329	Max	1704.119
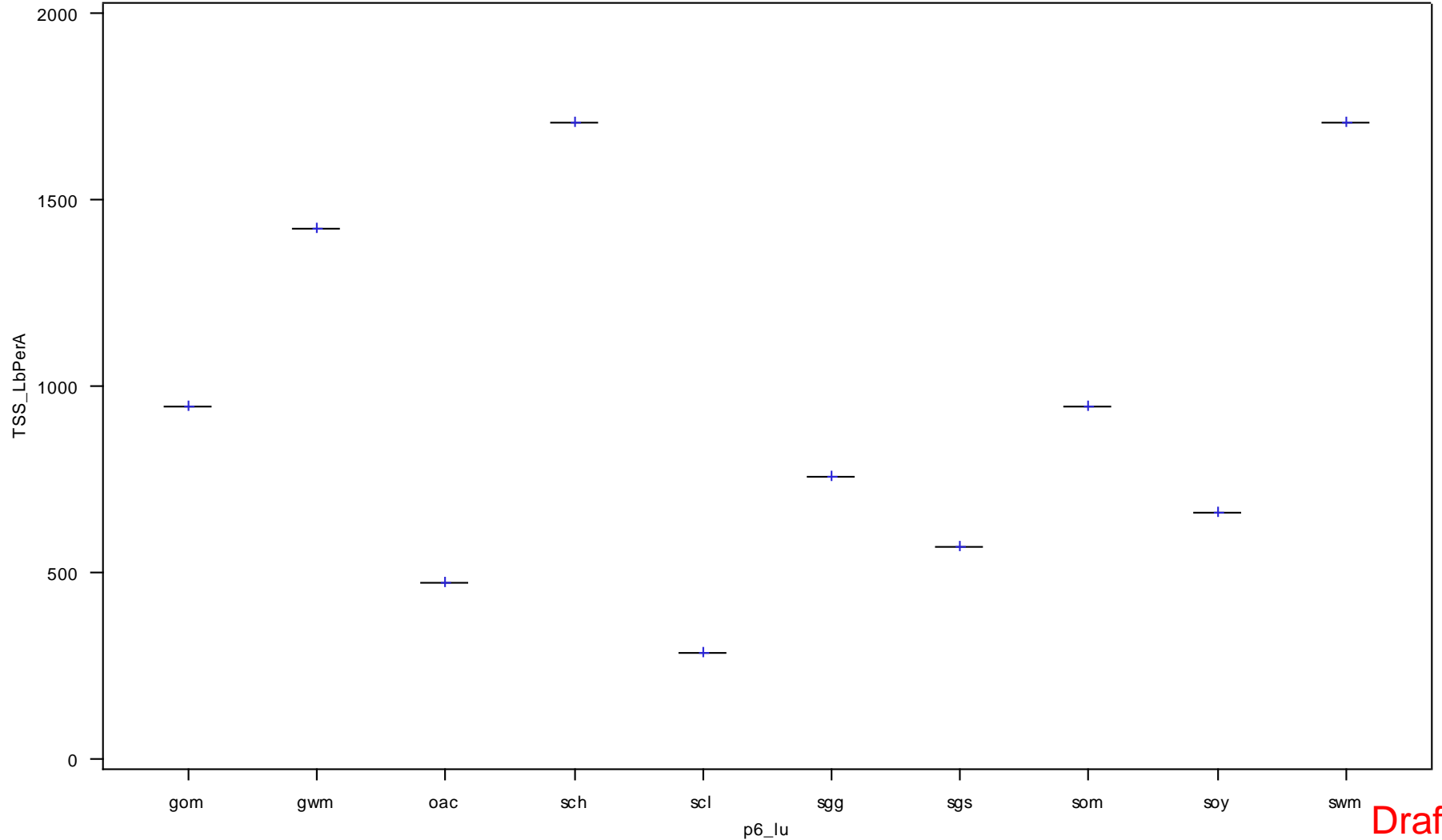
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Pasture—TN

Targets for Phase 6
Pasture and Hay-All Chesapeake Bay Land Segments

overall statistics					
Min	2.345677	Mean	10.24257	Max	25.14441
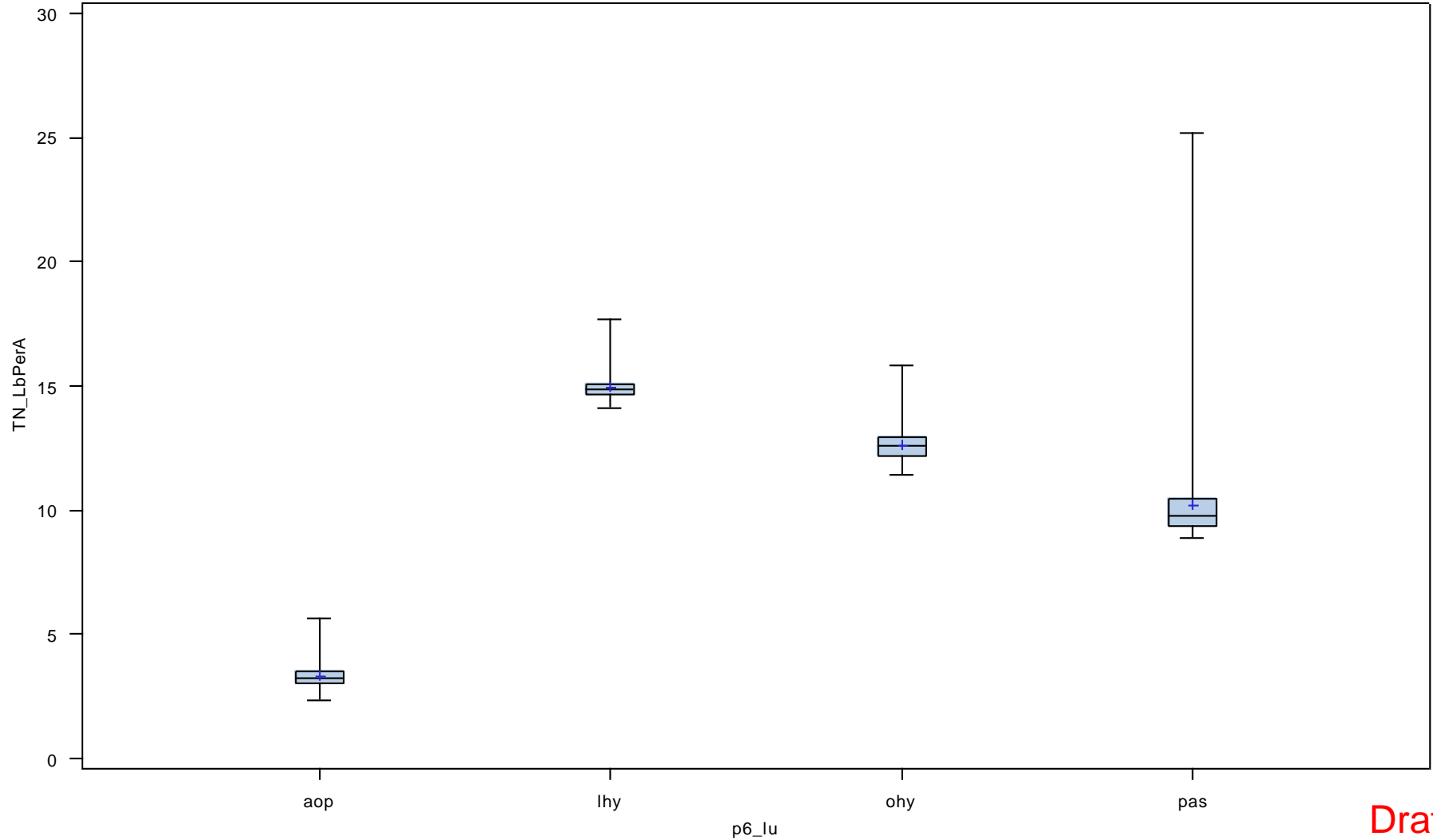
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Pasture—TP

Targets for Phase 6
Pasture and Hay-All Chesapeake Bay Land Segments

overall statistics					
Min	0	Mean	1.479607	Max	12.59762
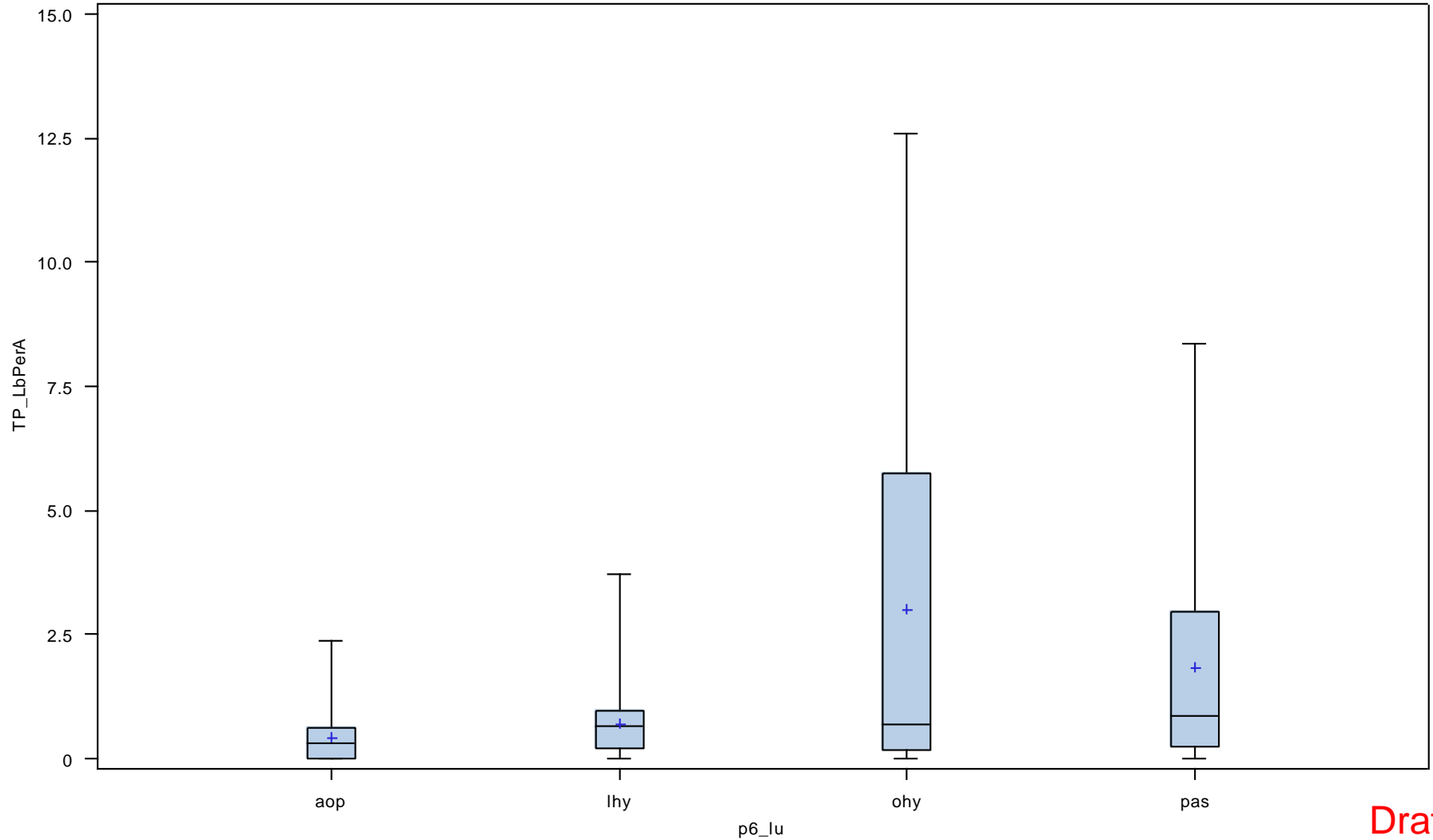
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Pasture—TSS

Targets for Phase 6
Pasture and Hay-All Chesapeake Bay Land Segments

overall statistics					
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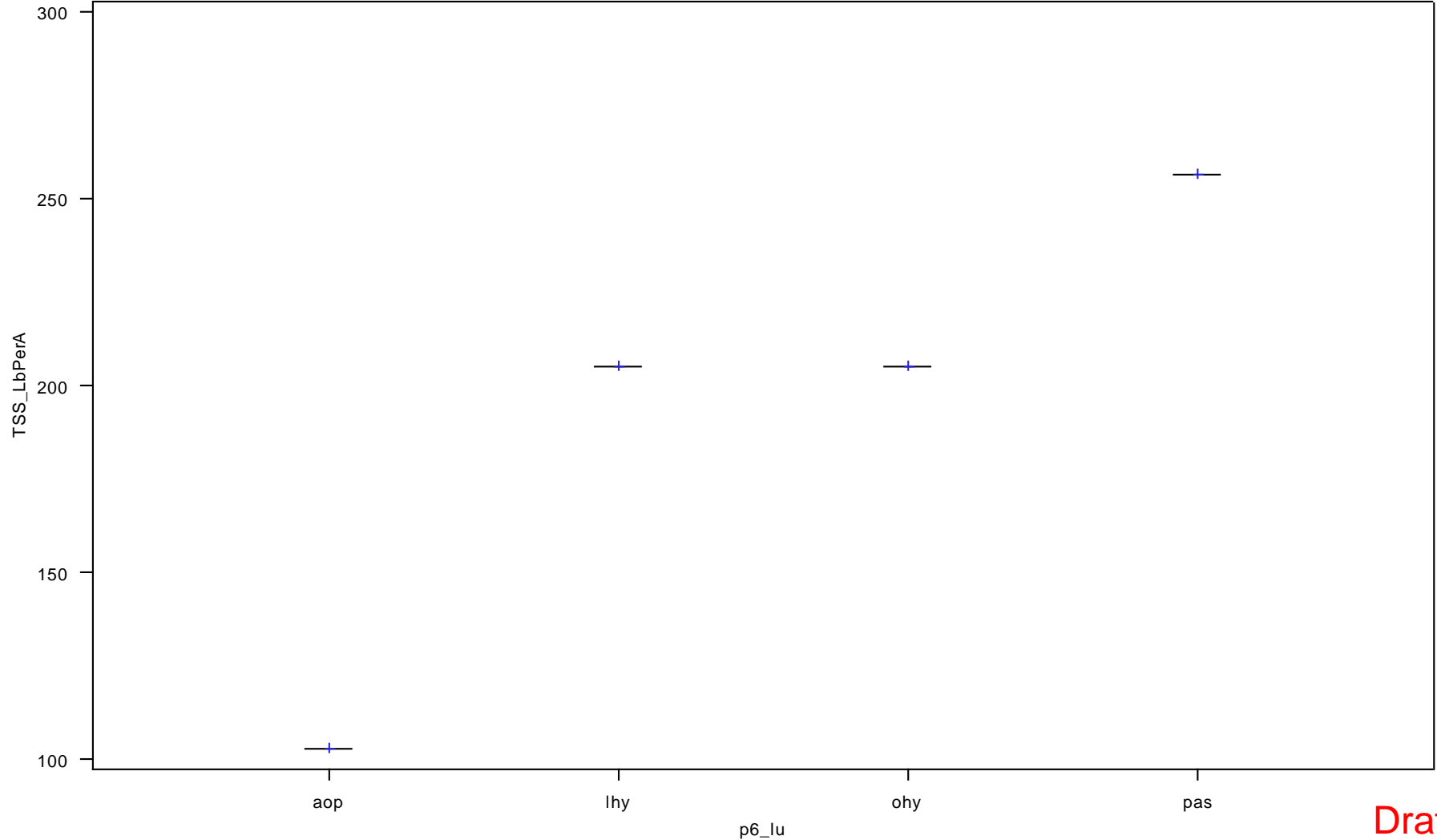
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Additional Data Expected

- SPARROW data using Phase 6 land uses and acres—Fall 2015

- Revised Phase 6 land uses and acreages
  - No federal lands are currently included

- Changes to the sector-specific relative land use export rates

- Pasture and forest phosphorus sensitivities

- RUSLE2 data that will inform the sediment loads

Improvements over Phase 5.3.2

- Transparency

- Involvement of workgroups and others

- Multiple models that better represent the Chesapeake Bay region than solely using literature from a broader geographic area

Questions?