Development of Phase 6 Model Land Use Export Rate Targets

Modeling Quarterly Review
April 22, 2015
Olivia Devereux

Overview

- Calculation method

- Data needed
  - Global target for a major land use group
  - Relative rates for land uses within a major land use group
  - Acres for Phase 6 land uses
  - Sensitivity to nutrient inputs

- Targets for each land use and segment

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 for each nutrient, land use, and land segment as lbs/acre.

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

- Literature targets are from the literature review and include the scaling to the global targets. There is one literature target for nitrogen and phosphorus for each land use.
  - Global targets are developed using multiple models (average of CEAP, Phase 5.3.2, SPARROW; except urban which does not use CEAP)
- 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.

Data Needed

- Global target for a major land use group
- Relative rates for land uses within a major land use group
- Acres for Phase 6 land uses
- Sensitivity to nutrient inputs

Purpose of Global Targets

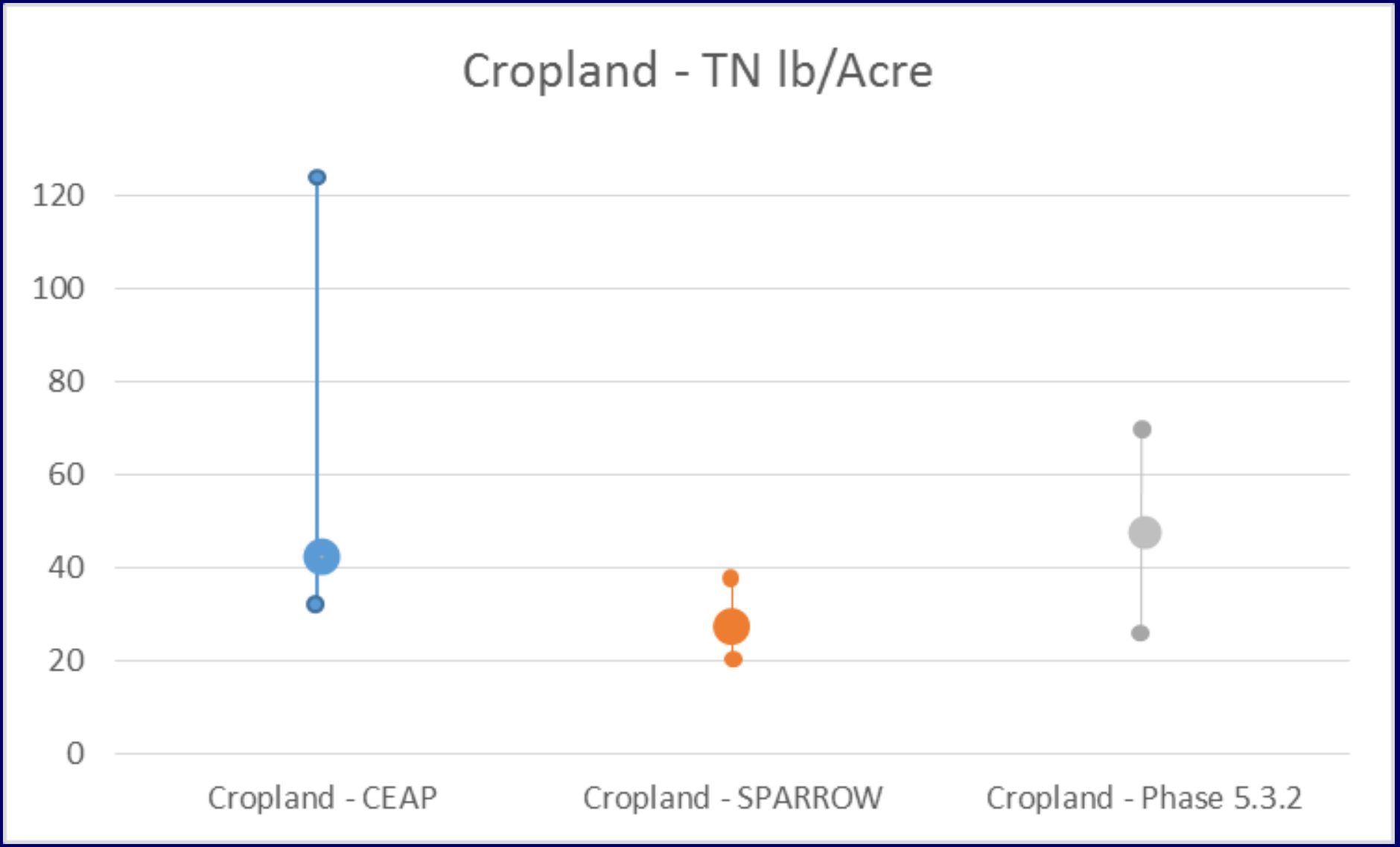
- Determine relative difference among literature review targets within each major land use group (e.g., crop, pasture and hay, urban stormwater, forest).
- Set the load for that major land use group.
- Incorporate multiple models.

Multiple Models

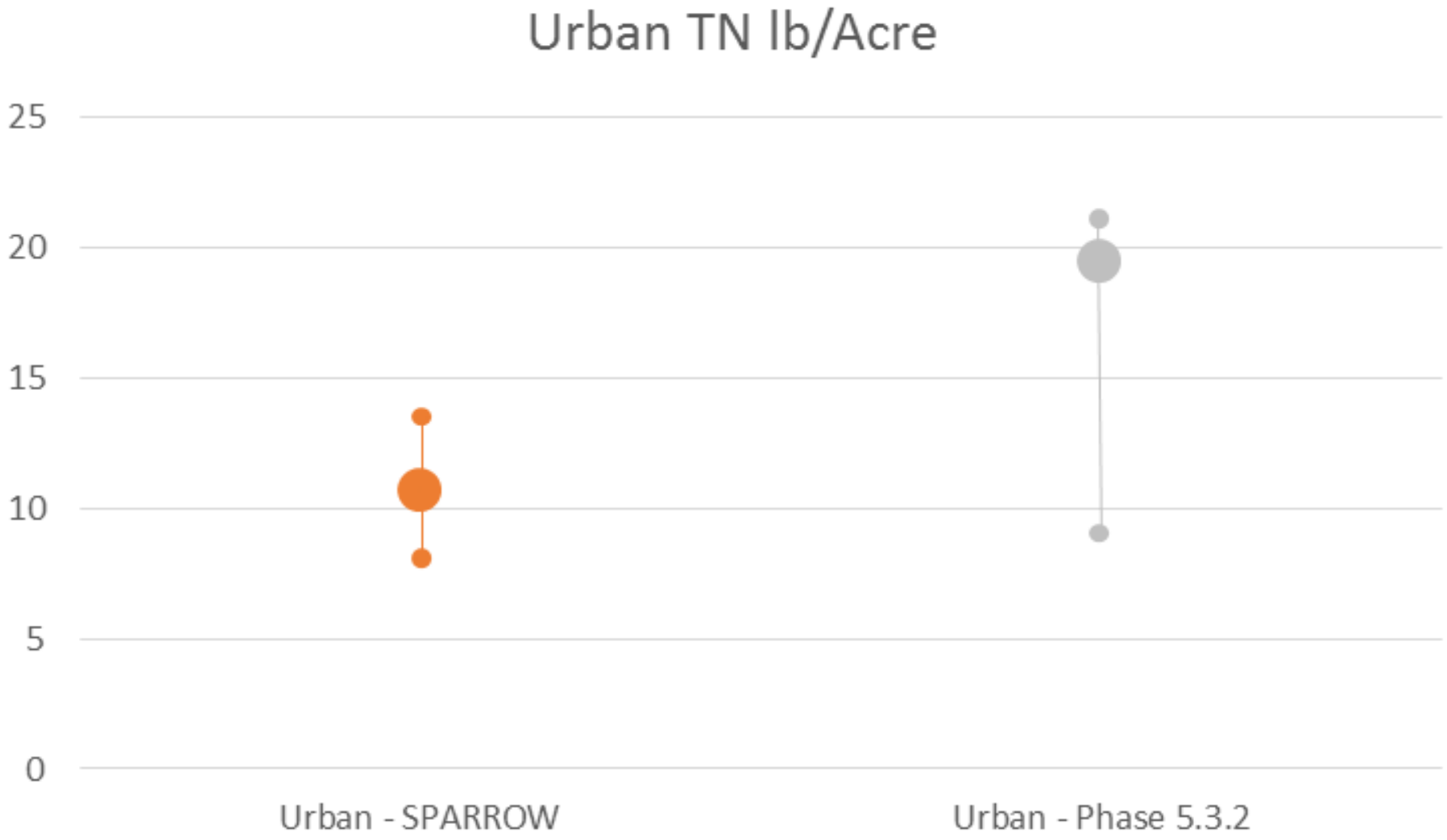
would be used in decision-making. The outputs of the individual models can be compared, and differences among the models can be related to the different assumptions and approaches. Together the models provide an average prediction, and differences among the predictions can be summarized (perhaps as a 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).

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.



Error bars are not representing the same information among the three models.
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



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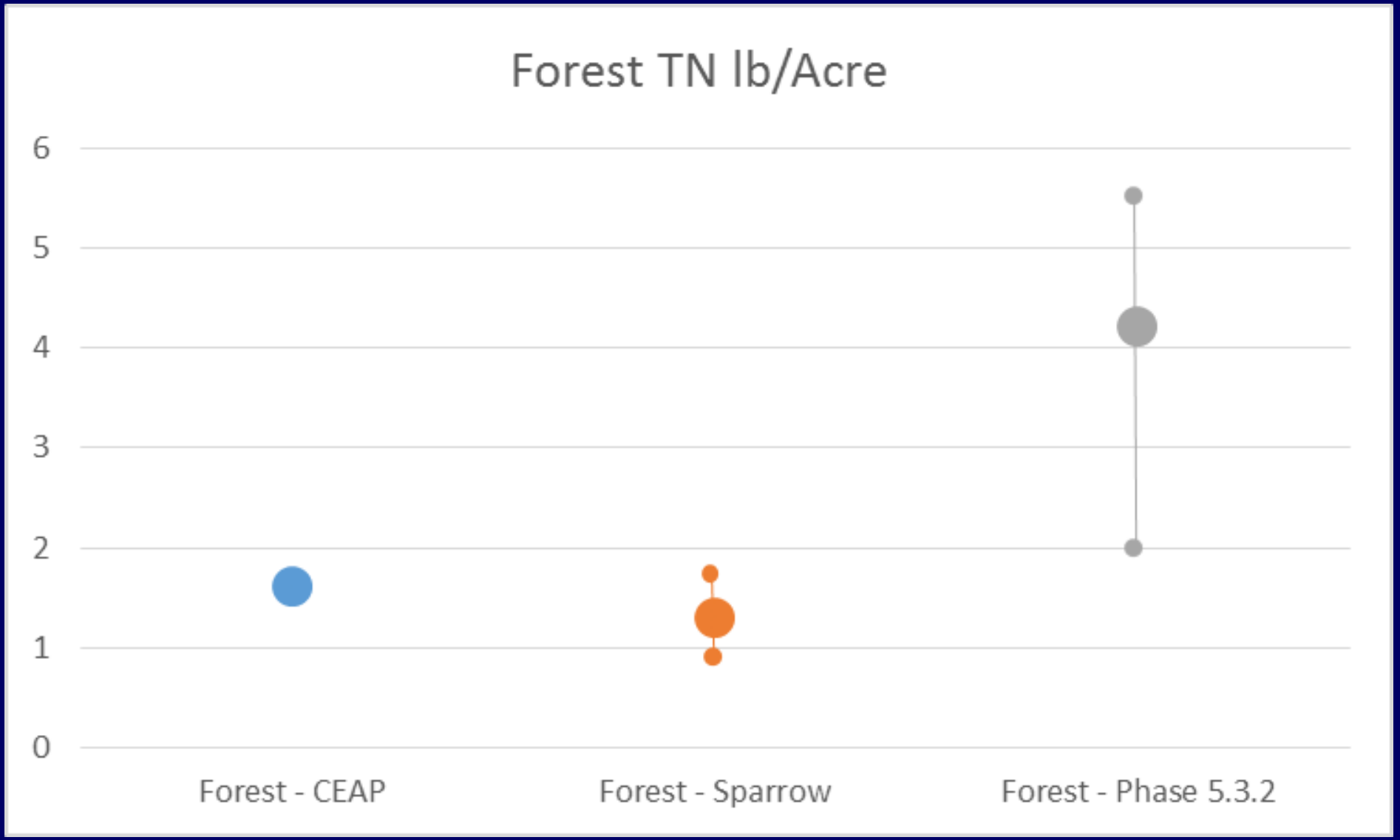
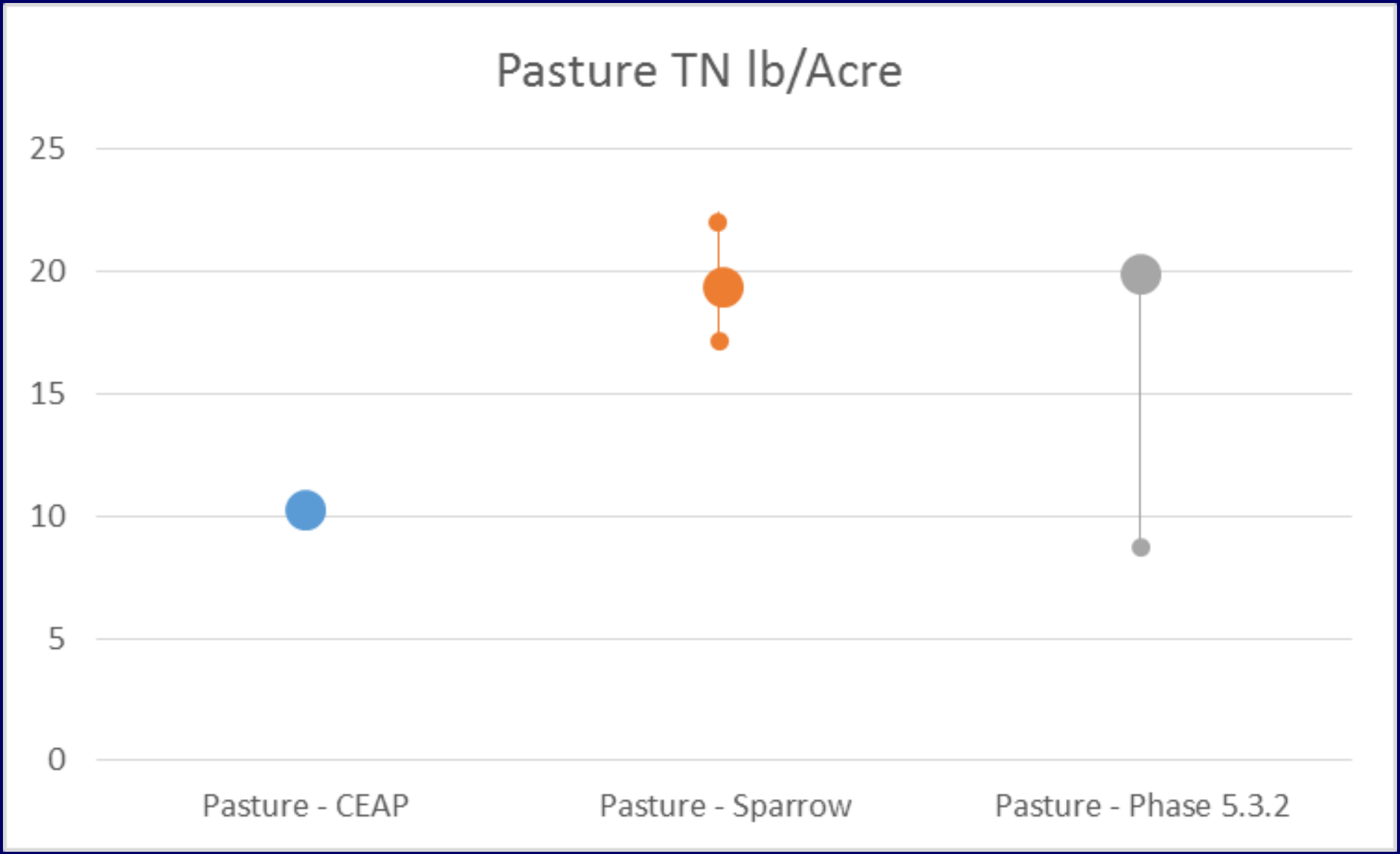
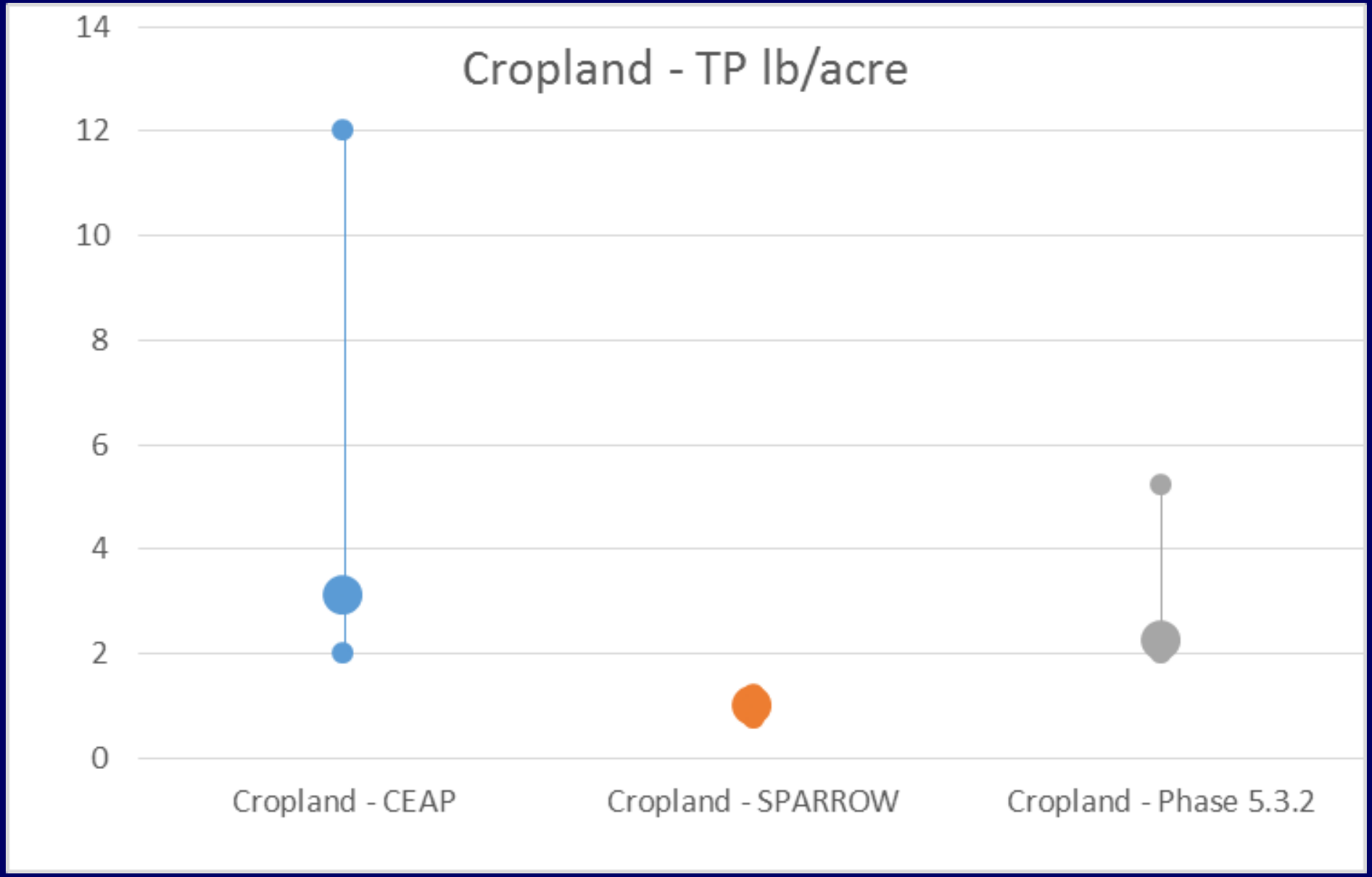


Error bars are not representing the same information among the three models.
CEAP: Did not provide a graph of the loading rate distribution of the forest acres
SPARROW: Standard Error of the loading rate, not a distribution
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments



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



Error bars are not representing the same information among the three models.
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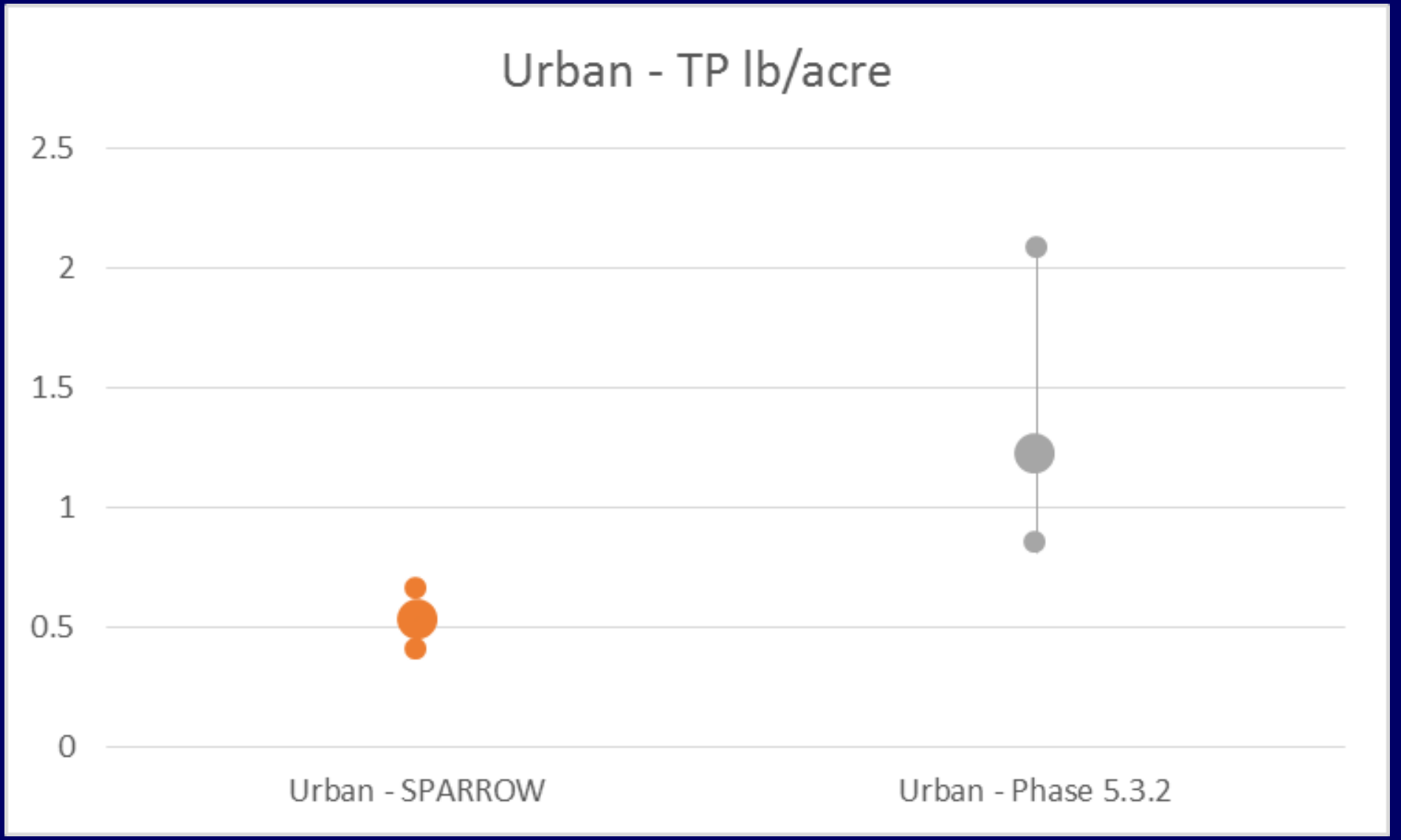
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments



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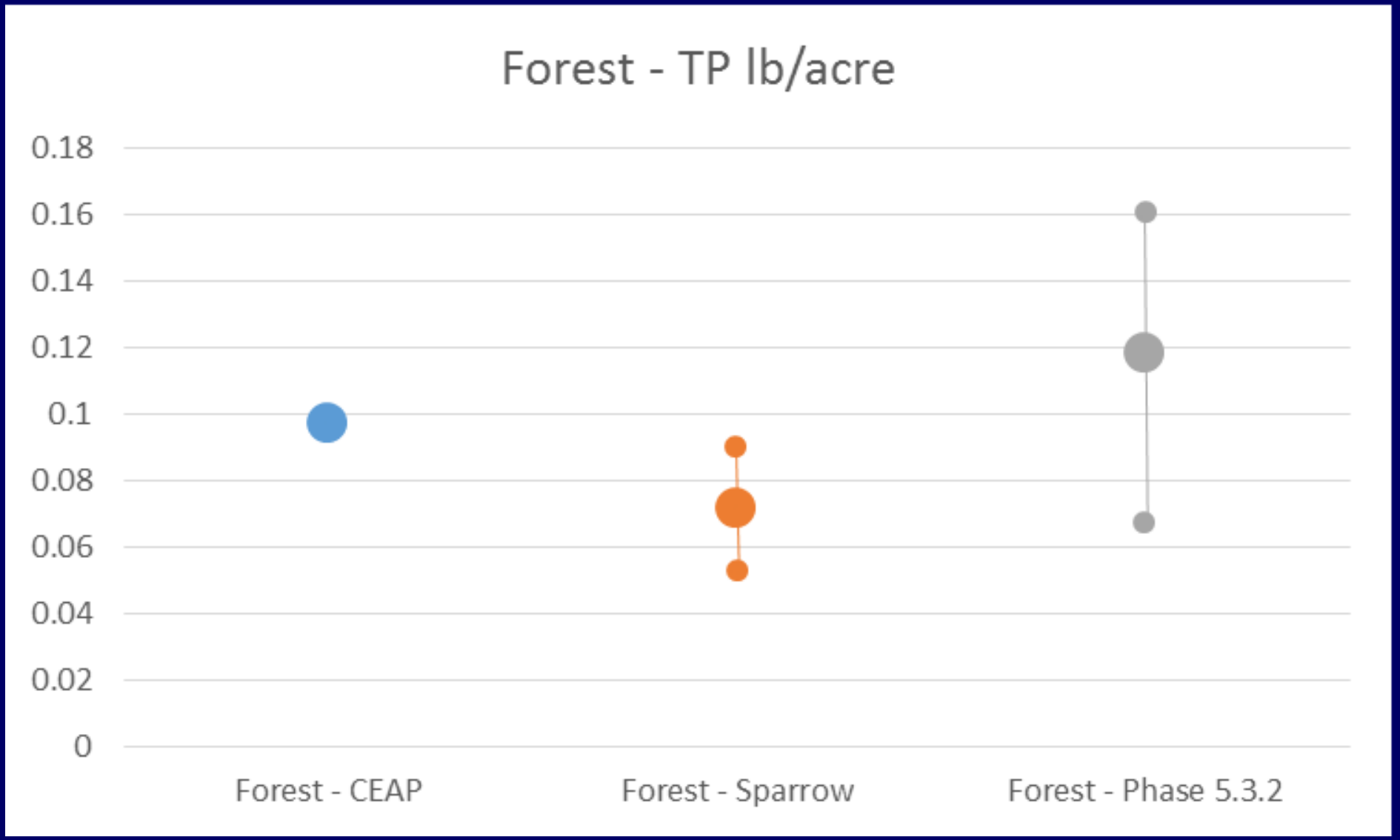

Error bars are not representing the same information among the three models.
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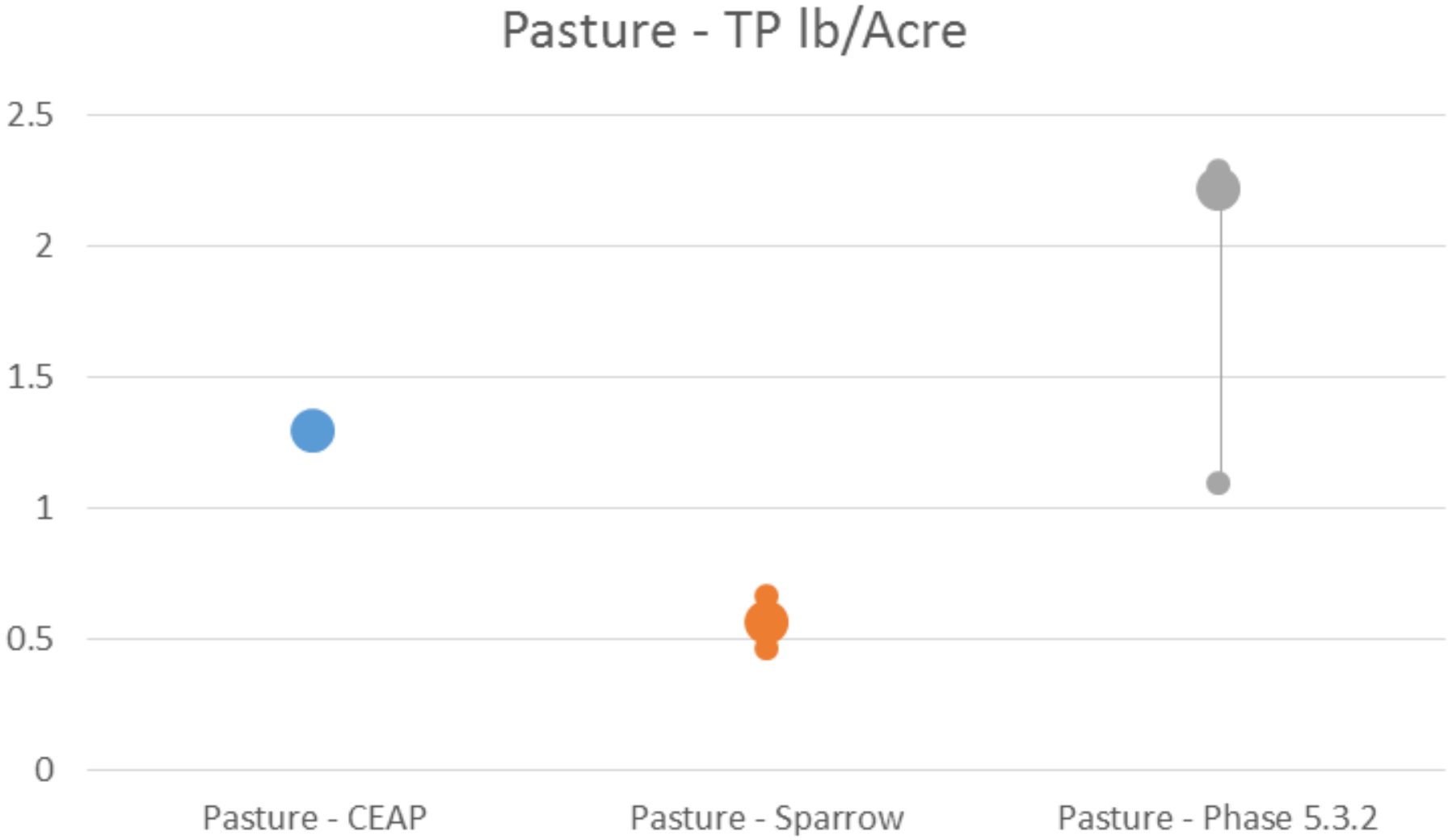
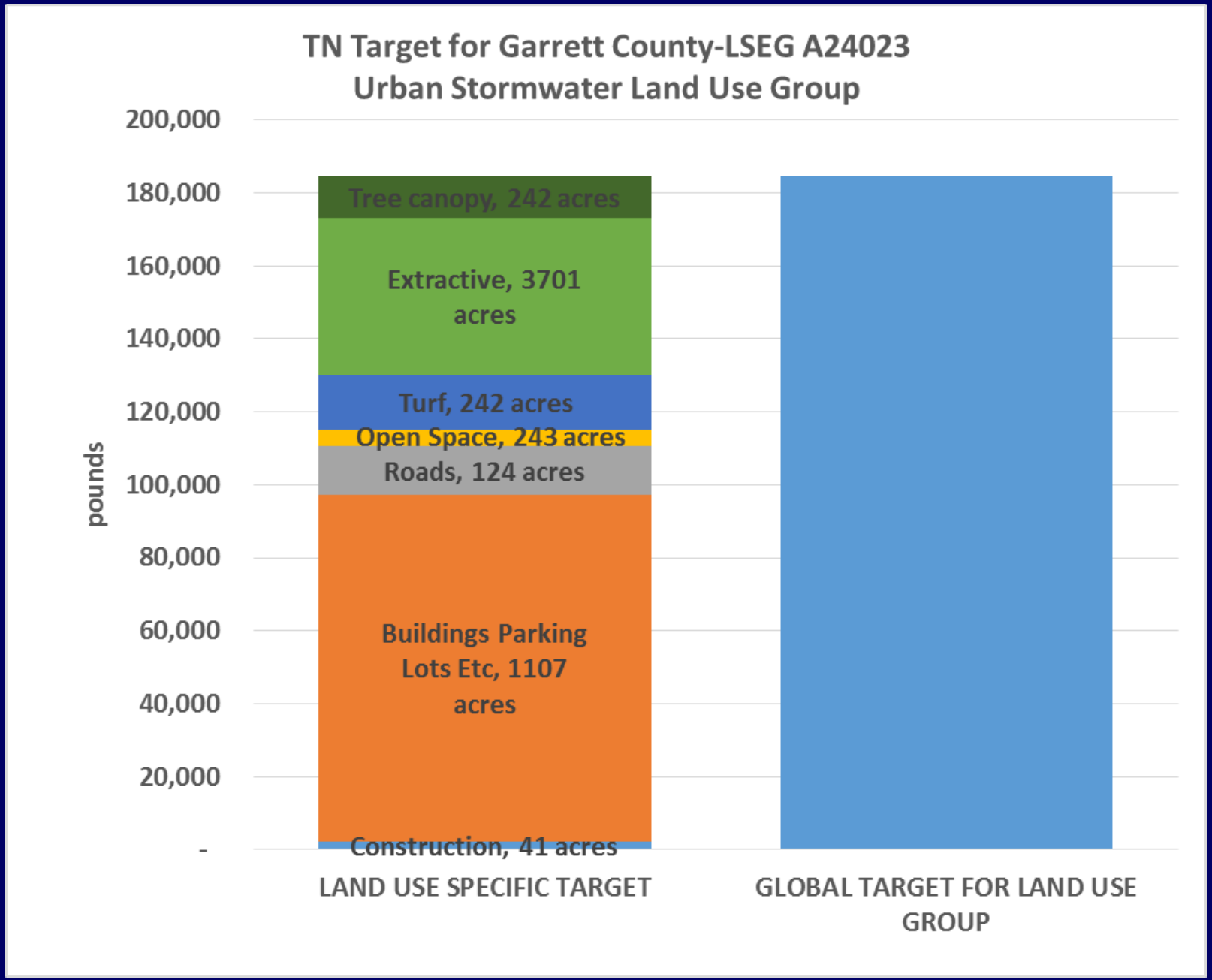
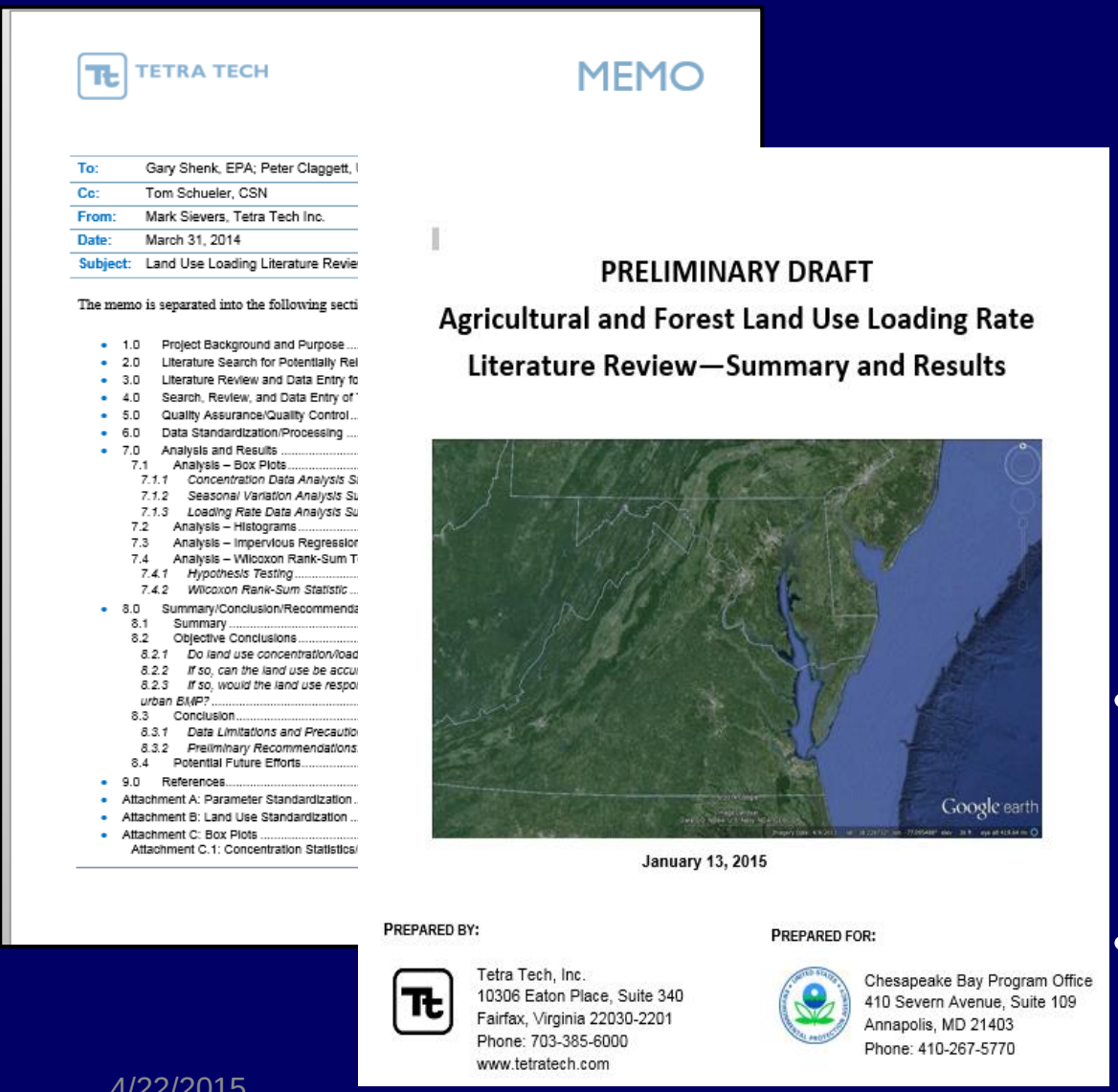


Error bars are not representing the same information among the three models.
CEAP: Did not provide a graph of the loading rate distribution of the pasture acres
SPARROW: Standard Error of the loading rate, not a distribution
Phase 5.3.2: 25th and 75th percentile of the distribution of land segments


TN Target for Garrett County-LSEG A24023
Urban Stormwater Land Use Group
pounds
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
Tree canopy, 242 acres
Extractive, 3701 acres
Turf, 242 acres
Open Space, 243 acres
Roads, 124 acres
Buildings Parking Lots Etc, 1107 acres
Construction, 41 acres
LAND USE SPECIFIC TARGET
GLOBAL TARGET FOR LAND USE GROUP

Relative Export Rate Data



TETRA TECH

MEMO

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

The memo is separated into the following secti

- 1.0 Project Background and Purpose ...
- 2.0 Literature Search for Potentially Rel
- 3.0 Literature Review and Data Entry fo
- 4.0 Search, Review, and Data Entry of
- 5.0 Quality Assurance/Quality Control...
- 6.0 Data Standardization/Processing ...
- 7.0 Analysis and Results .....
  - 7.1 Analysis – Box Plots .....
    - *7.1.1 Concentration Data Analysis S*
    - *7.1.2 Seasonal Variation Analysis Su*
    - *7.1.3 Loading Rate Data Analysis Su*
  - 7.2 Analysis – Histograms .....
  - 7.3 Analysis – Impervious Regressior
  - 7.4 Analysis – Wilcoxon Rank-Sum T
    - *7.4.1 Hypothesis Testing .....*
    - *7.4.2 Wilcoxon Rank-Sum Statistic ...*
- 8.0 Summary/Conclusion/Recommenda
  - 8.1 Summary .....
  - 8.2 Objective Conclusions .....
    - *8.2.1 Do land use concentration/load*
    - *8.2.2 If so, can the land use be accu*
    - *8.2.3 If so, would the land use respo*

  urban BMP? .....
  - 8.3 Conclusion .....
    - *8.3.1 Data Limitations and Precautio*
    - *8.3.2 Preliminary Recommendations*
  - 8.4 Potential Future Efforts .....
- 9.0 References .....
- Attachment A: Parameter Standardization ..
- Attachment B: Land Use Standardization ...
- Attachment C: Box Plots .....

  Attachment C.1: Concentration Statistics/

PRELIMINARY DRAFT

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

January 13, 2015

PREPARED BY:

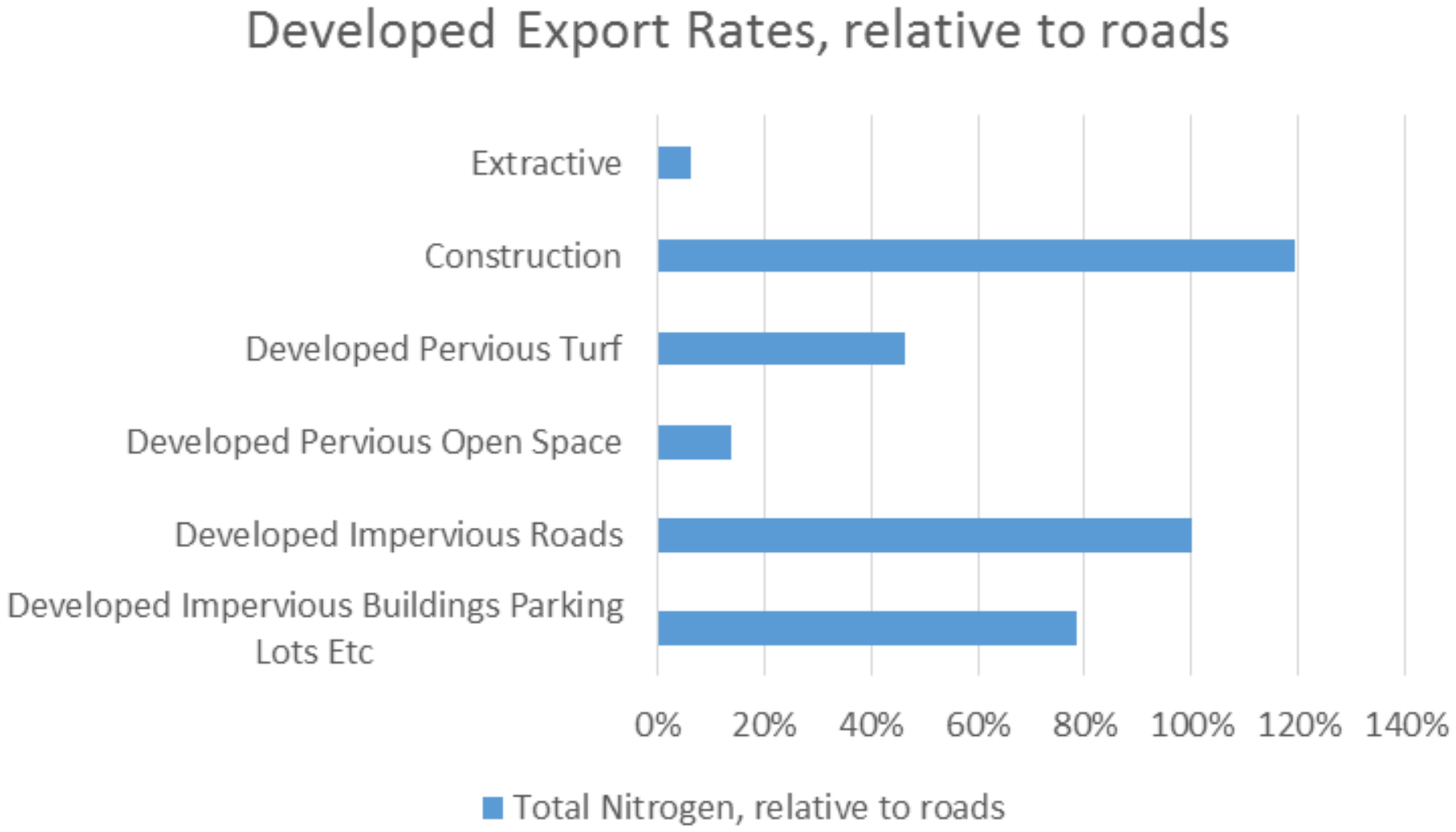
Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, Virginia 22030-2201
Phone: 703-385-6000
www.tetratech.com

PREPARED FOR:

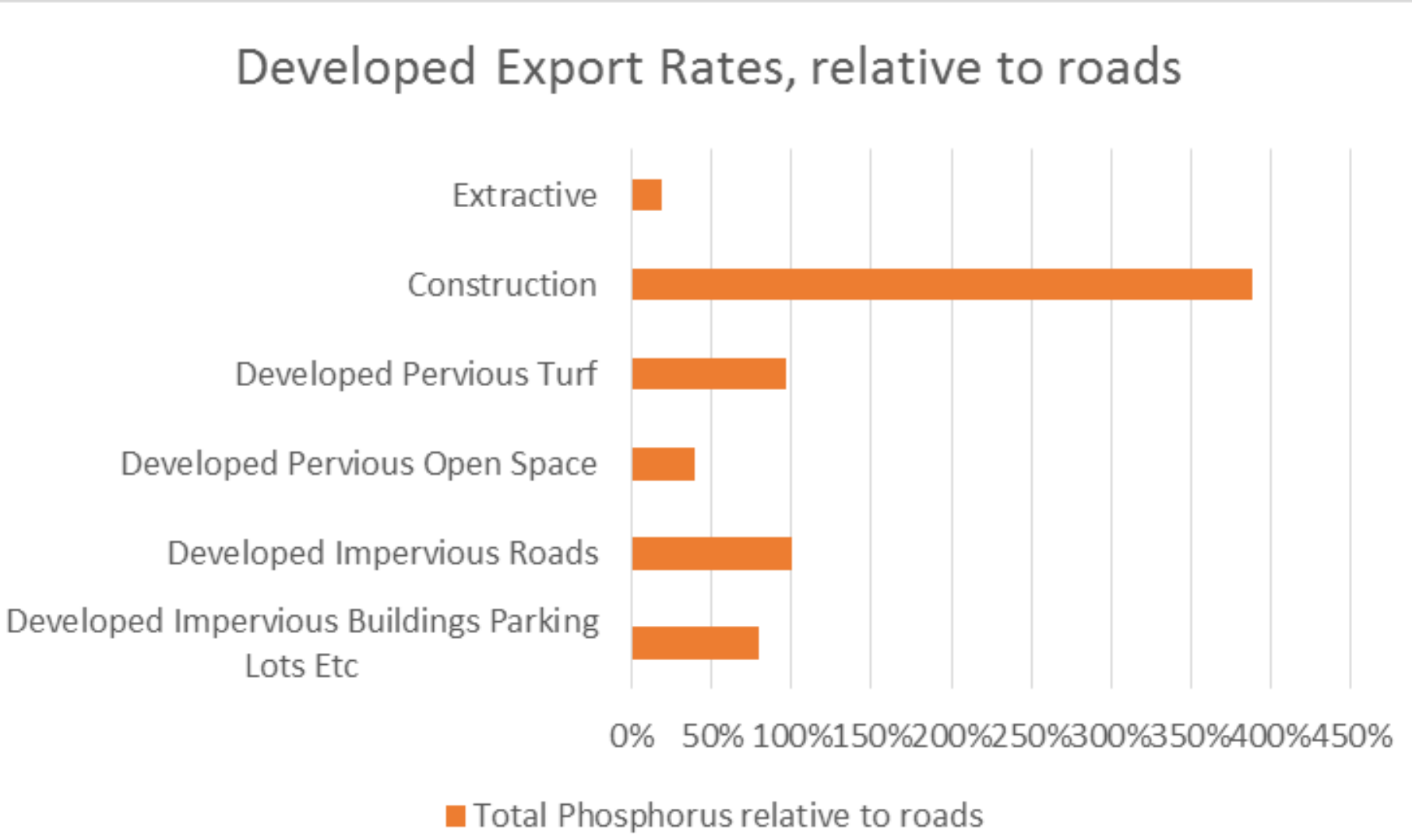
Chesapeake Bay Program Office
410 Severn Avenue, Suite 109
Annapolis, MD 21403
Phone: 410-267-5770

- Two Literature Reviews by Tetra Tech—Agriculture, Forest and Urban
  - Available on line on the Midpoint Assessment Website https://www.chesapeakebay.net/about/wmp_for_mpa_effort/land_use_load_literature_reviews
- Agriculture Literature Review by VA Tech and Water Stewardship
- Input from Expert Panels and Workgroups

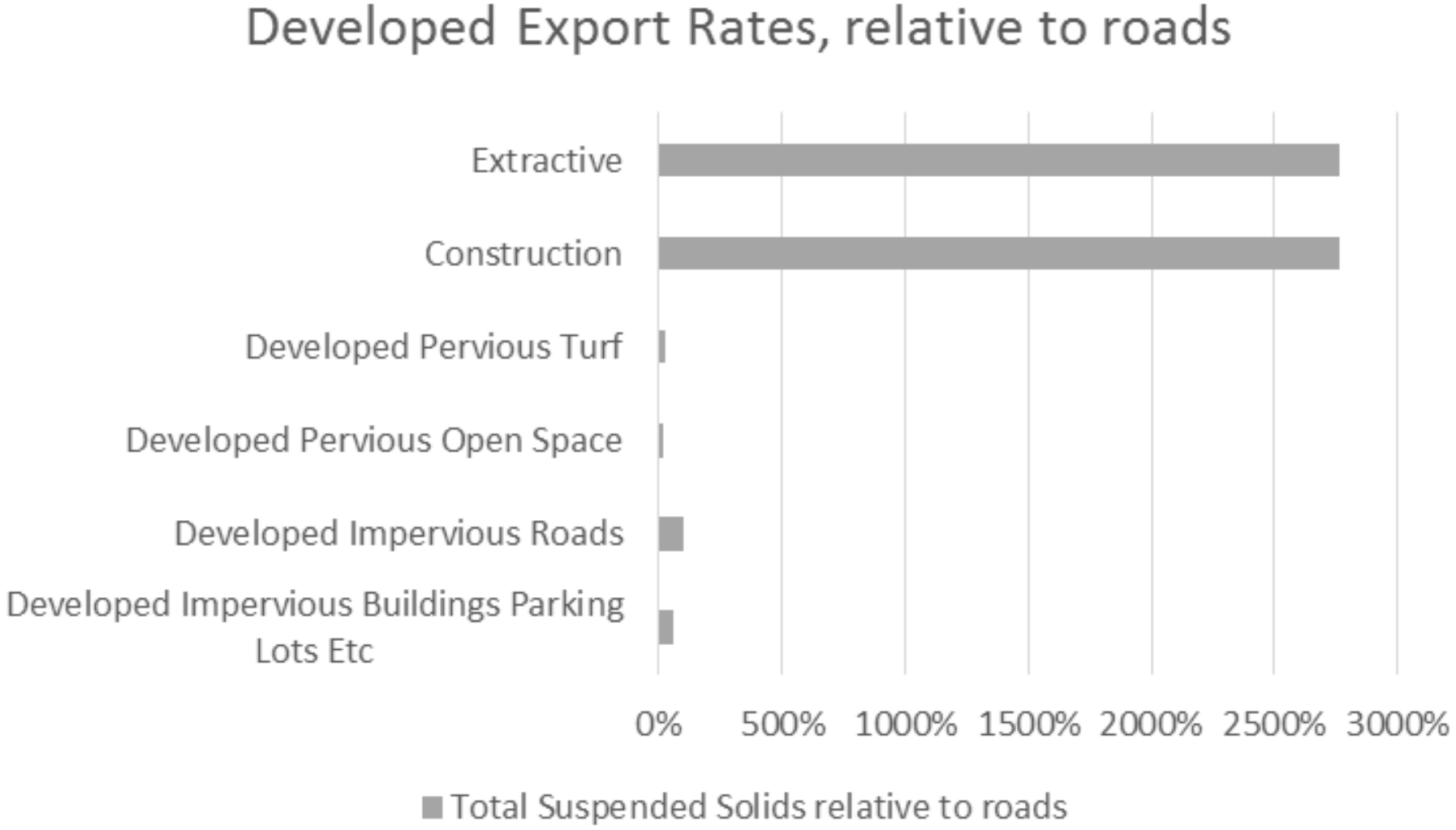
Developed TN Relative Rates



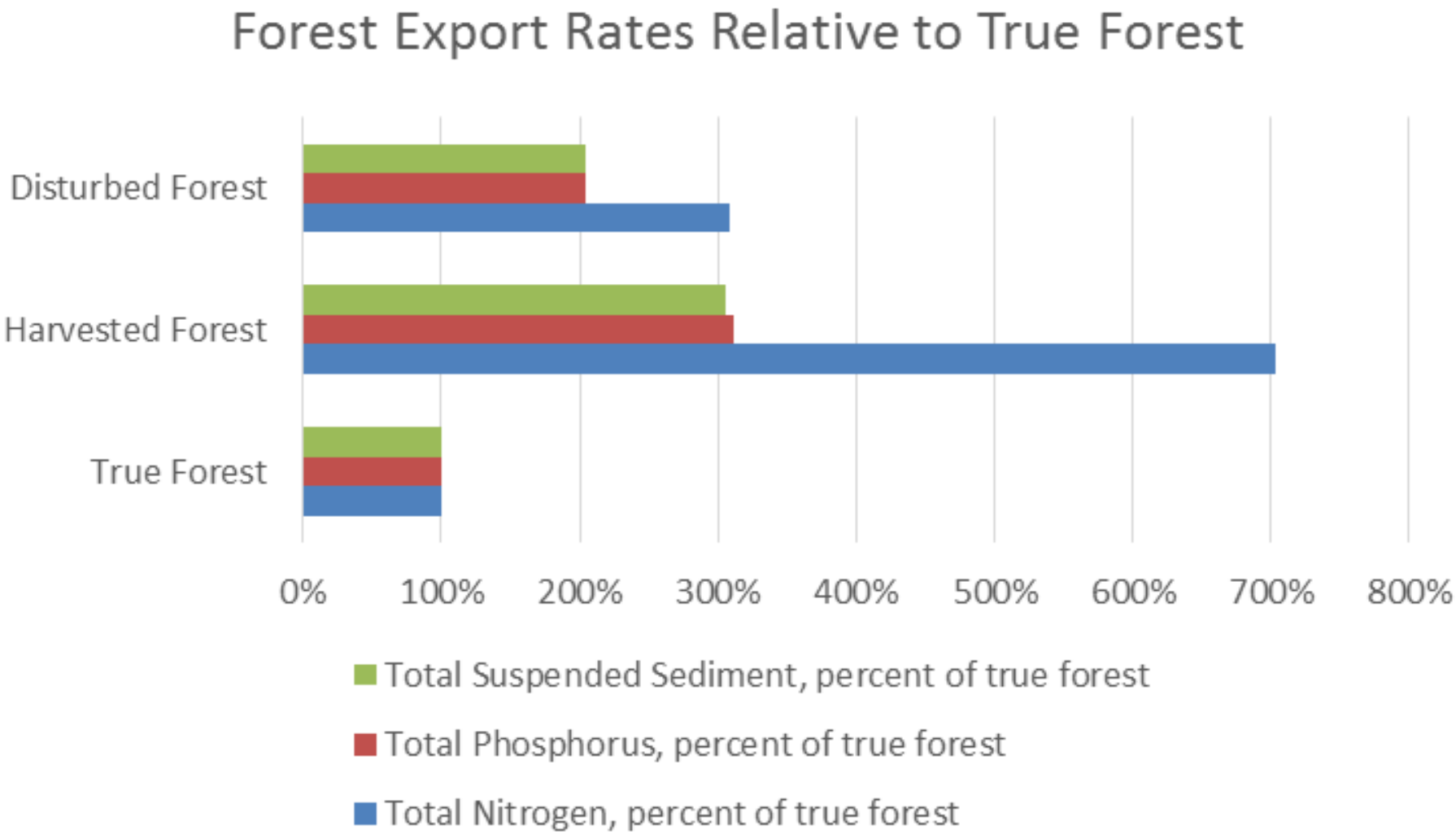
Developed TP Relative Rates



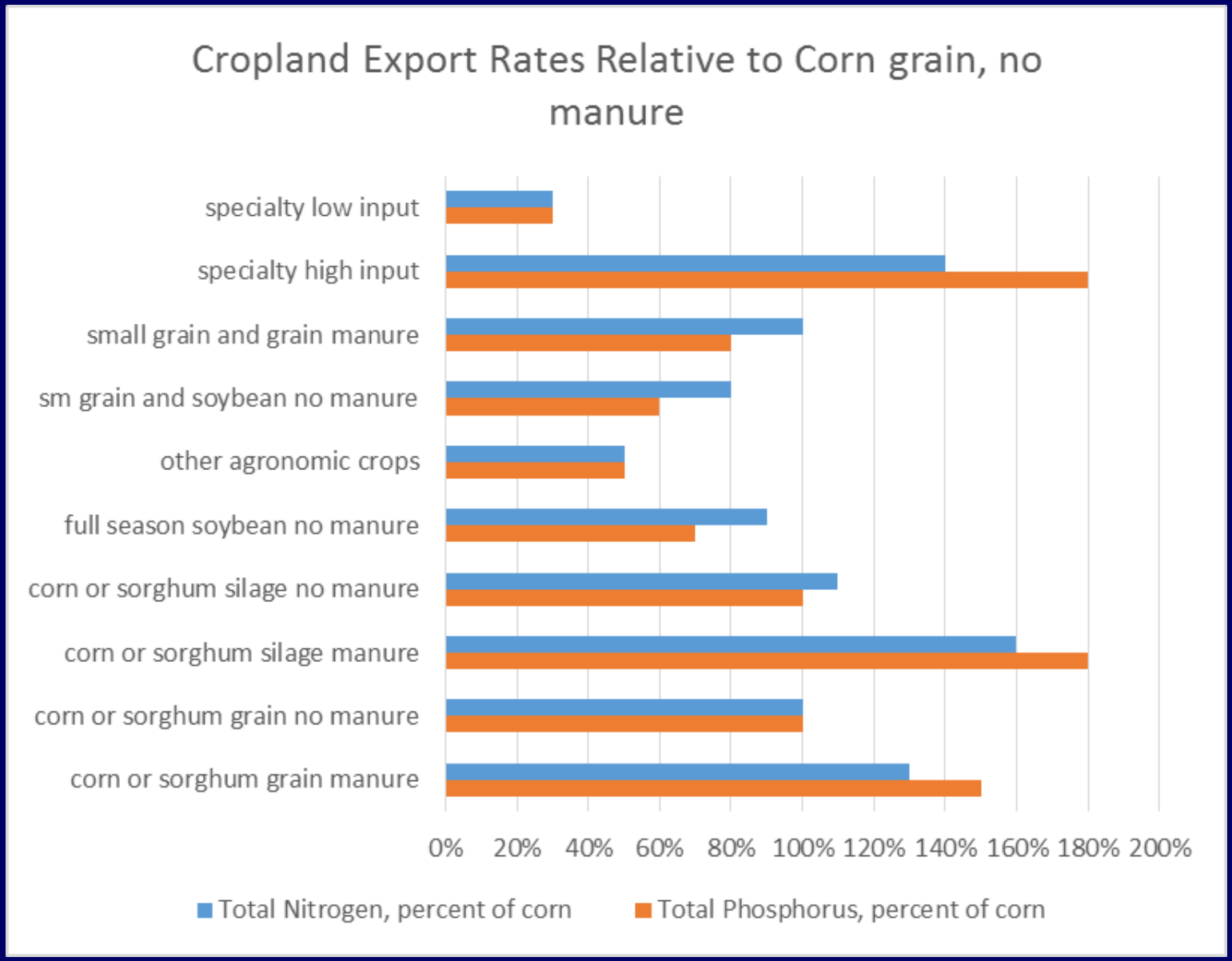
Developed TSS Relative Rates



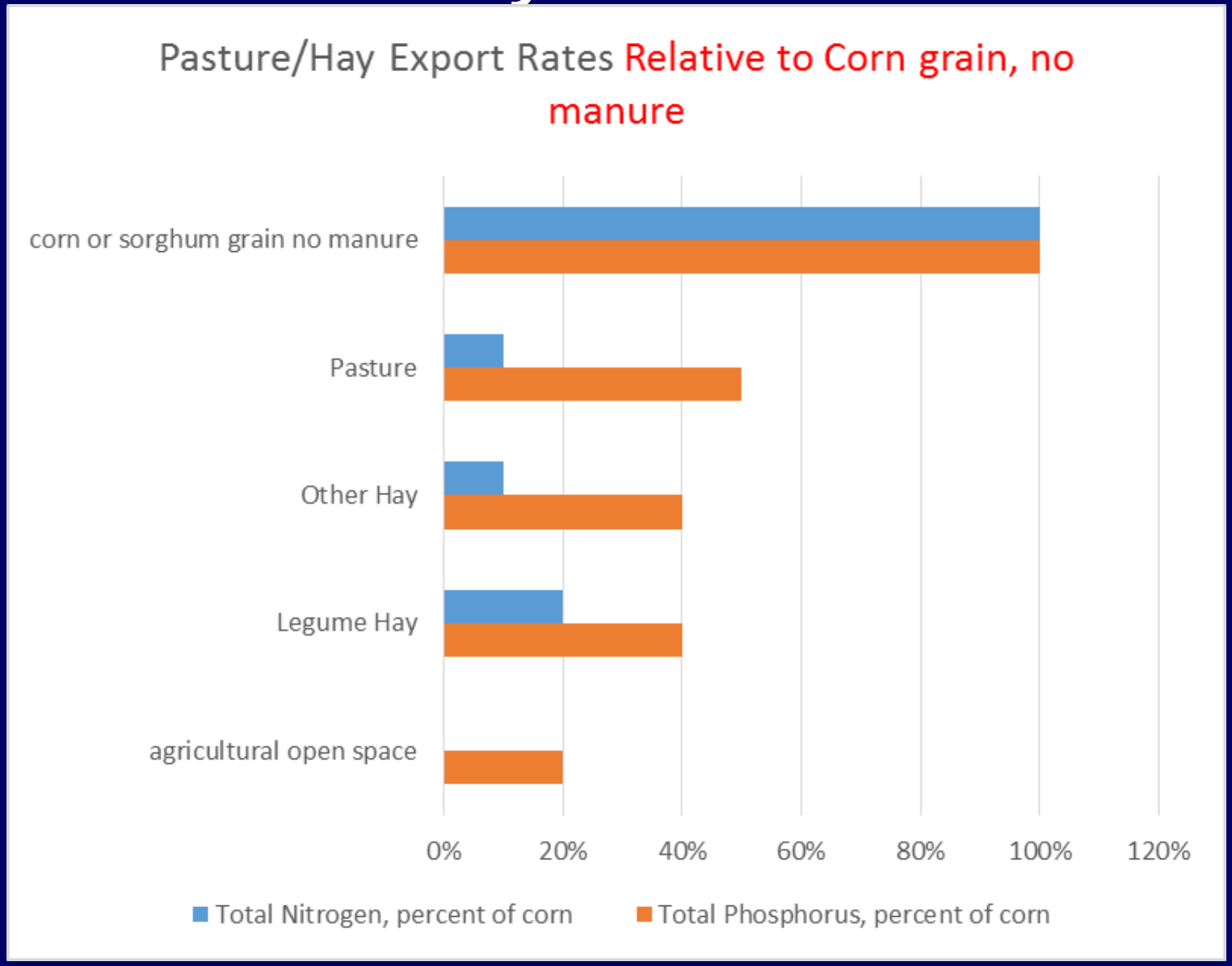
Forest TN, TP, TSS Relative Rates



Cropland Relative Rates



Pasture/Hay Relative Rates



Land Use Acre Crosswalk

- Need: Acres for each Phase 6 land use by land segment
- Solution: Crosswalk Phase 5 land uses to Phase 6
- Method: Used a fraction to parse Phase 5 acres among the new Phase 6 land uses
- Limited use: This is only for temporary use. The final calibration will have the actual mapped acres of Phase 6 land uses

Phase 6 Acres—Agriculture

P5 land use	Split	P6 land use
afo	1	feeding operation space nonpermitted
alf	1	legume hay
cfo	1	feeding operation space permitted
hom	0.05	other agronomic crops
hom	0.31	full season soybean no manure
hom	0.32	corn or sorghum grain no manure
hom	0.32	corn or sorghum silage no manure
hwm	0.165	corn or sorghum grain manure
hwm	0.165	corn or sorghum silage manure
hwm	0.33	sm grain and soybean no manure
hwm	0.33	small grain and grain manure
hyo	1	agricultural open space
hyw	1	other hay
lwm	0	corn or sorghum grain manure
nal	0	legume hay
nhi	0	corn or sorghum grain manure
nho	0	corn or sorghum grain no manure
nhy	0	other hay
nid	0.01	farmsteads impervious
nlo	0	corn or sorghum grain manure
npa	0	pasture
npd	0.01	farmsteads pervious
pas	1	pasture
trp	1	pasture
urs	0.5	specialty high input
urs	0.5	specialty low input

Phase 6 Acres—Natural

P5 Land Use	Split	P6 Land Use
for	0.1	wetland
for	0.9	TrueForest
hvf	0.1	DisturbedForest
hvf	0.9	HarvestedForest

Phase 6 Acres—Developed

P5 Land Use	Split	P6 Land Use
ccn	1	Construction
cex	1	Extractive
cid	0.1	Developed Impervious Roads
cid	0.9	Developed Impervious Buildings Parking Lots Etc
cpd	0.33	Developed Pervious Turf
cpd	0.33	Tree canopy over developed
cpd	0.34	Developed Pervious Open Space
nex	1	Extractive
nid	0.1	Developed Impervious Roads
nid	0.89	Developed Impervious Buildings Parking Lots Etc
npd	0.33	Developed Pervious Open Space
npd	0.33	Developed Pervious Turf
npd	0.33	Tree canopy over developed
rcn	1	Construction
rex	1	Extractive
rid	0.1	Developed Impervious Roads
rid	0.9	Developed Impervious Buildings Parking Lots Etc
rpd	0.33	Developed Pervious Turf
rpd	0.33	Tree canopy over developed
rpd	0.34	Developed Pervious Open Space

Method of Applying Sensitivities

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

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

- Sensitivities are determined from the Phase 5.3.2 WSM.

Sensitivity Crosswalk

- Need: A sensitivity for each Phase 5 land use for at least one nitrogen and one phosphorus input
- Solution: Crosswalk sensitivities from Phase 5 land uses to similar Phase 6 land uses
- These are applied to the Phase 5 inputs, so Phase 6 land uses are not relevant
- Updated sensitivities are being incorporated into the final targets.

Sensitivities

LU	N Sensitiv	P Sensitiv	N Proxy LU	P Proxy LU
afo	N	N	NA	NA
alf	Y	Y	NA	NA
ccn	N	N	npd	hwm
cex	N	N	npd	hwm
cfo	N	N	NA	NA
cid	Y	N	NA	None Identified
cpd	Y	N	NA	hwm
for	Y	N	NA	hwm
hom	Y	Y	NA	NA
hvf	N	N	for	hwm
hwm	Y	Y	NA	NA
hyo	Y	N	NA	hwm
hyw	N	Y	pas	NA
nex	N	N	npd	hwm
nid	Y	N	NA	None Identified
npd	Y	N	NA	hwm
pas	Y	N	NA	alf
rcn	N	N	npd	hwm
rex	N	N	npd	hwm
rid	Y	N	NA	None Identified
rpd	Y	N	NA	hwm
trp	N	N	pas	alf
urs	N	N	hom	hom
wat	N	N	NA	NA

Targets

- Next slides show the distribution of targets among sectors and land uses

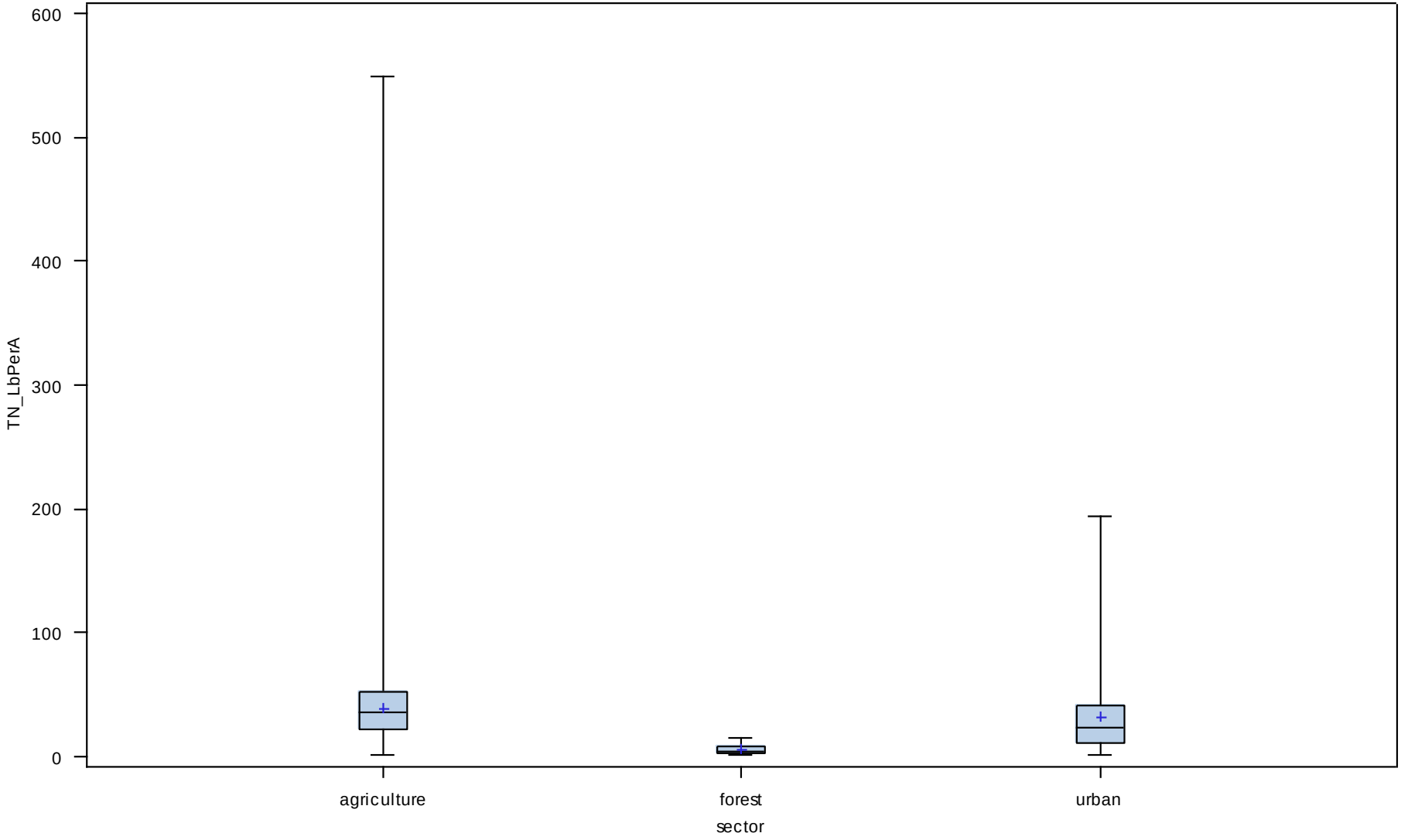
How Sectors Map to Major Land Use Groups

SECTOR	MAJOR LAND USE GROUP
Agriculture ⇨	✓ Pasture/Hay ✓ Cropland
Developed ⇨	✓ Urban
Natural ⇨	✓ Forest

Targets for Phase 6
All Chesapeake Bay Land Segments

Draft

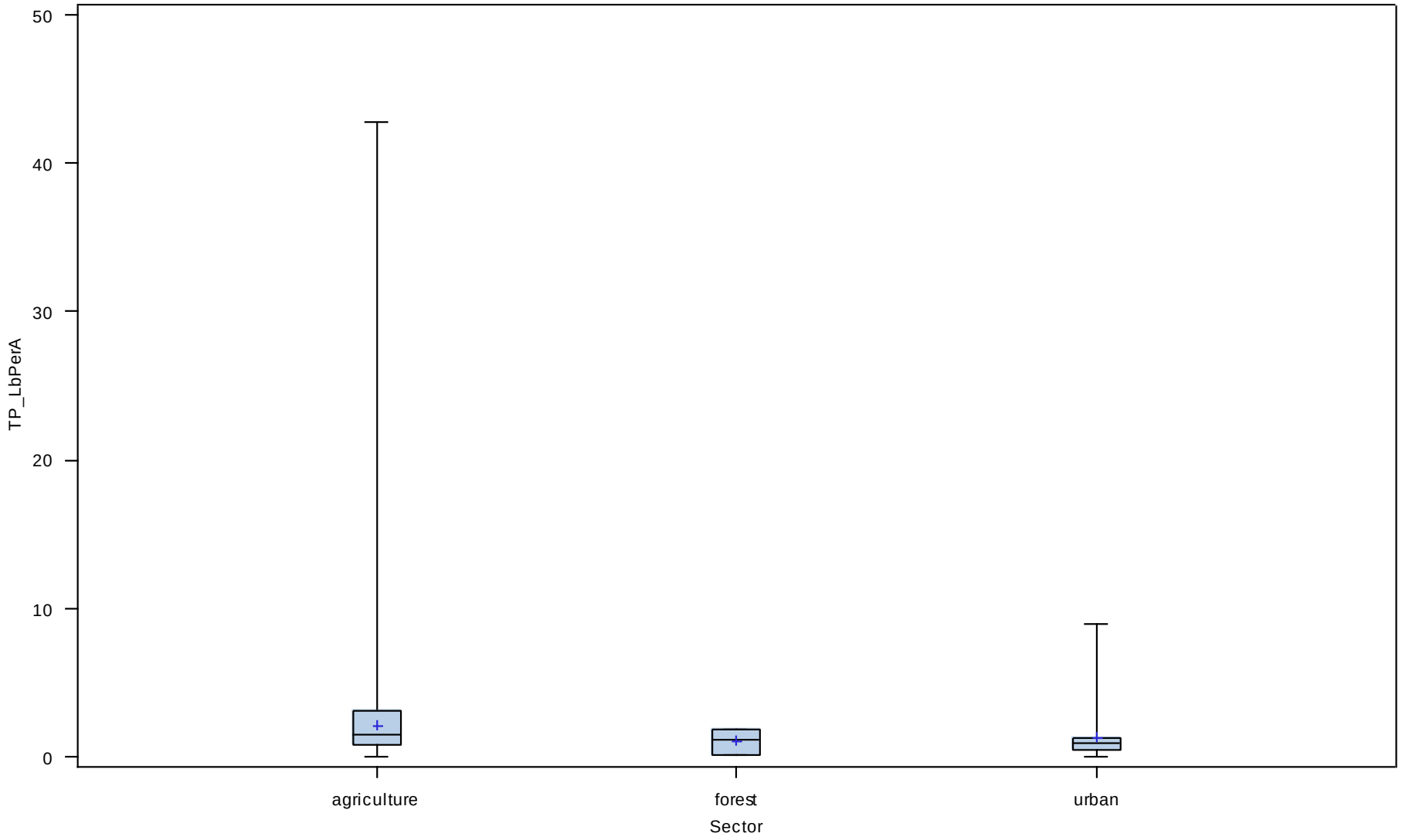
overall statistics					
Min	0.835682	Mean	31.95294	Max	548.5857



Targets for Phase 6
All Chesapeake Bay Land Segments

Draft

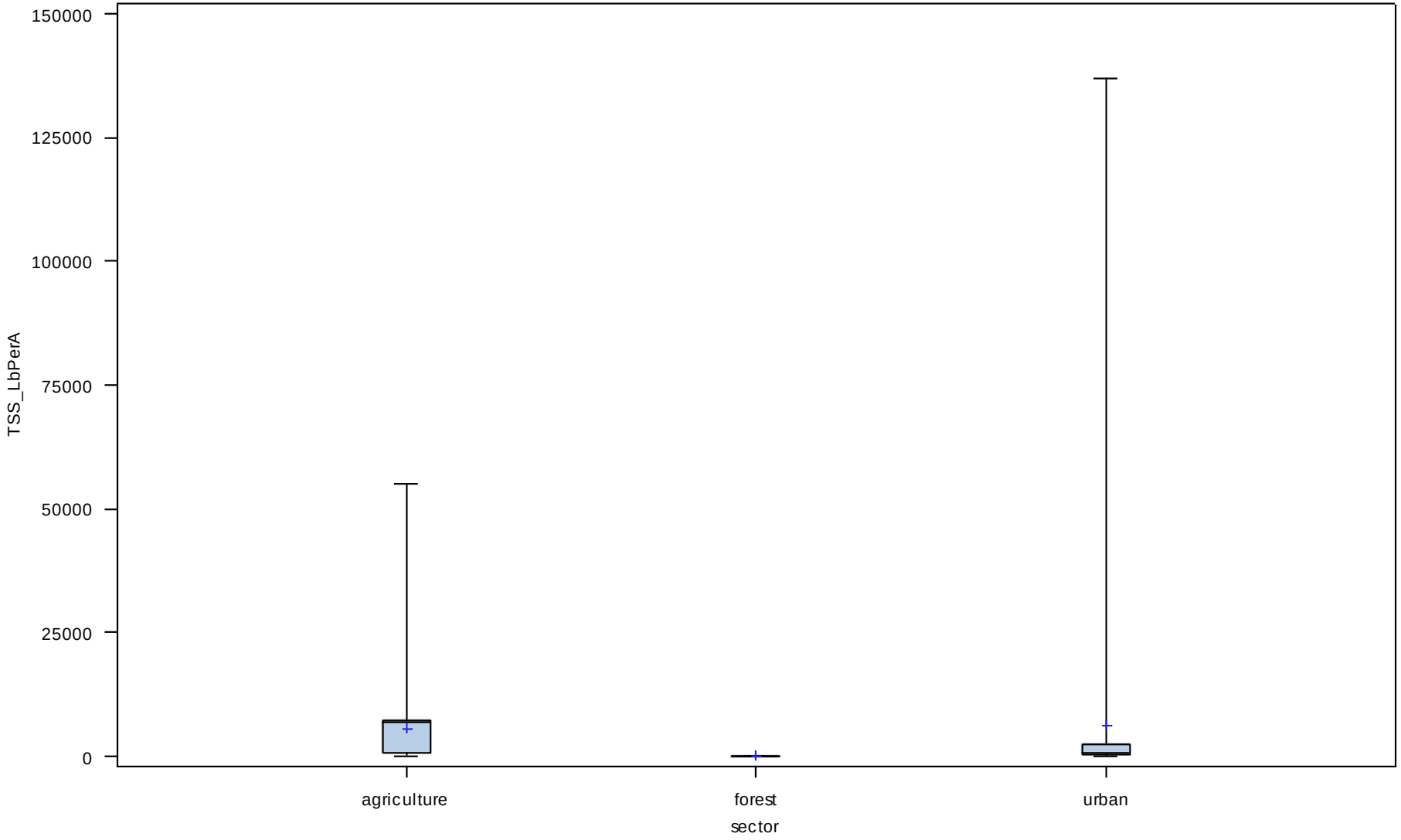
overall statistics					
Min	0	Mean	1.645454	Max	42.74792



Targets for Phase 6
All Chesapeake Bay Land Segments

Draft

overall statistics					
Min	6.621885	Mean	4936.099	Max	136893.3



Targets for Phase 6
Natural-All Chesapeake Bay Land Segments

Draft

overall statistics					
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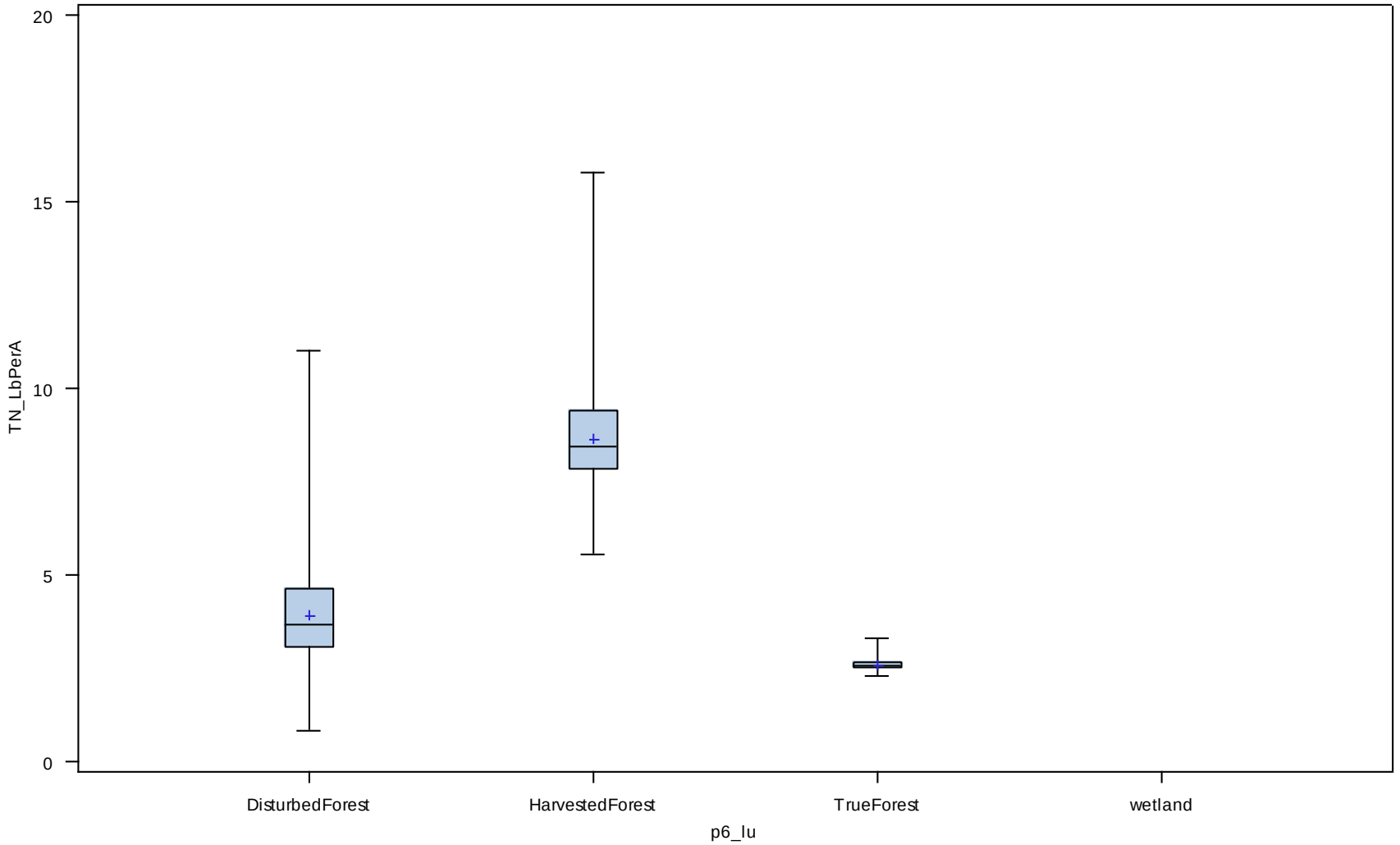

Targets for Phase 6
Natural-All Chesapeake Bay Land Segments

Draft

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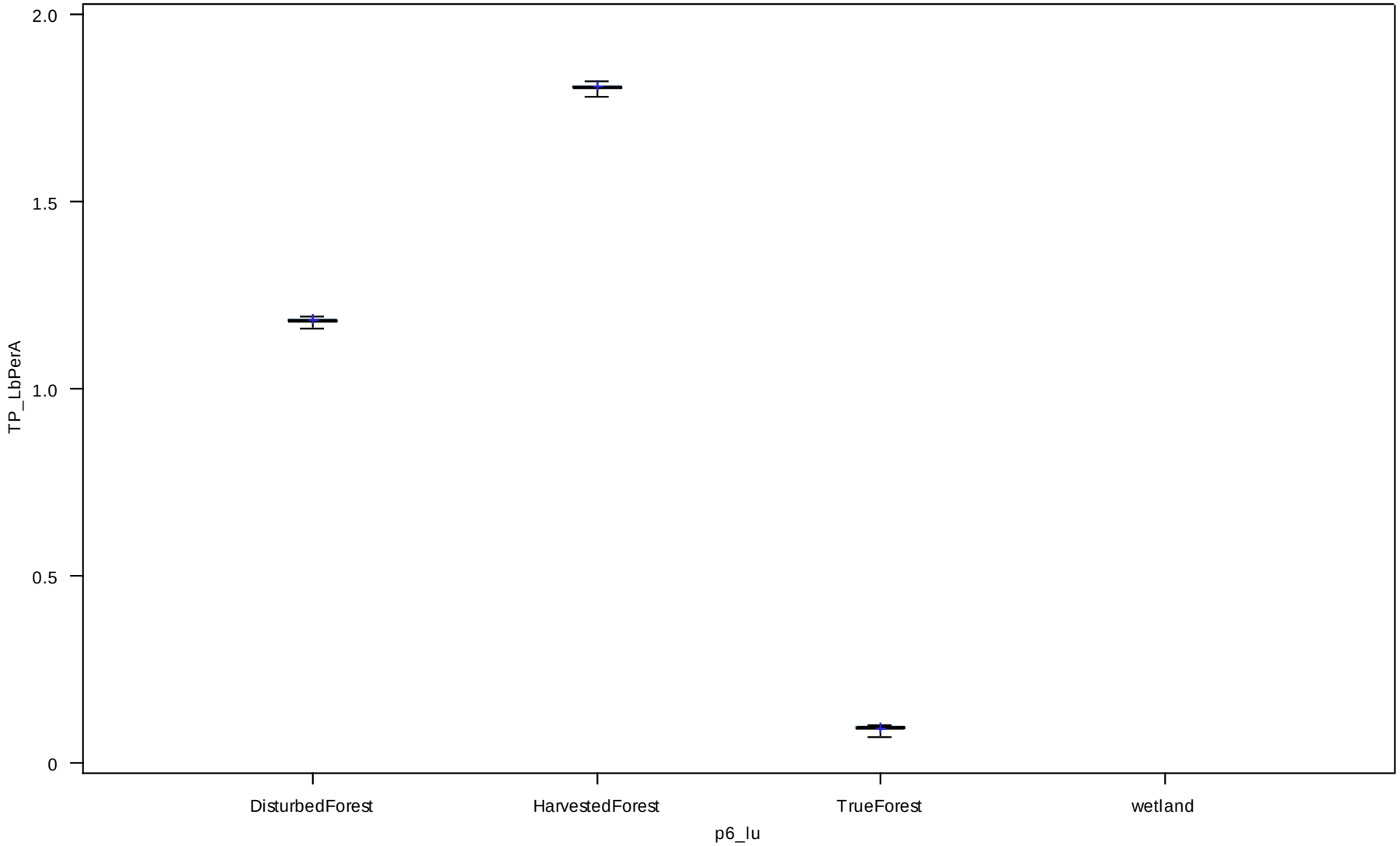

Targets for Phase 6
Natural-All Chesapeake Bay Land Segments

Draft

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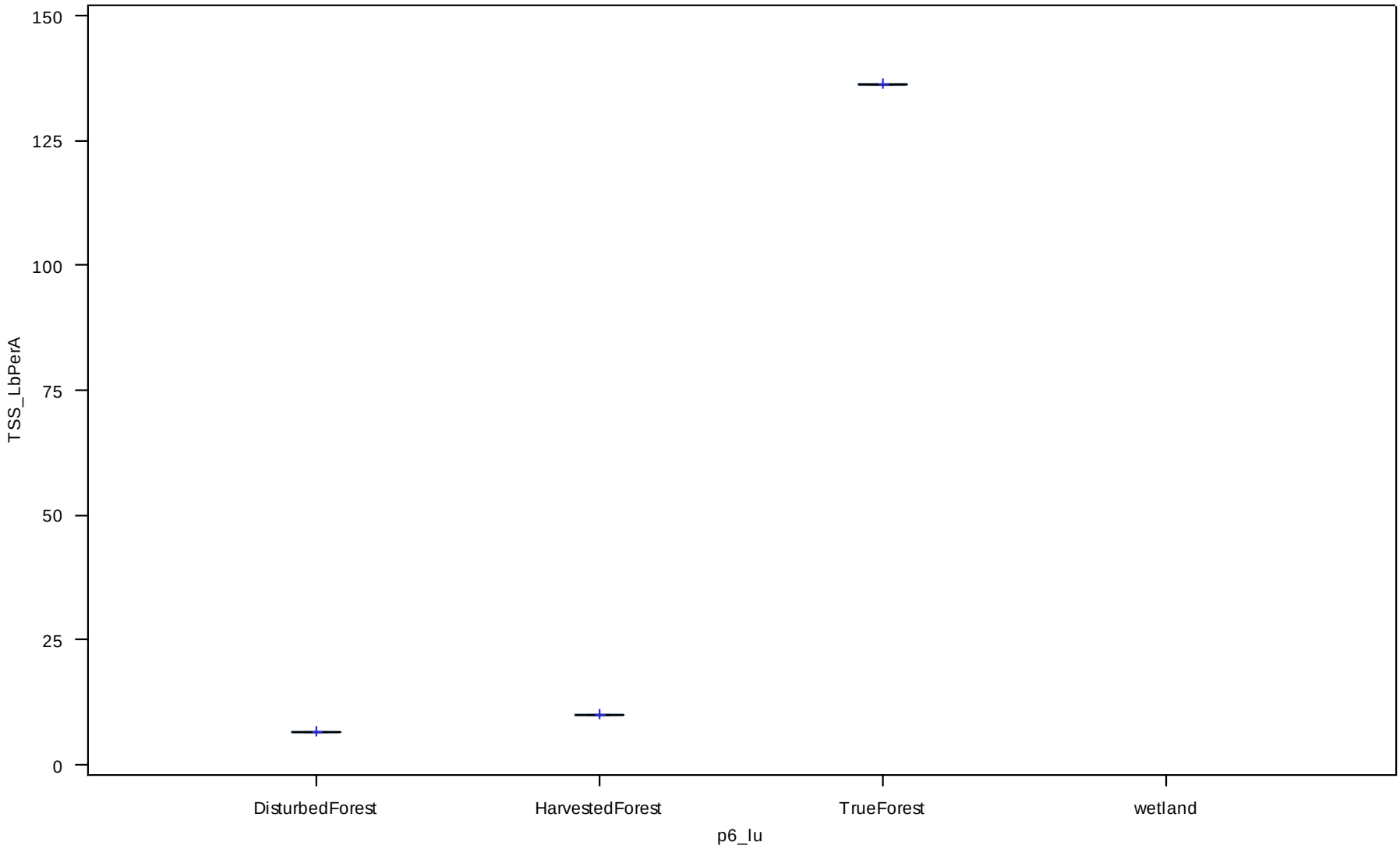

Targets for Phase 6
Developed-All Chesapeake Bay Land Segments

Draft

overall statistics					
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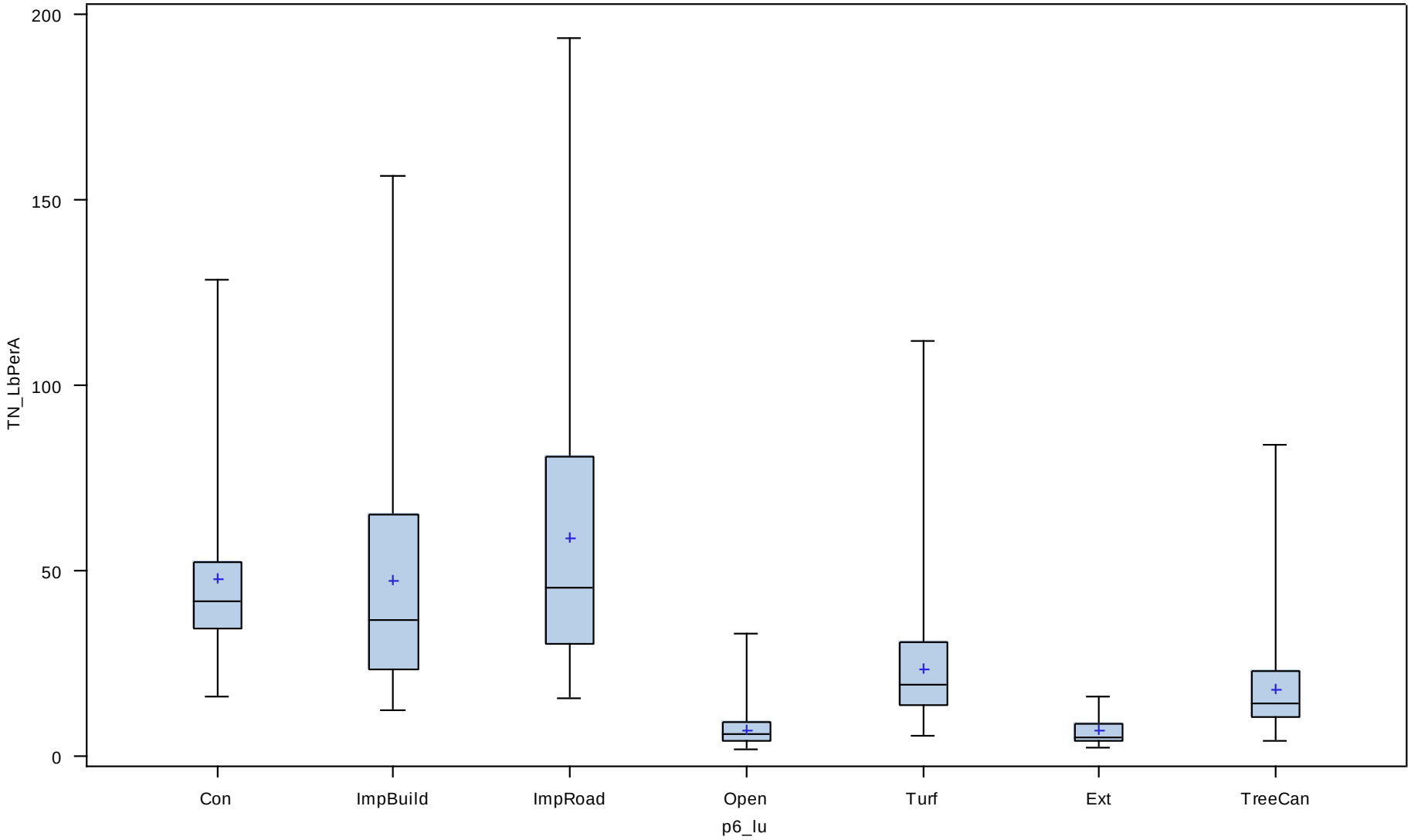

Targets for Phase 6
Developed-All Chesapeake Bay Land Segments

Draft

overall statistics					
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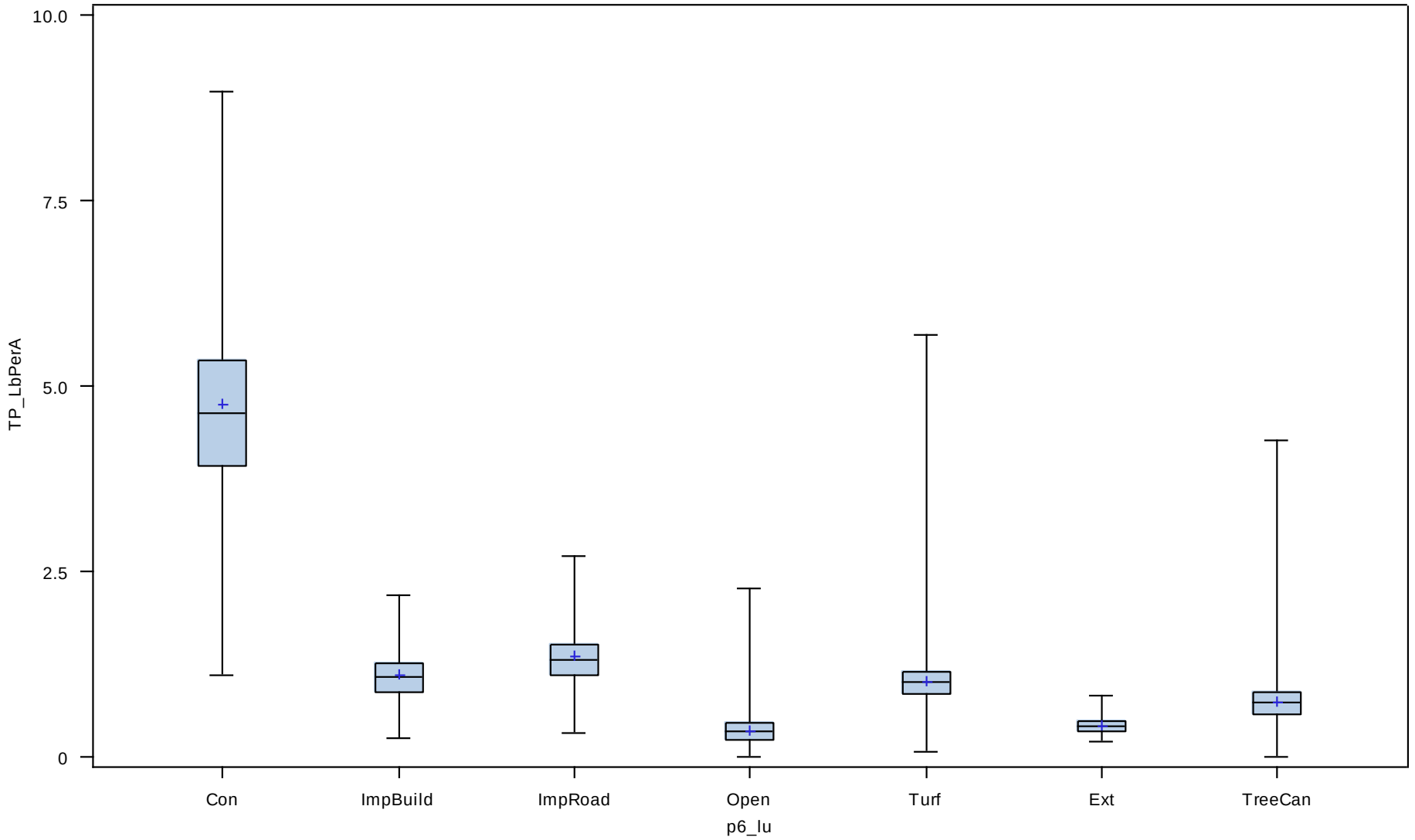

Targets for Phase 6
Developed-All Chesapeake Bay Land Segments

Draft

overall statistics					
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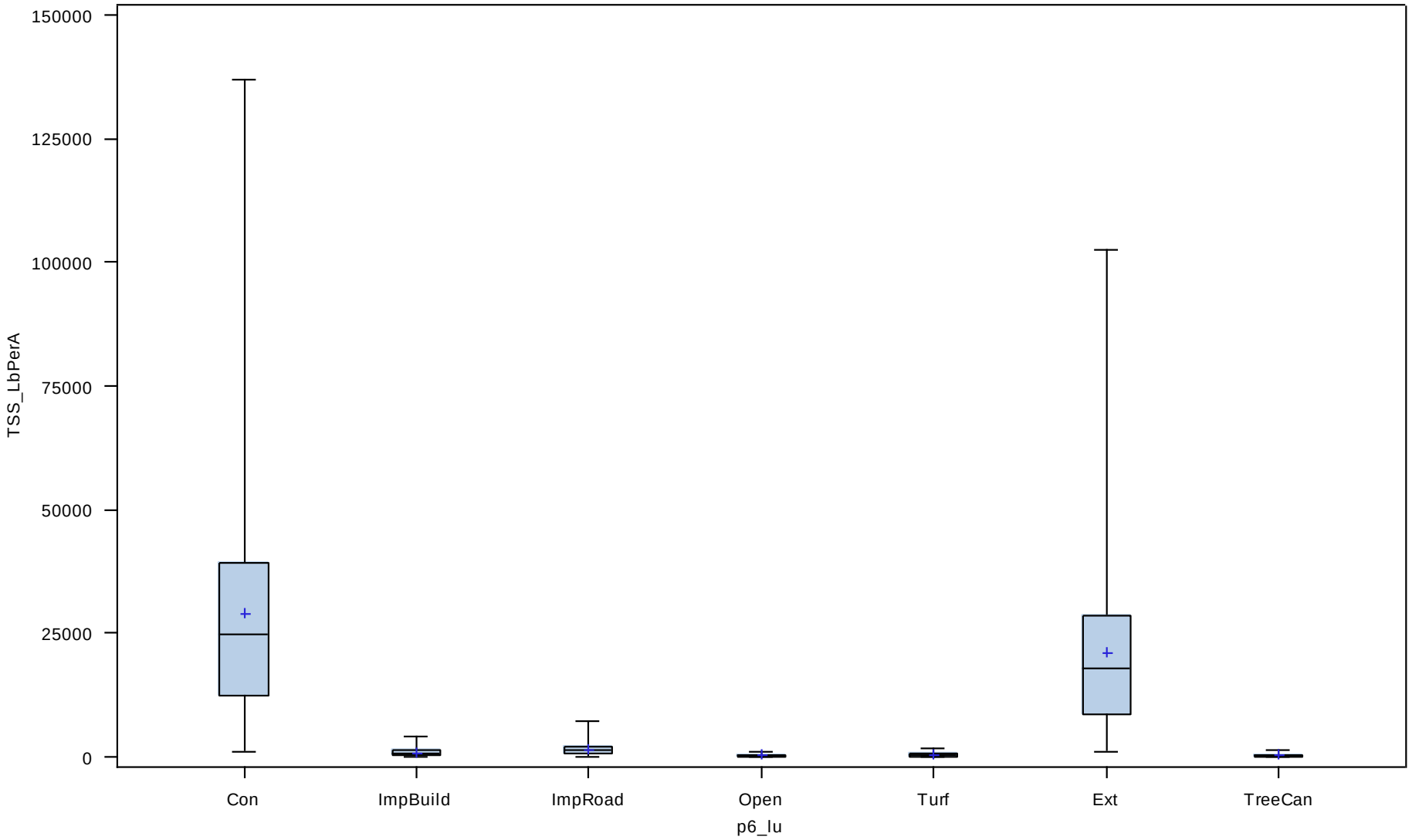

Targets for Phase 6
Agriculture-All Chesapeake Bay Land Segments

Draft

overall statistics					
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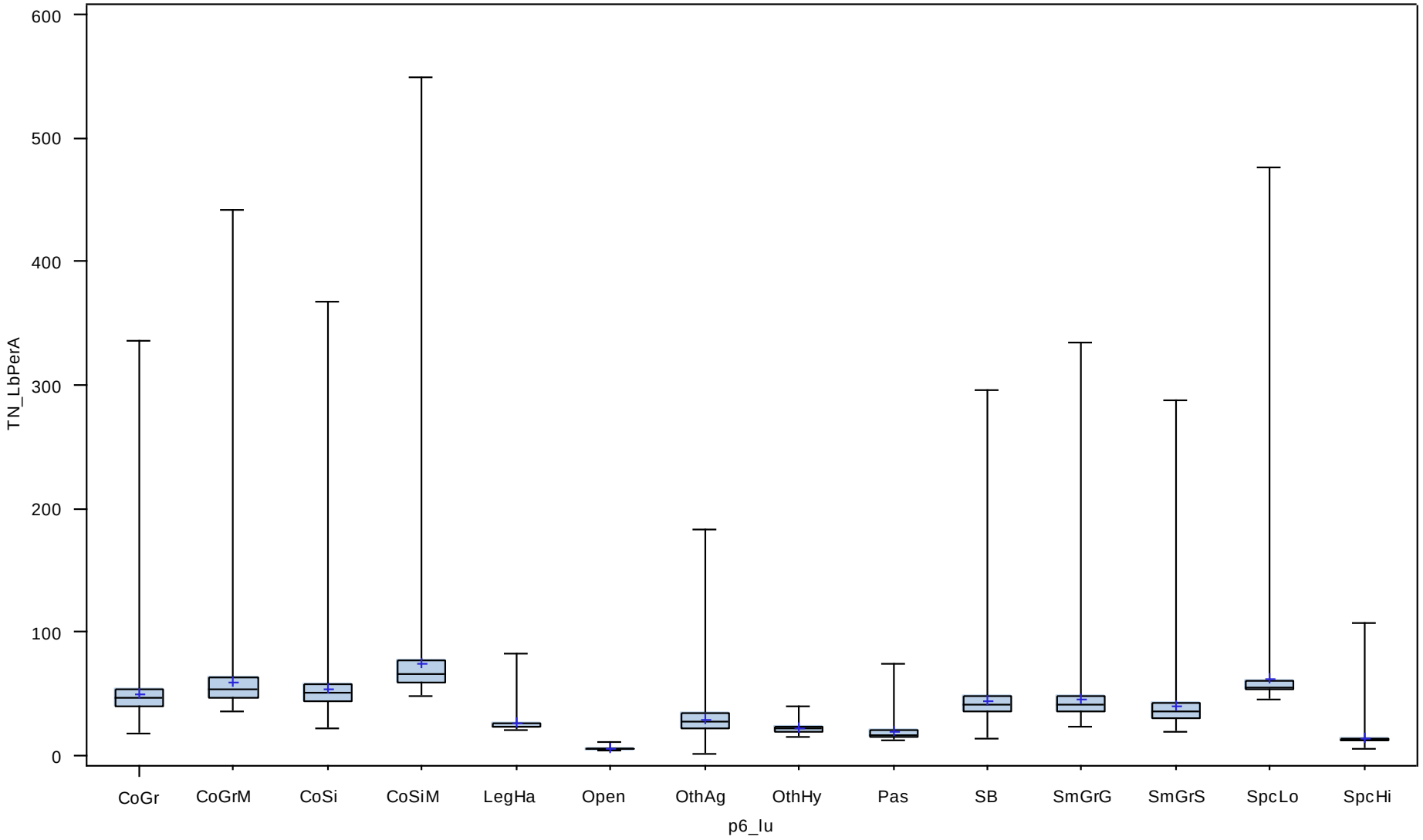

Targets for Phase 6
Agriculture-All Chesapeake Bay Land Segments

Draft

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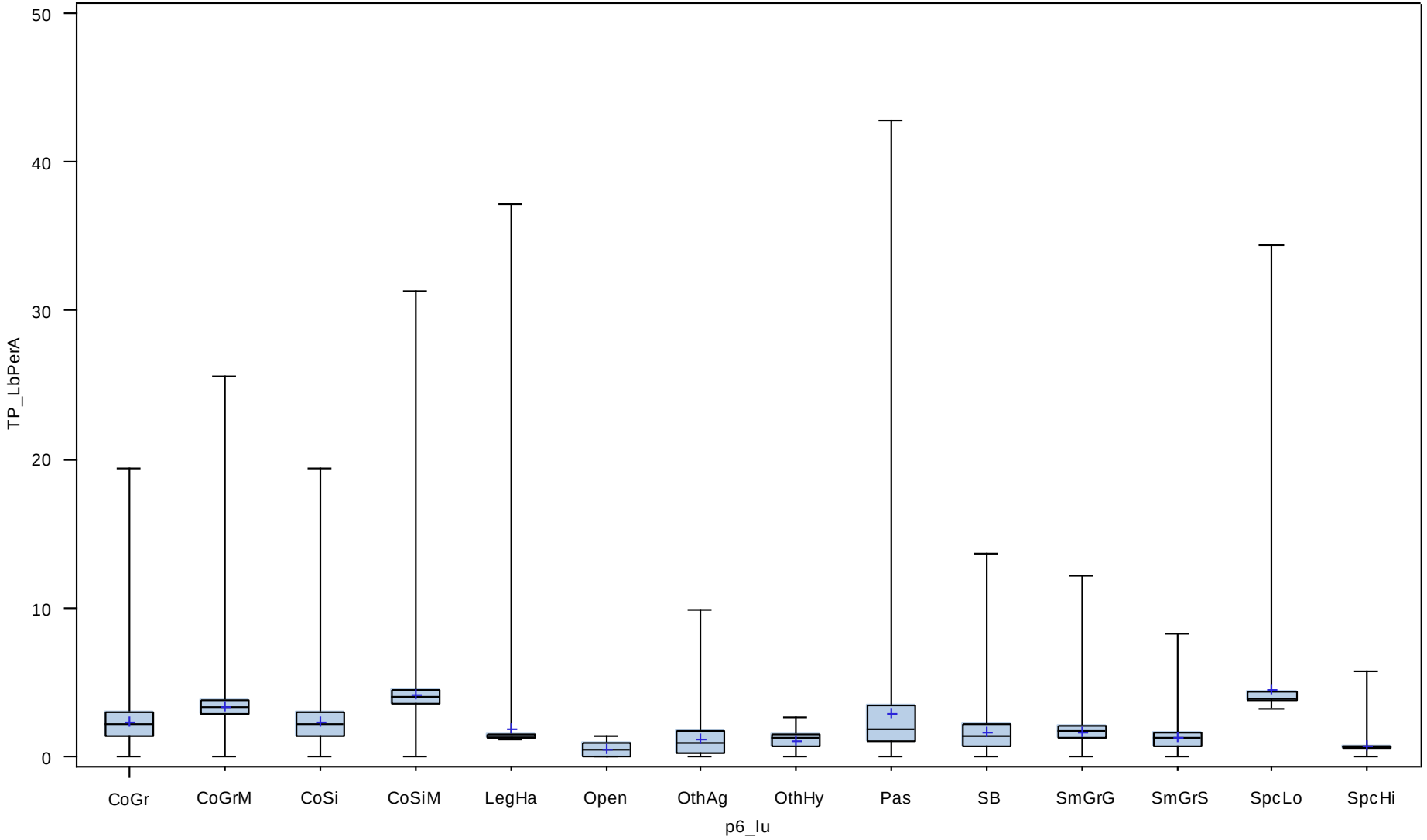

Targets for Phase 6
Agriculture-All Chesapeake Bay Land Segments

Draft

overall statistics					
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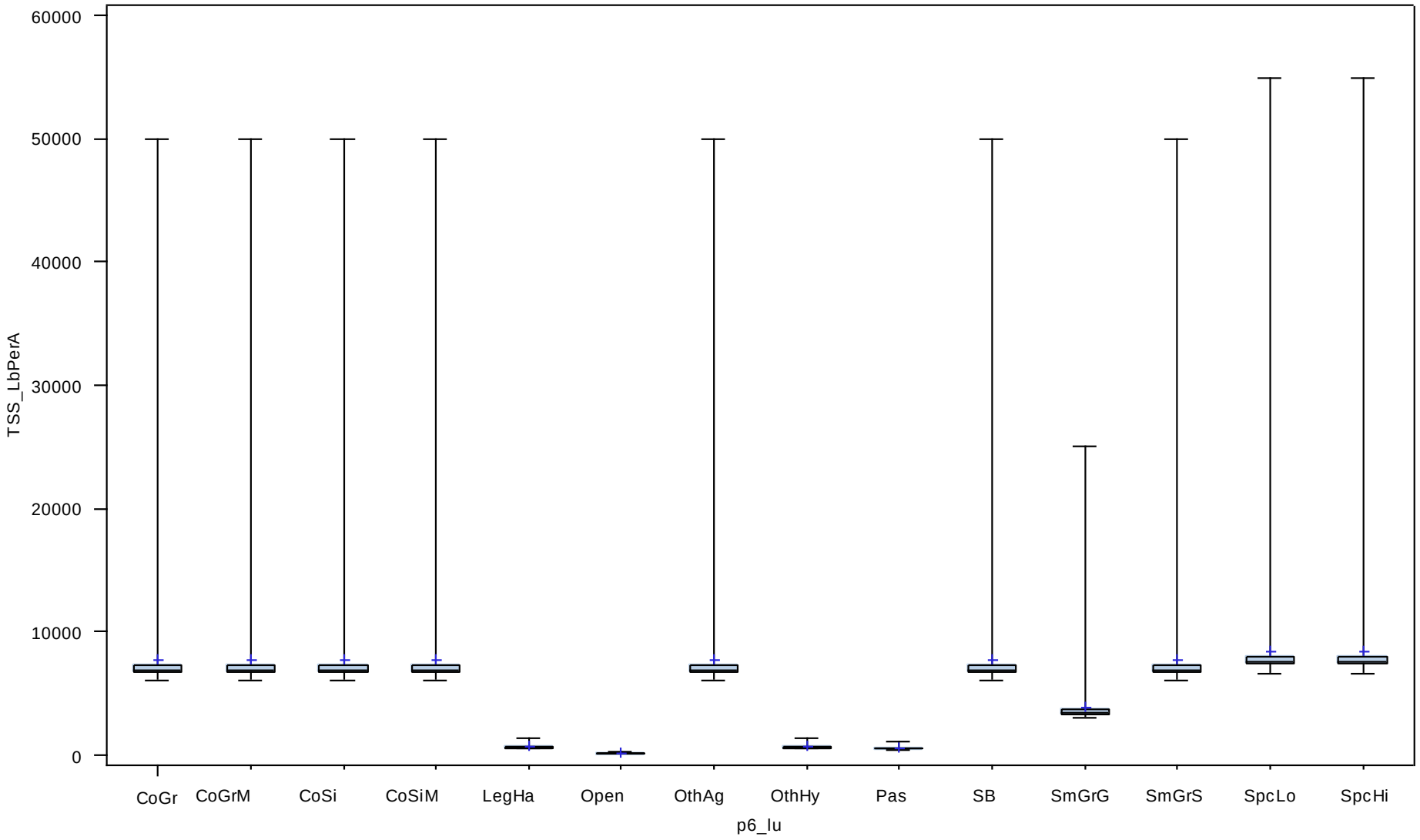
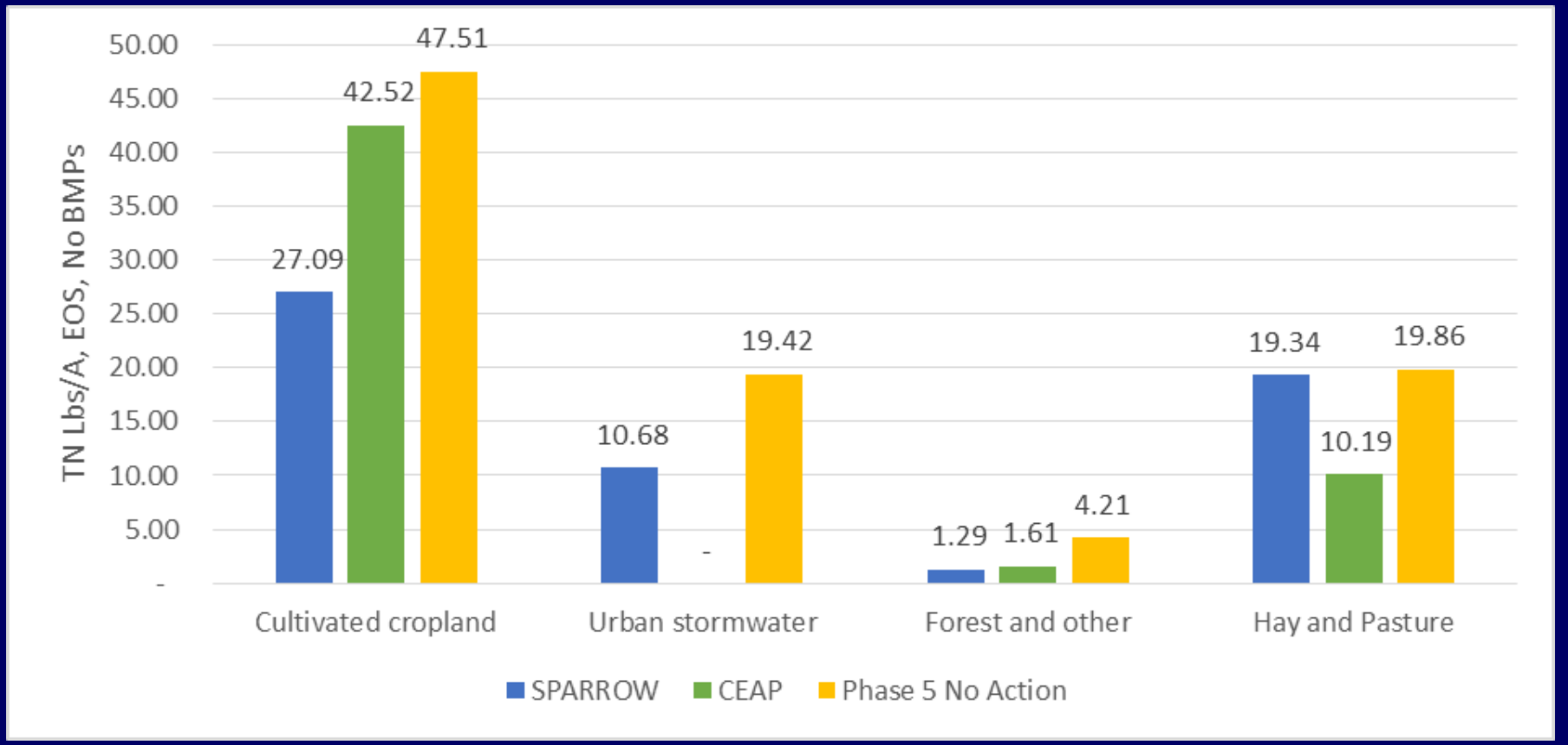


Updates Expected

- SPARROW data using Phase 6 land uses and acres
- Sensitivities
- Changes to the sector-specific relative land use export rates

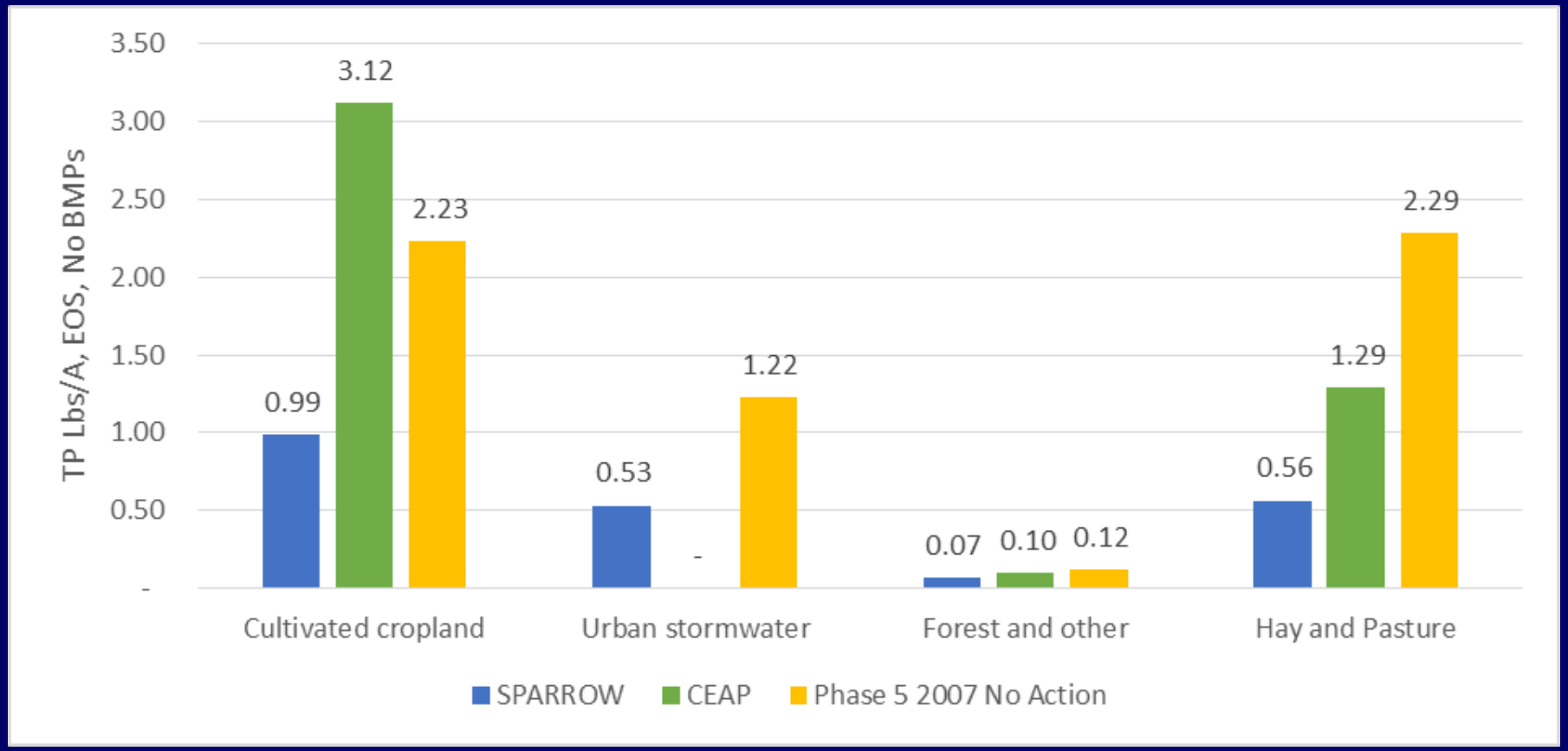
EARTH DAY

Global Targets—TN



Range and Average:
Hay/Pas = 10 to 20 lb/acre; Average = 16 lb/acre
Forest = 1.3 to 4.2 lb/acre; Average = 2.4 lb/acre
Stormwater = 11 to 19 lb/acre; Average = 15 lb/acre
Cropland = 27 to 48 lb/acre; Average = 39 lb/acre

Global Targets—TP



Range and Average:
Hay/Pas = 0.56 to 2.3 lb/acre; Average = 1.4 lb/acre
Forest = 0.07 to 0.12 lb/acre; Average = 0.10 lb/acre
Stormwater = 0.53 to 1.2 lb/acre; Average = 0.88 lb/acre
Cropland = 0.99 to 3.1 lb/acre; Average = 2.1 lb/acre