APLE Phosphorus Model: Preliminary estimates of P loading

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Annual P Loss Estimator (APLE) tool

- Developed by Vadas, et al. (USDA-ARS)
- Annual time step
- Edge-of-field (EOF) estimation
- Simulates sediment and dissolved P surface losses from soil, manure, and fertilizer sources
- Minimal subsurface loss or leaching to groundwater simulated

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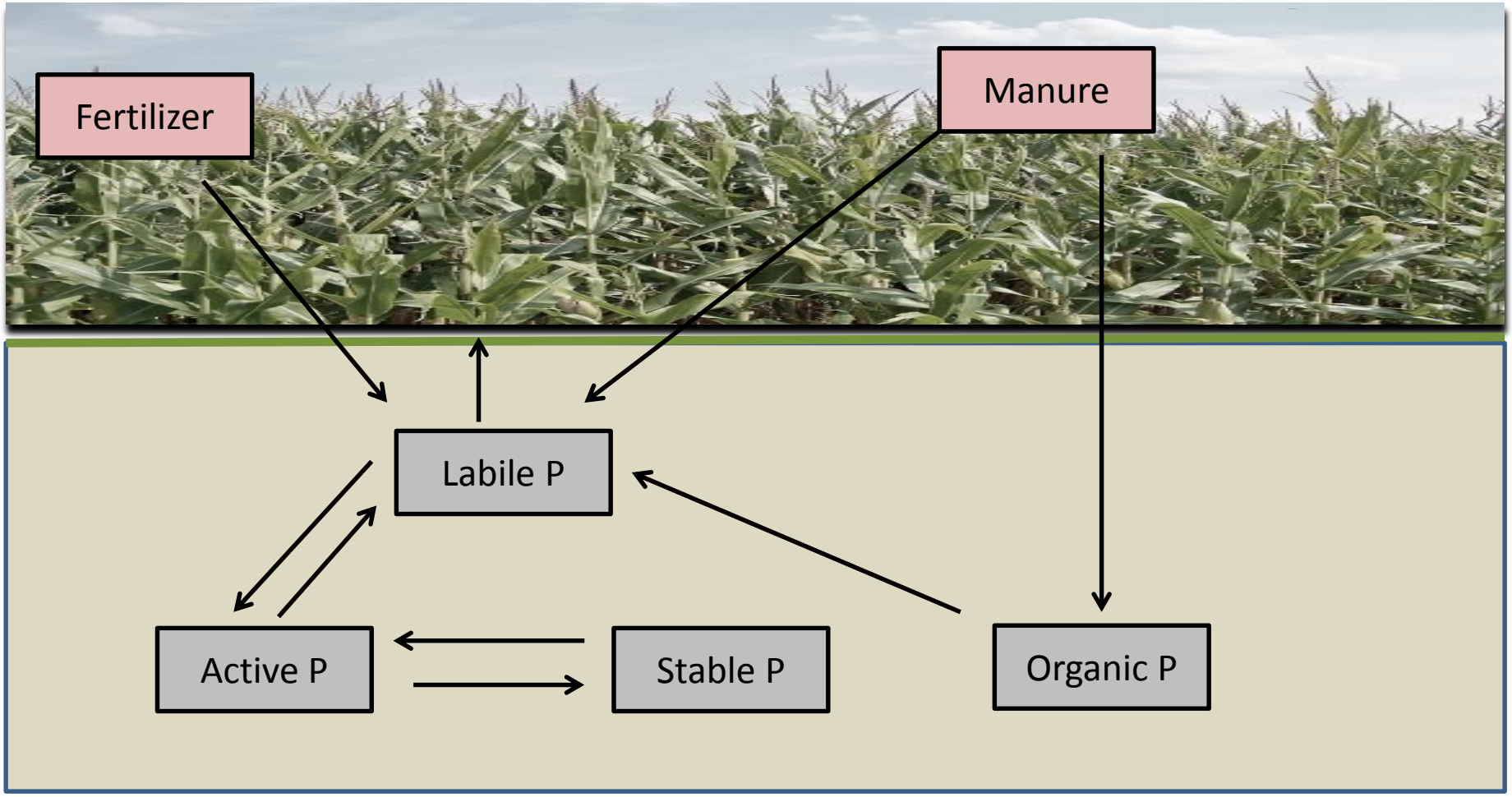
Diagram of APLE Nutrient Sources and Soil Pools



Equations to estimate Manure runoff P, Fertilizer runoff P, Sediment P loss, and Dissolved Soil P runoff

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(Adapted from Vadas, et al. 2007)

Nutrient Application Assumptions

- Application rates are user-defined by season
- Fertilizer
- Manure
  - solid or liquid forms (user-defined)
  - Direct excretion of manure (i.e. pasture) is considered a separate manure source
  - Proportioned as water-extractable P (WEP) and non-WEP

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APLE Equations

- **Sediment P Loss** (kg ha^{-1})= Eroded sediment * Soil Total P * P Enrichment Ratio
- **Manure Runoff P** (kg ha^{-1})= WEP * Runoff/Precipitation * Distribution Factor
- **Fertilizer Runoff P** (kg ha^{-1})= Fertilizer P * Runoff/Precipitation * Distribution Factor
- **Dissolved Soil Runoff P** (kg ha^{-1})= Soil Labile P * 0.005 * Annual Runoff * 10^{-6}

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Methodology

- The primary objective of our research is to identify, evaluate and improve the mechanics and representation of soil P as simulated within the Chesapeake Bay Watershed Model
- Using identical data provided by the CBP to estimate average EOF P loss for five land uses (*hwm, lwm, nhi, nlo*, and *pas*)
- LSEG county scale
- Simulation years: 1992-2005

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Methodology

CATEGORY	DATA PARAMETER	UNITS	DATA SOURCE
Soil Properties	Depth of soil layer(s)	Inches	Variable based on land use
	Mehlich-3 soil P	ppm	University soil test labs
	Clay content	Percent	Chesapeake Bay Program
	Organic matter content	Percent	Chesapeake Bay Program
Transport Factors	Annual rain	Inches	Chesapeake Bay Program
	Annual runoff	Inches	Chesapeake Bay Program
	Annual erosion rate	tons $acre^{-1}$	Chesapeake Bay Program
Field Properties	Field size (pasture land use only)	acres	Chesapeake Bay Program
	Annual crop P uptake	pounds $acre^{-1}$	Chesapeake Bay Program
	Manure application	kg ha^{-1}	Chesapeake Bay Program
	Manure solids	Percent	Scholarly literature
	Manure WEP/TP	Percent	Scholarly literature
	Manure incorporation	Percent and inches	Variable based on land use
	Fertilizer application	kg ha^{-1}	Chesapeake Bay Program
	Fertilizer incorporation	Percent and inches	Variable based on land use
	Degree soil mixing	Percent	Variable based on land use

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Results: annual Total P EOF losses by land use

LAND USE	MEAN	MEDIAN	MAX	MIN
hwm	10.1 kg ha^{-1} 9.02 lb ac^{-1}	5.98 kg ha^{-1} 5.32 lb ac^{-1}	131.0 kg ha^{-1} 117.0 lb ac^{-1}	0.011 kg ha^{-1} 0.010 lb ac^{-1}
lwm	4.34 kg ha^{-1} 3.88 lb ac^{-1}	2.46 kg ha^{-1} 2.19 lb ac^{-1}	83.2 kg ha^{-1} 74.0 lb ac^{-1}	0.002 kg ha^{-1} 0.002 lb ac^{-1}
nhi	10.9 kg ha^{-1} 9.70 lb ac^{-1}	6.56 kg ha^{-1} 5.87 lb ac^{-1}	131.0 kg ha^{-1} 117.0 lb ac^{-1}	0.011 kg ha^{-1} 0.010 lb ac^{-1}
nlo	5.05 kg ha^{-1} 4.49 lb ac^{-1}	2.87 kg ha^{-1} 2.55 lb ac^{-1}	83.4 kg ha^{-1} 74.2 lb ac^{-1}	0.002 kg ha^{-1} 0.002 lb ac^{-1}
pas	3.77 kg ha^{-1} 3.36 lb ac^{-1}	2.03 kg ha^{-1} 1.81 lb ac^{-1}	80.4 kg ha^{-1} 71.6 lb ac^{-1}	0.002 kg ha^{-1} 0.002lb ac^{-1}

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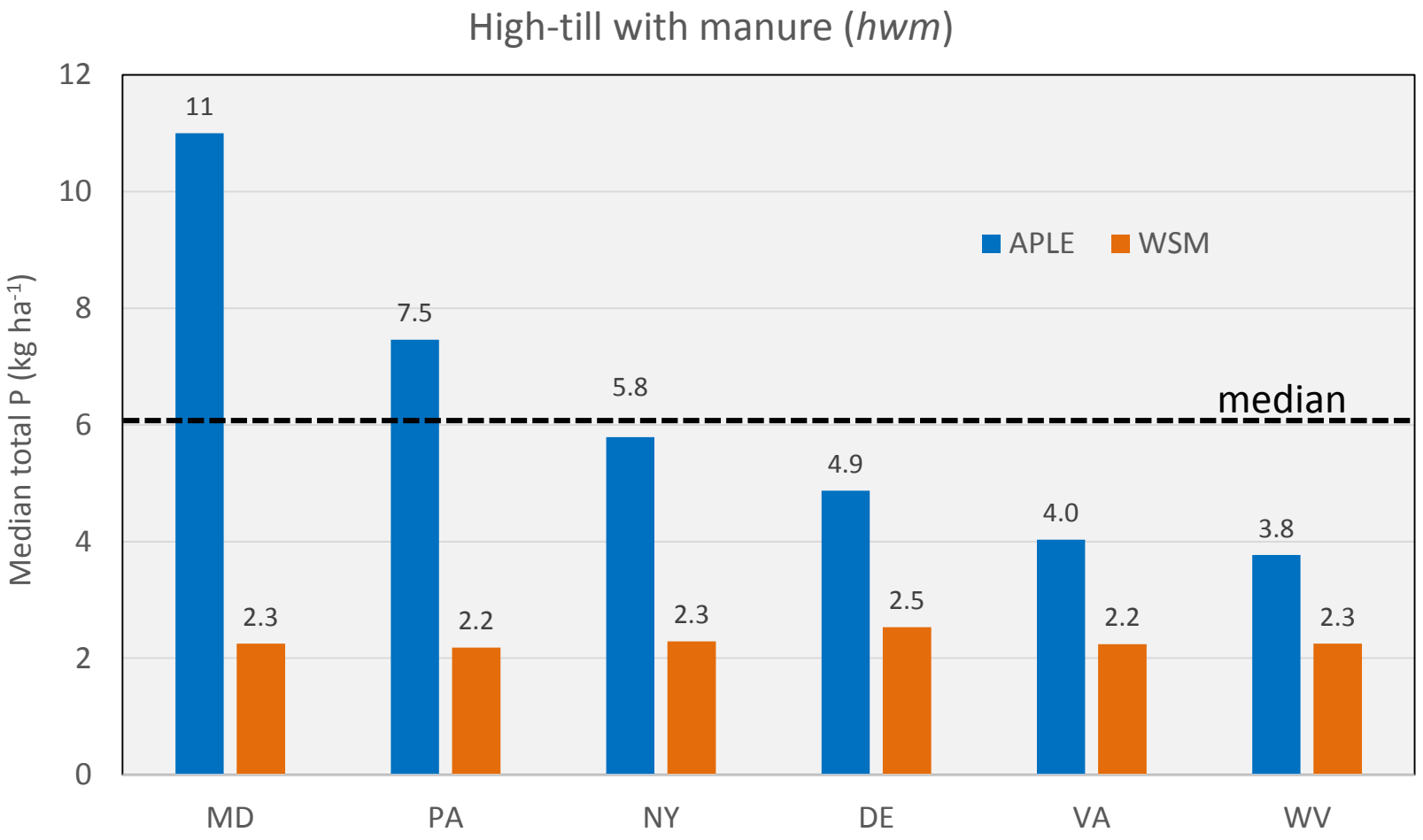
Median Total P loss: Estimations from APLE v. Bay Model (WSM) targets



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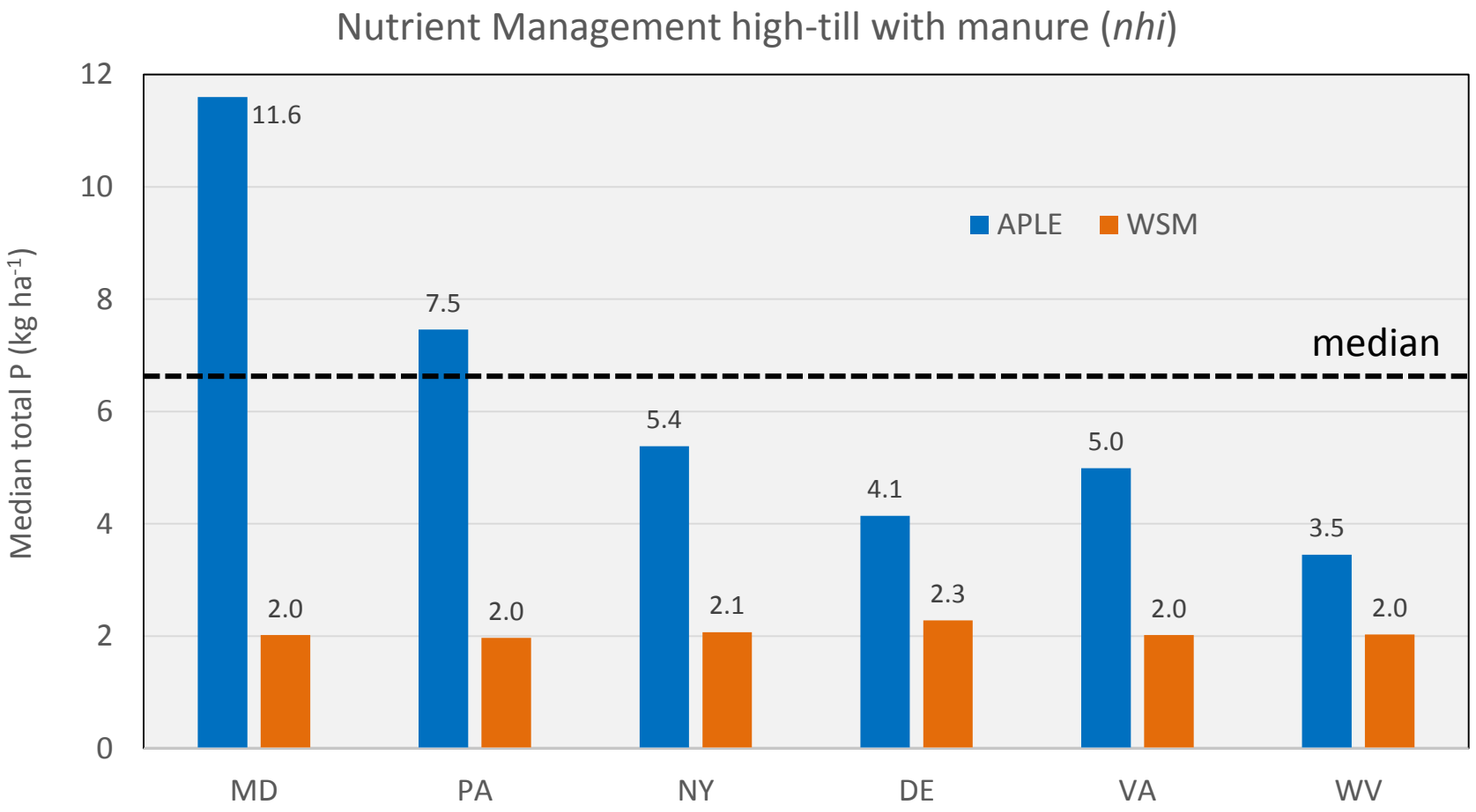

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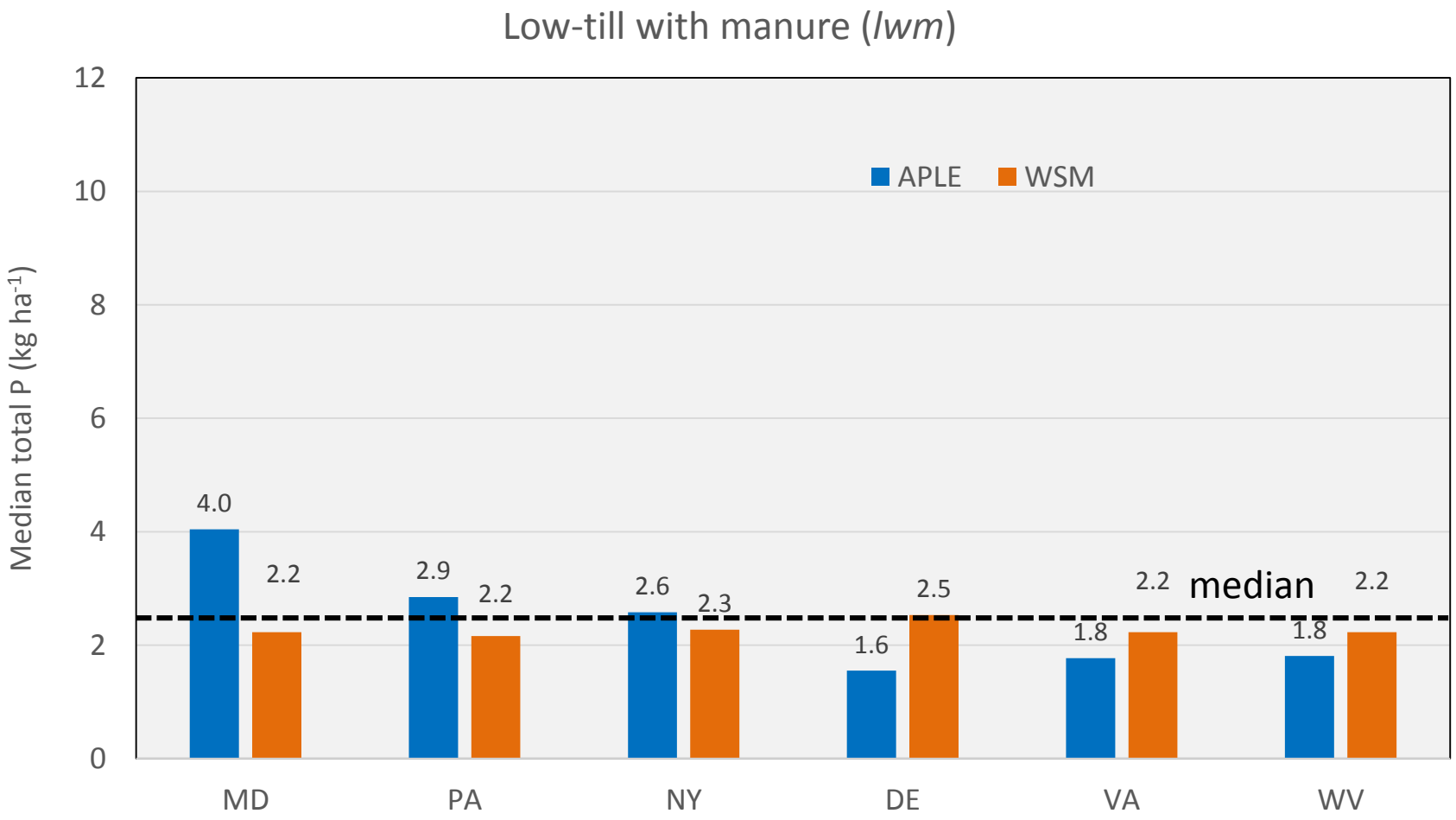

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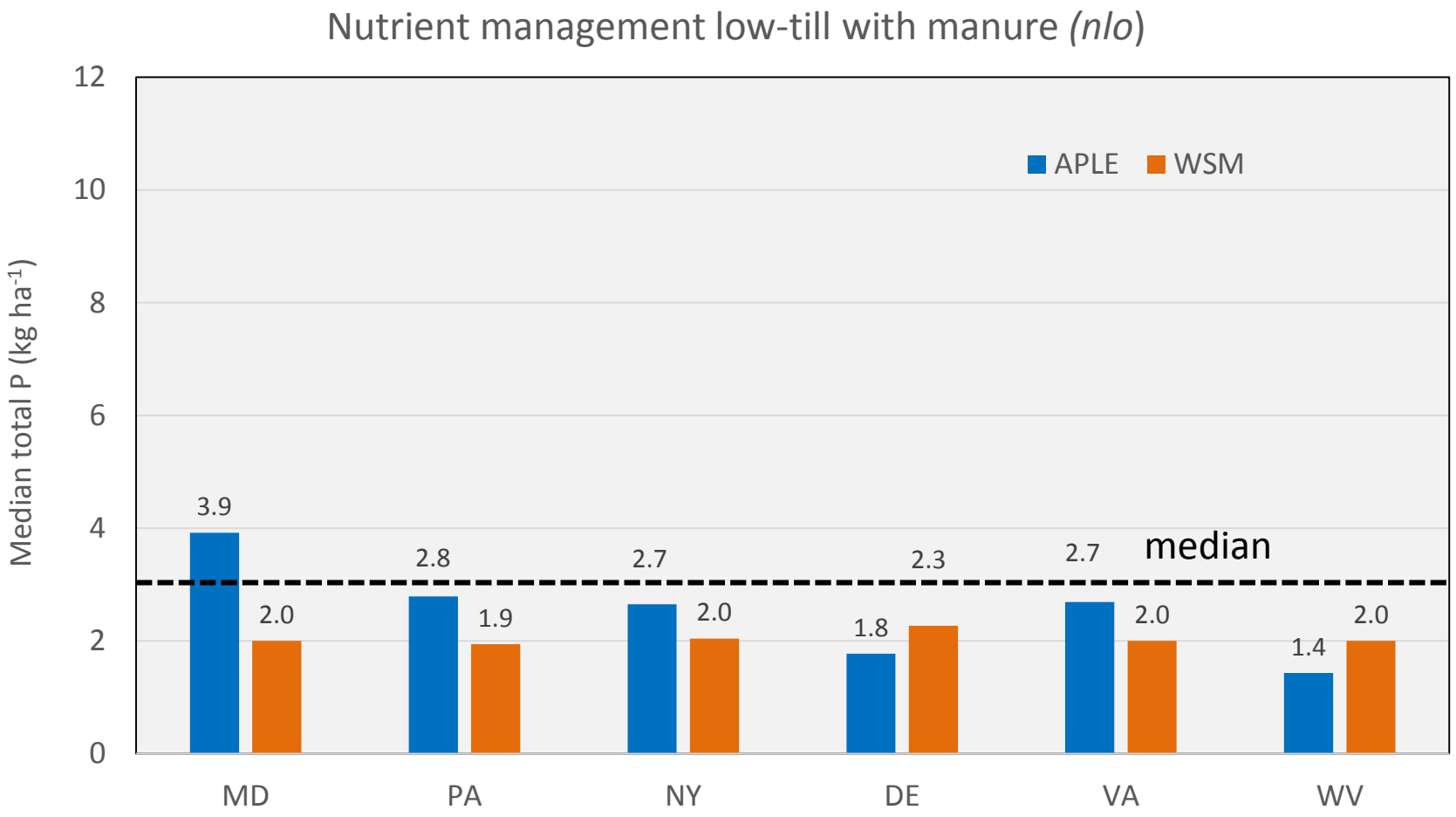

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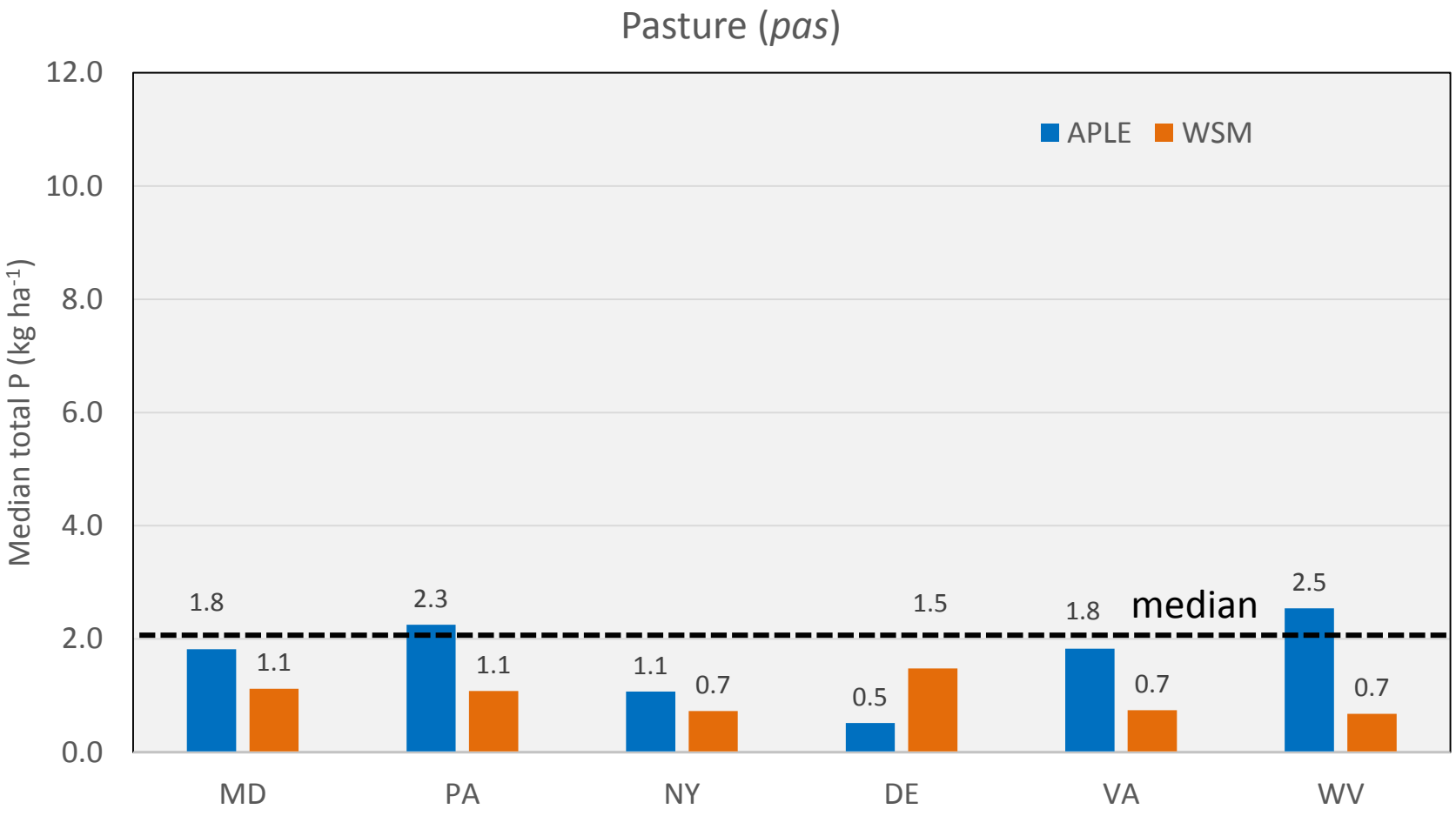

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Sediment contributions to TP loads

- **Sediment P Loss** = Eroded sediment * Soil Total P * P Enrichment Ratio
  - 97.9% of TP loads are sediment P loads for *hwm*
  - 94.7% of TP loads are sediment P loads for *lwm*
  - 85.1% of TP loads are sediment P loads for *pas*

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Results: annual Dissolved P EOF losses by land use

LAND USE	Mean Total P	Mean Dissolved P	Median Dissolved P
hwm	10.1 kg ha^{-1} 9.02 lb ac^{-1}	0.190 kg ha^{-1} 0.169 lb ac^{-1}	0.126 kg ha^{-1} 0.112 lb ac^{-1}
lwm	4.34 kg ha^{-1} 3.88 lb ac^{-1}	0.220 kg ha^{-1} 0.196 lb ac^{-1}	0.126 kg ha^{-1} 0.112 lb ac^{-1}
nhi	10.9 kg ha^{-1} 9.70 lb ac^{-1}	0.253 kg ha^{-1} 0.225 lb ac^{-1}	0.154 kg ha^{-1} 0.137 lb ac^{-1}
nlo	5.05 kg ha^{-1} 4.49 lb ac^{-1}	0.308 kg ha^{-1} 0.274 lb ac^{-1}	0.155 kg ha^{-1} 0.138 lb ac^{-1}
pas	3.77 kg ha^{-1} 3.36 lb ac^{-1}	0.549 kg ha^{-1} 0.489 lb ac^{-1}	0.274 kg ha^{-1} 0.244 lb ac^{-1}

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EXTRAS

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Model Validation

- P loss in runoff
  - Measured data from 28 crop studies from 13 states, Australia, and Ireland; 14 pasture studies from 5 states, Australia, and New Zealand
- Soil P dynamics
  - Measured data from 19 studies monitoring changes in soil P from 1 to 25 years
- Under all scenarios, the model was <u>not</u> calibrated differently

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