Annual P Loss Estimator (APLE)

User-friendly Model for Annual, Field-Scale Phosphorus Loss

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APLE Properties

❑ **Excel spreadsheet model that estimates (lb/ac) annual, field-scale, dissolved and sediment P loss in surface runoff**

❑ **Intended to function like a P Index**

- **Estimate P loss for given set of soil P, erosion, runoff, P application, tillage conditions**

- **Be more process-based than most P Indexes, but much more user-friendly than APEX, SWAT type models**

APLE Inputs

Soil Clay 1st layer	%	20
Soil Clay 2nd layer	%	20
Soil OM 1st Layer	%	1.9
Soil OM 2nd Layer	%	1.9
Field Area	Acres	1.00
Year		1
Factors	Annual Rain	inches	38.00
	Annual Runoff	inches	6.00
	Sediment Loss	ton/acre	1.50
Annual Crop P	Crop P Uptake	lb/ac	25.0

APLE Inputs

	Grazing Animals		Milk Cows	Heifers	Dry Cows	Calves
	Total Cow Days (# cows x # days)		0	0	0	0
			Beef Cows	Calves		
			0	0		
	Solid Manure Applications		**Winter**	**Spring**	**Summer**	**Fall**
Manure Applications	**Manure Applied**	wet ton/acre	0	0	0	0
	Manure Solids	%	0	0	0	0
	Manure Total P2O5 Content	lbs/wet ton	0	0	0	0
	Manure WEP/TP	%	0	0	0	0
	Manure Incorporated	%	0	0	0	0
	Depth of Incorporation	inches	0	0	0	0
	Liquid Manure Applications		**Winter**	**Spring**	**Summer**	**Fall**
Manure Applications	**Manure Applied**	gallons/acre	0	5000	0	5000
	Manure Solids	%	0	6	0	6
	Manure Total P2O5 Content	lbs/1000 gal.	0	6.1	0	6.1
	Manure WEP/TP	%	0	50	0	50
	Manure Incorporated	%	0	0	0	0
	Depth of Incorporation	inches	0	0	0	0
	Fertilizer Applications					
Fertilizer Application	**Fertilizer P Applied**	lb/ac	0			
	Fertilizer Incorporated	%	0			
	Depth of Incorporation	inches	0			
	Degree of Soil Mixing	%	15			

Dissolved P Loss from Surface Manure, Fertilizer

P applied — P into soil from tillage, liquid manure infiltration

(Vadas, 2006)

↓

P on surface X **Availability factor**

Fertilizer: 100%
Manure: % WEP

(Vadas et al, 2009)

↓

Available P on Surface X $\dfrac{\text{Runoff}}{\text{Precip.}}$ X **Distribution Factor**

(Vadas et al., 2004, 2005, 2008)

↓

Dissolved P in Runoff — All P not lost in runoff goes into soil
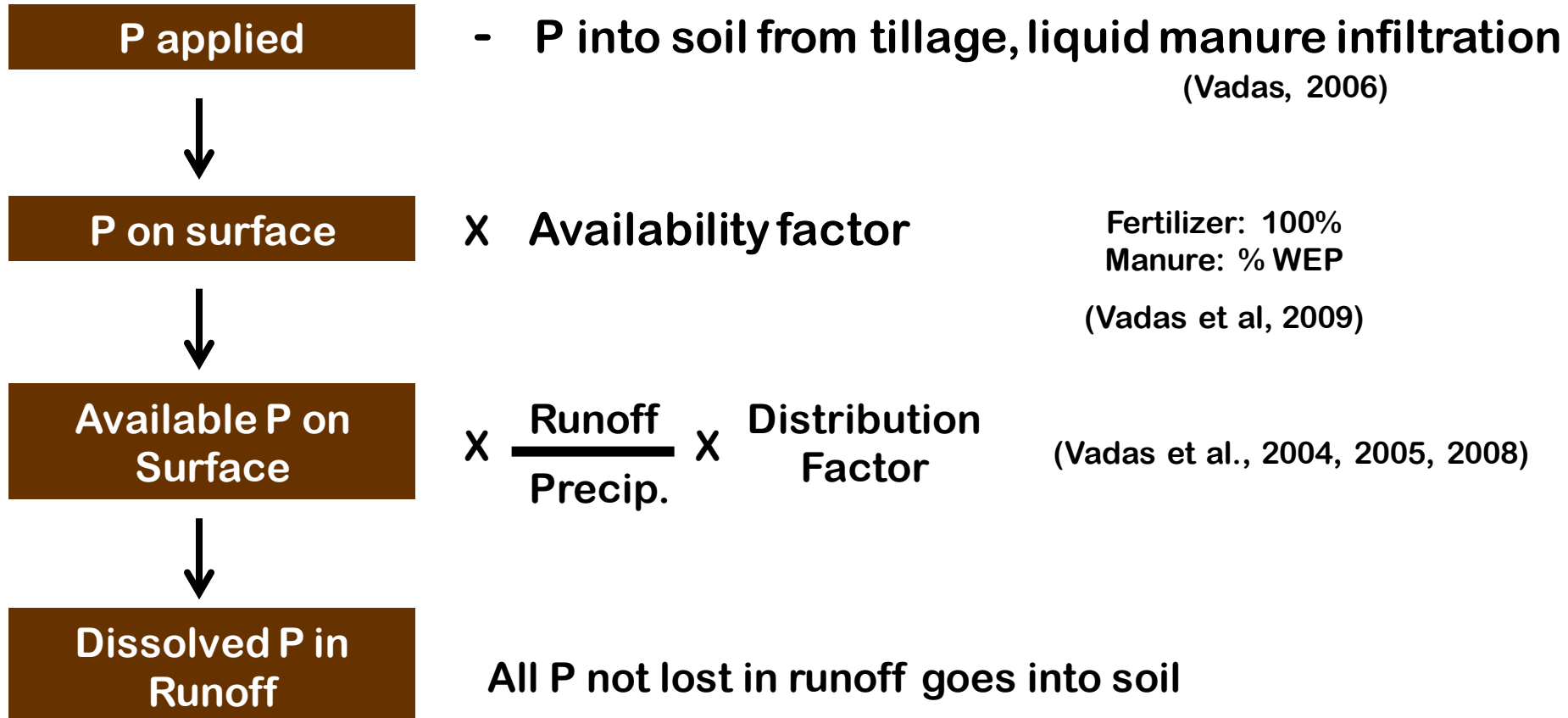
Dissolved and Sediment P Loss from Soil

Dissolved Soil Runoff P = (Soil Labile P) (0.005)
(Annual Runoff)

Vadas et al. (2005)

Sediment P Loss = (Eroded Sediment)(Soil Total P)
(P Enrichment Ratio)

Menzel et al. (1980) Sharpley (1980)

Soil Total P

Jones et al. (1984)   Sharpley et al. (1984)

Organic P	+	**Labile P**	+	**Active P**	+	**Stable P**
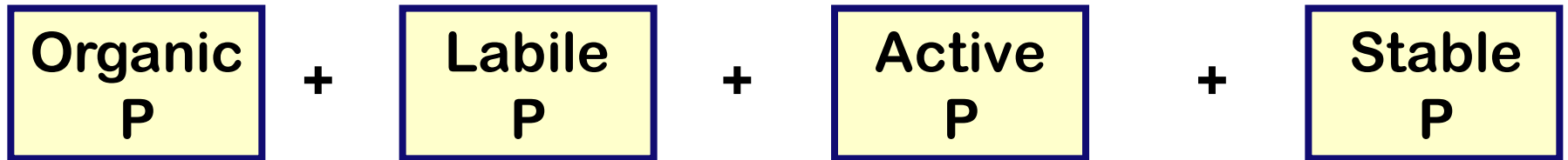
From OM   **From Mehlich-3 P**   **From Labile P and PSP**   **From Active P**

PSP

**P Sorption Parameter
from soil OM, clay, Labile P**
(Vadas and White, 2010)
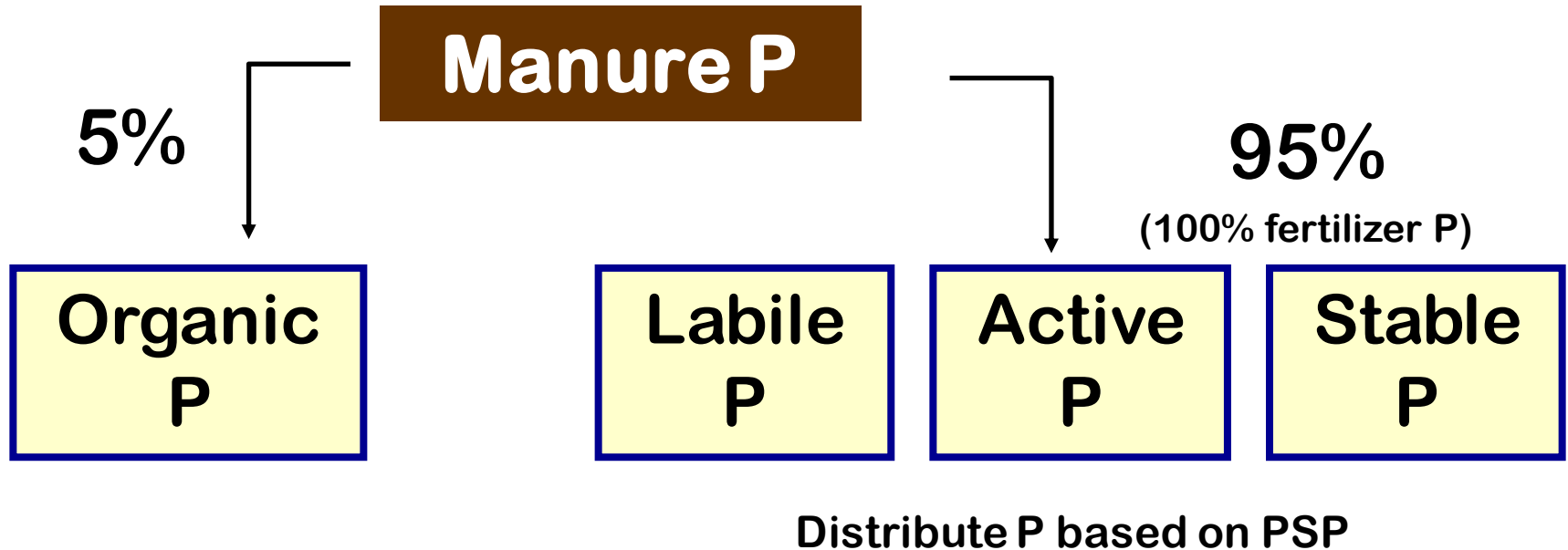
P Leaching out of topsoil
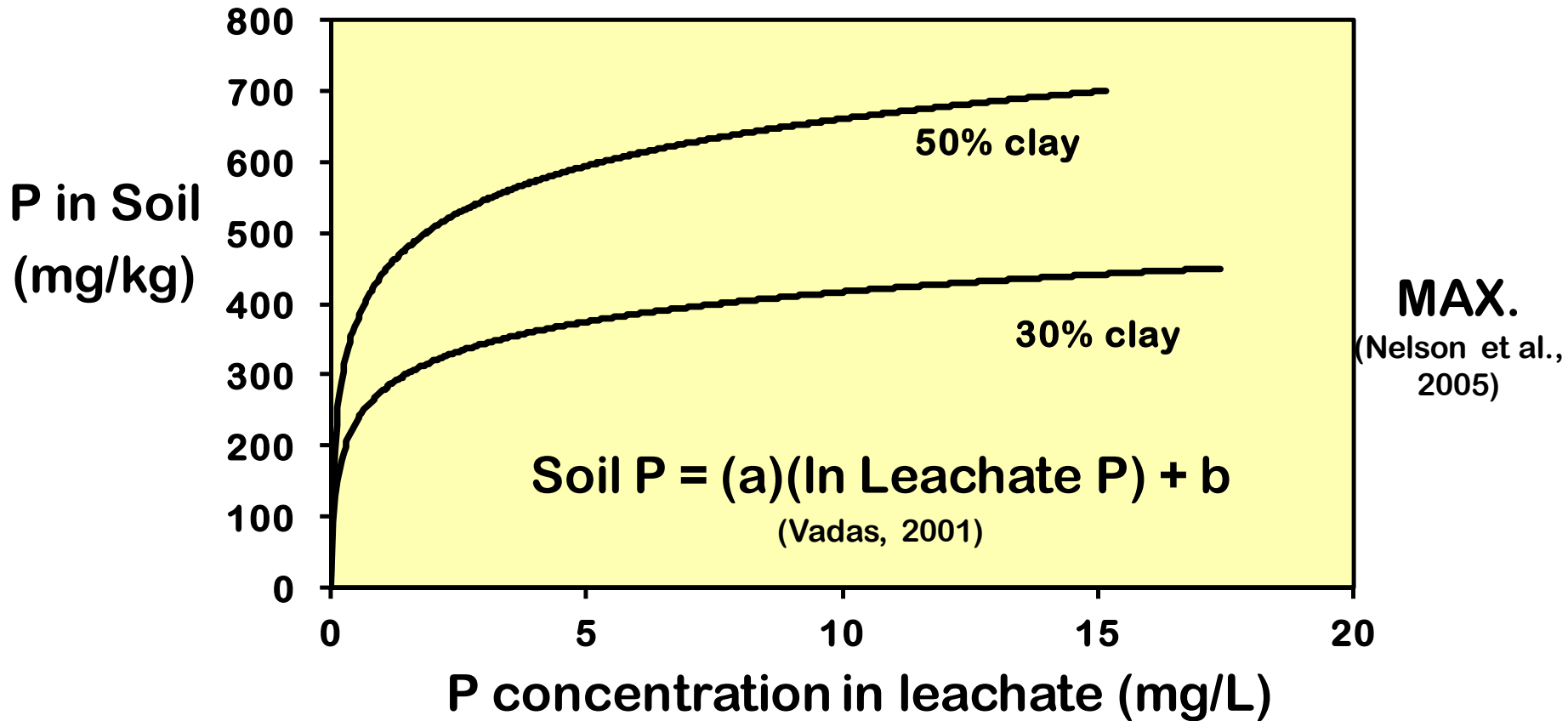
P Leaching out of topsoil


% precip. leaching through topsoil

$y = -0.07\ln(x) + 0.6$

Layer depth (inches)
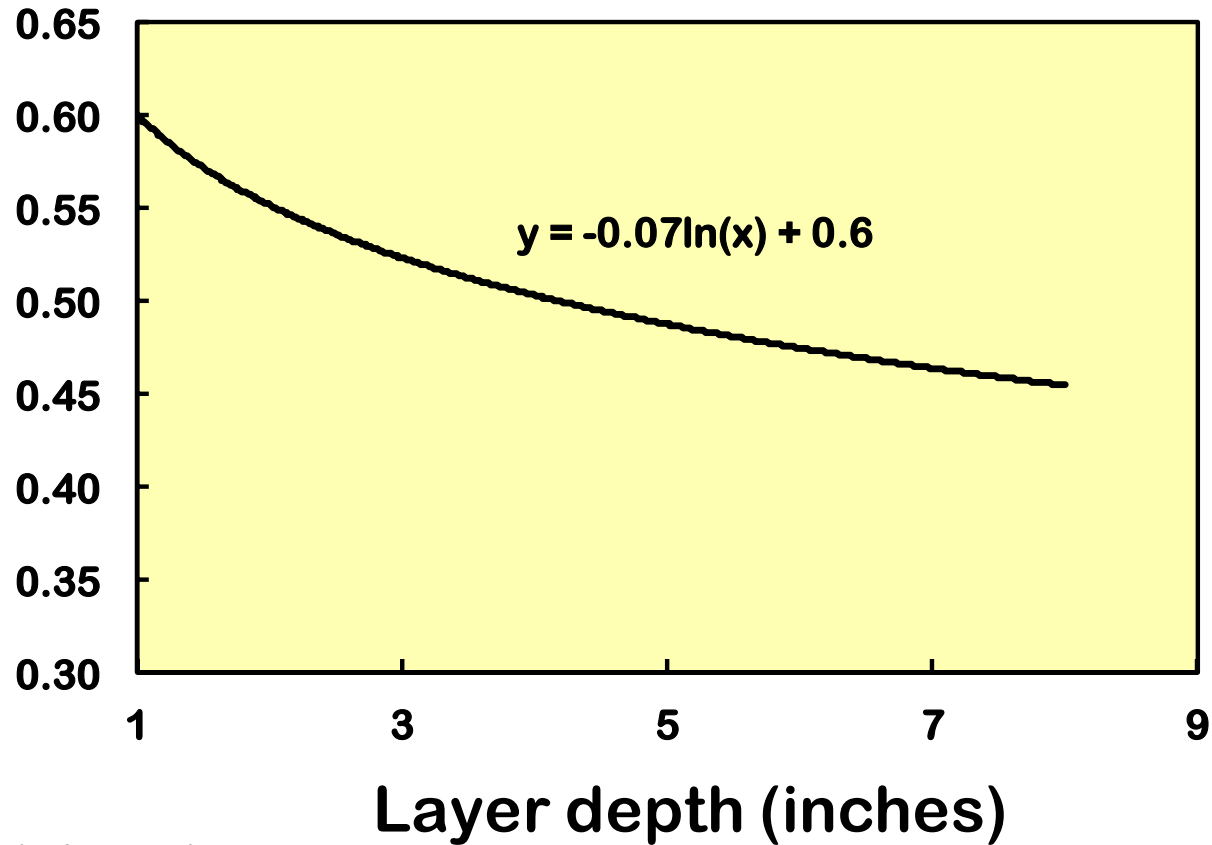
Nelson et al. (2005)

Soil P changes over time

Manure P

5%

95%
(100% fertilizer P)

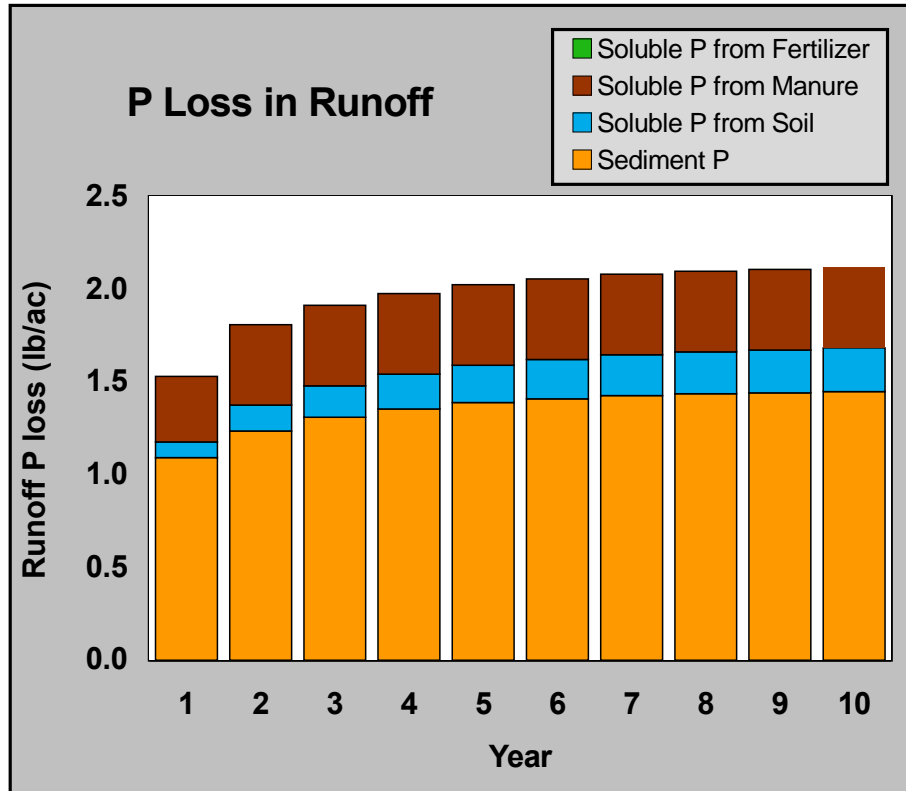| Organic P | | Labile P | Active P | Stable P |

Distribute P based on PSP

❑ **Two layers simulated within topsoil for P stratification**

❑ **P mixed between layers based on degree of mixing**

❑ **Crop P uptake from topsoil layers in proportion to relative soil P amounts**
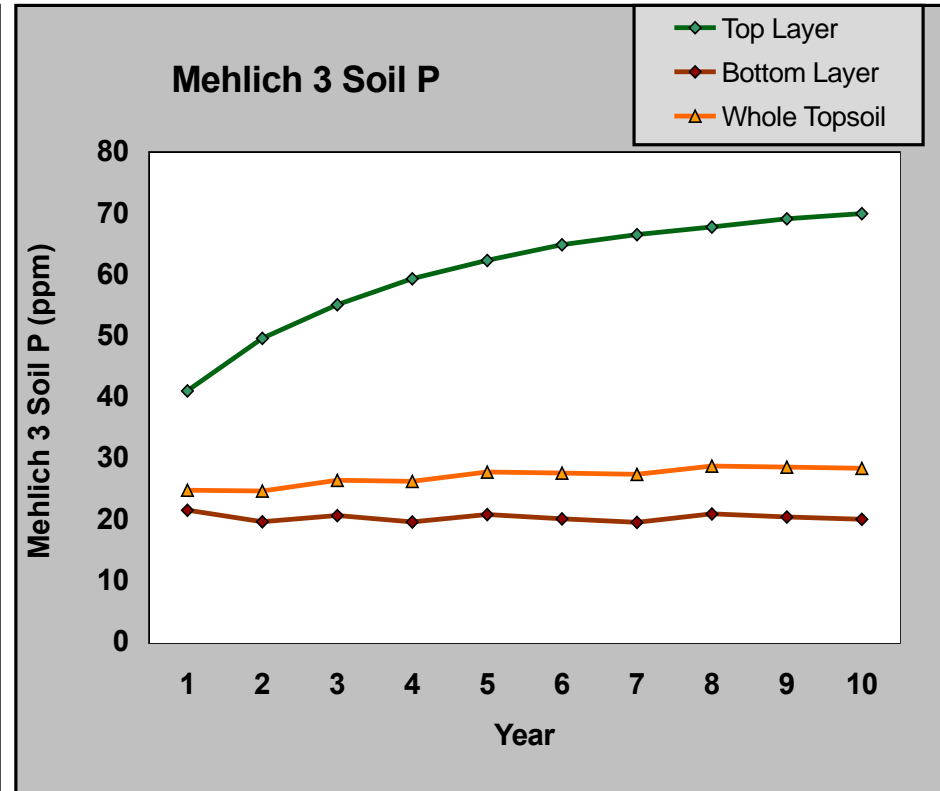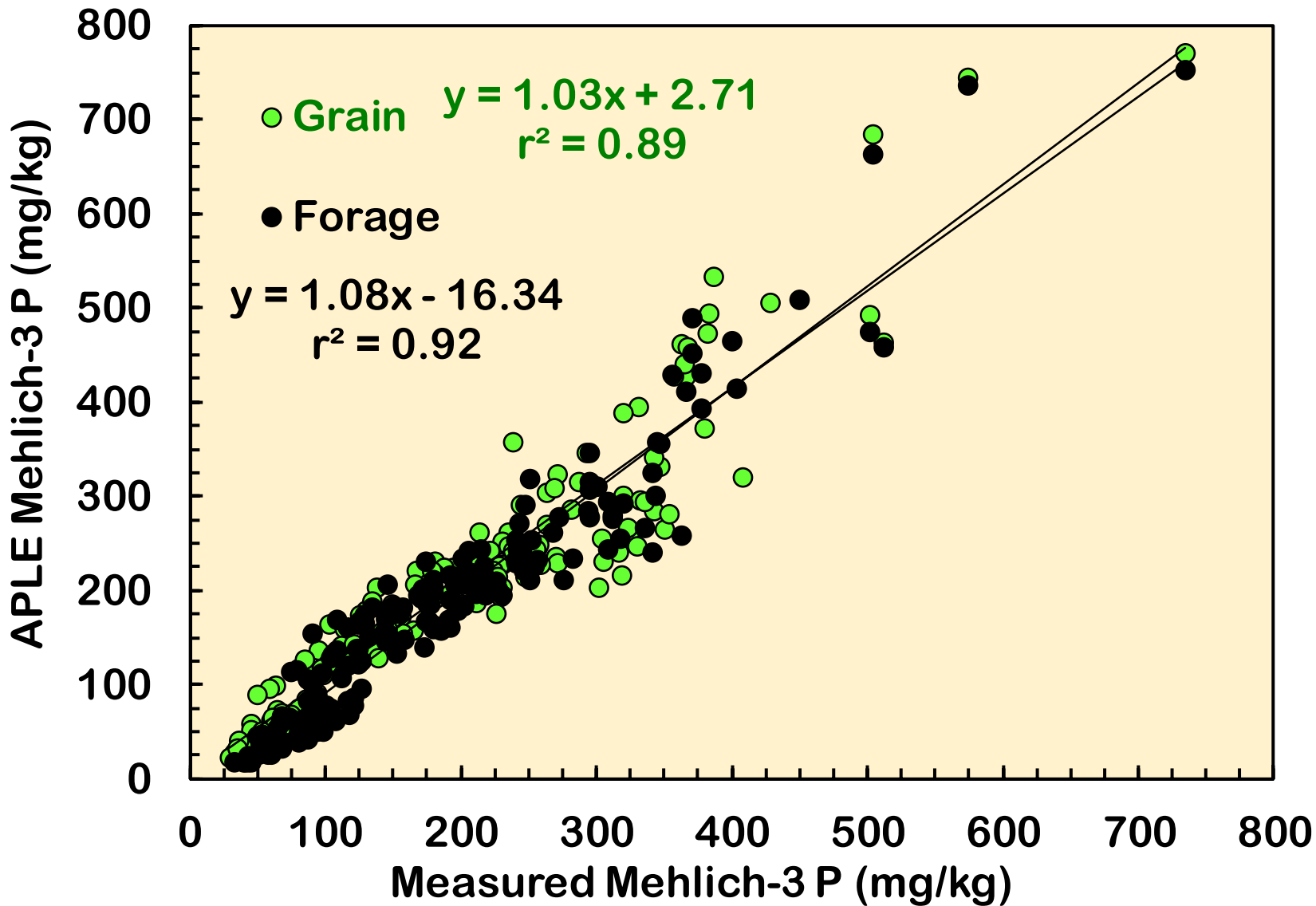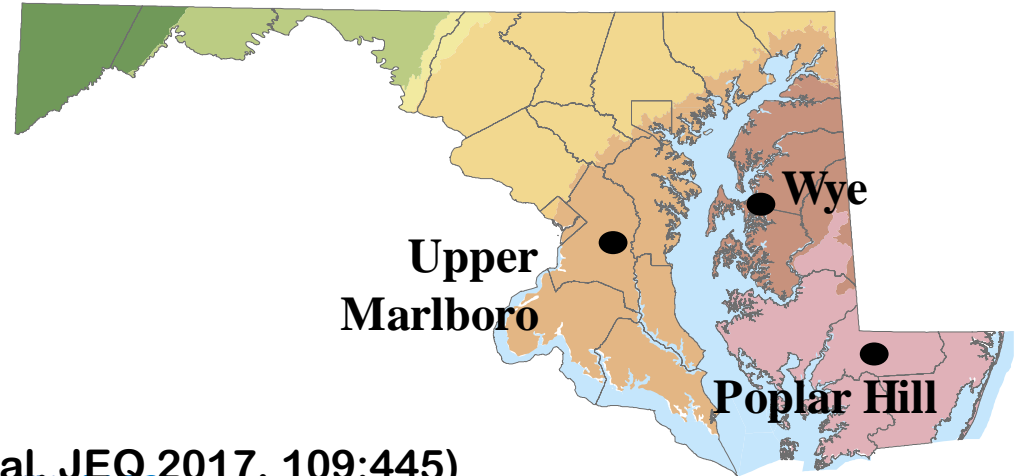
APLE P Loss and Soil P Evaluation

- For P loss, used measured data from 24 studies from 13 different states, Australia, and Ireland

- For soil P, used measured data from 19 studies, where monitored changes in soil P from 1 to 25 years

APLE Testing Results

Testing APLE for Soil P Drawdown

Upper Marlboro

Wye

Poplar Hill

Maryland NRCS State Office
339 Busch's Frontage Road, STE 301
Annapolis, MD 21409
http://www.md.nrcs.usda.gov

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- **Used field data** (Fiorellino et al. JEQ 2017, 109:445)
  - 3 sites (15% clay, 2.5% OM)
  - 1994-1997: soil P buildup – 0, 100, 200, 300, 400 kg P/ha/y
  - 1997-2001: No P application, no soil P measured
  - 2001-2015: No P application, Mehlich-3 soil P (0-15 cm) measured in 11 years
  - No-till management, both corn grain and forage harvest, crop P removal measured
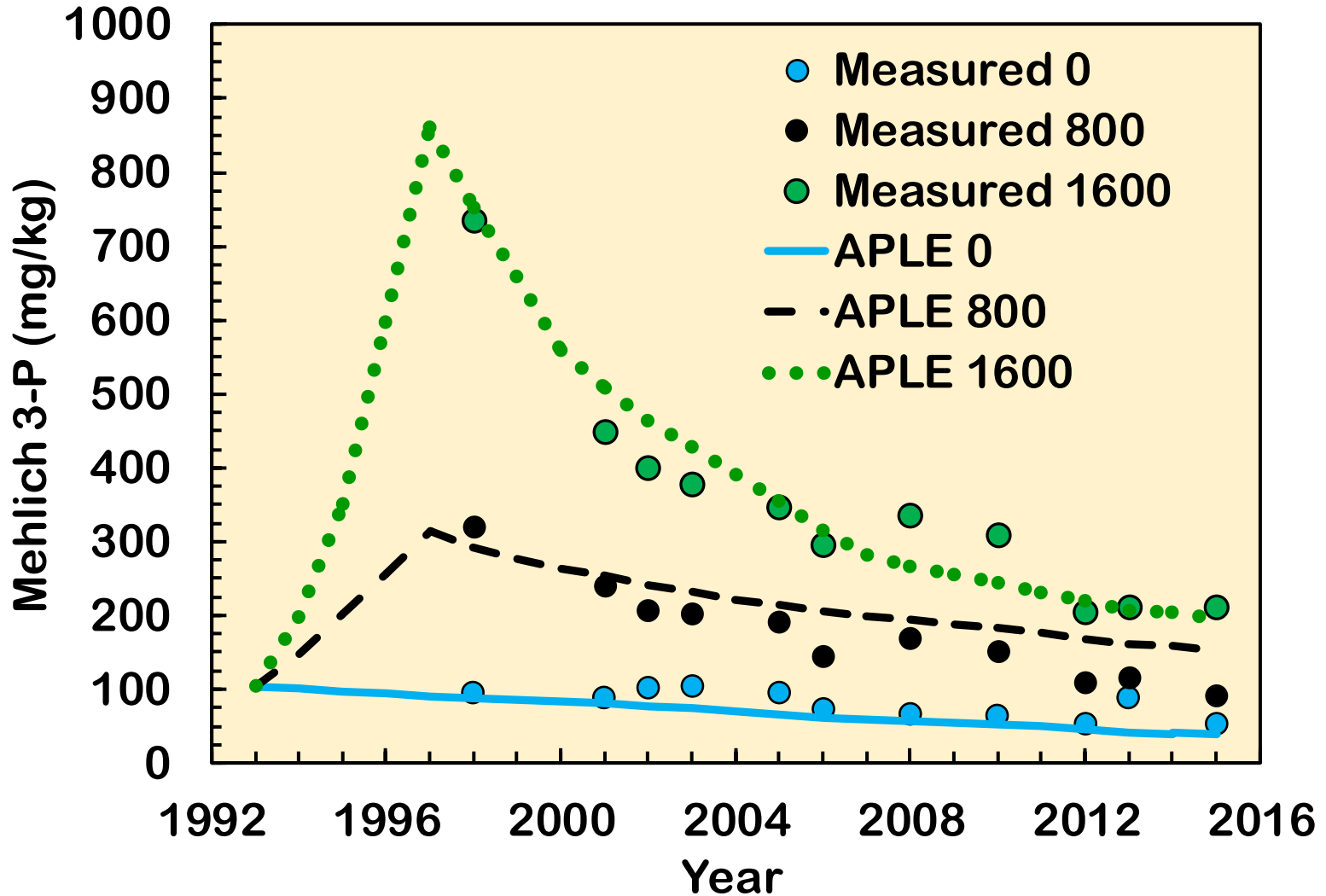- Simulated all experimental conditions with APLE, compared measured and simulated soil Mehlich 3-P

APLE Testing Results
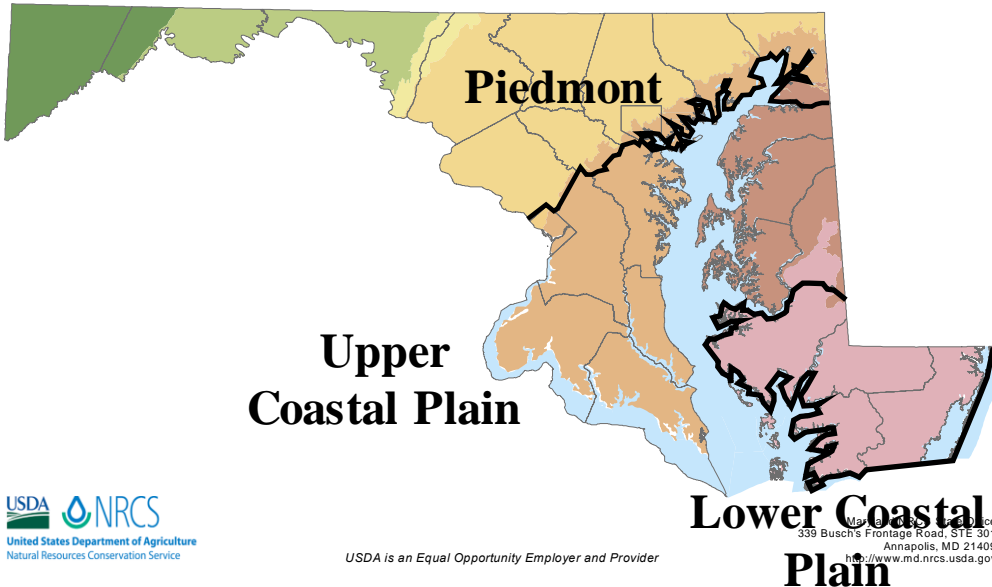
(Wye research site, grain harvest)

Use APLE to estimate state-wide impact of soil P drawdown and reduced P transport on P loss to Chesapeake Bay

Simulated

Major Land Resource Areas for Maryland and the District of Columbia
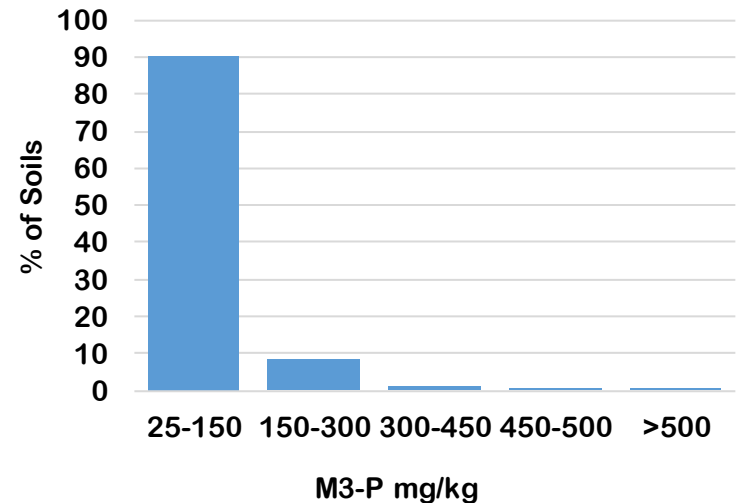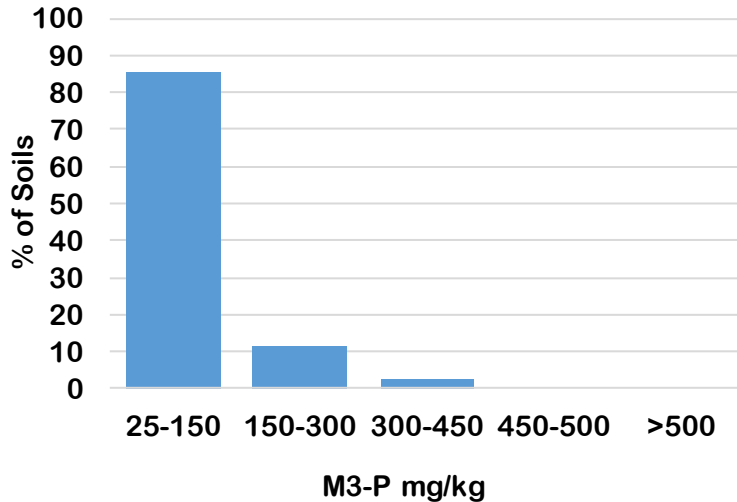
March 15, 2012

Piedmont

Upper Coastal Plain
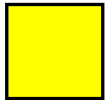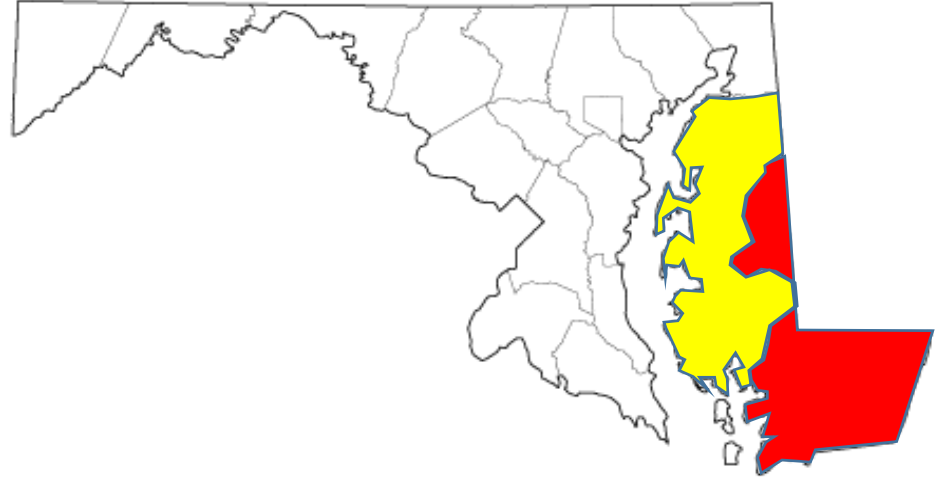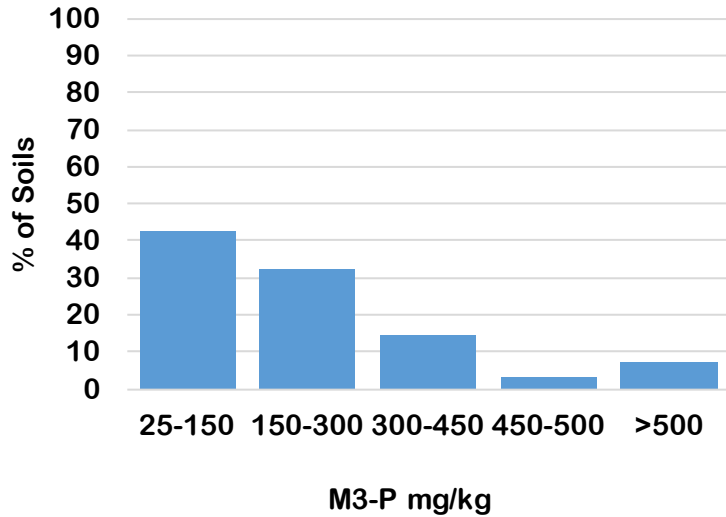
Lower Coastal Plain

- **Simulate statewide P loss over 40 y for:**
  1. Current soil P and runoff-erosion rates
  2. All soils at optimum 50 mg/kg and current runoff-erosion
  3. Soil P drawdown (no P added if soil P > 50 mg/kg) at current runoff-erosion
  4. Soil P drawdown and annual erosion reduction of 2.5% from previous year

Soil Mehlich 3-P

Agronomic Optimum = 50-75 mg/kg

P Loss with Current Conditions

Soil P	Piedmont			Upper Coastal Plain			Lower Coastal Plain		
	Area	APLE Total P loss	APLE Total P Loss	Area	APLE Total P loss	APLE Total P Loss	Area	APLE Total P loss	APLE Total P Loss
(mg kg^{-1})	ha	(kg ha^{-1})	(Mg)	ha	(kg ha^{-1})	(Mg)	ha	(kg ha^{-1})	(Mg)
Low Runoff and Erosion (4.5 cm, 112 kg/ha; 40% area)									
25-150	83,749	0.23	19.1	63,017	0.22	13.6	17,885	0.20	3.6
150-300	5,748	0.46	2.7	11,996	0.44	5.2	11,129	0.42	4.7
300-450	631	0.72	0.5	1,759	0.67	1.2	6,121	0.65	4.0
450-500	82	0.88	0.1	110	0.82	0.1	1,314	0.79	1.0
>500	156	1.30	0.2	180	1.22	0.2	3,023	1.18	3.6
Medium Runoff and Erosion (6.7 cm, 1344 kg/ha; 55% area)									
25-150	115,155	0.95	109.2	86,648	0.86	74.6	24,592	0.80	19.8
150-300	7,903	1.72	13.6	16,494	1.52	25.1	15,302	1.45	22.2
300-450	868	2.34	2.0	2,419	2.18	5.3	8,417	2.11	17.7
450-500	113	2.74	0.3	152	2.54	0.4	1,806	2.47	4.5
>500	214	3.80	0.8	248	3.57	0.9	4,157	3.48	14.4
High Runoff and Erosion (13.4 cm, 4482 kg/ha; 5% area)									
25-150	10,469	2.22	23.2	7,877	2.02	15.9	2,236	1.88	4.2
150-300	718	4.02	2.9	1,499	3.53	5.3	1,391	3.38	4.7
300-450	79	5.38	0.4	220	4.98	1.1	765	4.80	3.7
450-500	10	6.29	0.1	14	5.79	0.1	164	5.63	0.9
>500	19	8.71	0.2	23	8.14	0.2	378	7.93	3.0
Totals or Averages	225,916	0.78	175.1	192,659	0.77	149.1	98,682	1.13	112.0

Statewide P Loss Simulations

Figure showing Total P Loss (Mg) versus Year Simulated with four series: Current (red solid line), Optimum (green dashed line), Drawdown (blue dotted line), and Drawdown/transport (black solid line). Labels "30 y", "10 y", "42%", and "63%" appear on the chart.