Annual Phosphorus Loss Estimator (APLE) Model Sensitivity Analysis

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July 2015

A Review of Agricultural P-dynamics in the Chesapeake Bay Watershed Model

A Workgroup Report from the Chesapeake Bay Program Scientific and Technical Advisory Committee

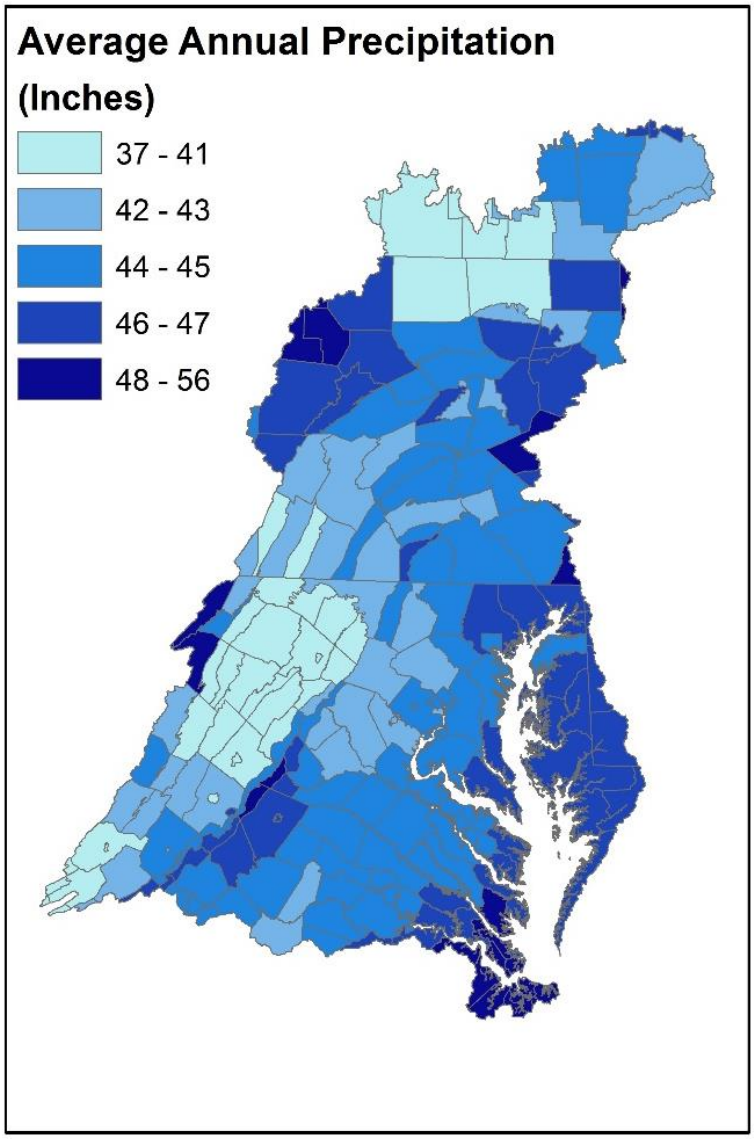
August 2014
STAC Publication 14-005

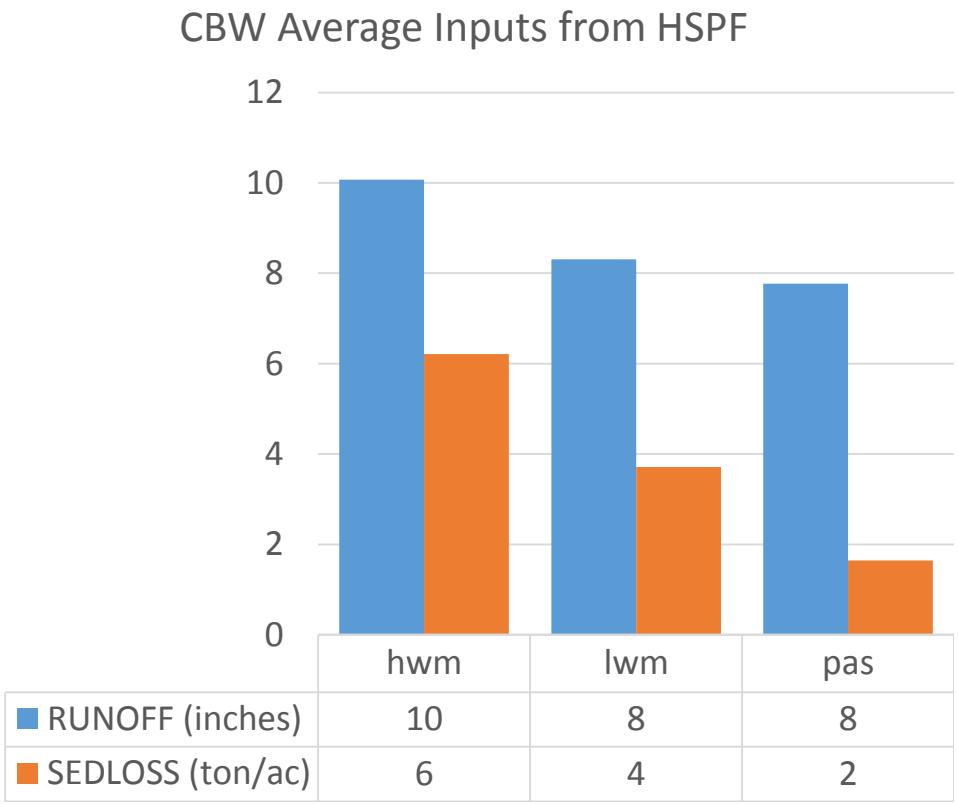
Objectives

- To implement APLE 2.4 in our suite of models
- To estimate APLE model sensitivity to change in phosphorus inputs in the Chesapeake Bay Watershed
- To approve and incorporate phosphorus sensitivities in Phase 6 model

APLE 2.4 Implementation

APLE Average Inputs (1992 - 2005)





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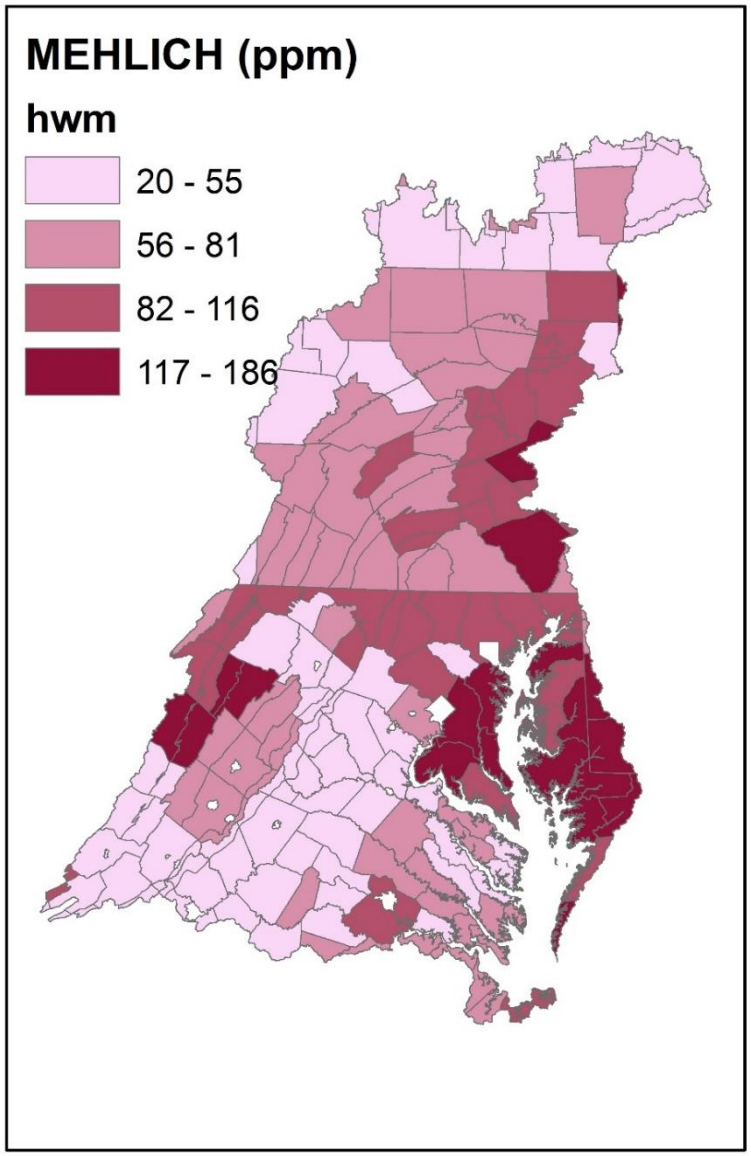
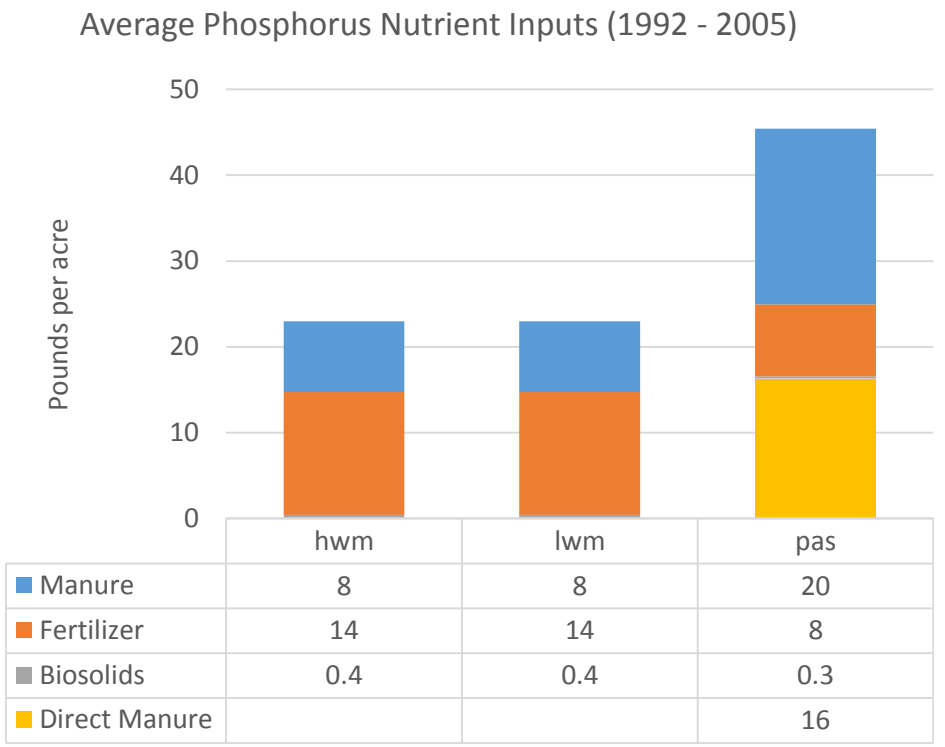
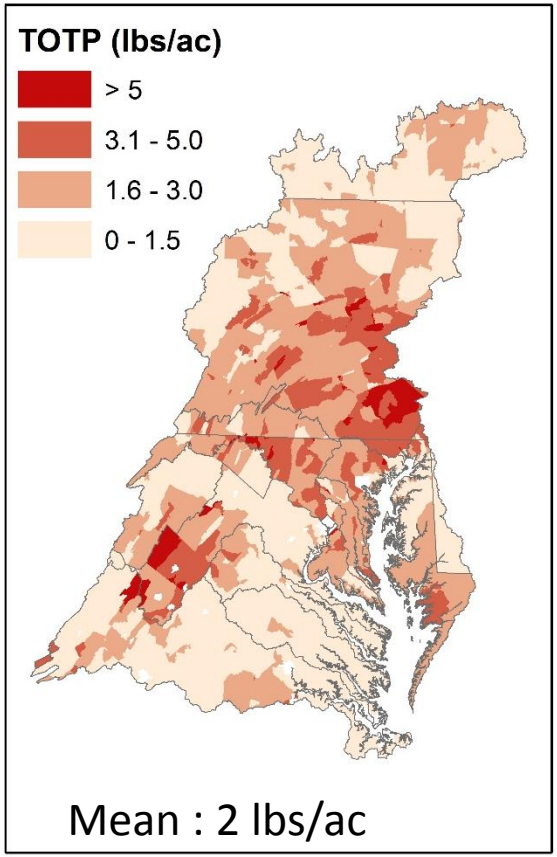




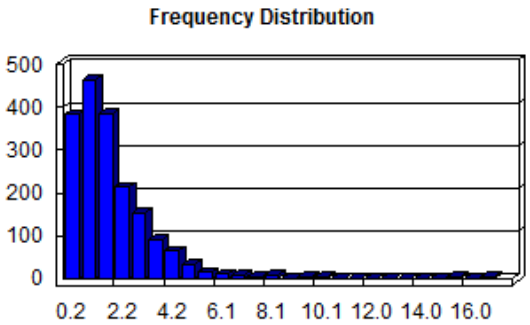
	MEHLICH	CLAY	OM	DEPTH 1	DEPTH 2	% INCORP	% MIXING	DEPTH INCORP
hwm	71	34	2	3	7	75	75	7
lwm	71	34	2	1	7	35	35	4
pas	69	34	2	1	7	0	12	0.5

APLE Average Annual Total Phosphorus Loss(1992 - 2005)

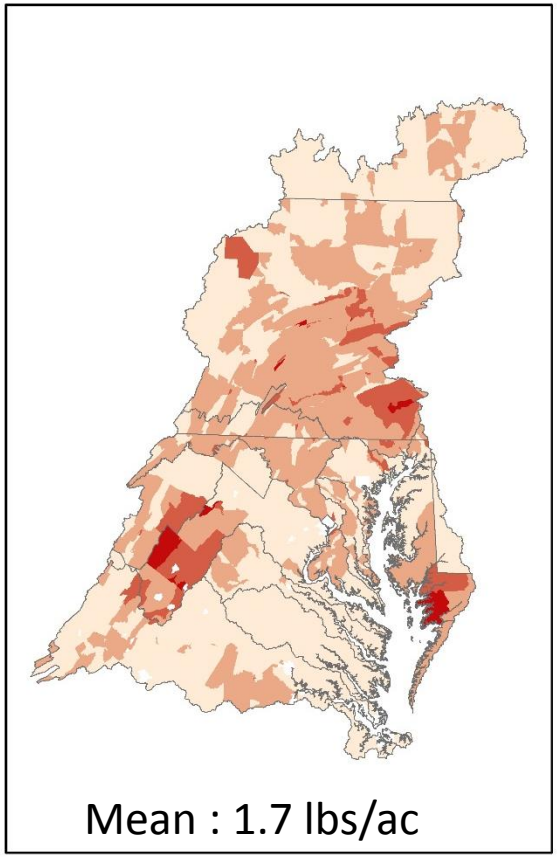
High Till



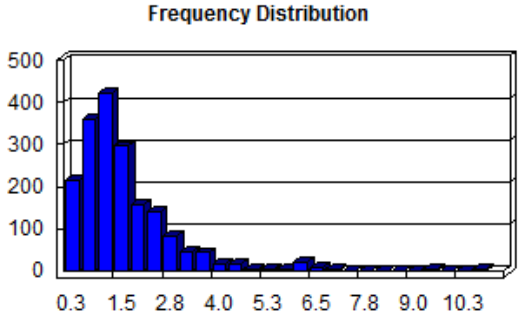
Mean : 2 lbs/ac



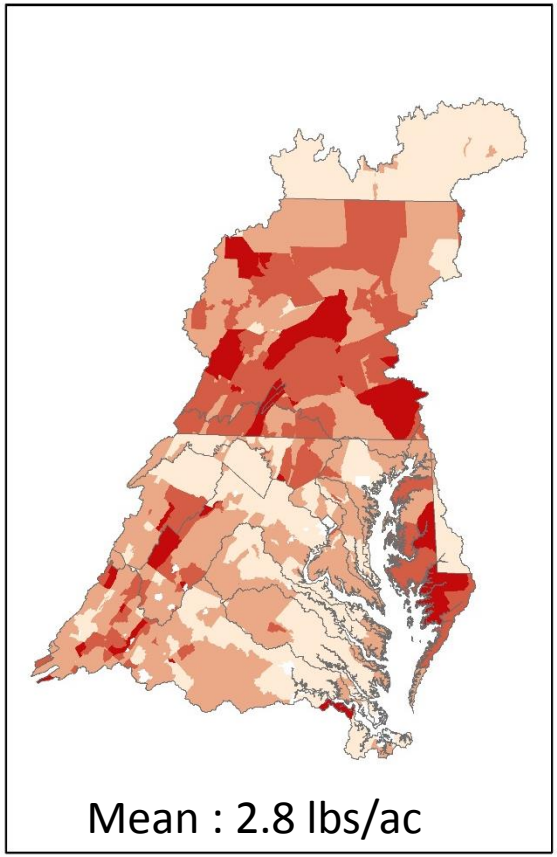
Low Till



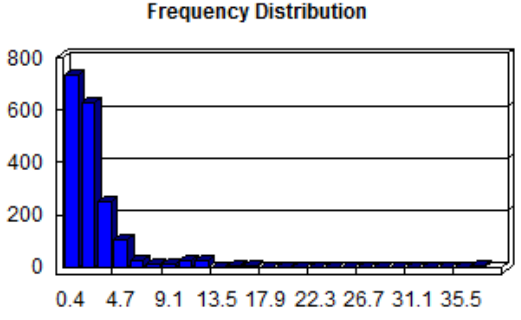
Mean : 1.7 lbs/ac



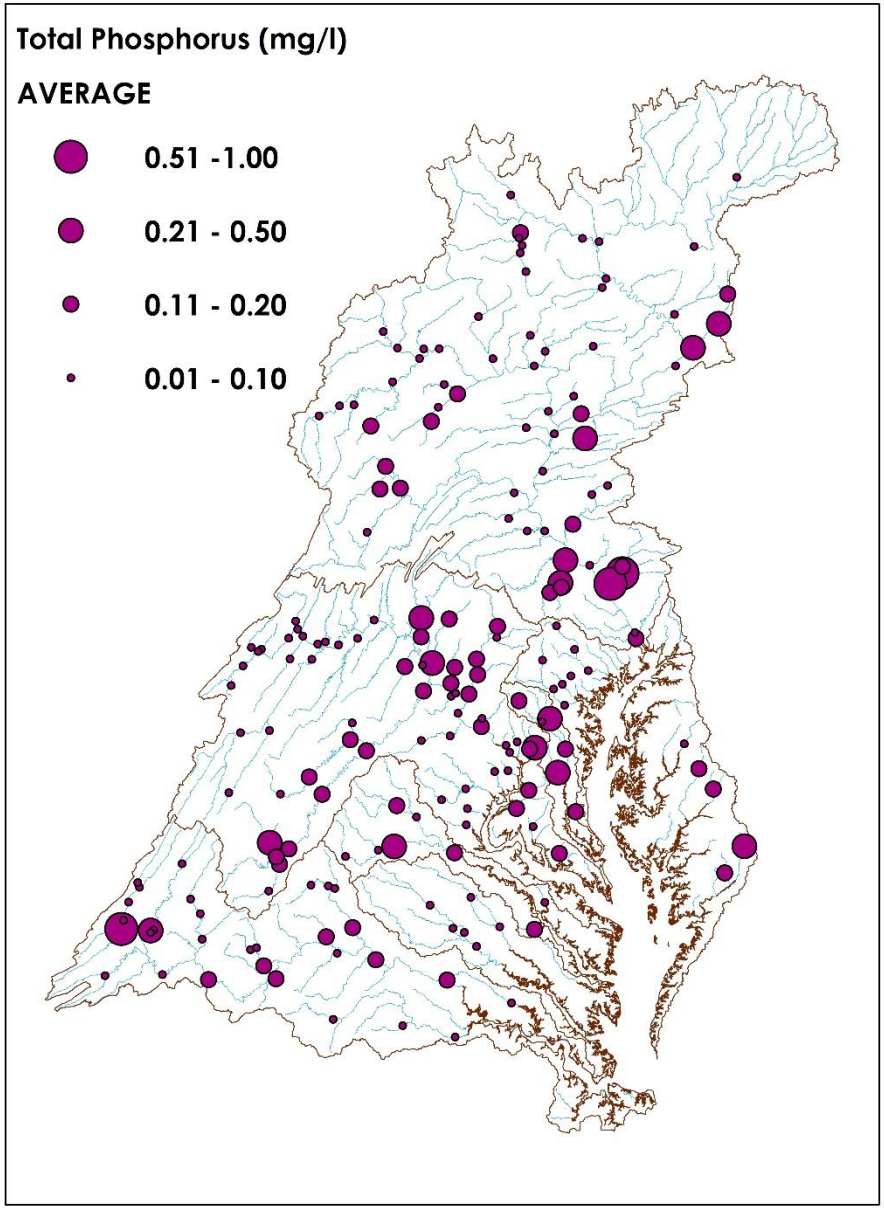
Pasture



Mean : 2.8 lbs/ac

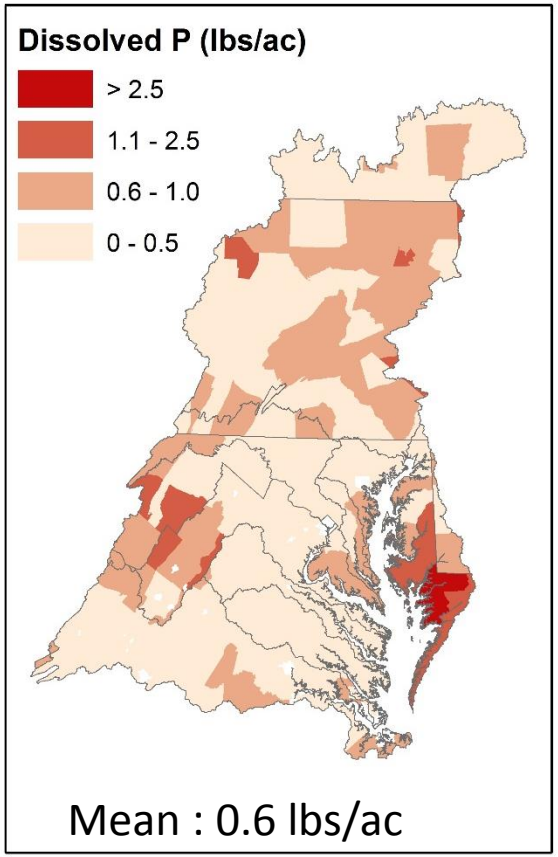


New Observed Water Quailty (1984 - 2013) for the Phase 6 Calibration

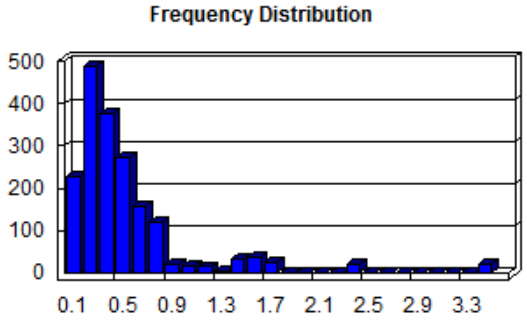


APLE Average Annual Dissolved Phosphorus (1992 - 2005)

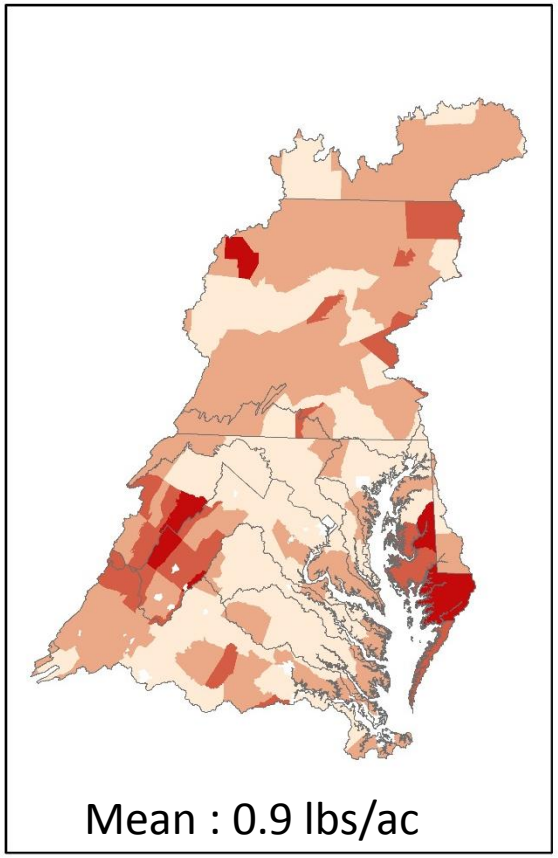
High Till



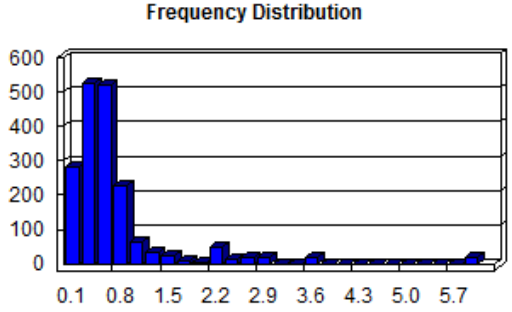
Mean : 0.6 lbs/ac



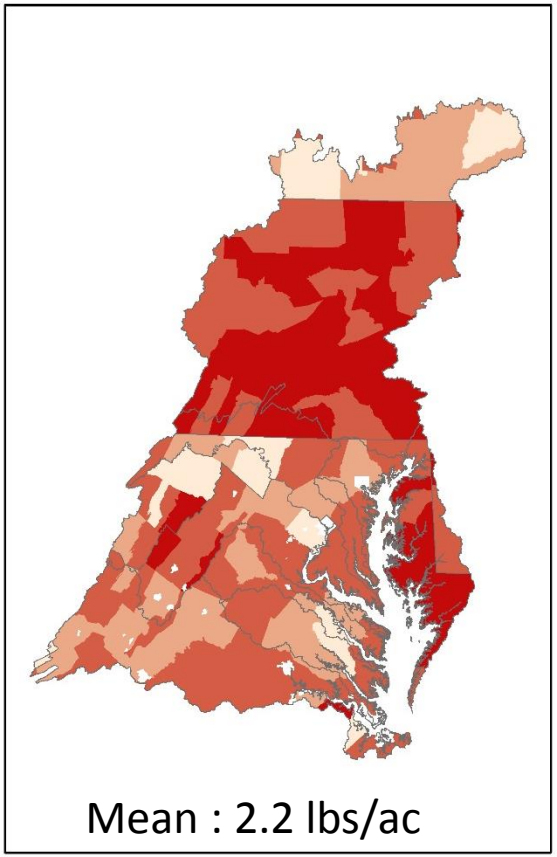
Low Till



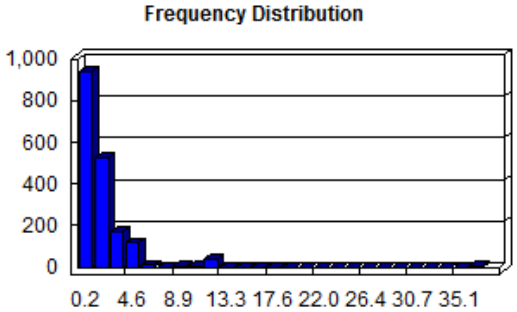
Mean : 0.9 lbs/ac



Pasture

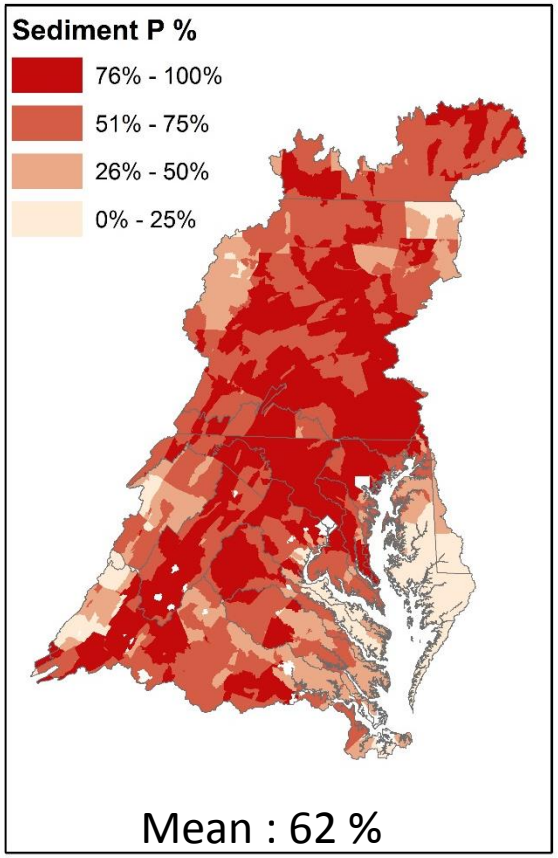


Mean : 2.2 lbs/ac



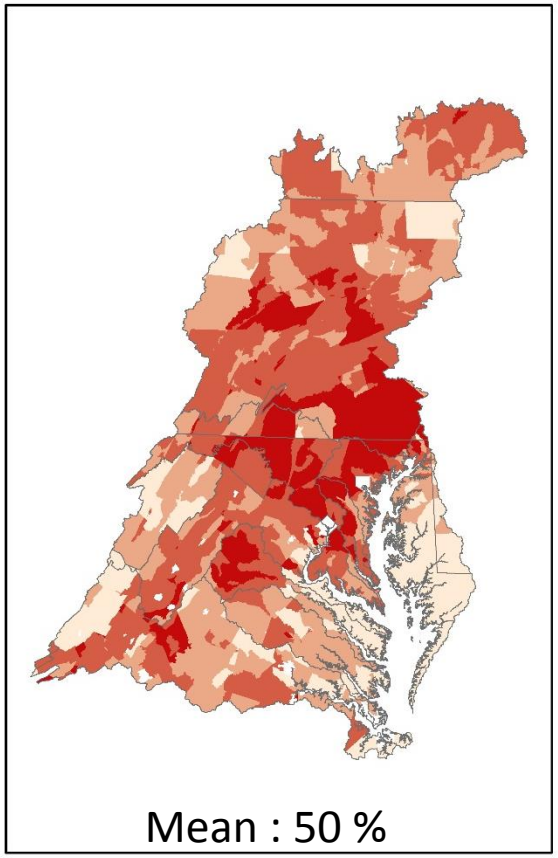
Sediment P Loss percent of Total Loss

High Till



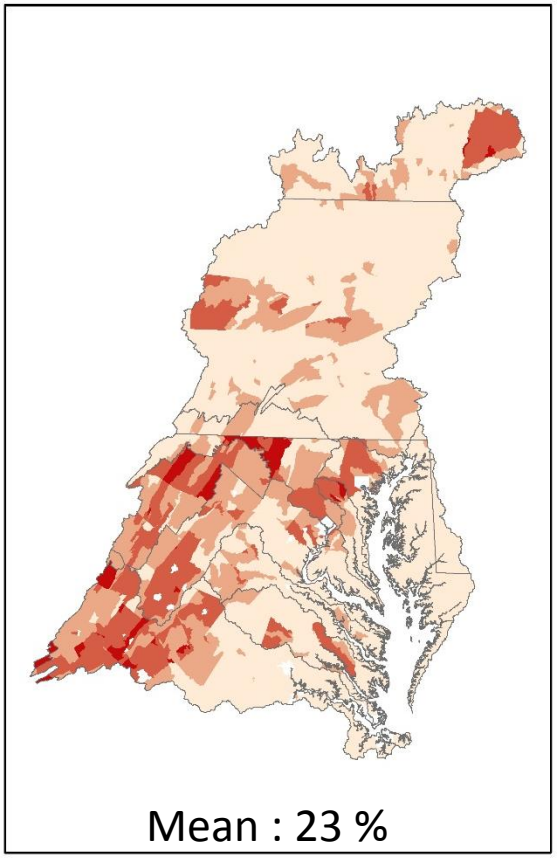
Mean : 62 %

Low Till



Mean : 50 %

Pasture



Mean : 23 %

APLE Summary Output

APLE Output (lbs/ac)	Sediment P Loss	Soil Dissolved P	Manure Dissolved P	Fertilizer Dissolved P	Total Dissolved P	Total P Loss	MEHLICH (ppm)
High till	1.40	0.42	0.13	0.06	0.61	2.02	77
Low till	0.90	0.49	0.28	0.11	0.87	1.77	83
Pasture	0.56	1.26	0.90	0.08	2.26	2.81	128

APLE Model Sensitivity Analysis

APLE Model Sensitivity due to Change in Inputs

- Base scenario 1992-2005
- High till with manure and pasture (2 landuses)
- Fertilizer, Manure, Direct Manure, Uptake, Runoff, Sediment, & Mehlich (7 variables)
- -60%, -30% , +30%, & +60% (4 scenarios)
- All P532 land segments (~300)
- ~15,000 simulations

Relative Sensitivity

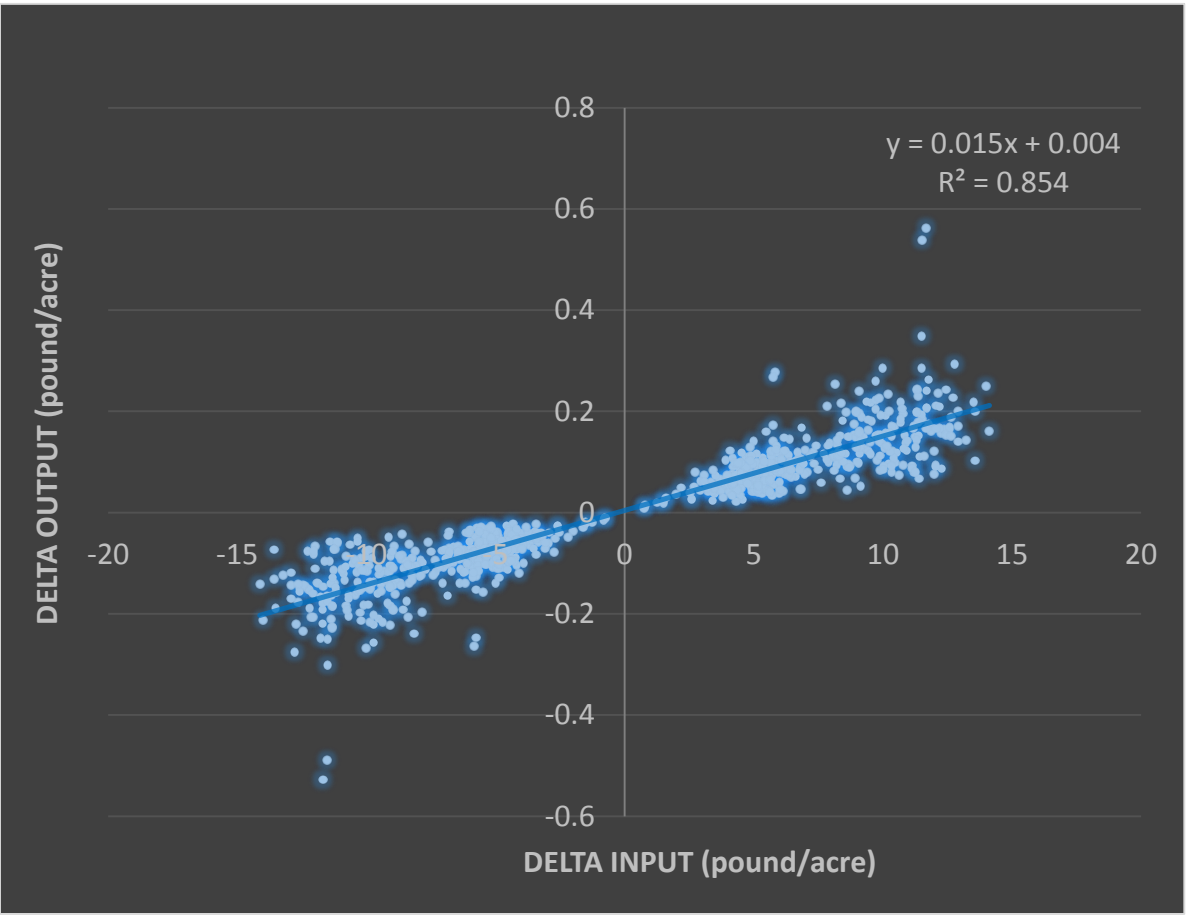
$$S_r = \left(\frac{O - O_b}{I - I_b}\right)\frac{I_b}{O_b}$$

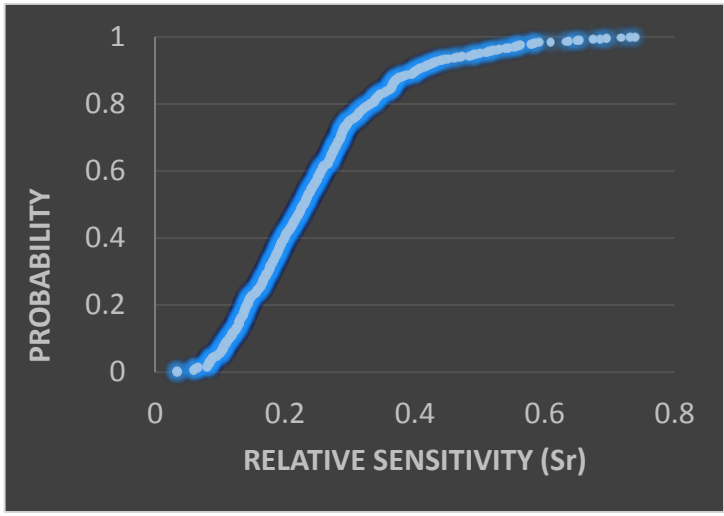
Where:
O = model output
I = model input
b = subscript represents the input and output value of the base scenario

Relative Sensitivity	
Insensitive	$Sr < \lvert 0.01 \rvert$
Slightly sensitive	$\lvert 0.01 \rvert \leq Sr < \lvert 0.10 \rvert$
Moderately sensitive	$\lvert 0.10 \rvert \leq Sr < \lvert 1.00 \rvert$
Sensitive	$\lvert 1.00 \rvert \leq Sr < \lvert 2.00 \rvert$
Extremely sensitive	$Sr \geq \lvert 2.00 \rvert$

Storm,D. ,T. Dillaha, and S. Mostaghimi. 1986. Modeling phosphorus transport in surface runoff. *ASAE* 31(1):117-127.

APLE Sensitivity due to Change in Fertilizer Input – High Till Landuse





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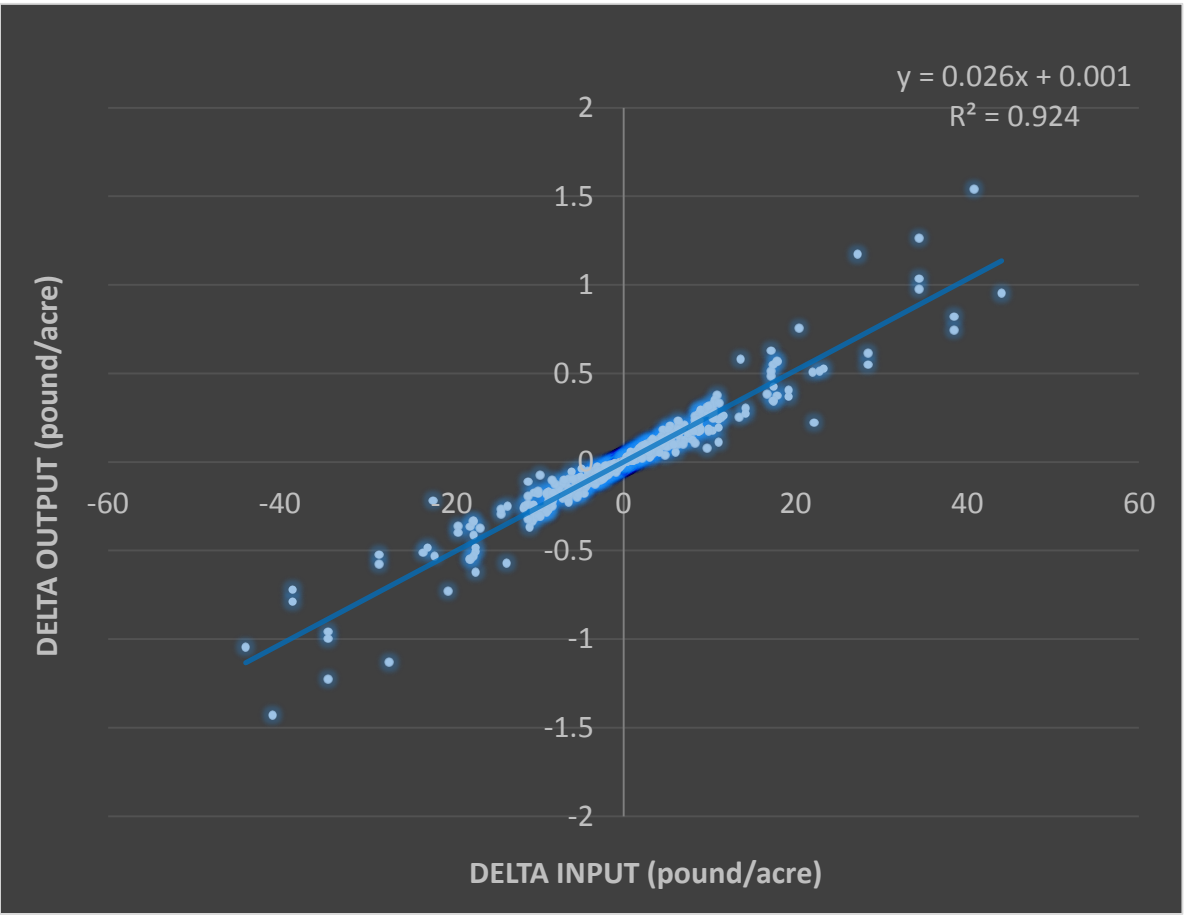

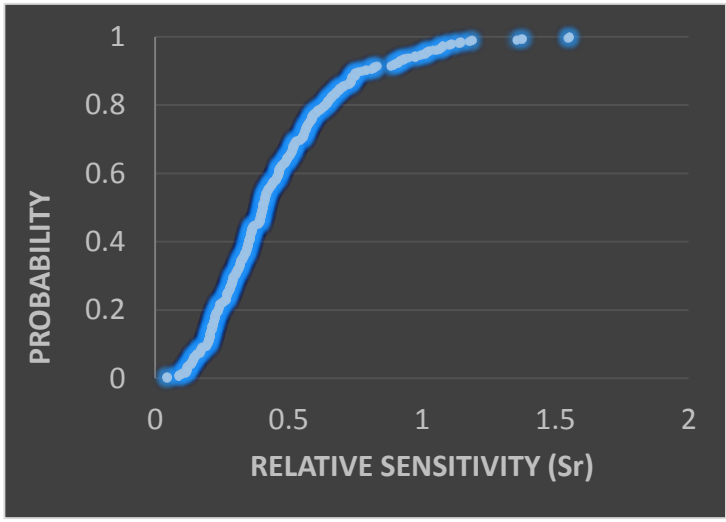

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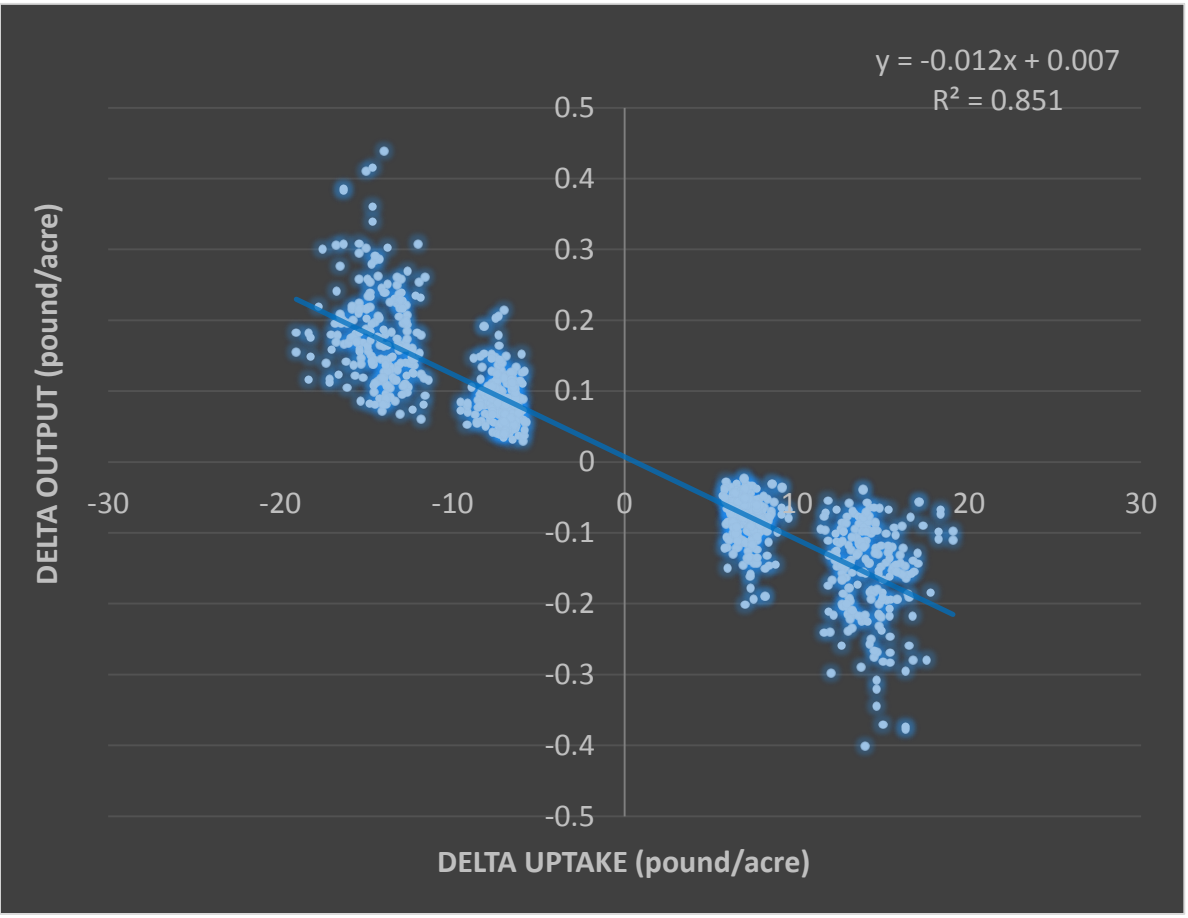
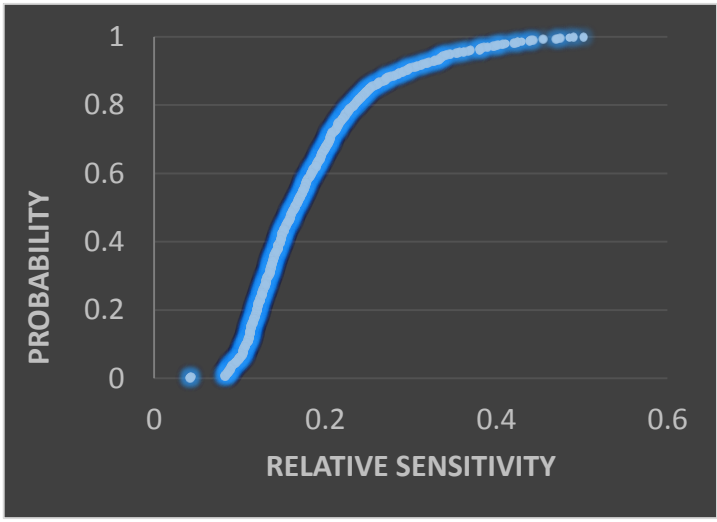
APLE Sensitivity due to Change in Uptake Input – High Till Landuse





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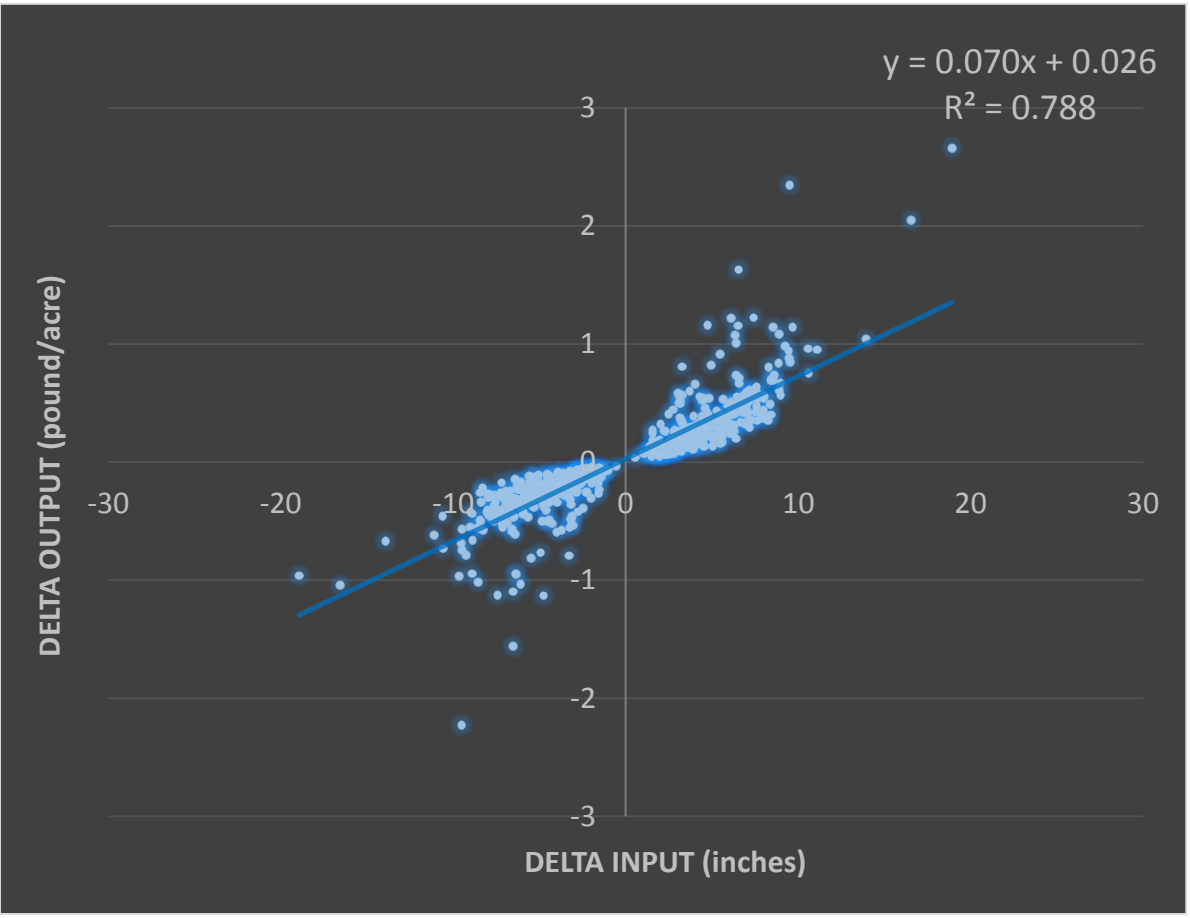
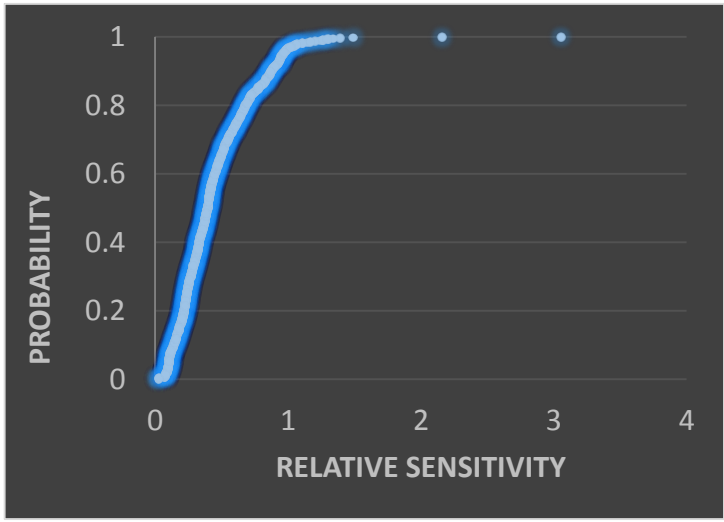
APLE Sensitivity due to Change in Runoff Input – High Till Landuse





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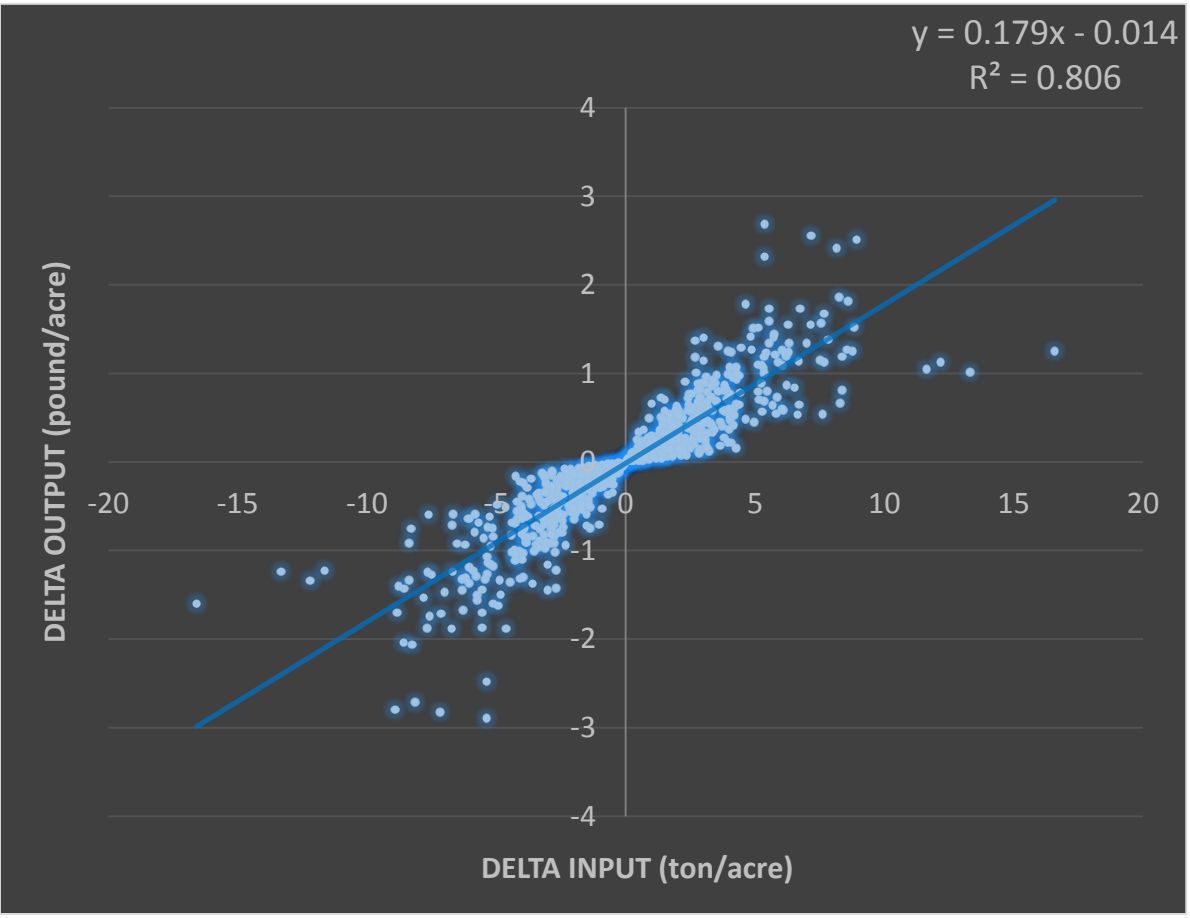
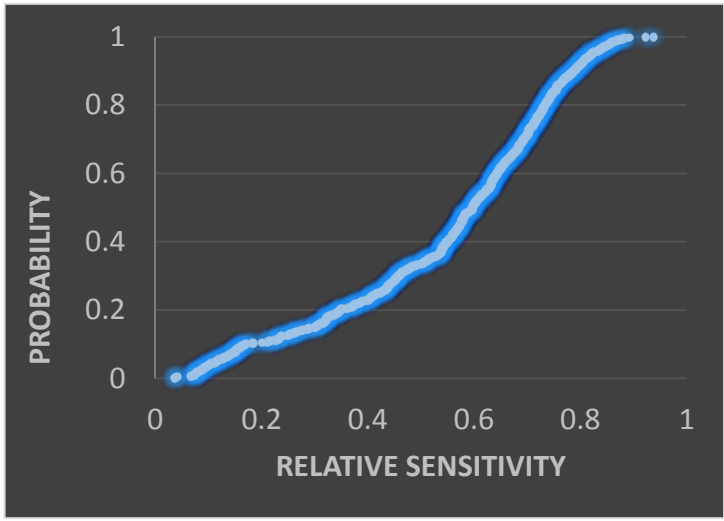
APLE Sensitivity due to Change in Sediment Input – High Till Landuse





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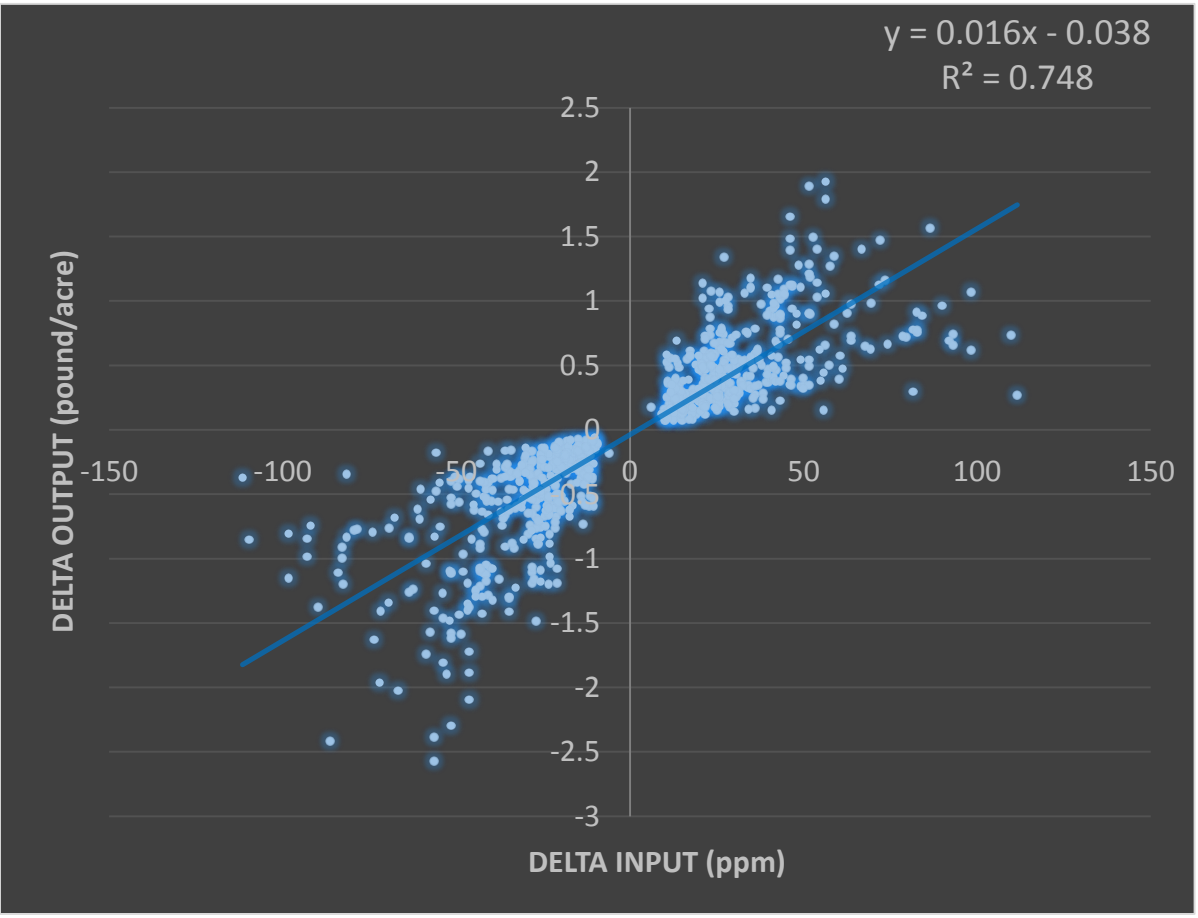
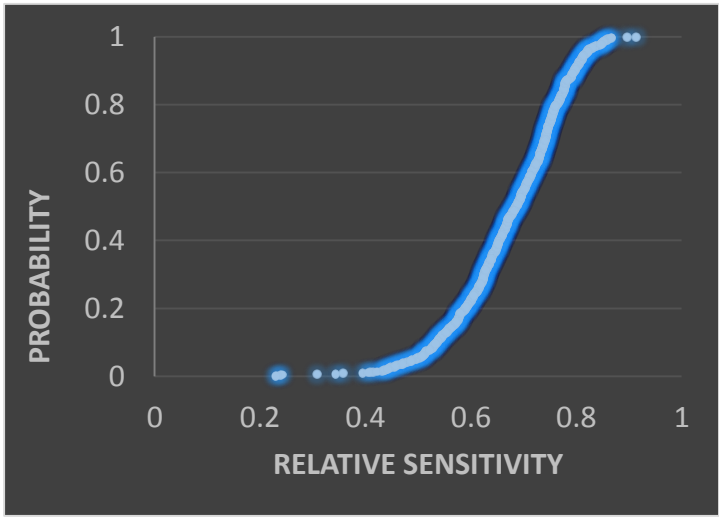
APLE Sensitivity due to Change in Mehlich Input – High Till Landuse





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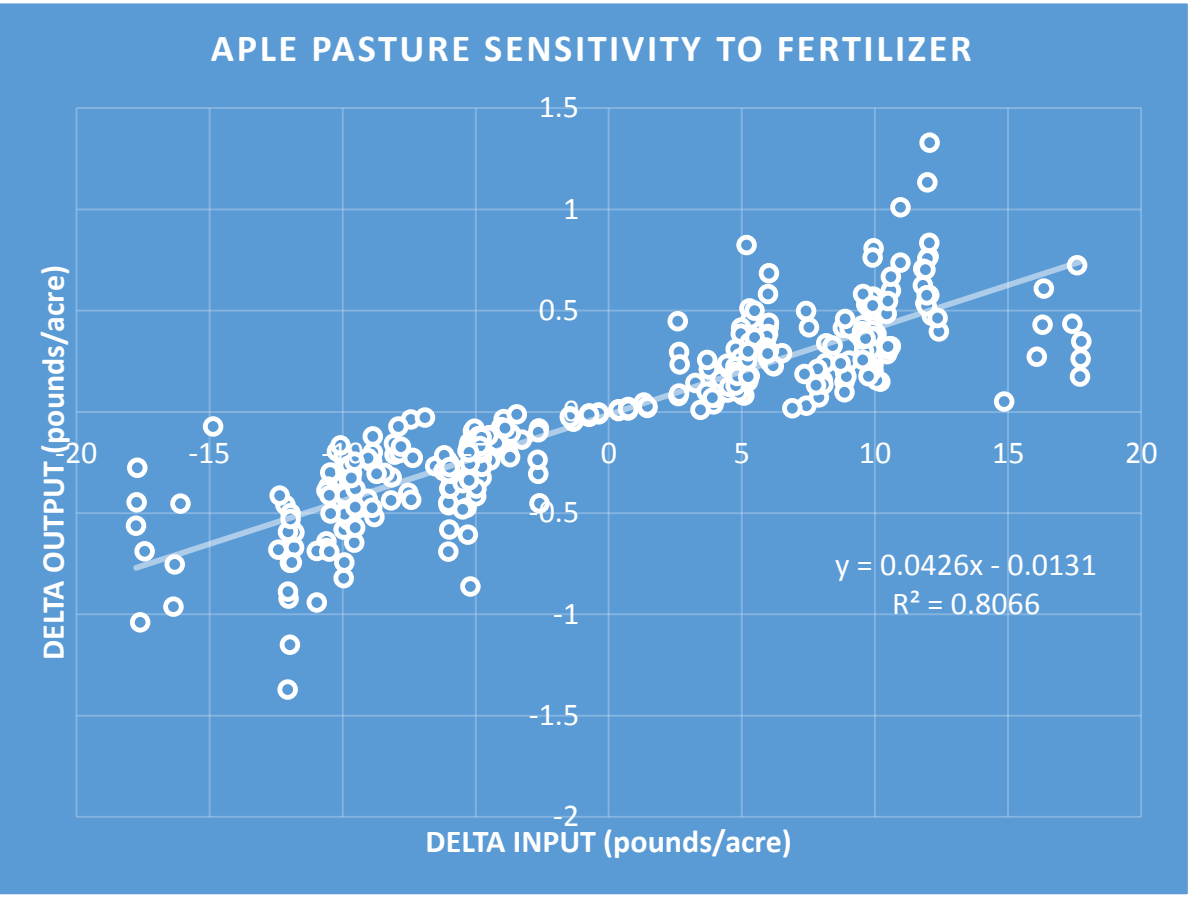
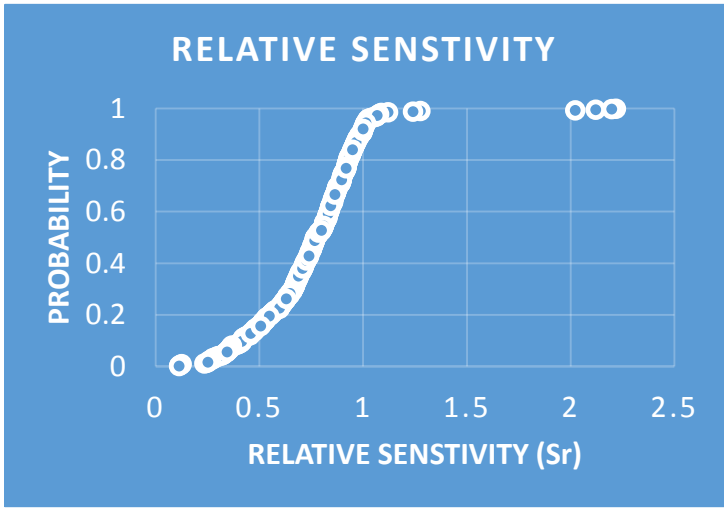
APLE Sensitivity due to Change in Fertilizer Input – Pasture Landuse





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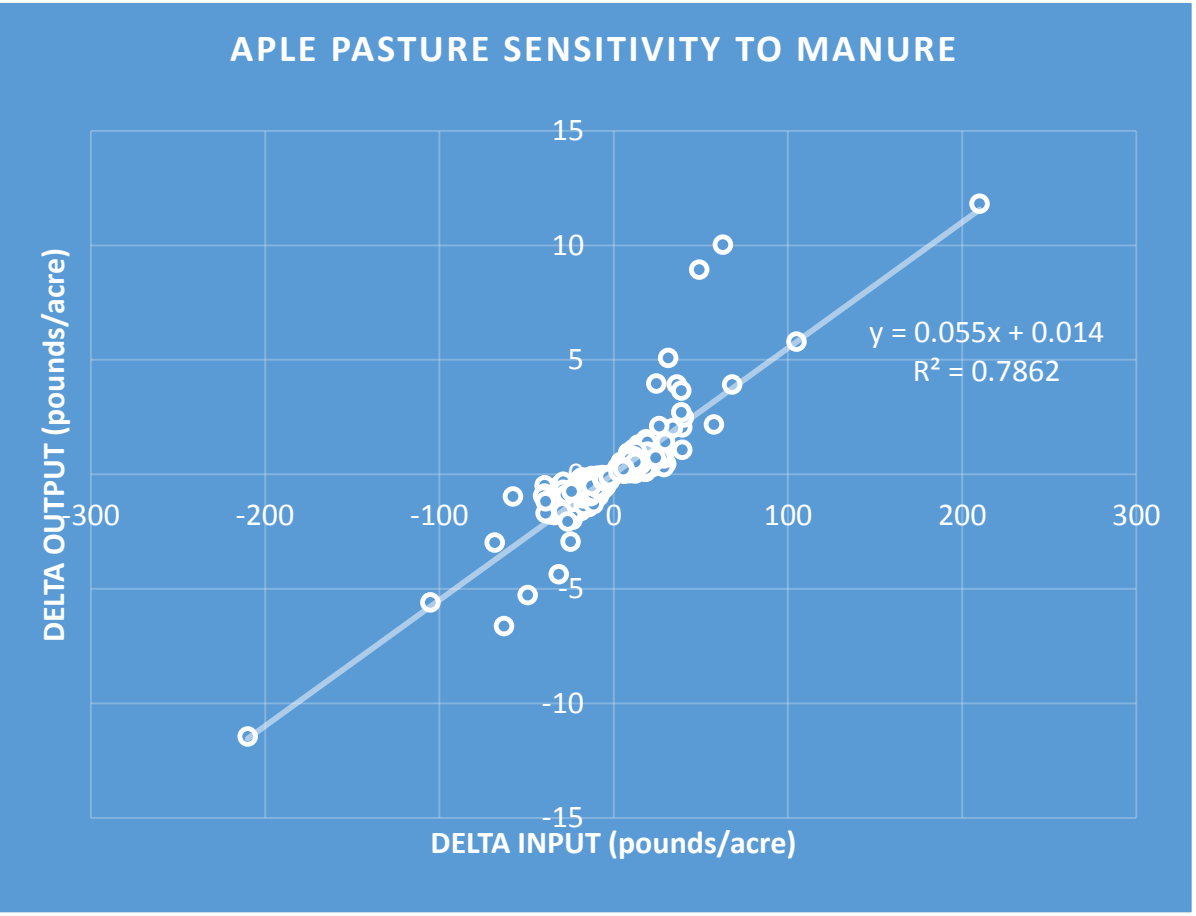

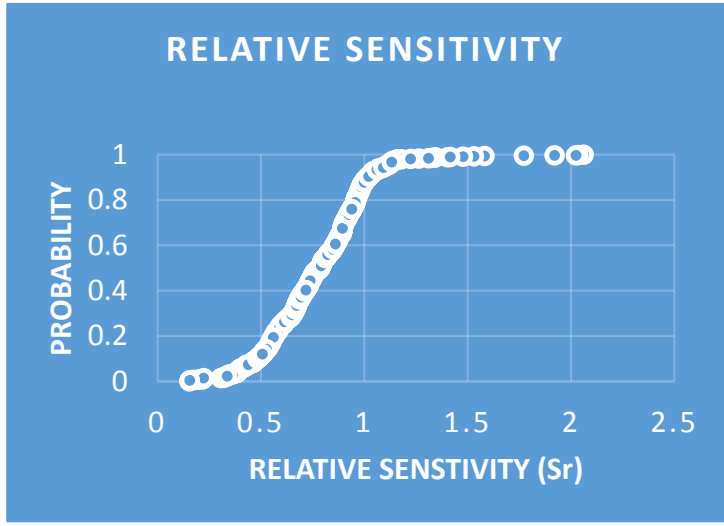

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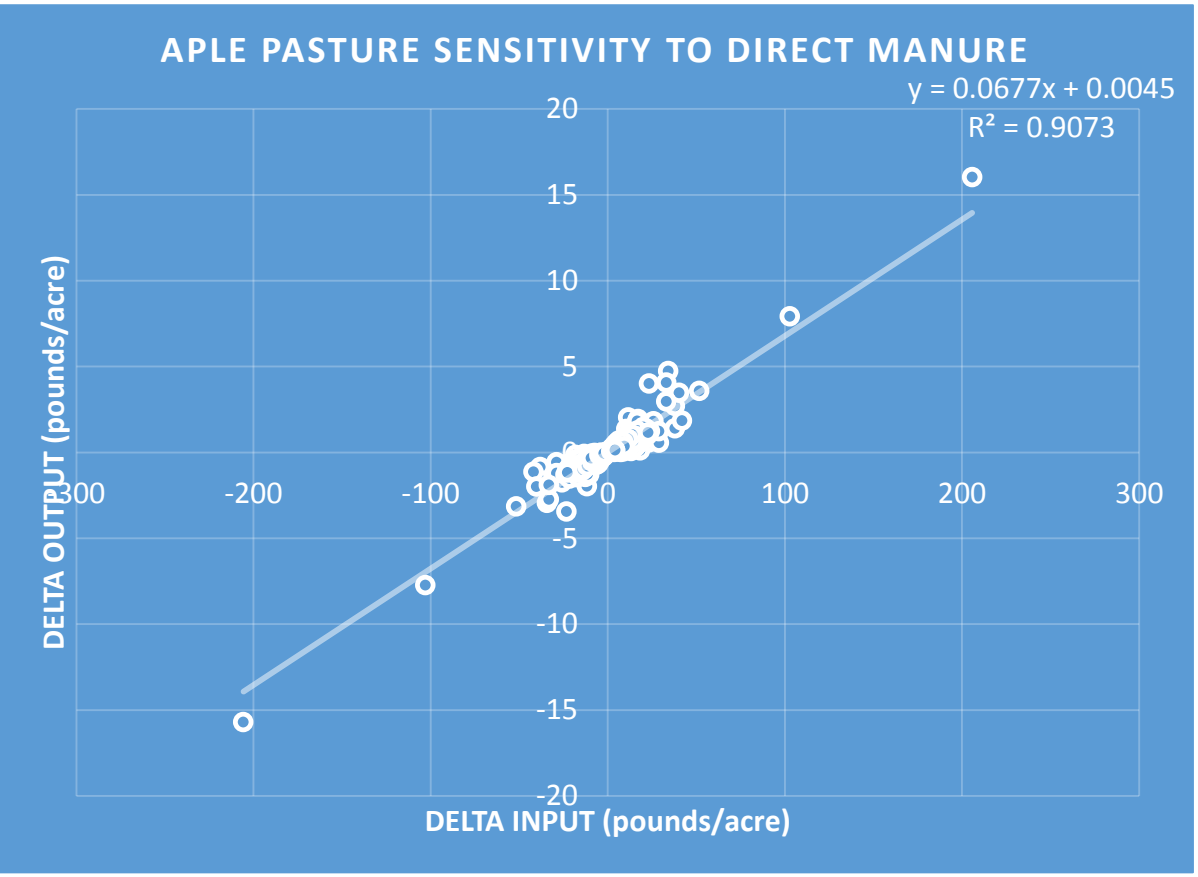
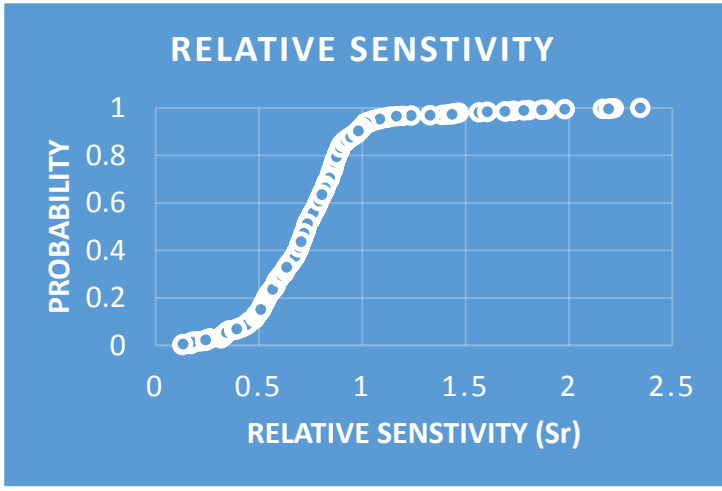
APLE Sensitivity due to Change in Direct Manure Input – Pasture Landuse





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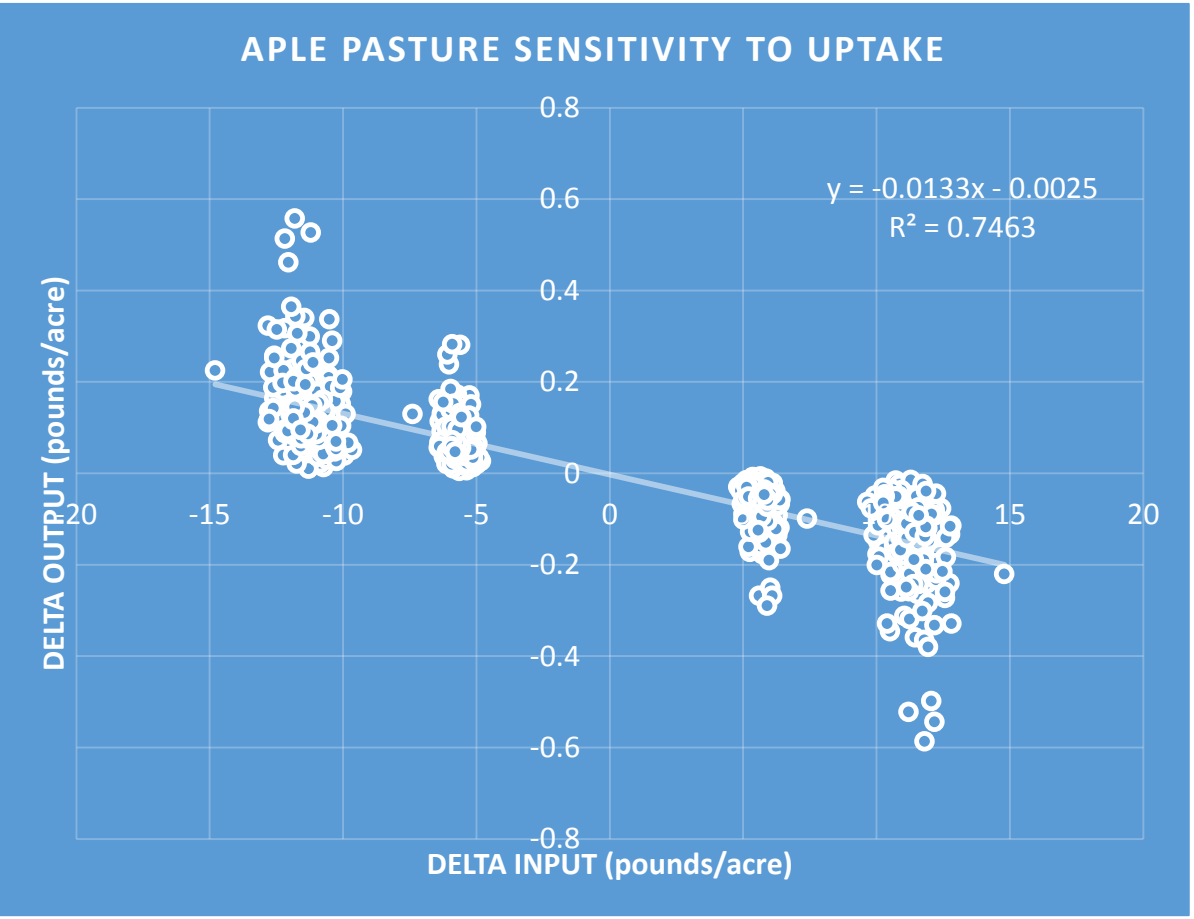
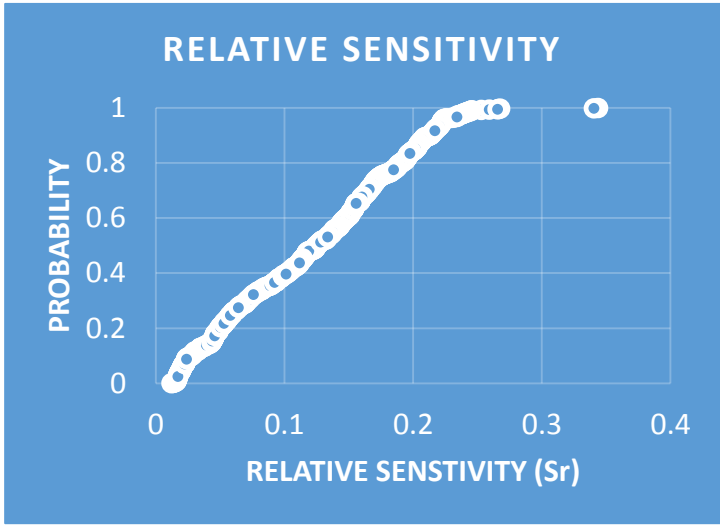
APLE Sensitivity due to Change in Uptake Input – Pasture Landuse





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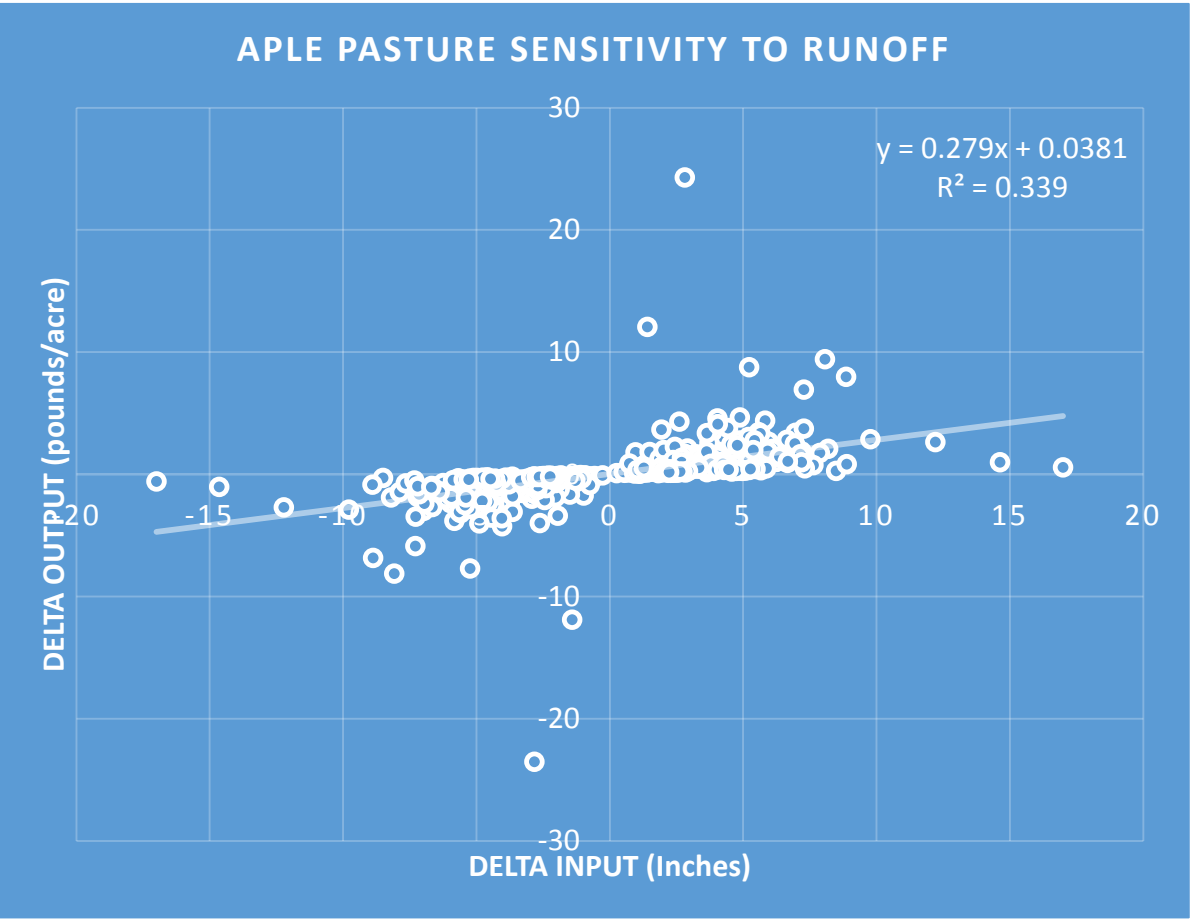
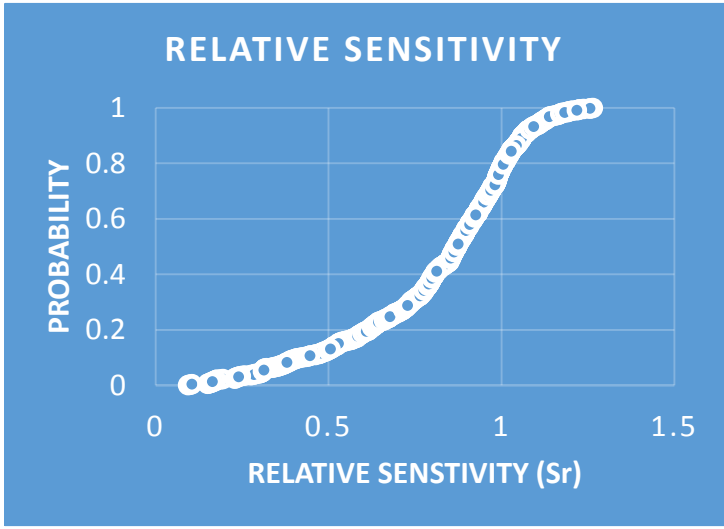
APLE Sensitivity due to Change in Runoff Input – Pasture Landuse





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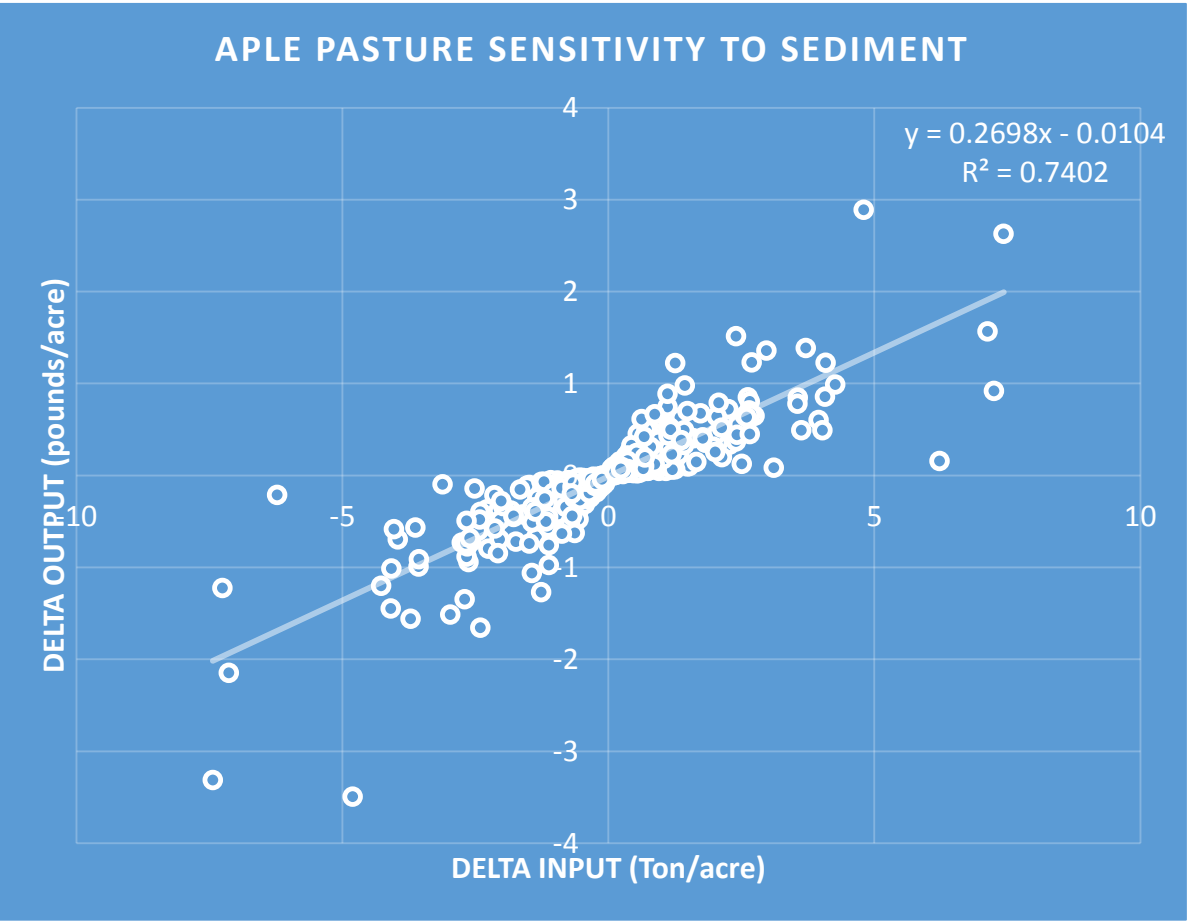

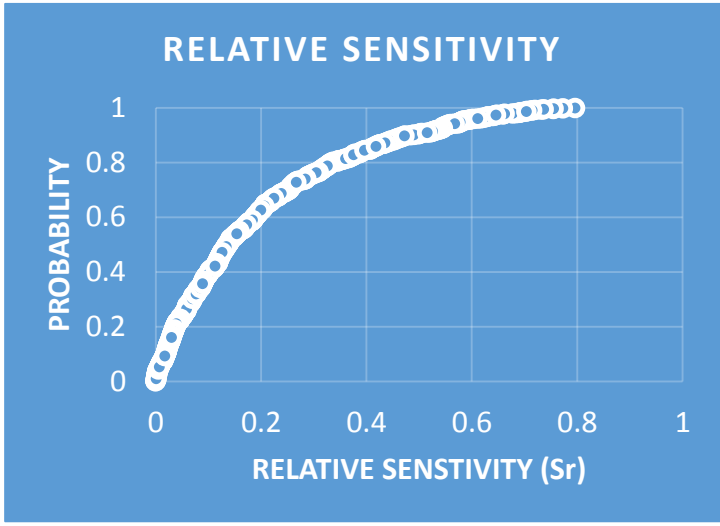

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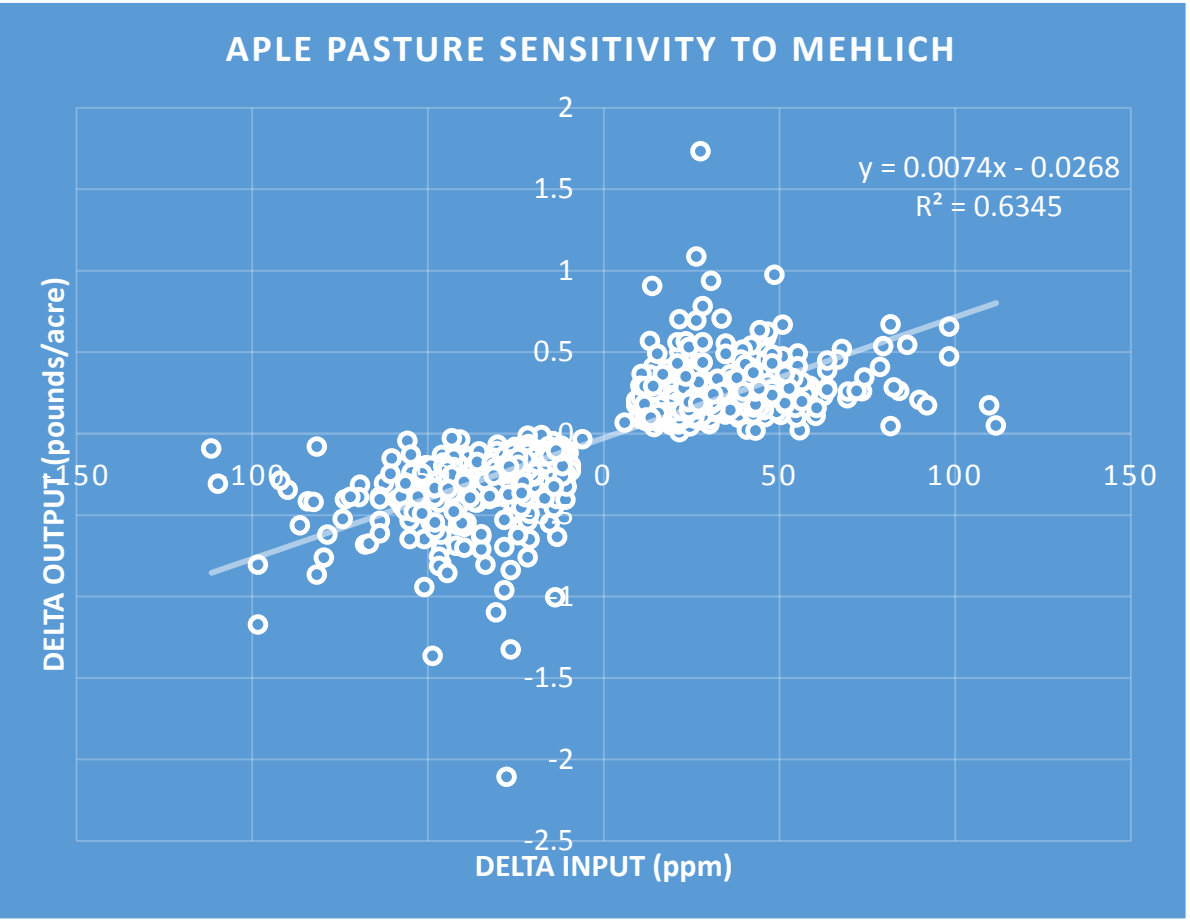
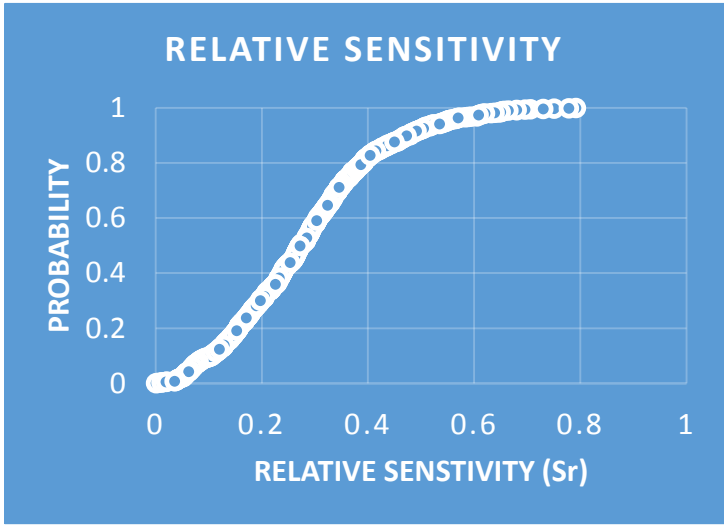
APLE Sensitivity due to Change in Mehlich Input – Pasture Landuse





Relative Sensitivity	
Insensitive	$Sr < \|0.01\|$
Slightly sensitive	$\|0.01\| \leq Sr < \|0.10\|$
Moderately sensitive	$\|0.10\| \leq Sr < \|1.00\|$
Sensitive	$\|1.00\| \leq Sr < \|2.00\|$
Extremely sensitive	$Sr \geq \|2.00\|$

High Till Landuse
APLE Model Sensitivity Analysis

LANDUSE	INPUT	UNITS	CBW SLOPE	CBW R2	MEDIAN SLOPE	AVERAGE R2	MEDIAN SR
high till	mehlich	ppm	0.016	0.748	0.017	0.998	0.700
high till	sediment	ton/ac	0.179	0.806	0.179	1.000	0.625
high till	runoff	inches	0.065	0.760	0.053	0.997	0.361
high till	manure	lbs/acre	0.027	0.910	0.019	1.000	0.290
high till	fertilizer	lbs/acre	0.016	0.854	0.016	0.999	0.237
high till	uptake	lbs/acre	-0.012	0.851	-0.011	0.998	0.173

- APLE is more sensitive to mehlich, sediment, and runoff than to fertilizer and uptake.

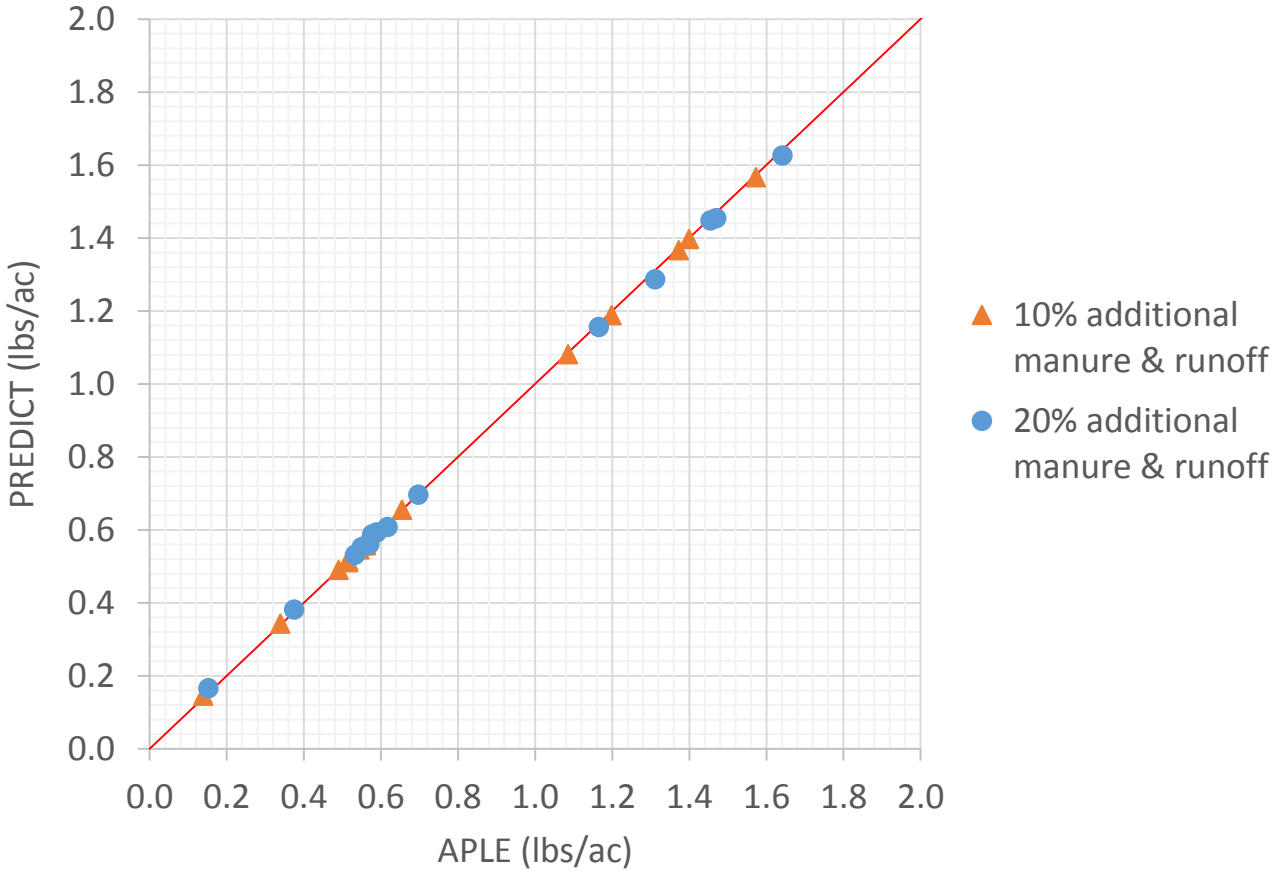
Pasture Landuse
APLE Model Sensitivity Analysis

LANDUSE	INPUT	UNITS	CBW SLOPE	CBW R2	MEDIAN SLOPE	AVERAGE R2	MEDIAN SR
pasture	runoff	inches	0.279	0.339	0.214	0.999	0.871
pasture	manure	lbs/acre	0.055	0.786	0.047	0.997	0.787
pasture	fertilizer	lbs/acre	0.043	0.807	0.040	0.998	0.771
pasture	direct manure	lbs/acre	0.068	0.907	0.041	0.999	0.731
pasture	mehlich	ppm	0.007	0.635	0.008	0.996	0.274
pasture	sediment	ton/ac	0.270	0.740	0.302	0.999	0.137
pasture	uptake	lbs/acre	-0.013	0.746	-0.012	0.999	0.125

- APLE is more sensitive to runoff and fertilizer than to mehlich, sediment and uptake.
- Pasture runoff median slope is approximately 4 times the value of the hightill slope.
- Pasture fertilizer median slope is approximately twice the value of the hightill slope.
- Pasture sediment and uptake median slopes are similar to hightill slopes.
- Pasture mehlich median slope is approximately half the value of the hightill slope.

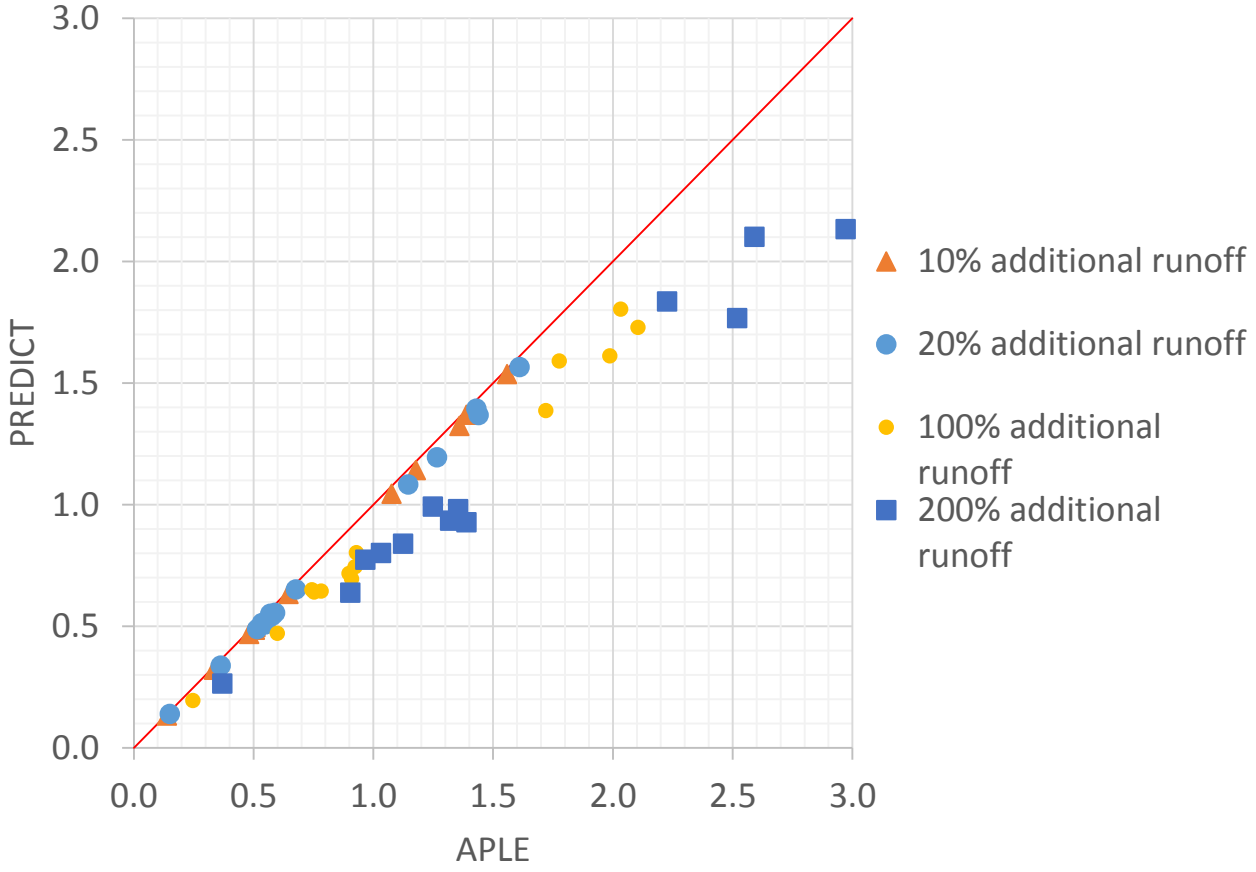
Validation

$$TPloss_{scenario} = TPloss_{base} + (\Delta\, Input_{\text{manure}} \times Sensitivity_{\text{manure}}) + (\Delta\, Input_{\text{runoff}} \times Sensitivity_{\text{runoff}})$$



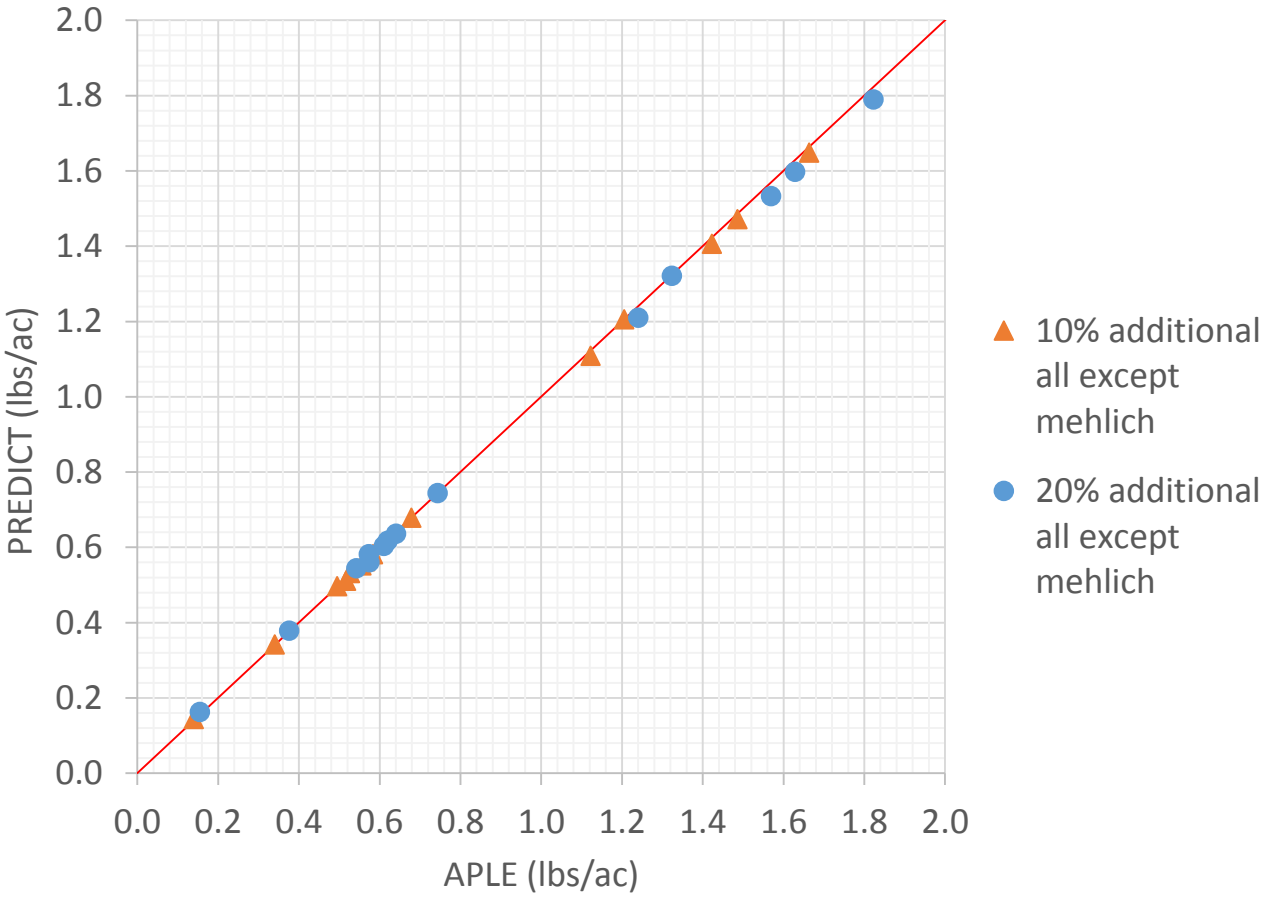
Validation

$$TPloss_{scenario} = TPloss_{base} + (\Delta\, Input_{\text{manure}} \times Sensitivity_{\text{manure}})$$



Validation

$$TPloss_{scenario} = TPloss_{base} + (\Delta\, Input_1 \times Sensitivity_1) + (\Delta\, Input_2 \times Sensitivity_2) + \ldots + (\Delta\, Input_n \times Sensitivity_n)$$



Next

- Phosphorus sensitivities are provisional.
- Prototype needs approval.
- Extend the simulation period.