Evaluation of the Kentucky phosphorus index and potential ways to improve it.

Carl H. Bolster

USDA-ARS

Animal Waste Management Research Unit

Bowling Green, KY

Agricultural Research Service

- In-house research arm of the USDA
- Solve problems related to agriculture that are important to the American public or "stakeholder"
- ARS is organized into National Programs including:
  - Nutrition, Food Safety & Quality
  - Animal Production & Protection
  - Crop Production & Protection
  - Natural Resources and Sustainable Agricultural Systems
    - Agricultural and Industrial Byproducts (NP 214)

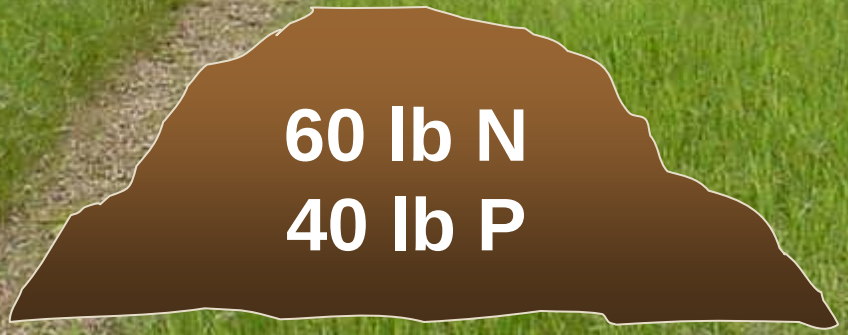
Animal Waste Management Research Unit

- Manage animal manure to the benefit of agriculture while minimizing its negative impacts
- Develop and evaluate waste management practices and treatment technologies to:
  - Protect water quality
  - Improve crop yields
  - Reduce air emissions
  - Control pathogens

Environmental Significance of P

- In freshwater systems P is usually the limiting nutrient
  - Increase in P can result in harmful algal blooms which can affect water quality
- Kentucky is 1 of 9 states with > 500 nutrient-related listings on the 303(d) list
- Runoff from agricultural fields can be a significant source of P loading
- Manure applications are of big concern

Litter vs. Forages: nutrient ratios that don't match



1 ton of litter

1 ton of bermudagrass hay

Response to P loading

- NRCS revised its 590 Nutrient Management Conservation Standard to include P-based planning strategies (1999)
  - Goal was to reduce P inputs from non-point sources
  - States could choose between three methods for assessing a field's vulnerability to P loss
    - Agronomic soil test P
    - Environmental threshold soil test P
    - P index (47 states have adopted P index)
    - KY adopted P index and environmental threshold STP

What is a P index?

- Very simple matrix (model) used to evaluate the risk of P loss from an agricultural field
- Each factor is weighted based on the perceived importance of that characteristic on P loss
- Each factor is assigned a rating value representing low to high (or very high) risk of P loss

KY P Index

Field Feature	Weight	Low (1 point)	Medium (2 points)	High (4 points)	Very High (8 points)	
Hydrologic soil group	1	A	B	C	D	4
STP level (lb/acre)	3	400-500	501-800	801-1066	> 1066	6
Field slope (%)	1	< 2	2 – 5	6 – 12	> 12	4
Land cover (%)	3	60 – 90	30 – 60	15 – 30	0 – 15	12
Vegetative buffer width (ft)	3	> 29	20 – 29	10 – 19	< 10	24
Impaired watershed?	1	NO			YES	8
Application timing	3	June – Sept.	A, M, O; Mar, N w/winter cover	Mar, Nov	Dec., Jan., Feb.	12
Application method	3	Injected	Incorporated within 48 hr.	Incorporated within 1 mo.	Unincorporated for > 1 mo	6
Distance	2	Over 150 ft	50 – 100	0 – 50	Adjacent	4
Location	1	BG region	All other			2
Index value						82

Interpretation of P Index

Index Value	Risk of P movement from field	Manure application
< 30	LOW	Crop needs for N
30 - 60	MEDIUM	Crop needs for N
61 - 112	HIGH	Crop removal for P
> 112	VERY HIGH	No P application

KY P Index

Field Feature	Weight	Low (1 point)	Medium (2 points)	High (4 points)	Very High (8 points)	
Hydrologic soil group	1	A	B	C	D	4
STP level (lb/acre)	3	400-500	501-800	801-1066	> 1066	6
Field slope (%)	1	< 2	2 – 5	6 – 12	> 12	4
Land cover (%)	3	60 – 90	30 – 60	15 – 30	0 – 15	12
Vegetative buffer width (ft)	3	> 29	20 – 29	10 – 19	< 10	3
Impaired watershed?	1	NO			YES	8
Application timing	3	June – Sept.	A, M, O; Mar, N w/winter cover	Mar, Nov	Dec., Jan., Feb.	12
Application method	3	Injected	Incorporated within 48 hr.	Incorporated within 1 mo.	Unincorporated for > 1 mo	3
Distance	2	Over 150 ft	50 – 100	0 – 50	Adjacent	4
Location	1	BG region	All other			2
Index value						58

Interpretation of P Index

Index Value	Risk of P movement from field	Manure application
< 30	LOW	Crop needs for N
30 - 60	MEDIUM	Crop needs for N
61 - 112	HIGH	Crop removal for P
> 112	VERY HIGH	No P application

Concerns with P Indices

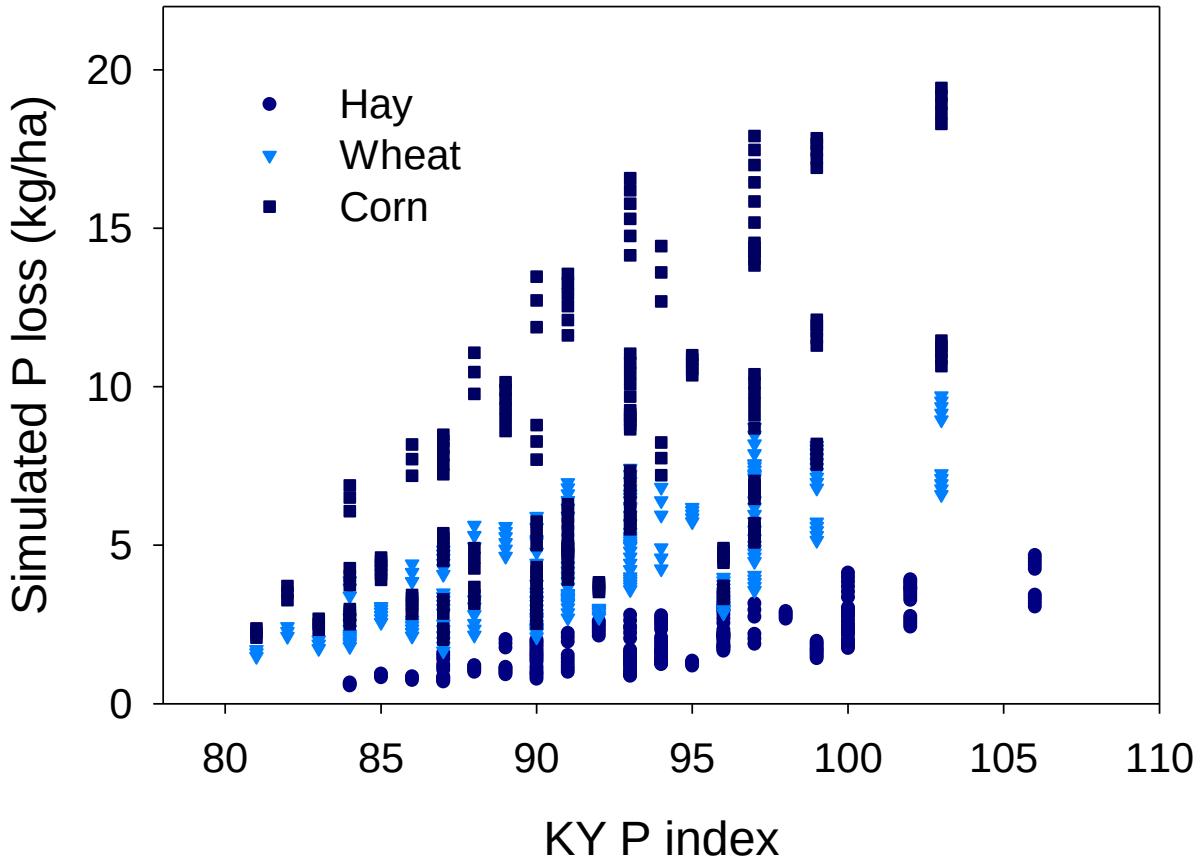
- P concentration in many water bodies has not decreased since use of the P index
- Increased soil test P levels in many fields (well above agronomic recommendations)
- Many P indices have been developed based on professional judgment rather than scientific data
- Large amount of diversity in P indices among the states
- Push from many to reevaluate the entire P index approach $\Rightarrow$ STP alone
- Criticism of P index approach has led NRCS to revise its 590 Standard
  - One requirement is that each state test the accuracy of their P index

How to Evaluate and/or Improve a P Index

- Ideally, a P index should be evaluated and/or updated using measured P loss data
  - However, very few data sets exist: Cost and time prohibitive.
- Alternatively: compare P index output with output from process-based P loss models.
  - Advantage – not data limited, can test a wide range of conditions.
  - Disadvantage – model must be a realistic representation of the processes governing P loss in the region of interest.

Evaluating the KY P Index

Correlations between APLE P loss and KY PI



r_{hay} = 0.78

r_{wheat} = 0.74

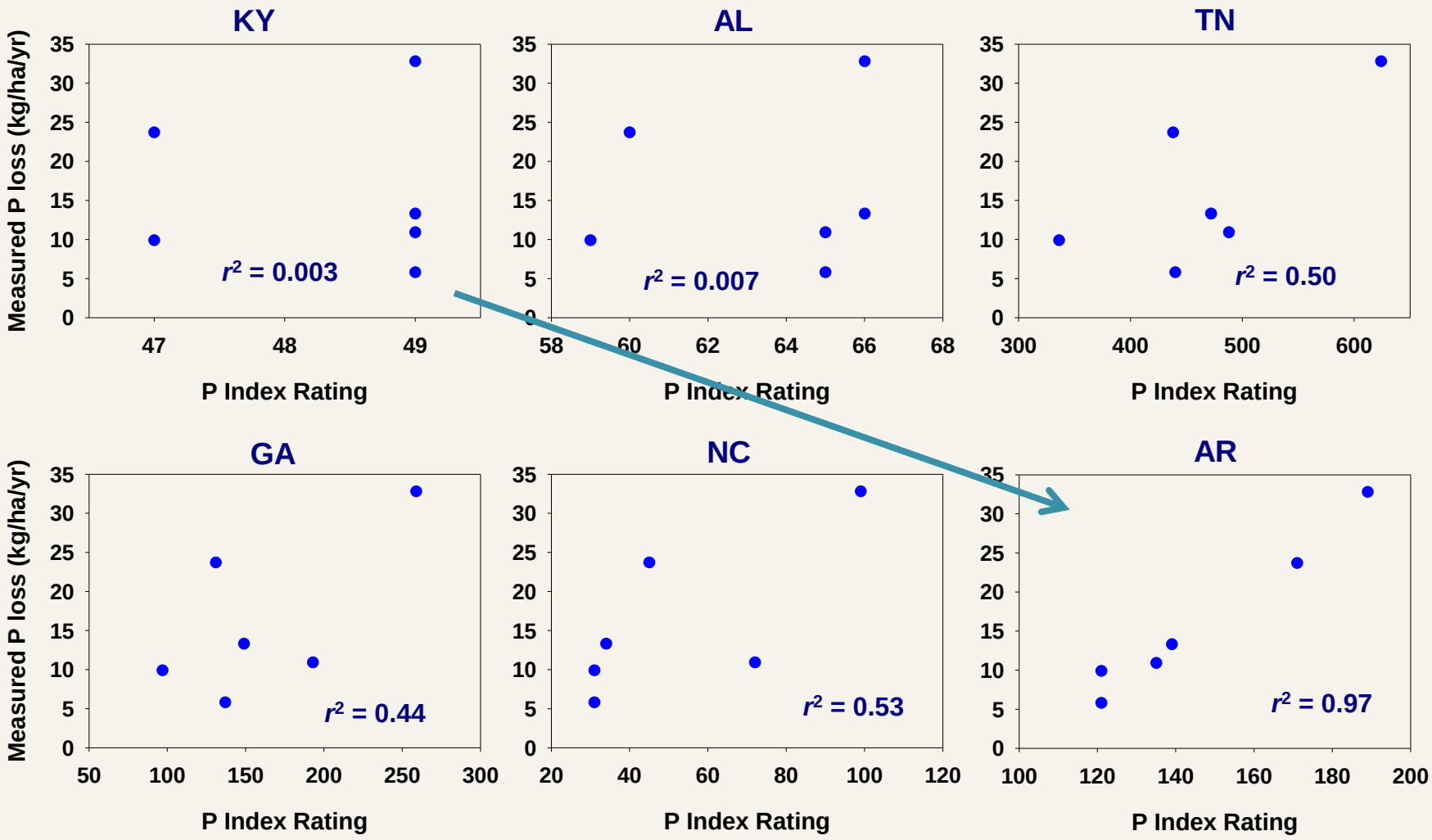
r_{corn} = 0.62

$r_{overall}$ = 0.29

Bolster, C.H. 2011. A critical evaluation of the Kentucky Phosphorus Index. Journal of the KY Academy of Sciences. 72:46-58.

Evaluating KY P index against measured P loss data collected in GA and NC

Correlations between KY PI and measured P loss data collected in GA and NC



Osmond et al. In Review. Comparing Southern Phosphorus Indices to Runoff Data. Journal of Environmental Quality.

Using Results from P loss Model to Improve Index Weighting: Example using the Pennsylvania PI

Well established PI which has been used by many states in the development of their PIs

Pennsylvania PI

$$PA\text{-}MI = (0.2 \cdot STP + MP \cdot AP_m + FP \cdot AP_f) * (SED+RO)$$

Source Factors:
STP – soil test P
MP – manure applied P
AP_m – manure application factor
FP – fertilizer P
AP_f – fertilizer application factor

Transport factors:
SED – erosion rate
RO – runoff potential

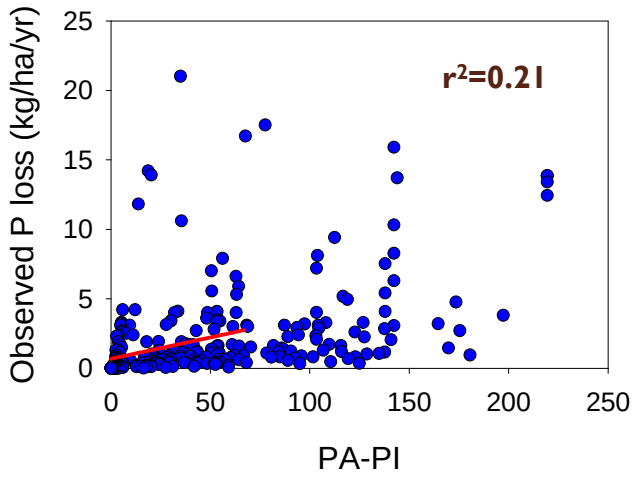
Modifying weights

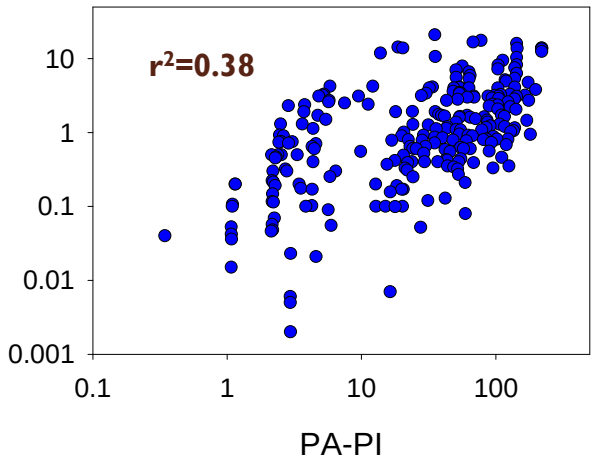
$$\text{PA-MI} = (W_1 \cdot \text{STP} + W_2 \cdot \text{MP} \cdot \text{Ap}_m + W_3 \cdot \text{FP} \cdot \text{AP}_f) * (W_4 \cdot \text{SED} + \text{RO})$$

Results from fitting model-generated data

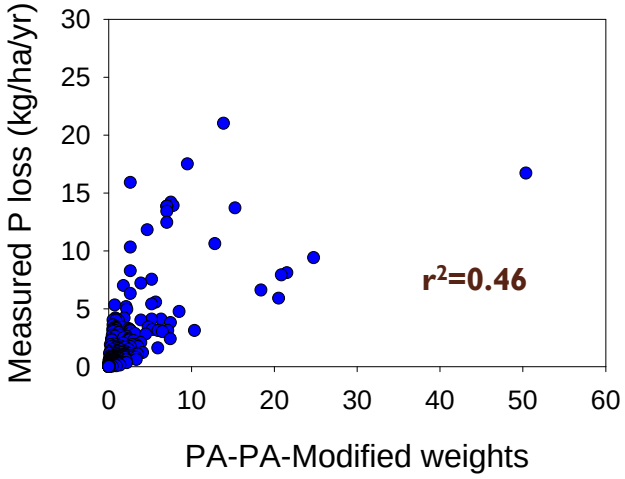
	PA PI	PA PI-MI
STP (W_1)	0.2	2.3e-2
Manure P (W_2)	1	2.2e-2
Fertilizer P (W_3)	1	4.9e-3
Erosion (W_4)	1	9.6e-2

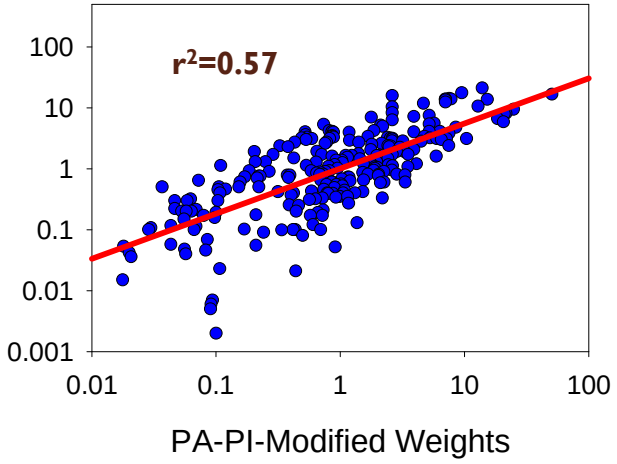
Original PA P Index





P Index with fitted weights





Comer: Regulators affecting farms

Bowling Green Daily News 4/1/2012

- Kentucky Agriculture Commissioner James Comer said federal regulators have taken on Kentucky farms, beginning in the western part of the state.
- Comer said regulators have tested area streams and found higher-than-allowed levels of nitrogen, phosphorus and potassium.
  - "They then go on farms and ask to see something called a water and nutrient management program, something that very few people even knew existed," he said. "They are having to take time off from farming and call an attorney because they don't know what this is.
- "They automatically assume it's the farmer's fault," Comer said. "But you really have no idea what the source is. A farmer is just an easy target for a regulator."
- Comer said if there is an instance where a farmer is dumping fertilizer in a creek or river, then he should be punished. He didn't specify what that punishment should be.
  - "But as expensive as fertilizer is, they wouldn't even want to waste an ounce," he said. "Most farmers are pulling their crops 60 feet back from a stream to have a buffer zone. They want to be stewards of the soil."

QUESTIONS?