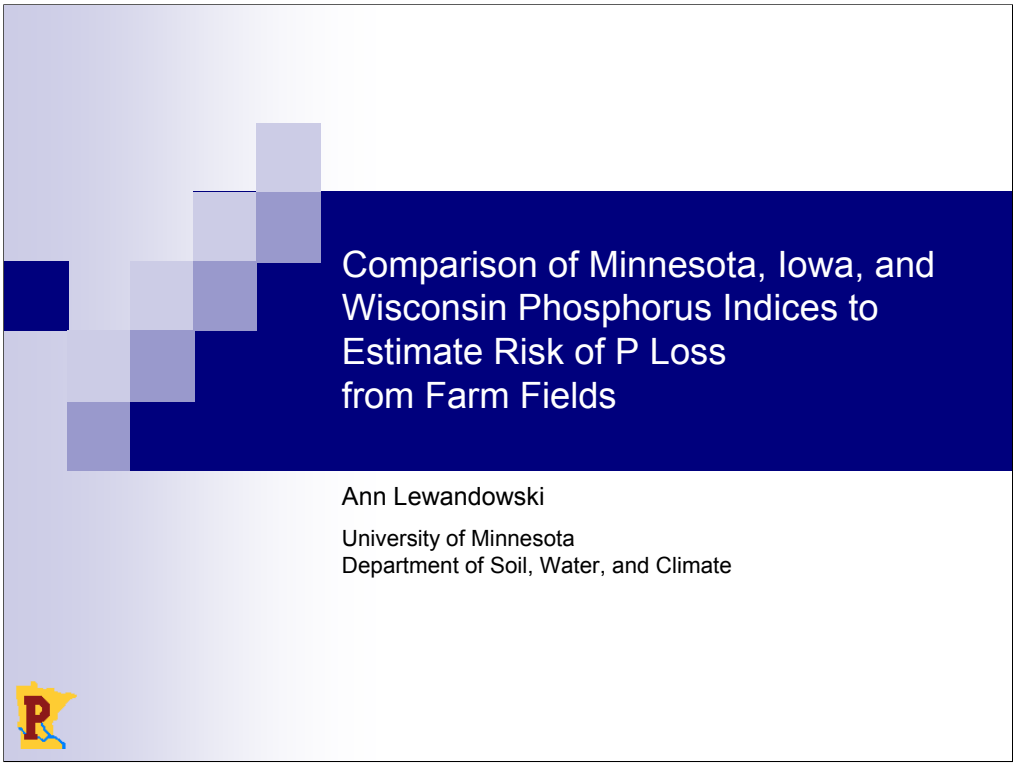


January 26th through February 3rd, Training sessions in Crookston, Staples, Willmar, Lamberton, and Rochester.

Why compare?

•A few people may be in the situation where cross border comparisons will be made. Understand why P indexes each generate different numbers.

•Understand choices made for the Minnesota PI model. In theory, there could be one highly detailed P Index for the whole region. But to simplify, and to accommodate specific state-level needs, each state has included or not included certain components.

Teams developing the indexes in the three states have had annual meetings and have similar indexes.

However, different agency and technical approaches have led to some important differences.

Similarities

- Pathway models
- Erosion is important component
- Relative index
- Not suitable for estimating actual P delivery or effect on receiving waters.
- Generate similar relative rankings of sites

All are modeling separate pathways of P loss. For each pathway, they multiply P sources by transport, e.g. multiply total soil P (source) by erosion (transport).

In contrast, in a matrix-based P index, all source and transport factors are in one table. Risks associated with each are added together.

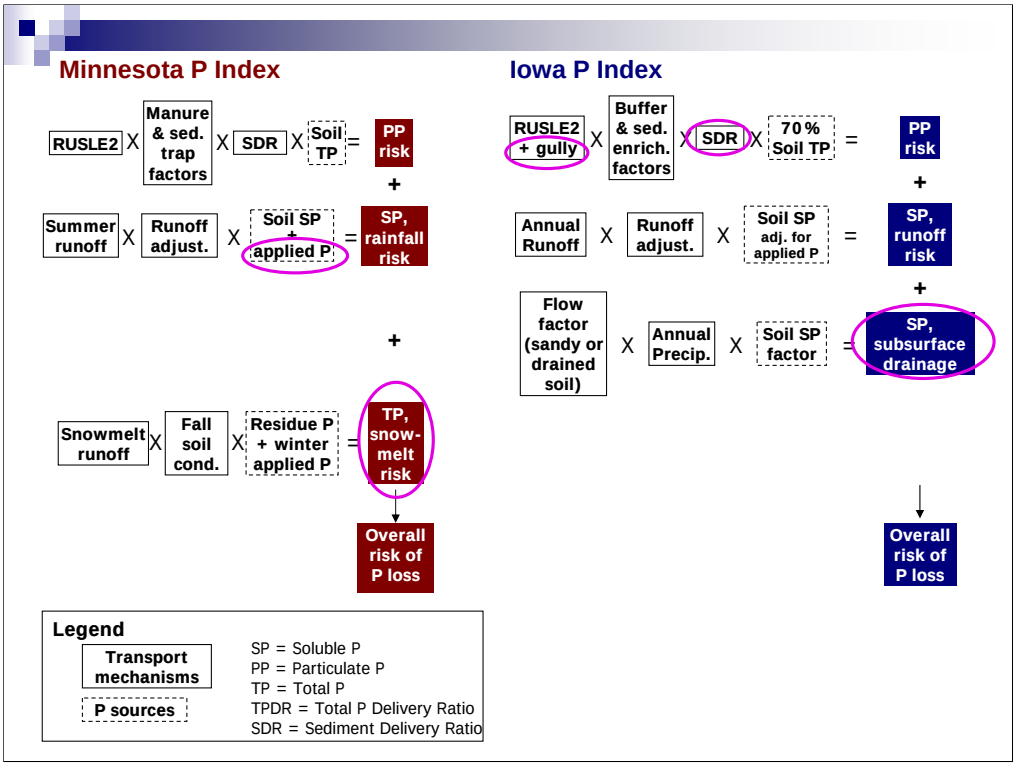
Why P index results are not estimates of load or effect on receiving waters:

•Components of the models are based on research at different scales. (e.g. SP, Fall soil cond., SDR)

•Actual delivery depends on intensity and timing of precipitation and antecedent conditions, which are difficult to model, and require more data inputs.

•RUSLE2 and P Index results assume long term averages.

•No consideration of receiving waters. Only indicates risk of P delivered to the waters' edge.



Iowa:

-Considers gully erosion losses. Potentially significant, but MN decided sheet/rill and gully erosion should be addressed separately. Gullies shouldn't be combined with sheet/rill erosion because method of calculating sediment loss is based on past events (while RUSLE does future predictions), and total soil P is different in subsoil.

-Uses four different SDRs (two are much higher than Minnesota's)

-Calculates distance to water from the center of the field.

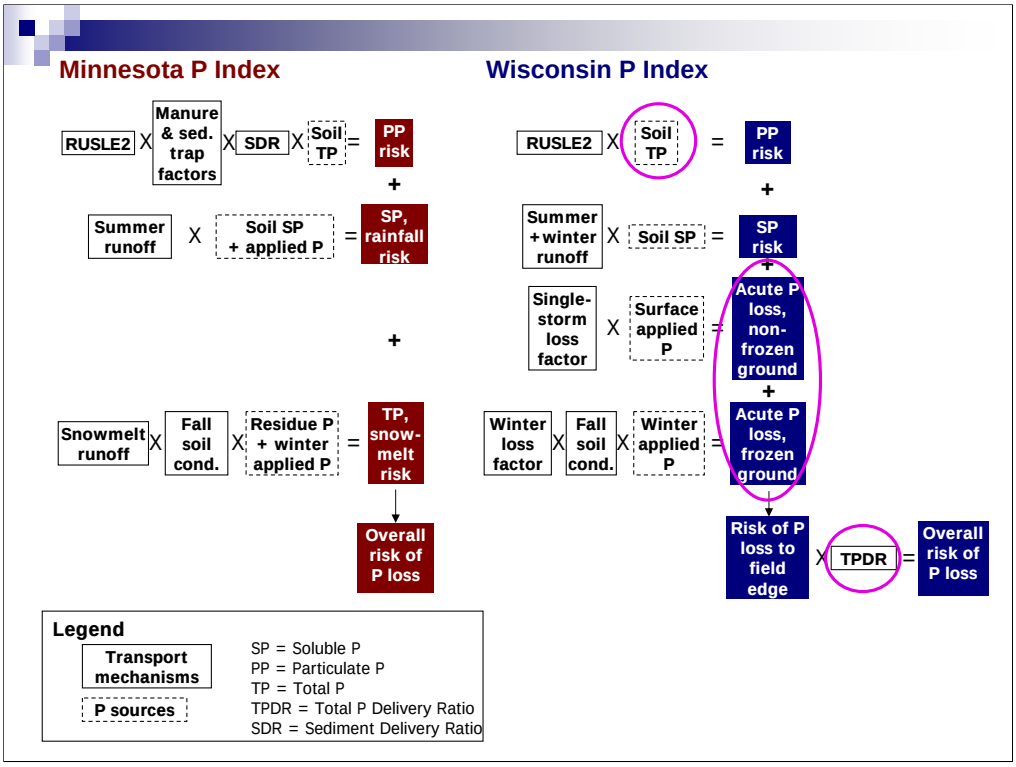
-No consideration of direct losses from applied P. Their approach is that manure applications are handled in regulations; whereas the PI considers long term risk related to soil changes. **This is an example of the effect of different purposes and approaches to creating a P Index. Don't expect them to accomplish the same purposes.**

-Includes a subsurface drainage pathway for sandy or artificially drained soils. Generally, this makes an insignificant contribution to P loss, but it could be a problem at some sites.

-No snowmelt pathway (but includes annual runoff estimate).

•Runoff: MN PI generates more extreme values that are probably more representative. Thus, MN has higher Index values with high runoff, and lower index values with low runoff. (Low runoff = low rainfall or high infiltration. High runoff = High rainfall or low infiltration.) But these differences are not huge. Runoff factor in IA is so small that it is hard to get a higher Iowa Index. For example, if RCN=90, 300ppm Olsen, 300lbs P2O5 on frozen ground, and high rainfall, then P index value for the runoff pathway is still only 1.65.

•Iowa uses sediment P enrichment factor. MN decided it was small and hard to predict. (Makes IA erosion pathway 30% higher if forages, or no-till + buffers.)



Key differences:

•SDR vs. TPDR. **TPDR is quite high**, so results are most different at high distance from water.

•Soil total P estimation is somewhat different. Each is based on in-state data. Soil total P estimates are most different at high SOM, and high applied P. **This is an example of why P indices are not transferable from state to state – they are based on in-state soils and research.**

•Acute loss pathways are only used if there are unincorporated manure applications. The MN methods for SP and snowmelt risk and the WI methods for SP and acute losses lead to similar total results (but not always).

For STP and erosion (PP) losses, manure rate has more impact on WI than MN results. For SP losses, manure rate has more impact on MN than WI results.

•Assumptions about winter and spring losses: WI assumes winter rain interacting with soil SP. Similar relative rankings at low to moderate manure applications.

•Different program interfaces lead to **different RUSLE2** results.

Original P Index

Lemunyon and Gilbert, 1993, J. Prod. Agric. 6:483

Risk Factors (weight)	Rating					Enter rating X weight
	None (0)	Low (1)	Medium (2)	High (4)	Very high (8)	
Soil erosion (1.5)	Not applicable	<5 tons/ac	5-10 tons/ac	10-15 tons/ac	>15 tons/ac	**1 X 1.5**
Irrigation erosion (1.5)	Not applicable	Qs<6 for very erodible soils or Qs<10 for other soils	Qs>10 for erosion resistant soils	Qs>10 for erodible soils	Qs>6 for very erodible soils	**0 X 1.5**
Runoff class (0.5)	Negligible	Very low or low	Medium	High	Very high	**1 X 0.5**
Soil P-test (1.0)	Not applicable	Low	Medium	High	Excessive	**4 X 1**
P-fertilizer rate (0.75)	None applied	1-30 P_2O_5 lbs/ac	31-90 P_2O_5 lbs/ac	91-150 P_2O_5 lbs/ac	> 150 P_2O_5 lbs/ac	**1 X 0.75**
P-fertilizer application method (0.5)	None applied	With planter > 2 in. deep	Incorporated immediately before crop	Incorp. > 3 mo. before crop or surface applied < 3 mo. before crop	Surface appl. > 3 mo, before crop	**1 X 0.5**
Organic P source rate (1.0)	None applied	1-30 p_2o_5 lbs/ac	31-60 p_2o_5 lbs/ac	61-90 p_2o_5 lbs/ac	> 90 p_2o_5 lbs/ac	**8 X 1**
Organic P source application method (1.0)	None	Injected > 2 in. deep	Incorporated immediately before crop	Incorporated > 3 mo. before crop or surface applied < 3 mo. before crop	Surface applied > 3 mo, before crop	**2 X 1**

Sum = 17.25

Add all weighted ratings to get a total P loss risk.

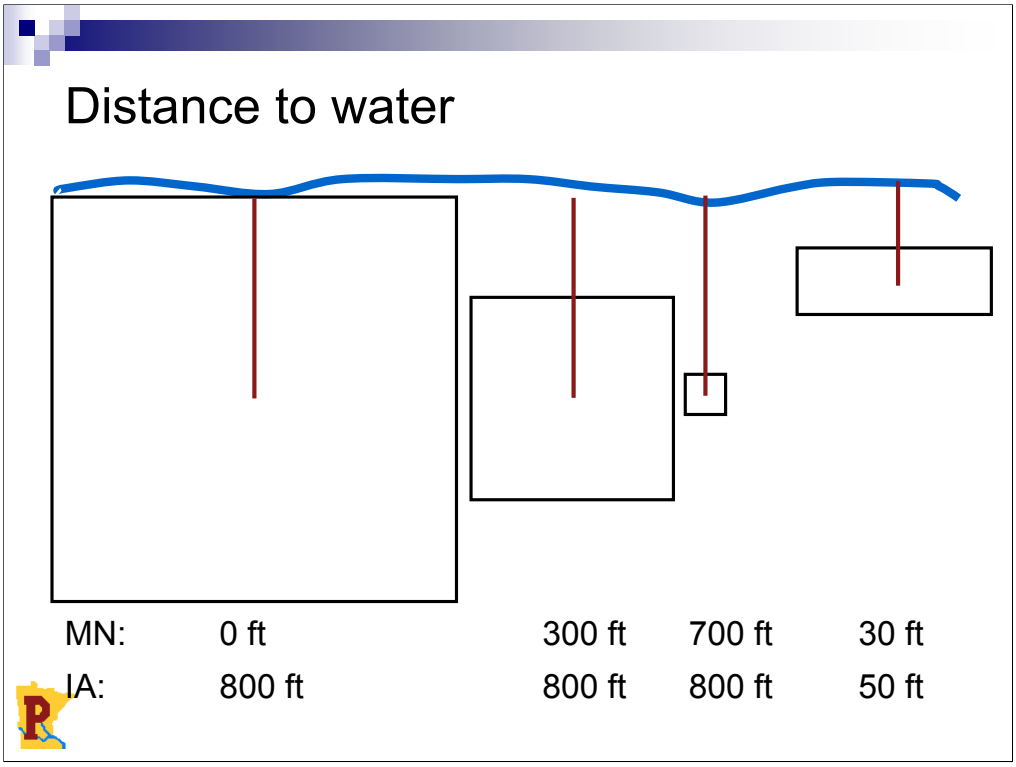
Adds transport and source risk factors, so high source with no transport still gives elevated risk.

Many regional refinements have been created, including multiplying transport and source.

Main constraint of this matrix approach is that ratings and weights are based on professional judgment, and do not have an empirical or mechanistic basis.

In response, in the late 1990's, Antonio Mallarino et al. in **Iowa began developing a P Index that took a more mechanistic approach** in which they modeled actual pathways by which P is lost.

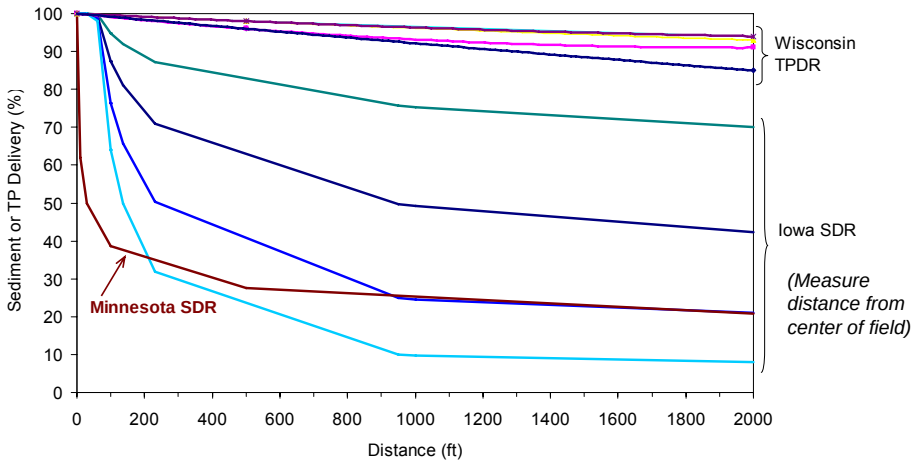
Lemunyon, J.L. and R.G. Gilbert. 1993. The concept and need for phosphorus assessment tool. J. Prod. Agric. 6:483-486.



Because Iowa measures from the center of the field and Minnesota measures from the edge of the field, the two P Indexes use different values for “distance to water.”

Can’t say which is more correct. Both (all three) can be justified by research.

Sediment and Total P Delivery Ratios



Wisconsin uses a Total P Delivery Ratio, while Minnesota and Iowa use a Sediment Delivery Ratio.

Iowa and Wisconsin have different delivery ratio curves for different landscapes. The lowest of Iowa's SDR curves (for the DesMoines Lobe landscapes) would be used for the landscapes of most of Minnesota. The second highest of Iowa's (for far NW and NE Iowa) would be appropriate for SW and SE Minnesota.

These aren't entirely comparable because **Iowa measures from the center of the field**.

Interpretation of P Index Results

	Minnesota	Iowa
Very low	0-1 No changes recommended	0-1 Impacts will be small
Low	>1-2 Minor changes recommended	>1-2 WQ impairment will be low.
Medium	>2-4 Small changes recommended. Avoid changes that increase risk.	>2-5 Some WQ impairment. Avoid changes that increase risk.
High	>4-6 Moderate changes recommended	>5-15 Large WQ impairment. Remedial action required
Very high	>6 Multiple, large changes recommended	>15 Extreme WQ impacts. Remedial action required.

Wisconsin does not provide interpretations. Strictly relative.

Iowa and Minnesota interpretations for low and medium are similar. Consider this when comparing results.

Agency Uses

	Minnesota	Iowa	Wisconsin (proposed)
When to use PI:	When rules say "no manure application"	All MMPs, and near sensitive waters	Part of NMP software
Standard:	If PI < 2, manure may be applied	If PI >5, manure application rates must be P-based	If rotation average PI > 6, manure applications must be < crop P requirements

All three states are only writing the PI into manure application rules. Not yet part of TMDL management. Only the MN PI interface is designed to be used for watershed (e.g. TMDL) planning.

Part of Iowa legislation, so Iowa PI is relatively stable.

In any case in Iowa:

- no manure application over crop N needs.

- if P Index is "High", must use P-based manure application rates. I.e., the P Index is only used to restrict manure applications on high risk sites.

- Other restrictions near sensitive areas

User Interface

	Minnesota	Iowa	Wisconsin
Format	MN PI	Excel	SNAP-Plus
RUSLE2	Runs in background. Results may be slightly higher than direct RUSLE2 runs.	User runs RUSLE2 separately.	Runs in background. Results are generally much higher than direct RUSLE2 runs.
Outputs	Easy creation of "what if?" scenarios. User-designed reports	Output to a simple table	Currently limited to pre-designed html NMP reports. PI totals only.

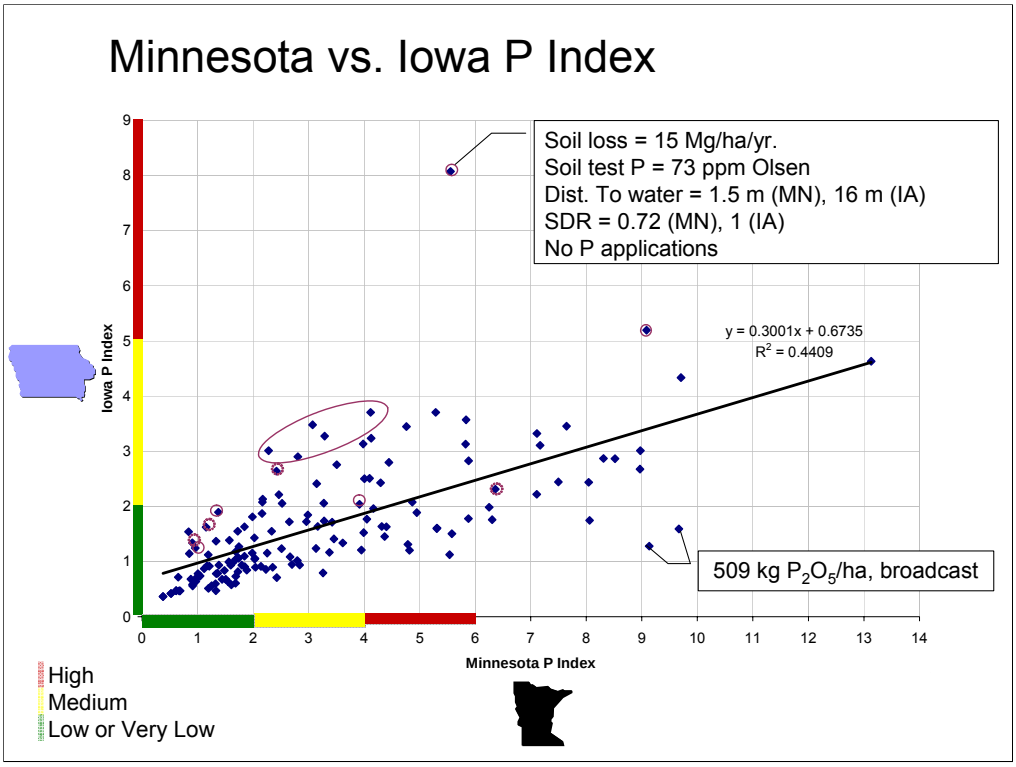
Huelskamp Creek Watershed Sites

- Subset of fields from Adam Birr's work in two watersheds in Nicollet Co.
- Mostly corn-soybean rotations

After comparing models and sensitivity, the third comparison is of PI results.

Used actual field scenarios from Adam Birr's work.

Caveat: It may not be appropriate to apply WI and IA PI's to central MN because their indices were designed based on WI and IA data.



A subset of Birr's Nicollet Co. paired watershed data.

MN values are 3X Iowa's, but interpretation categories (low/med/high) are similar between the two states.

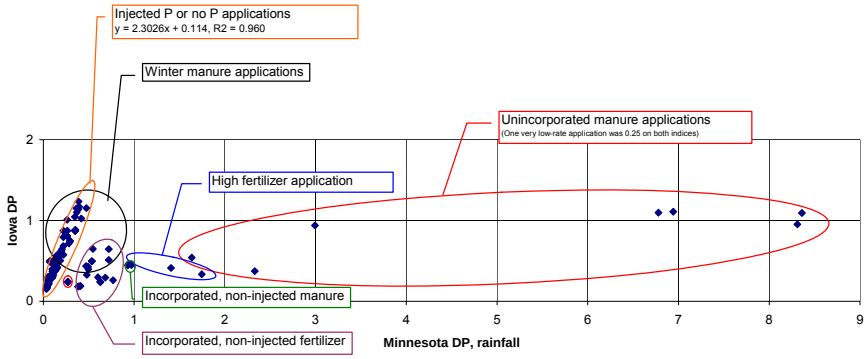
Circles mark sites where the IA SDR is greater than the MN SDR, because the fields are close to water. (Dotted circles also have potholes in the fields.)

The extreme outlier:

Pathway one is higher in IA because small field near water so Iowa SDR is 1 while Minnesota's is 0.7.

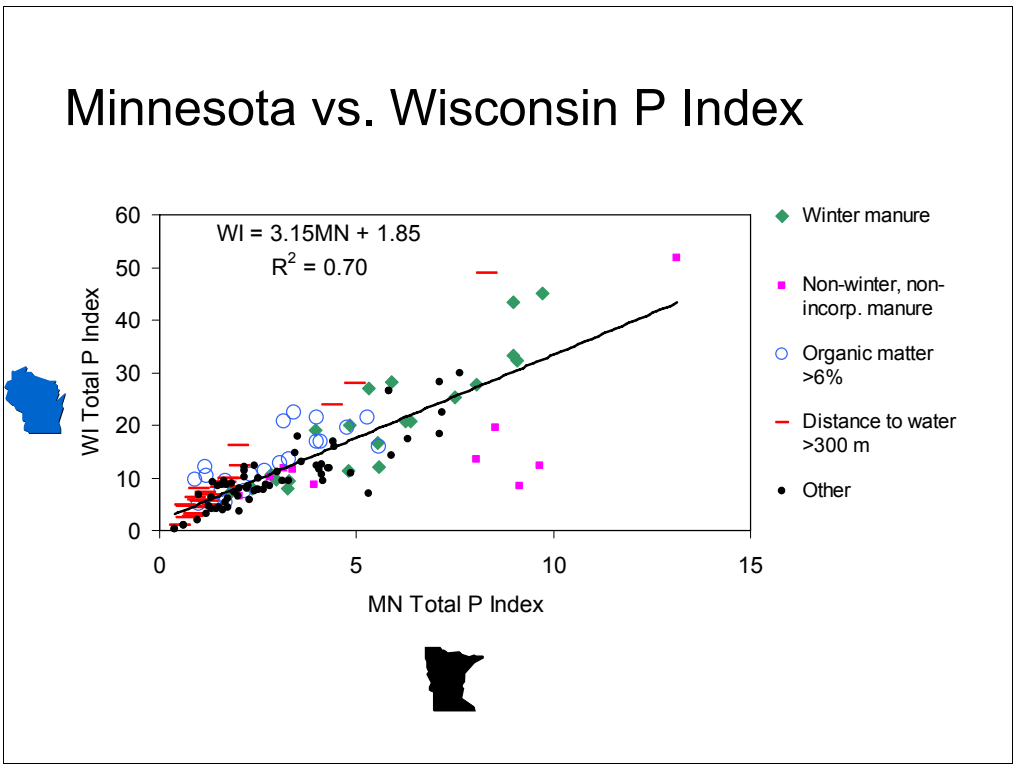
Pathway two is higher in IA because Iowa's SP is usually higher if no P applications.

Iowa vs. Minnesota: Soluble P Pathway



Without P applications, IA SP risk estimate is 2.3X MN's. But values are small and so have little effect on total PI.

MN [SP] estimate is almost 3X IA's, but IA's runoff estimates are 4.5X MN's.



WI values are 3X MN's.

The site with highest value for both: 17 t/ac/yr erosion and 689 lbs P2O5/ac surface applied manure. Compared to the Minnesota PI, Wisconsin's PI estimated a much greater soil test P increase due to the high manure application.

Total soil P: On average is 40% higher in WI. Some sites were 2.5X higher.

Delivery ratio: WI TPDR was 3.35 times the MN weighted delivery factor. Ranged from 1.4X to 6.2X.

1.4 (for difference in total soil P) X 3.35 (for difference in delivery ratio) = 4.7, which explains most of the difference between the two indexes.

Manure on frozen soil: WI acute losses were 2.5X MN snowmelt losses.

Erosion: In this example, the same RUSLE2 numbers were used for both indexes. However, a SNAP+ user may get higher sediment delivery numbers.

SNAP+ is nutrient management software, so P Index is part of total manure management planning.

Sediment Delivery Ratio. The WI Total P Deliver Ratio models a channel beginning at the field edge, so estimate of sediment delivery after the field is much higher than for Minnesota. MN significantly reduces delivery with distance to water.

Also, WI uses a Total P Delivery Ratio that is multiplied by P delivery from all three pathways. Thus, soluble and sediment are treated the same, because that is how the data was modeled to generate the factors.

Runoff calculation. WI uses runoff curve number from RUSLE2 instead of from CN tables.

Snowmelt. WI includes winter runoff in the rainfall runoff pathway. Multiplied by **soil** soluble P, whereas Minnesota multiplies snowmelt by surface P. Thus, WI is modeling winter rainfall losses, whereas Minnesota models spring snowmelt losses over frozen ground.

Event pathway. WI users wanted to emphasize that a large proportion of P losses come from a few events. So developers added an event pathway which estimates the risk of soluble P loss if a severe event (heavy rain or snowmelt) occurred shortly after application.

WI and MN (but not IA) use **%SOM to estimate soil total P**.

Quotes from **http://wpindex.soils.wisc.edu/pi.html**, February 2005:

"It is designed to indicate the **potential** for a field to deliver P to nearby surface water using readily available field management information, rather than as a predictive modeling tool for P delivery." "It should be applied over the whole farm, since simply moving the problem around within a watershed will not result in increased water quality downstream;"

"The Wisconsin PI provides a number for a given field in each year of its rotation. Comparing the rotational average PI number for all the fields on a farm or within a watershed allows the fields to be ranked in terms of their ability to contribute phosphorus to the nearest body of water. In the proposed revised Nutrient Management Standard 590 (September 17, 2004), if the planner is following a P Index strategy for phosphorus management, **any field that receives manure or other organic phosphorus inputs in excess of crop requirements must maintain a rotational P Index average below 6**."

Summary of PI Results

Minnesota vs. Iowa

- Minnesota PI generally 3X higher,
  and much higher if P applications
- Iowa PI higher if gully erosion, or in far SE and SW MN

Minnesota vs. Wisconsin

- Wisconsin PI generally 3X higher, due to:
  - high Total P Delivery Ratio
  - higher total soil P estimate

Key Differences

- Sediment delivery ratio
- Snowmelt and winter losses
- Surface P application
- Others: estimation of total P, erosion estimate

First three are major causes of differences.

Which is more correct? Can't say. All three work to estimate relative risk, but not for comparing results between indexes.

Snowmelt: MN assumes most losses in spring snowmelt, and no soil losses in winter. WI assumes soil DP losses in winter rains. **Assumptions appropriate for different climates, but make indexes not comparable.**

Surface P: WI and MN model differently. IA does not consider.

Why different?

- Algorithms emphasize in-state research data
- Agency emphases
- User interface choices

Agency differences:

•IA chose to address P applications with regulations and use the P Index for long term risk.

•In WI, emphasized the significance of single events in P loss, so the WI PI has separate pathways for single event losses instead of lumping them in with rainfall runoff soil SP losses (as in MN).

Comparing these indices illuminates issues related to developing mechanistic P indices, and illustrates the effects of different approaches.

•Erosion estimates and SDRs are critical components.

In theory, a single mechanistic P index could be created for the whole region or even the country, but its purpose is as a management tool, so must be quick to use. Simplification is done for the sake of usability, and each state needs to simplify differently.

This illustrates the importance – as with any model – of persistently training people in its correct use and interpretation.