Proposed Revisions to the Ontario P Index

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Introduction

The P Index has been part of the NMAN nutrient management software program in Ontario since the late 1990s. It was modified from the Maryland P Index, following an additive model, and the output was restrictions on P application rates and setbacks from surface water.

Table 1: The Current Ontario P Index

Site Characteristic	Rating				
Soil Erosion (T ha^{-1})	<5	5-11	11-17	>17	
Rating	2	4	8	16	
Water Runoff Class (based on slope and HSG)	VL	L	M	H	VH
Rating	1	2	4	8	16
P Soil Test (Olsen, ppm)	<15	15-30	31-60	61-100	>100
Rating	2	4	8	16	32
Fertilizer App. Rate (kg P_2O_5 ha^{-1})	0	<25	25-50	51-75	>75
Rating	0	0.5	1	2	4
Fertilizer App. Method	None	Band	Incorp. <2 wks	Incorp. >2 wks	Not incorp.
Rating	0	1.5	3	6	12
Manure/Bio App. Rate	0	<12	12-36	37-60	>60
Rating	0	0.5	1	2	4
Manure/Bio App. Method	None	Inject	Incorp. <5 days	Surface, pre-till	Surface, bare soil
Rating	0	1.5	3	6	12
P Index (Sum of ratings):	<15	15-29	30-50	>50	
P Movement Potential :	Very Low	Low	Moderate	High	
Setback UP TO crop removal (m)	3	3	3	30	
Setback OVER crop removal (m)	30	30	60	Do not apply	

Reasons for Updating the Ontario P Index

- Our understanding of P sources and transport pathways has greatly increased
- The original P Index was never validated against field measurements
- The different risks associated with dissolved versus particulate P need to be accounted for separately
- There was a desire for continuous rather than discrete variables, to avoid sudden jumps in risk categories
- Additional pathways for P loss needed to be addressed (i.e. tile drains)
- The calculations in the revised P Index should be more transparent and easily explained
- It should be easier to link the P Index outputs to mitigation options
- Validation of the P Index would be easier with an updated format

Considerations in P Index Revisions

- The inputs required to calculate the P Index should not exceed what is currently required for the NMAN program
- The output from the P Index should be proportional to the actual losses of P from the landscape into surface water from a particular combination of soil characteristics, climate and management
- Calculations within the P Index should be easily explainable
- Mitigation options for land managers should be easily discerned from the P Index results

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Modifications proposed for the Ontario P Index

- Structure of P Index changed from Additive to a Component model, where individual components have source X transport calculations
- Inherent risk of P losses is calculated separately from risk of losses from application of P sources (fertilizer, manure and biosolids)
- Contributing width for surface runoff determined by soil type, cropping system and drainage density (Gburek et al. 2002)
- Risk of P loss is calculated separately for Particulate and Dissolved P
- Net impact of tile drains on P loss is calculated (Reid et al. 2012)
- Factors are updated for calculation of the impact of rate, application method and material type on risk of losses from applied materials

P Index Calculations

Erosion	Predicted Soil Erosion (USLE) (tonnes ha^{-1} yr^{-1})	
Particulate P Source / area	$P_{Part}S_A$ = Erosion * (P_{Part} T^{-1}) * Bioavailability of P_{Part}	
Particulate P Source / volume	$P_{Part}S_V$ = $P_{Part}S_A$ / (mm annual precipitation * 10)	
Particulate P Source / stream length	$P_{Part}S_L$ = $P_{Part}S_A$ * ((CW – FD)/100)	
Surface Delivery Modifier (M_{SDp})	Reduction in P transport with Riparian Buffer or Grassed Waterway	
Tile Drainage Modifier (TDM)	Reduction in P transport with Tile Drains (Random or Systematic)	
Particulate P Delivery	Particulate P = $P_{Part}S_L$ * M_{SDp} * TDM	
Soil Test	Soil Test P (Olsen) (mg P kg^{-1} of soil)	
Dissolved P Source / volume	$P_{Diss}S_V$ = Soil Test P * 0.0027	
Dissolved P Source / area	$P_{Diss}S_A$ = $P_{Diss}S_V$ * Pr * 10	
Runoff Potential	RP = Runoff Fraction (from curve number) * Pr * 10 * ((CW – FD)/100)	
Dissolved P Source / stream length	$P_{Diss}S$ = $P_{Diss}S_V$ * RP	
Dissolved P Delivery	Dissolved P = ($P_{Diss}S$) * M_{SDd} *TDM	
Tile Drainage Flow Contribution (TDF)	Pr * MF * TD * CW/TSp	
Tile Drainage P Contribution	TDF * ($P_{Part}S_V$ + $P_{Diss}S_V$)	
Inherent P Index (PI_{IN})	PI_{IN} = Particulate P Delivery + Dissolved P Delivery + Tile Drainage P Contribution	
Interpretation of PI_{IN} values	PI_{IN} > 4000 No application of P	PI_{IN} < 4000 Calculate allowed P applications (Step 2)
P_{ap} (P application method coefficient)	Proportion of applied P that remains available to be dissolved in runoff after incorporation / banding	
P_{av} (P availability coefficient)	Proportion of P from each source that is soluble, relative to fertilizer P	
K_R (P runoff coefficient	Proportion of soluble P that actually enters runoff water	
Maximum allowable P application =	PI_{MAX} - PI_{IN}	
Applied P concentration in runoff water (P_{Ac}) =	**P_{ap} * P_{av} * K_R * Rate**	
Application Surface contribution (C_{APsur}) =	**(P_{Ac}) * (RP * Tile Modifier) * (1000/(Annual Precipitation*10) * ((CW – SD)/100)**	
Application Subsurface contribution (C_{APsub}) =	**(P_{Ac}) * TDF * (1000/(Annual Precipitation*10))**	
Application Contribution (C_{AP}) =	**(C_{APsur}) + (C_{APsub})**	
Test: $\sum(C_{AP}) \leq PI_{MAX} - PI_{IN}$		
Acronyms: CW = Contributing Width, FD = distance from field edge to surface water, MF = fraction of precipitation that enters tile drains through macropores, Pr = annual precipitation (mm), RP = runoff fraction, SD = Setback Distance for application, TDF = Tile Drain Flow, TSp = Tile Spacing		

Areas requiring further research and validation

Aside from validating the directionality and proportionality of the P Index as a whole to water quality data, there are individual components which require further research. These include:

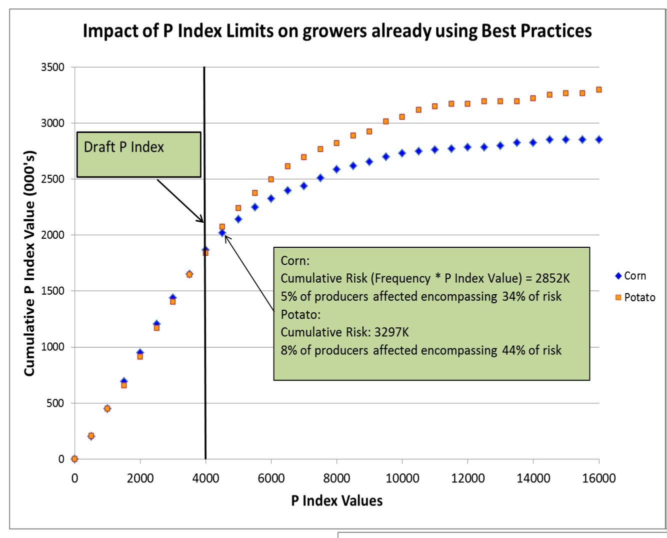
- Partitioning of tile flow between matrix and macropore flow
- Proportion of soluble P that becomes entrained in runoff water
- Reduction in P losses from different banding and incorporation systems
- Seasonality of P transport from the landscape
- Effectiveness of P mitigation strategies (buffer strips, etc.)

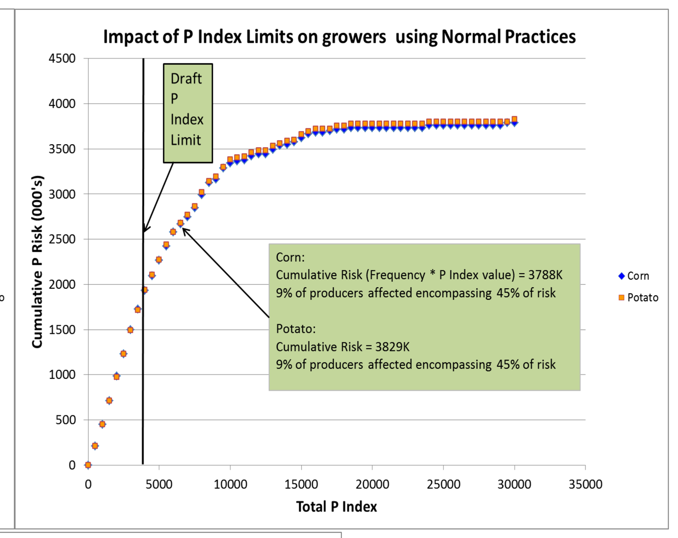
Sensitivity testing of the revised Ontario P Index

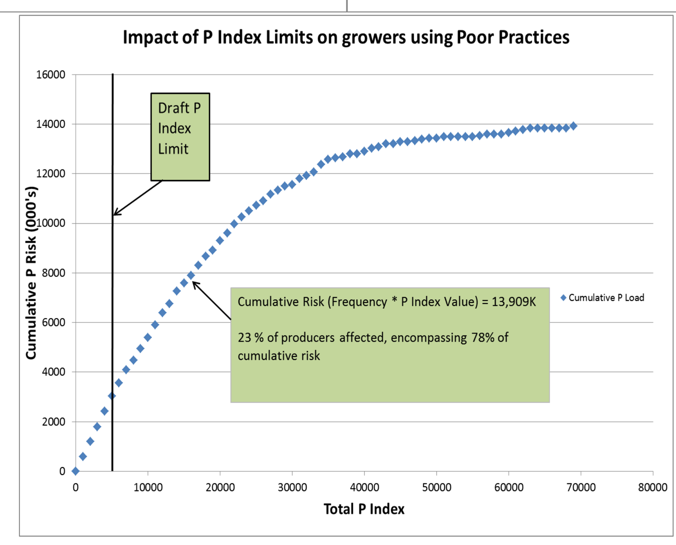
A Monte Carlo simulation was performed to assess the potential impact of the revised P Index on producers, as well as the potential reductions in P losses from agricultural land. Sample runs (n = 3000) were conducted for three different groups, with model criteria set to emulate:

1. Best management – P application followed recommendations, all P banded or incorporated
2. Normal management – limited P over-application, mix of banded and broadcast
3. Poor management – up to 100 kg ha^{-1} overage allowed, all broadcast

The cumulative impact across these sample populations were assessed by calculating the frequency distribution of the P Index values, then multiplying the frequency in each category by the P Index value for that category. These were then compared to a Draft P Index limit. All of the groups had some fields that exceeded the limit and would have restrictions on P application imposed, but the number increased as the level of management declined.







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