Using the SWAT Model for BMP implementation and diffuse source phosphorus reductions in the Pike River Watershed, southern Quebec, Canada:

INSTITUT DE RECHERCHE
ET DE DÉVELOPPEMENT EN
AGROENVIRONNEMENT

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Outline

- Context
- Site Description
- SWAT's set-up (Brochets, Walbridge, Castor)
- Results
- Scenarios

- Tranfer to SWAT-2005
- Tile drainage
- Modification to the code

- Conclusion

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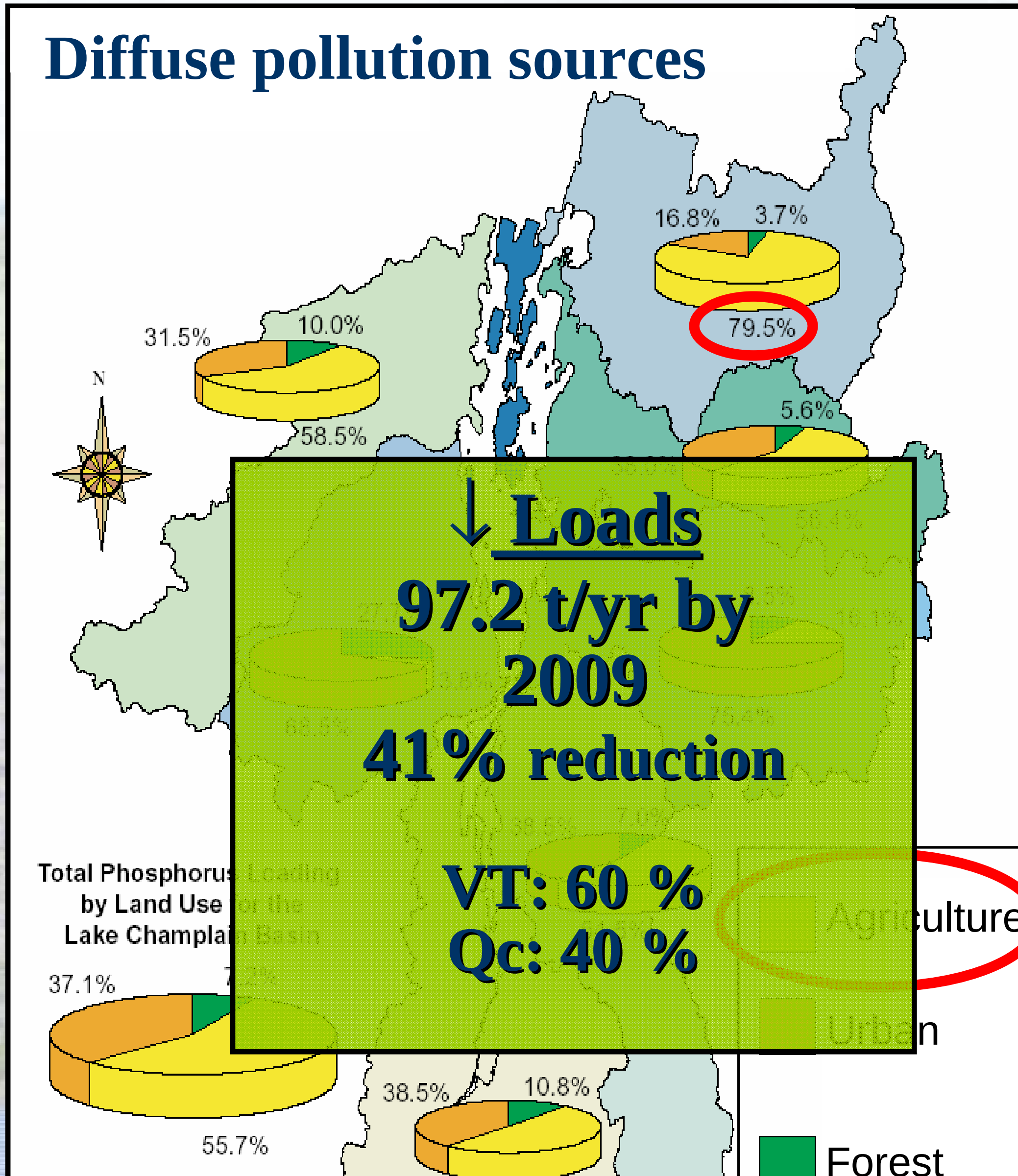
Context

Support decision making

Diffuse pollution sources



Source: *Estimation of Lake Champlain Basin Nonpoint Source Phosphorus Export*. LCBP Technical Report #31, Table 4.12.

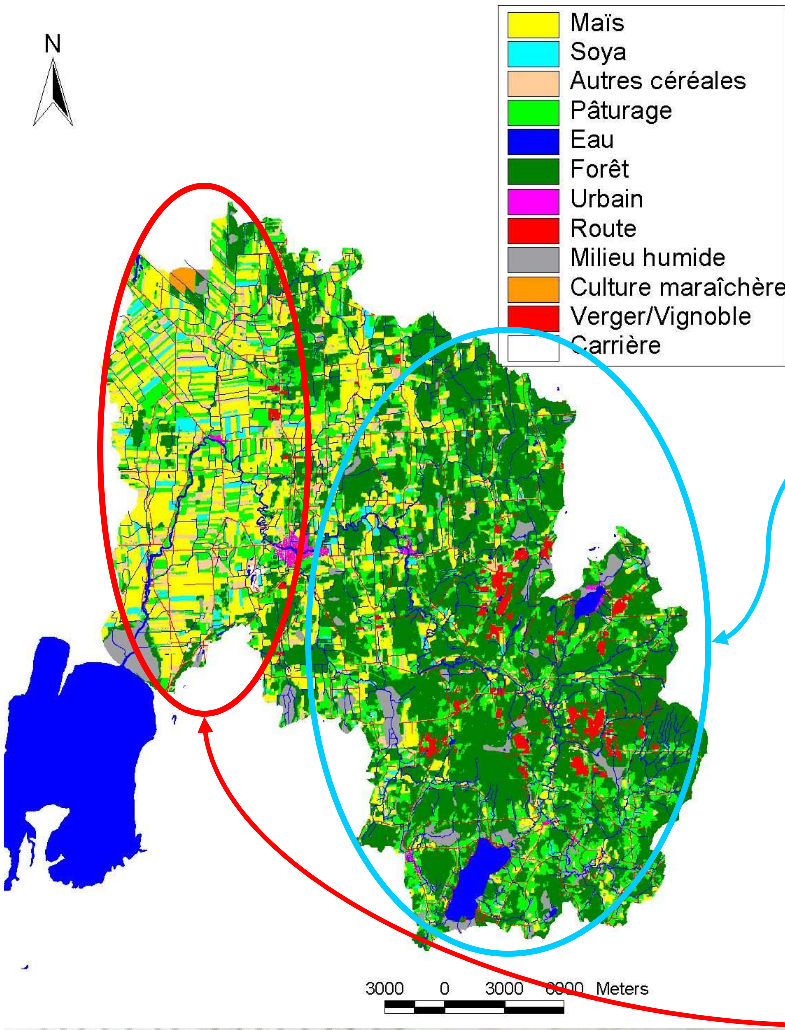
↓ Loads

97.2 t/yr by 2009

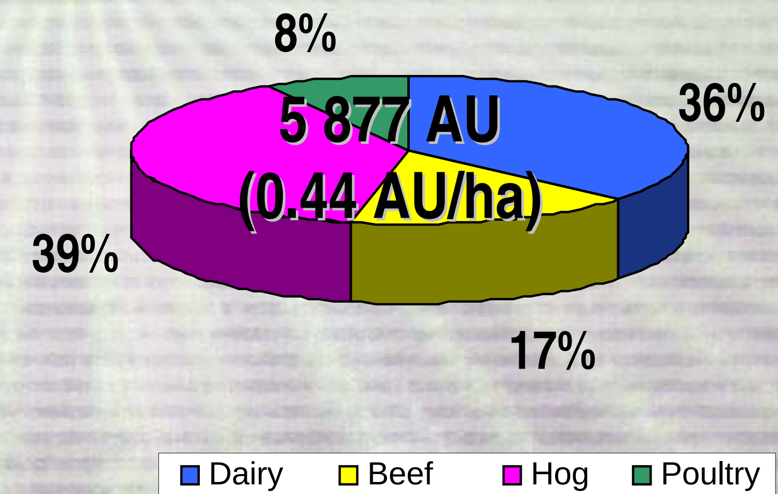
41% reduction

VT: 60 %
Qc: 40 %

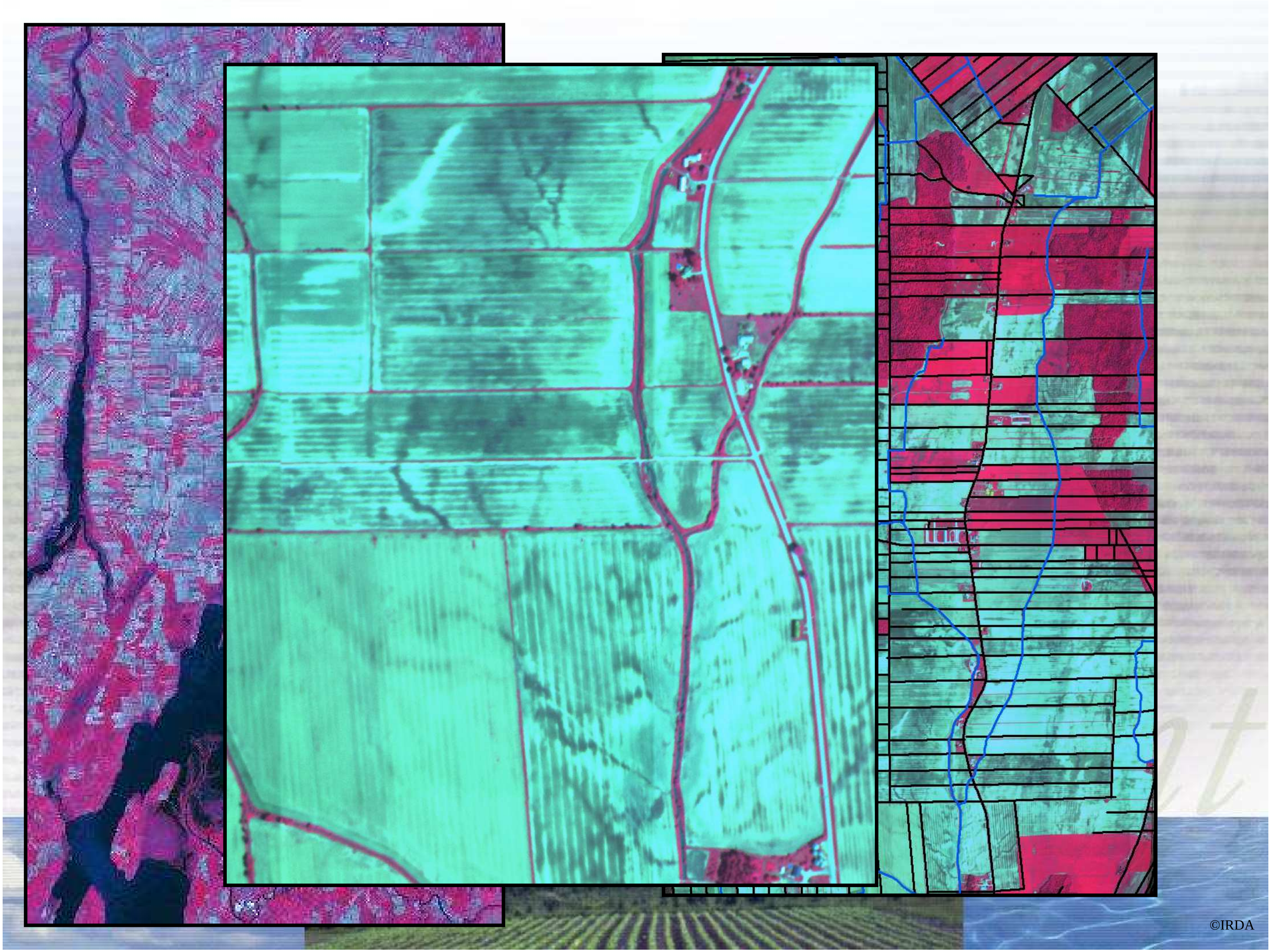
Study site



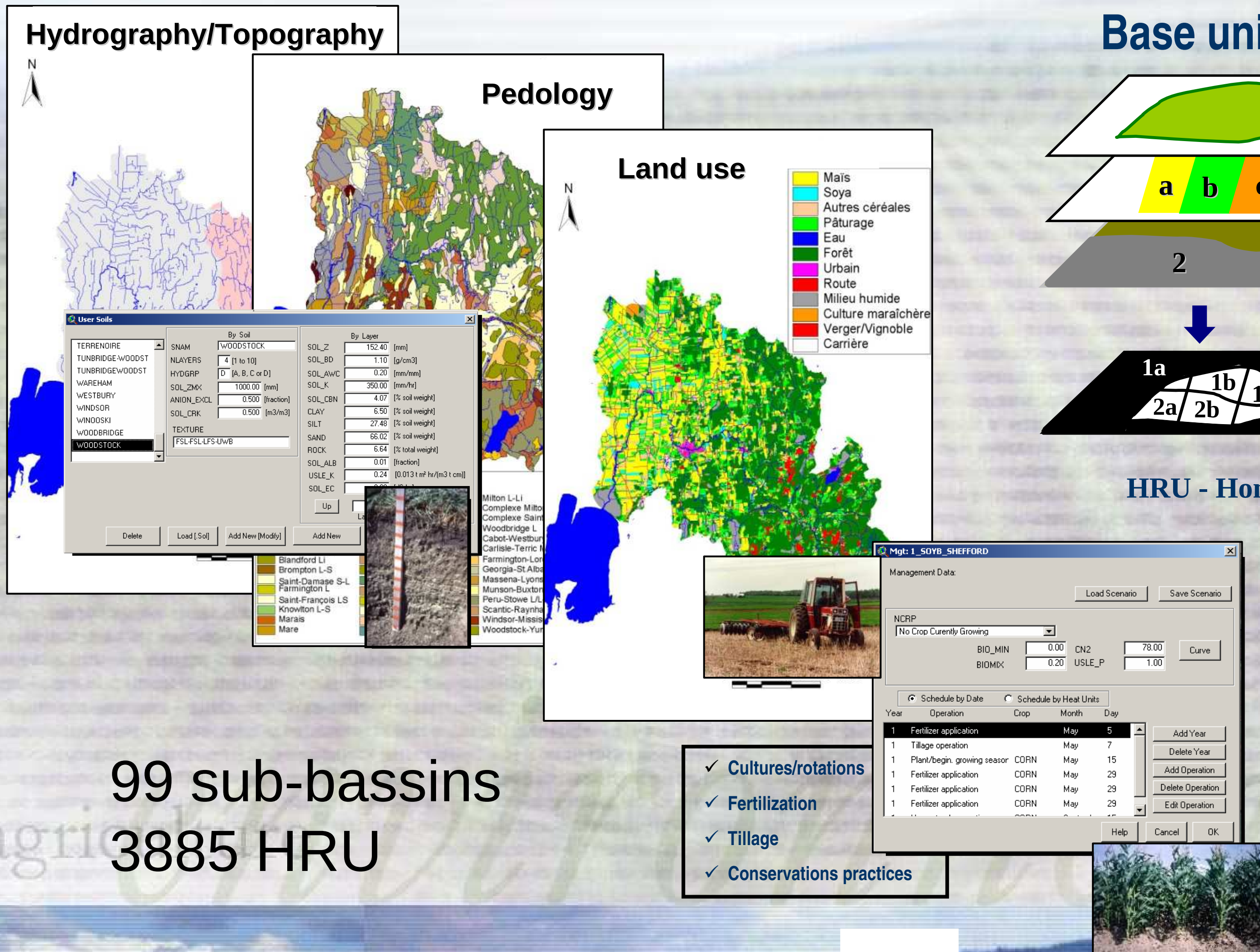
Upstream of Bedford (Ag. Area = 13 265 ha)



Downstream of Bedford (Ag. area=18 640 ha)



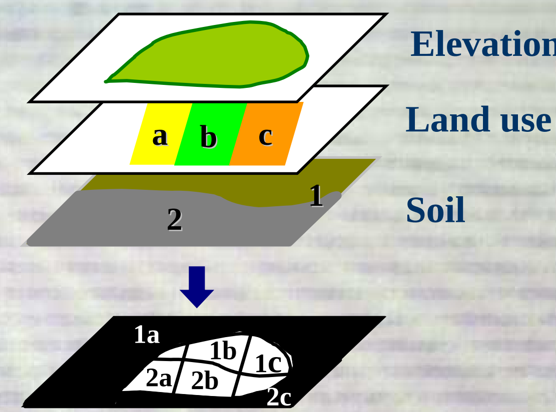
Data Integration



- ✓ Cultures/rotations
- ✓ Fertilization
- ✓ Tillage
- ✓ Conservations practices

99 sub-bassins
3885 HRU

Base unit : HRU

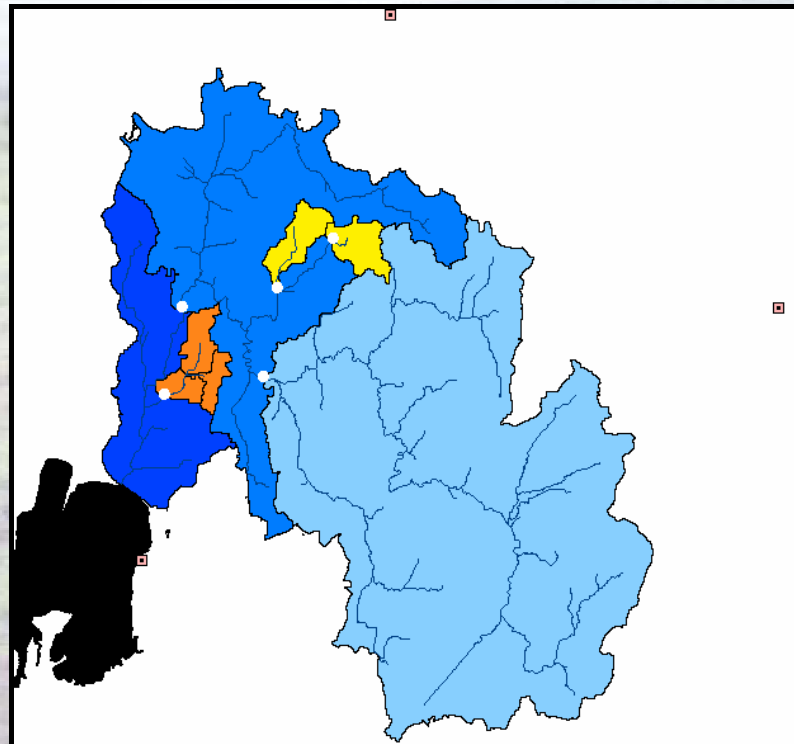


HRU - Homogenous Response Unit

Gauging stations

Brochets downstream :
- 563 km²
- Forest 44%
- Grassland 20%
- Corn 16%

Castor:
- 12 km²
- Corn 44%
- Grassland 28%
- Cereals 20%



Walbridge intervention & témoin:
- 15 km²
- Corn 36%
- Forest 26%
- Grassland 20%

Brochets upstream :
- 386 km²
- Forest 54%
- Grassland 20%

	Calibration	Validation
Brochets upstream	1999-2000	---
Brochets downstream	2002	2003
Walbridge	2002	2003
Castor	1998-1999	2000

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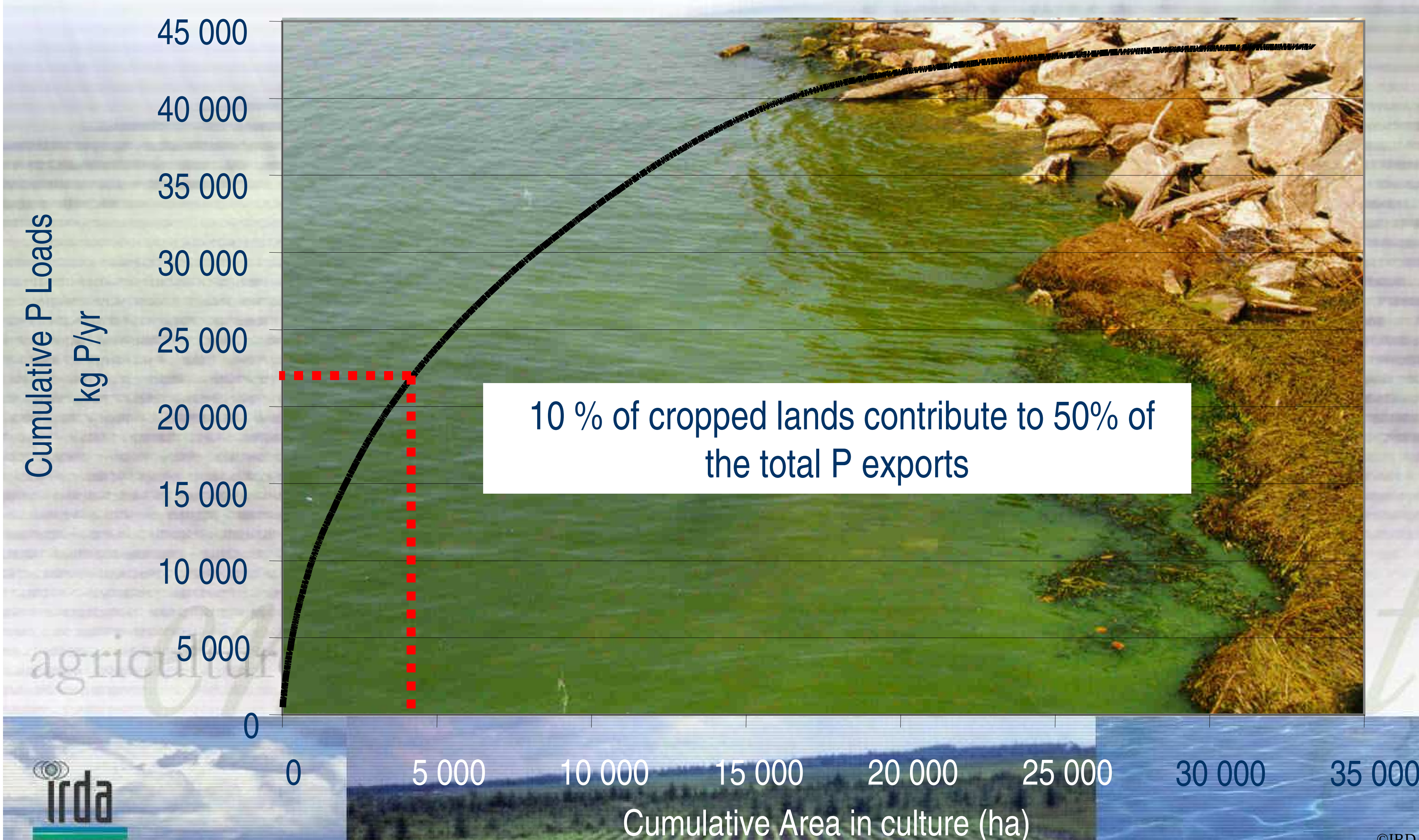
Results
Spatial Variability



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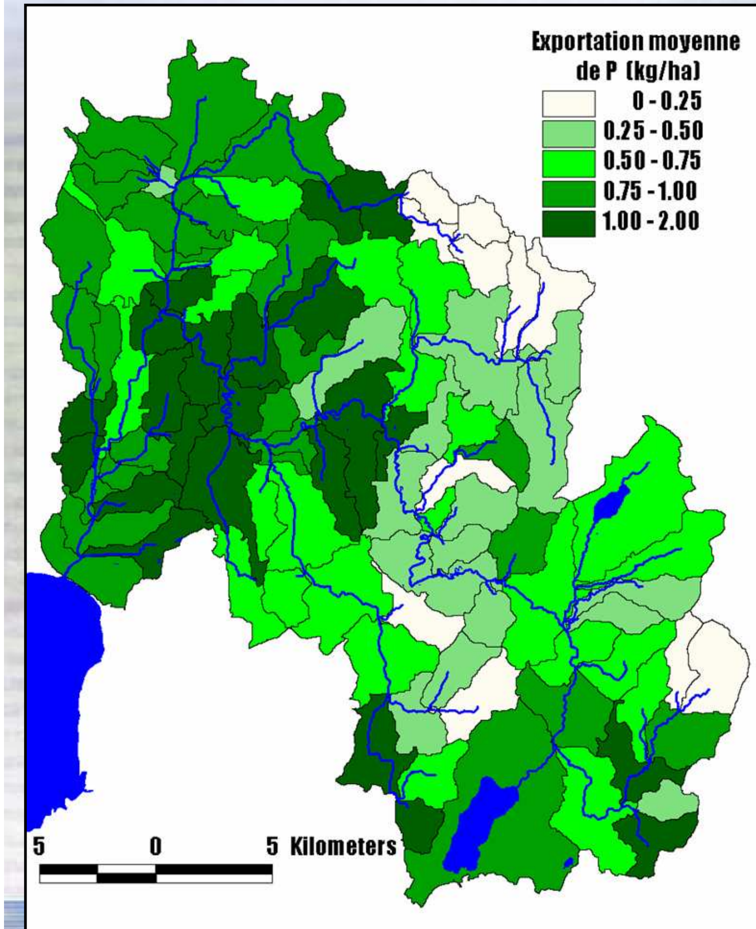
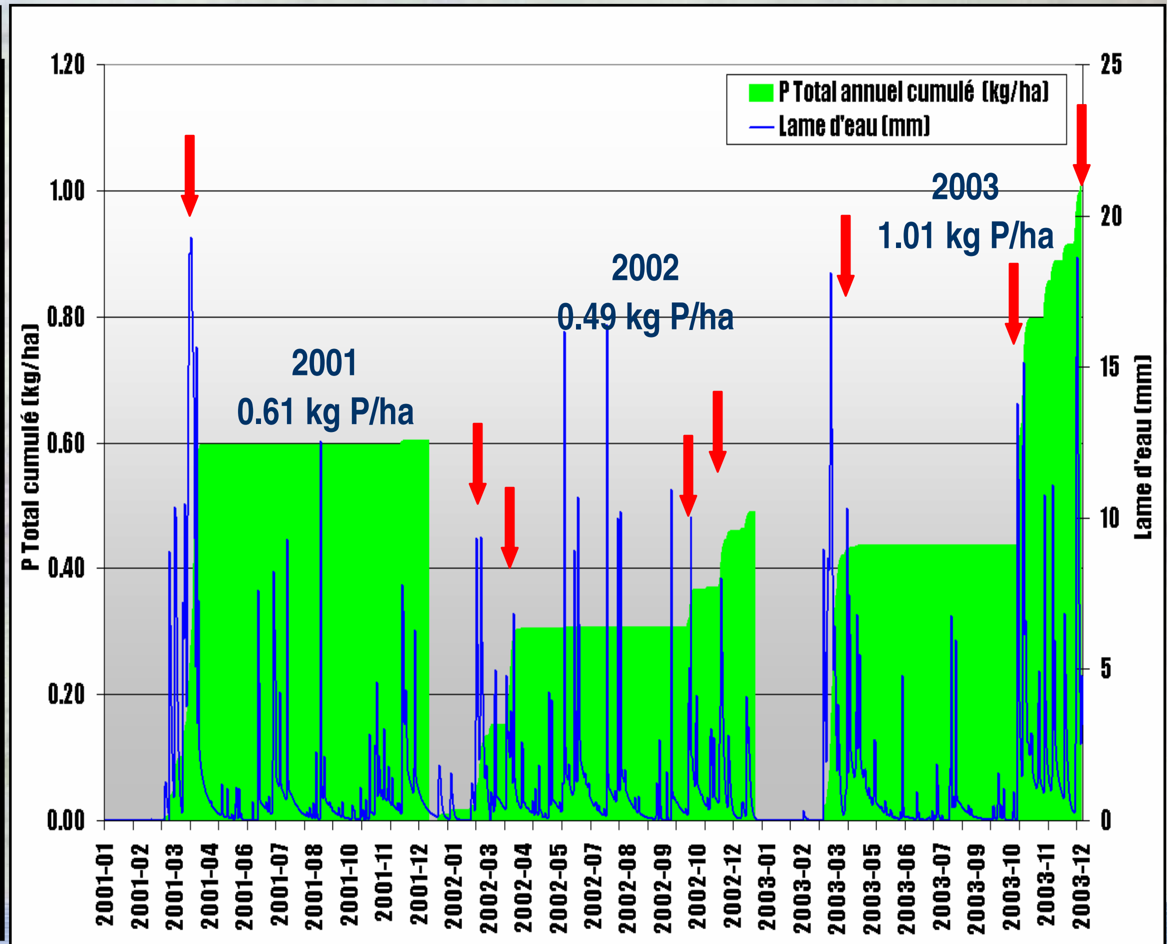
Modelling results
Temporal variability

Corn on a Milton badly drained sandy loam





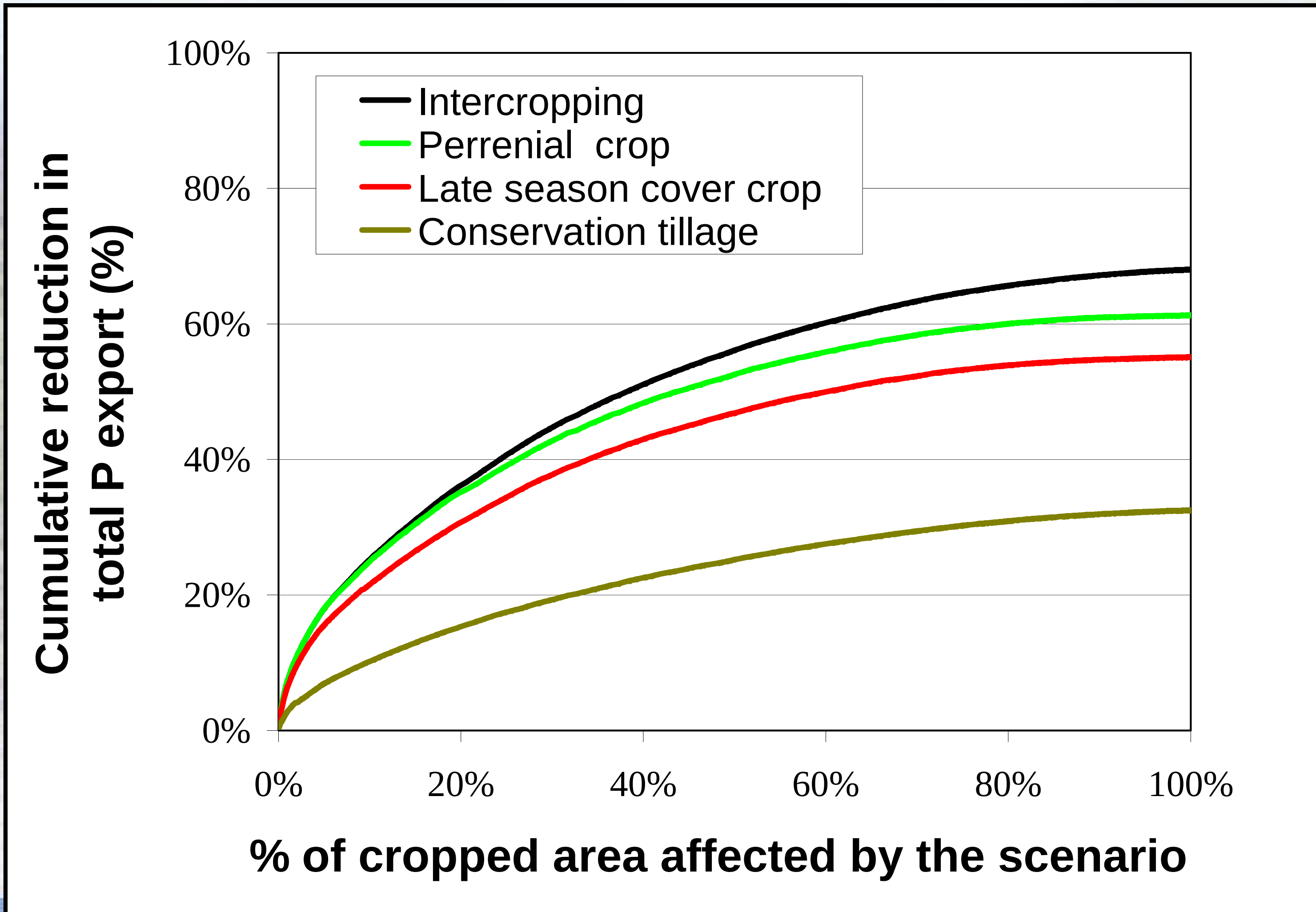
78% of P exports happened during 6% of the study period

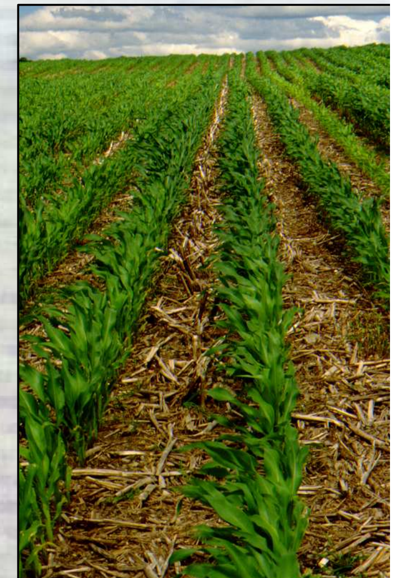
(62 days between 2001 et 2003)

Scenarios

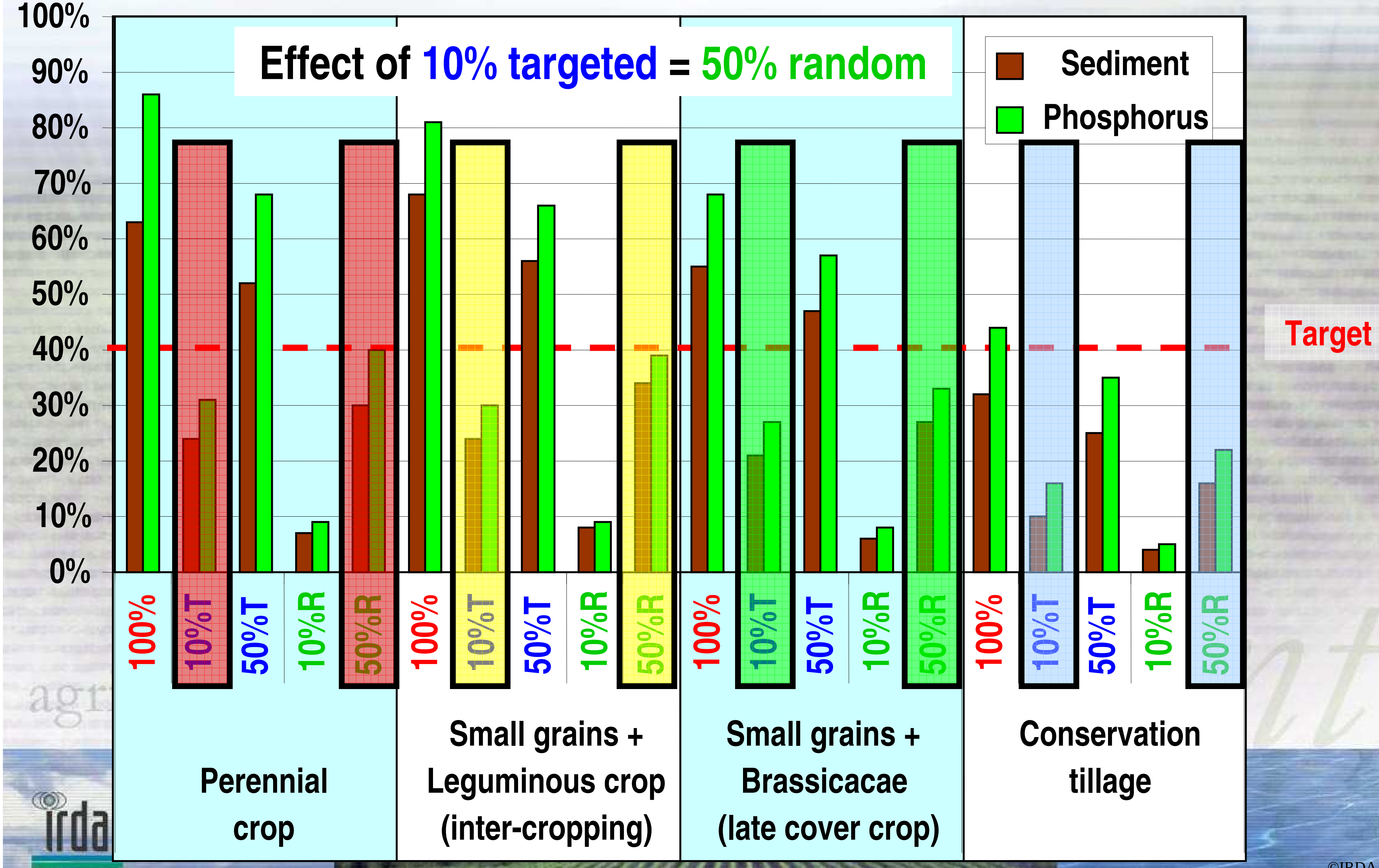
- Reference Scenario
- Alternative Scenarios
  - Mode and period of fertilizer application
    - Optimization of the period and mode of fertilizer application
  - Conservation tillage
    - No-Till
    - Reduced tillage
  - Cover crops
    - Perennial crops
    - Small grains + intercrop (leguminous crop)
    - Small grains + late season cover crop (cruciferous crop)
  - Hydro-agricultural structures
    - Buffer strips
    - Tile inlets

Phosphorus exports in relation to increasing adoption of BMPs





Sediment and phosphorus reductions obtained with varying level of BMP implementation



Résultats
Mixed Scenarios
Basic scenarios

Scenarios	Late Season Cover Crops	Reduced Tillage or Intercropping	Immediate Incorpo.	Perennial Crops	Buffer Zones	Structures Hydro-agricoles	Reductions Sediments %	 Total P %
Reference Scenario							30.5 t/ha	46.1 kg/ha
1				Flood Plain			1%	1%
2			100%				0%	3%
3					100%		9%	7%
4						100%	16%	12%
5			100%	Flood Plain			1%	3%
6					100%	100%	25%	19%
7			100%	Flood Plain	100%		10%	10%
8			100%	Flood Plain	100%	100%	26%	21%

Mixed Scenarios
Conservation Practices

Scenarios	Late season cover crops	Reduced tillage or intercropping	Immediate Incorpo.	Perennial crops	Buffer zones	Hydro-agricultural structures	Reductions Sediments %	Total P %
Reference Scenario							30.5 t/ha	46.1 kg/ha
9		100%					47%	35%
10		100%	100%	Flood Plain	100%		53%	40%
11		T10%	100%	Flood Plain	100%		25%	19%
12		T 10%	100%	Flood Plain	100%	100%	38%	29%
13		R50%	100%	Flood Plain	100%		31%	25%
14		R50%	100%	Flood Plain	100%	100%	43%	34%
15		T50%	100%	Flood Plain	100%		44%	32%
16		T50%	100%	Flood Plain	100%	100%	53%	40%

Scenarios	Late Season Cover Crops	Reduced Tillage or Intercropping	Immediate Incorpo.	Perennial Crops	Buffer Zones	Hydro-agricultural Structures	Reductions Sediments %	Total P %
Reference Scenario							30.5 t/ha	46.1 kg/ha
17	T 10%						27%	21%
18	T 10%		100%	Flood Plain	100%		35%	29%
19	T 10%	R 45%	100%	Flood Plain .	100%		49%	39%
20	T 10%	T 45%	100%	Flood Plain .	100%		53%	42%
21	T 10%	R 45%	100%	Flood Plain .	100%	T10%	51%	41%
22	T 10%	R 45%	100%	Flood Plain .	100%	100%	58%	46%
23	T 50%		100%	Flood Plain .	100%		63%	51%
24	T 50%	+ 50%	100%	Flood Plain .	100%		73%	59%
25	T 50%	+ 50%	100%	Flood Plain .	100%	100%	78%	63%

Publications

J. Deslandes, I. Beaudin, A. Michaud, F. Bonn and C. A. Madramootoo. 2007. Influence of Landscape and Cropping System on Phosphorus Mobility within the Pike River Watershed of Southwestern Quebec: Model Parameterization and Validation. Canadian Water Resources Journal, 32(1), 21-42.

A. R. Michaud, I. Beaudin, J. Deslandes, F. Bonn, and C. A. Madramootoo. 2007. SWAT-predicted influence of different landscape and cropping system alterations on phosphorus mobility within the Pike River watershed of south-western Québec. Canadian Journal of Soil Science, 87(3), 329–344.

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Premilinary Conclusion

SWAT:

- **A good tool for reproducing the transport dynamics of water, sediment and phosphorus from agricultural lands;**
- **Allow to identify the most sensittives zones in terms of P exports in watersheds in oder to target these for BMP applications;**
- **Allow to model agri-environmental scénarios with BMP;**
- **Allow to identify *some scenarios* that enable to reach the taget loads;**
- **Allow to establish realistic P export goals;**
- **Not a regulation tool;**

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Transfer to SWAT-2005

- **Almost no water in the drains**
- **Tile drainage routines were modified**
- **Revert to old routines***
  - Bring back code based of SWAT-2000
  - Change order of operations
    1. Tile drainage
    2. Lateral flow
    3. Seepage
  - Tile drainage based on soil LAYER water, not soil profile

*** In collaboration with U. Laval and UNESCO-IHE**

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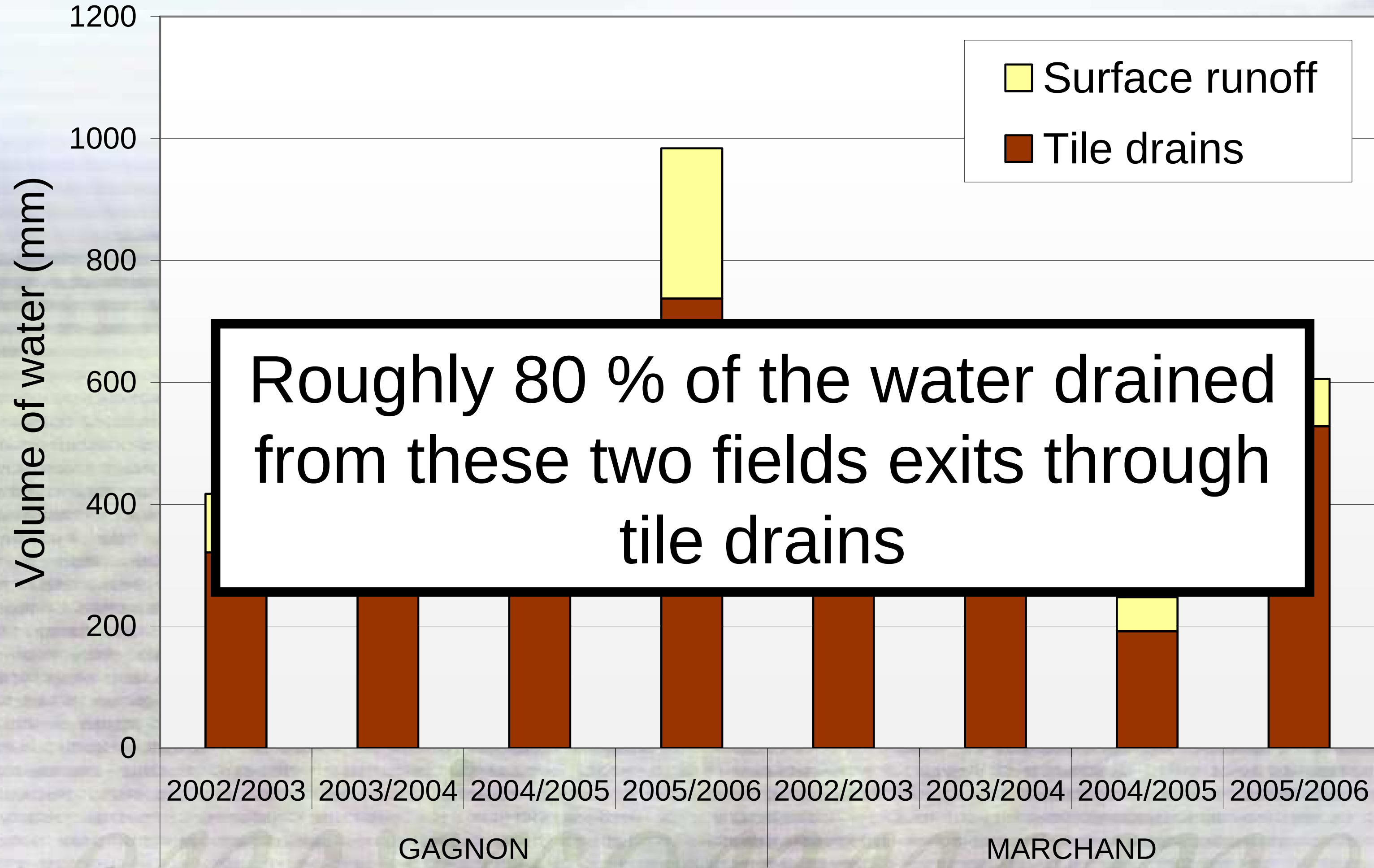
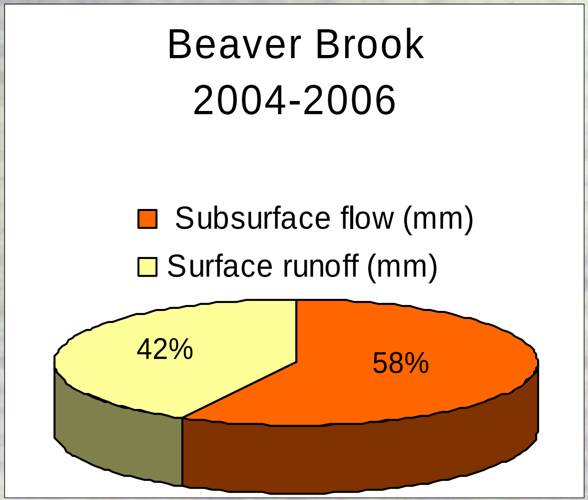
Drainage pathways for two fields in southern Québec



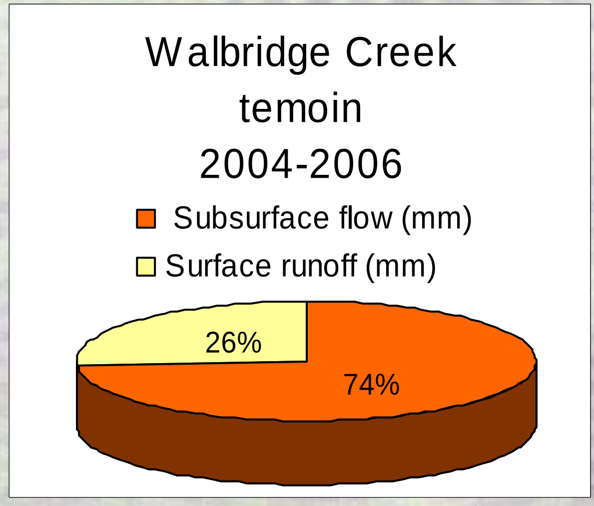
Roughly 80 % of the water drained from these two fields exits through tile drains

	GAGNON	MARCHAND	GAGNON	MARCHAND	GAGNON	MARCHAND
	Subsurface		Surface		Total	
2002/2003	320.821	378.860	96.351	75.260	417.172	454.120
2003/2004	426.505	520.076	80.707	21.880	507.212	541.956
2004/2005	357.759	191.346	157.041	55.871	514.800	247.217
2005/2006	737.340	527.679	246.689	78.115	984.029	605.794

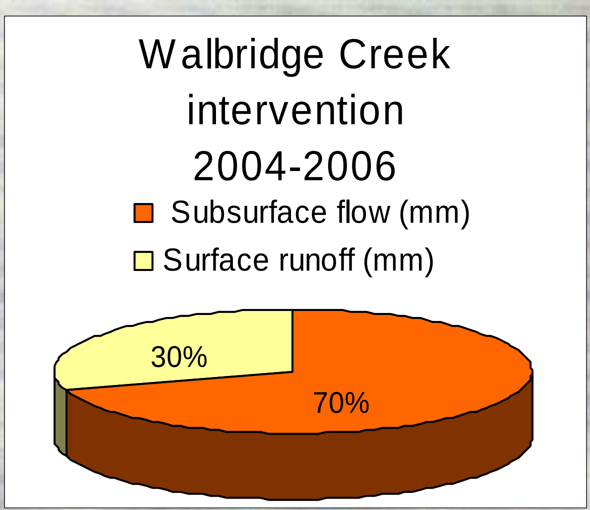
Flow Separation with multisonde



531 mm/yr.



601 mm/yr.



515 mm/yr.

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Measurements and sampling of surface and subsurface runoff

Partners

Développement durable, Environnement et Parcs Québec

Agriculture, Pêcheries et Alimentation Québec

Coopérative de Solidarité Bassin-versant de la Rivière-aux-Brochets

Corporation Bassin Versant Baie Missisquoi

McGill

Université de Sherbrooke

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Thank you!