

Agriculture and Water Quality

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Questions

- ◆ Does agriculture impact water quality?
- ◆ What are the impacts?
- ◆ How can management practices minimize the impacts?



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Agricultural Contaminants

- ◆ Nutrients
- ◆ Pathogens
- ◆ Sediment
- ◆ Pharmaceuticals (Veterinary Drugs)
- ◆ Endocrine Disrupting Compounds
- ◆ Metals?



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Impacts of Contaminants

- ◆ Ecosystem Health
 - NH_3 , P, sediment, pesticides
- ◆ Human Health
 - pathogens, NO_3
- ◆ Long-term Impact
 - pesticides, pharmaceuticals, EDCs



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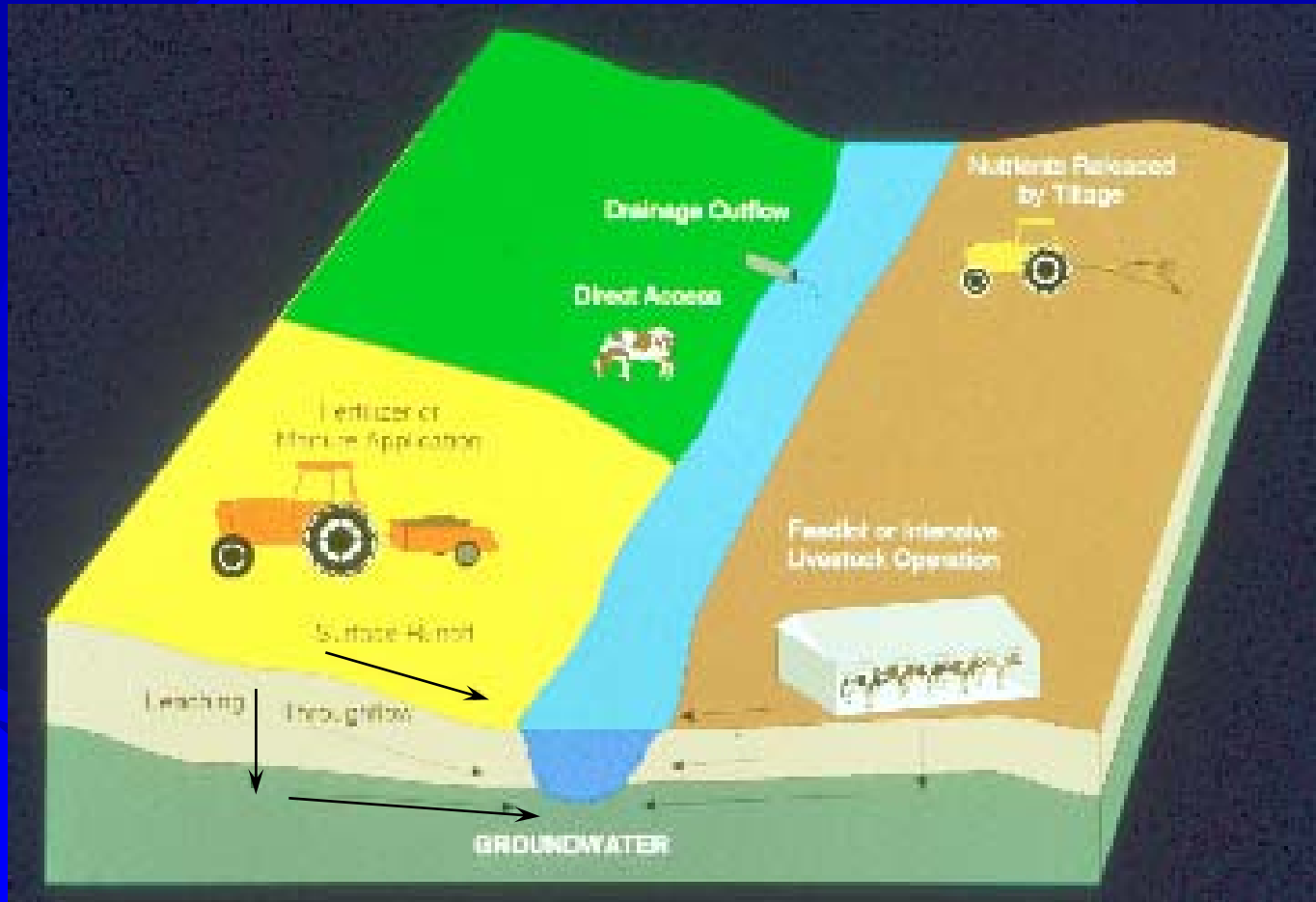
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Pharmaceuticals

- ◆ Antibiotics are the greatest concern
- ◆ Can antibiotics excreted in manure be transported to surface water?
 - **Low dose human ingestion**
- ◆ Can antibiotics excreted in manure result in resistance developing in natural populations
 - **resistant bacteria in the environment**



Transport Pathways



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Surface Runoff

- ◆ Runoff-generating rainfall occurs only occasionally but extreme events can be catastrophic and have long term consequences for water quality
- ◆ Snowmelt runoff occurs most years
Snow melts while soil is still frozen
Infiltration rate is very slow
 - **dependent on fall soil moisture**



Hydrology & Water Quality

- ◆ Transport pathways control water quality
 - **any change to a transport pathway will change water quality**
- ◆ Water quantity impacts water quality through concentration or dilution of contaminants
- ◆ Extreme events such as flooding impact water quality



Deliberate Change to Hydrology

Irrigation and Drainage

- ◆ Irrigation

 - Incident water is increased

 - Leaching is more likely

 - Return flow water contains contaminants

- ◆ Subsurface Drainage

 - Short cut for contaminant transport



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Irrigated Potato Management

- ◆ High value crop
- ◆ High requirement for:
 - Nutrients
 - Pesticides
 - Water
- ◆ Row crop
- ◆ Light-textured soils
- ◆ Shallow root system
- ◆ Nitrate and pesticide leaching

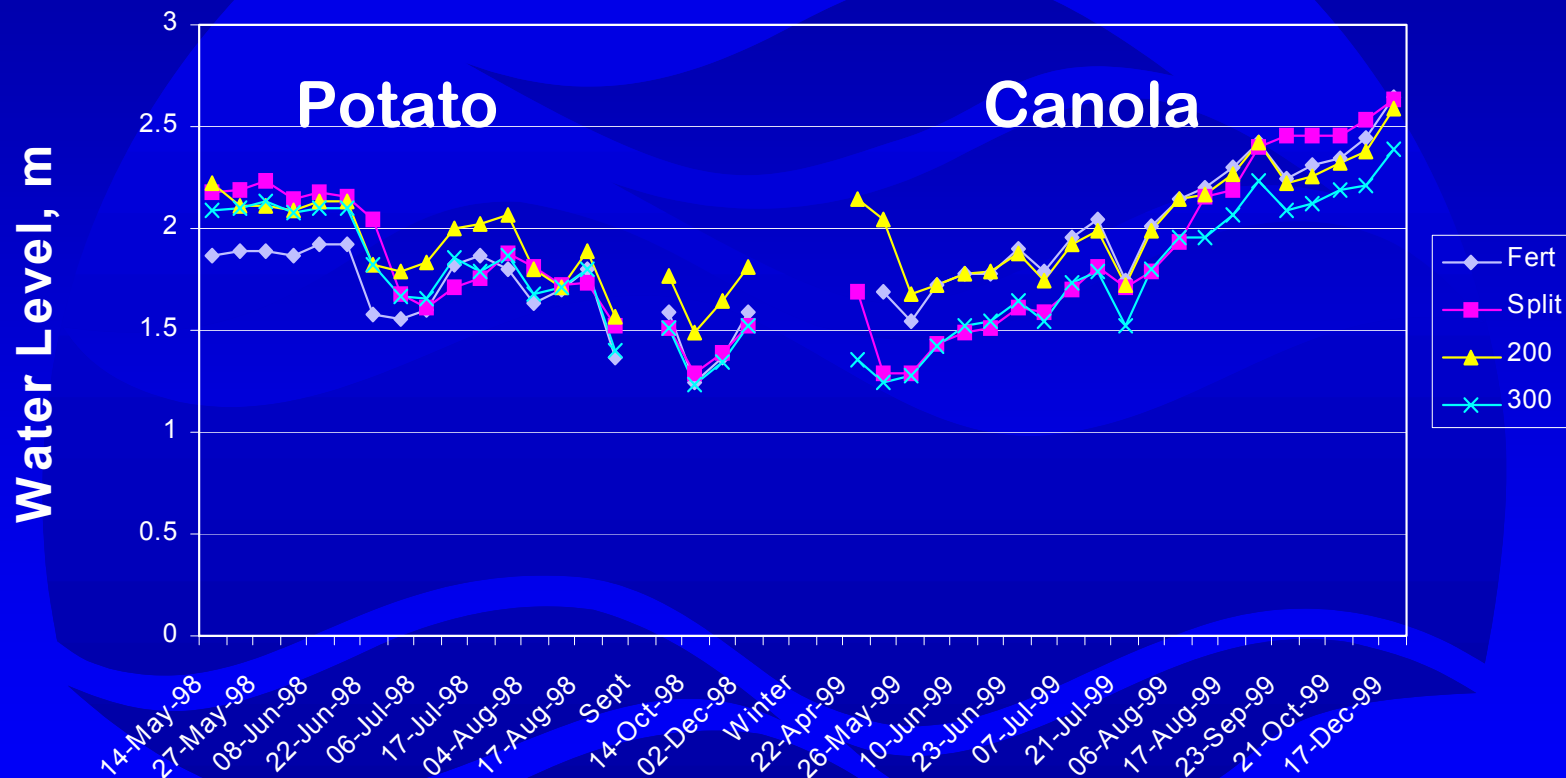


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Groundwater Level

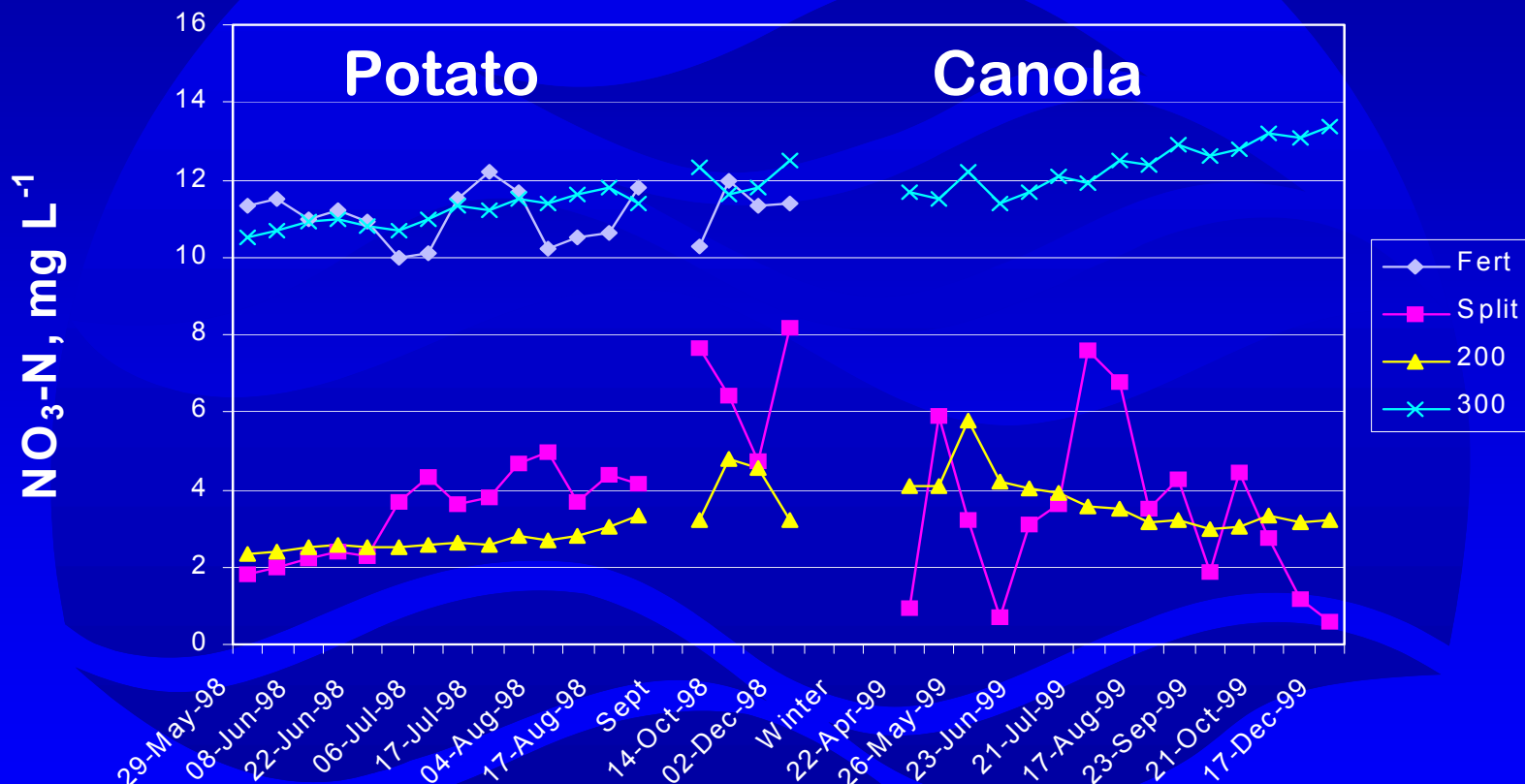


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NO₃ in Shallow Groundwater



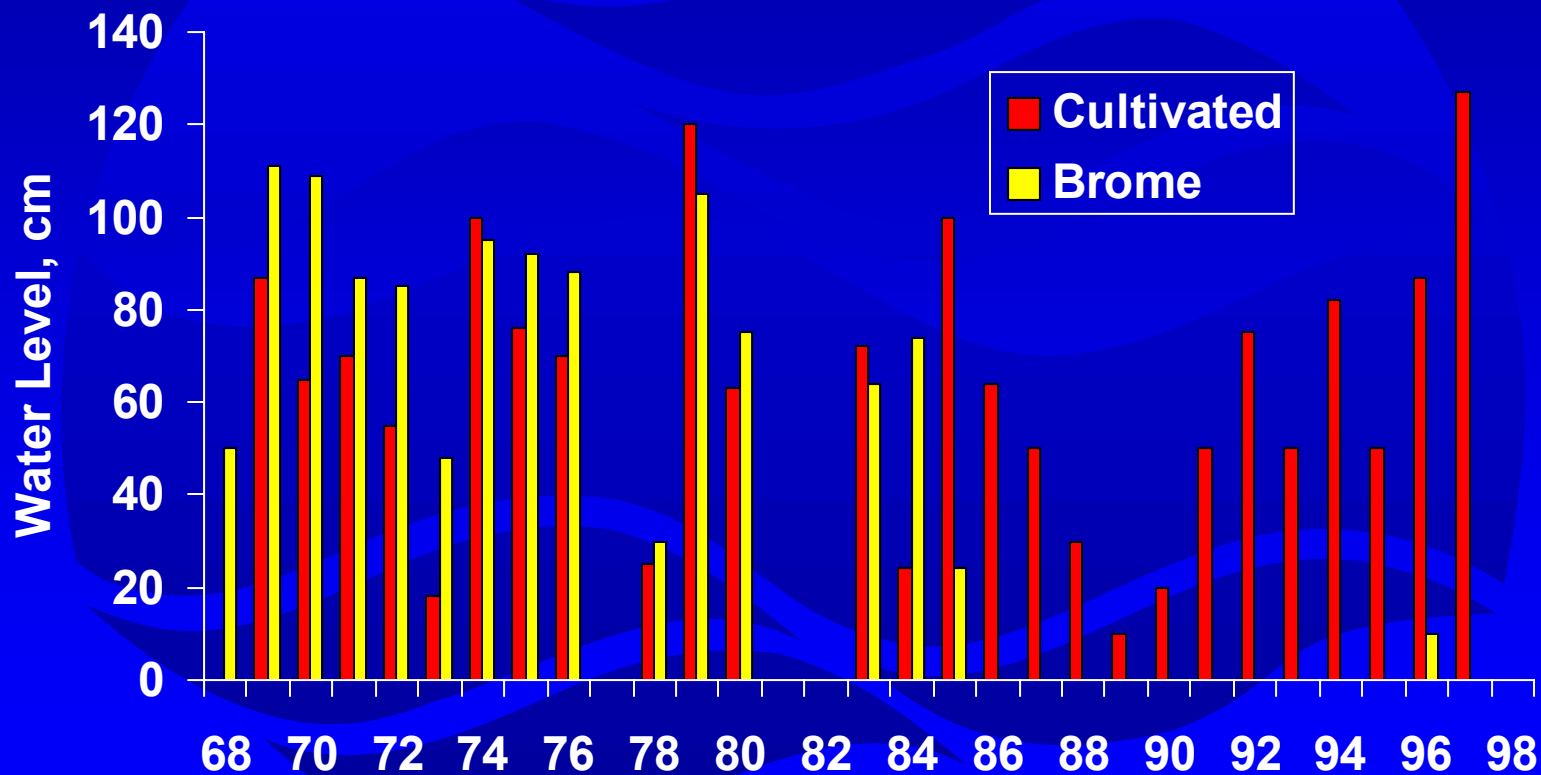
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Unintentional Change

Landuse and Wetlands (van der Kamp)



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Management & Hydrology

- ◆ Zero Tillage
Improved infiltration reduces runoff
- ◆ Fall Tillage
Increases snow redistribution
- ◆ Summerfallow
Increases snow redistribution
Higher soil moisture encourages runoff



Nutrient Loading to Water

Source	TP (10 ³ t/yr)	TN (10 ³ t/yr)
Urban		
MWTPs	6	80
Sewers	2	12
Septic Systems	2	15
Industry	2	12 (NH ₄ ⁺ & NO ₂ ⁻ only)
Agriculture (residual in the field after crop harvest)	55	293
Aquaculture	0.5	2
Atmospheric deposition to water	n/a	182 (NH ₄ ⁺ & NO ₂ ⁻ only)

Source: Nutrients & their Impact on the Canadian Environment

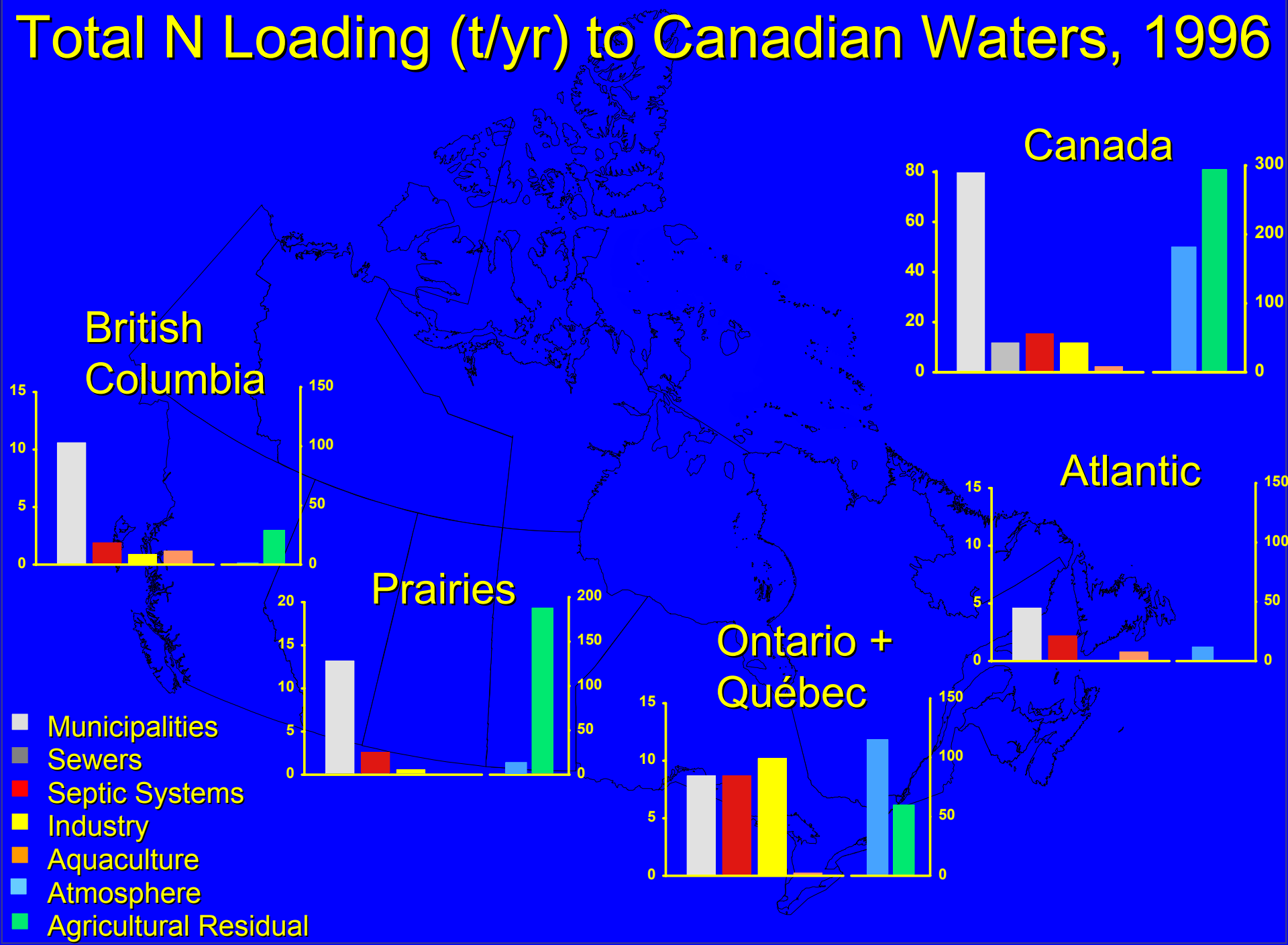


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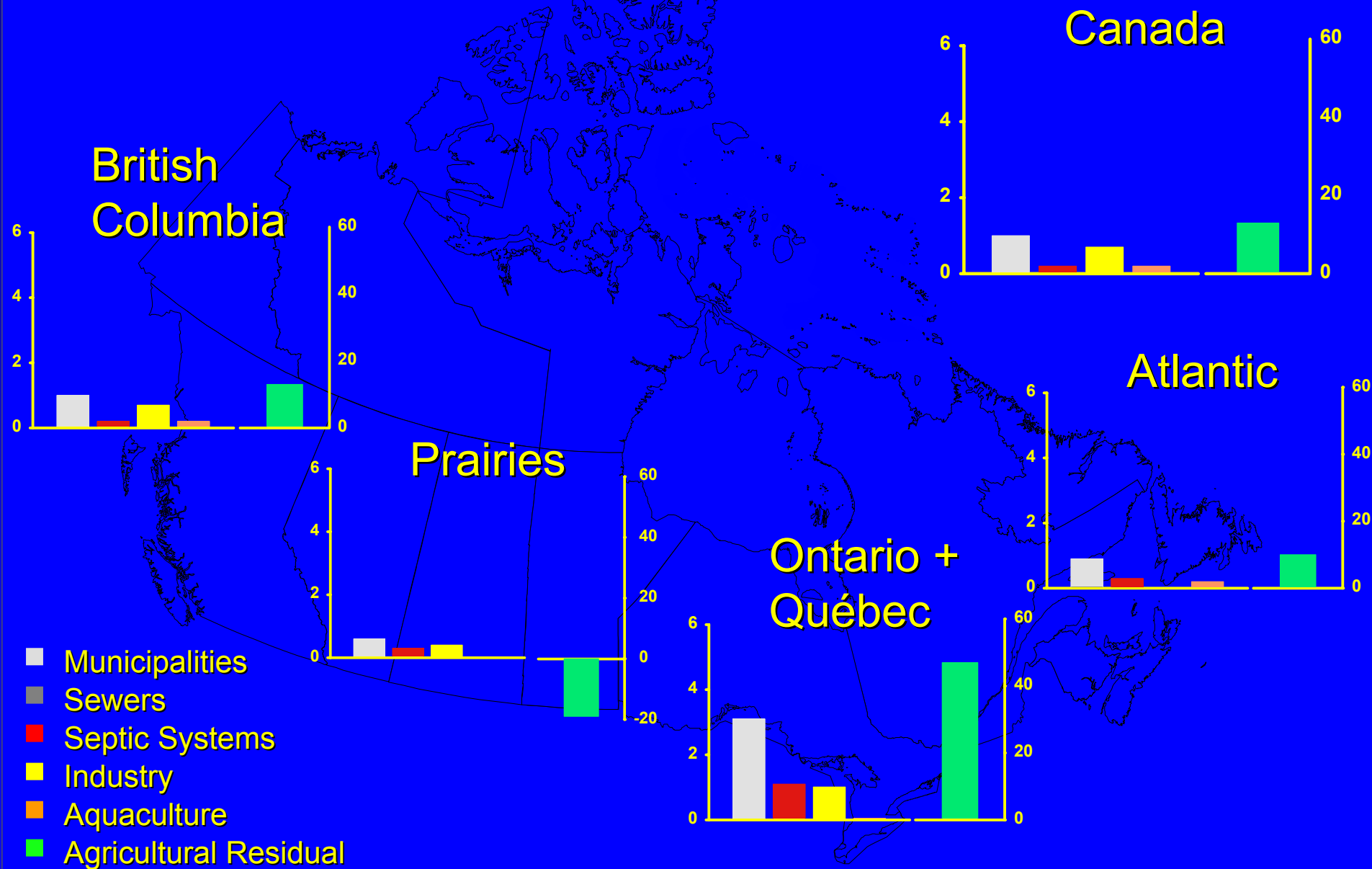
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Total N Loading (t/yr) to Canadian Waters, 1996

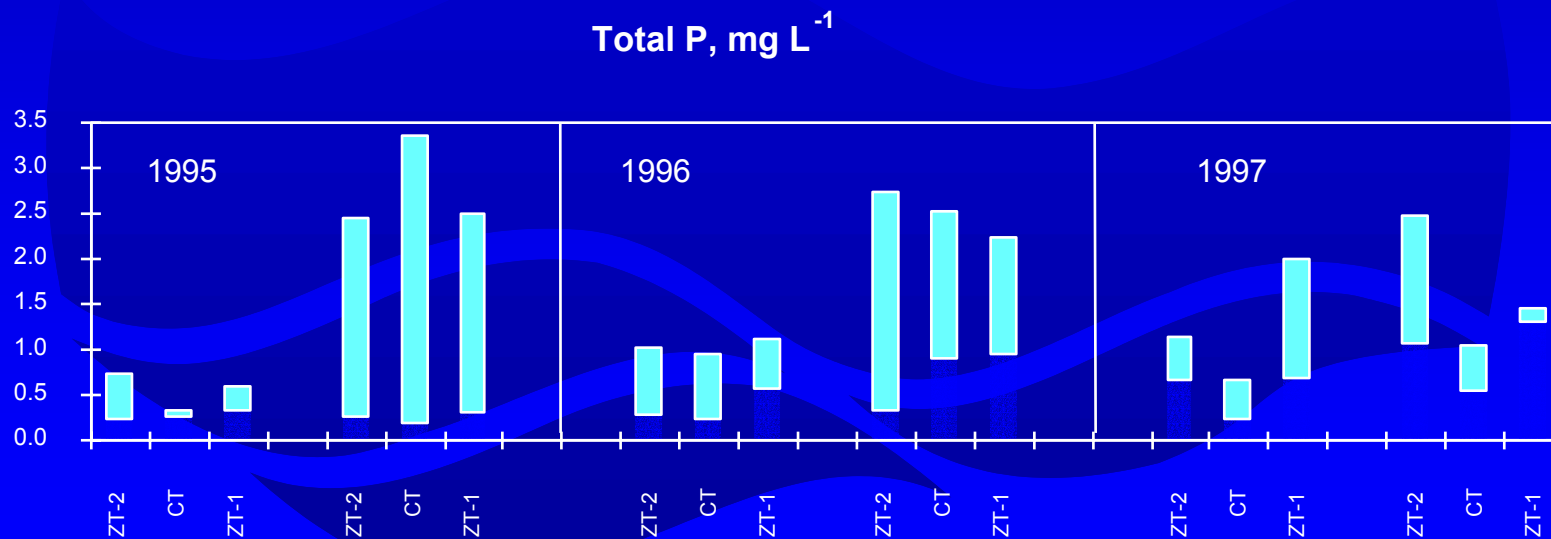


Total P Loading (t/yr) to Canadian Waters, 1996



Fertilizer & Water Quality

- ◆ NO_3 moves into soil with infiltrating water
- ◆ P fertilizer applications may accumulate in surface soil



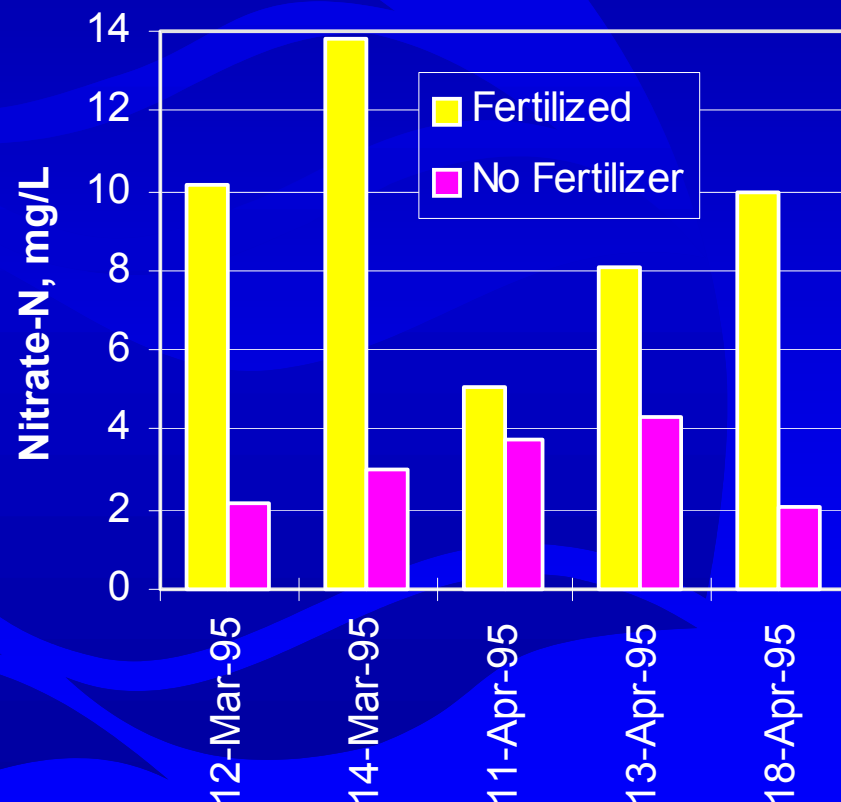
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Fertilizer for Winter Wheat

- ◆ Application of fertilizer to snow pack
- ◆ Salt melts through snow and is carried into soil with first snowmelt
- ◆ Timely supply of nutrients to crop



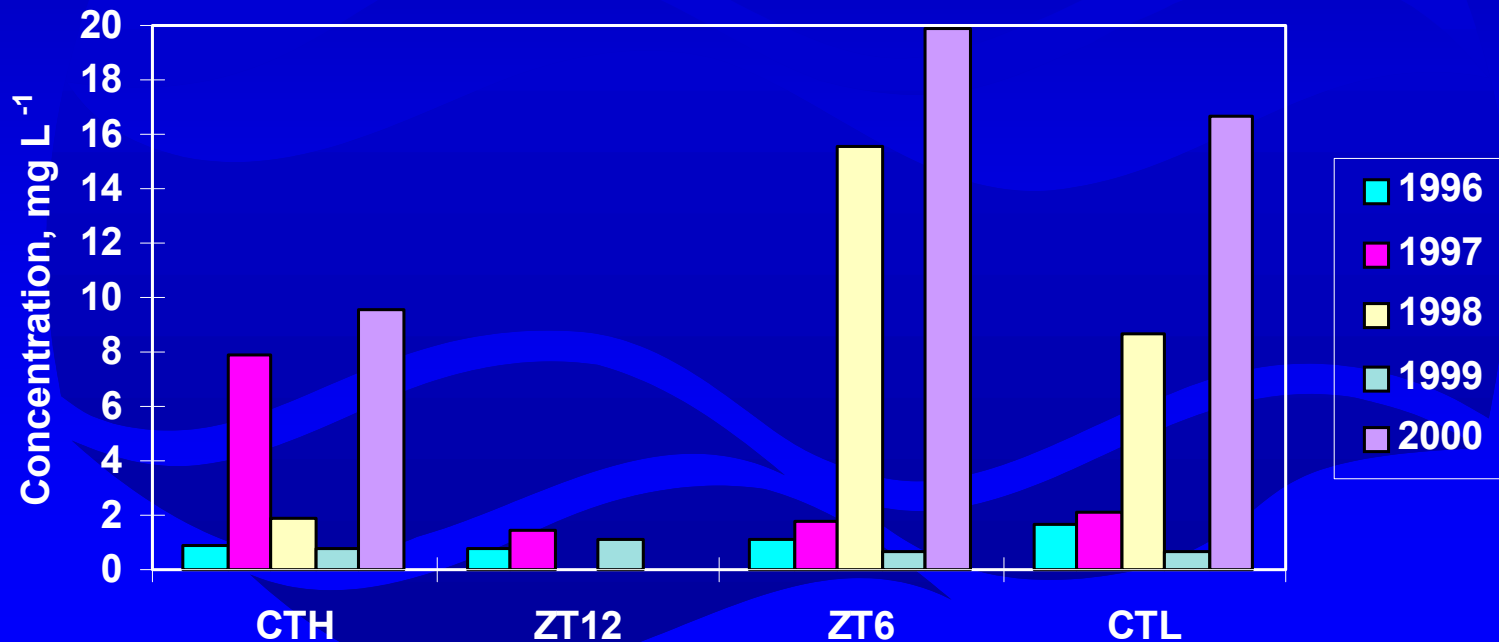
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Summerfallow & N in Runoff

- ◆ Fallow conditions lead to higher NO_3 concentrations in snowmelt runoff



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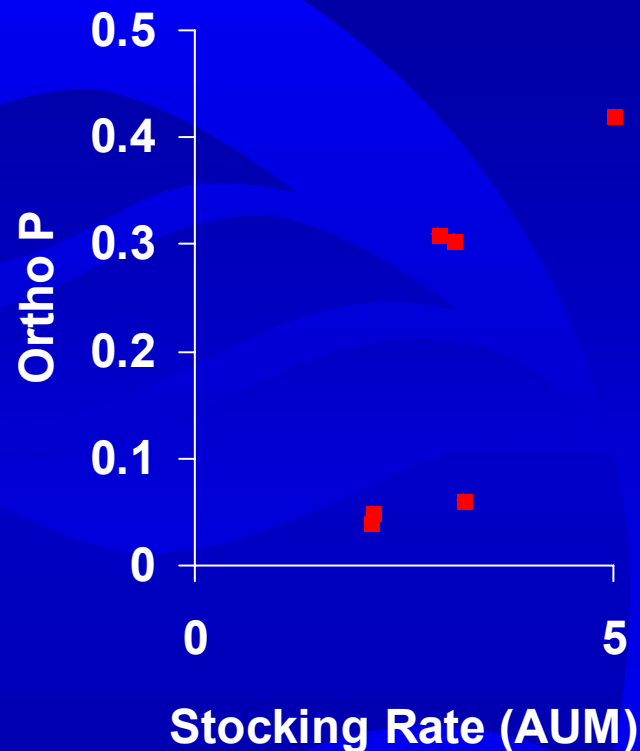
Manure

- ◆ Source of nutrients & pathogens
 - NH_3 & P
 - Bacteria, Protozoa, Viruses
- ◆ Pathways
 - Grazing
 - Overwintering
 - Storage
 - Field Application



Grazing

- ◆ Stocking rate influence runoff water quality
- ◆ Provision of alternate water source, shelter and feed



(Chu et al. 1996)



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Overwintering

- ◆ Same concerns as grazing:
- ◆ Higher stocking rate
- ◆ Shelter by creek
- ◆ Frozen ground
- ◆ Snowmelt

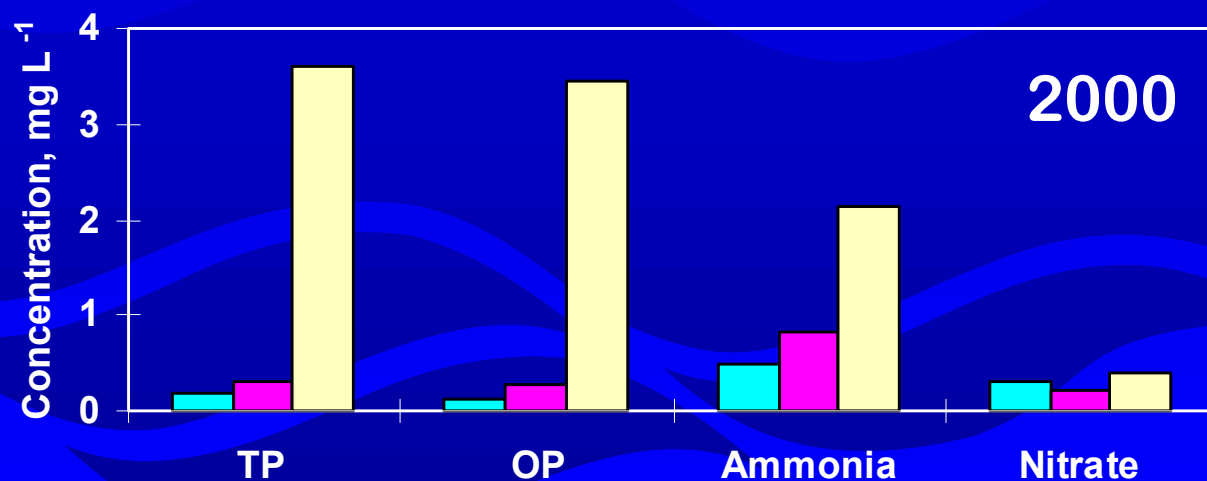
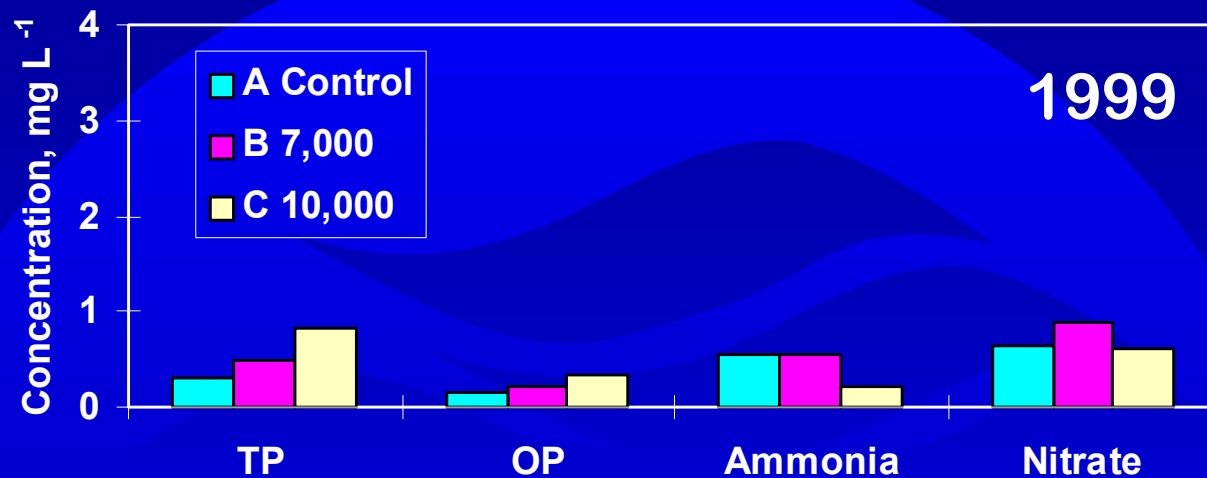


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Field Application - Snowmelt



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Field Application Simulated Runoff

	Total P	Ortho P	NH ₃	NO ₃	DOC	Cl	Coliform
	mg L ⁻¹					ct/100mL	
Before Manure							
A	2.30	0.26	0.28	0.39	7.80	3.48	1700000
B	1.21	0.03	0.21	0.22	5.34	4.03	
C	1.85	0.03	0.13	0.09	5.15	3.21	26200
Rain	0.02	0.01	0.17	0.04	3.06	3.29	>24000
After Manure							
A	0.61	0.04	0.42	0.75	6.24	25.39	249
B	1.98	0.94	1.76	5.16	9.21	29.94	17
C	0.88	0.23	0.69	3.62	6.77	34.27	127
Rain	0.01	0.00	0.44	1.50	4.85	31.20	<1

A is Control B is 7,000 gal/ac C is 10,000 gal/ac



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Sediment Issues

Stream Bank Erosion

- ◆ Direct cattle access
Alternative water source
- ◆ Flooding
Riparian Management
Upland management



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Upland Sediments

- ◆ Soil Erosion
Conservation tillage
- ◆ Landuse interactions
Water storage on uplands
- ◆ Runway Erosion
Grassed waterways



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Pesticides

- ◆ Irrigation return flow studies show that water that has passed over treated land contains pesticides
- ◆ Soil-incorporated pesticides are transported through soil erosion
- ◆ Soluble pesticides are transported in water if runoff occurs soon after application
- ◆ Pesticides persist and accumulate in sediments



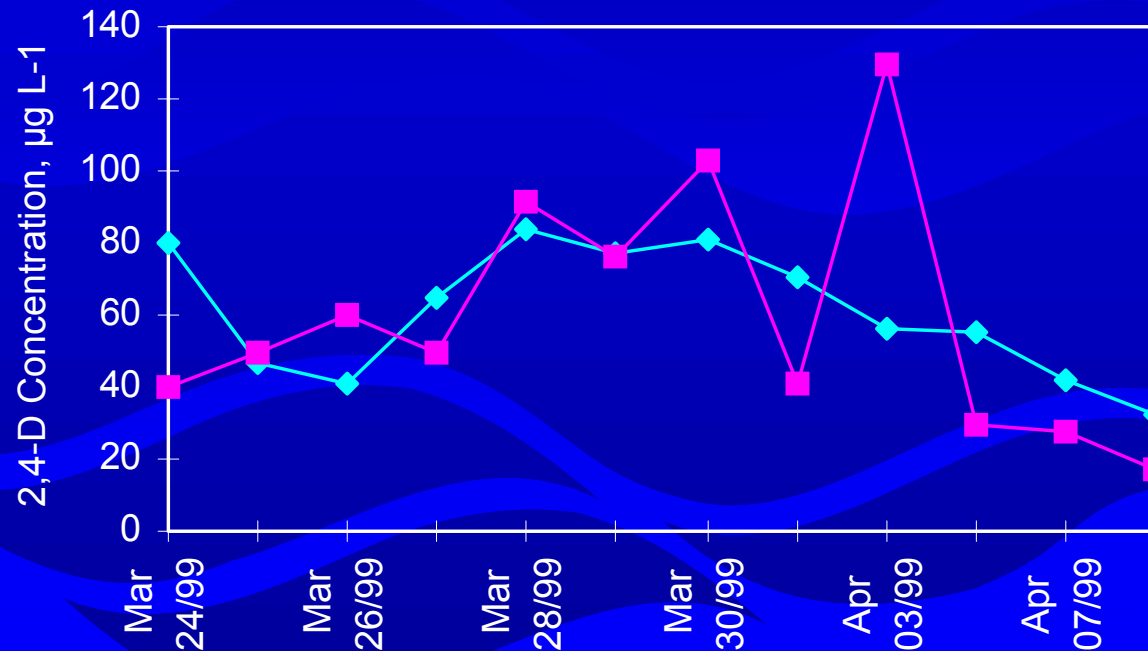
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Fall Pesticide Applications

- ◆ Late fall pesticide applications may not break down during the winter



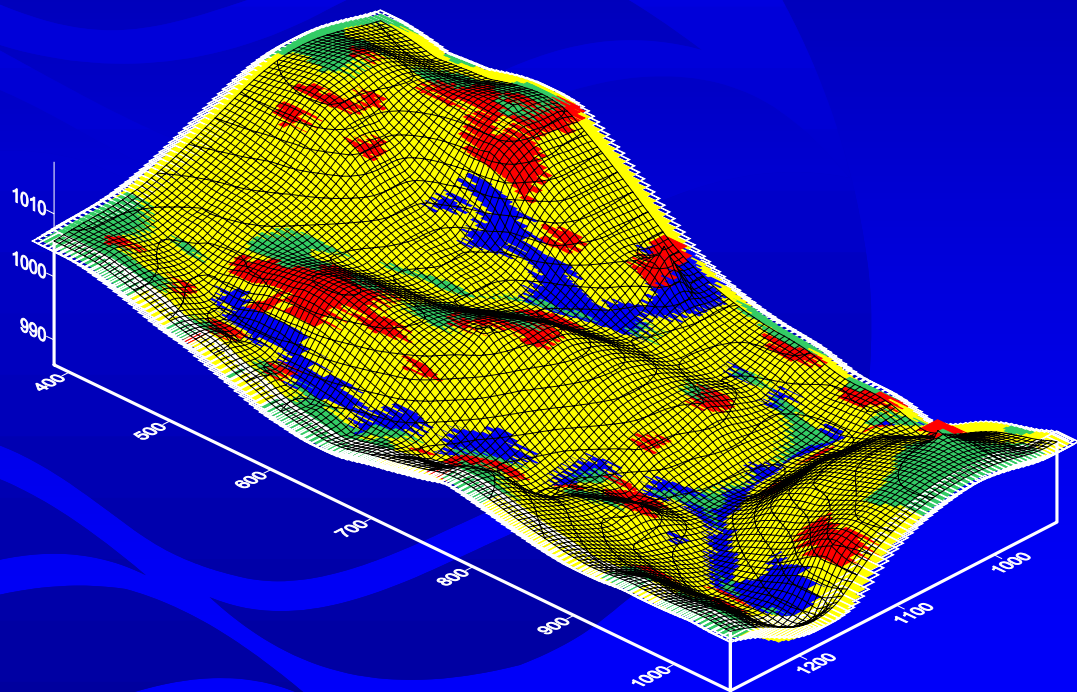
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BMPs & Contributing Area

- ◆ Where should BMPs be employed?
- ◆ Where is runoff generated?
- ◆ Does runoff reach the stream ?



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Conclusions

- ◆ Agriculture does impact water quality often through complicated mechanisms
- ◆ Best Management Practices can minimize impacts
- ◆ New BMPs should
 - Look at whole system
 - Cost effective where possible
 - Follow up is important

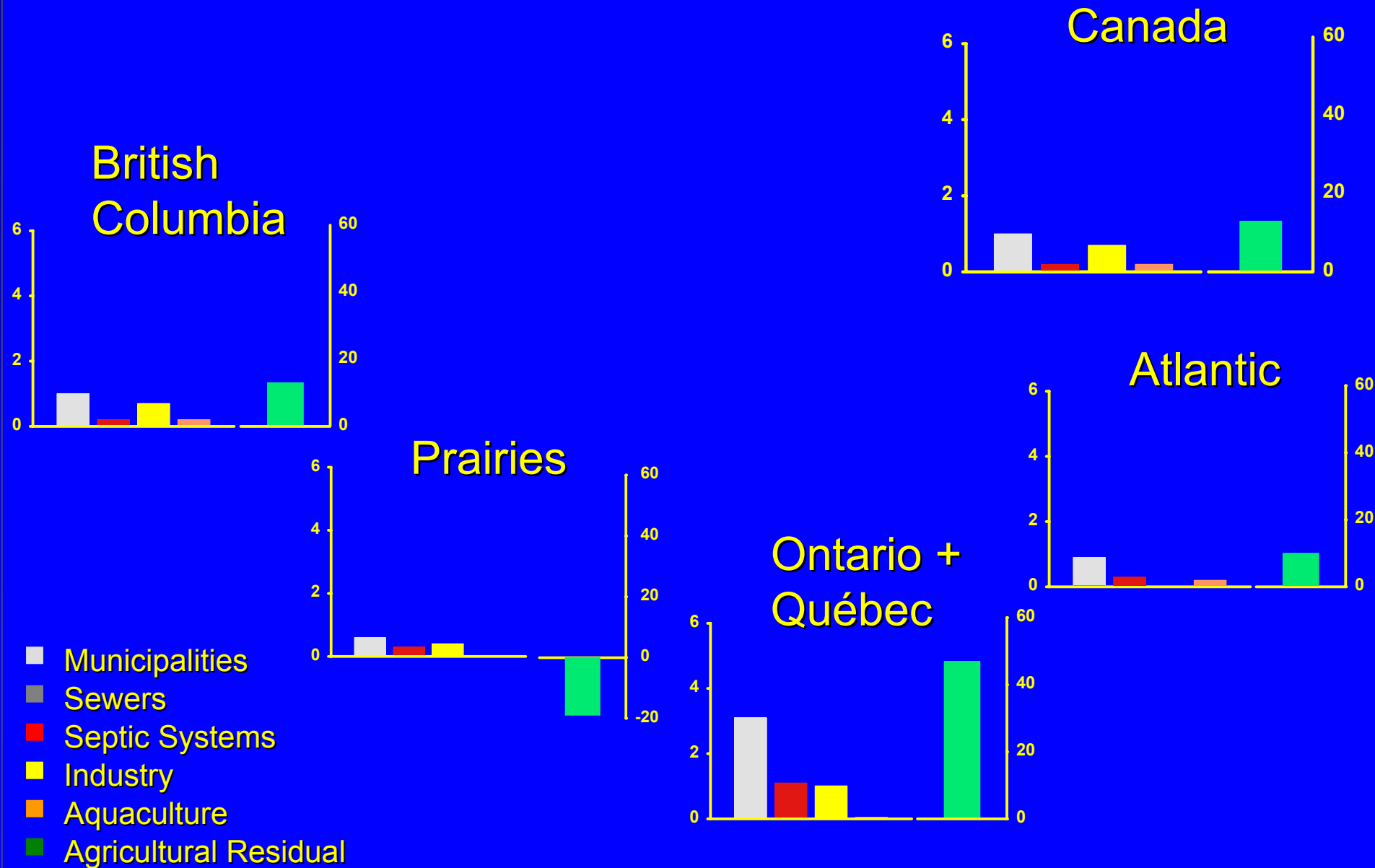


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Total P Loading (t/yr) to Canadian Waters, 1996



Total N Loading (t/yr) to Canadian Waters, 1996

