Integration of Watershed Planning and the APF for the Provision of ES:

A Pilot Watershed Approach for Wetland Restoration and Retention

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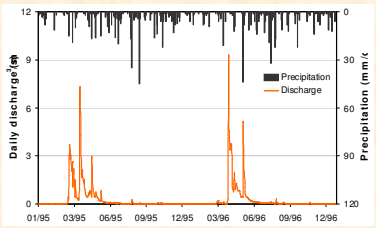
Presentation Outline

1. Introduction
2. The South Tobacco Creek watershed
3. Scenario development
4. The SWAT model
6. Preliminary results
7. Conclusion

Hydrologic Characteristics of Prairie Watersheds

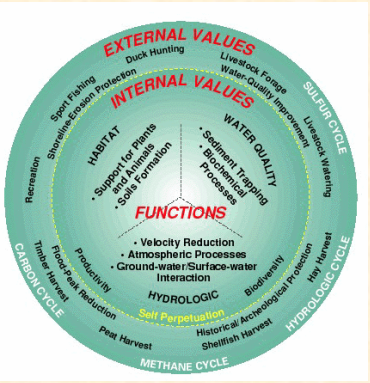
a) Semiarid
b) Cold
c) Flat
d) Potholes and depressions
e) Cultivated
f) Clay-rich soils
g) Spring snowmelt



Wetlands Functions and Values at Watershed Scale

1. Habitat
2. Hydrologic / water quality
   - Flood remediation
   - Sediment trapping
   - Nutrient removal
   - GW recharge and sustain low flow

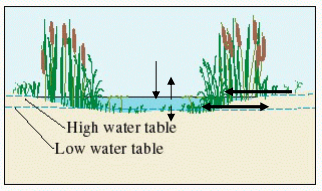
Not all wetlands perform functions equally well.
- Location/type/size
- Drainage area
- Management



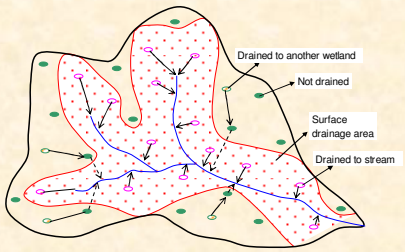
USGS National Water Summary on Wetland Resources

Wetland Restoration in Praire Watersheds

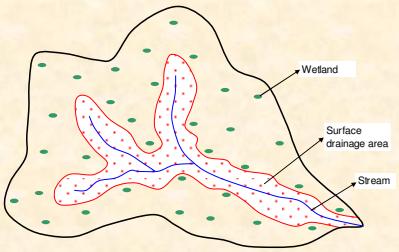
- Semi-arid/cold/snowmelt
  - Reduce spring flood risk
  - less evaporation
  - Sustain moisture and low flow
- Cultivated/grazing land
  - Many wetlands were drained
  - Heavy nutrient load
- Flat/clay-rich soils
  - Less soil erosion & sediment deposition
  - Dissolved nutrient >> Particulate nutrient
  - Less leakage/percolation
  - Nutrient local cycle (internal & external)



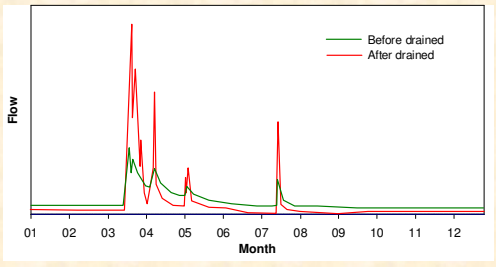
Flow Responses after Wetland Restoration



Before



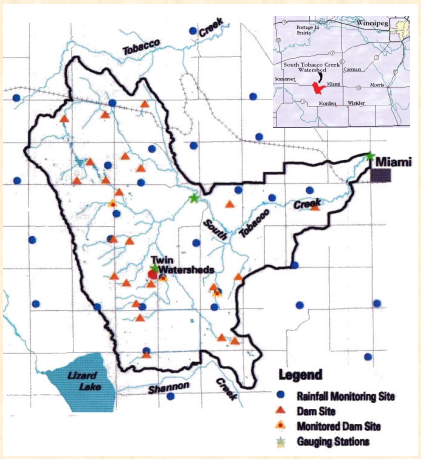
After



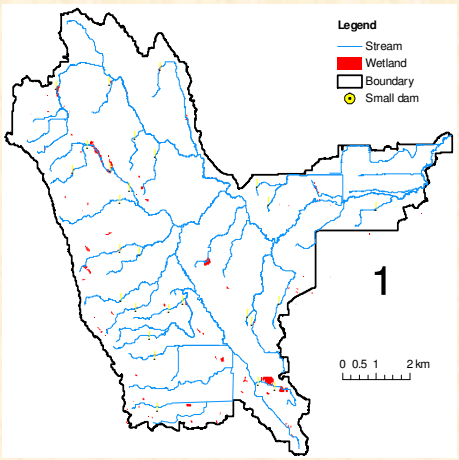
Research Objectives

- Develop an integrated economic and wetland-watershed hydrologic modelling system to estimate the restoration costs and water quality benefits of STC wetlands
- Calibrate and validate the integrated modelling system to fit into the conditions of the STC watershed
- Apply the integrated modelling system to prioritize locations for wetland restoration

The STC Watershed

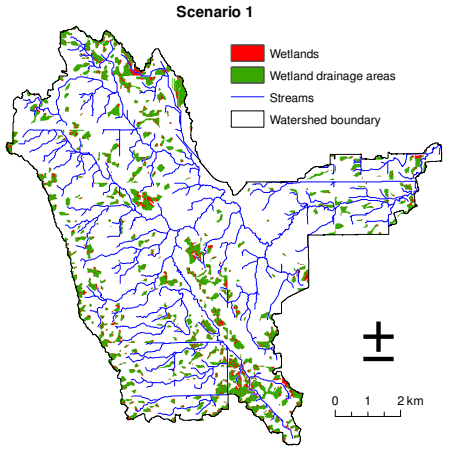


Location & monitoring stations

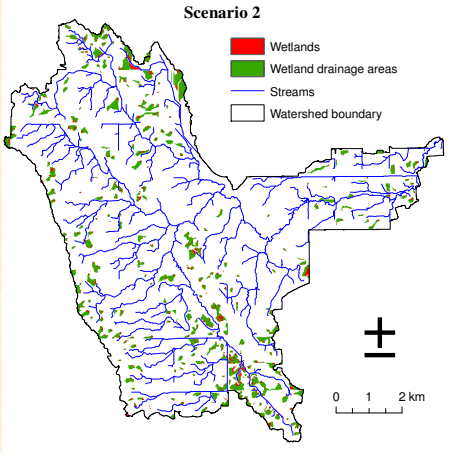


Existing wetlands (46.7ha, 0.6%)

Wetland Restoration Scenarios

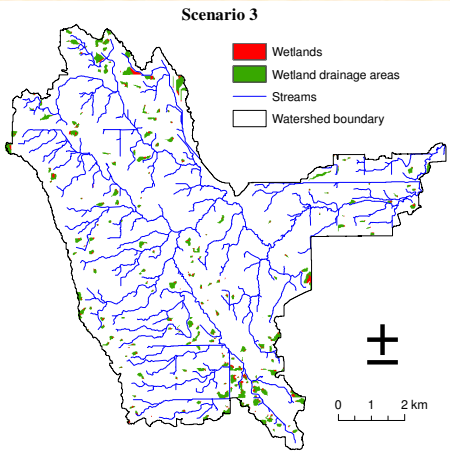


185ha, 2.49%

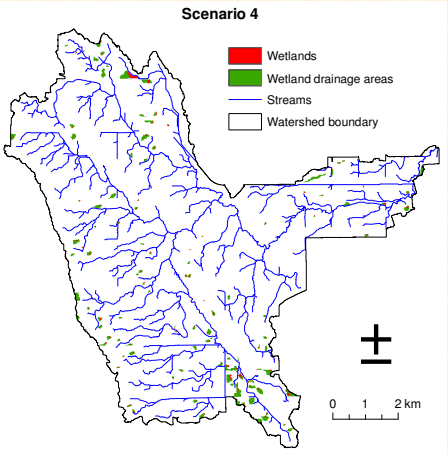


92.5ha, 1.24%

Wetland Restoration Scenarios

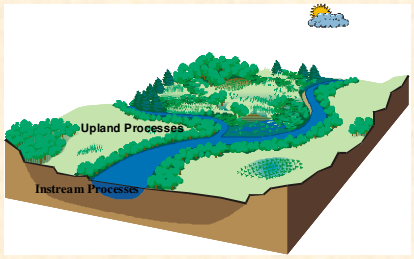


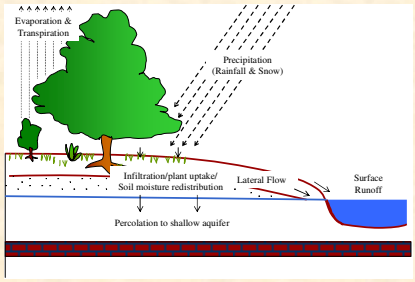
47.0ha, 0.63%



22.4ha, 0.30%

The SWAT Model

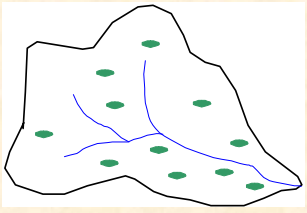


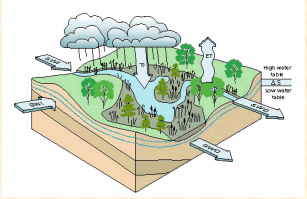


- Soil & Water Assessment Tool, USDA-ARS
- Spatial Scale: watershed or river basin
- Time scale: Continuous, daily
- Data organization: subbasins or hydrologic response units (HRU's)
- Land phase and routing phase modeling are based on mass balance calculations
- Inputs: weather, soil properties, topography, land use, and land management practices
- Outputs: simulated flow, sediment, and chemical concentrations at river reach, subbasin and HRU level

Wetland Module in SWAT

The concept of hydrologically equivalent wetland





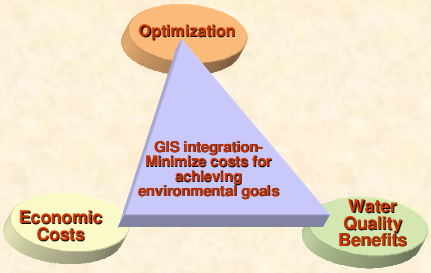
Parameter	Definition	Value
IPND1	Beginning month of mid-year nutrient settling season	4
IPND2	Ending month of mid-year nutrient settling season	10
WET_FR	Fraction of subbasin area that drains into wetlands	Calculation
WET_NSA	Surface area of wetlands at normal water level (ha)	Calculation
WET_NVOL	Volume of water stored in wetlands when filled to normal water level ($10^4 m^3$)	Calculation
WET_MXSA	Surface area of wetlands at maximum water level (ha)	WET_NSA
WET_MXVOL	Volume of water stored in wetlands when filled to maximum water level ($10^4 m^3$)	WET_NVOL
WET_VOL	Initial volume of water in wetlands ($10^4 m^3$)	0
WET_SED	Initial sediment concentration in wetland water (mg/L)	0
WET_NSED	Equilibrium sediment concentration in wetland water (mg/L)	0.35
WET_K	Hydraulic conductivity of bottom of wetlands (mm/hr)	0.25
PSETLW1	Phosphorus settling rate in wetland for months IPND1 through IPND2 (m/year)	10
PSETLW2	Phosphorus settling rate in wetlands for months other than IPND1-IPND2 (m/y)	10
NSETLW1	Nitrogen settling rate in wetlands for months IPND1 through IPND2 (m/y)	5.5
NSETLW2	Nitrogen settling rate in wetlands for months other than IPND1-IPND2 (m/y)	5.5
CHLAW	Chlorophyll α production coefficient for wetlands	1
SECCIW	Water clarity coefficient for wetlands	1
WET_NO3	Initial concentration of NO3-N in wetland (mg N/L)	0
WET_SOLP	Initial concentration of soluble P in wetland (mg P/L)	0
WET_ORGN	Initial concentration of organic N in wetland (mg N/L)	0
WET_ORGP	Initial concentration of organic P in wetland (mg P/L)	0

Economic Costs of Wetland Restoration (Alberta Research Group)

- Forgone cropping returns
- Restoration engineering costs
- Nuisance costs

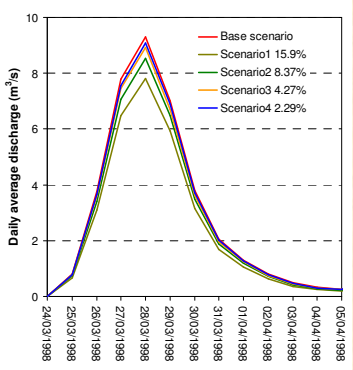
Cost-Effective Targeting of Wetland Restoration

- Baseline scenario
  SWAT simulation without wetland restoration
- Assessing environmental benefits of wetland restoration scenarios
- Integrated economic-hydrologic modeling framework

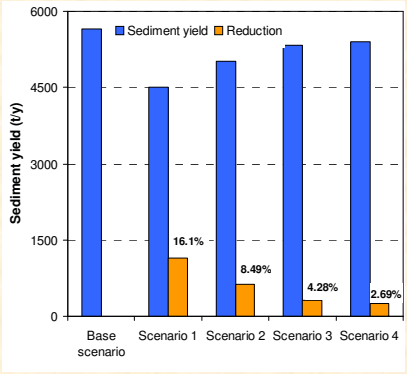


Effects of Wetland Restoration

Flood Attenuation

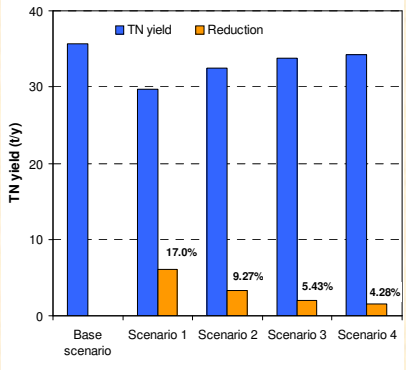


Sediment yield

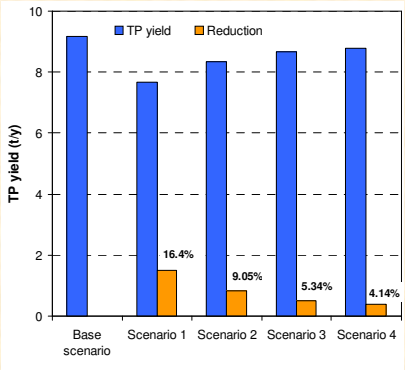


Effects of Wetland Restoration

TN yield



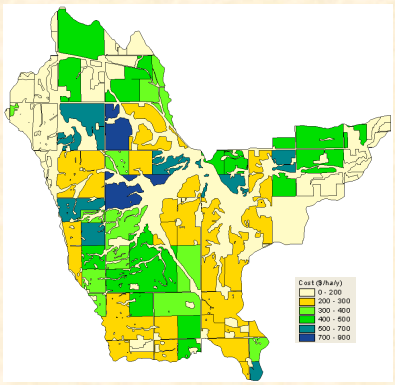
TP yield



Spatial Variations of Economic Cost and Water Quality Benefit

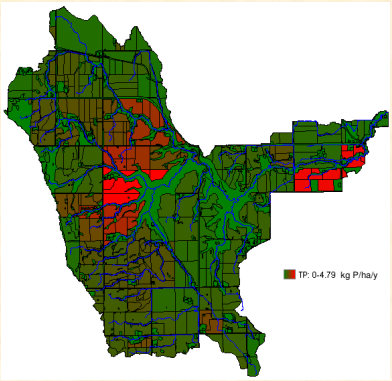
Economic cost

(Scenario4, $/ha/y)

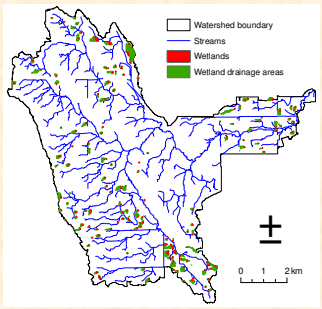


Water quality benefit

(Scenaro4, TP reduction at farm level, kg P/ha/y)



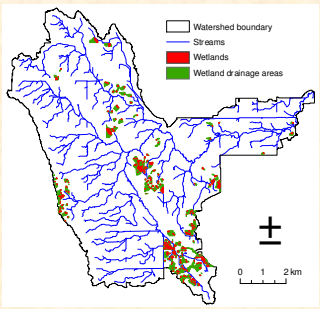
Evaluation of Two Policy Scenarios



Targeting scenario

Based on benefit to cost ratios

Minimize economic costs to achieve water quality goals



Price ceiling scenario

Based on economic cost only

Minimize economic costs subject to a price ceiling

Scenario	Area	TN	TP	Total cost	Avg. cost	TN-C/B ratio	TP-C/B ratio
	(ha)	(t/y)	(t/y)	($)	($/ha)	($/t)	($/t)
Targeting	28.5	1.71	0.432	10874	475	6400	24500
Price Ceiling	60.2	1.88	0.436	17642	272	8500	35400

Conclusions

- Wetland restoration provides significant benefits in reduction of sediment and nutrient yield at watershed scale
- Considerable spatial variations of economic costs
- Considerable spatial variations of wetland quality benefits
- Spatial targeting scenario is much more efficient in water quality benefits
- Spatial targeting is much more efficient in ecological benefits