Transforming the Agricultural Landscape, One Field at a Time

David A. Lobb
Watershed Systems Research Program /
Department of Soil Science
University of Manitoba

Potato Research Centre
April 26th, 2012
Fredericton, New Brunswick

Outline

Where we at, and how did we get here?

Where could we go in the future?

My vision of prairie agricultural landscapes in 2037

Thoughts on the future of agricultural landscapes further east

Where Are We At? and, How Did We Get Here?

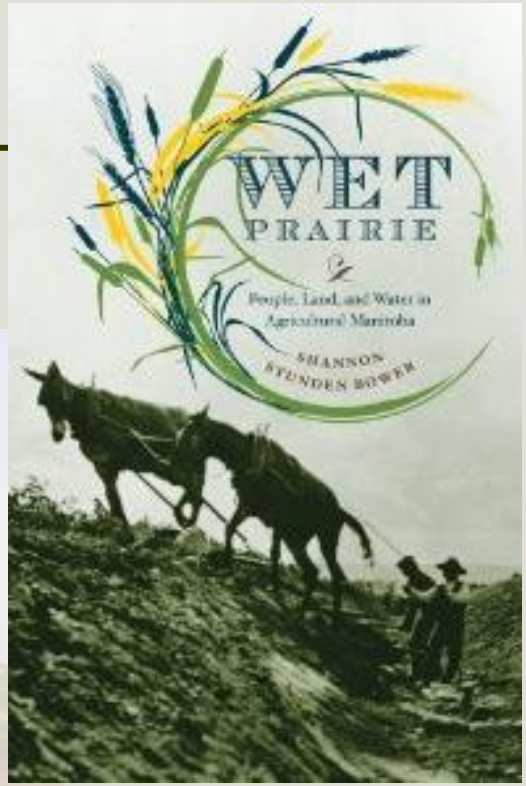
The History of Land Improvement in the Prairies

Where Are We At? and, How Did We Get Here?

The History of Land Improvement in the Prairies

Where Are We At? and, How Did We Get Here?

The History of Land Improvement in the Prairies



Where Are We At? and, How Did We Get Here?

The History of Land Improvement in the Prairies

Where Are We At? and, How Did We Get Here?

The Current State of Agricultural Landscapes

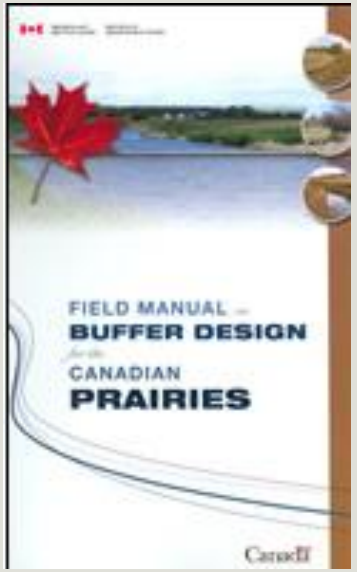
Where Are We At? and, How Did We Get Here?

The History of Land Improvement in the Prairies

Soil erosion and the degradation of soil quality gave rise to further land improvements:

Where Are We At? and, How Did We Get Here?

The History of Land Improvement in the Prairies



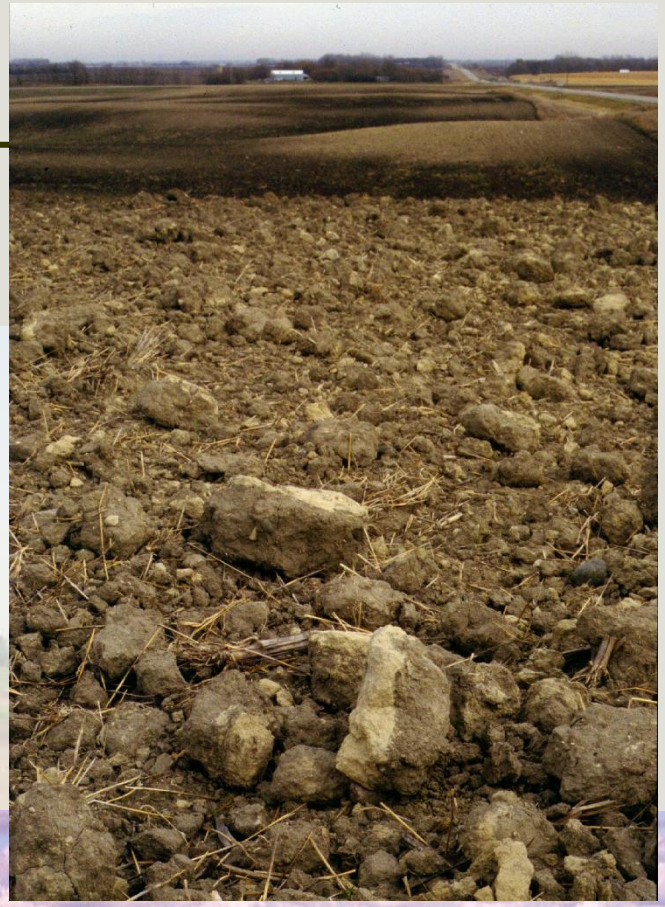
Water contamination and the degradation of water quality gave rise to further land improvements:

Where Could We Go?

A Vision For The Future

Where Could We Go?

A Vision For The Future



Integrated Soil Conservation:

⇨reduced soil erosion,

less crop residue on the soil surface?

* emphasis on reducing soil movement,
not maximizing crop residue cover

Where Could We Go?

A Vision For The Future

Integrated Soil Conservation:

⇨reduced soil erosion,

Where Could We Go?

A Vision For The Future

Conservation Tillage: primary tillage operations:

- In comparison to the mouldboard plough, the chisel plough may leave more crop residue on the soil surface (protecting against wind and water erosion), but it can move more soil further and with greater variability.

Where Could We Go?

A Vision For The Future

Conservation Tillage: tertiary tillage operations:

- All operations that disturb and move soil can cause significant levels of tillage erosion.

Where Could We Go?

A Vision For The Future

Conservation Tillage: seeding operations:

- High disturbance seeders can be as erosive as the mouldboard plough.

Tillage translocation and tillage erosivity of seeding operations

Seeding Tool	Tillage System	Tillage Translocation: Soil movement on level land			Tillage Erosivity: Tillage translocation variability on sloping land
		T_L (m) [a]	λ_{90} (m) [a]	T_M (kg m^{-1}) [a]	β (kg m^{-1} $\%^{-1}$) [a]
Air-seeder with Knives [b]	Conventional Tillage	0.10	0.69	4.4	0.1
Cultivator plus Air-seeder with Knives [b]	"	0.41	1.05	35	1.0
Air-seeder with Knives [c]	Zero-Till	0.16	0.88	8.2	0.1
Air-seeder with Sweeps [c]	"	0.51	1.33	30	1.0

[a] T_L = average distance of soil movement in till-layer; λ_{90} = distance to which 90% of translocated soil is moved; T_M = mass of soil moved per m width of tillage; β = mass of soil moved per m width of tillage per % of slope grade (+ve downslope).

[b] Experiments carried out in Manitoba, Canada, 2004.

[c] Experiments carried out in Saskatchewan, Canada, 2006.

Where Could We Go?

A Vision For The Future

Integrated Soil and Water Conservation:

⇨less crop residue on the soil surface

* emphasis on dissolved P from crop residues

Where Could We Go?

A Vision For The Future

Integrated Soil and Water Conservation:

⇨less crop residue on the soil surface

* emphasis on dissolved P from crop residues

Conventional vs. conservation tillage in snowmelt dominated runoff:

South Tobacco Creek
WEBs Twin Watersheds Study

- Edge-of-field runoff monitoring
- 80% of overall runoff was snowmelt

Where Could We Go?

A Vision For The Future

Integrated Soil and Water Conservation:

⇨less crop residue on the soil surface

* emphasis on dissolved P from crop residues

Conventional vs. conservation tillage in snowmelt dominated runoff:

South Tobacco Creek
WEBs Twin Watersheds Study

- Edge-of-field runoff monitoring
- 80% of overall runoff was snowmelt

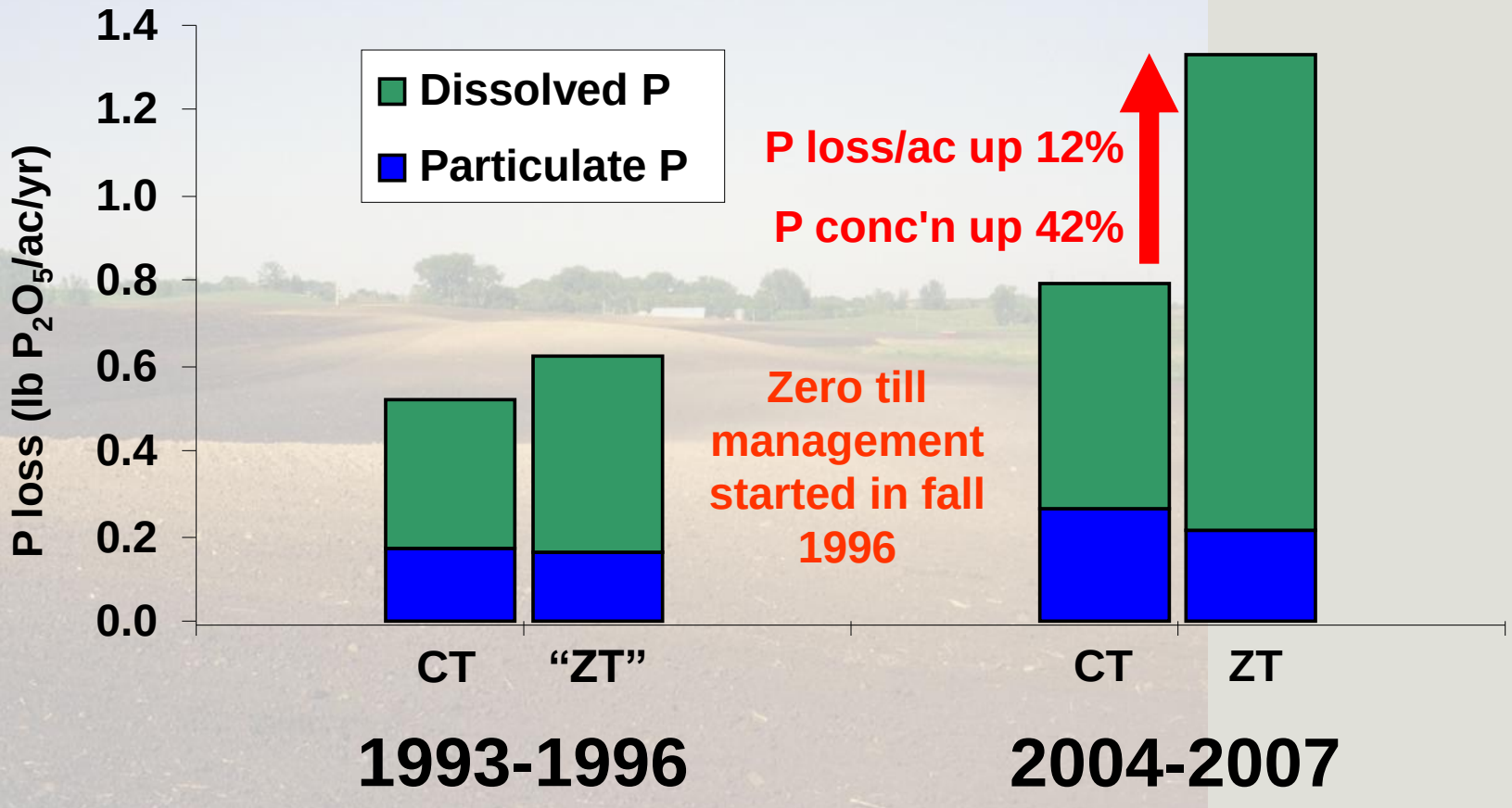
Effects of zero-till on water quality

✔ decreased total N export by 68%

✔ decreased sediment export by 65%

✘ but P was a different story ...

South Tobacco Creek twin watershed study:
average P loss from zero tillage was greater than from conventional tillage ...
because erosion of soil particles was a minor contribution to P loss in both



(Tiessen et al. JEQ 2010)

Where Could We Go?

A Vision For The Future

Integrated Soil and Water Conservation:

⇨less crop residue on the soil surface

* emphasis on dissolved P from crop residues

“Snow trapping” may be the best argument for maintaining crop residue cover on the soil surface.

Where Could We Go?

A Vision For The Future

Integrated Soil and Water Conservation:

⇨larger fields, narrow riparian areas

* less emphasis on vegetative filtering

Where Could We Go?

A Vision For The Future

Integrated Soil and Water Conservation:

⇨larger fields, narrow riparian areas

* less emphasis on vegetative filtering

Vegetated buffer strips not as effective as expected in SE Manitoba (Sheppard et al., 2006)

- DP = 74% of TP, snowmelt dominant runoff
- VBS reduced runoff [TP] in 50% of cases, increased P in 18%, had no effect in 32%
- overall average only 4% reduction in runoff [TP]

Where Could We Go?

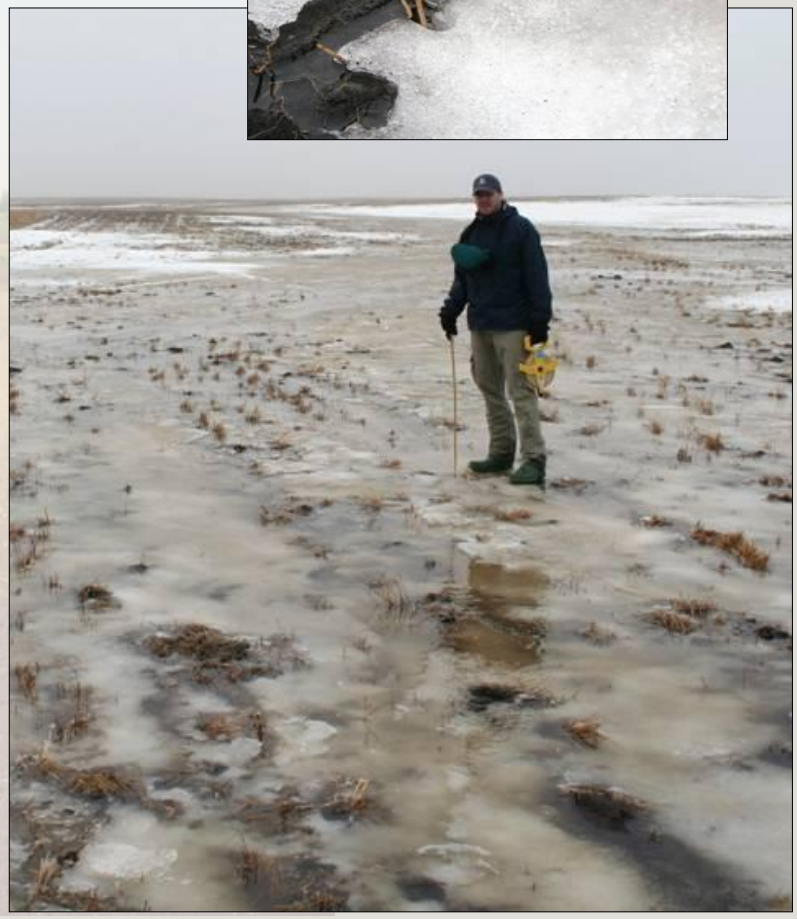
A Vision For The Future

Integrated Soil and Water Conservation:

⇨larger fields, narrow riparian areas

* less emphasis on vegetative filtering

Depth of interaction between runoff and soil is shallow during snowmelt over frozen soil



Where Could We Go?

A Vision For The Future

Integrated Soil and Water Conservation:

⇨larger fields, narrow riparian areas

* less emphasis on vegetative filtering

In-stream and near-stream processes (e.g., vegetated buffers and biological uptake) are minimal during snowmelt

Where Could We Go?

A Vision For The Future

Integrated Soil Conservation:

⇨larger fields, few field boundaries

* less emphasis on windbreaks

Where Could We Go?

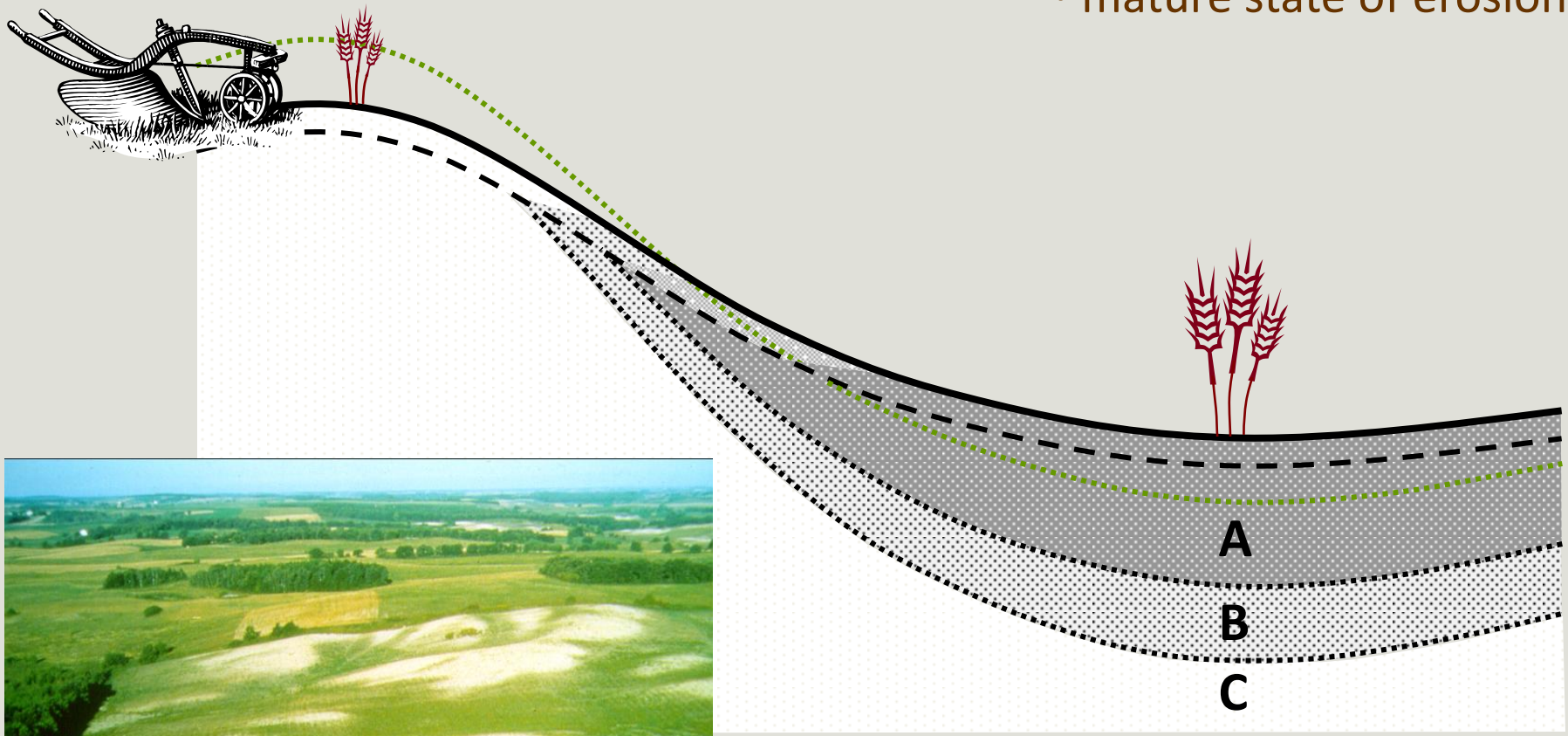
A Vision For The Future

Restoration of Soil-Landscapes:

- ⇨ less severely eroded and more productive hilltops
- ⇨ more functional wetlands

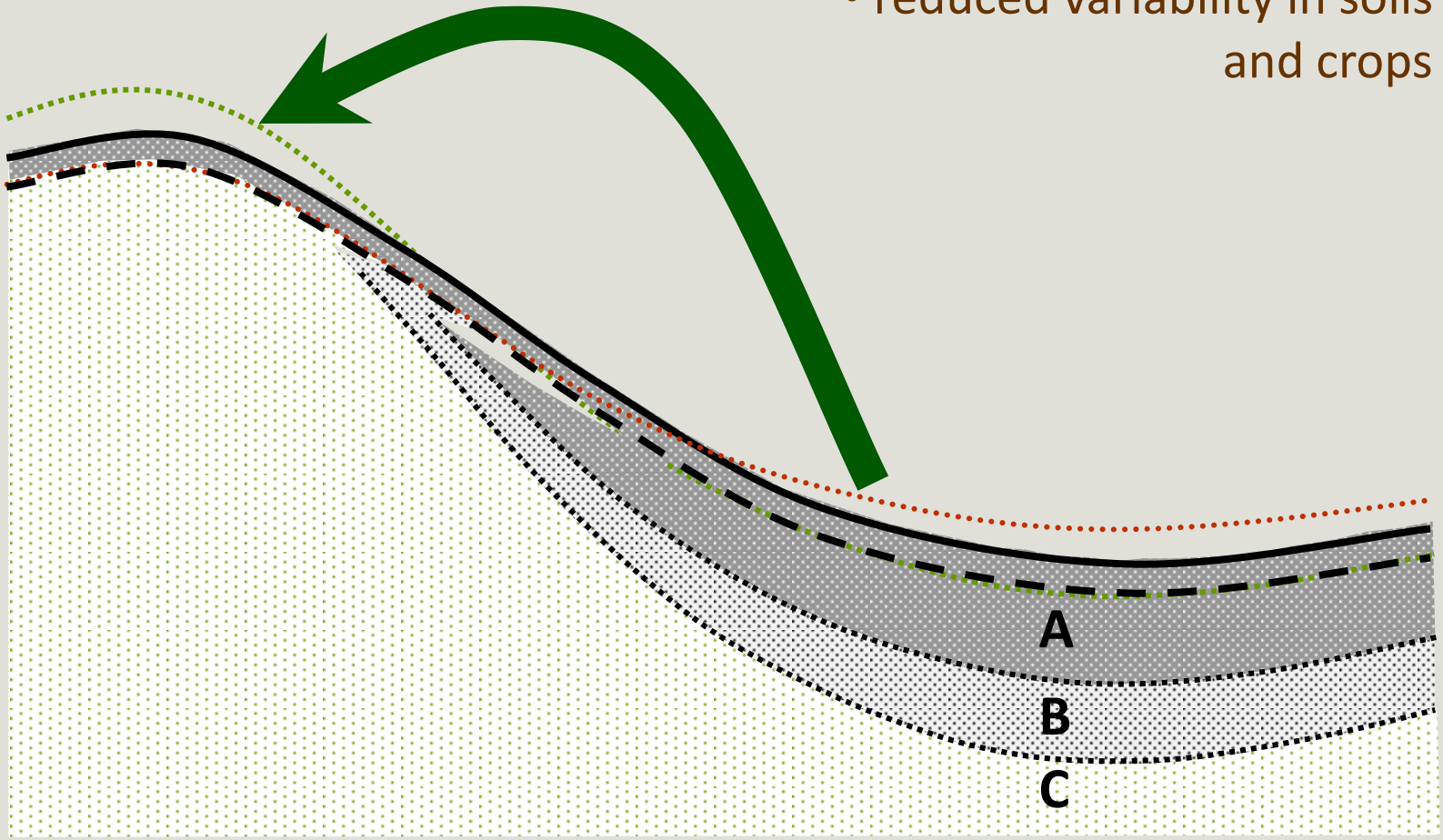
Soil-landscape variability in a hilly landscape

- several decades of cultivation (~1990)
- mature state of erosion



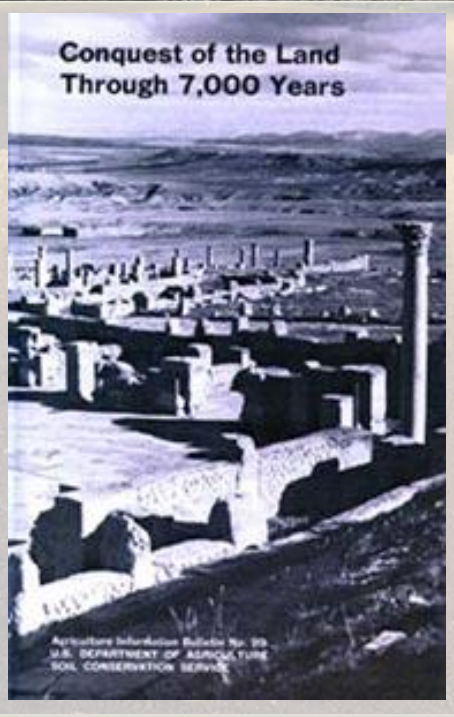
Restored soil-landscape

- reduced variability in soils and crops



Soil-Landscape Restoration

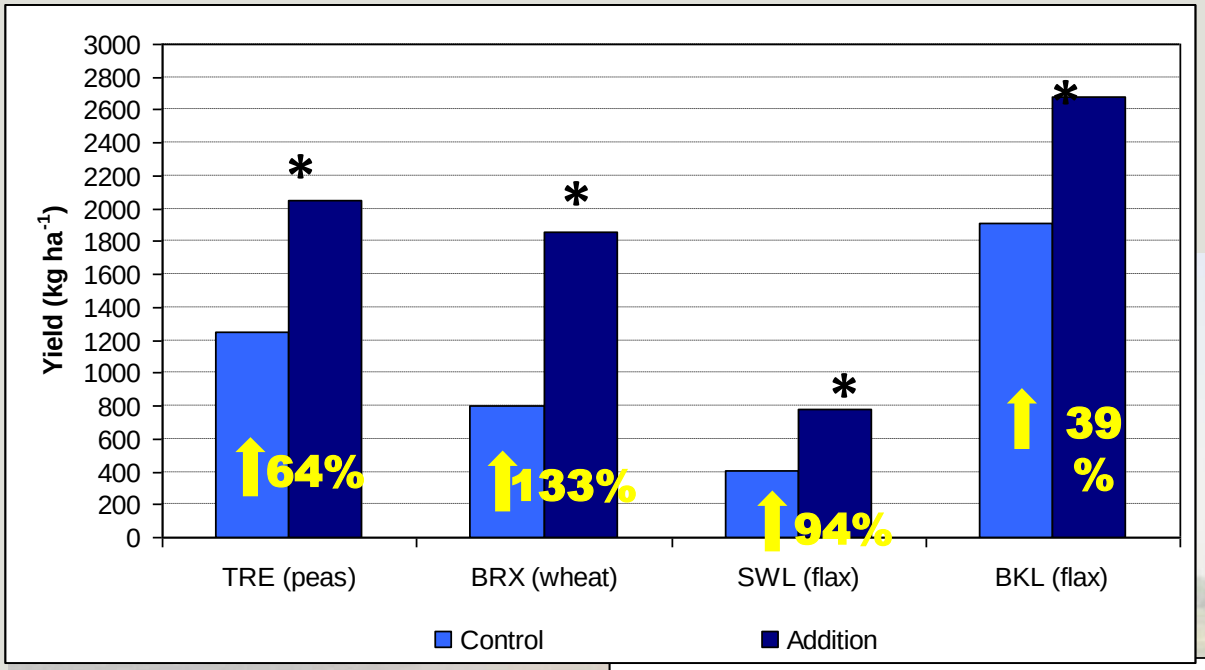
Returning eroded soil to the top of the slope in France in the 1930's.



Soil-Landscape Restoration

Restoration of Soil-Landscapes:

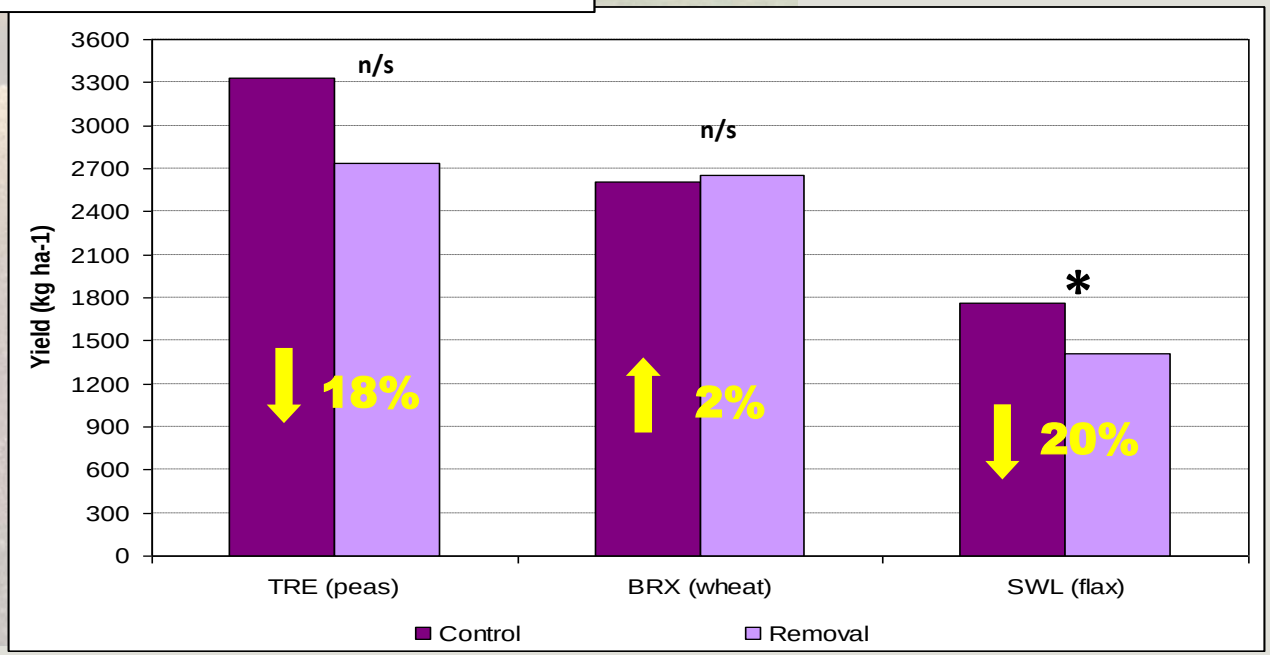
⇨ less severely eroded and more productive hilltops



Upper Slope ↑

Results - Yield

Lower Slope →



**Significant at P<0.10, **Significant at P<0.05,*

Where Could We Go?

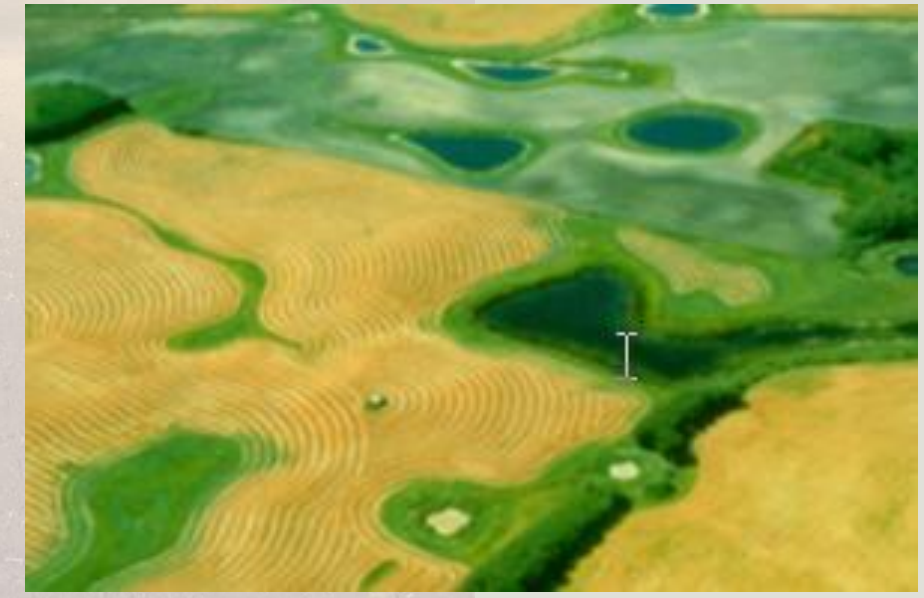
A Vision For The Future

Restoration of Soil-Landscapes:

⇨less severely eroded and more productive hilltops

⇨ more functional wetlands

Prairie Pothole Region



Where Could We Go?

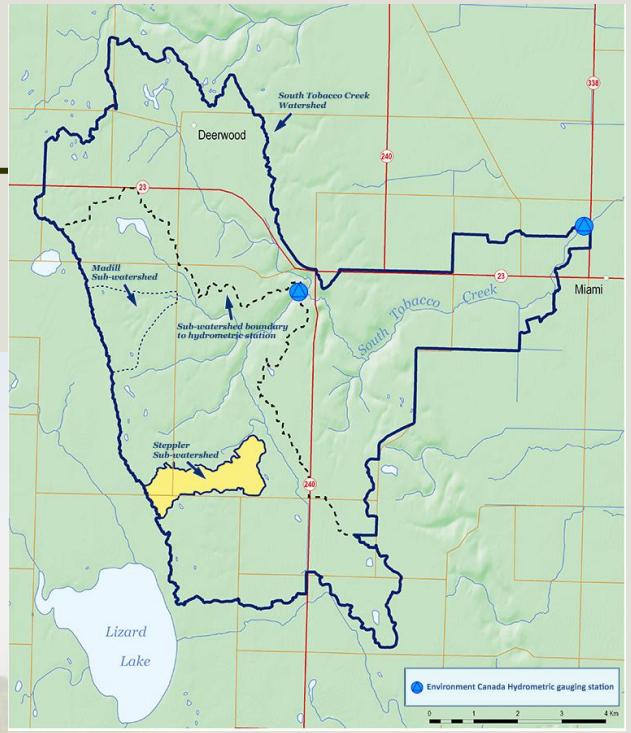
A Vision For The Future

Integrated Management of Surface Water:

⇨ on-farm water retention systems

Where Could We Go?

A Vision For The Future



Integrated Management of Surface Water:

⇨ on-farm water retention systems

Retention dams in the South Tobacco Creek WEBs project reduced loads of:

- sediment (77%)
- TN (15%), TDN (14%)
- TP (12%), TDP (10%)

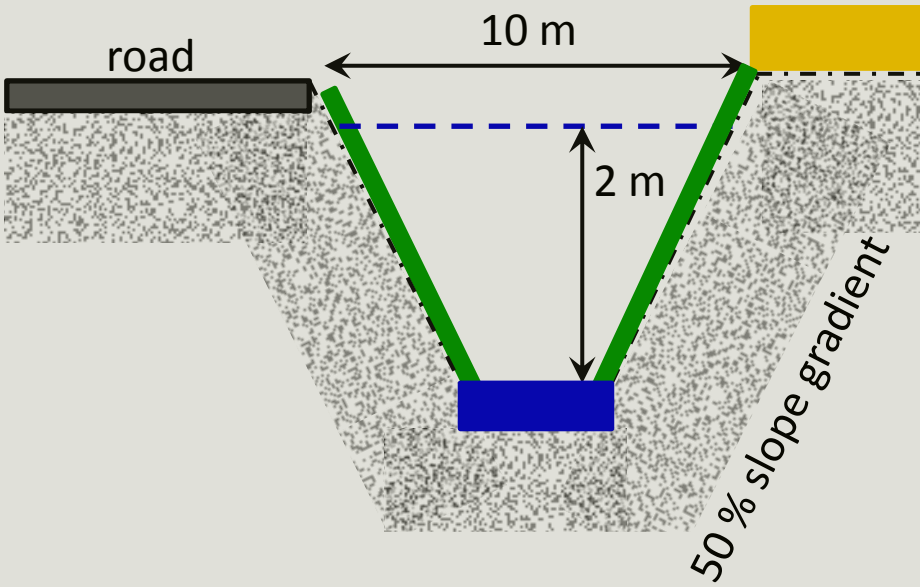

Image © 2012 GeoEye
607 m
© 2012 Google


Image © 2012 GeoEye
© 2012 Google
607 m

Where Could We Go?

A Vision For The Future

The Existing Surface Drainage System:



Retention Capacity =
12 m^3 per meter of ditch length

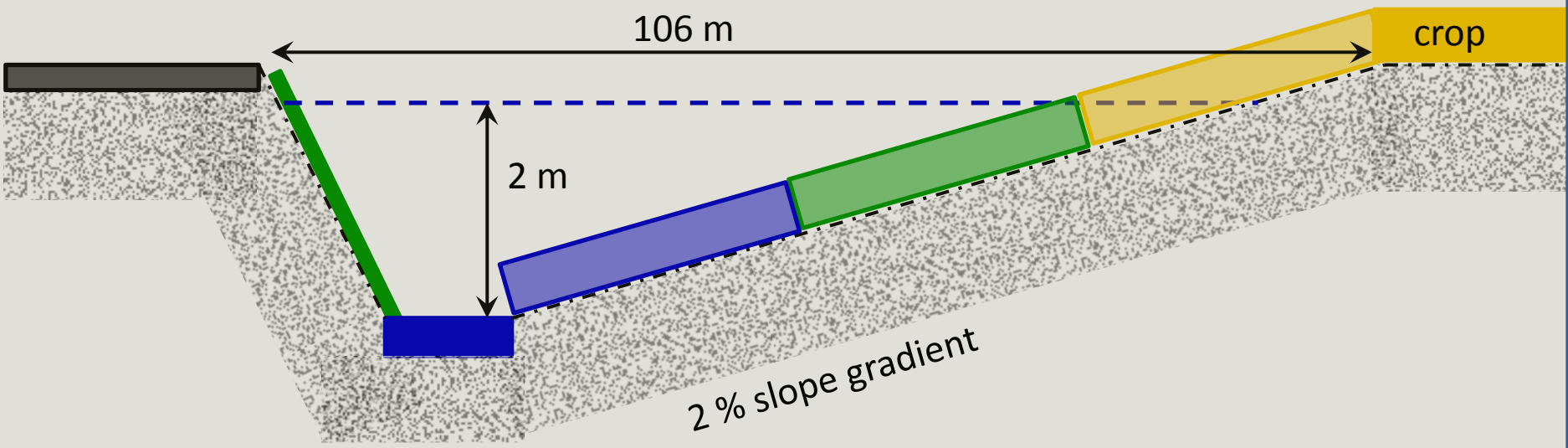
Retention Requirement =
48 m^3 per meter of ditch length

Drainage ditches are designed to convey water, not store or filter water.

Where Could We Go?

A Vision For The Future

An Alternative System:

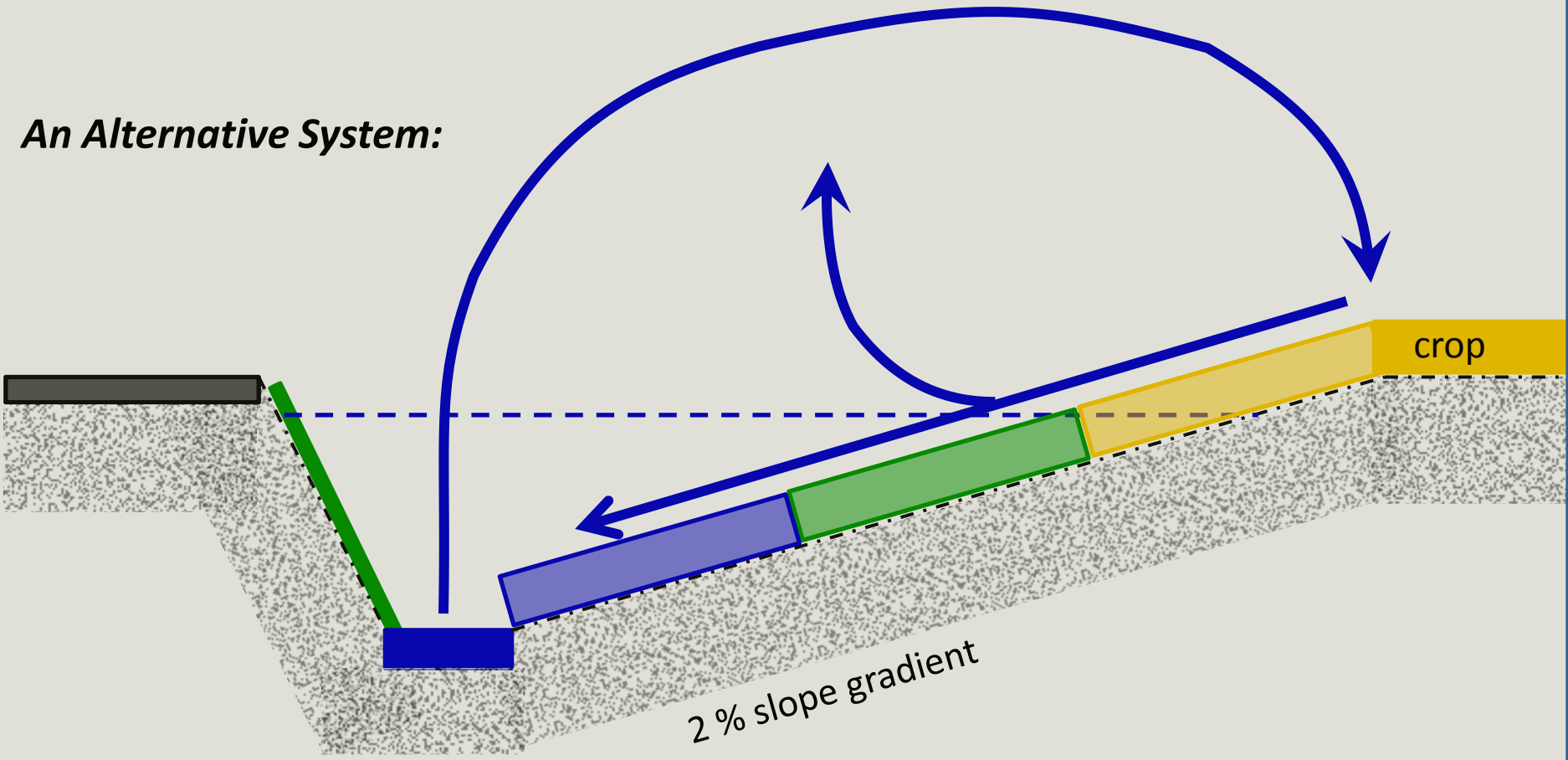


Retention Capacity =
108 m^3 per meter of ditch length

Where Could We Go?

A Vision For The Future

An Alternative System:



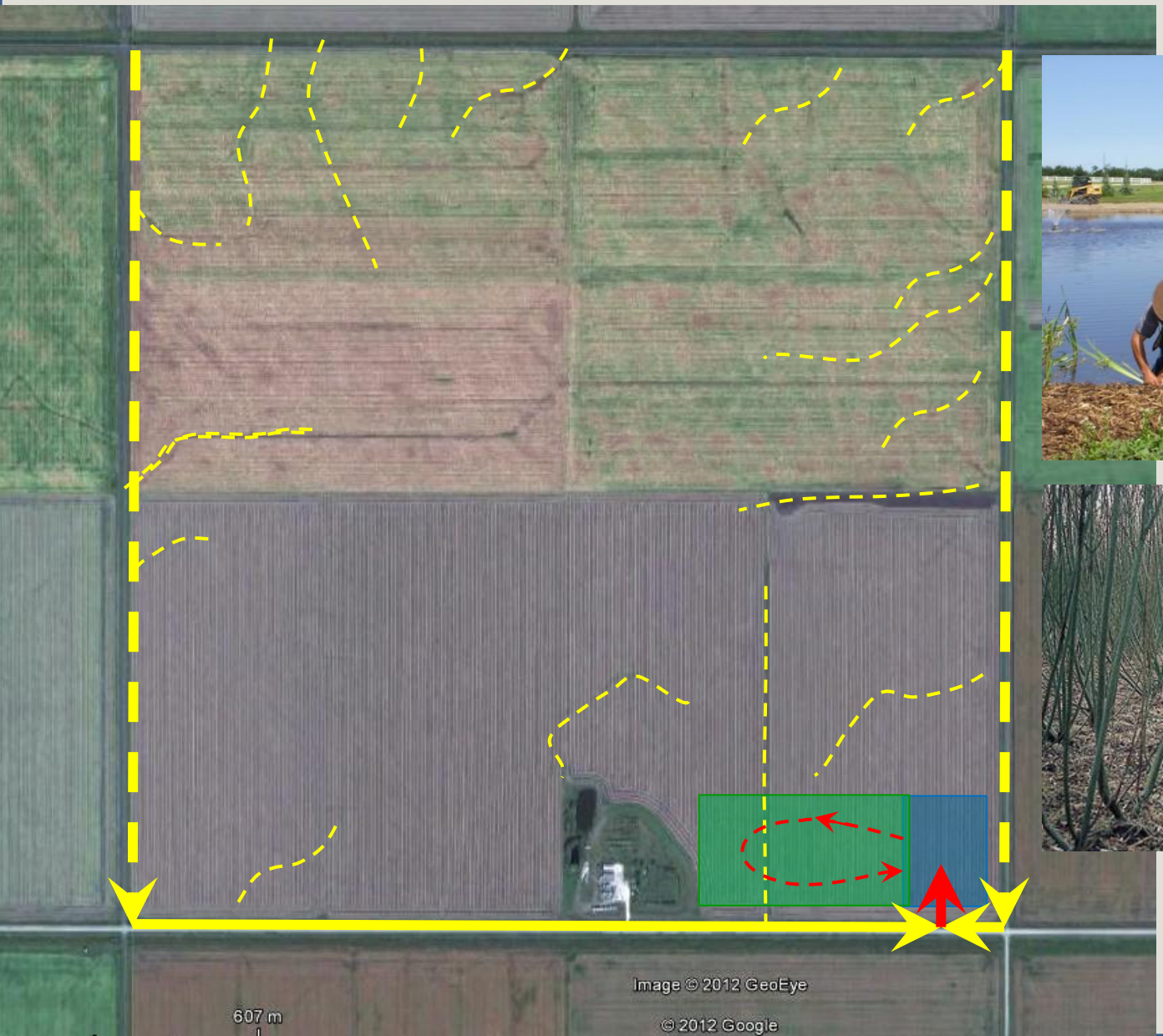


Image © 2012 GeoEye
607 m
© 2012 Google

Where Could We Go?

A Vision For The Future

Economic and Environmental Benefits:

- Increased field crop production through better drainage.
- Potential for irrigation of field crops in drought years.
- Increased crop production in filter field from added water (and nutrients).
- Potential for alternative/multi-use crops and diversification using the filter field (bioenergy crops).

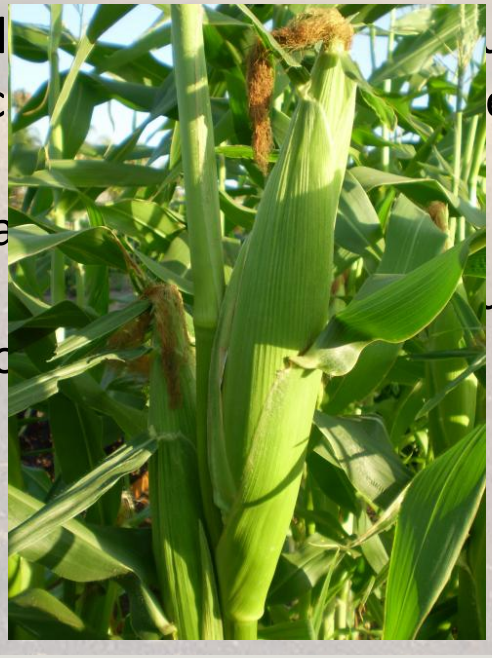
- Ecological goods and services
- Reduced runoff of water and nutrients
- Recreation and wildlife habitat

Where Could We Go?

A Vision For The Future

Economic and Enviror

- Increased field crop rainage.
- Potential for irrigat ears.
- Increased crop proc ed water (and nutrients).
- Potential use crops and diversific eld (bioenergy crops).



- Ecologica
- Reduced utrients
- Recreatic

Where Could We Go?

A Vision For The Future

Transforming the Agricultural Landscape, One Field at a Time

Summary:

Integrated Soil Conservation
Integrated Soil and Water Management
Restoration of Soil-Landscapes
Integrated Surface Water Management

Transforming the Agricultural Landscape, One Field at a Time

Summary:

Integrated Soil Conservation
Integrated Soil and Water Management
Restoration of Soil-Landscapes
Integrated Surface Water Management

⇨reduced soil erosion
⇨ less crop residue on the soil surface
⇨ larger fields, narrow riparian areas
⇨ larger fields, few field boundaries
⇨ less severely eroded and more productive hilltops
⇨ more functional wetlands
⇨ on-farm water retention systems

Transforming the Agricultural Landscape, One Field at a Time

Acknowledgements

Questions