Tillage: Implications For Soil and Water Conservation Practices

David Lobb
Department of Soil Science
University of Manitoba | Faculty of Agricultural and Food Sciences

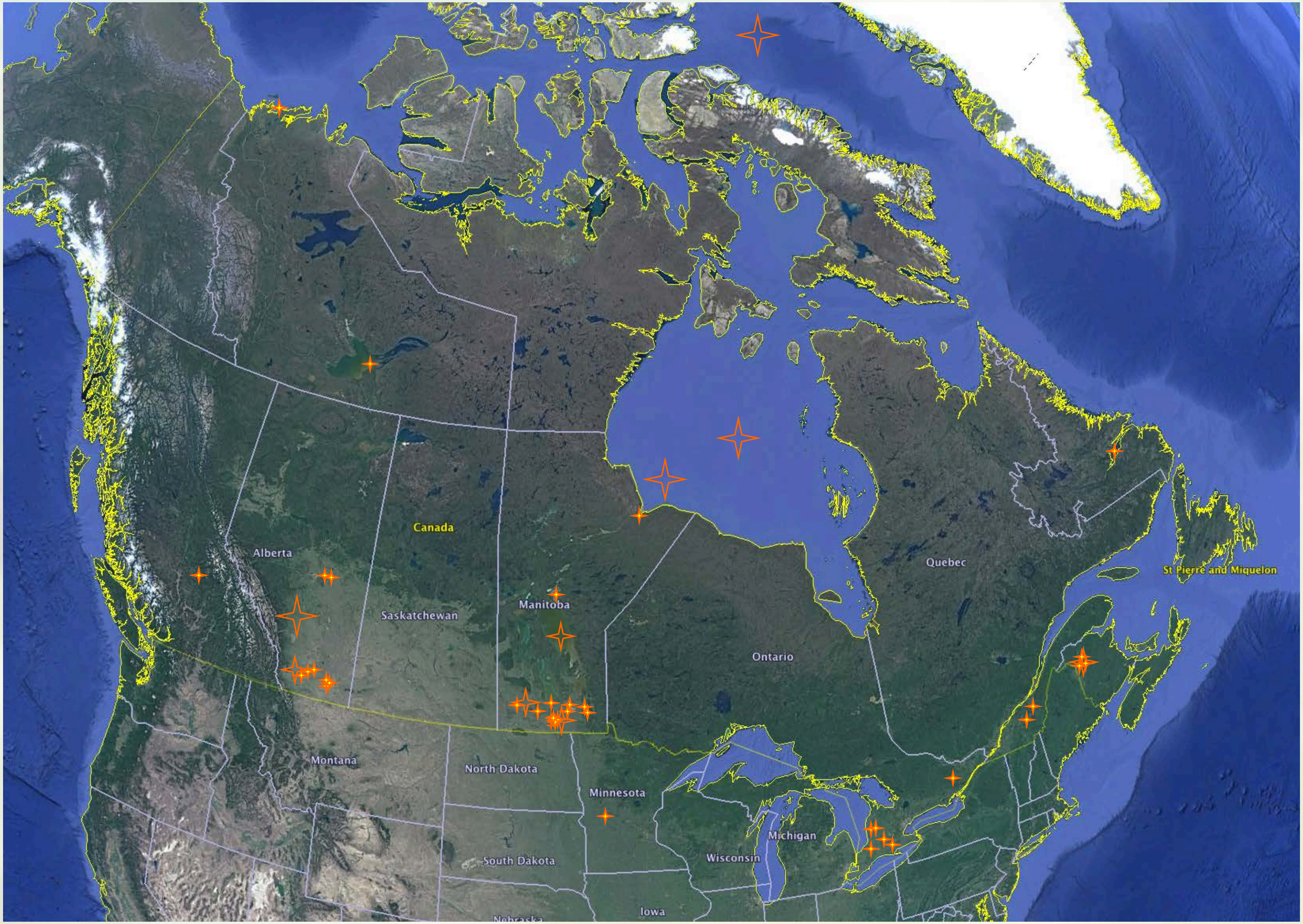
Lobb family farm (1978)

Managing Soil: Maximizing Profit
South Dakota Soil and Water Conservation Society

Sioux Falls, South Dakota

November 29th, 2018

The Great White North



Tillage The Good

Tillage was a critical part of clearing forest and breaking prairie for crop production.

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Alberta (1910s)

Tillage The Bad

Crop production and the associated tillage over the last 100 to 200 years in Canada has resulted in significant degradation of soil.

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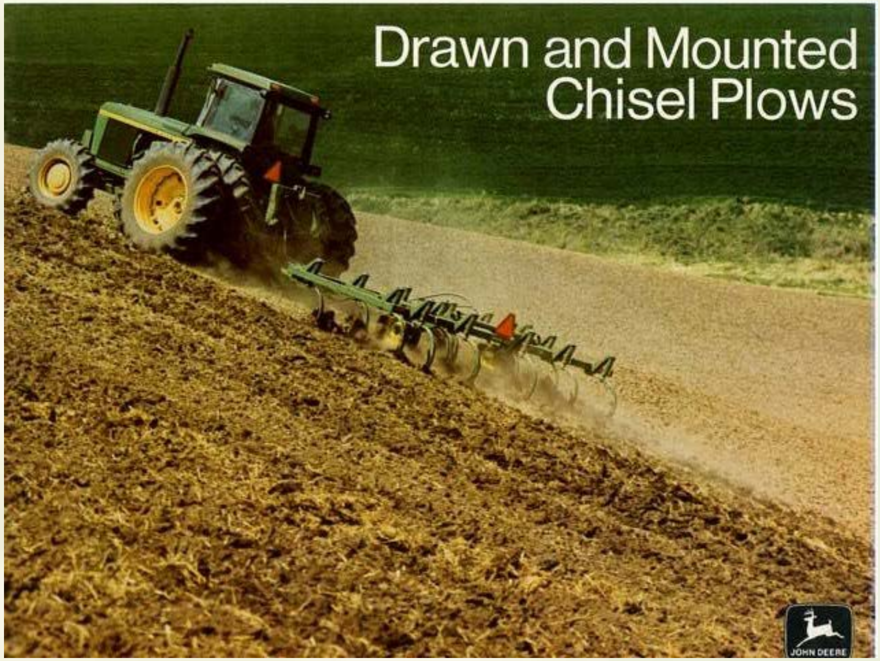
Saskatchewan (1930s)

The Dirty Thirties

TILLAGE THE BAD

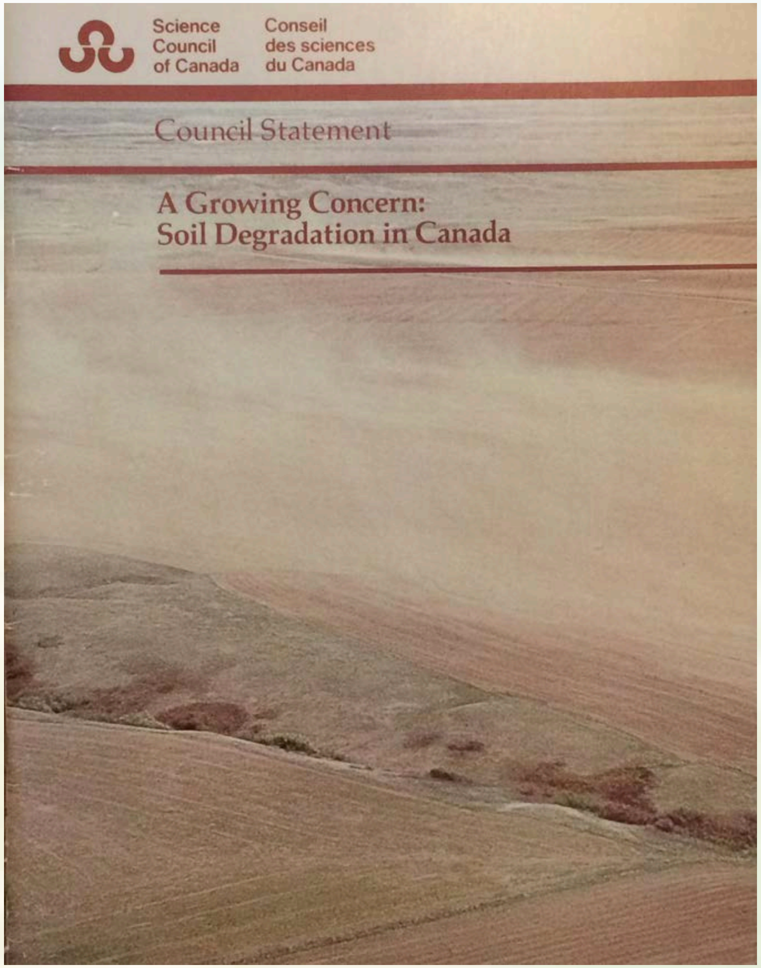
Crop production over the last 100 to 200 years in Canada has resulted in significant degradation of the soil.

The Heavy Seventies



The Cost of Soil Erosion

By the early 1980s, there were great concerns raised about the costs of soil degradation in Canada.



Don F. Rennie's 1985 paper: *"Soil and Water Issues and Options in Canada"*

Murray H. Miller's 1986 paper "Soil Degradation in Eastern Canada: Its Extent and Impact"

THE COST OF SOIL EROSION

Costs of Soil Degradation in Western Canada ($ millions)

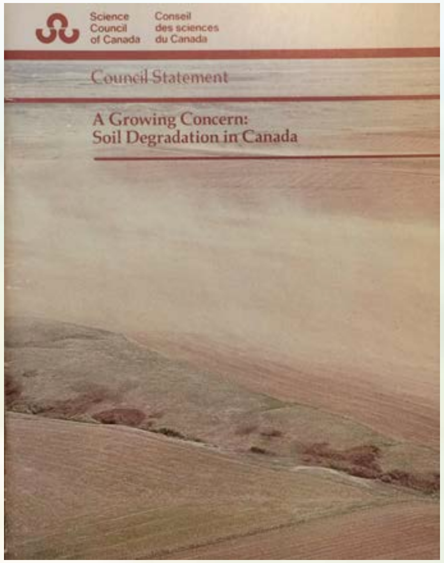
	B.C.	Alta.	Sask.	Man.	Total
Erosion	10	200	220	10	440
Organic Matter Loss	11	144	170		325
Acidification	5	5	50		60
Salinity	—	80	120	12	212
Compaction	12				12
Total	38	429	560	22	1049

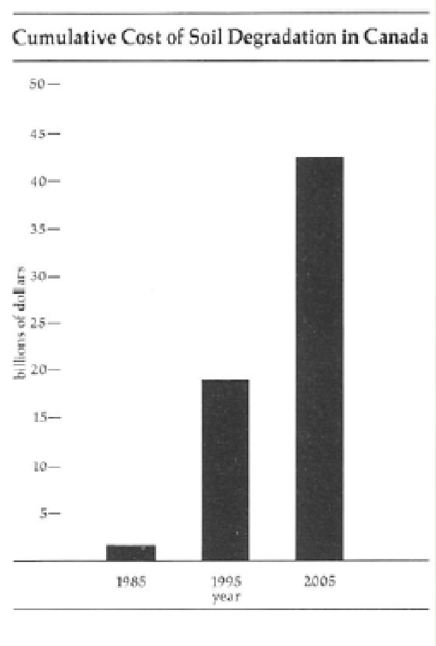
Source: D.A. Rennie, "Soil and Water Issues and Options in Canada," paper presented to the Canadian Agricultural Outlook Conference, Ottawa, 9-10 December 1985.

Costs of Soil Degradation in Central and Eastern Canada ($ millions)

	Ont.	Que.	Atlantic	Total
Erosion	68	10	11	89
Compaction	21	100	6	127
Acidification	1	4	6	12
Total	90	114	23	228

Source: D.A. Rennie, "Soil and Water Issues and Options in Canada," paper presented to the Canadian Agricultural Outlook Conference, Ottawa, 9-10 December 1985.

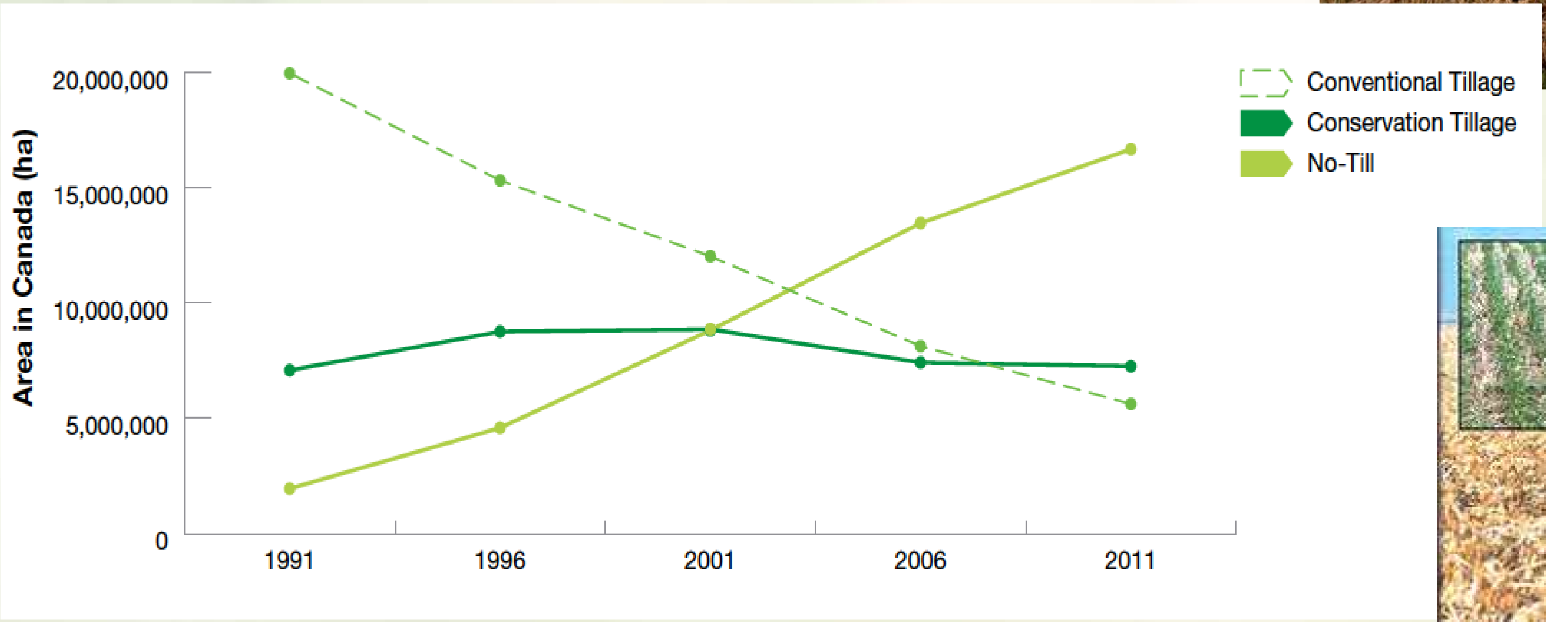


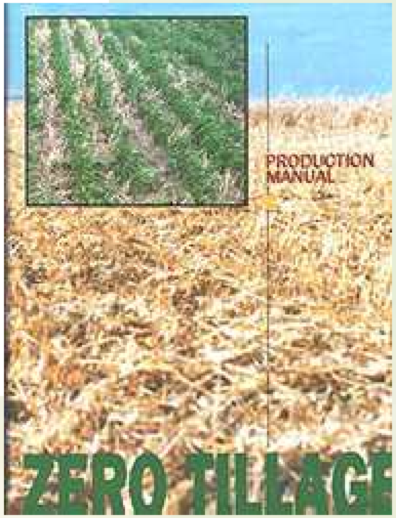


annual values
present values = ~2X

The Cost of Soil Erosion

In response, conservation tillage practices were promoted, and with the coincident drop in price of RoundUp, conservation tillage was widely adopted.

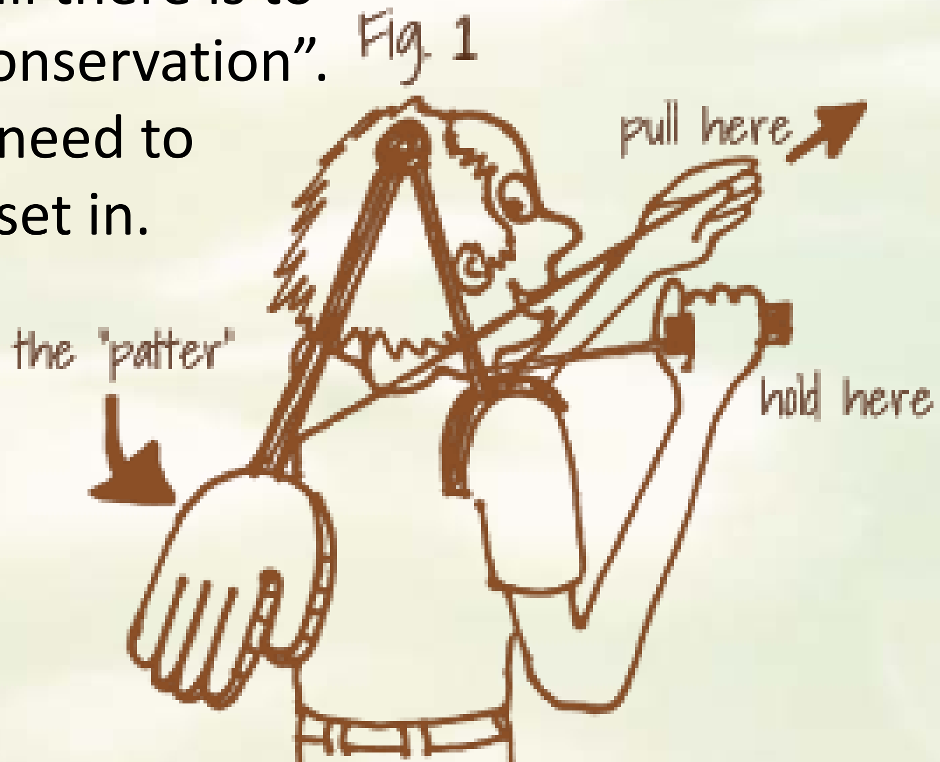




THE COST OF SOIL EROSION

With respect to public awareness, to government support through policies and programs, and to industry action, there has been a steady decline in interest in soil conservation.

A pervasive belief that "we know all there is to know about soil erosion and soil conservation". And, that "the job is done and we need to move on". A sense of fatigue has set in.



Current Assessment of Cost

After almost 40 years, there is a need to revisit these figures, to improve them and to update them to assess status and progress.

Science and technology have greatly advanced. There is a more complete and accurate understanding of soil degradation processes. There are better models for assessment and prediction.

There are more comprehensive and accurate databases – which serve as better model inputs/outputs for assessment and prediction.

Current Assessment of Cost

Economic Impacts of Soil Erosion:

Focus on the direct impacts of soil loss on crop production and market value.

Current Assessment of Cost

Economic Impacts of Soil Erosion:

Focus on the direct impacts of soil loss on crop production and market value.

Not the indirect impacts.

CURRENT ASSESSMENT OF COST

Economic Impacts of Soil Erosion:

Focus on the direct impacts of soil loss on crop production and market value.

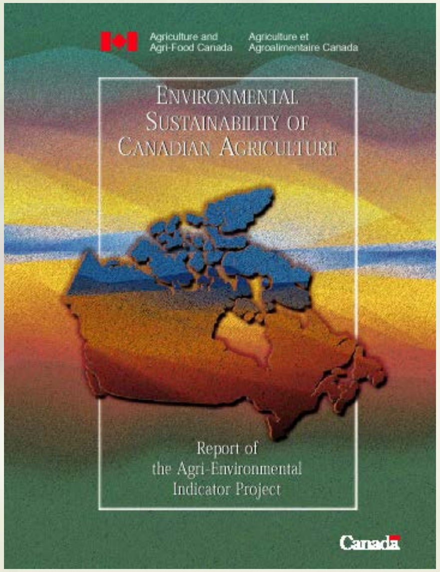
Not the indirect impacts.

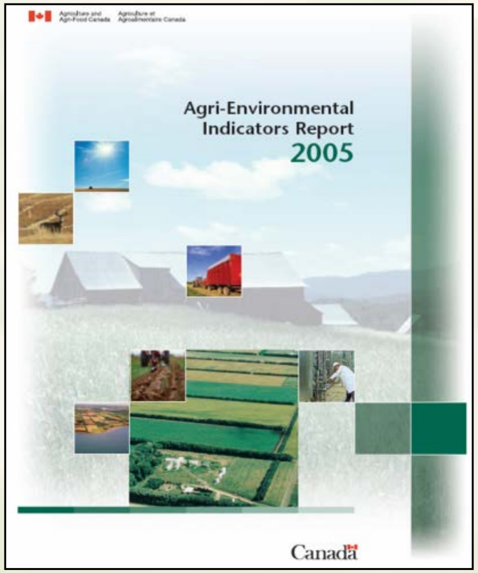
Not the off-field impacts.

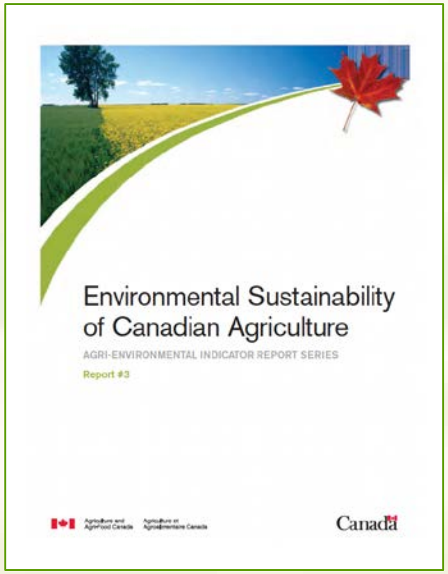
CURRENT ASSESSMENT OF COST

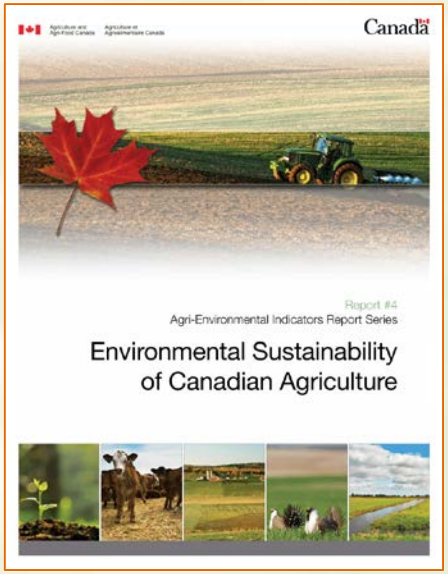
Assessment and Prediction Models:

Agri-Environmental Indicators Models:
AAFC's AEIP, NAHARP, SMP

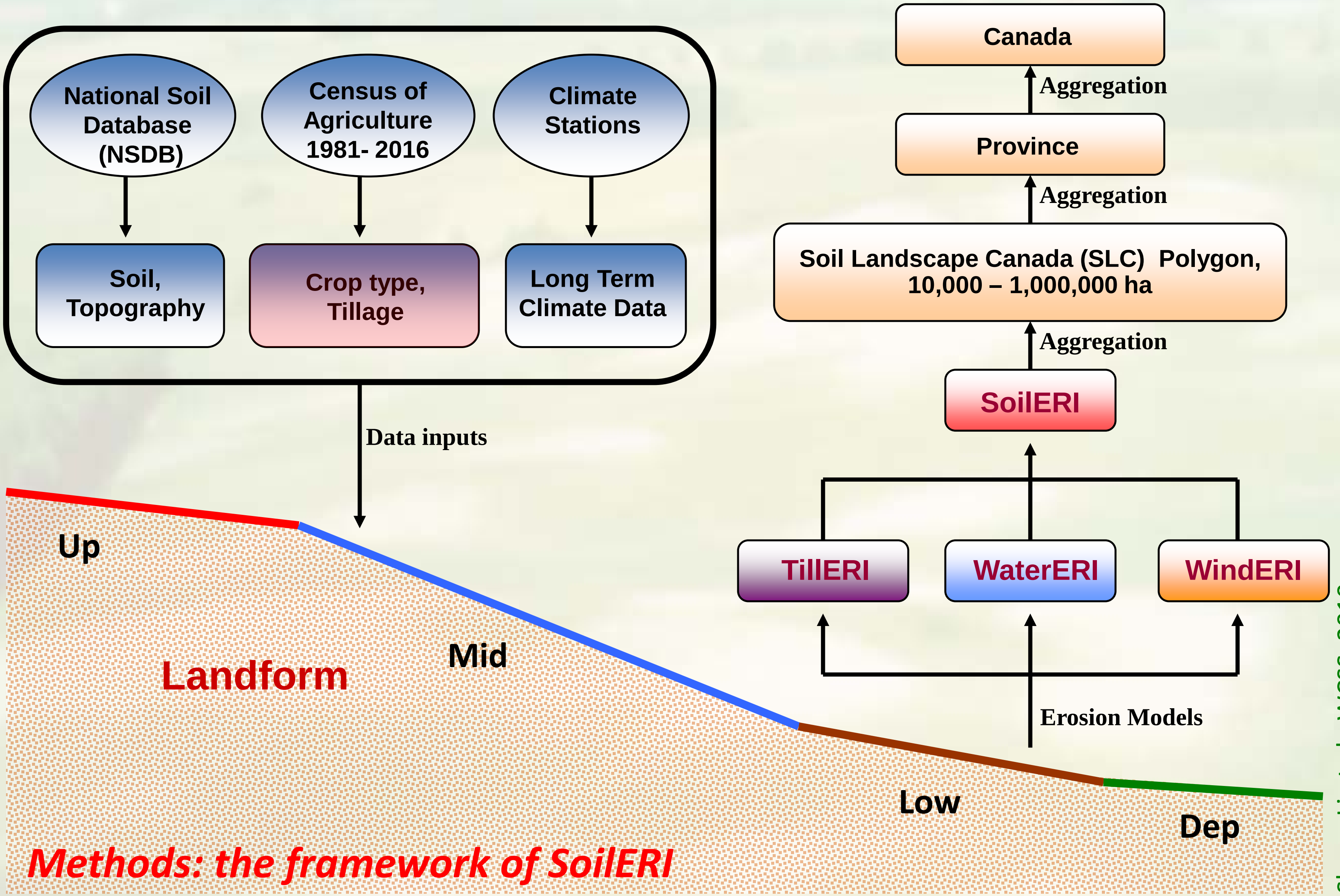








CURRENT ASSESSMENT OF COST

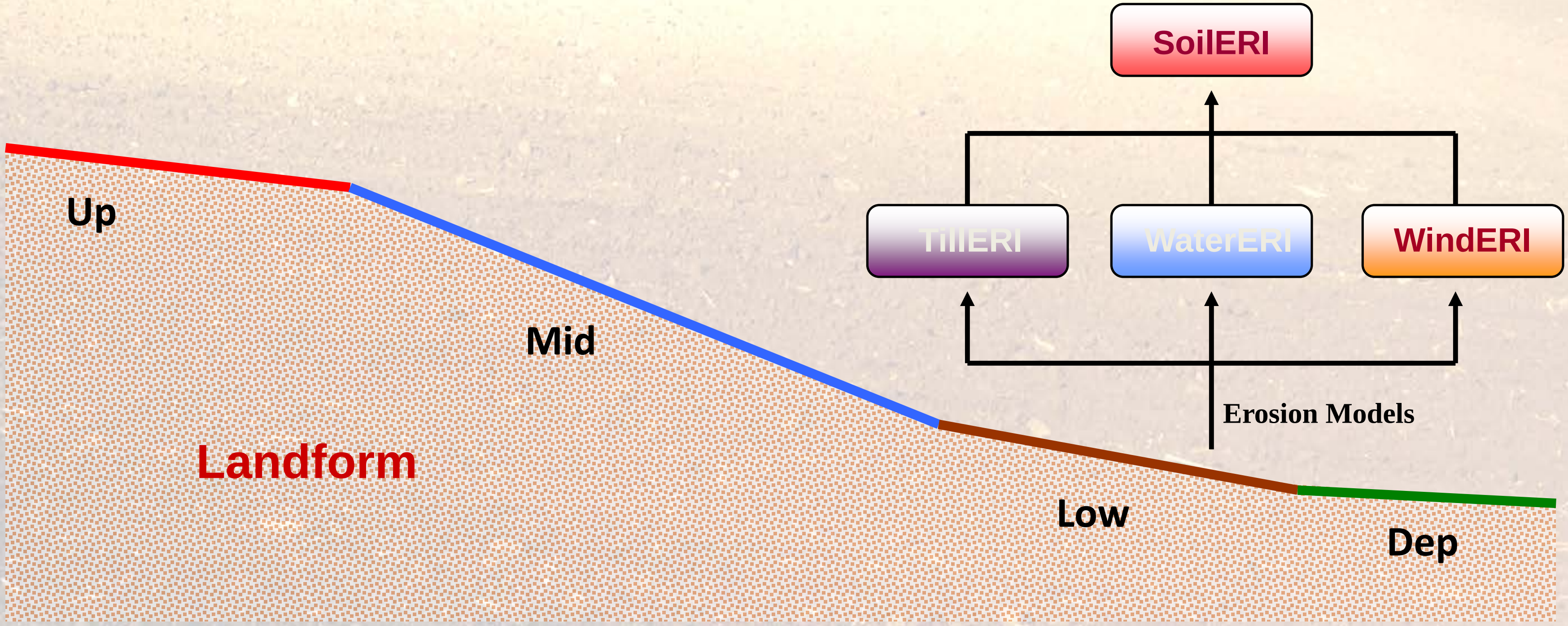


Methods: the framework of SoilERI

Sheng Li et al., WCSS, 2010

Methods: tillage erosion (WindERI)

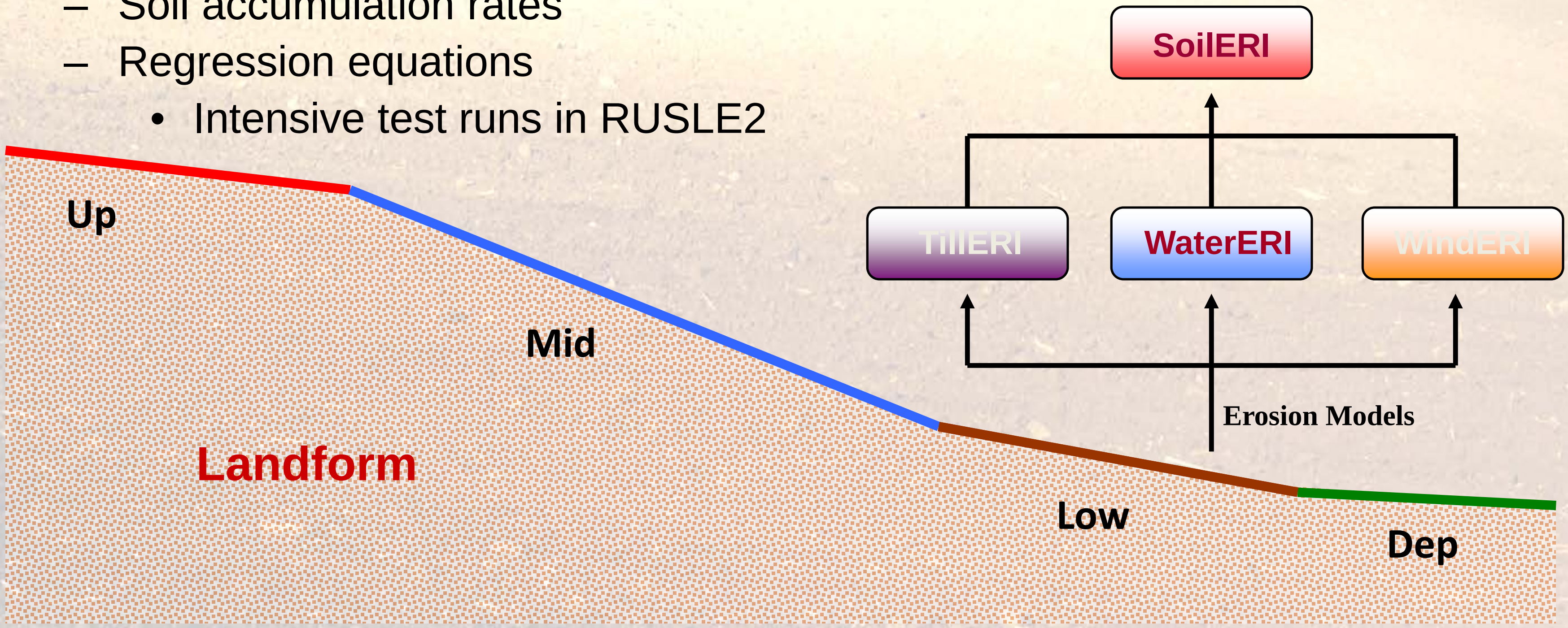
- Equation
  - Wind Erosion Equation (WEQ)
  - AWd = f(I,K,C,L,V)
- Individual factors
  - C-, L- and V-factor for the hillslope
  - I- and K-factor for each segment
- Adjustments
  - Expert knowledge
    - Processes and conditions in Canada



Sheng Li et al., WCSS, 2010

Methods: tillage erosion (WaterERI)

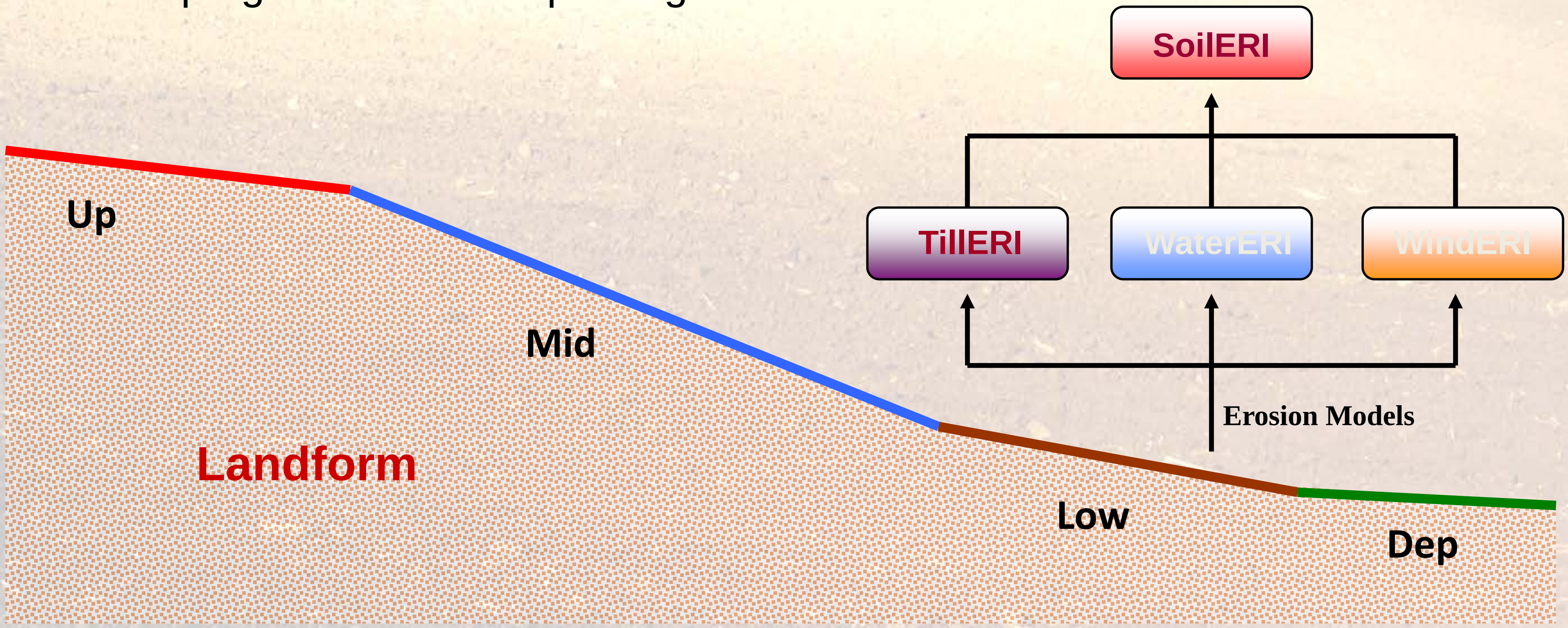
- Equation
  - Universal Soil Loss Equation (USLE)
  - $A_{Ti} = R \cdot K \cdot LS \cdot C \cdot P$
- Individual factors --- RUSLE
  - R-, C- and P-factor for the hillslope
  - K- and LS-factor for each segment
- Adjustments --- RUSLE2
  - Interactions between factors
  - Soil accumulation rates
  - Regression equations
    - Intensive test runs in RUSLE2



Sheng Li et al., WCSS, 2010

Methods: tillage erosion (TillERI)

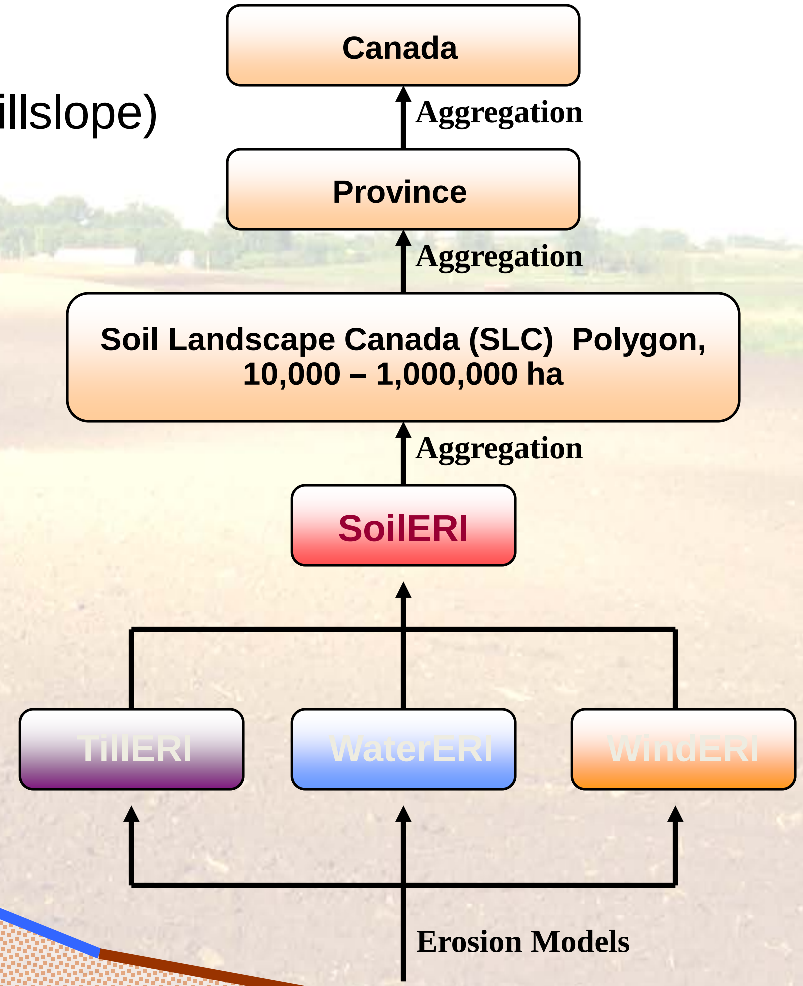
- Equation
  - $A_{Ti} = ET \cdot EL$
- Erosivity of tillage ET
  - Crop type and tillage system
    - Tillage equipment
    - Number of passes per year
  - Field experiment data
- Erodibility of Landform EL
  - Slope gradient and slope length

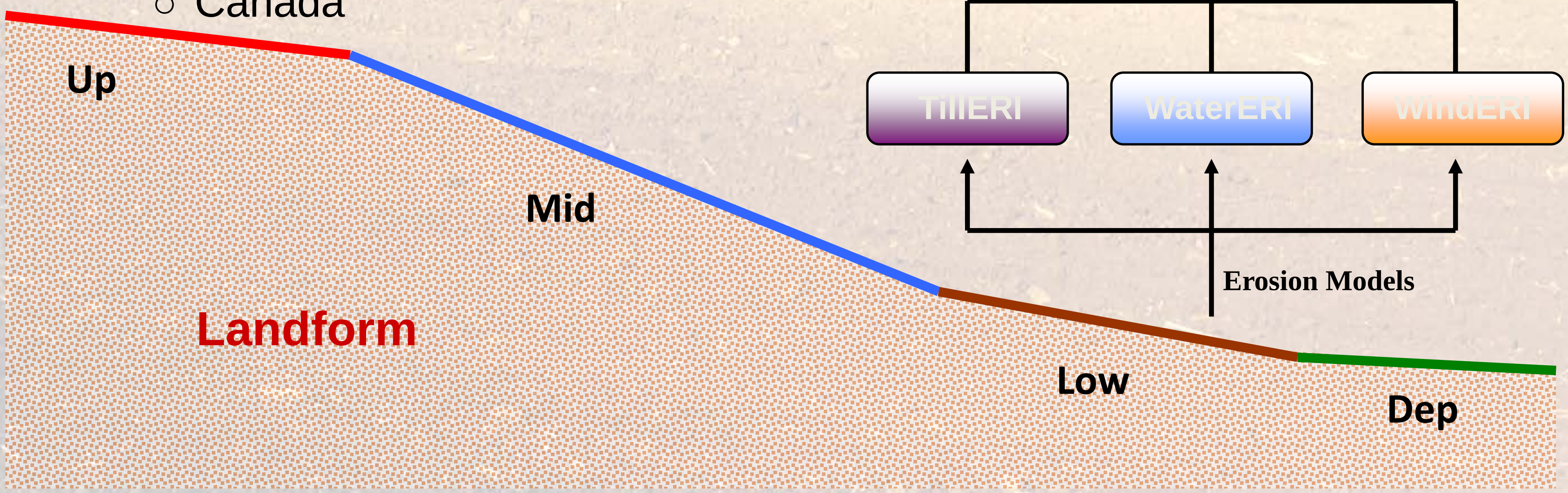


Sheng Li et al., WCSS, 2010

Methods: tillage erosion (SoilERI)

- Equation
  - $A_{Soil} = A_{Ti} + A_{Wt} + A_{Wd}$
  - For each segment in each landform (hillslope)
- Aggregation
  - Area-weighted across
    - Landform
    - Crop type
    - Tillage system
  - **Value for each segment**
    - SLC polygon
    - Province
    - Canada

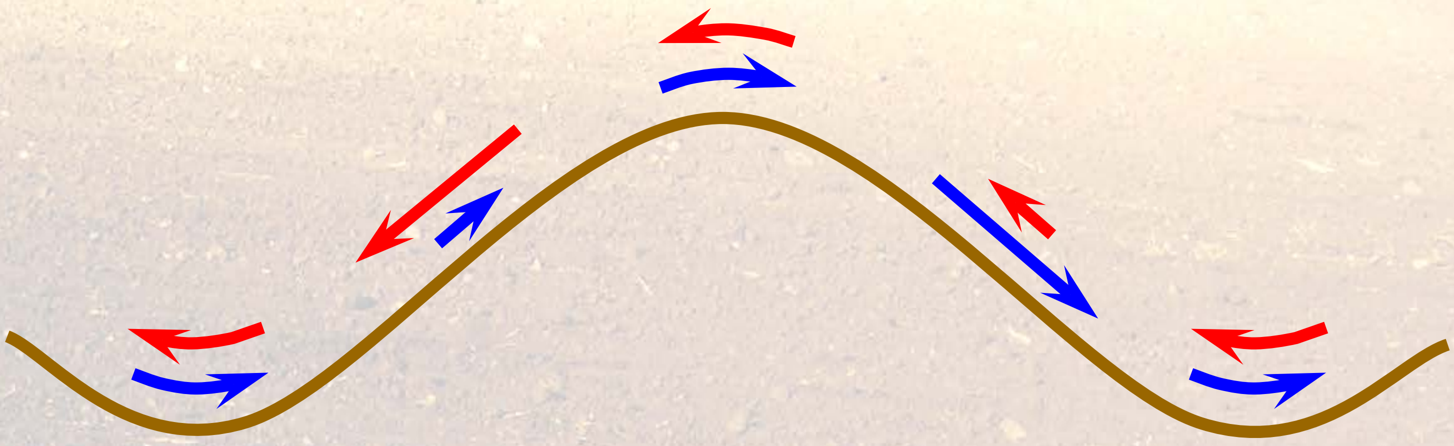




Sheng Li et al., WCSS, 2010

Tillage erosion

Tillage erosion is the net redistribution of soil resulting from the variability in soil translocation by tillage.



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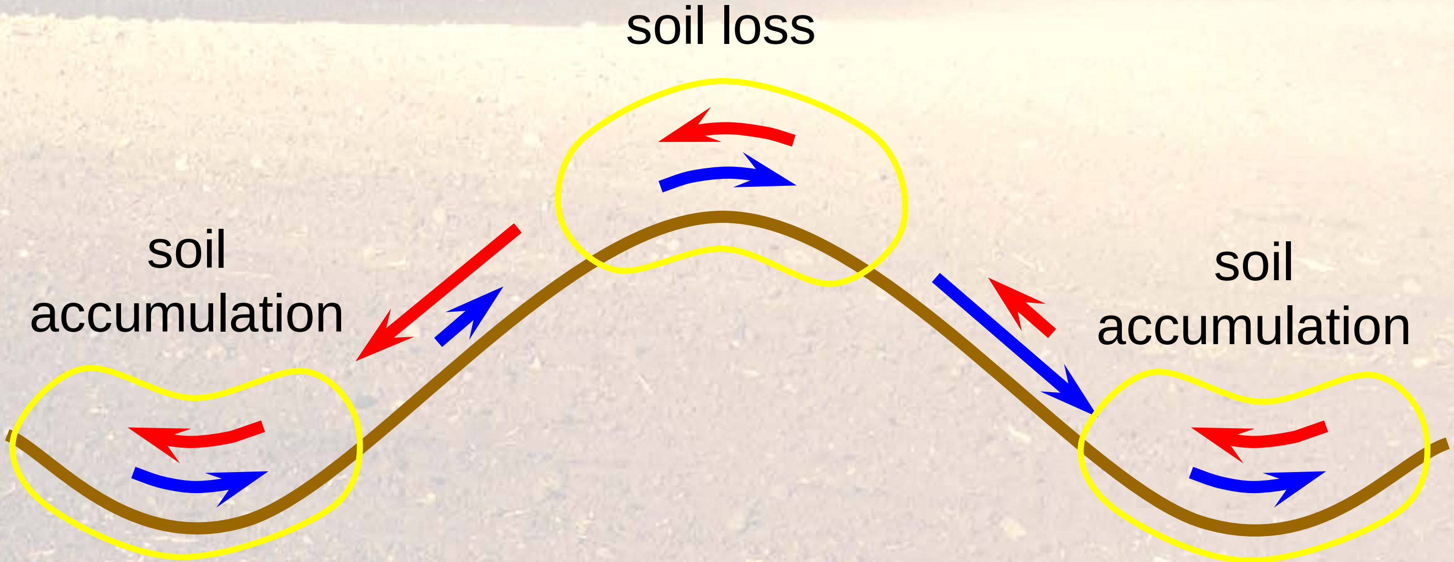
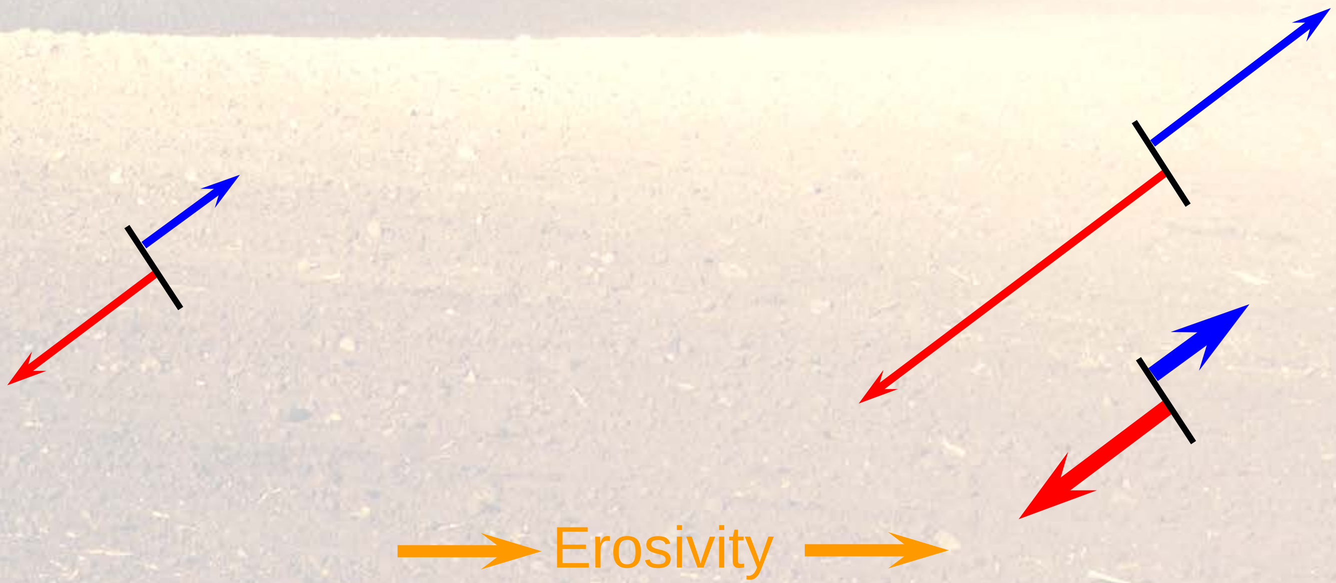


Tillage erosion

Areas with many short, steep slopes are highly sensitive to tillage erosion (e.g. hummocky landscapes).

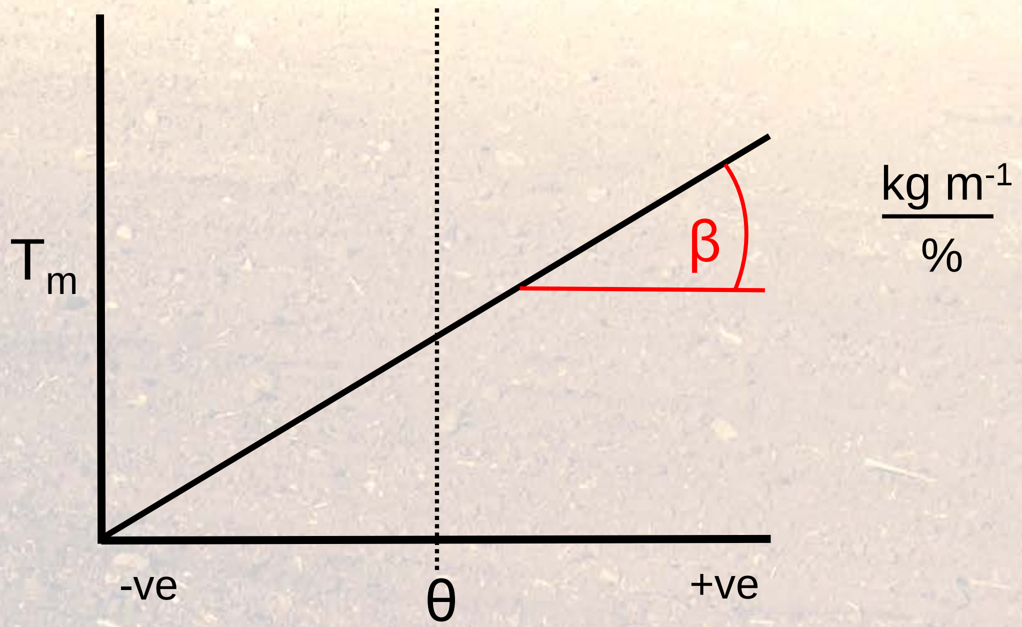
Tillage erosion

Cropping and tillage systems that employ intensive tillage (frequent, deep, fast) can cause severe tillage erosion.



Tillage erosion

Tillage erosivity is measured for individual tillage implements and operating practices. It is determined by the relationship between soil moved by tillage and slope gradient.



Tillage erosion

- Tillage erosion results in severe soil loss (20-100 t ha^{-1} yr^{-1}) on large areas (15-30 %) of cultivated landscapes.
- Tillage erosion causes more soil redistribution within some landscapes than wind and/or water erosion.

Tillage erosion

- Tillage erosion acts as a major delivery mechanism for water erosion, delivering soil to convergent areas of a landscape where overland flow concentrates.
- Tillage erosion exposes subsoil which is highly erodible to wind and water erosion.

Current Assessment of Cost

Assessment and Prediction Models:

Classes of Soil Erosion / Degree of Soil Loss:

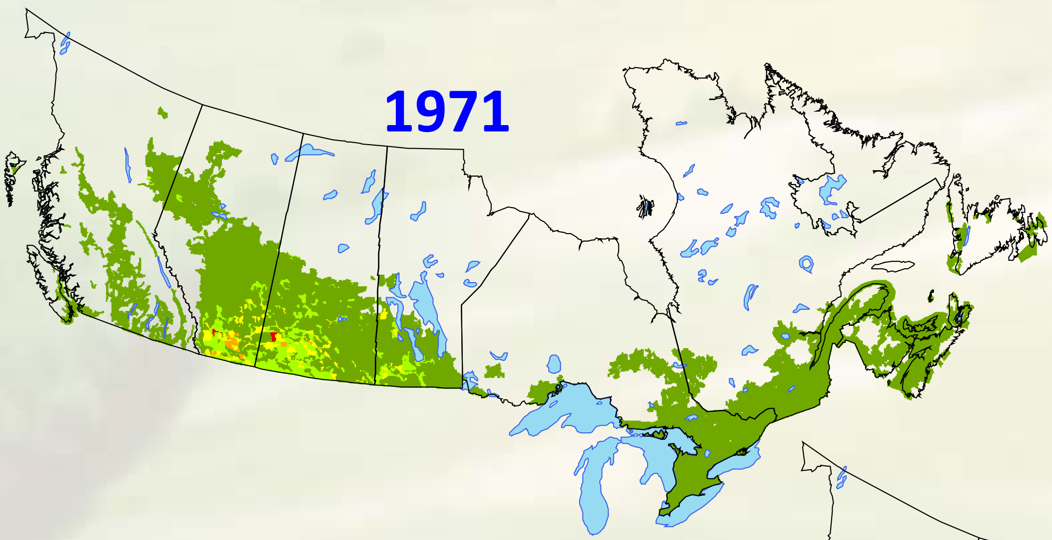
Soil loss rate	Class	
0 – 3 t ha^{-1} yr^{-1}	Extremely Low / Negligible	Sustainable
3 – 6 t ha^{-1} yr^{-1}	Very Low	Sustainable
6 – 11 t ha^{-1} yr^{-1}	Low	
11 – 22 t ha^{-1} yr^{-1}	Moderate	
22 – 33 t ha^{-1} yr^{-1}	High	
>33 t ha^{-1} yr^{-1}	Very High	

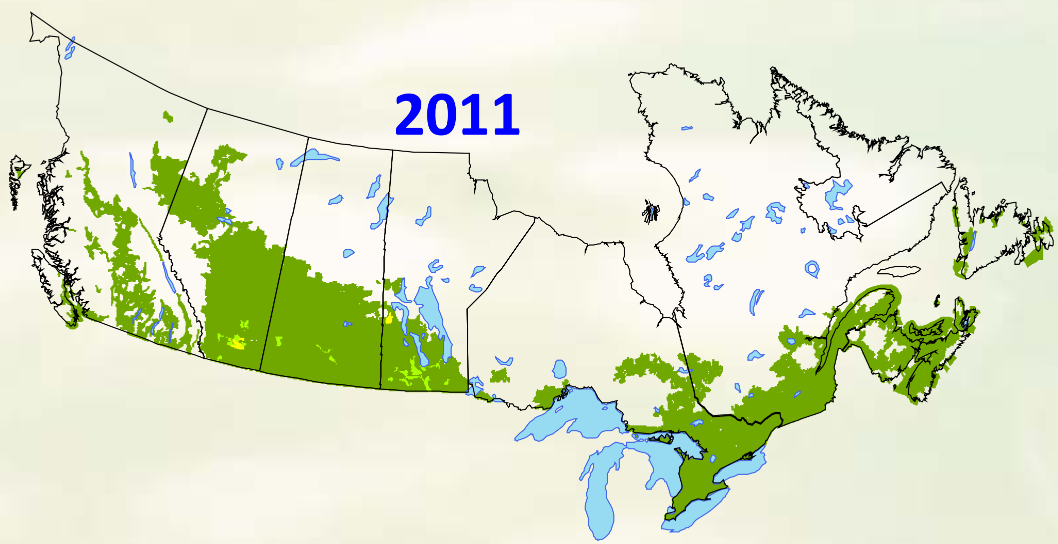
Results:

- Average annual soil loss rate for each SLC polygon, landform segment, soil, crop group and tillage system
- Mapped as most eroding segments (upper and mid slopes)
- Reported as share (%) of land in each class for each SLC polygon, rolled up to Province and Canada

Current Assessment of Cost

Distribution of Soil Loss Rates for 1971 and 2011: Wind Erosion





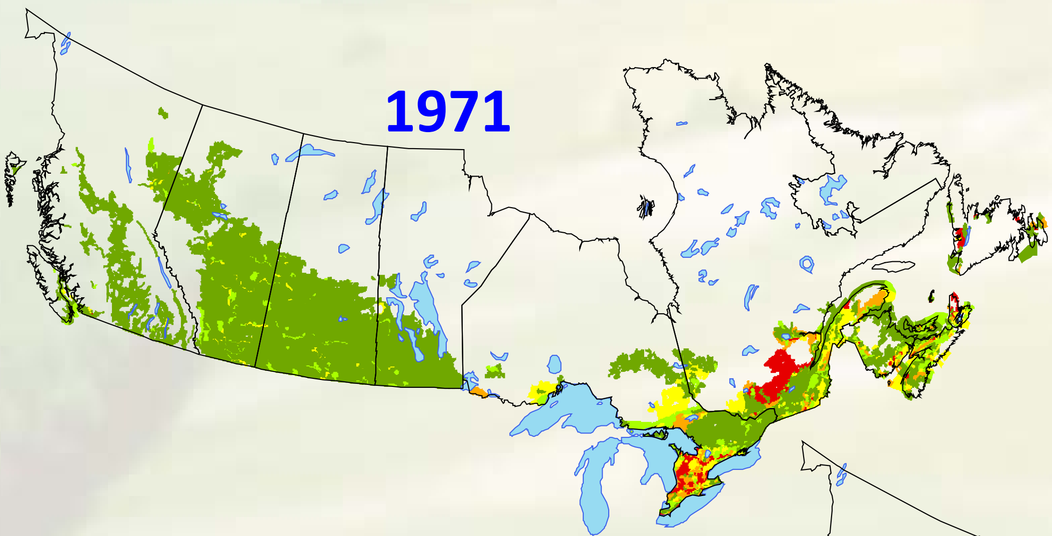
Soil Erosion Risk Classes

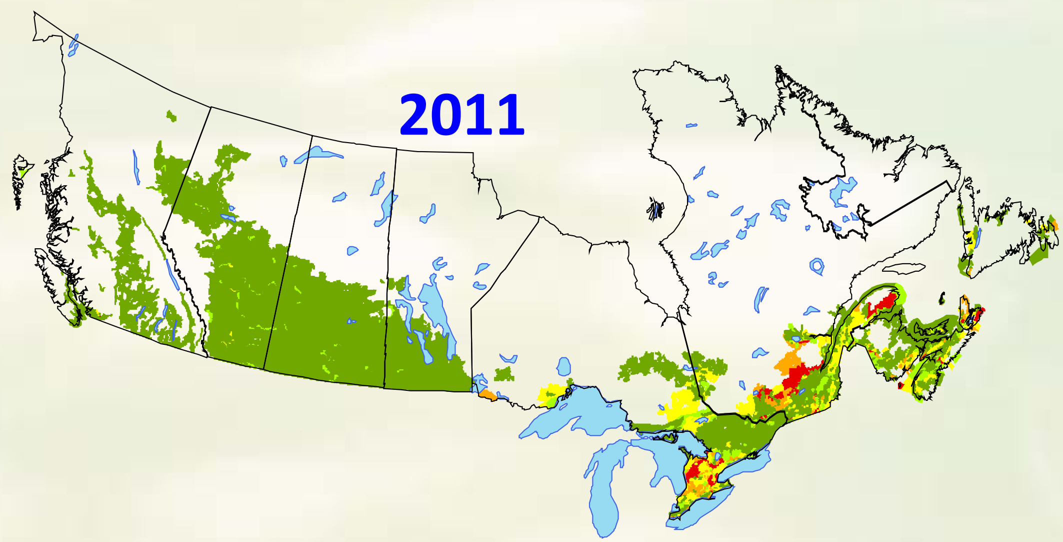
- Very Low
- Low
- Moderate
- High
- Very High

* Upper slopes

CURRENT ASSESSMENT OF COST

Distribution of Soil Loss Rates for 1971 and 2011: Water Erosion





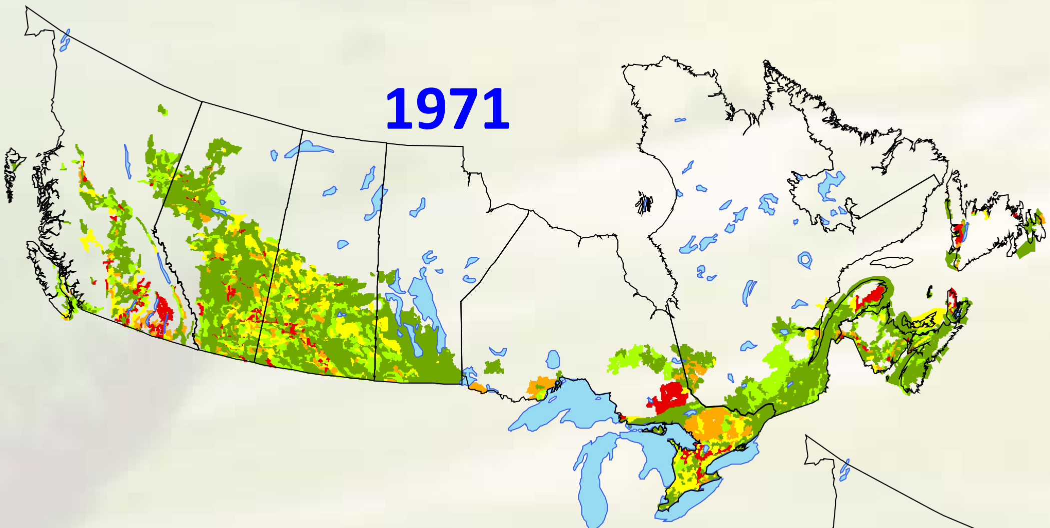
Soil Erosion Risk Classes

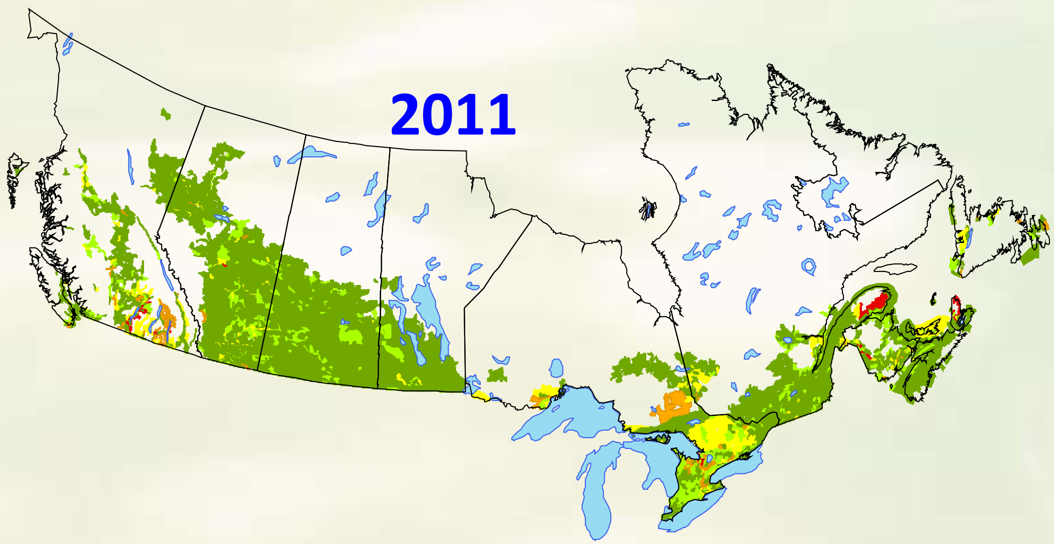
- Very Low
- Low
- Moderate
- High
- Very High

* Upper + Mid slopes

Current Assessment of Cost

Distribution of Soil Loss Rates for 1971 and 2011: Tillage Erosion





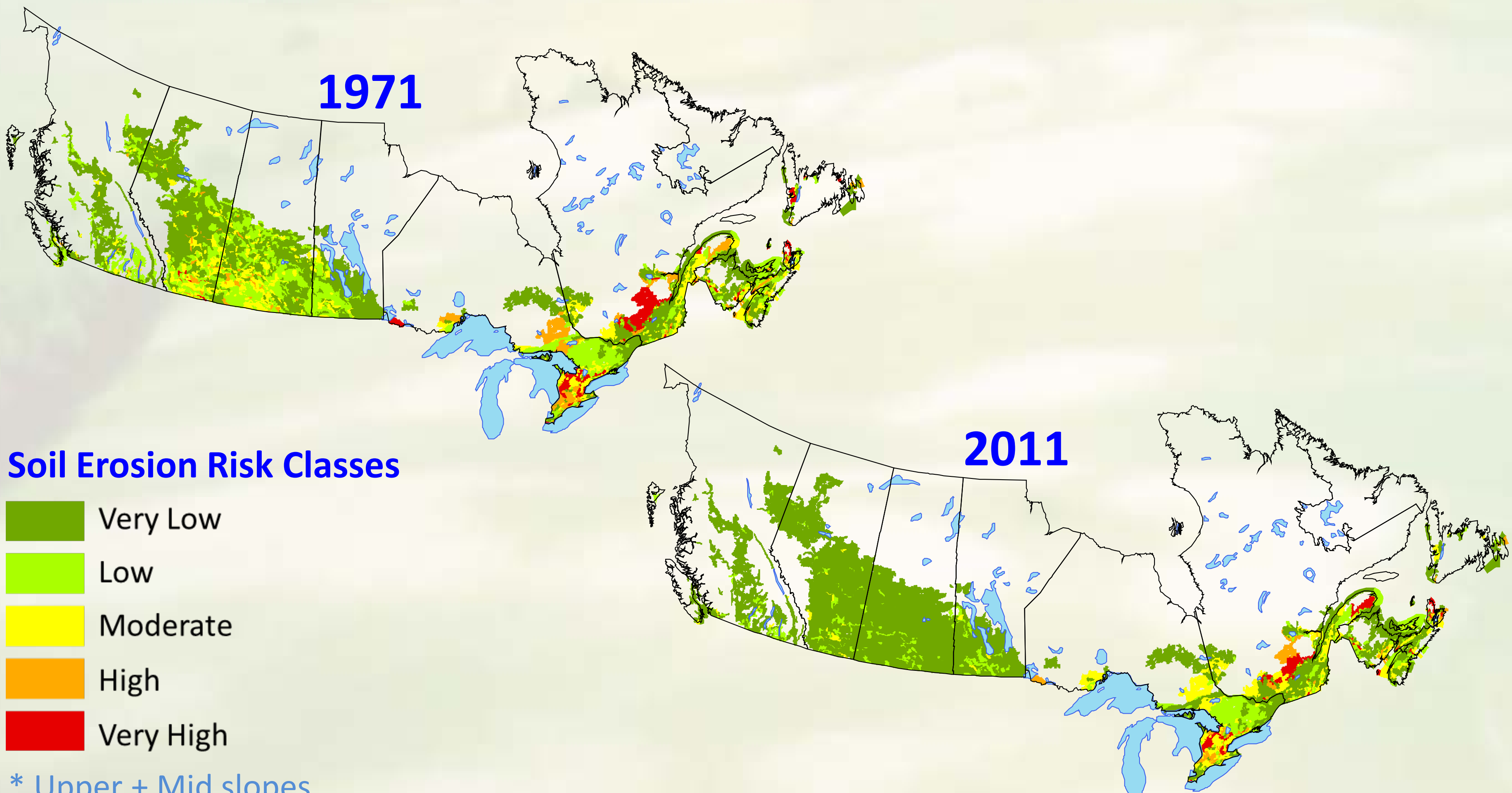
Soil Erosion Risk Classes

- Very Low
- Low
- Moderate
- High
- Very High

* Upper slopes

Current Assessment of Cost

Distribution of Soil Loss Rates for 1971 and 2011: Soil Erosion



CURRENT ASSESSMENT OF COST

Provincial Overview of Soil Erosion Between 1971 and 2011:
Wind, Water and Tillage Erosion, combined as Soil Erosion

	Negligible		Very Low		Low		Moderate		High		Very High	
	1971	2011	1971	2011	1971	2011	1971	2011	1971	2011	1971	2011
BC	17.1	54.6	22.9	32.4	48.3	9.0	8.6	1.9	0.4	0.5	2.6	1.6
AB	20.9	65.8	32.5	20.3	13.3	10.3	20.2	3.2	7.0	0.3	6.0	0.0
SK	0.0	60.1	19.5	22.7	44.2	15.9	17.2	1.2	15.3	0.0	3.7	0.0
MB	4.2	15.5	37.6	55.7	23.2	19.2	29.5	9.3	5.0	0.3	0.6	0.0
ON	5.5	10.0	16.4	17.8	10.4	14.5	25.0	29.0	18.6	15.4	24.0	13.4
QC	56.8	53.1	16.9	22.5	11.4	11.5	10.6	9.7	2.8	1.6	1.6	1.5
NB	20.6	27.4	21.1	16.0	32.9	33.7	7.9	9.6	7.0	6.5	10.4	6.9
NS	7.2	9.9	15.3	38.9	36.5	33.6	38.3	15.6	1.6	1.6	1.2	0.4
PE	11.5	11.9	7.5	7.9	4.1	3.9	65.7	76.3	11.2	0.0	0.0	0.0
NF	2.7	16.6	11.6	14.5	13.8	6.2	5.9	39.9	25.7	22.8	40.4	0.0
Can	**9.4**	**50.5**	**24.9**	**25.6**	**28.9**	**14.4**	**20.0**	**6.3**	**11.3**	**1.7**	**5.5**	**1.4**

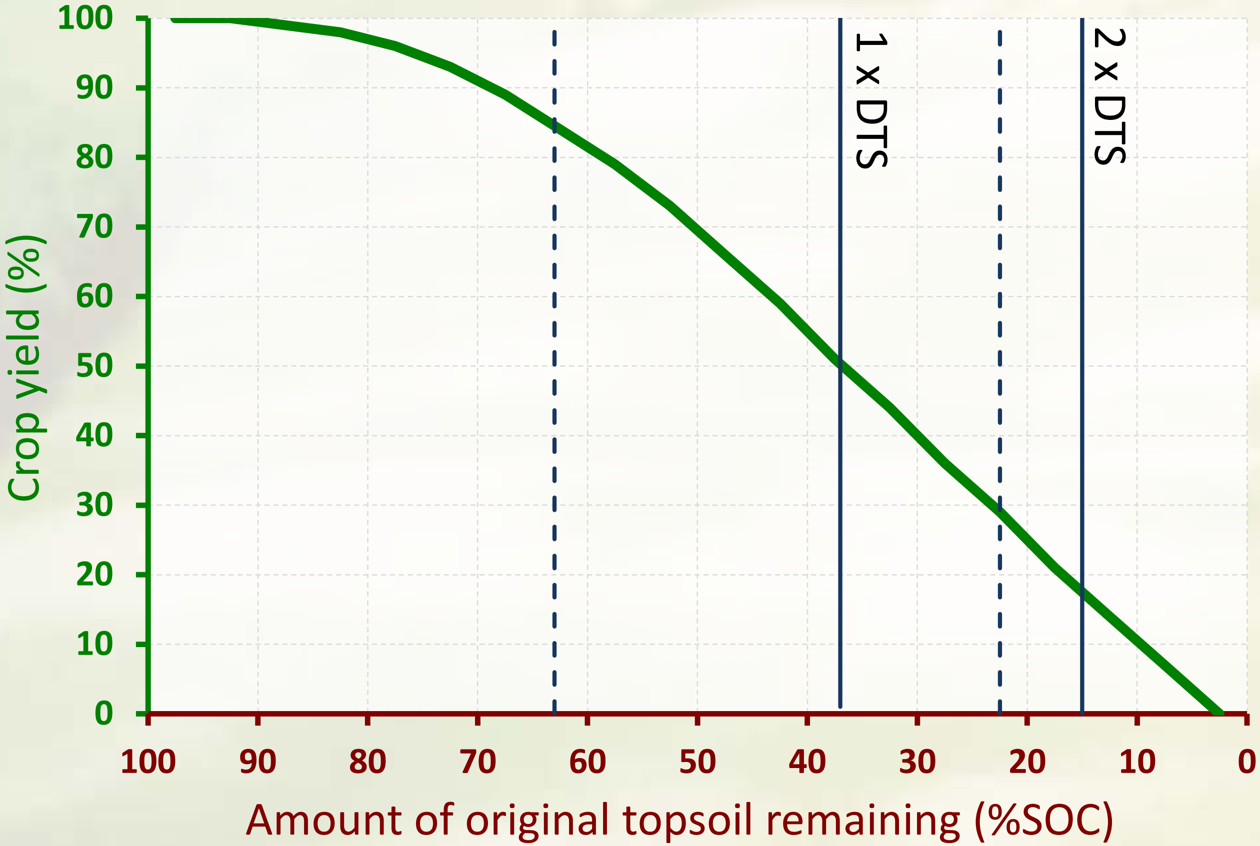
Current Assessment of Cost

Provincial Overview of Soil Erosion Between 1971 and 2011:
Wind, Water and Tillage Erosion, combined as Soil Erosion

	Negligible		Very Low		Low		Moderate		High		Very High		M to VH	
	1971	**2011**	**1971**	**2011**	**1971**	**2011**	**1971**	**2011**	**1971**	**2011**	**1971**	**2011**	**1971**	**2011**
BC	17.1	54.6	22.9	32.4	48.3	9.0	8.6	1.9	0.4	0.5	2.6	1.6	11.7	4.0
AB	20.9	65.8	32.5	20.3	13.3	10.3	20.2	3.2	7.0	0.3	6.0	0.0	33.3	3.6
SK	0.0	60.1	19.5	22.7	44.2	15.9	17.2	1.2	15.3	0.0	3.7	0.0	36.2	1.2
MB	4.2	15.5	37.6	55.7	23.2	19.2	29.5	9.3	5.0	0.3	0.6	0.0	35.1	9.6
ON	5.5	10.0	16.4	17.8	10.4	14.5	25.0	29.0	18.6	15.4	24.0	13.4	67.7	57.8
QC	56.8	53.1	16.9	22.5	11.4	11.5	10.6	9.7	2.8	1.6	1.6	1.5	14.9	12.9
NB	20.6	27.4	21.1	16.0	32.9	33.7	7.9	9.6	7.0	6.5	10.4	6.9	25.3	22.9
NS	7.2	9.9	15.3	38.9	36.5	33.6	38.3	15.6	1.6	1.6	1.2	0.4	41.1	17.6
PE	11.5	11.9	7.5	7.9	4.1	3.9	65.7	76.3	11.2	0.0	0.0	0.0	76.9	76.3
NF	2.7	16.6	11.6	14.5	13.8	6.2	5.9	39.9	25.7	22.8	40.4	0.0	71.9	62.7
Can	**9.4**	**50.5**	**24.9**	**25.6**	**28.9**	**14.4**	**20.0**	**6.3**	**11.3**	**1.7**	**5.5**	**1.4**	**36.8**	**9.5**

Current Assessment of Cost

Soil Loss and Yield Loss Relationship:



Non-linear response

Current Assessment of Cost

Soil Loss and Yield Loss Relationship:

SOIL EROSION AND CORN YIELD IN ONTARIO. I. FIELD EVALUATION

L. A. BATTISTON, M. H. MILLER, and I. J. SHELTON

Department of Land Resource Science and Ontario Institute of Pedology, University of Guelph, Guelph, Ontario, Canada N1G 2W1. *Received 20 Feb. 1987, accepted 29 Apr. 1987.*

BATTISTON, L. A., MILLER, M. H. AND SHELTON, I. J. 1987. Soil erosion and corn yield in Ontario. I. Field evaluation. Can. J. Soil Sci. **67**: 731–745.

Yield of corn (*Zea mays* L.) was measured at eight sites in 1982 and nine sites in 1983 on areas in farm fields exhibiting differing degrees of past erosion. Yield was also measured on depositional areas in some fields. Yield on depositional areas was, on average, marginally greater than on noneroded areas. Yield on severely eroded areas (all or most of original solum lost) ranged from 16 to 80% of that on noneroded areas with an average of 59%. There was little or no reduction in yield until the depth to Ck had been reduced to almost 50% of that on the noneroded profile. With further reductions in depth to Ck, yields declined rapidly on most sites. The primary cause of yield reduction varied from site to site and included reduced stand and seedling vigor due to a poor seedbed condition, nutrient deficiency and reduced available water holding capacity (AWHC). The impact of erosion on yield at a field and regional level was estimated based on the extent of erosion determined from aerial photographs and the site-specific yield measurements. Estimated corn yield on two fields was about 92% of that expected if no erosion had occurred. In a 90-km² area of the Regional Municipality of Waterloo, 18% of the cultivated land was estimated to be moderately to severely eroded. Based on the site-specific yield measurements, this erosion would result in a 3.6% reduction in average corn yield in the region. The implications of the findings on preventative and remedial measures and on future productivity in the region are discussed.

Key words: Erosion, yield, corn, seedbed condition, nutrient deficiency, water stress

[Érosion du sol et rendement du maïs en Ontario. I. Évaluation au champ.]
Titre abrégé: Érosion du sol et rendement du maïs.
Nous avons mesuré le rendement du maïs (*Zea mais* L.) à huit emplacements en 1982 et à neuf emplacements en 1983 dans des régions où les champs présentaient divers degrés d'érosion. Le rendement a également été mesuré dans des zones de dépôt, dans certains champs. Le rendement mesuré dans les zones de dépôt était, en moyenne, légèrement supérieur à celui mesuré dans les zones non-érodées. Le rendement mesuré dans les zones gravement érodées (perte de la totalité ou presque du solum original) variait de 16 à 80% du rendement mesuré dans les zones non-érodées (moyenne de 59%). La baisse observée du rendement était faible ou nulle tant que la profondeur du sol jusqu'à l'horizon Ck n'avait pas été réduite à presque 50% de celle du profil non-érodé. A partir de là, toute baisse ultérieure de la profondeur du sol jusqu'à Ck provoquait une baisse rapide du rendement à la plupart des emplacements. La cause principale de la baisse du rendement variait d'un emplacement à l'autre. Il pouvait notamment s'agir d'une baisse de la vigueur des peuplements et des semis due au piètre état des lits de germination, d'une carence en matières nutritives ou d'une baisse de la capacité de rétention de l'eau disponible (AWHC) L'incidence de l'érosion sur le rendement à l'échelle d'un champ et à l'échelle régionale a été évaluée à partir de l'importance de l'érosion déterminée par photographies aériennes et par mesures du rendement effectuées sur place. Le rendement estimatif en maïs dans deux champs a été établi à environ

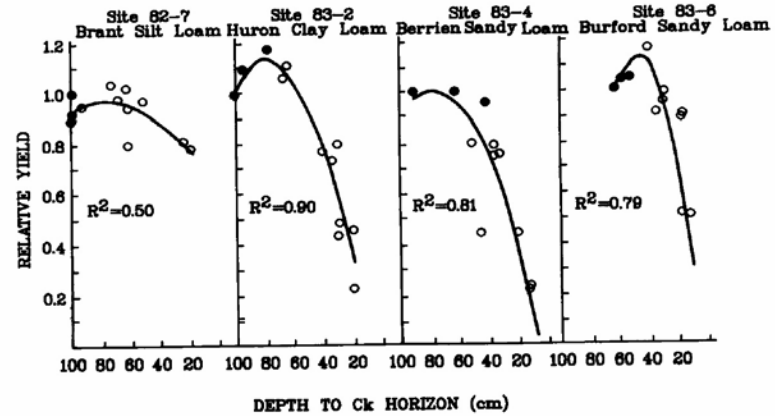


Fig. 3. Relative corn grain yield on four sites in relation to depth to Ck horizon. (Closed symbols and open symbols represent noneroded and eroded plots, respectively.)

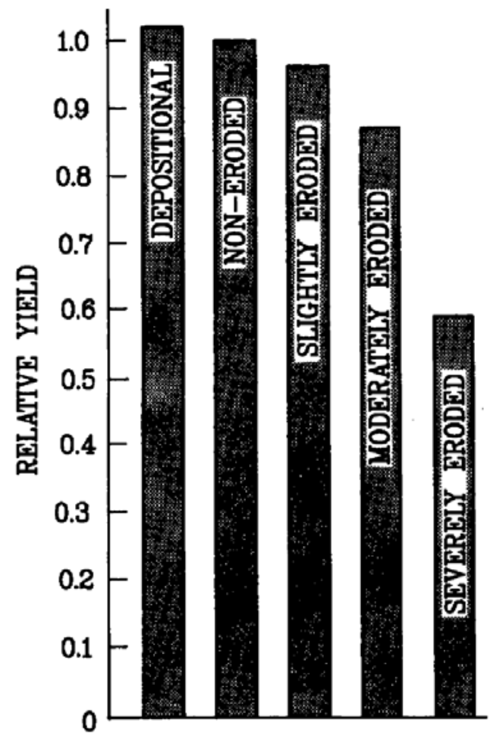


Fig. 1. Relative yield of corn grain on differing erosion phases.

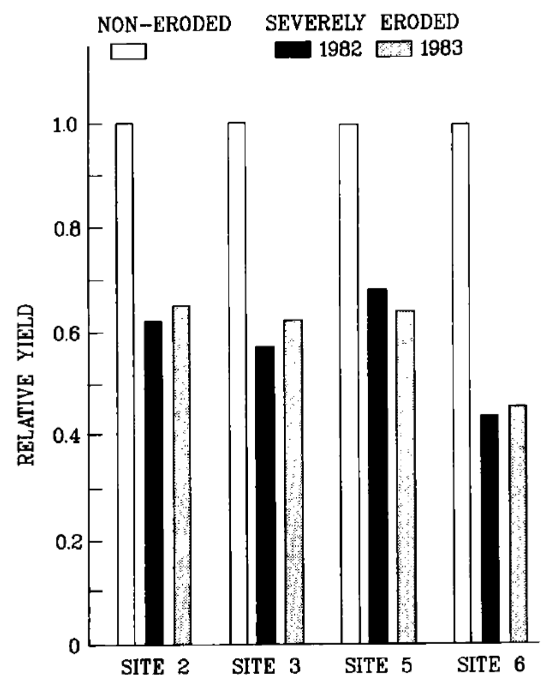


Fig. 2. Comparison of reduction in corn grain yield due to erosion on four sites in 1982 and 1983.

CURRENT ASSESSMENT OF COST

Annual Soil Loss and Crop Yield Loss in 1971 and 2011

	Units	1971 Low-Eroding Cropland (N-L)	1971 High-Eroding Cropland (M-VH)	1971 Total	2011 Low-Eroding Cropland (N-L)	2011 High-Eroding Cropland (M-VH)	2011 Total
Cropland Area	ha	25,149,351	14,663,025	39,812,376	35,211,104	3,676,329	38,887,434
	%	63.2	36.8	100	90.5	9.5	100
Soil Loss Rate	$t\ ha^{-1}\ yr^{-1}$	5.9	24.0		3.5	22.7	
Relative Crop Yield	%	99.5	83		95	40	
Crop Yield Loss	%	0.5	17		5	60	

CURRENT ASSESSMENT OF COST

… and Lost Value

	Units	1971			2011		
		Low-Eroding Cropland (N-L)	High-Eroding Cropland (M-VH)	Total	Low-Eroding Cropland (N-L)	High-Eroding Cropland (M-VH)	Total
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Degraded Value	$2016			13,570,289,116			
Non-Degraded Value	$2016			14,525,640,873			1
Lost Value	$2016			**$0.96 B yr^{-1}**			**$3.1B yr^{-1}**

Cumulative loss up to 1971 in the order of **$20-30B**

CURRENT ASSESSMENT OF COST

… and Lost Value

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Relative Crop Yield	%	99.5	83		95	40	
Crop Yield Loss	%	0.5	17		5	60	
Degraded Value	$2016			13,570,289,116			27,326,006,316
Non-Degraded Value	$2016			14,525,640,873			30,429,706,921
Lost Value	$2016			**$0.96 B yr^{-1}**			**$3.1B yr^{-1}**

Cumulative loss up to 1971 in the order of $20-30B

Cumulative loss from 1971 to 2011 in the order of **$40-60B**

Current Assessment of Cost

Why has the cost of soil erosion continued to increase since the 1970s and 1980s, rather than decrease???

- Although the area of moderately to severely eroded land has decreased in general, a considerable amount of area has not.

Current Assessment of Cost

Why has the cost of soil erosion continued to increase since the 1970s and 1980s, rather than decrease???

- Areas where soil erosion is now controlled through soil conservation practices still suffer from historical losses of soil.

Current Assessment of Cost

Why has the cost of soil erosion continued to increase since the 1970s and 1980s, rather than decrease???

- Restoring soil productivity on moderately to severely eroded areas is an extremely slow process.

CURRENT ASSESSMENT OF COST

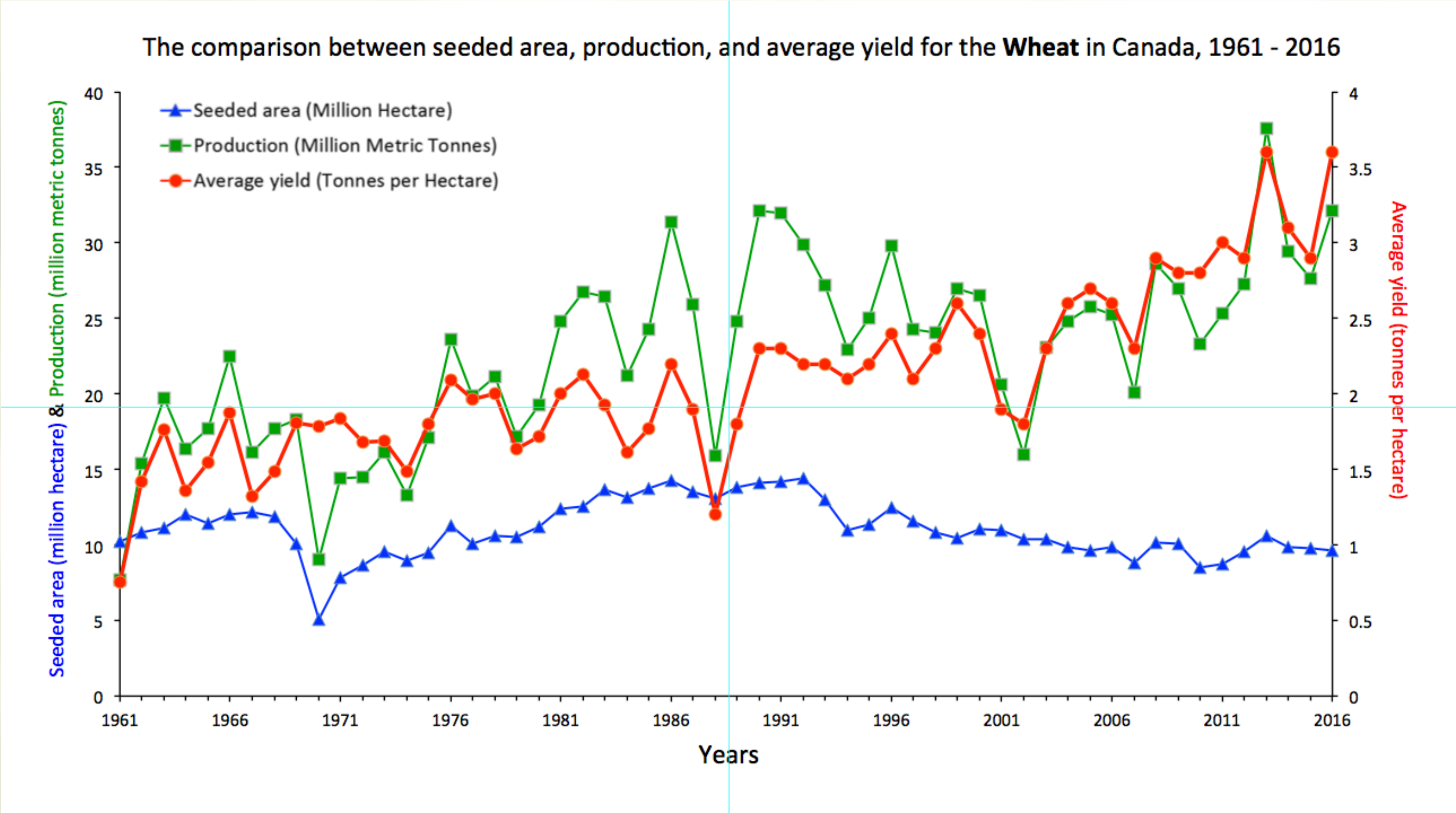
Why has the cost of soil erosion continued to increase since the 1970s and 1980s, rather than decrease???

- Cumulative soil losses have pushed yield losses into a state of steep decline.

Current Assessment of Cost

Why has the cost of soil erosion continued to increase since the 1970s and 1980s, rather than decrease???

- The value of crop production has increased. Growing higher yielding, higher value crops on more eroded land.



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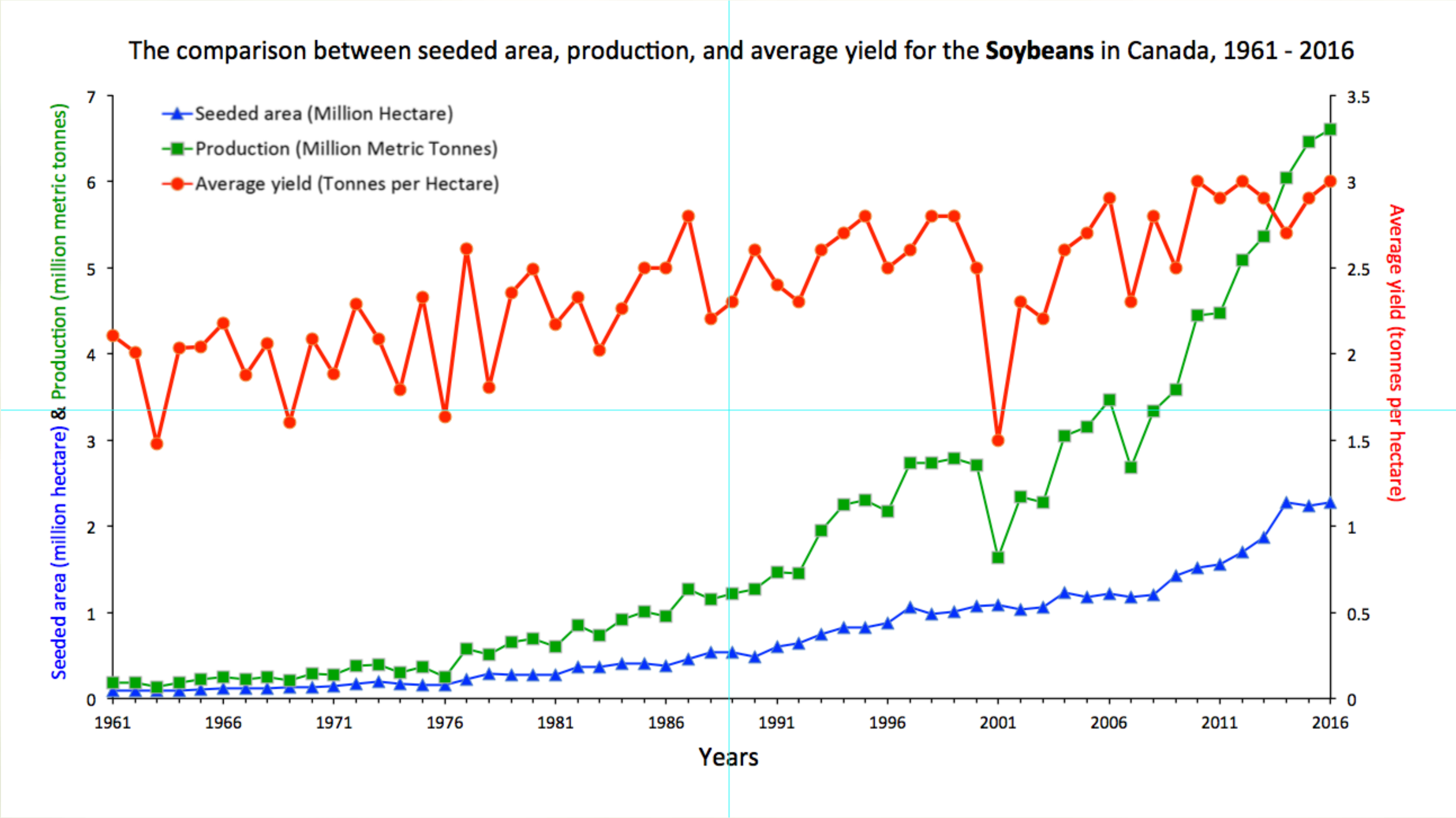

CURRENT ASSESSMENT OF COST

More in-depth study:

- Develop highly descriptive tillage profiles to account for variations in tillage equipment associated with climatic regions, soil types, cropping systems and for variations over time.
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- Use probabilities rather than means to describe to better represent likelihoods and uncertainties.

CURRENT ASSESSMENT OF COST

More in-depth study:

- Enhanced temporal resolution: Estimate soil loss rates on an annual basis, rather than every five years.
- Enhanced spatial resolution: Application of remotely sensed data and the estimation of soil loss rates on a raster basis rather than a polygon basis.
- **More comprehensive relationships between soil loss and loss in crop yield.**
- Develop relationships for a range of climate scenarios.
- More detailed market data.

Current Assessment of Cost

Take home message:

Soil erosion continues to cost Canadian agriculture and the economy substantially
—**the cost has gone up!**

Although soil conservation efforts have reduced the amount of cropland that is moderately to severely eroded—**more needs to be done**!

Current Assessment of Cost

Take home message:

Soil erosion continues to cost Canadian agriculture and the economy substantially
—**the cost has gone up!**

Although soil conservation efforts have reduced the amount of cropland that is moderately to severely eroded—**more needs to be done**!

STEP ONE: MINIMIZE SOIL EROSION (LOSS)
STEP TWO: RESTORE AND STABALIZE SOIL

Be Tillage Smart

- We must redefine and redesign conservation tillage, and foster its implementation.

We must consider how far soil is moved during tillage as well as how much crop residue is left on the soil surface

There are tillage operations that are more erosive than the moldboard plow

Be Tillage Smart

- We must redefine and redesign conservation tillage, and foster its implementation.

There are tillage operations that are more erosive than the moldboard plow

The current trend is towards higher speed tillage, throwing soil much further

Be Tillage Smart

- We must redefine and redesign conservation tillage, and foster its implementation.

There are tillage operations that are more erosive than the moldboard plow

Even seeding operations move a lot of soil and cause tillage erosion

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 β (kg m^{-1} %$^{-1}$) [a]
		T_L (m) [a]	λ_{90} (m) [a]	T_M (kg m^{-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.

Be Tillage Smart

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Even crop management operations move a lot of soil and cause tillage erosion

There are tillage operations that are more erosive than the moldboard plow

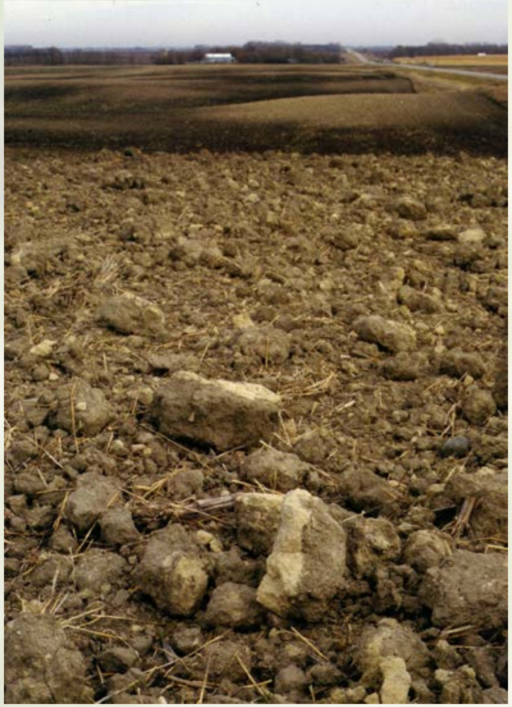
Be Tillage Smart

- We must redefine and redesign conservation tillage, and foster its implementation.

Even a moldboard plow can be used as a soil conservation tool

Be Land Smart

- Conservation tillage reduces the loss of soil organic carbon and productivity, we must focus on good crop management to increase organic carbon inputs into the soil and increase soil and crop productivity.



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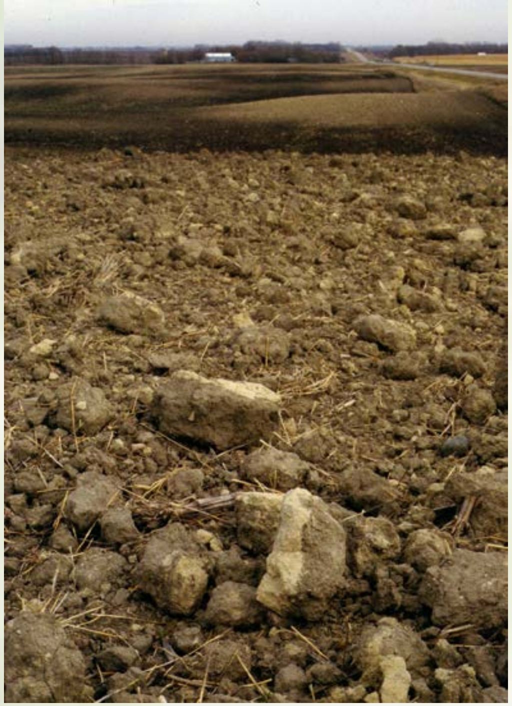


Be Land Smart

- Returning topsoil eroded by tillage erosion – a practice called soil-landscape restoration.

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

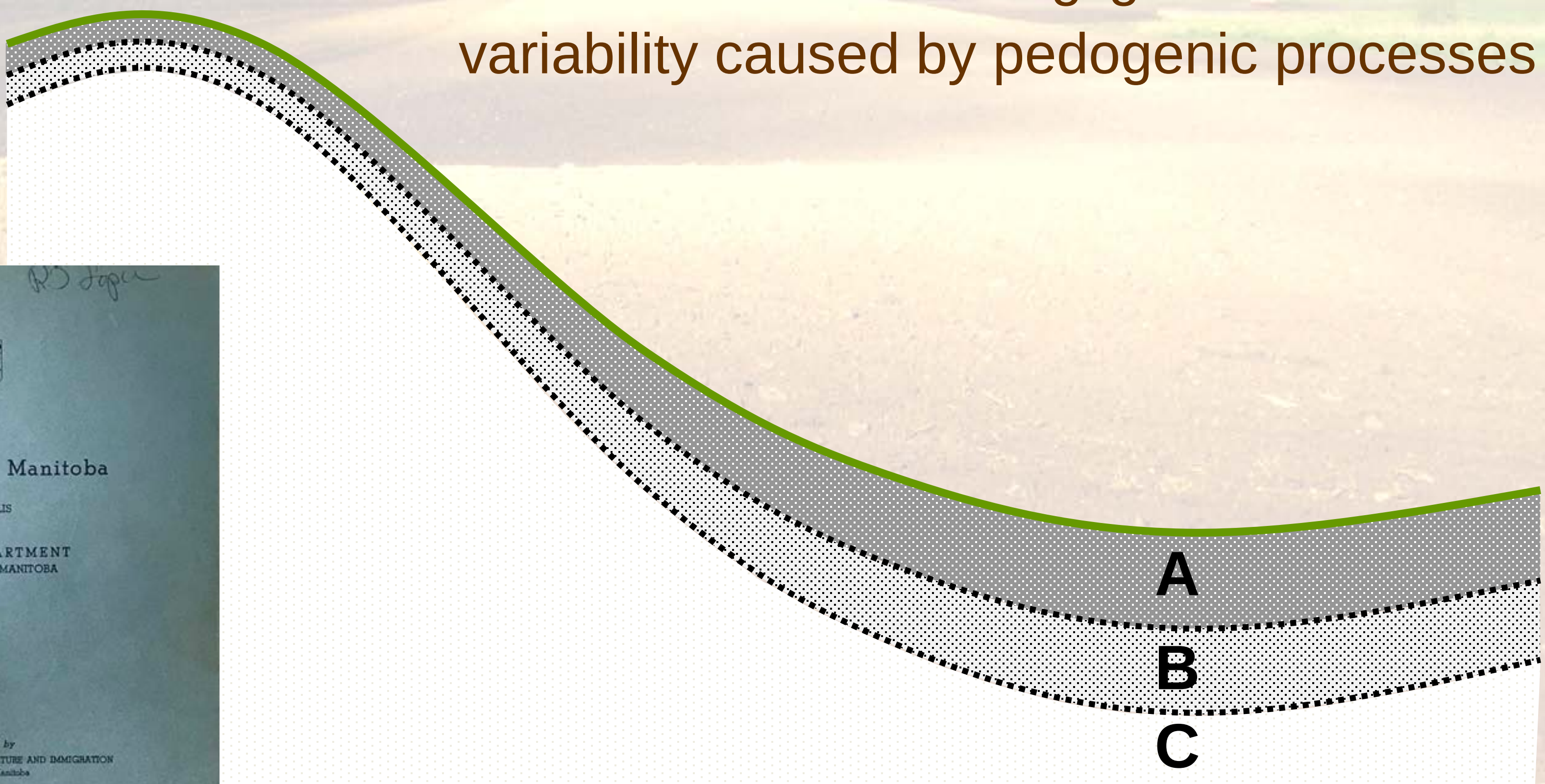
Soil-Landscape Restoration

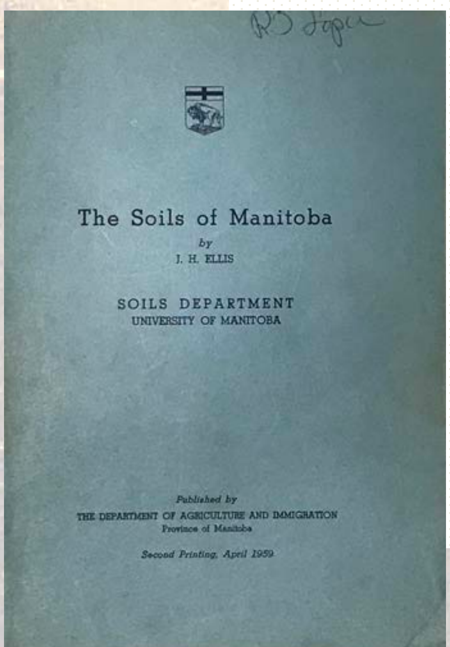
Soil-landscape variability in a hilly landscape

unbroken, uncultivated

negligible soil erosion

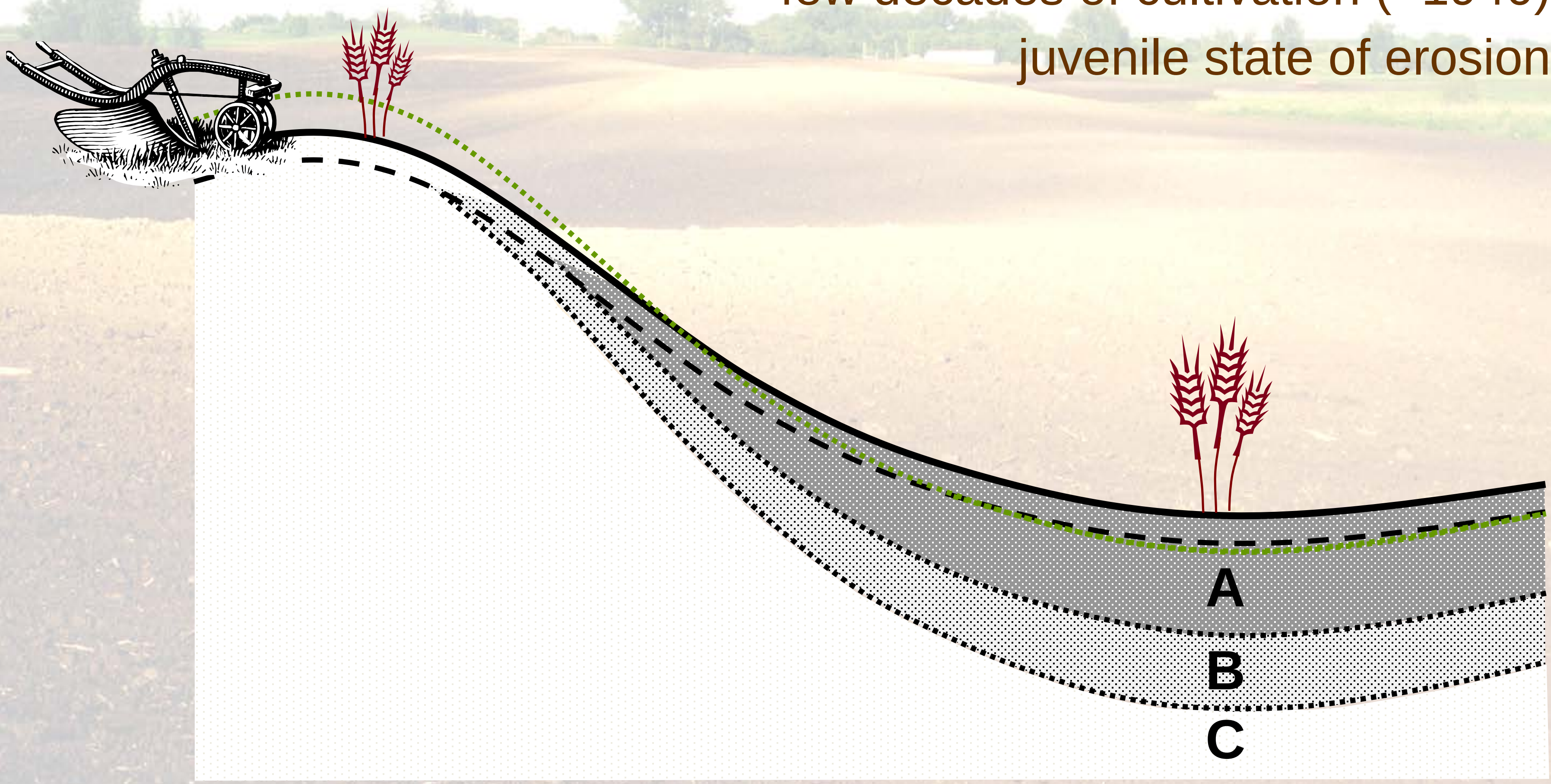
variability caused by pedogenic processes





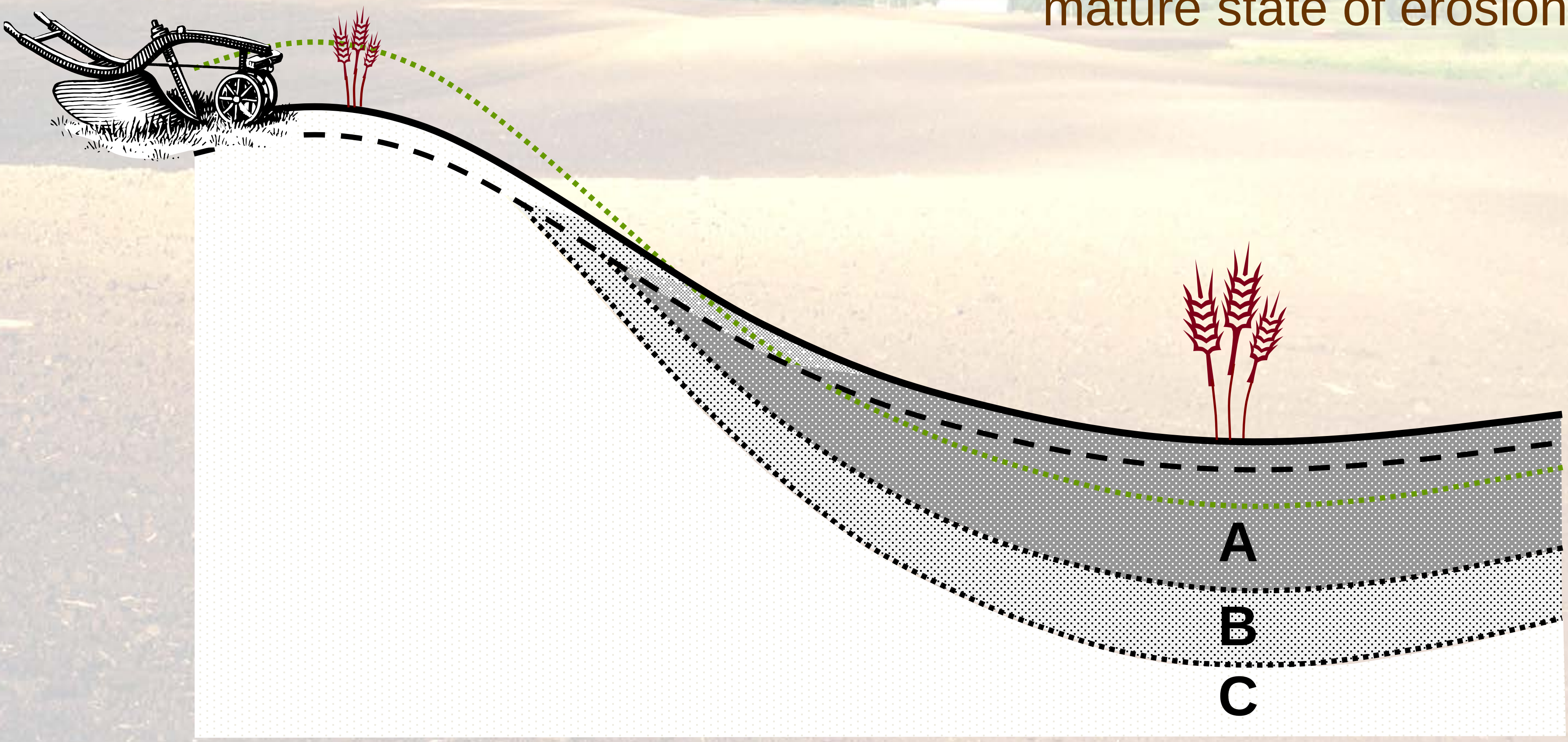
Soil-Landscape Restoration

Soil-landscape variability in a hilly landscape
few decades of cultivation (~1940)
juvenile state of erosion



Soil-Landscape Restoration

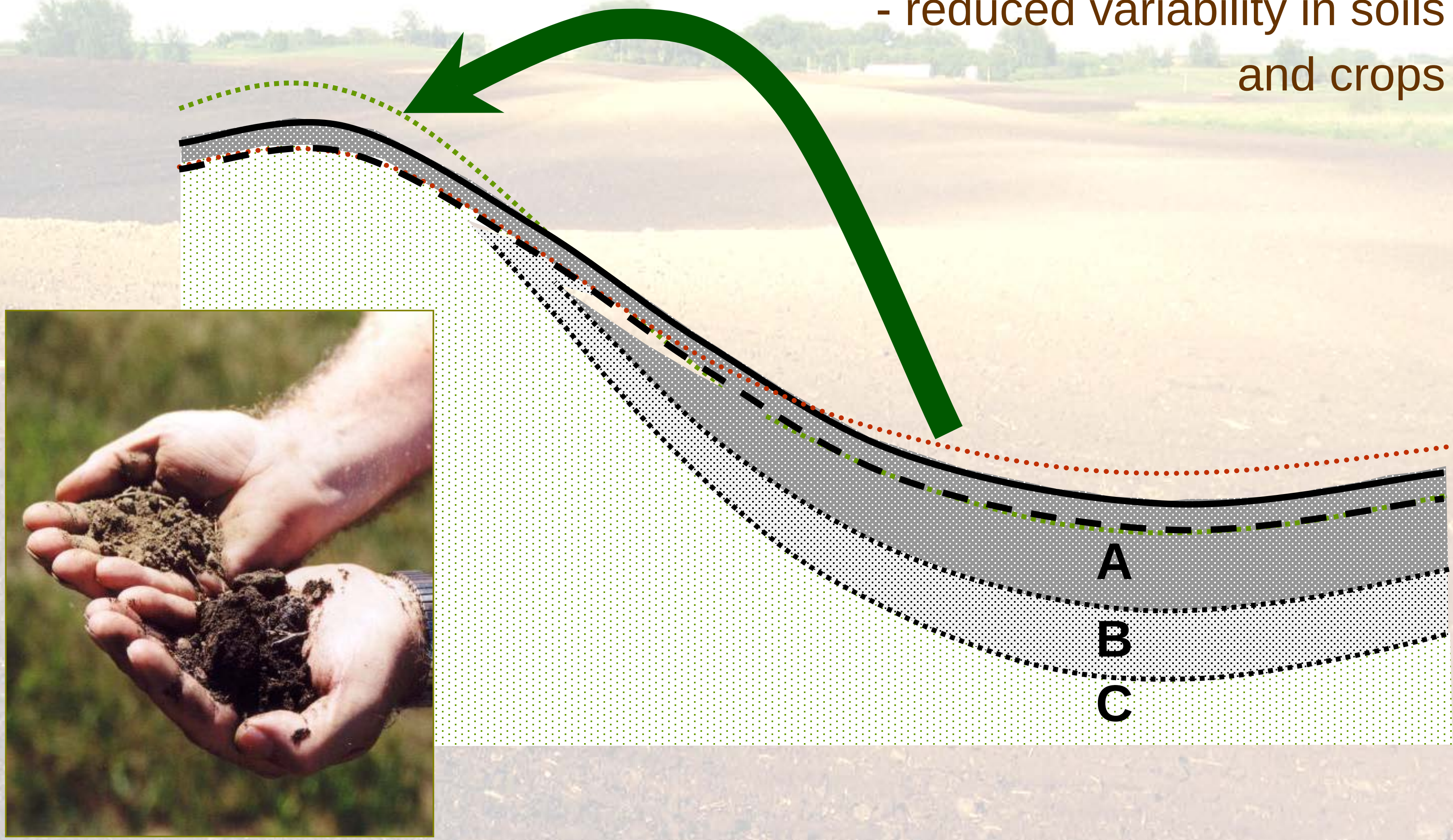
Soil-landscape variability in a hilly landscape
several decades of cultivation (~1990)
mature state of erosion



Soil-Landscape Restoration

Restored Landscape

- reduced variability in soils and crops



Soil-Landscape Restoration

Research Findings:

- The addition of as little as 10 cm of topsoil to severely eroded hill tops increased yields by 10% to 33% in wet years and 39% to 133% in dry years.
- Although, there was a significant reduction in removal plots at one of the three sites there was still a NET increase in crop production.
- Landscape restoration provides continued yield response on hilltops for several years after the initial restoration.
- The addition of topsoil improves water retention, soil nutrient status, and organic matter concentrations.
- The cost of rehabilitation can be recovered in 3 to 5 years.

Be Land Smart

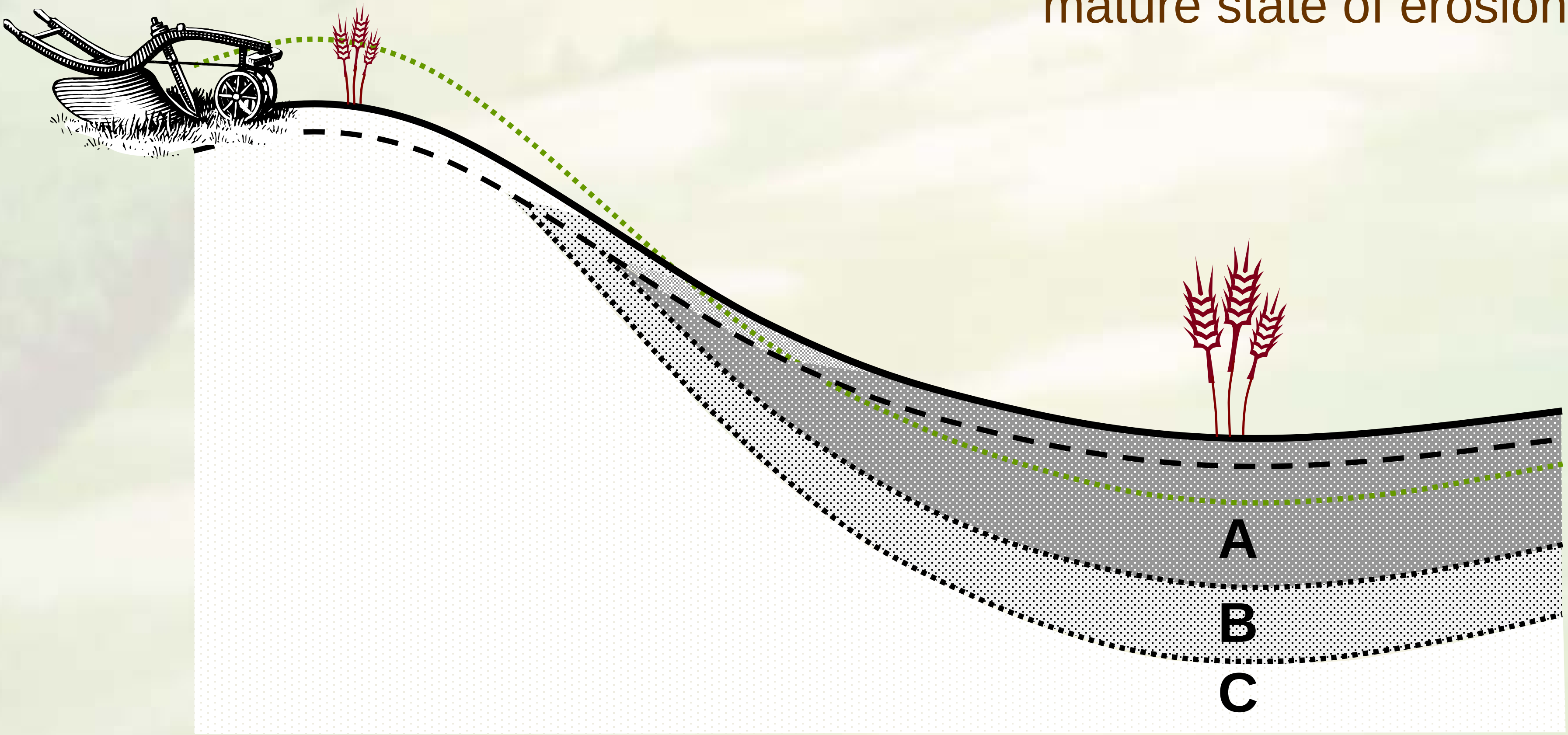
- More soil research needs to be carried out at the landscape scale.


Be Land Smart

- There is growing urgency to take effective action.
- Increasing variability in climate and the increasing severity and frequency of weather extremes can only amplify the losses in crop production and threaten farm and food security.
- The degradation of soil landscapes is increasing in areal extent, more of farm fields are suffering the loss of topsoil. This is a result of progressive tillage erosion.

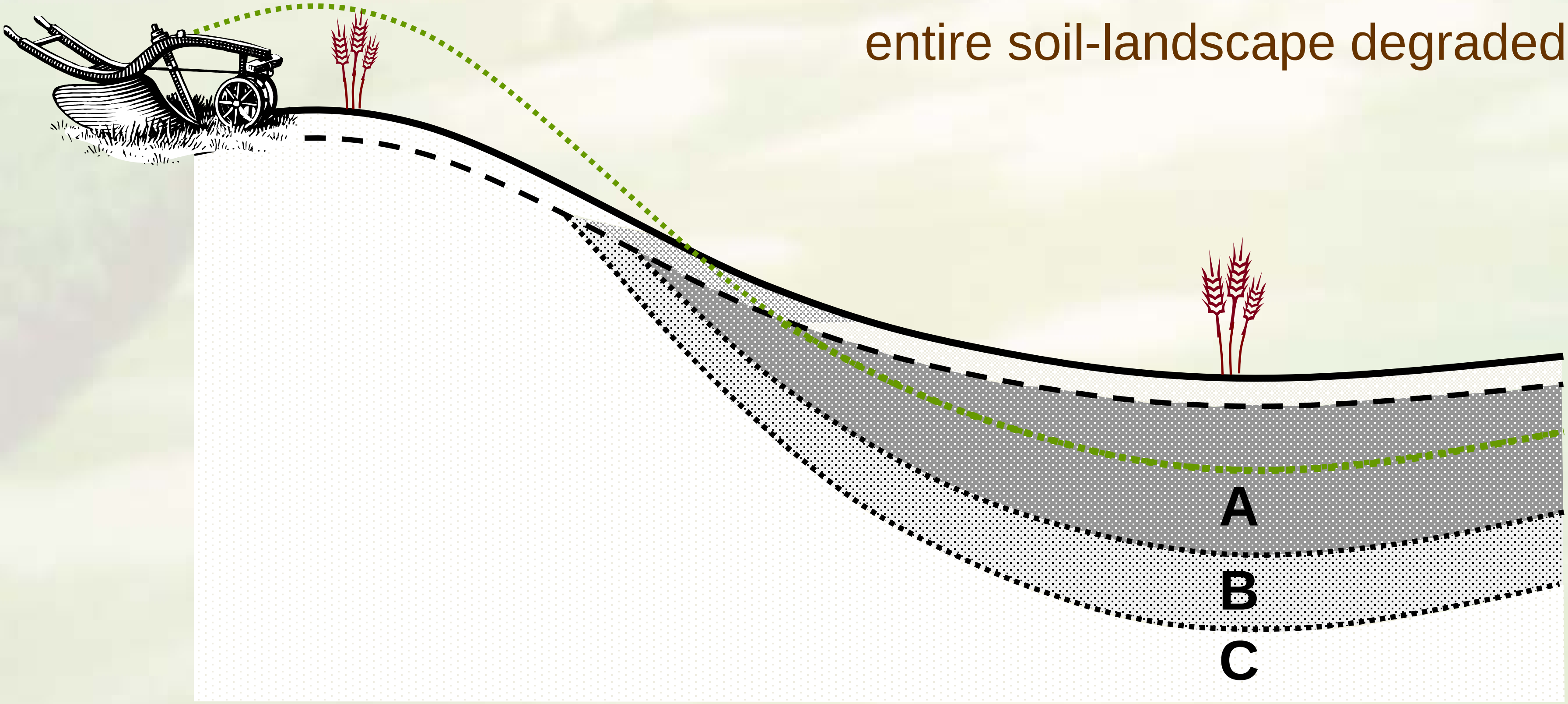
Be Land Smart

Soil-landscape variability in a hilly landscape
several decades of cultivation (~1990)
mature state of erosion



Be Land Smart

Soil-landscape variability in a hilly landscape
continued cultivation (~2010)
advanced state of erosion
entire soil-landscape degraded



There is a need for effective and preventative and corrective action!

Be Water Smart

- Keeping plant residues on the land surface may reduce the risk of wind and water erosion, but the major cause of soil loss is tillage erosion, the major source of sediments in surface waters is channel bank erosion, and the major source of nutrients is dissolved P from plant residues.

TILLAGE: IMPLICATIONS FOR SOIL AND WATER CONSERVATION PRACTICES

David Lobb
Department of Soil Science
University of Manitoba | Faculty of Agricultural and Food Sciences

Managing Soil: Maximizing Profit
South Dakota Soil and Water Conservation Society

Sioux Falls, South Dakota

November 29th, 2018