Soil Erosion and Soil Fertility: Myths and Realities

David Lobb
University of Manitoba

AGVISE Laboratories 2023 Soil Fertility Seminars

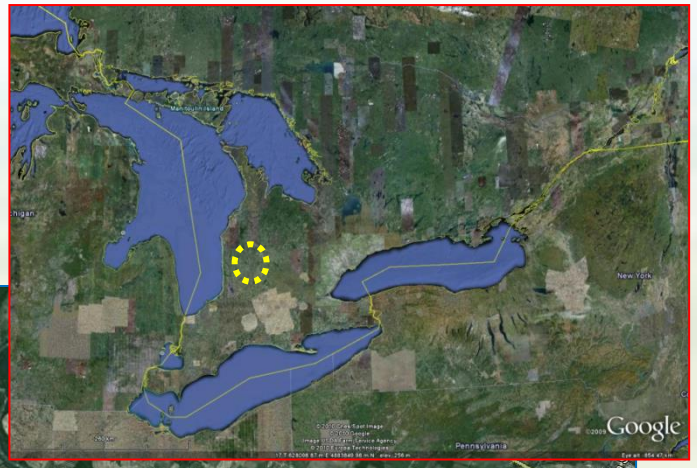
January 3rd, Watertown, South Dakota
January 4th, Willmar, Minnesota
January 5th, Grand Forks, North Dakota

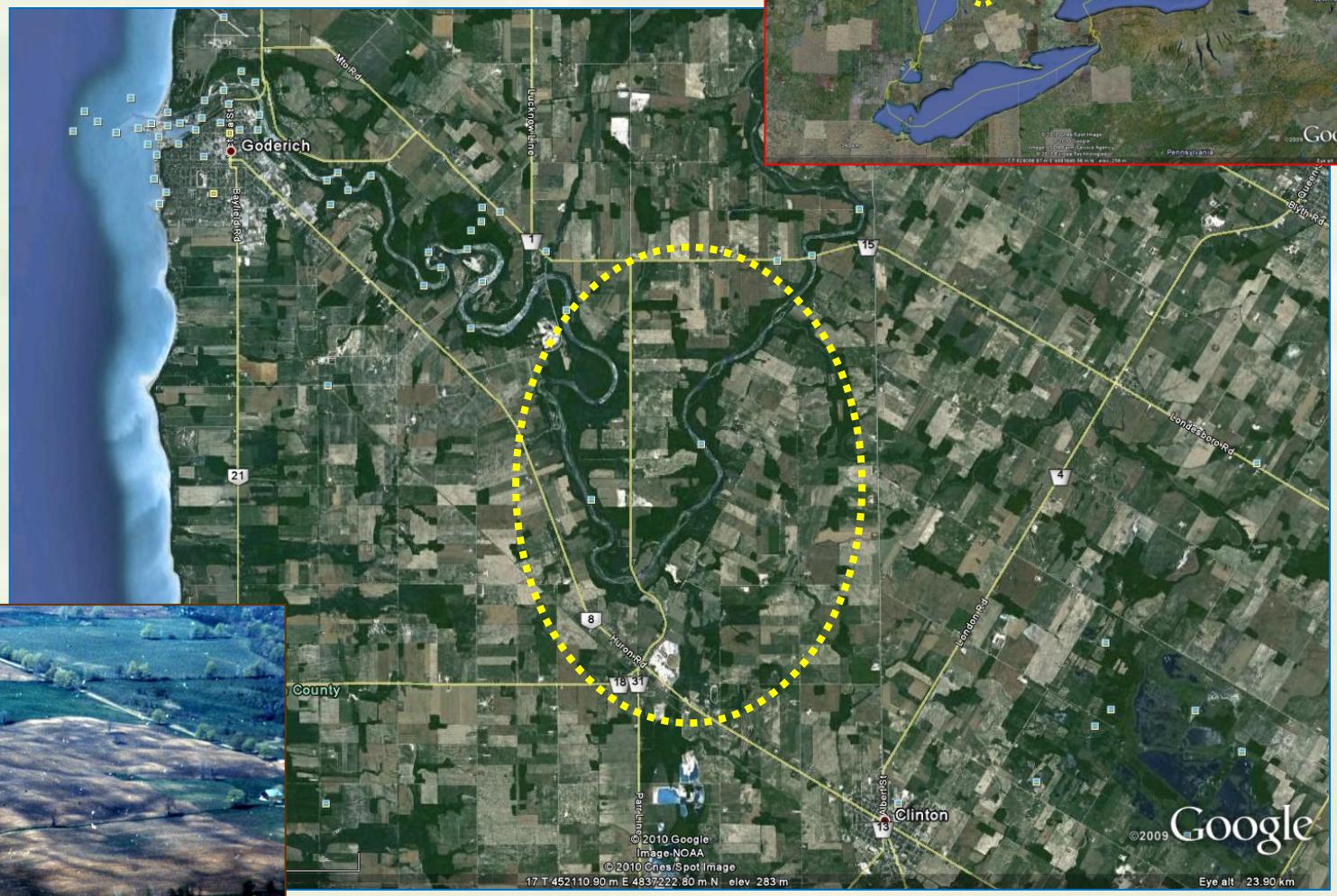
Manitoba, Timmerman, 2013

Outline:

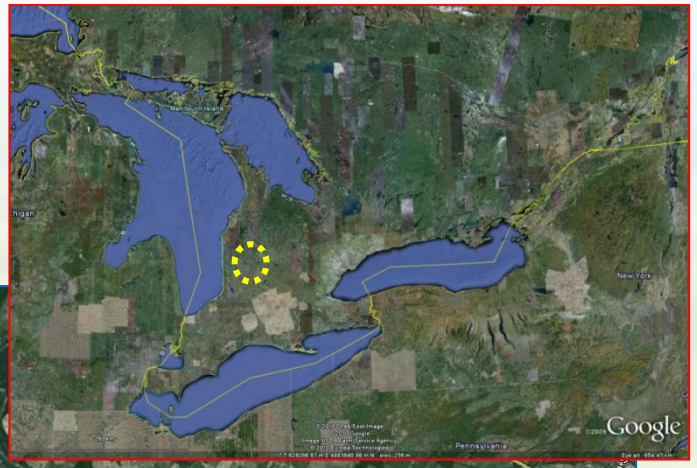
- My Background
- What we thought we knew…
- What we know now…
- What we can do…

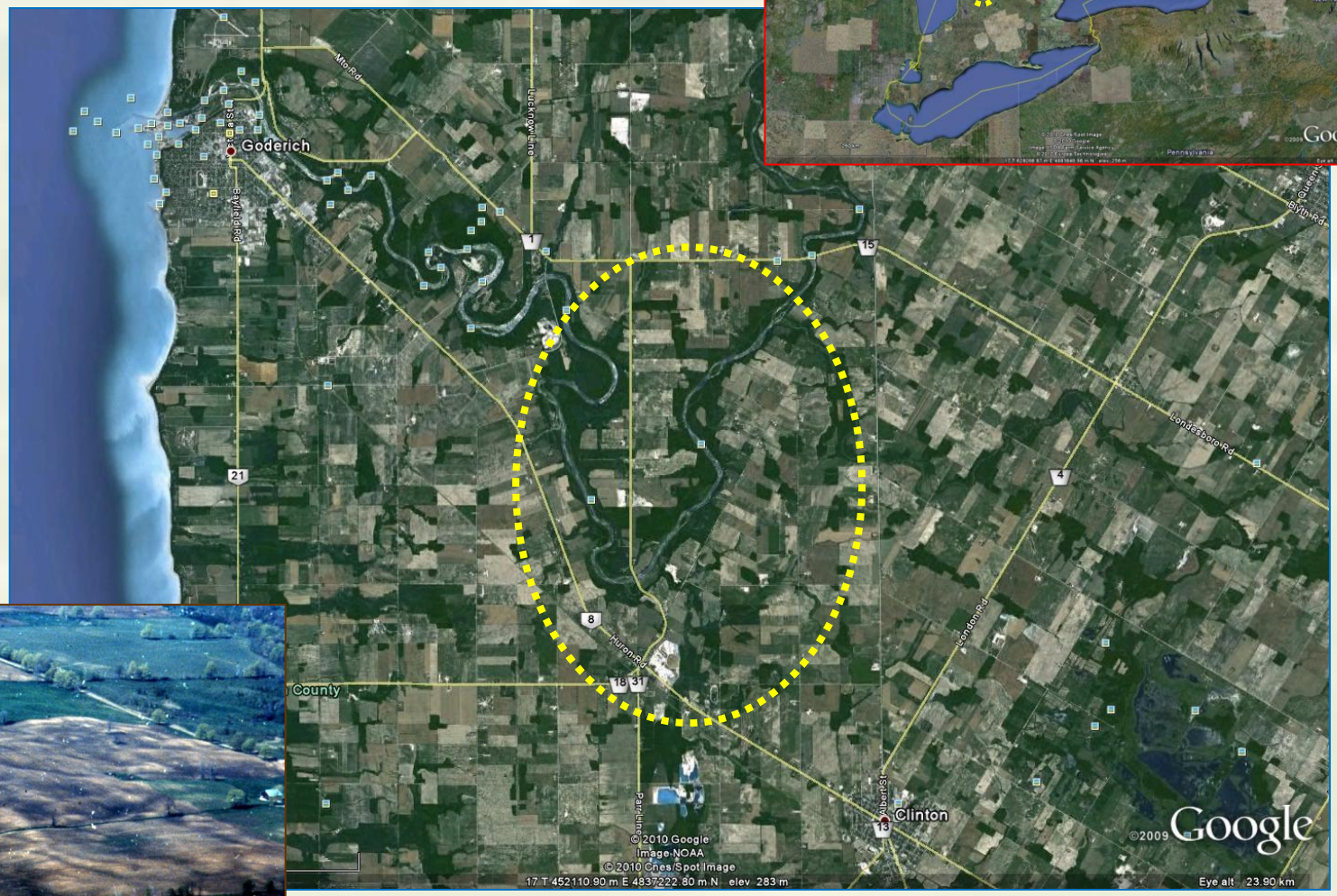
My Background…





My Background…





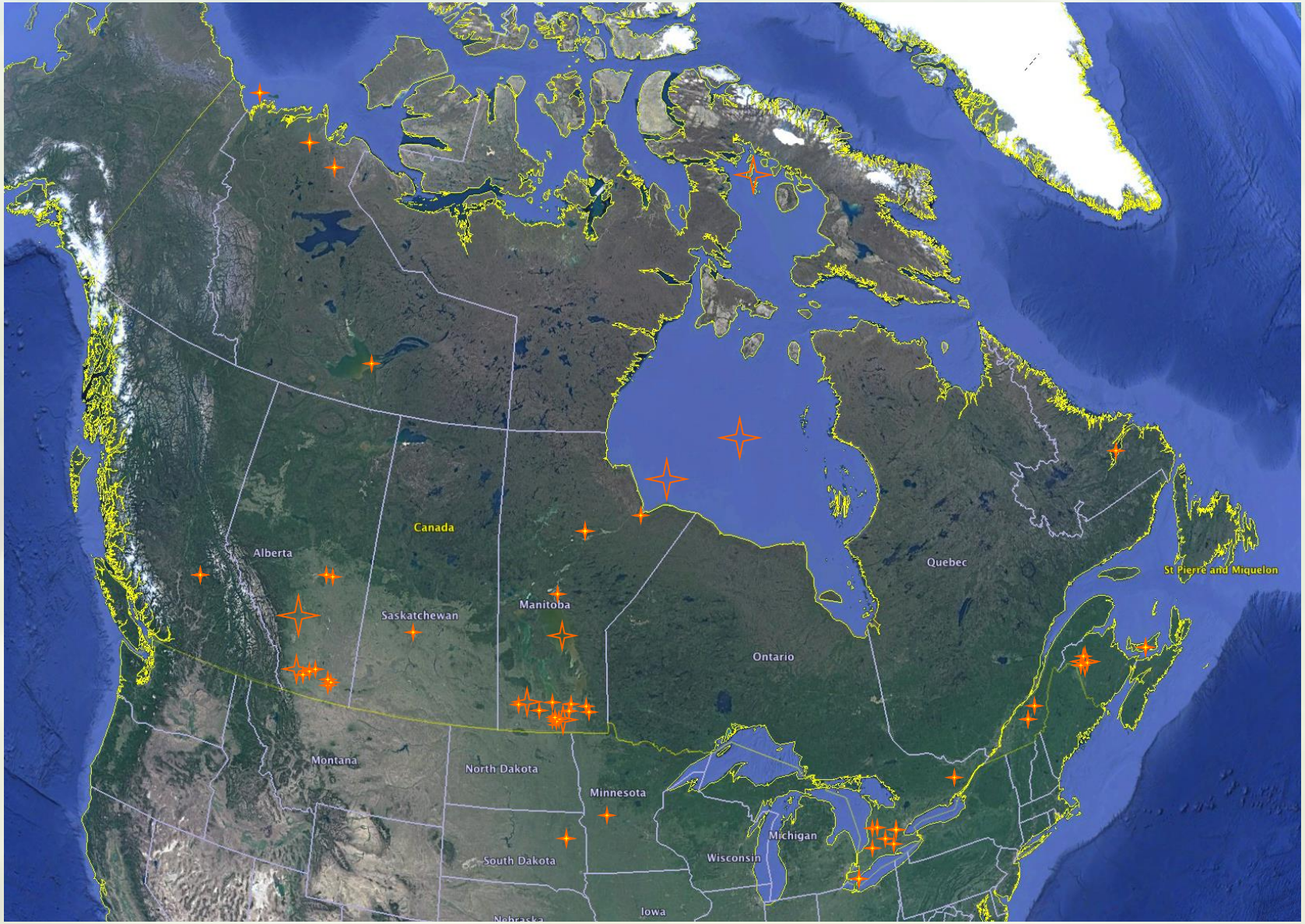
My Background…

Family farm, conventional till, cash-crop production

Clinton, Ontario, 1978

My Background…

Assessments of Soil Erosion and Sedimentation



What we thought we knew…

Soil erosion is a serious problem for agriculture, and a major part of that problem is its impact on soil fertility.

Minnesota, Lobb, 1999

Manitoba, AAFC

What we thought we knew…

Soil loss by wind and water erosion diminish soil fertility on site.

Saskatchewan, 1930s

Saskatchewan, 1980s, AAFC

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Manitoba, Lobb, 2020

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N, P, K lbs acre $^{-1}$ year $^{-1}$???

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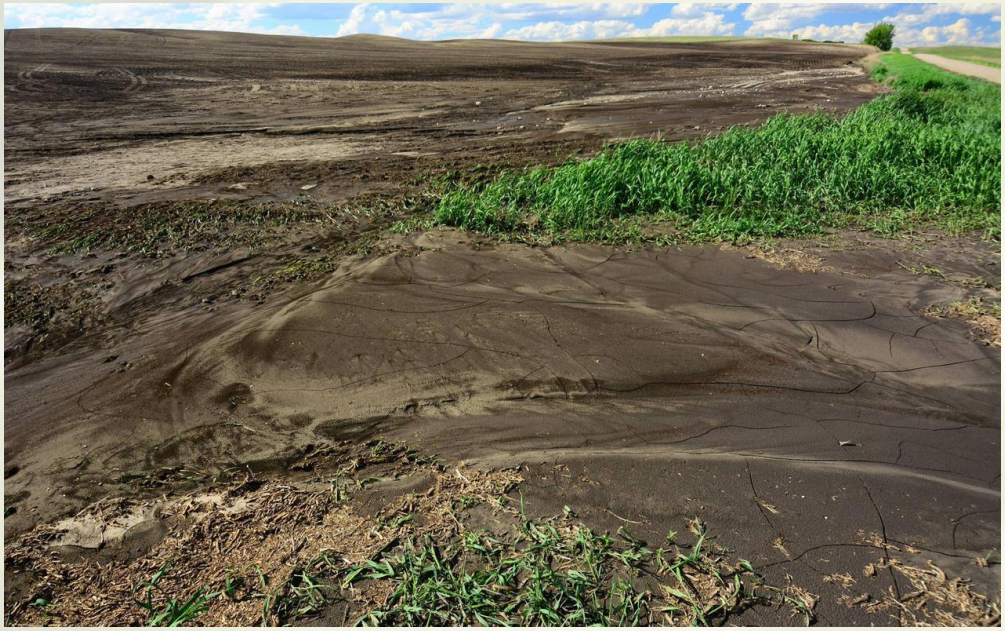
North Dakota, Rick Bohn/USFWS



Manitoba, Lobb 2020

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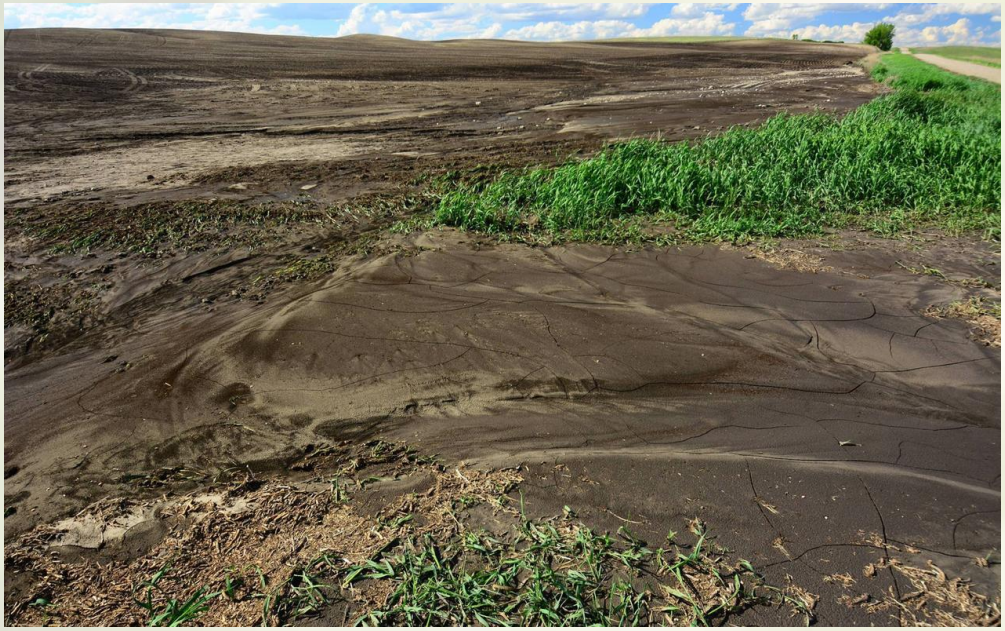


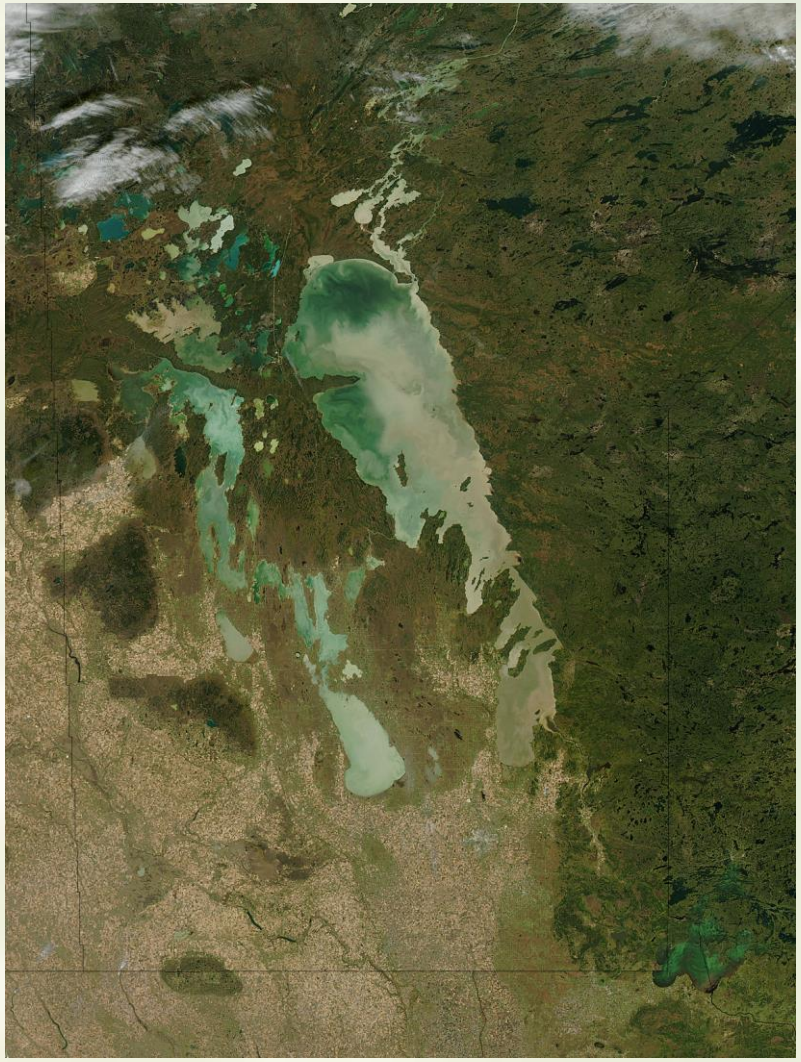
Manitoba, Lobb 2020

N, P, K lbs acre $^{-1}$ year $^{-1}$???

What we thought we knew…

And, soil erosion causes nutrient export and contamination off site.

Lake Winnipeg, 2010s



Manitoba, Lobb, 2007

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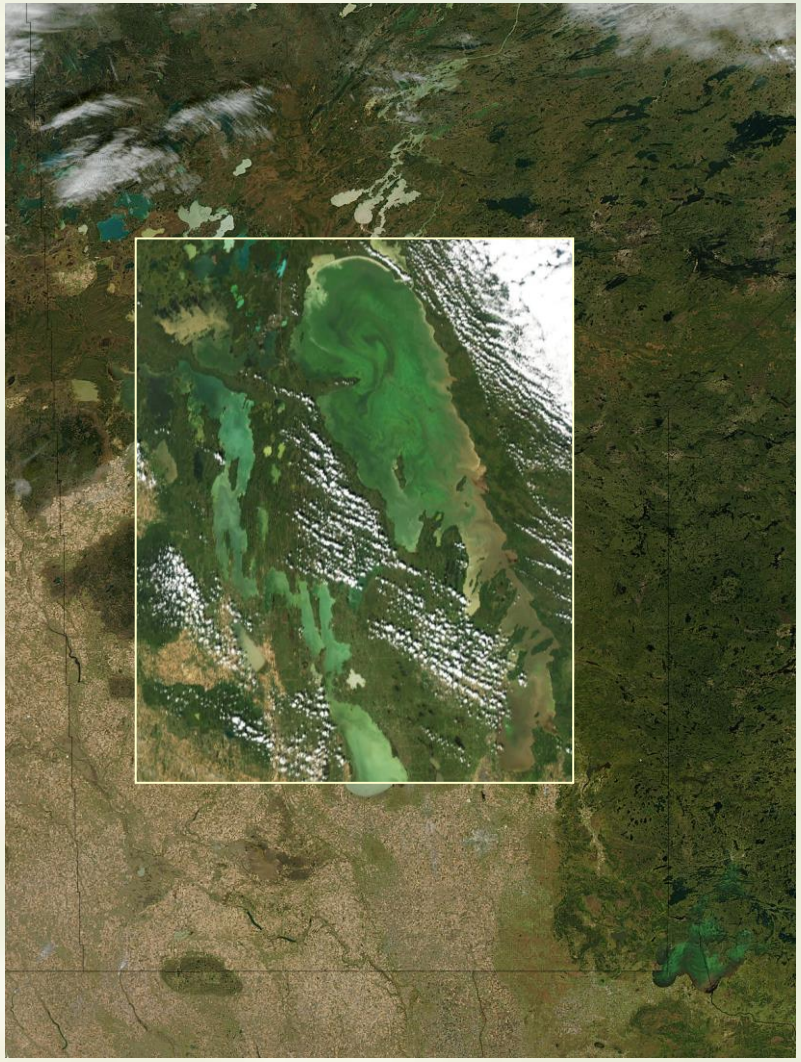

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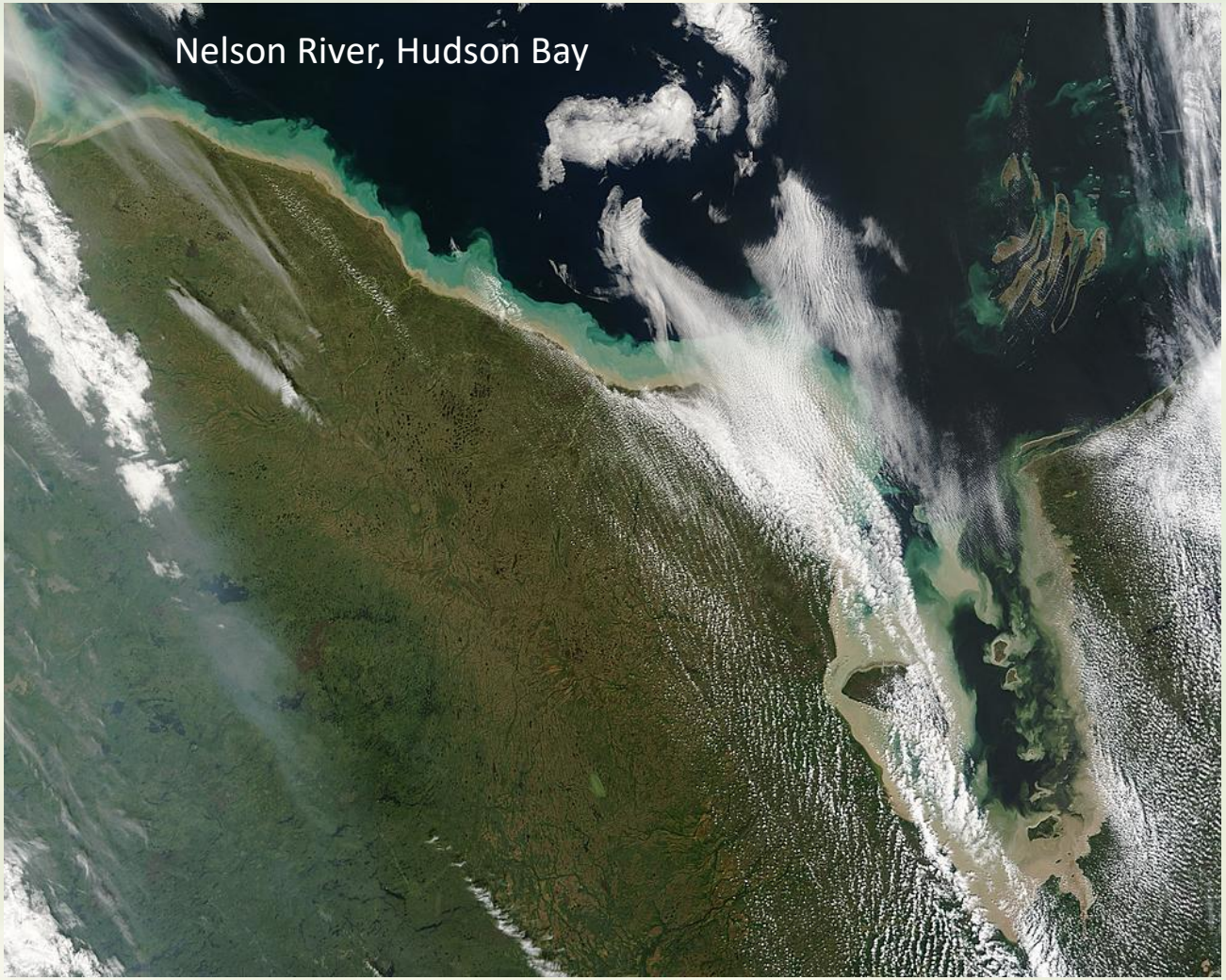

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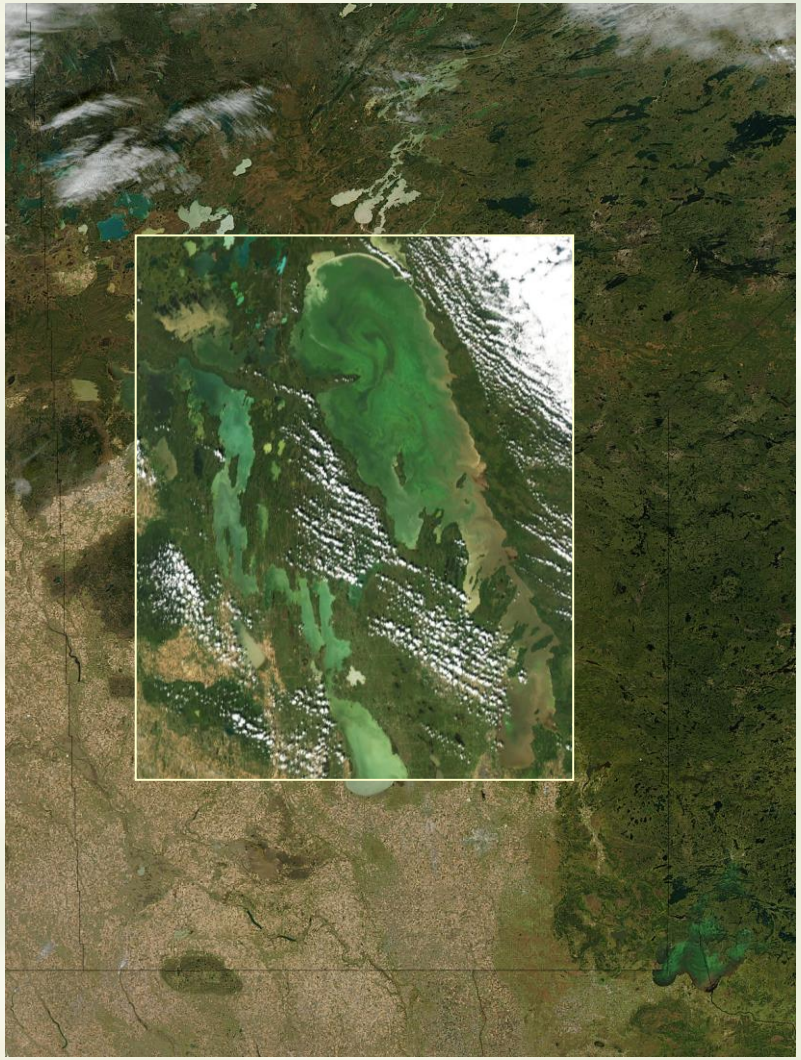

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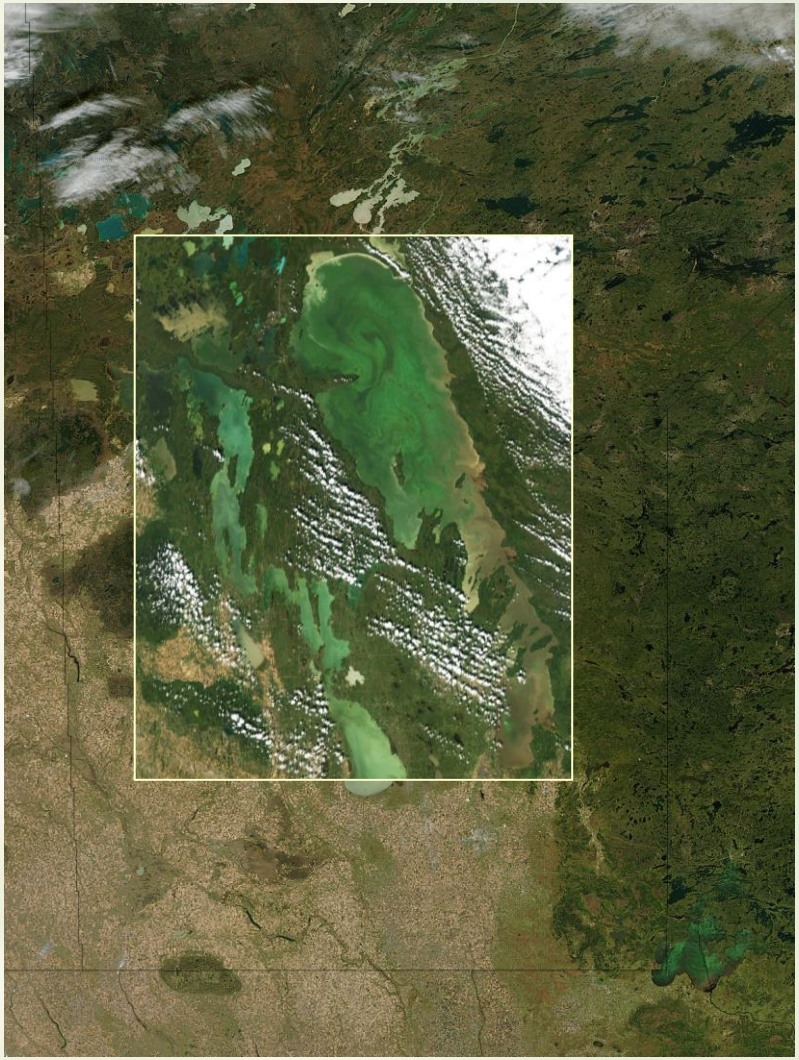

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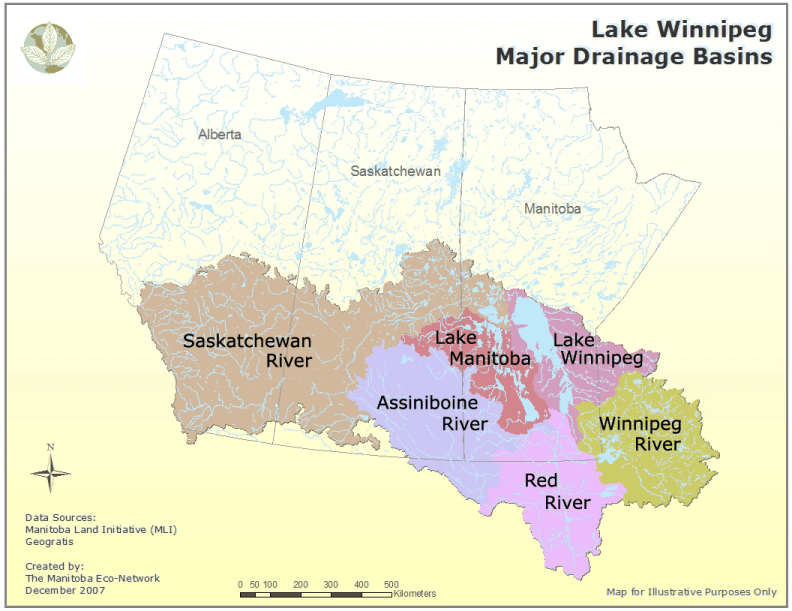
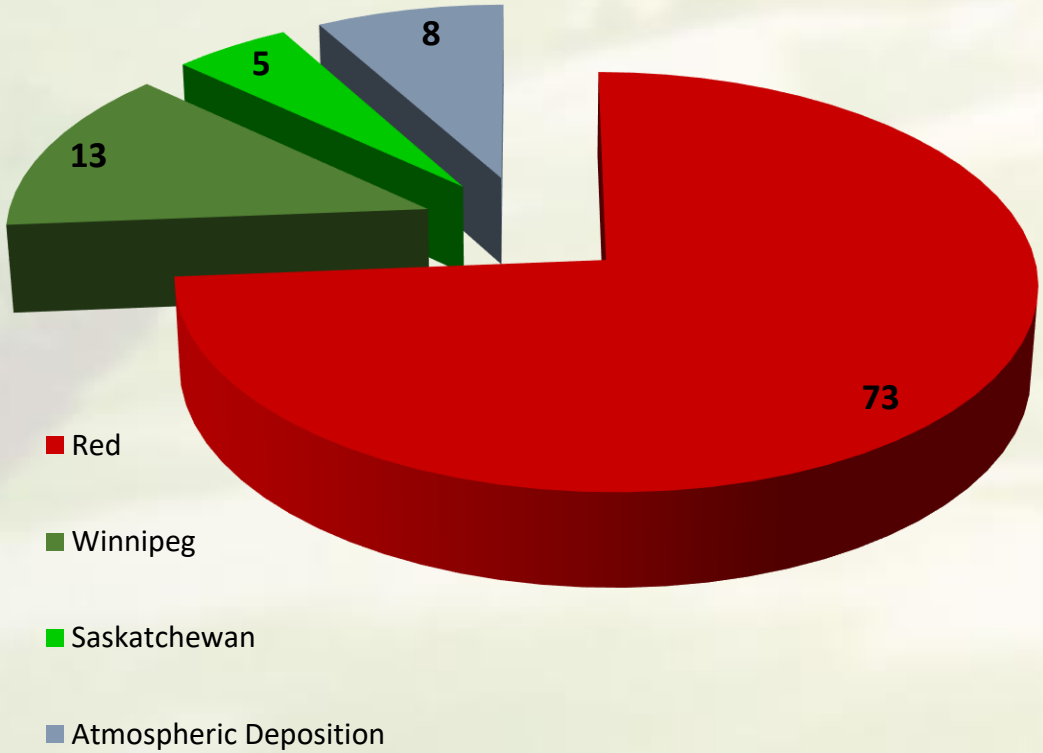




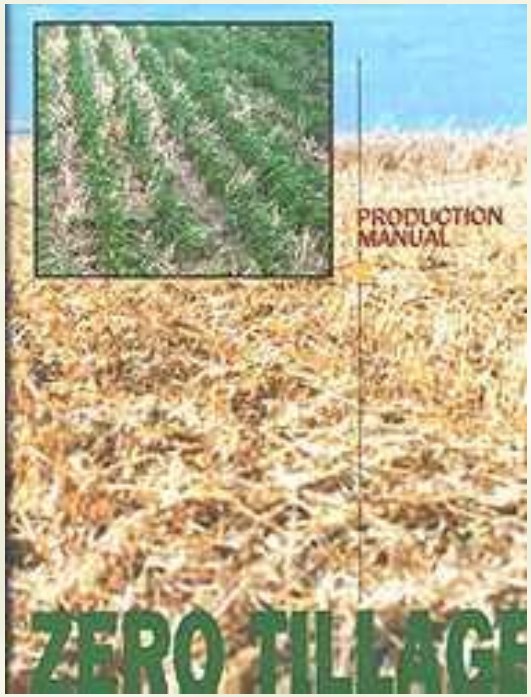
Sources of phosphorus entering Lake Winnipeg (1994-2001)

Bourne et al., 2002. State of the Lake Report

What we thought we knew…

Conservation tillage and increased crop residue cover protect the soil from erosion and reduce these agricultural and environmental impacts.

MANDAK, 1993



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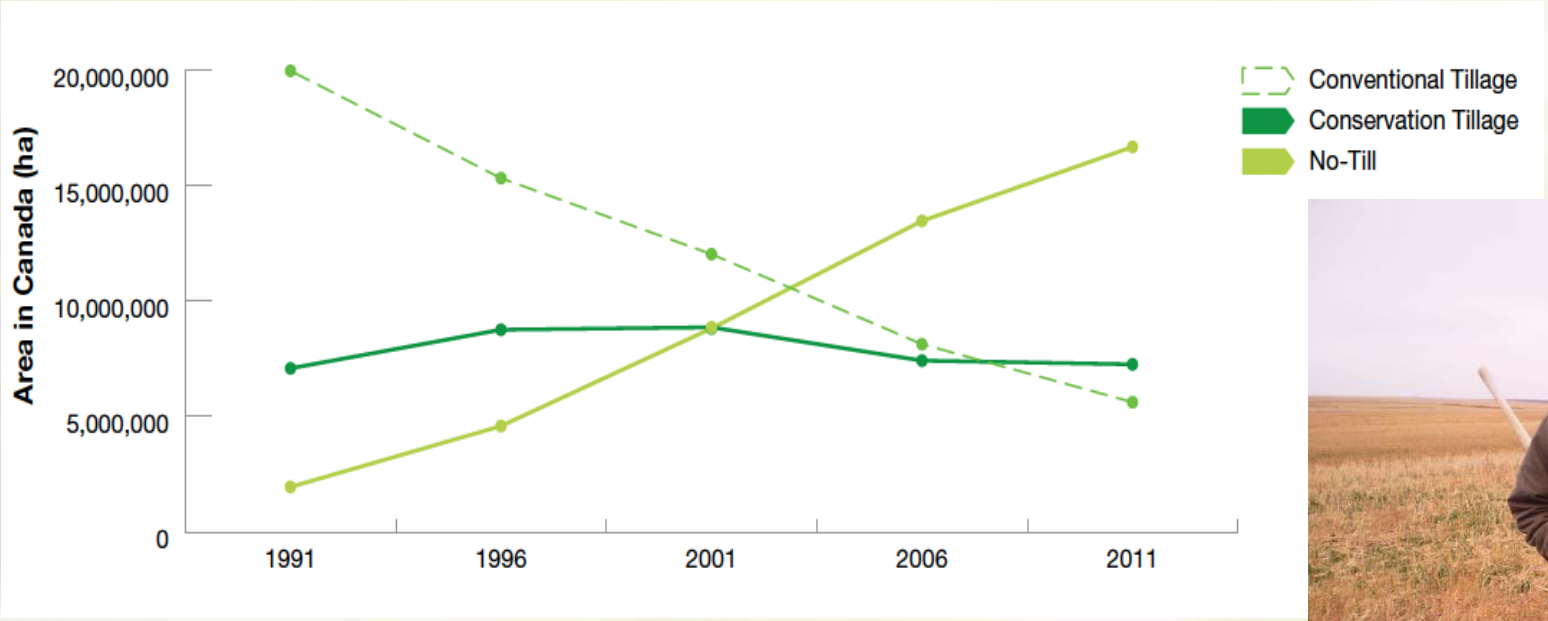


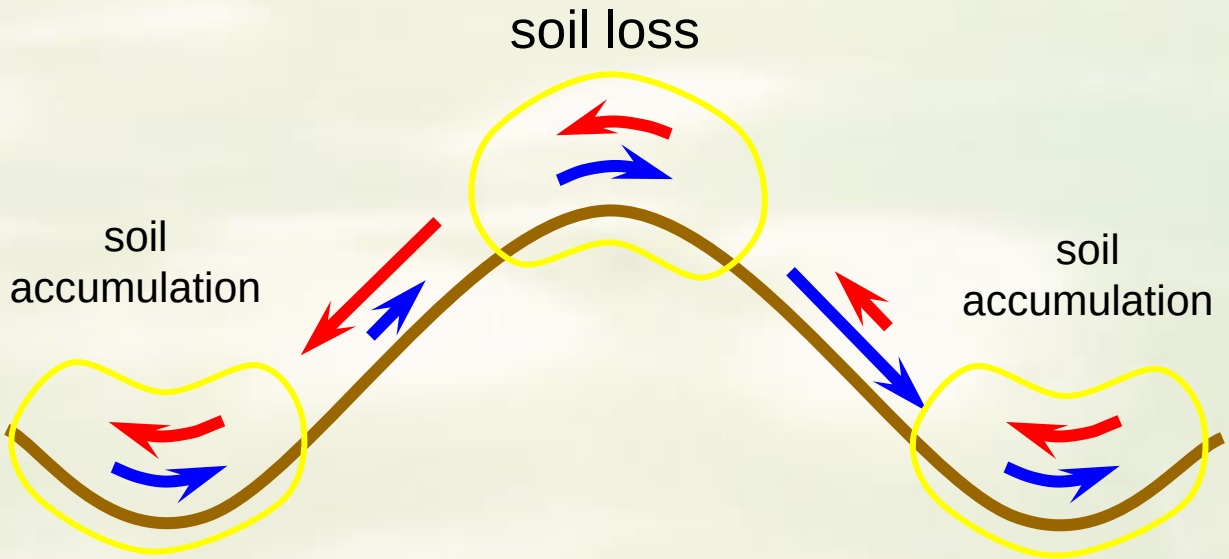
Census of Agriculture, 2016

What we know now…

A) The major cause of moderate to severe soil loss on cultivated land is tillage erosion, not wind or water erosion.

Minnesota, Lobb, 1999

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



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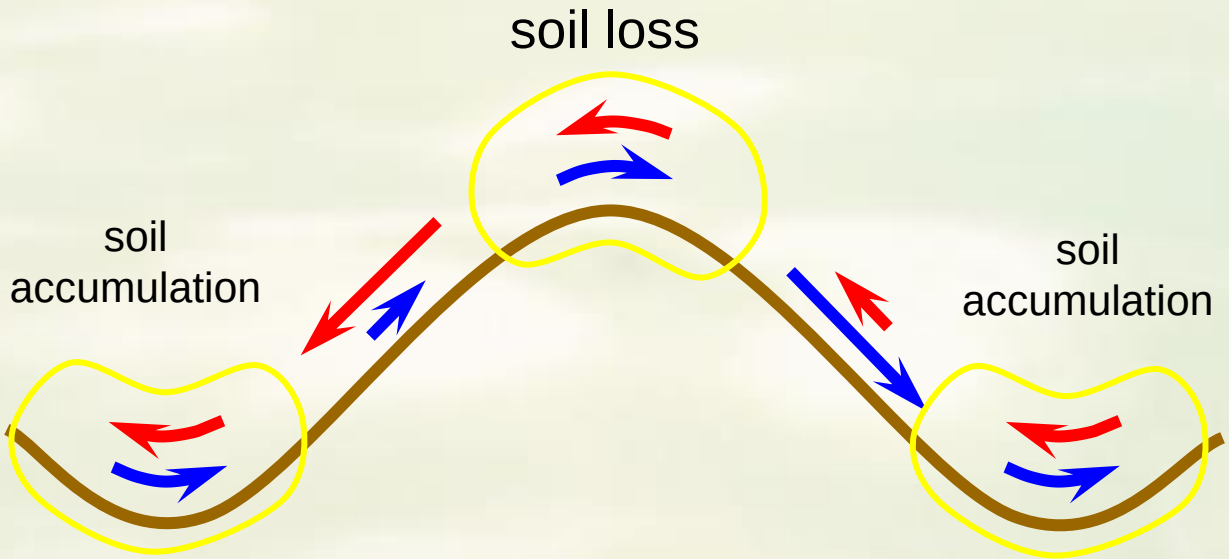

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Minnesota, Lobb, 1999

Manitoba, AAFC, 1980s

What we know now…

Patterns of water and tillage erosion on topographically complex landscapes in the North American Great Plains

S. Li, D.A. Lobb, M.J. Lindstrom, and A. Farenhorst

JOURNAL OF SOIL AND WATER CONSERVATION JAN/FEB 2008—VOL. 63, NO. 1

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Available online at www.sciencedirect.com
ScienceDirect

Catena 70 (2007) 493–505

CATENA

www.elsevier.com/locate/catena

Tillage and water erosion on different landscapes in the northern North American Great Plains evaluated using ^{137}Cs technique and soil erosion models

Sheng Li [a], David A. Lobb [a,*], Michael J. Lindstrom [b,1], Annemieke Farenhorst [a]

[a] *Department of Soil Science, University of Manitoba, Canada*
[b] *USDA-ARS, Morris, Minnesota, USA*

Modeling Tillage-Induced Redistribution of Soil Mass and Its Constituents within Different Landscapes

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Winnipeg, MB R3T 2N2
Canada

Michael J. Lindstrom
Sharon K. Papiernik
USDA-ARS
Morris, MN

Annemieke Farenhorst
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Univ. of Manitoba
Winnipeg, MB R3T 2N2
Canada

SSSAJ: Volume 72: Number 1 • January–February 2008

The extent of soil loss across the US Corn Belt

Evan A. Thaler[a,1], Isaac J. Larsen[a], and Qian Yu[a]

[a]Department of Geosciences, University of Massachusetts, Amherst, MA 01003

AGU ADVANCING EARTH AND SPACE SCIENCE

JGR Biogeosciences

RESEARCH ARTICLE
10.1029/2021JG006616

A Landscape Evolution Modeling Approach for Predicting Three-Dimensional Soil Organic Carbon Redistribution in Agricultural Landscapes

Key Points:

- A reduced complexity geomorphic model is developed to simulate 3-dimensional soil organic carbon transport since the start of farming

Jeffrey S. Kwang[1,2], Evan A. Thaler[1,3], Brendon J. Quirk[1,4], Caroline L. Quarrier[1], and Isaac J. Larsen[1]

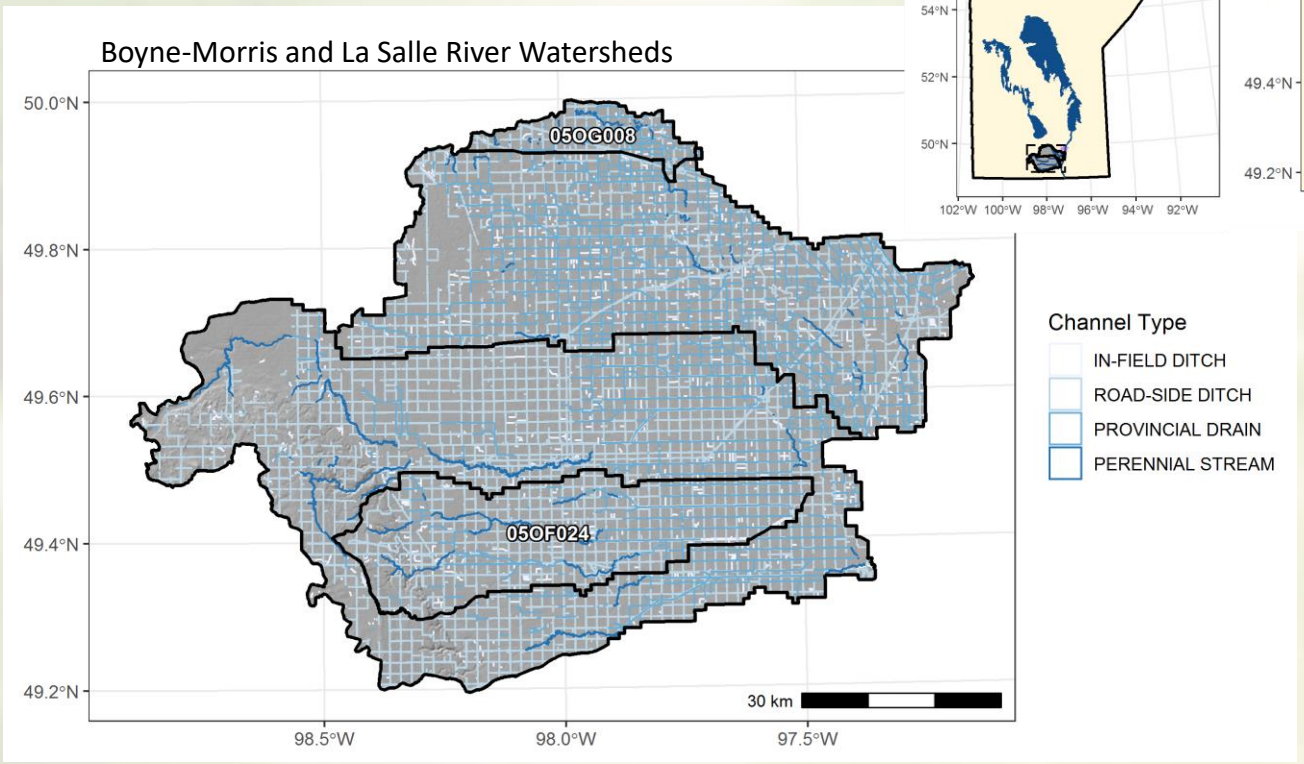
What we know now…

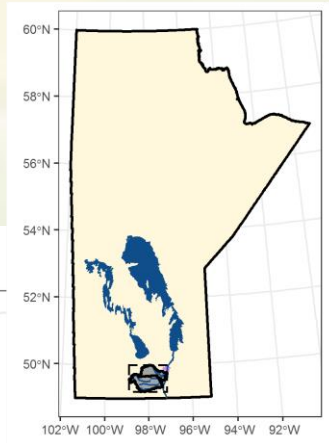
B) Tillage erosion is the primary driver behind the need for variable rate nutrient management in most landscapes.

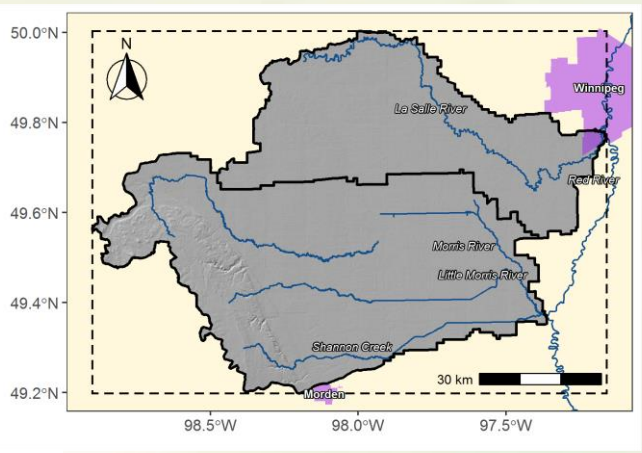
Minnesota, Lobb, 1999

What we know now…

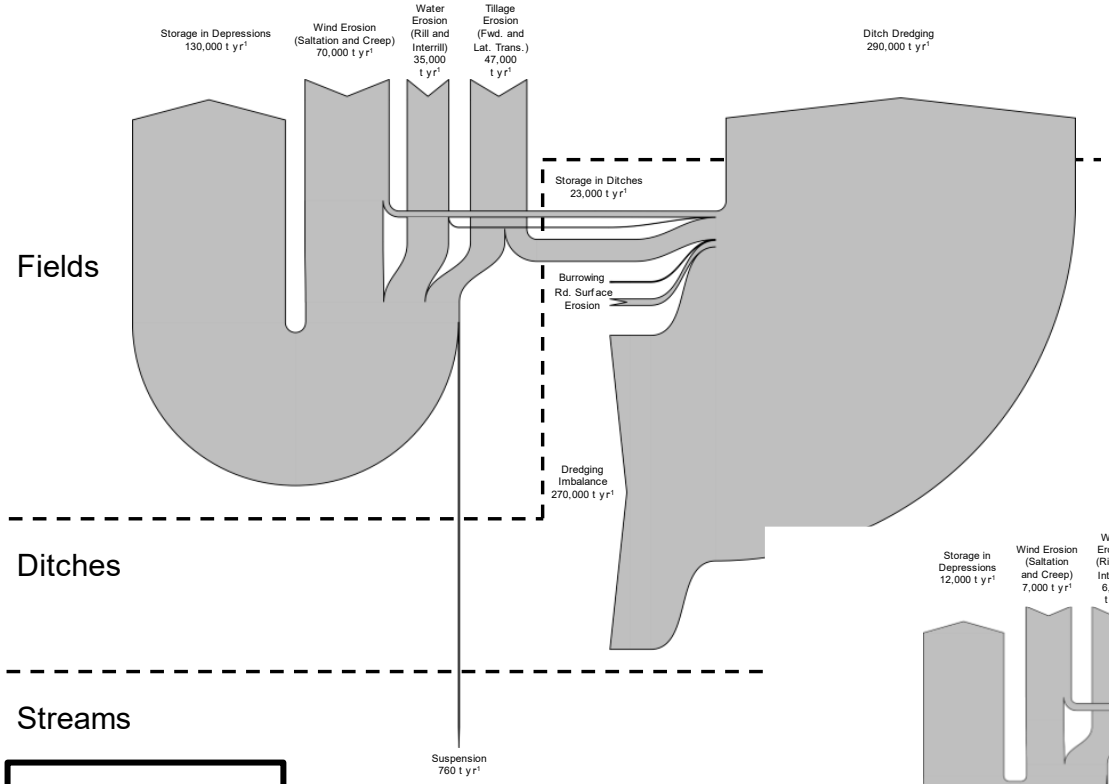
A) The major cause of moderate to severe soil loss on cultivated land is tillage erosion, not wind or water erosion.

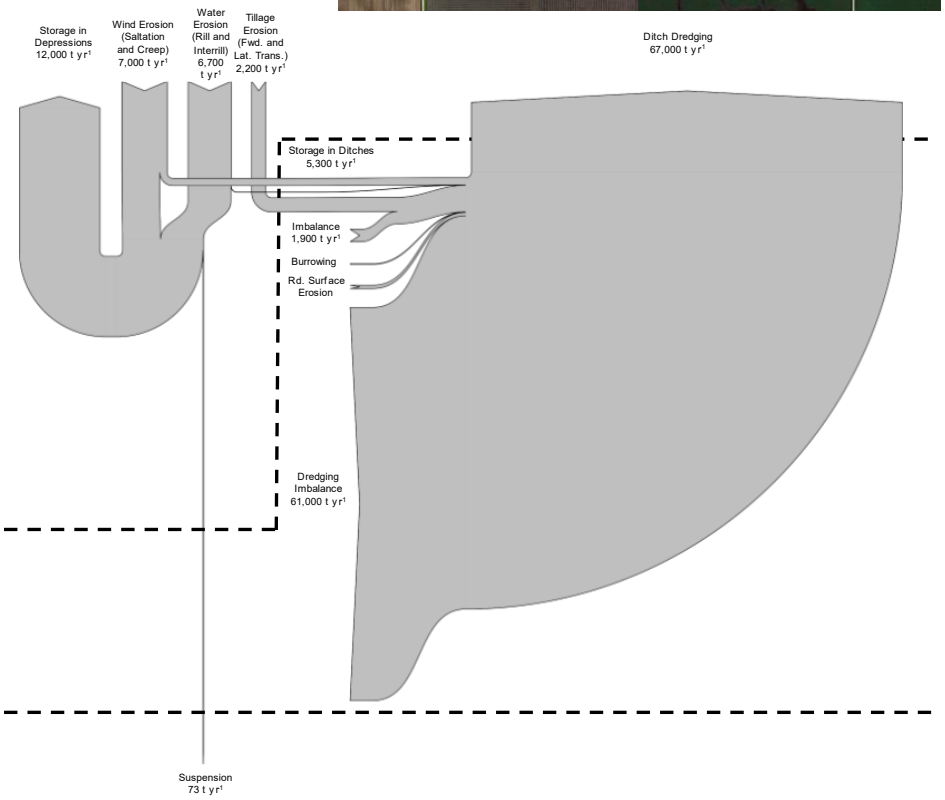






B.C. Brooks. 2022. MSc Thesis. UofM.





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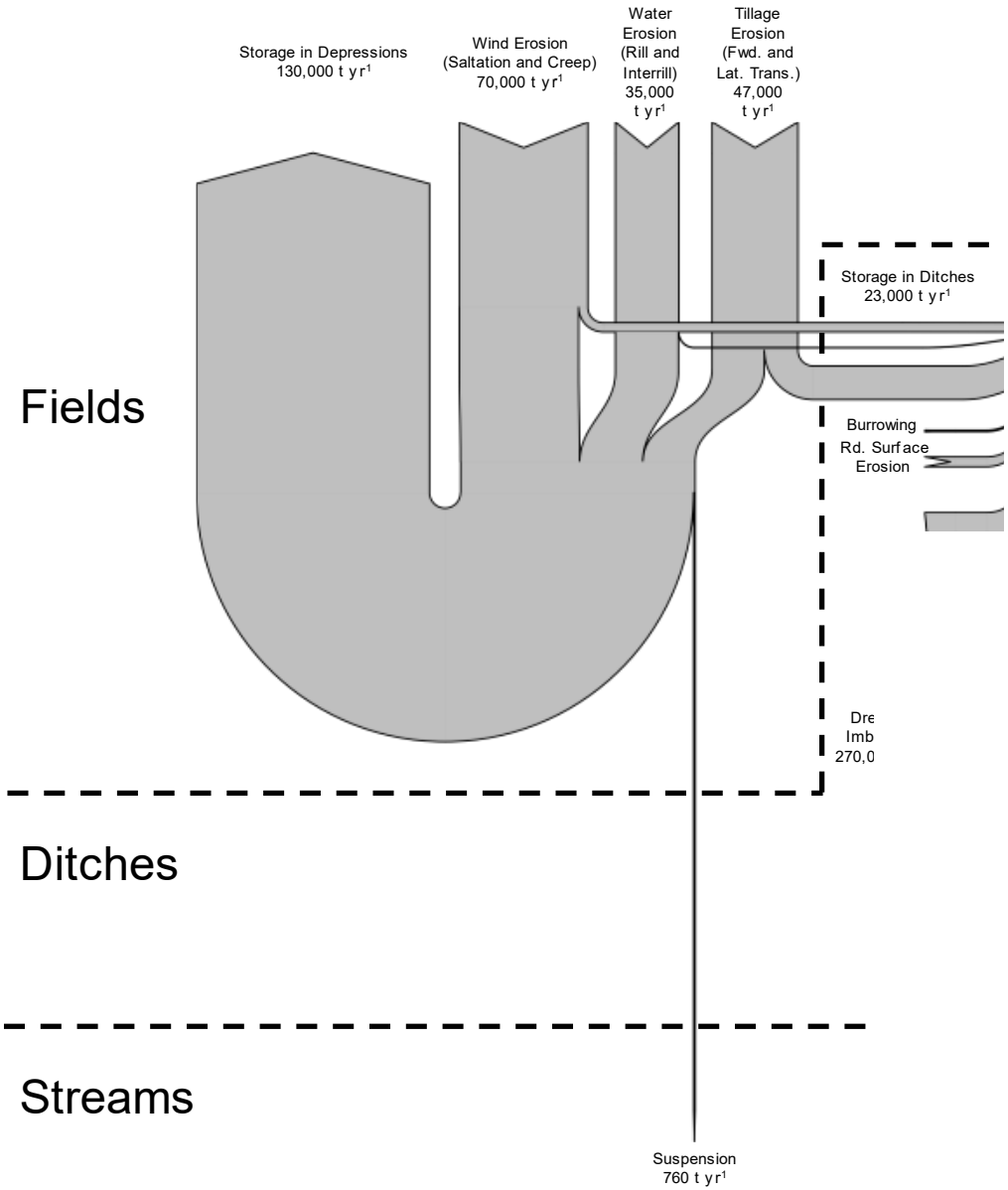
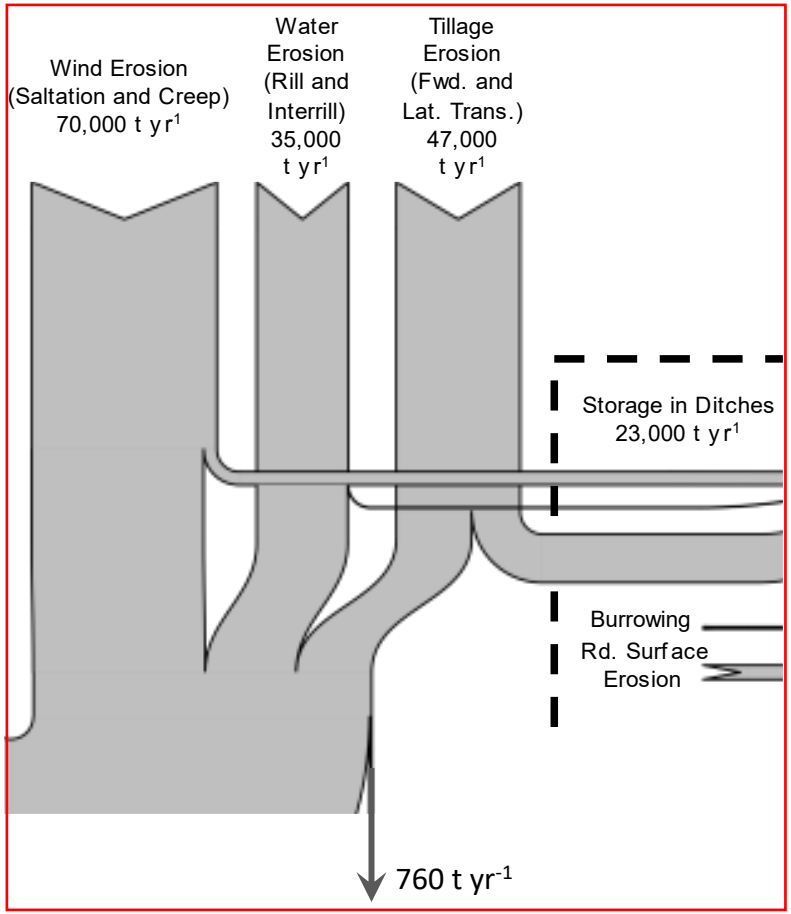
B.C. Brooks, 2022. MSc Thesis. UofM


Storage in Depressions
130,000 t yr1
Wind Erosion
(Saltation and Creep)
70,000 t yr1
Water
Erosion
(Rill and
Interrill)
35,000
t yr1
Tillage
Erosion
(Fwd. and
Lat. Trans.)
47,000
t yr1
Storage in Ditches
23,000 t yr1
Burrowing
Rd. Surface
Erosion
Fields
Ditches
Streams
Suspension
760 t yr1


Wind Erosion
(Saltation and Creep)
70,000 t yr1
Water
Erosion
(Rill and
Interrill)
35,000
t yr1
Tillage
Erosion
(Fwd. and
Lat. Trans.)
47,000
t yr1
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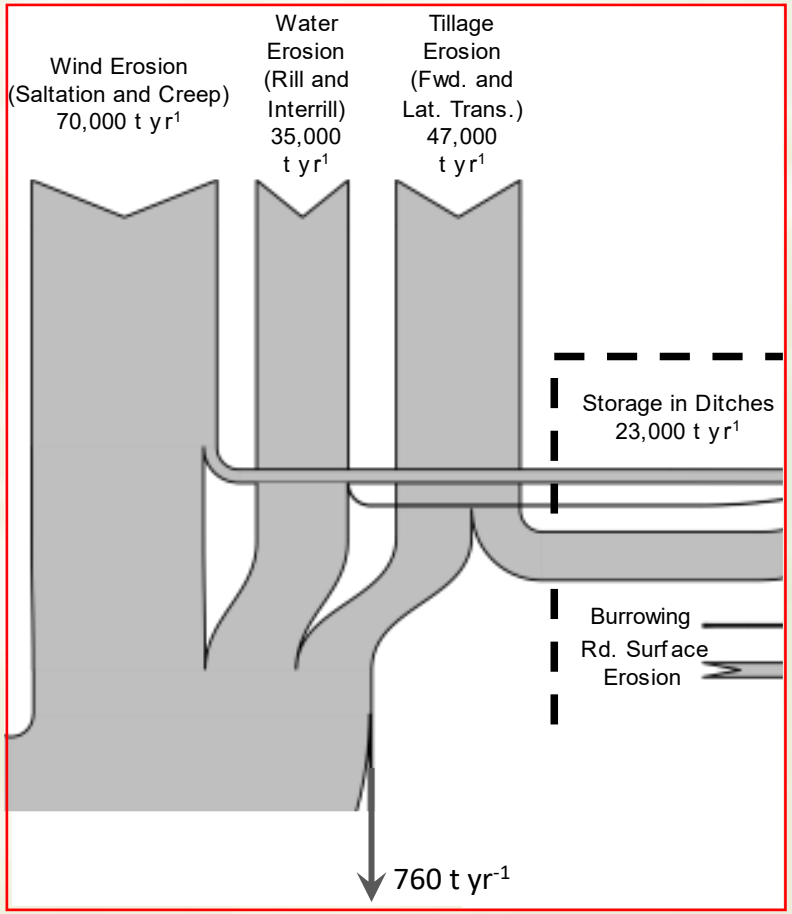
What we know now…

A) The major cause of moderate to severe soil loss on cultivated land is tillage erosion, not wind or water erosion.

Manitoba, Lobb 2015



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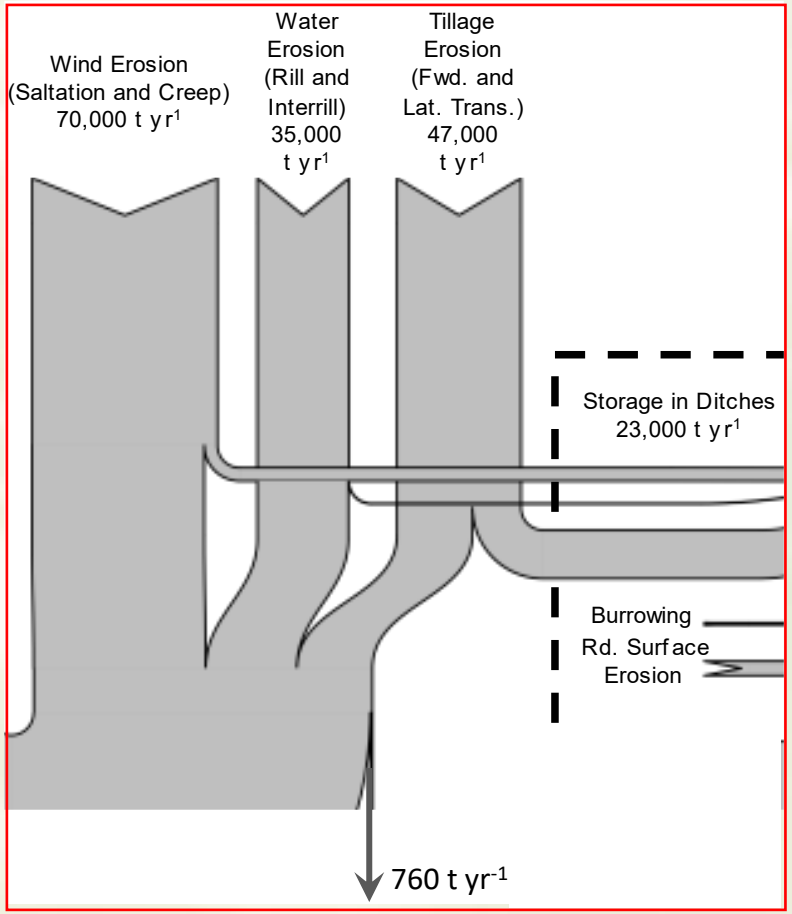
Manitoba, Lobb 2020



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North Dakota, Lobb, 2017

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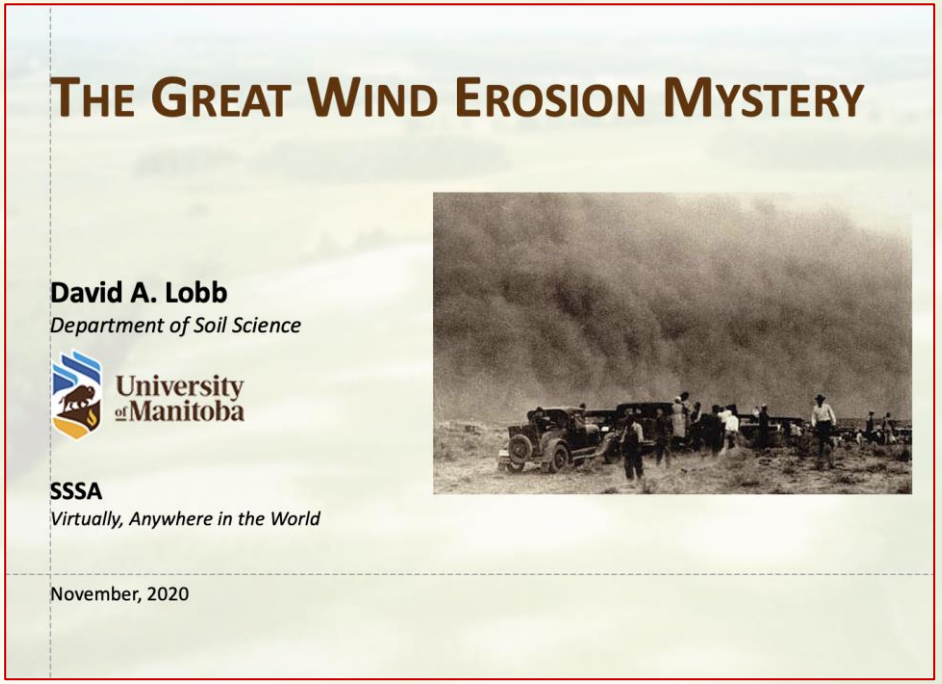
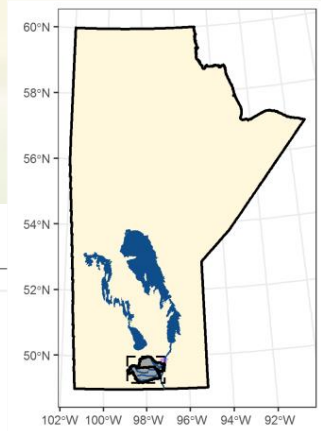
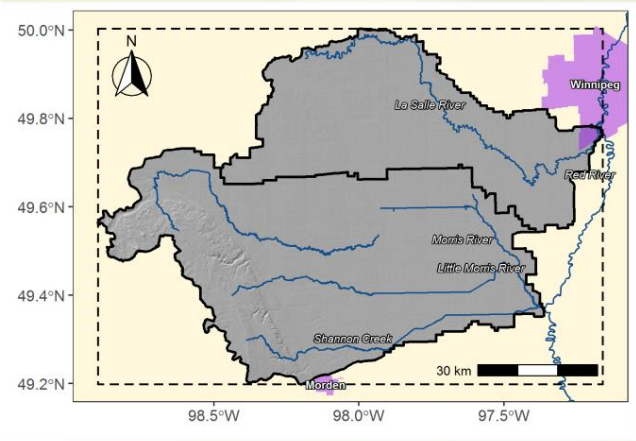


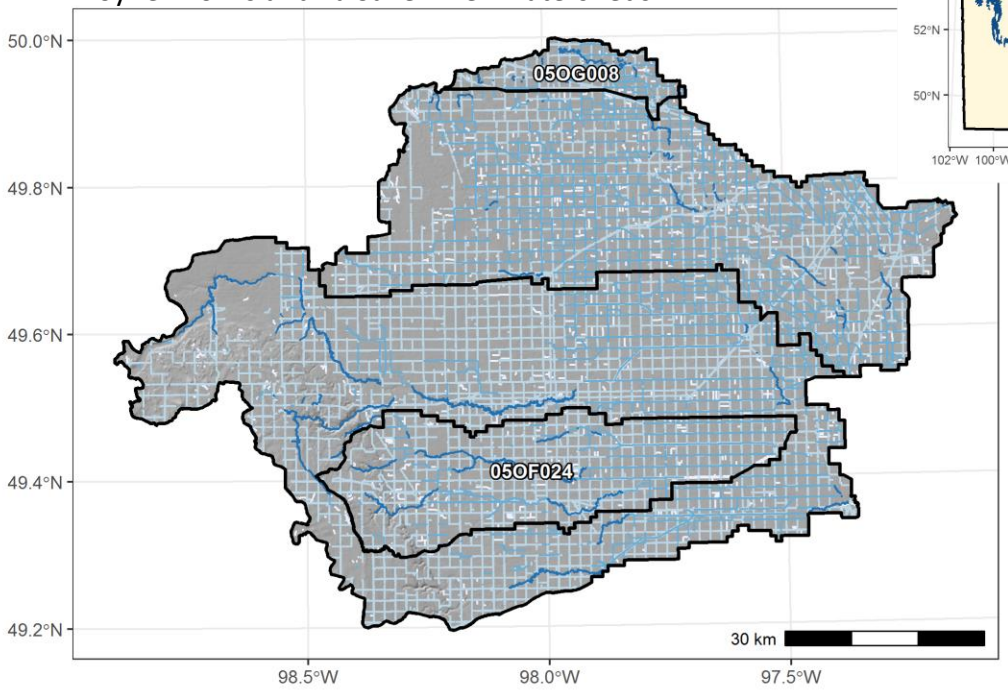
What we know now…

C) Detailed sediment budgets indicate that only a small amount of sediment, and therefore particulate P, enter these minor waterways via wind erosion.





Boyne-Morris and La Salle River Watersheds



Channel Type
- IN-FIELD DITCH
- ROAD-SIDE DITCH
- PROVINCIAL DRAIN
- PERENNIAL STREAM

B.C. Brooks. 2022. MSc Thesis. UofM.

What we know now…

D) The majority of sediments in our streams are from channel erosion, not from water erosion on agricultural land.

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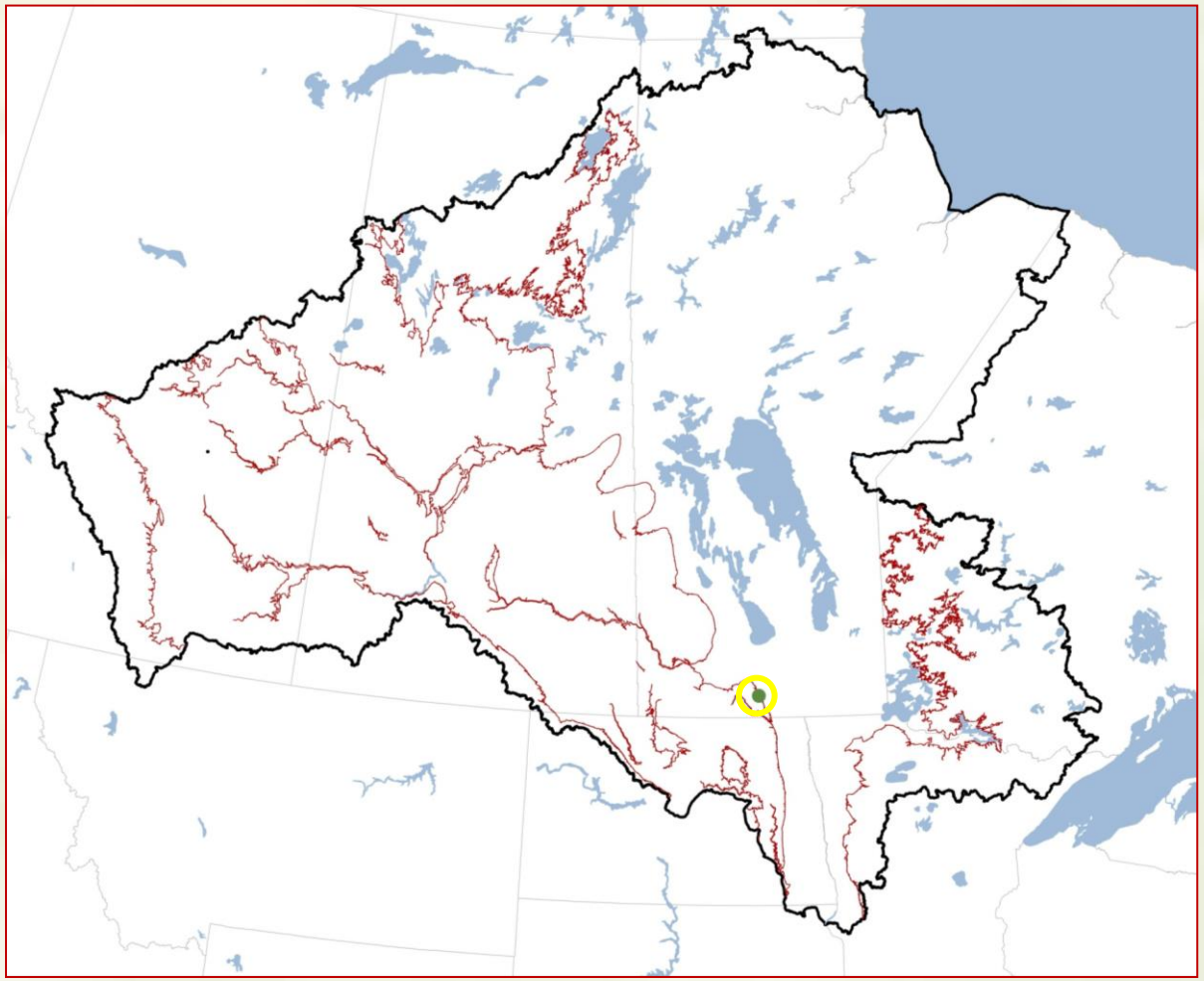


What we know now…

D) The majority of sediments in our streams are from channel erosion, not from water erosion on agricultural land.

What we know now…

E) Conservation tillage is not necessarily going to stop the soil erosion problem. It may make it worse.

Saskatchewan, 1990s

What we know now…

- 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 mouldboard plough

What we know now…

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

There are tillage operations that are more erosive than the mouldboard plough

Home farm, Ontario, 2021…OMG!!!

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

What we know now…

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

There are tillage operations that are more erosive than the mouldboard plough

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

What we know now…

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

There are tillage operations that are more erosive than the mouldboard plough

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

What we know now…

F) The crop residues on the soil surface are a major source of phosphorus that gets exported from fields.

Manitoba, Lobb, 2010

Manitoba, Lobb, 2021

What we know now…

TECHNICAL REPORTS: SURFACE WATER QUALITY

Conventional and Conservation Tillage: Influence on Seasonal Runoff, Sediment, and Nutrient Losses in the Canadian Prairies

K. H. D. Tiessen University of Manitoba
J. A. Elliott* Environment Canada
J. Yarotski Agriculture and Agri-Food Canada
D. A. Lobb and D. N. Flaten University of Manitoba
N. E. Glozier Environment Canada

Journal of Environmental Quality TECHNICAL REPORTS
SURFACE WATER QUALITY

Conversion of Conservation Tillage to Rotational Tillage to Reduce Phosphorus Losses during Snowmelt Runoff in the Canadian Prairies

Kui Liu, Jane A. Elliott,* David A. Lobb, Don N. Flaten, and Jim Yarotski

Journal of Environmental Quality TECHNICAL REPORTS
LANDSCAPE AND WATERSHED PROCESSES

Nutrient and Sediment Losses in Snowmelt Runoff from Perennial Forage and Annual Cropland in the Canadian Prairies

Kui Liu, Jane A. Elliott,* David A. Lobb, Don N. Flaten, and Jim Yarotski

Journal of Environmental Quality TECHNICAL REPORTS
LANDSCAPE AND WATERSHED PROCESSES

Critical Factors Affecting Field-Scale Losses of N and P in Spring Snowmelt Runoff in the Canadian Prairies

Kui Liu, Jane A. Elliott,* David A. Lobb, Don N. Flaten, and Jim Yarotski

What we know now…

NRC Research Press

REVIEW

Soil and water management: opportunities to mitigate nutrient losses to surface waters in the Northern Great Plains

Helen M. Baulch, Jane A. Elliott, Marcos R.C. Cordeiro, Don N. Flaten, David A. Lobb, and Henry F. Wilson

Journal of Environmental Quality

TECHNICAL REPORTS

SURFACE WATER QUALITY

Seasonal Efficacy of Vegetated Filter Strips for Phosphorus Reduction in Surface Runoff

J. A. Vanrobaeys,* P. N. Owens, D. A. Lobb, K. A. Kieta, and J. M. Campbell

Journal of Environmental Quality

SPECIAL SECTION

RIPARIAN BUFFER MANAGEMENT

Effectiveness of Vegetated Buffer Strips in Controlling Legacy Phosphorus Exports from Agricultural Land

Reza Habibiandehkordi,* David A. Lobb, Philip N. Owens, and Don N. Flaten

Environ Sci Pollut Res (2017) 24:18372–18382
DOI 10.1007/s11356-017-9406-6

RESEARCH ARTICLE

Uncertainties in vegetated buffer strip function in controlling phosphorus export from agricultural land in the Canadian prairies

Reza Habibiandehkordi[1,2] · David A. Lobb[1,2] · Steve C. Sheppard[3] · Don N. Flaten[1] · Philip N. Owens[4]

NRC Research Press

REVIEW

Phosphorus dynamics in vegetated buffer strips in cold climates: a review

Kristen A. Kieta, Philip N. Owens, David A. Lobb, Jason A. Vanrobaeys, and Don N. Flaten

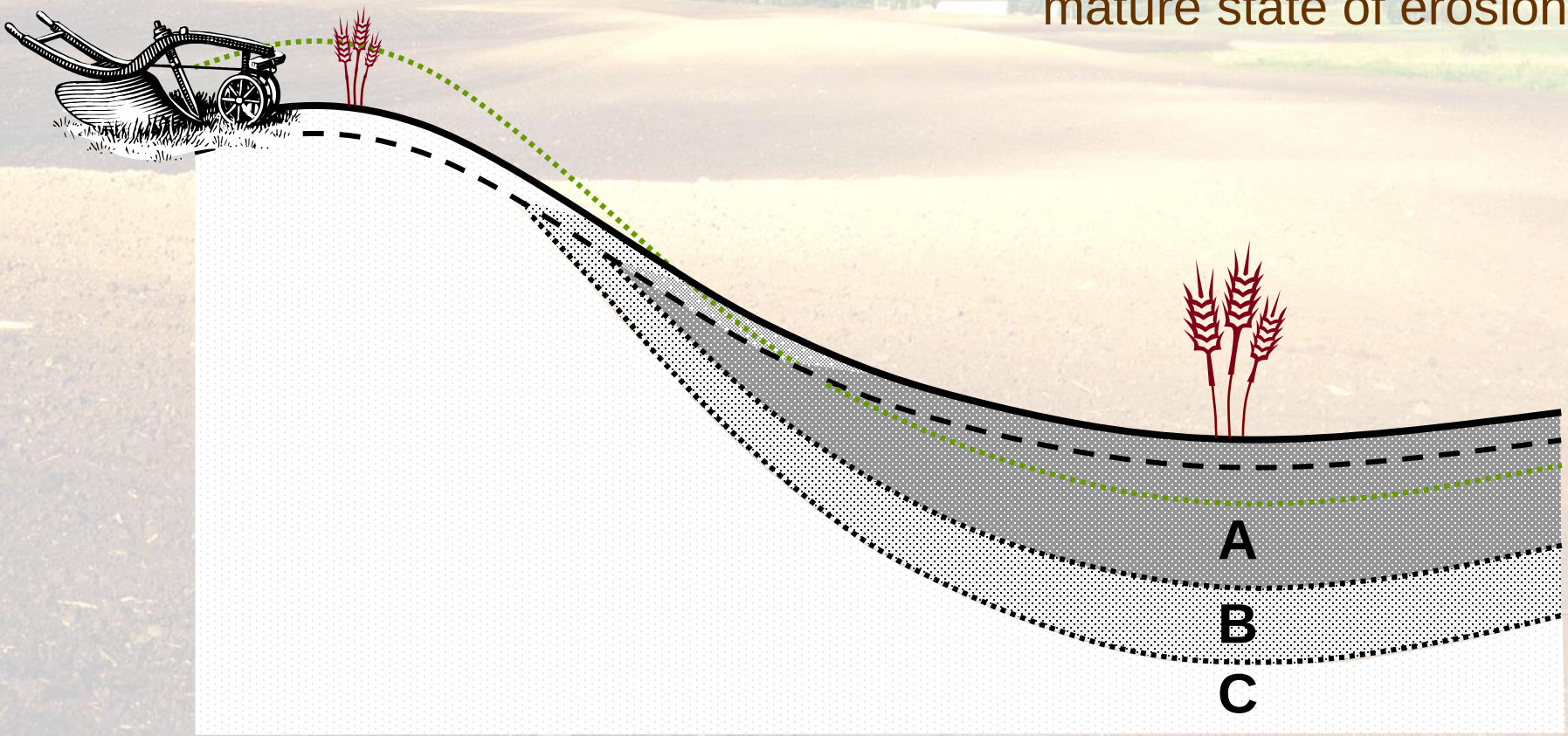
La Salle River Watershed, 2020

What we can do…

Soil-landscape variability in a hilly landscape

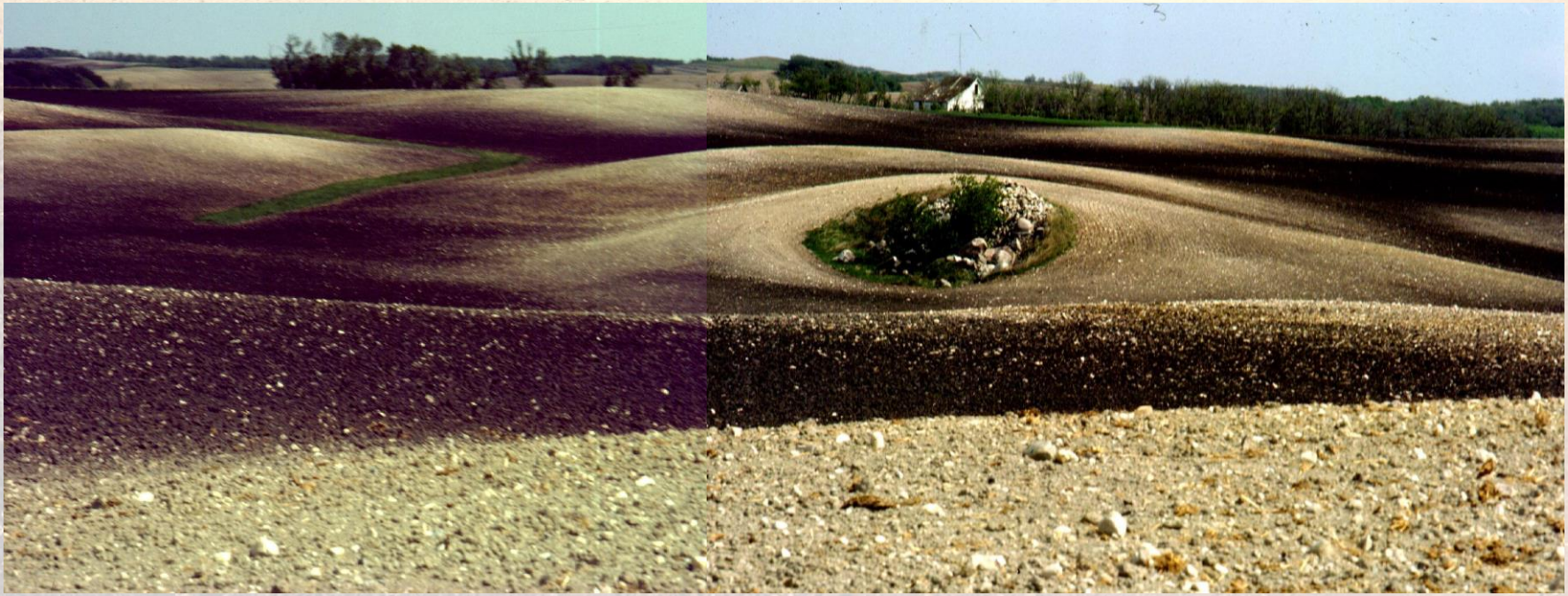
several decades of cultivation (~1990)

mature state of erosion



What we can do…

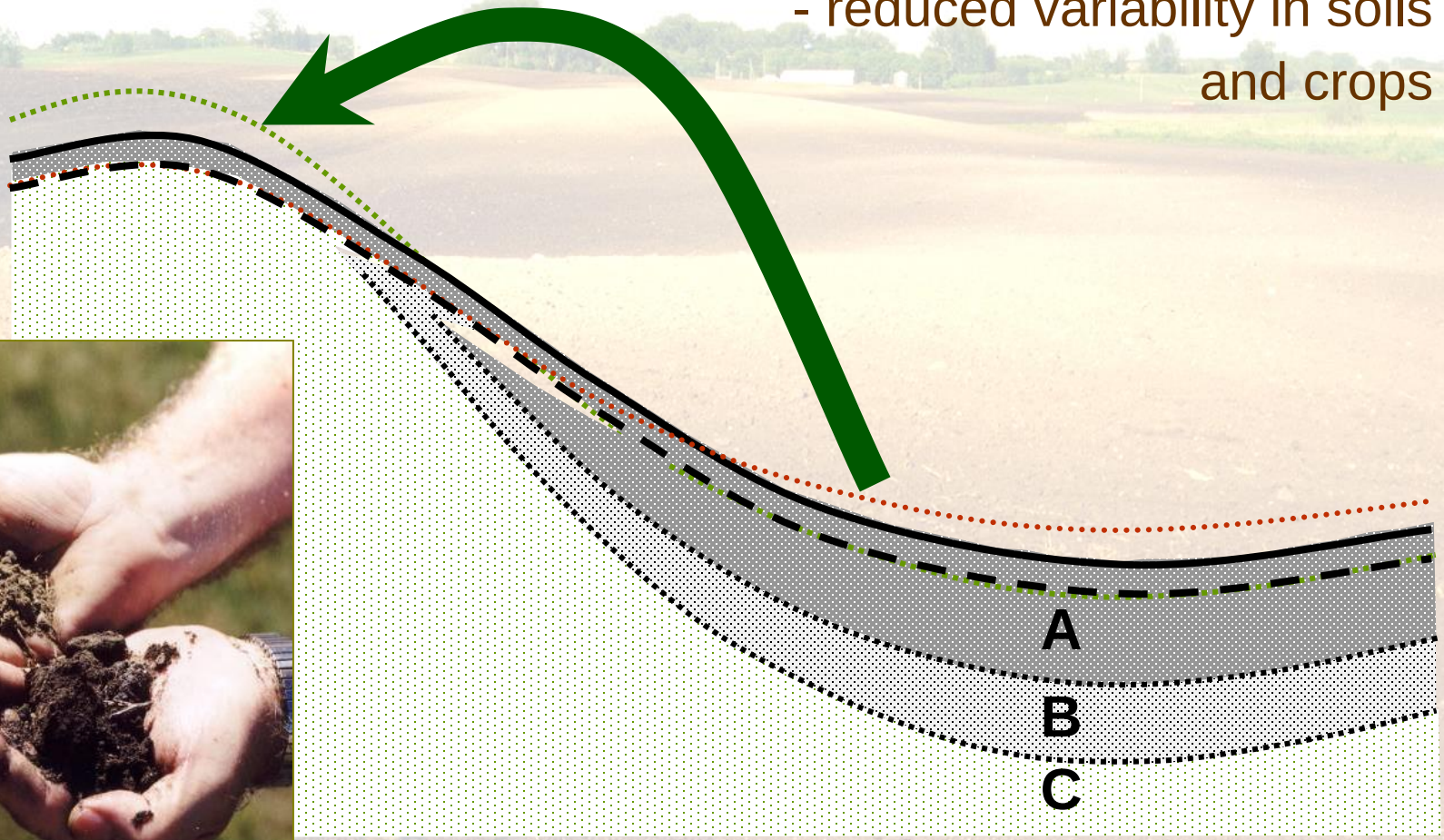
- Design a new generation of soil erosion models that integrate wind, water and tillage erosion.
- Redefine and redesign conservation tillage to manage soil movement as well as crop residue cover.
- Take a more aggressive approach to restoring eroded landscapes.



What we can do…

Restored Landscape

- reduced variability in soils and crops



Minnesota, Lobb, 2005

What we can do…

Manitoba, Smith, 2006

What we can do…

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.
- In balancing yields in areas of addition and removal, there was 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 content.
- The cost of rehabilitation can be recovered in 3 to 5 years.

What we can do…

Soil & Tillage Research 102 (2009) 67–77

Contents lists available at ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

Soil properties and productivity as affected by topsoil movement within an eroded landform☆

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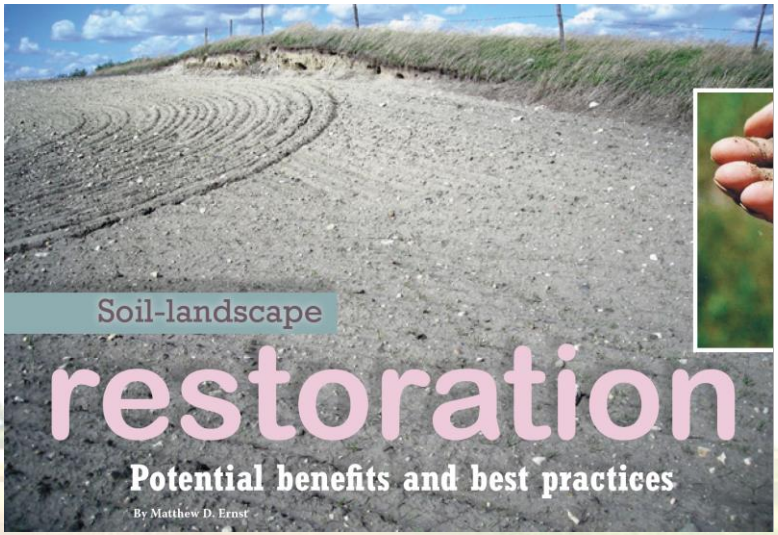
What we can do…



Self-study CEU quiz

Soil-landscape restoration: Potential benefits and best practices

Earn 0.5 CEUs in Soil & Water Management by taking the quiz for the article on pages 36–38 at www.certifiedcropadviser.org/education/classroom/classes/685. For convenience, the quiz is printed below. Cost: $10.

1. Low-yielding hilltops in the Prairie Pothole region are often the result of

a. wind erosion.
b. tillage erosion.
c. rapid soil drying.
d. underfertilization.

2. Riekman and Lobb demonstrated the impacts of tillage erosion using

a. corn seed.
b. wheat seed.
c. soybean seed.
d. grass seed.

3. According to the article, how much soil should be moved?

a. 1 inch.
b. 3 inches.
c. 4 inches.
d. 6 inches.

4. Seed movement was measured after two passes each with a tandem disk, field cultivator and high-speed shallow disk, and it was determined seed moved 16 to 23 ft with one pass and _____ with two passes.

a. 21 to 27 ft
b. 33 to 46 ft
c. 42 to 50 ft
d. 51 to 58 ft

5. In what season does Lobb suggest farmers move soil to remedy tillage erosion?

a. Winter.
b. Spring.
c. Summer.
d. Fall.

What we can do…

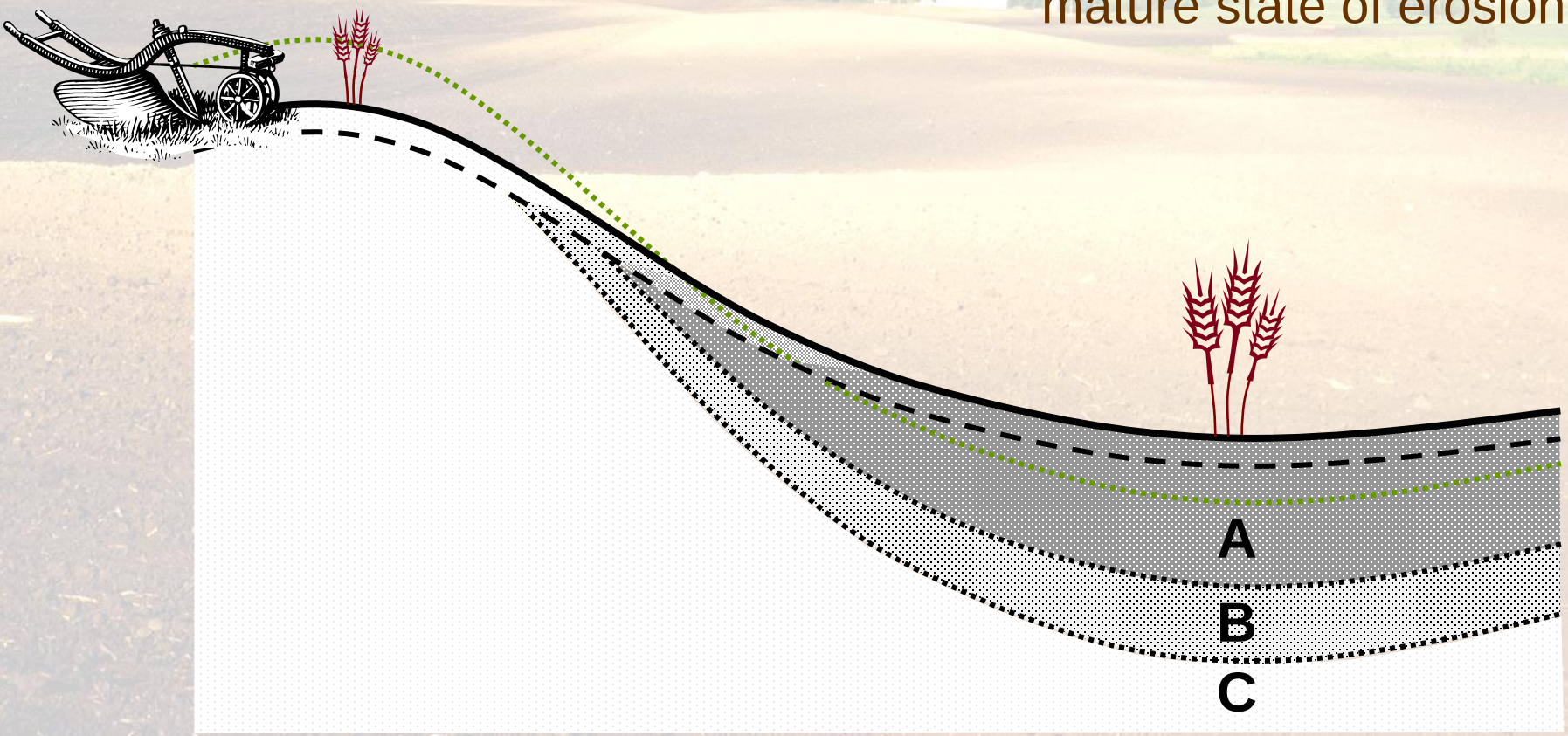
- There is growing urgency to take effective action.
- Increasing variability in climate and the increasing severity and frequency of weather extremes can only amplify the losses in crop production and threaten farm and food security.
- The degradation of soil landscapes is increasing in areal extent,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

What we can do…

Soil-landscape variability in a hilly landscape

several decades of cultivation (~1990)

mature state of erosion



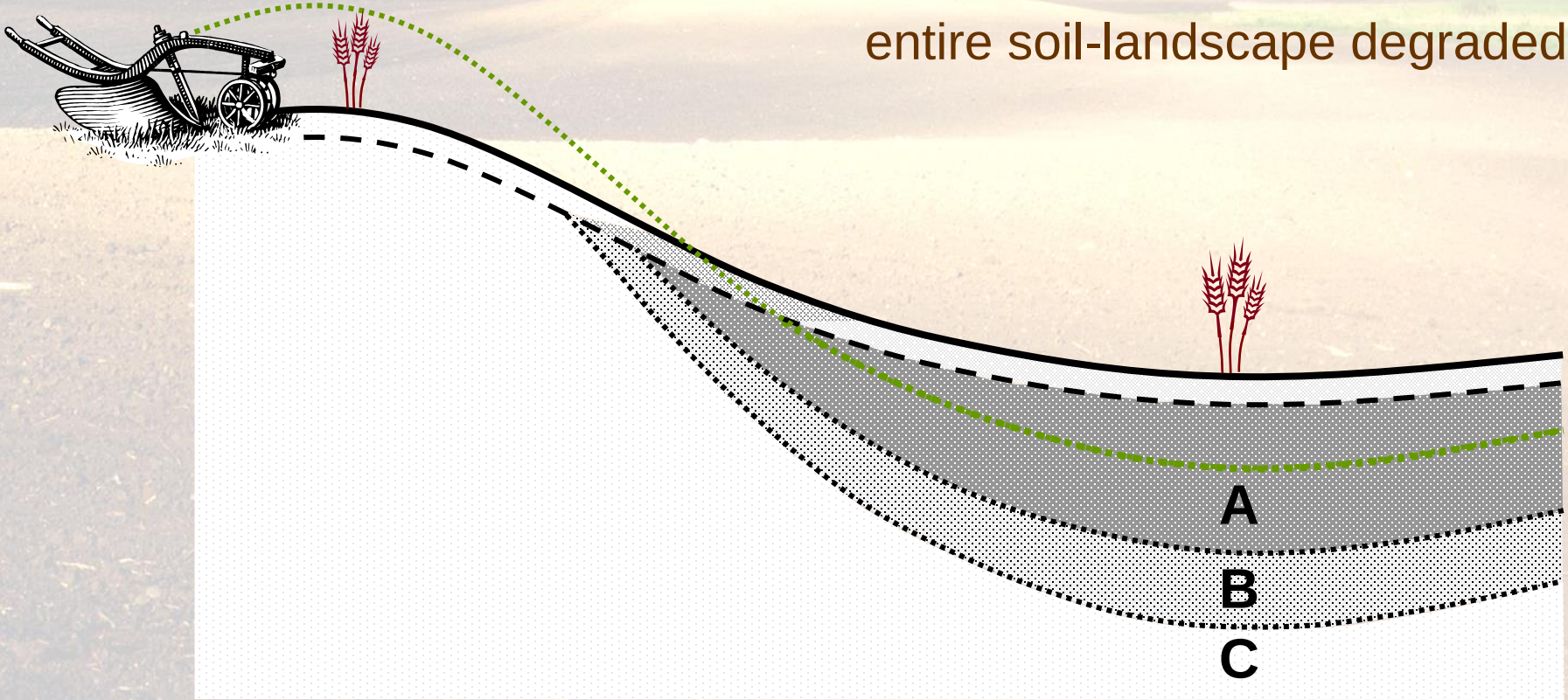
What we can do…

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!

Soil Erosion and Soil Fertility: Myths and Realities

Questions?

Soil Erosion and Soil Fertility: Myths and Realities

David Lobb
University of Manitoba

AGVISE Laboratories 2023 Soil Fertility Seminars

January 3rd, Watertown, South Dakota
January 4th, Willmar, Minnesota
January 5th, Grand Forks, North Dakota