I would like to thank the organizers for inviting me to give this presentation, and the participants for attending this session.

My presentation may be considered a bit provocative,
and I look forward to your feedback during the Panel Discussion.

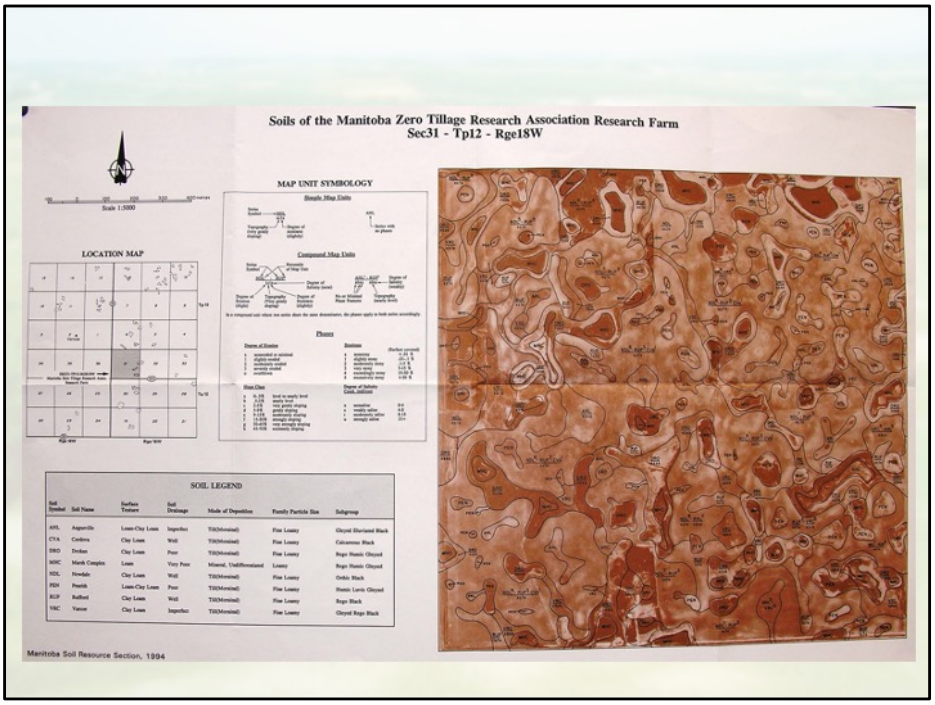
The need for a landscape approach in managing farms to achieve sustainability
In managing an agricultural operation, it is necessary to view the farm as a landscape, with each facet of that landscape having different requirements and risks for production. This complexity presents several challenges in achieving economic and environmental sustainability. In this talk, these challenges are addressed and recommendations provided, with the goal of enhancing management and, equally important, enhancing research and development, and policy and programming.

As we all know, farms are complex operations:
producing multiple crops; often with a mix of crops and livestock;
requiring a wide variety of equipment and production inputs;
and buying and selling into markets that fluctuate and are difficult to predict.
The weather, too, is highly unpredictable.

By comparison, the land could be viewed as the **most easily managed element** of a farm,
because it **doesn't change much**,
and if it does, it is **very slow**.

But, the land of a farm can be highly complex **spatially**.

It normally **consists on many facets**, each with characteristics that demand tailored management,
and each affecting the overall performance of the farm.



Much of the spatial complexity is reflected in the soil.

There are **many soils** found on most Prairie farms; the result of a variety of glacial parent materials, which are **strongly affected by the topography and hydrology** of the landscape.

This one section of land north of Brandon has only two Soil Orders,
but it has 8 different soil series and over 150 mapped soils units.
Yikes!

This spatial complexity is often **amplified by the degradation** of the land through erosion, compaction and salinization.

For example, the loss and accumulation of topsoil within hilly landscapes makes **dry areas drier** and **wet areas wetter**.

Another layer of spatial complexity that must not be forgotten includes:
the farm yards, buildings, roadways, fence lines, tree lines, surface and subsurface drains, roadside ditches, etc., etc.

All features that add to the variability of a **farm's land**, and
can affect the movement of materials **on-to** and **off-of** the farm, and **within** the farm, materials such as soil, water and a variety of production inputs and potential contaminants.

As such, it makes sense to view the farm as a **whole landscape**,
with **each facet** of that landscape having different requirements and risks for production,
and **all facets** being integrated into **one complex management operation**.

This is something that farmers face **day-in** and **day-out**,
and is often **not fully appreciated**.

This complexity presents **several challenges** in achieving economic and environmental sustainability.

Today, I am going to **focus on just one challenge** where **we can do better by viewing the farm as a landscape**.

Improving Soil Health

The concept of soil health has been around for over 30 years,
but interest in soil health has grown tremendously in the past 10 years,
and it will only increase in the future,
particularly in the next few years with the new federal climate change initiative supported by the ***On- Farm Climate Action Fund***.

Most of the farms in the Prairies have moderately to severely degraded soil health on a significant portion of their land
(typically 10-25% on about 75% of the farms).

Increasing SOC is **critical as a means** of improving **the health of a degraded soil**; thereby, increasing crop production and profitability,
and sequestering CO_2 from the atmosphere to address climate change.

What is the most effective strategy to increase SOC?

1. Determine the potential to increase SOC.
2. Identify what has caused the loss of SOC, and adopt practices that reduce, or stop the loss.
3. Adopt practices that increase SOC, where there is the greatest potential to do so.

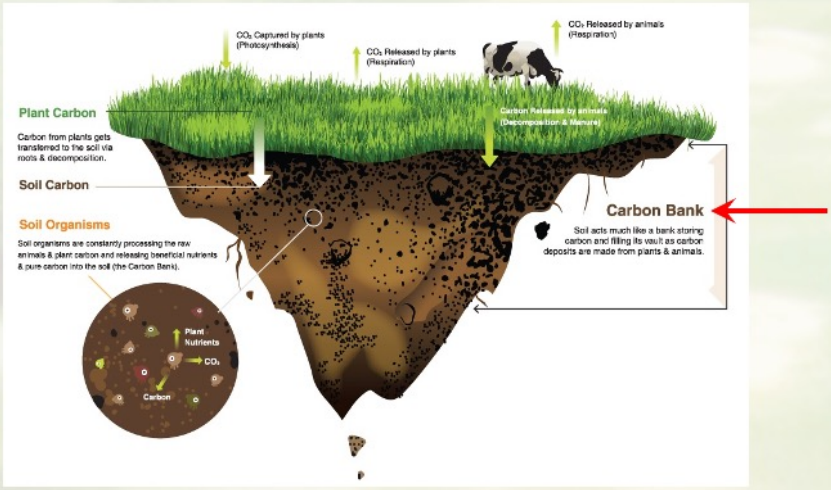
What is the most effective strategy to increase SOC? …
…This is a **key question** for policy makers, and for farmers.

First, determine the potential to **increase SOC**.
Then, identify what has caused **the loss of SOC**,
and **adopt practices** that **reduce, or stop the loss**.
And finally, **adopt practices** that **increase SOC**
where there is the **greatest potential** to do so within a farm.

This strategy seems pretty straightforward,
but it requires a **strong appreciation of the landscape**.

What is the most effective strategy to increase SOC?

1. Determine the potential to increase SOC.



The **potential to increase** SOC is a function of the amount of **OC currently in the soil**, and the **ecologic upper-limit** for SOC – the **maximum size of a soil's Carbon Bank**.

This ecologic upper limit varies greatly

(i) from **climatic region to region**,

(ii) with **soil texture**, …

What is the most effective strategy to increase SOC?

1. Determine the potential to increase SOC.

… and (iii) **within a landscape**,
as **topography affects the movement of water**
and the **moisture available** to support the production of **plant biomass**,
the **source of organic carbon** in the soil.

Water accumulates in lower slope positions of the landscape,
and the resulting greater soil moisture supports more plant biomass
and, often, different plant species,
Making the landscape more biologically diverse.

What is the most effective strategy to increase SOC?

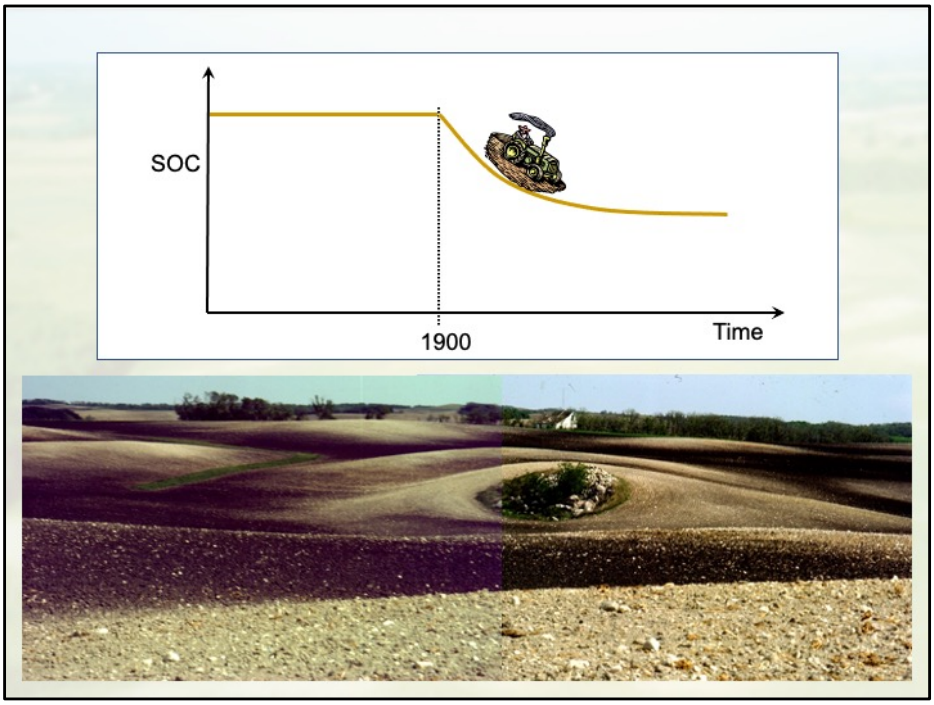
2. Identify what has caused the loss of SOC, and adopt practices that reduce, or stop the loss.

The current levels of SOC have been negatively impacted through cropping and tillage practices over the past 100 to 150 years; specifically, through:

(i) a shift from grassland to annual crops, which **produce less plant biomass**;

(ii) the use of summerfallow, which **produces no plant biomass**; and

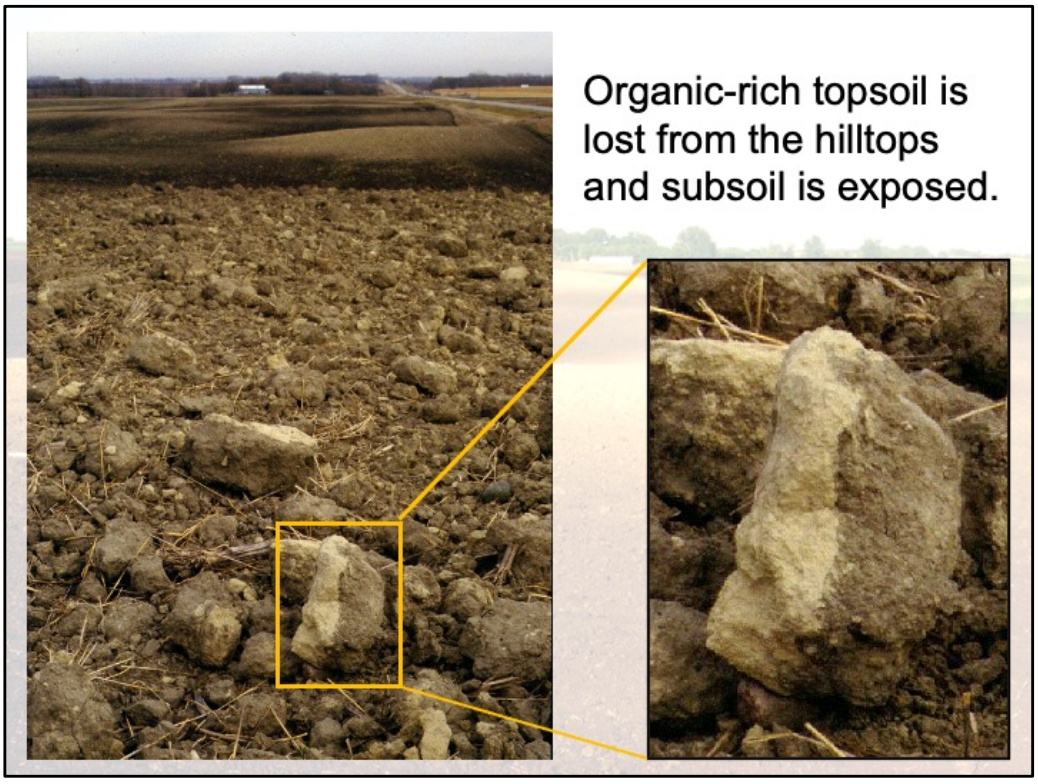
(iii) the use of tillage, which **accelerates the decomposition** of SOC and **accelerates the loss of organic-rich topsoil** through erosion.



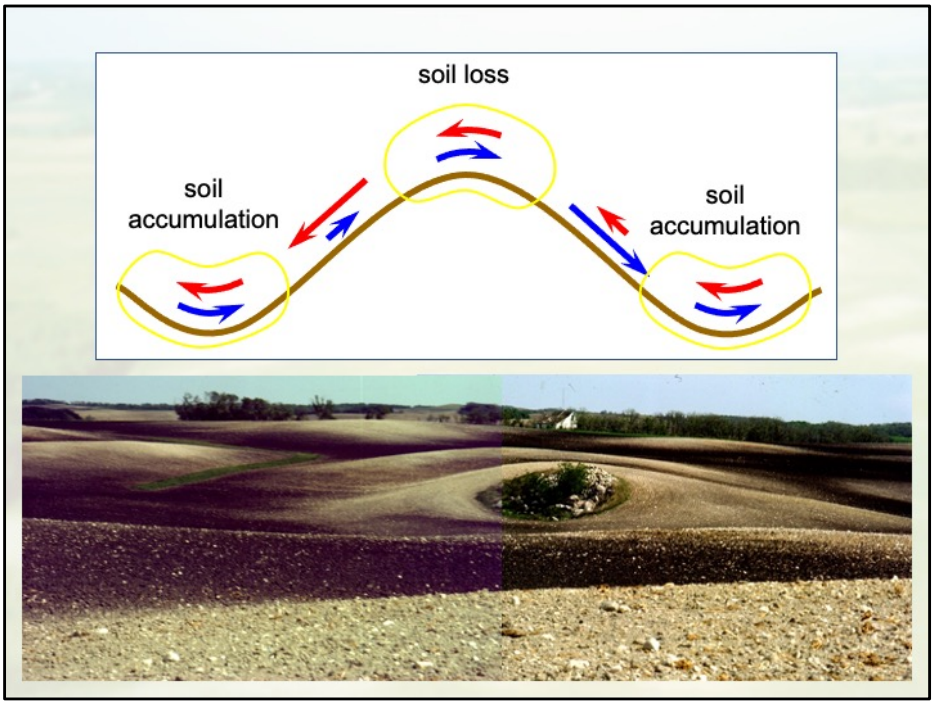
The loss of SOC has been **substantial** over this time period, (about one half)

but it has **not been uniform** within landscapes,
and this is due primarily to the **predominant role of soil erosion**.

This is the idealized representation of the change of SOC in the Canadian Prairies resulting from the cultivation of the native prairie grassland. Clearly, this does not represent the complexity of changes that occurs on hilly landscapes.



The most conspicuous evidence of severe soil erosion,
which is observed across the Prairies,
is the **loss of soil on hilltops**, where the organic-rich topsoil has been removed and organic-poor sub-soil has been exposed.



But, much of this lost SOC isn't actually lost,
it's just moved around within the field by tillage,
causing soil to be dragged down from the top of hills to the bottom
-- some areas lose SOC, and other areas gain it.

This process is called tillage erosion,
and it is now recognized as the major cause of soil erosion within Prairie landscapes.

This new understanding of soil erosion has dramatically changed the way we look at practices to reduce soil loss and the loss of SOC …

… that is the subject of a much longer presentation…
Many so-called conservation tillage implements are actually quite erosive. They may move less soil mass and may leave more crop residue on the soil surface, but they move soil at higher speeds, to greater distances, and, most importantly, with greater variability, which leads to greater tillage erosion.

What is the most effective strategy to increase SOC?

3. Adopt practices that increase SOC,

The last component of this strategy is the most important,
and possibly the most difficult to execute effectively.

Certainly, decreasing tillage intensity will decrease OM decomposition.
However, the most effective means of increasing SOC is by increasing plant biomass production.

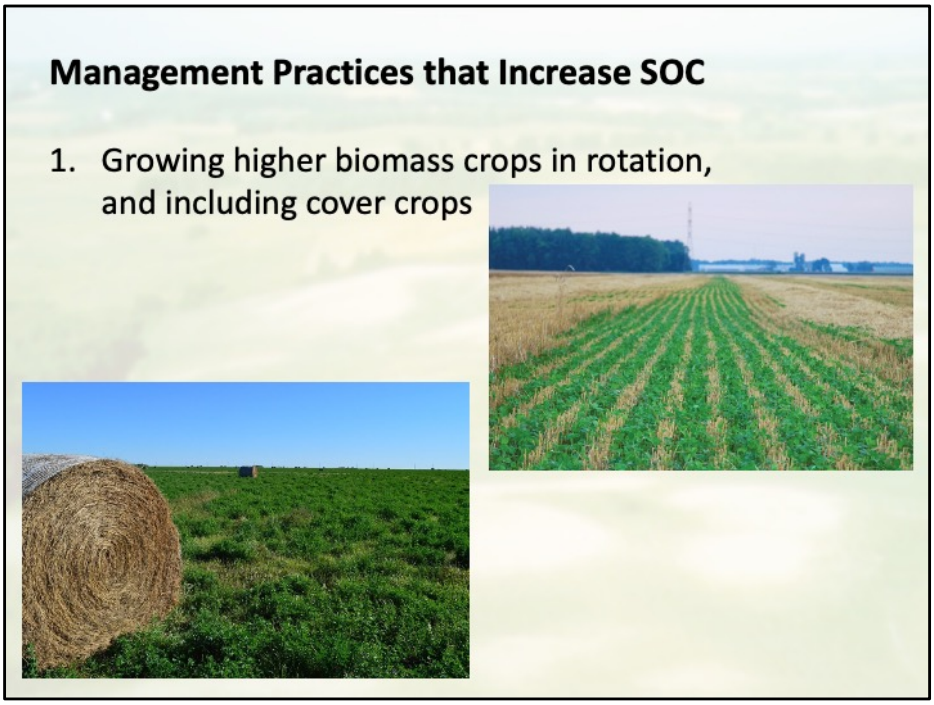
What is the most effective strategy to increase SOC?

3. Adopt practices that increase SOC,
   where there is the greatest potential to do so.

But, the ability to produce plant biomass varies greatly within a landscape,
and the need to produce plant biomass for the purpose of increasing SOC also varies greatly within a landscape.

And, it is no coincidence that the areas in greatest need of SOC
are the also areas least capable of producing it.

Consequently, extraordinary measures are needed to significantly increase SOC in these areas.



There are a few management practices that can increase SOC.

One is:
Growing higher biomass crops in rotation, and including cover crops as a means of producing more OC.

Management Practices that Increase SOC

1. Growing higher biomass crops in rotation, and including cover crops

Do these practices increase SOC in areas that desperately need it?
Do they increase SOC in areas of the landscape that already have high SOC levels?

but …

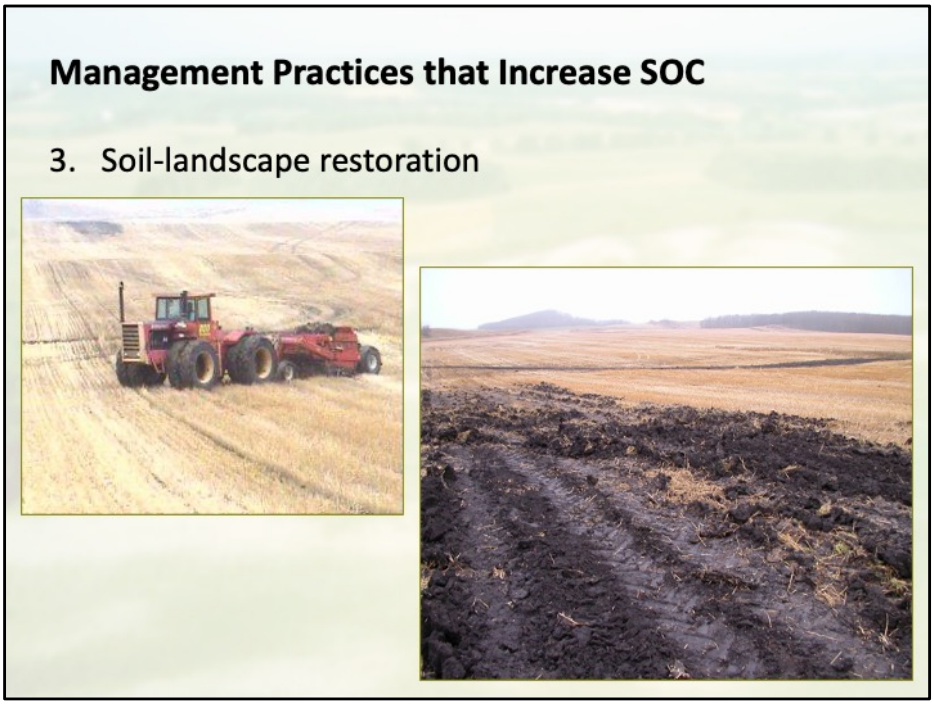
Do these practices increase SOC in areas that desperately need it?
Do they increase SOC in areas of the landscape that already have high SOC levels?

…probably not very much...

Management Practices that Increase SOC

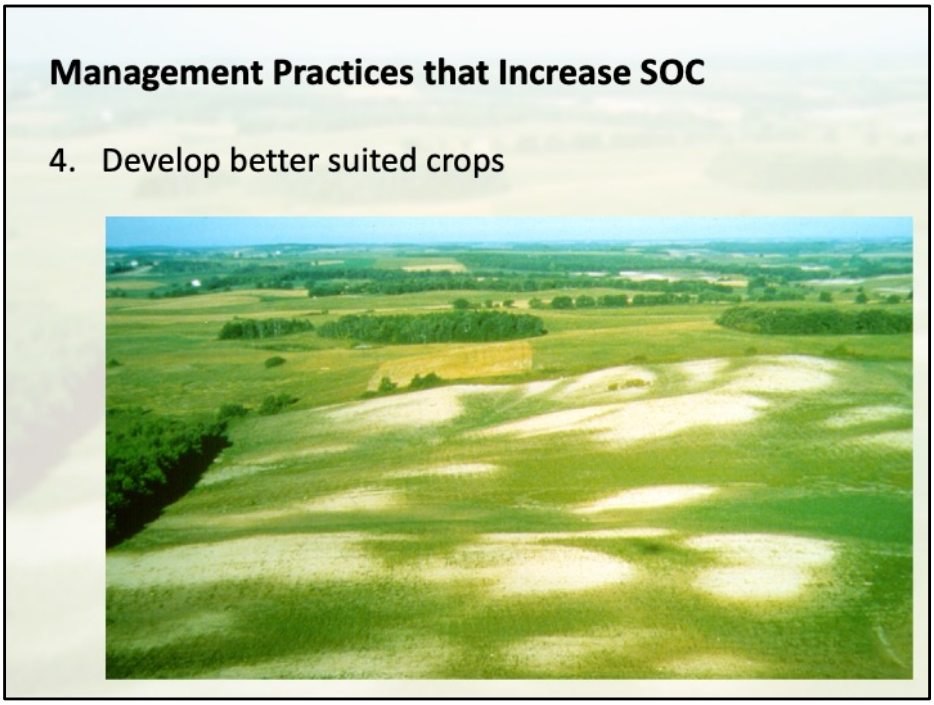
2. Importing OC as manure and compost

Two:
Importing manure and compost can provide OC,
but the net benefits of taking OC from one area of a landscape
and applying it to another must be considered.



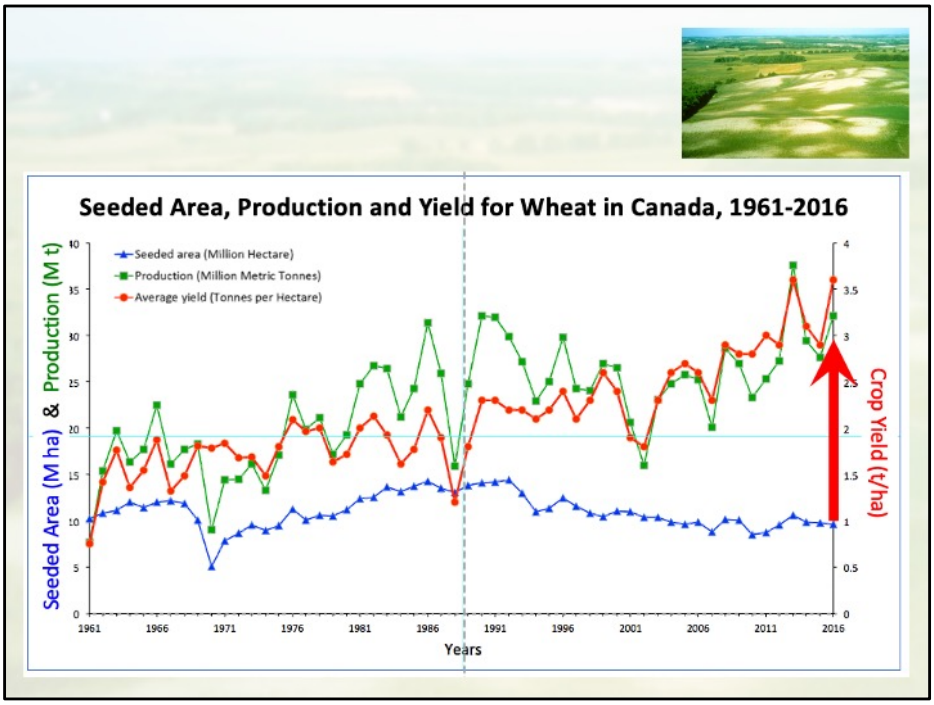
Three:
The removal of SOC from areas of the landscape where eroded soil has accumulated and applying it to areas where it has been lost,
the practice of soil-landscape restoration.

This may be the most effective means of increasing SOC
– the increase is large, and it is immediate
– but, again, the net benefits must be assessed at a landscape scale.



And another is:
to breed and select crops that are much better suited for these landscape conditions, crops that can produce more biomass more evenly throughout the landscape, year-in and year-out.

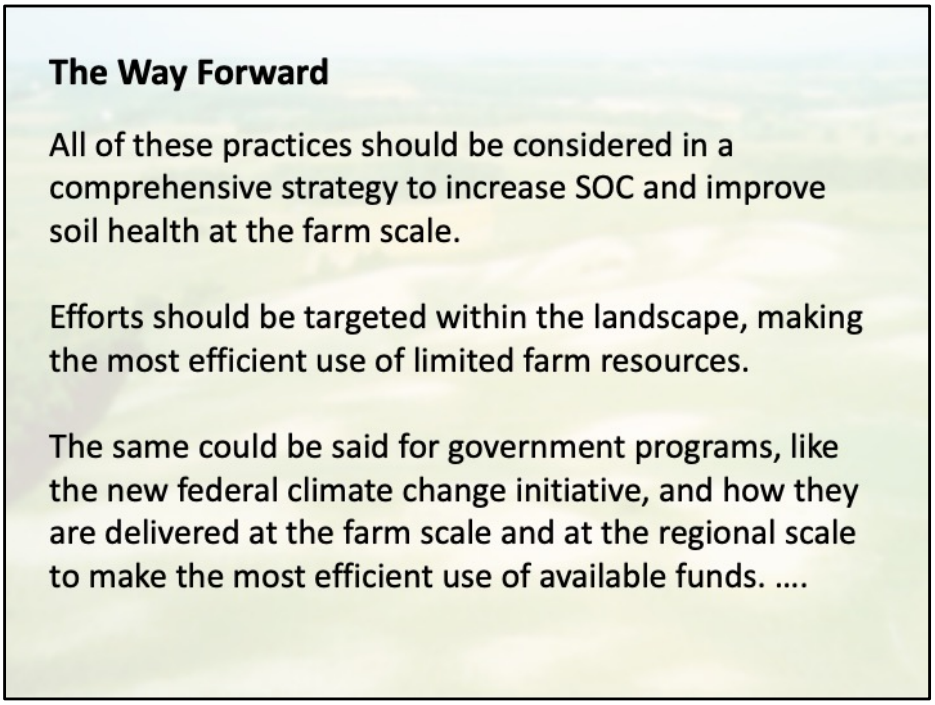
In addition to increasing SOC at a landscape scale, there are considerable agronomic, economic and environmental benefits in having more uniform and more stable crop production.



Breeding and selection of better crops,
along with better crop management practices,
have increased crop yields 2- to 3-fold in the past 50 years.

One can only assume, these yield increases have translated into a substantial increases in biomass production and, therefore, increases in SOC.
… Maybe more than that which can be achieved through practices like cover cropping.

It should be noted that these gains are in spite of the soil degradation…
What would these gains be, if the land wasn't degraded? 3- to 4-fold?



All of these practices should be considered in a comprehensive strategy to increase SOC and improve soil health at the farm scale.

Efforts should be targeted within the landscape, making the most efficient use of limited farm resources. A great example is the focusing of manure application to eroded hilltops.

The same could be said for government programs, like the new federal climate change initiative, and how they are delivered at the farm scale and at the regional scale they should also be targeted to make the most efficient use of available funds.

The challenge that we face in recommending these practices,
and in coupling them, and in targeting them,
is that almost all of the scientific information on which we base our understanding has been generated on near-level, non-eroded landscapes.

To illustrate this point…

I am going to pick on the Swift Current Research and Development Centre.
It is not unique.
And, it is not the strongest example.

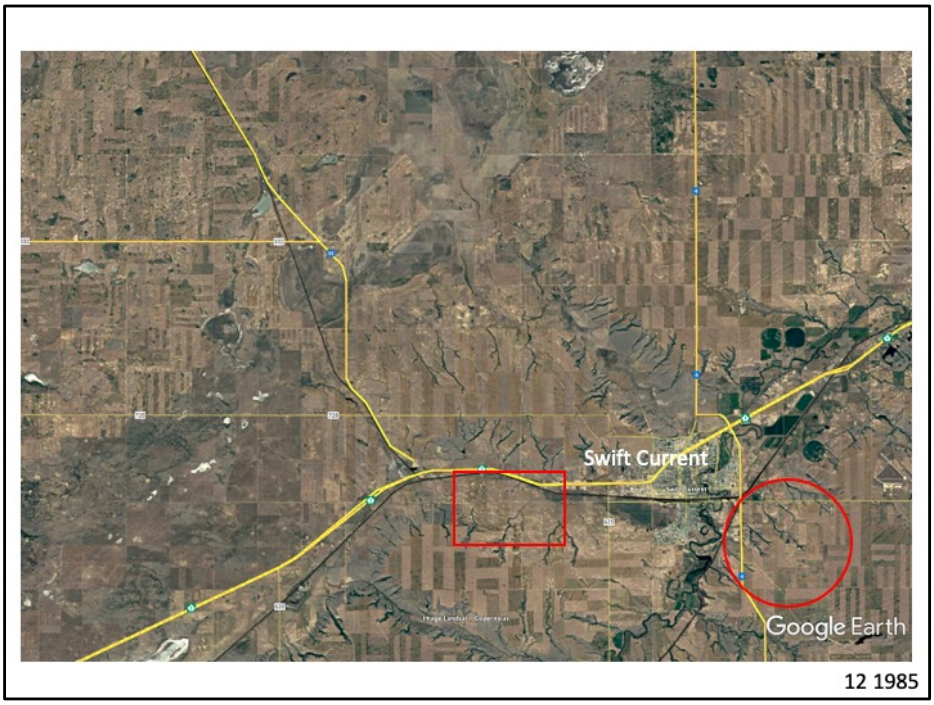
This Google Earth image shows the Swift Current area
and the Research Station
in December 1985.

You can see lots crop residue cover,
indicating lots of conservation tillage…

And here is the Station with its land base and research plots.

Research plots are absolutely necessary for the development of agricultural products and practices.
And, often ideal landscapes are best suited for the research.

But, how well do they extend to the landscapes of farms?



I randomly selected an area just outside of Swift Current to examine the landscapes of nearby farms.

Even with decades of conservation tillage, these farms and their landscapes are facing serious challenges…

… as we can see in the summer of 2018…

…and in the following spring…

… and the following summer…

04 2021

… and in the early spring of 2021…

… and in later in the spring of 2021…

07 2021

… and in the summer of 2021…

*** There is a great need for landscape-based research.

This is not to say there are not great examples of landscape-based research.
Two notable examples are the FarmLab study in SK in the 1980s,
and the Tillage-2000 study in Ontario in the 1990s.
And, there is great hope that AAFC's Living Labs initiative will give much-needed insight into the management of farm landscapes.

This is the **end of Part I**, and I am going to stop here.

Part II examines an equally important challenge, the **protection of surface water quality** and the benefits of a landscape approach. But, that will have to wait for another day.

Thank you.