FORGIVEN NOT FORGOTTEN: A SHORT HISTORY OF WIND EROSION ON THE CANADIAN PRAIRIES

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ABSTRACT

Since agriculture arrived on the Canadian prairies in the late 1800s, wind erosion has always been a constant threat. The 1930s saw some of the worst wind erosion but spurred the invention and adoption of soil management techniques to provide better crop residue management, the number one line of defense against wind erosion. The conservation tillage movement of the 1990s saw increased no-till and summer-fallow almost disappeared. However, recent trends of more intensive tillage on the Canadian prairies, the possible attainment of peak soil cover, and the uncertainty surrounding climate change, drought, and extreme weather events remind us that we cannot let down our guard against wind erosion.

BACKGROUND

After the last glaciation 10,000 yr ago, the Canadian prairies did not change much until the 1800s. Large tracts of treeless grassland were grazed by bison, living in harmony with indigenous nations. Pre-1800, there were an estimated 30-60 million bison in North America. The Canadian prairies are mostly semi-arid with annual precipitation increasing from only 10" in southeastern Alberta and southwestern Saskatchewan to about 22" in southern Manitoba. The Palliser Expedition in the 1850s warned that the driest area of the prairies (later known as the Palliser Triangle) would not support agriculture. However, the more expansionist Macoun Expedition of the 1870s promoted the idea of opening up the prairie to agricultural settlement.

By 1880, only 400,000 bison remained, and in 1882, the Canadian Pacific Railway reached Calgary, Alberta, almost at the Rocky Mountains. In the 1880-1900 period, cattle ranching and grazing dominated the prairies. However, in the early 1900s, further waves of settlers broke up the native prairie for agriculture using European farming methods including the moldboard plow, discs, and harrows (Fig. 1).

At first, the rich soils developed under native grasses for centuries, were quite productive. However, they were quickly mined of available nutrients and a lack of surface cover led to the first evidence of wind erosion, euphemistically referred to as 'soil drifting' (Fig. 2). Fairfield (1920) wrote that "*A triangular area beginning at Pincher Creek and extending east for about 100 miles is an area of severe soil drifting. There was not much problem when the land was new but some lands should not have been broken. To control - plow only when the soil is moist, do not disc, maintain claddiness, strip crop and use winter rye*".

Therefore strip-cropping became the norm with 2-yr rotations of wheat-fallow where upwards of half the land area was fallowed for soil moisture conservation. This system resulted in crop cover for only 4-5 months, followed by a 19-20 month fallow, or an approximate 80:20 fallow:crop split over a 2-yr period.

THE DIRTY THIRTIES AND BEYOND

The 1930s brought an economic-ecological one-two punch to prairie farming. The Great Depression coincided with severe drought for a number of consecutive years. Grasshoppers, cutworm and wheat stem sawfly damage to crops was widespread and wheat yields in 1937 were the lowest in 30 yr. However, there was progress in the 1930s. Firstly, the Prairie Farm Rehabilitation Act (PFRA) was passed in 1935 and staff were hired to combat drought and soil drifting in the prairie provinces. Secondly, the Noble blade cultivator, was invented in 1936 by Charles S. Noble at Nobleford, AB, and is credited with saving vast tracts of prairie land from severe erosion. This tillage implement was able to control weeds on fallow by severing roots just below the soil surface, while at the same time maintaining residue cover to protect against wind erosion.

Fig. 1. *Power machinery breaking virgin prairie sod in the early 20th century. (**Source**: Western Development Museum, Saskatoon, SK).*

Fig. 2. *Hot, drying winds picked up loose topsoil and produced towering dust storms (**Source**: Glenbow Archives, Calgary, AB).*

One of the most famous names in the history of wind erosion research, William S. Chepil, while probably better-known in the US, spent most of his life on the Canadian prairies. He was born at Gimli, Manitoba in 1904 (Smith, 1981). He received a B.S.A. in 1930, and an M.Sc. in 1932, from the University of Saskatchewan. He joined the Canada Department of Agriculture, as Officer-in-Charge of the new substation in Regina, SK, in 1931. In 1936 he transferred to the Soil Research Laboratory at Swift Current, SK, to undertake research on wind erosion and its prevention. From 1937-39, he attended the University of Minnesota, and was awarded a Ph.D. in 1941. In 1946, he took an 18-month assignment in Henan and Anhui provinces, China, as a soil reclamation specialist with the United Nations Relief and Rehabilitation Administration. In 1948, he left Swift Current to take up a position with USDA-ARS in Manhattan, KS, becoming leader of the wind erosion research program in 1953, when he and colleagues set out to develop the Wind Erosion Equation (WEQ) [Tatarko, 2005]. The WEQ led to an understanding of the fundamental factors causing and controlling wind erosion (i.e. soil cloddiness, ridge roughness, field length, climate, and vegetation). However, Dr. Chepil died of cancer in 1963, at age 59, before he could see the first publication of the WEQ in 1965. WEQ was used and enhanced until the official release of the new Wind Erosion Prediction System (WEPS) by USDA in 2005 (Tatarko, 2005).

THE CONSERVATION TILLAGE REVOLUTION

The early pioneers of conservation tillage (minimum tillage, no-till) research in the 1960s and ‘70s in southern Alberta, showed that crop yields were similar with conservation vs. conventional tillage practices, while wind erosion risk was greatly reduced by means of a surface layer of protective residue cover (Anderson, 1961; Lindwall and Anderson, 1977). In the 1980s, a Senate Committee Report (Sparrow, 1984), coupled with drought years in which wind erosion was again prevalent, provided the impetus for grassroots farmer-led organizations which promoted soil conservation practices on the prairies. These groups, active throughout the 1990s and 2000s included the Alberta Conservation Tillage Society, the Saskatchewan Soil Conservation Association, and the Manitoba-North Dakota Zero Tillage Farmers Association. As a consequence, summer-fallow area fell dramatically (to <5% of cropland) across the prairie provinces (Fig. 3). Continuous cropping became the norm.

The other major change was the rapid adoption of conservation tillage. In Alberta, conventional tillage (i.e. tillage incorporating most crop residue into soil) fell from 73% of the seeded area in 1991 to only 12% in 2016 (Fig. 4). In Saskatchewan, the corresponding change was from 64% to 7%, while in Manitoba it was from 66% to 41%. Conversely, the percent of seeded area in no-till or zero tillage increased from 3% to 69% in Alberta, from 10% to 74% in Saskatchewan, and from 5% to 20% in Manitoba during the same time period (Fig. 4).

The last push of wind erosion research on the Canadian prairies occurred in the 1990s and focused on the processes of overwinter change in soil aggregate size distribution as affected by fallow management (Larney et al., 1994a), quantifying soil losses (Larney et al., 1995), the impact of freeze-thaw cycles on soil aggregate breakdown (Bullock et al., 2001), freeze-drying effects on wind erodibility (Bullock et al., 1999), the effect of wind erosion on redistribution of soil nutrients and crop yield (Larney et al., 1998) as well as the phenomenon of herbicide transport on wind-eroded sediment (Larney et al., 1999). By the early 2000s funding for wind erosion research had ceased, largely because the problem was deemed to be solved by the land use and soil management changes outlined above.

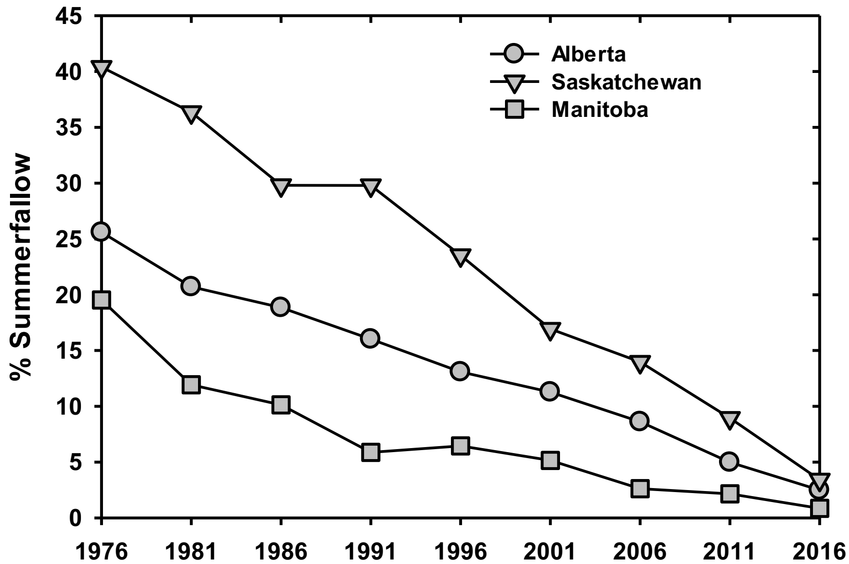

Fig. 3. *Change in summer-fallow area (as a percent of cropland) from 1976 to 2016 in the three prairies provinces (**Source**: Statistics Canada).*

THE RETURN OF TILLAGE?

After close to 30 yr of conservation tillage on the Canadian prairies, there has been an increase in tillage intensity (especially pre-seeding) in recent years. While there are no hard numbers, anecdotal evidence shows the rise of vertical tillage, often called 'tillage for no-tillers'. Vertical tillage systems depend on the manufacturer but generally wavy coulters, or in some cases knives, are mounted on a tool bar to break down crop residue and blacken the soil surface a bit (Hart, 2010). Although the coulters or knives run fairly shallow (2-3 inches), their action fractures the soil profile downward, or 'vertically,' improving moisture infiltration, crop root development and nutrient uptake and alleviating compaction.

As is usual in these scenarios, there is no one reason for the change, rather several overlapping drivers appear to be at play. Vertical tillage is partly fueled by equipment manufacturers trying to re-package existing technology as something new, without the benefit of research (McClinton, as quoted in Hart, 2010). Some of the earliest patents on wavy coulters date back more than 60 years. In addition, younger farmers who have grown up with conservation tillage, do not remember the years prior to conservation tillage when wind erosion was a problem. Another factor has been a series of wetter-than-normal seasons on the prairies which allows surface residue to build-up. Moreover, there are concerns that long-term no-till soils have low pH and high P concentrations (Teboh, 2016) in the shallow surface layer after many years of non-disturbance. 'Strategic tillage' may be promoted to alleviate this 'layering' effect.

HAVE WE REACHED PEAK SOIL COVER?

Huffman et al. (2012) documented increased soil cover on the Canadian prairies between 1981 and 2006. The improvement came primarily as a result of widespread no-till and a decline in summer-fallow. However gains were largely offset by a shift from higher-cover crops such as wheat, oats

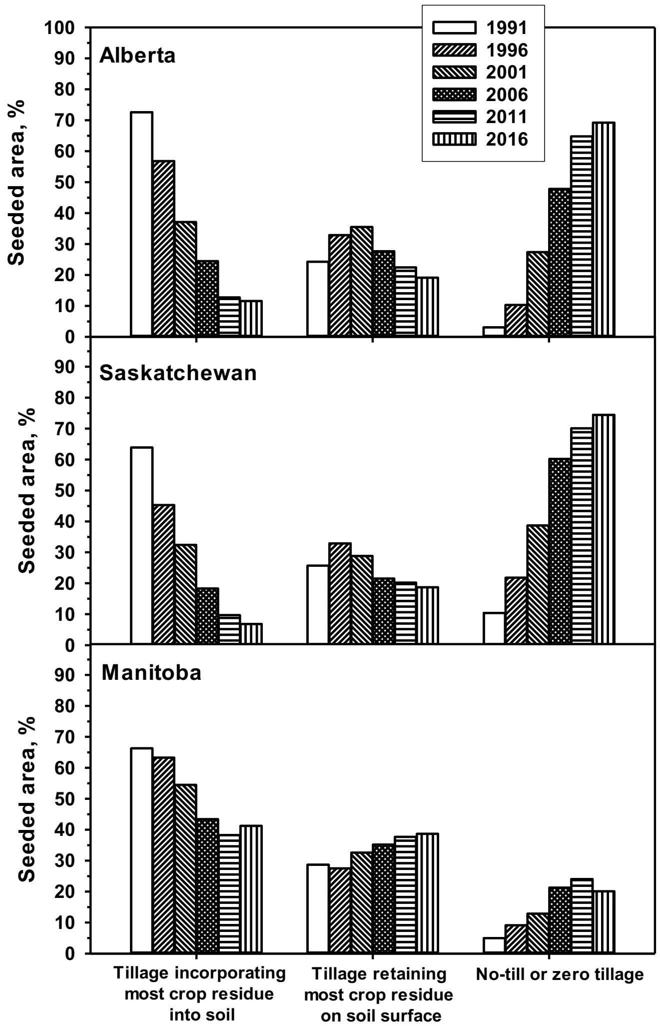

Fig. 4. *Change in tillage practices (as a percent of seeded area) from 1991 to 2016 in the three prairies provinces (**Source**: Statistics Canada).*

and barley to more profitable but lower-cover crops such as canola, soybean and potato. For many years, wheat was king on the Canadian prairies. In 1991, wheat area in the three prairie provinces was 34.3 million acres or 51% of all cropland while canola area was 7.5 million acres or 11% of cropland (Statistics Canada). By 2016, the areas of wheat and canola had converged dramatically, with wheat accounting for 22.1 million acres or 29% of cropland, and canola at 20.6 million acres or 27% of cropland. This trend has implications for soil cover and hence wind erosion risk, as canola produces less residue mass than wheat and decomposes faster (Soon and Arshad, 2002). Huffman et al. (2012) concluded that even though soil protection had improved, soil cover could decline over the next several decades if crop changes continue, the adoption of conservation tillage reaches a peak, or residue harvesting for biofuels becomes more common. In addition, the uncertainty of climate change and more extreme weather events (e.g. prolonged drought) could cause lower net primary productivity and hence residue cover, thus increasing wind erosion risk. Moreover, extreme weather events can lead to wildfires, which may also jeopardize soil surface cover, leading to wind erosion risk (Glen, 2012).

The bottom line is that we cannot become too complacent in the battle against wind erosion. It is always lurking in the shadows waiting to pounce, given the right set of environmental conditions. We can forgive past wind erosion but we should not forget.

REFERENCES

Anderson, D.T. 1961. Surface trash conservation with tillage machines. Can. J. Soil Sci. 41:99-114.

Bullock, M.S., Larney, F.J., Izaurralde, R.C. and Feng Y. 2001. Overwinter changes in wind erodibility of clay loam soils in southern Alberta. Soil Sci. Soc. Am. J. 65:423–430.

Bullock, M.S., Larney, F.J., McGinn, S.M. and Izaurralde, R.C. 1999. Freeze-drying processes and wind erodibility of a clay loam soil in southern Alberta. Can. J. Soil Sci. 79:127–135.

Fairfield, W.H. 1920. Soil drifting in Alberta. Proc. Meeting of the Western Can. Soc. Agron. Edmonton, AB. 1: 35-37.

Glen, B. 2012. Grass fire leaves blackened reminder of its rage. https://www.producer.com/2012/09/grass-fire-leaves-blackened-reminder-of-its-rage%E2%80%A9/ (accessed 4 Feb. 2020).

Hart, L. 2010. Vertical tillage a step backward. https://www.grainews.ca/features/vertical-tillage-a-step-backward/ (accessed 4 Feb. 2020).

Huffman, T., Coote, D.R. and Green, M. 2012. Twenty-five years of changes in soil cover on Canadian Chernozemic (Mollisol) soils, and the impact on the risk of soil degradation. Can. J. Soil Sci. 92:471–479.

Larney, F.J., Bullock, M.S., Janzen, H.H., Ellert, B.H. and Olson, E.C.S. 1998. Wind erosion effects on nutrient redistribution and soil productivity. J. Soil Water Conserv. 53:133–140.

Larney. F.J., Bullock, M.S., McGinn, S.M. and Fryrear, D.W. 1995. Quantifying wind erosion on summer fallow in southern Alberta. J. Soil Water Conserv. 50:91–95.

Larney, F.J., Cessna, A.J. and Bullock, M.S. 1999. Herbicide transport on wind-eroded sediment. J. Environ. Qual. 28: 1412–1421.

Larney, F.J., Lindwall, C.W. and Bullock, M.S. 1994. Fallow management and overwinter effects on wind erodibility in southern Alberta. Soil Sci. Soc. Am. J. 58:1788–1794.

Lindwall, C.W., and D.T. Anderson. 1977. Effects of different seeding machines on spring wheat production under various conditions of stubble residue and soil compaction in no-till rotations. Can. J. Soil Sci. 57:81-91.

Smith, A.E. 1981. Regina Research Station: 1931-1981. Historical Series No. 15, Research Branch, Agriculture Canada, Ottawa, ON.

Sparrow. H.O. 1984. Soil at Risk: Canada's Eroding Future. Report of the Standing Committee on Agriculture, Fisheries and Forestry, Supply and Services Canada, Ottawa, ON.

Soon,, Y. and Arshad, M. 2002. Comparison of the decomposition and N and P mineralization of canola, pea and wheat residues. Biol. Ferti. Soils, 36:10-17.

Tatarko, J. 2005. A history of USDA-ARS wind erosion research at Manhattan, Kansas, 1947-2005. https://infosys.ars.usda.gov/WindErosion/HistoryWERU.pdf (accessed 4 Feb. 2020).

Teboh, J.M. 2016. Does strategic tillage help minimize the impact of phosphorus stratification on crop yields in no-till farming? https://www.ag.ndsu.edu/carringtonrec/center-points/does-strategic-tillage-help-minimize-the-impact-of-phosphorus-stratification-on-crop-yields-in-no-till-farming (accessed 4 Feb. 2020).