Agriculture Canada

A HISTORY OF SOIL EROSION BY WIND

IN THE PALLISER TRIANGLE OF WESTERN CANADA

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A HISTORY OF SOIL EROSION BY WIND
IN THE PALLISER TRIANGLE OF WESTERN CANADA

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Cover photo. The western plains, as viewed by Captain John Palliser and the early settlers.

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Agricultural settlement in the prairie region of Western Canada started in about 1885 and continued until 1920. The settlers came from other parts of Canada and also from other countries. Because of the need for an immediate cash crop, and also because the climate was most suitable for growing them, cereals soon became the dominant crop in the entire region. Low precipitation during the growing season and abundant growth of weeds soon made it necessary to introduce a summerfallow cropping system, whereby only half of the crop land was cultivated each year to save enough moisture for a successful crop the following year. As the original structure and organic matter in the soil deteriorated from continuous cultivation soil erosion by wind became severe. Extensive soil erosion during the 1920's gave a warning of impending disaster and during the 1930's a prolonged dry spell culminated in dust storms and soil destruction of disastrous proportions.

It appeared that the productivity of 3 or 4 million hectares of agricultural land in the southern prairies had been completely destroyed. The land had become unproductive, and air and water pollution by wind-transported soil was critical. Sociological and economic stresses were extreme. As a result of the disaster, major programs of investigation and reclamation were undertaken by the federal, provincial, and municipal governments.

The purpose of this historical account is to examine the causes of the crisis, to describe the steps taken to control it, and to summarize the long-term programs that have been developed to prevent its reoccurrence.

DESCRIPTION OF THE AREA AND THE HISTORY OF ITS DEVELOPMENT

Exploration

In 1857, Captain John Palliser was commissioned by the Secretary of State for the Colonies "to explore that part of North America which lies between the north branch of the river Saskatchewan and the frontier of the United States, and between the Red River and the Rocky Mountains." The subsequent report of the Palliser expedition to the Royal Geographical Society and to the Colonial Office in London stated that sustained agriculture would be a precarious industry in the grassland region of Rupert's Land. The rectangular-shaped region stretches along the 49th parallel from longitude 100° to 114° W and extends north to the 52nd parallel of latitude. This low-rainfall area, described by Palliser as a desert, contains approximately 20 million hectares and is commonly called the Palliser Triangle. Palliser also described a fertile belt that surrounded the Triangle to the east, north, and west.

In 1867, four provinces in Eastern Canada were confederated under the British North America Act and became the Dominion of Canada. However, the vast regions of the northwest, known by various names such as the Hudson's Bay Territory, Northwest Territory, and Rupert's Land, remained under the domination of the Hudson's Bay Company. The Company was vitally concerned with this prairie region as a source of food. The buffalo not only supported the Indian people, but they also provided the Company with dried meat such as pemmican and jerky, as well as fresh meat. Also, the Company was opposed to any settlement in the area that might disrupt the fur trade, and therefore, in 1857, when the governor of the Company was asked what the probability was of establishing settlements within the southern territories of the Company, he replied, "None, in the lifetime of the youngest man now alive."

Soils and Vegetation

The soils of the Palliser Triangle belong to the Brown and Dark Brown great groups. The textural classes range from sands to loams and clays, and all combinations of the three. The Brown soils developed under shortgrass prairie, which consists chiefly of blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.) and other species such as needle-and-thread or common speargrass (*Stipa comata* Trin. & Rupr.), western wheatgrass (*Agropyron smithii* Rydb.), Junegrass (*Koeleria cristata* (L.) Pers.), and Sandberg bluegrass (*Poa secunda* Presl). Broad-leaved herbs or forbs common in this grassland type include pasture sage (*Artemesia frigida* Willd.), prickly-pear cactus (*Opuntia polyacantha* Haw.), and broomweed (*Gutierrezia diversifolia* Greene). Little club-moss (*Selaginella densa* Rydb.) is abundant in many locations. The Dark Brown soils developed on a mixed prairie, which includes short and medium-tall grasses. Besides the vegetation already described these soils also support bearded wheatgrass (*Agropyron subsecundum* (Link) Hitchc.), rough fescue (*Festuca scabrella* Torr.), roses (*Rosa* spp.), western snowberry (*Symphoricarpos occidentalis* Hook.), willow (*Salix* spp.), and trembling aspen (*Populus tremuloides* Michx.).

Climate

Precipitation varies throughout the region, but at Swift Current, in the center of the Triangle, the 49-year mean annual precipitation is 35 cm; of this amount, 9 cm is snow. Evaporation (from May 1 to September 30) from a free-water surface is 73 cm. Hot, dry winds reduce the effectiveness of the moisture received and reach velocities capable of initiating soil movement if the soil is not adequately protected by a growing crop, trash cover, or a cloddy soil surface.

Settlement

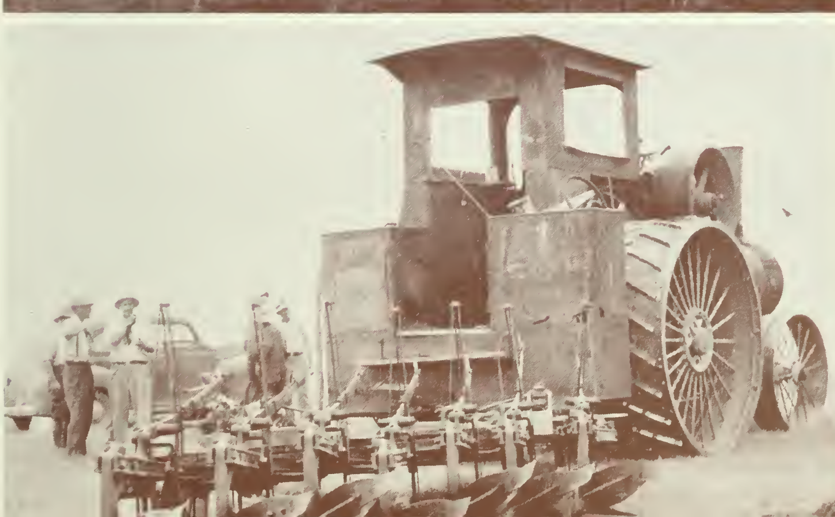
The Palliser report, which defined the grassland region as hazardous for agriculture, encouraged settlement only within the narrow belt that was described as fertile. Thus, by 1885, barely 100,000 people had settled between Winnipeg and the mountains, and by 1901 only 20,000 people were living in the entire grassland region. As the westward rush of American homesteaders closed the buffalo pastures to cattlemen in the western United States the ranchers were forced farther west. When the American ranchers discovered the wide-open and unsettled spaces of the Palliser Triangle, they quickly moved their ranching enterprises north into Canada. Consequently, many of the larger pioneer cattle ranches in Canada were originally extensions of American cattle empires. If the railways and the government had followed Palliser's recommendations, 259,000 square kilometres of superb rangeland would have been reserved for cattlemen, and settlement would have been confined to the narrow fertile belt. However, construction of the east–west transcontinental railway, which passed through the grassland region, opened the area for settlement and set the forces in motion that soon led to the creation of the dust bowl.

In response to the railway promoters and real estate agents, settlers came from the United States, Eastern Canada, the British Isles, and Europe. Between 1896 and 1914 the Dominion government gave away millions of hectares of homestead lands while the railway and land companies sold millions more. Some homesteaders were inexperienced, but others were merely speculating on the land and never intended to stay. Nonetheless, there were many experienced farmers among those who settled the Palliser Triangle. Most of these settlers had come from areas having high rainfall and they had learned to farm with moldboard plows, disks, and harrows in an environment where there was no rush to plant seed early in order to benefit from spring rains.

Agricultural Development

Early in this century, development of agriculture on the Canadian Prairies was greatly accelerated by the world demand for bread wheats. Without any assistance from soil survey reports or extension services, the new settlers selected and cultivated millions of hectares of the open prairie lands, which could be quickly and economically prepared for seeding to wheat. In 1915, further impetus was given by the record-breaking crop, which ended any doubts about the future of the Palliser Triangle as one of the greatest wheat-growing areas in the world. Yields of 2,016-2,688 kg/ha were common in the Palliser Triangle. In 1915, the Prairie Provinces produced 10 million metric tons of wheat on 5.6 million hectares of land—almost twice the crop ever produced in Canada before—and the average yield of 1,747 kg/ha remained a record for over 40 years. As a result of the big crop of 1915, the drive to plant more wheat was accelerated, and thousands of hectares of submarginal land were plowed up and cultivated. Consequently, this area of

Figs. 1 and 2. Open prairie land was quickly broken out of sod with large steam tractors.



low precipitation, comprising 20 million hectares of grassland that had supported buffalo herds for centuries, was suddenly exposed to the full force of the prairie winds.

Soil Drifting

Soil drifting started on the prairies as soon as the soils were cultivated. The drifting increased after periods of low precipitation, and subsequently caused crop failures (MacKay 1890). At about this time, it was found that in years of prolonged drought, land that had been left uncropped but kept weed-free the previous year could produce higher yields of wheat than land that had been in continuous grain cropping. In 1889, at the Experimental Farm, Indian Head, Saskatchewan, it was observed that the added moisture stored during the idle year made possible the greater yield returns (MacKay 1890). Thus began the practice of summerfallow (controlling weeds on uncropped land), and of using this black or bare summerfallow concept in 2- and 3-year rotations of fallow and wheat.

The large acreages devoted to black or bare summerfallow promoted wind erosion during the years of extended drought. During the 1930's, the wind moved millions of metric tons of soil from fields, burying fence lines and blocking district roads. The drifts choked out shelterbelts and gardens, reached the roofs of outbuildings, and seeped in the cracks around farmhouse windows and under doors.

Drought and Crop Failures

Inadequate moisture resulted in crop failures in 1917, 1918, 1919, and 1920. Because of unsuitable tillage practices, crop residues were destroyed, and when the winds came, soil drifting was inevitable. As the drought continued large numbers of settlers began to leave the region. From 1921 to 1926

Fig. 3. Burning of stubble made cultivation easier but contributed to soil drifting.

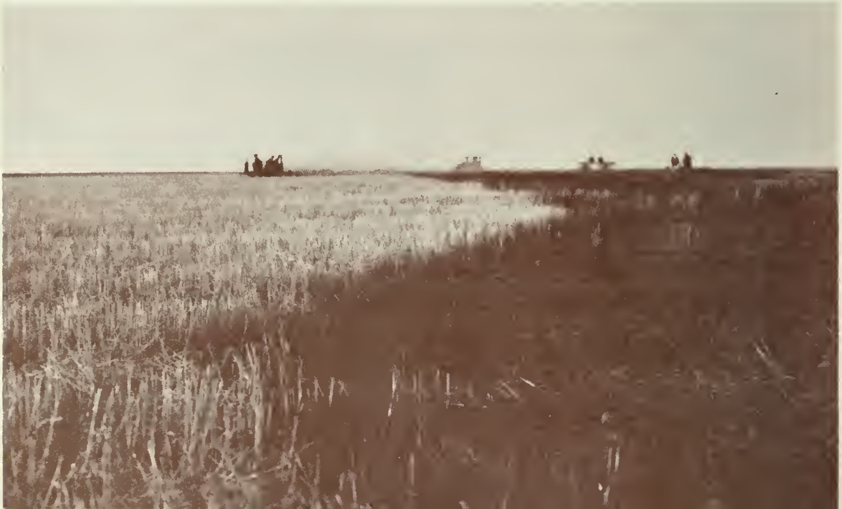
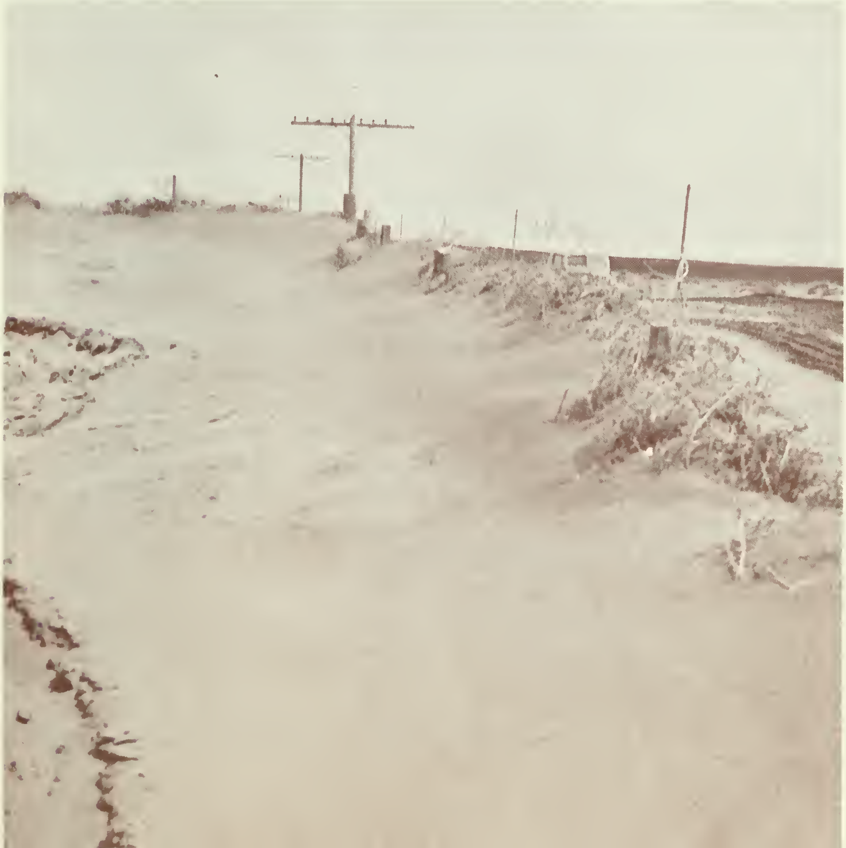


Fig. 4. Moldboard plows turned protective crop residue under.

Fig. 5. Drifting soil buried fences and blocked district roads.



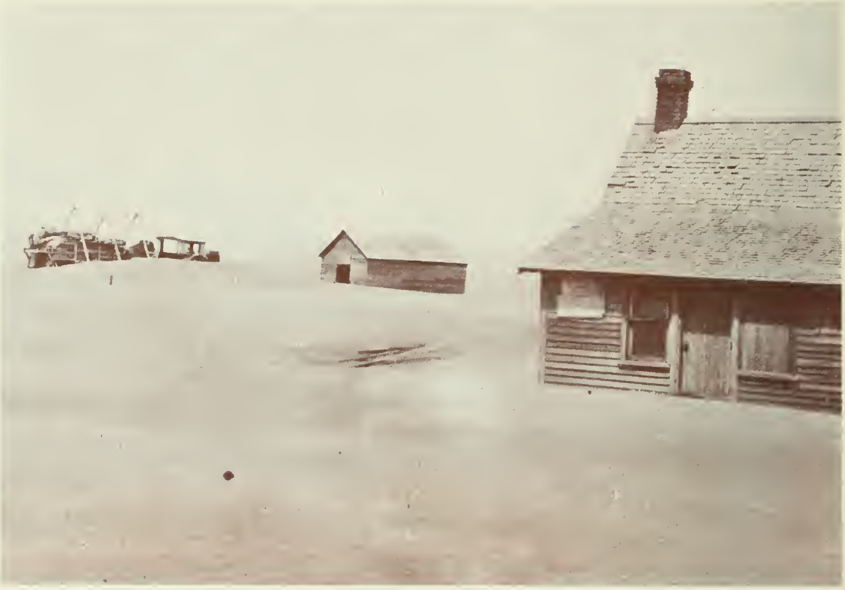


Fig. 6. Many farms were abandoned.

in Alberta, the movement from the southeastern part of the province became almost a stampede. Throughout the Palliser Triangle the previously heavy immigration became equally heavy emigration. In 1926, 10,000 farms in Alberta were abandoned. In Saskatchewan the count reached 5,000. When the exodus was at its height, the rains finally came and good crops were harvested once again throughout the late 1920's. However, the respite was only temporary: the 1930's brought again the black blizzards of drifting soil along with the beginning of the depression. When prices collapsed between 1930 and 1933, farm incomes were reduced to almost nothing. Besides all these problems, in 1933, grasshoppers descended on the area in clouds, leaving nothing of crops and gardens. Then in 1935, when a good crop was in prospect, rust destroyed it. Damage was so extensive that many more farms were abandoned, and the farmers moved to northern Alberta and Saskatchewan, where the crops were more stable. The people who stayed on their land wore out their machinery, their horses, and themselves and had no physical or financial resources left to take steps to combat soil erosion. This period of hardship and uncertainty brought the people of the area closer together and paved the way for future cooperative action. It was a time for thinking, planning, and acting for the future.

EFFORTS TO SOLVE THE PROBLEMS OF DRYLAND FARMING

Government Assistance

Neither the municipal nor the provincial governments had enough tax money to keep up their services during this time of crop failures and soil drifting. Because the federal government held title to the natural resources of Alberta and Saskatchewan, and had been responsible for bringing in the original settlers, the provincial governments turned to Ottawa for assistance.

As the number of welfare recipients increased in the 1920's and soil drifting began the provincial governments in both Alberta and Saskatchewan decided it was time to reexamine the status of the Palliser Triangle. In 1920, a survey commission was set up in Alberta and a Royal Commission was established in Saskatchewan to study the problems of dryland farming. In Alberta, the survey commission suggested that more irrigation might be helpful. The Royal Commission in Saskatchewan urged that a special experimental farm be established at Swift Current, Saskatchewan, to study the problems of dryland farming and to find the solutions to them. The federal government agreed, and immediately directed its Experimental Farms Service to establish an experimental farm at Swift Current. The Commission also proposed the establishment of an agricultural extension service to spread the latest information from the scientists to the farmers.

Prairie Farm Rehabilitation Act

In 1935, the Government of Canada passed the Prairie Farm Rehabilitation Act (PFRA) to assist the provinces in dealing with the disaster. The federal Department of Agriculture was responsible for administering the Act. The responsibility of combating soil drifting and of developing suitable farming practices was assigned to the experimental farms and stations in the Prairie Provinces. The Experimental Farms Service, supported by PFRA funds and personnel, organized programs and mobilized the forces that eventually found solutions to the soil-drifting problem. The research programs were carried out effectively, because they were interconnected and centrally controlled and directed. Without the assistance of the Experimental Farms Service, the PFRA could not have achieved its goal, the conservation of soil, so quickly.

A committee to study soil drifting was appointed under the National Committee on Agricultural Services to advise the federal Minister of Agriculture on the operations of the PFRA. The committee was made up of senior members of the federal Department of Agriculture, the three western provincial Departments of Agriculture, the three western Colleges of Agriculture, the Dominion Meteorological Service, the Board of Grain Commissioners, and the Canadian Pacific Railway.

Creation of Substations

This committee approved the establishment of 30 substations to be associated with the experimental farms across the prairies, and other substations were added later. The substations were privately owned farms that were managed in cooperation with the Experimental Farms Service.

The substations became centers for the development of the most effective soil conservation practices within their districts, covering a wide range of soil conditions and climates. Each substation served its district as a test center from which recommendations were made on the cultural practices and crop varieties best suited to those districts. As soil drifting was controlled on the substations neighboring farmers copied the methods, and their successes were, in turn, noted and used by others.

One of the emergency measures that was undertaken was the listing (planting crops in furrows) of drifting fields in order to trap and hold the

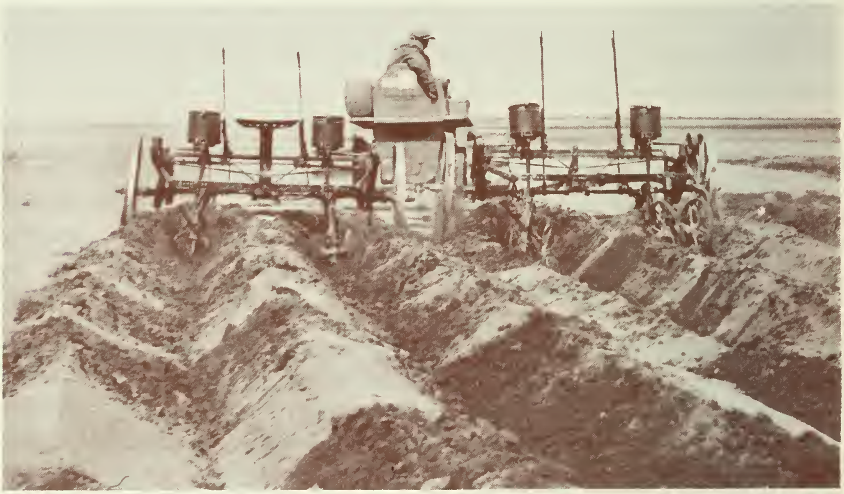
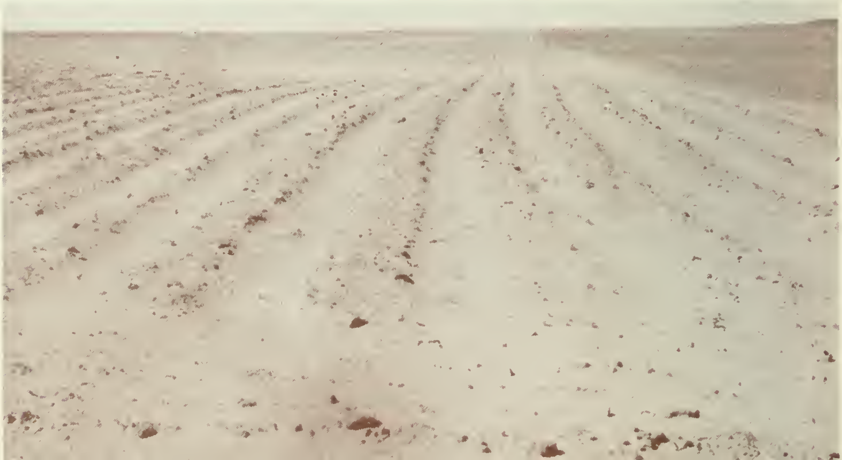


Fig. 7. Drifting fields were listed to trap and hold the moving soil.

Fig. 8. Furrows filled with drifting soil.



moving soil. Plows and cultivators were used to bring soil clods to the surface to resist movement of the soil by wind. Based on research carried out in southern Alberta (Experimental Station, Lethbridge 1938), strip farming in a 2-year rotation of grain and summerfallow was advocated, and assistance was given in laying out 40- to 80-m field strips at right angles to the prevailing winds. Surface working of summerfallow was encouraged in order to maintain a protective trash cover rather than plowing or black fallow. During this period farmers began to realize the importance of saving all available trash for use on the soil surface as a protection against erosion. As a result, trash-cover farming became almost universally adopted across the prairies.

Agricultural Improvement Associations

Another PFRA activity that proved to be of great value was the organization of Agricultural Improvement Associations (AIA's). Their purpose was to bring farmers together in organized groups to exchange ideas, inform PFRA and provincial agencies of conditions needing attention, and act as an exchange through which special activities could function and assistance be given. For example, small lots of seed of crested wheat grass (*Agropyron cristatum* (L.) Gaertn. and *A. desertorum* (Fisch.) Schult.) were provided to farmers through the AIA's to establish seed plots or to seed lands that were too dry or too sandy for grain farming. The experimental farms throughout the drought area had already tested this grass and found it suitable for establishment. The recommendations were to seed either in the fall or as early as possible in the spring. Seedings made into grain stubble or a cover of Russian thistle (*Salsola pestifer* Nels.) or other annual weeds established satisfactorily without any preseeding tillage. Trees for shelterbelt plantations and special implements for emergency control of excessive soil drifting such as lister shovels and listers were also distributed through the AIA's.

Individual Assistance

When an individual farmer had a soil-drifting problem that he was unable to solve, the staff of the nearest experimental farm would work with him and

Fig. 9. Drifted soil seeded to winter rye as an emergency control measure.

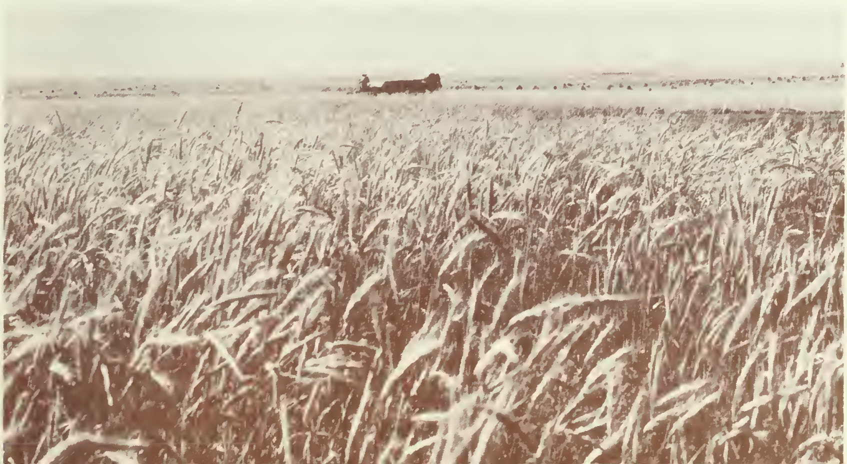


Fig. 10. Crested wheatgrass established following seeding into rye stubble after the rye was harvested.

help him. First, the soil movement was stopped by means of listing and ridging the fields in order to trap the moving soil. As soon as the drifting was stopped, these areas were seeded to a cover crop of winter rye, which had been found to establish readily. Grass was seeded into the stubble the following year, after the rye was harvested. The rye stubble shaded the grass seedlings and trapped snow, which provided additional moisture for growth the next spring. This technique for seeding grass was used successfully to return large areas of badly eroded land to grass (Clarke and Heinrichs 1941).

Community Pastures

Although most farmers were eventually able to bring the drifting soil under control, there were some farms where wind erosion was so severe that the land was finally abandoned and the ownership was turned over to the municipalities to pay the back taxes. These lands became a menace to adjoining farms. The PFRA, by agreement with the municipalities and provinces, took over the management of these properties, brought the soil drifting under control, and seeded the eroded areas to perennial grass, usually crested wheatgrass. In localities of sandy soil and dry climate, sometimes the entire property was submarginal for growing grain. In these cases, the lands were deeded to the federal government, who in turn developed them as community pastures.

After the period of emergency had passed, soil surveys revealed other large blocks of sandy land that needed reseeding to grass for the establishment of community pastures. By 1939, 41 community pastures

Fig. 11. **Large-scale seedings of crested wheatgrass were made on sandy soils covered with a growth of annual weeds.**

comprising some 330,000 hectares had been developed in the prairie region. By 1970, besides the established ranches, 810,000 hectares of community pastures provided grazing for 80,000 beef animals.

Water Conservation and Irrigation

Because the problems of soil erosion are associated with a semiarid climate, irrigation appeared to be a logical solution. The Saskatchewan River system crosses the Palliser Triangle, carrying runoff from the eastern Rockies to Hudson Bay. This river is deeply entrenched in a narrow valley and the cost of developing storage and distribution systems is high in relation to the potential value of the crops that are adapted to grow there. The development of this source of water has progressed to the point where about half a million hectares can now be irrigated. However, this irrigation system has been developed only in areas where the soil is suitable, and the project has had only a slight effect on the problem of wind erosion.

The development of small-scale dams and dugouts for storing water on individual farms has had a greater impact than the major development on the Saskatchewan River system. The influence of these smaller water-storage developments has been primarily sociological, because they have provided water for domestic use and for very limited irrigation of home gardens for growing fresh vegetables and beautifying the drab prairie farmsteads. In some instances, the small-scale systems have supplied water for livestock and allowed some diversification of production.

Shelterbelts

One of the activities encouraged by the PFRA was the planting of trees or shrubs for the protection of soil and crops from winds and storms. From the inception of this work until and including 1938, all members of AIA's who agreed to plant home shelterbelts were provided with the necessary planting material without charge, and the cost of transportation of the material was prepaid, providing the land had been properly prepared and favorably reported on by the tree-planting supervisors. Also, payments covering the cost of planting the trees were made on a basis of $3.50 per thousand. This planting policy was discontinued in 1939, and a new policy was started that prepaid express charges on shipments of trees going to all farmers in the designated drought area, not just to members of AIA's.

In 1938, AIA members were supplied with 909,000 trees and in 1939, the number of trees given out to 1,700 farmers was 1,277,700.

In addition to establishing home shelterbelts, the federal government through the PFRA undertook field shelterbelt projects at four prairie locations: Porter Lake in east central Alberta, Conquest in central Saskatchewan, Aneroid in south central Saskatchewan, and Lyleton in southwestern Manitoba. These projects were initiated to determine to what extent the planting of shelters at close intervals over a fairly small area would control soil drifting and if these shelters would benefit field crops in other ways. The most striking benefits were derived during the dry years (C.S.T.A. Review 1939) when farmers were able to produce vegetables and fruits in gardens that were sheltered by well-established tree belts, even in districts where there were complete crop failures. In many cases, too, yields from forage and grain crops were noticeably increased where protection was provided by tree shelters. Accordingly, the tree-planting program has been continued over the years and is still promoted and supported by the provincial and federal governments.

RESEARCH PROGRAM

Field and laboratory research was greatly expanded as a result of the Prairie Farm Rehabilitation Act (C.S.T.A. Review 1939). The objectives of the research were to improve moisture and trash conservation and soil stability, and to study the effect of trash accumulation on soil nitrification and crop yields.

Moisture Conservation

Tank and field experiments have shown that evapotranspiration moisture is the most important single factor influencing yield (Staple and Lehane

1954). The average rainfall over most of the prairie region is about 17 cm during the growing season (May 1 to July 31). This amount of rainfall plus 10 cm of available moisture stored in summerfallow will produce 1,000 kg of wheat/ha. Each additional 2.5 cm of water over the 27 cm will give an increase of 202–336 kg/ha up to 2,000 kg/ha. Beyond 2,000 kg/ha, yield increases per 2.5 cm of additional water level off rapidly. This study showed that in areas where precipitation is low, land that was cropped the previous year should not be seeded unless the depth of moist soil is at least 46 cm in clay soils, 61 cm in loams, and 76 cm in sandy soils at seeding time (Janzen et al. 1960).

When land is summerfallowed in preparation for seeding, 21 months elapse from the time a crop is harvested until the next crop is planted. During the first 9 months of the fallow period (first winter) about 5.6 cm (or 33%) of the total precipitation is stored. For the remaining 12 months only 4.6 cm (or 14%) of the precipitation is saved, for a total of 10.2 cm for 21 months of summerfallow (Janzen et al. 1960). To conserve this amount of moisture, tillage of summerfallow must be started as soon as weeds start growing in the spring (Korven et al. 1962).

Maintenance of a Cloddy Soil Structure

A study on particle sizes of soil established that soils containing 60% of particles less than 1 mm in diameter can be started moving by a wind of approximately 28 km/hour measured at a height of 30 cm (Experimental Farm, Swift Current 1958). On the southern prairies of Western Canada, winds often reach these speeds and faster in early spring, before and after seeding; therefore drifting occurs most years, unless an adequate trash cover has been provided to protect the erodible soil surface.

Scientists have found that overwinter aggregation effect on particle size varies with soil type and climatic conditions. The soil fraction of less than 1 mm in diameter of some loam, sandy clay loam, and clay loam soils in the south central United States increased from fall to spring (Chepil 1954). Research at the Experimental Farm, Swift Current, on a clay loam soil showed that erodibility decreased significantly from fall to spring (Anderson and Wenhardt 1966). Other studies (Bisal and Nielson 1964) revealed that after frost action, clay soil was more erosive, clay loam soil was less erosive, and almost no change occurred in sandy soil. It has been found that preseeding tillage and seeding of a clay loam soil will return the erodible soil fraction to approximately the same percentage of erodibility that existed after a season of summerfallowing the previous autumn (Anderson and Wenhardt 1966). The amount of trash incorporated into the soil had no apparent effect on the aggregation of soil overwinter.

Early in the history of soil drifting it was thought that disk-type machines pulverized the soil more than did sweep-blade implements. However, research has shown that the plow produces more clods and less fine material than the disk or blade cultivator during primary tillage on summerfallow, but that subsequent tillage nullifies the differences produced by primary tillage (Wenhardt 1962). It was concluded that tillage machines do not influence the erodibility of summerfallow fields except in their effect on trash conservation.

Trash Conservation

About 840 kg of surface trash/ha can control soil erosion by wind on medium and moderately textured soils (clay loam) (McCalla and Army 1961). The proper use of blade and disk tillage machines in a tillage sequence provides a means of regulating surface trash cover on a quantitative basis to meet the needs of good farming practices in different areas.

The blade cultivator used for summerfallow tillage keeps 55% of the original stubble and trash at the surface compared with 17% for the one-way disk or disker, and 6% for the plow (Anderson and Wenhardt 1966). The disk-type implements reduce surface cover by half with each operation at a setting 8–10 cm deep (Anderson 1961). With the use of the wide-blade cultivator, the trash reduction pattern is 15, 10, and 5%, or less of the original cover for the first, second, and third, or subsequent operations. When used for two operations after primary tillage with a disk implement, the wide-blade cultivator will return 11% and the rod weeder 14% of the original cover to the surface. The heavy-duty cultivator equipped with a rod-weeder attachment will conserve 12% more trash after two operations than can be accomplished with the cultivator alone (Anderson 1956).

Conservation of surface trash decreases as speed and depth of operation of both the heavy-duty cultivator and disk-type machines increase. The adjustment of disk-type machines is particularly important in maintaining

Fig. 12. Heavy-duty cultivators conserve crop residue, which traps snow for moisture conservation.

trash cover. Maximum trash is conserved by operating the disker at 5–6 km/hour, at a depth of 8–10 cm, with a narrow pan angle setting for the widest possible cut (Anderson 1964). During primary tillage, maximum trash stays at the soil surface when the top of the crop stubble is not more than 5 cm higher than the spacer spools on the machine.

The Effect of Trash on Crop Yield

Under dryland farming, rarely is enough trash accumulated to depress nitrification in the soil and thereby to reduce crop yields. Research conducted at Swift Current, Saskatchewan, has shown that in a continuous cropping system when all the straw produced by a crop is returned the subsequent yields are reduced by up to 18% (Soils Research Laboratory, Swift Current 1956). No depression in yield occurs when the straw is returned before the fallow period, nor is crop growth stimulated. In southern Alberta, where the annual and growing-period precipitation is similar but the evaporation is 8 cm less than at Swift Current, a straw mulch of over 4,500 kg/ha occasionally depresses nitrate production, reduces plant height, and lengthens the growing season of spring and winter wheat by 4 to 6 days (Anderson and Russell 1964). On the poorly drained clay soils in southern Manitoba, higher rates of added straw decreased the yield of oats (Ferguson 1957).

Insects and Disease

The introduction of the trash-cover system of farming had one serious disadvantage: it provided conditions that increased the population of the wheat stem sawfly (*Cephus cinctus* Norton) to epidemic proportions. As strip cropping became common so did many miles of the wheat field borders that sawflies work on, and the trash cover on adjacent strips provided ideal breeding conditions. For this reason, a wheat-breeding program involving varieties from all over the world was launched at Swift Current, and by 1946 the sawfly-resistant variety Rescue was licensed.

Entomologists in cooperation with pathologists throughout the prairie region and elsewhere set up programs that successfully controlled rust and infestations of grasshoppers, wireworms, and cutworms. These accomplishments together with the breeding of more suitable varieties of cereals and forage plants and the use of improved cultural methods helped in reducing crop failures on the prairies.

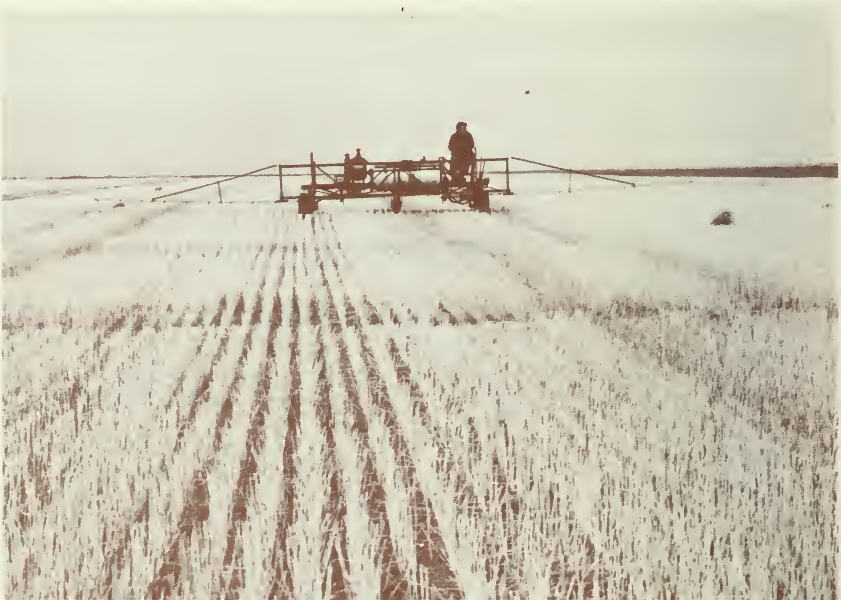
Other Related Research Programs

Continuing field research on residue and moisture conservation and weed control has resulted in the development of farm machinery that is well adapted to a dry-farming system. For maximum conservation of crop residue excellent equipment such as blade and heavy-duty cultivators, rod weeders, and wide-level diskers are now available. Results of recent work suggest that in order to conserve more residue, herbicides may be substituted for one or more tillage operations during the 21 months of fallow (Anderson 1971). Spraying in late autumn to control certain winter annual weeds can now be used effectively as a substitute for late-fall cultivation; this is another means of conserving crop residue, particularly when the residue is light. Recent developments in direct seeding (seeding without preseeding tillage) suggest that more moisture and crop residue may be conserved under a system of minimum tillage, without decreasing the yield. Research into the value of residues from various cereal and oilseed crops for controlling soil drifting has shown that only the cereal grains leave enough residue to effectively control soil erosion by wind (Anderson 1968).

The development of drought-tolerant varieties of spring and durum wheats is being studied in an attempt to stabilize annual yields and to provide enough residue. Attention is being given to root development in relation to the available moisture in the profile and to stomata size and leaf area. Breeding for resistance to disease and insects continues.

The impact of the value of seeded grass in livestock production induced researchers to turn their attention to forage crops and their management. In a plant-introduction program, the species of grasses and legumes that showed the greatest potential were selected. Also, at the same time, concentrated forage-breeding programs were started, which have provided many improved varieties and strains of perennial grasses and legumes for the semiarid prairie region. Thus, we now have three extremely drought-tolerant and winter-hardy alfalfa cultivars (*Medicago media* Pers.): Rambler, Roamer, and Drylander. Likewise, from the introduced Russian wild ryegrass (*Elymus junceus* Fisch.), we have the improved cultivars Sawki and Mayak; from tall

Fig. 13. Late fall spraying with herbicides leaves the stubble standing to trap snow.



wheatgrass (*Agropyron elongatum* (Host) Beauv.), the superior cultivar Orbit; from intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.), the cultivar Chief. Research is continuing with these and other grasses. One of the most promising of these is Altai wild ryegrass (*Elymus angustus* Trin.), which should provide an improved cultivar within a few years.

Perennial forage crops are no longer grown only in problem soils, though they are still used extensively to stabilize eroding sites. The value of grass–alfalfa mixtures for dryland hay and pasture has been vividly demonstrated, despite the infrequent occurrence of bloat on pastures containing alfalfa. Although good management greatly reduces or eliminates the risk of bloating, research on the development of nonbloating alfalfa varieties is being continued.

Well-managed fields of crested wheatgrass and Russian wild ryegrass with alfalfa have become reliable forage reserves for the expanding livestock industry. Research results have shown the importance of good establishment methods, correct plant populations, and efficient seeding patterns. It has been found, for example, that mixtures of Russian wild ryegrass and alfalfa do best when seeded in rows spaced 45–60 cm apart, permitting maximum plant development and sustained higher production. Similarly, perennial hay crops provide the most stable and the highest yields when crested wheatgrass and alfalfa are seeded in alternate rows spaced at least 45 cm apart. Where the land is rolling, the grass is seeded in widely spaced rows in one direction and the legume is cross-seeded in similar row spacings. This checkerboard dam effect eliminates soil erosion, decreases water runoff, and increases soil-moisture conservation.

Fig. 14. Seeding grass in widely spaced rows in one direction and legumes in similar row spacings but crosswise to the grass reduces soil erosion on sloping land.

CONCLUSIONS

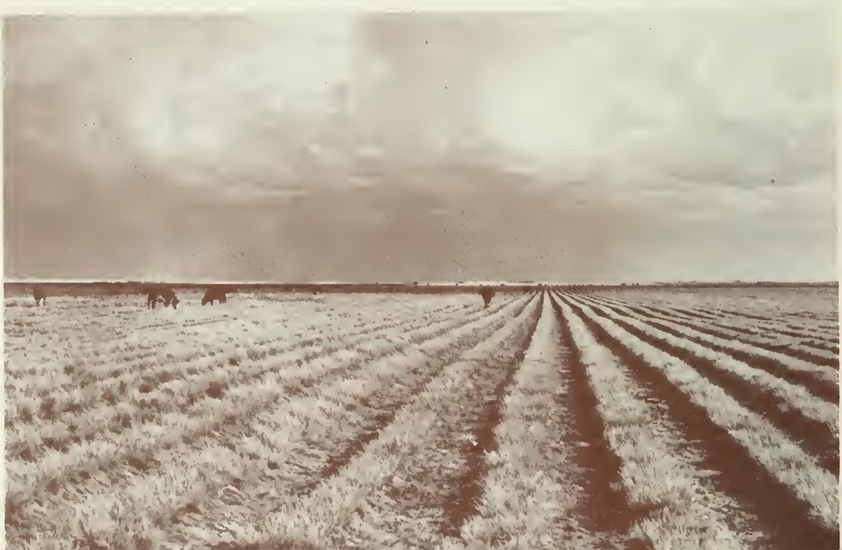
Need for Continuing Research Programs

Through the efforts of a great many agencies and individuals and with cooperation from the weather, the Palliser Triangle has been brought back to a good level of productivity. For the successful production and management of cereal and forage crops under the difficult conditions of moderate-to-severe drought, well-adapted species have been developed, management systems have been devised, and equipment has been designed and manufactured.

As a result of research and ingenuity it has been possible to sustain production in this region, but these factors alone do not guarantee the survival of the agricultural industry. The Palliser Triangle is best suited for the production of wheat, feed grains, and forage for beef cattle. Most of the wheat and feed grains are sold on international markets, and, although much of the beef is sold in Canada, the price is regulated by availability of meat from other countries. Because of these external influences, the survival of the industry in the Palliser Triangle depends also on a knowledge of current market requirements, improved production efficiency to increase the profit margin on products that can best be produced there, and tailoring the quality of these products to meet international demands. These aims must be accomplished without detracting from or polluting our natural resources. For the Palliser Triangle to be competitive with the advancing technologies of other countries, continuing research programs are needed.

To assist the producer in immediate and future production plans, intensified market research is needed for the short- and long-term projections for product development. Although this up-to-date information is needed for all products, it is particularly important for the hard red spring wheats and

Fig. 15. Russian wild ryegrass being grazed after the seed crop has been removed.



feed grains grown for export, which probably will come under governmental control for guaranteed protein content and available energy.

To improve the efficiency and stability of production in the hard red spring wheats and feed grains, yield must be increased by improving genetic capability and resistance to drought and disease. Also, standards of quality must be defined and regulated. All these factors are associated with the choice of systems of tillage and harvesting, the supplementation of deficient soil nutrients, and the use of insecticides and pesticides.

Efficient beef production requires not only improved genetic capabilities of the animal and the production of more efficient feed grains, but also improved productivity, stability, and efficient management of the essential forage crop. To achieve a genetic improvement potential requires improved knowledge of interactions with soil nutrient availability and supplementation and the extent to which these are associated with available moisture. Better systems of forage management and utilization from the time the land is prepared and seeded until the forage is harvested by the animal are also needed.

To make the progress that is needed to maintain and improve the growth of the agricultural industry in the Palliser Triangle, research and development must be reinforced by detailed up-to-date studies of climate, soil, management systems, and the economic implications of these systems. The development should also include a detailed study of the impact of these management systems on the production capability of the Palliser Triangle and of the economic and social aspects of any modification of the production environment.

Need for Sources of Information

There is a need for farmers to keep well informed on the latest progress in management practices. New methods are being devised, and improved products and varieties are being developed so quickly that it is difficult to set up an educational system that keeps the producer informed. However, for an information service to be economical and efficient, the producer must be taught to seek out the information. The information must be available in a clear, precise, and well-documented form and use all available communication aids. The information must be provided by very knowledgeable groups of specialists from government and industry whose function it is to provide the producer with all the related facts, not just a few isolated details.

SUMMARY

The main reason for the severe soil drifting that occurred on the prairies was that a cultural system was introduced that was not adapted to the ecological environment. The introduction was very rapid, on a large scale, and it coincided with periods of low precipitation, high winds, insect and disease outbreaks, and economic distress. One of the new technologies that was developed early in the settlement period (motor power for breaking and cultivating new land) resulted in the cultivation of large areas of sandy soils, which should have been left as native pasture. The system of black or bare summerfallow that made production of wheat possible in many arid areas was introduced over a wide region before it had been adequately tested for its suitability to the environment and before the required modifications were recognized and adapted.

The assistance of all levels of government and the cooperation of individual farmers were needed to set up the program that brought soil drifting under control. A strong research program and an effective extension service must continue to study the changing conditions and plan controls for wind erosion.

This case study emphasizes the complexity of the interactions among the various natural and introduced components of an environmental crisis, and the need for intensive appraisal of the potential consequences of introducing changes in management practices that disturb the natural balance before their widespread introduction.

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REFERENCES

Anderson, C. H. 1968. A comparison of annual crops for seed and residue in the semiarid region of Western Canada. Can. J. Plant Sci. 48:287-291.

Anderson, C. H. 1971. Comparison of tillage and chemical summerfallow in a semiarid region. Can. J. Soil Sci. 51:397-403.

Anderson, C. H., and Wenhardt, A. 1966. Soil erodibility – fall and spring. Can. J. Soil Sci. 46:255-259.

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

Anderson, D. T. 1964. Some factors affecting trash conservation with disk-type implements. Can. Agric. Eng. 6:11-13, 19.

Anderson, D. T. 1965. Some factors affecting trash conservation with the heavy duty cultivator. Can. Agric. Eng. 7:45-46, 49.

Anderson, D. T., and Russell, C. G. 1964. Effects of various quantities of straw mulch on the growth and yield of spring and winter wheat. Can. J. Soil Sci. 44:109-116.

Bisal, F., and Nielsen, K. F. 1964. Soil aggregates do not necessarily break down over winter. Soil Sci. 98:345-346.

Chepil, W. S. 1954. Seasonal fluctuations in soil structure and erodibility of soil by wind. Soil Sci. Soc. Am. Proc. 18:13-16.

Clarke, S. E., and Heinrichs, D. H. 1941. Regrassing abandoned farms, sub-marginal cultivated lands and depleted pastures in the prairie areas of Western Canada. Can. Dep. Agric. Publ. 720.

C.S.T.A. Review. 1939. Prairie Farm Rehabilitation. Can. Soc. Tech. Agric., Ottawa, Canada.

Experimental Farm, Canada Department of Agriculture, Swift Current, Sask. 1958. Annu. Rep. (Mimeogr.).

Experimental Station, Canada Department of Agriculture, Lethbridge, Alta. 1938. Results of experiments 1932–1936.

Ferguson, W. S. 1957. Note on the effect of stubble and straw residue on the availability of nitrogen. Can. J. Soil Sci. 37:145-146.

Janzen, P. J., Korven, N. A., Harris, G. K., and Lehane, J. J. 1960. Influence of depth of moist soil at seeding time and of seasonal rainfall on wheat yields in southwestern Saskatchewan. Can. Dep. Agric. Publ. 1090.

Korven, N. A., Wenhardt, A., Harris, G. K., and Janzen, P. J. 1962. Importance of working summerfallow early in southwestern Saskatchewan. Can. Dep. Agric. Publ. 1149.

MacKay, A. 1890. Experimental Farm for Northwest Territories Report. Appendix to the report of the Minister of Agriculture. Brown Chamberlain, Printer to the Queen's Most Excellent Majesty.

McCalla, T. M., and Army, T. J. 1961. Stubble mulch farming. Pages 125-196 *in* A. G. Norman, ed. Advances in agronomy. Academic Press, New York, N.Y.

Soils Research Laboratory, Canada Department of Agriculture, Swift Current, Sask. 1956. Prog. Rep. 1948–1954.

Staple, W. J., and Lehane, J. J. 1954. Weather conditions influencing wheat yields in tanks and field plots. Can. J. Agric. Sci. 34:553-564.

Wenhardt, A. 1962. Surface clod production characteristics of some tillage machines on a clay loam soil. Can. J. Agric. Eng. 4:33-36.

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