

WILLIAMS SERIES

North Dakota State Soil



SOIL SCIENCE SOCIETY OF AMERICA



Introduction

Many states have a designated state bird, flower, fish, tree, rock, etc. And, many states also have a state soil—one that has significance or is important to the state. The Williams is the state soil of North Dakota. Soils form the foundation of North Dakota, which is firmly recognized in the state’s motto “Strength from the Soil” that appears on the state’s coat of arms and the governor’s flag (**Fig.1**).

In North Dakota, the Williams soil series is among the most extensive and economically important soils in the state. The native vegetation of the Williams series includes species such as western wheatgrass, blue grama, needle-and-thread, green needlegrass, and prairie junegrass. These soils have high natural *fertility* and their content of *organic matter* creates highly productive landscapes. Most level to gently rolling areas of Williams soils are used for growing small grain crops such as wheat, barley, oats, flax, and sunflowers, whereas the steeper rolling and hilly areas are used as rangeland.

History

The soil name is derived from Williams County, North Dakota, although the type location is in Mountrail County, near the town of White Earth. In 1900, the Williams series was recognized as an official soil series for North Dakota.

William soils formed under short grass *prairies* and were mostly converted to small grain production and working rangelands upon settlement. These working landscapes are still present today, although more recently the region where these soils predominant has been focused on great amounts of oil and gas extraction.

What is Williams Soil?

The Williams soil profile (**Fig. 2**) is very deep, meaning there is no bedrock within 6 feet of the surface. These soils formed in *calcareous tills* (meaning that high levels of *carbonates* are naturally present) that were deposited by *glaciers*. These very deep soils also usually contain *water tables* that are more than 4 feet below the surface. However, water moves only moderately slowly through Williams soils.

Every soil can be separated into three separate size fractions called sand, silt, and clay, which makes up the soil texture. They are present in all soils in different proportions and say a lot about the character of the soil.



Fig. 1. The North Dakota coat of arms emphasizes the importance of soils (credit: http://ndstudies.gov/nd_coat_arms).



Fig. 2 This shows a profile of a Williams soil, the state soil of North Dakota (USDA-NRCS Soil Survey Staff). Credit: Smithsonian Institution's *Forces of Change*.

The surface layer, or A horizon, is the darkest layer due to enrichment with organic matter. The texture is typically loam. Beneath the surface layer are the B horizons, layers where changes occur. They are the brown and yellow layers immediately below the surface, and are loam or clay loam. Lowest in the soil profile is the C horizon, the material deposited by the glaciers and from which the Williams soil developed. It is loam or clay loam and likely contains some pebbles or cobbles.

The annual precipitation in areas with Williams soils is about 14 inches per year, which is not enough water to flush the calcareous materials from the soil profile. As you can imagine, the temperature regime in North Dakota is frigid with soils commonly freezing to several feet below the surface during winter months.

Where to dig a Williams

With more than 2.2 million acres of Williams soils in North Dakota, they can be found in twenty counties across the state (**Fig. 3**). The acreage of Williams is about 7% of the total area of North Dakota.

The Missouri *Coteau* cuts through North Dakota diagonally, bordered by the James River on the east and the Missouri River to the west. Williams soils are located predominantly in this glaciated Missouri Coteau region (**Fig. 3**). They occupy higher, rolling convex areas as opposed to depressional swales, or concave areas.



Fig. 3 The range of the Williams soil across North Dakota (credit: Smithsonian Institution's *Forces of Change*, <http://forces.si.edu/soils/interactive/statesoils/html/State-Soils/Default.aspx?selection=NorthDakota&tab=where>).



Fig. 4 Harvested wheat on a Williams soil in North Dakota (credit: USDA-NRCS Soil Survey Staff).

Importance

North Dakota has some of the greatest natural resources in North America with Williams soils among the most extensive and economically important soils in the state. For example, the prairie pothole region, bisecting North Dakota, is the primary nesting ecosystem for migrating waterfowl, producing ~50% of the ducks in North America (Smith et al., 1964). Additionally, North Dakota ranks first in the US for 12 commodities including honey, and first in the country for hard red spring wheat and durum. On average, North Dakota grows nearly one-half of the nation's hard red spring wheat (250 million bushels) and two-thirds of the durum (50 million bushels), with over 100 nations importing red spring wheat and durum from North Dakota (**Fig. 4**).

Uses

Due to the natural fertility and high organic matter content of these soils, they are used for cropland in areas that are gently rolling or level. Wheat, barley, oats, flax, and sunflowers are the principal crops. In contrast, in areas that are mostly rolling and hilly, Williams soils are used as rangeland. The native range vegetation consists of western wheatgrass, blue grama, needle and thread, green needlegrass, and prairie junegrass.

Limitations

Although Williams soils can be highly productive, the climate is the major limitation for agricultural uses. Because they are located in a region that has moderately low precipitation and a short growing season (110–130 frost free days), crop selection has its limitations. Crops, such as durum and spring wheat, that do not have excessive water demands and require shorter growing seasons, can thrive, while growing corn can have its challenges. In general, Williams soils are not limited for building construction, although special considerations are needed for road construction. Additionally, use of these soils for septic systems is limited due to low water flow. Although these limitations can restrict some agricultural crops and construction designs, Williams soils are excellent for supporting natural grassland ecosystems.

Management

Williams soils are highly calcareous, which can affect micronutrient availability to crops. For example, soybeans grown in these soils may suffer from iron nutrient deficiencies. Although plenty of iron is present in the soil, the forms of that iron are not readily available for plants to use. The region's low precipitation is another consideration for managing these soils. Farming methods that optimize the retention of soil moisture, such as conservation tillage to reduce soil water evaporation, are essential. Additionally, wind and water can increase loss of topsoil, decreasing the tilth of Williams soils. Management methods that provide soil protection from erosion are also essential.

Soil Formation

Before there was soil there were rocks and in between, CIORPT. Without CIORPT, there will be no soil. So, what is CIORPT? They are five major factors that are responsible for forming a soil like the Williams series. These are **climate**, **organisms**, **relief**, **parent material**, and **time**. CIORPT is responsible for the development of soil profiles and chemical properties that differentiate soils. So, the characteristics of Williams soils (and all other soils) are determined by the influence of CIORPT. Weathering takes place when environmental processes such as rainfall, freezing and thawing act on rocks causing them to dissolve or fracture and break into pieces. CIORPT now acts on rock pieces, marine sediments, and vegetative materials to form soils.

Climate—Temperature and precipitation influence the rate at which parent materials weather and dead plants and animals decompose. They affect the chemical, physical, and biological relationships in the soil. Williams soils developed under cold and subhumid (low to moderate precipitation) climatic conditions. The combination of these two resulted in the prairie vegetation that developed on these soils, with high organic matter content, whereas the low precipitation did not allow the carbonates to be *leached* from the soil profile.

Organisms—This refers to plants and animal life. In the soil, plant roots spread through, animals burrow in, and bacteria eat plant and animal tissue. These and other soil organisms speed up the breakdown of large soil particles into smaller ones. Plants and animals also influence the formation and differentiation of *soil horizons*. Plants determine the kinds and amounts of organic matter that are added to a soil under normal conditions. Animals breakdown complex compounds into small ones and in so doing add organic matter to soil.

Williams soils developed under perennial prairie grasses that supported large numbers of native herbivores, such as bison. Annually, prairie grasses died back leaving their roots and above-ground vegetation to decompose and contribute to the large organic matter pool that contributes to the high natural fertility of these soils.

Relief—Landform position or relief describes the shape of the land (hills and valleys), and the direction it faces makes a difference in how much sunlight the soil gets and how much water it keeps. Deeper soils form at the bottom of the hill rather than at the top because gravity and water move soil particles downhill. Williams soils are well drained because they formed on the higher positions of the landscape.

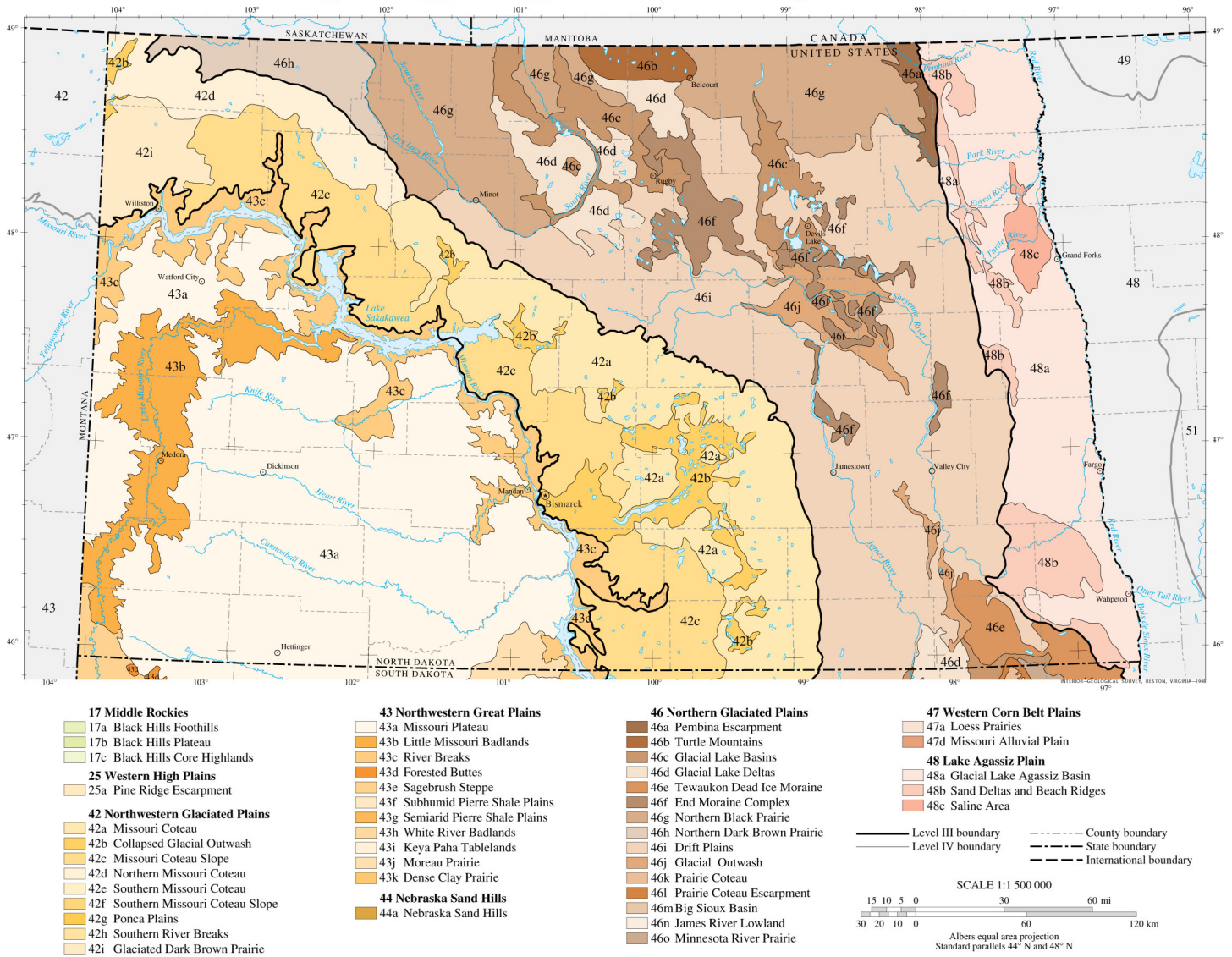
Parent material (C horizon)—Just like people inherit characteristics from their parents, every soil inherited some traits from the material from which it forms. Some parent materials are transported and deposited by glaciers, wind, water, or gravity. Williams soils developed from highly calcareous till deposited from glaciers that cut across the *Canadian Shield*.

Time—All the factors act together over a very long time to produce soils. As a result, soils vary in age. The length of time that soil material has been exposed to the soil-forming processes makes older soils different from younger soils. Generally, older soils have better defined *horizons* than younger soils. Williams soils formed in a more recent glaciation called the late-Wisconsin, about 10-12 thousand years ago. Comparatively, there are regions of western North Dakota that were glaciated 1-2 million years ago and regions of southwestern North Dakota that have never been glaciated with parent materials that are about 65 million years old. The soils of these regions are older and more highly developed.



Fig. 5 Typical till plain in production and demonstrates relief as a soil forming factor. Note the differences in A horizon thickness across landscape positions. (credit: USDA-Soil Survey).

Ecoregions of North Dakota



Ecoregions, Soils and Land Use in North Dakota

Red River Valley (ecoregion 48) – Lake Winnipeg is the remnant of glacial lake Agassiz, which extended south all the way to the border of South Dakota. The Red River Valley on the far eastern portion of North Dakota was formed from the sediments of this ancient glacial lake. The Red River is one of very few rivers in the US that flows north. Soils formed in the Red River basin are very clayey and experience extreme shrinking and swelling, but are among some of the most productive in the state and nation.

Till Plain (ecoregions 46, 42) – As you move west from the Red River Valley, you may see remnants of ancient sandy beaches that formed the shores of glacial lake Agassiz, transitioning to the rolling till plains. These till plains were formed from glaciers that brought materials from the Canadian Shield. Many important glacial processes that form different land features can be observed in this till plain area. *Moraines* tend to be loamy textured, while outwash features formed from glacial meltwaters tend to have soil textures that are sorted from gravels to sand to finer textures.

Unglaciated Southwestern (ecoregion 43) – The southwest of North Dakota has been left unglaciated over time. Parent materials in this region are quite old, about 65 million years old. Buttes and badlands can be observed in these regions, and many of the state’s famous fossils have been discovered here.



Fig. 6
Typical till plain of the region. (credit: USDA-Soil Survey).

Glossary

Calcareous: The presence of carbonates.

Canadian Shield: A large area in northern and central Canada of exposed Precambrian igneous and metamorphic rocks.

Carbonates: A salt mineral that contains an ion composed of one carbon and three oxygen atoms. The most common types are calcite (CaCO₃).

Clay: A soil particle that is less than 0.002 mm in diameter. Clay particles are so fine they have more surface area for reaction. They hold a lot of nutrients and water in the soil. A clay soil is a soil that has more than 40% clay, less than 45% sand, and less than 40% silt.

Coteau: A hilly upland or divide between valleys.

Ecoregion: Represents areas with similar biotic and abiotic characteristics which determine the resource potential and likely responses to natural and man-made disturbances. Characteristics such as climate, topography, geology, soils, and natural vegetation define an ecoregion. They determine the type of land cover that can exist and influence the range of land use practices that are possible.

Fertility: A soil's ability to supply nutrients and support plant growth.

Glacier: Related to a slowly moving mass of ice formed by the accumulation and compaction of snow.

Horizon: see Soil horizons

Leach: The removal of soluble material from soil or other material by percolating water.

Moraine: The sediments carried by a glacier and deposited when the glacier melts.

Organic Matter: Material derived from the decay of plants and animals. Always contains compounds of carbon and hydrogen.

Prairie: A large open area of grassland.

Sand: A soil particle between 0.05 and 2.0 mm in diameter. Sand is also used to describe soil texture according to the soil textural triangle, for example, loamy sand.

Soil Horizon: A layer of soil with properties that differ from the layers above or below it.

Soil Management: The sum total of how we prepare and nurture soil, select type of crops that are suitable for a type of soil, tend the crop and the soil together, type of fertilizer and other materials added to soil so as to maintain productive and preserve soil.

Soil Profile: The sequence of natural layers, or horizons, in a soil. It extends from the surface downward to unconsolidated material. Most soils have three major horizons, called the surface horizon, the subsoil, and the substratum.

Soil Texture: The relative proportion of sand, silt, and clay particles that make up a soil. Sand particles are the largest and clay particles the smallest. Learn more about soil texture at www.soils4teachers.org/physical-properties

Till: The sediments deposited by glaciers.

Topsoil: (A horizon) The horizon that formed at the land surface. Mostly weathered minerals from parent material with a little organic matter added.

Water Table: The top layer of ground water where the soil is filled with standing water.

Additional Resources

Lindbo, D. et al. 2008. *Soil! Get the Inside Scoop*. Soil Science Society of America, Madison, WI.

Lindbo, D. L., D. A. Kozlowski, and C. Robinson (ed.) 2012. *Know Soil, Know Life*. Soil Science Society of America, Madison, WI.

Web Resources

SOIL SCIENCE LINKS:

Soil Science Society of America—<http://www.soils.org/>

Soils4Teachers—<http://www.soils4teachers.org/>

Soils4Kids—<http://www.soils4kids.org/>

Smithsonian Soils Exhibit—<http://forces.si.edu/soils/>

Have Questions? Ask a Soil Scientist—<https://www.soils.org/ask>
https://soilseries.sc.egov.usda.gov/OSD_Docs/W/WILLIAMS.html

Natural Resources Conservation Service—<http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/>

Natural Resources Conservation Service, Educational Resources
—http://soils.usda.gov/education/resources/k_6/

References

Smith, A.G., J.H. Stoudt, and J.B. Gollop, Prairie potholes and marshes, in *Waterfowl Tomorrow*, J.P. Linduska, Editor. 1964, U.S. Gov. Printing Off.: Washington, D.C. p. 395-50.

National Cooperative Soil Survey U.S.A. Soil Series Description. https://soilseries.sc.egov.usda.gov/OSD_Docs/W/WILLIAMS.html

ND Game and Fish Geographic Regions. <http://gf.nd.gov/wildlife/plants-habitat/habitats/regions>

USDA-SCS. Soil Survey of Mountrail County, ND

http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/north_dakota/ND061/0/mountrail.pdf

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