A History of Plant Mineral Nutrients in North Dakota, with Special Emphasis on Historic Phosphorus Exports

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North Dakota’s soil before settler crop production was a relatively nutrient-rich prairie soil, with young (less than 10,000 years) soils east river and older, more fragile soils west-river.

The topsoil contained relatively high levels of available nitrogen, phosphorus and potassium. Native calcium and magnesium and micronutrient levels were high.
Some early settlers made money by collecting buffalo bones and sending them to the east for fertilizer. Native Americans also were paid to collect the bones.

Piles of bones near Fort Totten, ND in the 1880’s destined for shipment as fertilizer to the east. Photo courtesy of Buffalo Bone Days, 1939. (Nupp Printing, PA)
Metis men hauling bones from the prairie to railroad depots - 1880’s
1880, Kulm, ND- The first several years were especially hard due to crop failures and low prices. Buffalo bones were picked and hauled to Ellendale and exchanged for food and flour. Ellendale was their nearest town at that time and was 42 miles from their farm.

Mr. Krueger broke up about ten acres of land that first year, but 1889 was a drought year and he didn’t even get his seed back. Mr. Krueger, having nothing else to do after seeding, started picking buffalo bones. The bones were sold at Edgeley and Ellendale, Dakota. Here he received about $12 per ton. He would go out one day and come home the next with a wagon load of bones, camping out overnight. He sold about $70 worth of bones during the early part of summer in 1889. This helped the Krueger family quite a bit as they had no other income.

Near Lehr, ND, 1890, planted their first flax crop and collected buffalo bones- took to Ellendale, received $2 per wagon load.
They packed their belongings and traveled as far as Ellendale, N.D. and then Farther on as far as Kulm, N.D. which wasn't on the map at that time. They homesteaded 18 miles southwest of what is now Kulm. (1888). There were plenty of buffalo horns and bones available and occasionally a load of bones and horns were picked up and hauled to Ellendale to make some money to buy a few food supplies. This would always be a very weary and hard journey. If the oxen didn't get thirsty during the trip then it would take about a week, but if they did get thirsty, they would head for a lake and take their time to get going again. Luck was our lot most of the time except once the oxen tipped the load of bone into a lake and Mr. and Mrs. Isaak found themselves in the lake with the bones, shouting Gee! Haw! Get up! But that didn't help the situation any, altho it increased the weight of the load and the check was a little larger.

Mr. Lemke and the older children also picked buffalo bones with which the hills were strewn in those days, and hauled them to Ellendale and sold them.

1887 brought one of the worst prairie fires. After the fire, Mrs. Mueller took a knife and cut brush that was left by the fire to use as kindling as all wood was destroyed. The following winter brought a bad snow storm that lasted for three days. The snow covered all the buildings with only the house chimney showing. Mr. Mueller had to shovel the snow from the kitchen of the house in order to save the family. Mr. Mueller and his boys hunted the prairies for animal bones that were taken and sold in Ellendale, the closest town.
The Mundts often picked buffalo bones and took them to Ellendale to be sold and a few essentials were bought such as flour which was the most important part of the diet. This trip usually took them three days and many times there was no food left when they returned home. Snow was often so deep that the oxen would become stuck in the deep drifts.

Mr. Bittner and his daughter gathered buffalo bones, sometimes they gathered a wagon box full in a day. While they were gathering bones, Mrs. Bittner and Jacob broke up some of the sod for a crop. A team of horses and two oxen were used for plowing and it was Jacob’s job to lead them. The seed was sown by hand the first year. With the crop planted, the house was the next thing to think of. The bones were hauled to Ellendale and sold for $8.00 to $10.00 per load and lumber was purchased for the door and the window frames.

Mr. Netz gathered buffalo bones in 1889- $4 per load in Ellendale.
When Fort Browning (MT) was operating in 1868, one of the buildings was used to store bones. The real trade in buffalo bones did not begin until 1884, when the Michigan Carbon Works was paying $7/ton. By 1885 the price had risen to $12 by rail and $18 by boat. Most of the early trade was along the Yellowstone because that was where the first railroad was. As early as 1884, Charles Aubrey was paying $4/ton for bones along the Missouri, between Rocky Point and Fort Buford. At this time the bone picking began on a large scale along the Milk River. The Coulson Steamship was the first to pick up bones on the Missouri. Then the Benton Transportation Co. entered in the trade. However, the captains were reluctant to stop and pick up the bone piles and most were left. In 1887 Charles Sivyer replaced Aubrey in an effort to stimulate the trade. Sivyer encouraged the Metis-Cree of the Milk Valley to stack the bones along the right of way of the rapidly approaching St. Paul, Minneapolis and Manitoba Railway (Great Northern). Sivyer, however, unexpectedly sold out and left the country. The heaps of bones laid untouched until 1892 at which time Glasgow residents built their own craft to float the bones down river to markets. By the end of 1892 the bone trade was over.
Loading buffalo bones near Krem, ND.
Bones to be loaded onto a train car in Ellendale, 1888.
A typical fresh bone meal guaranteed analysis is 3-15-0.

After some time on the prairie before collection, most nitrogen would probably have returned to the soil, but the phosphorus (15%) would have been harvested.

From 1872-74, the Santa Fe railroad and others in Kansas shipped over 32 million pounds of bones to the east.
The official figures for bone harvest and shipment for North Dakota were destroyed by fire, but it is reasonable that the tonnage shipped east was at least as great as Kansas.

The pile shown in the Fort Totten photo image represented 150 box cars of bones, each box car holding the bones of approximately 850 animals.

(Buffalo Bone Days, 1939)

There were an estimated 9.5 million buffalo in the northern herd, with about 10 animals per ton of bone. Most skeletons were shipped east.
If 32,000,000 pounds of bones were shipped, containing 15% phosphate, then about 480,000 lbs of $\text{P}_2\text{O}_5$ was shipped out of North Dakota east and removed from the ecosystem.

For comparison, that is about 2 years P fertilizer use at present rates, which are at a historic high.
Even more devastating to ag-production and the natural fertility of soil was the loss of topsoil in the 1930’s and beyond.

Dust storm aftermath in McKenzie County, ND- (USDA-FSA image)
1910-1915 tillage, Red River Valley - Not a tree in sight.
Recollections from Bethany Nursing Home resident
Orville Stenerson from Dodge, ND interviewed by
Dr. Thomas DeSutter
1932- good year
1933- bad year
1934- Dry, lots of dust
1935, good year with rains
1936- Very bad year- the worst. Lots of dust
   and grasshoppers 3 loads of hay-
   compared to 20-30 in good year
Dust blackened the sky- had to turn on
   oil lamps to see at noon
Sold all the livestock. Kept only a dairy cow
Used russian thistle for forage. No wheat
1937- better than 1936, still bad
Wind erosion susceptibility in the USA, Hagen,
Dust storm near Williston
Emmons County, late 1930’s- new fence line sits on top of old fence line.
Dunes over a barn, Kidder Co., 1939
Bismarck, ND- While frequent dust storms have visited North Dakota this spring (1934) those on 11 days warrant special mention. The most severe of these storms occurred on April 21-22. The velocity of the wind was greater on the 21st, but the volume and density of the dust was greater on the 22nd. The latter storm caused the most comment because of the fact that the 22nd was a Sunday, and travel both by automobile and by plane was hazardous and difficult. Several aviators reported that dust was encountered at all levels up to 14,000 feet. A report on the storm of April 22 follows: A severe dust storm began at 11 AM and continued all day, ending the night following. Visibility at the station was as low as 200 yards, at various times. This was the most severe dust storm experienced at the Bismarck station during the 28 years I have been in charge.
Wind erosion assessment during the 1930’s, North Dakota

573,000 acre with serious erosion-area requiring methods to ensure continued productivity

9.1 million acres so severely eroded that further use for crop or livestock production is economically unfeasible.
Soil loss- 1930’s-
Black is ‘moderate wind erosion’ 25-75% topsoil loss
Grey dotted is ‘slight’ wind erosion- 25% topsoil loss
Oblique slash is total wind/water erosion- moderate- 75% topsoil loss

From ‘General Distribution of Erosion, USDA- 1936
(Note-only the first half of the ‘30’s)
In 1933 it was estimated that topsoil losses reduced annual productivity from 15 to 25 percent, and when the soil was fully stripped, fields became unproductive or “barren.”

Memo to the Secretary of Agriculture, August 22, 1933, National Archives, Record Group 114, MLR 1, box 74, and memo to Hugh H. Bennett, Soil Erosion Service, June 5, 1934, box 4.
In a prairie soil, nutrients released by parent material weathering are gathered by the plants and moved to the surface. In a grazed environment the nutrients are moved to some distance by the grazing animal, but returned at some point through manure or death to the grasslands.

Therefore, the soil organic matter present when the land was plowed was the natural conservation ‘bank’ of thousands of years of soil, plant and microorganism activity.
Initial wheat yields in the richer soils of eastern North Dakota were quite high for the time- 40 bushels per acre cited by Hiram Drache near the Sheyenne River, Kindred, ND. (30 bushels per acre, 1890 near Jamestown).

This would have only been possible if over 100 lb N/acre and substantial P and other nutrients were released from soil organic matter mineralization that season.

Rates of N mineralized today are nearly always less than 100 lb N/acre on fallow soils.
Analysis of dust in the 1930’s compared to the soil that remained showed that there was 19 times more $P_2O_5$ in the dust than in what was left.

Also 10 times more organic matter,

9 times more nitrogen, and

45 times more potassium.

With topsoil

Without topsoil
Effect of topsoil thickness on corn yields, Upham, ND, Lyle 1975.

Yield reduction per inch of topsoil loss, bushels/acre

3.4 bushels per acre
(7.4% of yield- 46 bushel per acre corn)

converted into today’s yields-
1 inch of topsoil loss ~ 14 bushels per acre
Estimate of topsoil lost from date of plowing to late 1930’s-
about 6 inches from hilltops and about 4 inches from slopes.

An average of 5 inches of topsoil lost in North Dakota from about 10 million acres of cropland. Total weight ~ 16 billion tons of soil.

At present, the surface 6 inches of soil contains about 2,000 lbs/acre of $P_2O_5$. Total $P_2O_5$ lost would have been 8 million tons— or 40 years of $P_2O_5$ application at present rates.
Land damaged annually by wind erosion in the Great Plains

From Hagen and Woodruff, 1973 Atmos. Env.
Grand Forks County, 1950’s
Wind erosion damage by year

Great Plains - 1955 - 469,000 acres

1977 - North Dakota 3.6 million acres
   (13% of cropland)

1980 - North Dakota 1 in. soil lost from 2.1 million acres

1982 loss of 1.6 Gt west of Mississippi - equivalence of 2 inches of topsoil from 2.4 million acres
Why aren’t growers and landowners more alarmed about continual soil loss?

They mask the effects with tillage.

They have no check for reference, or ignore the obvious.
Simultaneous cultivation and erosion on hidden soil losses and truncation of the soil profile
Brandon Montgomery and Dr. David Hopkins have revisited soil survey sites characterized in about 1960.

They have found
1960
Ap 0-6.3 in.
Bk1  6.3-16.8 in.
Bk2 16.8 to 34.3 in.
C 34.3 in. +

2014
Ap 0- 5.1 in.
Bw1 5.1 – 11.2 in
Bw2 11.2 – 15 in.
C  15 inches +

Data implies site lost about 19 in. topsoil in the past 40 years
Steele Co.

1960

Ap 0- 5.5 in.

Bw 5.5 in – 9.5 in

Bk1 9.5 – 17 in.

Bk2 17 – 21.3 in

C 21.3 in +

2014

Ap 0 – 6 in.

Bw 6 – 12 in.

Bk1 12 in – 20.9 in

C 20.9 in +

Indicates that about 3 inches of top soil lost in 40 years.
Research by Albert Simms at University of Minnesota and Jasper Teboh at NDSU conservatively found about 2,000 pounds per acre \( P_2O_5 \) in the surface 6 inches of soil.

If you have lost an additional 3 inches of topsoil from about half our cropped acres since 1940, we would have lost about 5 M tons of \( P_2O_5 \) and 16.5 M tons of N. This is the equivalent of about 30 years of N and P application at present rates.
Despite historic high rates of fertilizer nutrients, levels of P on many North Dakota farms are still low.

We probably have at least 70 years of no soil loss and continued P application to catch up to where we were in 1890.
Soil loss helps answer these questions:

Why don’t my soil P values improve?

Why is my soil pH increasing?

Why do I have more soil crusting?